Ammunition - A Descriptive Treatise

Vivian Dering Majendie

AMMUNITION

A Descriptive Treatise on the Different Projectiles, Charges Fuzes, Rockets, &c., at Present in Use for Land and Sea Service and on Other War Stores Manufactured in the Royal Laboratory

Elibron Classics

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BY CAPTAIN VIVIAN DERING MAJENDIE, ROYAL ARTILLERY,
ASSISTANT SUPERINTENDENT, ROYAL LABORATORY, WOOLWICH.

Ammunition for Smooth-bore Ordnance.

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Second Thousand.

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TREATISE ON AMMUNITION.

ERRATA.

Page 56, line 3 from bottom of text. *For* "object aimed at which" &c., *read* "object aimed at at which" &c.

Page 77, note 5. *For* "cane" *read* "canvas"

Page 78, line 22. *For* "fuze composition, made in it" &c., *read* "fuze composition, are made in it" &c.

Page 81, note 1. *For* "p. 79," *read* "p. 80,"

Page 81, note 4, line 3. *For* "303/60" *read* "30/3/60"

Page 87, line 1. *For* "ight" *read* "light"

Page 101, note 1, § 3rd, last line. *For* "filled." *read* "fitted."

Page 104, note 8, line 1. *For* "loading" *read* "fuze"

Page 104, note 8, line 2, ditto.

Page 104, note 8, § 2, line 2. *For* "1865," *read* "1863,"

Page 118, note 8. *For* $1\frac{1}{2}'$ *read* $1\frac{1}{2}''$

Page 144, § 5 of text. *Omit* "one seventh to one eighth"

Page 177, line 8. *Omit* from "In construction" &c. down to end of line 11, *and substitute* "The capacity of the hopper is about 95 lbs."

Page 223. The passage from "This light burns about 2 minutes" &c. down to "and packer's name, &c." ought to be placed before the "Note" on blue and green lights.

Page 255, paragraph on Diaphragm Shrapnel fuze, line 2. *For* "shrapnel," *read* "fuze,"

Page 256, line 4. *For* "is" *read* "are"

Page 257, line 7 from top. *For* "two" *read* "·2"

Page 257, line 19 from top. *For* 9″, *read* ·9″,

Page 267. Description of 20-seconds fuze, § 3, line 2. *For* "fig. 26" *read* "fig. 16"

Page 267. Description of 20-seconds fuze, § 3, line 5. *For* "fig. 26" *read* "fig. 9"

Page 274, line 3 from bottom of text. *For* "seam" *read* "same"

Page 275, line 13 from top of page. *Insert* comma after "numeral"

Page 377, line 9. *For* "of assisting" *read* "by assisting"

Page 392, line 3. *For* "xii" *read* "xiii"

Page 392, line 4. *For* "xii" *read* "vii"

Page 393, line 21 from bottom. *For* "31" *read* "263"

Page 396, line 13. *For* "12" *read* "xiii"

PREFACE.

THE following extract from the letter which I addressed to the Superintendent, Royal Laboratory, when officially submitting the first volume of this work, sufficiently explains its nature and object.

It also accounts for the great length to which the foot-notes have extended; and I would request particular attention to this explanation, without which the plan of the work will not appear very intelligible.

"In forwarding this part of the work for your consideration it is desirable that I should briefly explain,—

"1st. The object with which it was originally undertaken, and which I have kept in view during its preparation.

"2nd. Its exact nature, scope, and arrangement.

"1st. When I first joined this department as Captain-Instructor the want of some complete work on laboratory matters at once presented itself to me; such a work I presumed would materially assist the instructional staff, and tend to simplify and shorten the course of those under instruction to an extent which is indicated by the fact that the MS. notes made by officers in this department have extended sometimes to little short of 1,000 pages. But such a work I conceive will have a wider application. The number of officers and others of the two services who have the opportunity of going through a laboratory course is very small compared with that of those who have not this opportunity; and yet the subjects dealt with in this course are of equal interest and importance to all. It follows then that the absence of any work giving a complete description of the ammunition and laboratory stores generally in use must be attended with inconvenience and disadvantage to the service at large.

"Moreover, even to the yeomanry, volunteers, and militia forces a great number of the subjects dealt with in this work have a direct professional interest. It has been to meet these wants, admitted by very many officers, and appreciated by none more keenly than by myself, that this work has been undertaken and prepared.

"2nd. I felt, then, that this work was not intended for the sole use of any particular class of officers or others under instruction, of any particular course, long, short, or special, or of any particular branch of the service outside the department; it was required to meet the wants of all who might turn to it for reference or information.

"These considerations determined me in the first place to make the work as full and complete as possible, excluding, however, manufacture, upon which it is indispensable that an officer should make his own notes on the spot, actually observing and following the operations, of which a written description, even if accompanied with good drawings, would fail to convey an accurate idea.

"A difficulty, however, presented itself at the outset, which has influenced the arrangement of the work, and which it is therefore necessary I should name. It is evident that, while many officers will consult this work only to satisfy themselves as to the general construction and appearance of a particular store, others, such as firemasters, officers going through a long course, &c., may require very much fuller information.

"To have adapted the work exclusively to the requirements of the latter class would have in a measure defeated my original intention, by swamping the text with details and making it needlessly minute for general purposes; on the other hand, to have omitted these details altogether would have diminished its value. I accordingly met the difficulty by transferring all minuter details, and, as far as practicable, all measurements, from the text to foot-notes and to tables, leaving the text as general and accurate as possible. For example, it may be quite sufficient for ordinary purposes that an officer should know that a metal fuze is made of an alloy similar to gun metal—that information is given in the text; a note, however, gives the proportion of the ingredients of that metal, and to this note an officer requiring the information would be able to turn.

"Again, I have placed in an Appendix those subjects which required to be discussed at so great a length as to make them inadmissible in the body of the work, together with details of some experiments and lengthy extracts from the reports of committees or other works.

"Another explanation of the great length to which the foot-notes extend is this. I have been anxious to substantiate, if possible, every statement in my text, to put forward nothing but departmental details which does not rest on better authority than my own, and this has necessitated a vast number of references to other books, and, in some cases, extracts therefrom.

"These references to books will, I believe, serve another purpose; they will prove useful in guiding those who may desire it to other works bearing upon these subjects, and will afford a sort of guide for professional reading or inquiry.

"I have also endeavoured to quote in the notes the authority for the adoption of any particular store or pattern, or for any particular change, with date, and this will probably be found useful for reference.

"While endeavouring to make my work as complete as possible, I have carefully avoided going elaborately into theory or into those subjects, such as the flight and motion of projectiles, the chemical nature of laboratory compositions, &c., which connect themselves with other courses of instruction, although in several instances I have referred the reader to works where he may inform himself upon these subjects. I have not attempted, except in a very few instances, to describe any stores *not actually in the service*, or stores which having long since been practically superseded are not yet exhausted, and have never been officially pronounced obsolete, or stores which are at present only experimental.

"Such is the nature, scope, and arrangement of this work. It is necessarily somewhat lengthy; but the subject is a most extensive one, embracing a greater range, including a larger number of details, and having a wider professional interest probably than any other subject which could be named.

"Such a subject I thought if treated at all should be treated thoroughly.

"It is impossible but that in a work of this sort some errors should have crept in; but I have done my best to exclude them, and the greater part of the work, which has engaged me more or less since I first joined the department, has been revised and re-written as often as three times."

The great length to which this volume, devoted to smooth-bore equipment, has extended is due, as explained in the opening passage of the work, page 3, to the fact that many smooth-bore stores form part also of rifled-ordnance equipment, and are thus common to the two classes of ordnance. This first part, therefore, although strictly limited to smooth-bore equipments, is as indispensable to the study of ammunition for rifled ordnance as the forthcoming part of the work, which professes to deal exclusively with that part of the subject. Thus, for example, the Pettman general service fuze would generally be regarded as a rifled-ordnance store; but it belongs also to smooth-bore ordnance, and is included therefore in this volume. So of a vast number of other stores which belong to the two equipments, but which the plan of the work includes under the head of smooth bore, as having in many instances belonged to that class before rifled guns were introduced.

In some future edition it may appear desirable to reverse this arrangement, bringing the whole of the rifled-ordnance stores under that head, and occupying the smooth-bore part only with stores which *exclusively* belong to it. But for the present the plan which I have adopted appeared to me for many reasons to be the most convenient.

My object in keeping smooth-bore ordnance separate from rifled ordnance has been thereby to avoid the continual changes to which a combined account of the two would have been liable. As it is, the changes in smooth-bore stores even during the preparation and printing of this volume have been so numerous as to have made it no easy matter to ensure the correction of the work up to the date of publication, and these changes have materially increased the labour of its production.

Rifled ordnance, small arms, and rockets are all in a state of active transition, and it would be impossible at the present moment to produce anything like a complete or satisfactory work on these classes of stores. But we may hope that the changes in smooth bore equipments will not be more numerous than can easily be notod in the margin, and that this volume will remain substantially correct for several years.

I have now only to express my thanks to the many officers and others from whom I have received assistance in the preparation of this work. Among the large number who have so assisted me my thanks are, I think, specially due to the following:—To Brigadier-General Lefroy, who has placed at my disposal many valuable books and documents and the records of the Ordnance Select Committee for reference; to Captain Gordon, C.B., the Principal Superintendent of Stores, who has replied to my too numerous questions with a ready courtesy, for which I cannot sufficiently express my obligations; to Captain Browne, R.A., who, in addition to furnishing a valuable chapter on the "Principal Substances used in Laboratory Compositions," has assisted in the reading of the proofs; to M. Alphonse Lovey, who was so good as to correct the proofs of the various French extracts; to Quartermaster Hassall, who, during the period that he was attached to the instructional branch of the Royal Laboratory, took an active and most useful part in collecting the information for the work; and to Serjeant-Major O'Donnell and Serjeant-Instructor Macken, who have materially aided me in its completion.

V. D. M.

Royal Arsenal,
November 1867.

LIST of the principal BOOKS and DOCUMENTS referred to or quoted in this Volume.

1. *Shells and Shell Guns.* By J. A. Dahlgren, Commander in charge of Experimental Ordnance Department, Navy Yard, Washington. (Philadelphia, King and Baird; London, Trübner and Co., 1857.)
2. *A Course of Instruction in Ordnance and Gunnery,* composed and compiled for the use of the Cadets of the United States Military Academy. By Capt. J. G. Brenton, Ordnance Department, and Instructor of Ordnance and Science of Gunnery at the Military Academy, West Point. (New York, D. Van Nostrand, 1861.)
3. *A Treatise on Naval Gunnery.* Dedicated by special permission to the Lords Commissioners of the Admiralty. By Lieut.-General Sir Howard Douglas, Bart., G.C.B., &c. 3rd edition, revised and corrected. (London, Murray, 1851.)
4. *Treatise on Fortification and Artillery.* By Major Hector Straith. Revised and re-arranged by Thos. Cook, R.N., Professor of Fortification at the Hon. East India Company's Military College at Addiscombe. 7th edition. (London, Allen and Co., 1858.)
5. *The Artillerist's Manual,* compiled from various sources, and adapted to the service of the United States. By John Gibbon, First Lieutenant, 4th Artillery U. S. Army. (New York, Van Nostrand; London, Trübner and Co., 1860.)
6. *Handbook for Field Service.* By Col. Lefroy, with the aid of several Contributors. 3rd edition, revised. Published by authority. (Woolwich, printed at the Royal Artillery Institution. Published and sold by John M. Boddy, 36, Artillery Place, Woolwich, 1862.)
7. *Observations on the Theory and Practice of Shrapnel Shells or Spherical Case Shot.* By Major R. S. Seton, Retired Madras Horse Artillery. (Edinburgh, Ballantyne, 1854.)
8. *Extracts from the Reports and Proceedings of the Ordnance Select Committee.* Vols. I., II., III. Selected by order of the Secretary of State for War for the information of the Royal Artillery and the Royal Navy, to illustrate the quarterly Reports of changes of material. (London, Eyre and Spottiswoode, 1863 to 1866.)
9. *An Essay on the Motion of Projectiles fired from Rifled Arms,* with practical remarks on the employment of Rifled Ordnance. By Major C. H. Owen, R.A., Professor of Artillery at the Royal Military Academy, Woolwich. (London, Mitchell, 1862.)
10. *Elementary Lectures on Artillery,* prepared for the use of the Gentlemen Cadets of the Royal Military Academy. By C. H. Owen, Captain and Brevet Major, Royal Artillery, and J. L. Dames, Captain R.A., Instructor of Artillery. 3rd edition. (Woolwich, printed by authority at the Royal Artillery Institution. Sold by J. M. Boddy, 36, Artillery Place, Woolwich.)
11. *Ibid.* By Charles H. Owen, Captain R.A. and Brevet Major. 4th edition. 1865.
12. *Dictionnaire de l'Artillerie,* par le Colonel Cotty, Directeur Général des Manufactures Royales d'Armes de Guerre, &c. (à Paris, Agasse, 1822.)
13. *Manual of Bengal Artillery.* This work has no title page. On the back is the word "Artillery," and in MS. are written the words which I have given as its title. A copy is to be found in the library of the Royal Artillery Institution, Woolwich.
14. *The Imperial Dictionary.* English, Technological, and Scientific, adapted to the present state of Literature, Science, and Art. By John Ogilvie, LL.D. (Glasgow, Edinburgh, and London, Blackie and Son, 1861.)
15. *The Artillerist's Manual and British Soldier's Compendium.* By Major F. A. Griffith, R.F.P., Royal Artillery. 9th edition. (London, Parker and Son, Clowes and Son, Simpkin, Marshall, and Co.; Woolwich, Boddy, 1862.)
16. *A Naval and Military Technical Dictionary of the French Language.* In two parts, French-English, and English-French, with explanations of the various terms. By Lieut.-Colonel Burn, Assistant Inspector of Artillery. 3rd edition. (London, Murray, 1854.)
17. *Course of Artillery and Fortification,* published by authority for the use of the Royal Military College, Sandhurst, under the superintendence of the Council

of Military Education. Part I. Artillery. By Colonel Boxer, R.A., Superintendent of the Royal Laboratories. (London, Eyre and Spottiswoode, 1860.)
18. *Manual of Artillery Exercises.* Horse Guards, 1st January 1860. (London, Eyre and Spottiswoode, Parker and Son, 1860.)
19. *Notes on Material* as at present issued from the Royal Laboratory, Woolwich, for smooth bore guns, small arms, and rifled guns, Armstrong. By Captain G H. Fraser, R.A., Assistant Superintendent, Royal Laboratory. (Woolwich, Royal Laboratory Press, 1863.) Also later edition, corrected up to June 1864.
20. *The Shrapnel Shell in England and in Belgium, &c.* By Major-General Bormann, A.D.C. to His Majesty the King of the Belgians. (Brussels, 1859.)
21. *Synopsis of Reports and Experiments by the Ordnance Select Committee* (Shrapnel Shells). Quarto edition. (London, Eyre and Spottiswoode, 1858.)
22. *Supplement to above.* (London, Eyre and Spottiswoode, 1858.)
23. *A Treatise on Field Fortification* and other subjects connected with the duties of the Field Engineer. By J. S. Macaulay, Captain in the Corps of Royal Engineers. 2nd edition. (London, T. Bosworth, 1847.)
24. *Instruction Théorique et Pratique d'Artillerie,* à l'usage des Elèves de l'Ecole Militaire de Saint Cyr. Par M. Thiroux, Lieut.-Col. d'Artillerie. Quatrième édition. (Paris, Dumaine, 1860.)
25. *Traite d'Artillerie Théorique et Pratique.* Par G. Piobert. 3me edition. (Paris, Bachelier, 1852.)
26. *The Encyclopædia Britannica,* or Dictionary of Arts, Sciences, and General Literature. 8th edition. (Edinburgh, Adam and Charles Black, 1840.)
27. *Mémoires d'Artillerie.* Recueillis par M. Suirrey de Saint Rémy, Lieutenant du Grand Maître de l'Artillerie de France. 3me edition. (à Paris, 1745.)
28. *Military Commission to Europe* in 1855 and 1856. Report of Major Alfred Mordecai, of the Ordnance Department. (Washington, Bourman, 1860.)
29. *Aide Mémoire to the Military Sciences.* Framed from contributions of officers of the different services, and edited by a Committee of the Corps of Royal Engineers, 1850–1852. (London, Weale, 1852.)
30. *Histoire de la Guerre de la Peninsule.* Louis Napoléon. Précédée d'un Tableau Politique et Militaire des Puissances Belligérantes. Par le General Foy. (Paris, Bandoin Frères, 1827.)
31. *Expériences sur les Shrapnels,* faites chez la plupart des Puissances de l'Europe; accompagnées d'observations sur l'emploi de ce projectile. Par Decker. Ouvrage traduit de l'Allemand et notablement augmente, par Terquem, Professeur au Ecoles Royales d'Artilleries, et Favé, Capitaine d'Artillerie. (Paris 1847.)
32. *Remarks upon the Diaphragm Shrapnel Shell.* By Captain E. M. Boxer, R. A., Superintendent of the Royal Laboratories, 1858. (This essay will be found in Volume II. of Minutes of Proceedings of the Royal Artillery Institution.) The copy from which I have quoted, and to which my paged references refer, is one published in a pamphlet form.
33. *Diaphragm Shrapnel Shells.* Remarks upon the Memorandum which accompanied the Report of the Ordnance Select Committee dated the 18th June, as called for by the Secretary of State for War, by letter dated 11th August. By Col. Boxer, Superintendent Royal Laboratories. Dated "Royal Laboratory, Woolwich, 18th August 1858." This pamphlet is a letter to the Secretary of State for War.
34. *Diaphragm Shrapnel Shells.* Memorandum with reference to letter, dated War Office, 8th May 1858. By the Ordnance Select Committee. (This is the memo. referred to and answered in No. 33.)
35. *Diagrams of Guns* referred to in Treatise on Artillery, prepared for the use of the Royal Military Academy. By Capt. E. M. Boxer, R.A., section 2, Part. II. (London, Eyre and Spottiswoode, 1853.)
36. *Gurwood's Despatches.*
37. *The British Gunner.* By Capt. J. Morton Spearman, half-pay, unattached. (Published by Parbury, Allen, and Co., Leadenhall Street, 1828.)
38. *Traité Elémentaire d'Artillerie, par Decker.*
39. *Treatise on Artillery,* prepared for the use of the Practical Class Royal Military Academy, in the Course of Instruction prescribed by the Regulations of the Master General, of the 10th August, 1848. By Captain E. M. Boxer, R. A, Section 1. Part I. (London, Eyre and Spottiswoode, 1853.)
40. *Ancient Armour and Weapons in Europe,* from the iron period of the Northern Nations to the end of the 12th Century. With Illustrations from Contemporary Monuments. By John Hewitt. (Oxford and London, John Henry and James Parker, 1855.)
41. *Revue de Techn ologie Militaire,* ou Recueil de Mémoires, Observations, et Pro-

cédés relatifs à cette Science, &c. &c. Par L. Delobel, Lieut.-Col. D'Artillerie, Directeur de l'Ecole de Pyrotechnie de Belgique. (Paris et Liège, E. Noblet, 1857.)

42. *Instructions for the Working and Management of Portable Cupolas, &c., &c., &c.* By John Anderson, Esq., Assistant Superintendent Royal Gun Factories. 1st March 1861. (London, Eyre and Spottiswoode, 1861.)

43. *Manuscript Book of "Laboratory Work,"* by the late Sir Augustus Frazer, R.A. This work is in the Royal Artillery Institution Library.

44. *Small Volume of the above,* also called "Laboratory Work," and containing much different, and much of the same matter.

45. *The Great Art of Artillery* of Casimir Simienowicz, formerly Lieut-Gen. of the Ordnance to the King of Poland. Translated from the French by George Shelvocke, Jun., Gent. Illustrated with 23 copper plates. (London, printed for J. Jonson, at Shakespeare's Head in the Strand, 1729.)

46. *An Universal Military Dictionary in English and French,* in which are explained the terms of the Principal Sciences that are necessary for the information of an officer. By Charles James, late Major of the Royal Artillery Drivers. 4th edition. (London, T. Egerton, Bookseller to the Ordnance, 1816.)

47. *Manuscript Cadet Course,* being Notes on Artillery dictated to the Gentlemen Cadets of the Royal Military Academy, Woolwich, in 1854.

48. *Treatise of Artillery* by John Müller, Professor of Artillery and Fortification, and Preceptor in Engineering, &c. to His Royal Highness the Duke of Gloucester, 3rd edition. (London, printed by John Millan, Whitehall, 1780.)

49. *Manuscript Notes on Laboratory Matters* by Colonel Boxer. These notes form part of a course which Colonel Boxer commenced writing at one time, but which other duties prevented him from completing. There is a copy in the office of the Captain Instructor Royal Laboratory.

50. *Hand Book of Chemistry,* Theoretical, Practical, and Technical, by F. A. Abel, Professor of Chemistry at the Royal Military Academy, Woolwich, and Assistant Teacher of Chemistry at St. Bartholomew's Hospital; and C. L. Bloxham, formerly First Assistant to the Royal College of Chemistry, with a preface. By Dr. Hoffman. (London, Churchill, 1854.)

51. *A Dictionary of Arts, Manufactures, and Mines,* containing a clear exposition of their principles and practice. By Andrew Ure, M.W. Illustrated with nearly 1,600 engravings on wood. 4th edition. Corrected and greatly enlarged. In 2 vols. (London. Longman, Brown, Green, and Longman, 1853.)

52. *The Gunner:* showing the whole practice of Artillerie, with all the appurtenances thereunto belonging, together with the making of extraordinary artificial fireworks, as well for Pleasure and Triumph as for Warre and Science. Written by Robert Norton, one of His Majestie's Gunners and Engineers. (London, printed by A. M. for Humphrey Robinson, and are to be sold at the Three Pidgeons in Paules Churchyard, 1628.)

53. *Observations on the past and present state of Fire Arms,* and on the probable effects in war of the new musket, &c., &c. By Colonel Chesney, D.C.L. and F.R.S. Royal Artillery. (London, Brown, Green, and Longman, 1852.)

54. *Military Antiquities,* respecting a history of the English Army from the Conquest to the present time. By Francis Grose, Esq., F.A.S. A new edition, with material additions and improvements. (London, printed for T. Egerton, Whitehall, and G. Vearsley, Fleet Street, 1801.)

55. *Artillery Tables, Siege and Field, for Service and Practice,* with course of Laboratory Instruction. Compiled and revised in the office of the Permanent Select Committee of Artillery Officers, Dum Dum, in 1850 and 1851. Examined in the Military Board Office in 1853, and published under the authority of Government Letters in the Military Department, No. 548 of 14th January 1853. Completed 14th September 1852. (Calcutta, Carberry, 1853.)

56. *The Bombardier and Pocket Gunner.* By Captain Ralph Wellett Adye, Royal Artillery. 7th edition. Revised and corrected by William Granville Eliot, Captain Royal Artillery. (London. Printed for T. Egerton, Military Library, Whitehall, 1813.)

57. *Ibid.* 8th edition. 1827.

58. *The Annual Register, or a view of the History, Politics, and Literature* for the year 1811. (London. Printed for Osridge and Sons, &c. &c., 1812.)

59. "Observations with directions on the method brought into use by G. W. Manby "for saving persons from vessels stranded on a lee shore." This broadsheet is signed "Geo. W. Manby, Hon. Member R.H.S.," and was printed by "T. "Bensley, Bolt Court, Fleet Street, London." It bears no date. It contains many illustrations. The only copy of this broadsheet I have come across is much torn and mutilated. It is in the possession of Mr. Tozer, one of the

Managers of the Royal Laboratory. These "Observations" are embodied in an essay by Captain Manby, copious extracts from which are given in the Encyclopædia Britannica, vol. XIII., pp. 441–444.

60. *The Repertory of Arts, Manufacture, and Agriculture,* consisting of original communications, specifications of Patent Inventions, practical and interesting papers, &c. Second series. (London. Printed for the proprietors, and sold by W. H. Wyatt, at the Repertory and Patent Office, 9, Packer Street, Temple Bar.)
61. *List of Officers of the Royal Regiment of Artillery* as they stood in the year 1763, with a continuation to the present time, &c. &c. &c. By John Kane, Lieutenant and Adjutant Royal Invalid Artillery. (Greenwich, Delahoy, 1815.)
62. *Ordnance Regulations, Home.* 1st January 1855. (London, Eyre and Spottiswoode, 1855.)
63. *Journal of the United Service Institution.* Whitehall Yard. Published under the authority of the Council. (London, W. Mitchell and Son.)
64. *Pamphlet on the Manufacture of Gunpowder* as carried on at the Government Factory, Waltham Abbey. By Major Fraser Baddeley, Royal Artillery, Assistant Superintendent. (Waltham Abbey, printed for the author by E. Little, 1857.) See also "Gunpowder" in (English) Aide Memoire, where this pamphlet appears in the form of an article.
65. *Text Book on the Theory of the Motion of Projectiles.* The History, Manufacture, and Explosive Force of Gunpowder. The History of Small Arms. The Method of conducting Experiments; and on Ranges. For the use of officers sent to the Schools of Musketry. By Authority. (London, printed under the superintendence of Her Majesty's Stationery Office, 1864.)
66. *The Story of the Guns.* By Sir J. Emerson Tennent, K.C.S., L.L.W., F.R.S., &c. (London, Longman and Co., 1864.)
67. "*Miscellaneous.*" Vols. I., II., and III. These are certain miscellaneous papers referring to a number of artillery matters, bound up in several volumes, and belonging to General Lefroy, R.A.
68. *Application des Fusées au jet des Amarres de Sauvetage.* Par le General-Major Konstantinoff, Directeur de la Fabrication et de l'emploi des Fusées de Guerre en Russie. (St. Petersburg, Imprimerie du Journal de St. Petersburg, 1863.)
69. *Manuscript Volumes of Experiments* (Departmental experiments conducted in Royal Laboratory, Woolwich). This volume, which only contains an account of a very small proportion of the experiments conducted in the Royal Laboratory, is in the office of the Captain Instructor of that department.
70. *Manuscript Volumes of Practice Reports* (in office of Superintendent of Royal Laboratory, 1862).
71. *Report of Practice with 9-pr. Brass Guns, Field Service,* carried on under Captain Haultain, R.A., Plumstead Marshes, 1858, for the purpose of ascertaining the comparative effects in regard to range and accuracy of flight produced by charges of 2½ lbs. and 3 lbs. This report is also published in the proceedings of the Royal Artillery Institution, vol. II. p. 49.
72. *On the Causes, Effects, and Military Applications of Explosions.* By F. A. Abel, Esq., F.R.S., Director of the Chemical Establishment of the War Department. Read at a weekly evening meeting of the Royal Institution of Great Britain, March 21, 1862.
73. *Our Engines of War and How we got to make them.* By Captain Jervis-White-Jervis, M.P., R.A. (London, Chapman and Hall, 1859.)
74. *A History of the late Siege of Gibraltar;* with a Description and Account of that Garrison from the earliest periods. By John Drinkwater, Captain in the late 72nd Regiment, &c. &c. 4th edition. (London, Spilsbury and Son, Snowhill; Johnson, 72, St. Paul's Churchyard, &c., 1790.)
75. *List of Stores manufactured in the Royal Laboratory,* November 1864.
76. *Proportion of Ordnance Stores for Smooth-bore Ordnance for H.M. Ships.* April 1864.
77. *Proportion of Ordnance Stores for Brass Ordnance for Boats.* April 1864.
78. *Occasional Papers of the Royal Artillery Institution, Woolwich.* Vol. I. (Woolwich, printed at the Royal Artillery Institution, 1860.)
79. *Report of a Professional Tour of Officers of the Royal Artillery in* 1863. (Woolwich, printed at the Royal Artillery Institution, 1864).
80. *Report of Committee on Ordnance,* Major-General Cater, President. Assembled in 1857. Reported 26th July 1858. (MS. copy.)
81. *A Treatise on Ordnance and Armour,* embracing Descriptions, Discussions, and Professional Opinions concerning the Material, Fabrications, &c. &c. of European and American Guns, &c. &c., and their Rifling, Projectiles, and Breech Loading, &c. &c. By Alexander L. Holly, B.P. (New York, Van Nostrand, Broadway; London, Trübner, 1865.)

82. *Notes on Gunpowder*, prepared for the use of the Gentlemen Cadets of the Royal Military Academy. By Captain Goodenough, R.A., Instructor in Artillery, Royal Military Academy. (Woolwich, Jackson, 1865.)
83. *Official Catalogue of the Museum of Artillery in the Rotunda, Woolwich.* By Brigadier-General Lefroy, R.A., F.R.S., &c. (London, printed for Her Majesty's Stationery Office by Eyre and Spottiswoode, 1864).
84. *Transactions and Report of the Special Committee on Iron*, 1864. Printed at the War Office, 1864.)
85. *Report on the Military Affairs of the United States of America.* By Lieut.-Col. Gallwey, R.E., and Captain Alderson, R.A. (Printed at the War Office, 1864.)
86. *Specifications of various Patents*, published at the Queen's Printing Office, East Harding Street, near Fleet Street.
87. *Report on Ballistic Experiments.* By W. H. Noble, Lieut. R.A., Associate Member Ordnance Select Committee. 1st Report, 1863. 2nd Report, 1865. (London, Eyre and Spottiswoode, for Her Majesty's Stationery Office.)
88. *Price List of Woolwich Military Stores, Contract, Dockyard, and Miscellaneous Supplies.* Woolwich, 1st March 1865.
89. *A Course of Practical Instruction carried on at Woolwich* between August 1821 and July 1822. By R. Dering. This is a MS. Cadet Course of that period.
90. *Transactions and Proceedings of the London Electrical Society* from 1837 to 1840. Edited by one of the Committee. (London, Smith, Elder, and Co., 1841.)
91. *The Annals of Electricity, Magnetism, and Chemistry, and Guardian of Experimental Science.* Conducted by William Sturgeon, &c. Vol. IV. (London, 1840.)
92. *A Treatise on Electricity, in Theory and Practice.* By Aug. de la Rive, Professor in the Academy of Geneva, and Honorary Doctor in the University of Prague, &c. Translated for the author by Charles V. Walker, F.R.S., &c. In three volumes. (London, Longmans, 1855.)
93. *Journal of Sieges in the Peninsula.* By Sir John Jones.
94. *War Office Circulars* comprised in the Quarterly Lists of Changes in War Stores from 1860; and other Circulars as per numbers quoted, together with Boards' Orders, General Regimental Orders, Official Correspondence, &c.
95. *Report of the Special Armstrong and Whitworth Committee.* (London, Eyre and Spottiswoode, 1865.)
96. *Elements of Chemistry*, Theoretical and Practical. By William Allen Miller, M.D., &c. &c., Professor of Chemistry in King's College, London, &c. 2nd edition, with Additions. (London, Parker and Son, 1860.)
97. *Metallurgy:* The Art of Extracting Metals from their Ores and adapting them to various purposes of Manufacture. By John Percy, M.D., F.R.S., &c. &c. Iron and Steel. (London, Murray, 1864.)

LIST OF PLATES.

The plates referred to in this work, are the Chromo-Lithographic Drawings of laboratory material executed in the Royal Laboratory at Woolwich.

A complete set of these drawings, executed up to the present time, comprises many plates which are unconnected with this volume, drawings of ammunition for rifled ordnance, and small arms, and of rockets, which will be dealt with in the second volume; and the order of the plates is not the order in which the subjects are taken in this book. But the references have necessarily been given to the plates as they stand, and as they have been numbered in sets already issued; to have re-numbered or re-arranged them would have rendered the references useless as regards such sets, and would have been productive of great confusion.

It seems, however, desirable that a complete list of these drawings should accompany this work, more especially as in some of the earlier issues the plates were not numbered. Such plates may easily be numbered in accordance with the following list to facilitate reference[1]:—

[1] In some cases, plate 5 for example, new plates on the same subject and bearing the same number have been executed. In these instances the references to the figures will not always be correct.

Plate 23. *Obsolete.*
„ 24. Shell, Diaphragm Shrapnel, filled and finished.
„ 25. Manby's Life Saving Apparatus.
„ 26. Ground Light Balls (with tabulated dimensions).
„ 27 and 28. *Obsolete.*
„ 29. *Obsolete.*
„ 30. *Obsolete.*
„ 31. *Obsolete.*
„ 32. Drill Cartridges for Breech-loading Guns.
„ 33. Small Arm Ammunition, Whitworth Rifle.
„ 34. Shell, common, (with tabulated dimensions).
„ 35. Shell, Mortar, (with tabulated dimensions).
„ 36. Boxer's 2″ Fuze for B. L. Guns.
„ 37. „ Parachute Light.
„ 38. „ „ (with tabulated dimensions).
„ 39. Bursters.
„ 40. Small Arm Ammunition, Bundles of.
„ 41. Boxer's Life Saving Apparatus (with directions).
„ 42. Boxer's Life Saving Apparatus. Frame for Firing Rockets.
„ 43. Breech-loading Projectiles.
„ 44. Fuze, Percussion, Pettman, General Service.
„ 45. „ Time Wood, Boxer, 9, *see* Muzzle-loading Ordnance.
„ 46. Boxer Ammunition for Snider Rifles.
„ 47. Fuze, Time, Wood, 10 seconds, 7-pounder, Muzzle-loading Ordnance.
„ 48. Boxer's Shrapnel Shell for Muzzle-loading Ordnance.
„ 49. Fuze, Time, Metal, Armstrong, pattern E. (Freeth's modification).
„ 50. Fuze, Time, Wood, Boxer's, 20-sec. B.L. Ordnance.
„ 51. Fuze, Time, Wood, Boxer's, 20-sec. M.L. Ordnance.
„ 52. Boxer Ammunition for Snider Rifle.
„ 53.
„ 54.

Also the following plates of shell and fuze implements, which are issued with the different sets of implements to which they refer, but are not numbered or included in the regular sets of plates. On demand they could, however, be supplied with the other plates.

No. 1 set. Smooth Bore Garrison.
„ 2 „ do. do.
„ 3 „ Rifle and Smooth Bore Garrison.
„ 4 „ do. do.
„ 5 „ Smooth Bore Garrison.
„ 6 „ do. do.
„ 1 „ Smooth Bore Field.
„ 2 „ do. do.
„ 3 „ do. do.
„ 4 „ do. do.
Special set, Rifled Guns of Position.
„ 7 per. M.L. Gun for Mountain Service.
Implements, Naval Shell and Fuze, R. and S. B.

INTRODUCTION.

The principal warlike stores required for the service of all branches of the military and naval forces of this country are manufactured in Government factories established for the purpose, each factory or department confining itself to the production of some special class of article.

The class of warlike stores manufactured in the Royal Laboratory is Ammunition;—accepting the word in a comprehensive sense—a sense justified by its etymology and early usage,[1]—as embracing not merely the charge or projectile for guns, mortars, &c., but all tubes, portfires, fuzes and kindred appliances connected with the service of every description of ordnance, small-arm, and rocket.

Although special considerations necessarily determine the construction of each article of war stores, certain general considerations are never lost sight of in the production of all articles of this class. They must be efficient with due regard to cheapness. The materials employed and the construction of the articles must be such as will enable them to withstand, as far as practicable, the varying influences of climate, and the rough usage to which they are liable to be subjected on service. Simplicity of construction should be carefully studied; and where detonating or inflammable compositions have to be employed they must be so disposed as to reduce the risk attendant on their employment to a *minimum*. War stores which fail in any of these general conditions must be considered as but imperfectly satisfying the requirements of the service for which they have been introduced.

It is evident that where every detail connected with the construction of any particular article has been determined in the manner which will best meet both the general and special requirements of the service, any failure on the part of the manufacturer,—any *practical* departure, that is to say, from the *theoretical* construction,—will produce an article imperfectly adapted to meet the required end. Therefore, in dealing with warlike stores, it is important to look at them from two points of view, the one Abstract or Theoretical, the other Practical, and thus, first, to study their construction, to consider wherein that construction satisfies, or fails to satisfy, the requirements of the service; and then, turning to the workshop, observe the processes by which the manufacturer produces the articles which the inventor has designed.

A Laboratory Course, then, consists in a study of the natures, construction, uses, and methods of manufacture of the several articles

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[1] "*Ammunition* is derived from the Latin *muniri;* originally to protect by a wall, " then to fortify, then to supply all that is necessary to defence. The French use " *munition* in the same sense, though one may easily understand how it came to be " used in the more restricted sense of powder and shot. The *ad* in admunition or " ammunition is due to mediæval Latin usage."—*MS. Letter from Professor Max Müller, Sept. 20th,* 1865.

embraced under the head of "Ammunition;" and the completeness of the course will depend upon the time and attention which may be devoted to these several points, and upon the thoroughness with which the numerous details involved are mastered.

This work professes to deal only with that part of the subject which is designated above theoretical, and cannot therefore strictly be called a complete laboratory course. It is rather, as expressed on the title page, a treatise on ammunition and other laboratory stores, embodying a description of the several articles included under this head, of their applications and relative advantages, together with a sketch of the more salient points in their history, with such other miscellaneous information as seems to be germane to the subject or necessary to its comprehension.

The manufacture of these articles, or the practical part of the course, can only be studied in the workshops and by the machines where the processes involved in their production are being carried on. No description of these processes, however accurate, even if accompanied by the most elaborate drawings, could ever supply the place of actual personal observation; and this portion of the course can therefore only be completed in the Royal Laboratory. Similarly, the application of the knowledge thus acquired must be a matter of subsequent experience at the School of Gunnery or on service. For the study of the general principles, however, of the "theoretical" part of the subject, such personal attendance is not absolutely indispensable, however desirable; and in itself, therefore, a work which deals with that part only may be regarded as complete.

The subject may be divided and dealt with in the following order:—

Part	I.	Ammunition for	Smooth-bore Ordnance.
,,	II.	Do.	Rifled Ordnance.
,,	III.	Do.	Small Arms.
,,	IV.	Rockets.	

PART I.—AMMUNITION FOR SMOOTH-BORED ORDNANCE.

Under this head are included *all* ammunition and stores which form part of smooth-bore equipments. Many of these stores, however, form part also of rifled ordnance equipments, and are thus common to the two classes of ordnance.[1] Such stores are necessarily included in this part. It is desirable to point this out, in order to explain in some measure the great length to which the subject of ammunition for smooth-bore ordnance extends, as compared with that for rifled ordnance, and in order to make those who would study this work aware that a large portion of this first part is as indispensable to the study of ammunition for rifled ordnance as that part of the work which professes to deal solely with that subject.

Division of subject.

Part I. is divided into three sections.

A. Projectiles.

B. Charge.
- (*a.*) Firing Charge, or Charge proper.
- (*b.*) Bursting Charge.

C. Means of igniting the Charge.
- (*a.*) Means of Firing the Gun, viz., tubes, portfires, &c.
- (*b.*) Means of igniting the Bursting Charge, viz., fuzes.

Each of these sections permits of further subdivisions, and includes not only those stores which may fall naturally within the section, but such miscellaneous articles as connect themselves rather with the particular section under consideration than with either of the other two.

Marking stores with a numeral, to distinguish the pattern.

N.B.—The following Circular, No. 931 (Stores), 28th October 1865, affects War Stores generally, and is therefore quoted at length :—

" It has been decided by the Secretary of State for War, with the concurrence of His Royal Highness the Field Marshal Commanding-in-Chief and the Lords Commissioners of the Admiralty, with a view to a more ready and complete identification of stores of different patterns, to stamp in future all articles manufactured in Government Departments, so far as their size, form, and nature will permit, more particularly those which enter into the equipment of garrison, naval, and field artillery, with a Roman numeral in addition to the date of manufacture—to signify whether it is the I., II., III., or IV. pattern of any particular store.

" Officers commanding H.M. ships, and Officers commanding garrisons and field batteries at home and abroad, are enjoined, that whenever reference is made to any particular article of store, the numeral it bears, and date of manufacture where it is added, are invariably to be quoted."

See also War Office Circular, 7 (new series), § 1,126.

By a subsequent decision it was intimated that this regulation should take effect only from the 1st January 1866. " All patterns governing " supplies manufactured down to 31st December 1865, or sealed " previous to that date to govern future manufacture, are to be No. I., " only those sealed on or after 1st January 1866, to receive Nos. II., " &c."—War Office Circular, 8 (new series), § 1,162.

[1] Such, for example, as tubes, portfires, lights; much on the subject of the charge, bursting charge, the different cases for packing cartridges, &c., some of the fuzes, and many other stores which could be easily enumerated.

As by far the larger proportion of the stores at present in the service are Patterns I., it has been thought necessary in this work only to point out when a store is No. II. or III., &c. In all cases, therefore, where not otherwise specified, stores are to be assumed as being Patterns I. and marked accordingly.

SECTION A.—PROJECTILES.

Projectiles. Smooth-bored ordnance.

Three classes.

Projectiles for smooth-bore ordnance may be divided into three classes:—

(*a*.) Shot.
(*b*.) Shell.
(*c*.) Incendiary and Miscellaneous.

Subdivision (*a*).—*Shot.*

Shot. History.

Solid shot are the simplest, as they are the most ancient description of projectile.

If the date of the introduction of gunpowder is hidden in obscurity and uncertainty, how shall we attempt to determine the date of the introduction of a projectile which preceded gunpowder by many centuries,—which, in its primitive form of a *stone* projectile whistled from David's sling, and was hurled by "engines invented by cunning men"[1] from the walls of Jerusalem, in the old wars related in the Sacred narrative?

Solid shot.

Although shot, if so the rude projectiles of these early times may be called,[2] were not at first made of iron, it is probable that even in the most remote ages they had something of the form of the simplest description of shot—the "*round* shot"—of the present day; for we may easily believe that the stones thrown from the balistæ and the other engines of the day were selected with reference to their special fitness for this service,[3] and no scientific training was needed, but a simple knowledge of the practice of their craft, to teach the first artillerymen[4] that their rude engines would throw a round projectile straighter and further than one of any other form.

After the discovery of gunpowder, and the introduction of cannon, stone shot still continued to be used,[5] but by degrees these came to be superseded by lead and iron balls, which latter do not appear to have

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[1] II. Chronicles, chapter 26, verse 15.

[2] "Shot and shell are Teutonic words. Shot is from shoot. German, *schiessen*." —*MS. Letter from Professor Max Müller, September* 20, 1865.

[3] "Dans les temps anciens les pierres et les projectiles *globulaires* avaient été le pre- "mier essai."—*Instruction d'Artillerie*, p. 281.

Major Owen speaks of the "trebuchet" as being a machine for firing "*round* stones."—*Lectures on Artillery*, &c., edition 3rd, p. 2.

[4] "The term 'artillery' was applied to all kinds of weapons before the introduction of gunpowder."—Owen's *Lectures on Artillery*, edition 4th, p. 1.

[5] It is probable that stone shot were not retained long after the introduction of cannon, for they must have been too brittle to withstand the shock of the explosion of the charge. Gibbon says, "Stone balls . . . . were found too brittle to resist the "force of powder," *Artillerist Manual*, p. 156. Still, that they were used admits of no doubt. See on this subject *Ancient Cannon in Europe*, in Proceedings, Royal Artillery Institution, vol. iv. p. 307; and vol. v. pp. 7, 12, 22, &c.

come into at all general use until about the end of the 14th century,[1] although they had been employed in Italy as early as 1326.[2]

In addition to stone, and iron, and lead, various materials have been proposed and employed for shot, such as compound projectiles,[3] bronze, stone encircled with iron, wrought, iron, &c., but all these materials were open to certain objections;[4] and eventually shot for general purposes came to be made entirely of cast iron, which unites in a greater degree than any other material, the essential qualities of hardness, strength, density, and cheapness.[5]

It would be very difficult to determine exactly when each nature of the present Solid cast-iron shot was introduced; but all those shot which have rivet holes drilled in them may be said to bear date 1856,[6] when that method of attachment was adopted. The solid cast-iron shot for the 100-pr. and 150-pr. were approved in 1864.[7]

Red-hot shot

The history of red-hot shot—of these same solid cast-iron shot brought to a red heat for incendiary purposes—need not be treated as the history of a separate projectile, but it is interesting to note that the employment of heated projectiles of different sorts, dates not from some period subsequent to the introduction of cast-iron shot, but, in all

[1] "Stone projectiles were used before the introduction of gunpowder and very "generally after it, until the year 1400, when the French made them of cast iron."—*American Artillery Course*, p. 67.

"A la fin du XIV^e siècle, comme au commencement du XV^e, ... les canons "lançaient . . . . des balles de plomb."—*Le Passé et l'Avenir de l'Artillerie*, vol. i. pp. 42, 43.

"De 1378 à 1400, on faisait déjà usage de boulets de fonte."—*Instruction d'Artillerie*, p. 282.

See also "Ancient cannon in Europe," in Proceedings, Royal Artillery Institution, vol. iv. pp. 12, 13, 14, 25–36.

"Pendant la seconde moitie du XIV^e siècle; . . . . les grosses bouches à feu pro- "jettent des boulets de fer ou des boulets de pierre."—*Le Passé et l'Avenir d'Artillerie*, vol. iii. p. 107.

There is mention of iron shot having been used in the *early* part of the 14th century. "Ibn Nason ben Bia, of Grenada, mentions that . . . . balls of iron were "thrown by means of fire, 1331."—*Colonel Chesney on Fire Arms*, p. 43.

See also *Le Passé et l'Avenir d'Artillerie*, vol. iii. p. 72, where it is stated that small iron shot were made in 1326; and again, *ibid.* p. 81:—"En 1346 les Anglais "employaient à la bataille de Crécy trois canons qui lançaient des balles de fer."

I do not think, however, that we are justified in assigning an earlier date than the close of the 14th century for the general introduction of iron shot, and this is the conclusion arrived at by Lieut. Brackenbury, R.A., in his able paper on *Ancient Cannon in Europe*. Indeed Wilkinson in his "Engines of War," p. 48, states that iron shot were not used *in England* until the second half of the 16th century. "Iron "bullets . . . . were first used in England in 1560."

[2] Ancient Cannon in Europe, in *Proceedings, Royal Artillery Institution*, vol. v. pp. 22, 25, 36.

[3] At the Siege of Cadiz cast-iron shells filled "with lead, forming projectiles of great "strength and density, were thrown from mortars to a distance of $3\frac{3}{4}$ miles."—*American Artillery Course*, p. 69.

[4] "The defect of stone as a material for projectiles is a want of density and tenacity." —*American Artillery Course*, p. 67.

"Lead as a material for projectiles possesses the essential quality of density; but it "is too soft to be used against very resisting objects, since it is flattened even against "water . . . . Its use is chiefly confined to small arms and case shot ('spherical'), "which are generally directed against animate objects."—*Ibid.* p. 68.

"When great strength and density, combined, are required in a projectile wrought "iron may be used, but it is very expensive to work."—*Ibid.* p. 68.

[5] *Ibid.* p. 68.

[6] 12th September 1856, *General Regimental Order* 415, par. 44, date of approval of present pattern rivets, see p. 120.

[7] 150-pr. approved 19th April 1864. See War Office Circular, 3 (new series), par. 946.

100-pr. approved 17th May 1864.—*Ibid.* par. 947.

probability, from some centuries in advance. "Balls of red hot clay, " thrown from slings, may be considered as the prototype of hot shot, " and they were used by a native tribe to set fire to a Roman camp " during Cæsar's war in Gaul;"[1] and Simienowicz says, " The practice " of shooting red-hot iron is far from being of modern date; for long " before the mention of an artillery it was the custom of the ancients " to defend themselves with red-hot iron, as is testified by Diodorus " Siculus . . . . Vitruvius, speaking of the people of the town of " Marseilles, saith that they threw bars of red-hot iron from 'balistæ,' " to burn the besiegers' works."[2] But the full value and effect of red-hot shot were scarcely appreciated until the memorable siege of Gibraltar 1779–1783. Drinkwater ascribes the repulse of the grand attack upon the place mainly to the employment of these projectiles. On one occasion the garrison fired "eight thousand three hundred " rounds, more than half of which were hot shot."[3]

The spherical cast-iron shot thus adopted "for general purposes" were not, however, suitable for employment under all the various circumstances to which warfare and modern mechanical improvements and appliances gave rise; and for such purposes shot, which may be regarded as, after a manner, special, were introduced; some of them, such as chain shot and bar shot, again to disappear; while others, such as case, grape, steel, and hollow shot, are still retained.

Case Shot. Case shot, or as they are sometimes called "canister," are probably not of much more modern date than solid shot, for from the earliest times, since the introduction of cannon, artillerymen have been in the habit of firing upon occasions coarse gravel, old nails, bits of iron, bolts, stones, and the like,[4] known by the name of "langridge,"[5] or "pyrotechnic hail,"[6] and these projectiles may be considered the prototype of our present case shot.

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[1] *Equipment of Artillery*, p. 111.

[2] *Great Art of Artillery*, p. 303.

[3] Drinkwater's *Siege of Gibraltar*, p. 293.

[4] "A la fin du XIV[e] siècle, comme au commencement du XV[e] . . . . les cans l'ançaient . . . . des boîtes à mitraille remplies de balles de plomb ou des sacs remplis de pierres."—*Le Passé et l'Avenir*, vol. i. p. 42.

"Tin case, filled with steel bolts or darts, and canvas cartridges containing small " balls were used by Henry IV. of France."—Owen's *Lectures on Artillery*, edition 4th, p. 8.

The author of the Great Art of Artillery mentions another curious description of case shot:—"There is a way (which is none of the most despicable) of making " it into balls . . . . which is done thus: take of pitch 4 parts, colophone 1 part, of " wax 1 part, of sulphur 2 parts, and a little turpentine; melt these over a slow fire, " and being melted, throw into them 8 parts of quicklime, 4 parts of powder of tiles, " and 1 part of the filings of iron or hammer scales. Incorporate all these ingredients " well together; which done, add to them as many pebbles or musket balls as are " needful. Whilst this composition is cooling make it up into balls that they may " exactly fit the gun or mortar you intend to use.

" There are those who make this shot into balls with plaster or powder of alabaster " . . . . others again make it into balls with dirt or clay, which they set to dry in the " sun and wind."—*The Great Art of Artillery*, p. 307.

[5] In some dictionaries "langrage" or "langrel"; sometimes these names are applied to regular case and grape. I believe that "langrel" is properly a particular description of (now obsolete) shot, for in James' Dictionary the following passage occurs:— " *Langrel* shot, a sort of shot which runs loose with a shackle, or joint in the centre." —James' *Military Dictionary*, p. 813.

[6] " *Pyrotechnic hail*, by which one meant case shot or cartouch shot, partridge shot, " and grape shot."—*The Great Art of Artillery*, p. 306.

" What pyrobolists mean by pyrotechnic hail is a small parcel of little hard bodies, which being projected, perform an effect after the manner of natural hail; but it is somewaht more hard and perilous, an artificial hail being mostly of coarse gravel, river pebbles or any stones of the bigness of a pigeon's egg and sometimes of scandent balls or slugs, or little bits of iron and all such like things."—*Ibid.*

It is stated that canister shot were first used in the defence of Constantinople about the middle of the 15th century.

It seems certain that a projectile resembling the case of the present day in many respects, though differing from it in other, was used as early as the 16th century. This projectile, which was called "hagel-kügel" (hail shot) is described as a "leaden shell or rather box of "cylindrical form; its fuze was the old common fuze placed in the "axis of the shell and at one end of the cylinder; the bursting powder "surrounded and covered the fuze in the interior of the shell; the rest "of the empty space of the shell was filled up with 'hail'—pieces of "iron, bullets, or even pebbles; and, lastly, the shell was suitably "closed at the other end.

"This projectile was introduced into the gun so that its fuze was "turned towards the charge of the piece; the fire with it seems to "have been successful to such a degree that it was employed in "action." [1]

The *present pattern* tin case shot may be said to have been introduced in 1861, up to which date all case shot in use in our service had wooden bottoms. But owing to the difficulty in obtaining well-seasoned wood, Colonel Boxer proposed (26th May 1859) that sheet iron or tin plate should be substituted. This proposition was agreed to in 1861[2] for all case shot for garrison and naval service, wooden bottoms being retained for all case for bronze ordnance.

The iron case shot for 32-pr., 8-inch, 10-inch, and 100-pr. guns were not approved until the commencement of 1866.[3]

The history of Grape shot is in the main contemporary with that of case, for, like case, it may be considered as an improved description of langridge; and the projectiles described as "des sacs remplis de "pierres," which we are told were used as early as the 14th century,[4] and more especially those spoken of in Owen's Lectures on Artillery [5] as "canvas cartridges containing small balls," were merely rude forms of the quilted grape which, until the introduction of "Caffin's grape" in 1822, were generally employed. Grape Shot.

Bar shot and chain shot seem to come more properly under the head of grape than of case; and these there is every reason to believe were used very soon after the introduction of cannon.[6]

Modern grape shot, the "quilted grape" referred to above, consisted of an iron plate from the centre of which passed up an iron spindle, round which spindle were piled sand shot enclosed in a canvas bag, the bag being drawn together between the balls, or "quilted," by a strong line.

From a sort of rough likeness which this projectile bore to a bunch of grapes it obtained the name of "grape" shot.

In 1822 [7] a new pattern grape shot proposed by W. Caffin, Esq., late of the Royal Laboratory, Woolwich, was adopted, but not manufactured until 1856. The quilted grape, however, is not yet altogether obsolete;

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1 "*The Shrapnel Shell in England and Belgium*," &c., p. 61. See Appendix A. on the subject of this projectile.

2 27th March 1861. War Office Letter of that date, 79/B/307. See also *War Office Circular* 680, par. 241.

3 *War Office Circular*, 9 (new series), § 1,192.

4 *Le Passé et l'Avenir d'Artillerie*, p. 43.

5 Owen's *Lectures on Artillery*, edition 3rd, p. 10

6 The curious in such matters may see in the Royal Military Repository, Woolwich, a double-barrelled cannon for throwing chain shot.

7 Approved 2nd September 1822. Board's letter of that date.

although no longer manufactured, the existing stores, where serviceable are ordered to be used up; and re-issues of grape of this pattern which have been returned from ships or stations,[1] are sometimes made from the Royal Arsenal, Woolwich.

Hollow shot.

Hollow shot were originally proposed by General Shrapnel[2] some time in the early part of this century, and were introduced for all natures of guns and howitzers (except the 18-pr.) from the 10-inch to the 12-pr.[3]

They were common or naval shell securely plugged with iron. Some time in 1856–7[4] the manufacture of the smaller natures of hollow shot, 56-pr. downwards, was discontinued; but 10-inch and 8-inch hollow shot were manufactured until 1859–60,[5] when shells with countersunk gun-metal plugs were substituted.[6] Although hollow shot as a distinct projectile thus became obsolete, existing stores are to be used when serviceable for practice;[7] and all returned hollow shot, of whatever nature, when serviceable, are re-issued from the Royal Arsenal, Woolwich, "for practice only." Commanding officers of artillery are directed not to use any common shells, *as hollow shot,* "whilst any of the old pattern hollow shot remain at the station."[8]

Steel shot.

Steel shot were first used in England for the purpose of penetrating iron-plated vessels in 1859;[9] and from that time until 1865, when they were first regularly issued for service to Her Majesty's ships, steel shot of various descriptions, and the productions of various manufacturers, were experimented with on a large scale, from both rifled and smooth-bore guns.[10]

Spherical chilled shot.

Spherical chilled iron shot were introduced in 1867,[11] as the result of the success which had attended the use of this material for elongated projectiles. Chilled iron has become so closely associated with the name of Major Palliser, by whom it was proposed, *in conjunction with a particular form of pointed ogival head,* for rifle projectiles, that it is desirable that it should be understood that spherical chilled iron projectiles formed no part of Major Palliser's proposals. A spherical chilled iron shot is not a Palliser shot, which consists of a particular combination of form and material.

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[1] The question respecting the re-issue of grape of this pattern was raised in 1864 in connexion with the large stores which had accumulated in the Royal Arsenal from the Ionian Islands. The decision was that quilted grape should be re-issued when serviceable.

[2] *Petition presented by Henry Needham Scrope Shrapnel to the House of Commons*, p. 1.

[3] There were two natures of hollow shot of the 8-inch calibre, viz., the common shell plugged with iron, weight about 46 or 47 lbs.; and a shell specially made for the purpose and similarly plugged, weight 56 lbs. The heavier projectile was generally issued for sea, the lighter projectile for land-service.

[4] I have been unable to trace the exact date.

[5] Manufacture of hollow shot as a separate projectile discontinued for naval service, 8/2/59, War Office Circular 590, par. 7, and for land service, 22/6/60, War Office Circular 639, par. 93.

[6] See p. 25.

[7] *War Office Order* 61/Laboratory/1925, and *Royal Artillery Circular Memorandum*, 30th September 1864, par. 13.

[8] *Royal Artillery Circular Memorandum*, 30th September 1864, par. 13.

[9] *Proceedings, Royal Artillery Institution*, vol. iv., p. 205.

[10] For an epitomized account of these experiments, see *Proceedings, Royal Artillery Institution*, vol. iv., p. 205, *et seq.*; for a fuller account, see *Reports of Special Committee on Iron.*

[11] Approved 6/7/67. W.O. Letter 11/7/67, 75/12/3255.

There are at present eight different sorts of shot in the service, viz. :— Shot—Seven Classes.

1. Solid cast iron.
2. „ steel.
3. „ chilled.
4. Sand.
5. Hollow.
6. Case.
7. Grape.
8. Eprouvette shot.

1. *Solid cast iron* [1] (see table I., p. 322), or as they are sometimes called round shot, are of 12 different natures, viz., 150, 100, 68, 56, 42, 32, 24, 18, 12, 9, 6, and 3-prs. and are distinguished by their respective (approximate) [2] weights. Shot—Solid cast-iron. Sizes.

They are solid spheres of cast iron.[3] Description.

Solid cast-iron shot are riveted to wood bottoms when intended to be used with guns of position,[4] or with bronze guns,[5] but not otherwise; in the first case, because they keep the shot steady in the limbers, and in the second because the addition of the wood bottoms preserves the bores of bronze ordnance from injury by diminishing windage and so preventing the ricochetting of the shot through the bore, to which cause the denting of the bore of bronze guns, where no bottoms are used, is due.[6]

The bottom is attached by means of a cylindrical gun-metal rivet [7] (pl. 34, fig. 8), slightly hollowed out at one end, and with a projecting conical head at the other ;[8] a hole (pl. 34, fig. 11, K, L, M, N,) about one-tenth of an inch in depth, shaped like the frustum of a cone, the base of which is towards the centre of the shot, is undercut in the

[1] The words "cast-iron" are necessarily introduced in contradistinction to solid steel shot; but doubtless solid cast-iron shot will be more commonly spoken of, as heretofore, simply as "solid shot."

[2] For exact weights, see table.

[3] The iron used is a mixture of ordinary (hot blast) pig iron, old iron, and "founders' scrap;" no rule can be given as to the precise proportions of the several irons, which will vary to a certain extent with the nature of each, and with the size of the shot to be cast, the larger shot requiring a softer iron than the smaller sizes to ensure a true casting without "feeding."

The following example will give a fair idea of the component parts of an average charge:—

No. 1, pig iron - - - -	8 cwt.
No. 4, „ - - - -	10 „
Old iron - - - - -	4 „
Founders' scrap - - - -	10 „

[4] Except for practice. "Solid shot for *practice* with these guns are issued loose," *Horse Guards Circular Memorandum, Royal Artillery*, 19th May 1865, paragraph 4, also 27/1/65, 55/Artillery/2481.

[5] "The use of wooden bottoms with 6-pr. shot firing from brass guns with 4 oz. " charges at instruction practice in the Royal Navy is to be discontinued; it having " been ascertained that firing loose shot with such charges does not injure the bore " of the gun." Approved 29th December 1860, 75/12/845.—*War Office Circular* 665, paragraph 174.

[6] In some experiments which were carried on at Shoeburyness in November 1859 90 shot without wood bottoms were fired from a 9-pr. brass gun in 80 minutes; the practice had then to be discontinued owing to the breaking of the shot in the bore, and on examination the gun was found to have been rendered perfectly useless, the bore being dented in places to the depth of half an inch, the metal being cracked even to the outside, and the muzzle having become almost oval in form. *MS. Lectures* by the late Captain Lyons, R.A., Inspector of Ordnance. Also quoted in Owen's *Lectures on Artillery*, edition 4, p. 14, note 3. See also, on subject of injurious effect of windage on brass gun, Boxer's *Treatise of Artillery*, section i., part 1, pp. 156–7, where references to Piobert's *Cours d'Artillerie* are also given.

[7] 18th August, 1855, M./1661. Formerly the bottom was attached by means of tin strapping. This was an inconvenient plan for many reasons, see Rivets, p. 122.

[8] See p. 121.

shot, and the gun-metal rivet being passed through the wood bottom, its cylindrical or hollowed-out end is made to enter the small rivet-hole, and owing to this end being hollowed out, a few smart blows on the head of the rivet cause it to expand and fill up the conical hole, thus securely attaching the bottom to the shot.[1]

All solid cast-iron shot are painted black (with the exception of the 68-pr.) to preserve them from corrosion; the 68-pr. shot is painted red, instead of black, to distinguish it from the 8-inch hollow shot of the same calibre.[2]

Uses. Solid cast-iron shot are used against masses of men, to breach masonry, against wooden [3] shipping, and against material generally.

Sometimes, when fired against inflammable material, such as shipping, stores, &c., they are heated to a "wafer" red heat, and fired with reduced charges.[4]

Red-hot shot. Red-hot shot have been partially superseded by Martin's shell.[5]

Solid (cast-iron) shot are fired only from guns, carronades, and the 12-pr. sea service bronze howitzer (10 cwt.).

Packing and issue. Solid cast-iron shot are issued either—

(1.) Loose, unprepared for bottoms.
(2.) Loose, prepared for bottoms.
(3.) Riveted.

All solid cast-iron shot, except those for guns of position or bronze guns,[6] are issued (1) "*Loose, unprepared for bottoms.*" In this case they are not packed.

Solid cast-iron shot are only issued (2) "*Loose, prepared for bottoms*" when intended for service in India with guns of position or bronze guns, or on exceptional demands. They are then sent away with their rivet holes plugged with beeswax (to preserve them from rust), and not boxed.

For guns of position, or bronze guns, solid cast-iron shot are generally [7] sent away (3) *Riveted.* In this case they are packed in wooden boxes, the number per box varying with the nature of the shot.[8] The boxes are generally [9] made of deal plank, with elm ends.[10] They are

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[1] In principle this plan is similar to one which has long been in vogue for getting a hold upon heavy stones for the purpose of lifting them. See note on subject of lewis holes, p. 37. The simple and ingenious application of this principle by means of an expanding rivet I believe to be entirely original. It was proposed by Colonel Boxer, R.A. See p. 120.

[2] The 68-pr. shot appears to have been first painted red for naval service 5th May 1849, A./11831, see Ordnance Regulations, Home p. 162, paragraph 635. A proposal was made in 1864 to discontinue the practice, but the large existing store of old hollow shot prevented this from being carried out.—*Extracts from Reports, &c., Ordnance Select Committee*, vol. ii., page 63.

[3] Against iron-plated ships they are of little or no use, as is proved by the following conclusions arrived at by Captain Chads, R.N., from numerous experiments made at Portsmouth in 1854 at a range of 450 yards.

(1.) "That both solid and hollow shot would, under ordinary circumstances, pass through $\frac{1}{4}$ and $\frac{3}{8}$ths inch iron without breaking.

(2.) "That, under ordinary circumstances, solid shot will pass through $\frac{1}{2}$-inch iron without breaking; that hollow shot, under similar circumstances, will generally break up.

(3.) "That under ordinary circumstances all shot (cast iron), solid or hollow, will break up in passing through $\frac{5}{8}$ths inch iron."—*Proceedings, Royal Artillery Institution* vol. iv. p. 199.

[4] See *Board's order*, 31st January, 1855, 55 D./149, paragraph 1. For reason for employment of reduced charges, see p. 145.

[5] See pp. 64, 65. [6] See p. 9.

[7] See exceptions, p. 9, notes 4 and 5.

[8] See table XII. p. 331.

[9] I say "generally," because to save waste other hard woods are sometimes used for this purpose. These boxes are made in the Royal Carriage Department.

[10] Until 1864 the boxes for hot and tropical climates were made of teak with sabicu

merely rough boxes of various sizes, the lid of which fits with a dovetail to the body, and is tied on with tarred cord.[1]

The boxes are marked in *black* with the words "Round Shot," the nature of ordnance with which those in the box can be used, the number in the box, and the date of issue. For tropical climates (when the shot have teak bottoms attached) the boxes have in addition the words "For tropical climates" marked on the lid *in black*.

2. *Solid steel shot*[2] are made of three sizes, viz., 150, 100, and 68-prs. Shot—Solid steel. Sizes.
They are solid spheres[3] of steel, of the same diameter as the corresponding solid cast iron shot,[4] and of a quality "to produce an equal "effect to that obtained at Portsmouth between the 13th and 27th "January 1864 with the 68-pr. and 9·2 inch spherical shot supplied by Description.
"Messrs. Firth and Sons."[5]

The quality of the steel is a very important consideration. If too brittle it will break up on impact, and some shot of this character fired in 1862 led the Iron-plate Committee to report that "The blow given "by a wrought-iron or by a steel projectile to an iron plate is not so "much more effective than that given by a cast-iron projectile as to "render it desirable to substitute wrought-iron or steel shot for good "cast-iron shot. The higher price of steel or wrought iron over cast

ends; but it is considered that this is unnecessary. The bottoms being made of teak for such climates and by order 19/11/64, 57/Gen. No./3060 and 3069, the practice of making boxes for hot and tropical climates of *teak* was discontinued, except for small arm ammunition.

[1] These boxes are manufactured in the Royal Carriage Department.

[2] First issued for service to H.M.S. "Hector," 6th February 1865. They are supplied by contract by Messrs. Brown and Co.

[3] "Each shot to be a true sphere and to be subject to rejection if more than ·05 of "an inch out of round," *Specification*, 12th July 1864.

[4] See table I. p. 322.

[5] *Specification*, 12th July 1864. The measure of this standard of comparison is best obtained by reference to the experiments in question, the result of which is summed up in a Report furnished by Captain Cooper Key, C.B., R.N., "selecting "those cases where a fair hit was made on an uninjured portion of the plate at a "distance from the edge."

RANGE 200 YARDS.

Gun Charge.	Projectile.	Plate. Maker.	Plate. Thickness.	Ship.	REMARKS.
100-pr. S.B. 25 lbs. charge.	Firth's Steel.	Mersey Company.	5½-inch -	"Monarch"	Penetrated its whole diameter lodged in side; struck in wake of knee-chock which was sprung and started.
		Milwall Company.	5½-inch -	"America"	Penetrated plate and through backing to opposite side of deck; shot and iron splinters tearing planks open in a diverging direction to five feet diameter.
68-pr. S.B. 16 lbs. charge.	Firth's Steel.	Batterley Company.	4½-inch -	"Monarch"	Penetrated plate and into ship's side to a depth of one inch less than its own diameter. Plank inside started and broken.

"The comparative value of the material for the construction of projectiles which are to be used against armour plates appears to be as follows:—

1st Firth's steel.

&c. &c.

. . . . It may be considered as satisfactorily proved that the 10-pr. smooth-bore gun, with a charge of 25 lbs., will penetrate a 5½-inch plate and a sound line of battle ship's side, at the distance of 200 yards, with a shot of the material of Firth's (. . . . .) steel, and in doing so will make a hole in the ship that would endanger her if near the water line."—*Transactions and Report of the Special Committee on Iron*, 1864, p. 52.

" iron leads the Committee to believe that a greater effect can be per" formed at a less cost by the additional number of cast-iron shot that " can be used for the same price. *In this experiment the steel shot were* " *too brittle, and broke up in nearly every instance*."[1]

On the other hand, though great toughness is required, softness is to be avoided, or the work will be expended on the shot, which will be much "set up." The Committee, in their report of an experiment with spherical steel solid shot, fired at Shoeburyness, 1864, say, "The sho " were very tough, but were too soft for penetrating armour plates, for " although they did not break up on impact, they were considerably " set up.'"[2]

Solid steel shot are painted white,[3] and are further distinguished by a large S stamped upon them.[4]

Steel shot are used for firing against iron-plated vessels or defences.[5] They are issued loose, unprepared for bottoms.

No more steel shot will be made, as chilled cast-iron has been officially substituted for steel for battering purposes.[6]

Shot—Solid Chilled. Sizes. Desripttion,

3. *Chilled shot*[7] are made of two sizes only, viz., 150-pr. and 100-pr.

They are solid spheres of iron cast in iron moulds or chills, whereby a new character is imparted to the iron in the process of casting, rendering it intensely hard and white and brittle. An explanation of the effect produced by chill casting is afforded in the following passage :—

"The mode of existence of carbon in iron is in great measure determined by the conditions of solidification after complete fusion, and the temperature at which fusion has been effected. Rapid solidification favours the retention of carbon in the combined state, and by this means it is possible to convert characteristic grey iron into perfectly white iron. Thus by pouring liquid grey cast iron into a cold metallic mould, so as to cause the most sudden cooling possible the exterior of the solid iron, where it comes in direct contact with the mould, will be found to be in the state of white iron, while the interior will be in the state of grey iron. This principle is extensively employed in practice, in the process known as chill-casting. It is adopted when desirable to render the surfaces extremely hard, white iron being intensely hard as compared with grey iron."[8]

The chemical difference between white and grey iron consists principally in the condition of the carbon which it contains ; in white iron the carbon is in a combined state ; in grey iron it is generally uncombined, being mechanically diffused through the mass in the form of graphite, the amount of carbon not necessarily differing materially in either.

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[1] *Proceedings, Royal Artillery Institution*, vol. iv., p. 209.

[2] *Proceedings, Royal Artillery Institution*, vol. iv., p. 209.

[3] 11th August 1865, *W.O.C.*, 7 (*New Series*), par. 1118. For the composition of the white, or rather cream-coloured paint, see table XX. p. 345.

[4] Approved 21/9/65 ; *War Office Minute of that date*, 75/12/2587. Before that date the S was much smaller. It is now 1″ long.

[5] See p. 8, note 3, respecting the inefficiency of solid cast iron shot for this purpose. For a most interesting and complete *résumé* of the experiments made in this country with steel shot, and for a consideration of the relative merits of steel, cast iron, chilled cast iron, homogeneous iron, as materials for penetrating armour-clad vessels, see "Ex-" periments with Projectiles against Iron Armour" by Captain A. Harrison, R.A., *Proceedings, Royal Artillery Institution*, vol. iv. p. 195. For fuller particulars see *Reports of Special Committee on Iron*, 1861–4 ; and Holley's *Ordnance and Armour*, Part II. "Experiments against Armour," p. 623 to 780.

[6] 24th Oct. 1866, *W.O.C.* 12. (*New Series*) § 1348.

[7] Approved 6/7/67. *W.O. Letter* 11/7/67, 75/2/3255. See page 8 respecting these projectiles not having formed part of Major Palliser's proposals.

[8] Percy's *Metallurgy*, page 117.

We have thus in connexion with chill casting, these data, 1st, that white iron contains its carbon chiefly in a combined state; 2nd, that iron so constituted is intensely hard as compared with grey iron, in which the carbon exists chiefly as graphite; 3d, that rapid solidification such as chill casting "favours the retention of carbon in the combined "state," and thus tends to harden and alter the character of the iron.

The iron employed is carefully selected with reference to its susceptibility to chilling effects; thus certain grey irons will scarcely chill at all,[1] other irons are too hard and would be liable to "over chill" and to crack in cooling.

If the object be, as in the shot now under consideration, to produce a chilling effect through the mass, to produce, in other words, a wholly white iron projectile, it is necessary to strike a mean between too soft and too hard irons, and in practice the mean is generally found either in a mixture of white and grey cold blast irons in proportions which will vary slightly according to the size of the projectiles and the brand of the iron, or in the employment wholly of "mottled" iron, an iron which falls about midway as regards its chemical characteristics between white and grey iron, containing about half its carbon in a combined, and the other half in an uncombined state, and which may, in fact, be regarded as white and grey iron ready mixed.

Spherical chilled shot may thus be described as spheres of chemically white iron produced by the chilling process.

They are painted black, with a white ring round the centre.

Chilled shot are used against iron-plated vessels and defences.[2] Uses.

They are issued loose, unprepared for bottoms.

4. *Sand shot*[3] are made of 15 different sizes, viz., 4, 3, 2, 1, and Shot—Sand.
$1\frac{1}{2}$ lbs.; $13\frac{1}{8}$, 8, $6\frac{1}{2}$, 6, 5, 4, $3\frac{1}{4}$, 3, 2, and $1\frac{1}{2}$ ozs. (*see* table). They are Sizes.
merely small solid spheres of cast iron, which derive their name from Description.
the fact that at a time when the larger cast-iron shot were cast in iron moulds, or "chills," these shot were cast, as at present, in sand. They Uses.
are chiefly used in making up case and grape.

Sand shot, however, have a special application, being sometimes fired from mortars in charges of 100 pound shot for the 13 and 10-inch, and 50 pound shot for the 8-inch mortar. They are piled loose in the mortar upon a hemispherical wood bottom, which is placed over the cartridge,[4] and are used in this way where numbers of men are crowded together, or to drop among a hostile fleet of small boats, like a vertical fire of case or grape.[5] Stones are sometimes used for the same purpose.[6] Sand

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1 "Not all grey irons can be converted into white by this means." Percy's *Metallurgy*, p. 117.

2 Spherical chilled shot are much less effective than Palliser shot; but they are slightly superior to cast-iron, and though inferior to steel they are very much cheaper. For comparative effects of spherical steel, chilled and cast-iron shot, see Captain Noble's Report on *The Penetration of Iron Armour*, &c. Appendix giving result of various experiments, p. 39 to 54.

3 Sand shot are always demanded by weight thus—
"Shot cast in sand 1 lb.—14 cwt. 3 qrs."

4 When pound shot . . . . are used, they are brought up in a box or basket to the front of the mortar, in the same manner as shells. The number who brings "up the cartridge brings up a wooden bottom, which "3" places over the powder. "Nos. 2 and 3 empty the shot into the mortar and give the empty basket to 6."—*Manual of Artillery Exercises*, p. 107.

5 "En quelque sorte le tir à mitraille des feux verticaux."—*Instruction d'Artillerie*, p. 410.

6 "The charge must be covered over with a plank or piece of wood, and on this "the basket containing *stones* must be placed. The total weight of the stones should "be from 90 to 100 lbs. . . . . . . Granite stones are the best, as they are the least "likely to break."—*Manual of Bengal Artillery*, p. 80.

"When pound shot *or stones* are used," &c.—*Manual of Artillery Exercises*, p. 107.

shot of 1 lb. weight are issued for this purpose in boxes containing 100 and 50 respectively; and are known as "pound shot charges"[1] for mortars. When used for grape of "Caffin's pattern,"[2] they are painted black, otherwise they are not painted.

Packing and issue.

When sand shot are issued for pound shot mortar charges they are packed loose unpainted in boxes; 100 in a box for the 13 and 10-inch mortars, 50 for the 8-inch.

The boxes are similar to those used for solid shot, and are marked in *black* with the words "Shot," "1 lb.," the number in the box, and date of issue.

Shot—Hollow. Description.

5. *Hollow shot* are no longer separate projectiles,[3] common (pl. 34) and naval shells, with countersunk gun-metal plugs (pl. 34, figs. 1, 2, 3)[4] without wood bottoms or tops, being now supplied for the purpose.[5]

Hollow shot are fired from the same ordnance as common and naval shells, viz., guns, howitzers, and carronades.

Uses.

They are used against wooden ships *at short ranges*, the advantages resulting from their employment being that, while the splintering effect produced by them at short ranges is greater than that produced by a solid shot of the same calibre and the fragments are more numerous,[6] they can be fired from ligher guns.[7] They are not adapted for long ranges, because their accuracy is inferior to that of solid shot of equal diameter, in consequence of the greater effect of the atmosphere upon the lighter body, and because, owing to their rapid loss of velocity

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1 Sometimes called "Pierrier" charges from the French word "pierre" (stone); mortars of large calibre, but light metal, having been used to fire charges of stones which ultimately were replaced by these 1 lb. shot charges. Two brass "Pierriers" of 18 calibres were cast in the Royal Gun Factories in 1853; they weigh 18 cwt. each, and are to be seen at Chatham, There are several old "Pierriers" in the Rotunda.—(*MS. Letter from General Lefroy*, 5/8/63.)

Official Catalogue of the Museum of Artillery in the Rotunda, by Brigadier-General Lefroy, p. 41, Nos. 224, 225. *Straith's Fortification*, 7th Edition, p. 25.

Sometimes the word "Pierrier" has been applied to *guns* used for discharging large stones. I believe this application of the word, however, to be incorrect, though I think it necessary to call attention to the fact to avoid confusion. My authority for believing that the name is properly only applicable to mortars will be found in the following quotations from two French works; the quotations taken in conjunction with the remainder of this note give all the necessary information respecting the service of these pierriers.

"*Pierriers:* Par les pierriers il faut entendre mortier-pierrier qui sont veritable-" ment une espèce de mortiers, avec lesquels on jette des pierres dans une ville assiegé, " dans des tranchés et sur des ouvrages on jette même des grenades."—*Mémoires d'Artillerie*, vol. ii. p. 1.

"Pierrier: C'est une espèce de mortier, mais moins chargé de metal."—*Dictionnaire d'Artillerie*, par Col. Cotty, p. 331.

"*Charger un pierrier:* Les pierriers se chargent comme les mortiers jusqu'à l'introduction de la poudre inclusivement; alors on place un plateau de bois, et sur ce plateau un panier en osier; on remplit ce panier de pierres. Quand on n'a point de panier, on charge le mortier d'une couche de terre et d'une couche de pierres alternativement jusqu'à la bouche."—*Ibid.* p. 60.

2 The only grape in which the balls are exposed.

3 See p. 8, respecting the hollow shot in use until 1859–60, also same page respecting the existing stores of the old pattern being used, where serviceable, for practice.

4 See p. 100. The counter-sinking of the plug, flush with the surface of the shell, prevents the possibility of the shell jamming in ramming home when being used as a hollow shot without a wood bottom.

5 A separate projectile is thus done away with, common and naval shells serving in the double capacity of shells and hollow shot.

6 *Naval Gunnery*, 3rd edition; pp. 86, 168, see also pp. 254 to 270. *Experiments in H.M.S Excellent*, pp. 16, 17, 42, 44, 46, 47.

7 10 and 8-inch guns were specially introduced to fire shell and hollow shot.

(from the same cause), their penetrating power at long ranges is very inconsiderable.

Hollow shot are sometimes fired hot, but this application is a rare one.[1]

When common or naval shells are issued as hollow shot they are sent away "loose," not packed.[2]

6. *Case shot* are made of the following sizes: 3, 6, 9, 12, 18, 24, 32, 42, 56 pr., 10-inch and 100-pr. (*see* table). Shot—Case. Sizes.

They may be divided into three classes:—(1) iron case; (2) tin case with iron bottom; (3) tin case with wooden bottom. Description.

Case shot for the 32-pr. gun, 8-inch gun and howitzer, 68-pr. gun, 10-inch gun and howitzer, and 100-pr. guns belong to the first class,[3] and consist of hollow iron[4] cylinders with iron[5] ends, filled with sand shot of different sizes according to their natures, the interstices being filled with paper, shavings, &c. The bottoms of the 10-inch and 8-inch are slightly rounded, to permit of the cartridge being set home in simultaneous loading.[6]

The top end of case shot of this class is fitted with an iron handle.

The 32-pr., 8-inch, and 10-inch case shot of this pattern are distinguished as Pattern II.[7]

Class (2)[8] comprises case shot for all iron ordnance (except 5½ howitzer) above 12-pr., not included in class (1), viz., 18-pr. gun and carronade, 24-pr. gun and carronade, 42-pr. gun and carronade, 56-pr. gun, and 68-pr. carronade.

Class (3)[9] comprises case shot for all bronze ordnance, for all iron ordnance below the 12-pr. (inclusive), and for the 5½ howitzer (*iron* as well as bronze), viz., 6-pr. gun and carronade, 9 pr. gun, 12-pr. gun and carronade, 12-pr. howitzer, 4⅖-inch howitzer, 5-½inch howitzer, 24-pr. howitzer, 32-pr. howitzer.

Both classes consist of hollow tin[10] cylinders, filled, like class (1), with sand shot of different sizes, according to their natures, the interstices being filled with shavings, sawdust, &c. The tops of the cylinders are also of tin, soldered on, the distinguishing feature of the two classes

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1 "When it is desirable to fire *hot hollow shot* a small hole must be drilled through "the plug to allow of the escape of the heated air."—*Manual of Artillery Exercise*, p. 150.

2 See method of issuing loose empty shells; common, p. 29, and naval, p. 34.

3 Approved 25th January 1866, *War Office Circular* 9 (new series), § 1192, and extended to 8-inch and 10-inch howitzers by *War Office Letter*, 75/12/2828.

4 No. 18 W.G. for 10-inch, 8-inch, and 32-pr.; No. 16 W.G. for 100-pr.

5 No. 8 W.G. for all sizes.

6 "In consequence of the 8-inch" (experimental) "case shot being flat at the "bottom . . . . it was found that the charge did not reach the bottom of the "chamber, and nine miss-fires took place in ten rounds. Either the cartridge should "be rammed home by itself when using reduced charge, or the bottom of the shot "should be rounded off."—*Extracts of Reports, &c. Ordnance Select Committee*, vol. iii. p. 104.

7 In accordance with *War Office Circular* 8 (new series), § 1162, and in contradistinction to the old (No. I.) pattern case of these natures which, although no longer manufactured, are not yet obsolete. For land service the old pattern is re-issued if serviceable; but it is not now re-issued for naval service, 26/2/66, 75/12/2733.

8 Approved 27th March 1861, *War Office Letter* of that date, 79/B/307; and *War Office Circular* 683, § 241.

9 See p. 7 respecting all case shot in our service having at one time had wooden bottoms. It is impossible therefore to fix the date of the introduction of this class.

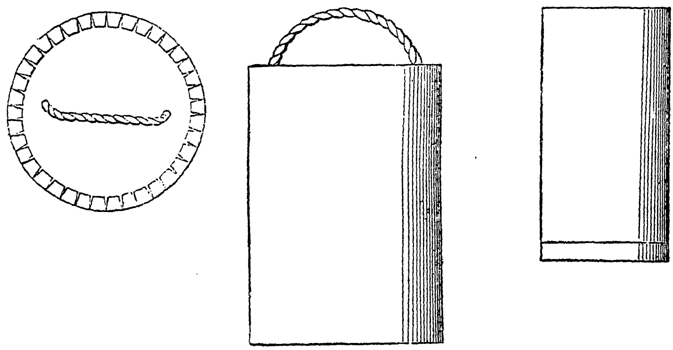
10 Tin plate, *i.e.* thin sheet iron tinned over. Tin plate, of a very pure quality, "charcoal plate," only is used. The following are the distinguishing marks or brands of the different sized plates used in the manufacture of the various natures of case shot: XXD, XD, XXXXS, XXXS, and XXS. See table III. p. 324.

consisting in the bottom being iron in the one class and wood in the other.[1] The bottom of class (2) is an iron[2] disc, secured by hammering the lower edge of the cylinder, which has previously been fringed, down upon the iron. A rope handle is fitted on to this iron disc for convenience in lifting.[3]

Case shot of class (3) have wooden bottoms, on account of the iron having a tendency to score and injure the bore of the bronze guns, and to

CASE SHOT.[4]

CLASS (2) 18-PR. CLASS (3).—FOR BRONZE ORDNANCE.



avoid a separate projectile for iron guns of corresponding calibre. The bottom is secured to the cylinder by tacks[5] placed 4 inches apart, the heads being soldered over;[6] it is allowed to project slightly below the case, this projecting part being shaped conical for Gomer-chambered ordnance, and for unchambered ordnance of corresponding calibre;[7]

[1] Throughout this course, when the "top" or "bottom" of a projectile is spoken of, the terms are applied to the sides or ends which in the gun are situated respectively away from and next to the charge.

[2] Sheet iron, No. 8, W.G.

It has been shown (p. 7), that the iron was substituted for the wooden bottoms for manufacturing reasons only, and not with any idea of altering the construction of the projectile; accordingly, the relative position of the ends of the projectile in the gun would naturally remain unaltered, and the end that went away from the charge before the change would continue, as a matter of course, to go away from it, after iron had been substituted for wood. It is necessary to point this out, and to bear in mind the object with which the rope handle is attached, viz., for "convenience *in lifting*," otherwise it might be supposed that this handle is intended to be used to swing the case into the gun, thus bringing the tin end next the charge. It is the more important to point out that the handle is not intended to be used in this way, because great uncertainty and misconception have existed upon the subject, and there has consequently not always been perfect agreement as to which end of these projectiles should go next to the charge. I wish therefore to emphasize the fact *that the tin end always goes away from the charge.*

[4] Case shot of class (1) is identical in appearance with the grape for the 10-inch gun, see cut, p. 19, except that the case for 10-inch and 8-inch has, as stated in the text, the bottom slightly rounded.

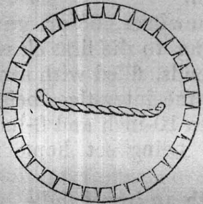
[5] Tin tacks No. 50 for 24-pr. and 32 and No. 72 for 12, 9, 6, and 3-prs.

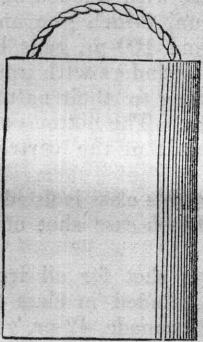
[6] To prevent the tacks from scoring the bore, and also to secure the tacks.

[7] The 12-pr. *gun* case is the only one affected by this rule, this being the only unchambered piece of ordnance with a chambered howitzer to correspond, the case for which has a wooden bottom, the only other gun (or unchambered ordnance) case which have wood bottoms being the 6 and 9-prs. Nor does there seem any reason for providing this 12-pr. gun case with a conical bottom, since this gun is not chambered, while the 12-pr. howitzer, which is chambered, has a different case altogether. The reason, probably, is to be found in a desire to apply the rule which was framed originally for shot and shell bottoms to case bottoms also; and as this application does no harm, if it does no good, it is admissible.

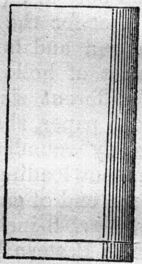
CASE SHOT.[4]

Class (2) 18-pr.





Class (3).—For Bronze Ordnance.



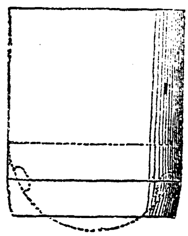
hemispherical for cylindrical-chambered,[1] and cylindrical for all other ordnance.

The 32-pr. howitzer case is the only case of class (3) which is fitted with a rope handle.[2]

The case for the 5½-inch howitzer has two holes made on the lower side of the hemispherical wooden bottom, to admit the fingers, and so assist in lifting.

24-PR. OR 5½-INCH HOWITZER.

The dotted lines show the wood bottom for 5-½inch howitzer.



It is impossible to lay down any positive rule as to the number and weight of the sand shot employed in making up each nature of case,[3] but it may be noticed that the case for howitzers and carronades are generally filled with lighter sand shot than the case for the corresponding natures of shot guns, and weigh less. The case for the 24-pr. and 12-pr. howitzers for sea service[4] contain larger balls than the same sized case for land service, and are of greater total weight.

Case for guns and carronades is painted[5] red;[6] howitzer case black.[7]

Uses.

Case shot are fired from all natures of guns, howitzers, and carronades, except guns with wrought-iron A tubes.[8]

Case shot is used against troops in masses, for the flanking defences of ditches, narrow defiles, and to destroy the rigging of shipping.[9] It is, however, effective only at short ranges, on account of its rapid dispersion, and because of the lightness of the balls, whereby their velocity is very soon lost. They would therefore rarely be available for ranges exceeding 300 or 350 yards.[10]

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[1] There are only two pieces in the service with cylindrical chambers, viz., the 5½-inch iron and the 4⅖-inch bronze howitzers.

[2] This is necessary on account of the weight of the projectile.

[3] See table III. p. 324.

[4] All other case are used indifferently for land and sea service. These are the only two natures in which any distinction is made for the two services.

[5] *War Office Letter*, 24/1/61/, 75/4/212, approves of this distinction of colour.

[6] See table XX. p. 345.

[7] See table XX. p. 345. Case of class (1), although used for 8-inch and 10-inch howitzers, is not howitzer but gun case, and is therefore always painted red, whether fired from guns or howitzers. The old pattern case for these howitzers, however, which belonged to class (2), differs from the gun case and is painted black.

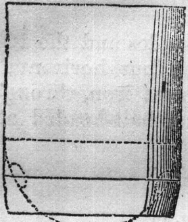
[8] See 31/8/65, 75/12/2572. For this reason no case shot are provided for the 150-pounder; all guns of that calibre having wrought-iron A tubes.

[9] "Case shot has always been considered the most destructive kind of ammunition "which is fired from artillery."—*Synopsis of Ordnance Select Committee Report*, Shrapnel shell, p. 5. See also Sir Howard Douglas' *Naval Gunnery*, 3rd edition, p. 421; also *Straith on Artillery*, 7th edition, p. 149. See also *American Artillery Course*, p. 485.

"Case shot produces its greatest effect against cavalry, taking into consideration "both men and horses; it is less efficacious against infantry, and still less against "artillery. This must be evident when it is recollected that cavalry, occupying a "greater surface, and being much higher, ought to be most exposed to its effects than "infantry; and that the latter will suffer more from it than the artillery, the guns "being separated from each other by considerable intervals."—*Manual of Artillery Exercise*, p. 17.

[10] "In grape and canister firing the apex of the cone of dispersion is situated in the "muzzle of the piece, and the destructive effect is confined to short distances."—*American Artillery Course*, p. 457.

"Beyond 300 yards the dispersion of the shot (the case being broken by the shock "of the discharge) is too great to be effective.—Owen's *Lectures on Artillery*, Ed. 3, p. 66



Packing and issue.

Case shot are always issued boxed in boxes similar to those used for shot. The number in each box varies with the nature of case.[1]

The boxes are marked *in black* with the words "Case shot," the nature of ordnance with which those in the box can be used, the number in the box, and date of issue; and for bronze guns [2] the number and weight of the shot with which each case is filled is marked on (*in black*) in addition. For tropical climates (when the case shot have teak bottoms) the boxes have also the words "For tropical climates," *in black*.

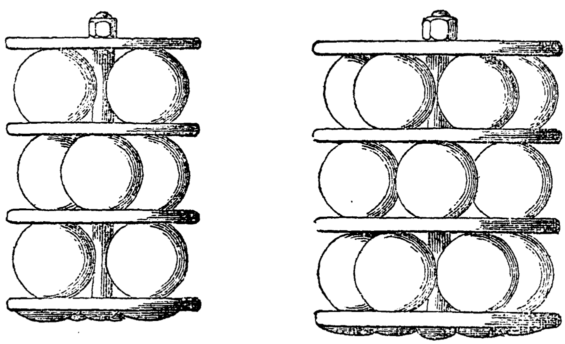
Shot—Grape. Sizes.

(7.) *Grape Shot*[3] are made of the following sizes, viz., 6, 9, 12, 18, 24, 32, 42, 56, 68 pr., and 10-inch (see table).[4]

Description.

All grape,[5] with the exception of that for carronades and the 10-inch gun, is made of Caffin's pattern,[6] and consists of four horizontal iron plates, the lower one wrought,[7] and the others cast iron, through the centre of which passes a wrought-iron [8] spindle, bolt-headed at the

GRAPE SHOT. Caffin's Pattern.



lower end and screwed at its upper end to receive a nut. Between the plates are arranged three tiers of sand shot,[9] three in each tier, except for the 56-pr., which has four shot, and the 68-pr., which has five. The bottom plate has indentations corresponding to the number of shot in the lower tier, in which indentations these shot rest. The

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also *Synopsis of Experiments by Ordnance Select Committee*, 8vo. edition, p. 66. Under favourable conditions, that is to say, when the ground is hard and level, they may be used at somewhat greater ranges. Captain Benson, in his *American Artillery Course*, says (p. 457), "The most suitable distance for field canister shot is from "350 to 500 yards" (in this he probably includes grape shot); "if the ground be "hard and the surface be uniform, the effect may extend as far as 800 yards."

1 See table XII. p. 331.

2 Except for the sea service 24-pr. and 12-pr. howitzers.

3 Caffin's pattern, approved 2nd September 1822, Board's letter of that date.

4 A grape shot for the 3-pr. iron gun was in the service until 1866, when it was formally abolished, 5th June 1866, *War Office Circular* 10 (new series), § 1244.

5 See p. 8, respecting the issue of quilted grape.

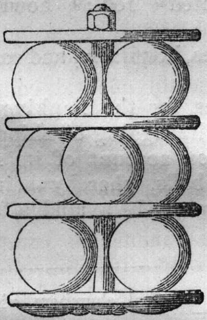
6 Wm. Caffin, Esq., late of the Royal Laboratory, Woolwich.

7 To enable it better to withstand the shock of the discharge. The iron used is flat, bar iron of the following thicknesses: 68-pr. to 32-pr. inclusive, $\frac{5}{8}$-inch; 24 and 18-pr. $\frac{1}{2}$-inch; 12·9 and 6-prs., $\frac{3}{8}$-inch.

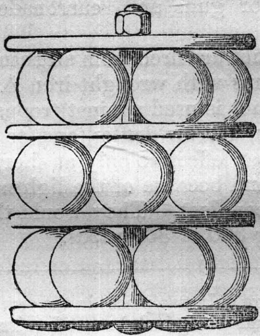
8 Bolt iron of the following sizes: $\frac{3}{4}$-inch for 68 and 56-prs.; $\frac{1}{2}$-inch for 42-pr. to 12-pr. inclusive; $\frac{5}{16}$ths-inch for 9-pr.; and $\frac{3}{8}$ths for 6-pr.

9 For sizes of shot see table IV. p. 324.

32-PR.



68-PR.



other plates have holes cast in them for the shot to rest in, and as these holes have to receive the upper parts of the shot of one tier, and the lower parts of the shot of the tier next above, each plate is furnished with double the number of holes that there are shot in a tier.[1] The whole are secured together by screwing the nut on to the spindle tightly down upon the upper plate.

All grape of Caffin's pattern are painted black.[2]

Advantages of Caffin's pattern

The advantages generally claimed for this pattern over the quilted grape are as follows:

1st. That it is made of less perishable materials.[3]

2nd. That it is more portable, and occupies less space in transport and in store, from the fact that it need not to be made up until required for use, grape of this pattern being easily put together.[4]

3rd. That its destructive effect is probably greater.[5]

4th. That its parts are interchangeable.[6]

Grape for the following ordnance is not made of Caffin's pattern:—

(*a*.) Carronades.
(*b*.) 10-inch gun.

Grape for (*a*) carronades resemble the case for the corresponding natures of ordnance, being tin cylinders with one end iron, and filled with balls. The balls, however, of the grape are larger and fewer,[7] and the cylinders are longer.

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[1] Of course the top plate, which has no tier above it, only requires the same number of holes as there are shot in a tier, but for the sake of uniformity of manufacture and for convenience in putting the shot together, no difference is made in this respect between it and the other cast-iron plates.

[2] See table XX., p. 345.

[3] Sir Wm. Congreve, in his letter submitting this grape, on behalf of Mr. Caffin, for approval, said, "This mode of combination is not only cheaper than the present mode "by canvas and cord, but more durable; in fact, grape shot, thus made up, would "last as long as common round shot."—*Sir Wm. Congreve's Letter* of 18th May 1822.

[4] The making up of the quilted grape was a comparatively tedious process, requiring considerable skill; and the quilted grape could scarcely be issued unmade up. The Caffin's pattern grape, however, may be put together in a very short space of time by unskilled men.

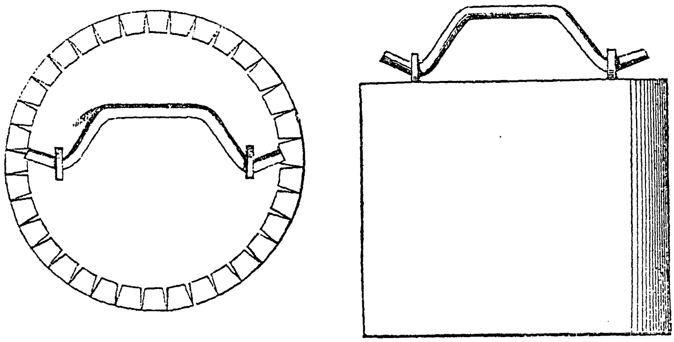
[5] The Report of the Committee on the subject, 28th August 1822, says, "A more "efficacious fire was obtained from this pattern than from the old quilted," and "Sir William Congreve, in his letter of the 18th May 1822, says, "The plates "and bolts used to combine the shot serve as so much additional missile matter as "langrage, which could not but be valuable, especially for naval service." Sir Howard Douglas, however, describes some experiments carried on at Gavre in France in 1840, with grape shot closely resembling "Caffin's" pattern, which seems to contradict this opinion. The grape "consisted," he said, "of 10 balls of 4 lb. each, "disposed in two layers between plates of wrought iron, through which passed a "central stem; the balls were confined laterally by three iron hoops, one above "another, and the upper plate was kept close over the balls by means of a screw." Respecting this experiment he remarks, "On the whole, however, grape shot confined "between iron plates appears to offer no advantage over that which is in canvas."—*Naval Gunnery*, edition 3rd, pp. 171, 172.

[6] Caffin's pattern grape is hardly ever reported unserviceable, but is generally returned, however bad, as "repairable," because in the majority of cases a sufficient number of good balls and plates can be obtained from those under examination to make up without trouble, and when re-painted, into grape as good as new. Whereas, in the case of the quilted grape, it frequently happened that the whole of the canvas bags and lines were rotted away and unserviceable, thus rendering unserviceable the whole of the grape under examination. This relative advantage of the Caffin's pattern will be more appreciated abroad or on service, where new bags and quilting lines, and instructed men to make up the grape, are not readily procurable.

[7] See tables III., IV., pp. 323, 324.

The (*b*) 10-inch grape is an iron[1] cylinder filled with 3 lb. balls, and having an iron[2] top and bottom, the top being furnished with an iron handle.

10-IN. GRAPE.



Those grape which are not of Caffin's pattern are painted red.[3]

Grape is fired from *iron* guns and carronades only.[4] It is not fired from guns with wrought-iron A tubes.[5]

Uses. Grape is used under the same circumstances as case, except that owing to the increased weight of the balls it is effective at longer ranges,[6] and is more destructive to the rigging of shipping.[7] Since the beginning of 1866 its issue has ceased for naval service.[8]

Packing and issue. Grape shot are always issued made[9] up and boxed, in boxes similar to those used for shot; the number in each box varies with the nature of grape.[10] The boxes are marked *in black*, with the words "Grape shot," the nature of ordnance with which those in the box can be used, the number in the box, and date of issue.

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[1] Sheet iron, No. 16 wire gauge.

[2] Sheet iron, No. 8 wire gauge.

[3] See table XX., p. 345.

[4] Grape is not supplied for howitzers, nor is it ever fired from bronze ordnance because of its liability to injure the bore. There seems, however, no reason why grape shot of the pattern of the carronade grape, viz. tin cylinders filled with balls, should not be fired from bronze ordnance with as little chance of injury to the bore as results from the firing of case from such guns, since the two projectiles differ only in the size of the balls and in the grape having an iron bottom, for which a wooden bottom might easily be substituted.

[5] See 31/8/65, 75/12/2572.

[6] "Under favourable circumstances grape may be used up to 600 yards."—*Lectures on Artillery*, edition 4, p. 78.

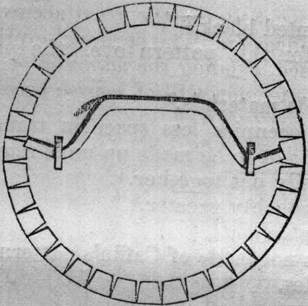
[7] "They" (grape) "will penetrate the enemy's barricade defences on the upper " deck, and though they cannot penetrate a mast, or by any direct wound bring it down, " yet they can break chain plates, cut shrouds, or stays, however thick, and from the " number of such chances will be very likely, in a strong breeze, to dismast the enemy." —*Naval Gunnery*, edition 3, pp. 421.

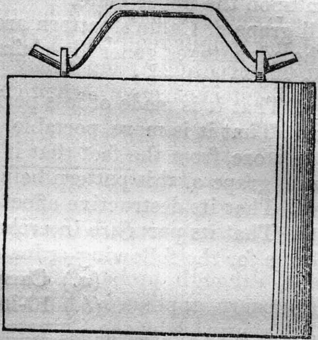
[8] 20th February 1866, *War Office Circular* 9 (new series), § 1189.

[9] There seems to be no reason why, if desirable, grape should not be issued unmade up, and for the purposes of transport this method has much to recommend it. At the same time I cannot discover that grape ever has been so issued.

[10] See table XII., p. 331.

10-IN. GRAPE.





(8.) *Eprouvette shot* is only made of one size, the 8-inch. They are cast-iron[1] shot, carefully turned after casting to a true sphere,[2] weighing 68 lbs.[3] They are provided with lewis holes.[4] Shot—Proving Powder.

They are not painted.

Eprouvette shot are used, as their name implies, for proof of powder with the eprouvette mortar;[5] hence the necessity for the great accuracy of form and weight required by the specification. The eprouvette proof is now, however, only temporarily retained, pending the adoption of an improved system of proof, when eprouvette shot will of course become obsolete. Use.

Subdivision (b).—Shell.

Shells, although probably not of so early a date as shot, are by no means modern appliances, having been used, it is stated, in the 12th and 13th centuries by the Chinese.[6] Indeed, we find even earlier mention than this of something of the nature of shells, for the Chinese, *before the Christian era*, employed "hollow globes of iron filled with a bushel of "gunpowder and so arranged that they exploded on the approach of "an enemy, so as to cause great destruction in his ranks."[7] They probably sprung originally from the "fire pots" of the ancients,[8] which were jars or vessels of different materials, filled with "Greek fire" and other incendiary compositions;[9] and it was but natural that these compositions should in great measure have gradually given way to the more powerful and destructive agent which the discovery of gunpowder rendered available. It seems certain that shells thrown by hand (hand grenades) or by slings, or from the warlike machines which preceded cannon[10] were used for some time previous to their regular introduction as a projectile for use with guns and mortars.[11] During many years Shell (of common class)—history. Hand grenades.

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[1] The mixture used is superior to that employed for ordinary solid shot, and carefully selected, in order to bring the size and weight of the shot within the very restricted limits allowed by the specification. The iron now used is hematite (a cold blast iron), 2 cwt.; langloam, No. 1 (a superior hot blast iron), 2 cwt.; founders' scrap (selected hard) 1 cwt.

[2] "A variation of ·005 inch in diameter" is allowed.—*Notes on Matériel*, p. 27.

[3] The limits of weight allowed are $\pm$ 1 oz.—*Ibid.*, p. 27.

[4] See p. 36, 37.

[5] See p. 142.

[6] Owen's *Lectures on Artillery*, edition 3rd, p. 5.

"*Du Feu Gregois et des Origines de la Poudre.*" Par M. Remaud et M. Favé, p. 186.

[7] Called "Thunder of the earth."—*Du Feu Gregois*, &c., p. 176.

[8] "I shall never allow that the military *ollæ* or fire pots are posterior to the hollow globes . . . . very far to the contrary. I dare affirm that our grenados are derived from the fire pots . . . . since I have the testimony of several great authors who lived in unspotted credit and reputation among the ancients, to support me in it."—*The Great Art of Artillery*, p. 236.

[9] Respecting fire pots and fire balls, and the history of military pyrotechny generally, see p. 58 *et seq.*

[10] Respecting the use of the sling and other instruments for throwing grenades, see *The Great Art of Artillery*, pp. 215 to 223.

[11] "The mortar and grenade were in common use previous to the recognized introduc-"tion of the bomb; the mortar was applied to the projection of huge stone balls, and "the grenade was thrown by hand."—Dahlgren's *Shell and Shell Guns*, p. 5.

"We do not find the least footsteps of the great grenados amongst the ancient "Pyrobolists, but their writings make ample and particular mention of the smaller as "what they were well acquainted with."—*The Great Art of Artillery*, p. 210.

the terms "Grenade" or "Grenado" appear to have been applied generally to all shells;[1] the name is derived from the Pome*granate*, the grains contained by the fruit being represented by the grains of gunpowder.[2] The word shell similarly is derived from the German "Schale," *i.e.* the outside, rind, bark of anything.[3]

By degrees the use of grenades was extended to mortars, to which their application was long restricted,[4] the shells being made both round and oblong.[5] The round sort retained the name of "grenades,"[6] the oblong sort were called "bombs;" probably from the noise caused either by the firing of the gun, or the bursting of the shell.[7] Both sorts were afterwards fired from cannon,[8] but to these, of whatever shape, the name grenade seems at first to have been invariably applied.

Shells first used as projectiles.

It is difficult to fix precisely the date at which shells or "grenades" were first used as projectiles. There is some doubtful record of their having been thus employed with mortars as early as 1376,[9] and we read of shells fitted with fuzes having been fired in 1421, at the siege of St. Boniface, in Corsica. They are spoken of by Gibbon[10] as "explosive globes," and are described as two hollow hemispheres of stone or bronze, "joined by means of a hinge, a circle of iron, and keys. The fuze to this rude shell consisted of a sheet iron tube enclosing the priming, and riveted to one of the hemispheres."[11]

It is not surprising and scarcely to their discredit that the artillerymen of those days should have failed to recognize in these rude and imperfect projectiles the important properties which improvements in their construction gradually developed, and that, in consequence, their use on their first introduction was partial and exceptional;[12] that such

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[1] And not only at first to shells filled with gunpowder, but sometimes to shells filled with "particular composition."—*The Great Art of Artillery*, p. 210.

[2] "They are called grenados from the resemblance they bear to the Punic fruit, "which we call pomegranates; for as the rind of these enclose a vast number of "grains, from whence they derive their name of grenates; so our military grenados "are filled with innumerable grains or corns of gunpowder, &c. . . . . The greater "grenados . . . . doubtless borrowed their names from the smaller sort, which have "a greater natural resemblance to the Punic fruit above mentioned than the large "have."—*Ibid.*, p. 210.

[3] "Shot and shell are Teutonic words . . . . Shell is the German schale, *i.e.* the "outside, rind, bark of anything. Thus shell is used in shell fish, *i.e.* fish with a shell, "the shell of an egg. From this it was transferred to the hollow iron ball enclosing "the powder."—*MS. letter from Professor Max Müller*, September 20th, 1865.

[4] "Long restricted to vertical fire from mortars," &c. &c.—*Equipment of Artillery*, p. 109.

[5] Cylindrical shells seem also to have been employed by Louis XIII. in 1627 and 1628.—*Ibid.*, p. 224.

[6] "Most pyrotechnists call those balls that are hollow and spherical grenados, and "those which are longish and oval they call bombs."—*The Great Art of Artillery*, p. 224.

[7] "These early cannon were called *bombardicæ*, from βόμβος, on account of the "great noise their firing occasioned."—Wilkinson's *Engines of War*, p. 49, see also Ancient Cannon in Europe, in *Proceedings Royal Artillery Institution*, vol. iv., p. 304.

[8] *The Great Art of Artillery*, p. 238.

[9] 1376, "at Jadra by Venetians."—M. Meyer, see *Dahlgren*, p. 1.

[10] Lieut. Gibbon, American Navy, author of "*Artillerist's Manual.*"

[11] Gibbon's *Artillerist's Manual*, p. 156. See also *Instruction D'Artillerie*, p. 283, where shells used at this siege are described.

[12] "There is a good reason . . . . to doubt whether the modern bomb was under-"stood and used at the remote epochs thus assigned, or if it be admitted that a correct "idea of it has been entertained, there seems to be a tolerable assurance in the sparse "and isolated occasions usually quoted that its construction and proper mode of "application were so indifferently comprehended as to interpose a bar to any useful "realization of its capabilities."—*Dahlgren's Shell and Shell Guns*, pp. 1, 2. It is probable that the accidents which attended their use caused them to be abandoned for the time.—*American Artillery Course*, p. 102.

was the case, however, cannot be doubted, for, although we find occasional mention of them as having been used here and there during the 15th and 16th centuries,[1] it seems certain that they did not come into general use, nor do they appear to have been appreciated or their construction to have been properly understood, until about the beginning of the 17th century.[2] A passage in Wilkinson's *Engines of War* seems to prove that mortar shells were not used *at sea* until the close of the 17th century.[3]

Shells first used for horizontal fire.

Hitherto the employment of shells had been restricted to mortars, and it was not until the beginning of the 18th century that they were used for horizontal fire, and then first only from howitzers.[4]

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[1] They are spoken of by different military writers as having been used in—
1521, at the siege of Mézières.—*Thiroux*, 49.
1552, at the siege of Rhodes by the Turks.—*Durtubie, Thiroux.*
1534, invented in Holland.—*Paixhans*, 350.
1542, at the siege of Bordeaux.—*Thiroux*, 46.
1580, used in Holland.—*Paixhans*, 350 ; see *Dahlgren*, p. 1.

"Valturiss, who is the oldest of modern writers on shell, ... carries the invention of bombs at least a century further back than Strada (viz. to somewhere about the date of the publication of his work, or 1472), for in his work there is the figure of a cannon somewhat of the howitzer kind, destined to throw a brazen ball filled with powder."—*Grose's Military Antiquities*, vol. i., p. 408.

"In 1478 an attempt was made to use . . . . hollow projectiles filled with powder, to which was attached a burning match to set the powder on fire."—*American Artillery Course*, pp. 101, 102.

"Il paroît que ce fut au Siége de Rhodes, en 1552, que les bombes furent d'abord employées."—*Dictionnaire d'Artillerie*, par Col. Cotty (Paris, 1822), p. 37.

"Hollow projectiles are said to have been used on the earliest recorded occasions; at Naples, 1495 ; at Padua, 1509 ; at Heilsberg, 1520 ; at Mézières, 1521 ; at Rhodes, 1522 ; and at Boulogne, 1542 ; and were made of cast iron, of bronze, of alloys of lead and tin, and finally of cast iron, as now. Although limited in the 17th century to the existing sizes, the preceding century had witnessed the use of bombs of a much larger size. At Boulogne, as early as in 1542, shells of 19 inches, French, at Berlin, 1683, mortars and shells, of 1,100 lbs. weight existed; at the bombardment of Genoa, in 1684, shells of 1,320 lbs. were thrown, and even as late as 1745 at the siege of Tournay the French threw shells of 18 inches, weighing 550 lbs."—*On the Military and Naval Uses of very large Shells.* By R. Mallet, Esq. See *Journal, United Service Institution*, vol. ii., p. 412.

[2] There is no lack of authorities to establish this fact ; in St. Julien's "*Forge de Vulcan*," shells of four different natures are described in detail (see *Dahlgren*, p. 3) ; and Dahlgren says—"Their first well authenticated use was by the Dutch Prince Henry of Nassau, in 1624, at the siege of Grol. The results must have been considered highly satisfactory, inasmuch as a more extended application of them ensued at subsequent sieges, and in reducing the Fort of Schink, the Prince employed them exclusively. *Their reputation now spread over Europe, and they were soon introduced into the services of other powers.*"—*Dahlgren*, p. 4.

"Le maréchal de la Force en fit usage au siége de la Mothe, en 1634, *et tout porte à croire qu'on ne s'en était pas encore servi en France avant cette epoque*, quoiqu'elles y fussent connues depuis longtemps. C'est donc par erreur que l'on en a attribué l'invention à un habitant de Venlo en 1588, puis'qu'on les a employées soixante six ans auparavant." —*Cotty's Dictionnaire de l'Artillerie*, p. 37.

"Les grenades-à-main et les grosses grenades, munies des fusées . . . . ont été employées par l'Artillerie des Provinces Unies des Pays-Bas, au siége de Bréda, en 1617 . . . . Si ces deux projectiles n'étaient point absolument inconnus auparavant, ils reçurent en Hollande les perfectionnements qui les rendirent efficaces et usuels." *Le Passé et l'Avenir de l'Artillérie*, vol. iii., p. 322. See also *Ibid.*, vol. ii., p. 345. See also *The Great Art of Artillery*, pp. 210, 214, 232, *et seq.*

[3] "It is stated by Voltaire in his *Essai sur l'Histoire Universelle* that bombs were first used at sea by the French in the bombardment of Algiers (October 28, 1681), previous to which it was thought impossible to use mortars anywhere but on land." —*Engines of War*, p. 51.

[4] "Shells began to be used in horizontal fire about 1700. In this stage of their progress they were fired from howitzers with small charges of powder."—*Equipment of Artillery*, p. 109.

Towards the close of the 18th century they were projected from guns.[1]

In addition to iron, various materials have from time to time been employed or recommended for shells—brass,[2] bronze, hardened lead,[3] and even glass[4] having been made use of for this purpose.

In the beginning of the 19th century shells of a distinct class—a class which depended upon different causes for their effects, viz. shrapnel shells—were introduced, but the history of these will be taken separately.[5]

Shell—Six classes.

There are at present six different classes of shells in the service, viz.:—

1. Common - -	Shells of the Common class.
2. Naval - -	
3. Mortar - -	
4. Hand grenade -	
5. Improved shrapnel [6] -	Shells of the Shrapnel class.
6. Diaphragm „ -	

Shell—Common. Sizes. Description.

1. *Common shells*[7] (pl. 34, fig. 11,) are made eight different sizes, viz. 10 inch, 8 inch, or 68-pr.; 56, 42, 32, 24, 18, and 12-prs. They are hollow concentric[8] spheres of cast iron,[9] having a fuze hole for the reception of the fuze, by means of which the bursting charge with which the shell is filled is exploded at the proper time.

The determination of the thickness of metal of a shell is an important point, for "the character of the projectile will vary with the "relations which exist between the iron shell and the bursting "charge."[10] In determining this thickness two opposite requirements have to be considered; if the shell is not made of a certain thickness it will not withstand the shock of the discharge of the gun; this consideration will therefore determine the *minimum* thickness of the metal, while any increase on this thickness will of course, by increasing the weight of the shell, be favourable to its range and penetration; on the other hand, in proportion as the thickness of metal

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1 "The next improvement, suggested by a casual experiment in 1779, was to fire "them from guns with large charges, and thus to combine with their other destructive "powers the increased velocity thus obtained"—*Equipment of Artillery*, p. 109.

2 The mutinous sepoys in India made use of brass shells. There is one taken from a limber box at Lucknow in the Museum of the Royal Artillery Institution.

3 "Hollow projectiles . . . . were made of bronze, of alloys of lead and tin."—*On the Military and Naval Uses of very large Shells.*

4 "Glass grenades are sometimes made use of with good effect . . . . these grenades "are used in Spain at present, and have been since the early part of the 15th "century."—*Aide Mémoire to the Military Sciences*, vol. ii., part 1. Art. Grenades, p. 190.

5 I have thought it better to give the history of shrapnel shells elsewhere (see p. 41), as that history embodies so much instructive matter, connected with the construction, application, &c of the shells, and of those which have sprung out of the original shrapnel, viz., the Improved and Diaphragm Shrapnel, that it should not be separated from the description of those projectiles.

6 The improved shrapnel shell is now neither manufactured nor issued, but the stores of this projectile are not exhausted, and I have therefore given it a place among the service shells.

7 Present pattern, *i.e.*, for Pettman's fuzes, approved 30th October 1861, *War Office Circular* 739, § 414. This change, however, did not give rise to a distinct change of pattern, but was applied to the existing shells, the patterns of which (with countersunk plugs) had been approved 22nd June 1860 and 25th July 1860, *War Office Circular* 639, §§ 93 and 97.

8 As nearly as possible; it is doubtful if any cast-iron shells are *perfectly* concentric.

9 The iron used is the same as for solid cast-iron shot (see p. 9, note 3), but the casting is made at a somewhat higher temperature.

10 *Shells and Shell Guns*, p. 64.

is increased the quantity of powder which the shell will hold, and consequently its explosive effect, will be diminished. It is by carefully balancing these considerations according to the circumstances of the case,[1] and by striking a judicious mean, that the dimensions of shells have had to be determined.[2] In common shells the thickness of metal is about one-sixth the diameter[3] (pl. 34, fig. 11, A, B). The weight of common shells (empty) is about two-thirds that of a solid shot of the same calibre.[4] The fuze hole is slightly conical[5] in form, and is made of a size to receive Boxer's common fuze[6] (pl. 2) and Pettman's land service percussion fuze[7] (pl. 7). It is of one diameter[8] for all common shells. The fuze hole is tapped with a right-handed thread[9] to enable it to receive a screw gun metal plug[10] (pl. 34, figs. 1, 2, 3), by which it is closed when not required for use, and to enable it to receive the Pettman's fuze, which being made of metal has to be screwed in.[11] Tapping the fuze hole also serves to roughen it, and so gives the wooden fuze a better hold, thereby diminishing its liability to be knocked out upon the shell striking against a hard substance in ricochet practice.[12]

The fuze holes of all common shells are countersunk[13] (pl. 34, fig. 11,

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[1] " These conflicting conditions must be harmonized according to the part which shell " guns are designed to fulfil, whether they are to be the principal or auxiliary power " of the batteries."—*Shells and Shell Guns*, p. 104.

[2] *Shells and Shell Guns* contains some interesting remarks upon this subject.

Admiral Dahlgren considers that English and French shells go to the two opposite extremes in the matter of the relations existing between the iron shell and the charge, "and probably to the utmost extent to which it would be advisable to carry either." The English 8-inch shell, he says, "Could not be made heavier without manifest " prejudice to its explosive power; the 22 cents. French shell could not be made to " contain a greater charge without the sacrifice of accuracy and penetration in a most " injurious degree" (p. 64) ; and reasoning from these facts, he concludes that "the " English shell extends its effects to a greater distance, but the French shell is more " powerful within the range of which it is capable, and it has yet to be satisfactorily " proven that the English shell can exercise decisive effect beyond this range" (p. 65).

The thickness of metal of ancient shells was much less than at present, being one-eighth, one-ninth, and one-tenth their diameters. They were, however, projected from much less powerful guns, and with considerably reduced charges. See *Great Art of Artillery*, pp. 224, 242.

[3] The 10 inch shell has a thickness of only one-seventh; this is because the gun is not considered capable of bearing the increased strain involved in the use of a heavier projectile.

[4] Except the 10 inch, which being thinner necessarily weighs proportionally less.

[5] The pitch of the cone is as nearly as possible one inch in nine inches, or *exactly* one in 9·375.

[6] See p. 250.

[7] See p. 273.

[8] At the top ; the diameter at the bottom will of course vary with the thickness of metal.

[9] 14 threads to the inch.

[10] See p. 100.

[11] Until the introduction of Pettman's fuze, the fuze hole was only tapped regularly to the distance required for the reception of the gun metal plug, the thread below this being irregular, merely a roughening of the sides, becoming fainter towards the bottom ; the introduction of this fuze, however, rendered it necessary to continue the thread regularly the whole way down ; and the preparation of (countersunk) shell in store to receive Pettman's fuze consists therefore in continuing and deepening the thread to the bottom of the fuze hole, not in altering in any way the size or shape of the fuze hole. See p. 308.

Shells which will receive Pettman's fuze are distinguished by a cross cut upon the gun metal plug, and all common shell are now so prepared. See Gun metal plugs, p. 100.

[12] Approved 8/2/54, see *Board's order*, 31st January 1855, 55/D./149, para. 28, art. VIII.

[13] 22nd June 1860, and 25th July 1860, W. O. C. 639, §§ 93 and 97.

D, H, J, E), so as to bring the top of the metal plug when it is screwed home flush with the surface of the shell, thus permitting of the projectile being used as a hollow shot[1] (without a wood bottom). The countersunk plug is also better preserved from injury in transport than a projecting plug, and shells thus prepared can be more readily piled as shot.

The 12-pr. (pl. 34, fig. 5) common shell differs from the rest in having its fuze hole fitted with a gun metal bush or socket (pl. 34, fig. 4) extending some way into the interior of the shell;[2] the object of this bush is to make the bursting of the shell more certain, it having been found in practice that on the explosion of the bursting charge the common fuze was blown out, and the whole of the gas frequently escaped at the fuze hole without bursting the shell;[3] the best remedy for this defect was evidently to reduce the size of the hole at which the gas escaped, and in some way to secure the fuze against being blown out.[4] Both these objects are satisfactorily accomplished by the long tapering bush, the upper part of which being made the same size as the fuze holes of all other common shells, will admit the same fuze, while owing to the conical form of the bush, and to its being continued below the metal of the shell, the orifice at the bottom is somewhat reduced, and the fuze is moreover almost completely protected from the direct action of the bursting charge.[5] The bush is countersunk and tapped in the same way as the fuze holes of other common shells, from which the 12-pr. differs in no other respect.[6]

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[1] See "Hollow Shot," *ante*, pp. 8, 14. The necessity for not having the plug projecting above the surface of the shell when using it as a hollow shot without a bottom scarcely needs explanation, for it is evident that otherwise there would be a liability of the shell jamming in the bore.

[2] Recommended, 9 August 1855. *Synopsis of Ordnance Select Committee Report—Shrapnel Shell*, p. 231. *Account of Alterations and Additions in Ordnance, &c.*, 22nd October 1855, para. 21.

[3] 7th June 1855, "From the reports of practice at Shoeburyness it appears that "the 12-pr. common shell fails to explode with the newly constructed fuze-hole." —*Synopsis, Ordnance Select Committee Report, Shrapnel Shell*, p. 229. "The 12-pr. "shells were bouched, as it was found in former experiments that with the large cone "fuze they did not burst, when not prepared in that manner."—*Ibid.*, p. 231.

There is probably in all common shells (except when metal fuzes are used) some loss of gas in this way (see Appendix L., p. 379); but the value of this loss decreases inversely as the size of the shell, and, except in the case of the 12-pr., is not sufficient to affect the bursting of the shell; in the 12-pr., however, owing to the great disproportion existing between the size of the fuze hole and the bursting charge, the gas is able to escape nearly as rapidly as it is generated; or at any rate the amount of gas which does not effect its escape instantaneously in this way is insufficient to burst the shell.

[4] I take no account of another method which suggests itself, viz., to reduce the thickness of metal of the shell, an arrangement by which the capacity of the shell for powder would have been increased, and the work for that powder to accomplish would have been diminished, because this remedy would certainly not be resorted to except in the absence of all other efficient and available remedies, since it would have reduced the weight, and consequently the range, accuracy, and penetration of the shell, already from its size and weight sufficiently limited; the difficulty might also have been overcome by reducing the size of the fuze hole, but such a plan would have been open to the objection that it would either have entailed the introduction of a special (smaller) fuze, or, if the present fuze had been retained it would have projected from the shell to a much greater extent than is considered desirable. The bush was proposed by Col. Boxer in 1855.—*Synopsis of Ordnance Select Committee Report,—Shrapnel Shell*, p. 229.

[5] It is reasonable also to suppose that the pressure of the gas upon the bush rather tends to tighten its hold upon the fuze, by pressing in the sides.

[6] A few old (common) shells may occasionally be met with which have had their fuze "holes bushed, having been cast too large for the present fuze."—*Notes on Material*, Capt. Fraser, 1st edition, p. 22.

All common shell, except when used as hollow shot, are fitted [1] with wood bottoms (pl. 34, fig. 11). The object of the bottoms is mainly to ensure the fuze occupying the proper position in the bore, viz. as nearly as possible in the axis of the piece, and on the side away from the charge,[2] otherwise not only would there be a great liability of the shell jamming in loading, but "frequent premature explosions would " occur from the disarrangement of the fuze." [3]

The bottoms, in addition, are useful for the same reasons as recommend their employment with certain classes of shot.[4]

The bottoms are attached by means of the same gun metal rivet (pl. 34, fig. 8) that is employed to attach wood bottoms to shot;[5] the rivet hole in this case being made exactly opposite the centre of the fuze hole.

All common shells are painted black.[6]

Uses

They are fired from guns, howitzers, and carronades, and from the $5\frac{1}{2}$-inch and $4\frac{2}{5}$-inch mortars.[7]

A shell may be made to burst either while in motion or when at rest: in the first case each of the fragments will have a forward velocity proportional to that of the shell at the moment of fracture, and spreading out will act in the same way as a charge of case or grape, or as the fragments of a shrapnel shell;[8] while, if the shell is stationary when it bursts its effect will evidently mainly depend upon the size of the bursting charge and the consequent violence of the explosion.

Shells may therefore be considered as having two distinct applications; they may be used as Missiles or as Mines.

As Missiles they are most formidable and most generally used against the *personnel* of an enemy, but as Mines they are most destructive against his *matériel*; [9] the circumstances of war are rare when shells cannot be advantageously employed in one or other of these capacities.

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[1] Before issue, as demanded, or before loading.

[2] "These sabôts are necessary in order that the fuze may be kept in the axis of the " bore when loading, and no doubt serve to decrease the rebounding of the shell when " in the bore."—Owen's *Lectures on Artillery*, edition 4th, p. 79.

"A bottom of some kind is necessary in firing with shells, on account principally " of the difficulty in placing it in loading so as to keep the fuze outwards, and in the " axis of the piece."—*Report of a Committee of Artillery Officers assembled in* 1819 *(Sir W. Robe, President) for the purpose of ascertaining whether any sort of bottom be necessary for shells*, *Miscellaneous*, vol. ii. p. 40.

[3] Colonel Boxer's *Sandhurst Course*, p. 20. Also Report of Committee of Artillery Officers, *Miscellaneous*, vol. ii. p. 40.

[4] See p. 9.

[5] See *ante*, p. 9; and see wood bottoms, p. 113, and rivets, p. 121.

[6] For paint, see table XX., p. 345.

[7] The 24-pr. and 12-pr. common shells are fired from the $5\frac{1}{2}$-inch and $4\frac{2}{5}$-inch mortars, see p. 38.

[8] See p. 43 respecting General Shrapnel having derived the principle of his shells from this observed effect. However, in the shrapnel shell, as explained elsewhere, the object is to obtain a minimum dispersive effect, and the principle of action of the two projectiles is thus diametrically opposite, the effect of the fragments of the common shell being in great part derived from the bursting charge.

[9] "In the experiments carried on at Portsmouth (1847) with shells buried in the " earth, and in others (1849) with shells embedded in timber, the explosions which " took place afforded the strongest proof of the prodigious power of shells acting like " mines."—*Naval Gunnery*, edition 3rd, p. 281. Perhaps the most direct application of shells as mines is their employment as "shell fougasses." A shell fougass consists in one or more shells buried in small heaps, to burst either under the ground or on its surface (see Macaulay's *Field Fortification*, p. 219). "Lorsque ces projec- " tiles s'enfoncent dans les terres, ils y font fougasse."—*Instruction d'Artillerie*, p. 441. But it must not be supposed that in speaking of shells as mines I intend only to refer to this their more direct application in that form. They are equally to be con-

But it is against shipping that shells are especially formidable, for here they are destructive alike to men and to material, and while the bursting of the shell shatters the timbers and structure of the ship, the splinters carry havoc among the crew. In addition to their direct destructive effects, the smoke caused by the explosion in the confined space between decks is a source of annoyance and confusion.[1]

Shells have sometimes been used to set fire to magazines, buildings, combustible stores, &c., but this may be considered as an altogether exceptional application,[2] and carcasses rather than shells would generally be used for the purpose.[3]

Common shells are also used empty as hollow shot, both cold and hot; their employment in this capacity has been already dwelt upon.[4]

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sidered as mines, whether they have been deliberately deposited by hand to act as such, or whether they have been lodged with more or less penetration, after being fired from a gun or howitzer.

The application of shells as mines.—" Transferable mines " was advocated with great ability and at considerable length by Mr. Mallet, in a lecture before the United Service Institution in 1858. This lecture is contained in the Journal of that society, vol. ii. p. 409–451, under the head of " The Military and Naval uses of very large shells." The manner in which Mr. Mallet proposed extending and intensifying this application was by the employment of monster shells 36 inches in diameter, weighing empty 2,481 lbs., and containing a bursting charge of 480 lbs. of powder, thus giving a total filled weight of about $1\frac{1}{4}$ tons, thrown from mortars of corresponding proportions. This is no place for going into the arguments for and against this scheme; I wish merely to record the fact and to indicate the direction in which those who care to pursue the subject at greater length may do so. Two of the mortars and a large number of the shell are at Woolwich, and may be seen in the Royal Arsenal.

[1] Sir Howard Douglas describes and discusses at considerable length the effect of shells bursting on board ship. These effects he speaks of as " tremendous,"—" terrific " effects, physical and moral."—*Naval Gunnery*, edition 3rd, pp. 278, 279, 280, 285–9, &c. &c. The fact of the tremendous effects of shells against ships is scarcely likely to be questioned, or I might have quoted a large number of authorities in support of my text. The practical view of the question, and the view which I believe to be entertained by all naval and military men, is very concisely embodied in the often quoted exclamation of the naval officer, " For God's sake, keep out the shells !"

The following account by an eye witness of the effect of shells in the action between the iron-clad " Merrimac " and the wooden ship " Congress " " exhibits," as Sir Emerson Tennent observes, " a realized epitome " of the effects of shells against shipping: —" The first shell that burst within the ' Congress ' killed every man at the nearest " gun; another and another burst amongst the crew, and the ship was soon a slaughter- " house. Operations were now out of the question. The wounded were in crowds, " horribly cut up. The ship too was on fire; the shells had kindled her wood-work " in various places. Nearly all the guns were dismounted, the bulkheads blown to " pieces, rammers and handspikes shivered, and the powder boys all killed. The " inside of the ship looked like the interior of a burned or sacked house. Every- " thing was in fragments, black or red burnt or bloody. The horrible scene lasted " about an hour and a half, and then she struck."—*The Story of the Guns*, pp. 225–6. See also some experiments carried on in 1851 to determine the amount of inconvenience likely to arise from smoke caused by bursting shells between ships' decks.—*Experiments in H.M.S. Excellent*, pp. 175–178.

[3] " Shells intended to set fire to magazines, buildings, &c. are generally filled with " Valenciennes composition, pieces of portfire, tar, rocket compositions, and other " combustibles."—*Straith's Artillery*, edition 7th, p. 138.

An immense number of cases might be quoted in which shells have been used to set fire to stores, &c. A modern instance of their employment in this capacity is the bombardment of Charleston in 1863, where the Federal squadron fired shells charged with " Greek fire." Their use on this occasion was officially objected to by the Confederate general as barbarous, &c. We do not learn that this objection carried with it any weight.

[3] Respecting the employment of shells as carcasses, see p. 70.

[4] See pp. 14, 15.

Common shell are issued in three ways:— *Packing and issue.*

(1.) Empty, loose, prepared for wood bottoms.
(2.) Empty, riveted.
(3.) Filled, riveted.

They are generally issued (1) "*Empty, loose, prepared for bottoms,*" for garrison service, and for India (garrison and field), and a certain proportion are so issued for naval service.[1] They are then sent away with the rivet hole plugged with beeswax, the gun metal plug[2] (with leather collar under the shoulder) screwed into the fuze hole, which is slightly beeswaxed to prevent rusting.

They are generally issued (2) "*empty, riveted*" for field service, (India excepted). They then have the bottom riveted on, the fuze hole closed as above, and are boxed in boxes similar to those used for shot, the number of shell in each box varying with the nature.[3] The boxes are marked on the lid *in black*, with the words "common shell," "for Boxer's fuze," the nature of ordnance with which those in the box can be used, the number of shell in the box,[4] and the date of issue, and *in red* the words "Large cone."[5] For tropical climates they have in addition the words "For Tropical climates" marked on the lid *in black.*

A proportion[6] of common shells are issued (3) *filled* for boat service, and for 24-pr. and 12-pr. howitzers when these guns are used for broadside purposes.[7] They are then issued riveted, completely filled with powder, and having Pettman's L.S. percussion fuze (pl. 7) screwed into the fuze hole,[8] the screw of the fuze hole being previously lubricated with beeswax; and are packed in boxes similar to those used for shot, the number per box varying with the nature.[9] On each shell is stencilled the word "Filled."[10] The boxes are marked on *the end* in black with the words "Common Shell," nature of gun or howitzer, "Pettman's Fuze,"[11] number in box, date of issue, and *in red* the word "Filled;" on the lid of the boxes is marked *in red* the words "Large cone." For tropical climates (when the shell have teak bottoms) the boxes have in addition *in black* the words "For Tropical Climates."

2. *Naval shells.*[12]—There are five different sizes of shells prepared specially for naval service, and for this reason known as "Naval Shells."[13] *Shell—Naval.*

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[1] It must be borne in mind that common as well as naval shells are issued for sea service, generally 24 and 12-pr. shells for howitzers and boat service, and of these a proportion are issued empty and others filled.

[2] See Gun-metal plugs, p.100.

[3] See table XII., p. 331.

[4] The 10-inch box containing only one shell is not marked with the number.

[5] This has reference to the cone of the fuze, see p. 237.

[6] The proportion to be issued filled will in a measure depend upon the magazine room, see also p. 34, note 5.

[7] *Notes on Matériel*, p. 23.

[8] Before the introduction of Pettman's fuze "filled" common shells were issued with the (at that time) gutta-percha wad (see Wads, p. 105) in the fuze hole underneath the gun-metal plug (see screw gun-metal plugs, p. 100). They have also upon occasion been thus issued for field service.

[9] See table XII., p. 331.

[10] In accordance with *War Office Letter*, 6/11/66, 75/12/2987.

[11] When issued (see note 8 above) with plug and wad in fuze hole the boxes are marked "for Boxer's Fuze" instead of with the words "Pettman's Fuze."

[12] See table V., p. 325.

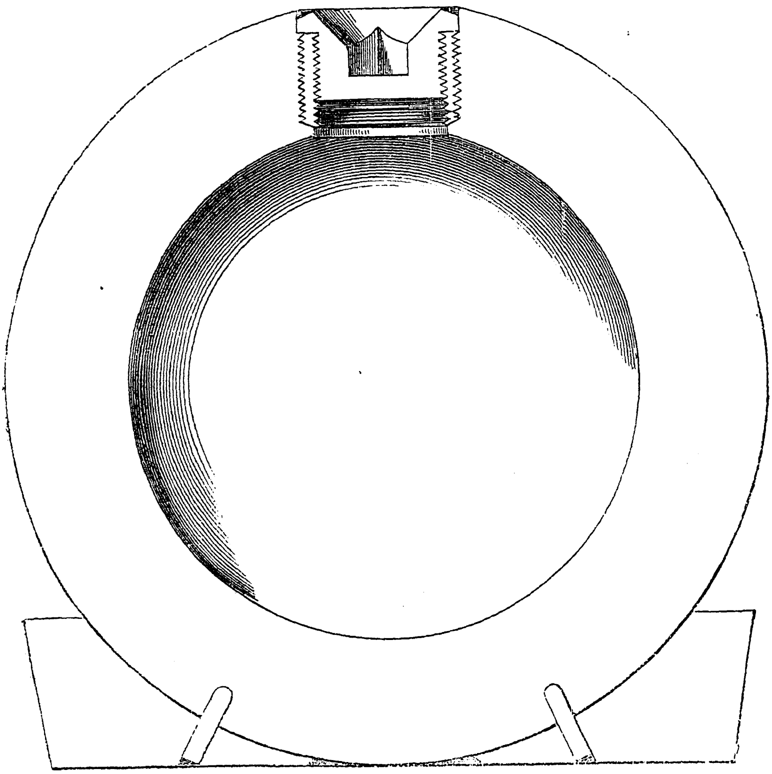
[13] These are the only shells *specially prepared* for naval service, but they are not the only shells issued to the navy, common shells, generally 24 and 12 pr. howitzer shells, being issued for boat and occasionally for broadside service. Diaphragm shrapnel shells, generally 8-inch, 32, 24, 12, and 6-prs., are also issued to the navy; these do not differ from diaphragm shrapnel shells for land service, except in a proportion of them being "filled" before issue.

Sizes. Description. These are the 150-pr.,[1] 10-inch 100-pr.,[1] 8-inch or 68-pr., and 32-pr.[2] They are only fired from guns and howitzers. They all differ from common shells of the same natures in three[3] respects.

1. In the size and shape of the fuze hole.
2. In the fuze hole being bushed.
3. In the number and arrangement of the rivet holes.

SHELL,—NAVAL.

8-inch.



1. The fuze holes are cylindrical instead of conical, and are much larger than those of common shells ;[4] they will receive Boxer's naval

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[1] Present pattern 150 and 100-pr. naval shell (with 4 rivet holes at top) finally approved, War Office Circular, No. 6 (new series), par. 1084.

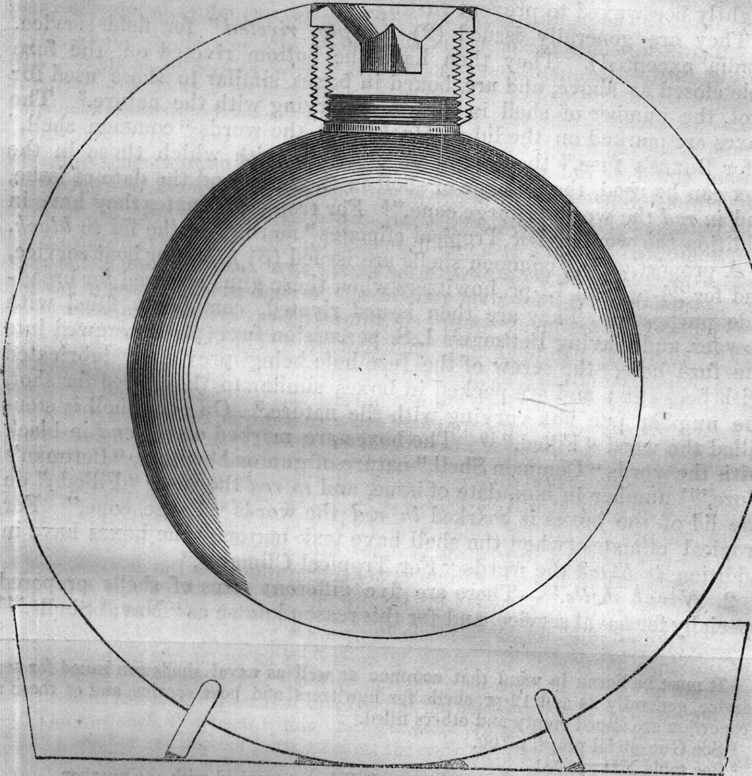
[2] The 32-pr. has sometimes been called the 6-inch.

[3] The 8-inch or 68-pr. naval shell is of rather greater external diameter than the corresponding shell for land service, and its metal is slightly thinner, being the same thickness as the 10-inch shell for both services. The 150 and 100-pr. naval shells also differ from common shells in being made of "diaphragm iron," *i.e.* half hot and half cold blast, see p. 54, note 5.

[4] Approved 12th August 1858, *Royal Artillery General Regimental Order*, 402, par. 36. It might be concluded from the remarks made in note 3, p. 26, that this enlargement of the fuze hole would affect injuriously the explosive force of the shells ; this, however, is not the case, for the fuzes used with naval shells are of metal, and *being screwed in* are not liable to be blown out on the explosion of the bursting charge ; hence there will be no loss of gas from this cause. The size of the fuze holes of naval shells is not therefore, within reasonable limits, a matter of much consequence ; whereas in common shells it has been show to be an important consideration.

SHELL,—NAVAL.

8-inch.



metal time (pl. 3, figs. 9, 12,) fuzes, or Pettman's sea service percussion fuze (p. 13, fig. 21).

2. The fuze hole is bushed with a gun metal cylinder, which is tapped with a right-handed thread,[1] to receive either of the above-named fuzes. The object of this bush is to diminish the chance of the fuze hole screw becoming rusty, whence difficulty and delay, and in some cases perhaps accidents, might result in screwing the metal fuzes into or out of "filled shells."[2]

The bush is carried to within ·2 of an inch of the bottom of the fuze hole, that thickness of iron being left to form a shoulder below the bush to support it on the discharge of the gun.[3]

The fuze holes of all natures of naval shells, except the 32-pr., are countersunk to permit of these shells being used as hollow shot, without wood bottoms.[4] The fuze hole of the 32-pr. is not countersunk, as this would involve a reduction in the length of the bush of these shells, which could be ill afforded.[5] The 32-pr. shell cannot, therefore, be used as a hollow shot *without a wood bottom.*

The fuze holes of naval shells are closed in the same way as those of common shells, with a gun metal screw plug.[6]

3. The 3rd point of difference between naval and common shells consists in the number and arrangement of the rivet holes.

The bottoms of the 10-inch, 8-inch, and 32-pr. are attached by means of two copper rivets, inclined to one another. These "naval" rivets are

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[1] Approved 9th September 1858, *Royal Artillery General Regimental Order* 402, par. 38. The pitch of thread is 16½ to the inch.

[2] In the event of the fuze hole becoming rusty a great deal of friction would be occasioned in screwing a metal fuze into or out of the shell; and as a large proportion of shells for naval service are issued "filled," to economize magazine room it is easy to conceive that serious accidents might arise in this way. Moreover, to screw these metal fuzes into an unbushed fuze hole would be a violation of a generally recognized principle that the contact of iron with any other metal in the neighbourhood of gunpowder should, as far as practicable, be avoided. Thus an unbushed shell would under the circumstances clearly be more dangerous than a bushed one; and it is quite easy to see how at any rate difficulty and delay, if not accidents, might be occasioned in the event of the fuze hole being rusty.

It will, perhaps, be said that the same arguments apply in the case of common shells when Pettman's *metal* fuzes are used with them, and yet that common shells are not bushed. Three important considerations, however, suggest themselves in explanation of this difference,—1st. Whereas the use of metal fuzes has until recently been the rule in the naval service, it is the exception for land service; 2nd. That the consequences of an accidental explosion of a shell on board ship would be infinitely more disastrous in the majority of cases than if the shell had exploded on land; 3rd. Owing to the coarser thread of the land service fuzes, and to the fact of the fuzes and fuze holes of land service shells being conical instead of cylindrical, the friction created in screwing a metal fuze into those shells is under all circumstances less than with naval shells and fuzes.

[3] The backward strain caused on the discharge of the gun by the *inertia* of the bush, and of the fuze which it supports, would, in the absence of such a shoulder, be thrown upon the threads of the screw (by which the bush is screwed into the fuze hole), and there would be a great probability of these threads stripping.

[4] See common shells, p. 26.

[5] The thickness of metal of the 32-pr. shell is so much less than that of the 10 and 8 inch shells, that the necessary length of bush to support the fuze properly could not be obtained except by adopting one of two arrangements, viz., dispensing either with the shoulder of metal below the bush, or with the countersink. As the shoulder of metal cannot be dispensed with without interfering with the efficiency of the shell (see above), it was necessary to resort to the other alternative, and accordingly the fuze hole of these shells is not countersunk, the bush being thus flush with the surface of the shell, and the plug projecting.

[6] See plugs, p. 101. Until 1863, when issued empty and riveted, a cork used to be driven into the fuze holes of naval shells in place of the gun-metal plug. This was abolished by order, 27/1/63.

merely cylindrical pins of copper without heads,[1] which pass through inclined holes in the sabôts into corresponding inclined holes in the shell, the bottom being secured not by the expansion but by the inclination to one another of the rivets (see woodcut, p. 30).

The single rivet system as applied to common shells is inapplicable to the two lower natures of naval shells, because the wood bottoms of the latter are hollowed completely through in the centre, the iron of the lower part of the shell being thus exposed flush with the bottom of the sabôt. The object of this arrangement is that when the guns are "double shotted,"[2] a not uncommon practice with the navy, the shot and shell may be in actual contact."[3]

Double shotting is forbidden with the 10-inch gun,[4] and the 10-inch naval shells have therefore the same bottom as the 10-inch common, but for the sake of uniformity have this bottom attached in the same way as the bottoms of other naval shells, viz., by two naval rivets.[5]

The 150 and 100-pr. have no wood bottoms, but tops,[6] which are

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[1] See page 121.

[2] The term "double shotting" is applied to all cases in which two projectiles, of whatever natures, are placed together in the bore of a gun; thus a gun loaded with two solid shot, a solid shot and a grape shot, or a double charge of case or grape, would be spoken of as "double shotted." (See *Naval Gunnery*, pp. 101, 102). In the present case, however, the term double shotting is applied simply to loading with a solid shot and a shell, the former being placed next the charge.

[3] Before this arrangement was adopted, and when the shot and shell were not in actual contact (the wood bottom intervening), the shell was frequently cracked, and in some instances broken up, by the shot striking it. Sir Howard Douglas mentions this fact having been demonstrated at some experiments at Gavre in 1842, where a wad took the place of the wood bottom; see *Naval Gunnery*, p. 239.

It was also clearly shown in some experiments in 1848 and 1849, on board the *Excellent*, when not only shell, but *shot*, were split by the intervention of a space, and it was considered to be "clearly shown that shot should be in close and immediate contact with each other, to prevent their splitting." *Experiments in H.M.S. Excellent*, pp. 141, 143. See also upon this subject, *Hand Book for Field Service*, p. 289, where the following passage occurs. "In double-shotting guns care should be taken that the two shot be brought into actual contact, for if a space be left between them they will both probably split. The intervention of a junk wad between two shot renders them more liable to split than if they had been placed in actual contact. The same precautions are necessary when firing a shot and shell together."

This effect is not difficult to explain: if, after loading a gun with a solid shot, a shell be placed in the bore slightly in advance of it, an air space intervening, the shell must necessarily receive a violent blow on the firing of the gun, from the shot being projected against it; now, if some substance be introduced between the two projectiles to fill up the vacant space, the violence of the blow received by the shell will be diminished in proportion to the density of this medium. ("The resistance which different mediums oppose to bodies in motion is proportional to the respective densities of the different mediums, and to the squares of the velocities of the moving bodies."—*Imperial Dictionary*.) If the medium, therefore, be a wooden bottom, the blow will be less violent than if nothing intervened between the two projectiles, but its violence will not be sufficiently diminished for the shell to be able to withstand it without considerable danger of being fractured or injured.

The strain upon the gun is also increased when the two projectiles are not in actual contact, on account of the temporary but violent check given to the forward motion of the shot, and consequently to the gas which is propelling it, on the former striking the shell.

[4] Double shotting, which is principally a naval practice, "is forbidden with the 10-inch gun, with the 8-inch gun of 52 cwt., and with all carronades."—*Handbook for Field Service*, edition 3rd, p. 296.

"Carronades, the 8-inch 52 cwt., and the 10-inch guns are never to be double shotted."—*Griffith's Artillerist's Manual*, edition 9th, p. 238.

N.B.—Both the works quoted on this subject are "Published by Authority."

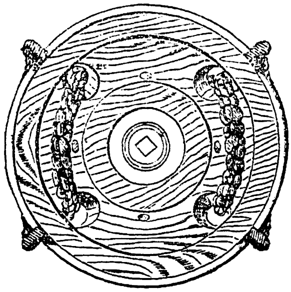
[5] Approved 6th October 1863, War Office Circular 855, par. 849, p. 121.

[6] See p. 117.

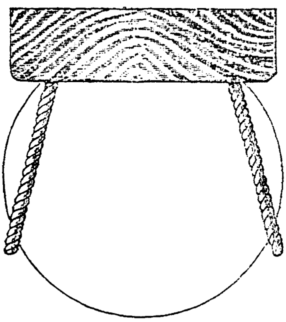
attached by means of four naval rivets;[1] these tops have two rope "beckets" passing through them for convenience of lifting and loading.[2]

100-PR. NAVAL SHELL, WITH ELM TOP PERMANENTLY RIVETED ON.

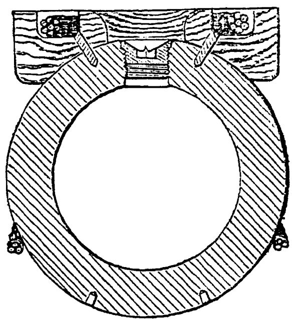
Scale, $\frac{1}{8}$.



Plan.



Elevation.



Section.

Although these shells have no wood bottoms, they are provided with two bottom rivet holes, like other naval shells, in case it should hereafter be thought desirable to attach wood bottoms.[3]

The 150 and 100-pr. naval shells have thus six rivet holes, four at the top and two at the bottom.

The advantages of the tops are, that they enabled shell boxes to be dispensed with, thus effecting a saving in storage, expense, and weight, besides expediting slightly the service of the gun, and avoiding the danger of the shell falling out of the box, or injuring the fuze.[4]

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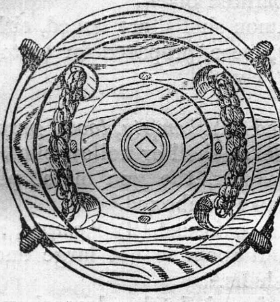
[1] Originally only two rivets were used; four were approved 10th March 1865; see *War Office Circular*, No. 5 (new series), par. 1041.

[2] The shells are brought up to the gun by means of the beckets, fuze downwards; the lower end of the shell is placed in the bore, and the beckets pulled through.

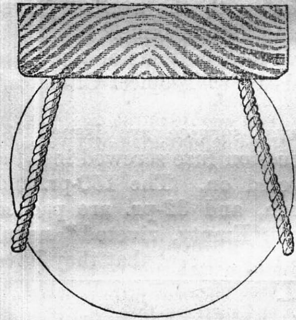
[3] Those first issued had tops and bottoms.

[4] See more fully respecting the advantages of tops, p. 119.

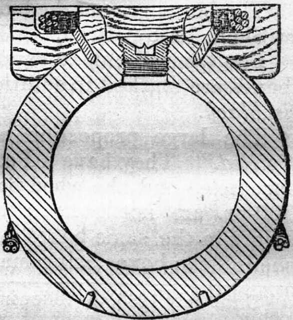
Scale, $\frac{1}{6}$.



Plan.



Elevation.



Section.

The 150-pr. and 100-pr. naval shells are lacquered internally with a mixture of:[1]—

Rosin -	- 12 lbs.
Brown Spanish	- 2 lbs.
Plaster of Paris	- 1 lb.
Turpentine -	- ½ pint

to diminish the liability to premature explosions, when fired with heavy charges.

All naval shells are painted black.

Packing and issue.

Naval shell, like common shells, are issued, either :—

(1.) Empty, loose, prepared for bottoms or tops.
(2.) Empty, riveted.
(3.) Filled.

A proportion are issued (1) "*empty, loose, prepared for bottoms*" (*or* "*tops*"), to be available as shell or hollow shot. They have the rivet holes plugged with beeswax, the gun metal plug screwed into the fuze hole, and are sent away unboxed.[2]

A small proportion[3] are issued (2) "*empty, riveted*" for drill purposses, or when the shell room is not large enough to take the full proportion of "filled" shells.[4]

They then have the fuze hole closed as above,[5] the bottom or top riveted on ; and, with the exception of the 150 and 100-prs., are boxed, one shell in each box. The boxes fasten by means of a hook and staple, and are somewhat different in construction to those used for land service.[6]

The boxes are marked on the lid *in black* with the words "Naval "Shell, 1858 pattern,"[7] "Empty," nature and date of issue.[8]

For tropical climates (when the shell have teak bottoms or tops) the boxes are marked in addition with the words "For Tropical Climates," *in black.*

The large proportion of shells for naval service are issued (3) "*filled.*" They have a Pettman's S.S. percussion fuze screwed into the fuze hole,[9] and the wood bottom or top riveted on. The 150-pr. and 100-pr. are not boxed ; the 10-inch, 8-inch, and 32-pr. are packed singly in the same boxes as are used for the "Empty, riveted" naval shells,[10] the boxes being marked in the same way, except that they have

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[1] Until July 1865, the following lacquer was used—
Coal tar pitch, 2 lbs.
Swedish pitch, 1 lb.
But when that lacquer was given up for rifled projectiles (23rd July 1865, *War Office Circular* 7 (new series), § 1120), it was similarly given up for these shells.

[2] See hollow shot packing and issue, p. 15.

[3] This proportion will vary with the magazine room on board, as, "when ships "cannot stow all the filled shells allowed, empty ones are to be supplied to complete "the proportion." *Revised Alphabetical Proportion of Ordnance Stores for Sailing Ships and Steamers, &c. Store Account Office, 13th April* 1853, p. 44.

[4] See note next above.

[5] Until 1863 a cork was used for "Empty riveted" naval shells, see p. 102, note 3.

[6] In 1864 a nail was introduced behind the hook to prevent it from coming out of the staple.

[7] This has reference to the fuze hole, which was assimilated in size to that for Moorsom's fuze in 1858. Approved 12th August 1858, 75/7/46. See *Royal Artillery General Regulation Order*, 402, para. 36, see also p. 239.

[8] Naval shells are always packed one in a box, and it is therefore unnecessary to specify the number upon the outside.

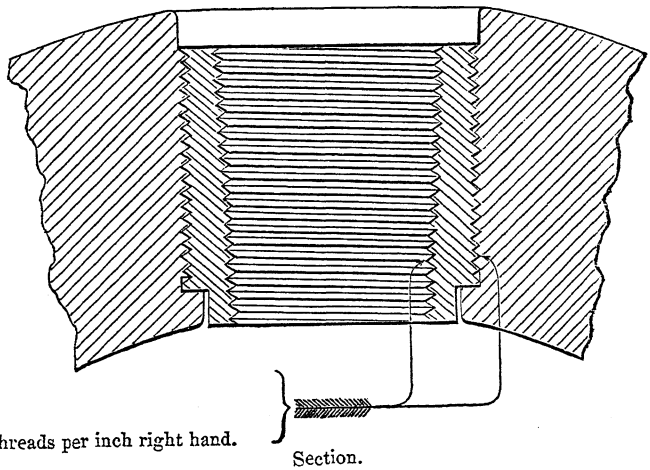
[9] Until 15th November 1865 only 75 per cent. of the filled naval shell had percussion fuzes screwed into them, the remaining 25 per cent. were filled with 7½ seconds fuzes and 50 per cent. 20 seconds fuzes were carried spare. But by order of that date "all shells filled for naval service (except field service segment "and spherical shrapnel), whether for rifled or smooth-bore guns," were directed to be "in future carried with percussion fuzes in the fuze holes, the usual proportion of "time fuzes being supplied in addition."—*War Office Circular* 8 (new series), § 1151.

[10] See p. 34.

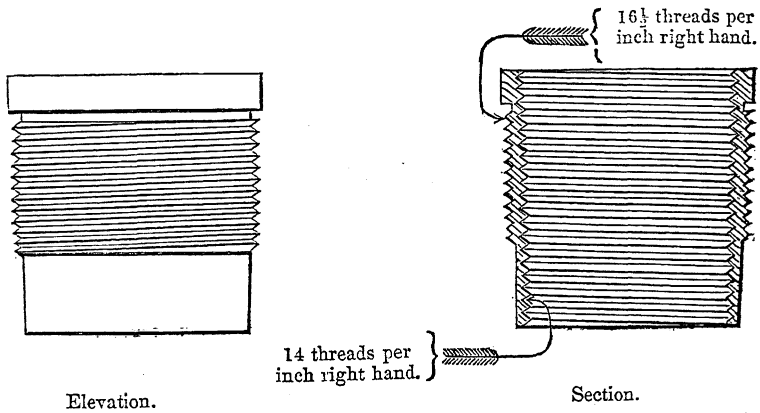
on them in *black* the word "Filled," instead of the word "Empty," also in *black* "Pettman's S.S. Fuze." The shells have stencilled on them the word "Filled."

☞ *In accordance with a scheme approved in* 1866,[1] *for the assimilation of fuze holes and the introduction of Pettman's general service fuze, it has been decided that when a sufficient supply of fuzes, adapters, and plugs are available, naval (spherical) shell are to be completed with general service bush, the existing stores of shell being fitted for the reception of this fuze by means of the "adapter for naval spherical shells"*[2] *permanently screwed in; also for future manufacture the* 32-*pr.* 8″ *and* 12″ *naval will have tops like the* 100 *and* 150-*prs.*

General Service Bush fitted in 150-pr. Naval Shell.
Full Size.



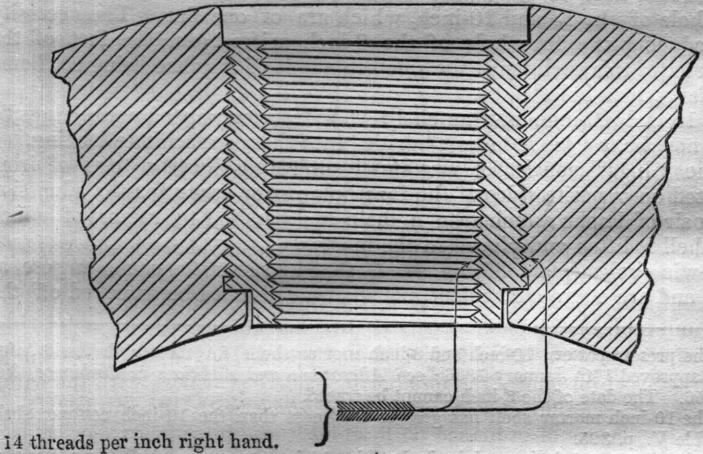
Adapter General Service Fuze Hole for Naval Spherical Shell.
Full Size.



The "F bush" is the bush which has been adopted for the M.L. and larger natures of B.L. rifled shells. It is slightly larger than the fuze hole of common shell, but the pitch of cone and thread are the same.[3]

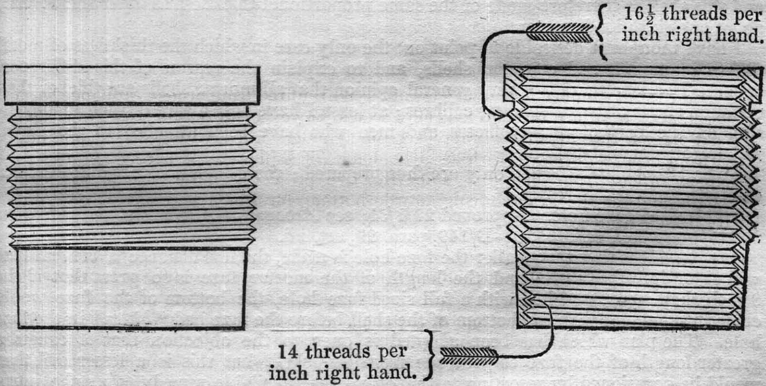
[1] See *War Office Circular* 10 (new series), § 1238; also *War Office Order* 5th July 1866, 75/12/2852. [2] See p. 109. [3] See p. 29, note 4.

General Service Bush fitted in 150-pr. Naval Shell.
Full Size.



Section.

Adapter General Service Fuze Hole for Naval Spherical Shell.
Full Size.



Elevation. Section.

It will receive the general service plug, Pettman's general service percussion or Boxer's M.L.O. and B.L. fuzes.

Shell—Mortar.
Sizes.

3. *Mortar shells* (*see* table, shell mortar fuzes, and plate 35, fig. 11). There are three natures of shells specially prepared for use with mortars only, (for land and sea service), and known as "mortar shells," viz., 13, 10, and 8-inch.[1] They differ from common shells in three respects,[2]

Description.

1. In having a larger fuze hole (not countersunk).
2. In being fitted with "lugs" or "lewis holes."[3]
3. In not having wood bottoms attached, and the consequent absence of rivet holes.

1. The fuze holes of mortar shells (plate 35, fig. 11, D, E,) are larger than the fuze holes of common shells,[4] to admit the longer and larger fuze, which is necessary for the greater time of flight of these shells.

The fuze hole of the 8-inch mortar shell is rather smaller than the fuze hole of the 13 and 10-inch, which are of one size. The necessity for reducing the fuze hole of the 8-inch arises from the fact of the diameter of this shell being too small to admit of the fuze being set home in a large fuze hole.[5]

2. 13 and 10-inch mortar shells were formerly fitted with "lugs,"[6] they now have "lewis holes,"[7] drilled into them to facilitate loading.

The "lugs" consist of two small projecting loops or ears of iron, situated on opposite sides of the fuze hole; they serve for the admission of a pair of hooks attached to a chain and handle,[8] by means of which the shell is lifted and placed in the mortar.

Lewis holes (plate 35, fig. K, L, N, M,) serve the same purpose as lugs, and are more convenient, not being liable to be knocked off the

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[1] The present pattern 10-inch and 8-inch mortar shells, *i.e.*, those with lewis holes, were approved 17th January 1856; see *Alterations and Additions in Ordnance*, &c., 30/6/56. The date of the 8-inch cannot be traced.

[2] The 10-inch mortar shell has greater thickness than the 10-inch common shell, see table V., p. 325.

In note 3 at p. 25 it is explained that the 10-inch common shell has a less proportional thickness of metal than other common shells, viz., about one-seventh instead of one-sixth the diameter, on account of the comparative weakness of the gun. No reason, however, exists for reducing the thickness of metal of the 10-inch mortar shell, and this shell is therefore made of the same proportional thickness as other shells, viz., about one-sixth its diameter.

I have thought it desirable to point out the only case in which the thickness of metal differs in mortar and common shells, and to explain the reason of this difference, because I believe there is a very general opinion that all mortar shells are thicker than common shells of corresponding calibres; at least, I have been aware of such an impression on the part of many officers and men who have been attached to the Royal Laboratory for instruction.

[3] The 13-inch and 10-inch only are thus prepared; the 8-inch does not differ from a common shell in this respect.

[4] This sized fuze hole. Approved 27/1/55; see *Account of Alterations and Additions in Ordnance* &c., 31/1/55, 55-D/149, para. 29, art. xii.

[5] It is evident that the smaller the fuze hole is made, the less distance a conical fuze will enter into the shell; and the length of the mortar fuze is so great that if the 8-inch shell were furnished with a full-sized fuze hole, the bottom of the fuze would come into contact with the bottom of the shell before the fuze had "*bitten*" in the fuze hole. The plan which has been adopted is open to the objection that it causes a greater length of the fuze to protrude from the shell, but this is a lesser evil than would be occasioned by resorting to the only other available remedy, viz., the introduction of a special fuze for use with this shell.

[6] The practice of fitting lugs to mortar shells is very ancient, for in *The Great Art of Artillery* the following description of the mortar shells of the time (1649) occurs: "Near the vent they have two little ears or handles, by which they are lifted into the "mortar."—*The Great Art of Artillery*, p. 224.

[7] Lewis holes adopted, 17/1/56, 137–B/6. See *Alterations and Additions in Ordnance*, War Office, 30/6/56.

[8] See "lug-hooks," p. 125.

shell in transport, and not interfering with the cleaning of the shell when in process of manufacture.[1] They consist of two holes, situated in the same position as the lugs, on either side of the fuze hole, and inclined towards one another. They admit two lewis hooks,[2] and by means of these the shells are lifted and placed in the mortar.[3]

The 8-inch mortar being a short piece, and the shell comparatively wieldy, any arrangement for lifting the shell and placing it in the mortar is unnecessary. These shells accordingly are not prepared with lewis holes.

3. Mortar shells have no wood bottoms attached, because in the case of the 8-inch mortar "owing to the shortness of the piece, the "shells can readily be placed in the right position, as regards the fuze "in loading,"[4] and the shells for the 13 and 10-inch having lugs or lewis holes, it is impossible, if these appliances for loading are made use of,[5] to place them in the piece otherwise than correctly.

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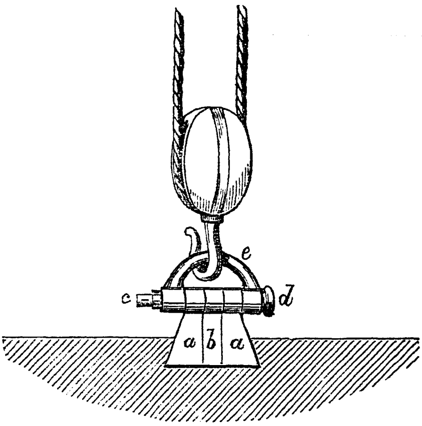
[1] This cleaning or removing the hard sandy crust which forms on the outside of the shell when it is cast, is performed by placing a number of shells in a large iron drum, which is made to revolve by machinery, the friction thus created breaking up and removing the crust. Mortar shells cast with lugs could not be "milled" in this way, and the labour and expense of cleaning the shell and removing the core (which is broken up by the same process) was much increased in consequence.

[2] See p. 124.

[3] I believe this principle of lifting heavy weights was first applied to lift heavy stones. Burn's *Naval and Military Dictionary* has the following mention of the word: "Lewis, *s.*, louve, *f.*; Lewis. Hole in a stone, *trou évidé à queue d'hironde, m.*" Turning to the word "*Louve,*" we find "Louve, *f.*, sling; iron pincers; ram's head; "*plug or pin of iron at the end of a crane rope, &c., by which ponderous stones are* "*lifted up.*" In the "*Imperial Dictionary,*" "Lewis" or "Lewisson" is described as "An instrument of iron, used in raising large stones to the upper part of a building. "It operates by the dovetailing of one of its ends into an opening in the stone, so "formed that no vertical force can detach it." The accompanying drawing and explanation of the instrument is also given.

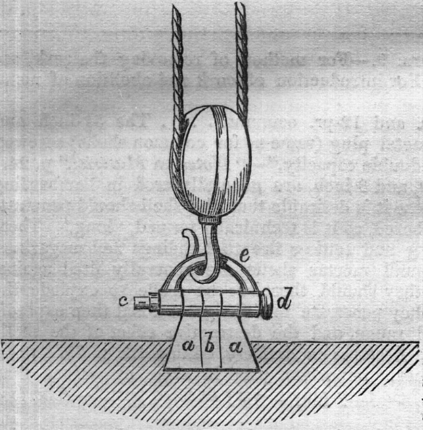


"*a a*, two moveable parts, perforated "at their heads to admit the pin-bolt "*c d*. These are inserted by hand into "the cavity formed in the stone, and "between them the part *b* is intro-"duced, which pushes their points out "to the sides of the stone, thus filling "the cavity; *e* a half ring-bolt, with "a perforation at each end; to this "tackle above is attached by a hook. "The fastening pin passes horizontally "through all the holes, entering at the "right side, *d*, and forelocking on the "other end, *c*."

This is evidently the same *principle,* although somewhat differently applied, as that of lifting weights by means of two holes inclined towards one another. The application of this principle to *projectiles* in the form of two inclined holes or slots is not so modern as might be supposed. In the Royal Military Repository at Woolwich is an old 10-inch carcase, with two inclined slots in it near one of the vents, evidently intended to serve the same purpose as the Lewis holes of the present mortar shells.

[4] Colonel Boxer's "*Sandhurst Course,*" p. 20.

[5] In the authorized Artillery drill book it is laid down that the lugs or lewis holes *are always* to be made use of in loading these mortars. Loading 13-inch mortar: "8 and 9, prepare shells as usual, and bring them up by means of beam hooks to the "left size of the muzzle. . . . . 2 and 3, lay hold of the ends of the beam-hooks, and "with 8 and 9 lift the shell into the bore, assisted by 6, &c." . . . . Loading 10-inch mortars: "8 and 9 bring up the shell with hand-hooks, and put it in."—"*Manual of Artillery Exercises,*" p. 107.



e
c
d
a
b
a

The fuze holes of mortar shells are not closed with a metal plug, but have a beeswaxed cork placed in them.[1]

Although mortar shells have no fuze hole plugs the fuze holes are tapped, or rather roughed, to give the fuze a better hold in the shell. This screw is only carried about half-way down the fuze hole. The fuze holes of mortar shells are not countersunk, their edges being beveled off to diminish their liability to injury.

Mortar shells are painted black before issue.

They are fired from mortars only.

Shells for 5½-inch and 4⅖-inch mortars.

There are two other natures of mortars besides the 13, 10, and 8-inch, viz., the 5½-inch (royal), and the 4⅖-inch (coehorn) mortars. Special shells, however, are not required for these mortars; *common* shells, 24-pr. (pl. 35, fig. 4), and 12-pr. (pl. 34, fig. 5, pl. 35, fig. 5) respectively, being used (without wood bottoms [2]) with these pieces.

Uses of mortar shell.

The character of a mortar shell is the same as that of a common shell; but its application is somewhat different. They are used for vertical instead of horizontal fire, and their employment is chiefly confined to the bombardment of towns, fortresses, and entrenched positions;[3] they are also sometimes employed with great effect against shipping.[4]

Packing and issue.

Mortar shells are issued—

(1.) Empty.

(2.) Filled.

In both cases they are unprepared for bottoms. For all services, except sea service, mortar shells are issued, (1) "*empty,*" and are sent away loose, with a beeswaxed cork in the fuze hole.

For naval service they are generally issued (2) "*filled,*" they then have the fuze hole secured as above, with the addition of a "kit "plaster"[5] placed over the cork for the better protection of the bursting charge.

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[1] *War Office Circular*, No. 590, para. 9.—For method of removing the cork, see Shell and Fuze Implements, p. 298. For introduction of cork and abolition of metal plug for mortar shells, see p. 99.

[2] "The same shells as the 24-pr. and 12-pr. common . . . . The 5½-inch and "4⅖-inch are issued loose with the metal plug (same as for common shells) screwed "in, and are of course available in a double capacity."—"*Notes on Matériel,*" p. 24.

[3] "The large mortar shells, 13, 10, and 8-inch, are generally used in bombarding "towns and works, and for this purpose it is desirable that the shell should penetrate "and burst, the fuze being therefore bored, as it is technically termed, 'long.' These "shells are most useful in destroying and setting fire to buildings and magazines, "levelling earthworks, &c. The small mortar shells are generally fired against "troops posted behind cover, and they should therefore be made to explode the "instant they reach the ground; if they penetrate into the ground and then explode, "the splinters will have little lateral range, and the destructive effect of the shells "will be greatly decreased."—Owen's *Lectures on Artillery*, edition 4th, p. 79.

"Mortars generally perform a more important part in siege operations than "howitzers; there are times even when they play a very decided part."—*American Artillery Course*, p. 488.

[4] Sir Howard Douglas, in his admirable work on naval gunnery, makes no mention of vertical firing; but I need hardly seek for authorities in support of the statement made in my text, that "mortar shells are sometimes employed against shipping." The fact that mortars form part of the armament of all sea forts and sea defences is in itself sufficient confirmation of this statement. As the iron plating of the *sides* of ships of war becomes more common it is reasonable to suppose that vertical fire will play a more important part than at present in naval operations.

[5] Approved, 8th March 1860. *War Office Circular*, 590, para. 9. Kit plaster, a round piece of "barras cloth," (a stout description of canvas) soaked in kit composition plastered over the fuze-hole, and sprinkled over the outside with sawdust to prevent it from sticking to objects with which it may come into contact. (See "Barras Cap" in "Carcasses," p. 73.) (For kit composition, see table XX., p. 345.)

When issued "filled," they are boxed, the number in each box varying with the nature of shell.[1] On the shell is stencilled the word "filled."[2] The boxes are marked *in black* with the words "mortar shells," "filled," for "Boxer's fuze," the nature of shell, weight of bursting charge, and date of issue; and *in red* with the words "large cone."

Shell—Hand Grenade. Sizes.

(6.) *Hand grenades* (*see* table)[3] are of two sizes, the land service or 3-pr., and the sea service or 6-pr. hand grenade.[4]

Description.

They are small shells resembling common shells in their character and main features, but differing from them in some points of detail. They may be at once distinguished from common shells by their inferior size, the 12-pr. being the smallest common shell made. The other points in which they differ from common shells are as follows:

1. In the proportionate thickness of metal.
2. In the size of the fuze hole, and in its being neither tapped nor countersunk.
3. In the absence of rivet holes.

1. The thickness of metal of the hand grenade is proportionately less than that of common shells, being about one-seventh instead of about one-sixth the diameter. This is to enable the grenades to hold a larger bursting charge; strength and weight not being required in these projectiles.[5]

2. The fuze hole, which is the same size for both natures, is smaller than the fuze holes of common shells;[6] it will receive the hand grenade fuze.[7] The fuze hole is not tapped, as owing to its not being fitted with a metal plug, and to a metal fuze never being used with a hand grenade, no screw is required, nor is it necessary even to roughen it with a view to preserving the fuze from being knocked out on striking.[8]

Hand grenades not being fitted with metal plugs, or used as hollow shot, do not require to have their fuze holes countersunk. The fuze holes of hand grenades are closed, like those of mortar shells, with beeswaxed corks.

3. Hand grenades do not have wood bottoms attached; rivet holes are therefore unnecessary.

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[1] See table XII., p. 331.

[2] In accordance with *War Office Letter*, 6/11/66, 75/12/2987.

[3] Respecting the early use of hand grenades, and the origin of the word, see the sketch given (*ante*, p. 21) of the history of shells.

[4] They were formerly always designated by the terms "land" and "sea service" grenades respectively; but are now sometimes spoken of as 3-pr. and 6-pr. grenades, independently of the service for which they are intended. The terms 3-pr. and 6-pr. have reference to their calibres, not to their weights.

[5] *Strength* is not requisite in hand grenades, because, being generally thrown by hand, they are not required, like other shells, to withstand the shock of a discharge; *weight* is not required, because, from the nature of the application of these projectiles, accuracy and penetration and great range—the only advantages derivable from increased weight in a shell—cannot be attained with them.

[6] It has been explained (see p. 26) how the escape of gas at the fuze hole of the 12-pr. common shell is sufficiently great to necessitate the adoption of an expedient to insure the bursting of the shell. If this is necessary in the case of the 12-pr., still more necessary is it in the case of the smaller shells with which we are now dealing. The remedy, however, is simple in the case of hand grenades, for, owing to the necessity for the employment of a special fuze with these projectiles (see p. 267), the objections urged in the case of the 12-pr. (see note 4, p. 26), against meeting the difficulty by decreasing the size of the fuze hole, do not hold good, and the size of the fuze hole is decreased accordingly.

[7] See p. 267.

[8] Evidently the shock which a shell thrown by hand receives on striking can hardly be violent enough to knock out the fuze if the latter has been set in with ordinary care.

They are painted black before issue.

Hand grenades are thrown by hand,[1] where other shells cannot conveniently be brought to bear. They are much used in the defence of places against assault, being thrown among storming parties, into crowded ditches, and wherever men are collected in masses for boarding purposes, and at such close quarters or under such circumstances as to make them available.[2]

The 3-pr. can be thrown by trained men about 28 or 30 yards.[3]

Another application is to fire them from mortars in large numbers, like charges of pound shot, upon masses of men;[4] they are available

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[1] Formerly the strongest men were selected and trained for this duty, and in consequence called "grenadiers." The term has been retained for the (nominally) tallest and finest companies of infantry, and is applied generally to men of a superior physique.

"Grenadier . . . . so called from carrying and throwing hand grenades . . . . " usually tall active soldiers."—*Imperial Dictionary.*

"Hand grenades are shells, about 3 lbs. weight, thrown from the hand by practised " men; hence the name grenadier."—Straith's "*Treatise on Artillery,*" p. 146.

"Grenadier, originally denoted a soldier who threw the grenade. . . . . The term " originated with the French in 1667."—*Encyclopædia Britannica.*

The fuze has to be lighted by hand. The difficulty of doing this has induced the French to apply a percussion arrangement to the heads of their hand grenade fuzes. For description of this arrangement, see Hand Grenade Fuze, note 7, p. 268.

[2] "Grenades are never thrown upon an enemy on level ground, as the splinters " would be as dangerous to those who used them as to the opposing party. They are " exceedingly useful for throwing over parapets, on to unflanked ditches, and upon " storming parties; likewise in the defence of stockades, houses, barricades, streets, " &c."—*Straith's Artillery,* p. 146.

"On les jette dans le chemin couvert ou dans les tranchées d'une place assiégée."—Cotty's *Dictionnaire d'Artillerie,* p. 156.

The French and Americans recognize a larger description of grenade in addition to hand grenades, called "rampart grenades." They are used to roll down ramparts and high places, being too large to be thrown by hand. "Grenades de rampart. Elles " ont dimensions plus fortes que celles à main; après avoir mis le feu à la fusée, on " les roule du haut du rampart dans le fosse. Elles sont du calibre des boulets de 24 " et de 16, au pésent de 3·916 kil., à 5·874 kil. (8 à 12 liv.)—"*Dictionnaire d'Artillerie,* p. 156.

"Grenades are of two kinds: The hand grenade, &c. . . . . *Rampart grenades* are " larger, and are used to roll down a breach in its defence, to throw over the ram- " parts, &c. Any kind of shell, unfit for firing, either from being defective in form " or solidity, may be used for the purpose."—*Gibbon's Artillerist's Manual,* p. 166.

Common shells have also been used in our service, and would always be available for the same purpose, although we do not recognize the term "rampart grenades."

[3] "A hand grenade may be thrown from 28 to 30 yards."—*Manual of Bengal Artillery,* p. 80.

"May be thrown to a distance of 13 fathoms" (*i.e.,* 26 yards).—Adye's *Pocket Gunner,* edition 5th, p. 147.

"A hand grenade, 3 inches in diameter, weighing 2 lbs. 10 oz., can be thrown by a " man to a distance of from 28 to 34 yards."—*Aide Mémoire to the Military Sciences,* vol. i., art. *Grenade.*

The French teach their men to sling hand grenades, and in this way they are made effective at a greater distance. They have also been fired from the shoulder from small "musketoons." See *Aide Mémoire to the Military Sciences,* vol. i., article "*Grenade.*"

[4] "They are sometimes bound up and quilted together, like grape shot, fuzes out- " wards, to be thrown from mortars for clearing works of their defenders, &c."—Straith's *Treatise on Artillery,* p. 146.

"The stone mortar is employed in siege operations to precipitate a large mass of " stones or *hand grenades* upon the heads of an enemy in the advanced trenches, or, " in like manner, to clear the breach of its defenders preparatory to an assault."—*American Artillery Course,* p. 179.

"As many grenades are put in a basket as it will hold. They are laid in layers, " the fuzes uncapped and placed upwards, so that the priming may not fall out. The " upper layer is covered with stones or dry grass, kept down by pieces of wood passed for this purpose under nearly the same circumstances as pound shot.[1]

Packing and issue.

Hand grenades are generally issued empty for land service, with the fuze hole secured with a cork. They are not boxed.

For naval service they are issued filled, with a hand grenade fuze[2] in the fuze hole, and the fuze covered with a kit plaster.[3] On the grenade is stencilled the word "filled."[4] These are boxed.

Shrapnel Shell.

Shells of Shrapnel class —History.

The Shrapnel shell was invented by General Shrapnel, of the Royal Artillery,[5] from whom it derives its name. "It consisted originally of "a thin iron shell, filled with musket or carbine balls, sufficient "powder being inserted with the balls to cause the bursting of the "shell when ignited by the fuze."[6]

It is important clearly to establish at the outset,[7]

1st. What was the proposed application of the shell.

2nd. What the principle of action upon which that application depends.

Object of Shrapnel shell.

1st. *The proposed Application of the Shell:*—It was intended, not to supersede case or grape, but to act as case or grape at longer ranges than were attainable with those projectiles,[8] and its character was defined with great exactness on its first introduction by the name which

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" through the basket. 33° of elevation has been found the best angle, as when fired " at this angle they do not bury themselves."—*Manual of Bengal Artillery*, pp. 79, 80.

In Major Seton's work upon shrapnel shells mention is made of another and somewhat remarkable application of hand grenades. " Some hundred and fifty years ago, " a species of shell, filled with hand grenades, was invented and thrown; the fuze of " the grenades igniting by the explosion of the shell, they themselves in time ex- " ploding."—*Observations on Shrapnel Shells*, p. 10, note.

Decker also says, " On dit qu'au siège du Rhodes, en 1522, les Turcs se sont " servis de bombes remplies de grenades; c'est là l'exemple le plus ancien d'un pro- " jectile, qui a une affinité éloignée avec les schrapnels modernes."—Decker's *Expériences sur les Schrapnels*, d. 13.

See *Aide Mémoire to the Military Sciences*, vol. i., art. " Grenade," where a great deal of information is given respecting these projectiles.

[1] See p. 13.

[2] See p. 267.

[3] See p. 38, note 5.

[4] In accordance with *War Office Letter*, 6/11/66, 75/12/2987.

[5] I mean not only that the shells were first constructed according to General Shrapnel's recommendation, but that he was the first who clearly perceived and practically applied the true principle of shrapnel fire. This subject, however, is too lengthy a one to be perfectly treated in a note; and in Appendix A. will be found authorities in support of this statement, and an inquiry into the validity of General Shrapnel's claim.

[6] *Synopsis of Ordnance Select Committee Reports on Shrapnel Shells*, p. 5.

[7] It is important clearly to establish and to understand these two points, because upon them hinges in great measure General Shrapnel's claim to the invention.

[8] " Shrapnel shell were not intended to supersede the case or canister and grape " shot which are still in the service, *but to be used at distances beyond the ranges of " case and grape*."—*Synopsis of Ordnance Select Committee Report on Shrapnel Shells*, p. 5.

Colonel Shrapnel thus speaks of his invention :—" The object now accomplished is " the rendering the fire of case shot effectual at all distances within the range of " cannon."—*Ibid.*, p. 6.

was then given to it, and which is still to a certain degree preserved,—the name of "spherical case shot."[1]

Action of Shrapnel shell.

2nd. *The Principle of Action of the Shell*:—The shrapnel shell acts as follows:—It describes a path similar to that of an ordinary spherical projectile up to within a short distance of the object aimed at, when, if the fuze be properly adjusted, the shell will be exploded, the bullets and fragments continuing their forward course with a communicated velocity equal to that of the shell at the moment of fracture, and describing, as they slightly disperse, "a curved cone, the apex of which "is at the point of explosion."[2] The effect of the shell, it will be seen, depends *in no way upon the bursting charge, which should merely be sufficient to open the shell and not sufficient to cause any dispersion of the bullets and fragments,*[3] *but entirely upon the velocity communicated to the pieces by the shell at the moment of rupture.* There is, therefore, as has been well said, this characteristic difference between

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[1] Shrapnel shell, or, as they were then called, "spherical case shot."—*Synopsis of Ordnance Select Committee Report on Shrapnel Shells*, p. 5. The name "spherical case shot" is a highly instructive one as to the proposed use and object of these projectiles; and it seems undesirable, therefore, that it should be altogether lost sight of, although it would be still more undesirable to speak of these projectiles *only* by that name, "to the prejudice," as the author of the *British Gunner* well says, "of the ingenious inventor Major-General Shrapnel. (See *British Gunner*, Introductory Notes.)

The following passage seems to prove that the name "shrapnel shell" was not substituted for that of "spherical case shot" in our service until 1852:—"Report of the "Committee on Mr. Shrapnel's letter of the 17th May 1852, requesting, on behalf of "the family of the late General Shrapnel of the Royal Artillery, the honour of the "Board issuing an order that the *spherical case shot* be called 'shrapnel shell,' instead "of 'spherical case' by some and 'shrapnel shells' by others, from the circumstance "that other nations have long since done this honour of invariably attaching his name "to this weapon; and because the family have not the means to afford the expense of "erecting a monument awarded to the graves of other distinguished officers, but which "such a distinction would be the means of representing.

"The Committee see no objection to this application of Mr. Shrapnel, and solicit "your Lordship's authority for his request being granted."—*Ibid.*, pp. 83, 84.

"Shells invented by the late General Shrapnel in future to be called 'shrapnel "shells,' instead of 'spherical case shot.'"—*General Order, 11th June* 1852, M/236. See *Account of Additions and Changes in Ordnance, &c.*, Director General's Office, Woolwich, 29th December 1852, par. 3.

[2] *Colonel Boxer's Remarks upon the Diaphragm Shrapnel Shell*, p. 24. "The bullets "when thus disengaged proceed (in accordance with Sir Isaac Newton's first law of "motion, that every body continues in a state of rest or uniform motion in a right "line, until a change is effected in it by the agency of some external force,) in the "same direction and with the same velocity as that impressed on the shell at the "instant of bursting; and they continue so to move on until brought to rest by the "continued forces of the air's resistance and gravity, or by impinging on any solid "body."—*Observations on the Shrapnel Shell*, p. 38.

I would direct the attention of those who wish to go more closely into this question of the part performed by the bullets of a shrapnel shell to Decker's *Expériences sur les Shrapnels*, p. 22, *et seq.*, and to Major Seton's *Observations on the Shrapnel Shell*, particularly the chapter, p. 25, headed "Some Remarks on the Theory of Shrapnels."

[3] The bursting charge is "merely sufficient to open the shell at the required "moment, and release the bullets."—Owen's *Lectures on Artillery*, p. 81.

"The charge of powder . . . is small, just sufficient to burst the shell."—*Observations on Shrapnel Shells*, p. 37.

"The bursting powder acts exclusively on the containing case or shell, without at "all affecting the contained bullets."—*Ibid.*, p. 38.

"This projectile is so arranged that the bursting charge shall merely release the "bullets without affecting in any degree their onwards motion."—Colonel Boxer's *Sandhurst Course*, p. 20.

"That the bullets, when relieved, shall be slightly affected in the direction of motion "of the shell by the action of the bursting charge. . . . The latter condition "embodies General Shrapnel's grand principle."—*Remarks upon the Diaphragm Shrapnel Shell*, p. 26.

a shrapnel shell and a common shell,—"that the former produces its "effect by means of the charge of the piece; the latter by means of "the charge of the shell,"[1] *and the principle involved in this distinction is, in fact, the leading principle of shrapnel fire.*[2]

The effect of the shell will therefore depend upon the velocity with which it is proceeding at the moment of rupture,[3] and thus, all other conditions being the same, will be proportional to the initial velocity of the projectile.[4]

The following account of the circumstances which immediately led to the invention of the shrapnel shell is given by Sir Howard Douglas:— "The first employment of shells fired direct from long guns at bodies "of troops at considerable distances was at the memorable siege of "Gibraltar in 1781. In firing from batteries placed high on the rock, "from which the whole interior of the besiegers' trenches and batteries "could be seen, round shot fired from heavy guns would evidently have "been wasteful and ineffectual practice against workmen and troops "thus exposed to the direct, though depressed fire of the fortress. "The distance being too great for grape or case shot, howitzer shells "were tried; but shells fired directly from howitzers had neither accu- "racy nor force sufficient to take full advantage of the command which "the batteries possessed over the works on the isthmus below. The "charges being small, the projectile velocity of the shells at the "moment of bursting was not sufficient to impel the fragments forward "with the force required to produce the desired effect, whilst the great "bursting charges which the shells contained, occasioned very great "dispersions of their splinters. Guns were therefore substituted for "howitzers, and 5½-inch shells fired from long 24-prs., with as large "charges as the shells could resist. The effects were prodigious; the "fragments of the shells were driven forward with far greater force; "the dispersion was less, on account of the great preponderance of the "projectile velocity, and the effect upon the whole troops and work- "ing parties in the enemy's trenches and batteries were extremely "destructive. This remarkable instance of the efficacy of direct shell "firing attracted the notice of all artillerists. The conditions of this "description of practice are materially different, as has been already "explained, from that of shells whose effects depend wholly upon

Origin of Shrapnel shell.

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[1] *Observations on Shrapnel Shells*, p. 38.

"Ce projectile se distingue encore des obus ordinaires, et même principalement en "ceci qu'il a pour destination, non pas d'éclater à sa chute ou après sa chute, mais "d'éclater en l'air, par conséquent pendant son trajet. On saurait par expérience si la "théorie ne l'avait pas déjà appris, que les éclats et les balles sont encore jetés en "rayonnant en avant pendant un trajet assez considérable, et c'est là l'effet caracté- "ristique des shrapnels."—*Expériences sur les Shrapnels*, p. 22.

[2] See *Observations on Shrapnel Shell*, p. 10, note.

[3] All other conditions, such as the size of the shell, the range, the distance from the object fired at, at which it explodes, &c., being the same.

[4] "The effect of this projectile is in proportion to the initial velocity."—*Aide Mémoire to the Military Sciences*, art. Shrapnel Shell.

Strictly speaking, it would perhaps be more correct to say that the effect of these shells is proportional to their "final" or "remaining" velocities, and this mode of expressing it would certainly eliminate one of the conditions which must be taken into account where the effect is expressed in terms of the initial velocity, viz., the range; but it would still be necessary to qualify the statement by the introduction of the words "all other conditions being the same" (conditions expressed in note 3), and it would not be so convenient an expression to use, as will be apparent when I have to refer to it in dealing with those advantages of the diaphragm shrapnel shell which are connected with the employment of full service charge, and the comparatively high initial velocities which these charges produce.

" their explosive force ; but the few fragments into which the common " shells are broken, usually 15 or 16, forming what may be termed a " charge of langrage, consisting of a few irregular lumps of iron, are " neither suited in form, nor capable in number, of producing any very " extensive effects upon large bodies of troops. The late Major-General " Shrapnel had the ability and sagacity to perceive that under such " circumstances the effects of direct shell firing might be prodigiously " increased by filling the shells with musket or carbine bullets, enlarging " the charges in proportion, and reducing the bursting charge to a " quantity just sufficient to break the shell with as little scattering " effect as possible upon the bullets ; and to that able and distin- " guished officer, therefore, is due the credit of the invention which " has rendered his name so justly celebrated." [1]

This shell appears to have been first experimented with, with a view to its introduction into the service, in 1803,[2] and to have been first employed in action against the French at the battle of Vimeira in 1808,[3] with the most remarkable effects, both physical and moral.[4]

Defects of original Shrapnel shell.

The valuable properties of the original shrapnel shell, however, were neutralized to a great extent by one very serious defect, viz., a liability to explode prematurely.[5] Before the introduction of Boxer's fuze this defect was attributed principally to " the setting down of the fuze com- " position, caused by its own *vis inertia*, together with the concussion " of the air, both tending to cause the effect at the time of the explosion

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1 *Naval Gunnery*, pp. 424, 425.

2 "The records of the Select Committee show that on the 3rd June 1803 experiments " were made in the presence of the Committee by Major Shrapnel, who fired shells " loaded with leaden balls."—*Ordnance Select Committee Report on Shrapnel Shells*, p. 7.

I have been unable to fix with any certainty the precise date on which General Shrapnel first *proposed* his projectile, for in the *Memoirs of Sir John Sinclair* the following passage occurs :—" He (Shrapnel) brought it forward in 1802, but could " gain little attention."—*Memoirs of Sir John Sinclair*, p. 243.

" Ce fut, dit on, en 1800 que Sir Shrapnel inventa son projectile, et en 1803 qu'il fit " à Mounht Bay ses premières épreuves ; d'autres eurent lieu en 1805 à Woolwich."— Decker's *Expériences sur les Shrapnels*, avant-propos, III.

The following passage, however, would seem to place it beyond doubt that it was as early as 1784 that General Shrapnel first brought forward shells on the same principle :—5th April 1813, Lieut.-Colonel Shrapnel wrote as follows : " ' Not- " ' withstanding *it is nearly* 30 *years ago* since I first exhibited the firing of balls in " ' metal cases.' "—*Ordnance Select Committee Report on Shrapnel Shell*, p. 34.

It is certain, from a letter of the Duke of Richmond's in the records of the Ordnance Select Committee, dated 1792, that the projectile was formally submitted to a committee of artillery officers in that year.

3 This action took place on the 21st August 1808 ; but there is little doubt from a letter of Colonel Robe, commanding the Royal Artillery in Portugal, that the shell had been used in the battle of Roliça, which took place four days previously, viz., on the 17th August 1808.—See *Ordnance Select Committee Report on Shrapnel Shells*, p. 14.

" Their efficiency was triumphantly established in the actions of the 17th and " 21st August, against Marshal Junot."—*Memoirs of Sir John Sinclair.*

" En 1808, les shrapnels étaient employés contre les Français à la bataille de " Vimiera."—*Expériences sur les Shrapnels*, avant propos. III.

4 For my authorities for this statement, and for more upon the subject, *see* Appendix B.

5 For proof of the existence of this defect, see *Synopsis Ordnance Select Committee Reports on Shrapnel Shell*, pp. 35, 38, 39. 66, 69. 70, 78, &c., ; also Colonel Boxer's *Remarks on Diaphragm Shrapnell Shell*, p. 2, &c.

The failures are stated to have " amounted to 17 per cent. in the extensive trials of " 1819, and to 22 per cent, in the trials of 1852."—*Supplement to Synopsis*, &c. p. 7.

"of the charge;"[1] it was also thought to arise in some cases from the shell being too weak to withstand the shock of the discharge.[2]

Although this defect was obviated to some extent by thickening the shell, and in a greater degree by the introduction of Boxer's fuze, it was not entirely removed by these measures[3] and it became evident, therefore, that the failures arose from other causes.

The main causes that were then assigned for these premature explosions were, either—

1st, That the fuze was driven out by the reaction of the bullets in the shell, thus enabling the flash of the discharge to communicate with the bursting charge; or,

2nd, That the percussion or friction of the bullets evolved sufficient heat to ignite the bursting powder.[4]

From a large number of experiments which were carried on, it was incontestably proved that to the last cause the failures were almost wholly attributable.[5] Attempts were made to remedy this in one or

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[1] *Synopsis Ordnance Select Committee Reports on Shrapnel Shell*, p. 66, &c.

In the old pattern fuze the composition was exposed and unsupported at the bottom; and it is easy to understand how the effect mentioned in the text might be produced by the shock of the discharge, particularly when the shortness of these fuzes (one inch) is considered; evidently, also, the liability to accidental premature explosion would increase as the range decreased, owing to the shorter length of fuze which would be used for the shorter ranges.

[2] *Synopsis Ordnance Select Committee Report on Shrapnel Shells*, p. 8, &c.

[3] "It was proved beyond doubt, that, however perfect the fuze might be premature "bursting would still happen."—*Remarks on Diaphragm Shrapnel Shell*, p. 3.

"It further became evident that the shell was sufficiently strong, in itself, to with "stand the shock received from the powder in the gun."—*Ibid.* p. 3.

[4] *Remarks on Diaphragm Shrapnel Shell*, p. 3. *Ibid. Appendix Ordnance Select Committee Report on Shrapnel Shell*, pp. 84, 89.

[5] "There cannot be a question that this is the principal cause of failure, for I have "myself seen several shells which were filled with balls and the bursting powder, but "without fuzes (the fuze hole being plugged with wood), explode on striking the butt, "and in these cases the powder could only have been ignited by the action of the bullets "in the interior."—*Remarks on Diaphragm Shrapnel Shell*, p. 3. 8-in. 32-pr. and 24-pr. shrapnel shells carefully selected were prepared as follows, and fired with charges of 10 lbs., 10 lbs. and 8 lbs. respectively:—

(1.) Filled with bullets and *the bursting powder*, and with a solid plug of wood firmly driven into the fuze hole.

(2.) Filled with bullets, but *without the bursting powder*, and with a solid piece of wood firmly driven into the fuze hole.

"*Nearly the whole of the shells with the bursting powder exploded in the gun, but "there was not* ONE *breakage with the shells* WITHOUT THE BURSTING POWDER. ". . . . These results lead me to the following conclusions: . . . . That by the "shock which the projectile received at the 'discharge,' sufficient heat was evolved "in some *part* of the interior of the shell, by friction, or condensation, to ignite the "bursting powder."—*Ibid.*, *Appendix*.

"If there be any fact in regard to artillery matters which has been thoroughly and "completely established by actual experiments it is this, that a separation is abso-"lutely necessary in order to the efficiency of the shrapnel shell. . . . . The results "of a series of experiments in 1852, 1853, and 1854, undertaken chiefly for the pur-"pose of ascertaining the cause of this defect (premature explosion) *left no doubt on "the mind of all who witnessed the practice that it was mainly attributable to the mix-"ture of the powder with the balls.*"—*Remarks upon Memorandum*, p. 2; also *Memorandum by Ordnance Select Committee on Diaphragm Shrapnel Shell*, p. 7, where these words again occur. See also table of practice carried on in 1853, with a view to "dis-"covering the real cause of failure" given at pp. 31 and 32 of Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell.* Also *Synopsis of Ordnance Select Reports, &c.*, pp. 89 and 191. "It appears to the Committee that . . . . the separation of the "bursting powder has prevented *premature bursts, a great point gained over the "original shrapnel.*"—*Report of General Brereton's Committee*, Dec. 14th, 1858. It is important to dwell upon this point, the main cause of failure of the shrapnel shell, because, as will presently be seen, the value of Colonel Boxer's improvements in this two ways;—by coating the interior of the shell with a cement to diminish the friction;[1] by fixing the balls with pitch, sulphur, plaster of Paris, and other materials,[2] and by reducing the charge of the guns; these attempts however, were attended with unsatisfactory results;[3] and in the meantime Colonel Boxer suggested the separation of the bursting charge from the bullets, "*as the only means of securing* "*success*."[4] This separation he proposed (in 1852) to effect by means of a wrought iron partition or diaphragm.[5]

The experiments which were carried on with shells constructed on this pattern were most satisfactory,[6] and in 1853[7] the Committee recommended the manufacture of a large number of the shells "with

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projectile as effected in the diaphragm shrapnel shell cannot be fully appreciated, nor, indeed, the necessity for introducing such improvements, or of superseding the original shrapnel in any way, recognized, if this point be not first incontestably established.

It is more than probable that in *some* cases the premature explosions arose from other minor causes, such as the splitting of the fuze in ramming home, and the partial withdrawal of the shell by the rammer, the head of the fuze being nearly the same size as the hole in the head of the rammer. Respecting the occurrence of explosions from this latter cause, see *Synopsis of Reports and Experiments by the Ordnance Select Committee, Shrapnel Shells*, p. 229, where the following passage occurs: "One very " serious defect I observed, however, with regard to the rammer head, the hole in the " centre is almost exactly the same size as the head of the fuze; the consequence was " that the shell was withdrawn with the rammer head, until I filled up the hole. This " may perhaps account for some of the failures." That *some* of the premature explosions resulted from these minor causes is, as I have said, more than probable, but that the *main* cause of failure was the heat generated by the percussion or friction of the bullets seems conclusively established by the passages and experiments above quoted.

[1] "Some shells so prepared were fired, but with the most unsatisfactory results."—*Remarks on Diaphragm Shrapnel Shells, Appendix.*

[2] "In some of the continental artilleries this has been effected by fixing the balls with sulphur, pitch, plaster of Paris, or other materials."—*Synopsis of Ordnance Select Committee Report on Shrapnel Shell*, p. 289.

[3] *Remarks on Diaphragm Shrapnel Shell, Appendix.*—The last remedy, even if it had proved successful, would have been objectionable from the reason that its adoption would have impaired the efficiency of the shell in direct proportion to the decrease in the initial velocity which would necessarily result from any reduction in the charge.

[4] *Remarks on Diaphragm Shrapnel Shell, Appendix.*—This was in 1849 (see *Remarks on Diaphragm Shrapnel Shell*, p. 2), and in September of the same year an experiment was made "with shrapnel shell having the bursting charge enclosed in " canvas bags, so as to separate it from the balls. This mode of preparation was " suggested by Captain Boxer, to prevent liability to premature explosion by the " friction of the balls within the shells."—*Report of the Committee*, see *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, p. 287.

"This experiment appears to have been very successful."—*Ibid.*, p. 287.

[5] "I have the honour to propose . . . . that . . . . the powder be separated from " the balls by means of *a wrought-iron partition*." Letter from Colonel Boxer to Secretary of Master-General of Ordnance, dated 10th May 1852.—*Remarks on Diaphragm Shrapnel Shell*, p. 2. *Ibid. Appendix.* "In consequence of the favour- " able result of the experiment (referred to in preceding note), Captain Boxer, on the " 10th of May 1852, proposed that shrapnel shells, from the 24-pr. upwards, should " be constructed with a wrought-iron plate for the purpose of separating the powder " from the balls."—*Synopsis of Ordnance Select Committee Reports on Shrapnel Shells*, p. 287.

[6] "The Committee consider that the result of this experiment is highly satisfactory. " . . . . The Committee desire to congratulate Captain Boxer on the success which " has attended his efforts to improve the shrapnel shell."—*Ibid.*, p. 288. "I am to " remark that Colonel Abbott appears to have overlooked the numerous failures which " occurred with the original shrapnel shell, amounting to 17 per cent. in the extensive " trials of 1819, and to 22 per cent. in the trials of 1852, whereas on the latter occa- " sion those with Captain Boxer's shells were under 6 per cent."—W.O. Letter, 1st April 1858. See *Supplement to Ordnance Select Committee Reports on Shrapnel Shell*, p. 7.

[7] The 1st October 1853.—*Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, pp. 287, 288.

"a view to their introduction into the service."[1] This recommendation was adopted, and the diaphragm shell provisionally approved.[2]

As, however, this arrangement was not applicable to the large existing stores of shrapnel shell, the Committee recommended that these shells should be rendered secure against premature explosion, and so made available for service, by separating the balls and powder by means of a socket and tin cylinder introduced at the fuze hole,[3] according to a former suggestion of Colonel Boxer's;[4] the recommendation was approved,[5] and all the shrapnel shell in store were converted in this way, and designated "Improved shrapnel shells."[6] But no *new* shells were *manufactured* on this pattern, the arrangement being only applied to the shrapnel shell *in store* as, admittedly, a makeshift, by means of which the one great defect of these shells, liability to premature explosion, would be overcome;[7] and the reason why the arrangement was not recommended for more general introduction was this:—The construction was defective in one very important respect, "the bursting powder, to cause rupture in the shell, must act through "the balls, and thereby cause a very great spread in all directions,"[8] an effect, which, as Colonel Boxer observes, is "contrary to the fundamental principle of Shrapnel shell."[9]

Introduction of Improved Shrapnel shell.

Moreover, the balls were liable, in spite of an admixture of antimony with the lead, to be much disfigured by being crushed against the sides of the shell at the moment of rupture, their velocity and striking force being in consequence greatly diminished. For these reasons the cylinder arrangement was applied *only to the existing store of shrapnel shell*, which were "improved" in this manner.

When these shells had been converted into "improved shrapnel" as above described, the service was supplied with shells constructed on the diaphragm pattern, which, as above stated, had been approved in 1853. In 1858 the details of construction were matured, and some of

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[1] *Ibid.*, p. 288.

[2] Dated 11th October 1853.—*See* Master-General's letter of that date.—*Synopsis of Ordnance Select Committee Report on Diaphragm Shrapnel Shell*, p. 289.

[3] *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, pp. 197, 200, 201, &c. See drawing of shell, *ibid.* p. 198.

[4] "My first idea was to place the powder in a cylinder in the continuation of the "fuze hole."—Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell*, p. 9.

[5] 23rd March 1854. See *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, p. 200; but it was not until January 1855, that the detailed instructions respecting the conversion of the existing store of shrapnel shell were promulgated to the Royal Artillery. See *Account of Alterations and Additions in Ordnance, Carriages, &c., &c.*, 31st January 1855, par. 29.

[6] The necessity for converting the large store of shrapnel shell into efficient projectiles became more imperative from the fact that at this time batteries were being equipped for despatch to the east, in anticipation of the war against Russia, which shortly afterwards broke out; and the demand thus suddenly created was greater than could be met by a supply of the diaphragm pattern.

[7] Colonel Boxer, in a letter dated 27th September 1853, says: "As there are a "great number of shrapnel shell now in store, I beg to say that having now for so long "a time turned my attention to the subject, I can with confidence undertake to prepare "these shells in such a manner *as to prevent the defect of premature explosion, although* "*it will be impracticable to make them as efficient as the diaphragm shell.*"—*Remarks on Diaphragm Shrapnel Shell*, p. 11.

[8] See *Remarks on Diaphragm Shrapnel Shell*, pp. 9, 10.

[9] *Ibid.* p. 10. "The fundamental principle" here referred to is the principle of preserving the balls as much as possible from the action of the bursting charge, and making their effect independent of any such action, and dependent only upon their own communicated velocity.

them were slightly altered,[1] and in that year the diaphragm shell of the present pattern was provisionally approved.[2]

The diaphragm shell was not *finally* approved until 1864.[3]

Shell—Improved Shrapnel.

Sizes.

5. *Improved Shrapnel Shell.*—There are nine sizes of improved shrapnel shell, viz., 8-inch, or 68-pr.; 56, 42, 32, 24, 18, 12, 9, and 6 prs.

Description.

The improved shrapnel is a thin cast-iron spherical shell, made with a slight lip under the fuze-hole, but in other respects concentric.[4] It contains a number of bullets, varying in nature and number with the size of the shell, carbine bullets being used up to the 12-pr. size, and musket balls for all the higher natures; smaller bullets (pistol and buckshot) being inserted when the shell has received its complement of the larger sized bullets. The bursting charge is contained in a tin cylinder attached to a gun-metal socket which is screwed into the fuze-hole, this cylinder passing down the centre of the shell.

To prevent the bullets from conglomerating, or losing their shape, they are hardened by mixing antimony with the lead;[5] and with the same object rosin is poured in between them to fill up the interstices. The rosin also serves another purpose, viz., effectually to imbed the

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[1] Colonel Boxer explains the state of the case thus:—"When the diaphragm "pattern was first proposed, I had no opportunity of making the necessary experiments "to determine various details in regard to the arrangement of the wrought-iron "partition, the depth of the grooves, &c., &c., which, although in appearance but "trifling, are nevertheless points upon which the success of the system depends. How- "ever, as the results of the first trials at Shoeburyness in 1852 and 1853 were reported "as highly satisfactory, and there was neither time nor opportunity to prosecute the "inquiries in relation to the *most efficient* arrangement at a period when the shells "were required for immediate service, the original designs were adhered to. *The* "*shells in question* were supplied by contractors, the majority of whom were totally "inexperienced, and, owing to the peculiarity of construction, it was impossible when "the shells were delivered, to test or examine them in a way to determine whether or "not the design had been correctly carried out. . . . . Owing to the above "causes the diaphragm shells which have been issued for service are defective, *both* "in design and workmanship."—*Remarks on Diaphragm Shrapnel Shell. Appendix.*

The following were the more important details which underwent modification in 1858. The strength of the flanges of the diaphragm were reduced to a *minimum* consistent with affording proper support and the metal was thickened round the junction shell and diaphragm, thus diminishing the tendency to fracture at this part and ensuring the proper action of the grooves and opening of the shell (see p. 53); the interior of the shell was coated with marine glue (see p. 52); the bases of some of the shells were thickened, as also the metal about the fuze hole (see p. 54).

[2] 29th September 1858, 75/12/213, General Regimental Order, 388.

[3] From 6-pr. to 8″ approved 27 September, 1864, *War Office Circular*, 3 (New Series), para. 953. The 100-pr and 150-pr. diaphragm were not included in this approval; the dates of their respective adoptions are, 100-pr., 16th November 1864, War Office Circular 3 (New Series), para. 1000; and 150-pr.

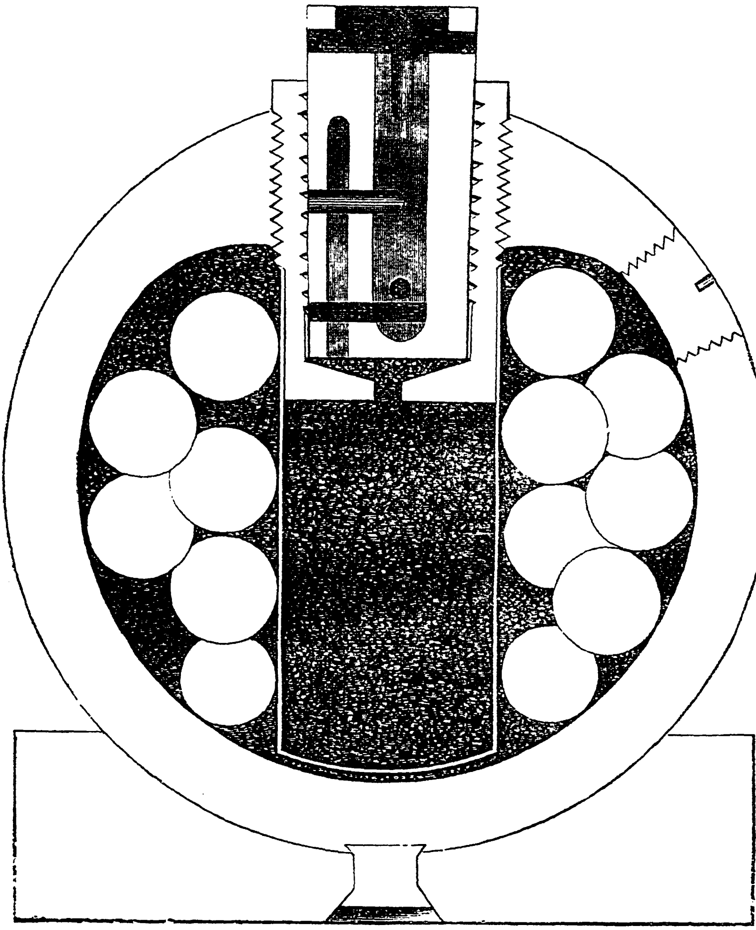
[4] The old shrapnel shells, in fact; see drawings showing dimensions and form of the shrapnel shell, in *Diagrams of Guns*, &c. by Colonel Boxer. Plate 43.

[5] Lead, 6 parts, antimony, 1 part; or about 15 per cent. antimony. This was proposed by Colonel Boxer for shells of the diaphragm pattern (see *Remarks on Diaphragm Shrapnel Shell*, pp. 11, 12, 14, also *Ordnance Select Committee Report on Shrapnel Shell* p. 80); and was applied to the "Improved Shrapnel" bullets. The liability of the bullets to mass together and to become shapeless masses of lead had been noticed among other defects of the original shrapnel shell, and various attempts were at different times made to overcome it; sand, clay, cement, and other substances were placed between the balls with this object, but these remedies were not altogether efficient, (*Ordnance Select Committee Report on Shrapnel Shell*, pp. 187, 215, &c.), in some cases the composition used failed from being too adhesive, as was proved by bullets having been found sticking to the pieces of burst shell. *Ibid.*, pp. 215, 219.

The necessity for hardening the balls of the "Improved shrapnel" is also rendered greater by the fact that the bursting charge in opening the shell necessarily crushes the bullets against the side of it, and the disfigurement of the balls arising from this cause is much decreased by the admixture of antimony with the lead.

balls, thus preventing them from pressing upon or breaking the tin cylinder which contains the bursting charge; and being a brittle substance when cold is broken up on the bursting of the shell, and the bullets are at once liberated.[1]

IMPROVED SHRAPNEL, 9-PR.



The socket[2] is a gun-metal cylinder slightly conical in the *interior*, projecting about ·2 inch above the outside of the shell, and carried into the interior so far as is necessary to admit the improved shrapnel fuze. The interior diameter of this socket is slightly less than that of the

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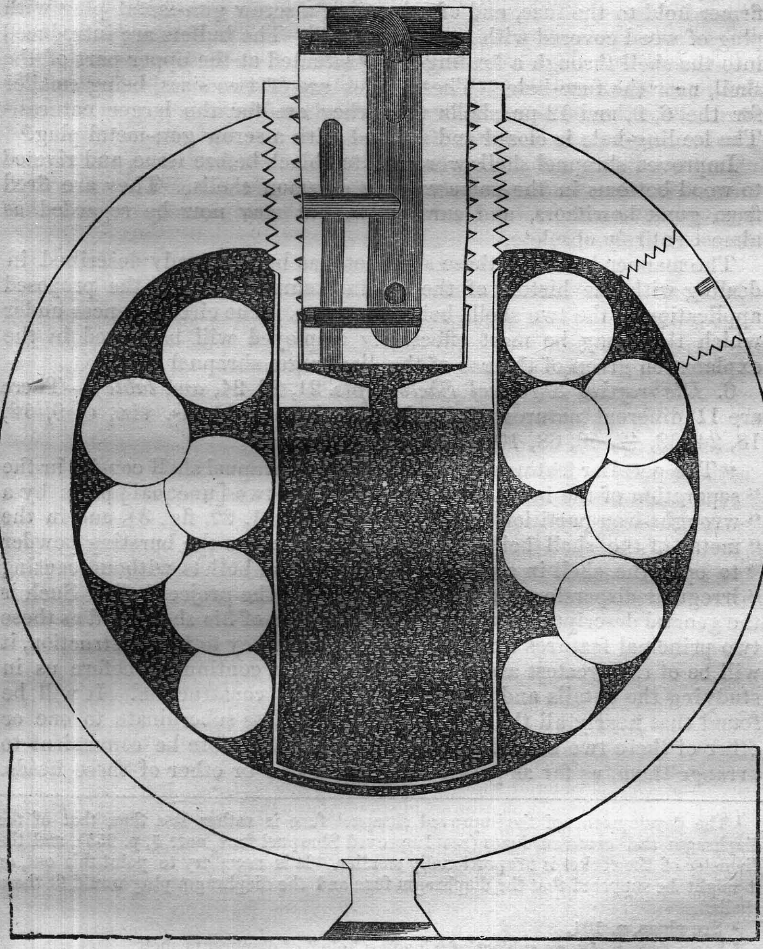
[1] See that part of the preceding note which has reference to some of the compositions experimented with having been too adhesive. "Rosin has been substituted and this "evil (the adhesion of the balls to the composition, and to the sides of the shell,) "diminished, if not entirely remedied."—*Ordnance Select Committee Report on Shrapnel Shell*, p. 219.

[2] Sometimes called a "bush" or "bouche" (see *Ibid.* p. 197); the term "socket" is, however, I believe, the more correct of the two; "bush" being generally (though not invariably) applied to a socket open at the end, such as the bush of naval shells.

IMPROVED SHRAPNEL, 9-PR.



diaphragm socket, or than that of the fuze-hole of a common shell.[1] The socket is closed at its lower end, with the exception of a small fuze-hole to allow of the passage of the flame from the fuze to the bursting charge. The tin cylinder is soldered on to this socket, of which, in fact, it forms the prolongation; the lower end of the cylinder (which is not in contact with the bottom of the shell), being closed. The socket is tapped with a right-handed screw, for the double purpose of giving a firmer hold to the fuze, and of admitting a screw gun-metal plug with plug of wood covered with serge attached.[2] The bullets are introduced into the shell through a loading-hole[3] situated at the upper part of the shell, near the fuze-hole. These holes are of two sizes, being smaller for the 6, 9, and 12-pr. shells than they are for the larger natures.[4] The loading-hole is closed and secured with a screw gun-metal plug.[5]

Improved shrapnel shells were painted black before issue, and riveted to wood bottoms in the same way as common shells. They are fired from guns, howitzers, and carronades, but may now be regarded as almost entirely obsolete.

The manner in which these shell act has been already described in dealing with the history of the original shrapnel shell,[6] the proposed application of the two shells being the same. The circumstances under which they may be most effectively employed will be stated in the explanation given of the use of the diaphragm shrapnel shell.[7]

Shell—Diaphragm Shrapnel. Sizes.

6. *Diagraphm Shrapnel Shell*[8] (*pls.* 21, 22, 24, *and table*).—There are 11 different natures of diaphragm shrapnel shells, viz., 6, 9, 12, 18, 24, 32, 42, 56, 68, 100, 150-prs.

Description.

" The peculiar features of the diaphragm shrapnel shell consist in the " separation of the interior of the shell into two [unequal] parts by a " wrought-iron partition or diaphragm (pls. 21, 22, fig. 3), and in the " metal of the shell being so disposed as to cause the bursting powder " to open the shell in a manner to relieve the bullets without causing " irregular dispersion from the trajectory of the projectile."[9] Such is the general description given by Colonel Boxer of his shell; and as these two principal features may be regarded as the key to its construction, it will be of the greatest assistance to keep them continually before us in studying the details and peculiarities of this construction. It will be found that nearly all the details are more or less subordinate to one or other of these two main features, and it will therefore be convenient to arrange them, as far as practicable, under one or other of these heads.

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[1] The development of the improved shrapnel fuze is rather less than that of the diaphragm and common fuzes (see Improved Shrapnel fuze, note 5, p. 255), and the diameter of the socket is proportionally smaller. It is necessary to point this out, or it might be supposed that the diaphragm fuze and the diaphragm plug would fit these shells.

[2] See plugs, p. 101.

[3] See note 8, p. 52, on subject of " loading hole " of diaphragm shell.

[4] The reason for this is obvious, 6, 9, and 12-pr. shells being filled with carbine balls, while the higher natures are filled with musket balls (see text, p. 48), and it is undesirable to make the loading hole larger than is absolutely necessary for the admission of the bullets, for fear of weakening the shell to an injurious extent.

[5] See " loading hole plugs," p. 104.

[6] See text and notes, pp. 41, 42.

[7] See p. 56.

[8] Finally approved 27th September 1864, War Office Circular, 3 (new series) para. 953, except 100-pr., approved 16th November 1864, and 150, approved . . . . . . No pattern of a 10-inch diaphragm shell has been approved, for there is no gun in the service with which it could be used, except with very reduced charges, and therefore with a great sacrifice of efficiency (see p. 43), the 10-inch gun being unequal to the strain involved in firing this projectile with the full service charge.

[9] *Remarks on Diaphragm Shrapnel Shell. Appendix.*

The subject may thus be treated as follows :—

1st. Those points which connect themselves with the separation of the bursting charge from the bullets.

2nd. Points connected with that peculiar disposition of the metal of the shell, by means of which the shell is opened without the flight of the bullets being affected by the bursting charge.

3rd. Miscellaneous details which do not fall properly under either of the above heads.

1st. *Those points which connect themselves with the separation of the bursting charge from the bullets.*[1]

The diaphragm shrapnel shell is a thin cast-iron shell, divided into two unequal parts by a thin cup-shaped wrought-iron[2] partition or diaphragm[3] (plts. 21, 22, fig. 3). This diaphragm is supported by four small projections or flanges (plts. 21, 22, fig. 3, C) on its circumference, equidistant from one another, which are cast into the metal of the shell.[4] It is situated with its convex side presented towards the fuze-hole, and of the two chambers thus formed in the interior of the shell the upper and smaller one, or powder chamber, contains the bursting charge, while the bullets are situated in the lower and larger division, which may therefore be spoken of as the bullet chamber.

There is a hole (plts. 21, 22, fig. 3, A) in the centre of the diaphragm, immediately underneath the fuze-hole, to allow of the gun-metal socket[5] (pl. 24, fig. 3), which is screwed into the fuze-hole passing down into the shell.[6] This socket is the same internal diameter and shape as the fuze-hole of a common shell, and of a length to receive the diaphragm fuze, and in the case of the 150 and 100-prs., the common fuze. It is consequently rather larger and more conical than the socket of the improved shrapnel. It also differs from the improved shrapnel socket in having a fire-hole (pl. 24, fig. 3, M) at the side instead of at the bottom, through which the flame from the fuze communicates with the bursting charge. To facilitate the passage of the flame from the fuze to the fire-hole the socket is made rather longer than the fuze, and a

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[1] See p. 46 respecting the necessity for such separation.

[2] The diaphragm of the 150-pr. is slightly depressed in the centre, to form a sort of cup round the socket, in which the powder will rest, thus making the ignition of the bursting charge more certain. A tough superior charcoal sheet-iron is employed for diaphragms; 6-pr. to 9-pr. inclusive, 18-wire gauge; from 12 to 24-pr. inclusive, 17-wire gauge; higher natures, 15-wire gauge.

[3] "Diaphragm," a partition or dividing substance."—*Imperial Dictionary.*

[4] Along a circle equidistant throughout its circumference from the centre of the fuze hole.

In the shell manufactured before 1858 the whole rim of the diaphragm was cast into the shell, but in the 1858 pattern shells the rim was reduced to the four projections by which the diaphragm is now mainly supported, the projections being made of the *minimum* strength requisite to prevent the diaphragm being displaced by the shock of discharge when very high charges are used. The support afforded in this way is about one-half of the support which the diaphragm had in the original construction; and in this way the resistance offered by the diaphragm to the action of the bursting powder was much reduced, and the tendency to fracture round the line of junction proportionally so (see note 1, p. 43).

[5] Sometimes called a "bush" or "bouche," see *Synopsis Ordnance Select Committee Report, Shrapnel Shell*, pp. 280, 281; see p. 48, note 2.

[6] Although this socket is a necessary element of the diaphragm construction, being required to complete the separation between the bullets and the bursting charge, it serves another purpose, viz., the protection of the fuze from the reaction of the bullets (see p. 45), and in this way also contributes towards the efficiency of the shell; and, more important still, by preventing the escape of the bursting charge at the fuze hole, it renders the whole of it available for the opening of the shell. For dimensions of socket, see table VI., p. 326.

shallow slot or groove is cut up to this fire-hole from the bottom of the socket. The socket is tapped to the depth of about an inch, to receive a gun-metal plug with a wood plug covered with serge attached,[1] (pl. 24, figs. 4, 5) with which the socket is closed until the shell is required for use. As in the case of the common shell, this screw also serves to give a better hold to the fuze.[2] The socket does not project like that of the improved shrapnel shell, but is made flush with the surface of the shell.[3] As the bullets are introduced into the shell through the socket the bottom has to be left open until after this has been effected. This hole is closed by means of a small gun-metal plug (pl. 24, fig. 1, P, R), which screws in.[4]

To fill up any interstices which there may be between the diaphragm and the side of the shell, or between the diaphragm and the socket—in act to insure a thorough separation of the bullets from the bursting charge,[5] the interior of the shell (both bullet and powder chambers) is coated with Jeffrey's marine glue.[6] The marine glue also prevents the shell deteriorating from rust.[7]

The bursting charge is inserted into the shell through a loading hole[8] (pl. 24, fig. 1, C, A, D) in the shell, corresponding to the loading hole in the improved shrapnel, but much smaller, as in the improved shrapnel it is required to be large enough to admit the bullets.

There are two sizes of loading holes, viz., small for all natures up to the 18-pr., inclusive ; and large for the higher natures. These holes are closed by a screw gun-metal plug[9] (pl. 24, fig. 7).

We now pass to, 2nd, *points connected with that peculiar disposition of the metal of the shell by means of which it is opened without the flight of the bullets being affected by the bursting charge.*

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[1] See plugs, p. 101.

[2] See "common shell," p. 25.

[3] It is unnecessary to countersink the fuze hole of these shells, as they could never be used as hollow shot.—(See "common shell," p. 26.)

[4] To make a close joint the threads of the screw of this plug, before it is placed into the socket, are smeared over with white lead.

[5] "In order to secure a perfect separation between the bursting powder and the "bullets."—*Remarks on Diaphragm Shrapnel Shell*, p. 41.

The importance of making this separation perfect and complete arises not only from the fact that otherwise the main object of these shells would be defeated, and the powder becoming mixed with the bullets the premature explosions sought particularly to be guarded against would probably occur, but, because, in case a premature explosion did *not* occur, the shell would be very liable not to explode at all, for the fuze, it must be remembered, communicates only with the powder chamber, from which, in the case of an imperfect separation, we may suppose the bursting charge to have wholly or in part escaped. There would thus possibly result from an imperfect separation either a premature explosion or no explosion at all.

[6] This coating was first adopted in the 1858 pattern shell, see *Remarks on Diaphragm Shrapnel Shell*, p. 41. "Jeffrey's Marine Glue" is a patent article.

[7] "To prevent deterioration from rust."—*Remarks on Diaphragm Shrapnel Shell*, p. 41. This is a point of considerable importance, as in case of the flanges of the diaphragm, by which it is fixed into the shell, becoming corroded to any considerable extent, or of the metal of the shell round the line of junction being similarly affected, the diaphragm would be liable to become loosened or displaced, and would thus fail in its object of separating the powder from the bullets.

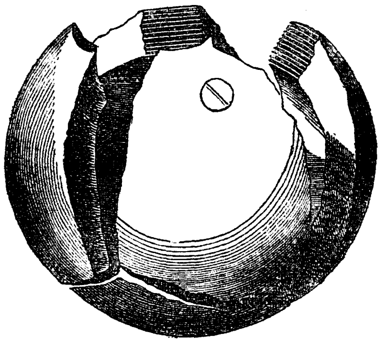
[8] It would perhaps be more correct to apply the term "Filling-hole" to this hole in the diaphragm shells, as shells filled with powder are directed to be spoken of as "filled" not "loaded" shells (75/12/571, 8/3/60; see War Office Circular, 590, par. 38).

In the improved shrapnel shell there is no such reason for altering the name of the hole, for the bullets, not the powder, are inserted at the "loading hole," and although the shells are generally spoken of as "*filled* with ball," there is no order upon the subject.

[9] See plugs, p. 104.

The importance of adopting an arrangement to ensure the bursting charge opening the shell without affecting the flight of the bullets will be appreciated when we consider that otherwise not only would General Shrapnel's "fundamental principle" be violated, but the efficiency of the shell would be injuriously affected in the highest degree by the bullets being liable to be blown up or down, or forwards or backwards, according as the fuze happened to be below or above, or behind or before at the moment of explosion,[1] and the effect of the shell would thus depend in a great degree (1) upon the accidental relative position of the powder and bullet chambers at the moment of explosion, and (2) (as any great dispersion of the bullets by the bursting charge would produce great divergence from the trajectory of the shell) upon its bursting at some exact known distance from the object fired at—conditions which, from the difficulty of *exactly* judging the distance of an object, and the still greater difficulty of *exactly* judging the distance of the shell from that object at the moment of rupture, it would be impossible to impose. For these reasons, therefore, an arrangement of the nature indicated is absolutely essential to the success of the system.

The plan adopted in the diaphragm shell is as follows :—The shell is weakened in the interior by four grooves (pl. 21, 22, figs. 2, 1 *bb*) equidistant from one another, which taper in width and depth as they approach the top and bottom of the shell. These grooves form so many "lines of least resistance," along which the bursting charge takes effect,



thus acting, "as it were, from the outside of the mass of balls,"[2] and so preserving the balls from the direct action of the bursting charge, and opening the shell into five or more large pieces.

But while the shell is weakened in the directions indicated by these grooves it is strengthened in another direction (plts. 21, 22, fig. 1 *m*), for the following reasons : as the shell will inevitably burst at the line of least resistance, wherever that may be, it is evident that if there were a greater tendency to fracture at any part of the shell than in the direction of the grooves, the effect of the grooves would be, as it were, neutralized, these being no longer lines of *least* resistance ; now, there is naturally, from the fact of the four little flanges (plts. 21, 22, fig. 3, C) by which the diaphragm is supported, being cast *into* the metal of the shell, and from the resistance offered by these flanges to the action of the powder, a great tendency to fracture round the line of junction

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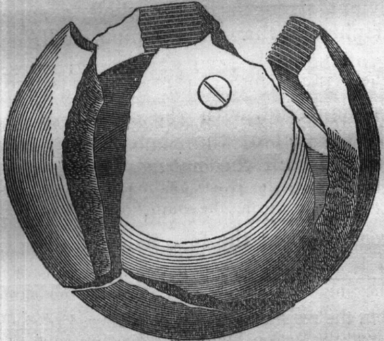
[1] *Memo. on Diaphragm Shrapnel Shell*, p. 4.

[2] *Remarks on Diaphragm Shrapnel Shell*, p. 10. The diagram here given is taken from Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell*, fig. 3, and is a copy of a photograph taken of " a shell burst with the regular bursting charge."



of the diaphragm[1]—a greater tendency to fracture, that is to say, than in the direction of the grooves, if a special arrangement be not made to guard against it. The necessity for so guarding against it will be fully recognized if the effect of a separation round the line of junction is clearly perceived, viz., that the upper part of the shell would be liable to be blown off, thus either failing to release the bullets or injuriously affecting their flight.[2]

Two remedies or arrangements suggested themselves, viz., either to increase the depth of the grooves or to reduce the strength of the flanges to a minimum, consistently with the security of the diaphragm, at the same time thickening the metal of the shell round the line of junction ; the second remedy was preferred to the first, which "would " have weakened the shell, and made it less capable of withstanding " the shock of a heavy charge ;"[3] *and in the* 1858 *pattern shells this remedy was adopted.*[4] The arrangement, therefore, by which the bursting of the shell is accomplished without the flight of the bullets being affected, consists (*a*) in the four grooves, and (*b*) in the tendency to fracture round the line of junction of the diaphragm being diminished to such an extent that the grooves are actually lines of *least* resistance.

Having dealt with details which are more or less intimately connected with the two main features of the shell, the

(3.) *Miscellaneous details, which do not properly fall under either of the above heads*, may now be treated of.

To ensure sufficient strength in the shell, a superior description of iron is used for diaphragm than for common shell.[5]

The weakening of the shell down the four grooves, and the strengthening of it round the line of junction of the diaphragm, have already been treated of as connected with the second of the main features of the projectile. The metal of the shell is not, however, of uniform thickness elsewhere. In all the natures above the 12-pr. it is made thicker at the bottom than at the sides, to enable the shells to withstand the shock of the discharge of the gun.[6] The thickness of metal has also been increased about the fuze holes of all natures of diaphragm

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[1] " It was found from the resistance which was offered to the action of the bursting " charge by the cast-iron projection below the diaphragm that there was a great ten- " dency to fracture through the line of junction."—*Remarks on Diaphragm Shrapnel Shells*, p. 39.

[2] " The explosion of the bursting powder would separate the shell at the part where " the wrought-iron partition joins the interior surface, and the bullets would either not " be relieved in the shell, or would be affected more or less in their proper course " according to the relative positions of the powder and the bullets at the moment of " explosion, and the force of the explosion itself."—*Ibid., Appendix.*

[3] *Ibid.*, p. 39.

[4] It is important to bear in mind that this improvement, upon which the success of the system in a great measure depends, was not adopted until 1858, and shells manufactured before that date are accordingly not considered serviceable. The shells made before 1858 may be distinguished by having a projecting instead of a flush socket.

[5] The mixture is ;—half hot, and half cold blast ; or, one-third hot, one-third cold, and one-third " scrap " *from above mixture.*

[6] First adopted in the 1858 pattern shells.—" In the improved designs for the larger calibres of shells, the metal has been made thicker at the bottom, or that part of it which is next the charge when the shell is in the gun, than in any other parts, for I found by careful experiment that . . . . . there was a liability to fracture . . . . . by the direct action of the bursting charge."—*Remarks on Diaphragm Shrapnel Shell*, p. 40. It is unnecessary to increase the thickness of the bottoms of the three lower natures, as the thickness which is necessarily given to them at the sides is found sufficient for the bottoms, the service charges for these shells being comparatively light.

shell to the extent requisite to afford proper support to the socket.[1] The bullets with which the shells are filled vary in number for each nature, carbine bullets[2] being used up to the 12-pr. (inclusive), and musket bullets[3] for the higher natures;[4] smaller bullets (pistol[5] and buck shot[6]) being inserted when the shell has received its complement of the larger-sized balls. They are hardened by a small quantity of antimony being mixed with the lead,[7] to prevent them from conglomerating, or losing their shape.[8] In the 150-pr. diaphragm 2 oz. sand shot are used; a few mixed metal bullets being inserted to fill up after socketing.[9] To assist in preventing conglomeration of the bullets coal dust is shaken in between them, filling up the interstices.[10]

Diaphragm shells are riveted to wood bottoms (pl. 24, fig. 2, a, g, h, e) by a single expanding rivet (pl. 24, fig. 6), in the same way and for the same reasons as common shells,[11] except the 150-pr., which is attached by four inclined copper rivets, like a naval shell.

Diaphragm shells are painted black before issue.[12] They weigh when filled with balls about (*see* table) seven-eighths[13] the weight of solid cast iron shot of the same calibres.

Diaphragm shell are fired from guns, howitzers, and carronades.[14]

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[1] First adopted in the 1858 pattern shells. "I found when very high charges were used the socket . . . . . was at times displaced and partially driven inwards, thereby cracking the metal at the fuze hole. In the present construction, I have remedied this defect by increasing the thickness of metal where the socket is screwed in. This thickness is, of course, more apparent in the lower than in the higher natures."—*Remarks on Diaphragm Shrapnel Shell*, p. 40.

[2] A spherical ball ·60 inch in diameter, and weighing *when made of lead* 350 grains, or 20 to the pound; in mixed metal (lead and antimony) 22 to the pound.

[3] A spherical ball ·68 inch in diameter, and weighing *when made of lead* 490 grains or 14½ to the pound; of mixed metal 1 oz. each or 16 to the pound.

[4] Larger balls are used for the 150-pr. diaphragm, *i.e.* balls of 8 to the pound before socketing, and after the socket is inserted filled up with balls 16 to the pound.

[5] 31st August 1852. "Captain Boxer, having requested that the shrapnel shells of " his construction may be filled with pistol bullets, after the usual number of lead balls " have been inserted, permission was given accordingly."—*Ordnance Select Committee Report on Shrapnel Shell*, p. 91.

The pistol bullet is ·556 inch in diameter and weighs in *lead* 27 to the pound; mixed metal 29 to the pound.

[6] A spherical bullet ·33 inch in diameter, weighing in *lead* 132 to the pound, and in mixed metal 140 to the pound.

[7] Lead 6 parts, antimony 1 part, or about 15 per cent. antimony. For the 150-pr. it is 4 lead, 1 antimony.

[8] See p. 48.

[9] About 250 sand shot and 30 1 oz. bullets.

[10] See p. 48.

[11] The rivet holes in all natures *above* the 18-pr. are the same size as the rivet holes of common shell; the lower natures have a somewhat smaller hole (and consequently a smaller rivet), to avoid weakening the shell unnecessarily. For size of rivet-holes, see table VI., p. 326. See also 'Rivets,' p. 121.

[12] Those who have studied the foregoing description will have no difficulty in distinguishing a pile of diaphragm shell from a pile of improved shrapnel; but it may be useful to collect here the several points of distinction. They may be distinguished, then, from the improved shrapnel in three ways:—(1st) By the *loading-hole*, which is much smaller in the diaphragm. (2nd) By the *socket*, which is flush with the surface of the diaphragm shell, but projects slightly in the improved shrapnel (it should be noticed that plug projects in both shells, but much less in the diaphragm than in the improved shrapnel); the diameter of the socket is also less in the last-named shell. (3rd) By the *fire hole*, which is situated in the side of the socket in the diaphragm shell, while in the improved shrapnel it is at the bottom of the socket.

[13] "Filled" (without metal plug, wood bottom and burster).

[14] The employment of diaphragm shrapnel shell with carronades must necessarily be restricted to very short ranges, the charges of carronades being too small to give the velocity requisite to produce any appreciable effects at long ranges. The same may

Application of Diaphragm Shrapnel shell.

The proposed application of the diaphragm shell is the same as that of the original shrapnel shell; viz., "not to supersede case or grape, "but to act as case or grape at longer ranges than are attainable with "those projectiles;"[1] and it is used therefore at ranges varying from 500 or 600 yards upwards, under circumstances very similar to those in which case and grape would be employed at shorter ranges, that is to say, against the *personnel* rather than against the *matériel* of an enemy.[2] The limit as regards the range at which they can be effectively employed is determined by the velocity which the shell should have at the moment of bursting; and in this respect the diaphragm shells have considerable advantage over the original shrapnel shells, which could only be fired with reduced charges (for fear of prematurely exploding them), and therefore with diminished velocities and at comparatively inconsiderable ranges,[3] while the diaphragm shell can be fired with the full service charge.[4] The distance in front of the object aimed at which they should explode to produce their greatest effect will depend upon the velocity which the shell has at the moment of fracture,[5] and this distance will vary from 20 to 120 yards.[6]

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be said of their employment with howitzers, though the greater charge will give a proportionally greater range and effect. But in determining the circumstances under which diaphragm shrapnel should be used, from any nature of ordnance, the artilleryman should never lose sight of the fact that velocity is the essence and limitation of shrapnel fire, and that, all other conditions being the same, the effect of shells of this class "will "be proportional to the initial velocity of the projectile." (See p. 43.)

It is a question whether, under certain circumstances, vertical shrapnel fire might not be effectively employed; and I think it is conceivable that circumstances might arise in which shrapnel shells fired from mortars would give good results—at ranges, for example, beyond the reach of pound shot charges.

[1] See pp. 41, 42, where also the action of a shrapnel shell is explained.

[2] "Shrapnel shell are most effective against troops (especially cavalry) in line, "column, or masses of any kind, when uncovered and at considerable ranges."—Owen's *Lectures on Artillery*, p. .

"The shrapnel shell is very destructive when used against bodies of cavalry or "infantry, as it produces the same effect as common case or canister shot from guns "or howitzers, but at a much greater range."—Griffith's *Artillerist's Manual*, p. 97.

"The shrapnel shell is by far the most effective projectile against skirmishers and "troops in line, and, if skilfully handled, is superior to any other missile under many "circumstances."—Col. Boxer's *Sandhurst Course*, p. 20.

"Shrapnel is case shot extended, but it requires very great skill on the part of those "who use it in order to combine the right elevation with the proper length of the "fuze."—*Manual of Artillery Exercises*, p. 17.

[3] See p. 46.

[4] "It appears to the Committee that the diaphragm shell can be used effectually "with the service charge."—*Report of General Sir W. Brereton's, K.C.B., K.H., Committee, December 14th*, 1858.

"In firing shrapnel shell from heavy ordnance with the old shell, it was necessary "to reduce the charge to prevent premature explosions; the diaphragm shell can be "fired with the service charge."—*Report of Colonel Sir George Barker, K.C.B., Royal Artillery, 11th January* 1858. See *Supplement to Synopsis of Ordnance Select Committee Report on Shrapnel Shell*, p. 22.

[5] Evidently, at long ranges, where the shell will have a low velocity at the moment of fracture, it will be desirable to burst it nearer the object than when the velocity is higher, and where the bullets will consequently preserve their effective striking force for a greater length of time.

[6] "The bursting of the shell should not be at a greater distance from the object than "about 120 yards," as the bullets, "from their comparatively small diameter, are much "influenced by the resistance of the air."—Colonel Boxer's *Sandhurst Course*, p. 20.

Shrapnel shell are intended to burst "30 or 50 yards short of" the object.—*Hand-Book for Field Service*, p. 5.

"The effect produced by the bullets will chiefly depend upon the bursting of the shell "at exactly the required instant; no precise rule can absolutely be laid down as to the "distance short of the object at which the shell ought to burst. It is generally con- "sidered that shrapnel shell should, if possible, be made to burst from 20 to 80 yards

The advantage of the diaphragm construction over that employed by General Shrapnel[1] in his original shell may be enumerated as follows :—1st. The fatal defect of premature explosion is completely overcome ;[2] 2nd. The shell will stand a full service charge, and its range and effects are proportionally increased ;[3] 3rd. The dispersive effect of the bursting charge on the bullets is probably reduced ;[4] 4th. The liability of the balls to become disfigured or to stick together is overcome ;[5] 5th. The keeping qualities of the shell are increased ;[6] and 6th. They may be carried "filled" with greater safety.[7]

Packing and issue.

Diaphragm shells are issued three ways :

(1.) Empty, loose, prepared for bottoms.
(2.) Empty, riveted.
(3.) Filled.

In all cases they are issued "filled with balls."[8]

They are issued (1.) "*Empty, loose*" only for India and on exceptional demands. In this case they have a diaphragm fuze hole plug[9] (leather collar underneath the shoulder) screwed into the fuze hole, the rivet hole plugged with bees-wax, and loading hole plug[10] screwed into the loading hole, the screw of which is lubricated with Rangoon-oil; and they are sent away loose and not boxed.

When issued (2) "*Empty, riveted,*" the usual condition of issue, except for India, as above stated, and for sea service, they have the fuze and loading holes secured as above, a wood bottom riveted on, and they are sent away in boxes similar to those used for shot and shell, the number per box varying with the nature.[11] The boxes are marked on the lid *in black* with the words " Boxer's Diaphragm Shrapnel Shell,—/58 pattern," the nature of ordnance with which those in the box can be used, the number in the box,[12] and date of issue. For tropical climates (when the shell have teak bottoms) the boxes have, in addition, the words " For Tropical Climates " marked on them *in black.*

They are generally issued (3) " *Filled* " for naval and boat service. They then have the fuze hole secured as above, and the papier maché

" short of the object ; or in practice the artillerist should endeavour to regulate the " fuze so that the shell may explode when about 50 yards (the mean between 20 and " 100) short of the object fired at. The bursting of a shrapnel shell at the proper " distance from the object fired at is of the greatest importance, &c."—*Owen's Lectures on Artillery,* p. 83.

"There is a point of much importance, which has been well established by the " results of the experiments lately carried on with diaphragm shell at Woolwich, " namely, that if the *elevation* be correct, it matters little whether the shell burst at " 100 yards or 20 yards from the object fired at."—*Remarks on Diaphragm Shrapnel Shell,* p. 44.

" The proper position of the point of rupture varies from 50 to 130 yards in front " of and from 15 to 20 feet above the object."—*American Artillery Course,* p. 456.

[1] For an inquiry into the general efficiency of these shells, and into the validity of the objections which have been urged against them, see Appendix C., p. 358.

[2] See p. 44.

[3] See p. 43.

[4] See p. 53.

[5] See p. 55.

[6] See p. 52.

[7] Owing to absence of friction with powder and bullets. See p. 52.

[8] The term " Empty " as applied to a diaphragm shell has, therefore, reference only to the absence of the bursting charge, and not to the absence of bullets ; these are always placed in the shells before issue.

[9] See screw gun metal plugs, p. 101.

[10] See p. 104.

[11] See table XII., p. 331.

[12] Except the boxes for the 150-pr., 100-pr., and 8 inch, which contain only one shell each, and are not marked with the number.

wad[1] in the loading hole underneath the plug, the wood bottom riveted on; and they are issued in boxes similar to those used for shot, the number per box varying with the nature.[2] The boxes are marked the same as the boxes containing "Empty, riveted" diaphragm, the word "Filled," marked in *red*, being substituted for "Empty." On the shell is stencilled the word "Filled."[3]

Subdivision (c.)—Incendiary and Miscellaneous Projectiles.

Under this head are included those projectiles which are used to carry fire into an enemy's position, whether with the object of setting fire to his buildings, stores, shipping, &c., or with the less directly offensive object of merely lighting up his works and discovering his working parties, &c.; also those projectiles which, like smoke balls and Manby's shot, have miscellaneous applications.

General history. The practice of throwing burning compositions and incendiary projectiles against an enemy dates from the most remote ages, and is probably nearly contemporary with the first employment of projectiles of whatever description.[4] Its antiquity has already been indicated by the mention which has been made of the facts that bars of red-hot iron and balls of red-hot clay were thrown from the balistæ to destroy the enemy and their works,[5] and that the grenade probably took its origin from the "fire pots" of the ancients.[6] Perhaps, however, the first and simplest form of burning composition employed was scalding water, which, we are told, was poured down upon besiegers when scaling a wall or breach.[7] The employment of burning oil for a similar purpose was a step in advance, which seems shortly to have followed.[8] In time boiling oil gave way to incendiary compositions of a more formidable and viscid nature, chief among which must be named the celebrated Greek fire.[9]

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[1] See p. 107.

[2] See table XII., p. 331.

[3] In accordance with *W.O. Letter*, 6/11/66, 75/12/2987.

[4] "Les hommes, des qu'ils ont cherché à se nuire, ont vraisemblablement fait "usage du feu contre leurs ennemis; et les récits qui attribuent à Alexandre le Grand "l'emploi des compositions incendiaires n'offrent rien d'invraisemblable; il est "certain que, plusieurs siècles avant nôtre ère, des mélanges de matières com- "bustibles furent employés dans les siéges, et lancés par les assiégeants ou par les "défenseurs. Thucydide, dans la relation du siége de Platée, Æneas le tacticien, "Végèce, Ammien Marcellin, et plusieurs autres écrivains en font mention."—*Le Passé et l'Avenir*, vol., iii. p. 2.

[5] See p. 6.

[6] See p. 21.

[7] See *Le Passé et l'Avenir*, vol. iii., p. 2.

[8] *Le Passé et l'Avenir d'Artillerie*, vol. iii., p. 2.—"The dwellers on the banks "of the Indus are said to have made a kind of oil which, being enclosed in earthen "jars and thrown against woodwork, caused so strong a flame as could only be "extinguished by mud thrown upon it."—Owen's *Lectures on Artillery*, edition 3rd, p. 4.

[9] Sometimes called "Wet fire, because it was observed to burn upon water" (*The Great Art of Artillery*, p. 227), or "Fire rain" (*ibid.*, p. 227), or "Oil of cruel fire" (*MS. notes*, by F. A. Abel, Esq., Chemist to the War Department); or "Maritime "fire" (Owen's *Lectures on Artillery*, edition 4, p. 3). The ingredients of Greek fire, as given by different writers, are very various; I select a few, some of which, at any rate, will amuse the modern chemist. "Saltpetre, naphtha, pitch, gum, and "bitumen" (Mr. Abel's *MS. notes*). "20 lbs. saltpetre, 8 lbs. sulphur vivum, and "5 lbs. of willow charcoal" (Owen's *Lectures on Artillery*, edition 3rd, p. 4);

This "fire" was generally thrown in pots or phials,[1] but sometimes it was projected in barrels from the warlike machines then in vogue,[2] or attached in a phial, or in a ball, to the heads of arrows, spears, and lances.[1]

"Tar, gum juniper, oil of turpentine, oil of bitumen, oil of sulphur, oil of nitre, or "saltpetre, oil of eggs, and oil of laurel or bay, each six parts; powder of dry bays "and of camphire macerated in brandy, of each 14 parts; of saltpetre, to the whole "weight of them all. Put all these into a glass vessel with a narrow neck well luted "and stopped up, then bury it in horse-dung for six months. This composition "shall be shaken every fourth day, and then distilled in seraphino."—(*The Great Art of Artillery, p.* 227.) "The residuum of turpentine, after the oil of it is drawn "off, oil of turpentine, of tar, of rosin, or pitch of cedar, of camphire, of bitumen, of "mummy, of new wax, of duck's grease, of pigeon's dung, oil of sulphur vivum, "oils of juniper, of laurel, of linseed, of hempseed, of petrol, oil of tyles, and of oil of "the yolks of eggs, each half a pound. Of saltpetre 10 lb., of sal ammoniac 7 ounces. "Let all these soak in brandy in such manner as to be covered by it, then buried in "horse dung, and renew it every third day. Then draw off a seraphino," (*sic*, probably means extract by distillation,) "which you shall thicken with ox dung "reduced to a very fine powder."—*Ibid.* p. 278.

"Probably contained sulphur, bitumen, naptha, camphor, and petroleum."—Cotty's *Dictionaire D'Artillerie*, p. 13.

"Prenez du soufre pur, du tartre, de la sarcocolle (espéce de résine), de la poix, du "sel décrépité, de l'huile de petrole et de l'huile commune. Faites bien bouilliér "tout ensemble. Trempez-y ensuite des étoupes, et mettez-y le feu. Si vous voulez "le transvaser, vous le passerez à l'entonnoir comme il a été dit plus haut. Allumez-"le, et il ne pourra être éteint qu' avec de l'urine, du Vinaigre ou du sable."—*Le Passé et L'Avenir*, vol. iii., pp. 18, 19.

Those who are curious in this matter will find other receipts given. *Ibid.* p. 19, and about seven others in the *Great Art of Artillery*, pp. 279 to 282. See also Grose's *Military Antiquities*, vol. i., p. 387 to 390.

[1] "These fires were thrown in pots at the enemy."—*The Great Art of Artillery*, p. 278.

"We will conclude, then, that the vessels which held the Grecian fire were made "of some *wood* or *metal*, and that they were open and not covered up like our fire "pots. The pots of earth or wood, &c." *Ibid.* p. 279. "That these ollæ or pots of "fire, and several other vessels filled with combustible composition, were used by the "ancients, to set fire to buildings, &c., is not to be disputed." *Ibid.* p. 385. "I "could bring several other authors in favour of the fire pots of the ancients." *Ibid.* p. 287. "It was thrown by hand enclosed in phials, in which it was kept."—Grose's *Military Antiquities*, vol. i., p. 389.

[2] *Grose's Military Antiquities*, vol. i., p. 389.

[3] *Ibid.*, vol. i., p. 389.

"Fire-arrows and darts were formerly called malleoli; I never met with any that gave "a more pertinent and rational description of them than Ammianus, who writes to "this effect. The malleolus, a kind of arrow, is formed thus:—'It is an arrow made "'of cane which between the cane or reed, and the head or point, is armed with an "'iron several times doubled, and made like a woman's distaff. The belly of it finely "'hollowed, and it is laid open or pierced in several places,' and 'the hollow trunk of "'it being filled with combustible matters, and fired, and shot easily from a large bow, "'(for if it be violently dismissed, the fire of it will be extinguished,) it will burn "'whatever it sticks in.'"—*The Great Art of Artillery*, pp. 398–9.

"Fire lances are not unlike a sort of long javelins, which were anciently called "phalaricæ, and were usually shot at the enemy by engines, or thrown by hand. "The phalarica is a kind of spear, armed with a great iron head, between which and "the staff it is wrapped round with rosin, bitumen, and tow steeped in oil, which is "called fiery, and being shot from the balista, sticks in any wooden works, and fre-"quently sets fire, &c."—*Ibid.* 401.

"Au bout des lances furent attachés des Vases que le cavalier devait briser sur "l'ennemi."

"D'autres lances avaient un fer creusé et ouvert à l'extremité, qui dardait un jet de "flamme pareil à celui qui s'echappe de la fusée."

"Les arcs lançaient des flèches portant aussi, près de leur pointe, une envellope "contenant la composition incendiaire," &c.—*Le Passé et L'Avenir*, vol. iii., p. 349. *Ibid.* 24, 27, and plate 2, figs. 10 to 14.

"The fiery darts of the wicked."—*Ephesians* vi. 16.

It seems probable that the effects of "Greek fire" were much exaggerated,[1] or at least that they were rather moral than physical; it is unquestionable, nevertheless, that the fire was much used,[2] and that it attained a great celebrity. The latter fact is sufficiently evidenced by the odium which even to this day generally attaches itself to the name of "Greek fire," by the strong moral feeling which exists against its use, and by the sort of tacit agreement which has been observed between civilized nations in respect to its non-employment.[3]

By degrees the number of incendiary compositions increased; the discovery of gunpowder, and its employment as a constituent of these

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[1] "Tout porte à croire que l'on a exagéré les proprietés du feu gregois."—*Cotty's Dictionnaire D'Artillerie*, p. 131.

"Les compositions . . . . n'inspirèrent plus autant de terreur quand elles furent con-" nues."—*Le Passe et L'Avenir D'Artillerie*, vol. iii., p. 352. A modern chemist reading over the ingredients in the different compositions professing to be "Greek fire," would certainly conclude that the *physical* effects had been exaggerated. Doubtless all these compositions had certain incendiary properties, and judiciously employed against combustible materials doubtless produced certain destructive incendiary effects; but that these effects were really as great as the writers of the time would have us believe, seems to be in the highest degree improbable, if not a physical impossibility.

[2] It is unnecessary, and would be in the highest degree laborious, to attempt to collect the different passages showing how generally the fire was employed in the early ages; but it may be mentioned that it was much more extensively used in *European* warfare than is generally imagined. Of this fact the following instances may be quoted:—"Philip Augustus, King of France, having found a quantity of it ready " prepared in Acre, brought it with him to France and used it at the siege of Dieppe, " for burning the English vessels in that harbour. It was also used at several other " sieges in France . . . . When the Bishop of Norwich besieged Ypres, A.D. 1383, " the garrison is said by Walsingham to have defended themselves so well with stones, " arrows, lances, Greek fire, and certain engines called guns, that they obliged the English " to raise the siege with such precipitation that they left behind them their great guns, " which were of inestimable value. A great part of that army was soon after besieged " in the town of Burburgh by the French, who threw such quantities of Greek fire " into it that they burned a third part of the town and obliged the English to " capitulate."—*Grose's Military Antiquities*, vol. i., pp. 389, 390.

[3] *Hewitt's Ancient Armour and Weapons in Europe*, vol. i., p. 90.

I have not overlooked the fact that "Greek fire," as it has been called, was used at the siege of Charlestown in 1863; but when I consider the strong official representations which the besieged general made on the subject to the Federals who were employing it, I cannot but regard this solitary instance of its employment in modern times as a violation of the rule which has by common consent been morally enforced against its employment. It is an exception which proves the rule, if ever exception did. At the same time, there certainly appears to be some inconsistency in condemning the employment of "Greek fire" and stigmatizing it with the epithets "cruel" and "barbarous," so long as carcasses and Martin's shells remain recognized instruments of warfare.

It may be interesting to give a few particulars of the Greek fire used at Charlestown. It is the invention of a Mr. Levi Short, and consists of two descriptions, one of which is a dry composition, the other liquid. The former is composed of saltpetre, sulphur, and lampblack driven into a little iron tube about 3 inches in length and half an inch in diameter, and open at one end. The composition is pierced a short distance up its centre with a fine hole and burns therefore with considerable violence from the open end. The outside of the tube is covered with pitch, with the object of creating a flame. A number of these tubes are placed inside a shell with the bursting charge, which is ignited by a fuze in the ordinary way. The explosion of the bursting charge opens the shell and ignites the little tubes of "Greek fire," which are thus scattered about among the enemy.

The liquid description is coal tar naphtha, which is thrown in shells or through hose, like water. It should be noticed here that experiments were some years ago carried on by the Ordnance Select Committee with petroleum, naphtha, and other inflammable liquids, with a view to determining its incendiary properties. The result of the experiments was not such as to justify the Committee in recommending their recognized employment, chiefly on account of the difficulty which presented itself of keeping it in a sufficiently *viscid* condition to be injurious.—See *Extracts from Reports and Proceedings of Ordnance Select Committee*, vol. i., pp. 469, 470.

compositions, or, at least, in conjunction with them, doubtless increased their reputation, as it must have increased their power and effects.[1] About the 17th century incendiary compositions were extensively employed. They were thrown in a variety of ways; in "fire pots" similar in character to those already alluded to,[2] in grenades[3] (in which form they must have closely resembled our modern carcass), at the ends of spears,[4] lances[5] and arrows,[6] as "fire rain,"[7] in the form of fire balls of all sorts,[8] such as "death's heads," the "pyrobolist's valet or attendant,"[9] "thundering balls,"[10] "fire crowns and garlands,"[11] "fire sacks,"[12] "stink balls,"[13] "light balls,"[14] "smoke balls,"[15] &c.

Of the projectiles thus enumerated the greater number have disappeared; some, however, such as light balls and smoke balls, are still retained in the service, the construction and even the compositions of those now in use resembling very closely those of the smoke and light balls of the 17th century.

With this slight sketch of the history of incendiary projectiles generally we may proceed to give a detailed account of those now in the service; and further particulars respecting their separate natures.

The incendiary and miscellaneous projectiles of the service are six in number, viz.:— Incendiary projectiles—Six classes.

1. Martin's shell.
2. Carcasses.
3. Ground light balls.
4. Parachute light balls.
5. Smoke balls.
6. Manby's shot.

1. *Martin's Shell.*[16]—There is no record of any projectile corresponding to Martin's shell having been employed until recently; and it seems certain that with whatever incendiary compositions shells may from time to time have been filled, it was reserved to the 19th century to devise the means of employing molten iron for this purpose, and of hurling shells filled with this terrible agent against an enemy. These shells were proposed by Mr. Martin, a civilian, in March 1855,[17] and appear to have been first experimented with in April 1856. 8-inch shells of Shell—Martin. History.

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[1] "It must be allowed that all the fire vessels of the ancients were but trifles and "children's play, when compared with ours; or at most, that they were but the "shadow of our modern fire-pots, because they wanted our thunder-imitating gun- "powder, &c."—*The Great Art of Artillery*, p. 385.

[2] *Ibid.* p. 382.

[3] "They were filled with gunpowder and sometimes with particular composition."—*Ibid.* 210.

[4] *Ibid.* 401. [5] *Ibid.* 401. [6] *Ibid.* 398. [7] *Ibid.* 274.
[8] *Ibid.* 249, *et seq.* [9] *Ibid.* 299. [10] *Ibid.* 272. [11] *Ibid.* 385.
[12] *Ibid.* 392. [13] *Ibid.* 296. [14] *Ibid.* 284. [15] *Ibid.* 287.

[16] Spoken of in the Select Committee Reports and War Office Circulars as "Martin's Liquid Iron Shells."

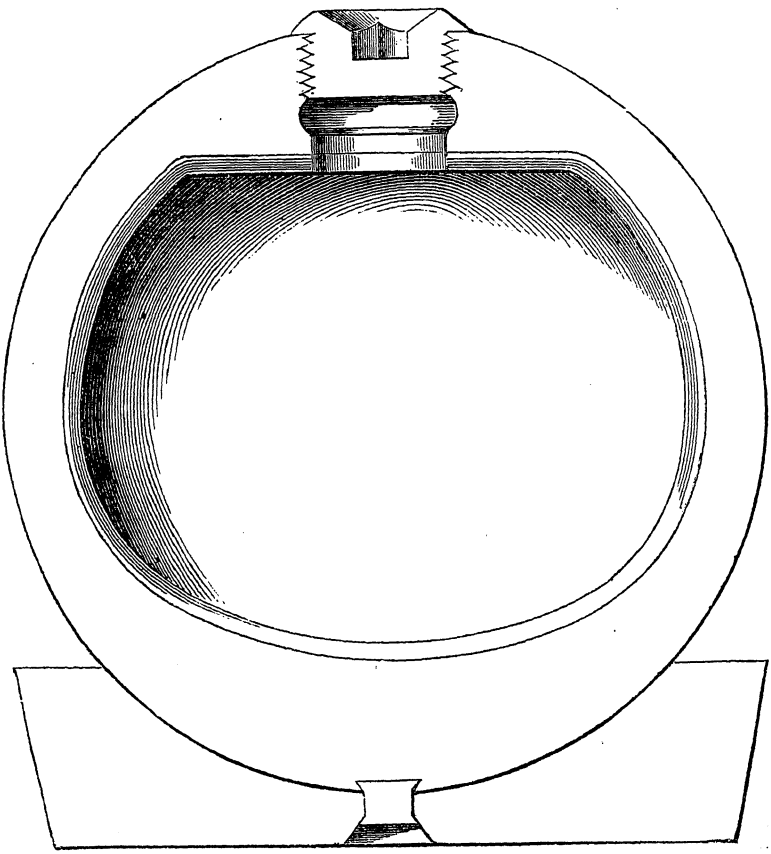
[17] It appears certain (*War Office Letter* to Mr. Martin, 20th July 1857) that Mr. Martin brought forward his invention as early as October 1854, although it does not seem to have been submitted officially to the Select Committee until the date I have given in my text. Mr. Martin's name is not the only one associated with shells of this nature, for in May 1854 Mr. Morris proposed a "liquid iron shell," which was rejected in the June of the same year. The subject was re-opened in December 1855, and Mr. Morris was invited to make some shells, at his own expense, for experiments; he did not avail himself of the invitation, which was kept open until 1857, when the authority for the experiment was, on the recommendation of the Committee, cancelled; also in January and February 1855, a Mr. Daft brought forward a shell of the same nature, which had been invented by a Mr. George Appleby; no mention is made of any trial having been made with these shells. However, in considering Mr. Martin's claim to priority of invention the War Office decided that his "claim to originality appears to hold good against

this nature were introduced into the service in October 1857,[1] though the present pattern was not approved until 1860.[2] No 10-inch were approved until 1860.[3]

Sizes.

Martin's shells are of two sizes, the 10-inch and 8-inch.[4]

MARTIN 8-INCH.



Description.

They are spherical cast-iron shells, coated in the interior with loam, and filled before loading with molten iron, which is poured in through a "filling hole," which corresponds to the fuze hole of a common shell.

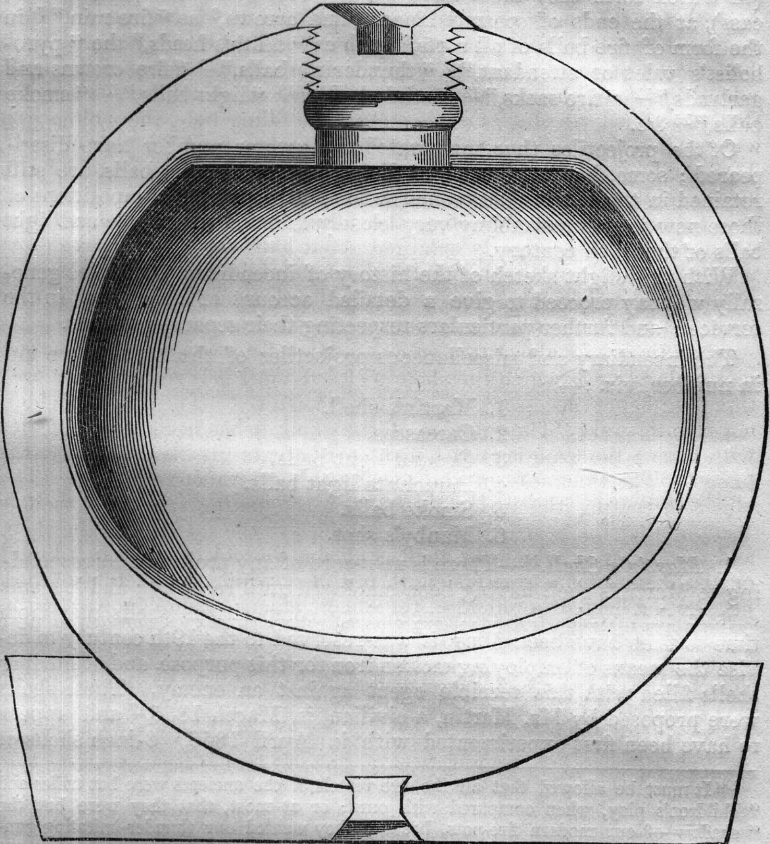
"Mr. Daft;" but the fact of Mr. Morris' shell having been proposed in April 1854—a few months previous to Mr. Martin bringing forward his shell (October 1854)—"seems," to use the words of the War Office Letter to Mr. Martin already quoted, "to justify caution in admitting you (Mr. Martin) to the credit of being the first "inventor." These facts are embodied in an *Ordnance Select Committee Report* No. 1,134, 24th July 1857.

1 "8-inch Martin's shells . . . . were introduced into the service by Lord Panmure's order in October 1857."—*Report of the Ordnance Select Committee, embodied in Horse Guards' Circular*, No. 856, 7th June 1860—24th December 1860, p. 3.

2 Approved 10th February 1860, *War Office Circular* 590, par. 4. The change in pattern made in the 1860 shells consisted in the groove in the filling hole being introduced. Previous to 1860 the filling holes were made plainly cylindrical.

3 30th May 1860, *War Office Circular* 639, par. 94.

4 Some 32-pr. Martin's shells have been manufactured and experimented with, but the experiments not having been satisfactory, the Select Committee did not recommend



Their external diameter is the same as that of common shells of corresponding calibres; their thickness of metal is less at the sides than at the top and bottom, in order that they may break up readily on striking an object; the metal at the bottom being made of such a thickness as will suffice to enable the shell to withstand the shock of the discharge of the gun. The top of the shell is made about the same thickness as the bottom, the thickness required being obtained by flattening the interior of the shell at this part, and not by rounding it off gradually as is done at the bottom.[1] The object of thus thickening the top of the shell, which has to withstand no shock or blow, is as follows: when the shells are filled, no plug is used to close the filling hole, the molten iron which flows into and fills this hole forming when "set" a plug of itself. The shell is thickened, then, to cause this metal to cool and solidify more rapidly.[2] In order that the metal when it sets in the filling hole may form a more effectual plug, the filling hole itself, which is otherwise cylindrical, is slightly enlarged about half way down, by a groove which is made in it at this point.[3] The metal flowing into and setting in this groove becomes more securely fixed than would be the case were the hole made plainly cylindrical.

The filling hole above this groove is tapped to receive a screw-gun metal plug,[4] with which the shell is closed until it is required for use; this plug being necessary to exclude moisture.[5] The filling hole is not countersunk. The interior of the shell, it has been said, is coated with loam; the loam is mixed with cow-hair, to give it greater consistency.[6] The thickness of the loam coating is about ·25-inch. The object of coating the inside with a non-conducting substance, such as loam, is that the heat is thus more confined in the *interior* of the shell, and the iron with which the shell is filled is thereby retained in a liquid or viscid state for a greater length of time; while the shell itself does not become heated so quickly, the inconveniences and danger arising

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their introduction into the service. The effect produced by small shells of this description does not appear to be great enough to compensate for the trouble and inconvenience necessarily involved in their employment. No intermediate sizes—42-prs. or 56-prs.—have been tried, as these guns are little used; nor have any 150-pr. or 100-pr. shells of this nature yet been manufactured, probably because these guns were introduced subsequent to the adoption of iron-plated ships, against which Martin's shells are comparatively useless.

[1] This square or flattened form answers the purpose better than the rounded form, as it gives the requisite increase of thickness exactly and *only*, at the point required, without interfering with the sides of the shell, any increase in the thickness of which necessarily diminishes the tendency of the shell to break up, as it is required to do, on striking an object. The flattened form also gives greater capacity to the interior of the shell, so enabling it to contain a greater quantity of molten iron. This form is not applicable to the bottom of the shells, because here the strength of the bottom must be, so to speak, *shaded off gradually* into the weakness of the sides, or the shock of the discharge would probably blow the bottom into the shell, fracture taking place round the angle where the sides joined the bottom.

The top of the shell being subject to no such shock or blow, and being thickened for quite another object (see text), is not liable to this accident.

[2] Evidently by thickening the metal of the shell at this part the length of the filling hole will be increased, and the metal at the top of the filling hole being thus so much further removed from the mass of molten iron in the interior of the shell will cool more rapidly.

[3] This groove was not made in the shells of the first approved pattern; but was first introduced in the shells approved in 1860, see p. 62, note 2.

[4] See plugs, p. 102.

[5] See p. 66 respecting the necessity of keeping the shell perfectly dry.

[6] The cow-hair also facilitates "ventilation" in casting.

from rapid expansion being thus avoided,[1] and the shell being more easily handled.

Martin's shells are painted black before issue, and are riveted[2] by single expanding rivets (pl. 34 fig. 8.) (in the same way as common shell) to wood bottoms.[3] When filled they weigh 115 lbs. and 159 lbs. respectively.[4]

Application. Martin's shells are used to set fire to wooden ships,[5] combustible stores, buildings, &c., in short, for the same objects as, and under similar conditions to, red hot shot, which they have in a great measure superseded.[6]

Action. They are fired against the object to be destroyed, and the shock of the concussion which they sustain on striking breaks up the shell and

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[1] It must not, however, be supposed that the shells do not expand at all. The following table extracted from the Committee's Report will show what the expansion of these shells is and at what rate it occurs.

	Inches.	Expansion.	Inches.
Diameter of shell before filling	7·87	—	—
,, one minute after filling	7·88	0·01″	—
,, eight minutes after filling	7·885	0·015	—
,, one hour after filling	7·95	0·08	—

See *Ordnance Select Committee Report* No. 856, 7th June 1860. Embodied in *Horse Guards Circular* of 24th December 1860, p. 9.

Another shell was gauged in the same way at different periods of time after filling with the following results :—

	Inches.	Expansion.
Diameter when cold	7·835	—
,, 15 minutes after filling	7·800	0·025
,, 30 ,, ,,	7·865	0·030
,, 45 ,, ,,	7·860	0·025
,, one hour ,,	7·855	0·020
Greatest expansion		0·030

Compare these results with those obtained in an experiment to determine the expansion of hot shot, given p. 145, note 4. Also *Handbook for Field Service*, edition 3rd, p. 299.

[2] Ordered to be riveted 17th February 1860, 75/12/505. See *War Office Circular* 590, par. 5.

[3] "It was found by experiment that the wood bottoms commence charring three " minutes after the shell is filled, and catch fire in about 15 minutes." See *Ordnance Select Committee Report* 856, 7th June 1860, embodied in *Horse Guards Circular* of 24th December 1860, p. 9.

The bottom is necessary to keep the filling hole of the shell towards the muzzle of the gun, and to keep the heated metal in the filling hole away from the wad, which is placed between the shell and the charge. It also serves as a sort of additional protection between the hot shell and the charge.

[4] *Ordnance Select Committee Report* 856, 7th June 1860, embodied in *Horse Guards Circular*, 24th December 1860, p. 8.

[5] Nor are they *altogether* useless against thin iron plates, as is proved by the following extract from the Committee's Report,—" Three struck iron plates of 1½ inch and 2 inches ; time filled, 11 minutes, 7 minutes, and 7½ minutes. They all broke up, *breaking away and forcing in large portions of the plates, much of the broken shells and molten iron passing into the section and setting it on fire*. See *Ibid.* p. 16.

[6] It must not be supposed that red-hot shot are *entirely superseded* by Martin's shells, for there are circumstances in which the former might be used with greater advantage than the latter; indeed, there are some circumstances, though rare, which would altogether forbid the employment of Martin's shells, such, for instance, as those referred to in Ordnance Select Committee's Report, 2,616 22/12/62. See *Extracts from the Reports of Ordnance Select Committee*, vol. i., p. 59). " Where space cannot be found " or made to place the cupola " (in which the iron for filling the shells is melted) " out " of the way of the guns, or where there is a danger of sparks entering magazines."

scatters forward its molten contents. They are most effective when they have been filled a few minutes.[1]

The grounds on which the Committee recommend their introduction are four:—1st. That they are easily filled.[2] 2nd. That they are more easily handled and placed in the gun than hot shot. 3rd. That in using them there is less danger of bursting the gun than with hot shot;[3] and 4thly, that their incendiary power exceeds that of hot shot.[4] To these might be added that they may, when desired, be made Advantages.

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[1] "The 8-inch shells . . . . appear to be most effective when filled between five and " eight minutes . . . . The same remarks appear to apply to the 10-inch shells, but the " number of rounds of this nature that have been fired is not sufficient to justify a precise " rule."—*Ordnance Select Committee's Report, No.* 856, *embodied in Horse Guards Circular*, 24th December 1860, p. 4. " One shell filled six minutes and another four and " a half minutes appear to have been the most effective in this practice."—*Ibid.*, p. 9.

[2] This statement of the Committee is intended to refer to the filling of the shells *after the iron is melted*, when the operation is simple enough. I give this explanation because otherwise I foresee that the statement nakedly expressed is liable to give rise to discussion on account of the difficulty which is believed by many to exist in preparing the cupolas and melting the iron. It does not properly enter into my province to discuss whether these operations are or are not difficult, but as connecting themselves with the employment of the projectile I offer the following considerations upon the subject:—In the first place, it is questionable whether the difficulties which are alleged to connect themselves with the working of the cupola have not been much exaggerated; in the second place, whatever difficulties may appear at the outset, there seems no reason why they should not be surmounted by efficient instruction, such as is now given at the Gunnery Schools of Artillery and Navy, and disseminated thence throughout the two services; in the third place, it must be borne in mind that the preparation of the cupola and practice in its use need not, and should not, be deferred until the shells are required to be used in actual warfare, but would be made a matter of ordinary drill in time of peace; in the fourth place, one or two instructed men in a crowd of uninstructed will be sufficient to direct and control the operations, and to cause the difficulties to disappear. Fifthly, and finally, I believe that any body of men of ordinary intelligence, who have never seen a cupola or been in any way instructed in its use, may, by carefully attending to the minutely detailed and admirable official *Instructions for the Working and Management of Portable Cupolas*, &c., which have been issued, dispense even with the two or three instructed men above referred to, and prepare the cupola, and melt a charge of iron without any assistance from practised hands. When these considerations are taken into account, and when it is remembered that, once under weigh, *ordinary labourers* can work the machine, reducing the metal to a liquid state in 20 minutes and making it yield a *ton of liquid metal every* 28 *minutes* (see *Instructions for the Working, &c. of Portable Cupolas*, p. 14, par. 70 and 71). Perhaps the unfavourable opinions which appear to be entertained by some respecting the use of these cupolas will be at least modified.

The following passage from a report of the Ordnance Select Committee bears upon the subject:—"They observe that Martin's shells were first adopted as being a far " more efficient means of offence than red-hot shot, and although the preparation of " these shells was attended with certain difficulties, it was considered that they were not " beyond the intelligence and education of the British artilleryman of the present day. " The technical instruction required for melting the iron is of a simple character and " very commonly diffused among the artizan class by the great extension of industrial " occupations in that direction."—*Extracts from Reports of Ordnance Select Committee*, vol. ii., p. 10.

[3] See what has been said, p. 63, about the loam coating preventing the rapid expansion of these shells, and p. 64 respecting their expansion.

[4] *Ordnance Select Committee Report, No.* 856, *7th June* 1860, embodied in *Horse Guards Circular Memo. of* 24*th December* 1860. Respecting the incendiary power of hese shells, I would refer those who wish for confirmation of this point to the numerous experiments recorded in this report. The following opinions have also been recorded by Capt. Hewlett, R.N., respecting these shells after much practice with them:— " I am of opinion that these shells filled with liquid iron are more certain and destruc- " tive in their incendiary effects than red-hot shot, or *any other missile at present* " *known.*" "I now beg to call their Lordships' attention to the fact that this trial " appears to be a *very conclusive one* as to the immense effect and destructiveness of " molten iron when used against wooden ships." "Each of the five shells that struck " the vessel fired the ship more or less, and the effect was that she was obliged to be

available as hot shot, by allowing them to remain for some time after filling, until the metal in the interior becomes set and the outer shell heated.[1]

In using these shells it is of the highest importance that the following points be attended to :—1st. That the shell is quite dry before being used, or there will be danger of accidents from the squirting up of the liquid iron by the steam which will be generated on pouring molten metal into a damp shell.[2] It would be desirable where practicable slightly to warm the shells before filling them.

2nd. That the shell be filled perfectly full, otherwise it will be more or less eccentric, and its accuracy of flight proportionally affected.[3]

3rd. That they are not fired immediately after filling, or they will be liable to break up in the gun.[4]

Packing and issue.

Martin's shells are always issued "riveted" they have the filling hole secured with the screw gun-metal plug,[5] and are packed in boxes similar to those used for shot, the number in each box varying with the nature of the shell.[6]

" sunk to prevent her being totally destroyed by fire."—*Horse Guards Circular Memo.*, of 24th December 1860, p. 19.

"At the present time, however, considering the increasing employment of iron plated " ships, and the probabilities of attack being made by vessels of this kind, the advan- " tages due to the employment of Martin's shells will be considerably reduced. The " great power and accuracy of rifled guns of large calibres will no doubt lead to an " extensive substitution of them for smooth-bore guns in sea batteries within a short " period, and will further narrow the circumstances under which Martin's shells will " be used. The use of molten iron is not contemplated for shells from heavy rifled " guns, as it is considered that even as an incendiary agent a shell with a large burst- " ing charge of powder is more dangerous than a shell of molten iron, while the suffoca- " ting effect of the smoke between decks and the destruction caused by splinters add " to the effect, and make it in every respect more formidable."—*Extracts of Reports of Ordnance Select Committee*, vol. ii., p. 10.

1 . . . . " One struck short and entered the bulk-head *en ricochet*, and set it on fire as a " red hot shot. This shell had been filled one hour when it was fired, and although " it had been rolled about its shape remained unaltered."—*Ordnance Select Committee Report*, 856, 7th June 1860, *embodied in Horse Guards Circular*, 24th December 1860, p. 9. " After 15 minutes the iron " (in the 8-inch shell) " becomes solidified, but the " shell will still act as a hot shot."—*Ibid.*, p. 4.

2 " The Committee recommended . . . . that they should be stored in a dry place, " and the attention of the officers, in whose charge they may be, called to the neces- ' sity of keeping the interior thoroughly dry, on account of the danger which would ' arise from the presence of moisture whilst pouring in the ' liquid iron.' "—*Ordnance Select Committee Report*, 856, 7th June 1860. See *Horse Guards Circular*, 24th December 1860, p. 3). " See that there be no moisture in the shells." *Instructions for the Working &c. of Portable Cupolas*, p. 18, par. xcvi.

3 " The Committee think it possible that the shells were not filled up, which would " account for their eccentricity and consequent erratic flight. It is very necessary " that these shells should be quite full, and as the iron settles down in the shell a little " a moment after it is poured in it is better to fill up a second time."—*Ordnance Select Committee Report*, 856, 7th June 1860, see *Horse Guards Circular* of 24th December 1860, p. 6.

It is evident that in addition to the concentricity and accuracy of flight of the shell being injuriously affected by not filling it completely, a partially filled shell could not have its filling hole plugged by the cooling metal in the same efficient way as a filled one, and for this reason, if for no other, it is necessary to observe that the shells are carefully filled to the top of the filling hole.

4 " The 8-inch shells should never be fired until they have been filled four minutes, " or they are liable to burst in the gun . . . . The same remarks appear to apply to " the 10-inch shells, but the number of rounds of this nature that have been fired is " not sufficient to furnish a precise rule."—*Ibid.*, p. 4, also *Ibid.*, pp. 13, 14.

5 See screw gun-metal plugs, p. 102.

6 See table XII., p. 331.

The boxes are marked on the lid *in black*, with the words "Martin's shell," nature, and the date of issue.[1] When for tropical climates (with teak bottoms) the necessary words are added.

2. *Carcasses* (see table VIII., p. 327, and pl. 20).—Considerable confusion and uncertainty existed for a long time, and until a comparatively recent date, respecting the application of the term "Carcass," a fact which admits of the following explanation :—As the range and powers of cannon increased it became necessary to strengthen the "fire balls" considerably, to enable them to withstand the increased shock due to a higher charge. This was effected in several ways, among others by encircling them with bars of iron, generally covered with canvas and quilted with cord; and "fire balls" thus strengthened received the name of "carcasses," a term which doubtless had reference to their construction, and which the *ribs* of iron and *skeleton* frame, filled with composition, rendered not inapplicable.[2] Gradually the oblong iron skeleton and canvas covering gave way to a yet stouter case, in the form of a thick spherical iron shell, into which the carcass composition was placed, the shell having in it vents for the passage of the flame when the composition should have become ignited.[3] This is the construction of the modern carcass, and to this projectile the name "carcass" was extended, being for some time used indifferently with these spherical iron shells, and with the oblong iron-frame and canvas-covered projectiles to which it had been first applied. Carcasses—History.

In this way we arrive at an explanation of the fact that nearly all works which profess to give an account of carcasses speak of them as of two natures, spherical and oblong, and describe, under the head of "carcasses," not only the projectiles which we now understand as such, but the oblong projectile with which modern artillerymen are familiar under the name of "Ground Light Balls."

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[1] The box containing the 8-inch Martin's shell has the date on the *end* instead of on the lid.

[2] I cannot produce any positive authority respecting the origin or early application of the word "carcass." It seems however to be implied in numerous works upon the subject which I have consulted, and very pointedly and strongly in the following extracts—that the distinctive difference between "carcasses" and "fire balls," as the names were first applied, is the one which I have suggested in my text, viz., that carcasses were first so called with reference to their construction; nor does this explanation appear to me in the slightest degree strained or fanciful: "On appelle "*carcasses* des balles a feu renferment une armature en fer plat, présentant la forme "que le projectile doit avoir, et destinée a lui donner plus de consistance."—*Instruction d'Artillerie*, p. 378.

"Les balles à feu se font avec les mêmes matières et se construisent presque de la "même manière que les carcasses. Leur différence consiste en ce que les carcasses "ont des bandes et des cercles en fer qui les lient, au lieu que les balles à feu sont "faites avec un sac de toile de forme ovale, et, de même que les carcasses, elles sont "cordellées avec du menu cordage, pour leur donner plus de solidité.—*Cotty's Dictionnaire d'Artillerie*, p. 23.

"There were formerly two species of carcasses in the service, viz., the old oblong "carcasses, a description of which will be found under the head of light balls, which "they very much resemble."—*British Gunner*, p. 101.

[3] The reasons for the adoption of the *spherical* form are so evident as hardly to require explanation. The iron shell construction admitted of the carcasses being used at longer ranges than the original oblong construction on account of its greater strength, but evidently the *full* range, the full advantage, that is to say, of this increased strength, could not be obtained except by altering the shape of the projectile—here, therefore, was one strong reason for the adoption of the spherical form; another, perhaps the principal one, was the great inaccuracy of flight of the oblong projectiles, a defect which might be regarded as inconsiderable so long as they were only used at very short ranges, but which it became necessary to overcome in proportion as the range increased.

In endeavouring to determine, therefore, the exact epoch at which carcasses were first employed, it is necessary carefully to distinguish between the carcasses first so called and carcasses as we now understand them. The history of the former sort blends almost imperceptibly into the history of fire balls and incendiary compositions generally, the history of the latter, spherical iron shell carcasses, is hardly as ancient. It is with the history of the latter that we are now concerned.

Probably carcasses, like shells, were occasionally and exceptionally used previous to their regular and general employment. In this way we may account for the mention which is made of their having been here and there employed as early as the 13th century.[1] From the description given of these projectiles, however, they seem to have resembled our modern carcasses in nothing but principle, and in being made of iron, their appearance and construction having been altogether different.[2] It seems certain that carcasses *of the present* construction are of much more modern date, and did not make their appearance until the 17th century;[3] and even as late as the close of the last and the beginning of the present century the original oblong carcasses had not been altogether superseded by those of the more modern spherical

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1 "De gros projectiles creux en fer, percés de plusieurs ouvertures, étaient lancés par "les trébuchets et portaient le feu au loin."—*Le Passé et l'Avenir de l'Artillerie*, vol. iii., p. 350.

"Ces projectiles étaient des vases en fer, percés d'ouvertures qui laissaient passer la "flamme."—*Ibid.*, p. 28.

2 They were of fanciful shapes, and filled with some of the numerous compositions of the time. They generally had four vents, or "doors" as they were called.—*Ibid.*, p. 29, and pl. 2, figs. 1 to 8.

3 I incline to the opinion that they did not make their appearance until the *end* of the 17th or *beginning* of the 18th century, and my grounds for holding this opinion are as follows:—I can discover no mention of carcasses, as we now understand them, in "*The Great Art of Artillery*," but in a note at p. 245 of the work the translator says—"Our carcasses are an improvement upon fire balls." This would make it appear as if carcasses had been introduced between the date of the first writing of the work in 1649 and its translation in 1729. This would fix the date of the introduction somewhere between the latter half of the 17th or the beginning of the 18th century. It may perhaps be urged that the translator is here applying the word "carcass" to what we now understand by "ground light balls," but I do not think this is the case, because in the description given of the different sorts of "fire balls" in the work which he is translating, some sorts appear to be almost identical with our modern "ground light ball," and the translator must therefore have meant something different to the ground light ball when he is speaking of carcasses being an improvement on these. Therefore, I conclude, he here applies the name carcass to the spherical iron shell carcasses.

James in his Dictionary certainly mentions their employment in 1592, but he does not say where, or under what circumstances they were then used, and I think this may be classed among instances of their exceptional employment previous to their regular introduction. He, however, speaks more precisely of their employment about the period which am inclined to assign for their regular introduction, viz., the close of the 17th century. He says they were then used by the Bishop of Munster at the siege of Grole, in 1672, where the Duke of Luxembourg commanded (p. 88). It is true that we also read of grenades filled with incendiary composition having been used at the siege of Breda, and at other operations in the Low Countries, about the beginning of the 17th century (see *the Great Art of Artillery*, p. 210, and 232 to 237); indeed, even earlier than this, "in 1588 at the siege of Vakterdonc, a town in Gueldres" (Grose's *Military Antiquities*, vol. i., p. 404), but the very fact of the employment of these projectiles as carcasses only seems to furnish an additional reason for believing that our *present form* of carcass, which is certainly better adapted for the purpose to which these grenades were applied, was not known at that time, but was subsequently introduced. I have, however, thought it safer, in spite of the strong presumptive evidence that they did not appear until the end of that century, to say that they did not make their appearance until the 17th century, without fixing any particular part of that century as to the period at which they came into general use.

iron shell construction, both sorts having been at that time in the service.[1]

Eventually, however (probably some time early in this century), the original oblong construction was altogether given up for carcasses, and only used for ground light balls, for which projectiles it is still retained.[2]

The first spherical iron carcasses had not always the same number of vents as at present, sometimes they had four, sometimes five, sometimes one or three vents,[3] but eventually they were all made with four,[4] and this number of vents came to be adopted for all iron carcasses.[5] The experience of the Crimea, however, showed that four vent carcasses were very liable to break up under the shock of the

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[1] *The Bombardier or Pocket Gunner*, edition 1813, p. 37, under the head of carcasses, their dimensions and weights, 1796, gives "round" carcasses for all natures of guns, howitzers, mortars, and carronades, from the 13-inch down to the 18-pr.; *also* four "oblong carcasses" for mortars and howitzers from the 10-inch to the 4$\frac{2}{5}$-inch. See also MS. work on "*Laboratory Work*," compiled about the beginning of this century by the late Sir Augustus Frazer, R.A., pp. 143 to 159, and at pp. 154–7, see drawings of the different natures of carcasses, including both spherical and oblong; indeed, it would almost appear from this work as if at that time there had been only one round carcass (the 13 inch), the other natures being oblong.

[2] The evidence as to the date when the oblong carcasses disappeared is most contradictory, probably in great measure owing to the confusion for some time existing between oblong carcasses and ground light balls. Müller's *Treatise of Artillery*, 3rd edition, published in 1780, has the following passage:—"None but round carcasses " are used at the present time, the flight of the oblong is so uncertain that they have " been quite laid aside." On the other hand I have shown (see note above), from *The Bombardier or Pocket Gunner*, and from Sir Augustus Frazer's *Laboratory Work*, that the oblong carcasses were in the service as late at least as 1796 and 1800. It seems certain, therefore, that they had *not* disappeared in 1800.

Nor do the contradictions cease here. James's *Military Dictionary*, edition 1816, says—"Oblong carcasses are obsolete in the British service," but *The Bombardier or Pocket Gunner*, edition 1827, still retains the four oblong natures. I imagine, however, that this is an error, for the *British Gunner*, 1828 edition, says—"The round " are the only species now employed, the use of the oblong being discontinued on " account of the uncertainty attending their ranges;" and in the preface of this work, speaking of the edition of the *Bombardier* published in the preceding year, the author says—"In 1827 Major Adye published an eighth edition, but in this, *while much " obsolete matter was retained*, many of the improvements to which the advanced state " of the service had led were entirely omitted" (preface, p. 3). It is certain, therefore, that the oblong construction ceased to be used for carcasses between 1800 and 1828, at any rate, and *most probably* between 1800 and 1816 (if the statement in James's Dictionary of the latter date, quoted above, be correct).

I have not overlooked the fact that Burns' *Naval and Military Dictionary*, edition 1854, describes carcasses as formed of "iron hoops and canvas and cord, and generally " of an oblong shape," but this *must* be an error (proceeding probably from the cause which I have assigned above for the different contradictions, viz. the confusion of the terms "carcass" and "light balls"), the oblong carcass having certainly disappeared before that date.

[3] "Formerly there were 13-inch round iron carcasses, with one, three, and five " holes each, but they are no longer in use; those with four holes being found to answer best.—*Laboratory Work*, p. 154.

[4] See preceding note. This change was probably officially adopted about 1808, a fact which I gather from a manuscript volume of experiments carried on under the superintendence of the Captain Instructor, Royal Laboratory, since 1855. In the report of some experiments which were made with carcasses in 1855, under Captain Orr's superintendence, the following passage occurs:—"In investigating the matter " some memoranda dated 1808, and signed 'William Congreve, Comptroller,' were " found, which observed that an alteration had been made about that period in the " pattern of the 13 inch carcass; but as there had been no demand for carcasses " during a peace, all the drawings had been lost except some with a thickness of metal " of 2·3 inches, and four vents."

[5] The *British Gunner*, edition 1828, describes all the natures of carcasses then in the service as having four vents, p. 101.

discharge, and experiments were carried on in 1855 which led to carcasses being made thenceforth with *three* vents.[1] As no patterns or drawings of carcasses existed at that time, and as it now became necessary to manufacture carcasses to meet the demand,[2] it devolved upon the Superintendent of the Royal Laboratory to submit drawings and patterns; and in 1860, these drawings and patterns were approved "to "govern the manufacture of future supplies." [3]

Until about 1854, another form of carcasses was employed in our service, viz., common or mortar shells, with a number of stars of "Valenciennes composition" placed inside them with the bursting charge; this composition, which is said to have derived its name from having been first used by the Austrians at the siege of Valenciennes [4] in 1794, was of the nature of carcass composition,[5] and when the shell burst, being ignited and scattered about, it set fire to all combustible materials upon which it fell. It was found, however, that these shells but imperfectly answered the purpose required of them, owing to the stars being blown to pieces by the bursting charge,[6] and accordingly Valenciennes stars are no longer used;[7] and the only recognized carcass in the service is the pattern approved in 1860.

Upon an emergency "shells may be made to produce the same effect "as carcasses, by putting into them, in addition to their bursting "charge of powder, pieces of portfire, ends of fuzes, and other strong "burning substances; these when scattered by the bursting of the

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1 *Manuscript Book of Experiments*, conducted by the Captain Instructor, Royal Laboratory, pp. 1–4.

2 Up to that time the existing store of carcasses had sufficed to meet the demand without any being manufactured.

3 Approved 9th July, 1860, 75/2/7. See *War Office Circular* No. 639, par. 96.

4 "Valenciennes composition, so called from its having been used by the Austrians "at the siege of that place."—*British Gunner*, p. 103.

"At the siege of Valenciennes the Austrians made use of shells filled with a peculiar "composition, which has since borne the name of that town."—*Straith's Artillery*, p. 147.

"This manner of using shells is mentioned by Captain Thomas Binning in 1689 "(p. 158):—'In your grenado you may put some little balls of unquenchable compo- "'sition, that when the shell breaks and brings down the rubbish of a house those "'little balls may raise fire afterwards.' It appears, however, to have fallen into "disuse, for it is not mentioned in *Adye's Manuscript;* and the name Valenciennes, "by which the composition has been distinguished since 1794, suggests that it was "unknown to the English Artillery when the Austrians used it at the siege of that "plae."—*Equipment of Artillery*, p. 98.

5 Valenciennes composition is composed as follows:—

Saltpetre	-	6·25 lbs.
Ground sulphur	-	2·5 ,,
Resin	-	1·25 ,,
Antimony	-	10 ozs.
Linseed oil	-	6·25 ,,

The 13, 10, 8, and 5½-inch shells contained nine stars of different sizes; the 4⅖-inch six stars. The proportions in each shell were—13-inch, 1 lb. 8 ozs.; 10-inch, 14 ozs.; 8-inch, 9 ozs.; 5½-inch, 5 ozs.; 4⅖-inch, 3 ozs.—Manuscript *Cadet Course*, pp. 382–3.

6 "It has been found by experiment lately that these stars are blown to pieces on "the bursting of the shell, and are therefore of little use when placed in ordinary "shells."—Manuscript *Cadet Course*, p. 383.

It has been suggested that these stars might be serviceable if placed in paper shells, as the bursting charge would not in that case have to be so large, and the shells would moreover contain more stars. Against this, however, it must be urged that a paper shell can be fired only with a very reduced charge, and is therefore available only for a very short range.

7 It was not until 1863 that Valenciennes composition was formally and officially abolished. The authority for its abolition is contained in *War Office Letter* 29/12/63, Woolwich, 57/4959.

"shell in which they are contained readily set fire to inflammable sub-"stances with which they may come into contact."[1]

There are nine different sizes of carcasses[2] (plate 20 and table VIII., p. 327) in the service, viz., 12, 18, 24, 32, 42, 56, 68 pr., 10″ and 13″. Sizes.

A carcass is a concentric cast-iron shell, filled with a combustible composition and having three fire holes or vents[3] for the composition to burn out of, situated in the upper hemisphere, equidistant from each other. The metal (pl. 20, section D, E) of a carcass is considerably thicker than that of a common shell of corresponding calibre, being rather more than one-fifth the diameter.[4] This construction is necessary because, being much weakened by the three vents, there would be a danger of the carcass breaking up under the shock of the discharge, if its strength were not increased by increasing the thickness of metal.[5] The determination of the thickness of metal is also influenced by another consideration, viz., the fact that as a carcass is not required to burst, it must be made of sufficient strength to withstand the pressure exerted upon it by the gas which is generated in its interior by the burning composition. Description.

This consideration also connects itself with the determination of the size of the vents, which are made of a size to admit of the composition burning freely without exerting an undue pressure upon the interior.[6] The vents are cylindrical in form, and are situated, as has been said, equidistant from one another in the upper hemisphere of the carcass,—in the hemisphere, that is to say, which goes away from the charge.[7]

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[1] *Straith's Artillery*, p. 147.

It is also laid down in an authorized *Course of Laboratory Instruction*, published by the "Permanent Select Committee of Artillery Officers at Dum Dum" "that shells, "common (unserviceable), are made into carcasses by having holes bored into them" (p. 58). I have not embodied this suggestion in my text, because it seems to me that it is not a very valuable one. The shells would be so much weakened by the presence of these additional holes that they could only be used with the most reduced charges, and their application would from this cause be so limited as to make shells thus prepared practically of but little value.—(See text above on this subject; and respecting the making of carcasses so much thicker than common shell.)

[2] Present pattern approved, 9/7/60, *War Office Circular* No. 639, par. 96.

[3] Sometimes called "fuze holes." The designation vent, or fire hole, appears to me, however, to convey a more correct idea of the nature and object of the holes.

[4] The proportion which the thickness of metal bears to the diameter is as nearly as possible as ·214 : 1, except in the case of the 13-inch, where the proportion is more nearly as ·23 : 1.

[5] Mention has already been made (see p. 69) of the fact that carcasses were not always made with three vents, and that the experience of the Crimea showed that four-vent carcasses were very liable to break up under the shock of the discharge. This experience, and experiments carried on in 1855, led to all carcasses being thenceforth made with three vents, and to the metal being made of such proportionate thickness as would enable the carcass to withstand the shock of the discharge.

[6] The diameter of the vents bears a fixed proportion to the thickness of metal, and is very nearly as ·9 : 1; expressed in terms of the diameter of the carcass, the diameter of the vents will be to the diameter of the carcass very nearly as ·192 : 1. These proportions do not quite hold good in the case of the 13-inch, where the diameter of the vents : thickness of metal : : (very nearly) ·8 : 1, or diameter of vents : diameter of carcass : : (very nearly) ·18 : 1.

[7] The distance apart of the vents is such as to bring them all within one hemisphere, and varies, of course, with the size of the carcass. It will be found that if a point be taken in the centre of the group of vents, and a straight line drawn from this centre to the nearest point of each vent, the length of the line will be (nearly exactly) double the diameter of the vent, or very nearly the thickness of metal multiplied by 1·8.

The 13 and 10-inch carcasses are fitted with lewis holes, which have superseded the lugs with which these natures were originally provided.[1] The object of the lewis holes is, as in the case of the two higher natures of mortar shells, to facilitate loading.[2]

The composition with which carcasses are filled is composed of the following ingredients, melted and mixed together :—

	lbs.	oz.
Saltpetre, ground[3] - - - -	6	4
Sulphur, ground[4] - - - -	2	8
Rosin, pounded[5] - - - -	1	14
Antimony, sulphide of[6] - - - -	0	10
Turpentine, Venice - - - -	0	10
Tallow, Russian[7] - - - -	0	10

The shell is completely filled with the composition,[8] and a cylindrical hole about ·5 inch in diameter and enlarged at its upper end, is made through the centre of each vent down into the composition, and driven with fuze composition.[9] There are thus three of these holes in each carcass; one of them passes more than half way through the compoition, and is longer than the other two, which are of equal length, the wo shorter approaching the longer on either side, about the centre of he carcass, without quite breaking into it.

The enlarged part of each hole is matched with a piece of quick match, a small hole is drilled into the fuze composition to ensure its

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[1] In the case of the 10-inch carcass, no distinction is made whether the projectile be intended to be fired from a gun, howitzer, or mortar; this nature of carcass always having lewis holes or lugs and vent hole, and thus being available for either nature of ordnance.

[2] See p. 313.

[3] See p. 318.

[4] See p. 316.

[5] Sometimes called "colophony." For distinction between rosin and resin see p. 316.

[6] Sometimes called "crude antimony." See p. 311.

[7] Russian tallow is generally used; but ordinary or "town made" tallow answers as well.

[8] It is most important that it should be *completely filled*, otherwise, and if interstices and spaces be left, there will be a danger of the shell proving unequal to the increased internal pressure to which it will be subjected; such increase of pressure arising from the generation of a greater amount of gas in its interior, in proportion to the number and extent of these spaces and interstices.

Moreover, if the carcass be not completely filled, the composition will be liable to suffer from the shaking to which it is almost certain to be subjected to on service, and will probably be fissured and cracked, if not partially pulverized, in this manner.

[9] For exact dimensions of the holes see table VIII., p. 327.

The method of making these holes into the composition connects itself more properly with the manufacture of the projectile than with a description of its construction; nevertheless, it may, perhaps, serve to make that description more intelligible if the method be briefly explained. It is as follows:—The composition is placed into the carcass in a hot, soft state through one of the vents, the other two being temporarily closed with bungs; and directly the carcass is full the bungs are removed and a wooden plug of the size and shape of the required hole is forced into each vent, two of these plugs being shorter than the third. The handles of the plugs are then tied together to prevent them from shifting. The plugs are greased previously to placing them in, to prevent the composition from adhering to them. When the composition is nearly "set" they are withdrawn, again greased, and then replaced. They are allowed to remain until the composition is quite cold and hard, when they are taken out, and the holes thus formed driven with fuze composition and matched.—(See on the subject of this hole, p. 74, note 1.)

ignition, and a plug of brown paper is placed into the hole over the match to protect it. Finally, each vent is secured by a "barras cap," (considerably larger in diameter than the vent), which is "kitted" over it, and sprinkled with sawdust to prevent it from sticking to other bodies with which it may come into contact.[1] Carcasses are riveted to wood bottoms when they are fired from guns and howitzers, but not when they are fired from mortars.[2] The bottom is fixed to that hemisphere of the carcass which has no vents in it, and is attached in the same way as that of a common shell, with a single expanding rivet,[3] the rivet hole being opposite the centre of the group of vents. All carcasses except the 13-inch have a rivet hole drilled in them, in order that they be used with or without wood bottoms, according to the nature of ordnance with which they are used.[4]

Carcasses are painted black before issue, and weigh, when filled, rather more than filled common shells of the same calibres.[5]

Carcasses are fired from guns, howitzers, carronades, and mortars.

Application. They are used to set fire to shipping, buildings, and combustible stores, being employed chiefly in bombardments, and in repelling naval attacks.[6]

Action. The fuze composition is ignited at each vent by the flash of the discharge, and continues burning during the flight of the projectile, gradually and thoroughly igniting the carcass composition, through the

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[1] It is the same arrangement as that of the "kit plaster" used to cover fuze holes of filled mortar shells. (See p. 38.)

It is hardly necessary to state that the barras cap and plug of paper must be removed from each vent before loading. (See *Manual of Artillery Exercises*, p. 107, for directions respecting practice with carcasses.)

[2] The reason for attaching wood bottoms to carcasses when fired from guns and howitzers is of course to keep the vents on the side away from the charge. In the case of mortars bottoms are unnecessary. (See p. 37.)

[3] The same rivet as is used with common shell. See p. 121.

[4] The 13-inch carcass could never be fired except from a mortar, there being no guns or howitzers of corresponding calibres. It is therefore unnecessary that it should be furnished with a rivet hole.

[5] In the case of the 13-inch, as there is no common shell of that size, the comparison is made with the mortar shell.

A reference to table V., p. 325, and table VIII., p. 327, will show that this calculation as to the comparative weight of carcasses and shells is very rough. In some instances the weights are nearly equal. In the case of the 13 and 10-inch, on the other hand, there is very great disparity of weight between the two descriptions of projectiles, the 13-inch carcass being about 30 lbs. heavier than the 13-inch shell; and the 10-inch carcass about 20 lbs. heavier than the 10-inch shell.

For this reason the full service charge is not allowed to be used in firing carcasses from the 13-inch sea service mortar and the 10-inch gun. (Upon this subject, and for the reason for reducing the service charge for the 13-inch sea service mortar when firing carcasses, and not reducing the service charge of the 13-inch land service mortar, which is a lighter piece, see note 2, p. 147.)

As regards the great disparity of weight between the 10-inch carcass and common shell, this is partly due to the fact that the shell, as already explained (see note 3, p. 25), is of proportionally thinner metal than other common shells. It will be observed that the disparity of weight does not exist to the same degree in the case of the 10-inch *mortar* shell, which is heavier than the 10-inch common shell, and consequently more nearly the weight of the carcass of that calibre.

[6] "Carcasses are chiefly employed in bombarding towns, to produce conflagration." —Col. Boxer's *Sandhurst Course*, p. 21.

"Carcasses are chiefly employed in bombarding towns, shipping, &c."—Owen's *Lectures on Artillery*, edition 4th, p. 84.

Carcasses "are much used in bombardments of towns and setting fire to shipping." —*Artillery Tables, &c., with Course of Laboratory Instruction*, p. 58.

interior of which it passes, and which attains its full violence when, but not until, the fuze composition is consumed.[1]

The carcass composition then burns with great violence out of the three vents, igniting all combustible substances within its reach.

Carcasses will burn from about three to 12 minutes, according to their natures.[2]

Their value as incendiary projectiles is neutralized to a certain extent by the fact that although they cannot be easily extinguished, they may be smothered by throwing earth upon them, or by rolling them away to a place where they can do no harm, or by throwing them overboard in case of their falling into a ship: and owing to there being no danger in approaching them, or much difficulty in handling them, these measures may generally be easily and safely taken.

'acking and ssue.

Carcasses are issued either—

(1.) Empty, loose, prepared for bottoms.
(2.) Filled (and finished[3]) and loose, prepared for bottoms.
(3.) Filled (and finished), riveted.

Carcasses are very rarely issued (1.) "*Empty, loose.*" All are issued in this way for India;[4] with the rivet-holes plugged with beeswax,[5] and unpacked.

Carcasses are issued (2.) "*Filled (and finished) loose, prepared for bottoms,*" for mortars only; they have the rivet-holes beeswaxed,[6] are packed in boxes, similar to those used for shot, the number per box varying with the nature.[7] The boxes are marked on the lid *in red*, with the words "Carcasses," "Filled," the nature of ordnance with which those in the box can be used, the number in the box, the date of issue, and tare and gross weight of box.[8]

The more common way of issuing carcasses is (3.) "*Filled, riveted.*" They are then packed in boxes, as above, the boxes being marked on the *side in red*, with the words "Carcasses filled," the nature and number; and on the top of the box, also *in red*, the packer's name, station, and date of issue, tare and gross weight. For tropical climates (when the carcasses have teak bottoms) the boxes have on them, in addition, the words "For tropical climates," *in red*.

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[1] It will be observed that by the arrangement adopted of making three holes and driving them with fuze composition, the surface of carcass composition which becomes ignited on the projectile first leaving the gun is inconsiderable, being gradually extended as the fuze composition burns away. Thus the violence or full effect of the carcass is in a measure restrained or economized until the time when it is required—until the time, that is to say, when the carcass reaches the object fired at; while the violence will *then* be greater—in proportion to the greater extent of surface ignited—than it would be if there were no holes with fuze composition. In fact, these fuze holes act much like the fuzes of shells, carrying the fire until the moment of required action arrives, the bursting charge of the shell, in this illustration, representing the carcass composition.

[2] The following table shows approximately the mean of the actual times of burning of a large number of carcasses burnt in the Royal Laboratory at proof by the Assistant Superintendent, at different periods:—

13-inch carcass, mean time	of burning	about	11·7	minutes.
10-inch do.	"	"	9·0	"
8-inch do.	"	"	8·0	"
32-pr. do.	"	"	7·0	"
24-pr. or 5½-inch	"	"	5·5	"
12-pr. or 4⅖-inch	"	"	3·5	"

[3] By "finished" I mean matched, primed, and the vents secured with the "kit plaster."

[4] Captain Fraser's *Notes on Matériel*, p. 5.

[5] Except the 13-inch, which has no rivet hole (see p. 73).

[6] See preceding note.

[7] See table XII., p. 331.

[8] The box containing the 13-inch is not marked with the tare and gross weight.

3. *Ground Light Balls.*—The history of ground light balls has been already in a measure indicated in the history of incendiary projectiles generally, and of the carcass in particular. Balls—Light Ground.

The great antiquity of the projectile makes it difficult to determine exactly when they were first employed, or to separate the history of light balls of the present construction from that of the "fire balls" of much earlier date.[1] It is certain, however, that ground light balls of the present construction preceded carcasses, being used *as* carcasses, long before the spherical iron shell carcass was introduced;[2] and it is probable that the construction was adopted for fire-balls as an inevitable consequence of the introduction of gunpowder as a propellant agent, and the development then given to the range and powers of cannon.[2] Before that date fire balls and light balls, for the two terms were commonly used almost synonymously,[3] were made of an infinite variety of shapes and constructions,[4] many of which, indeed, were retained until a comparatively modern date. History.

Balls of tow steeped in an incendiary composition were used for the purpose,[5] and balls of stone or iron covered with composition,[6] and paper shells similar to our present smoke balls filled with composition;[7] but the most common plan was to place combustible matters and composition into a stout canvas bag, either oval or spherical, and to strengthen the bag with woolding,[8] and in some cases with a saucer-shaped iron top and bottom.[9]

This latter construction, which we find in vogue as early as the 17th century, was almost identical with that of our modern light balls, with

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[1] See History of Incendiary Projectiles, p. 58.

[2] See p. 67.

[3] If any distinction existed it was as follows:—*Fire balls* were used to carry fire into the enemy's works, both to set fire to them and to light them up. They thus served the double purpose of carcasses and light balls, as we now understand the terms. *Light balls*, on the other hand, were not used for hostile purposes, but merely to light up the works of those who employed them. "Light balls are made in the same "manner as fire balls, but contain no shells, and are used to light up our own works." —Gibbon's *Artillerist's Manual*, p. 283; see also *American Artillery Course*, p. 361, to same effect.

At the same time, this distinction was by no means carefully preserved, for in the *Great Art of Artillery*, we find, under the head of "*Light Balls*," the following description of their use: "These may be thrown amongst the enemy when they are in "the ditch, or at the foot of a rampart, or preparing for an assault; they will also "serve to annoy those who are at work upon the galleries, or who approach you by "sap to lodge themselves in the mines. By their brightness they will also show you "whatever is doing without your walls; in short, these nocturnal lights will dis-"cover to you all the enemy's contrivances and stratagems to compass the ruin of "your fellow citizens and yourself. They moreover will not only serve to light you "in the night, but burn most outrageously and destroy everything that is within the "sphere of their action."—*The Great Art of Artillery*, pp. 284–5.

Extracts from other authors might be made to show that there was no precise and fixed meaning applied to these terms. Burns' *Naval and Military Dictionary*, for instance, gives them as synonymous.

There are therefore, I think, good grounds for saying that they "were commonly "used almost synonymously."

[4] "The form of fire balls may be very various."—*The Great Art of Artillery*, p. 245. In this work six different sorts of fire balls are described (p. 249 to 257), and four sorts of light balls (p. 284 to 286). "Various sorts are described by different "authors."—*Müller's Treatise of Artillery*, p. 206. "There are various sorts of fire "balls and light balls."—*James's Military Dictionary*, p. 34.

[5] Müller's *Treatise on Artillery*, p. 206.

[6] *Ibid.* p. 206.

[7] *Ibid.* p. 206. James' *Military Dictionary*, p. 34. This plan was not obsolete in 1828. See *British Gunner*, pp. 53, 54.

[8] See *The Great Art of Artillery*, pp. 249 to 257, where six different varieties of this form of fire balls are described.

[9] *Ibid.* p. 252.

the exception of the iron ribs, by which in these latter the ends are connected, and the projectile strengthened;[1] the addition of these ribs was an improvement which doubtless soon followed;[2] and projectiles of this construction were used, as has been explained, as carcasses until their supersession by the spherical iron shell carcass of the present pattern.[3]

To make fire or light balls more dangerous to approach they have at different times had grenades and small shells attached to them,[4] and this arrangement, which seems to have much to recommend it,[5] is still retained by the Americans.[6]

It is evident from the above that light balls (pl. 26) of the construction now in vogue date from some centuries back; indeed, even the compositions employed for fire and light balls in the 17th century were in their ingredients almost identical with those now used.[7] It must

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[1] These "fire balls" so nearly resemble the light balls of the present day that I append the description given of them in *The Great Art of Artillery*. "In the preparation of this, you must first have a bag (no matter whether it be spherical or "spheroidical), in the bottom of which you shall fix six or eight or more hand grenados, "with very short fuzes, which shall be turned downwards; these grenado's shall be "afterwards buried under a proper composition, with which the remainder of your fire "ball shall be quite filled up; you shall then have two iron basons like scales, the "rims of which shall be bored through with little holes. That which you design to "be uppermost shall be open at top like a milk strainer. To the opening of the upper "bason you shall solder an iron fuze, which must be filled with one of the compo-"sitions we have already given for fuzes. This done, clap your basons upon the top "and bottom of your ball, and lace them tightly on through the aforesaid holes in the "rims of them."—p. 252.

[2] Even at this early date (the 17th century) we find *iron wire* used to strengthen the balls, as the author of *The Great Art of Artillery* mentions its employment in the case of light balls, "for fear they should be dispersed in their projection, or fly to "pieces in the air, instead of remaining whole and entire as they ought."—*The Great Art of Artillery*, p. 285.

[3] See p. 67.

[4] See description of fire ball quoted from *The Great Art of Artillery*, note 1 above.

[5] See passage in *British Gunner*, extracted from Col. Jones' *Journal of the Siege of Ciudad Rodrigo*: "Light balls are of such excellent use in discovering working "parties, that surely some means ought to be taken to render them of dangerous "approach, by attaching (to them) a grenade or other missile so prepared as to "explode at uncertain periods of their burning.

"At these sieges two or three bold men of the Engineers' brigade were always in "readiness to run up and extinguish the light balls as they fell, and generally suc-"ceeded, in a few seconds, in smothering them with filled sand-bags, or by shovelling "earth over them."—*British Gunner*, pp. 55–56.

[6] "*Fire balls* are oval-shaped projectiles, formed of canvas sacks filled with combustible material . . . . the sack is placed in a spherical mould, ... and a layer of soft composition placed in the bottom. On this is placed the shell, with the fuze down, it being kept in its place by twine passing through the sides of the sack, or by a piece of canvas sewed to the sides," &c.—*Gibbon's Artillerist's Manual*, pp. 282–3. Also, *American Artillery Course*, p. 360, to same effect.

[7] In proof of this I give side by side the ingredients now used in ground light balls, and one of many compositions given in *The Great Art of Artillery* for the same purpose.

COMPOSITION

Of the present light ball.	Given in *The Great Art of Artillery*, p. 247.
Saltpetre.	Saltpetre.
Sulphur.	Sulphur.
Rosin.	Rosin ("colophone").
Linseed oil.	Meal powder.

and in treating of the preparation of these compositions the author says, p. 248: "You "will not do amiss if you sprinkle your composition over with a little oil of some "sort." We have thus the whole of the ingredients as at present used, with the addition of mealed powder.

not be supposed, however, that this construction and composition have been retained as being superior to anything which the modern artilleryman and chemist could suggest; on the contrary, both construction and composition admittedly very imperfectly answer the ends required of them, and the projectiles, although still in the service, are so inferior in many respects to the parachute light ball as to have become almost virtually obsolete.[1]

There are four natures of ground light balls (pl. 26, and table) in the service, viz., 10, 8, $5\frac{1}{2}$, and $4\frac{2}{5}$ inch.[2] Sizes.

Ground light balls are oblong[3] projectiles, about $1\frac{1}{2}$ calibres in length. Description. They consist of an iron skeleton frame (pl. 26, figs. 4, 5), partially covered with canvas, filled with an inflammable composition, and woolded (pl. 26. fig. 6 K.) over what may be distinguished as the cylindrical part with cord or twine, vents (pl. 26, fig. 5, *a b*) being provided at the upper end for the composition to burn out of.

The two higher natures differ from the two lower in several details of construction: in the first place, the skeleton frame consists, in the higher natures, of an iron cup at top and bottom, connected by four stout iron ribs,[4] equidistant from one another, welded together and riveted to the insides of the cups, the whole being strengthened by a circular iron band, which passes horizontally round the interior of the other ribs, and is riveted to them midway between the cups. The open or cylindrical part between the cups is covered with canvas,[5] and (after filling) woolded with cord. The lower natures have only an

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[1] Respecting the objections to which ground light balls are open, see p. 79.

[2] Captain Fraser in his *Notes of War Material* gives *five* natures of ground light balls, viz., the four I have given and the 13-inch. He, however, appends the following note to this statement: "There appears to be a doubt as to whether the 13-inch is "authorized, but a few were made and issued from the Royal Laboratory some time "back" (p. 1).

There seems to be no doubt that 13-inch ground light balls were in the service at the beginning of this century, as tables are in existence giving the dimensions of this nature, (in Sir Augustus Fraser's *MS. Laboratory Work*, under the head of carcases, he gives 13-inch "oblong hammered iron carcases," which are what we *now* call ground light balls; some old *Laboratory Course* Books also give the dimensions of "13-inch ground light balls,") and I am unable to discover that this nature of ground light ball has ever been officially pronounced obsolete. Practically, however, they may be said to have become so; several facts point to this conclusion, the most important of which I may enumerate. Foremen and others who have been employed in the Royal Laboratory at Woolwich for periods varying from 28 to 35 years speak with great certainty as to none having been manufactured during their service; the books of the department, which have been examined as far back as 1823, show that none have been issued during the period of 40 years; there is no pattern of a 13-inch ground light ball in the pattern room of the department; no one whom I have consulted can speak positively to having seen one, nor do there appear to be any in existence; they are always treated as non-existing, the *British Gunner* (1828 edition), the *Hand Book for Field Service* (third authorized edition), some *MS. Notes on Laboratory Material*, by Colonel Boxer, written several years back, all store returns and drawings, give only the four natures that I have named in the text; a memorandum of Colonel Boxer's for the Ordnance Select Committee, dated 24 January 1860, contains the following passage: "The following natures light balls are at present in the service . . . . viz., 10-inch, "8-inch, $5\frac{1}{2}$ and $4\frac{2}{5}$-inch;" and finally when, in 1862, the Ordnance Select Committee assigned charges to the different natures of ground light balls, they dealt only with the 10, 8, $5\frac{1}{2}$, and $4\frac{2}{5}$-inch, and treated the 13-inch as non-existing.

Therefore, although 13-inch ground light balls were doubtless at one time or another in the service, they may be regarded as having become altogether obsolete.

[3] As nearly as possible egg-shaped.

[4] The four ribs are made out of two bands of iron, the pieces of iron employed for the purpose being long enough to double, and form each two ribs.

[5] A stout description of cane called "Osnaburg" is used for the purpose; it is placed twice round the frame.

iron cup at *bottom* (pl. 26, fig. 1, E, A, F), the top being closed by carrying the canvas[1] covering over it, and the shape being defined by the ribs, which are arranged as in the higher natures.

The higher natures are fitted with two "lugs" (pl. 26, fig. 4, *c c'*) at the top, to facilitate loading;[2] the lower natures have no lugs; the former have also five vents, the latter only four. The vents are in both cases situate at the top of the light ball—through the cup in the one case, through the canvas in the other—between the ribs, the fifth vent in the 10 and 8-inch being made in the centre of the cup through the top junction of the two ribs; and, finally, the higher natures differ from the lower in being made altogether stronger, stouter iron being employed for the ribs and cups,[3] and cord instead of twine being used in woolding.[4]

The composition with which ground light balls are filled is composed of the following ingredients,[5] melted and mixed together:

	lbs.	ozs.	drs.
Saltpetre, ground[6] - -	6	4	0
Sulphur, ground[7] - -	2	8	0
Rosin, pounded[8] - -	1	14	0
Oil, linseed, boiled - -	0	7	8

The "ball" is completely filled with the composition, and cylindrical holes (pl. 26, fig. 7, S, Q, and fig. 3, P, R), which, when the composition is cold and hard, are driven with fuze composition, made in it at each vent, in the same way as in carcasses, and for the same reasons, viz., to facilitate the ignition of the composition.[9] These holes all penetrate towards the centre of the composition. In the case of the 10 and 8-inch the centre hole (pl. 26, fig. 7, Q) is longer than the others, and passes down the longer axis of the projectile, the others approaching it on either side. In the case of the $5\frac{1}{2}$-inch two of the holes are longer than the other two; in the $4\frac{2}{5}$-inch the holes are all the same length. These holes are matched with quickmatch (pl. 26, fig. 3, S T, and fig. 7, U, T) drilled into to facilitate ignition, and plugged with brown paper (pl. 26, fig. 3, O, Q, and fig. 7, R, B), in the same way as the corresponding holes in carcasses. When the balls have been filled and the composition is cold the canvas covered portion between the cups or cylindrical part is woolded with cord or twine, according to the nature.[10]

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1 The same canvas as for the higher natures, also passed twice round.

2 See mortar shells, p. 36.

3 Ribs { 10 and 8-inch bar iron ·375 inch thick.
$5\frac{1}{2}$ and $4\frac{2}{5}$-inch sheet iron ·072 inch thick (No. 15 wire gauge).

Cups { 10 and 8-inch sheet iron ·238 inch thick (No. 4 wire gauge).
$5\frac{1}{2}$ and $4\frac{2}{5}$-inch sheet iron ·072 inch thick (No. 15 wire gauge).

4 It is hardly necessary to observe that this increased strength is required to enable the larger projectiles to withstand the greater shock to which their greater weight and the larger charge used necessarily subjects them; to give them, in fact, substance corresponding to their weight and size.

5 It will be observed that the first three ingredients are the same as for carcasses, linseed oil being substituted for the antimony, tallow, and turpentine.

6 See p. 313.

7 See p. 318.

8 See p. 316.

9 See also carcasses, p. 74, note 1, where the exact object and effect of these holes is explained.

10 See text above.

The whole projectile receives two coats of slate-colour paint,[1] and a "kit plaster"[2] sprinkled with saw-dust is placed over the top, covering and protecting the vents.[3]

Ground light balls weigh when finished from about half to three-fifths the weight of common shell of corresponding calibre.[4]

They burn from 9 to 16 minutes, according to their natures.[5]

Application and uses.

Ground light balls are fired from mortars,[6] and are principally used to light up and discover the enemy's working parties,[7] and might on an emergency, or in the event of their falling among combustible stores, be available as carcasses, from the very similar and highly inflammable nature of their composition.

These projectiles but imperfectly answer the end required of them, for the following reasons :—

Disadvantages.

1st. From their construction they can only be fired with very reduced charges[8] and at inconsiderable ranges ; while their form tends not only further to restrict the ranges at which they are available, but to render them most inaccurate and uncertain in flight.

2nd. Their inaccuracy of flight is in a peculiar degree detrimental to the efficiency of the projectile, for evidently should they happen to fall at any distance from the object to be illuminated, or short of the object,[9] or into a ditch, or upon the wrong side of a parapet, building, or traverse, or into any soft, muddy ground, they will be more or less useless.[10]

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[1] For the composition of this paint, see table XX., p. 345.

[2] See p. 38.

[3] This "kit plaster" covers the whole top of the ball, and as far down as the woolding. To make it sit more closely the circular piece of barras used for the purpose is slit in three or four places, from the circumference towards the centre. As in the case of the carcass of course the kit plaster and the brown paper plugs must be removed before loading. See *Manual of Artillery Exercises*, p. 107.

[4] Their actual weights are given in table IX., p. 327.

[5] The approximate mean time of burning of light balls is as follows:—

10-inch light balls, mean time of burning about					15 to 16 minutes.	
8	"	"	"	"	14 to 15	"
$5\frac{1}{2}$	"	"	"	"	10 to 11	"
$4\frac{2}{5}$	"	"	"	"	9 to 10	"

[6] The ignition of the fuze composition at each vent, its gradual burning downwards and ignition of the light composition, is exactly the same as in carcasses, and I have not thought it necessary to repeat the description which I gave (at p. 74, note 1) of that action.

[7] "Light balls are employed to discover an enemy's position at night."—Colonel Boxer's *Sandhurst Course*, p. 29.

"Light balls are generally employed by the garrison of a besieged place to discover " at night the working parties of the enemy ; they may also be thrown into the ditch to " ascertain the strength and disposition of assaulting columns."—Owen's *Lectures on Artillery*, edition 4, p. 85.

"Light balls are of . . . . . . excellent use in discovering working parties."—Extract from Colonel Jones' *Journal of Siege of Ciudad Rodrigo; British Gunner* p. 55.

"Light balls are used to throw into the enemy's works at night when work is " supposed to be going on."—*Artillery Tables, &c., MS. Course of Laboratory Instruction*, p. 57.

[8] See charges, p. 148.

[9] The smoke will act as a sort of screen if the projectile fall short of the object " If it be not projected beyond the object it will have the contrary effect to that which " is intended."—Colonel Boxer's *MS. Notes*, p. 95.

[10] "If the ground upon which it falls be very soft, or if it should fall into a hole or " ditch, the light will be either in a great measure destroyed or obscured."—Colonel Boxer's *MS. Notes*, p. 95.

3rd. The safety with which they may be approached, and the ease with which they may be smothered with earth or thrown over the parapet or ship's side, go very far to reduce their practical value.[1]

4th. The composition with which they are filled is a comparatively dull burning composition, and inferior to those now generally employed for illuminating purposes; and this fact renders the projectile but a poor light, even when employed under favourable circumstances.[2]

5th. If all the foregoing objections were overcome there would still remain this one—that the area illuminated by a body burning upon the ground is necessarily very restricted; and the effect of a *ground* light of whatever construction would thus always be extremely limited.[3]

Packing and issue.

Ground light balls are always issued filled and finished, in boxes similar to those used for shot, the number per box varying with the nature.[4] The boxes are marked on the side *in black* with the words "light balls, ground," the nature and number; and on the lid, also *in black*, the packer's name, station, and date of issue, tare and gross weight. For tropical climates the boxes have on them, in addition, the words "for tropical climates," *in black.*

Balls—Light, Parachute. History.

4. *The Parachute Light Ball or Suspended Light.*—The idea of a parachute or suspended light originated with Sir William Congreve, who constructed and fired rockets on this principle about the beginning of the present century.[5]

The application of this principle in its present form—that of a parachute light ball or shell—is due to Colonel Boxer, who was led to the investigation of the subject by a passage in Sir J. Jones's *Sieges in the Peninsula*, in which the defects of the ground light ball are dwelt upon,

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[1] "Light balls are of such excellent use in discovering working parties, that surely "some means ought to be taken to render them of dangerous approach by attaching "(to them) a grenade or other missile so prepared as to explode at uncertain periods "of their burning.

"At these sieges two or three bold men of the engineers brigade were always in "readiness to run up and extinguish the light balls as they fell, and generally suc-"ceeded in a few seconds in smothering them with filled sand bags, or by shovelling "earth over them.

"The garrison always directed their fire on the men whilst so occupied, which "directed it altogether from the working party, employed perhaps at a few yards' dis-"tance from the ball, to its right or left. Some casualties occurred to the men thus "employed, but generally they had extinguished the light ball before a second dis-"charge of artillery could be brought upon them."—Extract from Colonel Jones' *Journal of the Siege of Ciudad Rodrigo*, and *British Gunner*, pp. 55, 56. I have before quoted this passage (see p. 75) in support of what I said respecting the desirability of attaching a shell to the projectile to render it more dangerous to approach; I have, however, thought the passage might well be repeated here, considering the very marked bearing which it has upon my text.

[2] The composition used is, as I have shown (p. 76, note 7), in its main ingredients a very old one. It burns with a dull red light, and with a good deal of smoke, and is almost better suited for carcasses than light balls.

It cannot be readily extinguished, even by throwing water upon it, but as has been explained, it may be smothered and temporarily extinguished, by heaping earth, or other non-combustible materials, upon it.

"The composition is not at all adapted for the subject aimed at, for the flame is not "only comparatively dull, but the smoke produced is of a black colour, and conse-"quently instead of reflecting the light it only obscures it."—Col. Boxer's *MS. Notes*, p. 97.

[3] "From its situation, that is upon the ground, and the illuminating power of the flame being comparatively small, its discovering property is very local, not exceeding from 15 to 20 yards around the light."—Col. Boxer's *MS. Notes*, p. 95.

[4] See table XII., p. 331.

[5] "We beg to state, in justice to Sir William Congreve, that the idea of a suspended "light was first suggested by this ingenious officer, and that parachute rockets were

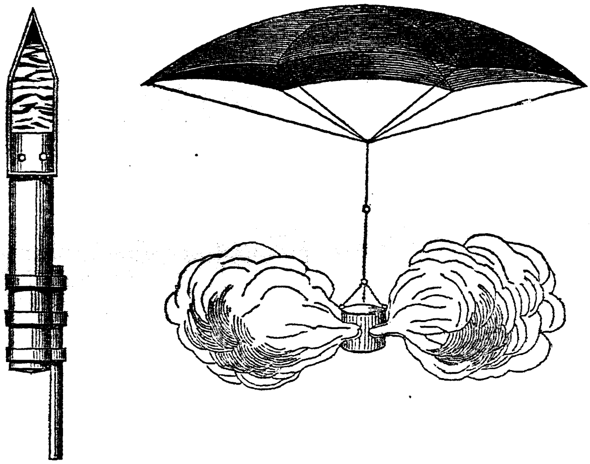
particularly the ease with which they may be extinguished; and in which the attachment of a shell or grenade to the ball, with a view to rendering it dangerous to approach, is strongly recommended.[1]

On reading this passage it occurred to Colonel Boxer, as he tells us, that the majority of the defects of the ground light ball might be overcome by the employment of a suspended light;[2] and he succeeded in producing a parachute light ball which, although admittedly defective in some respects,[3] so far satisfied the requirements of the service that it was introduced in 1850, although none were manufactured for service until 1855.[4]

Experiments carried on subsequently to the introduction of this first pattern led to the details of construction being considerably modified, with a view to the removal of the defects; and in 1863 Colonel Boxer submitted a new pattern of the three existing sizes, viz., 10″, 8″, and 5½″, which underwent further alterations in 1864, and was finally approved and introduced into the service in 1866 (pl. 37, 38). A further

" constructed and fired by him a great many years ago."—Col. Boxer's *MS. Notes*, p. 97.

I have managed to procure an old drawing of Sir William Congreve's parachute rocket, of which this figure is a copy.



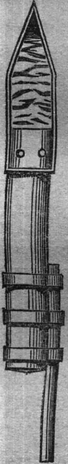
Parachute rockets, although no longer used for warlike purposes, are employed by firework manufacturers as an effective method of throwing a coloured light.

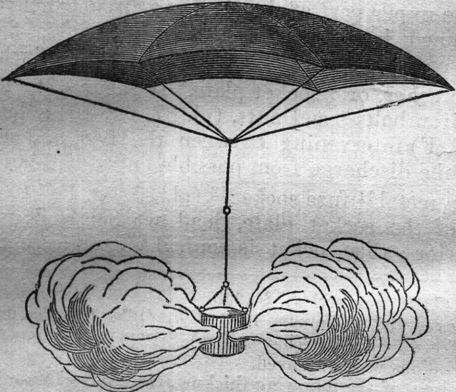
1 See p. 79, where the defect of the ground light ball is commented on, and where the passage in question is quoted at length in note.

2 " It occurred to the author upon reading the above note that a light suspended in the air would be far more efficacious than one upon the ground."—Col. Boxer's *MS. Notes*, p. 95.

3 " There are defects in this pattern."—*Letter from Col. Boxer to Under Secretary of State for War*, 25th April 1860.

4 It seems certain that these parachute lights were not *formally* adopted (" It cannot be traced that this light ball has been formally adopted into the service."—*Ordnance Select Committee Report* 720, 31st March 1860, Minute 779, 303/60); but they were manufactured for service in 1855 upon an order " dated 7th June 1855, D/294, " and 414; 10 inch were supplied for siege purpose in the Crimea."—*Letter from Col. Boxer to Under Secretary of State for War*, 25th April 1860. On 4th September 1850, M/313, " in consequence of the satisfactory termination of the experiments " with these lights at Shoeburyness the Board of Ordnance ordered an 8 inch and a 10 inch to be made and deposited in pattern room (with descriptive explanation), " as patterns, " in the event of such natures of stores being at any time required," and this may perhaps be regarded as a formal approval of the light; but their practical adoption dates from 1855.





slight modification, consisting in the introduction of a small bursting charge and the strengthening of the upper chains, was made a few months later.[1]

The most important improvement effected in this, the present, pattern consisted in the outer case or shell being made of iron instead of paper, thus greatly increasing the strength of the projectile, and rendering it available for a greater range.

A number of minor changes were also effected, such as an alteration in the pattern of the socket and upper inner hemisphere, a reduction of the number of vents from five to one, a different construction of vent, &c.; which all, more or less, tended to increase the efficiency of the projectile, and to develop its powers.

Sizes. The Parachute Light Ball[2] (see pl. 37, 38) is made of three sizes, viz., 10″, 8″, and 5½.″

Description. It consists of two hemispheres of tinned iron[3] soldered and riveted[4] together,[5] so as to form a spherical shell or hollow case to contain the parachute and light.

The lower hemisphere is thicker[6] than the upper, to enable it to withstand the shock of the discharge.

On the upper part of the shell is a circular hole closed with a removeable tinned iron circular washer[7] (pl. 37, fig. 3, C C') slightly rounded so as to correspond with the sphere of which it forms part.

This washer, or "socket plate," is secured to the upper hemisphere by five iron bolts[8] and nuts, (pl. 37, fig. 10) a leaden[9] washer (pl. 37, fig. 3, F, F) intervening between the two, and serving to exclude the flash of the discharge from possible entry at this joint.[10]

A gun metal[11] fuze socket[12] (pl. 37, fig. PP' OO') passes through the centre of the socket plate, lead washer, and upper hemisphere into the interior; this socket is conical,[13] open at both ends, and tapped[14]

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[1] *W.O.C.* 10 (new series), § 1243.

[2] Approved 2nd of January 1866, *War Office Circular* 9 (new series), § 1193, and *War Office Circular* 10 (new series), § 1243, 21st June 1866, when some further slight alterations were approved.

[3] Sheet iron of the following thickness is used. Lower hemisphere 11, W.G., for 5½″ and 8″, 9 W.G. for 10″; upper hemisphere 17 W.G., for 5½″ and 8″, 15 W.G., for 10″. The iron is the best charcoal iron, it is tinned by dipping it heated into melted tin after forming it into hemispheres.

[4] With copper rivets ·1″ in thickness, three rivets in each shell equidistant from one another.

[5] The edges of the two hemispheres do not coincide but overlap, a portion of the lower atmosphere being cut away or countersunk to admit the edge of the upper which thus fits into the lower hemisphere, resting upon the ledge formed by the countersink.

[6] See note 3 above, where the thicknesses are given.

[7] The same iron as is used for the upper hemispheres, viz. 17 W.G. for 5½″ and 8″, 15 W.G. for 10″.

[8] The bolts are ·25″ in diameter.

[9] Sheet lead ·1″ thick.

[10] When the socket plate is bolted tightly down on to the lead collar, the joint is made yet more secure by pressing the lead with a blunt tool against the socket plate, giving the appearance of soldering.

[11] The copper, tin, and zinc alloy used for other laboratory gun metal stores, see p. 100, note 2.

[12] Perhaps a more correct name would be bush, since this socket is open at the bottom.

[13] The same cone as the fuze hole of a common shell, *i.e.*, as nearly as possible 1 in 9; for the actual dimensions of the sockets, which vary in the different shells, see pl. 37, fig. 3, and table, pl. 38.

[14] With a right-handed thread 14 to the inch.

about the upper part for the reception of a screw gun metal plug (pl. 37, fig. 12), with which it is closed when not in use,[1] and to afford a better hold to the wood fuze[2] (pl. 38, figs. 16, 18, 20).

The parachute and light compositions are contained in two tinned iron[3] hemispheres (pl. 37, fig. 3, C''', and C''''), enclosed in the case above described. The lower of these hemispheres contains the light composition,[4] pressed in,[5] and consisting of—

Saltpetre, ground,[6] 7 lbs.
Sulphur, sublimed,[7] 1 lb. 2 oz.
Orpiment, red,[8] 11 oz.

and which burns for the following periods :—

10″	burns about	3	minutes	0	seconds.
8″	„	1	„	40	„
5½″	„	1	„	0	„

At the bottom of the lower inner hemisphere is a large circular[9] vent (pl. 37, fig. 3, MM'.) or "fire hole," closed with a stout[10] papier maché disc (pl. 38, figs. 14 and 15, and in section, fig. 5), which serves to afford support to the composition and to prevent it from being fissured or the priming displaced by the shock of discharge.

The space which intervenes between the light composition and the top of the plug (pl. 38, fig. 5 QO') is pressed with fuze composition, by means of which the composition is ignited and the plug blown out.

A hole[11] passes through the centre of the plug and contains a perforated[12] disc[13] of fuze composition[14] (pl. 38, fig. 5, O Q'), and a continuation of this hole extends into the centre of the light composition and is filled with a solid pellet of fuze composition (pl. 38, fig. 5, O NN').

The perforation of the plug pellet is continued through the intermediate layer of fuze composition, and a short distance into the pellet in the light composition to ensure ignition, and the hole is "laid" with quick match.

To prevent the vent from becoming enlarged by the action of the burning light composition, the edge is bent inwards and the angle filled with powdered clay.

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[1] See p. 103.
[2] See p. 25.
[3] Sheet iron of the following thicknesses is used: Lower (inner) hemisphere, 22 W.G. for 5½″, 17 W.G. for 8″, 15 W.G. for 10″; upper (inner) hemisphere, 17 W.G. for 5½″ and 8″, 15 W.G. for 10″. It will be observed that in the 8″ shell the two hemispheres are of the same thickness; similarly in the case of the 10″; but in the 5½″ shell the lower (inner) hemisphere is made of a thinner iron than the upper one, in order not unnecessarily to diminish the capacity of the shell.
[4] The composition is almost identical with that used for long and signal lights, and the old so-called "blue" light composition. (See p. 221.) It burns with a brilliant white light.
[5] By hydraulic pressure.
[6] See p. 315.
[7] See p. 318.
[8] Otherwise known as realgar, or sulphide of arsenic. See p. 312.
[9] For dimensions, which vary for each nature, see table on plate 38.
[10] For dimensions, see table on plate 38.
[11] For dimensions of this hole, which vary with each nature, see table on plate 38.
[12] Perforated on the principle of a tube, to ensure immediate and certain ignition. (See p. 236 respecting the priming of fuzes, &c. on this plan.)
[13] These discs are made by hydraulic pressure.
[14] See table XIX., p. 344.

The bottom (inner) hemisphere is closed at the top with a disc of tinned iron,[1] (pl. 37, figs. 3 and 4, LL"), bolted[2] on to a circle or washer of angle iron (pl. 37, fig. 3, I), distinguished as the diaphragm or "flange plate,"[3] which is riveted to[4] the inside of the hemisphere and rests upon the composition. The circular space in the centre of the flange plate is closed with a millboard disc, the edge of which is marine-glued[5] on to the light composition, and the top of which is marine-glued on to the plate with which the hemisphere is closed.

The chains (pl. 37, figs. 7 and 4), by which the hemisphere containing the light is attached to the cords of the parachute, are secured to three flanges on the flange plate, equidistant from one another, and are separately cemented down with a strip of calico and shellac varnish to ensure the chains being in the proper position on putting the projectile together, and to prevent "kinking."

The upper (inner) hemisphere (pl. 37, fig. 3, C''' C''') forms a case for the parachute. This case is slightly depressed at the top to allow room for the socket, and is attached at this part to the upper (outer) hemisphere by means of two stout chains (pl. 37, figs. 3 and 8).[6] The parachute (pl. 38, fig. 6) itself is made of calico[7] in the form of a large umbrella,[8] the ribs being defined by cords[9] (pl. 38, fig. 6, Q' Q" R") carried down the seam of the gores.

These cords are continued below the parachute for some distance,[10] and are then knotted together, formed into a coil a few inches long[11] (pl. 38, fig. 6, RR'), and finally connected to an iron ring.[12] From this ring depend the three iron chains, the lower extremities of which are hooked on to the flange plate. The light is thus actually attached to and suspended from the parachute at such a distance as to provide against the possibility of the parachute being injured by the flame or heat; the chains preserve the ropes from possible injury from the same cause.

The upper end of the parachute is connected with its case by means of a piece of cord,[13] which is attached to an iron loop inside the top of the hemisphere and threaded through a hole (pl. 38, fig. 6, SS') in the apex of the parachute. The cord is unravelled and smeared with kit composition, and the hole through which it passes is faced with leather,[14] considerable resistance being thus offered to the drawing out of the cord and of the separation of the parachute from the case.

The parachute and cords are carefully[15] folded and packed[16] into the

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1 Sheet iron, No. 22 W.G. for 5¼", 17 W.G. for 8", and 15 W.G. for 10".

2 For dimensions of bolts and rivets, see table on plate 38.

3 Tinned sheet iron, No. 19 W.G. for 5½", 17 W.G. for 8", and 15 W.G. for 10". The name "flange plate" is preferable to diaphragm, which this plate is not.

4 With iron rivets.

5 With Jeffrey's marine glue. See p. 52.

6 For dimensions, see table on plate 38. These chains are covered with calico to prevent them from "kinking."

7 White calico 39" wide for 10" and 8"; jacconett 36" wide for the 5½".

8 For detailed dimensions of the parachute of the different natures, see table on plate 38.

9 "White line, 18 per dozen" for 10" and 8", "whip-cord" for 5½".

10 See table on plate 38.

11 *Ibid.*

12 Tinned iron of the dimensions given, *Ibid.*

13 "White line, 8 per dozen."

14 The leather disc is 2·5" in diameter.

15 The careful and regular folding of the parachute and cords is a point of the highest importance; a blunder in the operation may render the projectile useless by interfering with the prompt action and opening of the parachute. See p. 85.

16 Pressed on under a screw press.

upper (inner) hemisphere, the coil of cord is fastened to the iron ring, and the whole laid carefully upon the hemisphere containing the light, the edges of the two hemispheres coinciding and being overlapped on the outside by the edge of the lower outer hemisphere.

A small bursting charge of powder (3 drams for the 10″, 1½ for 8″ and 1 for 5½″) is placed in a red shalloon bag, round the interior of the upper outer hemisphere immediately over the depression of the inner hemisphere. Two quick match leaders[1] are laid between the inner and the outer shells, the two upper ends being brought behind the bursters, and the paper removed in order that the flash from the fuze may have free access to the match; the lower ends, from which also the paper is removed, are brought together under the fire holes, and a direct and instantaneous[2] communication is thus established between the fuze and the priming pellet at the fire hole.

The two inner hemispheres have a groove indented round their circumference for the quick match to rest in, and that part of the fire hole, plug, and pellet over which the match passes is similarly indented.

The parachute light ball weighs, when completed—

	Average weight.
10 inch - - -	31¾ lbs.
8 " - - -	15 "
5½ " - - -	6¾ "

They are not painted.

Preparation and action

A fuze[3] prepared at such a length as to ensure action *during the descending portion of the trajectory*[4] is fitted into the socket, the shell placed in the mortar,[5] which is laid at 45°, and the fuze uncapped.

By the action of the fuze the bursting charge is exploded, the quick match and priming[6] are fired, and sufficient force is thus generated to separate the outer hemispheres and to relieve the parachute from its case.

The parachute is relieved and expanded in the following manner: The explosion of the bursting charge, match, and priming separates the two outer hemispheres, and, the case of the parachute being attached to the upper hemisphere, the two top hemispheres are carried away together, while the two lower hemispheres are forced in the opposite direction; and owing to the kitted cord which is attached to the case and strung through the top of the parachute, the latter is drawn out to its full length and immediately expanded by the air.[7]

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[1] See p. 226.

[2] See p. 225, where the action of confined quick match is explained.

[3] See p. 269.

[4] "Arrange the fuze so as to disengage the contents some time after the projectile "has attained its maximum height, for if the shell has much horizontal velocity, an "oscillatory motion will be the result."—Col. Boxer's *MS. Notes*, p. 96.

It is very important to attend to this point, and so to avoid the violent oscillations which will take place if the shell is ascending, due to the continued forward impulse of the heavier portions of the projectile in a direction contrary to that which the expanded parachute would naturally assume; the hemisphere containing the light being in fact, in this case, propelled forward and dragging the expanded parachute after it.

[5] Special mortars have been designed for firing these projectiles, lighter than the service mortars, which would, however, be available. Reduced charges are used. See page 148.

[6] The communication between the match and priming is, as pointed out in the text, instantaneous.

[7] The kitted cord, it must be understood, is drawn completely through as the parachute becomes extended. To assist the expansion of the parachute it is so folded in the case that on being drawn out the edges are at once exposed to the influence of the air, which is thus, so to speak, coaxed underneath it, until it is fully expanded.

The ignition of the light composition, the opening of the shell, and the expansion of the parachute thus take place almost simultaneously[1] on the action of the fuze.

After the parachute has become expanded it floats (pl. 38, fig. 6), with the illuminating hemisphere suspended from it, in whatever direction it may be carried by the wind; gradually falling to the ground and thus illuminating a considerable area, the extent of which will vary with the force of the wind and the elevation attained by the projectile.[2]

In using these projectiles, the force and direction of the wind, by which the direction and duration of their flight are enormously influenced, must be considered in laying the mortar, with reference to the object or area to be illuminated.[3]

Use. Parachute light balls are fired from mortars only.[4] They are used to light up the enemy's works and working parties, and generally to discover his position and operations[5] under similar circumstances to ground light balls,[6] to which they are preferred for the following reasons :—

Advantages. 1st. Because every disadvantage enumerated as inseparable from the ground light ball[7] is overcome: the range and accuracy of the parachute light ball is greater;[8] its effect is scarcely affected by any slight possible inaccuracy of flight; it is of course not liable to be approached and smothered or removed;[9] and the illuminating power is much greater, not merely because of the more brilliant composition employed,[10] but because a light suspended in air necessarily illuminates a greater[11] area; while the parachute also from being carried along by the wind increases its discovering properties.[12]

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[1] To an observer the action appears instantaneous.

[2] As a general rule, the duration of the light composition will exceed that of the time of falling of the parachute, even when fired at 45° with the full charge allowed tc be used.

[3] See note 12 below.

[4] See p. 87, note 2, respecting a special mortar being under consideration for these projectiles.

[5] "Light balls are of excellent use in discovering working parties."—Sir J. Jones's *Sieges in the Peninsula*, vol. i., p. 368, note 2.

"Light balls are used to discover an enemy's position at night."—Col. Boxer's *Sandhurst Course*, p. 29. See also Owen's *Lectures on Artillery*, edition 4th, p. 85; *Artillery Tables to written Course of Laboratory Instruction*, p. 85.

"These lights are intended principally to be used for siege purposes, to discover "working parties, &c. at night, and to illuminate any large area of ground."—*O.S.C. Report*, 720, 31st March 1860.

[6] See p. 79.

[7] See pp. 79, 80.

[8] See p. 79 respecting the necessarily restricted range and inaccuracy of an elongated projectile, such as the ground light ball, fired with a very reduced charge from a smooth bore mortar.

[9] See p. 81 respecting Col. Boxer having been led to contrive the original parachute light primarily with a view to overcome this objection to the ground light ball, which had been forcibly urged by Sir J. Jones in his *Sieges of the Peninsula*, vol. i., p. 368, note 11 (see p. 80, note 1, where this passage is quoted at length).

[10] See p. 80 respecting the inferiority of the ground light ball composition, which burns with a dull red light, as opposed to a brilliant white one.

[11] "The suspended light illuminates from 300 to 400 yards around the point over "which it is suspended."—Col. Boxer's *MS. Notes*, p. 95. "The ground light will "illuminate not more than from 15 to 20 yards."—*Ibid.* p. 95.

[12] Col. Boxer's *MS. Notes*, p. 95. "This motion of the ligh is generally considered "to be a defect, but if we consider the object aimed at, it would rather appear to be "the reverse. Should the wind be blowing directly towards the battery, the shell "must be projected to its greatest range."—*Ibid.* p. 96.

In this respect the new pattern parachute is very much superior to the old one, inasmuch as, being of a stouter construction and able to stand a higher charge, it will

2nd. The parachute ight is available for illuminating purposes at sea—on board ship or from coast batteries—in the event of night engagements or attacks;[1] the ground light ball is not.

3rd. The weights of the apparatus required to project the shell, and of the projectile itself, are considerably less than those of the ground light ball and service mortars.[2]

Among minor advantages of the parachute light may be reckoned its probable greater durability, since the part of it which is exposed is made of less perishable material than the ground light ball, while the interior is well protected; and its applicability to signalling, general illuminating, and firework purposes.

Parachute light balls are packed in wooden boxes, one in each. On the box is marked in black, "Ball Light, Boxer Parachute," nature, date. Packing and issue.

5. *Smoke Balls.*—Smoke balls are of ancient date, as may be gathered from the allusion which has already been made to them in the history of incendiary projectiles,[3] and from the fact that the author of *The Great Art of Artillery*, writing in the middle of the 17th century, gives a description of smoke balls,[4] and says, "We have a way of preparing "balls, which during their combustion cast forth a noisome smoke, and "that in such abundance that it is impossible to bear it."[5] Balls—Smoke. History.

The compositions then used for creating this "noisome smoke" were generally placed in canvas sacks, and other coverings similar to those for light balls, and we find no mention of paper shells similar to those now used having been employed at that period for the purpose. It is reasonable, however, to believe that this construction of smoke ball was not altogether unknown at that early date, for the paper shells were certainly then used for fireworks,[6] and the construction would naturally have recommended itself, where no great range was required, by its simplicity and cheapness. It is probable, therefore, that the present construction of smoke balls was nearly, if not quite, contemporary with

range further, and thus may be made to travel as far as may be necessary beyond the object or area to be illuminated, avoiding the possibility of the light being blown back over one's own batteries, as actually happened in some experiments with the old pattern at Malta in 1859, "when the light was fired against the wind, and came back and "eventually fell to the right rear; it would have lit up the battery far more than "surrounding objects."—*O. S. C. Report*, No. 720, 31st March 1860.

In the other three directions of the wind, the property of the light being carried along will certainly prove rather advantageous, as stated by Col. Boxer, than otherwise, since by keeping up a judiciously directed fire of these lights, the whole range of the enemy's works or position may be illuminated and reconnoitred.

[1] "They might also be employed at times in the naval service with great advantage." —*O. S. C. Report*, No. 720, 31st March 1860.

"It is also imagined that the suspended light would be of great value on board ship, "not only for war purposes, but also under a variety of circumstances in time of "peace. In coast batteries also it might be employed with advantage."—Col. Boxer's *MS. Notes*, p. 96.

[2] The weights of the projectiles respectively are—

	Ground light balls.	Parachute light balls.
10-inch - - -	71 lb. 2 oz.	$31\frac{3}{4}$ lbs.
8-inch - - -	34 lb. 2 oz.	15 lbs.
$5\frac{1}{2}$-inch - - -	8 lb. 12 oz.	$6\frac{3}{4}$ lbs.

The weights of the parachute mortars are not yet determined, nor indeed is the question of their introduction even decided upon.

[3] See p. 61.

[4] "Which the Germans call 'Dampflænd blend kügelen.'"—*The Great Art of Artillery*, p. 287.

[5] *Ibid.* p. 287.

[6] See *The Great Art of Artillery*, p. 193, where the whole process of making a paper shell, almost exactly as they are now made, is described. See also *Ibid.* pl. K, figs. 94 and 95.

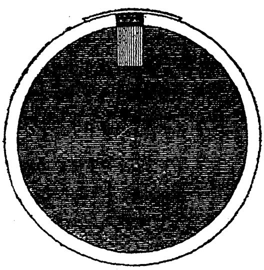
the earliest recorded employment of projectiles of this nature, and that it formed one among the many methods of construction then in vogue.[1]

In character the composition employed for smoke balls in the 17th century was very similar to that now used.[2]

Sizes. There are five sizes of smoke balls in the service, viz., 13, 10, 8, 5$\frac{1}{2}$, and 4$\frac{2}{5}$-inch.

Description. A smoke ball is a spherical concentric paper[3] shell, having a hole in it (corresponding to the fuze hole of a common shell), which provides for the ignition of the composition with which the shell is filled, in the first instance; and for the escape of the dense smoke which that composition emits when ignited, in the second.

Smoke Ball.



The thickness of the paper shell is from about $\frac{1}{17}$th to $\frac{1}{13}$th its diameter, according to the nature.[4]

The vent[5] is made slightly conical in form, like the fuze hole of a common shell; its dimensions vary with the nature of the shell.

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[1] I cannot find any mention of the employment of paper shells for projectiles of this class earlier than 1780, except the mention (to which I have alluded in my text) of their being used for fireworks; *Müller's Treatise of Artillery*, published at that date, gives this construction for light balls, and strongly recommends it (p. 206). This work contains no mention of smoke balls. *James's Military Dictionary* (edition 1816) gives the paper shell construction for smoke balls (p. 34), but also represents them as having four vents, like carcasses, instead of one, as at present.

[2] I give the compositions as employed now and in the 17th century, side by side, for the purposes of comparison.

Ingredients now used in smoke-ball composition.	Ingredients used in smoke-ball composition in 17th century.
Saltpetre.	Saltpetre.
Coal.	Coal.
Pitch (Swedish).	Pitch.
Gunpowder.	Tar.
Tallow.	Rosin.
	Sawdust.
	Crude antimony.
	Sulphur.
	The Great Art of Artillery, p. 287.

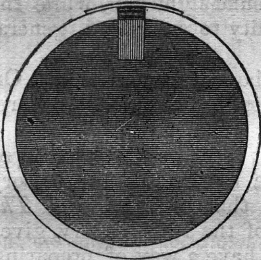
The three first ingredients, it will be observed, are the same, and although the last ingredient, sulphur, cannot be properly said to enter into our smoke-ball composition, still it is used by us in the manufacture of smoke balls, being sprinkled in with a small quantity of coal at different stages of the operation of filling for a purpose which is explained in the text (see p. 89). Thus, out of six ingredients which are now used in the manufacture of smoke balls, no less than four were used in the 17th century.

[3] A stout paper, called "cannon cartridge," 9-pr. paper, is used for the purpose. The shell is made by pasting successive slips or layers over a greased spherical wood "former" in the first instance, and then over one another. The "former" is removed, when the substance of paper pasted over it is sufficient to admit of it being done, by cutting open the shell and then placing the two empty hemispheres together, and continuing to paste layers of paper over them until the shell is brought up to gauge. This description properly connects itself with the manufacture, but it seemed to me that by introducing it here I should be making the construction of the shell more intelligible.

[4] In the {13-inch, 10 "} it is about $\frac{1}{17}$th the diameter.
" {8 ", 5$\frac{1}{2}$ "} " $\frac{1}{14}$th "
" 4$\frac{2}{5}$ " " $\frac{1}{13}$th "

[5] Sometimes called the "fuze hole," and although I prefer the designation "vent," as indicating more correctly the end which it serves, the term "fuze hole" cannot fairly be objected to, since the hole and its prolongation into the composition are, as explained in the text (see p. 89), driven with fuze composition to secure ignition.

SMOKE BALL.



The composition with which smoke balls are filled is composed of the following ingredients, melted and mixed together :—

Powder, L.G., bruised [1]	5 lbs.	0 ozs.
Saltpetre, ground [2]	1 „	0 „
Coal, pounded [3]	1 „	8 „
Pitch, Swedish	2 „	0 „
Tallow, Russian [4]	0 „	8 „

To this composition are added the following dry ingredients, which are mixed together, and one-third part of the mixture sprinkled into the shell on three occasions during the filling,—that is to say, when the shell is a quarter, half, and three-quarters full.

	12-inch.	10-inch.	8-inch.
Sulphur, ground	2 ozs.	1 oz.	$\frac{1}{2}$ oz.
Coal, pounded	2 ozs.	1 oz.	$\frac{1}{2}$ oz.

For the $5\frac{1}{2}$ and $4\frac{2}{5}$-inch small quantities are placed in *twice*.

These dry ingredients serve, by the sudden evolution of gas on the composition burning down to them, to clear the vent, which otherwise would be liable to become clogged by the lava of the burning composition, to an extent sufficient to interfere with the free passage of the smoke. The shell is completely filled with the composition, and a hole made in the prolongation of the vent, which, when the composition is cold and hard, is driven with fuze composition in the same way as in ground light balls and carcasses, and for the same reason, viz., to secure the thorough progressive ignition of the composition. This hole is also matched with quick match, bored into to facilitate ignition, and plugged with brown paper; and the shell receives two coats of stone colour paint ;[5] a kit plaster[6] being finally placed over the vent and sprinkled with sawdust.

The action of a smoke ball on the fuze composition becoming ignited is similar to that of a carcass or ground light ball, with the exception that instead of flame issuing from the vents, a dense smoke is given forth, whence the projectile derives its name. They burn from about one to eight minutes, according to their natures.[7] Action.

The two principal uses assigned to these projectiles are—1st. To suffocate or expel the enemy or his working parties from mines, case- Uses.

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[1] See p. 135.

[2] See p. 316.

[3] In old laboratory works this is frequently called "sea coal," a term formerly used to distinguish this coal from charcoal, the former being generally brought by sea from Newcastle or the northern coal fields. Indeed, to the present day firework makers frequently speak of charcoal as coal, and of course the distinction sea or sea-borne coal then becomes necessary. The coal used for smoke balls is required to be of a highly bituminous nature, such as is used for gas manufacture. It is generally procured from Newcastle.

[4] Russian tallow is generally used; but ordinary or "town-made" tallow will answer the purpose.

[5] For composition of this paint, see table XX., p. 345.

[6] See p. 38.

[7] The approximate mean time of burning of each nature of smoke ball is as follows:

13-inch	burns from about	7 to 8	minutes.
10-inch	„	5 to 6	„
8-inch	„	4 to 5	„
$5\frac{1}{2}$-inch	„	2 to $2\frac{1}{2}$	„
$4\frac{2}{5}$-inch	„	1 to $1\frac{1}{2}$	„

mates, between decks, or other confined situations;[1] 2nd. To conceal one's own operations or position, or to mislead the enemy with respect to them;[2] 3rd. Perhaps the most valuable use of smoke balls is to serve as signals in the Arctic regions.[3]

Whether to be considered as projectiles.

☞ Smoke balls are made, it will be observed, of such sizes as will enable them to be fired from the different natures of mortars, and they are generally spoken of and considered as projectiles. It is uncertain, however, whether they are intended to be fired at all. No charges have ever been assigned to them, and the charges which they would stand are so inconsiderable as to render them available only at the shortest ranges. Moreover, the question arises, under what circumstances would it be desirable to fire them? It would be extremely difficult, if not impossible, to project them into a mine or confined situation, and it is not easy to see how the object of deceiving the enemy with respect to one's position or operations by means of one of them could be assisted by using it as a projectile; for even in the case where this deception was sought to be established by creating a column of smoke away from one's position, the act of firing a gun would probably defeat the end in view; and when smoke balls are applied to their third use, that of signalling, it is hardly conceivable that it would be necessary to fire them from a mortar.

Therefore, although smoke balls are invariably treated and considered as projectiles, it seems that their right to be so considered, having regard to the nature of their construction and the circumstances of their employment, is very questionable.

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[1] "These balls are employed for throwing into mines or other confined situations "to suffocate or expel the working parties, &c."—Owen's *Lectures on Artillery*, edition 4th, p. 86.

"Smoke balls are used to throw into mines to suffocate or expel the working "parties."—*Manuscript Cadet Course*, p. 385.

It is easier to assign this use to smoke balls than it would be actually to employ them in this way, for there would certainly be considerable difficulty in placing or throwing one into an enemy's mine or casemate, or between his decks; still, it is not altogether impossible to conceive circumstances under which smoke balls might be made use of for this or a similar purpose; but, at the same time, in availing himself of this means of destruction, and in deliberately setting to work to suffocate his enemy, an officer would run some risk of incurring that sort of obloquy which, rightly or wrongly, has attached itself to acts of a similar character said to have been committed in Algeria.

[2] "Smoke balls are used . . . . to conceal your own position from an enemy."—Owen and Dames' *Lectures on Artillery*, p. 73. Here, again, it seems that the circumstances would be rare in which smoke balls could be employed as intended. Any attempt to conceal one's own position by raising a dense screen, as it might be considered, of smoke, would be more likely to attract than to divert fire; and so clumsy an attempt to deceive the enemy would almost certainly fail. But by creating a smoke by means of one of these projectiles, not in front of one's own position but *away from* that position, one might perhaps hope to mislead the enemy, or, at least, to divert his attention from the actual nature of one's operations.

[3] It is evident that a thick column of black smoke rising up amid the icebergs and white landscape of the Arctic regions must be visible to a greater distance than any other description of signal which could be employed.

The Arctic expedition, which was fitted out in 1852, comprising the following ships, "Isabel," "Assistance," "Resolute," "North Star," "Intrepid," and "Pioneer," was supplied with the following smoke balls—

10 inch	-	45.
8-inch	-	25.
5½-inch	-	55.

It is said that the North American Indians employ smoke signals on the prairies; and one can hardly conceive a more efficient means of attracting attention in an uninhabited country.

Smoke balls are always issued filled and finished, and boxed.[1] The boxes are marked *on the side in black*, with the words "Smoke balls," the nature and number; and on the lid, also *in black*, the station and date of issue, tare and gross weight. For tropical climates the boxes have on them, in addition, the words "For tropical climates," *in black*. Packing and issue.

6. *Manby's Shot.*—The plan of saving lives in cases of shipwrecks by means of a line thrown so as to establish a communication between the ship and the shore seems to have been first proposed about the close of last century, by Lieutenant Bell, Royal Artillery.[2] This officer proposed to project from a mortar a spherical shell filled with lead, and having "a deep-sea line" attached. Some trials were made with the apparatus in 1791,[3] before a Committee of the Society for the Encouragement of Arts, Manufactures, and Commerce, and the success of the experiment was so marked and unequivocal,[4] that in the following year the society adjudged the inventor a reward of 50 guineas.[5] Shot—Manby's History.

Lieut. Bell's claim to the priority of the invention was also recognized by a committee of artillery officers assembled at Woolwich in May 1811, to report on "Captain Manby's invention for saving the "lives of shipwrecked mariners," this committee reporting that they "feel that they should not entirely discharge their duty, were they to "omit observing, that the Committee of the Honourable House of "Commons do not seem to have been informed of all the means pro-"posed by the late Lieut. Bell, of the Royal Artillery, for the attain-"ment of the same laudable object; it being stated in that Honourable "Committee's Report, that Mr. Bell's invention is totally inapplicable "in all cases of vessels being stranded," and that Captain Manby's "invention is new.[6] In justice, therefore, to the memory of Lieut. Bell, "and to his surviving family, and with respectful deference due to the "judgment of the Honourable Committee, the concluding of the seven "observations inserted in one of the papers of Lieut. Bell's account to "the Society for the Encouragement of Arts, Manufactures, and Com-"merce, is subjoined in his own words, as published in that Society's "transactions, and the *Repertory of Arts* for 1808, p. 318, by which "observations it appears *that Lieut. Bell then proposed what Captain "Manby has since so ably and so successfully carried into effect.*"[7]

The passage "in Lieut. Bell's own words," referred to by the Committee, is as follows: "There is every reason to conclude, that this "contrivance would be very useful at all ports of difficult access both

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[1] See table XX., p. 331.

[2] It appears from Kane's List that Lieut. Bell was promoted from serjeant to a lieutenancy in the invalid battalion.—*Kane's List of the Royal Regiment of Artillery*, p. 21.

[3] 29th August 1791.—*Repertory of Arts for* 1808, vol. xiii., p. 315.

[4] The line was thrown to a distance of 400 yards.—*Ibid.*, 315.

[5] A full account of the experiments, and drawings and a description of the apparatus are given under the head of "Account of a method of throwing a rope on shore by "means of a shell from a mortar on board a vessel in distress." By Lieut. John Bell, Royal Artillery, in the *Repertory of Arts*, 1808.

[6] This allusion to the opinion of the "Committee of the Honourable House of "Commons" has reference to a report made by a Committee of that House in 1810, in which Lieut. Bell's claim to any merit attaching to priority of invention is ignored, and his proposition spoken of in the words quoted in the text, viz.: as "totally inap-"plicable in all cases of vessels being stranded;" while Captain Manby's proposition is treated as original. The incorrectness of this opinion is sufficiently shown by the passage from the Report above quoted, and by Lieut. Bell's own remarks, which I have given further on (see p. 92).

[7] *The Annual Register* for the year 1811, p. 521.

"at home and abroad, where ships are liable to strike ground before
"they enter the harbour, as Shields Bar, and other similar situations,
"when a line might be thrown over the ship, which might probably
"be the means of saving both lives and property; and, moreover, if
"a ship was driven ashore near such a place, the apparatus might
"easily be removed to afford assistance, and the whole performance is
"so exceedingly simple, that any person seeing it done, would not
"want any further instruction."[1]

It is thus placed beyond doubt that Lieut. Bell's proposition was not limited to throwing a rope from a vessel to the shore, but included the reverse operation of throwing a rope from the shore to the assistance of a stranded vessel, and this by almost exactly the same means as were subsequently successfully applied by Capt. G. W. Manby, R.N.

But if the merit of having been the first to propose this plan cannot, in justice, be conceded to Captain Manby, it is at least indisputable that that officer was the first practically to apply it, and that by his exertions the details were matured and the idea successfully carried into effect;[2] for, in spite of the success which had attended Lieutenant Bell's experiments, his proposition does not appear ever to have received official recognition, or to have been practically entertained or adopted.[3]

Captain Manby worked out the subject with great care and ingenuity, and in 1811 his plan was experimented upon by the committee of artillery officers before alluded to.[4]

The results of these experiments were in the highest degree successful, and the adoption of his propositions was recommended.[5] This recommendation led to an address being moved in the House, on the 14th June 1811, to the Prince Regent, "praying that he would be "graciously pleased to order that Captain Manby's invention should "be stationed on different parts of the coast, &c., and assuring him "that the House would make good the expense."[6]

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1 *Repertory of Arts* for 1808, vol. xiii., p. 318.

2 "Lieut. Bell then proposed what Captain Manby has since so ably and successfully carried into effect."—*Report of Artillery Committee, Annual Register* for 1811, p. 521.

"Mr. Bell had cursorily observed that a line might be carried over a ship from the "shore by means of his mortar; but for the actual execution of this proposal in a "variety of cases we are indebted to the meritorious exertions of Captain G. W. "Manby."—*Encyclopædia Britannica*, vol. xiii., p. 441.

3 It is not impossible that this arose from the fact that the inventor died shortly afterwards, in 1798. See Kane's *List of Officers of the Royal Regiment of Artillery*, p. 21.

4 This Committee was composed of the following field officers of Artillery:—Lieut.-General Lloyd, Major-General Ramsay, Colonel Borthwick, Lieut.-Colonel Rion, Lieut.-Colonel Spicer, Lieut.-Colonel Colebrooke, Lieut.-Colonel Beerer, Major Gold, Major Buckner. Their Report bears date, Royal Arsenal, Woolwich, 22nd May 1811, and is entitled "Report from the Committee of Field Officers of Artillery, "containing an account of the experiments made at Woolwich on the 18th and 20th "May last on Captain Manby's invention for saving the lives of shipwrecked "mariners." Printed by order of the House of Commons.—*Annual Register* for 1811, pp. 518 to 521.

5 The Committee were of "opinion that they cannot too strongly recommend an "invention, the partial application of which has been attended with such beneficial "effects. . . . . It is also the wish of the Committee to render their full tribute of "praise to Captain Manby for his ingenuity in so much improving and bringing into "practical use this invention, to the perfecting of which he has so zealously and "skilfully devoted himself."—*Annual Register* for 1811, p. 520.

6 The address was moved by Mr. Wilberforce.—*Annual Register* for 1811, p. 521.

The propositions which Captain Manby had submitted to the Committee were eight in number, from which the following are selected, as being the only ones having a direct bearing upon the history of the present service life-preserving apparatus:—A small brass howitzer 3-pr. bore, which, with its carriage, weighed 62 lbs., and was strapped on to the fore part of the saddle of a mounted man, 200 yards of log line being coiled upon a deal frame and slung as a knapsack on the back of the horseman, the line being projected from the howitzer by means of a "*kind of pear shot, 1½ diameters in length*," and weighing 4 lbs. 12 ozs. 12 drs. By means of this shot, and with a charge of 2½ ozs. of powder, the howitzer threw the line 143 yards. "Next, a "method of affording certain relief to vessels stranded in the darkest "night, with an improved mode of rendering the life rope more "distinguishable." This arrangement consisted, firstly, in firing what Captain Manby called "light balls," viz., paper shells filled with "stars," from a mortar, to throw a light over the scene; and, secondly, in projecting from the *5½-inch mortar*, charged with 8 ozs. of powder, a deep sea line attached *to a shell with four fuzes in it.*[1]

He also suggested at this time connecting the rope to the shot by means of "*some stout strips of hide plaited extremely close at the eye.*"[2]

It is, therefore, placed beyond doubt that Captain Manby's original propositions included, among other contrivances, 1st. A pear-shaped or oblong shot. 2nd. A shell of 5½-inch calibre. 3rd. A shell containing four fuzes. 4th. A plaited hide thong for the purpose of connecting the line to the projectile. The immediate connexion of these details, with the history and origin of the present service pattern, Manby's shot, will at once be perceived, the projectile now used being of an oblong form, 5½-inch calibre, containing four fuzes, and having a plaited hide thong. There is no record of the exact form in which Captain Manby's original propositions were adopted, but it would seem

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[1] Captain Manby's other propositions and experiments, briefly described, were as follows:—An arrangement for firing "by chemical agency of two substances, which "ignite from coming into contact with one another;" a plan for laying and firing from a boat "when the sea is continually breaking over it;" an arrangement by which the rope is coiled in a basket and then carried to the spot required; a rope ladder "intended to be projected or conveyed to a crew wrecked under a cliff," consisting of a single rope, with loops spliced to it at convenient distances for the support of the feet and hands when climbing; "the distance a deep-sea line can be "projected from the shortest 8-inch mortar" (in the course of this experiment a deep-sea line with 68-pr. shot attached was projected 439 yards; charge, 2 lbs.; elevation, 23°); the distance an 8-inch barbed shot "with a patent Sunderland 2-inch rope "attached" could be projected (the distance was 336 yards).

These propositions will be found *in extenso*, as I have already intimated, in the *Annual Register* for 1811, pp. 518 to 521. Much interesting information will also be found on the subject of Captain Manby's original propositions in the *Encyclopædia Britannica*, vol. xiii., pp. 441 to 444, where copious extracts are given from an essay published by Captain Manby himself in 1812, entitled "An Essay on the Preservation "of Shipwrecked Persons."

[2] Captain Manby's own words respecting this part of the subject are as follows:— "To connect the rope to the shot and prevent it from being burned by the powerful "inflammation at the discharge of the mortar, was most essentially necessary, and "success resulted from almost innumerable experiments; chains in every variety of "form and size broke, and proved that not only strength, flexibility, and elasticity, "but a body at once continuous and entire was required.

"At length some stout strips of hide, plaited extremely close at the eye, happily "effected the object so indispensably wanted."—*Observations with Directions on the Method brought into use by G. W. Manby.*

See also *Encyclopædia Britannica*, vol. xiii., pp. 461 to 464, where nearly the whole "observations" (extracted from Captain Manby's published essay) are given with illustrations.

from the "Observations, &c.," printed respecting his inventions, as if the majority of them were approved and introduced. It is certain, however, that many were allowed to lapse and become practically obsolete; and it appears that the two projectiles most used were, a spherical 24-pr. shot, or shell filled with lead, having an eye-bolt riveted to it, furnished with a stout twisted hide thong, for the purpose of attaching the rope, and a grapnel or oblong shot with a barbed iron staple, to which the rope was fastened, projecting from one end.

Some demands for this class of stores in 1857–58 lead to experiments being instituted by Colonel Boxer, Superintendent of the Royal Laboratories, the result of which was the introduction and issue, in 1859 or 1860,[1] of an improved and modified Manby's shot, and the pattern then introduced is, with the exception of some slight alterations, which were subsequently (in 1863[2]) made in the thong, the present service pattern. Spherical Manby's shot are not, however, altogether obsolete, a pattern of a 6-pr. having been deposited in the model room of the Royal Laboratory in 1862,[3] to govern the supply on special demand.

Without entering upon a detailed description of the different plans proposed from time to time for establishing communication between a stranded vessel and the shore, it will, perhaps, be well to mention that Manby's apparatus is not the only one which has been used for this purpose. The following passage from the *Encyclopædia Britannica* will sufficiently indicate the variety and scope of these inventions. "Mr. G. Delvigne "uses a howitzer instead of a mortar, while a portion of the line to be "carried is contained in the projectile. Mr. Greener has a method of "discharging a rocket, with a line attached, from a light harpoon gun. "When discharged, the rocket ignites, and is said to prolong the "range to a greater distance than if the gun or the rocket were alone "employed. Captain Jerningham, Royal Navy, has an anchor of a "peculiar form, which he proposes to fire from a Manby's mortar, in "sufficient numbers to afford the means of hauling a life-boat through "the surf. Mr. A. G. Carte employs a war rocket instead of a Den-"nett's rocket."[4] Kites have also been suggested as a simple means of carrying a line from[5] a wreck to the shore,[6] and are manufactured for this purpose by the "Shipwrecked Mariners' Society, London Bridge." The Board of Trade employed, to a great extent until 1865, Dennett's rockets, in preference to Manby's shot; and there can be no question that the balance of advantages inclines strongly to the side of the rockets.[7]

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[1] I cannot discover the precise date when these shot were introduced, but it appears that the first issue of them were made in May 1860 for the use of the Coast Guard at Lowestoft; and this marks their first *practical* introduction. The proportions of these shot, and of the different stores, fuzes, lines, &c., which together constitute a complete "Manby's apparatus," were not officially determined or laid down until 25th August 1862. See *War Office Circular* 793, par. 633.

[2] 12th October 1863.

[3] 13th January 1862.

[4] *Encyclopædia Britannica*, vol. xiii., p. 445.

[5] Evidently they are not generally available for carrying a line in the other direction, as the wind will almost invariably be blowing towards the shore.

[6] The *Times*, 10th December 1864, contains two letters on the subject.

[7] Rockets are more portable, as also is the apparatus from which they are fired; they carry their own illuminating agent, and are thus independent of fuzes, do not require so long a line as a shot fired from a mortar, where the angle of elevation is greater; and finally, are more accurate, owing principally to the fact that the deflection caused by the action of the wind upon the line is in a great measure corrected by the rocket having a tendency to fly up in the wind's eye.

In 1862 (3rd December) the Ordnance Select Committee experimented with some Manby's and Delvigne's shot against Dennett's 9-pr. rockets, and "the result was a

In 1865 a rocket, proposed by Colonel Boxer, R.A., was adopted by the Board of Trade to supersede Dennett's rocket, to which it is preferred, because,—"1st. The range of Colonel Boxer's rocket is little, "if at all, inferior; and in every other respect it is much superior. "2nd. The combination of Mr. Dennett's two rockets is very objec-"tionable, and from their velocity they frequently carry away the "line, and sometimes both do not ignite. They are also double the "expense."[1] These rockets are fast superseding Manby's shot at all stations, and the latter may shortly be expected to become entirely obsolete.

There are two natures of Manby's shot in the service, the 24-pr. oblong (pl. 25, fig. 1), or "cylindrical," and the 6-pr. spherical shot. They are designated 24-pr. and 6-pr. respectively from their calibres, not from their weights.[2] The 24-pr. oblong, or "cylindrical" Manby's shot, is a cast-iron cylindro-conoidal projectile,[3] with a slightly rounded base,[4] and about $1\frac{1}{4}$ calibres in length.[5] The shot is drilled down its longer axis for the reception of a wrought-iron bolt, which passes completely through the projectile from end to end,[6] and projects about five inches beyond the base, terminating in an eye, to which is attached a plaited hide thong, 2 feet in length. Four holes (pl. 25, fig. 2), for the reception of "fuzes,"[7] are drilled into the shot at the base, equidistant from one another and from the centre of the base, and slightly inclining inwards.[8] Sizes. Description. 24-pr.

"general conviction on the mind of everybody present, and shared by Mr. Delvigne, "of the great superiority of the rockets over either of the other plans." The rockets were fired singly and in couples at an angle of from 30° to 35°. "The single rockets "carried a line 240 yards, the double rockets 370 yards, with great steadiness of "flight, and with less length and weight of line in proportion carried out than the "pieces fired at 45°. The range obtained with Manby's apparatus, charge 12 ozs., "was 200 yards; and with the same mortar firing Mr. Delvigne's elongated shot, was "185 yards. The same shot, however, fired from the rifled $5\frac{1}{2}$-inch howitzer at 28° "with 10 ounces, attained a range of 298 yards, but the line broke three times."—*Extract from Reports and Proceedings of Ordnance Select Committee*, vol. i., p. 199.

On the subject of the employment of rockets for carrying a line, see a work published at St. Petersburgh, entitled "*Application des Fusées au jet des Amarres* "*Sauvetage*, par General-Major Konstantinoff," which contains a good deal of information upon this subject, and explains the construction of a rocket proposed by the author for this purpose, very similar to the Boxer life-saving rocket.

[1] Report of Captain Robertson to the Board of Trade. The construction of this rocket and of the apparatus which is issued with it will be described in the section on rockets in a succeeding volume of this work.

[2] See p. 96.

[3] Perhaps more strictly an obtuse cylindro-ogival.

[4] It is difficult to say whether this end should properly be called the "base," or the "upper end." When the projectile is placed in the piece, this end is towards the muzzle, and is therefore, strictly speaking, the "upper end," but the shot changes its position on leaving the piece, and what was the front of the shot in the gun becomes the base or hinder part during its passage through the air. Therefore, and as the term is a more convenient one to use, I have designated this end the "base" of the projectile.

I have also hesitated between the terms "slightly rounded" and "nearly flattened" in describing the form of the base, but have selected the former as conveying perhaps a rather more correct impression of the actual shape.

[5] For actual dimensions, see plate 25.

[6] A reference to the drawing of the section (see pl. 25, fig. 2) will show the manner in which the bolt is secured to the shot, viz., by means of a projecting head or shoulder on the bolt, which is pushed into the shot from the base up to this shoulder, so much of the bolt as projects at the top of the shot being hammered down to form the head, and thus securely riveting the bolt into its position.

[7] More properly lights, see pp. 97, 270.

[8] The inclination given is just sufficient to throw the flame of the burning "fuzes" free of the hide thong.

These holes are conical in form, and are about the same diameter as the fuze holes of the 13 and 10 inch mortar shells.[1] They are about 3½ inches in length, and are roughed in the interior to afford a better hold to the fuzes.[2]

The hide thong, or "strop," which is fastened to the eyebolt, is made of four strips of raw horse hide,[3] doubled through the eye and tightly plaited, the plait being further secured by being stitched in several places with hide.[4] The end of the thong is formed into a loop which is tightly woolded with fine tarred spun yarn.[5]

The shot and bolt are painted black before issue; the thong is unpainted. These projectiles weigh (with thong) about 30½ lbs.

6-pr.

The 6-pr. spherical Manby's shot is rarely demanded, and is scarcely to be considered as a service projectile. It consists of a diaphragm shell filled with lead,[6] and having an iron loop fixed into it, to which is attached a thong similar to that of the oblong projectile. This shot has no fuze holes.

It is painted black before issue, and weighs about 8 lbs.

Action of the oblong shot.

The action of the oblong shot is as follows;—the end of a line[7] is made fast to the loop hole of the thong, the rest of the line being carefully coiled either in a basket or upon the ground or deck,[8] and a fuze (pl. 25., fig. 5.) is placed in each of the four holes made for the purpose.

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[1] For the actual dimensions, reference must be made to pl. 25, fig. 2.

[2] This roughing is not affected in the same way as in mortar shells by means of a sort of thread, but is done by cutting a number of shallow groves about ·2 inch apart round the sides of the holes.

[3] The hide is prepared with lime, and is technically known as "horse-hide-raw-"lime." The strips are cut with a tapering towards each end, so as to give the required taper to the thong when completed. In the history of this projectile (p. 91) it has been mentioned that Captain Manby tried several materials for the thong before he adopted hide, and it is deserving of notice that Captain Jerningham, R.N., who carried on a large number of experiments with the apparatus, preferred manilla rope thongs to hide. In a report upon the subject he says—"Strops of manilla rope were "found to be the most serviceable."—*Captain Jerningham's Report,* Her Majesty's Ship, "Cambridge," Devonport, April 27th, 1860.

[4] In a 4-plait of double hide.

The hide known technically as "white horse" or "whit leather," is used for this purpose; it is the same material as is used for whip thongs. Until 1863 fine wire was used for this purpose; hide is preferred to wire because the latter had a tendency to cut the thong.

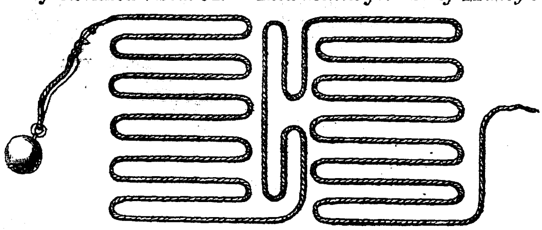
[5] It was not woolded until 1863; by woolding the end any chance of the line being cut is diminished.

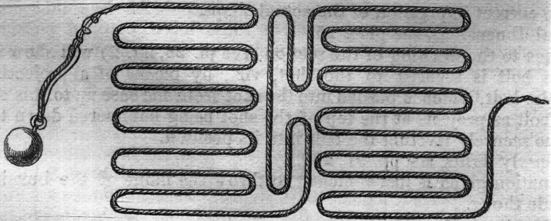
[6] Diaphragm shells are used because there are no other shell of this calibre; and it has not been thought necessary to manufacture a separate projectile, when a diaphragm shell answers the purpose perfectly well.

[7] The line generally used is "deep sea line;" but there is issued with each apparatus 113 fathoms of 1¼-inch rope.

See *War Office Circular* 793, par. 633.

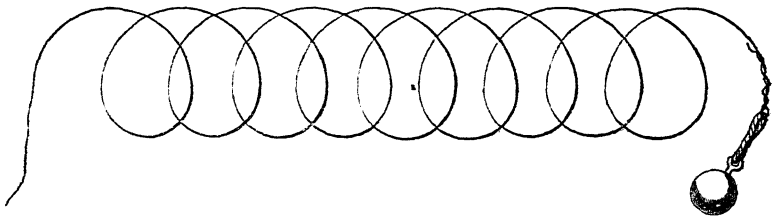
[8] The coiling of the line so that it may run out free without check is a matter of considerable importance. There are several ways of coiling it; in a basket, or if the beach be even and free from large stones as follows:—the length of the fakes not to exceed two yards, as if they are longer the rope is more liable to be broken "by the "proportionately increased vibration."—*Instructions for use of Manby's Apparatus.*



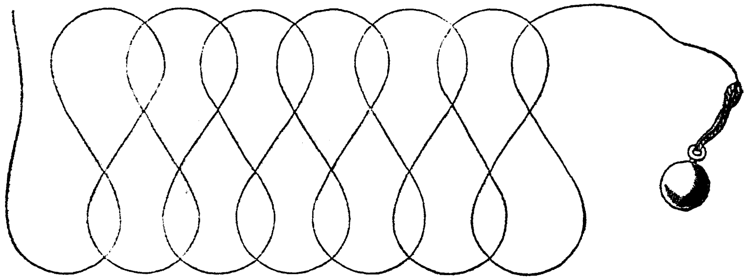


The fuzes being uncapped the projectile is placed in the piece[1] with its base towards *the muzzle*, and upon the discharge of the piece carries out the line, one end of which being retained, a communication is thus established between the vessel and the shore. The use of the hide thong is to remove the line from the immediate flash of the discharge, and so to prevent it from being burned.[2] The fuzes serve, by the bright light which they give forth, to indicate the path of the shot and guide the firing party in laying the piece. The strength and direction of the wind must be considered in determining the direction to be given, the trajectory being affected by them to a very great extent, owing to the influence which the wind has upon the line. With deep sea line, and with the ordinary charge of 12 ozs., the range varies from 400 yards downwards, according to the strength and direction of the wind.[3]

Another way, as used in the whale fishery, is as follows:—



A third method, called "chain faking," is sometimes employed.



A fourth method is shown in plate 42.

[1] A 5½-inch (coehorn) mortar specially prepared (with a crutch for firing quill-friction tubes), was used for projecting these shot (see W.O.C. 793, para. 598) until 1866,—but by 21/2/66, 51/20/8742, it was intimated that metal friction tubes might be used with them. On an emergency they could be fired from a 24-pr. gun or howitzer.

[2] "To connect the rope to the shot, and prevent it from being burned by the "powerful inflammation at the discharge of the mortar."—*Observations with directions on the method brought into use by G. W. Manby.*

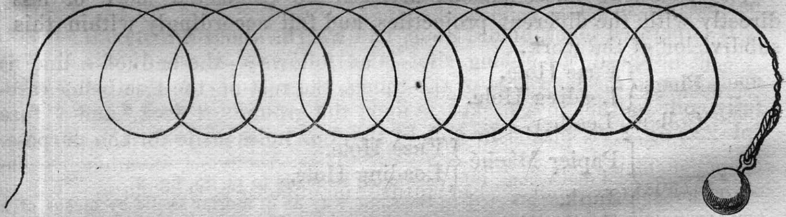
[3] In some experiments carried on in the Royal Laboratory 1859, with a charge of 12 ozs., elevation 45°, the range varied from 260 to 400 yards.

"For the Manby 24-pr. cylindrical shot the charge is 12 ozs., giving a range of "about 300 yards."—Captain Fraser's *Notes on Matériel*, p. 6.

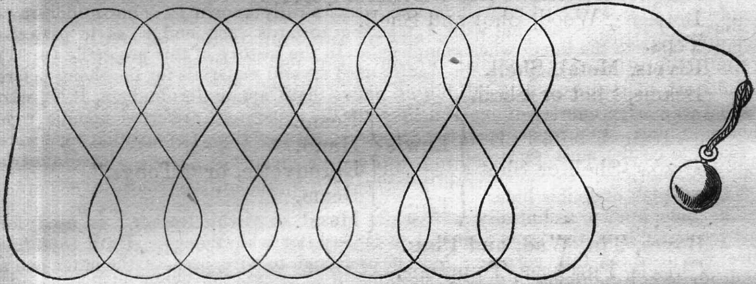
In Captain Manby's *Observations with Directions, &c.*, he gives the following charges and ranges for the spherical 24-pr. shot. (As this shot consisted of a shell of 5½-inch calibre filled with lead, it must have weighed considerably over 24 lbs., and probably was about the same weight as the present oblong 24 pr.)

Charge.	With deep Sea Line.	With 1½-inch Rope.
oz.	yds.	yds.
8	220	180
10	270	220
12	320	250

Another way, as used in the whale fishery, is as follows:—



A third method, called "chain faking," is sometimes employed.



A fourth method is shown in plate 42.

Action of the 6-pr. The 6-pr. is used in the same way, with the exception that, having no fuzes, the operation of fixing and uncapping them is dispensed with.[1]

Use. These projectiles are mainly used to establish a communication between the shore and a stranded vessel,[2] but the principle is applicable to a variety of other purposse, "such as throwing rafts or pontoon bridges across rivers in the absence of boats, and throwing suspension bridges across ravines or mountain torrents for the passage of troops and matériel: in naval matters, in landing through a surf, laying out anchors, or taking a vessel in tow by throwing a grapnel over a buoy fast to a line in heavy weather."[3]

MISCELLANEOUS STORES CONNECTED WITH PROJECTILES.

The following miscellaneous articles are connected more or less directly with the different projectiles, and fall accordingly within this subdivision of the work.

- Plugs
  - Fuze Hole.
  - Loading Hole.
- Collars, Leather.
- Wads
  - Papier Mâché
    - Fuze Hole.
    - Loading Hole.
  - Junk.
  - Grummet.
- Adapter Spherical Shell, General Service.
- Bottoms, Wood, Shot and Shell.
- Tops.
- Rivets, Metal, Shell.
- Beams, Shot or Shell.
- Hooks, Shell or Shot
  - Lewis
    - Beam.
    - Hand.
    - Eprouvette, or "Tongs."
  - Lug
    - Beam.
    - Hand.
- Boxes, Tin, Wad, and Plug.
- Chisels, Purchase, Tompions.
- Scrapers, Copper.
- Spouting and Trestles for Shells.
- Gauges, Iron ring, Shot or Shell.

It also appears that in the determination of these ranges the most unfavourable conditions had been taken, for in another part of his observations Captain Manby says, "An iron mortar . . . . will project a 24 lb. shot, with an inch and a half "rope attached to it 250 yards, or a deep sea line 320 yards, *against the utmost power* "*of the wind.*"

[1] No charge is laid down for the 6-pr., nor is there any data to enable me to assign even approximate charges and ranges to this projectile.

[2] With respect to this, the natural and simplest application of the projectile, the value of the invention will be more readily perceived if we bear in mind that "the "most fatal cases of shipwreck and the most frequent are those which occur within "the distance of from 300 to 60 yards off the land."—*Observations, &c.*

Captain Manby quotes several instances in which lives have been saved by his apparatus; and doubtless our Naval annals and the records of the Board of Trade would afford many other instances of its successful application.

[3] *Letter from Captain Jerningham, Royal Navy, to the Ordnance Select Committee,* May 21st, 1860. The application of the apparatus for aiding the passage of troops across rivers or ravines was proposed to the Ordnance Select Committee by a Mr. Dillon, and reported upon in 1861 (Report 1,740, 27/7/60. Committee Minute 4387, 15/7/61). The Committee reported that they met with "such a succession of diffi- "culties," that until the whole apparatus is revised "it is obviously much too "precarious an experiment to have any military value."

Plugs.

There are two classes of plugs, viz. :— Plugs—two classes.

(*a.*) Fuze Hole Plugs.
(*b.*) Loading Hole Plugs.

Plugs, metal, shell, fuze hole. History.

Until 1856 the fuze holes of shells were closed by plugs of cork or wood, but in the preceding year[1] Colonel Boxer had proposed substituting white metal[2] screw plugs, and in 1856, on the recommendation of the Ordnance Select Committee, this proposition was officially adopted,[3] and white metal plugs approved for the fuze holes of all shells, mortar included.

In 1858[4] the white metal plugs of *field service* shells were superseded by a plug, slightly altered in form, made of gun metal, the white metal having proved unequal to withstand the jolting to which it was inevitably exposed, and being liable from its softness to work loose in transport.[5] In the following year,[6] gun metal plugs were approved for *all* shells except mortar, for which white metal appears to have been retained.

But in 1860[7] white metal plugs altogether disappeared, for early in that year metal plugs for the fuze holes of mortar shells were discontinued, and corks re-introduced in their stead.

Plugs, metal, shell, loading hole. History.

The history of metal plugs for the loading holes of diaphragm shells is contemporary with that of these projectiles, the original pattern diaphragm having had its loading hole closed with a metal plug, and the approval of this shell in 1853,[8] having necessarily included the approval of the plug.

From the first these plugs were made of gun metal, and they differed from the present pattern only in the absence of the head, being merely small cylinders screwed to fit the loading holes.

In 1858 these plugs were first made with a head of the present pattern, as it was found that without a head the plug was liable to work into the shell during transport.

The loading hole plugs of improved shrapnel shells were at first made of wood,[9] but in a few months time[10] a gun metal plug of the present pattern was substituted for the wood.

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[1] 19th December 1855. *See Synopsis of Reports and Experiments by the Ordnance Select Committee, Shrapnel Shell*, page 232, also page 26, where (in 1853) substitution of wood for cork plugs in Shrapnel shells is approved.

[2] Lead and antimony in the proportion of lead, six parts, antimony, one part.

[3] Approved 21st February 1856. See *Ibid.* p. 233 ; see also, *Account of Additions and Alterations, &c.*, 30th June 1856, para. 12. A precis of the experiment by which the efficiency of these plugs was established, taken from the *Synopsis of Reports and Experiments by the Ordnance Select Committee on Shrapnel Shell*, page 233, is given at page 101, note 1.

[4] 2nd June 1858. See *Royal Artillery General Regimental Orders* 402, 16th June 1859, par. 41.

[5] The plugs became displaced from the jolting of the carriage, and are ground by rubbing against the other shells.

[6] 12th September 1859, 57/Woolwich/1627, *Royal Artillery General Regimental Order*, No. 415, 31st December 1859, par. 44.

[7] Metal plugs discontinued for mortar shells, and corks approved, 8th March 1860, 75/12/57, *War Office Circular* 590, paragraph 9.

[8] 17th November 1853, M/2127, see *Account of Alterations and Additions, &c.*, 31st January 1855, paragraph 2.

[9] "The hole shall be plugged with wood before issued for practice or service." Approved 27th January 1855 ; see *Ibid.*, 31st January 1855, par. 29, Section IV.

[10] Approved 9th May 1855, L/329, see *Ibid.*, 22nd October 1855. par. 12.

(*a*.) Fuze hole plugs.

(*a*). Fuze hole plugs are of ten different[1] natures.

1. Plug for fuze hole of common shell.
2. " " diaphragm shrapnel shell.
3. " " naval shell.
4. " general service fuze hole.
5. " filling hole of Martin's shell.
6. " fuze hole 10″ parachute light.
7. " " 8″ "
8. " " 5½″ "
9. Drill plug, with lanyard, common.
10. " " naval.

All these plugs are made of gun metal.[2]

Plug, metal, shell, fuze hole, common. Description.

(1.) *The plug for the fuze holes of common shells* (pl. 34, figs. 1, 2, 3) is slightly conical in form, and rather less than ¾-inch in total length.[3] The lower part of the plug is screwed with a right handed thread,[4] to fit the fuze holes of common shells.

The upper part of the plug, above this screwed portion, consists of a projecting head or shoulder, just large enough to enter the countersink of the fuze hole, the edge being rounded on its upper side, and the top of the plug being countersunk, and having a square key hole in the centre for the reception of an iron key,[5] by which the plug is screwed into or out of the shell.

A cross is cut on the top of the plug to indicate that the shell into which it is screwed has been prepared to receive Pettman's land service fuze.[6]

Underneath the shoulder of the plug is a leather collar (pl. 34, figs. 9, 10), or washer,[7] which, when the plug is screwed home, renders the interior of the shell more impervious to moisture.

Uses.

These plugs are used to screw into the fuze holes of common shells, whether filled or empty. They serve :—

1st. To protect the fuze hole from injury during transport, and when the shells are filled; 2nd, to enable the shells to be used as hollow shot (without wood bottoms); and 3rd, to exclude all dirt, and (in conjunction with the papier mâché wads provided for use with filled shells)[8] all moisture; and to prevent the possibility of the passage of any flame from without, in the case of a neighbouring accidental explosion, thus

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[1] The plug for the fuze holes of improved shrapnel shell is not included in this list, because it is no longer manufactured, but as these plugs cannot be considered entirely obsolete until the store of improved shrapnel shells become exhausted, they could not properly be altogether passed over, and accordingly mention is made of them at page 101, note 2. I have thought it better to introduce the plug in this way in preference to burdening the text with the description of an article now almost obsolete. I have followed this system with respect to other articles connected with improved shrapnel shell, such as the loading hole plugs, fuzes, &c., used with these shells.

[2] Or rather of an alloy similar to gun metal. The alloy is : copper, 11 lbs., tin, 1 lb., zinc, 1½ oz.

[3] For dimensions of these plugs see plate 34.

[4] 14 threads to the inch.

[5] See shell and fuze implements, page 307.

[6] See Common shell, page 25, and Pettman's land service fuze, page 276.

All Common shells now manufactured are thus prepared, and consequently all plugs now issued have the cross cut. *They are the same plugs as were issued previous to the introduction of this fuze, except in respect to having the cross.*

[7] See Collars, page 105.

[8] For application of these wads, see page 106.

enabling shells to be carried, or stored filled, without danger and without deterioration of the bursting charge.[1]

(2.) *The plug for the fuze hole of diaphragm shell*[2] (pl. 24, fig. 4, 5,) differs from the common plug in two respects,—1st, in having no cross cut upon the top, for the reason that Pettman's fuzes are not used with diaphragm shells, and any such distinguishing mark is therefore unnecessary; and, 2nd, in having attached to it, extending downwards into the socket, a wooden plug (pl. 24, fig. 4, T, Y), slightly conical in form and covered with serge, and of a size exactly to fill the socket.[3] Plug, metal, shell, fuze hole, diaphragm shrapnel.

The object of this addition to the plug is to prevent the powder of a filled diaphragm shell from working through the fire hole and choking the socket, and thus interfering with the insertion of the fuze. Uses.

In all other respects this plug is identical with that used for the fuze holes of common shells,[4] and it has the leather collar under the shoulder. Plug, metal, shell, fuze hole, naval.

Its application and object are the same also.[5]

(3.) *The plug for fuze holes of naval shells* resembles that used for the fuze holes of common shells in general appearance and construction, though differing from it in dimensions and details. It is necessarily a

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[1] "I have the honour to propose that an arrangement be made to render charged "shells secure, should an explosion occur in the boxes of the limber or wagon." (Letter from Col. Boxer to Mr. Monsell proposing the adoption of fuze hole plugs and wads. 19th December 1855.—See *Synopsis*, &c., page 232.)

That shells thus plugged *are* perfectly safe, as well as impervious to moisture, is proved by the experiments carried on by the Ordnance Select Committee on this subject. These experiments are so conclusive upon the general question of the efficiency of the plug, and the point appears to me so important a one to establish, that I give a *précis* of them as recorded in the *Synopsis*.

1st. A pile of ten live shells (diaphragm shrapnel) was formed, nine of them being fitted with a metal plug, the tenth, which was underneath, was exploded.

This experiment was repeated nine times without injury to these shells, using the same nine every time.

2nd. Two 9-pr. limber boxes were then packed, one with 18 24-pr. common shells, the other with 18 24-pr. diaphragm shrapnel shells, and with the due proportion of cartridges, bursters, &c., each shell containing 2 drs. of powder, and being secured as recommended.

The boxes were placed side by side and exploded simultaneously. The shells were scattered in all directions with such force as to break off several of the riveted bottoms, but none were fired by the explosion, and only one lost its metal plug, the bursting charge being effectually protected by the gutta-percha wad under the plug. An alteration has been made in the shape of the head of the plug which renders it *perfectly* secure.

3rd. Two limber boxes filled with common and diaphragm shells were run for hours over the roughest ground in the arsenal, and on examination no movement whatever was found to have taken place in the metal plugs with which the shells had been filled.

4th. A 24-pr. common shell with plug fixed was kept 24 hours under water its interior was then found to be perfectly dry.—*Synopsis*, &c., p. 233.

[2] The plug for the fuze hole of improved shrapnel shell resembles that for diaphragm in every respect but one, viz., the development of the cone, the improved shrapnel socket being straighter and more nearly cylindrical than that of the diaphragm.

[3] The ends of fuze cones are ordinarily used for this purpose, covered with serge, and fastened to the gun-metal plug by means of a brass pin.

For dimensions, &c., see plate 24.

[4] Consequently the same key can be used to screw it into or out of the shell.

[5] Of course it is never used in conjunction with a papier mâché wad, the wood plug covered with serge being an obstacle to such an arrangement; moreover, a papier mâché wad is evidently unnecessary for the socket of a diaphragm shell.

larger plug, to enable it to fit the fuze holes of naval shells, cylindrical instead of conical, and screwed to a different pitch.[1] The form of the head is also somewhat different, the edge being bevelled on its upper surface, not rounded, and there is no cross cut. The key hole is also larger than in the common plug.[2]

Use.

The two plugs resemble one another in all other respects, the naval plug also having the leather collar under the shoulder. Their application is the same, so far as their employment with *empty* shells goes;[3] but plugs are never issued with filled naval shells, such shells being always fuzed.[4]

Plug, metal, fuze hole general service.

(4.) *The plug for the general service fuze hole*[5] (pl. 43, fig. of 7-inch B.L. hollow shot) is a conical gun metal plug without any head, and having a square keyhole in the top of the same size as the keyhole in the naval plug. The cone is the same pitch as that of the common plug, but a thicker frustum. This plug serves for all fuze holes of the general service gauge. For smooth-bore ordnance its use will be confined to future issues of naval shell fitted and bushed to this gauge, or to existing naval shells fitted with the general service adapter. It will thus gradually supersede the naval plug.

Plug, metal, shell, Martin's.

(5.) *The plug for the filling hole of Martin's shells* is almost identical with the naval plug in respect to its general dimensions, shape, pitch of thread, and size of key hole. The two differ, however, in the screwed part of Martin's plug being shorter than that of the naval plug, and in the head being rounded on its upper edge, more after the manner of the common plug. The two plugs are interchangeable.[6]

Martin's plug is fitted with a leather collar underneath the shoulder.

The application of this plug is the same as that of the naval plug, viz., for use with *empty* shells only, to protect them from damp,[7] the filled shells being closed by the molten iron cooling and hardening in the filling hole.[8]

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[1] $16\frac{1}{2}$ threads, right-handed.

[2] A special key is provided for this plug. See Shell and Fuze Implements, p. 307.

[3] Until 1863 naval plugs were only used with those naval shells which were issued "empty, loose," and not with those issued "empty, riveted." The latter, being boxed, were fitted with a cork instead of a plug. For sake of uniformity, and to avoid confusion, this was altered in 1863 (Departmental Order, 11/2/63), and all empty naval shells, whether loose or riveted, issued with screw metal plugs in the fuze hole.

[4] See page 34. This of course renders the employment of papier mâché wads with these plugs unnecessary.

There is no reason whatever why filled naval shells should not be plugged instead of fuzed, if desired, since there is every reason to believe that the bursting charge of a shell plugged with a gun-metal plug is as secure from damp and danger as where a fuze is employed as a plug. The fitting of filled naval shell with fuzes is, however, dependent upon other considerations.

[5] This plug was first introduced for 7-inch B.L. hollow shot 30th May 1865, *War Office Circular* 5 (new series), § 1085. Its use was afterwards extended to all projectiles fitted with the general service bush.

[6] Although interchangeable, it would be undesirable to do away with either of these plugs. A plug of the length of the naval plug is necessary for naval shells; but to make use of this plug for Martin's shells (where so great a length is not necessary) would involve an additional expense of 13*s.* 7*d.* per 100 plugs, the cost of the two plugs per 100 being—naval 1*l.* 19*s.* $3\frac{3}{4}$*d.*, Martin's 1*l.* 5*s.* $8\frac{3}{4}$*d.*

[7] The paramount importance of keeping the interior of Martin's shells free from damp has been dwelt upon and explained at page 66.

[8] The plug is merely screwed into the shell when issued to protect it from damp, and is not required when the shell is filled with molten iron.—Minute from Superintendent Royal Laboratories to Ordnance Select Committee, *Report*, 2752, 1/4/63. See extracts from *Reports and Proceedings of the Ordnance Select Committee*, vol. i. p. 208.

(6.) *Plug for the fuze hole* (pl. 37, fig. 12) *of the 10-inch parachute light*[1] resembles the common plug, except in the absence of a cross cut upon the top. It is rather larger in diameter than the common plug, and rather shorter;[2] the pitch and direction of thread and angle of cone are the same. Plug, metal, shell, fuze hole, parachute 10″.

A cross cut is unnecessary upon these plugs. The plug for the 10-inch parachute light can be used only with that projectile; it serves to protect the interior from damp, dirt, &c., when not in use.

The (7) *plug for 8-inch parachute*[3] resembles that for the 10-inch parachute in all respects but one, viz., that it is rather smaller in diameter.[4] Ditto, parachute 8″.

The (8) *plug for 5½-inch parachute light*[5] is rather smaller in diameter[6] than that of the 8-inch parachute, but differs from it in no other respects. Ditto, parachute 5½″.

(9.) *Drill plug, with lanyard, common,*[7] is merely a common plug complete with leather collar), with a tarred lanyard 10 feet long attached. It is lacquered before issue.[8] Ditto, drill, with lanyard, common.

It is used, as its name implies, for drill[9] purposes, the object of the lanyard being to enable the gun to be unloaded by pulling out the shell, thereby avoiding the more laborious operation of depressing the muzzle.[10]

(10.) *The drill plug with lanyard, naval,* differs from the ordinary naval plug in the head, which is made like the head of a Pettman's sea service fuze, flat on the top, and with four wrench holes equidistant from one another and from the centre of the head.[11] It differs from the naval plug, also, in having a tarred lanyard 10 feet long attached, and in being lacquered.[12] In other respects the two plugs are the same, being adapted to the same fuze hole. Ditto, drill, with lanyard, naval.

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[1] Plug approved 2nd January 1866.—*War Office Circular* 9 (N.S.), § 1193.
[2] For dimensions, see plates 37, 38.
[3] Approved 2nd January 1866.—*War Office Circular* 9 (N.S.), § 1193.
[4] For dimensions, see plates 37, 38.
[5] Approved 2nd January 1866.—*War Office Circular* 9 (N.S.), § 1193.
[6] For dimensions, see plates 37, 38.
[7] Proposed by Commandant School of Gunnery, and approved 13th May 1863, *War Office Circular* 835, par. 773.
[8] For the composition of the lacquer used with these plugs and other brass work, see table XX., page 345.
[9] It is used "for drill with shells at field and garrison smooth-bore guns" (*War Office Circular* 835, par. 773) instead of Pettman's percussion fuze, answering the same end, as far as instruction in the method of screwing in the fuze is concerned, without the danger which necessarily attends in a certain degree, however slight, all operations with a percussion fuze, and with the advantage mentioned in text, that the gun may be safely unloaded.

The plug is not generally, if ever, used when drilling with time fuzes, the practice of the School of Gunnery when such fuzes are used being to go through the operations of boring, preparing, and fixing the fuze exactly as on service; nor does the question of danger, as in the case of percussion fuzes, connect itself with this practice. "We use a lanyard and metal plug when drilling with percussion fuze "(Pettman's). We bore and fix the time fuze when exercising with shrapnel or "common shell."—*Extract from letter from Colonel Gardner, R.A., Chief Instructor. School of Gunnery, Shoeburyness,* 31st August 1863.
[10] "To unload with facility."—*War Office Circular* 835, par. 773.
[11] The object of shaping the head like that of the fuze whose place it is to take at drill (see note 9 above) does not need explanation. In this respect the sea service drill plug is better suited to the end for which it is required than is the land service drill plug.
[12] See table XX., page 345.

Use. The naval drill plug, like the common drill plug, is used for drill purposes,[1] and the object of the lanyard is the same.

(b.) Loading hole plugs, two sizes. (*b.*) Loading hole plugs for diaphragm shells[2] (pl. 24, fig. 7) are of two sizes, viz.:—

(1.) Small, for all natures of diaphragm up to the 18-pr., inclusive.
(2.) Large, for all diaphragm above the 18-pr.

Description. These plugs resemble one another in construction, differing only in their dimensions, and in the pitch of the thread.[3] They are cylindrical plugs of gun metal screwed to fit the loading holes of the shells with which they are issued, and having a projecting head which prevents the plug being screwed in too far, or working into the shell during transport.[4] The head is flat on the top, with a groove cut across it for the purpose of screwing the plug[8] into or out of the shell.[5]

Uses. These plugs are used, as their name implies, to close the loading holes of diaphragm shells, whether empty or filled. They exclude all dirt, and (in conjunction with the papier mâché wads provided for use with *filled* diaphragm shell)[6] all moisture, and render the bursting charge safe against accidental explosion, thus enabling the shells to be carried, or stored filled, without danger, and without deterioration of the bursting charge.

Packing and issue of plugs generally. Fuze hole plugs, with the exception of drill plugs, are issued in the shells to which they belong.[7]

Drill plugs are issued loose, or in shells for drill as demanded.

Loading hole plugs are issued in the shells to which they belong, and 5 per cent.[8] spare wads and loading hole plugs are issued for field service and guns of position, in tin boxes[9] specially provided for the purpose.

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[1] It is also used at drill under precisely the same circumstances as the land service drill plug, viz., instead of Pettman's percussion fuze, and for the same reasons (see page 103, note 9). When drilling with time fuzes the navy do not generally, if ever, use this plug, a dummy white metal fuze being specially employed for drill purposes (see page 271).

[2] The loading hole plugs for the improved shrapnel shell are treated of in note 2, page 101. See what has been said in note 1, page 100, regarding the system followed throughout this work in respect to all articles connected with improved shrapnel shell, such as loading hole, plugs, fuzes, &c.

[3] For dimensions, see plate 24, fig. 7.

[4] See p. 99 respecting these plugs having been made until 1858 without heads.

[5] Screwdrivers are issued for this purpose with No. 3 set shell and fuze implements, R. and S. B., and with 2, 3, and 4 field sets. See page 307.

[6] The loading hole plugs for improved shrapnel shells differ from those of diaphragm shell in being larger and in having no head; being merely cylindrical plugs of gun metal screwed with a right-handed screw, and with a cut upon the top. They are of two sizes, small up to the 12-pr., inclusive; large for the higher natures. This difference in dimensions arises from the fact that above the 12-pr. musket instead of carbine balls are used. The sizes of the plugs are as follows:—

Small	-	·45 inches, length;	·805 diameter;	16 threads to 1 inch.
Large	-	·55 " "	·86 "	16 " "

[7] See p. 57.

[8] Until 21st November 1863 a proportion of spare loading hole plugs were issued. The issue of spare loading hole plugs was discontinued on that date.—See *War Office Circular* 855, par. 852. The reason that the issue of spare *loading hole* plugs was retained was because otherwise the loss of one of these plugs would render the shell useless.

Originally it was 10 per cent. spare for field service, and 5 per cent. garrison service. On the revisal of the field equipments in 1865, 5 per cent. was adopted for both services.

[9] See p. 126.

For howitzers and guns of position the boxes are rectangular, and for other field guns, cylindrical.

For garrison service spare loading hole plugs are issued in ordinary packing cases.

Leather Collars.[1]

Collars, leather, shell. History.

When metal plugs were introduced for shells in 1856 they were fitted with gutta-percha washers. In 1862[2] leather was substituted for gutta-percha, for the washers of diaphragm and improved shrapnel plugs *for service in India*, on account of the liability of the gutta-percha to deteriorate and become unserviceable in hot climates.[3] In 1863[4] *all* collars for all services were directed to be made of leather, the employment of gutta percha for this purpose being entirely discontinued.

Natures.

There are three sizes of collars, viz. :—

(1.) Small (S.B.), for common (pl. 34, figs. 9 and 10) and diaphragm and common drill plugs ; and for Pettman's land-service fuze.

(2.) Large, for the naval, Martin's, and naval drill plug and for the $7\frac{1}{2}$ and 20 seconds time and Pettman's sea-service percussion fuze.

(3.) Parachute, plug collar.

Description.

The three collars differ only in dimensions, being rings or washers of thin brown leather,[5] of a size to fit under the shoulder of the plugs with which they are respectively used.

Application.

They are fitted on to all fuze hole plugs, and serve to close the shell more effectually against moisture.[6]

Wads.

There are three classes of wads :—

(*a.*) Papier mâché.
(*b.*) Junk.
(*c.*) Grummet.

Wads, papier mâché.

(*a.*) Papier mâché[7] wads.—Wads for securing (in conjunction with the metal plugs) the fuze and loading holes of filled shells were first

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[1] Sometimes called washers.

[2] Approved 11th January 1862, *War Office Circular* 781, par. 553.

[3] Extracts from *Reports of Ordnance Select Committee*, vol. ii., p. 373.

[4] 16th August 1863, *War Office Circular* 855, par. 853.

The letters S.B. (smooth-bore) are necessary to distinguish this collar from the small R. (rifle) collar. The large collar serves for R. and S.B., and no distinction therefore is required.

[5] The leather used is ox hide, "brown seat," shaved to weigh about 11 lbs. per hide, and to gauge from 16 to 18 wire gauge in thickness. Hides as near this thickness as possible are purchased ; if they are too thick they are passed between rollers to reduce them.

The dimensions of the collars are as follows:—

	Diameter. Exterior.	Diameter. Interior.
Small (S.B.)	1·27 inch	0·985 inch.
Large	1·51 „	1·27 „
Parachute light	1·25 „	0·9 „

It will be observed that the interior diameter of the large collar is the same as the exterior diameter of the small one, thus enabling the two to be cut from one disc of leather.

[6] There does not seem to be any object in fitting drill plugs with these collars. The pattern drill plugs, however, are so fitted.

[7] Respecting the correctness of this name see p. 106, note 7.

adopted in 1856,[1] having been proposed by Colonel Boxer in the preceding year.[2]

History.

On their first introduction the use of wads was not confined to common and diaphragm, but they were also supplied for mortar shells. But on the metal fuze hole plug of mortar shells being replaced by a cork in 1860,[3] the discontinuance of wads for these shells followed as a natural consequence.

Natures.

On their first introduction the wads were made of gutta-percha, and this material was retained until 1863,[4] when papier mâché bees-waxed was substituted for both fuze hole and loading hole wads, the gutta-percha being found to deteriorate in warm climates.[5]

Papier mâché wads are of two natures, viz. :—

Wads, papier mâché, common.

1. Common.
2. Diaphragm.

Description.

(1.) *Common wads* (pl. 34, figs. 6, 7, and pl. 35, figs. 9, 10) are only made of one size, viz., to fit the fuze hole of common shells." [6]

Application.

They are discs of mill-board,[7] of the required thickness, and soaked in melted beeswax, which renders them less susceptible to the effects of climate and moisture.

These wads are used to place in the fuze holes of filled common shells, underneath the gun metal plug,[8] to render the shell free from any danger of accidental explosion, and to secure the bursting charge against deterioration from damp.[9]

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[1] 21st February 1856. See *Account of Alterations and Additions, &c.*, 30th June 1856, par. 12; also *Synopsis, &c.*, p. 232.

[2] Proposed 19th December 1855, *Synopsis, &c.*, p. 232.

[3] Plugs were discontinued for mortar shells 8th March 1860, *War Office Circular* 590, par. 9, and the abolition of wads for these shells was effected in the May of the same year (4th May 1860, *War Office Circular* 639, par. 105). The use of the wads was never extended to any but these three natures of shell, because they are inapplicable alike to naval, improved shrapnel, and Martin's shells; the first being always fuzed when filled, the second, having a serge plug in the socket (and, of course, as there is no communication with the powder through the loading hole, they could not be used for this hole as in diaphragm shell); and with Martin's shells and parachute lights they are not required.

[4] Approved 16th August 1863, *War Office Circular* 855, par. 853.

[5] *Ibid.* Also Extracts from *Reports and Proceedings of Ordnance Select Committee*, vol. i., p. 373.

[6] They are of such a size as to enter the upper part of the fuze hole with ease, while they require forcing to pass them completely *through* the fuze hole into the shell.

	Diameter.	Thickness.
Their dimensions are	·95	·25

[7] "Mill-board" differs from pasteboard in being made of the required thickness direct from the pulp, while pasteboard consists of sheets of paper successively pasted over one another until the required thickness is attained. I am not aware whether, strictly speaking, the term papier mâché is correctly applied to this material, papier mâché being, as I understand, pieces of paper (originally, it is said, old advertising bills torn from the walls) stuck together with paste, and pressed in a damp state into moulds.

[8] A boxwood drift is provided with No. 3 set of shell and fuze implements for garrison service, and with Nos. 3 and 4 sets field service implements, and with the naval implements (see p. 307) for the purpose of letting in the wad; it is removed by forcing it into the shell with the end of the fuze.

[9] That these wads perfectly answer the end required of them is proved by the experiments carried on by the Ordnance Select Committee in 1856 before the adoption of the wads was recommended. A *précis* of the experiments (taken from the *Synopsis, &c.*, p. 233) is given at p. 101, note 1. I would particularly direct attention to the statement that in the case of one of the shells losing its metal plug, "the bursting "charge was effectually protected by the gutta-percha wad under the plug."

2. *Diaphragm wads* (pl. 24, fig. 8) are of two sizes, viz.:
(1.) Small—for all natures of diaphragm up to the 18-pr. inclusive.
(2.) Large—for all diaphragm above the 18-pr.

Wads, papier mâché, diaphragm.

Description.

They differ from the common wads in size, being made to fit the loading holes, instead of the fuze holes, of the shells with which they are used. They differ from one another in dimensions.[1]

They are cut out of papier mâché and soaked in beeswax, in the same way as the common wads.

Application.

These wads are used to place in the loading holes of filled diaphragm shell, underneath the metal plug,[2] to close the hole more perfectly, and thus render the shell free from any danger of accidental explosion, and to secure the bursting charge from damp.

Wads, junk and grummet. History.

(*b.*) (*c.*) Wads, junk and grummet.—Junk wads were alone used until about 1824, when Captain Fead, R.N., proposed the substitution for certain purposes of grummet wads. This proposition was approved in 1827,[3] the date of the formal introduction of the grummet wad, although they appear to have been used experimentally as early as 1824.[4]

The grounds upon which the substitution of grummet for junk wads was advocated were chiefly,—1st. Saving of expense; the grummet wad is rather less than half the price of the junk wad.[5] This saving is effected partly on material and partly on workmanship.

2nd. Greater efficiency. This point was conclusively established by some experiments which were made upon the subject in 1849.

"The following table gives the average distance of many rounds that " shot in 32-pr., 8″ and 10″ guns were started out, when those guns were " run out with a strong jerk against the sweep piece; the guns being " loaded with distant charges and single shot.

"32-pr., 56 cwt. guns	With grummet wads the shot started out one inch. With junk wads $1\frac{3}{4}$ inches.
"8″, 65 cwt. guns	With grummet wads the shot started out $1\frac{1}{4}$ inches. With junk wads, 2 inches.
"10″, 85 cwt. guns	With grummet wads the shot started out $1\frac{1}{2}$ inches. With junk wads, 7 inches.

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[1] Their respective dimensions are as follows:—

	Diameter.	Thickness.
Small	0·385 inch	0·125 inch.
Large	0·48 „	0·125 „

[2] As in the case of the common wads, boxwood drifts for the purpose of setting in these wads are provided, with No. 3 set of shell and fuze implements for garrison service, and with No. 2, 3, and 4 sets for field service, p.299. These wads rarely, if ever, require to be removed, should it be necessary to do so, however, they must be forced into the shell.

[3] 6th November 1827. Letter from Lord High Admiral of that date.

[4] I conclude that this was the case from the fact that a return is extant in the Royal Laboratory Office of the saving of expense by this substitution of grummet for junk wads between 1824 and 1828.

[5] The following examples of the prices of the two will suffice:—Junk, 10″, per 100, 5*l.* 18*s.* 3*d.*; grummet, 10″, per 100, 2*l.* 1*s.* 11*d.*; junk, 8″, per 100, 3*l.* 13*s.* 6*d.*; grummet, 8″, per 100, 1*l.* 7*s.* 3*d.*; junk, 6-pr., per 100, 1*l.* 6*s.* 5*d.*; grummet, 6-pr., per 100, 11*s.* 6*d.* (*Price List of Woolwich Military Stores*, 1865, pp. 334, 335.) By the return referred to it appears that the saving of expense effected between 1824 and 1828 was 126*l.* 4*s.* $4\frac{1}{2}$*d.* In 1844, 100*l.* was awarded to Captain Fead for his invention. See *Board's Letter*, 5th August 1844, D/79.

"This experiment clearly shows the advantage of grummet wads over "junk wads, particularly with 10″ guns."[1]

Sir Howard Douglas also refers to some other experiments on board Her Majesty's ship "*Excellent*" in 1847, as proving that a grummet wad is more efficient than one of junk.[2]

3rd. Saving of storeage.[3]

For certain purposes, such as firing hot shot, &c., junk wads were necessarily retained.

In 1849, "split grummet" wads were first made by cutting an inch out of the circumference,[4] to obviate the difficulty in entering the wad into the gun when it had become enlarged by damp, or when made too high, and it was found that wads thus made expanded in the gun and served all the purposes required of them.[5]

This construction was subsequently, until 1865, partly given up; for although split grummet wads were recognized in the official drill[6] books, and artillerymen and sailors were instructed at the schools of gunnery, &c., in their preparation, the pattern grummet wad on which the issues were made from store was a whole unsplit wad until 1865,[7] when split wads became the recognized pattern. All the wads in store were ordered in 1866 to be cut.[8]

Wads, junk. Sizes.

(*b.*) *Junk Wads*[9] are made of 10 different sizes, viz., 6, 9, 12, 18, 24, 32, 42, 56, 68-pr. or 8-inch and 10-inch.[10]

They consist of cuttings of old "junk" beaten into a solid cylinder[11] and woolded over the ends with yarn,[12] the strands of which intersect at the centre of each end of the wad.

Description.

The sides of the wad are bound round with yarn,[13] and the wad brought up to a diameter about equal to that of the high gauge of the projectile,[14] the thickness varying from $1\frac{5}{8}''$ to $3\frac{1}{2}''$ according to the nature.[15]

Application.

Junk wads are used to place between the cartridge and the shot when firing with hot shot.[16]

They are also used to place over the shot when guns are to be kept loaded, so as to preserve the cartridge from damp and from the chance of ignition.[17]

Thicker junk wads are used "for proof of ordnance, one or more being "placed in front of the projectile."[18]

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1 *Experiments in Her Majesty's Ship "Excellent,"* p. 164.
2 *Naval Gunnery,* p. 155.
3 *Experiments in Her Majesty's Ship "Excellent,"* p. 165.
4 *Experiments in Her Majesty's Ship "Excellent,"* p. 164.
5 *Experiments in Her Majesty's Ship "Excellent,"* p. 164.
6 Forthcoming third volume of *Manual of Artillery Exercise.*
7 6th December 1865, *War Office Circular* 8 (new series), § 1165.
8 *War Office Circular* 951 (Stores), 14th April 1866.
9 These wads were made in the Royal Laboratory for several years; they are now manufactured by the Military Store Department.
10 Junk wads are not supplied for the 150 and 100-pr. guns, as hot shot are forbidden to be fired from them, 24/4/64, 57/2/8825.
11 The junk is hammered into a mould of the required size.
12 Single yarn.
13 Single yarn up to 32-pr. inclusive, three strands of spun yarn for higher natures.
14 See table XIV., p. 335. See *Naval Gunnery,* p. 152, respecting the objections to employing very high wads.
15 See table XIV., p. 335.
16 *Manual of Artillery Exercises,* pp. 58 and 145. Owen's *Lectures on Artillery,* edition 4, p. 97.
17 *Experiments in Her Majesty's Ship "Excellent,"* p. 163.
18 Owen's *Lectures on Artillery,* edition 4, p. 97.

(*c.*) *Grummet wads*[1] are made of 12 different sizes, viz., 6, 9, 12, 18, 24, 32, 42, 56, 68-pr., or 8″, 10″, 100, and 150-pr. Wads, grummet. Sizes. Description.

They are rings or circles of twisted[2] rope,[3] brought up to about the high gauge of the projectile[4] with which they are intended to be used, a small piece of the circumference being cut out or omitted; two "cross pieces" of rope[5] are tied on[6] at right angles to one another, the ends of these cross pieces projecting about half an inch beyond the grummet and being cut off with a bevel.

The use of the pieces[7] is to retain the form of the wad, and "nip or bite" upon the bore of the gun when the grummet is home.

Application. Grummet wads are used when firing at angles of depression, or at angles of elevation less[8] than 3°, to place over the shot and so prevent it from running out.[9]

In using them care should be taken always to place the cross pieces outside, *i.e.*, away from the projectile.[10]

Grummets,[11] that is grummet wads without cross pieces, have been used instead of wooden bottoms for shot and shell, and are still thus occasionally employed in India.[12] Their application in this form is as follows: "Two "grummets, one large and one small, are required for each shot and shell, "which are to be snaked together."

Adapter Spherical Shell, General Service.[13]

Adapter general service S.B. An adapter is required to enable naval shells fitted with the Moorsom fuze hole to receive the Pettman's general service percussion or the Boxer M.L. time fuzes. This adapter is merely a cylinder of gun metal, screwed externally to the diameter of the Moorsom fuze hole, and internally made conical and screwed to the general service gauge and pitch.

It is intended hereafter to adapt the existing store of naval shells by screwing permanently one of these adapters into the fuze hole.

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[1] See p. 107 respecting their introduction in 1827; they were made in the Royal Laboratory for several years.

[2] The strand which is required to make one grummet is coiled round the inside of the gauge and taken between the finger and thumb at the point of intersection and turned or twisted from right to left, until a three-stranded ring of the required size is formed, the ends being secured by splicing.

[3] Tarred 3½″ rope for 56-pr. and upwards, 2½″ for 12-pr. and upwards, 2″ for 9 and 6-pr., and 1½″ for 3-pr.

[4] See table XIV, p. 335. See also *Naval Gunnery*, p. 154, respecting the objections to employing very high wads.

[5] Tarred 2½″ rope for 10″, 150 and 100 pr., 2″ for 30-pr. and upwards, 1½″ for 9-pr. and upwards; 1″ for the lower natures.

[6] With tarred twine, one cross piece passed through the strands of the other.

[7] *Manual of Artillery Exercises*, page 58.

[8] *Manual of Artillery Exercises*, pp. 57, 145.

[9] See p. 107 respecting the superiority of grummet over junk wads for this purpose.

[10] "Otherwise they are not only less efficient in securing the shot from shifting, "but they are also liable to be drawn out again with the rammer."
Experiments in Her Majesty's Ship "Excellent," p. 165. See also *Manual of Artillery Exercises*, p. 145.

[11] The word "grummet" is applied to a rope ring worked in a particular manner.

[12] See p. 111.

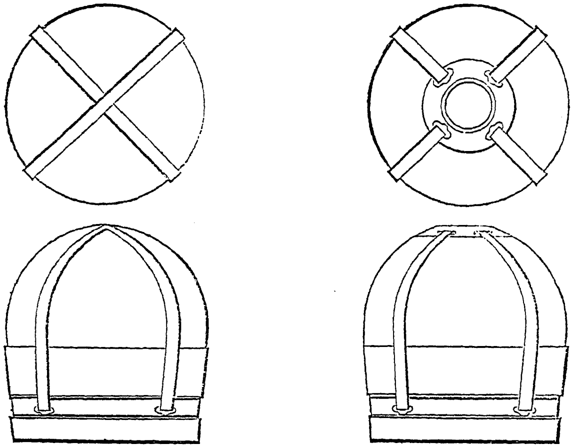
[13] Approved 4th Jan. 1867., *W.O.C.* 13 (new series), § 1396.

Bottoms,[1] *Wood, Shot or Shell.*

Bottoms, wood, shot or shell. History.

It is not easy to determine the exact date when wooden bottoms were first fixed to shot and shell, but it is certain that the practice is by no means a modern one. It appears to have been in vogue in the French service since about 1762.[2] The method at present employed of attaching the bottoms to the projectiles by means of rivets is, how-

SHOT. SHELL.



ever, comparatively modern, having been introduced on the recommendation of Col. Boxer, R.A., in 1855.[3] Previous to that date the bottoms had been attached by means of "tin straps," which, passing at right angles over the projectile, were soldered on to another tin strap which passed round the bottom.

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[1] Called by the French "sabôts à boulet," and this term *sabôt* is sometimes used in our own service. At one time bottoms were called "tamkins" "tampions" or "tompions," but these terms are now differently applied, being used to designate the cylinders of wood or stoppers placed in the muzzles of guns to prevent water, dust, &c. from entering, and also for drill purposes. To this day, however, the term tampion is sometimes applied to the *bottom* of grape shot. "Wooden bottoms were "originally called tamkins and tampions."—*Equipment of Artillery*, p. 94. See also respecting the original application of the word "tompion," *The Great Art of Artillery*, p. 231, where they are spoken of as being used to "confine the powder in the "chambers of mortars," which in those days were loaded with loose powder.

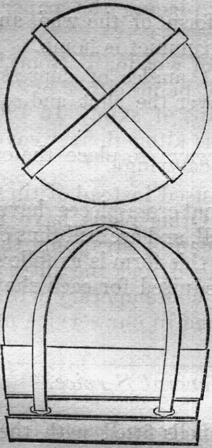
[2] *Le Passé et l'Avenir de l'Artillerie* indicates that this was about the date of the first employment of wooden bottoms; "Le boulet, relié par des bandelettes en fer-"blanc à un sabôt en bois," &c., *Ibid.* vol. iv. p. 113. See also *Ibid.*, vol. iv. p. 245. The plan appears to have been introduced by Gribeauval, not with the object with which wooden bottoms are now attached, but to facilitate fixing the charge to the projectile.

Cotty fixes the date of the first employment of wooden bottoms at some ten years later. "Les sabôts sont en usage dans l'artillerie Française depuis 1772."—Cotty's *Dictionnaire de l'Artillerie*, p. 394. This discrepancy may perhaps be explained by the hypothesis that on their first introduction wooden bottoms were only used for field guns, but that gradually they were extended to siege guns, not coming into general use ("en usage" as Cotty expresses it) until the date which he assigns.

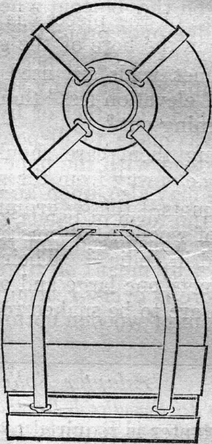
"Wooden bottoms were in general use for field service in 1796, and had been occasionally used in the earlier stages of gunnery."—Major Miller's *Equipment of Artillery*, p. 94.

[3] First adopted for shot and common shells, 18th August 1855. See *Account of Additions and Alterations in Ordnance, &c.*, War Department, 22 October 1855, para. 21, and extended to diaphragm in the December of the same year. See further on, Rivets, p. 120.

SHOT.



SHELL.



Other contrivances have been suggested to answer the same end; the French, for example, employed straps which, crossing over the top of the projectile, buttoned on to little flat-headed soft metal buttons on the bottom of the sabôt.[1] General Shrapnel in 1803 proposed the substitution of leaden collars for wooden bottoms;[2] and about 1818 a Mr. Wear proposed effecting the attachment by means of tin solder.[3] Bottoms have also been attached to shells by means of cement,[4] and it was proposed in the beginning of this century to carry the shot loose, fastening on the bottom when required by placing the paper cover of the cartridge over projectile and sabot.[5]

Grummets have also been used instead of wooden bottoms,[6] and are still so employed at many stations in India, being either by "snaking" two grummets together or by means of strips of skin. In 1803 a proposition was made to dispense with bottoms altogether, "covering the "shot instead with the paper cover of the cartridge."[7]

Canvas may also, upon an emergency, be used instead of tin strapping either in the form of bands, or of a bag.[8] Other plans have from time to time been proposed and tried, but the plan of strapping the bottom to the shot by means of tin as above described, and the introduction of which there is every reason to believe was contemporary with the first employment of wooden bottoms,[9] was retained in our service until 1855,

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[1] Cotty's *Dictionnaire de l'Artillerie*, p. 394.

"Memoranda and Extracts on the Subject of the Wooden Bottoms for Round Shot of Field Guns."—*Miscellaneous*, vol. ii., p. 223.

[2] *Synopsis of Ordnance Select Committee Reports: Shrapnel Shell*, p. 9. "The "Committee recommended that experiments be made before they decided as to the "advantages of this proposition, but there is no account of experiments with lead "collars on the Committee Records."—*Ibid.* p. 9.

[3] This plan, which consisted in "plating the bottom of the shot with pure tin, "and then soldering the wooden bottom to it by means of a small collar of tin,"—(*Miscellaneous*, vol. ii., p. 22, &c.)—was experimented upon by a committee of officers in 1819, and tested by Sir A. Dickson in France; no very conclusive result appears to have been arrived at, and the plan seems to have been only moderately successful. —*Miscellaneous*, vol. ii., pp. 37–44 and pp. 224–226.

[4] This system is still pursued in some parts of our Indian possessions.

There is in the Royal Artillery Institution at Woolwich a shell used by the mutineers in India with the bottom attached in this manner.

[5] See *Miscellaneous*, vol. ii., p. 222.

[6] See forthcoming third volume of *Manual of Artillery Exercises*. See also p. 109.

[7] This proposition was submitted to an Ordnance Committee in 1803, who reported against its adoption for the reason that "if the soldier should neglect (in the hurry of "action) to put the cover over the unstrapped shot, the bore of the gun would be "injured, and if it should be pointed, even under a very small angle of depression, the "shot would run out of the cylinder before the gun can be fired."—*Miscellaneous*, vol. ii., pp. 222, 223.

It should be noticed, however, that the Committee were of opinion, that "on service "when time admits of it, the *paper should be put over the shot and bottom*, which it "appears, by a course of experiments carried on at Woolwich in February 1801, tends "to preserve the bore of the gun."—*Ibid.*, p. 222.

[8] If tin or sheet iron cannot be procured, straps may be made of strong canvas, one "inch wide, sewed at the points of crossing. . . . . . Another method is to wrap "round the ball a band of canvas, one inch wide, one half of which is glued to the "ball, the other to the sabôt."—*Gibbons' Artillerist's Manual*, p. 343.

[9] "Le boulet, relié par des bandelettes en fer-blanc à un sabôt en bois."—*Le Passé et l'Avenir de l'Artillerie*, vol. iv., p. 113. "Le projectile était grossi par les "bandelettes de fer-blanc necessaire pour l'attacher au sabôt en bois."—*Ibid.*, p. 245.

That this plan has also been in use in our own service *at least* since the end of last century, and probably since bottoms were first used, may be concluded from the fact that Sir Augustus Frazer's "*Laboratory Work*," written about 1800, gives at p. 115, drawings of round shot strapped to wood bottoms "*old* and new pattern."

when, as already explained, the existing method of attaching the bottoms by means of rivets was adopted.

The present plan of hollowing out the bottom for naval shells was first adopted for one fourth of the naval shells supplied, on the recommendation of Capt. Sir J. Maitland, R.N., in 1856,[1] such bottoms being attached by strapping; two years later[2] it was extended to all 8-inch and 32-pr. naval shells, and in the following year[3] was extended to the 10-inch naval shells, and the present method of attachment adopted. In 1863[4] the 10-in. bottom was ordered to be made of the land-service pattern, *i.e.* not hollowed out and with one central rivet hole, but some months later,[5] for the sake of uniformity in the method of attaching all naval bottoms, the present interchangeable 10-inch bottom was adopted.

Some slight changes and modifications have, from time to time, been introduced in the bottoms for particular natures of shells, those for diaphragm shells for example having in the first instance all been made of end-wood, the present limitation of that pattern to the smaller natures of diaphragm shell (24-pr. downwards) not having been adopted until 1860;[6] and the assimilation of bottoms for chambered and unchambered ordnance of corresponding calibre was effected in 1860.[7]

Bottoms, wood, shot or shell. Six classes.

Wood Bottoms may be divided into six classes,[8] viz.:

1. Common.
2. Naval.
3. 10-inch (land or sea service).
4. Diaphragm shrapnel shell (up to 24-pr. inclusive).
5. 150-pr. diaphragm shrapnel.
6. Mortar.

They are made of well-seasoned elm, alder, teak or cedar; the two latter woods being employed for tropical climates, on account of their comparative immunity from the attacks of white ants;[9] or in the absence of a proper supply of teak or cedar, elm soaked in corrosive sublimate may be used.[10] For other than tropical climates elm is generally used, being a light, tough, and very durable wood; in the absence of a supply of seasoned elm, alder is used.

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[1] 26 March 1856. See *Alterations and Additions, &c.*, 30 June 1856, para. 15.

[2] 12 August 1858.—*General Regimental Order*, 402, para 36.

[3] 15 January 1859.—*War Office Letter to Principal Superintendent of Stores of that date*, 75/7/69.

[4] *War Office Minute*, 17 April 1863, 57/2/7481. As the 10-inch gun is not allowed to be double-shotted the bottom does not require to be hollowed out.

[5] 6 October 1863.—*War Office Circular*, 855, para. 849.

[6] 2 August 1860.—*War Office Letter* of that date, 75/12/714.

[7] Approved 8 August 1860. See *War Office Circular*, 639, para. 110. The change had been partially effected earlier in the same year. See *War Office Circular* 590, pars. 32 and 35. See also on the subject of the assimilation of 10-inch bottoms, *Extracts from Reports, &c. of Ordnance Select Committee*, vol. i., pp. 459–60.

[8] Bottoms for case shot are not included, these forming part of the projectile (see p. 16), and not requiring to be dealt with separately.

[9] Teak was first used for tropical climates 12th February 1859. *General Regimental Order*, 402, par. 1850. The use of cedar was sanctioned in 1865, on the recommendation of the *Ordnance Select Committee*, Report 3926, 9th October 1865. Approved 31st October 1865, *War Office Circular* 8 (new series), § 1152. All unserviceable bottoms at foreign stations are to be replaced on the spot by bottoms of teak or cedar, *War Office Circular* 9 (new series), § 1191. See also *Extracts, Ordnance Select Committee*, vol. iii., 363–4, respecting different woods and plans which have been tried.

The Committee say that teak is the best wood for tropical climates, but that "cedar "has likewise exhibited a remarkable immunity from attack."

[10] Approved 31st October 1865, *War Office Circular* 8 (new series), § 1152.

1. *Common Bottoms* (pl. 38, fig 11, *d, g, h, e*) are made of 12 different sizes,[1] viz.:—3, 6, 9, 12-pr., 4$\frac{2}{5}$-inch, 18, 24-pr., 5$\frac{1}{2}$-inch, 32, 42, 56-pr., 8-inch or 68-pr. Bottoms, wood, shot or shell, common. Sizes.

They are differently shaped, viz.: (*a.*) conical, (*b.*) hemispherical, and (*c.*) cylindrical, in accordance with the following rule[2]:— Description.

(*a.*) Conical,[3] for projectiles for gomer-chambered ordnance, and for unchambered ordnance of corresponding calibre.[4]

(*b.*) Hemispherical,[5] for projectiles for cylindrical chambered ordnance.

(*c.*) Cylindrical, for projectiles for all other ordnance.[6]

The wood is cut plank-ways,[7] in the form of a disc, of about the diameter of the low gauge of the projectile.[8] The sides of the disc are afterwards shaped conical, hemispherical, or are left cylindrical, according to the nature of projectile for which they are intended.

The upper surface of the bottom is hollowed out for the reception of the lower part of the projectile, and a rivet hole is drilled through the centre of the bottom; this hole corresponds in form to the rivet[9] which it is intended to receive, and by which the bottom is attached to the projectile, *i.e.*, a portion of it is cylindrical, and that part which is occupied by the head of the rivet conical. The nature of projectile with which the bottom is intended to be used is stamped on the under side of it.

Common bottoms are attached to the base of the following projectiles by means of a single expanding gun metal rivet:[10]— Application.

All solid (cast-iron) shot for bronze guns and guns of position; all common shell below the 10-inch,[11] except when they are used as hollow shot,[12] and in the case of the 24-pr. and 12-pr., except when fired from mortars; all diaphragm shrapnel shell, above the 24-pr.;[13] all Martin's shell; and all carcasses, except when they are fired from mortars.[14]

Their use is as follows:[15]—In the case of shot for bronze guns they Uses.

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[1] The 10-inch has a bottom of a different pattern, see p. 114.

[2] This rule does not extend to carronades, with which, in case of shells being required, such gun or howitzer shells as might be available would be employed, and the bottoms would thus be either conical, hemispherical, or cylindrical according to circumstances, and without regard to the fact that all carronades have cylindrical chambers.

[3] The bottom is thus a short frustum of a cone; the bottoms for the following ordnance are of this form: 8-inch or 68-pr.; 32-pr.; 24-pr.; 12-pr. (the 10-inch gun and howitzer has a separate bottom; see p. 114).

[4] This assimilation was approved 8th August 1860. On recommendation of Principal Superintendent of Stores, Woolwich; see *War Office Circular* 639, par. 110. It had been partially effected earlier in the same year; see *War Office Circular* 590, pars. 32 and 35.

[5] Strictly speaking not hemispherical; the *sides* only are rounded, and the bottom is not therefore a true hemisphere. Perhaps "cup-shaped" would be a more accurate description. Only the following ordnance require hemispherical bottoms: 5$\frac{1}{2}$-inch and 4$\frac{2}{5}$ths-inch ("Coehorn") howitzer.

[6] The following ordnance have cylindrical bottoms: 56-pr.; 42-pr.; 18-pr.; 9-pr.; 6-pr., and 3-pr.

[7] That is the grain runs horizontally across the bottom.

[8] The low gauge of the projectile is employed to gauge the bottoms, and they must pass through it. The cylindrical bottoms come up to it closely; the conical bottoms pass through it easily.

[9] See p. 121.

[10] See p. 121.

[11] For which a special bottom is provided, see p. 114.

[12] See p. 27.

[13] Special bottoms are provided for the lower natures, see p. 115.

[14] See p. 27.

[15] Their uses have been described elsewhere under the head of each projectile with which they are used, but it is thought better to recapitulate them collectively at this point.

preserve the bores from injury by diminishing windage,[1] while for guns of position they are useful to keep the shot steady in the limbers;[2] in the case of shells their principal use is to ensure the fuze occupying the proper position in the bore,[3] in addition to being useful in the preservation of the bores of bronze ordnance and the limbers of field guns, as for shot; in the case of Martin's shell and carcasses they are required to keep the front part of the projectile away from the charge.

They are also probably serviceable in all cases in a greater or less degree in diminishing windage, and thus improving the practice.[4]

Bottoms, wood, shot or shell, naval. Sizes.

2. *Naval Bottoms*[5] are made of two sizes only, 32-pr. and 8-inch, which are both cut conical. They differ from common bottoms in being hollowed completely through in the centre, so as to expose the iron of the shell flush with the lower surface of the bottom, thus permitting of the shot and shell being *in actual contact* when the guns are double-shotted.[6]

Description.

This construction renders the single expanding rivet system of attachment inapplicable to these bottoms, which are accordingly attached by means of two inclined rivets,[7] thus necessitating two inclined cylindrical rivet holes (pl. 34, fig. 12) through the bottom, one on either side of the central hole.

Application.

Naval bottoms are used only with the 32-pr. and 8-inch or 68-pr. naval shells,[8] when used as shells, and with the 32-pr. naval shell[9] when fired as hollow shot.[10] For future manufacture the bottoms will be superseded by tops.[11]

3. The *10-inch Bottom*[12] (pl. 34, fig. 12,) (land or sea service) is only made of one size, which is cut conical; it differs from a common bottom in having three rivet holes; one in the centre for use with common shell, the others as in naval bottoms, for use with naval shells. Thus the bottom is differently attached, according to whether it is used with common or naval 10-inch shell.[13]

The 10-inch bottom is not hollowed out because this gun may not be double-shotted.[14] The 10-inch bottom is used only with the 10-inch common, naval, diaphragm, and Martin's shells and carcasses, except in

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[1] See p. 9. [2] See p. 9.

[3] See p. 27.

[4] Sir Howard Douglas also says, speaking of some experiments made in 1842-1844. "It may be observed that the velocities were greater when the hollow shot had wood "bottoms, than when they had not, in the ratio of 1 to 0·98 nearly."—*Naval Gunnery*, p. 155.

[5] Present pattern approved 12th August 1858.—*General Regimental Order* 402, par. 36.

[6] See p. 32.

[7] See pp. 121, 122.

[8] See p. 112, respecting the 10-inch having at one time had this form of bottom. This was not needed, since this gun is not allowed to be double-shotted.

[9] The 32-pr. naval shell is not countersunk, and cannot therefore be used as a hollow shot without a wood bottom.

[10] See p. 34.

[11] See p. 118.

[12] 10-inch bottom present pattern, approved 6th October 1843, *War Office Circular*, 855, par. 849.

[13] The object of this is to preserve uniformity in land and sea service, and to avoid the necessity of altering the naval shells; the inclined rivet system being employed when these bottoms are used with naval shells, and the single expanding rivet system when used with common shells.—See on this subject *Extracts from Reports, &c. Ordnance Select Committee*, vol. i., pp. 459, 460.

[14] See p. 112 respecting the 10-inch bottom for sea service having originally been hollowed out like the other naval bottoms, and the ground upon which this form was objected to as likely to mislead. The store of hollowed out 10-inch bottoms is not yet exhausted.

the case of the common shell when they are used as hollow shot, and in the case of carcasses when they are fired from mortars.

Bottoms, wood, shot or shell, diaphragm shrapnel. Sizes. Description.

4. *Bottoms for Diaphragm Shell* up to 24-pr. inclusive, are of five different sizes, viz.: 6, 9, 12, 18, and 24-pr. They are made conical and cylindrical in accordance with the rule quoted for common bottoms.[1] They differ from common bottoms in the wood being cut end-ways, the grain thus running vertically up and down the bottom;[2] the object of this construction is to cause the bottoms to break up more readily and into smaller pieces on the discharge of the gun, and thus to diminish the danger to one's own troops or skirmishers in the neighbourhood of the guns. The flight of the projectile is also favourably affected in proportion to the readiness with which the bottom leaves the projectile.[3] On the other hand, the employment of end wood by weakening the bottom for firing purposes, weakens it also for transport, and to give it more *body*, as it were, the wood is carried higher up the projectile, the bottom being in fact made deeper. A tin[4] strap or band is also placed round the bottom to strengthen it; a groove being cut for the reception of this band. These bottoms are attached by means of a single expanding rivet[5] to diaphragm shell for ordnance of 24-pr. calibre and under.

5. The bottom for the 150-pr. diaphragm shrapnel is a common bottom with the naval attachment, *i.e.*, inclined rivets. There are four rivets used for this bottom, the rivet holes being countersunk to permit of the medium rivet being used.

6. *Mortar Bottoms* are of three sizes, viz.: for 13, 10, and 8-inch mortars. They are hemispheres[6] of wood; not hollowed out, nor provided with a rivet hole.

Bottoms, wood, shot or shell, mortar. Sizes. Application.

They are used with mortars when firing pound shot[7] and small shells, such as hand grenades,[8] and are placed over the powder, with the rounded side down, and the pound shot, 100 or 50, according to the nature of mortar,[9] piled loose, or in a basket, upon them.

Packing and issue of bottoms generally.

Wood bottoms, with the exception of naval and mortar bottoms, are either issued attached to the projectile, or strung on rods and mandrils, 20 (or a fraction, as demanded,) on each rod. The rods are iron; the bottoms are placed face to face upon the rod, which passes through the rivet holes. At the lower end of the rod is a flat disc of iron, and on to the upper end to keep the bottom steady is strung a wood washer, with rope handle or becket attached; the whole being secured by a nut which screws on to the top of the rod. Naval bottoms are on a wooden mandril, 20 (or less, as demanded,) on each, the hole in the centre being too large for an iron rod. The lower end of the mandril is shod with iron.[10] The bottoms are kept steady by a wooden wedge at each end of

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[1] See p. 113. The 6, 9, and 18-pr. bottoms are cylindrical, the 12 and 24-pr. conical.

[2] See p. 113.

[3] It is probable that this consideration first determined the adoption of this construction of bottom, for at first the bottoms of *all* diaphragm shrapnel were cut in this way (see p. 112); the other consideration named in the text probably influenced the *retention* of the end wood bottoms for the smaller nature diaphragm shell, which are chiefly used in the field. End wood was given up for the higher natures chiefly on the ground of expense.

[4] Tin XX. single, and X. double.

[5] See p. 121.

[6] Strictly hemispheres, not shaped like the "hemispherical" common bottoms.

[7] See p. 13.

[8] See p. 40.

[9] See p. 13.

[10] This was first adopted in 1865.

the mandril; a wooden washer intervening between the wedges and the bottoms. A rope becket is strung through the upper end of the mandril. Mortar bottoms are issued loose.

Tops, Wood, Shell.

Tops, wood, shell. History.

The necessity of economizing stowage on board ship, as far as practicable, has led from time to time to various suggestions by which the space occupied by shells in boxes might be reduced, a consideration which became of more importance as the proportion of shell guns in naval armaments was increased.

In the French service an attempt seems to have been made to suppress shell boxes and to provide compartments similar to those in limber boxes, which unship, and "in which the shells are stowed so as to take as little "room as possible."[1]

The French also proposed "to trice the shells to the beams."[2]

In 1849 Mr. Charles Hickes, a gunner, R.N., having the same end in view, proposed "a square wooden cover"[3] in which the shell, previously attached to a bottom, should rest, the fuze which passed into a hole in the cover being thus protected; a becket was attached to the cover for convenience of lifting and loading. These covers, "fuze covers," as they were sometimes called, were in the service until 1852,[4] when, for reasons which cannot be traced, they disappeared. Their disappearance is made more unaccountable by the fact that they seem to have been very successful.[5]

In 1853 Mr. Hickes proposed an improvement on the removable square wooden cover in the form of a round cover or top permanently attached to the shell,[6] being "strapped on in the same way as the "wooden bottom,"[7] and having a becket for lifting and loading.

The straps were made of zinc, and for these it was proposed to substitute "Muntz metal" of 12 oz. to the foot, as being "one half stronger "than zinc and not liable to corrode."

Other plans of attaching these tops, such as by means of marine glue, cement, &c., were proposed; and some modifications were made in the tops, which, it should be noticed, were proposed only for use with shells fitted with Moorsom's fuzes; and it was suggested that to distinguish the upper end of the shell, it would be advisable to paint the tops "a dead white."[8]

In 1855 these permanent tops were tried at Shoeburyness, and on board the "Excellent," with satisfactory results.[9]

For some reason which does not appear, but probably because of the pressure caused about that time by the Crimean war, the recommendation to fit all naval shells having Moorsom's fuzes with these permanent

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[1] *Naval Gunnery*, p. 504.

[2] *Ibid.* p. 315.

[3] See *Naval Gunnery*, p. 314, where a drawing of this arrangement is given; also memorandum from Colonel Boxer, R.A., to Ordnance Select Committee, November 5, 1863; also *Extracts from Reports, &c., Ordnance Select Committee*, vol. i., p. 476.

[4] March 1852.—*Ibid.* p. 476.

[5] Captain Chads, R.N., in a letter of the 19th December 1853, speaks of these covers as having been adopted generally in the service "with much advantage."—*Royal Laboratory Letter Book* 124, fol. 304.

[6] *Extracts from Reports, &c., Ordnance Select Committee*, vol. i., p. 475.

[7] Letters from Captain Chads, R.N., 19th December 1853.—*Royal Laboratory Letter Book*, No. 124, fol. 303.

[8] *Extract from Reports, &c., Ordnance Select Committee*, vol. i., p. 476.

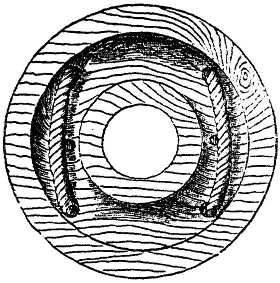
[9] Letter from Captain Key, R.N., to Ordnance Select Committee, dated Her Majesty's ship "Excellent," 14/10/63.

tops was not adopted, and the subject was allowed to drop, until 1863 when it was revived by Captain Key, R.N., who proposed "a modifi-"cation of Mr. Hickes' plan,"[2] suggested "by the present method of "securing wooden bottoms."[3]

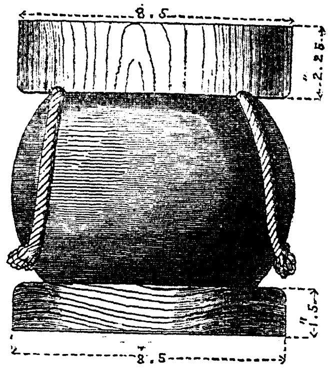
Captain Key's proposition was to attach the top by means of two inclined copper rivets, and the questions at once arose whether the tops should be permanent or removeable, and whether, if permanent, they should be used in conjunction with or without wood bottoms.

Experiments were made during 1864; and in the August of that year[4] bottoms and tops, permanently riveted on, were approved[5] for the 150-pr. and 100-pr. naval shell.

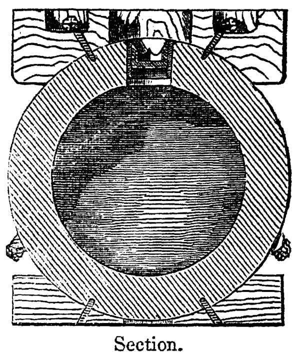
TOPS AND BOTTOMS, 100-PR.



Plan of Top.



Elevation.



Section.

Subsequent experiments showed the feasibility of dispensing with bottoms, which were accordingly given up, on the ground that without them "it is easier to introduce the shell into the bore of the gun" and to withdraw them when required, besides the saving of expense which is thus effected.[6]

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[1] Letter from Captain Key, R.N., to Ordnance Select Committee, 14/10/63.—*Extracts Reports, &c., Ordnance Select Committee*, vol. i., p. 475.

[2] Letter from Captain Key, R.N., to Ordnance Select Committee, 14/10/63.

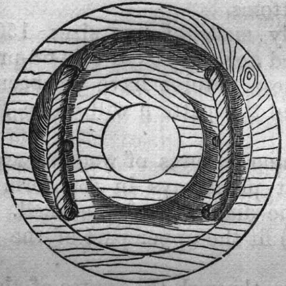
[3] *Ibid.*

[4] 27th August 1864, *War Office Circular* (new series), pars. 948, 949.

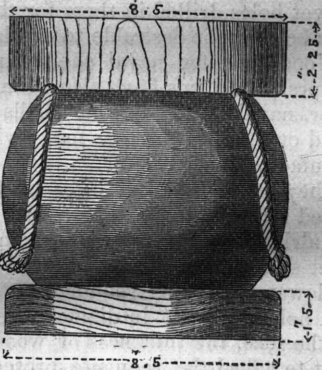
[5] The approval for the 150-pr. was "*provisional*" only.

[6] *Extracts from Reports, &c., Ordnance Select Committee*, vol. ii., p. 222. See, however, p. 114, respecting the probable effect of bottoms on the accuracy of flight of projeciles.

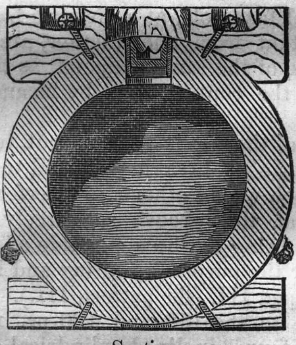
Tops and Bottoms, 100-pr.



Plan of Top.



Elevation.



Section.

It was then thought desirable to attach the top by means of more than two rivets. Three were proposed, but for manufacturing reasons this number was inconvenient, and on the recommendation of Colonel Boxer four rivets were used.

In 1865[1] tops, permanently fitted on with four rivets, and without bottoms, were approved for the 150-pr. and 100-pr. naval shells.

A further slight change was subsequently made, and Pattern II. tops for 150 and 100-pr. naval shell was approved early in 1866.[2] After this again the edges of the holes were rounded off, to facilitate the introduction of the wood fuze; and this pattern (III.) was approved of early in 1867. (See cut on page 33.)

Tops, wood, shell.

Although bottoms were given up, these shells were directed "still "to be prepared for the attachment of wood bottoms by having two "rivet holes drilled in them for that purpose;"[3] in case it should hereafter be thought desirable to employ bottoms.

Sizes.

Wood tops for naval shell[4] are only made of two sizes, 150 and 100-prs. Patterns have also been sealed for the 10″, 8″, or 68-pr. and 32-pr. naval shell. But no shells of these natures have yet been prepared or fitted to the tops for service, and the pattern will guide future manufacture only.

Description.

They are cylindrical discs of the same natures of wood as are employed for bottoms.[5] The wood is cut plankways in the form of a cylindrical disc, somewhat less than the diameter of the shell. The lower side of the disc is hollowed out to fit the upper part of the shell, the lower edge being rounded.

A hole about $2\frac{1}{2}''$ in diameter is made through the centre of the top for the fuze, the thickness of wood at this part (about $1\frac{1}{2}''$) being sufficient to afford the requisite protection to the cap and upper part of the fuze.

Around this central fuze hole, at a distance from its circumference of about 1″, and equidistant from one another, are situated four inclined cylindrical rivet holes, of the same diameter as those in naval bottoms,[6] for the reception of the copper rivets by means of which the tops are attached to the shell.

The upper surface of the top is grooved out to diminish its thickness and weight, to facilitate its breaking up, and to receive the top part of the rope beckets, which would otherwise interfere with stowage.

Through the top at this groove run freely[7] two rope[8] loops or "beckets," the splice being on the upper side of the top.

The beckets are for the purpose of lifting and loading.[9] The 150 and 100-pr. tops are stamped III. (for pattern III.).

Application and use.

Tops are fitted on to the 150 and 100-pr. naval shells instead of bottoms, by means of four[10] inclined cylindrical copper rivets.[11]

The use of the top is, 1st, to keep the fuze in the proper position in

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[1] 25th January 1865 and 10th March 1865.—*War Office Circular*, No. 5 (new series), par. 1044.

[2] 28th January 1866.—*War Office Circular*, 9 (new series), § 1187.

[3] *War Office Circular*, 5 (new series), par. 1041.

[4] Present pattern (with four rivet holes) approved 25th January 1865 and 10th March 1865.—*War Office Circular*, No 5 (new series), par. 1041.

[5] See p. 112.

[6] See p. 114.

[7] "Render freely through."—*War Office Circular*, No. 3 (new series), par. 948.

[8] $1\frac{1}{2}'$ white rope. The length of rope required is, 150-pr., 2′ 9″; loop, 2′ 6″.

[9] See p. 33, note 2, respecting the use of these beckets.

[10] See text above respecting two rivets having originally been used.

[11] See p. 121.

the bore; [1] and 2nd, to enable bottoms [2] and shell boxes to be dispensed with.

The advantages claimed for shells fitted with tops over those fitted with boxes and bottoms are :— Advantages.

1*st. Saving of Space in Stowage.*—It has been pointed out that this was the first object with which the employment of tops was advocated.[3] The saving of space has been computed at 50 per cent.[4]

2*nd. Saving of Expense.*—This was computed at 84 per cent. on the cost of the boxes, when tops and bottoms were proposed to be used;[5] as tops without bottoms are now used, the saving is probably somewhat greater.

3*rd. Saving of Weight.*—This amounted, when tops and bottoms were proposed, to from 12 to 15 per cent. on the shells as at present supplied.[6] It is now, in the absence of bottoms, somewhat greater.

4*th. Greater Expedition in loading, and generally an Increase of Convenience.*—It is stated that the guns can be more rapidly served with shells provided with tops and bottoms than with boxed shells,[7] and as shells with tops only are superior to those with tops and bottoms, on account, among other reasons, of the greater ease with which they can be introduced into the bore,[8] it follows that shells with tops only can be still more readily loaded than the same shells with bottoms and boxed; and it seems to be the opinion of naval men, by whom these shells are used, that the service of the gun is generally facilitated by this method of fitment, and that it gives rise to no inconvenience in fixing the fuze.[9]

5*th. Equal if not greater Security.*[10]—The shells are stowed on the tops, the fuze being downwards, and thus as perfectly protected as if the shell were in a box, with the additional advantage that, owing to there being in this case no box for the shell accidentally to fall out of, the element of insecurity involved in such a possibility is got rid of.[11]

Rivets, Metal, Shell.

A slight sketch of the different methods proposed and employed for attaching wood bottoms to projectiles has already been given in the history of wood bottoms,[12] and it has been explained that the present Rivets, metal, shell. History.

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[1] See p. 27.
[2] See p. 114.
[3] See p. 116 respecting the advantage of dispensing with boxes.
[4] Captain Key computed it at 50 per cent.—His *Letter* of 14/10/63. Also *Extracts from Reports, &c., Ordnance Select Committee,* vol. i., p. 475. When Mr. Hickes' original round tops were proposed, the saving was computed at about one-third gain; and this is probably the more correct estimate of the two; for it must be remembered that the practical gain cannot be measured by the difference between the content of the box and that of the shell with top, since a great deal of this space gained will be non-available. The gain of stowage is chiefly horizontal, the vertical thickness of the boxes being approximately made up for by the shelves now required.
[5] *Extracts from Reports, &c., Ordnance Select Committee,* vol. i., p. 475.
[6] *Ibid.* p. 475.
[7] Captain Key's letter to Ordnance Select Committee, 14/10/63.
[8] See p. 117.
[9] *Extracts from Reports, &c., Ordnance Select Committee,* vol. i., p. 475.
[10] "The shells are kept as secret and secure as in boxes."—Captain Chads' letter 19th December 1853.
See on the subject the opinion entertained by the Select Committee as to the safety of shells thus fitted.—*Extracts from Reports, &c., Ordnance Select Committee,* vol. i., p. 475.
[11] "An avoidance of the danger of the shell falling out of the box and injuring the "fuze."—Captain Key's Letter to Ordnance Select Committee, 14/10/63.
[12] See wood bottoms, pp. 110, 111.

method of riveting the bottoms superseded the tin strapping which had been previously employed.[1]

Rivets were first proposed by Col. Boxer in 1855,[2] and adopted, after a series of experiments by the Select Committee,[3] for common shells in the autumn of that year;[4] but their application was not extended to the shrapnel class of shells[5] until the December of that year. The rivets at first introduced were not, however, of the same pattern as at present, having a large flat head, which was found in some cases to interfere with the separation of the bottoms from the projectiles on firing.[6] Consequently, Col. Boxer proposed an alteration in the pattern, the head being made conical, instead of flat and square.[7] This alteration was approved in 1856,[8] but in 1859 a further slight change was made in the general dimensions of the rivet, the hollow being deepened, &c. The pattern then approved is the present land service rivet.[9]

The naval rivets were not proposed until 1858, and the system of single rivets being inapplicable to bottoms hollowed out in the centre, tin strapping was retained for those naval shells which were fitted with this particular form of bottom until 1859; but in 1858 Col. Boxer proposed attaching these bottoms by means of two cylindrical rivets inclined towards one another at an angle; the proposition was adopted, and the present pattern naval rivet approved 1859.[10]

Rivets for tops for the 150-pr. and 100-pr. naval shells were first adopted in 1864;[11] and in 1865[12] four rivets were directed to be used for each top, instead of two.

Rivets, metal, shell. Two classes.

Rivets for attaching wood bottoms and tops to projectiles may be divided into two classes—

(*a*) Common.
(*b*) Naval.

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[1] See wood bottoms, pp. 111, 112. For advantages of rivets, see pp. 122, 123.

[2] 10th January 1855. See *Synopsis of Ordnance Select Committee, Shrapnel Shell*, p. 224.

[3] An account of these experiments will be found *Ibid.*, pp. 285–6–8.

[4] Approved 18th August 1855.—See *Alterations and Additions in Ordnance*, War Department, 22nd October 1855, para. 21.

[5] Approved for shrapnel shells 19th December 1855, S/8519. See *Ibid.*, 30th June 1856, para. 6; also *Synopsis of Reports of Ordnance Select Committee, Shrapnel Shell*, p. 232.

[6] "I have observed in some few of the 9-pr. shot which have been recovered after "firing at Shoeburyness that the form of rivet at present used for attaching the wood "bottoms to shells and shot for field service is defective."—Extract from a letter from Captain Boxer, R.A., to the Director-General of Artillery, 28th August 1856. *Synopsis, &c.*, p. 233.

[7] *Ibid.*, p. 233.

[8] Approved 22nd September 1856. *Ibid.*, p. 234; also *Alterations and Additions in Ordnance, &c.*, 31st May 1857, para. 5.

[9] Col. Boxer proposed this alteration in 1857, but it was not approved until 12th Sept. 1859. See *General Regimental Order*, 415, 31st December 1859, para. 44. Some particulars respecting the difference of the rivets will be found in *Synopsis, &c.*, pp. 235–6–7.

[10] Approved 13th January 1859, 75/7/69, *War Office Letter* to Principal Superintendent of Stores of that date. Practically this system of attachment is regarded as having been adopted in 1858, and naval shells with the bottoms fitted on in that way are spoken of as "pattern 1858."

[11] 27th August 1864.—*War Office Circular*, No. 3 (*New Series*) paras. 948, 949.

[12] 25th January 1865, and 10th March 1865.—*War Office Circular*, No. 5 (*New Series*), para. 1041.

(*a*) *Common rivets* (pl. 34, fig. 8) are made of two sizes,[1] viz. : — Rivets, metal, Sizes.

(1.) Small ; for the bottoms of diaphragm shrapnel shells (pl. 24, fig. 6) up to the 18-pr. inclusive.

(2.) Large ; for the bottoms of all other riveted projectiles, except naval shell.

Description. — The two rivets differ only in dimensions,[2] their construction being identical. They are small gun metal cylinders, hollowed out at one end, and having a projecting head at the other. The head is the frustum of a cone, the broad flat base of which forms the top of the rivet.

Common (pl. 34, fig. 8) rivets are used to attach the bottoms to all projectiles except naval shell.

Use and application. — The application is as follows : The cylindrical shank of the rivet is passed through the hole in the wood bottom into the rivet hole in the projectile ; a few smart blows on the head of the rivet cause the hollowed out end of the shank to expand, filling up the rivet hole, and thus (the head of the rivet being too large to pass through the wood bottom) securely attaching the sabôt to the projectile.[3]

(*b*) *Naval rivets* are made of three sizes,[4] viz. : — Rivets, metal, shell, naval. Sizes.

(1.) Long ; for 150-pr., 10″, and 32-pr. tops.

(2.) Medium ; for 100-pr. and 8″ tops, and 32-pr. bottoms, and 150-pr. diaphragm shrapnel bottoms.

(3.) Short ; for 10″ and 8″ bottoms.

The three sizes differ only in length,[5] not in diameter or construction.

Description. — Naval rivets are merely cylindrical pins of copper,[6] without heads, and not hollowed out like the common rivets.

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[1] For some time a special (small) rivet was employed for 3-pr. solid shot ; but this, being found unnecessary, was discontinued in 1863. A small rivet is used with the lower natures of diaphragm, because too large a rivet hole might weaken the shell prejudicially.

[2] Their sizes respectively are:—

Large	Diameter of shank,	0·433 inch.	
	Length ,,	0·51 ,,	
Small	Diameter of shank,	0·310 ,,	
	Length ,,	0·43 ,,	

[3] The instructions issued with the implements for "fixing wood bottoms" are so clear and explicit that if attended to it is hardly possible that a mistake can be made. Although these instructions are given further on (see Shell and Fuze Implements, p. 292), I give that part of them which bears upon the application of the rivet: "Place a rivet in the rivet hole of the wood bottom, with the point projecting beyond "the concave surface ; place it on the shell, moving it about until the rivet drops "into the rivet hole, place the punch on the head of the rivet, and give it a few smart "blows with the hammer."

See also, on this subject, Solid Shot, p. 9.

[4] Rivet holes are placed in the bottoms of the 150-pr. and 100-pr. naval shells, with a view to permitting bottoms being attached to these projectiles in case it should hereafter be thought desirable to do so (see p. 34). In such a case, there would be a fourth naval rivet shorter than any of the three enumerated as being now in the service, viz., between 1·02 inch (high) and 1·0 inch (low) in length, and of the same diameter as the other naval rivets ; the same rivet, in fact, as was used with 10-inch naval shell bottoms before April 1863, up to which date these bottoms were hollowed out, (see p. 112), and the same rivet as would now be used with the old pattern 10-inch naval bottoms, of which the store is not exhausted.

[5] The dimensions of naval rivets are—

	Length. High.	Length. Low.	Diameter. High.	Diameter. Low.
Short - -	1·12″	1·1″	·252″	·238″
Medium - -	1·22″	1·2″		
Long - -	1·92″	1·9″		

[6] Copper wire No. 3 gauge used for the purpose.

Application. They are used to attach bottoms and tops to naval shell and the bottoms of 150-pr. diaphragm shrapnel shell. Two rivets are required to attach a bottom, four rivets to attach a top.[1] One is passed through each of the holes in the wood bottom or top into the rivet holes in the projectile, and driven home. The inclination which the rivets have to one another causes the attachment of the bottom or top.[2]

Advantages of rivet attachment. The advantages of the rivet system of attachment over the original plan of strapping them is as follows :

1st. The operation can be more easily and expeditiously performed; and it is so simple as to admit of shells and bottoms being issued separately where desirable, thus enabling a great saving in storage to be effected.[3]

2nd. The attachment by means of rivets is more secure and permanent.[4]

3rd. It admits of the windage being reduced.[5]

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[1] See p. 117 respecting two rivets having originally been employed for tops.

[2] The principle of this attachment will remind the reader of the lewis holes of mortar shells. (See p. 37.)

The following extract from the instructions issued with the implements used for "Fixing Wood Bottoms or Tops to Naval Shells" is given here as bearing upon the application of these rivets: "Place the bottom or top on the shell; pass the guide "wire through one of the rivet holes and into one of the rivet holes of the shell; "withdraw the guide wire; insert a rivet, and fix it slightly by a few smart blows "with the hammer; bring the other holes to correspond with those in the shell; "insert the remaining rivet or rivets; fix them slightly in the same manner; then "rivet all firmly."

[3] I rank this advantage first, because it seems to me to include more than either of the others; not only is a great saving of magazine and storage room effected, from the reason that when shells and bottoms are issued separately, the former may be piled out of doors, and the latter packed away; but the greater simplicity of the operation produces a corresponding saving of time in the manufacture; in other words, produces a saving of expense.

[4] The tin strapping, as every artillery officer of experience can testify, very frequently shifted in travelling, and sometimes broke, the projectile being often found in the limbers separated from the bottoms. Moreover, where the bottoms did not become actually detached, they were liable to turn round the projectile (on the loosening of the strapping), and in some cases shells were found with the bottoms still on, but hindside before; that is to say, with the fuze hole towards the wood bottom instead of away from it, thus completely defeating the object with which the bottom was originally attached ; and it is certain that, from every point of view, the attachment by means of tin strapping was inferior in security and permanence to that obtained by means of rivets. The following passage bearing upon this subject occurs in an official report made by the Captain Instructor of the Royal Laboratory in 1859, of an inspection made by him of the ammunition in charge of Artillery at ten different stations and forts in Ireland: "A large proportion of the shot is strapped, and "authority is demanded every month from Dublin by officers commanding batteries "to have this 'strapping' repaired, as it is constantly being broken by the action of "travelling. The 'riveted' shot very seldom become detached from the 'sabôts,' and "they can almost always be immediately repaired by an intelligent man."—(*Report made by Capt. Orr, R.A., Captain Instructor, Royal Laboratory, to Col. Boxer, Superintendent Royal Laboratory*, 31st January 1859).

[5] Evidently, by double the thickness of the tin strapping. Advantage has not, however, been practically taken of this, though in January 1857 Col. Boxer submitted to the Ordnance Select Committee a scheme proposing to reduce the windage. This scheme also had the merit of assimilating the windage to one uniform standard, the windage assigned therein to the different projectiles being about $\frac{1}{100}$th of the calibre. The Committee on Ordnance (1858), "recommended reducing the windage by a re"duction in the bore of the guns; as this plan rendered the existing store of shot and "shell available with old and new guns." On this subject see *Extracts from Reports of Committee on Ordnance* (1858) quoted in Appendix D.

4th. It is cheaper.[1]

5th. The practice with riveted shot is superior to that with strapped shot.[2]

Bearers, Shot and Shell.

Shot Bearers[3] are made of 10 different sizes, viz. 3, 6, 9, 12, 18, 24, 32-prs.; and 13 inch one size each; one size to serve for 8-inch or 100-pr., and one size to serve for 10-inch or 150-pr.[4] Bearers, shot or shell.

They are rings of iron,[5] somewhat less in diameter than the projectile for which they are intended, and have loop-shaped iron handles tied in at the points of junction with the ring with flat iron bands.[6] The whole bearer is painted black, and stamped with the nature.

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[1] Cheaper, both as regards material and workmanship. The following statement shows the comparative average cost of strapping and riveting 100 shells, taking the 32-pr. as an example.

Per 100 Shells.

—	Strapping.	Riveting.	Difference in favour of riveting.
	s. d.	*s. d.*	*s. d.*
Material - - -	9 6	2 9	6 9
Wages - - -	9 0	4 10	4 2
Total -	18 6	7 7	10 11

[2] This seems to have been conclusively established with regard to riveted *bottoms*, by some experiments carried on by Captain Haultain, Royal Artillery, with 9-pr. brass guns, at Woolwich, in 1858. The following extracts from the report made by Captain Haultain bear upon the subject:—

"At the outset of this practice, the trial of the two modes of fastening wooden "bottoms to the shot appeared comparatively a matter of secondary consideration, "and was altogether subordinate to the object proposed, viz., the trial of the two "charges; yet, from the results obtained, and from other considerations, its import-"ance will be apparent. . . . . Whilst the averages of *extent* of range, are as often in "favour of one as of the other, in *regularity* of range the superiority is decidedly on "the side of the 'rivet.' But it is principally in *direction* that its superiority is most "strikingly and invariably maintained. . . . . As far as this practice is capable of "furnishing a decided result, the superiority of the rivetted over the strapped sabôt "has been fully established to an extent little anticipated, probably, by any one, and "not easily to be accounted for. Without this superiority, and even with a supposed "slight inferiority, the advantages of the rivet over the strap, as a means of securing "the sabôt to the shot, were deemed sufficient, and justly so, for its adoption into the "service."—*Captain Haultain's Report of Practice with 9-pr. brass guns*, Woolwich, 1858, pp. 12 and 13. See more on same subject in same report.

Whether this 5th advantage can be claimed for riveted *tops* as against strapped tops I am not aware; but as the superior practice with riveted bottoms is probably due to the greater readiness with which bottoms thus attached detach themselves on firing, so it may be presumed the practice is likely to be better with shells that have tops *riveted* than with shells that have their tops strapped.

[3] Shot bearers were made in the Proof Department until about 1857 or 1858, since which date they have been manufactured in the Royal Laboratory.

Hot shot bearers are of an altogether different construction, and are made in the Royal Gun Factories.

[4] "Until recently, it appears there was but one pattern for naval service, viz. "10-inch or 68-pr."—*Notes on Matériel*, p. 3.

[5] Round bar iron, $\frac{5}{8}$ths for 13-inch, $\frac{1}{2}$ inch for 10-inch down to 18-pr. inclusive; $\frac{3}{8}$ths for the smaller sizes.

The whole bearer is formed of one piece of iron twisted into the required form.

[6] Originally the iron was twisted at this part, but the bearers were found to be weakened by this construction, which was accordingly superseded by the present one soon after the bearers passed to the Royal Laboratory.

Use.

Shot bearers are used principally for painting spherical projectiles; the 100-pr. and 150-pr. sizes are also used by the Navy to bring the shot up to the gun.[1]

Hooks, Shell and Shot.[2]

Hooks, shell and shot. Two classes.

Hooks for lifting mortar shells and facilitating loading may be divided into two classes:

(*a*.) Lewis hooks.
(*b*.) Lug hooks.

Hooks, shell, lewis. Natures.

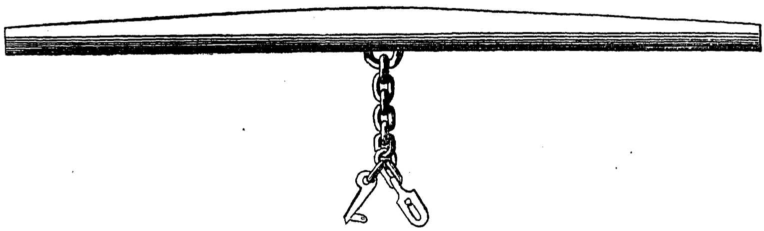
(*a*.) Lewis hooks are of three sorts—

(1.) Beam.
(2.) Hand.
(3.) Eprouvette, or "tongs."

Hooks, shell, lewis, beam.

(1.) *Beam lewis hooks* consist of a rounded wooden staff or beam, about 4 ft. 6 in. long, tapering slightly towards the ends. Suspended from the centre are a pair of iron chains about one foot in length, terminating in two iron "lewis" hooks or studs, inclining inwards.

Hooks, Beam Lewis.



The beam and iron work are painted lead colour,[3] and on the former is lettered in white "13 inch."

Beam lewis hooks are used in loading 13-inch mortars with shells or carcasses having lewis holes.[4] The studs or hooks are placed in the lewis holes, and the weight of the projectile by producing a tension on the chain tends to draw the hooks towards one another, thus making the hold secure. The projectile is lifted by means of these hooks, the ends of the beam resting on two men's shoulders, and placed in the mortar.[5]

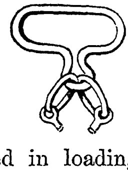
Hooks, shell, sling, chain.

Sometimes the iron chain work and hooks are issued separately, for attachment to a beam at the station. This store is distinguished as "hooks, sling, chain, lewis."

Hooks, shell, lewis, hand.

(2.) *Hand lewis hooks* consist of an iron loop-shaped handle, to which are attached two iron links about 3 in. long, terminating in two iron lewis hooks or studs. They are painted black.

Hooks, Hand Lewis.



Hand lewis hooks are used in loading 10″ mortars[5] with shells or carcasses having lewis holes. Their application is the same as that of the

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[1] Until 1866 the 68-pr. bearer was used for this purpose also. By 10/2/66, 57/2/12076, its issue to ships of war was directed to be discontinued.

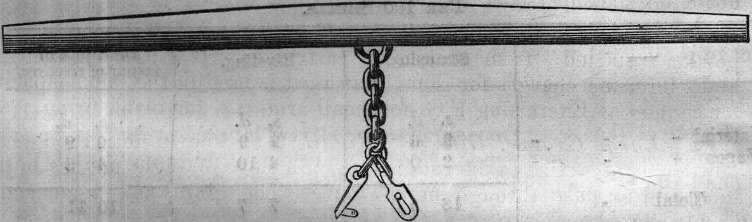
[2] The word "shot" is necessarily introduced to include the lewis hooks or tongs, which are used with eprouvette shot.

[3] The ordinary colour of artillery material.

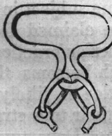
[4] See p. 36.

[5] *Manual of Artillery Exercises*, p. 107.

Hooks, Beam Lewis.



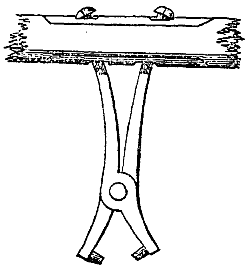
Hooks, Hand Lewis.



beam lewis hooks, except that the shell is carried by hand instead of on men's shoulders.

3. *Eprouvette lewis hooks*,[1] or "*tongs*,"[2] consist of a beam about four feet in length, on either side of the centre of which, 3″ apart,[3] are two elliptical slots, which pass with an inward inclination through the beam.[4] Hooks, shell, lewis, eprouvette.

EPROUVETTE TONGS.



Through these slots work a pair of iron tongs, the lower end of which is fitted with lewis studs having an inward inclination to correspond with that of the lewis holes in the shot.

These tongs are kept in the slots by being knob-shaped at the upper end.

To protect the beam from wear at the slots it is faced at its upper end and under side, in the neighbourhood of the slots, with iron.

The beam is unpainted; the tongs are painted black.

Eprouvette lewis hooks are used for placing the eprouvette shot[5] in the mortar for proof of powder, and will of course became obsolete on the adoption of a different system of proof.[6]

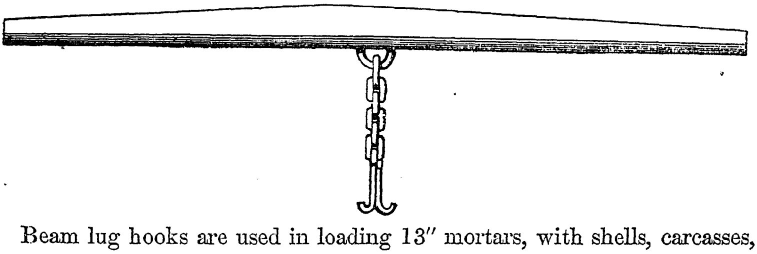
They are applied in the same way as beam lewis hooks, with the exception that instead of the grip being produced by the tension of the chain it results from the drawing down, by the weight of the shot, of the upper ends of the tongs through the inclined slots, the lower ends being thus brought close together.

(*b.*) Lug hooks are of two sorts: Hooks, shell, lug. Natures.

1. Beam.
2. Hand.

1. *Beam lug hooks* resemble the beam lewis hooks in all respects, except in the end of the chain being furnished, not with lewis hooks, but with a pair of common hooks for placing through the lugs of the projectile. Hooks, shell, lug, beam.

HOOKS, BEAM LUG.



Beam lug hooks are used in loading 13″ mortars, with shells, carcasses,

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[1] Approved 25th October 1861, *War Office Circular*, 739, par. 428.

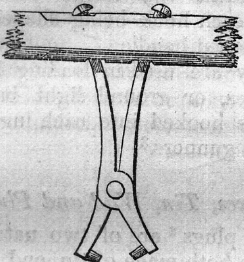
[2] They are sealed under the name of "Tongs."—*Ibid.*

[3] This measurement is on the upper side of the beam from edge to edge of the slots. On the lower side, owing to the inclination of the slots, they are of course nearer.

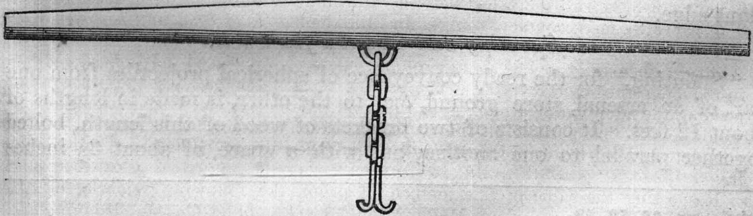
[4] In a vertical plane.

[5] See p. 21. [6] See p. 21.

EPROUVETTE TONGS.



Hooks, Beam Lug.

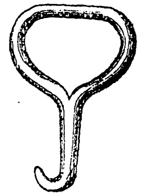


or ground light balls having lugs.[1] Their application is the same as that of the beam lewis hooks, with the exception that instead of studs being fitted into lewis holes the hooks are hooked into the lugs.

Sometimes the iron chain work and hooks are issued separately for attachment to a beam at the station. This store is distinguished as "hooks, sling, chain, lug."

Hooks, shell, lug, hand.

HOOK, HAND LUG.



2. *Hand lug hooks* consist of a pair of iron hooks, each hook being shaped at its upper end into a loop-shaped handle.

They are used in loading 10″ mortars with shells, carcasses, or ground light balls having lugs;[2] one hook is hooked into each lug, and the shell is carried by two gunners.[3]

Boxes, Tin, Wad and Plug.

Boxes, tin, wad and plug.

Tin boxes for wads and plugs[4] are of two natures, (1) rectangular, and (2) cylindrical. They are both made of tin, and are painted black, with the exception of the lids, which are painted red, and on issue lettered with the nature of the contents.

The lid of the rectangular box hinges on and fastens with a hasp and staple; that of the cylindrical box is removable, and merely fits on.

These boxes are issued to receive the whole of the wads and the spare loading hole plugs for diaphragm shells for field service and guns of position.

The rectangular box receives the whole of the wads and the spare loading hole plugs for howitzers and guns of position; the cylindrical box those for all other field guns.

Chisels, Purchase, Tompion.

Chisels, purchase, tompion.

The chisel for removing tompions from the muzzles of guns is a steel "chisel," about 7 inches in length, the end slightly curved, and having a blunt edge. The top of the chisel is knob-shaped, and a hole is made through the upper end, for a cord, by which, if required, the chisel can be slung.

Scrapers, Copper, for Shells.

Scrapers, copper, for shell.

Copper scrapers for scraping out shell which may have contained powder are made of nine different sizes, viz. 6, 9, 12, 18, 24, 32, and 10-inch, one size each, and one size which serves for the 8-inch or 68-pr., 56, and 42-prs.

They are cylindrical rods of copper, varying from about 13 to 22 inches in length.[5] One end is slightly hooked; the other is sharpened to a blunt edge.

Spouting and Trestles for Shell.

Spouting, for shell.

"Spouting," for the ready conveyance of spherical projectiles from one part of an arsenal, store ground, &c. to the other, is made in lengths of about 12 feet. It consists of two brackets of wood of this length, bolted together parallel to one another, but with a space of about $3\frac{1}{2}$ inches

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[1] See pp. 36, 72, 78.

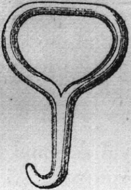
[2] See pp. 36, 72, 78.

[3] *Manual of Artillery Exercises*, p. 107.

[4] Present pattern approved 29th September 1864.—*War Office Circular*, 3 (new series), par. 980.

[5] Each size is about one inch longer than the other, the approximate length of any particular size can therefore be easily computed by taking the 6-pr. as 13 inches, and adding so many inches as there may be sizes between the 6-pr. and the size required, thus the 32-pr. would be 13 nches + 5 inches = 20 inches.

HOOK, HAND LUG.



between them. Over the two central bolts of each length are rectangular blocks of wood, by which the sides of the spouting are kept apart. The end bolts of each length have over them iron coupling, by means of which the lengths are coupled together. The upper sides of the brackets are faced with thin sheet iron, which protects the wood from wear. Curved or "circular" spoutings are issued and used for turning corners. These spoutings are used to roll spherical shells and projectiles from one place to another, a number of them being coupled together as required, and the projectiles rolled along the top. They rest upon wooden Trestles formed with three legs, bolted together, and about 2 feet 6 inches high. Trestles, for shell spouting.

The spouting and trestles are painted lead colour.

Shell spouting is used on a very large scale in the Royal Arsenal at Woolwich.

Gauges, Iron, Ring, Shot or Shell.

Ring gauges, for examining shot or shell, were furnished in sets for each calibre, from the $1\frac{1}{2}$ ounce sand shot up to the 13 inch. Each set contained two or more gauges, viz. high and low for the ordinary projectiles, and a high and low for those projectiles of which the diameter may differ from that of the ordinary projectile.[1] For example, there were four gauges for the 68-pr., viz. for all 68-pr. or 8-inch diaphragm shrapnel and naval shell, case, grape, and solid shot, low for ditto; high for the 68-pr. or 8-inch common and mortar shells, low for ditto. An order of 1866,[2] however, limits the issue of gauges for service to one high gauge for each calibre. These gauges are in reality only test rings. Gauges, iron, ring, shell or shot.

These gauges are merely rings of iron of the required size,[3] and having an iron handle. They are used to examine spherical projectiles, which should pass in all directions through the high gauges.

Low gauges as well as high gauges are issued to firemasters and inspectors of warlike stores, store stations, &c. The projectiles should not pass through the low gauge.

AMMUNITION FOR SMOOTH-BORE ORDNANCE.

SECTION B.—CHARGE.

The early history of gunpowder is involved in considerable obscurity, and it is not easy to determine exactly when it was first employed as a propellent agent. It seems certain that it was known in India and China before the Christian era, and *may* have been used in warfare at that epoch. It is probable, however, that it was not at all generally used in Europe Gunpowder. History.

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[1] See tables I. to IX., p. 322 to 327. Until latterly gauges were also issued for projectiles having the bottoms attached by tin strapping, larger than those required for the same projectiles with riveted bottoms. And as the stores of strapped projectiles are not yet exhausted these gauges may still be required, but they should be specially demanded, and they are not included in the table.

[2] *War Office Letter*, 29/9/66, 75/12/2914.

[3] For dimensions, see table XIII., p. 334.

for fire arms until the close of the thirteenth century or the beginning of the fourteenth.[1]

Cartridges. History.

More than three centuries elapsed after the first employment of gunpowder before the charges of guns were placed in cartridges. During this period loading was effected with loose powder, but the slowness of this method, and the danger attending it, led, in the early part of the 17th century, to the partial introduction of cartridges.[2] At first, however, cartridges were only used for rapid firing,[3] but gradually they came into more general use, although to the present day mortars are frequently loaded with loose powder.[4]

Various materials have at different times been used for cartridges: paper of all sorts, "double paper," "cured paper," and "paper royal," together with parchment, bladders, canvas, linen, merino, "wildbore," "bombazette;"[5] paper and parchment being the two which were most commonly employed, until the introduction of serge.

Introduction of flannel cartridges.

These two materials and all cotton and linen stuffs were, however, open to the objection that not being completely consumed by the discharge of the gun the unconsumed portions were left in the bore generally in a state of ignition, and had to be removed with a "wad hook," the service of the guns being in consequence very slow, and being attended moreover with considerable danger.[6] The parchment was also found liable to shrivel up

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[1] This is the conclusion to which the author of the *Le Passé et l'Avenir de l'Artillerie* comes after a patient and laborious investigation of the evidence. "On peut toutefois," he says, "le placer sûrement entre les années 1270 et 1320."—Vol. iii., p. 353. See also *Lectures on Artillery*, edition 4th, p. 4. *Notes on Gunpowder*, p. 2. *Proceedings Royal Artillery Institution*, vol. iv., p. 289, *et seq.* *Text Book*, pp. 36, 37. *James' Dictionary*, p. 346.

[2] "Diego Ufano connaissait l'usage des gargousses en papier renfermant la charge de " poudre, mais on ne les employait que dans les circonstances où l'on devait tirer plus " rapidement."—*Le Passé et l'Avenir de l'Artillerie*, tome iii., p. 307. See also the *Great Art of Artillery*, written in 17th century, where the employment of paper cartridges in loading "large cannons" is spoken of and described.

"Cartridges are either to be made of canvas, fustian, or other linnen cloth, or with " thick strong paper, especially of paper Royall."—*The Gunner*, (1628,) p. 27.

[3] "On ne les employait que dans les circonstances où l'on devait tirer plus rapide- " ment."—*Le Passé et l'Avenir de l'Artillerie*, vol. iii., p. 307.

"L'usage des gargousses en papier double, en parchemin ou en toile, était prescrit " pour les circonstances où le tir devait être très-prompt."—*Ibid.*, vol. iv., p. 28.

"On employait dans les circonstances qui exigeaient un tir rapide des sachets en " papier double, en parchemin ou en toile, qui contenaient la charge de poudre; mais " on continuait à se servir, habituellement, de la lanterne."—*Ibid.*, vol. iv., p. 231.

[4] *Manual of Artillery Exercise*, p. 107.

[5] "Gargousses en papier double, en parchemin et en toile."—*Le Passé et l'Avenir de l'Artillerie*, vol. iv., p. 28.

"Cartridges are either to be made of canvas, fustian, or other linen cloth, or of thick " strong paper, especially of paper royall."—*The Gunner*, p. 27.

"They are made of various substances, such as paper, flannel, parchment, and " flannel."—*Müller's Treatise of Artillery*, p. 201.

"The cartridge bag should be composed of wild-bore, merino, or bombazette, which " should be composed entirely of wool."—*Gibbon's Artillerist's Manual*, p. 340.

"Cartridges for heavy guns are now partly made of cured paper only, and partly of " cured paper with flannel bottoms."—*James' Dictionary*, p. 92.

Cartridge, a case of paper, parchment, or flannel.—*Ibid.*, p. 92.

[6] "The cartridges were . . . . made of paper, which required the operation of " worming guns after every discharge, on account of the lower end of a paper cart- " ridge remaining generally at the bottom of the bore in a state of ignition."—*Naval Gunnery*, p. 385.

The paper retained the fire too much, and the "bottoms remain in the piece and " accumulate so much that the priming cannot reach the powder."—*Müller's Treatise on Artillery*, p. 201.

"Le parchemin a l'inconvénient de laisser au fond du canon des culots qu'il faut " retirer avec le tirebourre, pour éviter des accidens graves."—*Cotty's Dictionnaire de l'Artillerie*, p. 151.

and choke the vents.[1] Sir Charles Douglas perceived that these objections might be overcome by the employment of flannel for cartridges, and in 1778 he "proposed that cartridges should be made of flannel."[2]

Sir Charles's propositions were not "immediately adopted," and "paper cartridges . . . . continued for some years in general use."[3] But the objections to paper cartridges were in a measure overcome by placing flannel bottoms to the cartridges, and this plan was occasionally adopted.[4] The advantages of employing flannel for cartridges, especially where quick firing was desired, were so evident that this material was introduced for *field* service cartridges some time about the beginning of the present century,[5] and it is probable that flannel was also adopted for naval cartridges about the same time.[6] When flannel came to be generally adopted, and when paper finally disappeared, it is not easy to determine, but it is certain that the latter was nearly obsolete in 1828,[7] and since that time flannel (serge) cartridges have been exclusively used.[8]

Weight of charge.

The weight of charge in proportion to the weight of the projectile has varied continually since the first employment of gunpowder. Indeed, these changes have been so numerous that it is impossible to do more than indicate the more important of them. In the latter part of the 15th century we find the charge fixed at one-ninth the weight of the stone shot,[9] but towards the close of that century the charge was increased to

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[1] "When they are made of parchment or bladders, the fire shrivels them up, whereby "they enter into the vent and become so hard that the priming iron cannot remove "them so as to clear the vent."—*Müller's Treatise of Artillery*, p. 201.

[2] *Naval Gunnery*, p. 385. For full details of this and Sir Charles Douglas's other suggestions "for improving, facilitating, and quickening the service of naval ordnance," see *Ibid.*, pp. 384 to 388.

[3] *Naval Gunnery*, p. 385.

[4] The cartridges of H.M.S. "Duke" were thus fitted at Sir Charles Douglas's own expense. See *Ibid.*, pp. 385, 386. See also *Müller's Treatise of Artillery*, Appendix (*Artillery Dictionary*) p. 8, where mention is made of parchment cartridges fitted with flannel ends, and covered over with a parchment cap, which was removed before loading.

"Cartridges for heavy guns are now partly made of . . . . cured paper with "flannel bottoms."—*James's Military Dictionary*, p. 92.

[5] I cannot fix the exact date at which flannel cartridges were first introduced, but I believe I am correct in saying "about the beginning of the present century," from the fact that *James's Military Dictionary* (edition 1816) says, "Those" (cartridges) "for field ordnance are all made of flannel" (p. 92); while from *Naval Gunnery* it appears that in 1778 "cartridges were all made of paper," and that they "continued "for some years in general use" (p. 385), therefore it seems certain that flannel cartridges must have been adopted about the very end of the last or the beginning of the present century.

[6] This seems to be indicated by the fact that according to the *Pocket Gunner*, edition 1813, flannel cartridges were at that period sometimes used for heavy as well as field guns, although paper was not yet obsolete.

[7] The *British Gunner*, edition 1828, gives eight descriptions of paper cartridges, with the remark, "The above are the only descriptions of paper cartridges in the "service, and they are now nearly obsolete," p. 123.

It is rather curious that in the *Ordnance Regulations* (home) of 1855 mention is made of paper cartridges as if they were still in reserve, the Commanding Officer of Artillery at each station being required to transmit half yearly to the Director of Artillery a return among other stores of "cartridges, paper and flannel (filled and "empty)," p. 150, par. 589.

[8] As I have before mentioned, mortars are even now sometimes loaded with loose powder; this, however, is merely a question of convenience, the ranges of mortars being regulated by the weight of charge.

[9] "Une livre de pouldre doibt suffire à gecter une pierre pesant neuf livres, et se la "pierre poise moings de neuf livres, on doibt soubstraire d'une livre de pouldre à "l'équipolent de ce que la dicte pierre pois moins, on adjouter se plus poise des dictes "neuf livres."—*Le Passé et L'Avenir de l'Artillerie*, tome iii., p. 153.

one-fifth,[1] or even in some cases to nearly one-fourth[2] the weight of the projectiles. But then, as now, the proportionate weight of charge varied with the different natures of guns, and we find it lying between one-sixth and four-fifths the weight of the projectile—in some cases even being the same weight.[3] In those days, however, the weight of charge did not afford, as it does at present, a just indication of its *strength*, for the nature of powder varied with the different arms, and by altering the proportions of the ingredients, or by pulverizing the saltpetre more or less thoroughly, or by making the mixture of ingredients more or less intimate, the artilleryman of the 15th century modified the strength and violence of action of his powder to suit particular applications,[4] a fact which will account for the very high proportional weight of charge used for some of the arms.

Two centuries later, when the composition of gunpowder was more settled, we still find the weight of charge varying considerably with the nature of piece and projectile. Sometimes it was as high as half the weight of the projectile,[5] sometimes as low as one thirty-second, and from that time to the present day changes, which it would be tedious and profitless to attempt to enumerate, have been continually made in the weights of charges; until in 1863 (see table),[6] the *present* scale of charges and method of marking cartridges was adopted,[7] and land and sea service cartridges assimilated. As regards the history of bursting charges so much as it seemed necessary to give will be found at page 168.

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[1] "La charge, qui avait éte d'un neuvième du poids de la pierre, etait portée au " cinquième, parce qu'on était parvenu à augmenter la résistance des bouches à feu." —*Le Passé et l'Avenir de Artillerie*, p. 195.

[2] "Si la bombardie tire une pierre de cent livres, on lui donnera vingt-quatre livres " de poudre, et on augmentera la charge de dix-neuf à vingt livres pour chaque cent " livres que le boulet pèsera de plus."—*Ibid.*, p. 194. See also *Ibid.*, p. 365.

[3] "Les bombardes, mortiers, commuines, moyennes et comtes reçoivent 16 livres de " poudre pour 100 livres de projectile; les passevolents, basalics cerbottanes et spru-" gardes, 10 pour 100; les arquebuses, 50 pour 100; les escopettes, 80 pour 100 ou " même poids égal."—*Ibid.*, p. 198.

[4] "La qualité de la poudre varie aussi avec la nature de la pièce. . . . . Trois moyens " concouraient à modérer la force d'impulsion, en rendant l'explosion plus lente; 1° " une moindre proportion de salpêtre; 2° une moindre purification de cette substance; " 3° une moindre pulvérisation et un mélange moins intime des trois substances. . . . " Ou fabriquait quatre poudres différentes est l'on se servait d'une detonation moins " vive à mesure que le projectile à lances était plus lourd."—*Le Passé et l'Avenir de l'Artillerie*, vol. iii., pp. 198, 199.

[5] "For balls or bombs of great weight . . . . you take half an ounce of powder for " every pound. This proportion may be observed for projectiles down to 100 lbs. " But from 100 lb. to 1 lb., you shall increase every quintary, that is, every fifth " number, with 15 *grains*," &c.—*Great Art of Artillery*, p. 228.

"In order to shoot grenados from cannon, the requisite of powder shall never " exceed one-eighth of the weight of the grenado and all its furniture."—*Ibid.* p. 242.

"La charge de poudre des pieces de campagne était habituellement de la moitie du " poids du boulet, mais on tirait souvent des grenades avec la charge du tiers."—*Le Passé et l'Avenir de l'Artillerie*, vol. iv., p. 13.

[6] Approved 24th March 1863, 75/3/623, *War Office Circular*, No. 822, para. 728.

[7] Up to that time sea service cartridges were differently marked and made up from those for land service. There were three natures of charges for each gun except the 10-inch, which had only two, these charges being designated "distant," "full," and "reduced," and being marked respectively in black, blue, and red, (*Ordnance Regulations, Home*, 1855, page 162, para. 633), the two latter having also a blue and a red ball respectively. To enable them to be distinguished at night the cartridges had three, two, or one row of stitches according to whether they were distant, full, or reduced. The alteration adopted in 1863 did not affect the nature of charges for each gun, but merely reduced them all to one uniform system of marking, thus rendering the same weight of charge available for both sea and land service, and thus (with the abolition of a few charges) considerably reducing the number of cartridges. The total reduction of cartridges effected by this change was about 30.

Gunpowder.[1]

Gunpowder is the agent employed for the firing charge of all ordnance, and for the bursting charge of all projectiles, and it will therefore be desirable to introduce at this point a short description of the composition, action, and properties of this substance.

Gunpowder is an explosive propellent agent, consisting of an intimate mechanical mixture of saltpetre, sulphur, and charcoal. The proportions of the ingredients vary in different countries.[2] In the powder which is manufactured at the English Government Factories, Waltham Abbey, they are as follows :[3]— Gunpowder, its description, properties, and varieties.

Saltpetre[4] - - - -	75 parts.
Sulphur[5] - - - -	10 „
Charcoal - - - -	15 „

The action of gunpowder is due to the rapid decomposition of the saltpetre by the charcoal, the actual effect being that the charcoal is burned by the oxygen of the saltpetre, with which it combines in the act of burning to form *Carbonic Acid.*[6]

By the burning of the charcoal the oxygen in the saltpetre becomes separated from another gas, *Nitrogen*, with which it was at first combined, and combines with the carbonic acid, the two forming a large volume of heated gas of great expansibility.

It is to the sudden evolution of these two heated gases (Carbonic Acid and Nitrogen) that the explosive force of gunpowder is mainly due.

In a mixture of saltpetre and charcoal alone this action is comparatively slow. Sulphur is therefore added to render it more rapid,[7] an effect which it produces on account of its igniting at a much lower temperature than either of the other two ingredients.[8]

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[1] No work of this description would be complete without some description of gunpowder, a substance which enters, in one form or another, into nearly all the important laboratory compositions, and it seems to me that this part of the work, when we are about to deal with gunpowder in its simplest form and most direct application, is the most suitable for the introduction of such a description.

This description, however, I would have it understood, pretends to no higher character than that of a *simple and elementary* account of the substance, and of its general action ; it is not put forward as a *treatise* upon the subject, and I have not attempted to go into it deeply or exhaustively; to do so would be foreign to my object, for gunpowder, it must be remembered, is not an article of laboratory manufacture, and this description is given merely with the object of affording the reader so much knowledge of the subject as is indispensable to the study of a laboratory course.

[2] The *Manufacture of Gunpowder*, p. 1.

[3] These proportions are not those which *theoretically* would give the greatest amount of gas. The charcoal is in excess to allow for ash, and the sulphur is diminished, as it acts injuriously on the metal of the piece.—See on this subject *Notes on Gunpowder*, pp. 2, 3.

[4] See p. 315.

[5] See p. 318.

[6] Where the proportion of charcoal is greater than that contained in common gunpowder, it will be less completely and rapidly burned, and the gas produced will be carbonic *Oxide* and not carbonic acid ; blasting powder, for example, "contains a "greater proportion of charcoal and less saltpetre, its action consequently is slower." —*On the Manufacture of Gunpowder*, p. 2.

Moreover, such powder will be less powerful, since, by the decomposition of the saltpetre in presence of much charcoal, a larger body of gas is formed, (2 CO for CO_2), but less heat is developed, and the expansion of the gas at the moment of explosion is considerably less.

[7] The rapidity of inflammation is one of the causes upon which the *explosive* effect of gunpowder depends.—See *Notes on Gunpowder*, p. 3.

[8] "In a mixture of nitre and charcoal alone, the oxidation (deflagration) proceeds with comparative tardiness ; the addition of sulphur greatly augments the combustibility

It also renders available a greater quantity of oxygen for the burning of the charcoal, by combining with the potassium in the saltpetre, and so liberating the oxygen with which the potassium was combined.[1]

The combination of the sulphur with the potassium, forms sulphide of potassium,[2] some of which is carried into the air by the escaping gases, where it catches fire and burns, producing the flash and white smoke,[3] with which all who are acquainted with the action of gunpowder must be familiar.[4] That portion which is not carried out to the air and consumed forms the solid residue of fired gunpowder.[5]

To produce these results it is merely necessary to raise the powder (or a portion of it) to a temperature slightly in excess of that which is requisite to ignite the sulphur, or about 600° Fahrenheit,[6] when the action described will ensue, the heated gas which is generated from the portion first ignited being transmitted by the expansive power through the interstices, and igniting each grain in its passage. The rapidity of action of gunpowder is determined, therefore, by two conditions:

Conditions which determine the rapidity of action of gunpowder.

(*a.*) The rate of burning of each grain; or the Velocity of Combustion.

(*b.*) The rate at which the grains successively become ignited; or the Velocity of Ignition.[7]

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of the mixture (in consequence of the low temperature at which it ignites)."—*Abel and Bloxham's Hand Book of Chemistry*, p. 237, see also *on the Manufacture of Gunpowder*, p. 1. "The addition of sulphur quickens the combustion, raises the tem- " perature of gases, and increases their expansion."—*Text Book*, p. 66.

[1] "The sulphur by its presence also renders available for the oxidation of the carbon " an extra amount of oxygen, viz., that which is united with the potassium, the latter " being at once converted into sulphide on the ignition of the powder."—*Hand Book of Chemistry*, p. 237; see also *on the Manufacture of Gunpowder*, p. 1.

[2] See end of preceding note.

[3] The white smoke is chiefly sulphate of potassa and carbonate of potassa; but there are other ingredients.—See *Notes on Gunpowder*, p. 21.

[4] "In practice, it is found that small quantities of many other products are invariably " formed, besides carbonic acid, nitrogen, and sulphide of potassium, among which " may be mentioned carbonic oxide, hydro-sulphuric acid, bisulphide of carbon " vapours, carbonate of potassa, cyanide and sulpho-cyanide of potassium, and aqueous " vapour. The most important products of a careful and complete combustion, on a " small scale, of powder of the above composition, have, however, been found to cor- " respond pretty closely to the above theoretical expression."—*Hand Book of Chemistry*, pp. 237, 238. See also Lieut. von Karolyi's paper on the " products of the combustion " of gun cotton and gunpowder," in the *Proceedings Royal Artillery Institution*, vol. iii., p. 383, also *Notes on Gunpowder*, pp. 21 to 23.

[5] Respecting the composition and proportion of this solid residue, see *Notes on Gunpowder*, p. 21.

[6] "The heat must be raised to about that at which sulphur would sublime," viz., " about 600° Fahrenheit."—*Text Book*, p. 69.

"One portion of the substance must in the first instance be raised to a temperature " a little above that necessary to sublime the sulphur, the heat required is between 600° " and 680° Fahrenheit."—Col. Boxer's *Treatise on Artillery*, section i., part i., p. 16.

"Gunpowder," says Captain Bishop, " explodes exactly at the 600° of heat by " Fahrenheit's thermometer."—*Ure's Dictionary*, vol. i., p. 980. See also *Notes on Gunpowder*, p. 7.

"It has been proved that powder may be inflamed not only by the powerful con- " cussion of iron against a hard substance, but by the concussion of comparatively soft " bodies, provided it be sufficiently powerful. Experiment has shown that powder " placed upon lead or even wood, may be ignited by the concussion of a leaden " bullet fired at it."—*Abel and Bloxham's Hand Book of Chemistry*, p. 245; see also *Synopsis of Ordnance Select Committee Reports, Shrapnel Shell*, p 89; also what has been said at p. 45 about the cause of the premature explosions of the original shrapnel shell; also Boxer's *Treatise on Artillery*, section i., part i., p. 16; also *Report on Ballistic Experiments*, p. 93, para. 63, 64.

[7] Called by Colonel Boxer "the velocity of the transmission of inflammation."—*Treatise on Artillery*, sect. i., part i., p. 19.

These conditions are subject to a great variety of modifications from a number of minor influences. It has already been shown how (1) the presence of the sulphur and (2) the proportions of the ingredients affect the rate of combustion of the powder. In addition, (3) the quality of the ingredients; (4) the method of manufacture; (5) the dryness of the powder; (6) the presence of foreign ingredients;[1] (7) the hardness of the powder; (8) its density; (9) the size of the grains; (10) their shape; and (11) the degree of glazing imparted to them, all influence, more or less directly, one or other of the two main conditions upon which the rapidity of action of the powder ultimately depends.[2]

It is, however, only with the four last-named that we need now concern ourselves, because the others vary but little for the different natures of powder, the manufacturer seeking, as far as possible, to control and modify the action of powder to meet particular applications mainly by altering the density, size, and shape of the grains, and by glazing them more or less highly, without in any way altering the constitution of the powder.[3]

As regards the *Density of the Powder.*—This point was not at one time thought of as much importance as it has recently been shown to be; and it is now certain that experiments with different powders are no criterion of their other qualities unless their densities be uniform.[4] A dense powder necessarily burns less rapidly than one of lower specific gravity, bulk for bulk, from the fact that the former contains in a given bulk more to consume than the latter, and from the fact that its texture is also closer, and hence less favourable to combustion.

A powder of high density stands travelling better, and dusts less rapidly, than one of lower specific gravity.[5]

As regards the *Size of the Grains.*—When a charge of powder is ignited each grain in its turn becomes ignited over the whole surface, and continues burning in concentric layers until it is consumed. It is evident, therefore, that as a large grain will take a longer time to burn

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[1] A plan for making powder non-explosive by this means has been patented by Mr. Gale of Plymouth, and has attracted some attention. He mixes a foreign non-explosive substance, such as finely powdered glass or bone dust, with the grains, and by this means destroys the interstices and cuts off communication from one grain to the other, making the powder practically non-explosive. He, in fact, dilutes the powder with so much foreign incombustible finely-powdered substance. By sifting out the diluent when required for use the explosive properties of the powder are restored. This proposal, it should be pointed out, is not original. The plan is fully described by Piobert (*Traité d'Artillerie, Théorique et Expérimental,* pp. 213–220, under the head of "*Moyens de Diminuer la Vitesse d'Inflammation de la Poudre*"), who used sand, and in some instances powdered sulphur, charcoal and saltpetre. Some experiments, which appear to have been successful as far as they went, were conducted by M. Fadéieff, "Professeur de Chimie à l'Ecole spéciale d'Artillerie à Saint Petersbourgh," the material employed being wood charcoal and mineral charcoal (graphite) in the proportion of one part of "carbo-graphite" to two parts of powder by weight.—See *Ibid.*, p. 220.

[2] See Colonel Boxer's *Treatise on Artillery,* sect. i., part i., pp. 17–21.

[3] An exception to this has already been mentioned in the case of blasting powder, which is made with less saltpetre and more charcoal; but this is mainly on account of the "great reduction in price" thereby effected.—*On the Manufacture of Gunpowder*, p. 2; *Hand Book of Chemistry*, p. 239.

[4] "Read memorandum from Lieutenant Noble. He points out that unless some "means are taken for ensuring greater uniformity in the density and strength of "powder it is useless to attempt any comparison as to range, unless guns are fired "with powder from the same lot."—Extracts of *Report of Ordnance Select Committee,* vol. iii., p. 22.

[5] Boxer's *Treatise on Artillery,* sect. i., part i., p. 20.

in this way than a small one, so, *all other conditions being the same*, a charge made up of large grains will take longer to burn than the same charge made up of smaller grains.[1] But the rate at which the grains successively become ignited will also be affected by the size of the grains; and here the effect will tend in the opposite direction to that just described, for as the interstices through which the gases pass[2] decrease as the size of the grain decreases (*all other conditions being the same*) the Velocity of Ignition will also proportionally decrease, and in a measure counterbalance the effect produced by the increased rate of burning of each grain. The direction and extent to which altering the size of the grains will affect the rapidity of action of the powder will depend upon the conditions under which the powder is ignited, such as whether it is exploded in an open train; in small enclosed charges; in large enclosed charges; whether the charge, if large, be thick and short, or long and thin; whether it fits the bore closely; which portion of it is first ignited, &c. These conditions are so numerous that no universal rule can be laid down; and if for ordinary purposes we assume that, *all other conditions being the same*, fine grain powder will burn quicker than large grain, except in large charges,[3] our conclusion is likely to be upset by a slight alteration in the shape or density or hardness of the grain. This, however, is perhaps on the whole the most correct general conclusion to arrive at. In the case of "mealed" or "dust" powder the Velocity of Ignition is so much

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[1] Boxer's *Treatise on Artillery*, pp. 17, 18; also *Text Book*, p. 70.

[2] The gases by which the grains successively become ignited.

[3] There can be no question that this is the case when the powder is in open trains or in small enclosed charges. If the powder be in trains the ignition of the particles is almost independent of the interstices; and it is evident, therefore, that the Velocity of Ignition will hardly be affected by the size of the grains, upon which th eextent of the interstices greatly depends; consequently, under these circumstances, all other conditions being the same, fine grain powder will burn quicker than large grain. "In experiments with trains of powder the increased surface exposed to the heated "gas was found to more than compensate for the diminished facility to its expansion; "and generally a train of small grain powder laid upon a surface without being "enclosed will be consumed more quickly than a train of large grain powder."—Colonel Boxer's *Treatise on Artillery*, sect. i., part i. p. 20.

So also with small enclosed charges, where, owing to the flame having to traverse an inconsiderable distance to complete the ignition of every grain, the effect of slow ignition is but little felt, and "a small grain gives the quickest combustion."—*Text Book*, p. 70.

In the case of large enclosed charges, however, the velocity of ignition becomes a more important element; and as the grains increase in size, the interstices being greater, the facility of ignition increases proportionally, and from *this* cause there would be a tendency to increased rapidity of action with large grained powder as the size of the charge increased. The results of such experiments as have been made upon this subject seem to indicate that the Velocity of Combustion scarcely decreases in corresponding proportion, and the increased Velocity of Ignition is thus not counterbalanced—the ultimate result being quicker action on the part of large grain powder in large charges than of fine grain.—See on this subject *Treatise on Artillery*, sect i., part i., p. 20, par. 58. "Large grains in large charges allow the quick passage "of the flame through the charge; and, although each grain is longer burning than "small grain would be, the whole charge is much more rapidly consumed."—*Text Book*, p. 70, par. 39. L. G. R. powder "has been described as a slower burning "powder than L. G., but on what ground the Committee are unable to say, as all "their experience goes to prove the contrary." *Extracts Ordnance Select Committee*, iii. p. 113.

Moreover, in the case of long charges ignited at the back end, the ultimate rapidity of action of the powder is influenced by another cause, viz., the fact that the front part of the charge becomes "set up" and the interstices destroyed. The front part of the charge thus becomes, as it were, one large grain, and its rate of combustion is proportionally reduced; or, if the gun be not long enough to burn it, this portion of decreased by the almost total absence of interstices that it more than counterbalances the increase in Velocity of Combustion due to the reduction in the size of the particles, and mealed powder (except, perhaps, when altogether unenclosed) is slower in its action than fine grain powder.[1]

As regards the *Shape of the Grains.*—The shape of the grains will also affect both the Velocity of Combustion and the Velocity of Ignition: the first, because an elongated grain exposes a greater surface than the same weight of grain shaped as a cube or sphere, and is therefore more rapidly consumed;[2] and the second, because if the grains are flat or angular, fitting compactly, as it were, into one another, the interstices for the passage of the heated gas will be fewer and smaller than when the grains are of a more rounded form, and the Velocity of Ignition will thence be proportionally decreased.[3] The direction and extent to which the rapidity of action of the gunpowder will be affected by the shape of

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the charge is blown out and lost. Different effects will be produced according to which part of the cartridge is first ignited, or according to the difference in the diameter of the cartridge and bore, and the consequent facility to the expansion of the powder afforded, independently of the interstices. *Further, it is not fair always to assume that larger grains give more interstices. This will depend upon the form of grain, and the reasoning which is based upon this assumption will thus be liable to be invalidated by a slight alteration in the form of the grain.* For these reasons it is difficult to lay down any precise rule upon this subject, though there is reason to believe that the one given in the text will generally be found correct under the ordinary conditions of practice.

This very interesting subject is discussed in Colonel Boxer's *Treatise on Artillery*, sect. i., part i., p. 17-20; and at considerably greater length in Piobert's *Traité d'Artillerie, Théorique et Expérimentale.* Some interesting experiments bearing upon the effect of very large grains in very large charge will be found in the *Report on Ballistic Experiments*, p. 70. It should be noticed, however, that although the 2 A 4 powder used on these occasions gave much higher velocities than the L. G. fired in comparison, this effect cannot be *wholly* ascribed to the difference in the size of the grains of the two, but in part to the density of the larger powder being "slightly less."—*Ibid.*, p. 72.

A yet more conclusive experiment was made in August 1865, when rifle L. G. and L. G. powders were used of *identically the same densities.* It appears from this experiment that a greater velocity was obtained with the R. L. G. than with the L. G. powder *with guns* in every case except one (10-inch), while, with mortars, the L. G. powder gave the highest velocities. For details see Appendix E., p. 370.

[1] "If the charge be composed of mealed powder a longer time is found to be neces- " sary for the complete combustion of the whole than in the case where the sub- " stance is granulated."—Boxer's *Treatise on Artillery*, sect. i., part i., p. 20.

[2] "If the form of the grain be elongated then will the quantity of gas generated in " a given time from a grain of similar weight to that of the cube or sphere be increased, " on account of the greater ignited surface, and consequently the time necessary for " its complete combustion is diminished."—Boxer's *Treatise on Artillery*, sect. i., part i., p. 19.

"Those [grains] round in form (the grains being of the same volume) are longest " in burning, there being a greater distance for the flame to penetrate, and the smallest " surface presented to the action of the flame."—*Text Book*, p. 70.

[3] "If the grains are of a rounded form there would be more interstices, and a " greater facility will be offered to the passage of the heated gas, and therefore this " shape is most favourable to the rapid and complete inflammation of the whole " charge. On the other hand, particles of an angular or flat form, fitting into each " other, as it were, offer greater obstruction to this motion; and the velocity of trans- " mission of inflammation is thereby diminished."—Colonel Boxer's *Treatise on Artillery*, sect. i., part i., p. 20.

"The rounded form of grain is the most favourable for the transmission of the " flame, the interstices being larger; the elongated or flat grains, if fitting into one " another, obstruct the passage of the flame, and retard combustion."—*Text Book*, p. 20; see also Piobert's *Traité d'Artillerie, Théorique et Expérimentale*, pp. 152-160, where this subject is fully and scientifically discussed.

the grains will depend upon the conditions under which the powder is fired. As a general rule, the flat or angular form gives the most rapid action in trains and small charges; the spherical form more rapidity in large charges.[1]

The degree of glazing imparted to the grains will also affect the rapidity of action of the powder, high glazing retarding the ignition of each grain.[2] Glazing also serves other purposes; it causes the powder to meal less,[3] and renders it less liable to absorb moisture.[4]

Advantages of gunpowder.

The considerations which recommend the employment of gunpowder as a propellent agent are—

1st. The gradual nature of its decomposition. This is a most important point, "for were it otherwise the gun, unless of enormous strength, " must be shattered in pieces, as well as the projectile, for in such a case " this great force being suddenly exerted upon one part only of the " material, there would not be time for the action to be distributed over " the particles at any great distance before those in the immediate vicinity " of the explosion were forced out of the sphere of the action of the " cohesive force, and consequently rupture must take place."[5] Fulminates and other explosive substances, which are much more rapid in their decomposition than gunpowder, would be inapplicable as propelling agents for this reason.[6]

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1 The reason of this will be readily perceived. As flat, angular grains retard the Velocity of Ignition, while they facilitate Velocity of Combustion, evidently the employment of this form will be most favourable to rapidity of action where the first of these elements (Velocity of Ignition) is of least importance; and this, as has been explained (see p. 134, note 3), is the case in trains and small charges. But in large charges Velocity of Ignition becomes of greater importance, and the increased rapidity of combustion of the flat grains is in such (large) charges more than counterbalanced by the greatly decreased facility to ignition.

The cubical grain will be slow under all circumstances, that form being not only unfavourable to rapidity of combustion, but also offering great obstacles to ignition.

2 "The glazing . . . . will interfere in some degree with the ignition of each " grain."—Col. Boxer's *Treatise on Artillery*, sect. i., part i., par. 21.

" The powder is considerably longer in igniting."—*Text Book*, p. 69.

3 " The principal advantages arising from it" (glazing) " is that the powder so pre- " pared will in travelling, owing to the smaller amount of destructive force consequent " on friction, produce less mealed powder."—Col. Boxer's *Treatise on Artillery*, section i., part i., p. 21.

" Glazing makes the powder more durable, causes less dust to be formed in trans- " port."—*Text Book*, p. 69.

"In transport very little dust is formed."—*On the Manufacture of Gunpowder*, p. 18.

4 " Glazing . . . . increases its preserving quality, being less liable to absorb " moisture."—*Text Book*, p. 69.

" Powder glazed in this way withstands the action of moisture to a far greater " extent than unglazed powder."—*On the Manufacture of Gunpowder*, p. 18.

5 Col. Boxer's *Treatise on Artillery*, section i., part i., p. 17.

6 See on this subject *Ibid.*, p. 17. *On the Manufacture of Gunpowder*, p. 1. *Notes on Gunpowder*, p. 2. *Text Book*, p. 6. Also report on Baron Lenk's gun cotton, in *Proceedings of Royal Artillery Institution*, vol. iii., p. 380, where the relative "*force brisante*" (" the time within which a certain weight of an explosive material in a " gun has been converted into a certain volume of gas, or the volume of gas produced " under otherwise equal conditions ") of gunpowder and gun cotton are spoken of. The relative effects produced upon a gun by fulminates and by gunpowder, may be illustrated and compared by a very simple chemical experiment. If two thin glass tubes be taken and a small charge of gunpowder placed in the one, and in the other an equal charge of, say, fulminating mercury, and if the two tubes be closed each with a cork and sufficient heat applied to explode the two charges, it will generally happen that the gunpowder will blow out the cork, while the mercury will shatter the tube.

The following extract from a paper on " *Some of the causes, effects, and military " application of explosions,*" read by F. A. Abel, Esq., F.R.S. before the Royal

2nd. The manner and degree in which the action may be modified to suit particular applications without altering the composition or chemical character of the powder.[1] The manner in which the necessary modification may be effected merely by altering the density of the powder, by varying the size and shape of the grains, or by glazing them more or less highly, by altering in short the *physical* character of the powder, has already been explained.

3rd. The comparative safety attending its manufacture and transport.[2]

4th. Its comparative cheapness, the saltpetre and sulphur being abundant natural productions, and the charcoal being easily and cheaply manufactured.[3]

5th. Its comparative keeping qualities.[4]

Principal powders used in laboratory manufacture.

The principal powders used in laboratory manufacture are known as—

(*a*.) Mealed powder.

(*b*.) „ pit powder.

(*c*.) Fine grain, or "F.G." (known until 1865[5] as "common F.G.")

(*d*.) Fine grain shell, or "shell F.G." (known until 1865 as "medium rifle powder, or R.A. medium.")

(*e*.) „ exercising, or "exercising F.G." (known until 1865 as "started F.G.")

(*f*.) „ rifle or "rifle F.G." (known until 1865 as "Enfield rifle powder," or "E.R.;" originally distinguished as J_2).

(*g*.) Large grain, or "L.G." (known until 1865 as "common L.G.")

(*h*.) Large grain, shell, or "shell L.G." (known until 1865 as common L.G., classes 3 and 4.)

Institution, March 21st, 1862, explains so clearly the relative effects of a gradual and instantaneous action in the chamber of a gun that I have thought it desirable to quote it at length:

"By the comparatively gradual decomposition of an explosive mixture, such as "gunpowder (when employed as a charge in a gun), the force exerted by the gases "generated in the confined space discovers, before it attains its maximum, that por- "tion of the chamber enclosing the powder (*i.e.* the projectile) which is separated "from the remainder. By the motion which it immediately imparts to this, the "*smaller* mass, the strain upon the *larger* mass, forming all but one side of the cham- "ber (*i.e.* the breech of the gun), is at once relieved, while the force continues, to "the close of its development, to act in the direction of the mass which has once "yielded to its influence, and thus propels the projectile."

"The explosion of a charge of a fulminate, on the other hand, in the chamber of a "gun, is so instantaneous that the maximum of force is at once developed, and the "strain thus exerted within the chamber, at the same time that it overcomes the "inertia of the projectile (or the moveable side of the chamber), will also overwhelm "the cohesive force which maintains the mass of the chamber entire and the breech "of the gun will therefore be shattered."

[1] "The inflammability of powder is greatly influenced by its physical nature."—Abel and Bloxham's *Hand Book of Chemistry*, p. 245, see also on the "*Causes, Effects, and Military Applications of Explosions*," p. 4.

[2] "Gunpowder under ordinary circumstances and with ordinary precautions is "safe in manufacture, store, and transport."—*Text Book*, p. 63. Also Abel and Bloxham's *Hand Book of Chemistry*, p. 237. *Notes on Gunpowder*, p. 2.

[3] *On the Manufacture of Gunpowder*, p. 1. *Text Book*, p. 63

[4] "None of the ingredients are deliquescent, nor are they hydroscopic, with the "exception of the charcoal, which is only slightly so. Therefore gunpowder, if not "exposed to a very damp atmosphere, may be kept for any length of time without "having its strength materially impaired."—*Notes on Gunpowder*, p. 2.

[5] The official designation of these powders was changed 9th January 1865, by *War Office Circular* 892, 57/Gen. No./3085, a copy of which is given in the Appendix for convenience of reference. See Appendix.

(*i.*) Large grain exercising, or exercising L.G. { known until 1865 as started L.G.

(*j.*) " rifle, or "rifle L.G." (known until 1865 as A^4.)

(*k.*) Pellet powder.

Mealed powder. (*a.*) *Mealed Powder* is ordinary cylinder powder reduced to a sufficiently fine dust to pass through a sieve of 120 meshes to the inch. It enters as an ingredient into several laboratory compositions, such as portfires, &c., in which extreme regularity of burning is not necessary; it is also used for priming paste.

Mealed pit powder. (*b.*) *Mealed Pit Powder* is made from a powder the charcoal of which has been charred in pits (hence its name) instead of cylinders. Like ordinary mealed powder, it will pass through a sieve of 120 meshes to the inch. It is used in fuze composition, being preferred to mealed cylinder powder for this purpose because of its greater regularity in burning.[1]

F.G. powder. (*c.*) *Fine Grain Powder, or "F.G."* is of a size to be retained upon a sieve of 36 meshes to the inch, and to pass through one of 16. It is used for the charge of the 7-pr. muzzle-loading rifled gun, for the charges of all smooth-bore small arms (except those for which shell F.G. is used), for the bursting charges of the four lower natures of Armstrong segment shells,[2] and was employed for the now obsolete bursting charges of rockets.

Shell F.G. powder. (*d.*) *Fine Grain Shell or "Shell F.G."* is of a size to be retained upon a sieve of 72 meshes to the inch, and to pass through one of 44, and is made with alder or willow charcoal. It was called until 1865 "*Medium*" rifle powder to distinguish it from the old rifle arm ("R.A.") powder made with dogwood charcoal (32 to 72 mesh), the size of the grain of the two powders being nearly alike. It is used for the bursting charges of diaphragm shrapnel shell, for the Brunswick rifle, and for Colt and Deane and Adams's pistol cartridges.

Exercising F.G. powder. (*e.*) *Fine Grain Exercising, or "Exercising F.G."* is merely old F.G. powder "started" from broken up cartridges, &c. It is used for blank small arm cartridges.

Rifle F.G. powder. (*f.*) *Fine Grain Rifle, or "Rifle F.G.,"* known until 1865 as Enfield Rifle Powder or "E.R." It was originally distinguished as "J_2," and is of a size to be retained upon a sieve of 20 meshes to the inch, and to pass through one of 12. For some time after the introduction of the Enfield Rifle ordinary fine grain powder was used with it, but it soon became apparent that this powder was unsuited for this arm, greater uniformity of action and regularity of combustion being necessary, and as the result of a number of experiments, a special powder (16 to 24 mesh) was introduced in 1859, and called "Enfield Rifle Powder." Experiments were however continued with a view to effecting further improvements in the character and composition of the powder, and in 1860 the present "Rifle F.G." powder ("J^2", as it was first called) was adopted for service rifled small arms,[3] with a few exceptions, such as Whitworth, Colt's, Deane and Adams', &c. It differs from fine grain, not only in the size of the grains but in some points of manufacture, the most important of these being the substitution of dogwood charcoal for alder, the more complete incorporation of the ingredients effected by

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[1] See *On the Manufacture of Gunpowder*, p. 7, and note. See also p. 251, note 5.

[2] For some time a special F.G. powder was supplied for the bursting charges of Armstrong segment shell, viz., a powder of 24 to 32 mesh, obtained after dusting R.F.G. This special powder, however, is no longer employed.

[3] Adopted, on recommendation of Special Committee on Gunpowder, 18th October 1860, 74/2/539, *War Office Circular* No. 665, par. 178. Whitworth's cartridges, Colt's, and Deane and Adams' are not made up with this powder.

working them in the mills for a longer time,[1] a difference in the density,[2] and in the grains being rounded and more even and highly glazed.

L.G. powder.

(*g.*) *Large Grain or "L.G."* is of a size to be retained upon a sieve of 16 meshes to the inch, and to pass through one of 8.[3] The grains are angular, somewhat irregular in shape, and very slightly glazed.[4] It is used for the charges of all smooth-bore guns (except wrought-iron guns). No more of this powder however, is to be made, and R.L.G. powder will be used for the charges of S.B. ordnance when the present store of L.G. is exhausted. Meanwhile L.G. will be used for all bronze and cast-iron smooth-bore ordnance. For wrought-iron smooth-bore ordnance R.L.G. comes into immediate use.

Shell L.G. powder.

(*h.*) *Large Grain Shell or "Shell L.G."* is merely L.G. of an inferior class, viz. classes 3 and 4 (under Circular 512).[5] It is used for the bursting charges of all shell, rifle and smooth-bore, except shrapnel and the four lower natures of Armstrong segment shell. It will ultimately be superseded by R.L.G. powder.

Exercising L.G. powder.

(*i.*) *Large Grain Exercising or "Exercising L.G."* is merely L.G. powder "started" from broken up cartridges. It is used for saluting and exercising charges for guns, that is, it is used in the same capacity for cannon as Exercising F.G. for small arms, *i.e.* for blank firing.

Rifle L.G. powder.

(*j.*) *Large Grained Rifle or "Rifle L.G.,"*[6] known until 1865 as A⁴ powder, is of a size to be retained upon a sieve of eight meshes to the inch, and to pass through one of four.[7] The grains are angular and highly glazed.[8]

It is used for the charges of rifle guns of 12 tons and under (except the 7-pr. guns) and for the charges of wrought-iron smooth-bore guns, being preferred to L.G. for this purpose on account of its greater uniformity. It will come into use for the charges of all S.B. ordnance when the present store of L.G. is exhausted, the manufacture of L.G. powder having been discontinued.[9]

Pellet powder.

(*k.*) *Pellet Powder* was recommended for temporary adoption with heavy guns by the Gunpowder Committee in 1866; and the destructive effects produced by the R.L.G. powder upon some large rifled guns about this time led the Ordnance Select Committee in 1867 provisionally to endorse this recommendation, pending the conclusion of certain experiments instituted with a view to discovering if the particular size and construction of pellet recommended was the one precisely best adapted for the purpose.

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[1] Enfield rifle powder is worked 5½ hours instead of 3½ hours.

[2] Enfield rifle powder is subjected to a pressure of about 50 tons per square foot instead of about 70.

[3] One pound of L.G. powder contains an average of 80,000 grains.

[4] Large grain powder is not regularly glazed, the process of dusting imparts sufficient glazing to it "without any further operation."—*Text Book*, p. 38.

[5] See classification of powder, p. 141.

[6] This was one of the experimental powders tried by the gunpowder Committee. Sir William Armstrong having observed the favourable results attending its experimental use recommended, 11th April 1860, its adoption for his guns generally. The Gunpowder Committee agreed to this as a temporary measure, and its provisional introduction was sanctioned.

[7] One pound of Rifle L.G. contains on an average 13,000 grains.

[8] Black lead is used to impart a higher glaze to the grains.

[9] "The manufacture of ordinary L.G. powder is to be at once discontinued. All powder made at Waltham Abbey or obtained by contract for employment with "ordnance, whether rifled or smooth bore, is to be rifle L.G." Approved 21st "February 1866, *W.O.C.* 11 (New Series), § 1291.

The substitution of cylindrical pellets for grains was recommended in the first instance by the manufacturing difficulties which were found to attach to the production of very large *grained* gunpowder. These difficulties may be referred to two heads:—1st. Expense. 2nd. Absence of uniformity in size, shape, and density.

The increased cost of very large grained powder is due to the comparatively small product furnished by a given weight of press cake. In the production of large masses of gunpowder which should range between narrow limits as to size and shape, and to which a smooth and finished surface has to be imparted, a considerable quantity of the press cake becomes broken into dust and small grains which have to be reworked before they can be usefully applied.

With regard to a want of uniformity, it is not difficult to understand that the variation in size and shape of grains which is inevitable in all granulated powder will increase greatly with the size of particles required, and a large grained powder made by the ordinary process must always in this respect be a less uniform powder than one made up of finer grains; and, as the action of powder depends so largely upon these elements, it is of the highest importance to eliminate as far as possible all variation due to these causes.

These difficulties it appeared to the committee might be in a great measure overcome by adopting the principle, extensively in vogue in the Royal Laboratory, of applying hydraulic power to the uniform compression of compositions. The system consists in converting meal powder or a similar composition into cylindrial pellets of a particular degree of firmness or density by submitting it to a well-regulated amount of pressure.

From the application of this principle to the manufacture of gunpowder we obtain the pellet powder which has been recently experimentally adopted for our heaviest rifle charges.

Pellet powder is not only much more uniform in size, shape, hardness, and density than ordinary granulated powder, or rather the size, shape, hardness, and density admit of much readier control when the powder is treated by this process than under the ordinary process, and is thus very much more uniform and defined in its ultimate action, while, as has been explained, it is also less expensive to manufacture.

Having then determined by experiment what size and shape and density of pellet are best suited to the end in view, it is always easy to produce by the pellet process any quantity of powder which, within reasonable limits, will give the same results.

The Gunpowder Committee tried a large variety of pellets, and ultimately expressed a preference for that which has been *provisionally* adopted, pending further inquiry into this part of the subject. The pellet is a small, very hard cylindrical disc of compressed gunpowder partially perforated in the centre.

The pellets are produced from cylinder mealed powder[1] made of

[1] The powder for making the pellets is arrested at that stage of its manufacture into ordinary powder which is known as "broken down mill cake." "After the ingredients are prepared and mixed they are incorporated in the mill for about 3½ "hours, and when this is finished the mixture is termed 'mill cake,' being to all intents "and purposes powder, only in a state of half cake and half dust. To be converted "into service gunpowder it would require to be pressed in the hydraulic press into "what is called 'press cake,' which press cake is afterwards broken up by machines "into the different sizes of grains we require. But to enable the mill cake to get "in between the plates of the press it is first passed through a breaking-down machine, "which crushes up any large pieces in the mill cake into meal. It is at this stage of "manufacture that we stop it and barrel it up when wanted for pellets."—*Extract from MS. letter from Captain F. M. Smith, Assistant Superintendent Royal Gunpowder Factory, Waltham Abbey, 25th April* 1867.

alder or willow charcoal, which is compressed by hydraulic power[1] into discs of the following dimensions and structure:—

Range of density of pellets, 1·65 to 1·7.
Diameter of pellets, ·75″.
Depth of ditto, 0·485″ to 0·495″.
Diameter of cavity, or indentation in the pellet - - - } 0·2″ at top. 0·15″ at bottom.
Depth of cavity, 0·25″.
Range in weight of pellets, 85 to 95 grs.

Before being pressed the mealed powder is slightly damped[2] to cause it to bind and to give the required degree of hardness of the powder.

When dry, the pellets are drummed for half an hour without black lead. The object of drumming is less to impart a surface than to round off the edges, which in transport would be apt to yield dust.

This pellet powder has been recommended for provisional adoption for the charge of all guns above 12 tons in weight. Its destructive effect upon the gun is very much less than that of R.L.G. powder, but its propellant force is not, in a gun of suitable length, at all affected.

Classification of powder.[3]

The classification of gunpowder was arranged as follows by the War Office Circular No. 512, 9th December 1858: 75/General No./126.

"Mr. Secretary Herbert desires that in future the following classification of gunpowder, in all magazines, shall be observed:[4]

"Class 1. New powder.

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[1] The hydraulic pressure applied is about 2,000 lbs. per square inch.

[2] The powder contains about 5 or 6 per cent. of moisture.

[3] A somewhat different classification to the one here laid down has generally been followed at Purfleet and Waltham Abbey. It is as follows:—

Class 1. Serviceable for exercise.
„ 2. Repairable for exercise.
„ 3. Serviceable for shells.
„ 4. Repairable for shells.
„ 5. Serviceable for sale.
„ 6. Do. for extraction.
„ 7. Serviceable, for service.
„ 8. Repairable, for service.

[4] It may be convenient to know under which marks the different classes of powder may be looked for, and the following extract from a letter from Major Henry, late Assistant Superintendent of Waltham Abbey, is given as explaining this point. To avoid repeating the words L.G., F.G., &c. the powders as named in Circular 892 have been numbered as follows:—

Names according to Circular 892.	—		Exercise.		Rifle.		Shell.		Redusted.	
	L.G.	F.G.	L.G.	F.G.	L.G.	F.G.	L.G.	F.G.	L.G.	F.G.
Numbered, for convenience -	1	2	3	4	5	6	7	8	9	10

"Class 1, in Circular 512, would come under 1, 2, 5, 6, that is to say, it would be " found in the barrels marked like 1, 2, 5, and 6. These barrels would all bear the " maker's name.

"Class 2, in 512, would also come under 1, 2, 5, and 6, but there would be no " maker's name, as this powder might come from all quarters, started from cart- " ridges, &c. The date of examination would be shown.

"Class 3 would come under 7 or 8, although new powder (M.R.A.) would also " come under 8.

"Class 4. No powder has been restoved for several years, and therefore this class " ceases to exist. If there should be any left it would come under 7 or 8.

"Class 5. Would not come under any of the new marks, as Circular 892 only " applies to powder *in use* in the service. Powder for extraction is 'sent to Waltham " 'Abbey,' 'and that for sale is taken away from Purfleet by the purchasers.'"

"Class 2. Powder which has been returned from the Royal Navy, and having been kept perfectly dry, has been found, after proof, to be equal to the required standard.

"Class 3. Returned powder, which may have become broken in the grain or dusty, if dry, may be considered fit for filling shells.

"Class 4. Returned powder fit for filling shells after being restoved.[1]

"Class 5. Condemned powder only fit for extraction.

"Samples of any powder which may be damaged or much caked are to be forwarded from Home Stations to the Superintendent Royal Gunpowder Factory, for his decision as to the best course to be adopted.

"At foreign stations the recommendation for the disposal of such condemned powder are to be made by the fire-master at the station, subject to the approval of the General or other officer commanding, who will forward the same for the decision of the Secretary of State."

(Signed) JOHN ROBERT GODLEY.

Extract from War Office Circular, No. 590, par. 10.

"Gunpowder taken out of shells to be carefully examined, and, if "found perfectly serviceable, set apart to be used again for filling "shells."

Recommended by the O. S. Committee.
Approved 10/2/60, 75/12/505.

Proof of powder.[2]

Extract from "*Ordnance Regulations*," "Home," 1855.
Article 559, 12th April 1850/E/468.

"The following rules are to be observed in proving large and fine grain gunpowder with the 8-inch Gomer mortar at all stations.

1. "The bed to be placed on a horizontal platform, and the mortar brought to exactly 45° elevation and properly pointed.

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[1] The practice of restoving powder has recently been discontinued by Order 8th May/67, 75/3/989.

[2] Powder is subjected to a variety of other tests, such as flashing, cubing, taking its specific gravity, testing its moisture, absorbing properties, examining it with regard to its freedom from dust, grit, or foreign matters, and with regard to the general condition of the grains (which "should be angular, crisp, and sharp to the touch, not "easily reduced to dent by pressure between the fingers").—*On the Manufacture of Gunpowder*, p. 20. See also *Notes on Gunpowder*, pp. 18 to 20.

"Good powder should exhibit perfect uniformity of texture; light specks or "glittering points indicate an incomplete mixture. The grains should be sufficiently "hard not to be easily crushed between the fingers, and not to soil these or a piece "of paper by mere contact."—Abel and Bloxham's *Hand Book of Chemistry*, p. 224.

The details of these tests, however, are not given, as they enter into a Waltham Abbey rather than a Royal Laboratory course. Indeed, I have hesitated about introducing the mortar proof; but as this most fallacious test is still continued, pending the adoption of a more scientific and reliable system, I have thought that it would make this portion of the work, in which gunpowder is treated of, more complete and of greater practical value to give the rules to be observed in conducting it.

Respecting the value of this method of proof, the following remarks by Major Mordecai are extracted from Major Baddeley's Pamphlet *On the Manufacture of Gunpowder*, p. 26:—"By comparing the results of the proof by the eprouvettes with "those furnished by the common pendulum, it would appear that the eprouvettes are "entirely useless as instruments for testing the relative projectile force of different "kinds of powder, when employed in large charges as in common. Powders of little "density, or of fine grain, which burn most rapidly, give the highest proof with the "eprouvettes, whilst the reverse is nearly true with the cannon. Thus, all the "eprouvettes concur in assigning the first rank among the cannon powders to the "powder F, which is the lowest on the scale by the cannon; whilst the powder A. "which is the strongest in the gun, is one of the weakest by the eprouvettes. Nor do "these instruments assign any superiority to powder which is well incorporated over

2. "To be fired with two ounces of powder, accurately weighed, and placed as uniformly as possible in the bottom of the chamber by means of a funnel.

3. "The 68-pound shot being carefully cleaned is then to be placed in the mortar gently and uniformly by means of a pair of lifting tongs provided for the purpose.

4. "The mortar being fired by means of a quick match placed in its vent, three times from the same sample, the actual range in feet must be carefully noted and the average of the three rounds shown thus :—

Example.[1]

First.	Second.	Third.	Mean.
244 -	- 230 -	- 248 -	- $240\frac{2}{3}$

5. "The mortar and shot to be carefully cleaned every round, and both to be kept well oiled when not in use.

6. "Great care should be taken in reporting the trials of powder to state as correctly as possible the marks (commonly known as distinguishing marks) in every particular, which are upon the barrels from whence the samples have been drawn, especially as respects the age of the powder, not omitting the date it was received at the station."

Detailed instructions relative to the periods at which proof of powder is to be taken, the manner of selecting the barrels, and the forms on which the proof reports are to be rendered, is given in War Office Circular 674, 5th April 1861 ; indeed, proof of powder should not be undertaken until the instructions contained in this Circular have been referred to.[2]

The subject of the charge may be most conveniently dealt with by subdividing it into (*a*) Firing charge, or charge proper, and (*b*) Bursting charge.

(*a.*) *Charge, Proper.*

The powder used for all bronze and cast-iron smooth-bore ordnance is for the present, and while the store lasts, L.G. Ultimately R.L.G. will be used for the charges of all smooth-bore ordnance.[3] Powder used.

" powder of the same kind in other respects, which has been very imperfectly " worked ; on the contrary, they all give results with the powder incorporated by " 15 minutes work under the rollers, equal or superior to those furnished by the " same powder worked 90 minutes. The only real use of these eprouvettes is to " check and verify the uniformity of a current manufacture of powder, where a " certain course of operations is intended to be pursued, and where the strength, " tested by means of any instrument, should therefore be uniform ; but as a means of " proving gunpowder received (as it is in our service) from manufacturers pursuing " different processes, these eprouvettes may be pronounced worse than useless, since " they lead to erroneous results."—See also *Extracts from Reports of Ordnance Select Committee*, vol. ii., pp. 243, 244, and vol. iii., pp. 200, 206, where the eprouvette test is strongly condemned, and a pendulum test recommended in its stead. Until pendulums or other suitable apparatus are provided, however, it is proposed to continue the eprouvette proof.

1 "The ranges quoted from the Ordnance Regulations are much shorter than is " usual with the powder now made, the L.G. powder generally giving from 280 to " 290 feet. It is the custom when a shot falls short of 240 feet to allow a second fire, " as it is concluded some mistake must have occurred to cause so short a range."—*Extracts from letter of Assistant Superintendent Royal Gunpowder Manufactory, Waltham Abbey*, letter, 21st April 1864, R., 93.

2 For convenience of reference this Circular and the Forms annexed to it are given in Appendix F, p. 371.

3 See page 139. It has now been decided by the Ordnance Select Committee to recommend the employment of R.L.G. powder for all smooth-bore ordnance, except mortars, and the manufacture of L.G. powder has been stopped.—*War Office Circular* 11 (new series), § 1291. See also *Extracts Ordnance Select Committee*, iii., pp. 206, 300

For wrought-iron smooth-bore ordnance R.L.G. powder will be at once used.[1]

Weight of charge, approximated rule.

It is impossible to give any invariable rule for the weight of the charge in terms of the weight of the projectile, because of the vast number of reduced and exceptional charges, and because even in the case of "ser- "vice" charges,[2] there is, in the majority of cases, more than one of these charges for each nature of gun, according to its weight of metal, or whether it is made of iron or brass.[3]

The following rule, however, is perhaps sufficiently approximately correct for general purposes :

For shot guns the weight of the mean service charge is from one-third to one-fourth that of the shot.[4]

For shell guns and howitzers the weight of the mean service charge varies from about one-sixth to one-twelfth, one-seventh to one-eighth that of the heaviest projectile.[5]

For carronades the weight of the service charge is about one-twelfth the weight of the shot.[6]

For mortars the weight of the charge varies with the range.

Reduced charges.

For the under-mentioned purposes and projectiles reduced charges must be used :

1. Double shotting.
2. Red-hot shot.
3. Manby's shot.
4. Martin's shell.
5. Carcasses *when fired from the* 13-*inch sea service mortar and* 10-*inch gun.*
6. Ground light balls.

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[1] The existing store of filled cartridges for this class of ordinance, with L.G. powder, is to be considered serviceable.

[2] "Service" charges, as distinguished from reduced and exceptional charges.

[3] The 32-pr. gun, for instance, has no less than five different "service" charges, varying from 10 lbs. for the 63, 58, and 56 cwt. guns, to 5 lbs. for the 32 cwt. gun. The 24-pr. gun has four "service" charges ; the 42-pr. and 68-pr. each three "service" charges ; and the 8-inch and several other guns have each 2 "service" charges. Again, the *brass* 9-pr. and 6-pr. guns have different "service" charges to the *iron* 9-pr. and 6-pr. guns.

[4] More nearly $\frac{1}{4}$th than $\frac{1}{3}$rd, as will be seen from the following table :—

The 150-pr.	mean "service" charge	is 35 lbs.	=	$\frac{1}{4}$th (about) weight of shot.
,, 100 ,,	,, ,, ,,	is 20 lbs.	=	$\frac{1}{5}$th exactly.
,, 68 ,,	,, ,, ,,	is 16 lbs.	=	$\frac{1}{4}$th (nearly) weight of shot.
,, 56 ,,	service ,,	is 14 lbs.	=	$\frac{1}{4}$th (exactly) ,,
,, 42 ,,	mean service charge	is about 12 lbs.	=	between $\frac{1}{3}$rd and $\frac{1}{4}$th ,,
,, 32 ,,	,, ,, ,,	is about 8 lbs.	=	$\frac{1}{4}$th exactly ,,
,, 24 ,,	,, ,, ,,	is nearly 6 lbs.	=	$\frac{1}{4}$th exactly ,,
,, 18 ,,	,, ,, ,,	is $3\frac{2}{3}$ lbs.	=	$\frac{1}{4}$th exactly ,,
,, 12 ,,	service ,,	is 4 lbs.	=	$\frac{1}{3}$rd exactly ,,
,, 9 ,,	mean service ,,	is $2\frac{3}{4}$ lbs.	=	between $\frac{1}{3}$rd and $\frac{1}{4}$th ,,
,, 6 ,,	,, ,, ,,	is $1\frac{3}{4}$ lbs.	=	between $\frac{1}{3}$rd and $\frac{1}{4}$th ,,
,, 3 ,,	,, ,, ,,	is 11 ozs.	=	almost exactly $\frac{1}{4}$th ,,

I should notice here that each solid shot has been taken at the weight commonly assigned, *i.e.*, the 8-inch or 68-pr. shot has been taken as weighing 68 lbs., the 32-pr. 32 lbs., &c. &c. In this way the practical application of the rule is made more easy.

[5] In the case of ordnance from which shot are not fired it has been necessary to take the heaviest projectile, *i.e.*, diaphragm shrapnel shell, except in the case of the 10-inch, from which this shell is not fired. For the 10-inch, therefore, I have taken the common shell, weight about 84 lbs.

[6] In most cases it is exactly $\frac{1}{12}$th, but in the 68-pr. it falls between $\frac{1}{13}$th and $\frac{1}{14}$th ; while in the 6-pr. it rises to $\frac{1}{10}$th. I have, however, thought it best to give the *mean* average, and this, as stated in the text, is $\frac{1}{12}$th.

From an original reference in red ink on a paper entitled "Remarks on the means "of extending the range of the 68-pr. carronades" in *Miscellaneous*, vol. ii., it would appear that the charges of carronades prior to 1798 were higher than at present being $\frac{1}{8}$th the weight of the shot ; but in that year it seems they were reduced to $\frac{1}{12}$th.

7. Parachute light balls.
8. Smoke balls.
9. Ricochet.
10. Angles of depression, greater than 15°.
11. Saluting and exercise.

(1.) *Double shotting.*—When guns are double shotted reduced charges have to be used to avoid increasing the strain upon the gun.[1] The following table [2] gives the maximum charges with which the 68-pr. 8-inch and 32-pr. guns may be fired double shotted with perfect safety, and the corresponding ranges, with certainty of operation through a (wooden) ship's side. Charges for double shotting.

68-pr.	95 cwt. gun	10 lbs. charge	400 yards.
8-inch	65 " " / 60 " "	5 lbs. "	200 "
32-pr.	56 & 58 "	6 lbs. "	450 "
	50 & 45 "	5 lbs. "	400 "
	42, 40, 39	4 lbs. "	300 "
	32 & 25 "	3 lbs. "	200 "

(2.) *Red-hot Shot.*—In firing red-hot shot the charge is not to exceed three-fourths the service charge,[3] because (*a*), owing to the rapid expansion of the shot, and the consequent reduction of windage, the strain upon the gun is proportionally increased;[4] and (*b*) a red-hot Charges for red-hot shot.

[1] "Reduced charges are used for this purpose, as with the full charges the strain "upon the metal of the gun would be greatly increased."—Owen and Dame's *Lectures on Artillery*, third edition, p. 64.

[2] Extracted from the *Handbook for Field Service*, p. 298. See also *Experiments in H.M.S. "Excellent,"* p. 147.

"Double shotting . . . . is forbidden with the 10-inch gun, with the 8-inch gun "of 52 cwt., and with all carronades" (*Handbook for Field Service*, p. 297), and no charges are therefore assigned for double-shotting these guns, nor are any other guns included in this list, because, double shotting being almost entirely a naval practice, it is not necessary to provide for other guns than the ones principally used by the navy for broadside purposes. There are no data respecting the 150 and 100-pr. guns. See also on this subject Sir H. Douglas's *Naval Gunnery*, pages 94 to 103.

[3] "The charges to be used in firing hot shot shall not in future exceed three-fourths "of the weight of the respective service charges for the several natures of ordnance." —*Account of Alterations and Additions in Ordnance, &c.*, 31st Jan. 1855, para. 1.

[4] "In consequence of the expansion of the shot, and the adjacent metal of the bore, "the windage is reduced, and a greater strain will be exerted upon the metal of the "gun; the expansion of the gas will also probably be increased by the heat generated "within the bore; moreover, very great penetration is not required, the object to be "attained is, that the shot merely lodge in the timbers."—Owen's *Lectures on Artillery*, edition 3rd, p. 81.

Experiments were made in 1858 in the Royal Gun Factories, and on board the "Excellent," to determine the expansion of the under-mentioned shot, with the following results:—

——		Dull-red Heat.	Red Heat.	White Heat.
		Inch.	Inch.	Inch.
68-pr. shot	maximum expansion	·08	·10	·19
	minimum " -	·06	·07	·08
	mean " -	·069	·086	·129
32-pr. shot	maximum " -	·07	·08	·12
	minimum " -	·04	·055	·05
	means " -	·061	·068	·083
24-pr. shot	maximum " -	·06	·075	·17
	minimum " -	·4	·055	·06
	mean " -	·048	·064	·097

—*Handbook for Field Service*, p. 299.

These experiments were carried on by the Committee on Ordnance, of which General Cator, Royal Artillery, was president. The conclusion to which the Committee came "from these experiments, and careful investigation of previous reports," was that the following should be allowed for the expansion of shot by heating: 68-pr., ·12; 32-pr., ·1; 24-pr. ·1.

shot is generally required to lodge in the object fired at—a ship, for example—and not pass through it.

Charges for Manby's shot.

(3.) *Manby's Shot.*—The maximum charge for the 24-pr. oblong Manby's shot is only 12 oz., giving, with 45° of elevation, a range of from 400 yards downwards, according to the strength and direction of the wind.[1]

If a higher charge is used, the line is generally broken.[2]

There are no data on the subject of the charge for the 6-pr. spherical Manby's shot.

Charges for Martin's shell.

(4.) *Martin's Shell.*—When firing these shells from 10 and 8-inch guns the charge is 8 lbs.; with the 68-pr. 10 lbs.[3] Reduced charges are necessarily used with these shells, (*a*)[4] to avoid subjecting the gun to

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[1] "For the Manby 24-pr. cylindrical shot the charge is 12 ozs., giving a range of "about 300 yards."—Capt. Fraser's *Notes on Material*, p. 6. See more upon this subject, p. 97, note 3.

[2] In some *experiments* which were carried on in the Royal Laboratory at Woolwich in 1859 with elongated 24-pr. Manby's shot and deep-sea line, the line broke with a 1 lb. charge. With a stouter line than deep-sea line (1½-inch rope, for instance) a heavier charge might perhaps be used.

[3] See *War Office Circular* 822, para. 728. On the subject of the 10 lbs. charge for these shells, the Ordnance Select Committee remarks: "It appears that there is "very little difference between the ranges given by 8 lbs. and 10 lbs.; and it becomes "a question whether 8 lbs., which is the saluting and exercising charge of the 68-pr., "should not also be the charge for Martin's shells."—*Extracts from the Reports and Proceedings of O. S. Committee*, vol. i., p. 129.

The following "Abstract of Practice" with Martin's shells, given *ibid.*, p. 129, may perhaps be useful for reference.

Date.	Nature of Gun.	No. of Rounds.	Elevation.	Charge.	Mean Weight of Projectile.	Mean Time of Flight.	Ranges. Minimum.	Ranges. Maximum.	Ranges. Mean.	Mean Difference of Range.	Mean observed Deflection.	Mean reduced Deflection.
1863.			°	lbs.	lbs.	Sec.	Yds.	Yds.	Yds.			
March 13 -	68-pr. 95 cwt. -	5	1	10	59	1·78	513	558	529 *618*	14·2	0·4	0·3
" -	" " -	5	3	10	59	3·68	958	1,070	1,031 *1,201*	33·0	1·5	1·3
" -	" " -	5	5	10	59	5·68	1,457	1,500	1,484 *1,832*	15·4	3·1	2·9
" -	8-inch - -	4	1	8	59	1·95	546	589	560 *608*	14·2	1·3	0·9
" -	" - -	5	3	8	59	3·66	983	1,012	994 *1,213*	10·0	1·2	1·2
" -	" - -	5	5	8	59	5·70	1,342	1,463	1,419 *1,484*	31·0	4·6	4·3
" -	10-inch - -	5	1	8	117	1·72	326	341	332 *380*	4·8	0·9	0·5
" -	" - -	5	3	8	117	3·12	536	682	633 *705*	39·2	1·6	1·0
" -	" - -	5	5	8	117	4·62	894	958	936 *1,018*	19·2	2·0	2·2
" -	" - -	5	7	8	117	6·55	1,316	1,454	1,368	43·0	9·8	6·1

The mean ranges, as obtained in former experiments, are interlined in italic figures.

[4] As regards "the strain upon the gun;" this is greater with a Martin's than with a common shell, because (1) the weight of the shell itself is greater (a filled 8-inch Martin's shell weighs 59 lbs.; a filled 8-inch common shell about 49 lbs., or 10 lbs. less; a filled 10-inch Martin's shell weighs 115 lbs.; a filled 10-inch common shell about 84 lbs., or about 31 lbs. less), and (2) the expansion of Martin's shell, however slight (see p. 64), produces a corresponding reduction of windage, and a proportionally increased strain.

This consideration has chiefly determined and rendered necessary the reduction of the charge for practice with these shells from the 10-inch and 8-inch guns.

an undue strain, and (*b*) because the shells themselves would probably not withstand the full service charge.[1]

(5.) *Carcasses, when fired from the* 13-*inch sea service mortar, and from the* 10-*inch gun*, are fired with charges not exceeding 16 lbs. and 8 lbs. respectively, because these pieces are unequal to the strain involved in firing a carcass with their maximum service charges.[2] Charges for carcasses.

In all other cases they may be fired with full service charges.[3]

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[1] As regards the shells being themselves unequal to the full service charge, this is due to the fact that they are heavy without the solidity and strength of which weight is generally an indication, and from the peculiar nature of their application they cannot be made of greater substance.

This consideration has chiefly determined and rendered necessary the reduction of the charge for practice with these shells for the 68-pr. gun.

[2] "In consequence of the extra weight of the 13-inch and 10-inch carcasses—30 lbs. " and 20 lbs. respectively more than the shells of these calibres—it is not considered " advisable to use the full service charges in firing them from the 13-inch sea service " mortars or 10-inch guns; as although the carcass will withstand the charge, it would " not be prudent to subject the gun or mortar to the extra strain. The maximum " charge to be used when firing carcasses from the 13 inch sea service mortar is to be " 16 lbs., and when firing them from the 10-inch gun 9 lbs."—*War Office Circular*, 639, para. 96. Subsequently, in 1864, by *War Office Circular* 855, para. 830, the 9 lbs. charge was abolished, and the 8 lbs. charge directed to be used in firing " carcasses, " Martin's shells," &c. &c.

It will, perhaps, be remarked that the 13-inch land service mortar is a much lighter piece than the sea service mortar of this calibre, and yet that the full service charge is allowed to be used in firing carcasses from these pieces. This is to be explained by the fact that while the maximum charge of the sea service mortar is very heavy—20 lbs.,—that of the land service is comparatively light—only 9 lbs.; and while the first of these mortars is unequal to the strain involved in firing a projectile weighing 234 lbs. with 20 lbs. of powder, the land service 13-inch is fully equal to firing the same projectile with a charge of 9 lbs.

[3] "With these exceptions, full service charges may be used in firing these projec- " tiles."—*War Office Circular*, 639, para. 96.

The following Abstract of Practice made with carcasses by the O.S.C. in 1866, and recorded in Extracts, &c., O.S.C., Vol. IV., pp. 153, 154, may be useful for reference:—

POWDER, L.G.

No. of Rounds.	Nature of Mortar.	Charge.	Mean Range.
5	13-inch L.S. - - - -	5	1,349
5	" - - - -	7	1,871
5	" - - - -	8	1,989
5	" - - - -	9	2,220
5	13-inch S.S. - - - -	7	1,840
5	" - - - -	10	2,508
5	" - - - -	13	3,126
5	" - - - -	16	3,632
5	10-inch L.S. - - - -	2½	1,165
5	" - - - -	3	1,477
5	" - - - -	3½	1,820
5	" - - - -	4	2,085
5	10-inch S.S. - - - -	4	2,469
5	" - - - -	6	3,220
5	" - - - -	8	3,845
5	" - - - -	9	4,049
5	8-inch - - - - - -	1¼	1,064
5	" - - - - - -	1½	1,210
5	" - - - - - -	1¾	1,512
2	" - - - - - -	2	1,674
3	" - - - - - -	2	1,599
5	5½-inch - - - - -	·344	576
5	" - - - - - -	·375	620
5	" - - - - - -	·406	683
5	" - - - - - -	·437	711
5	4⅖-inch - - - - -	·219	568
5	" - - - - - -	·250	601
5	" - - - - - -	·281	644
5	" - - - - - -	·312	686

Charges for ground light balls.

(6.) *Ground Light Balls* are fired with very reduced charges, varying, at an angle of 45°, from 2 lbs. to 1 oz., according to the nature of ball and required range. These projectiles are not sufficiently strong to withstand the shock of a heavy charge.

The following table, compiled by the Ordnance Select Committee after some experiments carried out by them in 1861–2, gives approximately the charges for ground light balls.[1]

Range.	10-Inch.		8-Inch.		$5\frac{1}{2}$-Inch.		$4\frac{2}{5}$-Inch.	
	Weight.		Weight.		Weight.		Weight.	
Yards.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
200	0	10	0	4	0	2	0	1
300	0	$11\frac{1}{2}$	0	6	0	3	0	2
400	0	$13\frac{1}{2}$	0	$8\frac{1}{2}$	0	$4\frac{1}{2}$	0	3
500	1	0	0	11	0	$5\frac{1}{2}$	0	$4\frac{1}{2}$
600	1	$2\frac{1}{2}$	0	$14\frac{1}{2}$	0	$8\frac{1}{2}$	0	$6\frac{1}{2}$
700	1	6	1	3	0	12	0	$9\frac{1}{2}$
800	1	12	1	10	1	0	—	
850	2	0	1	14	—		—	

Charges for parachutes.

(7.) *Parachute Light Balls.*—The 10-inch of the present pattern may be fired with a charge not exceeding $2\frac{1}{2}$ lbs., which at an angle of 45° will give an average range of from 1,200 to 1,400 yards.[2] The data respecting the maximum charges which may be employed with the two lower natures is not so complete. They have not been fired with higher charges than—8-inch, 1 lb.; and $5\frac{1}{2}$-inch, 8 oz. The ranges due to these charges have not been determined. Parachute light balls of the original pattern [3] will not stand a higher charge than 2 lbs.,[4] and, owing to their lightness, do not generally range farther than 600 yards before bursting.[5]

Charges for smoke balls.

(8.) *Smoke Balls* can be fired only with very reduced charges, something under a pound.[6] There is, however, nothing officially laid down upon the subject.

[1] *Extracts from the Reports and Proceedings of the Ordnance Select Committee*, vol. i., p. 104.

With reference to the practical value of this table, the Committee remark, in their report, that "These light objects are much affected by the wind, and their irregularities " are so great that average ranges, even if accurately determined, which would require " about 50 of each nature to be fired, would be of very little real utility, and all that " seems necessary is to give officers a guide to the charge to be used for a given range, " leaving them to correct it by their own observation at the moment. The above " table claims no higher degree of accuracy than is necessary for this purpose."—*Ibid.*

[2] By the range of a parachute light ball, I mean the distance to which it is projected before bursting, ascertained approximately, by measuring the distance from the mortar of any object over which it appears to burst.

That the shell will stand this charge, and that this charge will give the range assigned in my text, has been proved by several experiments, particularly on May 8th and June 4th, recorded in *MS. Vol. of Practice Reports*, p. 53.

[3] Those contained in paper shells. (See pp. 81, 82.)

[4] " In some experiments conducted in the Royal Laboratory in 1861 a $2\frac{1}{2}$ lbs. charge " was used, and the light ball was broken up."—*MS. Volume of Experiments*, p. 96.

[5] See *Ibid.*, 108.

[6] I conclude that these projectiles would only withstand a charge of a few ounces of powder from the fact that "star shells" of a similar construction cannot be safely fired, as has been proved by experiment, with a higher charge than about 12 ounces. In some experiments conducted in the Royal Laboratory in June 1861, with star shells, none of the shells were broken up with a charge of 12 ozs.; but out of three fired with a charge of 16 ozs. two were blown to pieces.—*MS. Vol. of Experiments*, p. 106. I would here, however, direct attention to page 90, where the question whether smoke balls would be likely ever to be fired at all, and whether they are properly to be considered as projectiles, is discussed.

(9.) *Ricochet Practice* is carried on with reduced charges, varying with the nature of gun and conditions of practice, as range, elevation, &c. &c. Charges for ricochet practice.

The following table of ricochet practice[1] shows the charge, elevation, time of flight, and effect, at different ranges, with various guns and howitzers, collected from a series of ricochet firing carried on at Woolwich between the 14th June and the 2nd October 1821, with round shot.

Recent experiments show that the table is sufficiently accurate for practical purposes.

Nature of Ordnance.	Range.	Charge.		Proportion the Charge bore to the Shot.	Elevation by Quadrant Degrees.	Number of Rounds fired.	Number of Shots that took effect.	Grazes made along the Face of the Work.	Of Rounds fired, Proportion that took effect.	Number of Times Traverses were struck.	Remarks.
	Yds.	lbs.	oz.								
24-pr., iron, 9 feet	400	0	8	48	11	15	10	13	2/3 - -		Work without traverses.
	—	0	10	38½	7¾	15	9	10	2/3 nearly		
	—	0	12	32	6¼	30	18	26	3/5 „		
	600	0	12	32	9½	30	15	19	1/2 - -		
	—	1	0	24	6½	30	17	19	1/2 nearly		
	—	1	4	19⅕	4¾	10	6	7	3/5 „		
	800	1	0	24	8½	30	10	11	1/3 - -		
	—	1	4	19⅕	6½	30	10	10	1/3 - -		
	—	1	8	16	5½	15	9	11	3/5 nearly		
	—	2	0	12	3¾	15	6	8	2/5 - -		
	600	0	12	32	9½	20	7	5	- -	3	Work traversed.
	—	1	0	24	6½	30	11	7	- -	6	
18-pr., iron, 8 feet	400	0	9	32	6½	30	23	27	3/4 nearly		Work without traverses.
	600	0	12	24	7¼	30	8	11	1/4 „		
	—	1	0	18	5	30	10	13	1/3 - -		
	800	1	0	18	7	30	10	10	1/3 - -		
	—	1	8	12	4¼	30	12	13	1/3 nearly		
	600	0	12	24	7¼	30	9	8	- -	5	Work traversed.
	—	1	0	18	5	30	13	9	- -	9	
12-pr., iron, 8½ feet	400	0	6	32	6½	30	16	19	1/2 nearly		Work without traverses.
	—	0	8	24	4½	30	20	21	2/3 - -		
	600	0	8	24	7¾	30	11	12	1/3 nearly		
	—	0	10	19⅕	6	30	12	15	1/3 „		
	—	0	12	16	4¾	5	2	2	2/5 - -		
	800	0	12	16	6½	30	7	10	1/4 nearly		
	—	1	0	12	4½	30	15	16	1/2 - -		
	600	0	8	24	7¾	15	7	3	- -	6	Work traversed.
	—	0	10	19⅕	6	15	6	2	- -	5	
9-pr. field service, bronze	600	0	5	28⅘	9½	10	—	2	- -		Work without traverse.
	—	0	6	24	7½	10	1	1	- -		
	—	0	7	20⁴⁄₇	6½	10	3	3	- -		
68-pr. carronade	600	2	0	34	6¼	10	4	5	- -		Work without traverses.
24-pr. howitzer, bronze	600	0	12	32	6½	25	15	16	- -		
	—	1	0	24	4¾	10	2	2	- -		
12-pr. do. do.	600	0	10	19⅕	5¾	10	3	3	- -		

(10.) Guns may be fired at *angles of depression* not exceeding 15° with the full service charge, but when fired at greater angles of depression, reduced charges are used, as follows: Charges for angles of depression.

Half charges - - from 15° to 30°
Quarter „ - - from 30° to 50°

With these charges, it has been proved by experiment, gun may be fired from wooden or iron garrison carriages[2] without cap squares, without danger of their being dismounted.

(11.) *For Saluting and Exercise.*—The charge varies from about half to three-quarters the service charge, according to the size of the gun[3] and for these services new powder is not used, but "started" Charges for saluting and exercise.

[1] From the *Handbook for Field Service*, pp. 133, 134.
[2] *General Regimental Order* (*Royal Artillery*), p. 461, para. 10.
[3] Except the sea service 6-pr. brass gun, which has a charge for exercise (or "instructional practice," as it is called in *War Office Circular* 665, para. 174) of only 4 ozs. See table XV., p. 336, or see *War Office Circular* 822, para. 728.

L.G. powder, *i.e.*, powder from broken-up cartridges which has become deteriorated. This powder is officially known as exercise L.G.[1]

Cartridge.

Cartridge.

For safety, convenience, and rapidity of loading,[2] the charge of powder is generally placed in a bag, made specially to contain it, and known as the cartridge.[3]

These bags are made of that particular description of woollen stuff or flannel known as serge; the very best and purest quality of serge only being used for the purpose.[4]

The advantages of serge over paper, &c. as a material for cartridges[5] are—

(1.) It is more completely consumed by the discharge of the gun.[6]

(2.) It packs better than paper and resists the action of travelling better.[7]

Cartridges are made of two shapes :—

(1.) Cylindrical—for all except Gomer-chambered ordnance.

(2.) Conical[8]—for all Gomer-chambered ordnance.

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[1] See *War Office Circular* 892 (quoted in Appendix G., p. 374).

[2] See p. 128.

[3] The name " cartridge " is perhaps more commonly applied to the *filled* cartridge than to the empty one, which is often spoken of as the " cartridge bag." It is, however, more correct to apply the term to the bag *per se*, speaking of it when empty as a " cartridge ; " when filled with powder as a " filled cartridge " (" cartridge, a case of " paper, parchment, or flannel, fitted to the bore of the piece, and holding exactly its " proper charge."—James's *Military Dictionary*, p. 92) ; nor, properly, is the name applicable only to the bag which contains the charge of a gun, rifle, &c., being also applied to the bags which contain the bursting charges of shells (see Store Returns, &c.)

[4] The principal points to be attended to in the selection of serge for making cartridges are—that it is composed *entirely of wool*, that it is close in texture, " hot " pressed " or calendered, and not frayed. " Hot pressing " stiffens the fabric, and improves it for the service for which it is required ; besides rendering it less liable to be attacked by moth and other insects. Cartridges have been specially prepared, by soaking them in crude wood naphtha, in corrosive sublimate, and in carbolic acid, with a view to preserving them from the attacks of moths and other insects. For an account of these experiments, the final result of which is not yet reported, see *Extracts from Reports and Proceedings of Ordnance Select Committee*, vol. i., pp. 193, 275, 367, and vol. iii., pp. 362–3.

[5] Its advantages have been already indicated in the history of the introduction of this material, see pp. 128, 129, but I have thought it better to repeat them more precisely here.

[6] " Flannel is used so that no ignited particles may remain in the bore of the piece " after the explosion of the charge."—Boxer's *Sandhurst Course*, p. 30.

" Le serge ne carbonne pas comme le parchemin, ce qui donne moins de risques " pour le feu."—Cotty's *Dictionnaire de l'Artillerie*, p. 398.

" Serge is used in preference to paper or parchment . . . . as it is not liable to " leave sparks in the gun."—Owen and Dame's *Lectures on Artillery*, p. 82.

" The cartridge bag should . . . . be composed entirely of wool, free from any " mixture of thread or cotton, which would be apt to retain fire in the piece."—Gibbon's (American) *Artillerist's Manual*, p. 340.

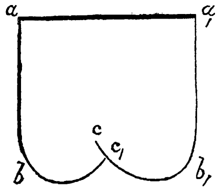
See also *ante*, pp. 128, 129.

This is a most important consideration, for where the cartridge is not completely consumed the unconsumed portions, whether in a state of ignition or not, have to be removed with a wad hook between each round, " the service of the guns being in " consequence very slow, and being attended, moreover, with considerable danger."—*Ante*, p. 128.

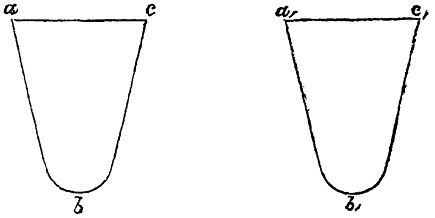
[7] " Serge resists the action of travelling better " than paper. Owen and Dame's *Lectures on Artillery*, edition 3rd, p. 82. At the same time it takes up rather more room. " The tonnage of flannel cartridges is one-fifth more than that of paper."—*Bombardier and Pocket Gunner*, edition 7, p. 95.

[8] More properly, perhaps, " conoidal," the end being rounded, but I have retained the term which is generally used.

The construction of these two classes of cartridges is as follows :—All cylindrical cartridges, and those for the 12-pr. howitzer, are made of one piece shaped thus :[1]



All conical cartridges (with the exception of those for the 12-pr. howitzer) are made of two pieces of serge shaped thus :[2]



In all cases the edges *a b c*–a_1 b_1 c_1 are made to overlap one inch or three-quarters of an inch according to the nature of cartridge,[3] and sewn with three or two rows[4] of running worsted[5] stitches, thus forming a bag open at the upper end.

This construction is adopted in preference to merely bringing together the edges (not overlapping), and then sewing them, because,—

(1.) The weight of the charge and the strain which it occasions is divided equally between the three rows of stitches, instead of being thrown altogether upon the inner row.

(2.) The possibility of a triple thickness of serge forming under the vent is avoided.[6]

The 25 lbs. cartridge for the 100-pr., and the 40 and 35 lbs. cartridges for the 150-pr. guns, have a broad piece of serge[7] sewn longitudinally round the upper part of the cartridge[8] and formed into a loop, or "becket," at the choke, to assist in loading[9] and in withdrawing it "from the case in which it may be deposited."[10]

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[1] For actual dimensions, see table XV., p. 336.

The sides of *a*, *b*, and a_1, b_1, of the 12-pr. howitzer are slightly sloped, to give it the required conical form.

[2] For actual dimensions, see table XV., p. 336.

[3] See table XV., p. 336. The following general rule, though not strictly correct, is sufficiently accurate for practical purposes. All cartridges (including bags for spare powder) above those for the 6-pr. gun, 12-pounder howitzer, and 5½ inch mortar have an overlap of one inch, and are sewn with three rows of stitches, the lower natures have an overlap of ¾ of an inch, and are sewn with two rows of stitches.

[4] *Ibid.*, see preceding note.

[5] Worsted known as "No. 20 Hank worsted," or about 75 needles full to the ounce, is used for the purpose.

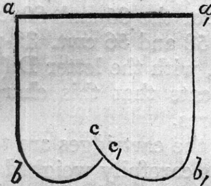
[6] Evidently with the present construction no more than two thicknesses of serge, *i.e.*, the overlap, can possibly be presented underneath the vent.

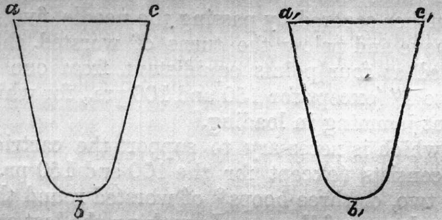
[7] Formerly worsted webbing 1½ inches wide.

[8] Originally this band was carried all round the cartridge to strengthen it, but it was found sometimes to be unconsumed, and on the proposition of Capt. Key, R.N., the present pattern was substituted.

[9] The unwieldy size of these cartridges renders necessary some such arrangement.

[10] *War Office Circular* 3 (new series), para. 950.


a
a1
c
c1
b
b1


a
c
b
a,
c,
b,

Cartridges are printed in black,[1] with the nature of gun and weight of charge, those for howitzers, and mortars, and carronades, having in addition the letters "How." and "Mor." and "Car." respectively.[2]

There are two exceptions, and two only, to this system of marking, viz., the 10 lbs. cartridge for the 65 and 60 cwt. 8-inch guns, and the 10 lbs. cartridge for the 58 and 56 cwt. 32-pr. gun, these cartridges being marked, in addition, with the letter D (for "Distant"),[3] and the weight of the gun, to indicate that this charge may not be used with lighter guns of these calibres.

Filled Cartridges.—If the cartridges are to be issued filled the required charge of powder is carefully weighed or measured[4] into them, after which they are "choked" and "hooped."

"*Choking*" consists in drawing together the open end of the cartridge into several pleats[5] with a brass needle threaded with three strands of worsted,[6] three turns being taken round the pleats, the choke thus formed being further secured by passing the needle five times through it alternately above and below the turns of worsted, thereby stitching down the worsted at four points equidistant from one another. The choke is cut off to 1″ (except for 150 and 100 prs., for which it is limited to 3″) to prevent jamming in loading.[7]

"*Hooping*," which is necessary to support the cartridge and retain it in its shape, consists (except for the 100 and 150 pr. cartridges) in making one, or two, or three hoops[8] of worsted round the body of the cartridge, and is done as follows:—In making the last stitch in choking the point of the needle is turned downwards, and carried through the powder, and out at the seam, dividing the space between the shoulder and bottom of the cartridge according to the number of hoops required. The worsted is then carried tightly round the cartridge, forming a

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1 Block type (see table XV., p. 336).

2 This system of marking was adopted 24th March 1863.—*War Office Circular* 822, para. 728, see history, p. 130.

Cartridges for carronades were not revised; but in the event of any being required the same plan with the letters "Car." is followed.

3 "Distant" is an old naval distinction; until 1863 naval cartridges were of three natures, "Distant," "Full," and "Reduced," and although the terms have not altogether disappeared, cartridges, with the two exceptions above named, are no longer so marked or distinguished.

4 Respecting the relative advantages of the two plans, weighing and measuring, see p. 178.

5 The description of choking and hooping cartridges falls more properly under the head of *Manufacture*, but, as in one or two other cases in this course, I find it impossible to make my description of the finished article complete, without describing the processes by which it is completed.

6 A stouter description of worsted than that which is used for sewing the cartridges being "14 hank," or from 38 to 40 needles full per ounce ,

7 This has reference chiefly to simultaneous loading, when if the choke be left too ong, it is liable to get under the shot, which would jam in the bore, and prevent its being rammed home.—(*Experiments on H.M.S. Excellent*, p. 173). Originally the chokes of land service cartridges were left longer that at present, the rule being not to exceed half the diameter of the cartridges, (see *Manual of Artillery Exercises*, p. 148); but the naval chokes were limited to 1″ in 1851, when simultaneous loading became general in the navy.—(See *Experiments on H.M.S. Excellent*, p. 173, and *Ordnance Regulations*, p. 162, para. 634). Afterwards the length was shortened to ½″, and so retained until about 1861, when the 1″ choke was reverted to. In 1863, when land and sea service cartridges were assimilated, all land service chokes were made of one uniform length of 1″, a length still retained, except for the 150 and 100-pr. cartridges, which being of large diameter, do not require to be cut so short.

8 See table XV., p. 336. A good *general* rule is, that the number of hoops corresponds with the number of rows of stitches; this rule, however, is only *approximately* correct, the number of hoops actually depending less upon the bulk of the cartridges (the consideration which governs the number of rows of stitches), than upon its length.

"hoop," which is stitched to the cartridge at two or three points in the same way as the turns of worsted at the choke were secured; one, two, or three hoops, as required, are made in this way.

The 150 and 100 pr. cartridges are hooped with blue worsted braid; each hoop is formed by running the braid round and through the cartridge, looping one end, and passing the plain end of the braid through the loop. The hoop is then hauled tight, the cartridge being worked and beaten into shape, and the braid secured with a half hitch formed, to ensure a secure fastening, *upon* the loop.

The diameters of cartridges for unchambered ordnance are rather less than the high gauge of the shot.[1]

The diameter of the cartridge is more important than might at first appear. Colonel Boxer says that Major Mordecai's experiments proved "that when the cartridge is of the same diameter as the bore of the gun "the initial velocity is less than when the cartridge is of less size."[2] This he explains as follows:—"When the cartridge perfectly fills that "portion of the bore which it occupies, it is only by penetrating "through the whole mass of the powder that the flame is communi- "cated to the front part of the charge; but when there is a space left "round the powder the heated gas will pass along this space in less "time than it would through the interstices between the grains, and "thereby the ignition of the whole charge will be more quickly accom- "plished. Although, then, the tension of the gas will be slightly "diminished on account of the greater space which it will occupy, still "the complete inflammation of the powder will take place before the "ball has moved so great a distance, and, therefore, the useful effect of "will be augmented. This effect will be greater in proportion as the "density of the gunpowder is increased; for it will be more advan- "tageous, when using dense powder, to communicate more rapidly "the heat required for its inflammation, than when the substance does "not present so great an obstacle to its complete combustion. More- "over, in addition to the actual augmentation of the useful effect of the "powder, a greater proportion of this useful effect is expended upon "the shot with the cartridge of reduced diameter, and a less proportion "in producing a permanent enlargement of the bore."[3]

Lieutenant Noble, in his Second Report on Ballistic Experiments, also observes, "It is evident that if the cartridge were made of the "same size as the bore of the gun from which it was fired, the only "method by which the gas first developed could penetrate the rest of "the charge is by passing between the interstices of the grains. When, "however, the cartridge is elongated, and consequently of less diameter "than the bore, the gas can pass along the space left between the "cartridge and the top of the bore, and thus facilitate the complete "ignition.

"This gas also has the effect of causing the shot to move, and so en- "larging the space which the powder occupies at the moment of its "maximum tension; it thus relieves the gun by causing the initial "strain to be spread over a greater surface."[4]

Clearly, therefore, there is a certain point to which it is advantageous to reduce the diameter of the cartridge; but any reduction below this

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[1] The diameter of the reduced charges is generally considerably below the gauge.

[2] *Treatise on Artillery*, pp. 79, 80.

[3] *Ibid.* p. 80.

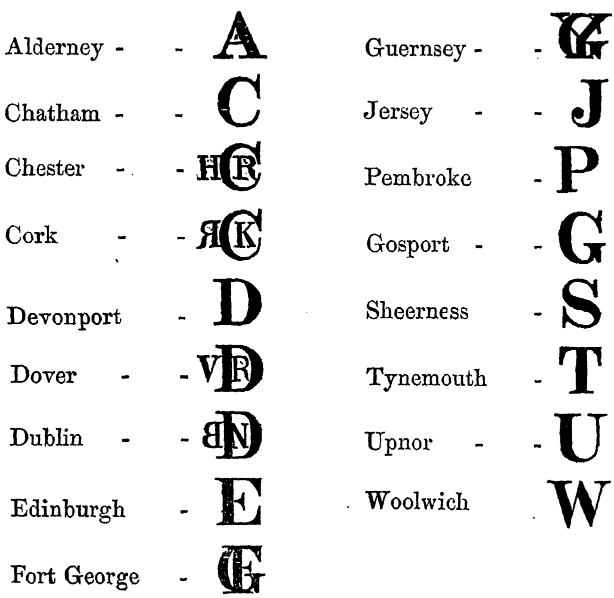
[4] *Second Report on Ballistic Experiments*, pp. 74, 75, see more on this subject down to 79.

point, which may for practical purposes be distinguished as the high gauge of the cartridge, entails loss of velocity.

"The effect of elongating the cartridge 5 inches, and reducing the "diameter of it from 7·4 to 6·0 inches, had the effect of reducing the "initial velocity by 67 feet, and the range by 25 yards and 63 yards."[1] Sir Howard Douglas says, "From experiments made in France (1842-"1844) with a 30-pr. and a 12-pr., long guns, projecting solid and "hollow shot, with and without wooden bottoms, it appears that, gene-"rally, the charges being equal, the cartridge which has the greater "diameter causes the shot to have a greater initial velocity."[2] The results of the experiments made on this subject by the Ordnance Select Committee, and recorded in Lieutenant Noble's Second Report on Ballistic Experiments, seemed to prove that the diameter of maximum efficiency is somewhat below that of the present service cartridges, and this report states that, "It might be worth while to alter the dimen-"sions of the present service cartridge with all smooth-bore cast-iron "guns. It has been proved that with the 68-pr. cartridge an elonga-"tion of nearly two inches does not affect the velocity and range, and "it is evident that the initial strain must be reduced by the use of a "cartridge 12 inches long instead of 10."[3]

After filling, all cartridges have stamped on the bottom the initial letter or monogram of the station at which they are filled, except those filled by the Royal Artillery, which are distinguished by having no initial letter stamped on them.[4]

The following initial letters and monograms have been adopted[5] for the different stations:



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[1] *Second Report on Ballistic Experiments*, p. 77.
[2] *Naval Gunnery*, p. 154.
[3] *Second Report on Ballistic Experiments*, p. 79.
[4] Approved, 28th May 1863. *War Office Circular* 835, para. 763.
[5] 19/3/64, 75/3/715.

Exceptional Cartridges.—The following cartridges may be considered as to a certain extent exceptional, and are therefore arranged under that head:— Exceptional cartridges.

(*a.*) 5 lbs. cartridge for 8-inch gun.
(*b.*) Bags to contain loose powder.
(*c.*) Drill cartridges.

(*a.*) *The 5 lbs. cartridge* for the 8-inch gun being shorter than the chamber has to be brought up to length to admit of simultaneous loading. The additional length is given by means of a coal-dust wad (a blue serge bag filled with coal dust[1]), which is choked into the cartridge over the powder. For L. S. saluting purposes this additional length is not required, and for this purpose therefore a coal-dust wad may be and is dispensed with. 5 lbs. cartridge for 8-in. gun.

(*b.*) *Bags for containing loose powder* are of two sizes, and will contain respectively 10 lbs.[2] and 15 lbs., or less, of powder. Bags for loose powder.

They are made of serge, and in construction resemble a large cartridge, with an overlap of one inch, and three rows of stitches; and when filled are choked in the same way, *but not hooped.*

They are marked in black with the No. of lbs. which they contain, and the nature of powder.

The principal use of these bags is to contain loose powder for the making up service and of exceptional charges, for filling shells, and for occasional requirements.

(*c.*) *Drill Cartridges.*—For drill purposes dummy cartridges[3] are issued, made of blue serge instead of white, and filled with coal dust instead of powder. The marking of the cartridges is the same as that of the service cartridges, with the exception that the printing is white instead of black,[4] and that the word "coal-dust" is added. In the 100-pr. and 150-pr. drill cartridges leather is substituted for serge, and the interior is filled with cuttings of waste material. Drill cartridges.

Cartridges[5] are issued either— Packing and issue.

(*a.*) Empty, or	(*b.*) Filled.

Cartridges, except for naval use, are generally issued (*a*) *Empty; always so for the Royal Artillery,*[6] except for active service.[7]

They are made up into bales,[8] the number of each nature in a bale being as follows:—

Cartridges, to contain	40 lbs.	200 of each.
" "	35 "	250 "
" "	25 "	250 "

[1] Welsh coal dust, 12 to 4 mesh, is used for this purpose. This size of grain is retained because a smaller size might work through into the powder. *Welsh* coal dust is preferred to any other, as being hard and little liable to dust. Other materials have been employed, such as cork and sawdust; the former was given up as being too expensive, the latter because it absorbed damp readily. On the subject of the necessity for employing a wad to elongate these cartridges, and of other plans which have been tried from time to time to accomplish the same object, see Sir Howard Douglas' *Naval Gunnery*, p. 433, 434, *et ante.*

[2] The 10 lbs. bag may be almost regarded as obsolete, as it is now rarely, if ever, issued, although as it exists in the service it would be supplied if demanded.

[3] Approved, 27th January 1863.—*See War Office Circular* 835, para. 762.

[4] In black the letters would hardly be distinguishable upon the dark blue ground.

[5] Drill cartridges are always issued made up, in common packing cases.

[6] It was formerly the practice always to issue cartridges *filled.*

[7] First issues to field batteries are generally filled.

[8] The making of cartridges into bales as here described, seems to have been first adopted on the recommendation of Lieut. Col. Hardinge, K.H., 1st December 1848 (see *Changes and Alterations, &c. &c.*, 16th August 1849).

Spare powder bags, to contain	15 ,,	300 of each.
Cartridges ,,	20 ,,	
,, ,,	18 ,, 16 ,, 14 ,, 12 ,,	400 ,,
,, ,,	10½ ,, 10 ,,	600 ,,
,, ,,	8 ,, 7 ,, 6 ,,	700 ,,
,, ,,	5 ,, 4 ,, 3 ,,	800 ,,
,, ,,	2½ ,, 2 ,, 1½ ,,	1,000 ,,
,, ,,	1¼ ,, 1 ,,	1,500 ,,
,, ,,	0¼ ,,	3,500 ,,

The bales are made up into two half bales or "ties," secured with packthread, the two being pressed together into one bale by hydraulic pressure,[1] and covered with "oiled canvas,"[2] and finally with stout hessian, secured by stitching. A full-sized bale should be a cube of about 19 × 18 × 17 inches.

The bales are marked similar to the cartridges which they contain, with the addition of the number of cartridges in the bale, the weight of bale, date of baling, and the number of bale for that day, with the words,

Cartridges, flannel, empty ; thus :—

Cartridges—Flannel—Empty
32-pr. 6 lbs. 700
R.L. 1. Weight, lbs. ozs. Date

Cartridges are generally issued (*b*) *Filled* for the navy, and they are so issued for exceptional land services[3] on demand. They are then packed according to the service for which they are required in one of the following descriptions of cases[4] :—

1. Metal lined case.
2. Brass pentagon case.
3. Brass rectangular case, plain.
4. ,, ,, ,, corrugated.
5. Barrels.
6. Boxes.

Cases, metal lined.

1. *The metal lined case*[5] is made of three sizes, Whole, Half, and

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[1] The pressure is about 1,120 lbs. per square inch.

[2] More properly, oiled or waterproof calico.

[3] Such as experimental purposes, volunteers, &c.

[4] Dell's case (see p. 10, note 2) is not included, as no more of this description will be made. See, however, recommendation of the Committee with reference to a number of these cases at Bull Point, that as long as the supply lasts they may be issued for land service in preference to breaking them up. They are still so issued. —*Extracts, Reports, &c., Ordnance Select Committee*, vol. ii., p. 88.

[5] The metal lined case is not properly a laboratory store, having been manufactured since 1832 in the Royal Carriage Department (previous to that date it was made in

Quarter. They may be described as rectangular[1] wooden boxes lined with tinned copper.[2] The cases are made of yellow deal, with corners of English oak, and two cleats of ash or elm down one side to take a rope grummet.[3]

At the top end of the box is a square lid or "door," hinged on copper wire,[4] and secured when closed by two gun-metal screw bolts, the door being furnished midway between the bolts with a copper ring for convenience in opening.[5]

The bolts are unscrewed by means of a gun-metal key with a wooden handle, which is issued for the purpose. Keys, metal, for cases.

The door shuts down over a circular opening in the lining, which is closed by a bung of tinned copper fitted with a copper ring [6] for lifting. This opening is 8·5, 7·18, 4·75 inches in diameter for the whole, half, and quarter respectively.

The bung rests upon a sort of ledge or groove in the lining, and with a view to protecting the contents of these cases from damp when filled the following composition, called "luting,"[7] is smeared over the junction of bung and lining :—

Tallow,[8] 6 lbs. } Melted and mixed together.
Beeswax,[9] 6 lbs. }

The half and quarter metal lined cases are seldom used for land service; by the navy they are used to contain small combustible stores, such as bursters, small-arm ammunition, fuzes, &c. &c.

The use of whole metal lined cases is chiefly confined to garrisons where the magazines are not very dry,[10] and siege trains and large sailing vessels,[11] to contain filled cartridges [12] or powder.

If used to contain loose powder, the powder is always placed in serge bags; the different sizes will contain respectively about 120, 60, and 30 lbs.

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the Royal Laboratory), but a laboratory course would hardly be complete without some description of this case, which I have accordingly introduced.

Originally ammunition was packed in *lead* lined barrels, then in lead lined cases, then in copper lined cases. In 1848 considerable alteration was effected in the cases, which were much improved, and some further alterations seem to have been made in 1854. (*MS. Memo.* furnished by Carriage Department, &c. 31st January 1855, para. 11.)

[1] Almost a cube.

	Whole Cases.	Half and Quarter.
[2] Copper used for lining bottom and body,	16 oz.	16 oz.
" " top	24 "	
" " necks	20 "	

All the fastenings of these cases are copper.

[3] Made of one-inch white rope.

A pattern case made of teak was approved for tropical climates 14th April 1864, see *War Office Circular* 2 (new series), para. 921, on account of teak being less attractive to white ants than fir.—*Extracts from Reports, &c., Ordnance Select Committee*, vol. ii., p. 2. This case was given up again 17/3/65, 51/24/3938.

[4] No. 10 wire gauge.

[5] Copper wire, No. 3 wire gauge.

[6] Copper wire, No. 5 gauge.

[7] Sometimes spelt "luten."

[8] Either Russian or "town made."

[9] Moderately pure beeswax, such as can be obtained in the ordinary market.

[10] See gun ammunition barrels (p. 164), which are ordered to be used in "*dry* magazines," thus limiting the use of metal lined cases to those magazines which are not dry.

[11] The necessity for economizing magazine room as much as possible aboard *steamers* is sufficient reason for not employing these cases for general naval purposes.

[12] For the number of cartridges which they will contain, see table XVII., p. 341.

When filled the cases are sealed by a circular paper label shellaced over each screw bolt, and bearing the packer's name and place and date of issue ; until these labels are broken or removed the case cannot be opened.

The cases are stencilled in black on the lid, with the nature[1] and number of cartridges which they contain. Below this is marked the name of the station for which they are intended, and on the right the date of manufacture.

On the side of the case between the cleats are stencilled the tare and gross weight. The object of this is to furnish a check against cases getting away empty, or with a deficiency of cartridges.

Cases, brass pentagon.

2. *The brass pentagon case*[2] (pl. 1) is of two sizes, Whole and Half. The whole case is a five-sided prism[3] made of sheet brass,[4] with the exception of the top and fittings,[5] which are made of cast brass.[6]

The body of the case is formed by bending the brass sheet up into the required prism,[7] and riveting and soldering the junction,[8] and then

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[1] In the case of the 5 lbs. cartridge for the 8″ gun the words "Coaldust wad" are placed upon the lid in addition, the object being to distinguish these cartridges from the old pattern with sawdust wads.

[2] Sometimes called "improved brass pentagon." This case was proposed by Col. Boxer, and adopted 1859. (First issue, whole, 11th October 1859, half, 24th February 1860) to supersede Dell's case, over which it presented several advantages. Dell's case, as explained in note 4, page 156, is no longer made, but as large stores exist at different stations, and as they are sometimes, in preference to breaking them up, used for land services (*Extracts from Reports, &c., Ordnance Select Committee*, vol. ii., p. 88), a short description of the case may perhaps be useful. Dell's case, which was patented by the joint inventors, "William Hale, engineer, and Edward Dell, merchant, both of Woolwich," in the year 1841 (see *Specification of Patent*, No. 9047), and adopted by Board of Artillery 20th May 1842, L/114, is an hexagonal prism of white metal, in some cases pure wrought or cast tin, but generally tin hardened by an admixture of about 2 per cent. of copper. (The mean of a number of analyses made in the Chemical Department gave tin 92 lead 3·5, copper 3·5, zinc and tin and antimony 1·0.) The hexagonal form was selected as being one which permitted of the cases fitting compactly together in the magazine and offering at the same time "a figure or shape of considerable strength and stiffness" (specification).

The upper end of the case is furnished with a circular lid or "cover," which hinges upon a curved bolt and shuts down over a circular opening on the top of the case upon a white metal bung, with which the opening is closed.

The arrangement for opening and closing the case is the same as that of the brass pentagon, with the exception that the lid of Dell's pattern is secured by means of a screw bolt similar to those in the metal lined case, and which can be unscrewed by the same key.

The junction of bung and case is made water-tight by luting.

Handles are fitted into the angles of the cases, and in some of those of later date the cover is made removeable from one side of the opening to the other by an arrangement similar to that adopted in the brass pentagon.

In addition to the hexagonal form Dell's cases were made pentagon for the top and bottom rows, and of several sectional sizes to fill up the magazines ; of these sectional cases there were (including the pentagons) no less than four, making with the hexagonal five natures of case in all, and as the cases were made whole, half, and quarter, there were no less than 15 varieties and sizes of Dell's case.

[3] The plan of this case is not a "regular" but an "irregular" pentagon, two of the angles of which are right angles and the remaining three 120°.

[4] Sheet brass, No. 13 wire gauge. The brass used is as nearly as procurable the following alloy :—Copper 70 parts, zinc 30 parts, by weight.

[5] Viz., top, lid, hinge bolt, knuckles, lock screw, button, and nuts.

[6] The proportion of copper and zinc in this brass correspond as nearly as possible with those employed in the sheet brass which is used for the rest of the case; see note.[2]

[7] The size of this prism is 19·3 inches high and 15·5 inches across, measuring from the centre of the largest side (in plan) to the obtuse angle opposite.

[8] The junction is formed up one of the right angles of the prism.

fitting into the open ends of the prism the top and bottom, which are also riveted and soldered in.

The body is strengthened by a strip of brass riveted up the inside of the largest face of the prism.

In the top of the case is a circular opening 8·1 inch in diameter,[1] which is closed by a brass bung[2] countersunk in the centre, and furnished with a copper ring handle.[3] This bung rests upon a grooved ledge inside the opening, the junction, as in the metal-lined case, being made water-tight by luting.[4]

Round the opening is a projecting neck, and over all shuts down a brass lid or cover, hinged upon a curved bolt, which is fixed to two projecting lugs on the lid, and works through a brass knuckle on one side of the neck.

The exterior of the neck and the interior of the lid are furnished with rims slotted away at intervals, the slots in the one corresponding with the projections in the other. The portions of the two rims not slotted away are inclined, forming, in fact, right-handed screws, the thread of which is partially slotted away.[5] The lid, when shut down over the neck, is screwed round from left to right, until it presses firmly upon the bung.[6]

The lid is secured in its position by a small "lock screw" on the knuckle, which, when screwed home, presses a small grooved brass "button" so tightly against the hinge bolt as to prevent the lid from being turned round.

To enable the lid, if desired, to be shifted to the other side of the opening,[7] the cases are furnished with two knuckles opposite to one another. At opposite angles of the case are placed two brass handles furnished with rope grummet.[8] The case receives two coats of drab paint[9] inside and out.

The half pentagon is literally a half of the case above described, the section being taken through the angle which subtends the larger face. It is thus an irregular four-sided prism, and either a right or left half section, according to which half is taken. In construction it is identical with the brass pentagon;[10] but the opening is only five inches in diameter instead of eight.

These cases, whole and half, are used for sea service. The whole case will take all cartridges except those for the 100 and 150-prs.;[11]

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[1] The diameter of this opening at its narrowest part is given, as it connects itself with the sized cartridge which can be put into these cases.

[2] The same sheet brass as is used for the body of the case.

[3] Copper wire, No. 3 wire gauge.

[4] See page 157.

[5] In Dell's specification the construction of this part of the case (which is the same as in the brass pentagon) is thus described:—"On the neck is cut or formed a screw, "there being spaces removed or *omitted to be produced*. . . . Within the cover is "formed a corresponding screw, with spaces or blank intervals."—*Specification*, p. 2.

[6] By this ingenious arrangement not only is the closing of the case more effectually performed, but the lid cannot be opened until it is unscrewed.

[7] In case of the knuckle becoming injured, or sometimes for convenience in opening the case, it might be desirable to shift the lid.

[8] Made of $\frac{3}{8}$-inch rope.

[9] For the composition of this paint see table XX., p. 345.

[10] Except in one unimportant respect, viz., that no support is required in the interior.

[11] For the number of cartridges of each nature which these cases will contain see table XVII., p. 341. The diameter of the cartridges for the 100 and 150 prs. is larger than the opening of these cases.

the half pentagons are generally used for small combustible stores, such as fuzes, lights, portfires, bursters, &c.[1]

The cases are sealed when filled by a small rectangular paper label bearing the packer's name and place and date of issue, which is shellaced on to the side of the lid and top of the case, crossing the junction of the two, and preventing the case being opened until the label is broken or removed. The cases are marked in the same way as the metal-lined cases,[2] with the exception that the whole of the marking is on the lid of the case and none on the side, where it would be liable to become obliterated.

Levers, cases, brass.

There are issued with these cases wooden levers[3] with two gun-metal studs for turning the lids, one stud being applied against the end of the hinge bolt, the other bearing upon the side of the lid; also gun-metal spanners for screwing or unscrewing the "lock screw."

Cases, brass rectangular, plain.

3. *The brass rectangular plain case*[4] is only made of one size. It is a rectangular case of sheet brass,[5] with cast brass top and fittings,[6] and differs from the brass pentagon only in shape and size, and in one or two small details; the method of closing and securing, and the general construction of the two cases, being the same. The points of difference are as follows:—

(1.) Shape and size. The case is a rectangle, $22 \times 18\frac{1}{4} \times 11$ inches.[7]
(2.) The opening in the top of the case is larger than in the brass pentagon, being 10 inches.[8]
(3.) The bung is provided with two handles instead of one.[9]
(4.) The lid, instead of being solid, is merely a ring of metal, the whole of the centre being removed, exposing the bung.[10]
(5.) There is only one knuckle instead of two, the lid thus not being removeable.
(6.) Two holes are made in the lid for the reception of the studs of the lever, by which the lid is turned round.

Like the brass pentagon, these cases are painted drab inside and out. They are luted and sealed, when filled, in the same way. These cases will take the filled cartridges of the 100 and 150-pr. guns,[11] and are issued to all ships which have charges over 16 lbs. Any ship which

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[1] Formerly small-arm ammunition was packed in these cases; but in the *Proportion of Ordnance Stores for Smooth-bore Ordnance for Her Majesty's Ships*, 1864, there is the following note, p. 32:—"Small-arm ammunition to be packed in metal-lined "cases, as metal or brass cases are not strong enough to bear the weight of lead ball. ". . . . This decision will only take effect in future equipments."

[2] See page 158.

[3] In 1866 a new lever for this purpose was adopted suitable for all metal cases; the lever is marked Pattern II. Approved 16 July 1866, *W.O.C.* 11 (N.S.), § 1322.

[4] Approved 8/4/64, *War Office Letter* 20/4/64, 57/2/8796.

[5] The same as is used for the pentagon cases.

[6] Viz., top, knuckle, handles (two), lid, hinge-bolt, lock-screw, and button.

[7] Two pieces of brass are used in making the body instead of one, the two seams, which are at diagonally opposite angles, being riveted and soldered. Two supports instead of one are required for the inside of the case.

[8] To admit the larger cartridges for which the cases are intended.

[9] These handles are made of cast copper instead of copper wire, a small proportion of zinc, about 1 : 12, being added to the copper.

[10] The object of this is to save the cost of unnecessary metal, which in a large number of cases would amount to something considerable.

[11] They will of course take all sized cartridges; but they are intended only for the cartridges or the two guns I have named, the diameter of which is larger than the opening of the brass pentagon case. If the opening of the pentagon had been enlarged there would have been a loss of space in packing in them the heavier cartridges for these two large guns.

has one rectangular case has all its ammunition, except for sea service thus packed.[1]

The same lever is issued with these cases as for the pentagon cases, the studs corresponding with the holes in the lid. The same spanner as is used for the pentagon serves for the rectangular case.

They are marked like the brass pentagon cases,[2] but have the tare and gross weight on the bottom.

Cases, brass rectangular, corrugated.

4. *The corrugated rectangular brass case*[3] is a rectangular case of corrugated[4] sheet brass,[5] with cast brass top and fittings.[6]

It is a deeper, longer, but somewhat narrower case than the plain rectangular case, being 22·3 × 22·85 × 9·85 inches.

The hole is smaller than that of the plain case, being 8½ inches in diameter, as large as the width of the case admits. It is placed about the centre of the case instead of, as in the plain case, at one end of the top. In other respects, except in the neck being somewhat lower, this case is identical with the plain rectangular case, the method of closing, lid, knuckles, handles, &c. being the same.

The advantages presented by the corrugated over the plain case are:—

1st. Saving of weight; the difference in favour of the rectangular case being about 22 lbs.[7]

2nd. Saving of expense; the difference being a little over 1*l.* per case.[8]

These cases were originally introduced for the cartridges for the 7″, 8″, and 9″ ins. rifled guns; their use has now been extended to S.B. cartridges, of which they will receive all sizes,[9] except the 150-pr. cartridges, which are too large in diameter. They will gradually supersede the plain rectangular case, of which no more will be made, as the 150-pr. gun, for which alone this case would be necessary, will cease to form part of naval equipments.

Cases, brass rectangular, corrugated, Pattern II.

With a view to facilitating the stowage of these cases in magazines[10] an alteration has been effected in the method of closing the case, which

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[1] The general substitution of rectangular for pentagon cases has not been recommended, because it would be attended with a loss of from 4 to 10 per cent. stowage in all but 3 out of 21 sizes of cartridges.—*Ordnance Select Committee's Minute* of 9/2/65 or 57/2/10,058.

[2] See page 160.

[3] The first pattern was approved 25/4/66, W.O. Letter 28/4/66, 75/Genl. No./505, but the dimensions of this case were 22·5 × 22·85 × 9·95. By W.O. Minute 28/4/66, 57/2/12,252, the case was ordered to be made of the present dimensions. None of the first pattern were ever issued, and the pattern approved 28/4/66, therefore became Pattern I. The formal approval of this pattern is given in *W.O.C.* 12 (new series), § 1369.

[4] The corrugations run from top to bottom, and are 0·15″ deep.

[5] Sheet brass 19 wire gauge, or considerably thinner than that employed in the plain cases, which is 13 W.G.

[6] See p. 160, note 6.

[7] The actual average weights are { Plain, about - 69 lbs.; Corrugated, about - 47 lbs. }

[8] The prices are:

	£	s.	d.
Plain, about	3	19	0
Corrugated, about	2	17	6
	1	1	6

The saving is due to the difference in weight of metal.

[9] See table XVIII.

[10] The projection of neck and lid boyond the sides of the case entails the necessity of placing battens between the No. 1 Pattern corrugated cases, thus causing certain loss in the magazines.

will be adopted for future manufacture. The neck of the case practically disappears, only sufficient being left to afford a shallow groove for the lid, on to which are fitted two countersunk handles, to rest in. The lid does not lock as in the other rectangular cases, but is secured by a brass rod, which is hinged over it; the hinge being a double-jointed one the rod can be turned aside or backwards, as may be most convenient. It is clamped over the lid when desired by means of a lock-screw in the centre. By this arrangement, while the opening is retained of the same size as in No. I. pattern corrugated case, the absence of the projecting neck enables the cases to fit close together in the magazine.[1]

These cases are distinguished as Pattern II.[2]

Barrels.

5. *Barrels.*—There are only three descriptions of barrel directly connected with the "charge," of which one only, the "gun ammunition barrel," is intended or regularly used for packing cannon cartridges; but there are a large number of barrels and kegs in the service for packing small-arm ammunition and various laboratory stores, and for manufacturing and departmental services, as follows:—

(*a*) Powder barrel.
(*b*) Gun ammunition barrel.
(*c*) Budge barrel.
} The only barrels strictly connected with the charge.

(*d*) Cartridge (small arm) barrel.
(*e*) Kegs for paint.
(*f*) ,, soap.
(*g*) ,, grease.
(*h*) Cement barrel.
(*i*) Store barrel.
(*j*) Bullet barrel.
(*k*) Charge tub.
(*l*) Mealed powder tub.
(*m*) Paste tub.
} Used only for departmental and manufacturing purposes.

In addition to these there are portfire buckets,[3] sponge buckets,[4] clothing vats, &c.

Barrels, powder.

(*a*) *Powder Barrels*[5] are made of three sizes,[6] Whole, Half, and Quarter. They are machine-made[7] barrels, the staves of which are of oak[8] (or teak for tropical climates[9]), and the heads of the same dowelled together;[10] they are "full bound" with ash and four riveted" copper hoops.

[1] See note 10 on preceding page.
[2] Pattern II. case was approved 28th January 1887, *W.O.C.* 13 (new series), § 1402.
[3] See page 230.
[4] See page 184.
[5] Approved 3rd Nov. 1862, *War Office Circular* 815, § 697, but not actually sealed until 2nd June 1866, *W.O.C.* 11 (N.S.), § 1324. See also Errata, p. 137.
[6] A fourth ("eighth") size has also been made to send away small quantities of powder, but is not recognized as one of the regular service powder barrels.
[7] Barrels made by machinery are not only superior in finish and strength of construction to the hand-made barrels, and much more durable, but they possess the advantage of having the staves uniform in size and thus interchangeable.

The Ordnance Select Committee, in their Report 3424, Minute 12821, expressed an opinion in favour of machine-made barrels, founded on the very favourable mention made of experimental machine-made barrels during two years of trial abroad. This opinion they subsequently endorsed and confirmed in 1865, Report 3988.
[8] Thoroughly seasoned American oak is preferred.
[9] "For issue to stations, where they will be exposed to the attack of white ants, they are to be made of teak."—*W. O. Circular* 11 (N.S.), § 1324.
[10] With *wood* dowels, an order exists on this subject.—*Ordnance Regulations, Home*, p. 142, par. 569.
[11] With copper rivets.

The principal dimensions[1] of the three sizes of powder barrels are as follows:—

—	Height.	Diameter.		Number of Staves.	Width of Staves at thickest Part.
		At Ends.	At Pitch.		
	Inches.	Inches.	Inches.	About[2]	Inches.
Whole - -	21·	15·	17·	22	2·45
Half - - -	16·9	11·9	13·4	18	2·5
Quarter - -	14·2	10·25	11·6	15	2·5

Powder barrels will contain respectively 100, 50, and 25 lbs. of powder.[3]

Powder barrels are used to contain loose powder,[4] and occasionally, though rarely, for the conveyance of gun ammunition.

When small quantities of loose powder or ammunition of any sort are sent by rail they are placed within a serge bag inside the barrel; the barrel is placed within a canvas bag, and the whole in an iron safety case [5] specially intended for the conveyance of ammunition or powder by rail. Under other circumstances the loose powder is placed loose in the barrel, and has no further protection. Cartridges, &c., however, are always placed in paper covers,[6] with or without waterproof bags inside, according to circumstances,[7] the barrel being also lined with paper.

Barrels, gun ammunition.

(*b*). *Gun Ammunition. Barrels*[8] were first made in 1860[9] on the suggestion of Admiral Caffin, with a square lid and fir top; but subsequently the Superintendent, Royal Laboratory, proposed substituting a circular lid and teak top, the object of the alteration being, "to prevent "the tightening of the lid from the warping and swelling of the "timber, and at the same time to secure a strong and close lid."[10] The proposition was adopted, and barrels with circular lids approved in 1863.[11]

Gun ammunition barrels are of two sizes, Whole and Half. They are respectively whole and half powder barrels, "full bound," instead of

[1] These dimensions were slightly increased 23d April 1861 (*War Office Circular* 724, par. 359), that the barrel might hold "100 lbs. large grain [R.L.G.] powder for "rifled guns;" but on 3rd November 1862 the original and present dimensions were reverted to (*War Office Circular* 815, par. 697).

[2] Sometimes, to use up spare stuff, the staves are made larger or smaller, when their number will of course vary.

[3] Until 1847 they were not filled completely; in that year they were ordered to be *filled*.

[4] The strong objections which present themselves to the employment of a barrel which has to be unheaded and partially unhooped to remove the contents, for containing loose powder, has led to a pattern being designed in the Royal Laboratory, the head of which opens. This barrel is of a different construction to the gun ammunition barrel, but if adopted will doubtless be used for cartridges as well as for loose powder. It is varnished outside; and it is proposed that loose powder should always be placed inside a waterproof bag or lining to the barrel for its better protection.

[5] See page 166.

[6] See page 167.

[7] See page 168.

[8] So called to distinguish them from barrels intended for small-arm ammunition. They were originally miscalled "improved powder barrels." Present pattern approved 19th April 1863, *War Office Circular* 859, par. 774.

[9] The whole barrel was approved 9th February 1860, *War Office Circular* 590 par. 39. The half not until 4th September 1862, *War Office Circular* 793 par. 634.

[10] *War Office Circular* 835, par. 774.

[11] 19th April 1863, *War Office Circular* 835, par. 774.

"quarter bound,"[1] the top end having a circular hole in it 10 inches in diameter[2] in the whole barrel, and $7\frac{1}{4}$ inches in the half barrel. Over this head is placed a wooden[3] top,[4] also having a circular hole to correspond with that in the head, this hole being closed with a circular wooden lid. The lid hinges on to the cover, and is fitted at the opposite side to the hinge, with a rectangular brass plate and screw bolt, by which the lid, when closed, can be secured. These bolts can be unscrewed by means of the same gun-metal key as is used for the metal lined cases.[5] For convenience of opening, the plate is provided with a gun-metal ring.

The method of securing the half gun ammunition barrel is slightly different to that described for the whole barrel. The brass ring is on the screw bolt, which thus requires no key to open it,[6] and the lid is not furnished with a plate, the bolt screwing into a socket in the oak head.[7]

Gun ammunition barrels are used for containing filled cannon cartridges or bursters, either for purposes of transport or for storage in magazines which are "so free from damp as to render the increased " protection afforded by the metal lined cases unnecessary."[8]

They are better adapted for these services than powder barrels, as their contents can be removed without unheading or coopering the barrel.[9]

Gun ammunition barrels are not intended or adapted for the reception of loose powder, and when such is issued in them it must be placed in a serge or other bag.

When filled cannon cartridges are packed in gun ammunition barrels they are placed for their better preservation in paper covers[10] (with or without waterproof bags inside, according to circumstances),[11] the barrel being also lined with paper.

The barrels are sealed when filled by a small safety label, similar to that used with metal lined cases, which is shellaced over the screw bolt in the whole barrel, or by a rectangular label over junction of lid and cover in half barrel.

Barrel, Budge.

(c.) *Budge Barrel.*—The budge barrel seems to have been in use for several centuries. Major Miller speaks of the "boudge barrell" having been included among the stores enumerated "in the earliest

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[1] A full bound barrel differs from a quarter bound barrel in having more ash hoops, that part of the quarter which in the latter barrel is uncovered being in the full bound barrel completely covered with hoops.

[2] In those first approved the hole was only $8\frac{1}{2}$ inches in the whole barrel; it was increased in 1865 to admit the larger cartridges which about that time came into vogue.

[3] Generally teak, as approved, but mahogany and other hard woods of this nature are sometimes used to save waste.

[4] This wooden top necessitates the head being set in slightly lower down than in the powder barrel, and the capacity of the gun ammunition barrel is thus *slightly* less.

[5] See p. 157.

[6] Evidently this plan of fastening is much less secure than that adopted for the whole gun ammunition barrel which will doubtless be adopted for *all* gun ammunition barrels in future supplies, or until the adoption of the universal barrel alluded to, p. 163, note 4.

[7] This necessitates the holes in the head and cover being made eccentric, so as to give a slight ledge on the former for the screw bolt of the latter to screw into.

[8] *War Office Circular* 590, par. 39, and *War Office Circular* 793, par. 634.

[9] See note 4, p. 163, on the desirability of adopting this principle for all barrels or cases containing powder

[10] See p. 167.

[11] See p. 168.

"printed instructions for the management of ordnance."[1] The name budge is corrupted from the old word *bouget*, a leather bag (now budget).[2]

There is only one size of budge barrel in the service. It is a quarter powder barrel with only one head, the open end being closed by a leather bag top, fitted on to the chime of the barrel by means of a stout ash hoop; this top can be closely drawn together by means of a leathern thong which runs through it.

Budge barrels are chiefly used to contain loose powder for the service of mortars; but they are available and useful for many similar purposes where it is undesirable to expose large quantities of loose powder.

They form part of naval siege and garrison equipments.

(*d.*) *Small Arm Cartridge Barrels* are made of three sizes, Half, Quarter, and Eighth. Barrels, Cartridge.

In dimensions and construction the half and quarter barrels are the same as the half and quarter powder barrels, except in having no copper hoops, and in being whole bound with ash hoops.

The eighth-size cartridge barrel resembles the half and quarter sizes in construction. Its principal dimensions are—

Height.	Greatest Diameter.	Size of Staves.	No. of Staves.
11·5 inches	8·5 inches	2¼ inches	13

These barrels are used for the conveyance and storage of small-arm ammunition,[3] the half size for blank, and the quarter size for ball, and the eighth size for small supplies. An order 25th August 1866,[4] however, directs that in future boxes alone are to be used for the carriage of ball ammunition; blank to continue, as heretofore, to be packed in half barrels, "or in quarter if found more convenient."

(*e.*) *Kegs for Paint* are made of five sizes. They are iron-bound kegs, and contain respectively No. 1 one gallon;[5] No. 2 a gallon and a half; No. 3 three gallons; No. 4 six gallons; No. 5 nine gallons. They are hooped with iron hoops only. Paint kegs.

These kegs are used for the issue of the ingredients (ground thick) of the paint for painting shot and shell, &c.

They are not used for the issue of paint mixed ready for use, which is issued in tin cans, of which there are seven sizes, No. 1 being the largest. Paint kegs are also used for the issue of various small stores as required.

(*f.*) *Kegs for Soap* are of three sizes, to hold respectively 1 cwt., 56 lbs., and 28 lbs. In size they very nearly correspond to the three powder barrels. Soap kegs.

(*g.*) *Kegs for Grease* are made of one size only to hold 28 lbs. They are hooped with iron and ash hoops. They have a bung in the pitch like a beer barrel. Grease kegs.

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[1] "The loose powder was kept in a 'boudge barrell,' covered safe with some hide, "garment, or cloth; and the proper charge was measured and loaded by means of "the ordinary copper ladle."—*Equipment of Artillery*, p. 117.

[2] *Ibid.* p. 117, note, "Reserves of loose powder for the infantry were carried in great "bouqets made of dry neats leather."

[3] Strictly speaking, therefore, these barrels do not connect themselves with the subject of ammunition for S. B. ordnance; but it seemed desirable, even at the risk of violating the principle adhered to as closely as practicable throughout this work of keeping separate the stores connected with each class of ammunition, to introduce a description of these barrels with the rest.

[4] *War Office Letter* 25th August 1866, No. 7669, 265, and 7669, 4454, 30/8/66.

[5] The measure of these capacities has been made in water.

Cement barrels.

(*h.*) *Cement Barrels* [1] are made of one size only, viz., to hold $4\frac{1}{2}$ bushels of Portland cement. They are made of white deal, and have a hole (6 inches in diameter) in the centre of the head, closed with a wooden bung, a close joint being made by means of a ring of kamptulicon fastened on to the bung; the bung screws down with iron screws.

Stove barrels.

(*i.*) *Stove Barrels* are of one size only. They consist of a whole powder barrel with only one head, and no copper hoops, the open end being closed with a removable wooden cover. The barrel is hooped with four broad ash hoops. They were used for restoving powder, but as this practice has recently been discontinued [2] stove barrels will be no longer required.

Bullet barrels.

(*j.*) *Bullet Barrels* are of one size only, viz., a quarter powder barrel with only one head. They are used in breaking up small-arm ammunition, to allow the bullets to fall into.

Charge tub.

(*k.*) *Charge Tub.*—One size only. It is a large open tub with three broad ash hoops. It is used in the Royal Laboratory to contain the measured proportions, "charges," of fuze, portfire, or other composition.

Mealed powder tub.

(*l.*) *Mealed Powder Tub.*—One size only. It is a small inverted tub, copper hooped; the open (small) end is closed by a removable wooden cover. These tubs are used in the Royal Laboratory to contain mealed powder for manufacturing purposes.

Paste tub.

(*m.*) *Paste Tub.*—One size only. It is a small tub hooped with two broad ash hoops. The open (large) end is unprotected by any cover. These tubs are used in the Royal Laboratory to contain paste for manufacturing purposes.

Boxes, ammunition.

6. *Ammunition Boxes.*[3]—(See Table xviii.) Cannon cartridges are issued to field batteries *at home* in rough deal boxes [4] similar to shot and shell boxes,[5] and measuring $28\frac{1}{2} \times 10\frac{5}{8} \times 11\frac{3}{4}$ inches.[6] The boxes are lined with brown paper, and each cartridge is placed in a paper cover [7] or pulp bag,[8] and on demand in a waterproof bag.[9] Boxes are marked with the nature and number of their contents on the end of box, and the name of the station on the top.

Cases, Iron, for Conveyance of Ammunition by Rail.

Cases, iron, for conveyance of ammunition by rail.

Iron safety cases are of two sizes, half and quarter.

They are hollow cylinders of iron large enough to admit respectively half and quarter powder or ammunition barrels. One end is permanently closed, the other has a removable circular iron lid, which is secured to the cylinder by means of four iron screw bolts. These bolts are unscrewed or tightened by means of a spanner, which accompanies the cases. The cases are painted black inside and out. Round the upper surface of the lid are the words [10] "To be emptied immediately and returned to" (the name and place being labelled on when the case is despatched).

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[1] Approved 11th November 1865, 57/24/408/P. It is unlikely that any more of these barrels will be made.

[2] Discontinued by order 8th May 1867, 75/3/989.

[3] Approved 10/1/62, see *War Office Circular* No. 759, par. 494.

[4] These boxes are manufactured in the Royal Carriage Department. They are generally made of deal with elm ends, although refuse wood of various descriptions is frequently used up in their manufacture.

[5] Except that they are copper, instead of iron fastened.

[6] See table XVIII., p. 344.

[7] When paper is used, that description known as "cannon cartridge, 9-pr." paper is employed. Indeed, it seems probable that this paper got its name from being employed for this service, and principally with field service, *i.e.* 9-pr. cartridges.

[8] See covers for cannon cartridges, p. 167.

[9] See waterproof cartridges, p. 168.

[10] The words are cast in the lid.

These cases are used for the better protection of ammunition, powder, or combustible stores, when sent by rail.

The stores are placed inside a half or quarter powder or ammunition barrel, which is placed inside a canvas bag [1] and finally into the iron case.

When loose powder is sent by rail it is placed inside a flannel bag [2] within the barrel, being packed as above.

Bags for iron cases are of two sorts—(*a*) canvas, (*b*) flannel.

Bags, canvas, are of two sizes half and quarter. They are nearly cylindrical open mouthed bags of stout canvas, large enough to admit respectively a half or quarter powder or ammunition barrel. Bags for iron cases, canvas.

The bottom of the half size bag is formed by a circular piece of canvas; the quarter size is made in one piece, the bottom being shaped like the bottoms of cartridges for unchambered ordnance.

The principal dimensions of these bags are (approximately)—

——	Half Size.	Quarter Size.
	ft. in.	ft. in.
Length - - -	2 5	2 5
Diameter at mouth - -	1 10	1 8
Diameter at bottom - -	1 1	rounded

These bags are used to contain filled powder or ammunition barrels, in iron cases, for conveyance by rail.

Bags, flannel, are of two sizes, half and quarter. They are (nearly) cylindrical open mouthed bags of serge large enough to receive the contents of half and quarter powder barrels *within the barrels*, when powder is sent by rail. Bags for iron cases, flannel.

The bottom of the half size is formed by a circular piece of serge; the quarter size is in one piece, the bottom being shaped like the bottoms of cartridges for unchambered ordnance.

The principal dimensions of these bags are (approximately)—

——	Half Size.	Quarter Size.
	ft. in.	ft. in.
Length - - -	2 5	2 5
Diameter at mouth - -	1 7	1 6
Diameter at bottom - -	1 1	rounded

These bags are used to contain loose powder in the barrels when sent by rail,[3] the barrel being afterwards placed in a canvas bag, and in an iron safety case.

Paper Covers for Cannon Cartridges.[4]

Cannon cartridges when not packed in metal, or metal lined cases, and for field or boat service, however packed, are placed for their better preservation from damp, in pulp or paper[5] covers.[6] Covers, paper, cartridge.

[1] See p. 167.
[2] See p. 167.
[3] When small quantities of powder are sent the 10 or 15 lb. bags (see p. 155) are used.
[4] Approved 24th March 1865.—*War Office Circular* No. 822 par. 729.
[5] Formerly paper was used. "Cannon cartridges, 9-pr." paper. Pulp covers or bags are now used.
[6] See *War Office Circular* 793, par. 605, respecting *field* service cartridges being so issued.

These covers are marked with a number from 4 to 19, each cover taking a variety of charges.[1] When issued filled they are marked "like "the cartridge inside, to prevent the necessity of opening it to ascertain "its contents."[2]

Waterproof Cartridges.

Waterproof cartridges.

When specially demanded waterproof cannon cartridges are, for their better preservation, packed in waterproof paper bags.[3]

When they are used the paper covers are also used, as a cover for the waterproof bag, and to prevent its being rubbed or worn.[4]

The waterproof paper [5] used for these bags consists of two thicknesses of "white-fine" paper, having between them an even thin layer of india-rubber dissolved in mineral naphtha. This paper is formed into bags of the required size by cutting out a rectangular piece of the size required,[6] and doubling this piece into a rectangular bag, the side edges of which slightly overlap one another, and are cemented together with the glutinous india-rubber solution, the bottom of the bag being also closed in the same manner.[7]

These waterproof bags are only supplied from Woolwich,[8] *when specially demanded.*[9] The words "waterproof bags" are always placed on the outsides of cases containing ammunition so packed.

(*b.*)—*Bursting Charge.*

Bursting charge. History.

The history of bursting charges is in the main contemporary with that of shells; and it would be laborious and unprofitable to go into all the different minor changes which have from time to time been effected in the different bursting charges. It will therefore be sufficient to quote here the date of authority for the introduction of the bursting charge of each shell in vogue until 1864, when the practice of *filling* shells was adopted, and at p. 172, note, I have given the date of the first employment of paper bags and calico covers, in place of the serge bursters previously employed. Since the promulgation in 1864 of the Order (see below) that shells are (with certain exceptions, see text, p. 172) to be filled by

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[1] See table of cartridges, XV., p. 336.

[2] *War Office Circular*, No. 822, par. 729.

[3] The question whether these waterproof paper bags are liable to deterioration from the softening of the india-rubber seems to have been satisfactorily settled by a report from the Chemist of the War Department to the Ordnance Select Committee, to the effect that "they have not sustained any injury by the protracted exposure to a warm "and damp atmosphere, which they have received."—*Extracts from Reports of Ordnance Select Committee*, Vol. i., p. 204.

[4] As the paper cover is always placed over the waterproof bag, and is always marked with the nature of each cartridge, it is, of course, unnecessary to repeat this marking upon the waterproof bag, which therefore never receives any other mark than its distinguishing number.

[5] The paper is procured by contract, and is a sealed pattern store (date of sealing 8/11/64, 75/3/750). The specification which governs its supply is as follows:—

Each ream to weigh 49 to 52 lbs.

Each sheet to measure 29 × 19½ inches.

The sheets to be perfectly waterproof by an even intermediate layer of pure india-rubber.

Each sheet to be formed of two sheets of paper weighing 305 grains.

India-rubber weighing 435 grains.

[6] In the case of the larger bags two pieces of paper are required, but the principle of construction is exactly the same.

[7] These edges do not overlap, but are merely brought together with the solution between them.

[8] *War Office Letter* 20 Nov. 1863. 75/3/676.

[9] *War Office Circular* No. 842, par. 794.

capacity instead of by weight, a Table of Bursting Charges (see Table XVI., p. 340) is only useful as giving the *approximate* weight of the several charges, and this Order, of course, in the case of those shells to which it is applicable, cancels all previous authority respecting the weight of the bursting charges of such shells.

	lbs.	oz.
13-inch, charge of - - - - - -	10	8
Approved 20th August 1855, see *Account of Alterations, &c.* 30th June 1856.		
10-inch mortar shell, charge of - - - - -	5	0
Approved 1st March 1859, General Regulation Order, 415, par. 1.		
10-inch naval shell, charge of - - - - -	6	4
10-inch common shell, charge of - - - -	6	4
Approved 27th October 1862, War Office Circular, 815, par. 672.		
8-inch common, naval, mortar, charge of - - -	2	4
Approved 8th December 1854, M/4796, *Account of Alterations, &c.* 31st January 1855, par. 4.		
56-pr. common shell, charge of - - - - -	2	0
Approved 1st March 1859, 75/12/246, General Regulation Order, 402, par. 27.		
42-pr. common shell, charge of - - - - -	1	6
Approved 1st March 1859, 75/12/246, General Regulation Order, 402, par. 27.		
32-pr. common shell, charge of - - - - -	1	2
Approved 1st March 1859, 75/12/246, General Regulation Order, 402, par. 27.		
24-pr. common shell, charge of - - - - -	0	12
Approved 20th February 1858, 75/12/92, General Regulation Order, 402, par. 27.		
18-pr. common shell } Approved 19th November 1859. Table of charges for ordnance and bursting charges for shells. Authorized 1859.	0	10
12-pr. common shell	0	6
Hand grenade 6-pr.	0	4
Hand grenade 3-pr.	0	2

Bursting charges for diaphragm shrapnel approved 29th June 1864, War Office Circular, No. 2 (new series), par. 915, except 6-pr., which remained without increase, as originally approved 19th November 1859; see Table of charges for ordnance and bursting charges for shells, authorized 1859. On 22nd September 1864, see War Office Circular, No. 3 (new series), par. 954, it was ordered that all shells, with certain exceptions (see p. 172), were to be filled by capacity instead of by weight; and on the 2nd October 1865, by War Office Circular 927, a new scale of approximate bursting charges was adopted (see Table XVI., p. 340. This scale was not applied to the bursters themselves until the following year, when patterns of bursters adapted for these approximate bursting charges were sealed.[1]

Gunpowder is used for the bursting charges of shells; most of the considerations which recommend its employment for the charge of the gun[2] connect themselves with, and recommend, its employment for the charge

[1] 8th June 1866, *War Office Circular* 10 (new series), § 1234.
[2] See p. 136.

of the shell, viz., the gradual nature of its decomposition;[1] the comparative safety attending its manufacture and transport; and its cheapness. The powder used for the bursting charges of all shells, except diaphragm shrapnel, is large grain shell, or "shell L.G."[2] For this, when the present store is exhausted, R.L G. powder will be substituted. For diaphragm shells "shell F.G." powder is used, a quick acting powder being desirable in order that the rupture of the shell and the release of the bullets may be effected as promptly as possible, thus diminishing the possibility of the charge acting upon the balls.[3]

Except for diaphragm shrapnel shells the bursting charge is always as much as the shell will hold, the shells being filled by capacity, "the "powder being well shaken down by tapping the shell with a mallet "during the process," instead of as formerly by weight,[4] enough room being left for the introduction of the fuze.[5]

The advantages of thus filling the shells are four—

1. The effect of the shell is increased.[6]

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[1] The gradual decomposition of a shell charge is scarcely less important in its way than the gradual decomposition of a gun charge, although not for the same reason. The superiority of gunpowder over a fulminate for this particular purpose is well explained by Mr. Abel: "Enclosed in a shell, a charge of a fulminate will produce a "much greater shattering effect than gunpowder upon the metal envelope, reducing "it to a much larger number of fragments; but the pieces of the shell produced by "employing gunpowder as the bursting agent will be propelled with much greater "violence, because there is still a development of force after the rupture of the shell, "while, with the fulminate, the entire force is at once expended upon the bursting of "the shell."—*Some of the Causes, Effects, and Military Applications of Explosions*, p. 3.

[2] See p. 139. Where "shell L.G." is not procurable, "L.G." would be used.

[3] "A very rapidly burning powder is necessary in many instances: for example, in "shrapnel shells, in which the charge of powder is required to break open the shell "without interfering by any great dispersive effect with the flight of the enclosed "bullets or fragments of metal."—Abel, *On some of the Causes, Effects, and Military Applications of Explosions*, p. 3.

[4] Approved 22nd September 1864, see *War Office Circular*, No. 3 (new series), par. 954; also, *War Office Circular*, 884, and *Royal Artillery Circular Memo.* 13th December 1864, par. 3.

[5] "Care must be taken to leave room for the displacement of powder by the fuze, "which will be about 4 ozs."—*War Office Circular*, 884.

[6] This statement may appear to be open to question, for it is not uncommonly believed, and until lately was generally taught, that a greater effect is produced by a partially filled shell than by one completely full. "It is a query how much powder "should be put in a shell; . . . . . . it is agreed by most officers that they "should not be quite full; one that has taken most pains to find out is of opinion that "they should be full within one-third of what they can hold."—Müller's *Treatise of Artillery*, pp. 205–206. Again, "Until lately the bursting charge only filled a certain "portion of the interior of the shell, for it was considered that the smaller charge "would cause the shell to break into larger fragments."—Owen's *Lectures*, &c., edition 4, p. 78. There is little doubt that with the smaller charge the fragments will be larger (see extract from Piobert given below), but looking to the nature of work which a shell is required to perform, and the circumstances of its employment, its general effect may certainly be said to depend less upon the size of the fragments than upon their number, their velocity or striking force, and the explosive power of the projectile, and these, as the following extract from Piobert shows very conclusively, are greater with a full than with a reduced bursting charge: "Expériences sur l'éclatement des projectiles creux dans les circonstances du service.—On a cherché d'abord "l'influence de la grandeur de la charge des projectiles creux sur le nombré et le poids "dés éclats et sur la vitesse dont ils etaient animés par suite de l'éclatement, afin "d'avoir tous les éléments nécessaires pour apprécièr leurs effets. Les bous de 22 "centimètres ont été chargés avec diversés quantités de poudre, depuis celle qui fait "surêment éclater, jusqu'à celle qui remplit le projectile; on a obtenu le résultats "suivants :—

2. The danger of premature explosion is diminished.[1]

"*Expériences sur l'éclatement de l'obus de 22 centimètres et de 26 millimètres*
"*d'epaisseur de parois.*

Charge de Poudre.	Nombre des Eclats de plus de 100 Grammes.	Poids Moyen des Eclats.	Vitesse Moyenne des Eclats.
K.		K.	M.
0·70	19 à 20	1·029	93
1·00	23	0·860	162
1·50	27 à 28	0·744	161
2·00	37	0·528	420

"Tous les projectiles étaient en fonte ordinaire de bonne qualité.

On voit, par ces résultats, que le nombre des gros éclats augmente avec la charge, mais dans un rapport moins grand; par suite, leur poids omyen diminue. La vitesse communiquée aux éclats par l'explosion augmente aussi avec les charges, mais dans un rapport plus grand que celui de ces charges."—*Piobert, Traité d'Artillerie, Théorique et Expérimentale*, p. 353; see *ibid.*, pp. 354, 355.

The following experiments made on board the "York" in 1853 also establish this point very clearly:—

Nature of Shell.	No.	Bursting Charge.	Number of Splinters found.	Missing Portions of the Shell.
32-pr. or 6-inch shells	1	10 ozs.	11	2 lbs. of iron.
	2	14 "	14	2 " "
	3	16 "	23	½ " "
	4	18 "	20	6½ " "
8-inch shells	1	1½ lbs.	24	1 " "
	2	2¼ "	21	2 " "
	3	2½ "	26	14 " "
	4	2½ "	31	11½ lbs. of iron, and the fuze.
10-inch shells	1	4 "	20	11 lbs. of iron, and the fuze.
	2	5½ "		6½ lbs. of iron.
	3	6 "	35	20½ " "

"These experiments clearly show that shells will burst into a greater number of "pieces when close filled with powder than when only containing their present "bursting charges."—*Experiments in Her Majesty's Ship "Excellent,"* p. 111.

Moreover, "the amount of smoke caused by their bursting will also be greater, an "inconvenience which has been proved to be of no small magnitude."—*Ibid.*, p. 112.

[1] This consideration applies, perhaps, rather to elongated than to spherical shells, which do not appear to be liable to explode prematurely from this cause. But with rifled shell premature explosion almost invariably results from partially filling the shell.

"In the practice on the 22d July four shells burst very short (at from 200 to 300 "yards); and on examining other shells which had been filled at the same time it "was found that a small space had been left between the top of the powder and the "fuze. In the practice of the 28th great care was taken to completely fill the shells, "and the result was that they all burst at the proper distance."—*Extracts from Reports and Proceedings of the Ordnance Select Committee*, vol. i., p. 338.

"There is no doubt that a partially filled shell is more liable to premature explosion "than one wholly filled."—*Ibid.*, vol. ii., p. 197.

The Committee, in recommending the complete filling of the Armstrong shells mainly on this account, "turned their attention to the general question," and extended their recommendation to the spherical shells named in the text, for this and the other reasons given above. See upon this subject *ibid.*, vol. ii., pp. 196, 197.

3. The shells are less eccentric and consequently more accurate in flight.[1]

4. The issue of bursters is much reduced and simplified.[2]

Diaphragm shrapnel shells are not filled by capacity but with measured charges, because the bursting charge of these shells is required to be the *minimum* sufficient to ensure the proper opening of the shell,[3] and the capacity of the shell cannot therefore be adopted as the measure of the charge.

Except for (*a*) diaphragm shrapnel shells for all services and (*b*) all shells for field and siege service, loose powder is used for filling, the powder being generally carried in 15 lb. or 10 lb. bags, or in spare cartridges.[4]

Bursters.

But for the above named (*a*) and (*b*) shells the powder is issued in measured charges, and placed in bursters, for the following reasons:

(*a.*) The necessity for the employment of measured charges for *Diaphragm Shrapnel shells for all services* will appear from what has been stated above, viz., that the charge should be the *minimum* sufficient to open the shell; and for

(*b.*) *Field and Siege Service Shells* of all natures it is recommended by the following considerations. These shells not being carried filled, the issue of powder for filling them in some form or another is indispensible, and it is thought more convenient and less dangerous to issue it in made up charges approximating as nearly as possible to what will suffice to fill the shells, than in any other way.

For these services, therefore, made-up bursting charges in bursters are retained; but it is distinctly laid down that these shells must be *completely filled* before use, "by tapping them with a mallet during the "process;"[5] accordingly if the contents of one burster are insufficient to completely fill a shell another must be opened to make up the deficiency.

Cartridges, calico, bursters, bags, paper.

The bursters or "cartridges" in which the bursting charges for these shells—field and siege services, and diaphragm for all services—are issued, consist of a pulp or paper bag,[6] which contains one charge, and is placed inside a calico bag.[7]

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[1] "The filled shells will probably be less eccentric than one partially loaded, and "consequently be more accurate in flight than the latter."—*Owen and Dames' Lectures, &c.*, ed. 3, p. 66.

"This irregularity is much greater when the shells are partially loaded with lead, "sand, and even with the bursting powder, any of which is liable to change its place "in the shell during flight. The disadvantage produced by partial loading is manifest "from the fact that shells so loaded neither range so correctly nor so far as when "they have been entirely filled with the loading material."—*Naval Gunnery*, p. 257; see also *ibid.*, pp. 201, 261.

"Their flight will be more accurate."—*Experiments in Her Majesty's Ship "Excellent,"* p. 112.

[2] Measured and made up bursting charges are now only required with field and siege shells, and with all diaphragm shells, their issue being discontinued for other services.

[3] See pp. 43, 44, 50.

[4] On an emergency cartridges would be opened for the purpose. "The shells, "when required for service, should be filled from the spare powder or cartridges" (*Extracts from Reports and Proceedings of Ordnance Select Committee*, vol. ii., p. 197), or any available powder might be employed.

[5] *Royal Artillery Circular Memorandum*, 13th December 1864, par. 3.

[6] Bags made direct from the pulp; the same as those used for common cartridge covers.

[7] Approved 2nd June 1860, 75/12/657, *General Regimental Order* 428, para. 13. Previous to 1860 serge bags, generally cuttings and remnants of old cartridges, were used, without a paper bag.

The calico employed is shirting (with as little paste dressing as possible—a dressing of size not objected to), sewn into a bag.

The calico and paper bags are numbered, to correspond with one another, from 1 to 7, each bag taking a variety of charges,[1] as follows :

			lbs.	oz.	drms.		lbs.	oz.	drms.
No. 1 bag to contain		-	0	0	24	or under.			
2 „ „	above	-	0	0	20	to	0	0	30
3 „ „	„	-	0	0	30	„	0	0	70
4 „ „	„	-	0	0	70	„	0	13	0
5 „ „	„	-	0	13	0	„	2	8	0
6 „ „	„	-	2	8	0	„	4	0	0
7 „ „	„	-	4	0	0	„	12	0	0

When filled the calico bag is marked in black with the word "burster," and the weight of the charge ; for diaphragm shell the bursters have on them in addition the nature of shell. The bags are choked by being tied with twine ; the choke is not cut off.[2]

Blowing charges.—In some cases "where it is not desirable or safe "to burst the shells,"[3] reduced bursting charges, called "blowing charges," are used. Blowing charges.

These charges[4] are as follows :—

From 12-pr. to 24-pr. inclusive - - 3 ozs.
„ 32-pr. to 13-inch „ - - 4 ozs.

The loss of weight of each shell, consequent upon the difference of weight between the blowing and bursting charges, is considered immaterial in practice.[5]

And it has been proved by experiment that the deviation from the path of the projectile caused "by the action of the blowing charge at "right angles to that path is quite inappreciable when considered in "its relation to the amount of deflection due to the inaccuracy of the "gun itself."[6]

Blowing charges are made up from loose powder, and are placed loose

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[1] See table of bursting charges, XVI., p. 340.

A reference to this table will show that Nos. 1, 2, 3, 4, 5, and 7 bags are used for smooth-bore ordnance, but not No. 6 ; this bag is used for the bursting charges of *rifle* projectiles only.

Nos. 4 to 7 *paper* bags are the same as are used for the smaller natures of cannon cartridges (see table of cannon cartridges, XV., p. 336) ; thus the paper bags run in an unbroken succession from 1 to 19, Nos. 1 to 3 being for bursting charges only, Nos. 4 to 7 for covers for cannon cartridges *and* bursting charges, and Nos. 8 to 19 for covers for cannon cartridges only. It should be noticed that when used for bursters they are called "bags," and when used for cannon cartridges they are called "covers." The calico bags are from 1 to 7 only, and are only used for bursters.

[2] Up to 1859 the choke was cut off.

[3] *Extracts from Reports, &c., Ordnance Select Committee*, vol. i., p. 32.

[4] Proposed by Col. A. J. Taylor, Royal Artillery, and approved 7th October 1862. —*War Office Circular*, 815, para. 676.

On the subject of the introduction of these blowing charges, see *Extracts from Reports, &c., Ordnance Select Committee*, vol. i., pp. 32–3 and 348–9.

[5] "Col. Taylor considers that this loss of weight would be immaterial in practice." —*Ibid.*, p. 32.

It was formerly the practice, at least with mortar shells, to fill up the vacant space with sand or available material.

[6] *Extracts from Reports, &c., Ordnance Select Committee*, vol. ii., p. 198. These experiments, which were made with more particular reference to an accident which occurred at Plymouth in 1864 during practice, seemed to establish that the deflection from the path of a 68-pr. common shell at 1,000 yards, moving with a velocity of 950 feet per second, would not exceed 1 yard in 50 yards.

into the shell, except in the case of mortar shells, when they are placed in woollen bags, which are jammed into the fuze hole by the fuze.[1]

Bags, worsted shalloon, for blowing charges.

The bags or "cartridges" are made of red shalloon,[2] and are of two sizes, one to contain 4 ozs. for the 13, 10, and 8-inch mortar, and the other to contain 3 ozs. for the 24-pr. and 12-pr. common shells when fired from the $5\frac{1}{2}$-inch and $4\frac{2}{5}$-inch mortars.[3] They are narrow towards the mouth, to fit the fuze hole, and have a brass ring at the mouth to prevent the bag from falling in. Below this narrow portion they bulge out so as to bring the charge as much as possible about the fuze, and so ensure its ignition.

Packing and issue.

Bursters are issued either—

(*a*) Empty, or
(*b*) Filled.

Bursters are generally issued (*a*) *Empty* from Woolwich, and it depends upon the nature of the service whether they are re-issued from the store station to which they are in the first instance consigned, empty or filled.

When issued empty the calico bags are printed and made up in bales, the same way as cannon cartridges,[4] the number in each bale being as follows :

No. 7	800
" 6	1,300
" 5	2,500
" 4, " 3, " 2, " 1	5,000

The paper bags are sent away in vats. These do not have the nature of the charge printed on them.

Bursters are issued (*b*) *Filled* on demand, or for active service.

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[1] Approved 2nd March 1865, *War Office Circular* 5 (new series), para. 1045. The reason for bringing the charge up around the fuze in the case of mortar and not in that of common shells is that, owing to the fuze of the former having no powder channels, there would be a possibility of the non-ignition of the blowing charge if it were introduced loose; while with the common fuze the action of the powder channels secures the ignition of the blowing charge, wherever it may be situated in the shell.

This plan of placing the blowing charge into a bag seems to have been in vogue until 1855, when the Boxer fuze was introduced. "The reduction in the size of " the fuze hole, and the increase of space in the shell, consequent on the use of a " smaller fuze, created some little difficulty in doing this; and on some authority " which cannot now be traced, the Royal Laboratory prepared shells and fuzes specially " for practice, the former having a brass cylinder to receive the bursting charge, and " keep it separate from the sand within with which the shells are weighted."—*Extracts from Reports, &c., Ordnance Select Committee*, vol. ii., p. 198.

These sockets were let into the shell much in the same way as the sockets and tin cylinders in the improved shrapnel, and special fuzes, containing three inches of composition for 13, 10, and 8-inch, and 2 inches for $5\frac{1}{2}$ and $4\frac{2}{5}$-inch shells, were used with them. But never having been formally and officially introduced, and having only, as it appears, been used at Woolwich, they are hardly to be considered service stores; and since the re-introduction of the bags in 1865 their issue, and that of the fuzes for use with them, has been discontinued.—*Ibid.*, vol. ii., p. 279.

[2] Shalloon is preferred to serge as being thinner and more convenient for the purpose.

[3] It is a question whether these bags could be used with the 12-pr. shells and small mortar fuzes, on account of the length of the fuze; if the common fuze were employed with the shells, the use of the bag would be unnecessary.

[4] See pp. 155, 156.

They are then packed according to the nature of service for which they are required, in one of the cases used for packing cannon cartridges,[1] though generally in the sectional or small-sized cases.

Waterproof bursters.—When specially demanded waterproof, the non-waterproof bag is superseded by a waterproof paper bag, of the same description as is used for cannon cartridges.[2] Over this is placed the ordinary calico bag, marked and secured as usual.

Filled Shells.

Filled shells.

The circumstances under which shells are issued filled, viz., to the navy only, or on special demand, have been detailed under the head of "Packing and issue" of each nature of shell.[3] It may, however, be convenient to recapitulate here, in connexion with the subject of the bursting charge, how each nature of shell, *when filled,* is secured.

(1.) *Common shells.*—These are issued riveted, completely filled with powder, and with the Pettman L.S. percussion fuze screwed into the fuze hole.[4]

(2.) *Naval shells.*—They are issued riveted to top or bottom, completely filled with powder, and have Pettman's S.S. (or, when fitted with the General Service bush or adapter, Pettman's G.S.) percussion fuze screwed into the fuze hole.[5] 50 per cent. spare 20 seconds fuzes, and 25 per cent. 7½ seconds spare are issued with the shells, but not *in* them. The same proportion of 20 seconds and 9 seconds wood time fuzes are issued with shells having the General Service fuze-hole or adapter.

(3). *Mortar shells.*—When mortar shells are issued filled they are completely filled with powder, the fuze hole closed with a beeswaxed cork, and over all is placed a "kit plaster."[6]

(4.) *Hand grenades*, when issued filled, have a hand grenade fuze in the fuze hole, and a kit plaster over it.

(5.) *Diaphragm shrapnel shells.*—Filled diaphragm shrapnel shells have the loading hole secured with a *papier mâché* wad underneath the loading hole plug and are issued riveted.

The fuze hole is secured with the ordinary diaphragm fuze hole plug; care being taken in filling the shell to see that the fire hole in the socket is clear, and to shake a little powder into the socket. The shells are filled from bursters, and not by capacity.

MISCELLANEOUS STORES CONNECTED WITH CHARGE.

The following articles, being connected more or less directly with the subject of the charge, are introduced at this part of the work:—

Machines for filling cartridges, Caffin's.
Funnels.

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[1] See p. 156.

[2] See p. 168.

Waterproof *calico* was for a short time used for the larger bursters, but was discontinued in November 1864.

[3] See pp. 29, 34, 38, 41, 57.

[4] See note 8, p. 29, respecting the employment of metal plugs and papier mâché wads for the fuze holes of filled common shell before the introduction of Pettman's fuzes.

[5] Until 1865, when the existing store of Moorsom's fuzes was ordered to be broken up, a proportion of these fuzes were issued with 32-pr. guns. Until November 1865, 25 per cent. 7½″ fuzes were issued in the shells, the remaining 75 being Pettman's S.S.

[6] See p. 38.

Measures, copper, powder.
Magazine, portable, Fead's.
Cases, leather, cartridge.
Shoes, magazine.
Cloths { for airing powder. / hair.
Wadmiltilts.
Hides, tanned, or powder.
Drivers, metal, cooper.
Hammers, cooper.
Scissors for magazine use.
Types for marking cartridges.
Gauges, brass, ring, for filled cartridges.
Buckets, sponge.
Hoops, copper, for powder barrels.
Rivets, copper, for ditto.

Caffin's Machine for filling Cannon Cartridges.

Machines, filling cartridges, Caffin's. History.

This machine is an adaptation of a principle applied by Wm. Caffin, Esq., late of the Royal Laboratory, in the small arm cartridge filling machines. It was designed and proposed by Admiral Caffin, R.N., in 1838; and subjected to a trial on board H.M.S. "Excellent," in the early part of 1839, in comparison with the plan then in vogue of filling cartridges by copper measures, and recommended for adoption by Captain Hastings, R.N., "because powder may be filled "more expeditiously, more safely, and more accurately by it than by "the mode at present in use."[1] This recommendation was approved, and the machine adopted for naval use in May 1839.[2]

They have always been made in the Royal Laboratory, except for a short period between about 1859 and 1860, when a large number were supplied by contract.[3]

Natures.

Caffin's machine for filling cannon cartridges[4] is made of one size only.[5]

Description.

It consists of a gun-metal wheeled "carriage," which receives two brass measures, and travels up and down on gun-metal rails underneath a large wooden hopper.[6]

The hopper is for the reception of the powder from which the cartridges are to be filled; the measures are for measuring the charge into the cartridges. There is a hole in the bottom of the hopper through which the powder flows into the measures as they are respectively brought under it; and there are two holes, fitted with brass spouts, through which the measures, in their turn, discharge their contents into the cartridges.

The machine is so arranged that while one measure is filling the other is emptying, and by working the carriage backwards and forwards—which is done by means of ropes attached to a wooden treadle and worked by the feet—cartridges can be filled with great rapidity.

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[1] Letter from Captain J. Hastings, H.M.S. "Excellent," 17th May 1839.

[2] Board's order, 24th May 1839.

[3] The first contract for these machines seems to have been dated 2nd August 1859, 75/9/170, and the last 16th June 1860, 7309/293.

[4] Not regularly sealed until 13th Sept. 1866. *W.O.C.* 11 (N.S.), § 1319.

[5] For some time there were two sizes in use, and a third, larger, size was even made; but when these stores were formally sealed in 1866 the "medium" size was alone retained.

[6] Polished mahogany.

'The metal fittings of these machines are all of copper, brass, or gun metal, and the parts are mostly made removable for cleaning.[1] To diminish the chance of accidents from friction, the surface below the hopper, against which the upper part of the carriage rubs in travelling, is lined with serge; again, to prevent any powder from falling under the wheels, small copper trays are fixed over the wheels to catch falling grains, a wooden tray is also fixed underneath the treddle with a similar object. In construction the three sizes are identical, but the hoppers and measures being of different sizes, the general dimensions of the machines are modified accordingly; the capacity of the hopper in the three sizes is respectively about 200 lbs., 95 lbs., and 45 lbs.

The measures are as follows:

No.		lbs.	ozs.
2	Measures to contain, each - - -	2	0
2	" " - - -	2	8
2	" " - - -	2	10
2	" " - - -	3	0
2	" " - - -	3	8
2	" " - - -	4	0
2	" " - - -	5	0
2	" " - - -	6	0
16			

The measures are interchangeable, the difference in capacity being effected merely by altering the size of the bodies without altering the diameter of the top and bottom rims, or the length of the measures.

On each machine are labelled the following directions for its fixing and use:

Directions for fixing and using Caffin's Machine for filling Cannon Cartridges.

Fixing the Machine.

A machine should be supplied to a ship as soon as she is put into commission, in order that it may be properly fixed by the dockyard; the most eligible place is in the main magazine, opposite to a light. The trough should be placed by the dockyard, to catch any grains of powder that may fall when at work.

Should the gunner, when working the machine, observe that too much powder escapes he must screw up the boards, taking care to preserve their parallelism; and, in adjusting them, to allow a sheet of writing paper to pass freely between the plate on the top of the measures and the cutting-off collar under the upper board.

Should it be *absolutely* necessary to take the machine to pieces, although this is to be avoided if possible, the same adjustment must be observed in putting it together again.

Using the Machine.

Care must be taken to dust it thoroughly with a painter's brush both before and after use; to do this effectually the carriage for the measures must be taken out, and the upper and lower boards well brushed, as also the top plate and frame of the carriage. This should also be done when-

[1] Gun-metal spanners for removing the nuts are issued with the machines.

ever it may be necessary to shift the measures, and likewise occasionally during the operation of filling the cartridges.

Whenever the top plate of the measures is taken off for brushing or changing the measures, it is never to be put down on the floor or deck; but held in the hand until replaced, that no grit or dirt may be collected upon it.

The man who fills must also be careful to brush away any grains of powder into the trough that may escape over the top of the measures.

When the cartridges to be filled agree in weight with any of the measures, a cartridge of that charge may be filled from each discharging shoot; but when the required charge differs in weight from any one of the measures, then if the weight can be made up by two measures of different capacities these are to be placed in the machine, and the cartridge in such case will have to be placed under each shoot in succession to make up the charge required: for instance, a 5 lb. and a 4 lb. will give a 9 lb. charge; a 4 lb. and a 3 lb. a 7 lb. charge; and so on.

These machines are approved for naval use only, but they would of course be available for land service. On land, however, cannon cartridges are at present filled by weight instead of capacity; and, although the filling is less rapidly performed than with Caffin's machine, the weight of powder in each cartridge is exactly correct, whereas, the density of the powder and the charges delivered by the measures being variable, the weight of measured charges will vary in a corresponding proportion, and effect a difference in large cartridges of more than half a pound.[1]

Funnels.

Funnels are used for the following purposes:—

(*a.*) For loading mortars.
(*b.*) For filling cannon cartridges.
(*c.*) For filling shell.

Funnels, tin, for mortar.

(*a.*) *Funnels for loading mortars* were formerly[2] made of copper; they are now made of tin,[3] painted black inside and out. The funnel is about nine inches in diameter at the widest part, and contracts to about two inches, being fitted with a spout about 2½ feet long. These funnels are used for loading mortars when the charge is introduced loose.[4]

Funnels, copper, naval cartridge.

(*b.*) *Funnels for filling cartridges* are made entirely of copper.[5] There is only one size of funnel for this purpose, viz., that known as the "Royal Navy funnel," which is used for filling naval cannon cart-

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[1] An experiment was made in the Royal Laboratory in 1864 to test the relative merits of the two methods of filling cartridges. The details of this experiment are given in Appendix H., p. 374. These details may be epitomised as follows: Three natures of cartridges were filled, 68-pr. 16 lbs., 32-pr. 10 lbs., and 7-inch B.L. (Armstrong) 12 lbs. The number of each filled per hour by the two methods were as follows: machine 202, 222, and 331, against 160, 160, and 203 by scales. But to produce these results the number of men employed were,—for the machine, five men for each of the smooth bore cartridges, and six men for the Armstrong cartridges; and for the scales only three men and one boy in each case. Moreover, while the cartridges filled by the scales all weighed correctly, those filled by the machine varied for the 16 lbs. charges from 16 lbs. 10 ozs. to 16 lbs. 3 ozs. with new L.G. powder, and from 17 lbs. to 16 lbs. 3 ozs. with "started" L.G.; for the 10 lbs. charge, from 10 lbs. 8 ozs. to 10 lbs. 3 ozs. (new powder); and for the 12 lbs. charge, from 13 lbs. 6½ ozs. to 13 lbs. 1 oz. (new "Rifle L.G.") See Appendix H., p. 374, for further details.

[2] Until about 1858 or 1859; I have not been enabled to fix the exact date.

[3] Tin known in the trade as "XXX single tin sheet" is used for these funnels.

[4] See *Manual of Artillery Exercises*, p. 104, where one "filling funnel," as it is there called, is included among the stores required for the service of mortars.

[5] Copper sheet, 18 wire gauge.

ridges,[1] but which is equally serviceable, if required, for filling land service cartridges.

(*c.*) *Funnels for filling shells* were all made of copper until 1859,[2] when leather funnels with copper spouts were substituted, except for filling naval shells. There are now six sorts of funnels for filling shells—

1. Naval shell funnel.
2. Common, large.
3. „ small.
4. Diaphragm, large.
5. „ small.
6. Boat magazine funnel.

Funnels, copper, naval shell.

The (1) *funnel for filling naval shells* is made entirely of copper,[3] and is about 6·4 inches in diameter at its widest part, contracting to about 1·0 inch, and being fitted with a cylindrical spout about 2·5 inches in length. These funnels form part of the equipment of the Royal Navy.[4]

Funnels, leather, with copper spouts, common, large

The (2) *large common funnel*[5] is made of kid, with a copper spout. The principal dimensions are, *in round numbers*, as follows :—Length of spout, $2\frac{1}{2}$ inches ; width of spout at end, $\frac{3}{4}$ inch ; depth of kid, 5 inches ; width at top, 7 inches ; at bottom, $1\frac{1}{4}$ inch.

This funnel is used for filling all common, mortar, and rifled shells, except for field service. It is supplied with Nos. 3 and 6 garrison sets of implements, and with the naval implements.[6]

Funnels, leather, with copper spout, common, small

The (3) *small common funnel*[7] resembles the large common funnel, except in dimensions, which are as follows :—Length of spout, about $1\frac{1}{2}$ inch ; width of spout at end, $\frac{1}{2}$ inch ; depth of kid, $3\frac{1}{2}$ inches ; width at top, 5 inches ; at bottom, $\frac{3}{4}$ inch.

This funnel is used for filling common shells for field service only, and is employed for this purpose in place of the large common funnel, on account of its inferior size. It is supplied with Nos. 3 and 4 set of implements for field service.[8]

Funnels, leather, with

The (4) *large diaphragm funnel* differs from the common funnels only in being smaller, and in the spout being cylindrical instead of

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[1] Other sizes have also been made for filling cannon cartridges for use in the Royal Laboratory and Sub-laboratories, and to meet special demands ; but the funnel named in the text is the only recognized one for this purpose, none being included in land service equipments.

[2] 13th May 1859, *War Office Circular* 590, par. 25. The change was made principally with reference to convenience in packing in the cases containing the sets of implements.

[3] 32-ounce copper sheet.

[4] It might at first sight appear desirable to abolish this funnel, substituting the large or small common shell kid funnel ; but as the latter costs as much, is less durable, and of no value when worn out, such a change could not be recommended, especially as the space occupied by the copper funnel on board ship is inconsiderable.

[5] Called the mortar funnel until 1865, when, on the revision of the sets of implements, this funnel was taken into use for common and rifled shells, except for field service, and the present designation was adopted.

[6] And with the special set for rifled siege guns, which is not included in this volume.

[7] The funnel was known as the common funnel until 1865, when, on the revision of the sets of implements, the mortar funnel was taken into use for common shells, except for field service ; a distinction of "large" and "small" then became necessary.

[8] See page 307.

copper spout, diaphragm shrapnel, large.

slightly tapered. The principal dimensions are:—Length of spout, about $\frac{1}{2}$ inch; width of spout, $\frac{3}{8}$ inch; depth of kid, 3 inches; width at top, 4 inches; at bottom, $\frac{3}{8}$ inch.

This funnel is used to fill all diaphragm shells above the 18 prs.[1] It is issued with No. 3 set of garrison implements[2] and No. 3 set of field implements.[3]

Funnel, leather, with copper spout, diaphragm shrapnel, small.

The (5) *small diaphragm funnel* differs only from the large diaphragm funnel in being smaller. The principal dimensions are:—Length of spout, $\frac{1}{2}$ inch; width of spout, $\frac{1}{4}$ inch; depth of kid, $2\frac{1}{4}$ inches; width at top, $2\frac{1}{2}$ inches; at bottom, $\frac{1}{4}$ inch.

This funnel is used for filling diaphragm shells up to the 18 pr., inclusive. It is issued with No. 3 set of garrison implements, and with Nos. 2 and 4 sets of field implements.

Funnel, leather, boat magazine.

The (6) *boat magazine funnel*[4] is made entirely of leather.[5] The ordinary service funnel would, however, answer the same purpose, and there seems no reason why this special funnel should be retained.

Copper Powder Measures.

Measures, copper, powder.

Measures for powder are merely cylindrical copper[6] cups of different sizes. A set generally consists of the seven following sizes:—4 lbs., 2 lbs., 1 lb., 8 ozs., 4 ozs., 2 ozs., 1 oz., which will suffice for ordinary purposes; but on demand measures of the following sizes are supplied:—12 lbs., 10 lbs., 8 lbs., 7 lbs., 6 lbs., 5 lbs., 4 lbs., 3 lbs., $2\frac{1}{2}$ lbs., 2 lbs., $1\frac{1}{2}$ lbs., $1\frac{1}{4}$ lbs., 1 lb., 12 ozs., 10 ozs., 8 ozs., 7 ozs., 5 ozs., 4 ozs., 3 ozs., $2\frac{1}{2}$ ozs., 2 ozs., 1 oz., $\frac{1}{2}$ oz., $\frac{1}{4}$ oz.; their capacities being calculated with reference to L.G. powder.

Copper measures for each diaphragm bursting charge are also issued. They differ from the others only in being furnished with a copper handle. The sizes are 80 drms., 70 drms., 60 drms., 50 drms., 40 drms., 30 drms., 24 drms., 18 drms.; their capacities being calculated with reference to shell F.G. powder.

Leather Cases for Cartridges.

History.

Cases for carrying filled cartridges, and bringing them up to the guns, were formerly made of wood, and called "cylinders." The substitution of leather for wood for this purpose was first adopted for the naval service, and extended subsequently to the land service. Many of the wooden cylinders are doubtless still in existence at different stations; and the name "cylinder" is sometimes, though improperly, applied to the leather cases. They are now a contract store.

Natures.

There are altogether nine different sizes of leather cases for smooth-

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[1] See page 104 respecting the loading holes of diaphragm being larger above the 18-prs.
[2] See page 307.
[3] See page 307.
[4] Approved, *War Office Order* 57/2/9382, 10/9/64.
[5] Basil.
[6] Copper sheet 14 wire gauge is used for the 12 lbs. measure, and 15 wire gauge for the lower natures.

bore[1] cartridges in the service; they are shown in the following table, with the guns with which they are intended to be used.[2]

Distinguishing Name or Number.	Dimensions in Inches.		Use.
	Diam.	Depth.	
D.	—	—	For 150-pr. guns.
Mortar	$9\frac{1}{2}$	15	For 13-inch sea service mortars and 100-pr. guns.
1	9	11	10-inch guns, 10-inch howitzers, 13-inch (L.S.), and 10-inch mortars.
2	9	17	68-pr., 56-pr., and 42-pr. guns.
3	8	19	8-inch guns.
4	7	16	32-pr. guns of 63 to 56 cwt.
5	8	12	8-inch howitzer.[3] 32-pr. guns of 50 to 39 cwt. 24-pr. guns of 50 to 33 cwt.
6	7	9	32-pr. guns of 32 and 25 cwt. $5\frac{1}{2}$-inch and $4\frac{2}{5}$-inch mortars.
7	$6\frac{1}{2}$	11	8-inch mortars.[4] 18-pr. and smaller smooth-bore guns.

They are merely leather cylinders with a moveable leather lid and a long leather handle, up and down which the lid slips. The different sizes vary only in length and diameter. They are distinguished on board ship as follows:[5]—

Lower deck cartridge cases are painted white.
Middle deck „ „ blue and white stripe.
Main deck „ „ red.
Quarter deck and forecastle „ black and marked upper deck.

They are used for bringing the charge, whether in cartridges or in loose powder,[6] from the magazine to the gun, and protect the charge from damp and accidental explosion.[7] They are not uncovered "until the sponge is out of the bore."[8] They are not required when the charge is very small, and can be placed under the arm; for field service, for example, except when loading with loose powder.

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1 The cases for rifled ordnance are not included in this list.

2 In addition to those enumerated in this table there are still in store some cases of an obsolete pattern, "No. 2, old pattern," originally intended for 10-inch mortars and 10-inch howitzers. These will be issued; but when the store is exhausted Nos. 7 and 5 cases will be issued (as shown in table) for service with these guns.

3 See preceding note, respecting "No. 2 old pattern" case being issued for these guns until the stock is exhausted.

4 See note 2 above, respecting "No. 2 old pattern" case being issued for these mortars until the stock is exhausted. It should be noticed, however, that a case would not generally be required for so small a charge as 2 lbs. (the service charge for the 8-inch mortar), except when loading with loose powder.

5 *Proportion of Ordnance Stores for Smooth-bore Ordnance for Her Majesty's Ships*, p. 16.

6 In case of mortars when cartridges are not used.—See *Manual of Artillery Exercise*, p. 107.

7 This point was conclusively established by experiments made on board the "*Leviathan*," "*Menai*," and "*York*" in 1847, 1852, and 1853. "These experiments "certainly prove the great security of the present leather cartridge cases."—*Experiments in Her Majesty's Ship "Excellent,"* pp. 86–88, and 90–94, where details of the experiments are given.

8 *Manual of Artillery Exercises*, p. 145.

Magazine Shoes.

There are four different patterns of magazine shoes, viz. :—

1. Shoes, magazine, service pattern.
2. Shoes, magazine, Waltham Abbey pattern.
3. Goloshes, leather, Waltham Abbey pattern.
4. Goloshes, leather, service pattern.

Shoes, magazine, service.

The (1) *Service Magazine Shoe*[1] is made of 10 different sizes, from 2 to 11.[2] The size of the shoe is stamped upon the sole. These shoes tie over the ankle with a leather thong. They are made entirely of untanned leather.

Shoes, magazine, W. A. pattern.

The (2) *Magazine Shoes for Waltham Abbey*[3] are a species of untanned leather ankle-jack or "Blucher" boot,[4] generally made of 7, 8, 9, 10, and 11 sizes.[5] They are issued only to the Gunpowder Factory, Waltham Abbey.

Goloshes, leather, W. A. pattern.

The (3) *Golosh, leather, Waltham Abbey*[6] is a large loose untanned leather boot, the high sides of which extend a considerable distance up the calf; they are made of sizes suitable to cover magazine shoes from 6 upwards.[7] These boots are issued only to Waltham Abbey and Purfleet, and are used when working amongst loose powder.

Goloshes, leather, service.

The (4) *Service Golosh* is an untanned leather slipper, fitted with a strap and buckle to fasten over the ankle. They are made of sizes suitable to cover magazine shoes from 6 upwards.

Magazine shoes and goloshes are intended, as their name implies, to be worn in magazines and buildings containing combustible stores and compositions, as a precaution against accidents. The orders respecting their employment are most peremptory,[8] and no person should be allowed to enter a magazine or composition building without shoes, except in bare feet or stockings.

Cloths for Airing Powder.

Cloths, canvas, airing powder.

Cloths for Airing Powder are merely large canvas[9] cloths fitted with a brass ring at each corner, and on two of the sides. The usual size is six feet by six feet, but they have been made and issued of other sizes. Their use is sufficiently indicated by their name. They are issued to military store officers, inspectors of warlike stores, &c. on demand.

Hair Cloths.

Cloths, hair.

Hair Cloths[10] are of one size only, viz. 15 feet by 12 feet. They are cloths made of horsehair of the above size. They are generally black,

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[1] Approved 11th July 1860, *War Office Circular* 639, par. 154.

[2] It does not follow that all these sizes have been issued; but they are procurable.

[3] Approved 27th October 1860, *War Office Circular* 665, par. 193. Sometimes known as "Blucher's magazine, W.A. pattern."

[4] The slipper pattern shoe or golosh is unsuitable for use at Waltham Abbey, where the shoes are exposed to so much greater wear and tear than elsewhere, on account of their liability to wear down at heel.

[5] Of course other sizes would be made if demanded.

[6] Approved. See *Minute*, 51/Purfleet/510.

[7] Other sizes would of course be issued if demanded.

[8] "The several persons whose duty obliges them to go into the magazines are " invariably to take off their shoes and put on magazine slippers before they enter, " or else to enter bare footed, &c. &c."—*Ordnance Regulations, Home*, p. 123, 1855.

"1. All persons so employed are to change their clothes, viz. coat, waistcoat, " trousers, cap, and shoes, and wear the suits specially provided for this purpose."—*War Office Circular* 870 (*Combustible Stores*), 12th July 1864.

[9] Sail canvas, No. 6.

[10] Present pattern, "with double warp and shoot," approved 7/1/62, *War Office Circular* 759, par. 498 These cloths are procured by contract.

with white stripes. Hair cloths are used to place upon the floors and tables of magazines, or buildings where powder work is carried on, to prevent accidents from grit. They are also used to lay down on a jetty to roll powder barrels over, and generally for similar purposes.

Wadmiltilts.

Wadmiltilts[1] are made of two sizes: large, 14½ feet by 12 feet; and small, 9 feet by 6 feet. They are strong, rough, woollen cloths of the above sizes, and are used principally for covering powder and protecting ammunition generally,[2] and, exceptionally, for placing on the floors or tables of magazines to diminish the liability of accidents from grit,[3] &c. &c. Wadmiltilts.

They are issued with siege trains, to magazines, and for boat service, &c.

Tanned Powder Hides.

Tanned Powder Hides[4] are of one size only, weighing on the average 80 lbs. They are, as their name implies, large hides,[5] and they are used for similar purposes to hair cloths, as circumstances may recommend. Hides, tanned powder.

They are issued to magazines, &c. &c.

Hammers, Cooper.

Hammers[6] for use in magazines[7] have a gun-metal[8] head, slightly curved, and about 6½ inches in length; one end of the head is flat, the other end presents a dull edge. Hammers, cooper.

The haft of the hammer is made of ash, and is about 10 inches long. These hammers are for heading and unheading powder or ammunition barrels, and performing such coopering operations in a magazine, or wherever powder is being handled, as may be required. Only these or wooden cross-head mallets should be used for such purposes.

"In heading or unheading powder barrels, the persons employed are "never to use the bare adze against the copper hoops, but are invariably to apply a driver."[9]

Drivers, Metal, Cooper.

Drivers[10] for use in magazines have gun-metal[11] heads and ash hafts. The haft is strengthened with a gun-metal ring near the upper end. Drivers, metal, cooper.

These drivers are for coopering powder and ammunition barrels, and for performing coopering operations in a magazine, or wherever powder is being handled, tightening hoops, &c. as may be required.

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1 Wadmiltilts are procured by contract.

2 See *Ordnance Regulations, Home*, p. 141, par. 560, where the employment of wadmiltilts under certain circumstances is enjoined. "A barrel of powder wrapped "in a wadmiltilt is safe from the explosion of two similar barrels in the open at a "distance of 10 feet; but it is not safe, when not so wrapped at a distance of 15 feet." *Report O.S.C.* 4470, 30th January /67.

3 Hair cloths or hides should properly be employed for this purpose.

N.B.—There is also a description of wadmiltilt specially prepared for covering carts containing ammunition, and known as "*covers, wadmiltilts, with canvas ends.*" These wadmiltilts are fitted with canvas ends, straps, and buckles, for the purpose of attaching them to the carts.

4 Contract store.

5 Bull's hide.

6 Sometimes called adze.

7 This pattern, which has not been sealed, was deposited in the pattern room, Royal Laboratory, in 1860.

8 The same alloy as for 7½ and 20 service fuzes, see note 7, p. 258.

9 *Ordnance Regulations, Home*, p. 142, par. 570.

10 Pattern deposited in Pattern Room, Royal Laboratory, 18/9/61.

11 The same alloy as for 7½ and 20 second fuzes, see p. 258, note 7.

Scissors for Magazine use.

Scissors, metal.

Scissors for magazine use [1] are made entirely of gun metal.[2]

They are employed in making up cartridges, and whenever scissors are required to be used in the presence of gunpowder.

Types for marking Cartridges.

Types for marking cartridges.

Types for marking cartridges are issued in sets,[3] as required, for each description of cartridge. They are blocks of gun metal,[4] with the letters raised.

Gauges, Brass Ring, for filled Cartridges.

Gauges, filled cartridges, brass ring.

Ring Gauges for examining filled cartridges are made of 13 different sizes, viz. 3, 6, 9, 12, 18, 24, 32, 42, and 8″ (howitzer); 56-pr., 68-pr., 10″, 100 and 150-prs. (See Table XVII.)

They are merely gun-metal rings of the required size with a handle on which is stamped the nature and size. The metal is not lacquered.

Ring gauges are used in the making up and examination of filled cartridges, over which they should pass freely.

Sponge Bucket.[5]

Bucket, sponge.

There is only one description of sponge bucket in the service; it is a wooden iron-hooped bucket painted black and fitted with a rope handle. The top edge of the staves is rounded off to prevent injury to the sponge stave, and the ends of the rope handle are hosed with leather.

These sponge buckets are used for the purpose of wetting the sponge head when it may be required to do so. They are issued for garrison service.[6]

Hoops, Copper, for Powder Barrels.

Hoops, copper, for powder barrels.

Copper hoops for powder barrels are of two sizes for each description of barrel, viz., bilge and chime hoops. There are thus eight different sizes of hoops,[7] viz. :—

Whole barrel	Bilge. / Chime.
Half ,,	Bilge. / Chime.
Quarter ,,	Bilge. / Chime.
Eighth ,,	Bilge. / Chime.

They are made of (commercially) pure copper, ·08″ thick, for all but the whole barrel, for which they are ·09″ thick.[8]

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[1] Pattern deposited in Model Room, Royal Laboratory, 18/9/61.

[2] The same alloy as for 7½ and 20-second fuzes, see p. 258, note 7.

[3] The nature and number of sets required should be specified on the demand.

[4] White metal was originally used for this purpose, and for some types (those for mortars for example) is still supplied.

[5] Present pattern approved 27th October 1865, *War Office Circular* 8 (new series), § 1167.

A pattern was previously approved 22nd May 1865, *War Office Circular* 6 (new series), par. 1098. The only difference between the present pattern and that sealed in May 1865 was that the top edge of the staves of the present pattern is rounded off instead of being left sharp as in the former pattern.

[6] Leather buckets are issued with field batteries for similar purposes.

[7] Other sized hoops have been issued for repair of barrels, but for the future it is proposed to issue only the hoops named.

[8] See table XXII., p. 348, for exact dimensions in all directions of these hoops.

Rivets, metal, for Copper Hoops.

Metal rivets for copper hoops are made of five sizes, viz. :— Rivets, metal, for copper hoops.

One size for whole barrel hoops.	For departmental manufacture.
„ „ half barrel hoops	
„ „ quarter and eighth barrel hoops	
No. 270[1] for whole barrels	For repairs only.
„ 269[1] for half and quarter barrels	

They are rivets of (commercially) pure copper, with a round flat head, and differ only in size.[2]

Hints on Coopering.

The following *hints on coopering* are introduced as likely to be useful, and as being connected with this part of the work.

Powder barrels consist of three parts, viz.—

1. Staves.
2. Heads.
3. Hoops.

The most protuberant part of the barrel is known as the "bilge," and the centre of the bilge is distinguished as the "pitch." 1. Staves.

Between the bilge and the end of the barrel is the "quarter."

The extreme end is known as the "chime."

To distinguish one end of the barrel from the other, that which is opened (when required) is known as the "top end," the other as the "back end." The top end may be known by having the staves bevelled off close to the chime to facilitate heading.

There are thus also the "top" and "back bilge," the "top" and "back quarter," the "top" and "back chime."

The heads are known as the "top heads" and "back heads" respectively. When a head is in three parts, the "dowels" having been broken or pulled asunder, the two outside pieces are known as the "cants" or "outsides;" the other part is known as the "middle" piece. 2. Heads.

Barrels are either "full bound" or "quarter bound," according to the number of hoops. All powder barrels, either full or quarter bound, have four copper hoops, the remainder ash. These hoops are situated about the chime and round the bilge of the barrel, and are known as the "copper chime" and "bilge hoops." 3 Hoops.

On the "full bound" barrel there are also six ash hoops at each end, situated one below the copper bilge hoop; four at the quarters and one above the copper chime hoops.

Quarter bound barrels have the same number of copper hoops as full bound barrels, but only three ash hoops at each end, situated one above and one below the copper chime hoop, in other words, they have no quarter hoops.

A barrel can be unheaded in two ways. The first and more common method is to place the barrel with the top end uppermost, and then to remove the top chime hoops and loosen the top quarter hoops. The left hand is then pressed upon the middle piece of the head, which is struck gently with the adze or mallet close to the chime on the side nearest the cooper, until it is started out of the groove and falls into the barrel. To unhead a barrel. First method.

The second method is called "boxing out" the head, and is adopted when the groove is deeper than usual, or when from other causes, such as the barrel being incorrectly made and having too sharp a curve, Second method, or "boxing."

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[1] The figures 270 and 269 are those by which these rivets, which have generally been obtained by contract, are known in the "nail book."

[2] See table XXII., p. 348.

the head cannot be readily removed by the first method. The hoops are loosened and removed as before, and the left hand placed upon the head, and a few smart blows are struck with the mallet round the pitch of the barrel, by which means the staves are, as it were, sprung back, and the head being thus released falls through.

Heading a barrel—head whole.

To head a barrel.—The head, if whole, is placed with its bevelled edge (on the side away from the cooper) in the groove, the left hand is then placed upon it, and the head slightly struck, as much as possible in the direction *away* from the workman, with the adze or mallet; in this manner it is driven into the groove all round. The chime hoops are then replaced. If on heading a barrel the head should accidentally be driven a little below the groove, it can generally be jarred back into its place by laying the barrel on its side and tapping the top end of the staves.

Head in two pieces.

When the head is in two pieces, the dowels (if still adhering) must be cut away. The larger piece is then placed with the whole of the left front in the groove to the left hand side, away from the workman. The small piece is then placed alongside the larger, its further edge also entering the groove; the left hand is then placed over the junction, and by means of a few gentle blows given with care and at the spots where they may seem to be most required the head is driven into the groove.

Head in three pieces.

If the head is in three the dowels must be cut off and the pieces matched according to the lettering on the head. One of the "cants" or "outsides" is then placed as the larger piece in the last case, and supported by the left thumb, which is brought over the side. The middle piece is then placed against it, its further edge in the groove, and its straight edge pressing hard against the side of the "cant." The other cant is then placed in the groove; and proceed as when the head is in two pieces.

Flagging.

Sometimes when the barrel is headed the head will be found to be a little out of round or injured at the edge, thus leaving an opening between the head and staves. It then becomes necessary to use the "flagging tool." One of its teeth is pressed against the inside of the stave where the opening appears, and the other tooth outside the stave to the right. By pressing against the handle, and using it as a lever, the opening is widened, and a little "Dutch rush" or "flag" (if not procurable, paper or rag will serve) is placed inside the gap; the flagging tool is then removed, and the stave being released springs back into its place, pinching in the rush against the head.

To avoid using a knife (*which should never be allowed to enter a magazine*) the rush should be placed as much as possible flush with the top of the head of the barrel.

To alter the size of a hoop.

If the ash hoops are too large they may be reduced in diameter to the required size by placing a small three sided prism or wedge of wood, called a "Dutchman," between the shoulders or notches of the hoop. If the hoop is too small it may be enlarged by cutting away part of the shoulders.

Taking to pieces or "shaking" a barrel for stowage.

Before taking a barrel to pieces for stowage (called "shaking" a barrel) the staves must be numbered round the inside with a piece of chalk or a pointed tool. The hoops are then removed and laid aside. The ash hoops (if the barrel is to be sent away) are seldom packed with it; the copper hoops are doubled up. The head is divided into two or three pieces by pulling open the joints without breaking the dowels.

The staves are then packed round the copper hoops and the "ends," and the pack secured with twine or with some of the wooden hoops.

To put the barrel together again the pack is untied and the copper hoops unbent. One of the copper chime hoops is then taken in the left hand and held at about the height of the barrel from the ground, the cooper kneeling on his right knee. The staves, as numbered, and with their top ends uppermost, are then arranged round the inside of the hoop, their lower ends resting upon the ground, the first few staves as they are arranged being supported by the outside of the left leg and left foot. In this manner the barrel may be built up, when the upper bilge hoop is slipped on. The barrel is then turned round and the other bilge hoop slipped on. The head is then put together and the back head is placed into the barrel (working chiefly from the inside); the back chime hoop is then placed on. The barrel is then headed up, the top chime hoop being previously removed to admit of this being done; the chime hoop is then put on again. To put a barrel together.

All the hoops, except the bottom chime hoop and the top bilge hoop, must be removed; remove the required stave and replace it by another, and then replace the hoops. To remove a stave without "shaking" the barrel down.

The heads of vats (chiefly used for the conveyance of clothing, harness, &c.) are secured by means of two hoops nailed round the inside of the chime of the vat, the head being between them. Heading and unheading vats.

To unhead a vat thus secured the "outside lining hoop" (as the hoop above the head is called) must be removed, and this is done by "prising" out the nails with a chisel or lever of any convenient sort, commencing at the "lap" of the hoop.

To head the vat.—The head is laid upon the inside lining hoop, and the outside lining hoop is nailed over it.

AMMUNITION FOR SMOOTH-BORE ORDNANCE.

SECTION C.—MEANS OF IGNITING THE CHARGE.

This section may be divided into—

(*a*.) Means of igniting charge (proper).
(*b*.) Ditto bursting charge.

(*a*.) *Means of Igniting Charge Proper, or Firing Charge.*

Under this head are included all those stores which are directly or indirectly connected with the firing of the gun. Means of igniting the firing charge.

These may be divided into classes as follows:—

Class 1. Tubes.
„ 2. Portfires.
„ 3. Lights.[1]
„ 4. Match.

The rudest and earliest contrivances for firing cannon seem to have been red hot spikes or bars, which were introduced into the vent, and History of tubes.

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[1] Signal lights hardly connect themselves with the firing of guns, but they are not easily separable from portfires; indeed many "portfires" are merely signal lights, and this seems on the whole the most suitable place for their introduction.

communicated fire to the charge,[1] and a pair of bellows for heating the priming irons formed part of the artillery equipment in the 14th and 15th centuries.[2]

Doubtless, however, this plan was found inconvenient and dangerous, more especially with the larger guns which were gradually being introduced; and it is not surprising to find it in a great measure, if not entirely, superseded before the middle of the 15th century, by the plan of priming with loose powder;[3] a small train being laid up to the vent, and particular instructions being given to the gunner to stand away from the gun after lighting the priming, "pour éviter le dict danger et "péril qui pourraient advener en vostre personne." [4]

How the priming powder was ignited does not appear; it may have been effected by means of a heated iron rod, or by means of a match made for the purpose, most probably the latter, although there is no mention of the match or of the linstock used for holding the match until the 16th century.[5]

No further improvement in the means of firing the charge was effected until some time about the beginning of the 17th century,[6] when artillerymen had recourse to the occasional employment of quickmatch, which placed in the vent acted as a weak tube.[7] The match used for this purpose was called *porte-feu*,[8] a name which we still retain and apply to our "portfires."

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[1] "Le feu était mis à la poudre par une baguette de fer rougie à feu de charbon."—*Le Passé et L'Avenir de L'Artillerie*, vol. iii., p. 78. In 1379 we find again, "Le feu "était mis à la charge par une baguette de fer rougie au feu."—*Ibid.*, vol. iii., p. 103. Again, 1432, "Le feu était mis à la charge avec des broches de fer rougies au feu."—*Ibid.*, vol iii., p. 121.

[2] "Des soufflets faisaient partie d'approvisionnement des canons mis en batterie."—*Le Passé et L'Avenir de L'Artillerie*, vol. iii., p. 121.

[3] Some time between 1400 and 1450. The first mention of priming powder—"poudre d'amorce"—occurs in the *Le Passé et L'Avenir de L'Artillerie*, vol. iii., p. 149. The passage is extracted from an old French work, and is in such old fashioned French as to be almost unintelligible, and I have thought it unnecessary to quote it.

[4] *Ibid.*, vol. iii., p. 149 (see preceding note).

[5] *Le Passé et L'Avenir* contains no mention of the linstock or match until the beginning of the 17th century. "L'Affût du faucon portait . . . . une boute-feu "(linstock) avec sa mèche."—*Ibid.*, vol. iii., p. 319. But Major Miller, quoting Whitehorne, who wrote in 1560, describes the linstock or linte-stock, as "a matche "fastened to the end of a staffe a yarde or two yardes long."—*Equipment of Artillery*, p. 104. This places the match at least as early as the 16th century; and it may have been used in the latter half of the 15th, or on the first introduction of priming powder.

[6] *Le Passé et L'Avenir de L'Artillerie*, vol. iii., p. 338.

[7] The explosive action of quickmatch when confined in a cylinder of paper or linen or any other material in the form of a "leader" (see p. 226) is well known, and is similar to that of a tube (for an explanation of this action see p. 225), the hole being in this case not up the centre as in the tube, but between the match and the sides of the cylinder or vent.

But it is evident that quickmatch is much less powerful than a tube; for the double reason that the quantity of explosive matter which it contains, and so the quantity of gas which it evolves, is less than that of a tube of the same size, and that the space between it and the sides of the vent is proportionally much greater than the space formed up the centre of a tube. (For advantages of small hole in tube, see p. 203.) It is instructive to remark that the name which the French now commonly give to their tubes "Etoupille" is derived from the word "Etoupe," which signifies in pyrotechny a "thread or match prepared in a particular way." James' *Military Dictionary*, p. 415.

[8] This name occurs in a description given in *Le Passé et L'Avenir de L'Artillerie*, vol. iii., p. 338, of the operation of priming a mortar in those days. "Un morceau "d'une étoupille qui était nommée *porte-feu* était placé dans la lumiere du mortier et "entouré de cire qui l'y fixait, après quoi on amorçait encore avec de la poudre fine "dont on remplissait le bassinet. Une autre partie de cette étoupille appelée *porte-"feu* était placée dans le boute-feu, et le bombardier s'en servait pour mettre le feu "d'abord à la fusee de la bombe, puis à l'amorce du bassinet."

Although about this time, or even earlier, the flint had been introduced as a means of firing small arms,[1] no attempt seems to have been made for about 200 years to extend its employment to cannon.

Quickmatch tubes.

In the meantime an improvement was being made in the method of priming guns ; the quickmatch was no longer used by itself, but was placed inside a tube which could be dropped into the vent, and the top of this tube being primed the train of loose priming powder was done away with. The great improvement was made apparently some time in the first half of the 18th century,[2] perhaps rather earlier. The advantages resulting from the introduction of tubes were not only (*a*) increased rapidity of fire,[3] the difficulty and delay, which must have been considerable, of threading the quickmatch into the vent and training loose powder up to it being done away with ; but (*b*) the protection of the vent,[4] which in the absence of a tube, more especially when loose powder was used, became worn or burnt away very rapidly ; and (*c*) greater security from accidents, such as might and no doubt did frequently result when priming had to be used.

About this time, too, viz. the end of the 17th or beginning of the 18th century, it seems probable that portfires were introduced, for we find mention of them in works of a few years later date.[5]

We thus arrive at the fact that tubes made with quickmatch threaded through them and primed, and which were fired by slow match or portfires, were in use about the beginning of the 18th if not during the close of the 17th century.

Regular tubes.

No doubt it was soon discovered that these tubes were too weak, and that a great increase of strength might be obtained by substituting for the quickmatch composition with a cavity up it, and in a few years we find mention of this improvement having been effected. The French tubes are described in 1768 as being "filled with mealed powder " moistened with spirits of wine ; a small hole is made through them " the size of a needle, through which the fire darts with great " violence and gives fire to the cartridge, which must be pierced " beforehand with the priming iron." [6]

This description would answer perfectly for a tube of the present day ; it only remains, therefore, to inquire into the material then employed for the bodies of the tubes, and the connexion between the tubes of the early part of the 18th century and the "common" tubes (pl. 5, figs. 1 to 5) at present in use will be complete.

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[1] *Le Passé et L'Avenir de L'Artillerie*, vol. iv., p. 58, *et seq. Hythe Text Book*, p. 99.

[2] "Tubes of this kind were in use in 1766." *Equipment of Artillery*, p. 113.

In Muller's *Treatise of Artillery*, published in 1780, one of these tubes is described ; the tube is made of tin, "through this tube is drawn a quickmatch, the cap is filled " with mealed powder moistened with spirits of wine." These tubes had a cap of paper tied on, " but latterly this cap is made of flannel steeped in spirits of wine, and " with saltpetre dissolved in it, and there is no occasion to take it off, since it takes " fire as quick as loose powder," p. 203. James, in his *Military Dictionary*, p. 415, describes the same tube.

[3] Muller speaks of tubes as "tubes *used in quick firing.*" (*Treatise of Artillery*, p. 203) ; and it is not improbable that they were *first* used specially for quick firing.

[4] Appendix to Muller's *Treatise on Artillery*, *Artillery Dictionary*, *at the end*, *p.* 30.

[5] "Portfires have been in use since the beginning of the last century."—*Equipment of Artillery*, p. 104.

Muller, writing in 1768, says, "Portfires are used sometimes instead of matches to " set fire to powder or composition."—*Treatise on Artillery*, p. 202.

And an old *Traité d'Artifices*, prepared at Strasbourg in 1764, and quoted in Scheel's *Mémoires d'Artillerie*, p. 160, says that tubes were fired " avec une mèche ou " une lance à feu."

[6] Muller's *Treatise on Artillery*, p. 203.

Various materials were used for the bodies; the most common was tin, which, however, was objected to as being injurious to the composition which it contained, and as being very succeptible to corrosion.[1]

The French employed reeds,[2] and some experimental tubes as it appears were made of copper[3] which was no doubt preferred to tin, then as now on account of its non-liability to corrosion.[4]

In addition to tin, brass, copper, and reeds, other materials have from time to time been adopted or suggested for tubes; paper, which seems first to have been employed by the Dutch,[5] pewter,[6] zinc, thin iron, and finally, in 1778, quill.

Some of these materials were badly suited for the purpose, and the only ones at present employed in our service are copper (pl. 5), quill (pl. 5), and paper (pl. 5) on an emergency. In the French service reeds[7] are still retained.

Tubes for many years were made of different lengths, and every piece of ordnance had a tube of the same length as its own vent.[8] In some cases they were made pointed and long enough to pierce the cartridge, doing away with the separate operation of pricking.[9] But this latter arrangement was found inconvenient, because from the end of the tube which projected inside the vent sometimes becoming bent by the explosion of the charge there was occasionally a difficulty in withdrawing the tube, the gun being in a way spiked.[10]

The plan of having tubes of different lengths was also manifestly inconvenient, but for a long time it was thought necessary, as the peculiar action of a tube, by which it ignites gunpowder at some distance from it, was not recognized. It is not easy to say exactly when the simplification of reducing all tubes to one uniform length was effected, but it seems certain that it did not take place until some time in the present century.[11]

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[1] "An objection is made against these tubes, which is that tin is apt to spoil the " quickmatch when they are kept for some time; and it is imagined that salt water " would soon corrode them."—Muller's *Treatise on Artillery*, p. 203.

" Le fer-blanc avait l'inconvénient de se rouiller facilement, et de gâter en peu de " temps la composition que l'on mettait dans les fusées."—Cotty's *Dictionnaire de l'Artillerie*, p. 139.

[2] "The French use a small reed to which is fixed a wooden cup about two inches " long."—Muller's *Treatise on Artillery*, p. 203.

[3] The fore-mentioned Saxon made his of copper tapering towards the end."—*Ibid.*, p. 203.

[4] Brass was substituted for tin on account of the latter being subject to corrosion." —*Equipment of Artillery*, p. 113; also *Pocket Gunner*, edition 1827, p. 382.

[5] Paper tubes retain to this day the name of paper or Dutch tubes.

[6] " Lieut.-Col. Harding of the Royal Artillery has invented a pewter tube."—James' *Military Dictionary*, p. 416.

[7] Thiroux, *Instruction d'Artillerie*, p. 69.

Reed tubes were for some time in use in our service, but are now quite obsolete.

[8] *Equipment of Artillery*, p. 113.

See also *Pocket Gunner*, edition 1813, p. 382, where the lengths of the different tubes are given; the largest for the 13-inch mortar was 12·2 inches, and the shortest for the 4⅖-inch mortar 3·6 inches. " On les fait . . . . de longueur et de grosseur " proportionnée aux lumières."—Cotty's *Dictionnaire D'Artillerie*, p. 139.

[9] " Autrefois on les faisait . . . . assez longues pour que le bout pût percer la " cartouche, ils évitaient par la manœuvre du dégorgeoir."—Cotty's *Dictionnaire de l'Artillerie*, p. 139.

It does not appear that English tubes were ever made in this way.

[10] " Ils éprouvoient l'inconvénient de voir leurs pièces enclouées par le porte-feu qui " restait dans la lumière, et se trouvait souvent comme rivé intérieurement par le " refoulement occasionné par l'inflammation de la poudre." *Ibid.* p. 139.

[11] Major Miller says it was not effected " until after 1813" (*Equipment of Artillery*, p. 113); and the *Pocket Gunner* of that date gives, as stated in note 8 above, the different lengths of the tin tubes then in use. But a later edition of this work (1827).

Hitherto we have had to do only with tubes which required the application of a match or portfire to ignite them, nor was the introduction even of these tubes by any means universal, the slow match and powder horn continuing to be used in our navy until quite the end of last century, probably because metal tubes (and with the exception of paper and reeds, no others were then known in our service) were considered dangerous and objectionable between decks.[1]

Introduction of quill tubes.

But in 1778 Sir Charles Douglas, on his appointment to the "Duke," brought before the Admiralty and the Ordnance several propositions "for improving, facilitating, and quickening the service of naval "ordnance,"[2] including introduction of flint locks and quill tubes; these propositions, however, were not immediately entertained, and the match and priming horn continued for some years in general use.[3]

But although flint locks and quill tubes were not officially or generally adopted, Sir Charles Douglas caused them to be supplied at his private expense to his own ship; "he bought a sufficient number of "common musket locks, which being let into pieces of wood, as into "the stock of a musket, might then be fastened with iron wire to the "guns. He purchased . . . . goose quills for tubes, and the "ingredients necessary to fill and prime them."[4]

The value and importance of this improvement was completely established in the great battle of the 12th April 1782. "On Sir "Charles Douglas' appointment to be captain of the fleet he was suc- "ceeded in the command of the 'Duke' by Captain, afterwards Lord "Gardner, and in the battle of the ensuing year the quick and efficient "firing of that ship was so conspicuous and powerful as to enable the "gallant Gardner to widen the gap which his leaders had made in "the enemy's line, and so open the way for Rodney to pass to a "memorable victory. That glorious day settled the question of locks, "by bearing down all further opposition to the introduction of im- "provements which the prejudices of the time deemed useless and "unnecessary refinements; but that battle having likewise put an end "to the maritime part of the war, no measures for the supply of locks "to naval ordnance appear to have been taken till 1790, when 'brass "locks' of a new pattern were provided, and continued in general use "throughout the late war. These no doubt contributed greatly to the "efficiency of our practice, to the accuracy and rapidity of which all "French authors attribute the superiority of our gunnery in the "actions and battles of the early part of the war, the French not "having adopted locks till 1800."[5]

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also gives tin tubes of different lengths, and it would appear that even if they were no longer manufactured the store was not yet exhausted.

Cotty's *Dictionnaire de l'Artillerie* (edition 1822) speaks of them as being of different lengths (p. 139).

The *British Gunner*, edition 1828, speaks of all the tubes then made as of two lengths, the brass three inches, and the paper two inches (p. 403). The simplification was therefore most probably effected between 1813 and 1828.

1 "Tin tubes would manifestly be dangerous and highly objectionable on the "fighting decks of a ship."—*Naval Gunnery*, p. 385.

2 *Naval Gunnery*, p. 385.

3 *Ibid.*, p. 385.

4 *Ibid.*, pp. 386–7.

5 *Ibid.*, pp. 387–8.

Sir Howard Douglas also quotes a passage from Lord Saumarez's *Naval Evolutions*, p. 46, which ascribes the invention of locks and quill tubes solely to Sir Charles Douglas, and which bears ample testimony to the value of the invention. The passage is as follows:—"Although strong prejudice and attachment to old customs prevented "the general adoption of that excellent system of naval gunnery (locks, quill tubes, This passage seems to fix the official adoption of flint locks and quill tubes for naval use at 1790.

The improvement was certainly a most important one, as tending to make the service of the guns both quicker and safer;[1] at the same time there were objections to the extension of the system *with the existing locks and tubes* to field service, because of the uncertainty of a single flint, and the difficulty of replacing it, and the obvious objections to a priming of loose powder.[2] These objections Sir Howard Douglas proposed to overcome by the employment, in the first place, of a lock with two flints, which would do away with the necessity which until then existed for the occasional employment of a match or portfire, and in the second place, of a tube with a peculiar priming which would do away with the priming of loose powder hitherto used.[3]

These locks were adopted for the navy in 1818,[4] but there is no record of the adoption of the tube.

In principle this tube was not unlike the "match" tube[5] proposed by Lieut. Fynmore, R.N. and adopted a few years later,[6] and which was generally used for all ordnance with flint locks until the adoption of the percussion principle several years later.

When or to what extent flint locks were adopted for land service is uncertain, but there is little doubt that it was some years after their introduction for naval use, and that their employment for land service never became general,[7] and a large, probably the larger, proportion of

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" flannel cartridges, &c.) of which Sir Charles was the sole inventor, it was found " to answer so well by Captain Gardner, who had so great a share on the 12th of " April 1782, that it afterwards became universally adopted in the navy."—See *Naval Gunnery*, p. 387, note.

[1] The following passage from a letter of Sir Alexander Dickson's to Sir Howard Douglas sets forth fully the advantages of locks:—"The use of locks with heavy " ordnance, particularly in the operations of a siege, presents very great advantages, " for by the employment of slow match only the fire is frequently retarded, and " nothing can be more dangerous than lighted portfires in a battery. I have seen " several very shocking accidents occasioned by the use of them, owing to the want " of presence of mind of the gunner having the portfire lighted in his hand at the " moment of a shell falling near him. In the sieges I have directed I have ever " prevented as much as in my power the use of portfires, but Ciudad Rodrigo was " the only operation in which I was fully successful in this respect, and it was to the " help of about 16 or 20 naval gun locks, in addition to the slow match used, that I " was indebted for the vigorous fire kept up in that attack. I trust in future, there- " fore, that in all siege equipments each piece of ordnance will be supplied with a " lock, the use of which under every circumstances, except in heavy rain, would " supersede the portfire, which in the very confined situation of a land battery, and " where much powder is in circulation, is so dangerous."—*Ibid.*, pp. 389–90, note.

[2] MS. letter of Sir Howard Douglas to Sir A. Fraser, 1818.—*Miscellaneous*, vol. i., p. 71.

[3] This tube is described as being one " with a large cake of priming, and notched " or mitred, so as to fold down into a groove in the pan, which upon being shut would " grind in the priming, exposing fresh surfaces easily ignited," and " be secure from " wind and rain."—*Ibid.*

[4] *Naval Gunnery*, p. 388, and note on same page.

[5] The match tube is not yet obsolete; see for a description of it, &c., p. 4.

[6] Probably between 1818 and 1824; men who were in the Royal Laboratory in 1824 speak positively to the Fynmore tube being then manufactured. The *British Gunner*, 1828 (p. 402) includes these tubes.

[7] A passage in *Naval Gunnery*, pp. 389–99, would almost imply that flint locks were never used for land service, and that their proposed adoption " remained in a state " of suspension, until at length the discovery of the percussion principle and its " application to fowling pieces indicated that all flint locks would ere long be super- " seded by percussion locks and tubes."

But there is no doubt flint locks were used for land service to a certain extent, and I conclude therefore that the passage refers merely to a lock of a particular construction, and not to locks generally.

land service guns continued to be fired with common quill or paper or tin or brass or reed tubes[1] by the application of a lighted match or portfire.

The next improvement was the adoption of the percussion principle for firing guns, an improvement which greatly increased the accuracy of the practice, particularly at sea or against moving objects, by making the firing of the gun more instantaneous,[2] besides effecting a great economy of material and space by the abolition of portfires, priming powder, &c.

Detonating tubes.

It is difficult to fix with absolute certainty the date of the introduction of the first percussion or detonating tubes, but there are good grounds for believing that none were made for service until 1831.[3]

These tubes were proposed by Mr. Marsh of the Royal Arsenal Surgery,[4] and consisted of a quill body, with a side quill filled with detonating composition, fixed on at right angles to the body, much as the "nib-piece" of the present copper friction tube is fastened on. The tubes were varnished over completely with sealing-wax varnish,[5]

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1 Mention is made of tubes of these different materials in Sir Augustus Frazer's MS. *Laboratory Work*, pp. 22–32. The *Pocket Gunner*, edition 1813, p. 381, edition 1827, p. 382, and *British Gunner*, edition 1828, p. 403, and in some MS. directions for making tubes which were in use in the Royal Laboratory.

2 "In every case where there is much motion (and there will be a great deal more in "propelled than in sailing ships) the shot will not be delivered from the cylinder until "its direction is altered, more or less, from that in which the piece was pointed when "the trigger was pulled. *It is thereby not only vastly important to use those means "that are best calculated to produce the most instantaneous discharge possible*, but "also to consider what direction and what particular part of a vessel's motions are "most favourable for firing the ordnance with the greatest prospect of effect."—*Naval Gunnery*, pp. 404–5.

"Coast battery guns will be required to 'shoot flying,' but they will have little "chance of hitting active steamers at considerable distances, ... unless the action "of the lock and tube be so quick as to produce the most instantaneous possible "discharge."—*Ibid.*, p. 391; see also *Ibid.*, p. 398.

3 "The detonating tubes for that ship (the 'St. Vincent') were the first made."—MS. Letter from Sir Augustus Frazer to Hon. Capt. Duncan, dated 29*th Dec.* 1831. *Miscellaneous*, vol. i., p. 193.

There seems to be an impression, however, that *experimental* percussion tubes had been made before this by Sir William Congreve and others, but I have not been able to find any authority to support this opinion.

4 Several persons employed in the Royal Laboratory speak so positively to Mr. Marsh having proposed these tubes, that I have no hesitation whatever in giving him the credit of the invention, although I have not been fortunate enough to come across any official recognition of the same.

Sir Augustus Frazer, in the letter quoted in preceding note, says, "Mr. Marsh, of "the Arsenal, is very zealous as well as very intelligent in the cause of percussion "and detonating improvements."

5 Red sealing wax dissolved in spirits of wine.

Several foremen and others of the Royal Laboratory who were engaged for some years in the manufacture of these tubes have described them to me; and in a small book of miscellaneous matter in Sir Augustus Frazer's handwriting, lent to me by General Lefroy, the following description of the tube occurs:—

"*Quill Naval Detonating Tube.*

"*Main tube*, quill 2½ in. long; nib cut off at bottom.

"*Side tube*, quill 1 in. long, snipped on one side by cutting knife.

"*Composition.*

"*Main tube*, common.

"*Side tube*, ·2 inch, mealed powder at end joining main tube; remainder of composition, half chlorate of potassa, half sulphuret of antimony.

"Both main and side tubes to be pierced with two sized pincers, to be cemented at joint, and both tubes varnished, care being taken that the main tube will freely enter the vent after varnishing."

and were known as the rectangular percussion quill tubes.[1] With this tube the lock was "fixed to the vent field out of the way of the explo- " sion from the vent,"[2] an advantage which no doubt originally recommended this construction to the inventor. But the tube was open to the objection of being comparatively sluggish in its action, thus defeating the principal object of the introduction of the percussion principle.[3]

Some slight alterations were made in the tube with a view to remedy this defect, apparently with but slight success, and a great variety of percussion arrangements and hammers for firing them were submitted for approval about this time and during the next few years.[4]

Eventually the plan of tying the detonating quill across the top of the main tube, which was cut into a crutch to receive it, was tried, and some few of these "crutch-tied" tubes seem to have been manufactured for service.[5]

This construction was not found convenient, the heads being liable to shift, and a further and final improvement was made in 1846, by the introduction, on the recommendation of the late Colonel Dansey, R.A., of the cross headed detonating quill tube (pl. 5),[6] which continued in the service until 1866.[7] Evidently, however, this plan, and that adopted in the "crutch-tied" tube, though doubtless increasing the rapidity of action of the tube, necessarily brought the hammer over the explosion of the vent. "Thus it was necessary to devise some " means by which the hammer, after having struck fairly upon the head " of the tube placed in the vent, should instantaneously slip or be drawn " aside, so as to be out of the way of the explosion through the vent. " Various modes of effecting this have been devised in the British and " in other naval services, but the most efficient and simple implement of " this nature is that invented in 1846, by the very able and skilful officer " Colonel Dundas, Inspector of Artillery."[8]

Cross-headed detonating tube.

The following description of the now obsolete cross-headed detonating tube may not be without interest.

The body of the tube is made of goose quill about 2·5 inches in

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[1] See account of the *Changes and Additions in Ordnance, &c.*, May 20th, 1846, par. 1.

[2] *Naval Gunnery*, p. 392.

[3] "This construction was found, however, to be so sluggish as not to accomplish the " great desideratum in naval gunnery, which is, that the firing of the charge and the " actual delivery of the shot from the gun shall take place as quickly as possible after " pulling the trigger line."—*Ibid.*, p. 392.

[4] Descriptions of some of these plans, and of the trials to which they were subjected, are given in a little MS. book of miscellaneous matter by Sir Augustus Fraser, lent to me by General Lefroy, vol. xix., pp. 1, 14, &c. It appears that in 1832 a "Joint " Naval and Artillery Committee" was formed to inquire into the subject; as, however, none of the plans submitted met with approval it is unnecessary to detail them. For an account of the different locks tried see *Naval Gunnery*, pp. 392 to 397.

[5] At least so I am told, but there seems to be some doubt as to whether these " crutch-tied" tubes were ever anything but experimental.

[6] Approved by the Master-General, 9th September 1846. See *Account of the Changes and Alterations in Ordnance, &c. &c.*, 20th July 1847, par. 1.

[7] *War Office Order*, 6th September 1866, 75/10/445.

[8] *Naval Gunnery*, p. 392.
Col. Dundas' lock seems to have been approved by the Master-General, 2nd October 1846. See *Account of Changes and Additions in Ordnance, &c., &c.*, 20th July 1847, par. 7.

length,[1] cut clear of pith and scraped clean on the outside to the required gauge.[2]

At a very short distance from the top of the tube[3] a hole is bored transversely through both sides of the quill. Into this hole, after the body has been driven[4] and pierced[5] in the usual manner,[6] a small pigeon's quill or "snipe" is inserted, crossing the tube at right angles, and secured by being tied on with fine silk. The snipe has previously been filled with detonating composition consisting of—

Potash, chlorate of[7]	6 ozs.
Antimony, sulphide of[8]	6 ,,
Glass, ground[9]	1 oz. 10 drams.

damped with spirits,—methylated, 1 quart; shellac, 357 grains; in the proportion of 75 minims to 1,000 grains of composition.

The open[10] end of the snipe is filled with shellac putty.[11]

The portion of the tube above the snipe is filled with L.G.[12] powder to increase the flash, and closed against moisture by shellac putty.[13]

The body of the tube is varnished black,[14] and the head snipe, with a thicker varnish, red.[15]

These tubes are ignited by percussion, the blow being delivered by a hammer fixed on to the gun for the purpose, and thrown over on to the tube by the pull of a lanyard. The pull must be a sharp one, or there will be a chance of the tube and cross-head being bruised without igniting.

They were formerly used for land[16] and sea service, but they have

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[1] Only the extreme point or nib of this tube is removed, the tube being filled from the top, which makes it unnecessary to cut off as much from the end as must be removed in the case of the common quill tube. Indeed, except for convenience in inserting the clearing wire, it is unnecessary to cut off even the point of these tubes.

[2] The working gauge is ·196 inch.

[3] As short a distance as possible, for the reason that all the quill above this hole will have to be crushed by the hammer before the blow reaches the "snipe." The distance is actually about ·1 inch, or ·15″, meaning to the centre of the hole.

[4] With a drift, No. 7 W.G., having a projecting point.

[5] With No. 19 copper wire.

[6] See note 1 above, on these tubes being filled from the top.

[7] See p. 315. [8] See p. 311.

[9] Bottle or window glass is preferred to flint glass on account of its superior hardness. Moreover, chemically, bottle or window glass is generally superior. "Common bottle glass or window glass should be used. Flint glass contains a small "proportion of silica, and a large proportion of the oxide of lead; and chemical "research has shown that the combination of the bases with the acid in such a com- "position is comparatively unstable: the consequence will be a separation of the "alkali potash, which is very deliquescent."—Col. Boxer's *MS. Notes*, p. 70.

The chemical superiority of bottle or window glass is not, however, so apparent for those detonating compositions from which, as in the one under consideration, and as in most of those employed for tubes, fuzes, &c., the influence of the atmosphere is almost completely excluded; it is only when exposed to air that flint or lead glass is more prone to change.

[10] The nib is not removed from the end of the snipe.

[11] For composition of the shellac putty, see table XX., p. 345.

[12] L.G. powder is preferred to a finer grained powder, as being less likely to get into and choke the central hole of the tube.

[13] See table XX., p. 345.

[14] For composition of this varnish, see table XX., p. 345. "It is desirable to "varnish or paint the whole surface of the tube, as the quills are liable to attract "moisture from the atmosphere."—Col. Boxer's *MS. Notes*, p. 72.

[15] See table XX., p. 345.

[16] See history, p. 192.

been completely superseded on land by the copper friction tube; for sea service by the quill friction tube.

They are open to the following objections :—

"1st. It is evident that before the blow from the hammer can take effect upon the detonating composition the projection beyond the cross quill must be destroyed, and therefore a comparatively large amount of force is required to ignite the tube.

"2nd. Should the vent of the gun be at all enlarged, and the blow not sufficiently strong, the cross quill will be doubled up, and the whole tube forced into the vent, till the top of it is flush with the vent field. Should this happen, it will cause great delay, for it is exceedingly difficult either to remove the tube or to ignite it on account of the putty at the top. This circumstance constantly occurs in practice, and the difficulty is generally overcome by forcing the tube down the vent with the priming wire, a most dangerous operation on account of the presence of the detonating composition, which is very liable to ignite by the friction." [1]

Adoption of percussion principle for land service.

Thus far we have traced the application of the percussion principle to *naval* guns only; we have now to see how far the same contrivances have been brought into use for land service.

There is no doubt that detonating tubes were not used on land for several years after they had been introduced into the navy. An attempt seems to have been made in 1832 to employ for field service detonating tubes, on the same principle as the rectangular detonating quill tube then in use in the navy; with the exception that tinned brass was substituted for quill.[2] There is no record of these tubes having been adopted, nor was any subsequent attempt to introduce detonating tubes for field service more successful. But in 1845 the "rectangular percussion quill tube" was adopted for garrison and siege service [3] and in the following year superseded, on the recommendation of Col. Dansey, by the cross-headed tube (pl. 5).[4]

In 1846, therefore, we have the cross-headed quill tube in general use for land-service, except for field service, with which common tubes and portfires continued to be employed.

Percussion caps.

It should also be mentioned here that in 1844 Major Jacob proposed, as an improvement on detonating tubes and hammers, the employment of a percussion cap, and the experiments with these caps seem to have been decidedly successful.[5]

Friction tubes adopted.

In the meantime the attention of some of the officers and foremen in the Royal Laboratory had been directed to a tube brought over to this country by a German officer, Lieut. Siemens, which depended not upon percussion, but upon friction, for its ignition.[6] Several attempts were

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[1] Col. Boxer's *MS. Notes*, pp. 71, 72.

Perhaps a safer plan would be to place the head of another detonating tube over the vent and fire it by means of the hammer on the chance of the flash from the detonating composition igniting the first tube.

[2] An account is given in the little MS. Book of miscellaneous matter before referred to (vol. xvi., p. 58), of the "brass detonating tubes then (1832) on trial for field service." In appearance they must have been very like the present copper friction tube. They seem to have answered but indifferently, and there is a remark to the effect that "their utility in superseding common tubes and portfires was not yet apparent."

[3] Approved 21st November 1845. See *Account of the Changes and Additions in Ordnance, &c.*, May 20, 1816, par. 1.

[4] Approved 9th Sept. 1846.—*Ibid.*, 20th July 1847, par. 1.

[5] For account of the trials made by two committees to whom this "percussion gun "cap" was submitted, and for extracts from their Reports, see *Naval Gunnery*, pp. 398 to 403.

[6] In 1841 100 "metal friction tubes," invented by Lieut. Siemens, were ordered to be made in the Royal Laboratory for experiment.—Board's Letter, 24 Dec. 1841, M/1425.

made to introduce them, and Colonel Dansey designed some quill friction tubes,[1] which, however, were not introduced. It seems that an objection was made to them on the ground that the detonating composition would eat away the friction bar, and so speedily render them unserviceable.

In 1851 [2] Mr. Tozer of the Royal Laboratory succeeded in perfecting a copper friction tube (plate 5), of the pattern now in use, and this tube was adopted for all land service artillery, whether field, garrison, or siege, on 24th June 1853.[3] It was not recommended for naval service, on the ground that any metal tube would be dangerous and highly objectionable between decks.

A few years later, however, Colonel Boxer recommended a quill friction tube, for naval service, which was adopted in 1856.[4]

This tube resembled that now in use, although a change was made in the pattern in 1859, when the loop was dispensed with [5] and an arrangement made by which the tube would be supported under the pull of the lanyard in a small "crutch" fitted on to the side of the vent.[6]

In 1865,[7] however, the original plan of a loop was reverted to, complaints having been made of the crutch arrangement being inconvenient, and the adoption of this pattern was followed (in 1866) by the abolition of the cross-headed detonating tube.

The introduction of friction tubes was a great improvement for both land and sea service; in the field they superseded, as we have seen, the common tubes and portfires, the objections to which have been already pointed out, viz., that they retarded the service of the guns, and that their employment was attended with considerable danger; and, moreover, the risk of setting fire to ripe corn, dry grass, &c., is much less with friction tubes than with portfires, "for the setting fire to a country "more generally arises from cutting the portfire than from the dis- "charge."[8] For garrison and siege and sea service they superseded, in the two former services entirely, in the latter service partially,[9] the detonating tube. Subsequently, in 1866,[10] the detonating tube became altogether obsolete. In this way the hammer is got rid of and the firing of the gun is in all probability more instantaneous. The only objection entertained to them by the navy seems to be that the friction bars are apt to cut the men's bare feet.[11]

The few minor alterations which have been made in the different tubes of late years, such as the substitution of copper for brass for the

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[1] Some quill friction tubes were ordered to be made for experiment, 21st May 1841, M/207, and were reported ready for issue, 18th August 1841.

[2] This tube seems to have been first submitted on 23 May 1851. Experiments were also made the same year with quill friction tubes on pattern of one obtained from French frigate "Bellepoule," but more detonating composition was required than it "was deemed prudent to use." Some more of Col. Dansey's quill friction tubes were tried in 1845.

[3] Board of Ordnance letter, 24th July 1853, M/316.

[4] Approved 16th July 1856.—See *Account of Alterations and Additions in Ordnance, &c.*, 31st May, 1857, par 2.

[5] Approved 21 April 1859.—*Royal Artillery General Regimental Orders*, 415, 1 Dec. 1859, par. 10.

[6] For description of the "friction tubes without loops" see note 3, p. 206.

[7] 21st November 1865, *War Office Circular* 8 (new series), § 1148.

[8] Sir Alexander Dickson, quoted in *Naval Gunnery*, p. 390, note.

[9] One third cross-headed tubes were issued to the navy in case of failure on the part of the friction tubes.

[10] *War Office Order*, 6th September 1866, 75/10/445.

[11] The same objection was urged against Major Jacob's caps, see Report of Naval Committee, *Naval Gunnery*, p. 402.

common metal tube in 1854;[1] the abolition of this tube in 1865;[2] the varnishing the detonating tubes black, instead of with red sealing-wax varnish, in 1857;[3] the adoption of tin or zinc cases for packing in the same year,[4] the introduction of the dummy friction tube for drill in 1863;[5] the introduction of a slightly improved quill friction tube (Pattern II.) in 1866,[6] and the lacquering in the following year of metal tubes *inside* as well as out;[7] these changes it is unnecessary to dwell upon. All that remains to be noticed regarding the history of tubes is the introduction for special purposes of tubes fired by electric agency.

Application of electric agency.

Until 1856 guns were fired at proof by the clumsy and dangerous plan of priming the vent with a tube, or with fine powder, and placing over it a piece of portfire intended to burn about three minutes and fastened on to the gun by means of clay. All being ready the portfires were lighted and the proof party then retired to a safe distance.[8] A curious accident, which took place in May 1852 at the proof butt, Woolwich, illustrated in a remarkable manner the danger of this plan. Several 56-prs. were being proved, when, owing to the lengths of portfires not burning precisely the same time, the charge of one gun became ignited before that of some of the others. This gun burst, and one of the fragments striking the adjoining gun, swung it round in the direction of the Arsenal. The piece of portfire, however, was not displaced, and the charge becoming almost immediately ignited, the shot was projected over the Arsenal and town of Woolwich, falling eventually in the Dockyard, but happily without doing much damage.[9]

In spite of this accident guns continued to be fired in the manner described.

Another accident of a similar description was narrowly escaped a few years later (close of 1855), when one of the fragments of a burst mortar struck and slewed round another mortar, "laying" it exactly for the Royal Artillery Barracks. Luckily, however, this mortar had fired just before being struck. This last escape resulted in an order being given by Col. Eardley Wilmot, that guns should only be proved one at a time; and meanwhile Mr. McKinlay, the proof master, had turned his attention to the firing of guns at proof by galvanic agency, and had contrived a tube with that object.

The principle of firing powder by electricity was not new, although it had not been previously applied on a large scale to the firing of the charges of guns, having hitherto been mainly used for the exploding of mines. The first employment of electricity as an agent for effecting the ignition of gunpowder, dates as far back as 1751, and is due to

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[1] Copper had been previously employed for the friction tube, and, indeed, as before pointed out (see p. 190), for common tubes before 1768, after which the common metal tubes in this country continued to be made of brass until the close of 1854. In that year Captain Frazer recommended the substitution of copper for these tubes; in making the suggestion he stated, "The composition will be better kept, the chemical action on "the copper not being so strong, and I have found, on trying some of the brass tubes "in the Laboratory that they sometimes, by expanding, act as a partial spike in the "vent when fired."—Letter from Capt. Fraser, R.A. to Superintendent, Royal Laboratories, 28 August 1854.

[2] 13th October 1865, *War Office Circular* 8 (new series), § 1149.

[3] 24th Dec. 1857. See Royal Artillery, General Regimental Orders, 4)2, par. 14.

[4] *Ibid.*

[5] Approved 10th July 1863.—*War Office Circular*, 842, par. 802.

[6] See *War Office Circular* 8 (new series), § 1148, note.

[7] Lacquering inside provisionally approved, 2/5/67, *W.O. Letter* 3/5/67, 75/10/509.

[8] *Proceedings Royal Artillery Institution*, vol. i., p. 36.

[9] See account of this accident given *Ibid.*

Franklin; while later, in 1767, Priestley turned his attention successfully in the same direction.[1] The electricity then employed was "frictional electricity," and the experiments which were made with it were scarcely of a practical or useful character. "It was not until "1831, that an actual application of frictional electricity to mining "purposes was first made by Moses Shaw of New York, who with "fuzes charged with gunpowder and fulminate of silver succeeded in "exploding several mines simultaneously, detaching large masses of "rock. It is stated by him in his account of the experiments, that he "was unable to operate during the greater part of the year, on account "of bad weather. In 1842 and 1843, Messrs. Warrentrap, of Brunswick, and Götzmann of Freiburg, made more successful experiments. "Having effected improvements in the insulation of the conduction "wires used, and employing fuzes which contained a mixture of sulphide of antimony and chlorate of potassa, they succeeded in exploding "from eight to ten mines simultaneously through 78·5 metres. Notwithstanding these results, they were compelled to abandon the "attempt to employ electricity as a certain agent for the explosion of "gunpowder, on account of the evil influence of atmospheric moisture. "In 1845 the subject was again brought up by Mr. Charles Winter, "who succeeded in inflaming powder, through a telegraph wire, reaching "between Vienna and Hetzendorf, a distance of 4,906 metres."[2]

The success of the Ruhmkorff coil in 1853 induced the Austrian Government to call upon the Imperial Engineer Academy to "propose "a system of exploding charges by electricity,"[3] probably intending that the electricity employed should be electro-magnetic instead of frictional.

"The somewhat complicated character of the induction coil machine," however, "and the necessity for the employment of some voltaic battery "with it, appear to have been accepted at the outset, by the Austrian "investigators, as formidable obstacles to the application of the apparatus "in question to military purposes. Attention was therefore again "directed to the application of frictional electricity; and, after three "years' experiments, a system of operation, involving the employment "of an electric machine, was considered to have been sufficiently successful for introduction into the engineer service. The system in "question appears to have furnished very important results, and to "have been frequently applied to industrial operations."[4]

The objections to this system are "that some scientific skill is "required in the manipulations, that great care is needed in the preservation of the apparatus, and that the inductive action is sometimes "so energetic that explosions are occasionally determined in other "mines, not intended to be included in the series, and not connected "with the machine."[5]

The method of ignition employed with frictional electricity, was simply the separation of the wires, the spark from which, passing through the powder or other explosive substance, fired it.

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[1] "The employment of electricity as an agent for effecting the ignition of gun-"powder suggested itself to Franklin in 1751, and to Priestly in 1767."—Abel on *Recent Applications of Electricity to the Explosion of Gunpowder*, p. 1, see also *Ibid.* p. 10.

[2] Abel on *Recent Applications of Electricity to the Explosion of Gunpowder*, pp. 10, 11.

[3] *Ibid.* p. 11. A description of the apparatus employed is given, *Ibid.* pp. 11, 12.

[4] Abel on *Recent Applications of Electricity*, p. 11. A description of the apparatus employed is given.—*Ibid.*, pp. 11 and 12.

[5] *Ibid.*, p. 12.

It is stated that Mr. Hare was the first who "entertained the idea" of exploding mines by voltaic electricity by rendering incandescent a wire traversed by a galvanic current.[1]

This was probably about 1831.[2]

The idea was realized about 1838[3] by Mr. Roberts,[4] who devised a description of fuze, or "cartridge," which is thus described: "Two " copper wires are procured about a tenth of an inch in diameter, and " three yards in length, well covered with silk or cotton tarred, so that " their insulation may be very good. They are twisted together for a " length of six inches, care being taken to leave their lower extremities " free for a length of about half an inch (separating them about half " an inch), from which the insulating envelope is removed in order to " stretch between them a fine iron wire after having taken the pre- " caution of cleaning them well. The upper extremities of the two " copper wires are likewise separated, in order to allow of their being " placed respectively in communication with the conductors, that abut " upon the poles of a pile. The body of the cartridge is a tin tube " three inches long and three-quarters of an inch in diameter, the " solderings of which are very well made, in order that it may be " perfectly impermeable to water. A glass tube might equally well " be employed, were it not for its fragility, which has caused a tin " tube to be preferred. The system of copper wires is introduced into " the tube, fixing them by means of a stem that traverses it at such a " height that the fine iron wire is situated in the middle of the tin tube, " so arranged that the ends of the copper wire do not anywhere touch " the sides of the tube. The cork is firmly fixed at the upper extremity " of the tube with a good cement; the tube is then filled with powder " by its other extremity, which is likewise stopped with a cork, that is " cemented in the same manner."[5]

Some attempts had been made to apply this principle of ignition to the firing of guns as early at least as 1853;"[6] but they were chiefly of an experimental and imperfect nature; and it was not until 1856, when Mr. McKinlay submitted his "galvanic tube" (pl. 5), that the principle can be said to have been definitively adopted for this particular purpose.[7]

Galvanic tube. The system of ignition adopted in the galvanic tube was that which Roberts had previously made use of in his "cartridge;"[8] but the application was necessarily somewhat different,[9] and the cartridge body filled with powder was replaced by a tube driven and pierced in the usual manner and fitted with a head containing the arrangement for firing it.[10]

The body of the galvanic tube (pl. 5 fig. 6). was made of quill (pl. 5, fig. 1) $2\frac{3}{4}$ inches in length, driven and pierced in the usual

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[1] De la Rive's *Treatise on Electricity*, vol. iii., p. 319.

[2] *The Annals of Electricity*, vol. iv., p. 359. It is stated in this work that the idea was suggested by the abortive efforts of an ingenious individual of the name of Shaw, to effect this object by mechanical electricity.

[3] *Transactions and Proceedings of the London Electrical Society from* 1837 *to* 1840, p. 77.

[4] *Ibid.* p. 77. Also De la Rive's *Treatise on Electricity*, vol. iii., p. 319.

[5] De la Rive's *Treatise on Electricity*, vol. iii., pp. 319, 320. I have given this extract at length, in order satisfactorily to establish Mr. Roberts' claim to the first application of the principle which is followed out in the galvanic tube.

[6] Abel mentions that a gun at Dover was fired by a battery at Calais by voltaic agency in that year.—Abel on *Recent Applications of Electricity*, &c., p. 4.

[7] The date of the adoption of McKinlay's galvanic tube is 9th February 1856.—*War Office Letter* of that date, 273/24/1.

[8] See text above.

[9] Compare description of Roberts' cartridge with that of the galvanic tube at p. 201.

[10] See p. 201.

way.[1] On to the top of the tube was secured, by means of shellac varnish, a nearly hemispherical box wood head (pl. 5, fig. 2) ¾ of an inch in diameter. This head had a central vertical hole, into which the top of the body fitted. The upper or flat side of the head was cupped out,[2] the bottom of the cup being flush with the top of the body.

Through the head, on either side of the central hole, were two horizontal perforations, which were lined or bushed with copper tubing (pl. 5, fig. 3).[3] These perforations were so situated that the upper surfaces of the bushes were exposed in the cup. These surfaces were connected by a fine steel[4] wire (pl. 5, fig. 2), which passed through the cup, its ends being soldered on to the bushes. The cup was filled with L.G. powder,[5] and capped with a disc of stout paper (pl. 5, fig. 5),[6] over which was a disc of a finer[7] paper (pl. 5, fig. 4), the edges of which were snipped, and varnished over the edge of the cup.

The body was unpainted. The head of the tube is varnished yellow.

These tubes were fired by means of a voltaic battery, the action being as follows :—The circuit wires of the battery were placed in the copper bushes, one end in each, and the current passing along these wires was brought to the bushes, and thus to the steel wire by which these bushes are connected. This wire being of inferior conducting power offered a resistance to the passage of the current, and becoming instantaneously[8] heated to redness, the powder in the midst of which it was situated was ignited and the tube fired.[9]

These tubes were used for proof of ordnance and experimental firing from the date of their introduction in 1856 till 1862, when they were in a great measure superseded for these purposes by the electric tubes[10] (pl. 5, fig. 2). They were formally pronounced obsolete in 1866.

Electric tubes.

The galvanic tube continued to be used from the date of its introduction in 1856, for proof and experimental purposes, until 1862, when an instrument and tube for firing guns, by means of "magnetic induction" or "magneto electricity," were perfected by Mr. Abel (Chemist to the War Department) and Professor Wheatstone.

Not only is the nature of the electricity employed for these tubes different from that hitherto in vogue, being magnetic instead of galvanic electricity; but the principle of ignition is different, being one which had originally been proposed by Messrs. Statham and Brunton about 1851,

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1 Driven from the top. It is only nibbed to the same extent as the detonating quill tube, see p. 195, note 1.

2 To the depth of 0·2 inch.

3 13½ oz. copper sheet.

4 Steel wire, about No. 40 wire gauge. Some of the first galvanic tubes had platinum wire, but iron wire being cheaper and equally effective it was adopted instead.

5 L.G. powder was preferred to a smaller grained powder, as being less likely to get into and choke the central hole of the tube, and so interfere with its action.

6 "White wrapping" paper.

7 "Purple fine" paper.

8 The rapidity with which the wire becomes incandescent depends upon the strength of the current of electricity, but for practical purposes it may be regarded as instantaneous.

9 "The . . . . method . . . . consists in causing the current (at the place where "the powder is to be exploded) to traverse a short piece of fine wire made of some "metal of inferior conducting power, such as platinum or iron, which in consequence "of the resistance offered to the passage of the current is raised to a red heat on "completion of the metallic circuit, of which it forms a portion. The thin wire is "surrounded with gunpowder."—*Abel on Recent Application of Electricity to the Explosion of Gunpowder*, p. 2.

10 See p. 209.

and applied by them in a fuze, known commonly as "Statham's fuze," in which a spark *passing through a priming material* is substituted for the incandescence of a wire, and for the simple spark of frictional electricity,[1] in order to bring about the ignition of the powder. The Statham's fuzes "are prepared by taking two ends of copper wire " covered with ordinary gutta-percha ; their extremities are stripped " of the gutta-percha, they are twisted, and the ends are bent so as to " make them enter into an envelope of vulcanized (sulphured) gutta- " percha, which has been cut off from a copper wire, which has been " for a long time covered with it. Upon this envelope a sloping cut is " formed, and after having maintained the extremities of the copper " wires at about the eighth of an inch from each other, their points are " covered with fulminate of mercury, in order to render the ignition of " the powder more easy. The cut is filled with powder ; and the " whole is wrapped round with a piece of caoutchouc tube, or else it is " placed in a cartridge filled with powder. In the Statham fuzes, it is " the sulphuret of copper adhering to the layer of vulcanized gutta- " percha, which is removed from the copper wire that it covered, " which by being inflamed under the action of the induction spark " brings about the explosion."[2]

Statham's fuzes were originally intended to be fired by means of voltaic electricity,[3] but they were subsequently used by M. Ruhmkorff and Colonel Verdu (of the Spanish service) in some experiments with electro-magnetic induction, or "volta-induction," instituted with Ruhmkorff's coil,[4] and were probably used with that apparatus by the Russians in their mining operations at the siege of Sebastopol, and by Messrs. Dussant and Rabatter at the port of Cherbourg in 1854.[5]

Subsequently experiments were made at Woolwich with a view to determining whether any priming material superior to the sulphuret of copper proposed by Statham could be employed ; and in the end' the " best results were obtained with fulminate of mercury."[6]

About this time attempts were made to substitute magneto-electricity for electro-magnetism, and in the first experiments at Woolwich a powerful magneto-electric machine which had been constructed by Mr. Henley and exhibited by him at the Paris Exhibition in 1855 was employed.[7] Even with this powerful instrument it was evident that some other priming material than that employed by Statham was requisite to ensure certainty of action ; still more evident was it that the old plan of allowing the spark to act upon gunpowder itself could not be depended upon.[8] The final efforts were therefore directed to the discovery of a suitable agent to serve as a perfectly certain medium (or priming material) for effecting the ignition of charges by means of the magneto-electric machine.[9]

After a long series of careful experiments conducted by Messrs. Abel and Wheatstone[10] the priming material at present in use[11] was adopted,

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[1] "It happens that when, by the effect of the length of the conductors that abut " upon the mine, the circuit presents too great a resistance, the induction spark is able " to pass through the powder without inflaming it."—*De la Rive*, vol. iii., p. 321.

[2] De la Rive's *Treatise on Electricity*, vol. iii., pp. 321, 322.

[3] Abel on *Recent Applications of Electricity*, &c. &c., p. 2.

[4] *Ibid.*, p. 16 ; De la Rive's *Treatise on Electricity*, vol. iii., p. 321.

[5] Abel on *Recent Applications of Electricity*, &c., p. 7.

[6] *Ibid.*, p. 8.

[7] *Ibid.*, p. 16.

[8] *Ibid.*, p. 16.

[9] *Ibid.*, pp. 16, 17.

[10] These experiments are detailed in Abel on *Recent Applications of Electricity*, from which I have made a lengthy extract in Appendix I., see p. 375.

[11] See page 210.

and a system of tubes for firing guns,[1] fuzes for firing mines,[2] and magnetic machines for exploding these tubes and fuzes, was designed.

The system of firing guns, &c. by means of magneto-electricity presented several advantages over the existing plan of employing voltaic agency;[3] and in 1862[4] the "electric tube" (pl. 5, fig. 2), which was the result of the above-named experiments, superseded the galvanic tube for proof and experimental purposes.

Class I.—Tubes.

Tubes. General description.

Tubes for firing guns may be generally described as hollow cylinders of quill[5] or copper or paper driven with mealed powder[6] damped with methylated spirits,[7] and pierced up the centre with a fine hole; each tube being fitted with an arrangement for igniting it, according to its nature.

These tubes are made of a size to enter easily the vents of all service guns, viz., about ·2 inch,[8] the diameter of all vents being about $\frac{2}{9}$ths of an inch; they are from 2·5 to 3 inches in length.

Upon the hole up the centre of the composition the action of the tube depends; without this hole it would burn as a fuze or portfire.[9] The actual effect of the hole is to expose a large surface of composition to immediate ignition; and the gas which is thus generated being subjected to considerable pressure in the cavity, necessarily rushes in the only directions in which an escape is open to it, viz., through the tube, with accumulating force, producing an explosion, the effects of which are directed in the prolongation of the tube.[10]

The distance at which these effects will be serviceable varies, of course, with the force of the tube,—in other words, with the velocity with which the gas issues from it. This will depend "upon the amount "of pressure which the particles have been subjected to in the cavity." Now, the pressure increases in proportion to the quantity of gas generated, and diminishes as the space which is occupied by the gas increases. If this principle be taken into account, it is evident that a small cavity in a tube is more advantageous than a large one, for the quantities of gas are as the ignited surfaces, whereas the spaces occupied by the gas are as the squares of those surfaces;[11] therefore, although by

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1 See page 209.

2 See page 284.

3 For an enumeration of these advantages see page 211.

4 The electric tube was not *officially* introduced until 27th January 1866, *War Office Circular* 9 (new series), § 1201. Pattern II. was approved 23rd May 1866, *War Office Circular* 10 (new series), § 1237. The first issue, however, was made in 1862, which marks the date of its practical adoption.

5 The quill tubes (pl. 5, fig. 5) are not quite cylindrical, but the slope of the side is so slight that the term "cylindrical" may be allowed in a general description.

6 Mealed rifle F.G. powder is now generally used; but any powder will answer the purpose.

7 The quantity of methylated spirits used should be as small as possible, merely sufficient to *lay the dust* of the powder, and so to cause it to bind better. The more spirits are used the greater the chance of the composition fissuring and cracking when the spirits evaporate.

8 Not to exceed ·216 inch at the thickest part. Before varnishing, the body of the tube must not exceed ·208 inch, except in the case of the common quill tube, which, not being painted, may be ·216 inch.

9 Colonel Boxer's *Sandhurst Course*, p. 29.

10 The effects are sensible also in an upward as well as in a downward prolongation of the tube, and to the same distance and extent; but in a tube the downward effects alone are utilized, and practically therefore the upward effects may be disregarded.

11 The curved surface of a cylinder $= 2\pi rh$, where $h =$ height; volume $= \pi r^2 h$; and as the gases are as those curved surfaces, while the space which they occupy is as the volume, we have the pressure, or, in other words, the force, varying inversely as the square of the radius or circumference.

increasing the cavity the quantity of gas is increased, the amount of its elasticity is at the same time diminished.[1]

The quantity of composition in a tube will also affect its strength to a certain degree; and thus, with tubes of the same external diameter, the thickness of the metal employed for the bodies is a consideration which should not be overlooked. The thicker the material the less powerful, *cæteris paribus*, will be the tube.[2]

There are seven different sorts of tubes—

1. Copper friction tube. 2. Quill " "	Service tubes.
3. Common quill. 4. Match or Fynmore. 5. Paper, or Dutch. 6. Electric. 7. Dummy friction.	Tubes for exceptional and miscellaneous services.

Tubes, friction, copper (service).[4]

1. *Copper Friction Tube* (pl. 5).[3]—The body of this tube is made of copper,[5] and is about three inches in length. Near the top of the body, and at right angles to it, is fastened a small hollow cylinder or "nib piece" (pl. 5, figs. 4, 5) of copper[6] nearly half an inch in length. The nib piece is secured in its place by two projecting arms,[7] which are bent round the body; it is then woolded on by means of fine copper wire (pl. 5, fig. 3), and finally[8] soldered.

A fire hole is drilled into the body, in the prolongation of the nib piece,[9] to allow of the passage of the flame from the detonating to the tube composition.

When the body has been driven and pierced in the usual way a "friction bar" (pl. 5, figs. 6, 7) is inserted in the nib piece. The friction bar is a small, flat rasp of copper,[10] having an eye or loop stamped in it at one end, the remainder of the bar being roughened on both sides by a number of small grooves which are stamped across it, the end of the bar being doubled over to increase friction.

Above and below this bar are placed small rectangular patches of the following detonating composition:[11]—

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[1] Colonel Boxer's *MS. Notes*, p. 75.

[2] When the quill friction tubes were introduced it was observed that they were more powerful than the copper friction. This was accounted for by the copper being thicker than the quill.

[3] Approved 24th July 1853. Board's letter, M/316.

[4] The word "service" is introduced to distinguish this tube from that for the 7-pr. M.L. gun.

[5] 16 ounce copper sheet.

[6] 10 ounce copper sheet.

[7] These arms forming part of the nib piece. See pl. 5, figs. 4, 5.

[8] Copper wire, No. 30 W.G. "The tubes first made had not the copper wire "attached. It was found that some of them, when fired, burst open at the junction "between the rectangular tube and the body, and in some the rectangular piece was "blown away by the explosion of the composition."—*Memorandum from Colonel Boxer to Ordnance Select Committee*, 10/11/64.

[9] This is done after the nib piece is secured in its place, the drill being inserted through the nib piece.

[10] 24 ounce copper sheet.

[11] It will be observed that this composition contains no ground glass, like that of the detonating tube (see p. 195). In the friction tubes the friction is promoted by means of the withdrawal of the friction bar, which is sufficient to ensure its ignition without the glass; and any increase of sensitiveness beyond the degree which is absolutely necessary is to be avoided, as rendering the tubes more liable to accidental explosion. But in the detonating tube, where the effect is produced by a blow, and results, so to speak, immediately from the friction established by this blow between the particles of composition, a higher degree of sensitiveness is necessary; hence the employment of ground glass in the one case and not in the other.

Potash, chlorate of[1]	- -	6 ozs.
Antimony, sulphide of[2]	- -	6 ,,
Sulphur, sublimed[3]	- -	$\frac{1}{2}$,,

previously damped into a paste, and formed into rectangular patches with—

Spirits, methylated	- -	1 quart
Shellac	- - - -	824 grains

in the proportion of 200 minims to 1,000 grains composition; the patches being subsequently dried.

The nib piece (pl. 5, fig. 9) is tightly pinched together,[4] flattening it on to the composition and friction bar, and thus making the withdrawal of the bar without the ignition of the detonating composition almost impossible.[5] The looped end of the friction bar is slightly turned up to facilitate the introduction of the hook of the lanyard.

The top of the tube is plugged with shellac putty;[6] the bottom is closed by a disc of paper[7] varnished on.[8] The tube is lacquered internally and externally in brass lacquer,[9] to diminish liability to corrosion.[10] The mouth of the nib piece is varnished with a thick shellac varnish;[11] the top and nib piece then receives a coating of thin varnish, and finally the whole tube[12] is varnished black.[13] When finished these tubes will resist water for a considerable time.[14]

They are ignited by the friction established by the quick withdrawal of the friction bar, into the eye of which the hook of a lanyard is introduced.

Before pulling, the lanyard should be stretched out to its full length;[15] the pull should be sharp,[16] and rather in a downward than in an upward direction.[17]

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[1] See p. 313. [2] See p. 311.

[3] See p. 318. The sulphur is added principally with a view to lengthen the flash and thus make the ignition of the tube composition more certain.

[4] By means of a stout pair of pincers, considerable force being exerted, in order that the detonating composition may be forced into the grooves of the friction bar.

[5] Doubtless, however, the friction bar *may* be, and sometimes is, withdrawn without firing the composition. See text above respecting the sort of pull which should be given to the lanyard to ensure the action of the tube.

[6] See table XX., p. 345. [7] "White fine" paper. [8] With thin shellac varnish.

[9] See table XX., p. 345.

[10] Internal lacquering provisionally approved 2/5/67. *W.O. Letter*, 3/5/67, 75/10/509.

[11] See table XX., p. 345. The object of using a thick varnish for this purpose is to exclude moisture as much as possible from the most susceptible portion of the tube.

[12] Top and nib piece included. In this way it will be observed the nib piece—the part from which it is most important to completely exclude moisture—receives two coats of varnish.

[13] Copal varnish. Originally shellac varnish was used, but it was found to chip off in transport, and copal varnish was substituted. The object of varnishing these tubes is to close the joint completely against the entry of moisture.

[14] These tubes may be soaked in water for several days without deterioration. On the 3rd March 1865 I caused 12 of the tubes to be placed in water. On the 8th March, *i.e.*, in five days, six of the tubes were taken out and fired; five fired as well and quickly as new tubes, and ignited the puff; the sixth had become damp, and fired sluggishly, without firing the puff. Two tubes were taken out on the following, *i.e.*, the sixth day; both fired well. Of two tubes taken out on the seventh day one failed, and both tubes tried on the eighth day failed completely. This seems to show that new well made tubes will resist water at least four or five days.

[15] *Manual of Artillery Exercise*, p. 83.

[16] *Ibid.*, p. 83. A slow pull will sometimes, in the event of the detonating composition having become a little damp, be liable to withdraw the friction bar without igniting the detonating composition, just as a lucifer match may be passed slowly over a rough surface without igniting it. This illustration may be found useful in instruction, the nature of pull being compared to the action of striking a match. Besides, the slower the pull the longer the interval between the word "fire" and the actual firing of the gun.

[17] To avoid jerking the tube out of the vent.

Copper friction tubes are issued for land service only; they are not available on board ship on account of the inconvenience which necessarily results from the employment of a metal tube between decks.[1]

Packing and issue.

These tubes are packed 100 or 50 in a zinc cylinder, the lid of which is luted to the cylinder with beeswax and turpentine, and secured by a strip of calico varnished on and painted black. The lid is labelled on the top with the nature and number of tube and date of issue,[2] and since the tubes have been lacquered internally the word "lacquered" has been added on the label.

On the side of the cylinder are labelled in large letters the words "Not to be placed in the magazine on any pretence whatever."

Tubes, friction, quill.

2. *Quill Friction Tubes*[3] ("with loops") (pl. 5).—The body is made of quill (pl. 5, fig. 1) $2\frac{1}{2}$ inches in length,[4] driven and pierced in the usual way. About ·2 inch from the top of the tube a small horizontal slit (pl. 5, fig. 1) is made transversely through both sides of the quill; through this slit is inserted a copper[5] "friction bar" (pl. 5, fig. 6) similar in general appearance to that of the copper friction tube, but rather stouter.

The friction bar passes completely through the tube, projecting on both sides of it, the roughened end of the bar in one direction, the looped end in the other. The roughened end is slightly bent downwards to increase friction in its withdrawal, and the looped end is twisted until the loop is vertical instead of horizontal, the introduction of the hook of the lanyard being thus facilitated.

The quill is strengthened about this part[6] by being woolded above and below the friction bar[7] with fine copper wire[8] (pl. 5, fig. 2).

On to the top of the friction bar, inside the quill, is driven[9] a small quantity of the following detonating composition:[10]—

Potash, chlorate of[11] - -	6 ozs.
Antimony, sulphide of[12] - -	6 ,,
Sulphur, sublimed[13] - -	$\frac{1}{2}$,,
Powder, mealed[14] - - -	1 ,,

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[1] *Naval Gunnery*, p. 385.

[2] Until June 1864 the cylinders were stencilled and not labelled. The tops of the cylinders for the different natures of tubes were further distinguished by being painted different colours. The stencilling was found liable to become obliterated.

[3] Present pattern (II.) approved, *War Office Circular* 8 (new series), § 1148, note date not recorded, but was early in 1866. Pattern I. approved 21st November 1866, see *Ibid.* Originally approved with a loop of slightly different construction, 16th July 1866, see *W.O.C.* 8 (new series), § 1148; and afterwards, from 1859 to 1865, made without loops. The friction tubes "without loops" were identical with those "with loops," except that the leather band round the head was not formed into a loop, but merely served to enlarge the head sufficiently to fill up a "crutch" which was placed alongside the vent.

[4] Only the extreme point is removed, as in the detonating quill.

[5] 30 oz. copper sheet.

[6] Strengthened that it may better resist the withdrawal of the friction bar. Evidently, in the absence of some such precaution to make the upper part of the quill rigid, there would be a great chance of the bar being withdrawn without exploding the detonating composition.

[7] The woolding extends nearly ·2 inch in each direction.

[8] No. 30 copper wire.

[9] Tightly driven by means of a metal drift, so as to ensure its entering the grooves of the bar.

[10] It will be observed that this detonating composition is the same as that employed for the copper friction tube, with the addition of 1 oz. of mealed powder. This addition is made with a view to increasing and prolonging the flash and so making more certain the ignition of the tube; for it must be borne in mind that there is only one patch of detonating composition in these tubes, and that on the side of the friction bar away from the body. A flash too feeble to surround the bar, or so rapid as not to be prolonged beyond the complete withdrawal of the bar, would therefore *possibly* fail to ignite the tube.

[11] See p. 313. [12] See p. 311. [13] See p. 318. [14] See p. 138.

previously damped into a paste and formed into circular patches with spirits,—methylated, 1 quart; shellac, 448 grains in the proportion of 200 minims to 1,000 grains of composition; the patches are not dried before being driven into the tube; over the detonating composition a little gunpowder[1] is driven; above this a little ground clay; and, finally, the tube is headed up with beeswax.

The whole of the upper part of the tube and the roughened projecting end of the friction bar are then varnished,[2] and the end of the bar is dipped into ground glass to increase the friction. A small parchment cap (pl. 5, figs. 8, 9) is afterwards tied over the top with fine kitted silk.

Round that part of the tube through which the friction bar passes is tied with kitted silk a stiff leather[3] band (pl. 5, figs. 4 and 7), which forms a horizontal loop about 1½ inches long.

The end of the loop is kept open by the insertion of a small plug of leather[4] (pl. 5, fig. 4) which is secured by a copper wire[5] staple. The upper part of the tube, cap, and loop are varnished;[6] and the body of the tube is varnished black.[7]

Action.

These tubes are ignited by the friction established by the withdrawal of the friction bar, into the eye of which the hook of a lanyard is introduced. The pull should be of the same nature as that which is directed to be given with the copper friction tube.[8] The object of the loop is to support the tube under the pull, the loop being placed over a pin alongside the vent, and the strain is thus borne, not by the quill body of the tube, which would be liable to break, but by the leather loop.[9]

Quill friction tubes are used for naval service only, and on demand for signal guns. They are used also for firing life buoy portfires.

Packing and issue.

These tubes are issued 100 or 50 in a zinc cylinder,[10] closed and secured in the usual way. The top of the cylinder is labelled with the nature and number of tube, and the numeral II. to indicate the pattern. On the side of the cylinders in large letters is labelled "Not to be " placed in the magazine on any pretence whatever,"[11] and the following "Directions for quill friction tubes:"—

"*Fitting the Lanyard.*—After passing the lanyard through the guide plate, a knot or stop is to be made on it, at such a distance from the hook that it shall be not less than one inch and a half from the guide plate, when the hook is placed in the eye of the friction bar of the tube.

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[1] Generally shell F.G., but almost any powder would answer the purpose.

[2] See table XX. p. 345.

[3] "Brown seat hide."

[4] "Cross hide." The original tubes, "with loops," had not this plug of leather, and were open to the objection of the loop closing, and giving rise to inconvenience and delay in opening it to place over the pin.

[5] No. 21 copper wire.

[6] See table XX., p. 345.

[7] See table XX., p. 345.

[8] See p. 205.

[9] In the quill friction tubes "*without* loops" the leather band round the tube rested in a small crutch fixed round the vent, and upon which the strain was thus thrown.

The upper part of the vent is enlarged to prevent the body of the tube having any bearing.

[10] Quill friction tubes "without loops" were packed 150, in zinc cylinders.

[11] A restriction which is generally observed with all stores containing detonating composition, except percussion caps.

"*Using the Tube.*—The tube is to be inserted into the vent, and the leather loop placed over the supporting pin.

"The hook of the lanyard is to be placed in the eye of the friction bar of the tube.

"When firing, the lanyard is to be pulled smartly."

The cylinders are generally issued to the navy in deal boxes; these boxes are of two sizes, viz. :—

Small; which contains 10 cylinders of 100 each, or 1,000 tubes with loops.[1]

Large; which contains 20 cylinders of 100 each, or 2,000 tubes with loops.[2]

On the box is stencilled, in addition to the nature and number of tube, the restriction about not being placed in the magazine.

Tubes, common, quill.

3. *The common quill tube* (pl. 5) is a goose quill (pl. 5, fig. 1) three inches in length,[3] cut clear of the pith, and scraped clean on the outside to the required gauge.[4]

The top of the quill is slit into seven prongs (pl. 5, fig. 2),[5] which are woolded over and under with worsted until a head or flat cap about half an inch in diameter is formed. The lower end of the quill is cut off for filling.

The body of the tube is driven and pierced in the usual way. The "cup" of the tube is thickly plastered with a priming paste, consisting of mealed powder, distilled water, and gum-arabic,[6] and then dredged with dry mealed powder. A paper[7] cap is twisted over the cup and the wire again passed up through the hole in the tube through the priming and cap.[8]

These tubes are not varnished.

They are fired by the application of a lighted match or portfire, and are used for occasional and exceptional services, such as signal guns and saluting "chambers" at the Tower and St. James' Park and other stations. They would not be issued as service tubes unless specially demanded.

Packing and issue.

These tubes are issued either 100 or 50 in a zinc cylinder, closed and secured in the usual way, and labelled on the top with the nature and number of tube and date of issue.

Tubes, match, Fynmore's.

4. *The Match or Fynmore tube*[9] (pl. 5, figs. 1 to 4) is the same as the common quill with the addition of eight strands of worsted, each two inches in length, which are attached to and hang from the cup. These strands are converted into match, whence the tube derives its name, by smearing them with a thick paste of mealed powder, methylated spirits,

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[1] Or 1,500 tubes "*without loops.*"

[2] Or 3,000 tubes "*without loops.*"

[3] Three inches in length before the slitting, not after the removal of the nib.

[4] The working gauge is ·196″, although, as before stated, a ·216 gauge is finally employed.

[5] It appears from the following extract from Sir Augustus Frazer's MS. notes that at one time these tubes were made with six prongs, and afterwards with eight:—"The "slitting knife has at present seven cutters or blades; at first they had only six, and "after that by order of Colonel Wood they were made with eight blades."—*Laboratory Work*, p. 24.

[6] Formerly mealed powder, methylated spirits, and shellac were used. The object of using shellac or gum-arabic with the priming is to cause it to adhere to the worsted.

[7] "White fine," cut into a small rectangle.

[8] To ensure the important operation of the piercing of the tube not being omitted.

[9] See respecting introduction of this tube, page 192.

and gum arabic,[1] and drawing them through dry mealed powder. These tubes are not painted.

Match tubes were introduced for employment with flint locks, the strands of worsted being laid in the pan instead of priming. They are still sometimes demanded, but it seems doubtful whether they ought not now to be considered obsolete.[2]

The match tubes are issued each in a paper cover, 50 in a zinc cylinder, closed and secured in the usual way, and labelled on the top with the nature and number of tube and date of issue. Packing and issue.

5. *Paper or Dutch tube* (pl. 5) is a rolled paper [3] cylinder (pl. 5, fig. 3) $2\frac{1}{2}$ inches in length, on to the top of which is rolled spirally a narrow strip [4] of the same paper (pl. 5, fig. 1), so as to form a head or cup. Paper tubes.

The body of the tube is driven and pierced in the usual way, and the cup is filled with a priming paste of mealed powder and distilled water, built up conically and pierced.[5]

The tube is capped with a piece of paper [6] previously saturated in a solution of saltpetre and water, tied on to the head of the tube with fine silk, and after capping the wire is again passed up the tube and through the cap.

The whole tube with the exception of the cap is varnished black.[7]

These tubes are fired by the application of a lighted match or portfire; they do not require to be uncapped before firing.

They were formerly a service tube,[8] but are now no longer manufactured for this purpose. They would only be made on an emergency in the absence of quill or other tubes, but since, on such occasions, they might be advantageously employed, and are easily made, their manufacture is still included in a laboratory course. They are open to the objection of being liable to clog the vent by the peeling or stripping of the body, which then becomes difficult to remove, and the portions left in the vent in this way are in the majority of cases in a state of ignition.

These tubes not being an article of Laboratory manufacture are never issued. Packing and issue.

6. *Abel's Electric Tube*[9] (pl. 5).—The body is quill (pl. 5, fig. 1), about $2\frac{3}{4}$ inches in length driven and pierced in the usual way. The tube has an egg-shaped beech wood head, in which are three perforations; one passing down the longer axis of the head receives in its lower part the top of the body of the tube, which is fixed to the head Tubes, electric, Abel.

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[1] In proportion of 1 oz. of gum arabic dissolved in $\frac{1}{2}$ pint water to 1 quart of spirits.

[2] There is reason to believe that in some cases they have been fired by portfires, but it should be distinctly understood that this use is an improper one, the common quill tubes being intended to be employed when the ignition is to be effected by a lighted match or portfire. Respecting the employment of the Fynmore tubes as primers for Armstrong guns, particulars will be given in the section on rifled ordnance.

[3] "White fine" is employed when procurable, but other papers might on an emergency be used for the purpose. If "white fine" paper be used the rectangle should be 4·5 inches × 0·5 inches.

[4] A rectangular strip 19 × 0·4 inches.

[5] The little cone of priming is generally built up round the piercing wire, which is pushed through the tube and made to project for the purpose. In this way the piercing of the priming is ensured; if it were not pierced the ignition of the tube would be of course retarded.

[6] "White fine" paper.

[7] See table XX., p. 345.

[8] See p. 190.

[9] Present pattern (II.) approved 23rd May 1866, *War Office Circular*, 10 (new series), § 1237. See p. 203, respecting previous approval.
These tubes were first called magnetic or "magneto-electric."

by shellac varnish; above this it receives two fine copper wires (pl. 5, fig. 5) completely insulated in a covering of gutta-percha,[1] at a distance apart of about $\frac{1}{16}$th of an inch.[2]

The other two perforations, which are horizontal, are parallel to each other on each side of the central one, and at right angles to it, are lined or bushed with copper (pl. 5, fig. 6).

The piece of double covered wire above referred to, is originally about $1\frac{3}{4}$ inches in length, which allows of the gutta-percha being removed from about $1\frac{1}{4}$ inches of the wires. These bare ends of the fine wires, which are made to protrude from the top of the tube-head, are then pressed into slight grooves in the wood, provided for their protection; and the extremity of each is passed into one of the horizontal perforations, in which position it is fixed by the introduction of the copper bush, so that the wire is firmly wedged between the wood and the exterior of the bush, and is thus, at the same time, brought into close contact with a comparatively large surface of metal.[3]

The other ends of the wires are embedded in the following explosive "priming composition:"[4]

Copper, sub-phosphide of.
Copper, sub-sulphide of. } [5]
Potash, chlorate of.

A small cylinder of paper is rolled round the gutta-percha, projecting slightly below it, to receive the priming material, the bottom being afterwards closed with a piece of fine gut, and the whole varnished.

These tubes are varnished black all over.[6]

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1 "This double-covered wire consists of two copper wires of 0·022 inch diameter, "enclosed side by side, at a distance of $\frac{1}{16}$-inch apart, in a coating of gutta-percha of "$\frac{1}{8}$-inch diameter. It has been prepared by the Gutta Percha Company for this par-"ticular purpose, in considerable lengths (300 yards), from which the pieces of requi-"site length are cut off as required. The insulation of the two wires has been found "perfect throughout the whole length manufactured at one time."—*Abel on Recent Applications of Electricity, &c.*, p. 22, note.

2 "It is indispensable to the proper insulation of the wires . . . . that the terminals "should be at least one-sixteenth of an inch apart."—*Ibid.*, p. 20.

3 The whole of this passage is taken nearly verbatim from *Abel on Recent Applications of Electricity, &c.*, p. 22.

4 It is of the highest importance that the ends of the wires should be actually in contact with the composition.

5 The ingredients to be used for this composition, and more especially the proportions in which they should be employed, were the result of a very large number of careful experiments, conducted by Messrs. Abel and Wheatstone, the character of the composition being a very important element in the fuze; if of too high a conducting power, not only would the required sensitiveness of the mixture be interfered with, but, an almost perfectly continuous connexion being established between the two poles of the magnets, the passage of the current would be facilitated to such a degree as to prevent the ignition of the composition; on the other hand, it was essential to success that the priming material should possess considerable conducting power, or the current would not pass at all, and so no spark would be produced. "Considerable difficulties "were encountered in the endeavours properly to balance these conditions," which, however, the present mixture is described as exactly satisfying, this mixture being "possessed of high conducting power attainable without detriment to the ready ex-"plosiveness of the material."—*Abel on Recent Applications of Electricity, &c.*, p. 21. Moreover, it is of a very stable character, and tubes "primed with it have been found "to have lost none of their delicacy and certainty when tried two years after prepa-"ration."—*Ibid.*, p. 20.

An interesting and detailed account of the introduction of this priming material is given *ibid.*, pp. 16 to 21, and for convenience of reference I have, in Appendix J, quoted the passage at length.

It is not thought desirable to make public the exact proportions in which the several ingredients are employed.

6 See table XX., p. 345.

The electric tube can be fired by means of any electric agency, but is specially intended to be fired by means of a magneto-electric apparatus or "magnetic exploder."[1] The action is as follows: The circuit wires of the apparatus, *completely insulated*,[2] are placed in the bushes of the tube; the "induced" current of electricity passes along these wires, through the bushes, to the fine copper wires, and so to the priming material in which their terminals are embedded. There, owing to the priming composition being of high conducting power, the current leaps from one wire to the other in the form of a spark, exploding the sensitive composition in its passage, the flash generated by this explosion firing the tube. Action.

The electric tubes are used for firing guns at proof, and for other experimental firing, having superseded the galvanic tube for this purpose, or for firing a large number of guns simultaneously;[3] they are also used for firing the "time" guns at Edinburgh, Glasgow, Sunderland, Newcastle, and other northern towns, the current being daily flashed at noon along ordinary telegraph wires from the Royal Observatory at Greenwich.

Advantages of magneto-electricity over voltaic agency as a means of firing charges.

"The system of firing charges by magneto-electricity possesses important advantages over the application of the voltaic battery to that purpose, the principal of which are as follows:

"The magnetic exploder is at any time ready for immediate employment; it is easily transported by hand, being of small dimensions and weight; it is not liable to injury or derangement, provided the most ordinary care be applied to its preservation and transport; it may be employed for many years without suffering any important diminution of its power; and, as all arrangements in connexion with the instrument are mechanical, any injury which they may sustain can be repaired by ordinary workmen.

"The electric tube is more certain than any tube arrangement applied with the voltaic battery, and as safe as any arrangement employed for igniting gunpowder by friction or percussion. It may be preserved for a great length of time in any climate, and will bear very rough treatment without chance of injury.

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[1] This tube can also be fired by any other known system of electricity, frictional, voltaic, or electro-magnetic.

[2] "It need scarcely be stated that in dealing with electricity of induction, defects in "the insulation of the main and branch wires had to be very carefully guarded "against. Several failures in the first experiments were eventually traced to some "defect of that kind. An instance even occurred, before the proper method of pro-"tecting the connexions of the charges with the insulated wires was adopted, in which "the deposition of moisture upon the gutta percha-covered wire, near the charge, "prevented the ignition of the latter, by forming a connecting link between the "extremity of this wire, where it was exposed and attached to the fuze, and the un-"covered wire leading to the earth in consequence of the two wires being in contact "at a distance of several inches from the fuze. It is therefore always a preliminary "precaution of primary importance, that the insulating covering of the wire to be "employed be carefully inspected, while the latter is being laid out for use, and that "any imperfections be protected from possible contact with the earth, or from the "access of moisture; a result easily attainable by the application of some waterproof "envelope to the injured portion."—*Abel on the Recent Application of Electricity, &c.*, p. 29.

[3] The account of the experiments given by Mr Abel would seem to indicate that with a small apparatus as many as twenty-five charges can be fired simultaneously, or "with such rapidity that the effect on the ear was as one explosion."—*Abel on Recent Application of Electricity, &c.*, p. 25.

But "with battery-power of great magnitude, and with the successful fulfilment of "the numerous indispensable conditions and precautions (which long experience has "shown to be involved in considerable uncertainty), it is possible to fire at one time a "very much larger number of charges."—*Ibid.*, p. 34.

"The implements and materials required for carrying on operations with the magnet, in addition to the instrument, the wire, and the tubes, are very few in number, inexpensive, and easily replaceable; they occupy but little space, and require no more care in their transport than ordinary artisan's tools.

"All the operations necessary in the employment of the magnet (the connexion of the tubes with the instrument, their introduction into the charges, and the explosion of these), are of the simplest possible character, and can therefore be performed by any person of ordinary intelligence.

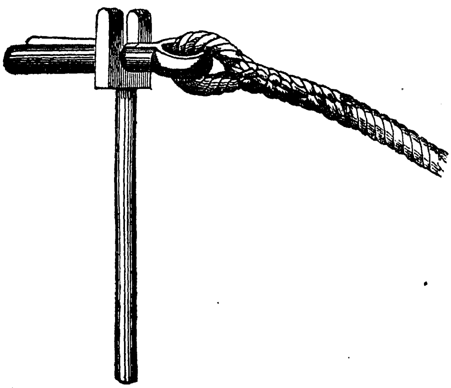
"It can be confidently affirmed that the general certainty of the magneto-electric arrangement is decidedly greater than that of voltaic batteries, and that the necessity of ensuring a proper insulation of wires and connexions, though it may be regarded in the light of a difficulty by those accustomed to carry on operations with the voltaic current, is in reality a condition which may be fulfilled readily and with certainty by the use of very simple means and precautions."[1]

Packing and issue.

Electric tubes are issued by fifties in zinc cylinders, closed and secured in the usual way, and labelled with the nature and number of tube, and date of issue. On the lid is stencilled the numeral II. (for Pattern II.)

Tubes, dummy, drill.

7. *The Dummy Friction Tube*[2] consists of a cylindrical steel bar, or "stem," three inches long, which enters the vent of the gun, and is



Scale, half natural size.

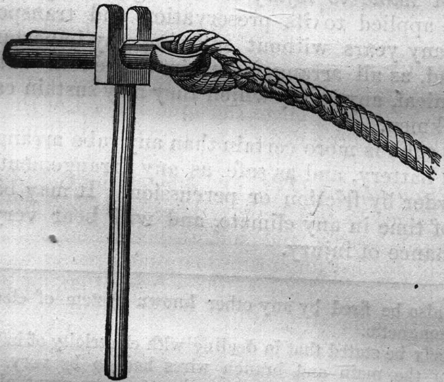
forked or crutch-shaped at the head. A steel V-shaped spring or "prong," to which a tarred lanyard 10 feet long is attached, "is "placed in the fork, and is drawn through by the same motion as is "required for firing a tube."[3]

These tubes are used as substitutes for friction tubes at drill, for land, and partially for sea service.

[1] *Abel on Recent Application of Electricity, &c.*, pp. 33, 34.

[2] Proposed by Col. Taylor, R.A.; *original pattern* approved 10th July 1863, *War Office Circular*, 842, para. 802, but the prongs "having been found liable to fracture at "the eye," the present pattern, "in which the prong is made stronger, and the split "of the spring is carried through its neck, instead of the latter being solid," was approved 18th June 1864.—*War Office Circular*, 2 (new series), para. 918.

[3] *War Office Circular*, 842, para. 802. A pull of about 18 lbs. is required to withdraw the prong, which is considerably greater than is necessary to fire a friction tube.



Scale, half natural size.

Class 2.—Portfires.

There are five different descriptions of portfires. *Portfires, natures.*

(1.) Common.
(2.) Miner's.
(3.) Slow or blue.
(4.) Coast Guard.
(5.) Life buoy.

The (1) *Common Portfire.*[1] *Portfires, common. History.*

The general history of common portfires has been indicated in the history of the means of igniting the charge, where it is stated that the name "porte-feu" was originally applied to the quick match which was used to place in the vents of guns.[2] Portfires, as we now understand the name, were probably not used until the end of the 17th or the beginning of the 18th century,[3] previous to which time slow match and red hot iron bars were used for the purpose.[4]

The changes which have been made in them since their introduction have been comparatively few und unimportant, such as slight alterations in dimensions and in the quantity of mealed powder, in the substitution of 100 lb. for 60 lb. paper, and of spirit for oil paint.

The common portfire (pl. 8) is formed of stout paper[5] rolled up[6] into a hollow cylinder about 16 inches long, ·675 inch in external, and ·45 inch in internal diameter. The case is closed at one end[7] and driven[8] with the following composition, which burns with great local heat, at a mean rate (when driven) of about one inch in 50 seconds:[9]— *Description.*

	lbs.	oz.
Saltpetre, ground[10] - -	6	0
Sulphur, sublimed[11] - -	2	0
Powder, cylinder, mealed[12] -	1	4

The exposed end of the composition is primed with a paste of mealed powder and methylated spirits, and a small hole, ·1 inch in depth, is bored into the centre of the composition to facilitate ignition.[13]

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[1] Until 1865 they were also distinguished as "L.S." (long-small), an old distinction, the origin of which I have not been able to trace, but which there was certainly no sufficient reason for retaining.

[2] See p. 188.

[3] See p. 189.

[4] See p. 188.

[5] A stout brown paper, known as "100 lb. paper," *i.e.* weighing 100 lbs. per ream, is used; until about 1856 a paper weighing 60 lbs. per ream, and known as "portfire paper," was employed. The change seems to have been effected on account of a difficulty in obtaining the original paper, and as the 100 lb. paper answered the purpose, portfires were then and have since been made of it.

[6] The paper is first pasted on one side, and then rolled upon a cylindrical steel former, the size of the interior of the required case, viz. ·45 of an inch.

[7] After the case is dry; the paper being turned in fold by fold, so as to form a solid bottom.

[8] Driven by hand, with a number of steel drifts, tipped with gun metal, and a mallet weighing 1 lb. 10 ozs.

The details of the process of driving, as those of making the case, are connected with the manufacture and not with the description, and need not therefore be introduced here.

[9] See limits of time of burning allowed at proof, p. 214.

[10] See p. 313.

[11] See p. 318.

[12] See p. 138.

[13] Ignition is facilitated by this hole, owing to the greater surface of composition which is thus exposed. This improvement was introduced on the recommendation of Colonel Boxer, who applied it in the first instance to his fuzes (see p. 236).

The case is painted flesh colour on the outside,[1] and the date of manufacture and driver's name are stamped upon it. Common portfires burn from 12 to 15 minutes.[2]

They are used for land[3] and sea service, for firing guns in the absence of friction tubes, or in the event of these failing, and they would also be employed, as their name implies, to *carry fire* wherever required.

Packing and issue.

Common portfires are tied up in bundles of 12 or fractions, as demanded, with a brown paper cap tied over the open end of the whole bundle. They are then packed in deal packing cases, lined with brown paper, on which are stencilled the nature and number, date of issue, &c.

For sea service they are packed in brass pentagon cases.

Portfire, miner's.

The (2) *Miner's Portfire* differs from the common portfire in the case being longer and thinner, in the proportions of the ingredients of the composition, which is also less closely driven, and in not being painted.

The case is about 19 inches long, about ·3 inch in external, and about ·2 inch in internal diameter, a thinner description of paper than that used for common portfires being employed.[4]

The composition is[5] —

	lbs.	oz.
Saltpetre, ground - - -	4	0
Sulphur, sublimed - -	2	0
Powder, cylinder, mealed - -	2	0

The composition is driven comparatively lightly, thus accelerating the rate of burning of the portfire.[6] The end is primed but not bored into.

Miner's portfires are not painted. They burn about seven minutes, or at the rate of about three inches per minute. They were used by miners and others in blasting operations until the introduction of "Bickford's mining fuze,"[7] whence their name; one end of the portfire being placed into the charge, the other end being ignited. They may be used on an emergency instead of common portfires, for which they form a cheap and not inefficient substitute.[8]

They form no part of land or sea service equipment, and are now rarely issued, and that only on special demands.

Portfire, slow, blue.

The (3) *Slow or Blue Portfires* seem to have been first made by the garrison at Gibraltar in the great siege (1779–1783) in the emergency to which a want of common portfires and match gave rise,[9] and since

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[1] See table XX., p. 345. Until about 1855 oil paint was used, but this was found to affect the composition injuriously, and was accordingly discontinued (see p. 237 respecting the objection to using oil or grease in the neighbourhood of composition).

[2] These are the extreme limits allowed at proof.

[3] By *War Office Circular* 8 (new series), § 1149, the proportion of common portfires in field, siege, and garrison equipments was diminished.

[4] "White wrapping paper," 45 lbs. per ream, is used.

[5] This is a quicker burning composition than that employed with common portfires, the sulphur and mealed powder being present in larger proportions.

[6] See also preceding note respecting the composition being quicker burning as a composition than that employed for common portfires.

[7] Subsequently improved upon by Ord's mining fuze, see p. 283.

[8] It should be noticed, however, that being but lightly driven and not being painted they would not stand much knocking about or exposure.

[9] "Portfires were made at Gibraltar in the following manner: Two ounces of "nitre were dissolved in a gallon of water, and sheets of soft brown paper dipped in "the solution; these when dry were rolled up to about the size of common port-"fires."—*The Pocket Gunner* (edition 1813), p. 291. "Slow match was made at "Gibraltar during the last siege in the following manner:—Eight ounces of salt-"petre were put into a gallon of water and just made to boil over a slow fire; strong "blue paper was then wetted with the liquor, and hung to dry; when dry each sheet "was rolled up tight, and the outward edge pasted down to prevent its opening; "half a sheet thus prepared will burn three hours."—*Ibid.*, p. 235. I cannot find

that time, although never very generally used, their manufacture has not been entirely discontinued; the advantages which recommended their employment for certain services, such as on board ship and for night firing,[1] having doubtless been held sufficient to justify their retention in the service.

Description.

The slow or blue portfire is made of blue porous unsized paper,[2] saturated with a boiling solution of—

Saltpetre, ground,[3] 3 ozs.
Water, distilled, from one to two quarts, according to nature of the paper.[4]

When dried the paper is rolled into a solid cylinder 16¾ inches long and ·7 inch in diameter.[5]

Slow portfires are unpainted; they burn slowly, or rather smoulder, whence their name; one portfire burns from two to three hours.

They may be used upon an emergency instead of common portfires,[6] or instead of slow match, and for certain services, such as on board ship, where they would not throw fire about the decks, or in night firing when it is undesirable to discover your position; present some advantages over common portfires;[7] they are also used at Purfleet and elsewhere for proof of powder.

Until recently they formed part of siege train equipment, but are now no longer issued except on special demand.

Packing and issue.

Slow portfires are issued in the same way as common portfires, with the exception of the paper cap, which is not required.

Portfire, coast guard. History.

The (4) *Coast Guard Portfire*[8] (pl. 8) was introduced probably between 1830 and 1840.[9] Previous to their introduction the old blue lights were used; these, it seems, were objected to because having to be held in the hand while burning, the man who held them became a mark for the enemy's or smuggler's fire. A light which could be stuck into the ground while burning was therefore adopted, though

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any mention of these portfires in Drinkwater's *History of the Siege of Gibraltar*, but as Major Adye, by whom the first edition of the *Pocket Gunner* was prepared, was at Gibraltar a few years subsequent to the siege, no doubt the statement which I have quoted above is correct. In some MS. papers belonging to the Royal Artillery Institution, containing an account of some operations during this siege, the following passage occurs:—"Each non-commissioned officer was provided with a lighted slow "*and paper match*, and two portfires." The paper match was very possibly the "slow portfire," to be used instead of slow match or portfires, as necessity might arise.

[1] See text above.

[2] Blue "sugar loaf" paper (*i.e.* the paper used for wrapping up sugar) is used, but almost any porous paper would answer the purpose.

[3] See p. 313.

[4] The quantity of water is regulated in accordance with the absorbent powers of the paper.

[5] The paper is unpasted, except down the seam formed by the last roll. Perhaps the simplest and best description which could be given of these portfires would be "a solid roll of touch paper."

[6] See p. 214, respecting the occasion upon which they were first made.

[7] "Under some circumstances these portfires may employed with great advantage." —Col. Boxer's *MS. Notes*, p. 61.

[8] These were sometimes known, until 1865, when the distinction was given up, as "percussion portfires." The name has reference to the fact that they were generally fitted by the Coast Guard with a detonating arrangement (see p. 216), but they were never issued from the Royal Laboratory so fitted, and the name was an incorrect one.

[9] I can quote no official authority for this statement, but this is the conclusion to which my inquiries among foremen and others who have been employed for many years in this department led me. At the same time it should be stated that the Laboratory books, which have been searched back as far as 1820, contain no mention of the regular introduction of these portfires.

why the original composition should have been altered for one considerably inferior in brilliancy and illuminating power is not so easily explained.

Description. The coast guard portfire case is made of a stouter description of paper[1] than that of the common portfire, and is shorter and thicker, being about 8½ inches long,[2] 1·4 inches in external and 1·0 inch in internal diameter.[3]

The composition[4] with which the case is pressed[5] is—

	lbs.	oz.
Saltpetre, ground[6] - -	8	0
Sulphur, ground[7] - - -	4	0
Powder, cylinder, mealed[8] -	1	0

On to the lower end of the case is fixed[9] a tin cone (pl. 8, fig. 8) three inches in length filled with rosin to strengthen it. The cone forms a spiked end to the portfire and enables it to be stuck into the ground.

A rolled paper[10] collar (pl.8, fig. 4) is fixed[11] on to the outside of the case, about 2 inches from the upper end; and the end of the portfire is protected by a rolled paper cap[12] (pl. 8, fig. 6), which can be removed at will. The end of the cap rests upon the collar, which protects it from being accidentally knocked off.

The coast guard portfire is painted very light grey. It burns from 5 to 6 minutes.[13]

It is used by the coast guard as a signal light, for which purpose, however, it is imperfectly adapted; because, in the first place, the composition possesses comparatively small illuminating power, and, in the second, the case is liable to become choked with the lava which the composition forms in burning, and the light is thus obscured.[14] A "long light" fitted with a cone instead of a handle, would probably answer the purpose much better.[15]

"These portfires are generally fitted by the coast guard with a con-"trivance for igniting them by percussion, consisting of a glass globule "filled with sulphuric acid, which is embedded in mixture of chlorate "of potassa and sugar, placed upon the top of the composition;" on the breaking of the globule, "a violent action ensues, and enough heat is "evolved to ignite the portfire composition."[16]

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[1] Rocket paper, weighing 168 lbs. per ream.

[2] 8·625 inches, exclusive of the thickness of bottom of case.

[3] The case is in diameter the same as the half pound signal rocket case, the same former and guage being used.

[4] A quicker burning composition than that employed for common portfires, owing to the presence of a larger proportion of sulphur.

[5] The composition is now pressed by hydraulic pressure, not driven by hand.

[6] See p. 313.

[7] See p. 318. The only reason for employing ground instead of sublimed sulphur is its comparative cheapness. It is neither so fine nor so pure.

[8] See p. 138.

[9] This cone is secured to the case with twine, a fringed edge which projects beyond the base of the cone being fitted over the case and woolded, and a piece of fine paper pasted over the twine.

[10] The original "portfire" (60 lb.) paper is used for the collar.

[11] Secured by shellac varnish.

[12] The same paper as for the collar (see note 10 above); the cap is formed by rolling the paper upon a former to the required size, and then choking and plugging one end.

[13] These are the extreme limits allowed at proof.

[14] "The composition for these portfires is not sufficiently strong to force the solid "residue from the case, and consequently after a short time the light becomes much "obscured."—Col. Boxer's *MS. Notes*, pp. 55, 56.

[15] Col. Boxer's *MS. Notes*, p. 56.—It is in contemplation to effect this change, and thus supersede coast guard portfire altogether.

[16] *Ibid.*, p. 55.—He adds, "A much safer means, however, might be devised." See p. 214, note [8], respecting these portfires having been called "percussion portfires."

Coast guard portfires are issued 100, or less, as demanded, in deal packing cases, not lined, but each layer battened down. The boxes are marked with the nature and number of portfire, date of issue, weight, &c.

Packing and issue.

The (5) *Life Buoy Portfire* [1] (plate 19) was introduced at the time of the introduction of Lieut. Cook's R.N. life buoy, of which it forms a part, viz., some time about 1827.[2]

Portfire, life buoy. History.

The first life buoy portfires seem to have differed from those now in use, in the composition being the same throughout, and in being ignited by means of a flint lock and the match tube; subsequently a detonating hammer and cross-headed tube were used; and eventually Mr. Richardson, gunner, R.N., proposed the present arrangement for firing, by means of a friction tube, which was adopted 1862.[3] The latter plan is a great improvement on the others, which necessitated the pulling of two triggers, one to fire, and the other to release the buoy, thus making it possible, by the accidental pulling of the wrong trigger first, for the buoy to be released unignited.

Description.

The life-buoy portfire (pl. 19, fig. 3) consists of seven pieces of portfire of the same external diameter as the common, but larger internally, viz., ·55 of an inch, the thickness of case being thus less,[4] and the quantity of composition in a given length more.[5]

The different pieces of portfire are of unequal lengths; they are driven with the same composition as is used for coast-guard portfires,[6] with the exception of the first 3½ inches of the first length, for which the following quicker burning composition is used :—

Quick composition (for first 3½ inches)—

Saltpetre, ground,[7] 3 lbs.
Sulphur, sublimed,[8] 2 lbs.
Powder, pit, mealed,[9] 1 lb.

The object of using a quick burning composition for the first few inches of the portfire is to diminish the chance of its being extinguished by the water, in which, on the first falling away of the life buoy or until it settles, it is liable to become submerged.[10] The end which first be-

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[1] Present pattern approved 24 April 1862.—*War Office Circular*, 781, par. 556; and *War Office Circular*, 793, page 19, erratum. Originally designated in store returns, &c., "Fuzes fixed to plates." This name was entirely given up in 1865, and the name by which they had been more familiarly known, that of "life buoy portfires," adopted in official documents.

A more correct name would be one which it seems has sometimes been applied to them, "life buoy lights." This name is employed by Col. Boxer in his *MS. Notes*, p. 63.

[2] I cannot discover the exact date, but it was certainly before 1828, as the records of the Royal Laboratory, Woolwich, contain letters of that date authorizing the issue of fuzes and plates to Lieut. Cook for the use, apparently, of the mercantile navy. On the 13th September 1826, a life buoy on a plan of Sir William Congreve was adopted. I believe therefore that Lieut. Cook's buoy must have been introduced about 1827.

[3] 24 April 1862.—*War Office Circular*, 781, par. 556; and *War Office Circular*, 793, page 19, *erratum*.

[4] The same paper is used as for common portfires, but as the case is thinner a smaller quantity is of course required.

[5] The illuminating power of the portfire is thus increased, while the case, being more readily burnt away, is less liable to become choked and the light obscured.

[6] See p. 216.

[7] See p. 313.

[8] See p. 318.

[9] See p. 138. *Pit* powder is probably used because it burns rather quicker than ordinary mealed powder.

[10] A quick burning composition is necessarily, *cæteris paribus*, better able to resist water than a slow burning composition, for the quantity of gas generated by the former in a given time is of course greater than that generated by the latter, or in

comes ignited is slightly bevelled off on one side,[1] a hole ·5 inch deep, and about a quarter of an inch in diameter is bored into the composition and driven with mealed powder, the whole of the surface of the composition being plastered with priming paste and finally capped with paper.[2] The ends of the other lengths (with the exception of the last length), are all cut at an angle of 45°, thickly primed,[3] and a small hole[4] bored through the priming into the composition to facilitate ignition.

The lengths of portfire are connected by means of small tinned-copper elbows (pl. 19, fig. 5), or "mitres," their junctions with the case being secured against damp with a cement made of—

Kit composition[5] } Equal parts, melted and mixed.
Spanish brown[6] }

The last end of the last length is neither bevelled off, primed or bored into, but closed by a tinned-copper cylinder (pl. 19, fig. 4), cemented like the "mitres."

The whole portfire is painted black.[7]

The portfire when complete is laid upon a gun metal[8] plate.

This plate is rectangular (pl. 19, figs. 1, 2), 8·65 inches by 5·75 inches, the edge of the plate is turned up so as to form a little wall,[9] and a number of small walls or traverses half an inch in height are disposed about the upper side of the plate,[10] in such a way as to effect a separation between each length of portfire when fixed to the plate, thus diminishing the chance of one length becoming ignited before its time by the flame from the length adjacent. Opposite to the first end of the first length is a small gun metal socket[11] (pl. 19, fig. 6), for the reception of the quill friction tube,[12] by which the portfire is ignited.

This socket is so placed that the fire of the tube will strike directly on to the end of the portfire.

At each corner of the plate is a hole for the escape of the water; and about the plate are several smaller holes, for the wires by which the portfire is fixed to the plate, to pass through, and which also form so many outlets for the water.[13]

In the centre of the plate, on its lower side, is a rectangular stem[14]

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other words the force of the water being the same the volume of gas available to resist it is greater.

"The power of a burning composition to resist the penetration of water to the mas "is in direct proportion to the volume of gas evolved and to the rapidity of its escape, "and, consequently, to the rapidity with which the composition burns."—*Extract from MS. Letter* from F. A. Abel, Esq., Chemist to the War Department, March 15, 1865.

[1] To admit of the tube striking directly upon the priming and composition and not upon the case.

[2] "White fine;" tied on.

[3] The object of priming these ends is not only to carry on the fire, but to insure the blowing off of the little copper mitres.

[4] One-tenth of an inch deep.

[5] See table XX., p. 345.

[6] Spanish brown is a pigment; it is added, however, not to give colour, but as a "drier:" without it the kit would remain sticky and soft. Formerly red lead was used instead of Spanish brown.—Col. Boxer's *MS. Notes*, p. 63.

[7] See table XX., p. 345.

[8] The alloy used is copper, 9 lbs., tin, 1 lb., zinc, 2 ozs.

[9] This wall is slotted away opposite the first length, to permit of the gas escaping freely on the ignition of the portfire.

[10] These traverses are not fixed on to the plate, but form part of the casting.

[11] Screwed on to the plate.

[12] These sockets were originally introduced for the quill friction tubes "without loops." The present quill friction tubes require to have the looped end of the strap cut off before they can be used for firing life buoy port fires on plates of the old pattern; but the plates now made are adapted for the quill tube with loops.

[13] Being somewhat larger than the wires.

[14] Part of the cast plate.

(pl. 19, fig. 2), which fits into the socket of the life buoy, and is slotted to enable it to be securely clamped by a screw.

Before the portfire is fixed, the plate is painted black.[1]

The portfire is placed between the traverses, upon little paper[2] floats,[3] and secured to the plate with copper wires[4] passed over the portfire through the holes in the plate, and twisted underneath.

The whole—portfire and plate—finally receives another coat of black paint.[5]

These portfires burn from 20 to 25 minutes.

Application. The application of the life buoy portfire is as follows :—It is secured by means of the plate stem (pl. 19, fig. 2) to the top of a life buoy praseded over the side of a ship.[6] A quill friction tube[7] is placed in the tube socket (pl. 19, fig. 8), and a short lanyard (pl. 19, fig. 7) hooked into the friction bar, the other end of the lanyard being hooked on to a part of the apparatus which does not fall away with the buoy. Thus, on the buoy falling, the portfire and tube being necessarily carried with it, the tube is fired and lights the portfire. The length first ignited, as it burns away, communicates the fire to the second length, and so on, until the whole are consumed; the light which is afforded for the 20 or 25 minutes during which the portfire is burning, serving at night to indicate the position of the life buoy to the man overboard, or, when he shall have reached the buoy, to those engaged in his recovery.

They are issued to the Royal Navy, unpacked.

Class 3.—Lights (Signal and other).

History. If one were called upon to trace signal lights back to their source, and to assign the date of their first employment, one might justly say that their prototype is to be found in the rudest contrivance for giving light used in the very earliest days of the world's history.[8]

When lights were first used as signals it is impossible to say, but doubtless the expedient early recommended itself; and there is little doubt that signal lights of various descriptions, in the form of beacons, for example, were employed in the remotest ages. Lights of the nature now used are probably of much more modern date, although the "blue light," (a wooden cup tapering down into a handle, the cup being filled with blue-light composition), from which they may be said to have immediately derived their origin, has no doubt been in our service for a considerable period.[9]

A "long light" was proposed in 1841[10] by Capt. Stevens, Royal

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[1] See table XX., p. 345.

[2] Generally pieces of an empty portfire case, the curved form of such pieces presenting a convenient shape for the portfire to rest in.

[3] These floats serve to raise the portfire from the plate, and prevent it from resting in any water which might accumulate on the plate. They are generally cemented to the plate, and to the portfire, with the kit and Spanish brown cement.

[4] No. 19, wire gauge.

[5] See table XX., p. 345.

[6] See description of this buoy, p. 230.

[7] In those plates of which the slot has been widened to receive friction tubes with loops, these tubes can be used; otherwise the loop must be cut off. See p. 218 note 12.

[8] See *History of Light Balls, &c.*, p. 75; see also *Great Art of Artillery*, p. 382 to end of work.

[9] I can trace nothing respecting the origin of the blue light; but there seems no doubt respecting its comparative antiquity. There are still several of these to be found at different stations.

[10] 16th October 1841. A copy of Captain Stevens' letter of that date is in the Royal Laboratory Office. It would seem, however, from a letter of Admiral Codrington's, 6th February 1842, that these lights had been proposed by Capt. Stevens as early as 1832; but the first formal proposition certainly appears to bear the date above assigned.

Marine Artillery, and approved the following year.[1] This light differed from that now in use principally in the absence of any arrangement for igniting it by percussion. The head of the light was matched, and capped with paper; it had to be ignited by the application of a lighted match or portfire.

In 1856[2] the present "long light," (pl. 6, figs. 1 and 2), proposed by Colonel Boxer, was introduced, and the blue light, which had been in vogue until that date, was superseded by the present "signal light" (pl. 6, figs. 12, 13, and 14). A "Manby light" (pl. 25, figs. 15 and 16), which differs from the "long light" only in the method of ignition, was introduced in 1860,[3] and Colonel Boxer proposed[4] extending the method of ignition to all long and signal lights in preference to the percussion cap arrangement. The proposition, however, was rejected,[5] mainly on the grounds that percussion caps were generally more easily obtainable than detonating primers. In 1865[6] the Manby light disappeared from the service, the existing stores being altered to long lights.

Lights. Natures.

There are at present three different natures of lights in the service, viz.,—

(1.) Long.
(2.) Signal.
(3.) Coloured (red).

Light, Long Description.

(1.) *The Long Light*[7] (pl. 6, figs. 1, 2) is made of stout brown paper[8] rolled into a hollow cylinder 9½ inches long, 1·78 inches in external and 1·46 inches in internal diameter.

The bottom of the case to the distance of about 2 inches, is left open for the reception of the handle (pl. 6, fig. 15), a hole being punched completely through both sides of this part of the case for the wooden pin by which the light is secured to the handle.

Above this open part is a layer of ground clay,[9] compressed[10] to ·2-inch in thickness, and forming a support for the composition with which the next 6·6 inches of the case is filled.[11]

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[1] Approved 4th February 1842, A/865 (Board's letter).
[2] Approved 1st January 1856. *Account of Alterations and Additions, &c.*, 30 June 1856, par. 13.
[3] They were first issued in this year, but not officially approved until 25th August 1862. *War Office Circular* 793, par. 633.
[4] 19th December 1860.
[5] 15th April 1861. 82/B/147.
[6] 25th May 1865. 57/194234.
[7] Approved 1st January 1856.—*Account of Alterations and Additions, &c.*, 30th June 1856, par. 13.
[8] 100 lb. paper.
[9] Clay, ground fine and thoroughly dried.
[10] By hydraulic pressure.
[11] The composition is pressed into the case by hydraulic pressure. It is first formed, by hydraulic pressure, into cylindrical pellets (pl. 6, figs. 3 and 4), each 1·33 inches long, and which become further reduced when pressed into the case. The pellets are of two kinds, "soft" and "hard." A soft pellet consists of 1·7 inches loose composition compressed into 1·33 inches; a hard pellet of 2 inches compressed into 1·33 inches. The diameters of hard and soft pellets are the same, viz., somewhat less than the internal diameter of the case, to permit of their being easily introduced, and because the pressure to which they are subsequently subjected expands them to the full size of the inside of the case. Each light contains 5 soft pellets and 1 hard, the latter being placed on the top of the others. The object of having the pellets of different densities is as follows:—If they were all made hard, they would probably not amalgamate into the uniform unbroken column of composition which is necessary to ensure the fire being carried properly through the mass. On the other hand, if the density of the last pellet were not greater than that of the others, the density of the mass would not be uniform, as this pellet receives less pressure than those below, to which some of the pressure of the upper pellets is communicated.

To make the pellets amalgamate better the bottoms of the drifts are cut across with a few grooves.

The composition[1] is—

	lbs.	ozs.
Saltpetre, ground[2]	7	0
Sulphur, sublimed[3]	1	12
Orpiment, red[4]	0	8

The distance from the top of the composition to the top of the case is half an inch (pl. 6, fig. 1); this space is thickly plastered with a priming paste of mealed powder and distilled water, sprinkled with dry mealed powder, and receives the percussion arrangement, consisting of a hollow cylindrical copper tube[5] (pl. 6, figs. 10 and 11), a quarter of an inch in diameter, which passes transversely completely through the upper part of the case. One end of this tube rests against the inside of the case;[6] the other end, which is slightly tapered, projects about ·35-inch from the opposite side in the form of a nipple.[7] Inside the tube are strands of quick-match,[8] and that part of the tube which is opposite the centre of the composition is slotted away[9] to permit of the flame from the quick-match passing to and igniting the composition.

The nipple end of the tube is closed by a small disc of tissue paper shellaced over it. The upper part of the case, to the depth of about three-quarters of an inch, is encircled with a tin band (pl. 6, fig. 5) or "collar," a few folds of paper being removed from the outside of the case, to bring the surface of the collar flush with that of the rest of the case. The object of this band is to strengthen the upper part of the case and prevent it from yielding under the blow required to fire the light.

The light is capped with a cylindrical tin cap (pl. 6, fig. 6), painted inside with an anti-corrosive,[10] and secured with a band of fine paper,[11] which is pasted round the junction of cap, collar, and case.

The whole light,[12] with the exception of the top of the cap, is painted light drab.[13]

On the top of the cap, and on the side of the case, are stencilled the words "long light," and on the opposite side of the case is a label with the following directions for use:—

"Secure the light on the handle by the pin; place a percussion cap "upon the nipple, and give the cap a smart blow upon a hard substance "such as metal or stone."

The handle (pl. 6, fig. 15) for these lights is made of wood,[14] and is about 10 inches in length. The end which fits into the light is enlarged for about 2 inches to the full diameter of the interior of the case, and has a hole through it for the reception of the wooden[15] pin by which the handle is secured to the light. The rest of the handle is cylindrical, with a small knob at the end to give a more secure hold. On one side of the handle a groove is cut up to the pin hole to facilitate the introduction of the pin at night.

The pin is tied on to the handle.

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[1] The same as the old so called "blue" light composition, although the light is rather white than blue. When a really *blue* light is required a different composition is used (see p. 223). When white lights are demanded the composition in the text is used. [2] See p. 313. [3] See p. 318.

[4] Otherwise known as realgar or regulus, or sulphide of arsenic, see p. 312.

[5] No. 24 oz. copper.

[6] Or rather against the tin band with which the upper part of the case is surrounded (see text), a hole being made through the case.

[7] In size and shape corresponding very nearly to the nipple of an Enfield rifle.

[8] Six-thread match.

[9] The slot is rectangular and ·75 of an inch in length.

[10] See table XX., p. 345. [11] Generally "purple fine" paper.

[12] Including the inside of that portion of the case which is intended for the reception of the handle. [13] See table XX., p. 345. [14] Beechwood. [15] Boxwood.

The knob end of the handle and the portion which fits into the light, are painted black ; the rest of the handle is unpainted.

Application and action.

The long light is ignited as described in the instructions which are labelled upon it, viz., the light having been secured upon the handle by the pin, a service percussion cap is placed upon the nipple and struck a smart blow "upon a hard substance, such as metal or stone."[1] The cap fires the quick-match in the copper tube, which, through the slot, ignites the priming and composition, the tin cap being blown off by the sudden evolution of gas.

The light then burns with great brilliancy[2] from 5 to 6 minutes.

Long lights are used both for land and sea service, for signalling or illuminating purposes.

Packing and issue.

They are issued in zinc cylinders, 8 lights in each, and one handle.[3]

The cylinder is closed and secured in the usual way;[4] the lid is painted white and stencilled black, with the nature and number of its contents, date of issue, and packer's name. A label is also placed upon the cylinder with the words, "The caps to be taken from the general "store."[5]

Lights, Signal. Description.

The (2) *Signal Light* (pl. 6, fig. 13, 14) differs from the long light only in being shorter, and in containing one-sixth the quantity of composition,[6] viz., 1·1 inches instead of 6·6 inches.

It burns one minute.

It is stencilled with the words "Signal Light," instead of "Long Light," and labelled with the same directions for use.

Signal lights are used both for land and sea service, for signalling or illumination purposes.

Packing and issue.

They are issued, 8 in a zinc cylinder, with 1 handle.[7] The cylinder is closed and secured in the usual way, the top is painted blue, and stencilled in black, with the nature and number of the contents, date of issue, and packer's name; and with the directions "The caps to be "taken from the general store."

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[1] Unless the blow is sharp and the substance hard the cap will not always be ignited.

[2] The brilliancy of the light is due mainly to the presence of the red orpiment (sulphide of arsenic). The following expanation of the part which a substance like sulphide of arsenic performs in a light composition is given by Colonel Boxer in his *MS. notes*, p. 3, "Being decomposed at a comparatively low temperature, the metal "is set free and disseminated through the flame in a state of incandescence, causing "the intensity of the light to be very considerable; moreover, the heated particles "coming in contact with the atmosphere are thereby oxidized, forming a white "smoke, which is very favourable to the reflection of the light." The above explanation occurs under the head of sulphide of antimony ; but at p. 4 Colonel Boxer remarks that "sulphide of arsenic . . . . possesses the same useful properties as the "sulphide of antimony, but the fumes of the latter are less injurious than those of the "former ; and it would therefore seem advisable to substitute sulphide of antimony for "the sulphide of arsenic in the blue light composition."

It should be noticed that the solid residue resulting from the burning of this composition is considerable, and care must be taken to hold the light where the particles cannot come into contact with anything combustible.

[3] Until 1865 they were accompanied with a proportion of 12 caps. They are now, however, issued without caps, which must be procured from the small-arm supply on charge, or from any other available source.

[4] See p. 206.

[5] *War Office Minute* 57/2/116. See note 4 above.

[6] The composition is introduced in the form of 1 hard pellet (see p. 220, note 11), and is really rather more in quantity than one-sixth that in the long light.

The number of inches of *loose* composition which a long light contains is $2 + 5 \times 1{\cdot}7 = 10{\cdot}5$; while the pellet in the signal light contains 2 inches *loose* composition. This will account for the signal light burning a full minute, or rather over one-sixth the time of the long light.

[7] See p. 221.

Light, long, coloured.

The (3) *Coloured or Red Light* resembles the long light in its general construction, but differs from it,—1st. In the method of priming and igniting, the upper part of the light being primed to a depth of ·5 of an inch with a thick priming paste, and matched with strands of quick-match tied into a bunch above the calico cap with which the light is closed. The light is fired by the application of a lighted match or portfire to the quick-match.

2nd. In the composition, which consists of—

	lbs.	ozs.		lbs.	ozs.
Strontia, nitrate of -	5	0	Shellac - -	1	2
Calomel - -	3	3	Copper, sulphide of	0	4
Potash, chlorate of -	4	$14\frac{3}{4}$	Dextrine - -	1	6

3rd. In being rather shorter, and containing only about 5 inches of composition.

4th. In the handle, which is of a slightly different shape, being permanently attached ; and,

5th. In being painted red all over, handle included.[1]

This light burns about 2 minutes with a red flame.

The red light hardly ranks as a service light, being issued occasionally only to Her Majesty's ships, the Royal Yacht, Dover and Edinburgh Castle, &c., for displays.

Packing and issue.

These lights are issued in metal lined cases, either whole or half, containing respectively 100 and 42. The case is stencilled with nature, number of contents, date of issue, and packer's name, &c.

Blue and green lights.

Note.—Blue and green lights have also been supplied for exceptional purposes; to the English ships, for example, which were present at the Cherbourg and Portsmouth fetês of 1865. Their construction is identical with that of the red light above described, with the exception of the compositions and of the colour which each light is painted, viz., the blue lights blue and the green lights green.

The compositions for these lights are as follows :—

Blue.

	lbs.	ozs.		lbs.	ozs.
Potash and copper, chlorate of -	2	4	Shellac - -	0	$10\frac{1}{2}$
Calomel - -	1	5	Potash, chlorate of	2	7

Green.

	lbs.	ozs.		lbs.	ozs.
Baryta, nitrate of -	5	0	Charcoal - -	0	3
Sulphur - -	1	8	Shellac - -	0	2
Calomel - -	1	0	Potash, chlorate of -	2	0

White lights of a similar construction are also sometimes issued. The composition is the same as that in the service long and signal lights.[2]

CLASS 4.—MATCH.

Match. Two descriptions.

There are two descriptions of match in the service, viz. :—

(1.) Quick.
(2.) Slow.

History.

Both quick and slow match have doubtless been known and used for many centuries. In the history of the means which have been em-

[1] There are a few other minor points of difference, such as the less thickness of the case of the long light, the absence of marking on the outside, &c. &c., which it is unnecessary to enumerate.

[2] See table XIX., p. 345.

ployed for firing the charges of guns it has been stated that guns were fired about the beginning of the 17th century by means of a piece of quick match called "porte-feu" placed in the vent, which acted "as a "weak tube."[1] Worsted has been used instead of cotton for quick-match, but it would seem not to have been employed in our service since 1778.[2]

Slow-match was certainly used for igniting the priming powder as early as the 16th century, for mention of the linstock occurs about that period,[3] and most probably it was employed for this purpose and others of a similar character even before that date.[4]

"Before the invention of flint locks slow burning match was used for firing small arms as well as ordnance; its rate of burning was also applied to measuring the time which a sentry had to remain on his post, "so many thumbs' breadths being allowed to each;" consequently an army of the 17th century required vast quantities of match among its provisions of stores. The estimate of material for 30,000 men in 1620 included "186 tunne of match."[5]

In 1782 the French adopted a slow-match, invented by Col. La Martillière of the Artillery, consisting of rope or hemp soaked in a solution of three-quarters of an ounce of sugar of lead[6] and one pint of rain water. It burns 5 inches per hour.[7] The same sort of match appears to be used by the French at the present time.[8] English slow match has generally been made of hemp, loosely twisted and soaked in a boiling solution of saltpetre and water, or saltpetre and lime water, in the proportion of 8 ozs. of saltpetre to 1 gallon of water;[9] but for a considerable period[10] a lye of wood ashes and water has been substituted

[1] See p. 188. The *Great Art of Artillery*, p. 125, describes "How to prepare " several sorts of quick-match for artificial fireworks." Among these sorts is one which is almost identical with the quick-match made in the present day. "There is " another kind of pyrotechnic quick-match which is not twisted at all, but is only " . . . . steeped in good brandy for some hours, and then powdered over with flower " or meal of gunpowder and dried. There are those who add a little gum arabic or " tragacant to the brandy, particularly when they would have it stick fast to any-" thing." We have here in the quick-match of the 17th century all the ingredients of the match of the 19th century, the cotton ("you should make the match of the tow " of flax, hemp, or cotton"), the mealed powder, and the gum arabic, the only difference being the employment of brandy instead of distilled water."

[2] "Worsted quick-match no longer in use since 1778."—Sir Augustus Fraser's *MS. Laboratory Notes*, p. 58.

[3] See p. 188.

[4] See p. 188. The following description, "How to prepare the common sort of " match," is given in the *Great Art of Artillery*, p. 123. "Let there be twisted " some rope of half an inch diameter, made of the second combings of flax or hemp, " free from any of the stalks, then take ashes of oak, ash, elm, or maple three parts, " of quick lime one part, and make a lye of it as usual; to this you shall add one " part of saltpetre; and of the juice of horse or ox dung, well filtrated and gently " expressed through a woollen cloth or sieve, two parts." Then follow instructions for boiling the rope in the solution "continually for the space of two or three days," after which the rope was to be well wrung and hung on poles to dry in the sun.

[5] *Equipment of Artillery*, pp. 102, 103.

[6] Acetate of lead.

[7] The *Pocket Gunner*, edition 1827, p. 229.

[8] *Instruction d'Artillerie*, p. 369.

[9] Almost every work upon such matters gives these ingredients and proportions, and therefore I conclude that they were generally used.

[10] I cannot say when the change was effected. Inquiries made at Chatham, where the match is now manufactured, place it beyond doubt that wood ashes have been used for more than 20 years, and for how long before that period it is impossible to say. It is curious, however, that the different works upon the subject should not have noticed this change; but I am not aware of a single book published up to the present time in which slow-match is described which does not give saltpetre instead of the wood ash solution.

for the saltpetre solution, and the present service match is made in this way. Doubtless economical considerations recommended the change.

Since their first introduction quick and slow match have been continually used for various purposes by artillerymen and others. The former, though no longer employed for firing guns, except at proof of powder, is extensively used in articles of Laboratory manufacture, and for various other purposes, as a means of communicating ignition; while the latter still forms part of land and sea service artillery equipments, and always accompanies portfires in order to furnish the means of lighting them.[1]

1. *Quick-match* consists of cotton wick of different thicknesses boiled in a solution of gum arabic, mealed powder, and distilled water in the following proportions:—

——	4-Thread[2] Wick.	6-Thread Wick.	10-Thread Wick.
	lbs. ozs.	lbs. ozs.	lbs. ozs.
Cotton wick[3] - - -	1 10	2 2	2 7
Powder mealed[4] - -	20 0	20 0	24 0
Gum arabic[5] - - -	0 8	0 9	0 10
	Pints.	Pints.	Pints.
Water, distilled - - -	8	9	10

Quick-match when "raw,"[6] or unenclosed, burns at the rate of about 1 yard in 13 seconds.[7]

But when enclosed in a small[8] tube of any description it explodes instantaneously, from the same cause as that which produces the action of an ordinary tube,[9] the gas, which in the raw match is subject to no restraint, being here unable to escape as quickly as it is formed, necessarily rushes forward, igniting fresh surfaces in its passage, and producing a violent[10] explosive effect.[11]

Advantage is taken of this property of quick-match to effect, where required, the simultaneous ignition of a number of combustibles, such as fire works, stores for proof, &c. &c. In such cases the match is

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1 *Equipment of Artillery*, p. 102.

2 Four-thread match is the one most used in Laboratory operations; but the others are sometimes employed; indeed two-thread match and match of various thicknesses have also been made.

3 Ordinary wick, otherwise known as "cotton yarn;" when used for making quick-match it should be very slightly twisted, quite free from lumps, and not too thick.—Col. Boxer's *MS. Notes*, p. 17.

4 See p. 138. The solution only contains two-thirds of the quantity of mealed powder specified, one-third being used to sprinkle over the match after it is made.

5 The object of the gum arabic is to cause the powder to adhere to the cotton.

6 The word is technically used to describe quick-match in its natural condition.

7 The burning of quick-match is very irregular, varying with the condition of the match and the quantity of powder over its surface. One yard in 13 seconds is about the mean rate of burning of new match. As it becomes deteriorated it burns more slowly. There is no difference in the rates of burning of the match of different threads.

8 "Small," because evidently the match would be practically unconfined in a very large tube.

9 See p. 203.

10 The violence of the explosion will depend upon the amount of pressure to which the gas is subjected in the tube, and will vary therefore with the strength of the match, the size of the tube in relation to the size of the match, and the resisting power of the tube to the explosive effects.

11 See p. 189, respecting the early employment of quick-match for the firing of guns.

placed inside a tube or cylinder of paper,[1] the internal diameter of which is the same as that of the miner's portfire.[2] The ignition of any combustibles which it is not safe to approach, may be readily effected in the same way, the paper tube being made of the required length by fastening a number of lengths together[3] and pasting a piece of paper over the junction.

A paper case with a piece of quick-match enclosed is known as a "leader"[4] or "pipe match."[5]

It would be impossible to enumerate all the purposes for which quick-match, either "raw" or in the form of a "leader," is employed. There are very few combustible stores into the manufacture of which it does not enter in one form or the other; and as a "leader" it is useful under various circumstances indicated above; it is also used at Purfleet to fire the mortar at proof of powder.[6]

Quick-match is issued with siege equipments for such miscellaneous purposes as it may be required for.

Packing and issue.

It is issued either in long packing or in metal-lined cases, and should be demanded by weight.

The following are the approximate lengths to a pound of each nature:—

10 thread,	280 feet	
6	,,	364 ,,
4	,,	544 ,

2. *Slow-match*[7] consists of hemp[8] slightly twisted,[9] boiled in a ley of water and wood ashes[10] in the proportion of—

Wood ashes, 1 bushel.
Water, 50 gallons.

This amount serves for 100 lbs. of yarn.

Slow-match burns at the rate of 1 yard in 8 hours. It is used as a means of carrying fire for lighting portfires, or similar purposes.

Packing and issue.

It is issued both for land[11] and sea service.

Slow-match is issued loose in skeins or parts of skeins placed in a case with other stores. If a large quantity is demanded it is issued in bales or casks. It should be demanded by weight; about 4 yards go to a pound.

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[1] Linen and calico have been exceptionally used.

[2] See p. 214. The same form is used in making leaders.

[3] One end of each length of leader is slightly enlarged to permit the small end of another length entering it.

[4] Whence has been coined the verb to "lead," "leading" fireworks, &c., signifying in pyrotechny laying a "leader," as above described, up to them.

[5] This term is now rarely used.

[6] A powerful tube would lend some part of its force to projecting the shot, and it would be impossible to determine accurately how much projectile force was due to the tube and how much to the powder. Quick-match, on the other hand, forming, as before pointed out (see p. 189), a very weak tube does not sensibly augment the strength of the charge.

[7] Slow-match is not manufactured at the Royal Laboratory but at Chatham, under the superintendence of the Store Department.

[8] Pure Russian hemp.

[9] The hemp is either spun loosely into yarn or slightly twisted.

[10] Carbonate of potash. Almost any salt would answer the purpose, the function of the salt being slowly to propagate the heat from fibre to fibre; see p. 224, respecting the French slow-match, made with a salt of lead (acetate of lead), and p. 224 respecting the original English slow-match, which was made with saltpetre. Wood ashes are used on account of being cheap and readily procurable.

[11] By *War Office Circular* 8 (new series), § 1149, the proportion of slow match in field siege, and garrison equipments was diminished.

MISCELLANEOUS STORES CONNECTED WITH MEANS OF IGNITING CHARGE.

The following stores are all more or less intimately connected with the firing of the gun and the service of the vent:

Lanyards.
Tube { Boxes. / Pockets.
Thumbstalls.
Powder-horn.
Portfire bucket.

A description of the Life Buoy, with which the life buoy portfire is used, is also introduced.

Lanyards.

Lanyards for firing friction tubes[1] are of five sorts, viz.:

(1.) Garrison service lanyard, short.
(2.) " " " long.
(3.) Field " "
(4.) Naval " " short.
(5.) " " " long.

The (1) *Garrison lanyard*[2] (*short*) is made of white line,[3] tarred, and measures 7 feet 6 inches;[4] a hand loop 6 inches long is formed at one end of the lanyard by an eye splice, the splice being covered over, or "hosed" with leather;[5] on to the opposite end of the line is spliced an iron hook, which is browned;[6] to prevent it from rusting. The splice is hosed with leather. Lanyard, friction tubes, garrison (short).

The (2) *Garrison lanyard*[7] (*long*) differs from the ordinary garrison lanyard only in being 12 feet long. It is used for all guns of 9-inch calibre and upwards,—rifle and smooth-bore, and will supersede the ordinary garrison lanyard for future manufacture.[8] Lanyard, friction tube, garrison, 12 feet long.

The (3) *Field service lanyard*[9] differs from that for garrison service only in being shorter.[10] It measures 5 feet 4 inches. Lanyard, friction tube, field.

The (4) *Naval lanyard*[11] (*short*) is made of untarred white line,[12] and Lanyard, friction tube, naval (short).

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[1] The lanyard for firing detonating tubes is now obsolete, consequent on the removal of these tubes from the list of service stores.

[2] Present pattern, tarred line, approved 22nd November 1862.—*War Office Circular*, 815, para. 683. Before that date the lanyards were made of white line, not tarred. The change was proposed by Lieut.-Col. A. H. Graham, Royal Artillery; and by *War Office Circular* above quoted it was directed that "existing lanyards of "white line be tarred or soaked in corrosive sublimate by military store officers when "necessary."

[3] "White line, 18 per dozen."

[4] When finished, from the extreme end of the loop to the point at which the hook is attached.

[5] Thin basil.

[6] The hook is browned by dipping it heated into linseed oil.

[7] Approved 23rd May 1866, *War Office Circular* 10 (new series), § 1257.

[8] See *Ibid.*

[9] Present pattern, tarred line, approved 22nd Nov. 1862.—*War Office Circular*, 815, para. 683.

[10] So long a lanyard is evidently not required for field as for garrison service, on account of the difference in the height of the carriages.

[11] Present pattern approved 18/10/60, *War Office Circular*, 665, para. 167. Before that date the hook was of a smaller and weaker construction.

[12] Same line as that for land service.

is about 8 feet long;[1] one end is fitted[2] with a box-wood "toggle," or handle, about $2\frac{1}{2}$ inches long; on to the opposite end is spliced a stout iron hook,[3] considerably thicker than that used for land service. The hook is browned and the splice hosed in the usual way; about 15 inches from the hook is whipped on to the lanyard a string loop 3 inches long, "for half cocking."[4]

Between the loop and the hook a small leather washer, or stop, runs on the lanyard, and prevents it from being pulled completely through the guide plate. This lanyard is for use with all smooth-bore guns except 100 and 150 prs.

Lanyard, friction tube, naval (long).

The (5) *Naval lanyard* (*long*) differs from the short naval lanyard in being 9 feet 6 inches long, in being made of stouter line, and in the loop being fixed 24 inches from the hook. It is used for the 64-pr. M.L. and all guns of 6 tons and over. The only smooth-bore guns with which this lanyard is used are the 100-pr. and 150-pr.

Tube Boxes.

Tube boxes are of three kinds—

(1.) Leather.	(2.) Tin.	(3.) Wood.

Box, leather, tube.

The (1) *Leather tube boxes* are of two sizes, (*a*) small, (*b*) large.

The (*a*) small box[5] is a nearly rectangular leather[6] box, lined with stout untanned hide.

The box is about 5 × 3 × 3 inches, the back being slightly hollowed out to fit the breeching loop. It is fitted with a leather lid, which is secured when closed by a brass hasp. At the back of the box is a leather loop, through which passes a short strap,[7] by means of which the box is attached to the breeching loop or cascable.[8] There is also a perpendicular leather thong with a hole in it, for buttoning on to the breech pin. There is no perforated plate in these boxes.

Leather tube boxes are used to contain quill friction tubes[9] when firing with the guns with which these tubes are respectively used.

They are issued to ships only, the supply being restricted to such guns as are not graduated upon the rear of the cascable. Eventually they will be superseded by the large box.

The (*b*) large box[10] is hollowed out on the lower side to fit the top of the cascable, on to which the box is strapped when supplied with

[1] Finished.

[2] The lanyard is passed through the toggle and knotted.

[3] An increase in the size of this hook was the alteration effected 18/10/62. See p. 227, note 11.

[4] This expression is the one officially used, but it does not seem a very correct one, since the lanyard is not intended to be employed with a hammer. The operation designated "half cocking" consists in placing the loop over the guide plate, after the tube has been placed in the vent, until the word "ready" is given, and by this means to avoid the accidental premature firing of the gun. Such an arrangement is necessary on board ship, since the tube has to be placed in the vent before the gun is "trained," to ensure no loss of time in firing; and it would be unsafe to place the lanyard in the hand of the number who has to fire the gun, during the training, without making it impossible for a chance pull on his part, due perhaps to the rolling of the ship, or other causes, to fire the gun.

[5] Supplied by contract; (approved 29th January 1858, 57/24/267). The store of old pattern boxes, designated "leather-box O.P.," are not yet exhausted. The O.P. boxes are still issued, but as every day they are becoming more nearly obsolete, it is unnecessary to describe them. When these O.P. boxes are used for friction tubes, the perforated plate with which they are fitted must be removed.

[6] Brown leather about ·1 inch thick.

[7] Can be demanded separately.

[8] Termed "necklet" by the navy.

[9] They were used to contain cross-headed tubes until these tubes became obsolete.

[10] Approved 27th October 1866, 57/24/4372.

muzzle-loading guns. The lid is closed by means of a brass hasp. It is used for the same purpose as the small box, and has been introduced into the service for immediate use with all guns, the ends of the breeching loops of which are graduated for the wood tangent scale, which graduation would be covered by the small box. Prospectively the large box will altogether supersede the small one in all supplies for the armament of vessels.

Box, tin, tube.

The (2) *Tin tube box* is a rectangular tin box, about 4 × 4 × 3 inches in size, with a lid secured with a hasp. On the back of the box are two tin loops for the reception of the leather belt,[1] by means of which the box is attached to a man's waist.

The whole box is painted black inside and out.

Tin tube boxes are used to contain 100 copper friction tubes for garrison service. They are supplied for garrison service only.

Boxwood tube.

(3) *Wood tube boxes* are of two sizes, "large" and "small."[2] They are wood packing cases with hinges and hasps, and painted white, to contain respectively 20 and 10 cylinders of quill friction tubes (with loops). The total number of tubes in a box being 2,000 and 1,000 respectively, the boxes are issued for naval service only.

Tube Pocket.

Pockets, tube.

Tube pockets[3] are only of one nature, viz., a brown leather pocket, with flap lid and rounded base, about 6 × 3 × 4 inches large.[4] The lid is secured with a leather thong and button. On the back of the pocket are two loops for the reception of the belt[5] or strap by which it is attached to a man's waist.

Leather tube pockets are issued for field and boat service only.

Thumbstalls.

Thumbstalls.

Thumbstalls are of two natures, viz., for land service and sea service. The land service thumbstall resembles the thumb of a huge glove, made of serge, and padded under the "ball" of the thumb with leather. There is a piece of string attached to the thumbstall for tying it on to the hand.

The sea service thumbstall[6] is made entirely of wash leather, with a leather strap and buckle to fasten it to the wrist.

"Thumbstalls are worn to protect the thumb, which is pressed on the "vent whilst a piece is being loaded, in case the metal has become "heated by long-continued firing."[7] The leather pad on the land service thumbstall is to wipe the fire away from the vent immediately before "serving" it. The land service thumbstall is no longer issued.

Powder-horn.

Powder-horn.

The powder-horn[8] is a bullock horn, about 12 inches in length. The larger end is closed by means of a wood top, in the centre of which is a

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[1] The belt can be demanded separately.

[2] This nomenclature was adopted 13/8/66, *War Office Minute* 61 (Laboratory), 2182. Up to that date the boxes were called 3 and 4. Nos. 1 and 2 were for detonating tubes, but when these tubes became obsolete the boxes of course became unnecessary and were abolished; it then became necessary to alter the nomenclature of 3 and 4.

[3] Manufactured in Royal Carriage Department. Present pattern approved 15th September 1865, *War Office Circular* 7 (new series), para. 1123. A pattern, differing from the present one only in depth of the ends of the cover had been approved 14th May 1862.

[4] The depth measurement, 4 inches, is taken at the deepest part of the pocket.

[5] Can be demanded separately.

[6] Approved 30/9/67, 57/2/10386.

[7] *Equipment of Artillery*, p. 116.

[8] Present pattern approved, 20th July 1865, *War Office Circular* 7 (new series), para. 1125.

hole, tapped for the reception of a screwed brass cap and wooden plug, by which it is closed. Through this hole the powder is introduced. The small end of the horn is fitted with a brass spout, having a thumb-spring, by which the horn is opened or closed.

A line for suspending or carrying it is attached to the bend of the horn by means of two eyes.

The horns are filled with powder, and are used for priming guns fitted with flint locks, where such exist, or with other guns where necessary. They are also sometimes used to introduce a little powder for the purpose of blowing out a rammer or projectile, which may have become jammed in the chamber at drill or any other time.[1] These horns are nearly obsolete, but may be found at some few stations; and the Royal Artillery are still instructed in their use.[2]

Portfire Bucket.

Buckets, portfire.

There is only one portfire bucket in the service. It is a wooden inverted bucket, iron-hooped, and closed at both ends, with the exception of a circular hole in the upper (smaller) end. At one side of this hole is a portfire clipper. The barrel is painted a dark slate colour.

Portfire buckets are used to cut off the lighted ends of portfires, and so to prevent the danger which might result from those ends being thrown unextinguished between the guns.

The bucket is filled with water, into which the ends of portfire fall.

Portfire buckets are issued only when specially demanded for garrison service.

Life Buoy.[3]

Buoys, night, life.

The life buoy, with which the life buoy portfires[4] are used, consists of two hollow spheres of copper (painted black[5]) about 14 inches in diameter, at opposite ends of a horizontal rectangular wooden bar, the distance apart of the two globes being about 20 inches;[6] a cylindrical[7] bar passes vertically through the centre of the other, the top of it, which is about 30 inches above the horizontal bar, being fitted with a brass socket, into which the stem of the portfire plate fits, and where it is secured by a screw.

Inside the vertical bar is a brass "balance rod," weighted at the lower end with iron, and attached by means of a chain to a trigger bolt in the side of the ship. This chain also suspends the life buoy, which has no other support.

The distance of the buoy from the side of the ship and the direction of its fall are regulated by two brass rods fixed parallel to the ship's side, and at a sufficient distance from it to steer the buoy clear of it.

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1 "If a shot jams in the bore," and cannot be removed by depressing the gun, "the cartridge must be drowned, and afterwards a small quantity of fine powder "introduced by the vent and the shot blown out."—*Manual of Artillery Exercise*, p. 145. It is particularly to be noticed that under no circumstances should the powder be introduced into the vent direct from the horn, as an accident under such circumstances would probably be attended with serious consequences. *The powder must be poured from the horn into the hand, and thence into the vent; the horn, which is, in fact, to be regarded as a small magazine, being kept in the back ground.*

2 See *Manual of Artillery Exercise*, p. 77, where "powder horn filled with L.G. "powder," is included among the stores.

3 Respecting the introduction of the buoy, see p. 217. Parts of these buoys are made in the Royal Laboratory, and other parts are procured by contract.

4 See p. 217.

5 Ordered to be painted black 2nd July 1866. *W.O.C.* 11 (N.S.), § 1324.

6 This is the distance between the nearest points on the circumference of the two spheres; from centre to centre they are about 34 inches.

7 Or nearly so, the bar being slightly tapered.

The buoy is protected externally by guard irons, which surround it at a short distance.

The portfire is protected from the effects of damp, &c. by a gun-metal cover fixed permanently to the ship's side, immediately over the portfire. It is to this cover that one end of the lanyard is fixed.

The trigger bolt, to which the chain by which the buoy is suspended is attached, is connected by a line, or "pulley," with a brass knob inside the ship.

When the knob is pulled, the trigger bolt is released, the chain becomes detached, and the buoy falls away, the balance-rod shooting out at the same time, and keeping the buoy in an upright position in the water. As the buoy falls away the portfire becomes ignited.[1]

These life buoys are issued to the Royal Navy, buoy and appurtenances complete, with a proportion of spare portfires;[2] or, on demand, any of the parts of the apparatus, enumerated in the following list,[3] are supplied:

Buoy, only.
Bolts, trigger.
Caps, brass.
Cover,[4] { Plate. / Portfire.
Irons, { Guard. / Guide.
Knobs.
Lanyards with hooks.
Portfires, fixed to plates.
Pulleys.
Rods, { Balance. / Brass sliding.
Scutcheons, brass.
Screws, iron.
Sockets, brass.

Subdivision (b.)—Means of igniting the Bursting Charge.

The bursting charge of a shell is ignited by means of a fuze[5] so contrived as to effect its ignition at any particular moment during its flight, or upon or after impact.[6] Fuzes. History.

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[1] See p. 219.

[2] Ten portfires to each buoy.

[3] *List of Stores manufactured in Royal Laboratory*, p. 82.

[4] The plates are procured by contract, but the portfires are Royal Laboratory manufacture.

[5] I am indebted to Professor Max Müller for the following derivation of the word "fuze":—"*Fuze* and *fuzee* seem to be varieties of the same word, and from it comes "the French word *fuseau*, a spindle, and *fusée*, what is twisted round a spindle. The "same word *fusée* is in French transferred to the small cylinder which contains the "explosive substance in fireworks; shells, or, strictly speaking, fuze, would go back "to the Latin *fusus*, spindle; *fusee* to a mediæval Latin form *fusata*, what is twisted "round a spindle. But I suppose the distinction between the two words is due to the "technical writings of military men. The French *fusil* comes from quite a different "source—from Latin *focus*, used in the sense of fire (*fuoco*, *feu*), from which, as "adjective, *focile*, fire arm."

[6] "The fuze is the soul, the ground work, of any system of explosive projectile. It "is the criterion of the system; and, indeed, what is a shell fired with a fuze not "fulfilling the required condition of determining the bursting of the projectile at the "precise point in its trajectory which will best suit the intended purpose? It is "inferior to a solid shot, because the latter is cheaper and less dangerous to keep in "store; and this applies more strictly to shrapnel. The untimely explosion of projec-"tiles may accidentally render some service, but in cases like those under considera-"tion we never ought to rely for efficiency on accidental occurrences."—*The Shrapnel Shell in England and Belgium*, p. 15.

Although shells of a rude and imperfect sort are said to have been used as early as the 14th century, and were no doubt employed as early as the 15th century, "it seems certain that they did not come into "general use . . . until about the beginning of the 17th century;"[1] and we can hardly expect, therefore, to find much mention of fuzes until about that date.

Probably the earliest shells had some arrangement corresponding to a fuze for igniting their bursting charge; but what this arrangement was we can only conjecture. The only description of a fuze in use in the 14th and 15th centuries which I have been able to find is one, which occurs in Gibbon's *Artillerist's Manual* and Thiroux's *Instruction d'Artillerie*, of an iron fuze said to have been used in 1421 at the siege of St. Boniface in Corsica. This fuze is spoken of as "a sheet "iron tube enclosing the priming, and riveted to one of the hemispheres "of the shell."[2]

Time fuzes.

But in the second half of the 16th century we come across several sorts of fuzes, the rudest of which appear to have been hand grenades, three parts filled with powder, and the remaining space with a mixture of mealed powder and sulphur, to which the fire was to be applied and so conducted to the bursting charge;[3] this mixture of mealed powder and sulphur evidently answering to the fuze of the grenade.

Schafftenberg describes with sufficient accuracy the fuzes which were employed at that period for incendiary and other shells then coming into more general use. These fuzes seem to have been made of cast iron, cylindrical in form, generally about the diameter of a finger, in some cases larger, and of different lengths; and they were driven with a composition of saltpetre, sulphur, and mealed powder.[4] But perhaps the application of these ancient fuzes is of more consequence than the details of their construction, in which, however, it is evident they resembled very closely the fuzes which were used in the British service until about 15 years ago, and which are employed by some foreign artilleries to this day.

The fuzes of the 16th century, although, of course, intended to communicate fire to the bursting charge of the projectile, differed materially in the manner of their application from the fuzes now in use. In the 16th century artillerists were ignorant of the fact that the flame from the charge would ignite the fuze if placed towards the muzzle and in consequence they had recourse to some rude devices for igniting the fuze and charge separately.[5] In some cases the fuze was placed away from the charge, as at present, and the gunner lighted it before firing the charge;[6] in other cases the fuze was turned towards the charge, and the same fire which was applied to fire the gun was supposed to ignite the fuze.[7]

Guns and mortars continued to be fired after a clumsy and dangerous fashion of this sort, slightly varied according to circumstances, for some time;[8] and although there is good reason to believe that the present

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[1] See page 23.
[2] Gibbon's *Artillerist's Manual*, p. 156; *Instruction d'Artillerie*, p. 283.
[3] *Le Passé et l'Avenir d'Artillerie*, vol. iii., pp. 260, 272.
[4] *Ibid.*, p. 274–279.
[5] Distinguished from the present plan by being called "*tir à deux feux.*"
[6] *Le Passé et l'Avenir*, &c., vol. iii., p. 274–276.
[7] "Alors le feu mis à la lumière de la pièce se communique au tube du boulet, qui "brûle en l'air."—*Ibid.*, p. 276. See following note.
[8] The author of the *Great Art of Artillery*, writing in 1649, describes two or three ways of igniting the fuze. One is to place between the charge and the projectile a fluted or perforated wood tompion, the fluting or perforations of which were filled

method of placing the fuze towards the muzzle, and allowing the flash from the charge to ignite it, was actually practised as early as the first half of the 17th century,[1] it is almost certain that this plan was scarcely understood,[2] and that it did not become by any means general until about the middle of the 18th century.[3] From that time, however, time fuzes have always been ignited by "a single fire;" and as wood fuzes had been introduced about a century before this[4] the system of time fuzes which was in vogue in this country until the introduction of the Boxer system of fuzes, and which, indeed, is still employed in other countries, may be said to date directly from the early part of the last century.[5]

How the old fuzes were prepared to burn the required time does not appear; whether by boring, or cutting off, or otherwise. It is not improbable that they were allowed to burn their full time, like our present hand grenade fuze;[6] or, if regulated at all, the difference in the

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with mealed powder, which became ignited by the flash of the discharge, and communicated the fire to the fuze. Another plan, "much the more dangerous of the two," was to place the fuze next the charge, with a perforated tompion between the two, the fuze being in the hole in the tompion. He also describes the method above referred to of lighting the fuze before firing the charge (pp. 231, 232). Another plan is described at page 241 as a great improvement, viz., by making the gun with two vents or touch holes, "one of which descends obliquely into the chamber where the powder "is, and the other perpendicularly upon the grenado, by which the fire is conveyed "to light a kind of quick-match with which the grenado and its fuze are coated all "round, to the end that whilst the powder is taking fire the grenado may be in readi- "ness to depart, and only wait for the motion which is to be given by the flash of "the gun."

[1] This plan is described in the *Great Art of Artillery*, p. 241: "The bottom of "this *grenado* shall be turned inwards, or towards the powder in the gun, and conse- "quently its fuze must be directed outwards towards the muzzle of it. Though the "*grenado* be fixed in this posture you need not fear its being fired before it gets out "of the piece, for being agitated by the flash of the powder, it must in its excursion "through the chase of the gun be turned and whirled round several times before it "can reach the muzzle; therefore it will be impossible for it to miss taking fire from "the flash, which wraps itself round it by turns."

[2] The description given in the above note seems to imply that the writer was unacquainted with the fact that the lighting of the fuze probably takes place *instantaneously* on the firing of the charge; he seemed rather to suppose that it took place during the "excursion of the shell through the chase of the gun," and that if the shell did not turn and whirl several times in the bore ignition would not take place.

[3] The author of *Le Passé et l'Avenir* claims for his countrymen the credit of having first introduced "*le tir à un seul feu*," in 1747; and there seems to be little doubt that it became general about this time. But that the merit of the discovery that fuzes could be thus ignited belongs to the French is doubtful. It has been shown above that it had been practised, not in France, but in Poland, about a century before the French claim to have introduced it; and Major Miller says it had been practised in England long before 1766, the date which is assigned for its introduction into France. —*Equipment of Artillery*, p. 101.

[4] "La fusée en bois fut employée dans les Provinces Unies des Pays-Bas, pour les "projectiles creux explosis, des les premières années du xvii^e siecle."—*Le Passe et l'Avenir*, vol. iii., p. 321.

Simienowicz (1649) also describes wooden fuzes, p. 212.

[5] Even the ingredients used were the same, though the proportions differed. In the *Great Art of Artillery*, p. 211, four different fuze compositions are given; they all contain the same ingredients as our present fuze composition, and no others, and the method of priming the fuzes was much the same.

"This concavity must be filled with powder finely mealed, which must be moistened "with a little gum or glue water, that it may stick together the closer."—*Ibid.*, p. 211.

[6] I find that the length of the fuze bore a certain proportion to the diameter of the grenado (the *Great Art of Artillery*, p. 211, says two thirds). Thus each shell must have had its own fuze, the length and time of burning of which was doubtless proportional to the ordinary range of the projectile. Moreover, the adoption of *iron* fuzes originally would go to prove that the fuzes were not prepared by cutting to length.

time of burning was perhaps effected by using compositions which burned at different rates.[1]

No doubt, however, the ancient fuzes burnt with much less regularity and certainty[2] than those now in use. The method of preparing, driving, and proving[3] the composition was probably much ruder than at present; and the burning of fuzes, it is now well known, is materially affected by the care and exactness with which these different operations are performed. Little by little improvements were effected, until, about the close of the last century, time fuzes were, as was then considered, brought to perfection.[4] That the system was in reality very far from perfect will presently appear;[5] nevertheless, it had so far improved that fuzes burnt at a certain known rate, and could be prepared by cutting or boring for any required time of flight.

Between 1829 and 1832,[6] when shells and shell guns first became general in the navy, gun metal time fuzes recommended by General Miller[7] were adopted for all filled naval shells, for reasons set forth at length hereafter;[8] and they have since been retained for naval use, although the subsequent introduction and general use of percussion fuzes has materially altered the circumstances of the case.[9] They are now, however, gradually being superseded by the Boxer wood time fuzes.[10] It would be almost impossible to trace accurately the various

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In some cases, also, we find the fuzes fixed to and forming part of the shell. Such fuzes could therefore scarcely have been prepared to time in any way.

There is a passage in the *Great Art of Artillery*, p. 224, which seems to show that fuzes were prepared by boring:—" But the whole mystery is to know of what dimen-" sions to bore the fuzes, for there is a certain limited time at the period of which the " grenado is to perform its effects." But judging from the context, I should be inclined to think that the author refers to the *original* boring of the composition channel during the manufacture of the fuze, and not boring into the composition itself to prepare it for a given time of flight. The "whole mystery" is, unfortunately, not explained.

1 Thus we have, as before stated (p. 233, note 5), four different fuze composition given in the *Great Art of Artillery*, the ingredients of all of which were the same, but the proportions different, and the rates of burning of which must therefore have varied accordingly.

2 In the *Great Art of Artillery* instructions are given for the preparation of a fuze, with threads of quick-match stuck about it here and there, " for fear the fuze should " unluckily go out by the violence of the wind during the flight of the bomb."—p. 225.

3 Instead of proving compositions by burning them carefully to time, as at present, with a stop-clock beating tenths of seconds, we find among the instructions for proof, in the 17th century, one that the compositions (of "fire balls" in this case, but doubtless the same rude method was generally practised) should burn "during the time " you can rehearse the Apostles' Creed."—*Great Art of Artillery*, p. 488.

4 *Expériences sur les Shrapnels*, p. 44.

5 See advantages resulting from introduction of Boxer fuzes, p. 240, where the defects of the old system are set forth.

6 It seems that metal fuzes were at first only adopted for *filled* shells, and the first ship thus fitted out was the "Talavera," in 1829, which carried 20 filled shells per gun, these shells being fitted with metal fuzes.

In 1832 (by Board's letter 5th November 1832, *a*/1132) the Admiralty signified their approval of filled shells with *metal* fuzes being issued to such ships as had 68-pr. carronades and shell guns, with available storage. This, in fact, marks the first *general* adoption of metal fuzes.

7 *Experiments in Her Majesty's ship "Excellent,"* p. 13.

8 See p. 263 and Appendix L., p. 379, where the relative advantages of metal and wooden fuzes are considered.

9 See Appendix L., p. 379.

10 Ultimately, when enough Boxer fuzes and adapters have been made, the metal time fuzes will entirely disappear. See *W.O.C.* 10 (*New Series*), § 1236. Also *W.O. Minute* 5th July /66. $\frac{75}{\frac{12}{2852}}$

slight changes made from time to time in the service fuzes, wood and metal; and since no change of a material or important character was effected until 1850 it would be profitless to do so.

At that date there would appear to have been in our service no less than 19 time fuzes of different sorts, viz., 16 wood and 3 metal. The 16 wood time fuzes were as follows:—10 shrapnel fuzes, *i.e.*, an 8-inch shrapnel fuze for use with the higher natures of these shells; a $5\frac{1}{2}$-inch shrapnel fuze, uncut; the same cut or bored to different lengths, from ·1 inch to ·7 inch, and lettered as follows: A=·1 inch, B=·2 inch, C=·3 inch, D=·4 inch, E=·5 inch F=·6 inch, G=·7 inch, one inch not lettered.[1]

There were five mortar and common fuzes, viz., 13-inch, 10-inch, 8-inch, $5\frac{1}{2}$-inch, and $4\frac{2}{5}$-inch, the $5\frac{1}{2}$-inch being used for all common shell up to the 24-pr. inclusive, and with some 32-pr. shells; the 8-inch being used with those 32-prs. which did not take the $5\frac{1}{2}$-inch, and with the 42 and 56-pr. and 8-inch shells; and the 10 and 13-inch being used with the shells of those calibres respectively.

There was also a wooden hand grenade fuze.

The three metal time fuzes were designated respectively according to the lengths of composition which they contained, 4-inch, 3-inch, and 2-inch ("short range"); the latter was a mealed powder fuze.[2]

The whole of these fuzes were prepared by cutting to length or by boring into the composition from the bottom, and in the whole of them the composition was thus unsupported at the bottom.

In 1849[3] Colonel Boxer submitted a fuze of a new construction, in which the composition was supported at the bottom, and the preparation of which consisted in boring through a hole at the side into the fuze composition. These fuzes were designed principally with a view to remedying the defect of premature explosions to which the service shrapnel shell were found to be liable, and which Colonel Boxer conceived to arise from "the setting in of the fuze composition caused by "its inertia, together with the concussion of the air, both tending to "cause the same effect at the time of the explosion of the powder."[4]

These fuzes were submitted to a number of "severe trials in practice, "both with spherical case shot and with common shell, in the marshes "at Woolwich and Shoeburyness, at varieties of ranges, and with full "service charges from 24-pr., 32-pr., and 8-inch guns."[5] The result of these trials were so satisfactory as to induce the Committee to recommend (in 1850)[6] the adoption of this pattern fuze "for shells discharged

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1 "Fuzes of eight descriptions are sent on service, which are marked on the tangent "scales of guns, and lettered, as well as the fuzes and the cases in which they are "packed."—*A Course of Practical Instruction carried on at Woolwich between August* 1821 *and July* 1822, p. 37.

2 I have gathered the above account of the service fuzes at the time of the introduction of the Boxer system from various works and manuscripts, and from hearsay. The metal fuzes are described in *Naval Gunnery*, pp. 317–320, and I have every reason to believe that it is perfectly correct; but these 19 fuzes represent a state of things greatly improved on that which had gone before. In 1819 it would seem, from a memorandum in an old manuscript work lent me by General Lefroy that of bored (shrapnel) fuzes alone there were 21 different varieties, exclusive of "a mealed powder and unbored fuze," and exclusive, probably (for this memorandum seems to refer to shrapnel fuzes only), of the common, mortar, and hand grenade fuzes. See p. 241, note 3, respecting various propositions made, from time to time, with a view to reducing the number of fuzes.

3 27th April 1849. *Synopsis, Ordnance Select Committee Reports, Shrapnel Shells*, p. 66.

4 *Ibid.*, p. 66.

5 *Ibid.*, p. 78.

6 20th August 1850. *Ibid.*, p. 78.

" from guns and howitzers, the fuzes for shells from mortars remaining " as at present established." This recommendation was approved, and the fuzes adopted the same year.[1]

These fuzes, although resembling in *principle* the present service fuzes, differed from them in several points of detail, chief among which may be named, the being made on a straighter cone, the different method of priming, the having only one powder channel, one row of side holes (which read $\frac{2}{10}$ths of an inch), thus necessitating two fuzes for each shell, one reading even, the other odd-tenths, the composition bore being concentric, the fuze being capped with paper, the caps being painted black for even-tenth fuzes and white for odd-tenth fuzes. It was not until 1852,[2] that Colonel Boxer proposed any material alteration in the details of his fuzes, but in that year he advocated the employment of two powder channels and two rows of side holes instead of one, the side holes reading odd and even tenths respectively, thus diminishing by one half the number necessary for each shell.[3] Some other slight alterations were made in this fuze, and the composition bore was placed eccentrically, " to leave as much wood as possible between the " side channels and the composition in the fuze."[4] The fuze was also made with a projecting head.[5]

Further alterations were subsequently made. In 1853, with a view to affording support to the powder in the channels, pieces of quick-match were placed in the bottom side holes (one of which, the bottom hole, was bored completely through into the composition),[6] and later in the same year both the bottom side holes were bored into the composition, an additional hole being added to permit of this being done without shortening the time of burning of the fuze.[7]

All these fuzes, and the Boxer fuzes originally approved had putty in the side holes, instead of clay as at present;[8] they were also somewhat differently primed to those now in use, a piece of match being tied in by catgut, and the sides of the cup being " slightly rubbed over " with mealed powder damped with spirits of wine;"[9] but they all had a hole bored into the composition at the top, to secure ignition, and this simple though great improvement may be considered as a distinctive and very important feature of the Boxer fuzes as compared with those which they superseded.[10]

A few slight changes were made in the method of priming in August 1853, when Colonel Boxer proposed " painting over the whole interior " of the cap with mealed powder damped with spirits of wine," in an almost liquid state, this operation being performed *before* the drilling of the hole into the composition, instead of after, the diameter of the

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[1] Approved 2d September 1850. *Ibid.*, p. 78, and *Account of Alterations and Additions in Ordnance, &c.*, 1st September 1851, par. 3.

[2] 21st August 1852. *Synopsis, Ordnance Select Committee Report, Shrapnel Shell*, p. 81.

[3] *Ibid.*, p. 81.

[4] *Ibid.*, p. 194.

[5] See drawing given, *Ibid.*, p. 136.

[6] *Ibid.*, pp. 131, 139. Respecting the great importance of this quick-match, see p. 252.

[7] *Synopsis, Ordnance Select Committee Reports, Shrapnel Shells*, p. 132. For further explanation respecting this additional hole, see p. 253, note 1.

[8] *Ibid.*, p. 139.

[9] *Ibid.*, p. 139.

[10] The *Synopsis, Ordnance Select Committee Reports*, teems with testimonies to the very great efficiency of this hole, pp. 115, 117, 123, 124, and 150, &c.; indeed so great an improvement was it considered that existing fuzes were ordered to have the priming pierced, or if necessary the composition drilled into to secure their ignition. *Ibid.*, pp. 121 to 124; also 127, 128.

hole also being slightly increased from one-tenth to one-eighth of an inch.[1]

This plan seems to have been successful,[2] and in December 1853 [3] the Committee recommended the adoption of "Boxer's fuzes with two "channels and one inch of composition for all shrapnel shells, and "Boxer's fuzes with two channels and two inches of composition for all "common shells, to be fired from guns and howitzers." [4] The recommendation was approved, and the fuzes in question introduced into the service early in 1854.[5] A further alteration was made in March of the same year,[6] on the suggestion of Colonel Boxer, viz., the removal of the "projecting head of his fuzes for shrapnel and common shells," to render them less liable to be knocked out on ricochet.[7]

In spite of the success which had so far attended the use of the Boxer fuzes, they seem to have been open to the objection of irregularity of burning, for which no satisfactory explanation could be offered until the experiments during the summer of 1854 "led to the discovery, "by Captain Boxer, that the grease with which the instruments used "for boring were touched, in the manufacture of his fuzes was com- "municated to the wood, and ultimately to the fuze composition, in- "creasing its time of burning, and otherwise affecting its efficiency;" [8] consequently all wood fuzes were directed to be prepared for the future with dry bits, and the irregularity in their times of burning was thus remedied.[9]

The removal of the projecting head of the fuzes in March 1854,[10] gave rise to a difficulty which had not been foreseen, viz., that when fired with high charges, the fuzes were liable to be set into the shell by the shock of the discharge, thereby causing premature explosion. And if new fuzes, made accurately to gauge, were liable to this, to how much greater an extent would the defect be apparent in fuzes which, from the effects of climate, &c., had shrunk considerably. Moreover, it is conceivable that in some cases a very straight coned fuze, such as those at that time in the service, might be so much shrunk as to be too small for the fuze hole altogether,[11] and others so much swollen as to be altogether too large.

As a remedy for these defects Colonel Boxer recommended in 1855 [12] increasing the angle of the cone for all common,[13] shrapnel,[14] and mortar [15] fuzes. This recommendation was endorsed by the Committee,[16] who at

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[1] *Synopsis, Ordnance Select Committee Reports, Shrapnel Shells*, p. 143.
[2] *Ibid.*, p. 150.
[3] 21 December 1853. *Ibid.*, p. 195.
[4] *Ibid.*, p. 195.
[5] 8th February 1854. Account of *Alterations and Additions in Ordnance &c.*, 31st January 1855, clause 28, par. 3. The *Synopsis*, p. 197, gives the date of the approval as 17th February 1854.
[6] 16th March 1854, *Ibid.*, p. 201.
[7] *Ibid.*, p. 201.
[8] *Ibid.*, p. 219. "This discovery," the memorandum continues, "is particularly "valuable, as it also accounts for the defects in rocket fuzes, which have for many "years been prepared in a similar manner, and have been injured by a similar "cause."
[9] "This defect in all wood fuzes has now been remedied by the disuse of grease." *Synopsis, Ordnance Select Committee Report*, p. 219.
[10] See text above.
[11] I have heard it stated by officers that such has frequently been the case in India.
[12] 11th May 1855, *Synopsis, Ordnance Select Committee Report*, p. 227.
[13] *Ibid.*, p. 227. [14] *Ibid.*, p. 228. [15] *Ibid.*, p. 228. [16] *Ibid.*, p. 231.

the same time recommended the adoption of "metal fuze caps for all "wood fuzes (shrapnel, common, and mortar)."[1] These alterations were approved, and on the 18th August 1855[2] the "large cone" with metal cap was officially introduced. No material[3] alterations have been made in the fuzes since that date, which may therefore be regarded as the date upon which the present service common and shrapnel fuzes were finally adopted.

The first *mortar* fuze on the Boxer principle was a "small cone" fuze, adopted 27th January 1855;[4] but the enlargement of the cone was extended to the mortar, as to the common and shrapnel fuzes, in the August of the same year;[5] and, as has been stated, metal fuze caps were adopted for these fuzes at the same time.

We have thus the common, shrapnel, and large mortar fuzes of the present pattern bearing the same date, viz., 18th August 1855.

The small mortar fuze appears to have been adopted about the same time as the large mortar fuze,[6] and was at first made with the small cone; subsequently the cone was enlarged, uniform with that of the other fuzes.

The hand grenade fuze underwent no alteration.

The original parachute light fuze ($1\frac{1}{2}$ inch composition) does not appear to have been ever officially introduced; but when the pattern of the parachute light was altered in 1866 the present pattern fuzes for that projectile were also approved.[7]

The Manby fuze was adopted at the same time as the Manby shot, viz. about 1859 or 1860,[8] but no *official* approval of the fuze is to be found until 1862.[9] An alteration was effected in this fuze in 1864,[10] when the present pattern with paper lining was introduced.

The Boxer naval metal time fuze, 20 seconds and $7\frac{1}{2}$ seconds, were not introduced until 1857. The Admiralty recommended their adoption towards the close of 1856 and early in 1857.[11] The recommendation

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[1] 11th May 1855, *Synopsis, Ordnance Select Committee Report*, p. 231.

[2] *Account of Alterations and Additions in Ordnance, &c., &c.*, 22nd October 1855, par. 21. The *Synopsis* contains no notification of the approval of the Committee's suggestions.

[3] Some minor alterations in details, such as the painting of the interior of the metal caps with an anti-corrosive, have been made, but substantially the fuze remains as then approved.

[4] *Account of Alterations and Additions in Ordnance, &c., &c.*, 31st January 1855, clause 29, par. xi.

Some of the old pattern mortar fuzes in the Crimea were prepared by boring into the composition at the side, instead of sawing them according to a suggestion of Col. Boxer, notified by telegram by authority of Secretary of State, to the officer commanding the Royal Artillery in the Crimea.

[5] 18th August 1855.

[6] I have not discovered any formal authority for the introduction of the small mortar fuze, but perhaps it was intended to be included in the approval of the other mortar fuze. However, it certainly must have been introduced about the same time, for I find that the first issues for service bear date 16th April 1855 (with "small cone,") and 24th September 1855 (with "large cone") in both cases to battering trains for the Crimea.

[7] Fuzes approved 2nd January 1866 *War Office Circular* 9 (new series), § 1199. In the same year a further slight alteration was made in the 8″ and $5\frac{1}{2}$″ parachute fuzes; but no fresh pattern was approved.

[8] See p. 94.

[9] 25th August 1862, *War Office Circular* 793, par. 633.

[10] 14th February 1864, *War Office Circular*, No. 1 (new series), par. 875.

[11] 21st January 1857, 6132 N.

was communicated to the Superintendent Royal Laboratories, who regarded the letter in question as conveying authority for their adoption, at any rate for that of the 20 seconds fuze.[1] Indeed, the same impression seems to have prevailed generally, for the authority of this letter is quoted in the official list of changes signed by the Director General of Artillery, which appeared a few months later, in which the introduction of the fuze is notified.[2]

It appeared, however, that this letter was not intended to convey absolute authority for the introduction of the fuze,[3] although practically its introduction must be assigned to this date.[4]

The 7½ seconds fuze was not approved until the following year.[5]

Both these fuzes were at first made of very much smaller diameter than at present, with a left handed body thread, and with a right handed neck thread. The shoulder of the fuzes was also rather differently shaped, being made square instead of round.[6]

But towards the close of 1858,[7] they were ordered to be assimilated in gauge, and direction of body thread to the Moorsom fuzes, of which large numbers were then in the service. The neck thread was also necessarily [8] changed from right to left, and the present rounded form of shoulder was adopted.

The following year the formal authority for the adoption of the 20 seconds fuze was promulgated.[9] The 9 seconds fuze for M.L. ordnance was approved in 1866 [10] for immediate use with certain M.L. rifled shell, and with a view to the prospective supersession of the 7½ seconds metal time fuze for naval spherical shell.[11] Similarly the 20 seconds M.L. fuze, approved 1867,[12] will ultimately take the place of the 20 seconds metal time fuze. The introduction of these fuzes seals the ultimate fate of *metal* time fuzes.[13]

Having traced the history of the introduction of the present service time fuzes, it is desirable to notice categorically the advantages which

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[1] Letter from Col. Boxer to Capt. Caffin, R.N., 27 October 1857.

[2] *List of Alterations and Additions in Ordnance, &c. &c.*, 31st May 1857, par. 7. "Metal fuze for naval service. Proposed by Capt. Boxer, R. A., ordered 21st Janu- " ary 1857, 6132 N."

[3] *War Office Letter*, 16th November 1857, 75/T/11.

[4] "Practically," because, although the fuzes were still experimented with by the Ordnance Select Committee, they seem to have been manufactured for service, and I find that they were issued from the Royal Laboratory for service in China as early as the 11th February 1857.

[5] 22nd February 1858, Royal Artillery *General Regimental Orders* 402, 16th June 1859, par. 17.

[6] Some of the first fuzes also had wood instead of paper linings, but I am inclined to think no *service* fuzes were wood lined. Wood was found to be liable to warp and split, and there is a note to this effect in a MS. book of Department experiments in the office of the Captain Instructor Royal Laboratory, p. 13.

[7] 9th September 1858, Royal Artillery *General Regimental Orders*, 402, 16th June 1859, par. 17.

[8] "Necessarily," because it is requisite for the neck thread of these fuzes to run in the opposite direction to the body thread (for reasons, see p. 259, note 3), which had thus been made right handed.

[9] 11th April 1859, 75/7/82. *The Royal Artillery General Regimental Orders* 415, 31st December 1859, par. 5, gives the authority as 1st April, but the letter in the Royal Laboratory Office bears date 11th April.

[10] 26th June 1866, *War Office Circular* (new series), § 1236.

[11] *War Office Letter*, 5th June 1866, 75/12/2852.

[12] 7/6/67.—*W.O. Letter*, 3/7/67, 75/12/1742.

[13] See Appendix L., p. 379. The existing store, however, is so large that practically metal time fuzes will be in the service for many years, but no more will be manufactured.

recommended the introduction of the Boxer system o fuzes, and which resulted from their adoption.

The advantages are as follows :—

1st. *Freedom from premature explosions, resulting from the setting down of the burning composition into the shell on the shock of the discharge.* In the fuzes which Colonel Boxer's superseded, the composition being unsupported at the bottom, was liable to this defect,[1] especially when the shrinking of the wood, which frequently took place, deprived the composition of the support of the sides.[2]

2nd. *Greater regularity of burning,* owing to the support afforded to the fuze composition. It is quite conceivable that in many cases where the shock of discharge was insufficient to set the unsupported composition into the shell it caused great disturbance in the composition, loosening or cracking it and causing premature and uncertain bursts.[3]

3rd. *Greater safety in their preparation.*—The old fuzes were prepared either by boring out the superfluous composition or by sawing off the end of the fuze to the required length. Both these operations are obviously attended with greater danger [4] than the simple one of boring a small hole through the side to the composition.

4th. *The preparation of the fuze was greatly simplified and shortened.*—There can be little doubt that the preparation of the Boxer fuzes is

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[1] See passage p. 235, quoted from *Synopsis Ordnance Select Committee Report, &c.*, p. 66.

[2] The extent to which the wood sometimes shrunk away from the composition and left it without any support may be inferred from the fact that among the directions issued from the Royal Laboratory in 1853, for the examination of wood fuzes in store, is the following:—"Ascertain the state of the composition; that it is not damp or "unsound, that it has not separated from the wood, and, further, prove that it adheres "firmly to it by striking the fuze sharply, *and by endeavouring to push the composition "through the fuze.*"—*Ibid.*, p. 122.

The reports made by the officers who first used the Boxer fuzes in the Crimea bear testimony to their superiority in this respect. Capt. Turner says—"Not a single "instance has occurred in my battery of a shell bursting at the muzzle or short of "what it was bored for." Capt. Pennycuick says—"The fuzes are admirable, as "they never burst at the muzzle of the gun, as the common fuze frequently did." Capt. Morris says—"Their general accuracy admits of no question as to their supe-"riority over the old fuze," an opinion in which Col. Lake "perfectly agreed." Capt. Pipon says—"The Boxer fuzes answered admirably . . . . not one having "burst at the muzzle of the gun." Capt. Wodehouse says—"I do not think that "any one of these shells has burst at the muzzle of the gun," and he also bears testimony to their invariable accuracy.—*Ibid.*, pp. 215 to 217.

It must not be supposed that the introduction of the Boxer system entirely and finally got rid of premature explosions, for it is quite conceivable that in case of the wood of one of these fuzes shrinking away from the composition, which it is of course liable to do, though not to the same extent as in the old fuzes which were less protected from atmospheric influences, the flame might flash instantaneously down the cavity thus formed and pass through the bored hole, or the two bottom side holes into the shell; but the introduction of the Boxer system entirely got rid of premature explosions arising from a very fruitful cause, viz. "the setting down of the burning "composition into the shell on the shock of the discharge."

[3] "There are other causes to which premature bursts have sometimes been attri-"buted . . . . the disturbance of the composition in short fuzes by the force of the "charge."—*Synopsis, Ordnance Select Committee Report, &c.*, p. 84. See testimony of officers commanding batteries in the Crimea, quoted in the preceding note, to superior accuracy of this Boxer fuze.

[4] The old naval fuzes had to be sawn into *through the metal*, an operation so dangerous that it was not allowed to be carried on in the neighbourhood of any explosive material.—*Col. Boxer's MS. Notes*, p. 83.

much simpler and more expeditious than that of the old pattern, and any one who has used the two will readily testify to the very great superiority in this respect of the present fuzes.[1]

5th. *Great reduction in the number of fuzes.*—In consequence of the time which it took to prepare the old fuzes, several bored to different lengths had to be carried into the field for each shell,[2] whereas at present no more than one, which can be readily prepared on the spot, is necessary for each class of shell ; nor, until the introduction of the Boxer system, were any successful attempts made to reduce the numbers of fuzes by assimilating the fuze holes,[3] each mortar shell, for example, having its own fuze.[4]

6th. *In general construction and numerous details the Boxer fuze was a great improvement on the old one.*—It has been shown,[5] for example, that in the matter of the different method of priming an important improvement was effected ; the metallic cap, with the simple arrangement for removing it, the painting of the body of the fuze, whereby it was rendered less perishable, and the more complete protection of the composition from damp, were all improvements of appreciable importance.

Thus far we have dealt with the history of time fuzes only; it will now be interesting to trace that of fuzes, which depend upon impact for their action.[6]

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[1] Several testimonials in their favour on this point are to be found in the reports of officers commanding batteries of Royal Artillery in the Crimea. Capt. Turner says: —"The time saved by the new pattern fuze is invaluable." Capt. Brandling says:— " With regard to Boxer's fuzes I am of opinion that they are a great acquisition to " the service. Some of the non-commissioned officers of the troop who have been in " the habit of preparing these fuzes that they can now serve shrapnel shell as quickly " as round shot." Capt. Morris says :—" The far greater celerity with which they " can be bored and fixed," and Col. Lake endorses this report. Capt. Wodehouse says:—" The rapidity with which they are prepared."—*Ibid.*, pp. 215 to 217.

[2] See p. 235.

[3] An attempt was made in 1819 and another in 1845 to reduce the number of common and mortar fuzes from five to three or two, but both the Committees which dealt with the subject gave it up on the grounds of the great difficulty in disposing of the existing store of shells. They agree, however, that such a reduction would be most desirable. A proposition was also submitted on 27th October 1828 (*Synopsis, Ordnance Select Committee Report, Shrapnel Shell*, p. 64), to reduce the number of bored spherical case fuzes from seven to three, viz. to C = ·3-inch, D = ·4-inch, E = ·5-inch, and this proportion seems to have been approved 19th November 1828 ; but whether the approval was subsequently revoked, or whether the propositions were never carried into effect I cannot say, but there seems no doubt that there were seven bored shrapnel fuzes in use at the time of the adoption of the Boxer system.

I think, therefore, that I am justified in stating in the text that no " successful " attempts were made to reduce the numbers of fuzes by assimilating the fuze holes."

[4] See p. 235 respecting the fuzes in the service before the introduction of the Boxer fuzes, viz. 19 in all, for which were substituted six Boxer fuzes, (exclusive of fuzes for parachute light and Manby's shot, which were not then provided, and which accordingly cannot be included in a comparative calculation,) the fuze for the hand grenade remaining unaltered.

[5] See p. 236.

[6] See p. 271, respecting the distinction between percussion and concussion fuzes. I have taken the history of the two as that of one sort of fuze, not attempting to trace separately that of fuzes, which might be called percussion, and that of fuzes, which might be called concussion, since ; 1st, an attempt to do so might lead to confusion, as the two names have generally been carelessly and unscientifically applied (pp 271, 272); and 2nd, because the *principle* of action embodied in so-called percussion or concussion fuzes is evidently the same, both necessarily depending upon impact for their ultimate action.

History of percussion and concussion fuzes.

Such fuzes were certainly used as early as the first half of the 17th century, for the following passage occurs in the *Great Art of Artillery*, written about that period. "Of grenados that are commonly called " blind:[1] Pyrotechnicians have certain grenados which stand in no " necessity of being lighted when they are projected, from whence they " are called *Blind*, which is a common term amongst them, for such " grenados and other balls as stand in no need of being fired at the " time of their projection; but as soon as these strike the ground, or fall " upon any hard substance they have the same effect as other grena- " dos."[2] A description is also given of the fuze used with these shells, rude and clumsy, it is true, but essentially concussion or percussion. The simplest fuze is one for use with hand grenades. A number of side holes were bored in the fuze, filled with mealed powder, and in the bore of the fuze was placed a piece of quick-match with a leaden bullet tied to the lower extremity of it. The match seems[3] to have been coiled up to a size exactly to fit the bore of the fuze. "Then light " your match and as soon as it has acquired a good coal, put it into " the fuze with its bullet downwards, and throw the grenado where " you think fit, and be assured that as soon as it strikes against the " ground the leaden bullet and its match will fall down into the fuze, " and by lighting the meal powder in the side holes of it, it will fire " the grenado, and split it into a thousand pieces."[4]

Evidently this fuze was not applicable to shells projected from guns or mortars, as the shock of the discharge would have caused the bullet and match to fall down, producing premature explosion. A different and more elaborate arrangement was therefore required for these projectiles, and of such contrivances a description occurs a little further on. The tube (B) was made of iron, and was hollow from the bottom, up the centre, to near the top, where it was screwed. The sides of the fuze were "full of holes and its inside made rough like a file. This " barrel receives two flints, which are screwed tight in contrivances like " the cock of a gunlock, which are soldered to a substantial iron rod as " may be seen in C. First, then, this barrel must be fixed in the shell, " its upper end passing through the *vertex* or top of the grenado, where " it is screwed fast with a little square plate of the thickness of two or " three lines only, as you see in G. The lower end of the barrel which " receives the flints, shall rest upon a round plate with air hole in the " middle of it, as you see in E, to keep it fixed in its position. Now " the iron rod that has the cocks of the flints soldered to the upper end " of it, shall have its lower extremity turned into a screw, to fit a " female screw in the middle of a large round iron plate, as you see in

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1 *The Great Art of Artillery*, p. 237.

2 These "blind" shells must not be confused with shells fitted with fuzes, filled with "blind composition," of which mention is made by some authors. These were time, not percussion fuzes, used "not to discover the flight of the shell in the night." Blind fuze composition is given in the *Pocket Gunner*, as:—

	lbs.	ozs.	
Mealed powder	6	0	13 inch and 10 inch fuzes.
Wood ashes	4	0	
Mealed powder	7	0	8 inch and smaller fuzes.
Wood ashes	0	3	

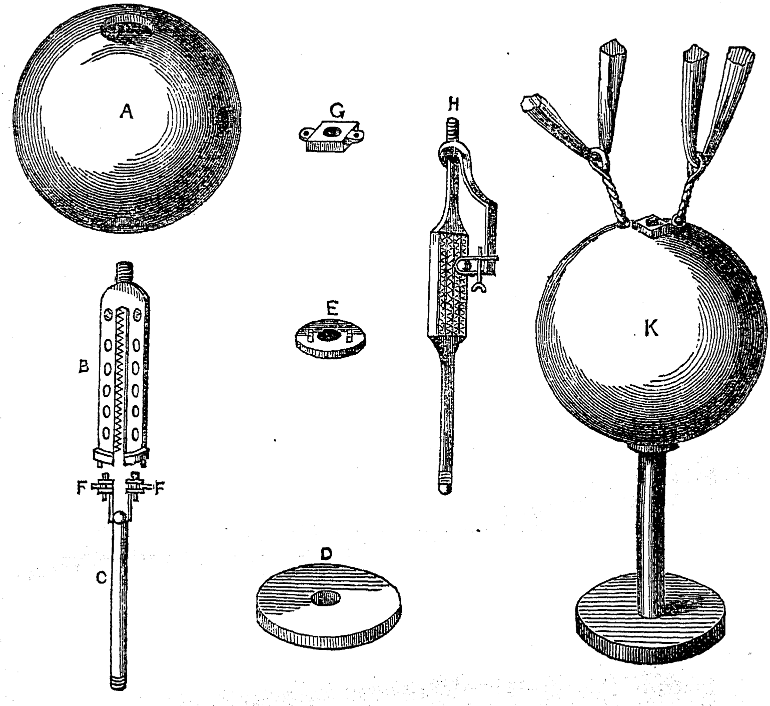
Bombardier or Pocket Gunner (Edition 1813), p. 187.

The 3 ozs. of wood ashes in the last composition is probably a misprint, and I should be inclined to read it as 3 lbs. However, the misprint, if such it be, is repeated in the different editions of the work.

3 *The Great Art of Artillery*, figure 110.

4 *Ibid.*, p. 212.

"D, which serves for a foot to the grenado, and all its furniture, and "upon which it falls when it comes to the ground."[1]



These drawings are copied from the *Great Art of Artillery*, fig. 121. A represents the "grenado;" B the barrel of the fuze; C the iron rod to which the flints are fixed; and F the flints; G the "little square plate," or nut, by which the upper end of the barrel is fixed to the shell; E is the "round plate with a hole in the middle of it;" K is the "grenado" complete; H is another fuze of similar construction.

The action of this fuze, and of another of a very similar construction, of which a drawing is given above, is as follows:—"The grenado "falling in the above said direction, the flints in the barrel will by the "superincumbent weight of the *grenado* be violently forced upwards, "and consequently, rubbing impetuously against the rough inside of "the barrel, will strike such a fire as must ascend the *gunpowder* in "the *grenado* through the holes in the sides of the barrel, by which "means it will have the same effect as the former."[2]

I am not aware that any concussion or percussion fuze actually existed in the English service before 1846,[3] when a wooden concussion fuze, the invention of Quartermaster Freeburn, Royal Artillery, was introduced for land service (32-pr. shells and upwards) but attention seems to have been anxiously directed towards the production of an efficient fuze of this description some little time before this date.[4]

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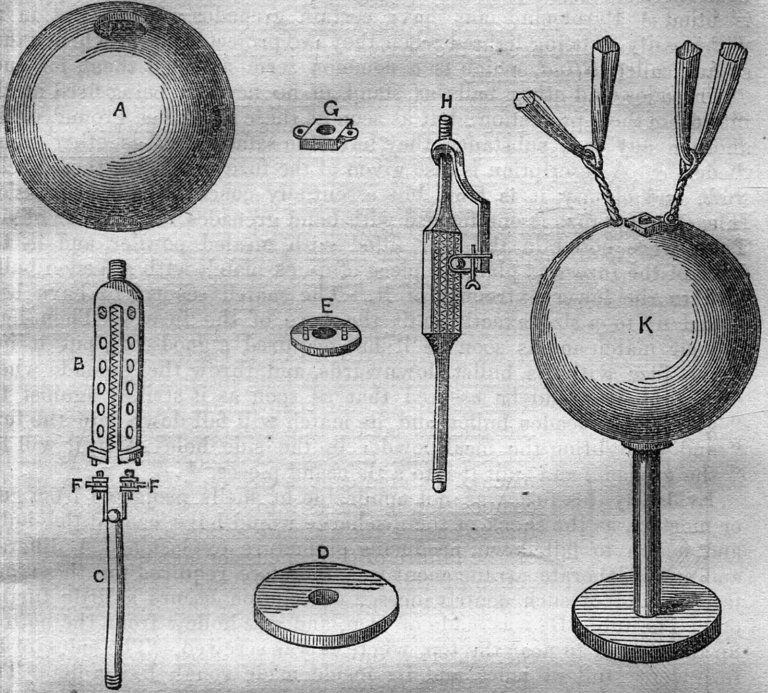
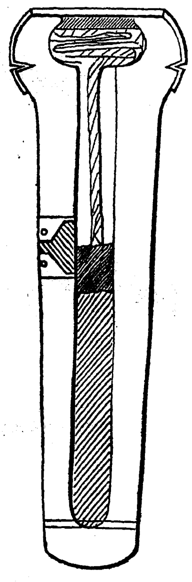
[1] *Great Art of Artillery*, p. 237.
[2] *The Great Art of Artillery*, p. 238.
[3] Approved for *land service only*, 12th October 1846, M/386.—See *Account of Changes and Additions in Ordnance, &c.*, 20th July 1847, para. 3, and letter of that date, *Royal Laboratory Records*.
[4] No less than five were tried before a mixed military and naval committee, Sir Thomas Hastings, President, in 1845. The fuzes were the invention respectively of Col.


A
G
H
E
B
F
F
C
D
K

Freeburn's fuze.

The Freeburn fuze, which is simple and ingenious in its construction, consists of a conical beech wood body with cup-shaped head, body and head together being about six inches in length. The composition bore is situated down the centre of the fuze, and extends from the top to within a short distance of the bottom, which is left solid, thus affording support to the composition.

Three rectangular perforations are made from the outside of the fuze into the composition bore; these perforations are equidistant from one another, and are situated in a horizontal plane about $2\frac{1}{4}$ inches from the top of the fuze, *or far enough down to ensure their being within the shell,* and not against the sides of the fuze-hole, when the fuze is fixed. In each hole is placed a small gun-metal wedge, the larger end inwards. These wedges are supported in the inside by the composition, which is driven about half way up them;[1] on the outside they are wedged in with wood secured with copper wire, and the holes are thus completely closed. A strip of paper, about an inch broad, and painted white, is pasted round the fuze, covering the holes. A long piece of match conducts from the top of the composition to the cup, where the end is coiled, the interior of the cup being primed; and the fuze is capped with paper and a piece of painted canvas tied on. The bottom of the composition is bored into through the side of the fuze to ensure the ultimate action of the fuze in case of the failure of the concussion arrangement. The action of the fuze is as follows. The composition being ignited by the flash of the discharge, burns away, and the wedges are thus at once deprived of their internal support. The shock of impact causes the wedges to fall inwards, leaving a passage at so many of the holes as may have thus become opened for the flame from the burning composition, which passing out explodes the bursting charge.



(half full size.)

These fuzes are available as long as the composition continues burning, viz., from 12 to 13 seconds.

Freeburn's fuze, being made of wood, was not considered available for naval service,[2] and some attempts were accordingly made to introduce an efficient metal percussion or concussion fuze for naval use; several fuzes were tried,[3] among them one of Quartermaster Freeburn's invention in metal.[4]

Dansey, R.A., Capt. Norton, Mr. Marsh, Mr. Wilton (this fuze is spoken of as the "Wilton fuze"), and Mr. Reece.

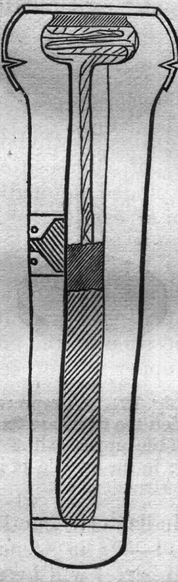
The Committee reported 27th March 1845, "Norton's fuze seems to have answered "best, but with this there were 9 premature explosions out of 50." The Committee did not consider that any of the fuzes were sufficiently perfect to warrant their adoption, but they recommended that further experiments should be made with Col. Dansey's, Captain Norton's, and Mr. Marsh's fuzes.

[1] Mealed powder is substituted for the top half-inch of fuze composition, since by burning away more rapidly the wedges will be sooner deprived of internal support and the fuze thus be sooner prepared to act.

[2] See p. 263, respecting naval preference for metal fuzes.

[3] The records of the Royal Laboratory Woolwich contain references to a large number of experiments made about this time, and up till the introduction of the Moorsom fuze, to secure such a fuze.

[4] Whether the principle of this fuze was the same as that of the wooden fuze by this inventor does not appear.



(half full size.)

In 1850[1] the desired end was attained by the introduction of a metal percussion fuze, invented by Commander Moorsom, R.N., for sea service, and in the following year this fuze was perfected and formally introduced.[2]

Moorsom's fuze (pl. 3), consists of[3] a gun-metal body, cylindrical in its general form, with a projecting head or shoulder. The total length of the fuze is nearly four inches. Below the head it is screwed to a depth of nearly an inch, to the present naval fuze-hole gauge;[4] and below this the body is plain, tapering towards the bottom. Moorsom's fuze.

Inside the fuze are three chambers, the whole being situated below the screwed part of the fuze.[5] The two upper chambers are situated transversely in the fuze, one above, and at right angles to the other. In their transverse sections these chambers are elliptical, the major axes being vertical. Longitudinally they extend nearly across the fuze, contracting slightly towards each end. In the centre of each end of each chamber is a little recess for the reception of a small patch of detonating composition consisting of—

	oz.
Antimony, sulphide of - - -	6
Potash, chlorate of - - -	6

made into a paste, with a varnish of shellac, 112 grains, methylated spirits, 1 pint, in proportion of $\frac{1}{4}$ gill to 20 ozs. of composition; and a fire-hole, through which the flame of the exploded detonating composition may pass, communicates from the bottom of each recess to the outside of the fuze. In each of these chambers is suspended, by means of a fine copper wire,[6] a cylindrical gun-metal hammer (pl. 3, figs. 22, 23) having a small projection or nipple at each end, the hammers being so placed that these projections are severally presented within a very short distance of the patches of detonating composition at the ends of their respective chambers[7] (pl. 3, fig. 17). The upper side of each hammer is in contact with the top of each chamber, and thus, as the hammers are cylindrical and the chambers elliptical, the diameters of the former being slightly less than the minor axes of the ellipse, there is necessarily a space between the lower side of each hammer and the bottom of each chamber.

The third chamber is cylindrical, and is situated vertically in the bottom or taper part of the fuze. In the upper end of it is a recess, in

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[1] The original pattern seems to have been approved early in this year.

[2] The last ("C") pattern was approved 16th July 1851 (Confidential letter of that date); experiments were continued throughout 1850 with Moorsom's fuze of "A," and "B," and "C," patterns, as appears from the Royal Laboratory records.

[3] A description of the Moorsom fuze, which is now obsolete, cannot be introduced amongst the service fuzes, and at the same time cannot be omitted altogether, as the principle of the fuze, that of wire suspension, is one which subsequent inventors of fuzes have made free use of. Armstrong's original iron concussion fuze was on this principle; the hammer in his white metal time fuze was also suspended by a leaden wire; his "C" percussion fuze, Dyer's pattern, has the pellet suspended by copper pins, and the detonating hammer in the Boxer 2-inch fuze for rifled ordnance is suspended by a copper wire.

[4] This was the gauge, direction, and pitch of thread originated by Moorsom, the time fuzes having been previously much smaller in diameter and left-handed. In 1858 the time fuzes were assimilated to the Moorsom (see p. 239). This combination of diameter, pitch, &c. has generally hitherto been spoken of as "the Moorsom gauge," though it is possible that the distinction will gradually die out now that the Moorsom fuzes have been rendered obsolete.

[5] Thus bringing them all *within* the shell.

[6] 18 wire gauge.

[7] Sometimes called the "Magazines."

which detonating composition is placed, and a fire-hole is made horizontally through the fuze immediately above this recess; the ends of the fire-hole being enlarged so that the powder of the shell working into the enlargements is brought nearer to the detonating composition, and the explosion of the bursting charge thus made more certain and instantaneous.

Below this patch of detonating composition is suspended by means of a fine copper wire[1] a small cylindrical gun-metal hammer (pl. 3, figs. 24, 25) with a projection at its upper end. Between this projection and the detonating composition is a fine copper "guard" wire.[2] Below this hammer is a cylindrical pillar or column of lead (pl. 3, figs. 26, 27) which rests upon the bottom of the fuze when it is secured, and the top of which is within a short distance of the bottom of the hammer. (pl. 3, fig. 17). On the outside of the top (pl. 3, fig. 19) of the fuze are four[3] wrench holes, equidistant from one another. A piece of tracing paper is secured by shellac varnish over the four holes of the horizontal chambers, and a piece of the same paper is varnished over the lower part of the fuze.[4] The fuze is lacquered externally.

The action of the fuze is as follows:—The shock of the discharge shears the suspending wires, and the hammers are thus free to act; on the shell striking an object the hammers are thrown violently forward, one of their projections being thus necessarily brought into violent contact with one of the patches of detonating composition, which being exploded flashes through its fire-hole into and explodes the bursting charge.[5]

In the vertical chamber special provision is made against premature explosion by (1st) the lead pillar, and (2nd) the guard wire. The former prevents or diminishes reaction in the hammer, such as would necessarily take place in the absence of such an arrangement,[6] and the guard wire being interposed between the hammer and the detonating composition serves as a further precaution in the event of reaction not being entirely done away with.[7]

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[1] 21 wire gauge.

[2] 26 wire gauge.

[3] The original Moorsom had two only.

[4] Thus securing the joint formed by the screw-plug or cap, which closes this end of the fuze. The object of this paper, however, was not so much to exclude moisture, as to preserve the *secret* of the fuze, the secret consisting in the little lead pillar, without which premature explosions would have invariably resulted. Formerly the fuzes were (*apparently*) completed, with the exception of this last piece of paper. They then passed into the hands of a workman to whom the "secret" had been confided. He removed the cap, inserted the lead pillar, replaced the cap, and varnished the paper over the junction. At first this last fitting was done by Capt. Moorsom himself; by letter, 21st December 1850, A/1459 all Moorsom fuzes were directed to be forwarded to H.M.S. "Excellent" at Portsmouth, when completed at Woolwich, "in order that Capt. Moorsom may put in the last fitting." So secret was the construction of these fuzes kept, that the first description which appeared of it in this country, I believe, was one in the *Occasional Papers, Royal Artillery Institution* vol. i., p. 92, translated by Captain Orr, R.A., from a French account of the fuze, this account in its turn, having been compiled from a Russian source.

[5] Evidently in one direction, viz., if the shell strikes bottom foremost, there will be no action. In any other direction of striking action should result.

[6] See note 4 above, respecting the secrecy observed in regard to this last fitting, on which indeed the success of the fuze depends.

[7] Nevertheless premature explosions sometimes did take place with these fuzes, that these, it is not improbable, resulted from one of the two horizontal hammers and not from the vertical hammer. These hammers being released by the shock of discharge become liable to be affected by the ricochetting of the shell through the bore, and as such ricochetting doubtless sometimes takes place, it is conceivable that the hammers may in such cases be thrown against one of the patches of composition and produce premature explosion.

History of cussion and concussion fuzes (*continued*).

We have thus in 1851 the two services provided with their respective concussion or percussion fuzes, the land service with Freeburn's, the sea service with Moorsom's. On the introduction of the Boxer system of fuzes in 1850[1] and the assimilation of fuze holes which took place consequent thereupon, Freeburn's fuze may be said to have begun practically to disappear from the service, inasmuch as although not formally pronounced obsolete, the shells with which it could be used were no longer manufactured. On the adoption of the present fuze holes and cone in 1855[2] the Freeburn fuze was not altered to suit the new shells, and became virtually obsolete, although stores of it existed,[3] and the authority for its abolition was and is still wanting.

From that date until the autumn of 1861, the land service had no percussion or concussion fuze, but in January 1860 some fuzes of a construction designed by Mr. Pettman, one of the foremen of the Royal Laboratory, Woolwich, were tried departmentally and found to answer extremely well.

The principle of these fuzes, which was entirely original, was the same as that of the present service Pettman's fuzes, but in their details they differed materially from those now in use: the cone plug was hollowed out on the lower side and made with a sharp edge which rested upon a leaden disc one-tenth of an inch thick; on the discharge of the gun the plug was forced into the disc, and the thin edge coming into contact with the bottom of the fuze was "upset" and formed a kind of rivet which prevented reaction; under the steady plug was an enlargement of the bore of the fuze which formed a shoulder on to which the plug fell on the discharge of the gun; the top of the ball had in it a hole instead of being fitted with a projecting stud, the stud being on the lower side of the steady plug; the inside of the fuze, in the neighbourhood of the ball, was spherical, as in the present sea service fuze, and was formed into ridges intended to assist the action of the ball; the fire holes were made at the side of the fuze instead of at the bottom, which was solid; the ball had no groove round it, and had a covering of gut only. Such were the principal points of difference between the original and the present Pettman's sea service fuzes.

Further modifications were subsequently made: the shoulder in the interior was removed, a lead cup was substituted for the disc, the bore of the fuze was made cylindrical, the ridges in the neighbourhood of the ball being still retained, and a cone plug similar to that in the present land service fuze was adopted; an attempt was also made to manufacture the fuzes in white metal, but one trial was sufficient to prove that this material was not strong enough to withstand the shock of the discharge.

In April 1860 the fuze was formally submitted, with a view to its adoption for sea service; a number were made and experimented with by the Ordnance Select Committee and by Captain Hewlett on board the "Excellent" at Portsmouth. The result of these experiments was in the main satisfactory, but the fuzes were defective in being liable to explode on striking water. This defect led to further modification in the details of construction: the ball was covered with silk, in addition to the gut, with a view to rendering the fuze less sensitive; the ridges were done away with, with the same object; the projection on the steady plug was transferred to the ball; a groove was cut round

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[1] See p. 236.

[2] See p. 238.

[3] And still exist; the fuze could of course be used with any shells with the old fuze holes; but it may certainly be considered as having been no longer in the service since 1855.

the ball to increase the quantity of detonating composition, and so to increase the flash; and the present pattern sea service cone-plug was adopted further to increase the flash and to lead the fire through the bottom instead of out at the sides of the fuze. Although greatly improved by these alterations, the sensitiveness of the fuze was not yet regulated with sufficient exactness to ensure non-ignition on striking water, accordingly the sensitiveness of the ball was further diminished by covering it with two thin copper hemispheres, and the bore of the fuze was enlarged in the neighbourhood of the ball, to ensure action in case of the fuze striking sideways.

These fuzes were approved and adopted for naval service in August 1862.[1]

In the meantime experiments had been conducted at the suggestion of H.R.H. the Field Marshal Commanding-in-Chief with a land service fuze on the Pettman principle. The first of these fuzes were made about the end of 1860; they had cylindrical bores, no ridges, the ball covered with gut and silk, and grooved, and a cone plug of the present sea service pattern, and were screwed to fit the common fuze hole.

Owing to the rounded form which had to be given to the lower part of the bore of these fuzes it was not practical to undercut them, to prevent reaction, and Mr. Pettman found it necessary to resort to the present forms of bottom plug (but without the quick-match) with the stud for the lead cup to coil round. The present land service cone-plug was adopted at the same time. These fuzes were found liable to become choked by the powder dust of the bursting charge working in through the fire holes, from which the paper disc was blown off by the compressed air escaping from the inside of the fuze on the crushing of the lead cup. A remedy for this was found in the piece of quick-match threaded horizontally through the bottom plug, and by this means also the flash of the fuze was increased.

Hitherto the fuzes, being intended to fit the existing store of common shells without altering the fuze hole, were screwed for a distance of only ·6 inch,[2] the lower part being turned plain; but they were found too weak to stand the shock of a 10 lb. charge (32-pr. gun), and consequently the diameter of the lower part was increased[3] and the fuze screwed the whole way down, as at present, thus necessitating retapping the fuze holes.[4]

The fuzes thus modified were adopted for land service in October 1861.[5]

Subsequently Mr. Pettman proposed a modification of his sea service fuze to adopt it for use in rifled as well as smooth-bore shells. This "general service" fuze was introduced in 1866,[6] for immediate use with certain rifled shells, and prospectively to supersede the sea service Pettman fuze for naval shells.

The Moorsom fuze remained in the (naval) service until 1865[7] when the existing stores were ordered to be broken up. Practically, however, it may be said to have been superseded on the introduction

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[1] 2nd August 1862, *War Office Circular* 793, par. 610.

[2] The length of the thread on the screw metal fuze hole plugs for these shells.

[3] By the depth of the thread.

[4] See p. 25, note 11.

[5] 30th October 1861, *War Office Circular* 739, par. 414.

[6] 19th May 1866, *W.O.C.* 10 (new series), § 1235.

[7] Ordered to be broken up 2nd May 1865, *War Office Circular* No. 6 (new series), par. 1090.

of the Pettman fuze in 1862;[1] between that date and its final disappearance in 1865 the issue of the fuzes was restricted to 32-pr. shells in reduced proportions.[2]

The same activity in respect to the improvement of the fuze system, time and percussion, which has prevailed in this country during the past 20 years or so, has been observable abroad, and the number of fuzes which, within or about that period, have been contrived by foreign artillerists for smooth bore and rifled guns is so great that any attempt to describe them is altogether out of the question. In addition to our own numerous rifled ordnance fuzes, the following are amongst the most celebrated:—The "Bormann fuze,"[3] used by the Belgians; the "Breithaupt,"[4] by the Austrians; the French "Billette" fuze;[5] the "Bourbon" fuze,[6] experimented with, in Russia and Holland; the "Snoeck" fuze,[7] used in Holland; the "Splingard" fuze;[8] the French hand grenade percussion fuze;[9] the French Shrapnel fuze;[10] the two fuzes used by the Austrians for the gun cotton shells;[11] the Russian leaden fuze;[12] the "Parrott" fuze;[13] and the "Tice" fuze,[14] in use in the American service.

Fuzes may be divided into—[15]

Class 1. Time fuzes.

„ 2. Percussion or concussion[16] fuzes.

And a supplementary class—

Class 3. Fuzes for mining purposes.

Class 1.—Time Fuzes.

(1.) A time fuze is one which is capable of being prepared to ignite the bursting charge at some particular *time* after the projectile leaves the piece.

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[1] The manufacture was stopped 17th January 1862 in anticipation of the introduction of the Pettman sea service fuze.

[2] *War Office Circular* No. 832.

[3] Described in *Lectures on Artillery*, edition 3rd, p. 78.

[4] Described in *Ibid.*, edition 3rd, p. 79.

[5] Described in Delobel's *Revue de Technologie Militaire*, vol. ii., p. 408.

[6] Described in *Ibid.*, vol. ii., p. 414.

[7] Described in *Ibid.*, vol. ii., p. 416.

[8] Described in Gibbon's *Artillerist's Manual*, p. 295–7.

[9] Described in Thiroux's *Instruction d'Artillerie*, p. 375.

[10] Described in *Ibid.*, p. 374; and Delobel's *Revue, &c.*, vol. ii., p. 393.

[11] Described in *Report of Professional Tour of Officers of the Royal Artillery* in 1863, p. 26.

[12] Mentioned in *Synopsis, Ordnance Select Committee Reports, Shrapnel Shell*, p. 217.

[13] *Report on the Military Affairs of the United States of America*, p. 36.

[14] *Ibid.* p. 41.

[15] Other divisions might be adopted, as wood and metal, land service and naval, time fuzes with the composition in a vertical column, and those with the composition (as in the Breithaupt and Bormann and Armstrong E pattern time fuzes) in a horizontal layer; or time, percussion and concussion; or fuzes for horizontal and fuzes for vertical fire, &c.; but it appears to me that the one I have adopted is the most general and characteristic.

[16] There are no so called "concussion" fuzes in the service, but in a general classification of fuzes the name cannot be omitted.

There are 14 different *time* fuzes in the service,[1] viz. :—

1.	Boxer's common fuze.	Regular service fuzes.[2]
2.	„ diaphragm shrapnel fuze.	
3.	„ large mortar fuze.	
4.	„ small „	
5.	„ 20 seconds fuze.	
6.	„ 7½ „	
7.	„ 9-second fuze for muzzle - loading ordnance.	Adopted for M.L. rifle ordnance, and will supersede 5 and 6 for smooth bore shells.
8.	„ 20 second „	
9.	Hand grenade fuze.	Fuzes which may be considered as, to a certain extent, special and exceptional.
10.	10-inch parachute fuze.	
11.	8 „ „	
12.	5½ „ „	
13.	Manby's shot fuze.	
14.	White, for drill.	

Fuze, time, wood, common.

1. *The Common Fuze*[3] (pl. 2), is a truncated beechwood[4] cone[5] about 3 inches in length. The thick end or top of the fuze, which is about an inch in diameter, is cupped out to the depth of a quarter of an inch to receive the priming and match, four holes (pl. 2, figs. 13, 14, *a a*) being bored through the sides of the cup for matching. The fuze is bored *eccentrically*[6] (pl. 2, figs 13, 14, *bb*), parallel to its longer axis, from the bottom of the cup to within a short distance of the bottom of the fuze; the diameter of this bore is rather more than a quarter

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[1] The "improved shrapnel fuze," in accordance with the plan which I have adopted with regard to the stores connected with this now nearly obsolete shell (see p. 100, note 1), is not included among the service fuzes, but it is described in note 5, p. 255.

[2] The "regular service fuzes" include two for horizontal fire for each service, land and naval, and two for vertical fire, common to the two services. See p. 241 respecting the great simplification effected by the adoption of the present system of fuzes.

[3] Present pattern approved 18th August 1855 (see account of *Alterations and Additions in Ordnance*, 22nd October 1855, par. 21); original pattern on same principle but of different construction (see p. 236), adopted 2nd September 1850, *Synopsis, Ordnance Select Committee Report, Shrapnel Shell*, p. 78.

[4] "Beech wood is found to be particularly well adapted for fuzes, as it is hard, tough, and little liable to alteration in form, even when kept for a great length of time. The wood should be cut in the 'rough,' and either seasoned in the ordinary way, or by . . . . desiccation."—Col. Boxer's *MS. Notes*, p. 78. Respecting the relative merits of wood and metal fuzes, see p. 263, and Appendix L., p. 379.

[5] The conical form is the only one available for wooden fuzes, which are always liable to a certain amount of expansion or contraction from the effects of temperature. In a conical body such expansion or contraction is comparatively of little account, the fuze only projecting rather more or rather less from the shell, but fitting no less accurately. A conical wooden fuze can also be more rapidly, easily, and securely fixed than one of any other conceivable form or construction; moreover, a conical fuze hole is undoubtedly the best, whether regard be had to the smaller aperture thus available for the escape of the exploded bursting charge (the necessary strength and thickness of fuze being retained), or whether considered in connexion with the possible employment of metal fuzes with the same shells, as in the case of common shells.

The development of cone of the common fuze is ·11″ per inch, or increasing as nearly as possible 1 inch in 9 inches (the *exact* increase is 1 in 9·375). For causes which led to the increase of cone from ·065 per inch to the present pitch, see p. 237.

[6] Eccentrically to allow room for the powder channels, leaving as much wood as possible between them and the composition, and to bring the side holes on to one side of the fuze.—*Synopsis Ordnance Select Committee, &c.*, p. 194.

of an inch. This bore is pressed[1] or driven[2] "with fuze composition" consisting of—

Saltpetre, ground[3]	- -	3 lbs.	4 oz.
Sulphur, sublimed[4]	- -	1 „	0 „
Powder, pit, mealed[5]	- -	2 „	12 „

The top of the composition is matched with two strands of quick-match (pl. 2, fig. 21), threaded through the holes made in the sides of the cup for the purpose ; the top of the composition is disturbed,[6] and the match "set down" upon it,[7] with a little mealed powder ; a third piece of match being threaded underneath one of the other strands on the side on which the wood is thickest; the whole of the interior of the cup is plastered with a priming paste consisting of mealed powder and distilled water,[8] then dredged with dry powder. Finally[9] a hole (pl. 2, fig. 15 *h*), one-eighth of an inch in diameter[10] is drilled vertically through the priming and match into the composition to a depth of 0·7 inch from the top of the fuze,[11] the bottom of the hole marking the zero point,[12] a small indentation being made upon the outside of the fuze opposite to it ; the object of the hole is to increase the certainty of ignition by exposing a large surface to the flash.[13]

The third piece of match is coiled round the inside of the cup.

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[1] By hydraulic pressure.

[2] The old plan of driving fuzes by hand with a mallet and drifts, although now nearly obsolete in the Royal Laboratory at Woolwich, where it is only practised for experimental or other fuzes, of which the number to be made is too small to justify the construction of presses, is still included in a Laboratory course, as being the only plan which would probably be available at an out station, or on an emergency. The relative merits of the two plans admit of no question, the pressure being vastly superior.

[3] See p. 313.

[4] See p. 318.

[5] See p 138. *Pit* powder is preferred to cylinder powder as being more rapid and more regular in its action (*Manufacture of Gunpowder*, p. 7). The greater *rapidity* of the powder is due to the difference in the nature of the two charcoals, pit charcoal being prepared at a much lower temperature than cylinder charcoal. If cylinder powder be employed instead of pit, "it will be necessary to add an additional 8 ozs. "in order that the composition when driven may burn at the same rate" (Col. Boxer's *MS. Notes*, p. 79). The greater *regularity* of burning of pit powder cannot be so satisfactorily explained. Theoretically, the cylinder powder should burn rather more regularly than the other, being, as is believed, more completely charred, but, practically, there can be no doubt that composition prepared with pit powder burns with the greater regularity. Out of six large mortar fuzes driven, to determine this point, with fuze composition containing cylinder powder, the extreme variations were from 32 to 36½ seconds (*MS. Book of Experiments* in Captain Instructor's Office, Royal Laboratory, p. 109). The only explanation that suggests itself, therefore, is that the fire is propagated more regularly through the mass in the quicker burning composition ; there is no doubt that of two compositions of equal uniformity the slower will burn with less regularity than the other, the slight defects not having time to develop themselves as it were in the quick composition, while in the slow composition they are sufficiently marked to produce appreciable irregularity.

[6] With a pointed tool.

[7] By means of a drift and mallet.

[8] Of the consistency of thick cream.

[9] When the priming is thoroughly dry.

[10] See p. 237 respecting the increase in the diameter of this hole from one-tenth to one-eighth of an inch, and the considerations which determined the present size.

[11] From the extreme top of the wood of the fuze.

[12] Since the fuze composition will commence to burn in regular layers from the bottom of this hole.

[13] Respecting the great importance of this hole and the stress laid upon the improvement effected by its introduction, see p. 236.

On the side of the fuze on which the wood is thickest[1] two small[2] "powder channels" (pl. 2, fig. 22 N P, and figs. 13 and 14 *d d*), are drilled from the bottom to within a short distance of the top of the fuze, about half way between the composition bore and the side of the fuze and parallel to the latter. These channels are filled[3] with shell F. G. powder.[4] Opposite to and breaking into the powder channels two rows of "side holes"[5] (pl. 2, figs. 13 and 14 *e e*, &c.), ten in a row, are drilled horizontally from the outside of the fuze; the holes of each row are situated ·2 of an inch apart,[6] the holes of one row not being opposite to those in the other row, but dividing the spaces, and the holes in the two rows thus indicating respectively odd and even tenths of inches (pl. 2, fig. 16).

The top side hole of one row is situated ·2 of an inch below the zero point of the fuze, and the top hole of the other row ·3 of an inch.

The side holes, with the exception of the two bottom holes, are filled with shell F. G. powder pressed down,[7] and covered with finely ground clay similarly pressed[8] (pl. 2, fig. 15). The two bottom side holes are drilled through into the composition (pl. 2, fig. 15) to ensure the ultimate action of the fuze in case of imperfect boring or non-preparation in the hurry of action;[9] a piece of quick-match is threaded into each of the bottom side holes to afford support to the powder in the powder channels on the discharge of the gun.[10]

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[1] See p. 236 respecting the object with which the composition bore was placed eccentrically.

[2] The channels are ·125 of an inch in diameter. With reference to this size, which might appear excessive, the following passage occurs in the Synopsis, p. 122:—"The " side channels should not be reduced in size. It has been found by experience that " the channels are of the least diameter that would be sufficient to insure ignition." And in a note on the same page—"The powder in the small channels is ignited, but " has not sufficient force to perforate the paper at the bottom, and for *that* reason " small channels do not answer."

[3] Not pressed, the powder being merely poured in.

[4] See p. 138. This powder is used on account of its fineness of grain and consequent rapidity of action. See p. 134.

[5] The side holes are of the same diameter as the powder channels, viz. ·125 of an inch.

[6] From centre to centre, measuring vertically.

[7] This is done before the powder channels are filled; wires exactly fitting the powder channels are inserted up them, forming, as it were, bottoms to the side holes, or foundations into which the powder is pressed by hand. The object of the powder is to prevent the clay being carried by the bit into the continuation of the side hole which is made when the fuze is prepared, and thus choking or retarding its action.

[8] The clay is to exclude moisture and to save the fuze against accidental ignition through these holes.—*Synopsis, Ordnance Select Committee Report, &c.*, p. 99.

At one time putty was used.—*Ibid.*, p. 179.

[9] *Ibid.*, p. 131.

[10] "This quick-match affords a support to the powder in the channels, and thereby " prevents its removal by the shock at the discharge of the gun."—*Ibid.*, p. 139. The quick-match is a most important feature in these fuzes; without it continual failures must arise; this fact was proved in the early experiments with fuzes of this construction made without quick-match, the only support to the powder in the channels being that afforded by the paper over the bottom of the fuze, which was "forced " away by the powder in the channels acting against it on the explosion of the charge." —*Ibid.*, p. 131. See also *Ibid.*, p. 133. It does not follow that the absence of quick-match will cause *invariable* failure, for in those cases in which, the range being long and the side holes falling within the shell, the action of the fuze is independent of the powder channels, and in other cases where the side holes do not fall within the shell ultimate although irregular action might take place in the manner explained in the following passage:—"The channels . . . . . might have been partially empty and " therefore not in a state for the communication of the flame, until, by a revolution " of the shell or by its striking on the ground, some grains of powder were shaken to " a position opposite the side hole, and thus brought into contact with the flame of " the still burning fuze composition."—*Ibid.*, p. 131.

These two side holes are situated respectively at 2 inches and 2·1 inches from the zero point.[1] The ends of the powder channels[2] are closed with a piece of quick-match pressed down and secured with shellac putty.

Over the top of the fuze is placed a disc of stout pasteboard[3] (pl. 2, fig. 24), having a tape loop attached, and the fuze is capped with a tin[4] cap (pl. 2, fig. 23), the interior of which is painted with an anti-corrosive.[5] The cap is secured on to the fuze by being pinched round the sides. A strip of thin[6] paper is pasted over the two rows of side holes, and the projecting end turned and pasted over the end of the fuze; a disc of the same paper is also pasted over the end of the fuze.

The whole fuze, with the exception of the top of the cap, receives a coat of drab-white varnish,[7] and a strip of black varnish[8] is carried over the *even* row of side holes. The end of the fuze and the junction of the cap and body are also varnished black.[9]

The side holes, with the exception of the two bottom ones,[10] are dotted, those on the black ground yellow, those on the drab ground black.

The tenths (pl. 2, fig. 16) of inches which the side holes read respectively are stamped against them in vermilion,[11] with the exception of the two bottom holes, which are not numbered.[12] The fuze is stamped in vermilion, near the top with the numeral of pattern, the number of

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[1] It was necessary that *both* the bottom holes should be bored through, or the quick-match support could not have been introduced in the unbored hole, and the powder in the channel on that side being unsupported failures would have resulted when the fuze was prepared on that row (see p. 252, note 10). It was not less necessary to make the last hole *additional* to the required length of fuze, as if the hole next above it on the same row, viz. 1·9 inches, had been bored, the full time of burning of the fuze would have been reduced to the number of seconds corresponding to 1·9 inches of composition, viz. 9½ seconds. The following passage explains this :—"If " the lower side hole *only* (*i.e.* two inches) is bored through to the composition, then " 1·9 inches having no hole or quick-match, the evil will only be half remedied ; on " the other hand, if 1·9 inches as well as two inches should be bored through to the " composition, then two inches becomes of no use, because the shell would always " burst when the composition is burnt to 1·9 inches. Col. Boxer is aware of this, " but suggests that one hole should be made at two inches and the other *below* it."—*Synopsis, Ordnance Select Committee Report on Shrapnel Shell*, p. 132. The original passage refers to the diaphragm fuze, but the same explanation applies of course to the common fuze ; to avoid confusion, however, I have altered the figures to suit the common fuze, placing two inches for one inch, and 1·9 inches for ·9 inch.

[2] Below the bottom side holes.

[3] Pasteboard, composed of two sheets of "rocket paper" and one sheet of "100 lb. " brown wrapping paper ;" the two sheets of rocket paper are pasted together, then the brown on top.

[4] Block tin, ·016 inch thick (wire gauge 27).

[5] See table XX., p. 345. The object of the anti-corrosive is to prevent any action being established between the priming and the cap ; in very old fuzes the latter will sometimes be found completely eaten away.

[6] "White fine."

[7] See table XX., p. 345. It will be observed (table XX.) that all the varnishes used in connexion with these fuzes (except paint for the figures) are made with spirit and not with oil ; this is because oil might affect the composition in case it should penetrate to it (see p. 237) ; moreover, spirit paint dries more rapidly, and the manufacture is thus facilitated.

[8] See table XX., p. 345.

[9] See table XX., p. 345. The varnish for the junction of cap and fuze is made rather thicker than that which is used for the body, being intended to exclude moisture at this joint.

[10] There is no necessity for indicating the position of the bottom side holes, at which, if not prepared for a shorter range, the fuze will act without preparation.

[11] See table XX., p. 345.

[12] See last note but one.

thousand, and lower down with the month and year of issue, thus: 124.—7/65.[1]

Preparation.

The preparation of the fuze consists in boring by means of a "hook-borer,"[2] provided for the purpose, through one of the side holes,[3] into the fuze composition, allowing one-tenth of an inch for each half second time of flight.[4] The fuze is then placed[5] in the shell, and uncapped, *when the shell is in the bore of the gun,*[6] by giving the tape a sharp pull.

Action.

On the discharge of the gun, the fuze is ignited by the flash of the explosion,[7] and the composition commences burning from the zero point, at the rate of one inch in five seconds,[8] until it reaches the bored hole. Here the flame from the burning composition passes into the powder channel into which a communication has been opened at the bored side-hole, and is thence flashed instantaneously down into the shell. Should the bored side-hole fall *within* the shell the flame passes direct (horizontally) to the bursting charge,[9] and is independent of the powder channels,[10] but when this hole falls against the metal of the shell,[11] the only communication is by way of the powder channels, the other passage being closed.

If the fuze be left unbored, it will act at its full time, viz., 10 seconds, since the 2-inch hole is bored into.[12]

Common fuzes can be used with all common shells;[13] and with the 100-pr. and 150-pr. diaphragm shrapnel shells.[14]

Packing and issue.

Common fuzes are packed in zinc cylinders, 50 or 25 in each accord-

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1 This was first adopted in 1864, *War Office Minute*, 75/7/1154, 22/11/64.

2 See "Shell and Fuze Implements." p. 307. See also Regulations for preparation of fuzes.—*Manual of Artillery Exercise*, pp. 14, 15.

3 Except when the full time of burning—10 seconds—is required, when the bottom side hole being already bored no preparation is required, see text above.

4 See note 8 below respecting the rate of burning of fuze composition.

5 Driven in by means of a mallet and setter (p. 307) in the larger shells, or by striking it against the wheel of the limber, or other hard substance, in the case of smaller shells. A very slight blow suffices for the purpose, as the shock of the discharge sets the fuze securely home. Indeed, it is quite sufficient to *press* the fuze home with the hand.

6 "This operation not being performed until the shell is in the bore, much reduces "the chance of an accident, and renders the priming less liable to injury from wet." —*Manual of Artillery Exercises*, p. 15, see also *Ibid.*, p. 81.

7 See p. 233 respecting this fact not having been generally recognized by artillerists until the middle of the 18th century.

8 This is the normal rate of burning of fuze composition, when properly pressed, perfectly dry, and subject to no disturbing influences; but it is subject to variation, from atmospheric pressure, damp, and other causes. On this subject see a paper "On the "influence of Atmospheric Pressure upon some of the Phenomena of Combustion," by Dr. E. Frankland, F.R.S.—*Proceedings Royal Artillery Institution*, vol. iii., p. 14; and which for convenience of reference I have given in Appendix K.

9 Which is thus, as it were, ignited at two points—through the bored hole, and by the exploded powder channel.

10 See p. 256, where the absence of powder channels in mortar fuzes is explained.

11 Or, in the case of the 12-pr. common shell, against the sides of the socket.

12 See p. 253, note 1; no greater time of burning than 10 seconds can be got out of these fuzes, as although the composition, is continued below the 2-inch hole, and there is another hole at 2·1 inches, the fuze will always act at the first hole which is bored into the composition and if no hole is bored above the 2-inch, *i.e.*, if the fuze be unprepared and allowed to burn its full time, it will necessarily act when it comes to this 2-inch hole. The additional 2·1-inch hole, therefore, adds nothing to the time of burning of the fuze.

13 When the 24-pr. and 12-pr. common shells are fired from the $5\frac{1}{2}$-inch and $4\frac{2}{5}$-inch, mortars and their time of flight exceeds 10 seconds, the special "small mortar" fuze (see p. 258) is used, otherwise the common fuze is used.

14 The diaphragm fuze would also be available with these shells for times of flight not exceeding 5 seconds.

ing to the demand. The lid is closed in the same way as that for ubes, viz., with beeswax and turpentine, and a strip of calico varnished on.

The lids of the cylinders containing 50 fuzes are painted white and stencilled black with the nature and number of fuze, date of issue, and number of thousand.

The cylinders which contain 25 have a printed label with the same particulars.[1]

The cylinders are packed in deal packing cases, 10 cylinders in each, paper shaving or other soft substance being used to fill up interstices. The lid is secured with iron screws, stencilled with the words "Large Cone"[2] in *red;* and in black with the nature and number of fuze, number of thousand and packer's name and date of issue.

For *Field* service common fuzes are repacked and issued by the Military Store Department, *when the battery is packed by the Department*, in rectangular canvas bags,[3] and in tin boxes containing respectively 16 or 10 in the bags and 10 or 8 in the boxes.

When the battery is not packed by the Store Department the fuzes are issued in zinc cylinders, the bags and boxes separately.

For all boat services common fuzes are issued in tin boxes [4] specially intended for boat magazines.

Fuze, time, wood, diaphragm, shrapnel.

2. The *Diaphragm Shrapnel fuze* [5] (pl. 2) differs from the common shrapnel, 1st, in containing only one inch of fuze composition,[6] instead of two, because (*a*) a less time of burning is required in a diaphragm than in a common fuze, since the diaphragm shell is not used at extreme ranges [7] and is always required to burst short of an object; [8] and (*b*) the longer the fuze the less the capacity of the shell for bullets.[9] 2nd. The powder channels of the diaphragm fuze are connected by a groove cut on the end of the fuze, and laid with quickmatch. By this arrangement the simultaneous explosion of both powder channels, and a consequent increase of flash,[10] is secured.

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[1] This plan of a label will doubtless ultimately be generally adopted, in preference to stencilling, which is liable to become worn off and obliterated.

[2] See p. 237.

[3] See p. 287.

[4] See p. 287.

[5] Present pattern approved 18th August 1855.—*Account of Alterations and Additions in Ordnance, &c.*, 22nd October 1855, par. 21.

The *improved Shrapnel fuze* is identical with the diaphragm fuze in all respects but one, viz., in being made on the old "small cone" (see p. 50, note 1, and p. 237), *i.e.*, straighter and smaller in diameter than the present cone, the pitch of cone being ·065 inch per inch. The fuze is distinguished by the top of the cap being painted red. It can only be used with the improved Shrapnel shell.

[6] When a fuze is said to contain a certain number of inches of composition, the measurement must always be understood as referring to the solid composition, *i.e.*, the length of composition between the zero point and the side hole at which the full time of burning of the fuze is obtained, and exclusive of the composition above and below these points.

In the case of the common and diaphragm fuzes, for example, the measurement is between the zero point and the upper of the two bored side holes; in the case of the mortar fuzes it is between the zero point and the bottom side hole.

[7] See p. 56; in the case of 100-pr. and 150-pr., the range of which is sufficiently great to necessitate a longer fuze, the socket is made of a length to receive the common fuze.

[8] See p. 56.

[9] As the socket to contain it must be continued to a great depth in the shell. See also note [6] (above).

[10] This is to make the ignition of the bursting charge more certain. It must be borne in mind in connexion with this point that the bursting charge is not in immediate contact with the fuze, but the flame has to pass through the small fire hole in the socket, and in proportion as the flash is increased the chance of its passage is made

The full time of burning of the diaphragm fuze is 5 seconds, and the upper of the two bored side holes is marked 0 (for 10).

In other respects this fuze is identical with the common fuze.[1]

Their preparation and action is also the same.[2]

The diaphragm fuze is intended for use with all diaphragm shrapnel shell,[3] and is available *for times of flight not exceeding* 5 *seconds* for common shells.

Packing and issue.

Diaphragm shapnel fuzes are packed and issued in the same way as common fuzes,[4] *i.e.*, in zinc cylinders, 50 or 25 in each and 10 cylinders in a deal case. The closing and marking of the cylinders and boxes are the same as for common fuzes, with the exception of the designation of the fuze.

For field service, if packed by the Military Store Department, they are placed in canvas bags[5] or tin boxes,[6] which contain respectively, bags 12 or 8, boxes 12, 10, or 8.

For boat service they are packed in a tin box[7] specially intended for boat magazines.

Fuze, time, wood, mortar, large.

3. *The large Mortar fuze*[8] (pl. 2) differs from the common fuze in the following principal points :—

1st. In size.

2nd. In the absence of powder channels.

3rd. In the position and dimensions of the composition bore.

4th. In the arrangement of the side holes.

5th. In the painting and marking.

1st. The mortar fuze is considerably longer than the common fuze, to receive six inches of fuze composition, a greater time of burning being required for shells of which the time of flight is necessarily longer than that of shells for horizontal fire. The cone, however, has the same development as that of the common fuze, although necessarily a longer and larger frustum.

2nd. Powder channels are not required in these fuzes because the top side hole falls *within* the shell,[9] there is thus always a direct communication from the burning fuze composition to the bursting charge through the bored side hole.[10]

3rd. The absence of powder channels obviates the necessity for boring the composition bore excentrically, it is therefore situated in the axis

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more certain; moreover, the powder channels of these fuzes being one inch shorter than those of the common fuze contain so much less powder, and the flash produced by the explosion of the two is only about equal to that produced by the explosion of one channel in a common fuze.

[1] The diameters of the two fuzes at their thickest parts are the same, viz., 1·09 inches.

[2] See p. 254. The use of the powder channels in these fuzes is even greater than in the common fuzes, since the explosion of the charge *always* depends upon them.

[3] See p. 254 respecting the employment of common fuzes with the 100-pr. and 150-pr. diaphragm shell, for times of flight exceeding 5 seconds.

[4] See p. 255.

[5] See p. 287.

[6] See p. 287.

[7] See p. 288.

[8] The present pattern approved 18th August 1855. See *Account of Alterations and Additions in Ordnance, &c.*, 22nd October 1855, para. 21. These fuzes were known as "mortar fuzes for 13″, 10″, and 8″ mortar shells" until 1865, when the present more compact designation was adopted.

[9] In the case of the 13-inch the thickness of metal is so great that the two top side holes do not fall within the shell, but the ranges at which the 13-inch is used are rarely as short as would correspond with these holes. In the 8-inch shell also the reduction in the size of the fuze hole scarcely permits of the fuze being set home far enough to bring the *top* hole quite within the metal.

[10] See p. 254 respecting use of powder channels in common fuzes.

of the fuze. It is of a length to receive six inches of composition. Its diameter is slightly larger than that of a common fuze bore.[1]

4th. There is only one row of side holes instead of two, and these holes are situated spirally round the fuze, to avoid weakening the wood by boring too much into one side of it.[2]

The holes are the same distance apart as in the common fuze, viz., two inches;[3] with the exception of the bottom hole they are merely indentations, indicating the points at which the fuze must be bored for the different times of flight, and they contain no powder or clay. The bottom hole (pl. 2, fig. 2 *e.*) is bored through into the composition, but contains no quick-match,[4] nor is it closed or protected in any way.[5] It is situated six inches from the zero point of the fuze, the top hole is two inches from zero (pl. 2, fig. 3, 2.)

5th. The whole fuze is painted drab,[6] with the exception of a black[7] ring round the junction of the cap and body.

A ring is cut round the fuze at zero, and this serves also to mark the depth to which the fuze will enter the fuze hole of a 13″ or 10″ mortar shell.

Below this, at a distance of 9″, is another ring showing the depth to which the fuze will enter the fuze hole of the 8-inch mortar shell.[8] Rings are also cut to indicate the length of composition at each inch from 2″ downwards, and the side holes which fall on these rings are dotted red, the number of inches to which they correspond being stamped against them in red.[9] The intervening side holes are not numbered.

The large mortar fuze differs also from the common fuze in one or two minor points of detail, viz., in the matching (pl. 2, fig. 4), which is effected by doubling 6″ of match and setting it down upon the composition, the ends being coiled round inside the cup; in the consequent absence of match holes in the sides of the cup; and in the absence of any paper over the side holes or end of the fuze. In other respects the construction of the two fuzes is identical, and the mortar fuze is also stamped with the numeral, number of thousand, and month and year of manufacture in the same way as the common.

The rate of burning of the large mortar fuze is the same as that of the common fuze, viz., one inch in five seconds, and its full time of burning is consequently 30 seconds;[10] its preparation and action are the same as those of the common fuze, with the exception that a brace Preparation and action.

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[1] The bores of the two fuzes bear about the same proportion to the general dimensions of the respective fuzes. A large bore is desirable when the column of composition is long to prevent the rate of burning being affected by the accumulation of solid residue within it.

[2] Any unnecessary weakening of the fuze in one direction is to be avoided, as tending to make the fuze more liable to split when subjected to exceptional atmospheric influences, or in boring.

[3] Measuring vertically from centre to centre.

[4] The absence of powder channels makes quick-match unnecessary. See p. 252.

[5] This is a defect, a remedy for which is under consideration.

[6] See table XX., p. 345.

[7] See table XX., p. 345.

[8] See p. 36 respecting the difference in the size of the fuze hole for the 13′ and 10″ mortar shell and that of the 8-inch.

[9] See table XX., p. 345.

[10] At proof they are always timed to burn rather over than under 30 seconds, the margin of error allowed being all in excess, viz., from 30 to 32 seconds. This is because it is considered that a mortar fuze should always be rather long than short. *If necessary* a small quantity more saltpetre than is contained in the usual proportions is added to produce this result.

and bit[1] are used in its preparation, instead of the hook-borer; that it cannot be prepared for shorter times of flight than 10 seconds; or for minuter subdivisions than seconds instead of half seconds, and that the action is of course independent of powder channels, the side holes as before explained always falling within the shell.

The large mortar fuze is used for the 13-inch, 10-inch, and 8-inch mortar shells, and is available for use with no other shell.

Large mortar fuzes are generally issued in whole metal-lined cases, 330 in each. The fuzes are placed in loose, and the case filled with paper shaving, or other soft material. The bung is lutened in the ordinary way.[2] Smaller quantities are issued in half and quarter cases. The case is stencilled with the nature and number of fuze, date of issue, numeral, number of thousand, and packer's name.

Fuze, time, wood, mortar, small.

4. *The small Mortar fuze*[3] (pl. 2) differs from the large mortar fuze in dimensions, being shorter, to contain three inches of fuze composition instead of six inches, and a smaller frustum of the same cone, to fit the common fuze hole. The composition bore is also smaller, being the same diameter as that of the common fuze. The notation of the small mortar fuze runs from 1″ to 3″ (pl. 2, fig. 9). The construction of the two fuzes is in other respects identical.

Its rate of burning, preparation, and action are the same as those of the large mortar fuze.

The small mortar fuze is intended for use with the 24-pr. and 12-pr. common shells when fired from the $5\frac{1}{2}''$ and $4\frac{2}{5}''$ mortars at ranges beyond those for which the common fuze (which would generally be used with these shells up to 10 seconds) is available. It can be used with these shells for from 5 to 15 seconds time of flight,[4] or on an emergency it might be used with other common shells.[5]

Packing and issue.

Small mortar fuzes are generally issued in whole metal-lined cases, 1,000 in each; the fuzes are placed in loose, and the case filled with paper shaving, or other soft material. The bung is lutened in the ordinary way. Smaller quantities are issued in half and quarter cases. The case is stencilled in black with the nature and number of fuze, date of issue, numeral, number of thousand, and packer's name.

Fuze, time, metal, Boxer's 20-seconds.

5. *The 20 seconds fuze*[6] (pl. 3) resembles the common fuze in principle, but differs from it materially in construction. The body of the fuze is made of gun metal.[7] It is 5 inches in (external[8]) length, the lower part being conical; above this, for about an inch, it is

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[1] See p. 307.

[2] See table XX., p. 345.

[3] Probable date of approval of *present pattern* 18th August 1855, see p. 238, note 6, These fuzes were known as $5\frac{1}{2}''$ and $4\frac{2}{5}''$ mortar fuzes, or "mortar fuzes for $5\frac{1}{2}''$ and $4\frac{2}{5}''$ mortar shells," or "long range fuzes" for "shells fired from Royal and Coehorn mortars" until 1865, when the present designation was adopted.

[4] Owing to the bush on the 12-pr. shell these fuzes cannot be depended upon to act at shorter times of flight than seven seconds, the three top side holes falling against the socket.

[5] In the 10″ and 8″ one or two of the upper side holes would fall against the metal.

[6] Present pattern (with exception of present arrangement of bottom side hole, which was not approved until July 1865) finally adopted 9th September 1859.—Royal Artillery *General Regimental Order* 402, para. 47.

[7] Strictly speaking, the alloy which in the Royal Laboratory and throughout this work is spoken of as "gun metal" is not gun metal, a small quantity of zinc being added to improve the castings. The alloy is copper 11 lbs., tin 1 lb., zinc $1\frac{1}{2}$ ounces; or, proportionally expressed, copper 90·96 per cent., tin 8·27, zinc ·77.

[8] Including the neck.

cylindrical, and screwed with a right-handed thread to fit the (Moorsom) bush of naval shells.[1]

Above the screwed part of the fuze is a plain cylindrical projecting shoulder,[2] upon which the fuze rests when it is screwed home; on the upper side of this shoulder are four wrench holes (pl. 3, fig. 14), equidistant from one another, by means of which the fuze is screwed into or removed from the shell.

From the centre of the group of wrench holes there projects upwards a cylindrical "neck," nearly half an inch in length, screwed with a left-handed thread,[3] to receive the cap, by which the fuze is closed until the moment of ramming home.

The fuze is bored down its longer axis, from the top of the neck to within about ·2 inch of the bottom. The bore is about half an inch in diameter, and is tapped with a fine thread, for the reception of a hollow rolled paper[4] cylinder (pl. 3, figs. 1, 2, 3), smeared with shellac varnish on the exterior for better protection against damp, with which the bore is lined. The lower end of the cylinder is closed with a card-board disc.

The bore, lined as described, is pressed,[5] or driven[6] with fuze composition;[7] the composition being thus separated by the paper lining from the metal, a necessary precaution to prevent the deterioration of both metal and composition which would result from the contact of the two.[8] The paper lining also helps[9] to protect the composition from exposure at the side holes, and the preparation of the fuze consists, as will presently appear, in breaking through this partition and exposing the composition at the required hole.

The fuze is matched and primed in the same way as mortar fuzes.

The priming, match, and composition are bored through in the usual way to facilitate ignition.[10]

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[1] The pitch of thread is 16½ to the inch. This gauge and pitch are admittedly inconvenient. A conical fuze hole, as before pointed out (p. 250, note 5), is the best, not only for wooden but also for metal fuzes, "whether regard be had to the smaller aperture "thus available for the escape of the exploded bursting charge," or whether considered in connexion with the readiness with which a metal fuze may be screwed into or out of it (see p. 31, last part of note 2); and the sharp pitch tends to prolong and complicate still further the operation of screwing the fuze into the shell. The expense and inconvenience entailed in altering a fuze hole, particularly where metal fuzes are concerned, are, however, so considerable that, admittedly inconvenient as are this gauge and pitch, no proposition that I am aware of was ever formally submitted for their alteration until 1865 and 1866, when this subject was fully gone into by the Ordnance Select Committee, whose report is given in *Extracts Ordnance Select Committee*, vol. iv. p. 143. The adoption of the general service bush, which was the result of the Committee's deliberations, will, by degrees (see p. 35), be extended to naval shell; and thus the Moorsom gauge and the fuzes adapted for it will eventually disappear.

[2] Sometimes called a collar.

[3] Left-handed, or in the opposite direction to the body thread, in order that the fuze may not be loosened in the shell when the cap, which may have become tightened, is unscrewed. The pitch of thread is 16½ per inch.

[4] "100 lb." paper.

[5] By hydraulic pressure.

[6] See p. 251, note 2, respecting the old plan of driving fuzes.

[7] See p. 251.

[8] "We find, where gunpowder is in contact with metal, that there is great deteriora- "tion, both of the metal and of the gunpowder. The old naval fuze was altered for "that reason. I applied a paper lining to it, because we found that the composition "of the fuze became so much deteriorated that it burnt very irregularly."—*Colonel Boxer's Evidence before Armstrong and Whitworth Committee*, question 1714.

"The metal has an injurious effect upon the composition unless entirely separated "from it."—Owen's *Lectures on Artillery*, edition 4th, p. 81.

[9] "Helps" only, since protection is also afforded by the ground clay.

[10] See p. 236.

Two rows of side holes (pl. 3, fig. 12), disposed as in the common fuze,[1] are drilled horizontally completely through the metal of the fuze into the composition bore, the fuze composition being protected from exposure at these holes principally by the paper lining, but partly by the ground clay with which the side holes, with the exception of the bottom hole,[2] are pressed.

The top hole of one row is situated 1·5 inches below the zero point, and the top hole of the other row 1·6 inches, and as both these holes fall on the conical part of the fuze, *within the shell*, powder channels are unnecessary.[3]

The bottom hole is four inches below the zero point, and is drilled through the paper lining into the composition to ensure the ultimate action of the fuze in case of imperfect boring, or non-preparation in hurry of action.[4] This hole is made rather larger than the others, and contains a perforated powder pellet, over which a piece of fine paper is secured with shellac varnish to exclude moisture.[5]

The fuze is capped with a gun-metal[6] cap (pl. 3, fig. 11), which screws on to the neck. This cap is cylindrical in form, but with the sides slightly "squared" or shaved off, to give a hold to the key. A leaden washer (pl. 3, fig. 16) is placed over the neck, and on to this the cap, when screwed home, presses tightly, thus closing and protecting the fuze more effectually; a leather collar[7] (pl. 3, fig. 15) is secured[8] by shellac varnish to the under part of the shoulder of the fuze, with a view to excluding moisture more completely from a filled and fuzed shell.[9] The side holes are dotted white.

The *times of burning, or times of flight,*[10] in seconds and half seconds,

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[1] That is, the holes in each row ·2 inch apart, measuring vertically from centre to centre, and one row dividing the spaces of the other row. See p. 252.

[2] The lowest hole, that is to say, on the even row.

[3] See p. 254 respecting use of powder channels.

[4] See p. 252. It will be observed that only the bottom hole of the fuze is drilled into the composition, while in the common fuze the bottom side hole of each row is bored, an extra side hole being added to admit of this being done (p. 253, note 1). The explanation of this is that in the common fuze the boring of the side holes is necessary, not only to ensure the ultimate action of the fuze, but also, and *principally*, to permit of the requisite quick-match support being afforded to the powder in the channels. Now this support is required for the powder in each channel, and accordingly the bottom side hole of each row must be bored; but in the 20 seconds fuze, which has no powder channels, the only object of boring this bottom hole is to ensure the ultimate action of the fuze, and this end is attained by boring the last side hole on the fuze.

[5] This improvement was not adopted until some time in 1865. Up to that date the hole was open, and the composition at this point therefore completely exposed. With regard to this alteration, Col. Boxer says, in a Minute to the Director of Ordnance,— The fuzes which are not so altered burn slower after they have remained in store some time, "principally owing to the exposed communication hole at the "bottom," but this defect is remedied by the new plan.—*Minute of Col. Boxer to Director of Ordnance*, 14/10/65.

[6] The same metal as is used for the body of the fuze.

[7] Parchment has been used for this purpose, and subsequently gutta percha, which was retained until 1863, when it was superseded by leather, for reasons given, p. 105.

[8] Until 1864 these collars were not secured to the fuze, being placed on loose, but they were found liable to fall off, or at times to become stretched over the shoulder.

[9] Sir Howard Douglas gives the following additional reason for the employment of collars on metal fuzes: "A washer of parchment or some other material should be "placed under the collar or head of the fuze, that there may be no contact between "the metals of the fuze and the shell, by which intervening grains of gunpowder "might become crushed and ignited."—*Naval Gunnery*, p. 327.

[10] The times of burning and of flight are of course synonymous. This method of notation appears to be superior to that adopted for common and mortar fuzes, since the time of flight of the projectile is always an implied constituent in the calculation of the length of fuze required; and an additional operation is involved in the reduction of the time of flight and burning into terms of the length of composition.

are stamped against the alternate side (pl. 3, fig. 12) holes.[1] The figures are not coloured.

The whole of the fuze body and cap are lacquered to preserve it from corrosion.[2] The fuze is stamped on the bottom with the date of manufacture, and on the side of the shoulder with the numeral and number of thousand.[3]

Preparation. The preparation of the fuze for any time of flight between $7\frac{1}{2}$ and 20 seconds consists in boring, by means of a brace and short bit, or by means of a hook borer,[4] provided for the purpose, through the clay and paper lining at one of the side holes[5] into the fuze composition.[6] The fuze is then screwed into the shell *and uncapped, when the shell is in the bore of the gun*,[7] by unscrewing the metal cap.

Special preparation for times of flight less than $7\frac{1}{2}$ seconds But if the fuze be required for a shorter time of flight than $7\frac{1}{2}$ seconds,[8] further and special preparation is requisite.

To make it available for any time of flight from $\frac{1}{2}$ second upwards, the first 1·4 inches of composition must be removed, or bored through,[9] and a brace and long bit, with a stop, are provided for this purpose.[10]

The top hole then becomes, by the lowering of the zero point to within

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It is true that in using the common fuze and others notated by length of composition, insensibly one acquires the habit of speaking of the length of fuze due to a given range, without any mention of the time of flight, but in reality before the length of fuze was determined the time of flight, and consequently the time of burning of a given length of fuze, must have entered into the calculation; *at least, if it is a matter of calculation, and not merely one of observation.* Thus, when we say that a fuze of ·4 inches is required for a diaphragm shell fired from a 9-pr. gun at 800 yards, the process involved in the calculation by which this result is arrived at is, a determination that the shell should burst two seconds after leaving the gun to produce the required effects, that consequently the fuze should burn two seconds, and that the length of fuze required to give this two seconds is ·4 inches. Therefore it would seem to be a simplification to express the notation in terms of the times of burning or flight rather than in terms of the length of fuze; at the same time, the service generally are so well acquainted with fuzes on the latter plan that a change now could scarcely be advocated.

[1] The alternate holes, that is to say, in each row, thus: on the even row the fuze is stamped at the top hole 8 seconds, the next hole on that row is missed, and the third hole numbered 10. On the odd row the top hole is not numbered, the second hole is numbered $8\frac{1}{2}$ seconds, the third hole is missed, and the 4th hole numbered $10\frac{1}{2}$. Thus, taking the two rows together, the notation runs, 8, $8\frac{1}{2}$, 10, $10\frac{1}{2}$, 12, &c.

[2] For composition of lacquer employed, see table XX., p. 345.

[3] First adopted November 1864.

[4] Until 1865 a hand-borer was also included in the naval implements for this purpose.

[5] Except when the full time of burning, 20 seconds, is required, in which case, the 20 seconds hole being already bored, no preparation is necessary.

[6] See Naval Shell and Fuze Implements, p. 304.

[7] The precaution of not unscrewing the cap of the fuze until the shell is in the gun is of the utmost importance. "A terrific accident occurred in the shell-room, or on "deck, on board H.M.S. 'Medea,' by the ignition of a fuze in unscrewing a cap, and "the like accident occurred on one other occasion."—*Naval Gunnery*, p. 316. The accident on board the "Medea" is described, *Ibid.*, p. 280. These accidents led to the screw being placed on the outside of the fuze.—*Ibid.*, p. 316.

[8] In the event of a deficiency of short range $7\frac{1}{2}$ seconds fuzes.

[9] See p. 304. The stop must be placed not 1·4″ but 1·94″ from the point of the bit, this distance being 1·4″ comp. + 54″ distance from top of neck to zero point.

[10] The top hole, as has been explained (p. 260), is 1·5 inch from the zero point, but when 1·4 inch of composition is removed, the zero point becomes lowered by exactly that distance, and there will then only remain (1·5 − 1·4) = ·1 inch of composition between the new zero point and the top side hole, which accordingly no longer reads $7\frac{1}{2}$ but $\frac{1}{2}$ seconds.

·1 *of an inch of it, ½ second instead of 7½ seconds,*[1] *and each of the remaining side holes reads 7 seconds less than it is marked.* The preparation of the fuze then proceeds as usual.

Example.—If the fuze be required to burn 5 seconds, 1·4 inches of composition must be removed, as above described, and as a constant error of 7 seconds will thus be established, the fuze must be bored at the hole 12, since 12 − 7 = 5.

Action.

The action of the fuze is the same as that of the mortar fuze, the composition being ignited by the flash of the discharge, and burning at the rate of ·1 inch in 5 seconds until it comes to the bored hole, whence it issues into and explodes the bursting charge.

If the fuze be left unbored it will act its full time, viz., 20 seconds, since the bottom side hole is bored into; and the perforated powder pellet will shoot forth the flame with violence.

The 20 seconds fuze can be used with all naval shells, for 7½ seconds, or greater, times of flight.[2] It will be gradually superseded by the 20 seconds Boxer wood fuze for muzzle-loading ordnance.[3]

Packing and issue.

The 20 seconds fuzes are issued in rectangular deal packing cases, similar in appearance to the shot and shell boxes. The box is lined with brown paper, and contains 50 fuzes; the lid is secured by iron screws, and stencilled black, with the nature and number of fuze, date of issue, number of thousand, and packer's name.

Fuze, time, Metal, Boxer's 7½ seconds.

6. The 7½ *seconds fuze*[4] (pl. 3) resembles the 20 seconds fuze in general appearance, construction, and dimensions, but differs from it, 1st, in being adapted for shorter times of flight, and, 2nd, in being capable of adjustment for ¼ instead of ½ seconds.

1st. The fuze is driven or pressed with mealed pit powder[5] instead of fuze composition, and the rate of burning is thus increased from 1 inch in 5 seconds to 1 inch in 2½ seconds, or 2 inches in 5 seconds, the normal[6] rate of burning of pressed meal powder; and the full time of burning of the fuze is thus proportionally reduced.

The reduction in the time of burning of a 20 seconds fuze of one-half would give 10 seconds, and, accordingly, since this is in excess of the full time of burning required, an inch of composition is removed,[7] leaving 3 inches of solid mealed powder, burning at a rate of 1 inch in 2½ seconds, and giving, therefore, a total duration of action on the part of the fuze of 7½ seconds.

2nd. The side holes of the fuze are disposed as in the 20 seconds fuze, in two rows and ·2 inch apart, but there are more holes, viz., 15 in the even-numbered, and 14 in the odd-numbered, row, thus placing

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[1] Of course the value of this hole will depend upon the quantity of composition removed; thus, if 1 inch of composition be removed, the hole will be situated 1·5″ − 1 inch = ·5 inch from the zero point, and will then read 2½ seconds. But in such a case the fuze would not be available for a shorter time of flight than 2½ seconds, whereas by removing 1·4 inch it becomes available for ½ second or the shortest time of flight likely to be required.

[2] Or on an emergency, as has been explained, for shorter times of flight.

[3] See *W.O.C.* 10. (New Series) § 1236.

[4] Present pattern (with exception of present arrangement of bottom side hole, adopted in July 1865,) approved 9th September 1859, *Royal Artillery General Regimental Order* 402, par. 17.

[5] See p. 138. *Pit* powder is preferred to cylinder for the same reason that recommends its employment in fuze composition, viz., its greater regularity of burning. See p. 251, note 5.

[6] See p. 254, note 8, and Appendix K., p. 378, respecting the effect which various atmospheric influences will have upon the combustion of a column of burning composition.

[7] The removal of this much of composition necessitates the employment of a longer piece of match.

the top hole of one row (pl. 3, fig. 6) ·2 inch from zero,[1] and the top hole of the other row (pl. 3, fig. 8) ·3 inch from zero. As mealed powder burns 1 inch in $2\frac{1}{2}$ seconds, each tenth of an inch of powder is consumed in $\frac{1}{4}$ second, and these holes, therefore, are equivalent to $\frac{1}{2}$ and $\frac{3}{4}$ seconds times of burning; the remaining holes represent successively 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, and 2 seconds (pl. 3, fig. 8), and are numbered as in the 20 seconds fuze, by the times of burning or flight being stamped against the alternate holes[2] of each row. The holes are dotted red.

The $7\frac{1}{2}$ seconds fuzes may be readily distinguished,—

1st. By a groove which is cut round the top of the cap, and painted red (pl. 3, fig. 7).

2nd. By the letters "M.P." (for mealed powder) being stamped upon the top of the shoulder[3] (pl. 3, fig. 13).

3rd. By the side holes being dotted red (pl. 3, fig. 8).

4th. By the different readings of the side holes (pl. 3, figs. 8, 12).

In all other details of construction the $7\frac{1}{2}$ and 20 seconds fuzes are identical.

The preparation and action of the two fuzes are also the same,[4] with the exception that, as before stated, the rates and times of burning differ from those of the 20 seconds fuze.

The $7\frac{1}{2}$ seconds fuze can be used with all naval shells, for times of flight from $\frac{1}{2}$ to $7\frac{1}{2}$ seconds inclusive; and with the 64-pr. M.L. rifled guns. It will be gradually superseded by the 9 seconds Boxer wood time fuze, and no more will be manfactured.[5]

Packing and issue.

These fuzes are issued in the same way as the 20 seconds fuzes, viz., in rectangular deal packing cases, 50 in each.[6]

The lid of the case is, however, distinguished by being painted vermilion, and stencilled in black, with the nature and number of the fuze, date of issue, number of thousand, and packer's name.

Reasons for making naval fuzes of metal.

The 20 seconds and $7\frac{1}{2}$ seconds fuzes, being intended for naval use, were made of metal in preference to wood for the following reasons:—

1st. A large proportion of naval shells are carried filled and fuzed, and until 1865,25 per cent. of the fuzes were time fuzes. A metal fuze permitted of this being done without danger of accidents, whether resulting from accidental ignition[7] in the magazine, or while loading, or from the falling out of the fuze.

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[1] In the 20 seconds fuze, the top side hole is, it will be remembered, 1·5 inch from zero (see p. 260).

[2] See p. 261, note 1. The two top holes are not numbered; the second hole on the even numbered row is 1, the next hole on that row is missed, and the 4th hole is 2 seconds; the 2nd hole on the other row is $1\frac{1}{4}$ seconds, the 3rd hole is missed, the 4th hole is $2\frac{1}{4}$; the figures thus run 1, $1\frac{1}{4}$, 2, $2\frac{1}{4}$, &c., &c.

[3] It might be thought that the red ring would sufficiently distinguish the two fuzes, but the cap is liable to removal, and in the absence of the cap this distinction would disappear; or it may be urged that the side holes, their number and marking, would show at once whether the fuze is a 20 or $7\frac{1}{2}$ seconds; but this distinction, although available under ordinary circumstances, is no longer so when the fuze is in a shell, and it is at such a moment that the distinction of the two fuzes might be required.

[4] With the exception, of course, that the special preparation described (p. 261), by which the 20 seconds fuze can be made available for shorter times of flight than these for which it is naturally intended, does not apply to the $7\frac{1}{2}$ seconds fuze.

[5] See *W.O.C.* 10 (New Series), § 1236.

[6] See p. 262.

[7] "Wood fuzes are more liable to be accidentally ignited than metal fuzes."—*Naval Gunnery*, p. 315. "Such is the comparative safety of metal screw fuzes and metallic "caps, that shells so fitted are found to be proof against the explosion of a shell in "immediate contact."—*Ibid.*, 320.

"As shells on board ship are generally kept loaded, with their fuzes attached, "there is less chance of accident with the metal than with the wood fuze."—Colonel

2nd. The bursting charge of a shell fuzed with a metal fuze is little subject to deterioration from damp, or even from temporary immersion.[1]

3rd. A metal fuze is less liable than a wooden one to deterioration from the effects of damp or climate, or to injury from the effects of violence.[2]

4th. A metal fuze is less liable than a wooden one to be broken or knocked out on striking a ship's side or other hard substance.[3]

5th. The explosive effect of the shell, considered as a mine, is greater with a metal fuze which screws in, than with a wooden one.[4]

The several reasons here enumerated are those which were urged 35 or 36 years ago as arguments in favour of the introduction of metal time fuzes for naval use, and which have been since held sufficient recommendation for their retention; but within this period circumstances have greatly altered. The improvements made in fuzes, in the facility and comparative safety with which they can be prepared, in the method of packing them, the introduction of fuze hole plugs and wads, the reduction (subsequent to 1850) of the size of fuze holes, and, most important of all, the introduction of serviceable percussion fuzes, which by an order of 1865[5] are now always issued in filled naval shell, so completely alter the conditions of the case as to weaken materially the force of the original arguments in favour of metal fuzes, if not entirely to destroy them; while the arguments against these fuzes on the grounds of comparative expense and inconvenience are rather increased than diminished.[6]

Fuze, time, wood, Boxer, M.L. 9 seconds.

7. *The 9-seconds fuze for M.L. ordnance*[7] (plate 45) resembles the

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Boxer's *MS. Notes*, p. 80. Also Owen's *Lectures on Artillery*, edition 4th, p. 90. Also *Experiments in H.M. Ship "Excellent,"* p. 89.

"In this and other experiments recorded in this book will be found satisfactory "evidence of the security of shells with metal fuzes."

[1] "A shell with its fuze fixed may be immersed in water for a short time without "injury."—Colonel Boxer's *MS. Notes*, p. 81. "Metal fuzes protect the bursting "charge of the shell from . . . . moisture."—Owen's *Lectures on Artillery*, edition 4th, p. 92.

[2] "Wood fuzes having been found perishable, or to deteriorate by damp or heat in "the vicissitudes of naval service . . . . all sea service shells . . . . are now fitted "with metal screw fuzes."—*Naval Gunnery*, p. 315.

"The fragility of wooden fuzes, which, in large cannon especially, are liable to be "broken by the collision of the projectile with the bore, their rapid decay at sea, the "deterioration of the composition, ... have caused efforts to be made to substitute "metallic fuzes for wooden fuzes."—*Shells and Shell Guns*, p. 149.

"Metal fuzes are stronger and more serviceable than wooden fuzes."—*Owen's Lectures on Artillery*, 4th edition, p. 92.

[3] "Metal fuzes are not so easily knocked out on striking any hard substance, such "as the side of a vessel."—*Ibid.*, p. 92.

"They are not so liable to be broken or knocked out, either in the gun or on "striking and passing through a ship's side."—*Naval Gunnery*, p. 320.

"The fuze is not liable to separate from the shell in penetrating into a material."—*Colonel Boxer's MS. Notes*, p. 81.

[4] "Shells fitted with metal fuzes burst with greater violence than those which have "wooden fuzes."—*Naval Gunnery*, p. 315.

"The bursting powder will also act as a much more powerful mine by the greater "resistance offered to its escape through the fuze hole."—*Colonel Boxer's MS. Notes*, p. 81.

See for a full and scientific theoretical investigation of the subject of the loss of gas at the fuze hole, Piobert's *Théorique et Expérimentale*, pp. 335–346.

[5] 15th November 1865, *War Office Circular* 8 (new series), § 1151.

[6] See Appendix L., p. 379.

[7] Approved 26th June 1866, *W.O.C.* 10 (New Series), § 1236.

The designation 9 seconds fuze does not seem quite correct, looking to the fact that the so-called "20 seconds" fuze contains only double the quantity of composition; or perhaps it would have been better to designate the 20 seconds an "18 seconds" fuze. See also note 4, p. 266, respecting the burning of the fuze in a *spherical* shell.

common fuze in its main features of construction, but differs from it in several points of detail.

The points of difference may be most conveniently explained by arranging them under the following heads :—

(1.) Points of difference in the head of the fuze.

(2.) Points of difference in the body of the fuze.

(3.) General dimensions.

As regards (1.) *the head of the fuze*. The principal difference here consists in the introduction of a gun metal plug, which is screwed permanently into the upper part of the composition bore, flush with the top of the fuze. The object of this plug is to close the top of the fuze completely, and so to prevent (*a*) the extinction of the fuze when striking end on, and (*b*) the great acceleration of the rate of burning of the composition which is induced by the pressure of the air on an unprotected fuze fixed in the apex of a rifled shell.[1]

The presence of the plug necessitates a different method of priming. From the centre of the plug projects downwards a copper pin (pl. 45, fig. 5), round which is looped (pl. 45, fig. 8) a piece of quick-match (pl. 45, fig. 4), the ends of this match being passed through two escape holes (pl. 45, fig. 2), which are provided in the side of the head for the escape of the flame from the burning composition.

The quick-match is laid in a groove round the head of the fuze, and is covered by a strip of thin sheet copper,[2] the copper being covered by a tape band,[3] one end of the copper band being exposed.

The band and upper part of the fuze are painted black; the top of the fuze is varnished with shellac varnish.

(2.) *The body of the fuze* differs from that of the common fuze principally in being lined with a paper[4] cylinder (pl. 45, fig. 8). This lining serves two purposes, 1st. In the event of the wood shrinking, as it will sometimes do in dry hot climates, it prevents the formation of a space or groove between the wood and composition, which would cause the fuze to explode[5] instead of burning regularly; and 2nd. It enables the side holes to be made deeper, thus diminishing the thickness of wood to be bored through in preparing the fuze.

In addition to being deeper the side holes differ from those of a common fuze in being plugged with rifled powder only, the ground clay being dispensed with. The bottoms of the powder channels are not, as in the common fuze, closed with shellac putty, but, like those of the diaphragm fuze, are connected at the bottom with a piece of quick-match.

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[1] See on this subject Appendix K., p. 378. The extent to which this acceleration takes place is indicated by the fact that the total acceleration of the time of burning of a 20 seconds metal time fuze which has no such plug, fired in a 64-pr. M.L. shell, is 3 seconds; *i.e.* a 20 seconds fuze burns only 17 seconds.—*Minute by Gen. Lefroy*, 18/7/65, on 75/7/1329. The difference would of course be greater in shells having a higher velocity.

[2] The copper band is 5·1″ long, ·3″ wide, and ·002″ thick; the end is narrowed slightly.

[3] The object of covering the quick-match thus carefully is not merely to protect the priming from moisture, but to secure the fuze against accidental ignition. An experiment was made in the Royal Laboratory at Woolwich in March 1865, to determine how far the fuzes were secure in this respect. The result was satisfactory. The following are the details of the experiment. Four 7-inch B.L. common shells were placed upright and a 10 lbs. cartridge exploded in centre, and this repeated a second and third time with same fuzes; none of the fuzes ignited. Four 7-inch B.L. common shell were placed round a 10 lbs. cartridge with the fuzes resting on the cartridge, and cartridge exploded, this repeated a second and third time; one fuze out of 12 may be expected to light.

[4] "White wrapping" paper. The outside of the cylinder is varnished with shellac before being placed in the fuze.

[5] On the principle of a tube.

Above the level of the top side hole the composition bore is driven with mealed (pit) powder instead of fuze composition, to insure greater accuracy when the fuze is prepared for short ranges.[1]

(3.) *In dimensions* this fuze differs from the common in being altogether about one inch longer to give room for the plug, and in being cut from a somewhat thicker part of the same cone to adapt it to the general service fuze hole.

In other respects the construction is identical with that of the common fuze.

Preparation. The preparation of the 9-seconds and common fuzes is the same, with the exception that the 9-seconds fuze is uncapped by stripping the tape and copper band from the priming, by means of the exposed end of copper which is left to lay hold of.

This should not be done until the shell is in the bore of the gun.

Action. When the fuze composition becomes ignited it burns out of the two escape holes provided for the purpose, the action in other respects being the same as that of the common fuze.

The 9-seconds fuze can be used with all *muzzle-loading* shells having the "general service" fuze hole or adapter, and, in addition to being used with all M.L. rifled shells so fitted, it has been adopted for use with naval spherical shell[2] having a suitable bush or adapter. It will gradually supersede the $7\frac{1}{2}$ seconds fuze for these latter shell.[3] It is available for times of flight from 1 to 10 seconds.[4] This fuze is available as a percussion fuze when firing (even with low charges) against earth works or ships without any preparation, the fuze in such cases being driven into the shell on impact and the shell exploded.

Available as percussion fuze.

Packing and issue. The 9-seconds fuzes are packed by fifties in zinc cylinders, labelled "Fuze, time, Boxer, 9-seconds, for M.L. ordnance." On the side of the cylinder are labelled the following directions, similar directions being enclosed in each cylinder.

INSTRUCTIONS for PREPARING and FIXING BOXER 9-SEC. TIME FUZE FOR MUZZLE-LOADING ORDNANCE, GENERAL SERVICE BUSH.

The fuze is similar to the Boxer wood time fuze for breech-loading rifled ordnance, except that there is no detonator, the top being closed by a solid metal plug. The fuze is ignited by the flame of the exploded charge, which passes by the windage, and lights the priming of quick-match contained in the groove round the head of the fuze. The priming is protected from injury or accidental ignition by being covered with a band of copper and tape.

Preparing and fixing the Fuze.

The fuze is prepared in the same manner as the ordinary wood time fuzes. In fixing the fuze it is not necessary to use a mallet, it is suffi-

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[1] Pressed mealed powder burns twice the rate of fuze composition, and thus by substituting mealed powder for fuze composition twice the length is obtained, the chance of the boring tool cracking the composition, as it would be liable to do if it entered near the top, being thus diminished and the accuracy of the fuze at short ranges increased.

[2] For reasons which induced the Ordnance Select Committee, when engaged in the assimilation of fuze holes, not to attempt to extend the assimilation, as far as spherical shell were concerned, to any but "Naval shell," see *Extracts Ordnance Select Committee*, vol. iv. page 143, *et seq.*

[3] *War Office Letter*, 5th July 1866, 75/12/2852, and *War Office Circular* 10 (new series), § 1236.

[4] The fuze is called a 9 seconds fuze because this is its mean time of burning *in rifled shell*, in which, notwithstanding the plug, a certain acceleration of burning does take place. In a spherical shell, however, the fuze will burn the full time due to two inches of composition, *i.e.* 10 seconds.

cient to press the fuze with the hand, screwing it at the same time into the bush or adapter ; when the fuze cannot be screwed any further with the hand it is then properly secured.

Uncapping the Fuze.

The fuze should not be uncapped until the shell is placed in the bore of the gun. To uncover the priming, take hold of the small end of the copper band, which is left exposed, and unwind from left to right smartly, so as to thoroughly detach the band from the head of the fuze.

N.B.—With reduced charges, to insure the ignition of the fuze, it may sometimes be necessary to farther expose the quick-match priming —a slight touch with the finger will easily make the ends of the quick-match project from the groove,—and when very reduced charges are used two or three strands of quick-match should be tied in addition round the projecting part of the fuze."

Fuze, time, wood, Boxer, M.L. 20 seconds.

8. *The 20-seconds fuze for M.L. ordnance*[1] (pl. 51) resembles in part the 9-seconds fuze for M.L. ordnance, and in part a mortar fuze.

It has, that is to say, the metal plug in the head, the escape holes, the priming and copper and tape bands round the head, and the paper lining, which are characteristic of the 9-seconds fuze, while in respect of having only one row of side holes, disposed spirally, and of having no powder channels, its construction is that of a mortar fuze.

In two respects the fuze differs from both those which it generally resembles. It contains four inches of fuze composition,[2] (pl. 51, fig. 26) and a hole is bored transversely through the fuze immediately below the composition for the reception of a pellet of mealed powder pierced like a tube (pl. 51, fig. 26). The ends of the hole are protected by discs of thin paper secured with shellac varnish. Notation of the side holes is as in the large mortar fuze, from 2 inches downwards, but each hole is numbered, in tenths of inches.

Preparation and action.

The preparation of this fuze is the same as that of the mortar fuze[3] in so far as the boring is concerned. It is uncapped in the same way as the 9-seconds fuze.

Its action is that of a mortar fuze, with the addition of a certain increased violence or intensity of action due to the powder pellet in the bottom, when the fuze is left to burn full length.

The 20-seconds M.L. fuze can be used with the same shells as the 9 seconds M.L. fuze, *i.e.*, all M.L. shells, rifled or smooth bore, having the general service bush or adapter. It will gradually supersede the metal 20-seconds fuze for naval spherical shell.[4] It is available for all times of flight from 10 to 20 seconds.[5] This fuze is available as a percussion fuze when firing (even with low charges) against earth works or ships without any preparation, the fuze in such cases being driven into the shell on impact and the shell exploded.

Available as percussion fuze

These fuzes are packed by fifties in zinc cylinders labelled as the 9 seconds fuze though with the necessary modifications.

Fuze, time, wood, hand grenade.

9. *The Hand Grenade fuze* is a conical wood[6] fuze, rather more

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[1] Approved, 7/6/67, *W.O. Letter* 3/7/67, 75/7/1742.

[2] There is ·1″ of mealed powder on the top of the composition bored into to facilitate ignition. But as the hole all but extends through the mealed powder, this pellet does not sensibly increase the time of burning of the fuze.

[3] But, owing to the side holes being bored deeper, is not nearly so slow or laborious.

[4] See note 3, p. 266, also *W.O.C.* 10 (New Series), § 1236.

[5] In spite of the plug a certain acceleration of the rate of burning takes place in rifled shells, and the mean time of burning of the fuze in rifled shell would probably be about 18 seconds. But the fuze would burn its full time in spherical shell. It will gradually supersede the 20 seconds metal time fuze.

[6] Beechwood, of the same description as is used for common fuzes. See p. 250, note 4.

than two inches long,[1] and with a projecting rounded head. The head is cupped out, and the composition bore extends from this cup completely through the fuze, down its longer axis. The lower end of the fuze is bevelled off to almost a point. There are neither side holes nor powder channels, nor any marks indicating the length of composition, with the exception of a ring which is cut round the outside of the fuze at zero.

The fuze contains 1·5 inch of solid fuze composition,[2] which is exposed and unsupported at the bottom.[3]

The fuze is matched like a mortar fuze, the piece of match used being about three inches long, and is primed and bored into in the usual way to insure ignition. It is capped with a disc of cardboard,[4] over which is tied [5] a piece of fine paper.[6]

These fuzes are not painted; they have the numeral, number of thousand, and month and year of issue stamped upon the side.

Action.

Hand grenade fuzes are not to be cut, bored, or prepared in any way, being intended to burn the full time due to 1·5 inches of fuze composition, viz., 7½ seconds.[7] They are placed in the grenade uncapped, and ignited by means of a portfire,[8] and the grenade thrown in the direction required.[9] The fuze composition continues burning at the usual rate of one inch in five seconds, until it is consumed, when the flame passes through the end of the fuze to the bursting charge of the grenade, and explodes it. The hand grenade fuze is available with either the 3-pr. or 6-pr. hand grenade.

Packing and issue.

Hand grenade fuzes are issued in half metal lined cases, 1,200 in each, the case being filled up with paper shavings or other material, closed and lutened as usual. It is stencilled on the top in black with the nature and number of fuzes, date of issue, number of thousand, and packer's name. For naval service they are generally issued fixed in filled grenades, and covered with a kit plaster.

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1 Total length, inclusive of head.

2 See page 251.

3 The absence of support for the composition for a hand grenade fuze is of no consequence, as the fuze is exposed to no shock by which the composition could be "set down" or cracked. See page 235.

4 See page 253, note 3. 5 With twine. 6 "White fine."

7 The full time of burning of the fuze is as short as is consistent with safety, the shell containing the fuze being, it must be remembered, in a man's hand. It is therefore clearly unnecessary and undesirable to construct the fuze with a view to its preparation for a shorter, and therefore for an unsafe time of burning. See for a plan by which the time of burning of the fuze can be practically reduced, note 9 below.

8 The French hand grenade fuze is ignited by means of friction, which seems a superior method to lighting the fuze by a portfire :—"La fusée est allumée avant de "les jéter, ou bien en les jétant, au moyen d'une étoupille à friction."—Piobert's *Traité d'Artillerie Elementaire et Pratique*, p. 282.

The particular arrangement employed is fully described in Thiroux's *Instruction d'Artillerie*, p. 375.

A new hand grenade was introduced into the American service by a Mr. Ketchum in 1861. It is elongated, and is kept point downwards in falling by a feather in the base, and when it falls to the ground the "striker" is driven into a copper cap on a nipple, and the shell exploded. The striker is only put in when the shell is going to be used.—See *Report on the Military Affairs of the United States of America*, p. 43.

9 It is sometimes the practice, and used to be taught at drill, to wave the arm three times after the fuze is ignited and before the grenade is thrown, in order to allow time for the consumption of a portion of the fuze composition, and thus to make it impracticable for the enemy at whose feet the hand grenade may fall to take it up and throw it back again or away from him. In fact, this plan is tantamount to preparing the fuze for a shorter time of flight, according to the number of seconds that it is retained in the hand after being ignited; but the practice is not a very safe one, and would require to be exercised with the greatest care.

Fuze, time, wood, parachute, 10-inch.

10. *The Fuze for the 10-inch Parachute light*[1] (pl. 38, figs. 18, 19) resembles the common fuze[2] in principle and in general construction, but differs from it:

1st. In containing three inches of solid fuze composition instead of two inches, and consequently in being available for 15 instead of 10 seconds' time of flight.

2nd. In the side holes reading times of burning (pl. 38, fig. 18) or flight, instead of lengths of composition. The top side hole is 1·2 inches below the zero point,[3] and is accordingly numbered six seconds. The remaining holes are, as in the common fuze, two-tenths of an inch apart, and disposed in two rows to divide the spaces and read seconds and half seconds.

3rd. In the powder channels being connected at the bottom, as in the diaphragm fuze.

4th. In the fuze being varnished blue[4] all over, except the cap; in the whole of the side holes[5] being dotted yellow;[6] and finally, in a printed label with the words "time of burning" being pasted above the row of side holes. The number of thousand, month and year of issue, are marked upon the fuzes as usual.

Packing and issue.

These fuzes are prepared in the same way as the common fuze, and are used with the 10-inch parachute light.[7] On an emergency they would be available for use with common shells.

The 10-inch parachute fuzes are packed 25 in a cylinder.

Fuze, time, wood, parachute, 8-inch

11. *The fuze for 8-inch Parachute light*[8] (pl. 38, figs. 16, 17), differs from the 10-inch parachute fuze only in being shorter,[9] and containing two inches of solid composition instead of three inches; the composition is made rather slower, bringing the duration of burning of the 2 inches up to 13 seconds. It is intended for use with the 8-inch parachute only, but is available on an emergency for use with the 10″ parachute, and with all common shells.

Fuze, time, wood, parachute, 5½-inch.

12. *The fuze for 5½-inch Parachute light*[10] (pl. 38, figs. 20, 21), resembles the 8-inch parachute light fuzes in all particulars, except length, and the position of the top side hole, which reads 3·5 seconds; it contains only 1·5 inches of solid slow composition, and is available for

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[1] Pattern approved 2nd January 1866, *War Office Circular* 9 (new series), § 1199.

[2] See page 250.

[3] The fuze is not supposed to be required for a shorter time of burning than is due to 1·2 inches, and it is undesirable to place more holes higher up the fuze, because of the likelihood of the flash of the discharge communicating through the thin paper at these holes (which would be exposed above the socket) with the powder in the channels, and causing premature explosion; or, if premature explosions do not occur, there is a likelihood of ultimate failure on the part of the fuze, resulting from the escape of the flash at the exposed holes, instead of downwards into the shell, the resistance offered at these holes to such escape being less than that presented in a downward direction.

[4] See table XX., p. 345.

[5] Except the two bottom side holes, which, not requiring any boring, are not dotted.

[6] In the common fuze, only the side holes on the black are yellow. For the composition of the paint see table XX., p. 345.

[7] These fuzes are not available with the lower natures of parachute light, because the upper side holes would be exposed above the socket, and premature explosions might result.

[8] Approved 2nd January 1866, *War Office Circular* 9 (new series), § 1199. In the same year a further slight alteration was sanctioned in this fuze, viz., the employment of a slower composition and the consequent prolongation of the time of flight, for which the fuze is available.

[9] It is cut from the smaller end of the same cone.

[10] Approved 2nd January 1866, *War Office Circular* 9 (new series), § 1199. See note next but one above.

times of flight between 4 and 10 seconds (inclusive). This fuze is intended for use only with the $5\frac{1}{2}$-inch parachute light, but it can also be used with the 8″ parachute.[1]

Fuze, time, wood, Manby's shot.

13. *The fuze for Manby's shot*,[2] (pl. 25, figs. 3, 4, 5), is a frustum of a large mortar fuze cone taken at its thickest part,[3] and rather over three inches in length. The composition bore is concentric with the longer axis of the fuze, and is considerably larger in diameter than that of the mortar fuze,[4] in order to increase the quantity of burning composition and the illuminating power [5] of the fuze. The composition bore is lined with a hollow cylinder of rolled paper,[6] to prevent the fuze exploding on the principle of a tube, in the event of the wood shrinking away from the composition.[7] The composition bore is pressed[8] or driven[9] with 2·5 inches of solid fuze composition,[10] matched (pl. 25, fig 7), primed, bored into, and capped (pl. 25, fig. 8) like a large mortar fuze.

The Manby fuze contains no side holes or powder channels, not being intended to be prepared for any particular time of burning. The position of the first and second inches are indicated by rings cut round the fuze.

The fuze is painted drab[11] all over, except the cap, which is not painted; a black[12] ring is painted round the junction of the cap and fuze.

They are marked with the numeral, number of thousand, and month and year of issue in the usual way.

These fuzes are intended for use with Manby's 24-pr.[13] life saving apparatus at night.[14] They are placed in the holes prepared in the base of the shot, four fuzes in each shot, and being uncapped become ignited by the flash of the discharge, and serve to distinguish the path of the shot through the air, and indicate any error that there may be in "laying." Strictly speaking, therefore, they are rather lights than fuzes.

Packing and issue.

The Manby fuzes are issued in zinc cylinders, 16 in each, with a paper containing the following printed directions for use :—

"Fix the fuzes firmly in the shot with the mallet and setter. Remove
" the caps from the fuzes by giving the tape a sharp pull, when the
" shot is ready for firing.

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[1] The fuze is so short that the upper part of it is not thick enough to bite in the fuze hole of common and diaphragm shell, hence it could not be used with such shells.

[2] Present pattern (with paper lining) adopted 14th February 1864.—*War Office Circular* No. 1 (new series), par. 875 ; respecting adoption of original pattern, see p. 238.

[3] As nearly as possible ; the largest diameter of the mortar fuze is 1·565 inch, that of the Manby fuze 1·59 inch ; the development of cone of the two fuzes is the same.

[4] The bore of the mortar fuze is ·37 inch in diameter, that of Manby's fuze ·75 (measuring outside the paper lining), or ·6 inch (measuring inside paper lining).

[5] See p. 97 respecting the use and object of this fuze.

[6] 100 lb. paper.

[7] "I find, in consequence of the largeness of the bore for the composition of the " Manby fuze, the wood is liable to shrink, and thus cause the fuze to explode instead " of burning. To obviate this I propose to insert a paper lining similar to that used in " my naval time fuze."—*Letter from Colonel Boxer to Director of Ordnance*, 21 January 1864. This alteration was adopted 14th February 1864.—*War Office Circular*. No. 1 (new series), par. 875.

[8] By hydraulic pressure.

[9] See p. 251.

[10] See table XIX., 344.

[11] See table XX., 345.

[12] See table XX., 345.

[13] The 6-pr. Manby shot have no fuze holes.

[14] See p. 97.

"*Note.*—Care must be taken to protect the priming of the fuze from moisture."

The cylinders are closed and secured in the usual way; the band painted white, and the top painted white and stencilled black with the nature and number of fuze, number of thousand, month and year of issue.

Sometimes when demanded in larger quantities they are issued in packing cases, as many as demanded in each, the case being marked as above, with the addition of the packer's name.

These fuzes are also sometimes issued in rectangular boxes fitted up in the interior with holes or sockets for the reception of 16 fuzes, a mallet, and setter.

These boxes are painted a stone colour, and the lid secured with a hasp and padlock; there is also a cleat upon each end through which passes a rope becket for convenience of lifting. The box is stencilled on the lid in black with the nature and number of its contents.

Fuze, time, metal, white, for drill.

14. *The white metal Drill fuze*[1] is merely a $7\frac{1}{2}$ seconds fuze filled with clay instead of composition, and the body of the fuze tinned to distinguish it.

In other respects the two fuzes are identical. These fuzes are used, as their name implies, for drill purposes by the navy, the men being instructed by means of them in the manner of boring and preparing the service fuzes, without the chance of sprinkling grains of powder or bored-out composition about the decks.

Packing and issue.

White drill fuzes are issued in the same description of cases as the service metal time fuzes, the case being stencilled in black with the nature and number of fuze, date of issue, number of thousand, and packer's name.

Class 2.—Percussion and Concussion Fuzes.

A percussion or concussion fuze is one which is independent of the element of time of flight, and which depends wholly upon impact for its ultimate action.

Distinction between "percussion" and "concussion" fuzes.

The distinction between percussion and concussion fuzes was until 1863 altogether arbitrary, and the application of the terms depended upon the sense in which the inventor of any particular fuze chose to apply them.

Sometimes the name "percussion" has been restricted to such fuzes as contain a percussive or detonating arrangement, while those fuzes have been called "concussion" which are independent of any such arrangement;[2] in other cases the application of the terms seems to have

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[1] The name white metal fuzes for drill tends to mislead, as implying that the fuzes are made of "white metal" (*i.e.* lead and tin), whereas they are actually gun metal, tinned white.

[2] Sir Howard Douglas adopts this distinction. He says—"A concussion fuze is "provided with an internal mechanism, so nicely adjusted as to withstand the first "shock the shell receives, viz. that occasioned by the explosion of the charge, and "resist any other that may be occasioned by grazing short, while it shall yield to the "concussion occasioned by the impact of the shell on the body struck; this concus-"sion, by shaking the burning composition of the fuze into the wadded cavity of the "shell, instantly causes the latter to explode. A 'percussion' fuze or shell is one "fitted or filled with a chemical composition of highly explosive character, which "bursts the shell at the moment of striking, without being previously ignited."—*Naval Gunnery*, p. 282, note.

been rather a matter of accident than founded upon any accurate or well considered distinction.[1]

Perhaps the best distinction which could be drawn, looking to the natural meaning and application of the words,[2] would be to call those fuzes which depend *upon the direct impact* of the fuze "percussion," and those which do not require for their action such direct impact, but merely the concussion resulting from the impact of the shell, "concussion" fuzes.

The adoption of this definition, however, would have the effect of altering the nomenclature of all the fuzes of this class, whether rifle or smooth bore, at present in the service, to concussion, since there is no existing fuze which depends upon *direct impact* for its action.[3]

In 1863 [4] a definition was suggested by the Ordnance Select Committee and adopted to govern the future application of the words percussion and concussion.

This definition is as follows:—"A percussion fuze is one which is "prepared to act by the shock of discharge, but put in action by the "second shock on striking the object. A concussion fuze is one which "is put in action by the shock of discharge, but the effect of that action "is restrained until it strikes the object."[5]

Under this definition all existing fuzes become percussion,[6] and the only fuze, now no longer in the service, which fulfils the requirements of a concussion fuze is Freeburn's,[7] on which, indeed, it is probable this definition, by an inductive process was based.

There are at present three percussion fuzes for smooth-bore ordnance.

1. Pettman's land service percussion fuze.
2. " sea " "
3. " general service "

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[1] A good instance of this is afforded in the naming of two of the Armstrong fuzes; one, the iron fuze, which was in use until 1862, was called a "concussion" fuze; while the C pattern fuze, by which it was superseded, and which depended upon identically the same principles of action, was called a "percussion" fuze; indeed, the C pattern percussion fuze was itself on its first introduction called a concussion fuze.

[2] "*Percussion*, the act of striking one body against another."—*Imperial Dictionary.*
"*Percussion*, a striking, a shock."—*Webster's Dictionary.*
"*Percutio*, to strike, to hit, &c. &c."—*Ainsworth's Latin and English Dictionary.*
"*Concussion*, Latin, concussio, from concutio, to shake, from con and quatio, quasso, "to shake or shatter."—*Imperial Dictionary.*
"*Concussion*, a shaking."—*Webster's Dictionary.*
"*Concutio*, to shake, to jog, &c. &c."—*Ainsworth's Latin and English Dictionary.*
The meaning of the two words broadly expressed and for the practical purpose now under consideration may then be taken as follows:—Percussion, a striking, concussion, a shaking.

[3] With the exception of the Boxer 2-inch time fuze for rifled ordnance, which however is generally spoken of as a time fuze, its employment as a percussion fuze being to a certain extent exceptional. However, when used as a percussion fuze this fuze does depend upon direct impact; it must be actually struck and driven into the shell. The term percussion would therefore be rightly applied to it under the definitions suggested.

The percussion fuzes for rifled ordnance, C. Patt, Dyer's, Freeth's, and the Pillar, depend also, it is true, upon the shell striking head foremost, or nearly so, but not upon the actual striking of the fuze.

[4] 16th January 1863.—*War Office Circular* 822, par. 725.

[5] *Ibid.*

[6] It is a question whether the Boxer 2-inch time fuze for rifled ordnance when used to act on impact should not under this definition be called a concussion fuze, since it is put into action by the shock of discharge in the same sense as Freeburn's fuze, while the object of that action is restrained until the object is struck.

[7] See preceding note.

1. *Pettman's land service Percussion fuze* [1] (pl. 7) consists of seven principal parts, viz. :—

The Body (figs. 1, 15, 16).
The Top Plug (figs. 2, 3).
The Bottom Plug (figs. 13, 14).
The Lead Cup (figs. 11, 12).
The Cone Plug (figs. 9, 10).
The Detonating Ball (figs. 6, 7, 8).
The Steady Plug (figs. 4, 5).

The Body (pl. 7, figs. 1, 15, 16) is made of gun metal.[2] It is 2″ in extreme length, and is conical [3] in form, and screwed to fit the fuze holes of common shells.[4] Above the screwed part is a plain projecting shoulder upon which the fuze rests when screwed home, and upon the top of this shoulder are four wrench holes equidistant from one another, by means of which the fuze is screwed into or removed from the shell.

The body is hollow from end to end, being tapped [5] at top and bottom to receive the top and bottom plugs. The interior is otherwise plain and cylindrical, with the exception of a slight rounding inwards immediately above the bottom plug.

The Top Plug (pl. 7, figs. 2, 3) is a cylinder of the same alloy as the body [6] screwed to fit the upper end of the fuze ; on its upper side is a square key-hole by which it is screwed into the body, or removed for the purpose of inspection or repair.[7] This plug closes the top of the fuze.

The Bottom Plug (pl. 7, figs. 13, 14) is a cylinder of the same alloy as the body,[8] screwed to fit the lower end of the fuze. On its upper side it has a small projecting stud, and on its under side a small cut, by means of which it is screwed into the body.

This plug is perforated with two holes, one vertical through its longer axis, which serves as a fire-hole through which the flash of the exploded detonating composition communicates with the bursting charge, the other horizontal and intended for the reception of a strand of quick-match to prevent the powder dust from the bursting charge working into and choking the fuze.[9]

The Lead Cup (pl. 7, figs. 11, 12) is a hollow cylinder of pure [10] lead completely open at the bottom, but having merely a small hole at the top. This cup rests upon the bottom plug, the lower part of it adapting

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[1] Adopted 30th October 1861, *War Office Circular* 739, par. 414.

[2] The same "gun-metal" as is employed for the 7½ and 20 seconds time fuze, see p. 258, note 7.

[3] The common fuze hole taper 1 in 9·375. The extreme lower end of the fuze is slightly, almost imperceptibly, rounded.

[4] The thread is right-handed, and 14 to the inch; see p. 25, note 11, respecting the alteration which is necessary in such common shells as have not got a cross upon the plug to enable them to receive these fuzes, and p. 308 respecting the special set of implements issued for this purpose.

[5] Right-handed, 20 threads to the inch.

[6] See note 2 above.

[7] It is an advantage of these fuzes that they admit of ready inspection and repair of the interior arrangement when required.

[8] See note 2 above.

[9] See p. 248, where this point is explained.

[10] The purity of the lead is a very important point, the strength of the cup being calculated upon the assumption that the lead employed is perfectly pure. Any admixture which may tend to increase the strength of the lead cup would tend to diminish the certainty of action of the fuze with low charges ; on the other hand, any decrease in its strength would render the fuze more liable to accidental premature explosion. The cup should weigh between 175 and 185 grains.

itself to the rounded form of the interior of the lower part of the body, and thus surrounding, though not touching, the stud of the bottom plug.

The Cone Plug (pl. 7, figs. 9, 10) is made of rather a harder alloy than the body of the fuze,[1] for a reason which will presently appear.[2]

It is called the "cone" plug from the top edge being bevelled, which gives the upper part of the plug a conical form, otherwise it is a plain cylinder which exactly fits the interior of the body.

From the lower side of the plug projects a stud similar to that upon the bottom plug, and the plug is perforated vertically with a fire-hole.

The cone plug rests upon the lead cup, its stud entering the small hole in the top of the cup.

The Detonating Ball (pl. 7, figs. 6, 7, 8) is a solid sphere of the same alloy as the cone plug;[3] it is roughed or "milled" over its surface, and a groove is cut round its horizontal circumference for the double purpose of allowing a greater quantity of detonating composition to be placed upon the ball, and of giving that composition a better hold.

At the extremities of the vertical axis of the ball are two projections, the lower one is conical, the upper cylindrical, with a small shoulder round its base.

Round the neck of each projection is a small groove. The ball is plastered over its whole surface up to, but not in, the grooves at the neck of each projection with the following detonating composition:—

Potash, chlorate of[4] - - -	6 oz.
Sulphide antimony[5] - - -	6 oz.
Sulphur, sublimed[6] - - -	$\frac{1}{2}$ oz.
Powder, mealed, L. G.[7] - - -	$\frac{1}{2}$ oz.

Damped into a paste with spirits, methylated, one quart; shellac, 112 grains, in the proportion of 40 minims of the varnish to 100 grains of composition.

The composition is covered with fine gut,[8] tied on with silk cord and varnished,[9] and afterwards with thin silk[10] similarly secured and varnished.

These coverings of gut, silk, and varnish not only diminish the sensibility of the ball to the point requisite to secure it against premature explosions,[11] but they also effectually protect the detonating composition from damp.[12]

The ball rests with its lower or conical projection in the fire-hole of the cone plug, the upper or cylindrical projection entering a hole in the steady plug.

The Steady Plug (pl. 7, figs. 4, 5) is a cylindrical plug of the seam alloy as the ball and cone plug,[13] exactly fitting the interior of the fuze. A hole is drilled through the vertical axis of the plug, not to serve as a

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[1] The alloy is copper seven parts, tin one part, or, expressed decimally, copper 87·5, tin 12·5 per cent. [2] See p. 276.

[3] See note 1 above. The exact weight of the ball is also of importance, see p. 275, note 9. It should weigh between 125 and 140 grains, or covered, 134 to 146.

[4] See p. 315. [5] See p. 311.

[6] See p. 318. [7] See p. 138.

[8] Sheep's gut. [9] For varnish, see table XX., p. 345.

[10] Sarsenet.

[11] Such as might result from the friction of the ball, if the composition were naked, against the inside of the fuze during the flight of the shell.

[12] Pettman's fuzes are therefore little, if at all, sensible to the effects of damp, as, independently of the protection afforded by the covering of the ball, the fuze itself is securely closed, and the ball, the only part liable to deterioration, is thus doubly protected.

[13] See note 1 above.

fire-hole, but for the admission of the upper projection of the ball. The top side of the plug is slightly hollowed out.[1]

The steady plug occupies a position in the fuze immediately underneath the top plug and immediately over the ball.

When the fuze has been placed together, with the several plugs and parts occupying the positions described, the key-hole in the top plug and the cross cut in the bottom plug are filled with shellac putty, and discs of fine paper[2] are secured over the top and bottom of the fuze[3] with shellac varnish, the better and more completely to exclude moisture.

A leather collar[4] is secured[5] by shellac varnish to the under part of the shoulder of the fuze.

The numeral number of thousand of the fuze and the year and month of issue are stamped on the top of the fuze[6] between the wrench holes. The whole of the exterior of the fuze is lacquered[7] to prevent corrosion.

These fuzes require no preparation. Their action is as follows :— Action
The shock of the discharge crushes up the lead cup,[8] a result which is due partly to its own inertia, and partly to that of the cone plug, ball, and steady plug which rest upon it.[9]

The position of the movable parts of the fuze, *i.e.*, cone plug, ball, and steady plug is thus shifted to one nearer the bottom of the fuze by so much as the lead cup has flattened, and all reaction is checked by the cup flattening round the studs of the bottom and cone plugs, these parts being thus securely riveted, as it were, to the bottom of the fuze.

The great use of the steady plug will now appear. It serves, as its name implies, to *steady* the ball at the moment of the shock of discharge; in its absence the ball, being unsupported at the top, would fall, on the flattening of the lead cup, on to its side, and in proportion to the violence with which the detonating compostion would thus be brought into contact with the sides of the fuze so would premature explosions more or less certainly result.[10]

After the shock of discharge the steady plug is of no further use, the rotation or movement of the shell in the bore disengages it from the

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[1] The only object of this hollowing out is to remove the " burr " which is necessarily thrown up by the drilling of the hole, and which would prevent the steady and top plugs from coming into close contact.

[2] Tracing paper.

[3] Over the whole of each end; the paper is subsequently broken at the four wrench holes.

[4] The same collar as is used for common plugs, see p. 105. See also same page on the subject of these collars having been originally made of gutta percha.

[5] See p. 260, note 8.

[6] The Pettman's fuzes were always stamped with the number of thousand, this mark therefore indicates the actual number made up to a particular date, whereas, as explained at p. 254, note 1, the stamping with the number of thousand of the majority of fuzes was not adopted until 1864. The system of stamping these fuzes with the *date* (in addition to the number of thousand) was not adopted until that year.

[7] For composition of lacquer see table XX., p. 345.

[8] See what has been said, p. 273, note 10, respecting the importance of the cups being of one uniform strength, otherwise the required action may not take place.

[9] The importance of keeping the ball within strict limits as to weight will now be apparent, for evidently any increase in its weight will tend to cause the crushing of the lead cup under lighter shocks than that of the discharge of the gun, and will tend therefore to make the fuze less safe, while any decrease in its weight entails the possibility of the non-crushing of the lead cup and the consequent non-action of the fuze under low charges.

[10] It must be remembered that the position of the fuze in the gun is with its longer axis not as it has been placed throughout the above description, vertical, but horizontal, there would thus be no chance of the ball balancing itself on the cone plug in the absence of the steady plug. It would inevitably fall on to the side of the fuze.

ball[1] which rests during the flight of the shell within the chamber of the fuze.

On the shell striking an object the ball is thrown forward with a force proportional to the momentum of the shell and the violence of the shock; the detonating composition being thus brought into violent contact with some part of the interior of the fuze is exploded, and the flame passes through the fire-holes in the cone and bottom plugs into the shell.

One or two points which do not properly connect themselves with a description of the construction or directly with the action of the fuze require explanation.

It has been explained that the studs on the cone and bottom plugs serve to prevent reaction, they also serve by their form to prevent the lead cup from flattening over the fire-holes, which would thus be closed and all communication between the interior of the fuze and shell cut off.

The reason for making the ball, cone, and steady plugs of a harder alloy than the rest of the fuze is as follows :—In the case of the ball, if the projections are not made of a certain strength, they would yield under the shock of a heavy discharge, and premature explosion would result. The required strength can only be given by increasing the size of the projectiles or by making them of a stronger material. To increase the size would increase what may be considered as the dead points or "points of impact" of the ball,[2] and the other alternative, that of making the projections and consequently the whole ball of a harder alloy, was therefore adopted.

As regards the cone and steady plugs, these, if made of a soft material, would be liable to yield under a heavy shock, and they are therefore brought to the requisite strength by employing a harder alloy.

The shape of the projections on the ball is regulated by the following considerations :—It is desirable that it should be such as to permit of the ball readily freeing itself, due regard being paid to the support of the ball between the plugs. Now, in the case of the lower projection, the present conical form is that which permits most readily of the liberation of the ball, and at the same time affords a sufficient hold ; in the case of the upper projection however more hold is requisite, or the ball might become freed from the steady plug under the shock of discharge, whence premature explosions might result; this projection is therefore made cylindrical.

Pettman's L. S. fuzes can be used for all those common shells *which have a cross cut upon the plug.*[3]

Packing and issue.

Pettman's L.S. fuzes are issued each fuze wrapped in brown paper and 135 in a deal packing case. On the top of the case are stencilled in black the nature and number of fuze and date of issue, on the bottom the number of thousand, and on the side the words "Not to be placed "in the magazine on any pretence whatever."[4]

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[1] See p. 278, note 8, respecting the non-employment of those fuzes with breech-loading rifled shells.

[2] Since, being uncovered with detonating composition, no action could result from the impact of one of these projections on the inside of the fuze.

[3] All common shells are now prepared to receive Pettman's fuze, but the existing stores of common shells which have not the cross cut upon the plug, and which consequently will not receive the fuzes, may not yet be extinct at out-stations. Respecting the preparation which such shells would require to adapt them for the fuzes, see p. 25, and p. 308, respecting the special sets of implements requisite for the operation.

[4] This restriction is applied to all stores containing detonating composition.

2. *Pettman's Sea service percussion fuze* (pl. 13)[1] differs from the L.S. Pettman fuze principally in an arrangement by which the sensitiveness of the fuze is so exactly regulated as to bring it within the limits prescribed for naval service, viz., that the fuze shall not explode when striking water with a high velocity, while it shall explode on striking a ship's side, or similar hard substance, with a low velocity.[2]

Fuze, percussion, Pettma sea service.

This arrangement consists, 1st, in placing immediately over the detonating composition on the ball (pl. 13, figs. 6 and 7) two hemispherical cups of thin sheet copper (pl. 13, figs. 8 and 9),[3] the thickness of which has been exactly calculated with reference to the degree of sensitiveness required.

The junction of the two cups round the horizontal circumference of the ball[4] is covered with a strip of tissue paper varnished on; and afterwards the ball receives the usual coverings of gut, silk, and varnish.[5]

2nd, the interior of the fuze is enlarged about the centre (pl. 13, fig. 1), so as to make the blow which the ball strikes on impact equal in every direction.[6]

Pettman's sea service fuze differs from the land service in a few other details of construction. It has no bottom plug, the bottom of the fuze being solid with the exception of a fire hole in the centre, which is closed with a disc of cardboard (pl. 13, figs. 18, 19, 23), over which is varnished a disc of fine paper.[7]

The cone plug (pl. 13, figs. 11, 12) is of an improved construction, the stud being prolonged downwards in the form of a hollow cylinder, which is driven and pierced like a tube,[8] the lower end being closed with a cardboard disc (pl. 13, figs. 16, 17, 23).[9] This construction, and the absence of a bottom plug stud, necessitates a different arrangement for checking re-action. The lower part of the interior of the fuze is hol-

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1 Approved 2nd August 1862, *War Office Circular* 793, para. 610.

2 It is sometimes considered that the sensitiveness of the sea service fuze is less than that of the land service fuze; this, however, can hardly be said to be the case; indeed, where the direction of striking is sideways, the sea service fuze is probably (owing to the enlargement of the interior) the more sensitive of the two. But the difference consists, as stated in the text, in the sensitiveness of the sea service fuze *being exactly regulated and brought within certain limits*, whereas the sensitiveness of the L.S. fuze is not so regulated or considered.

3 The copper is rolled down to ·008." The weight of these cups is limited to from $5\frac{1}{2}$ to $6\frac{1}{2}$ grs. each. It is evident that any increase in thickness will tend to render the fuze less liable to act on striking a ship's side, while any decrease in thickness will tend to make it more liable to explode on striking water, and as the limits are very restricted, great delicacy and exactness is necessary in the manufacture of these cups.

4 In some early experiments the junction was placed round the vertical circumference, but premature explosions resulted. This was believed to proceed from the partial separation of the cups on the shock of discharge, and the scraping downwards of the cups over the detonating composition. The ball of the S.S. fuze is the same size as that of the L.S. fuze, viz., from 125 to 140 grs. uncovered, and 148 to 160 grains covered; the groove of the S.S. ball is cut *not* round its circumference, but rather nearer one end of the ball, in order to avoid having the groove at the junction of the cups.

5 See table XX., p. 345.

6 This is an important point where the sensitiveness of the fuze has to be exactly regulated, since, evidently, however accurately that sensitiveness might be regulated for the fall of the ball with the fuze end on, if that fall were not exactly the same when the fuze struck sideways, the sensitiveness would be proportionally affected under such conditions of striking. In the L.S. fuze, where the exact degree of sensitiveness is not considered, such an arrangement is, of course, unnecessary.

7 Tracing paper.

8 See p. 202.

9 This disc serves the purpose of the quick-match in the L.S. fuze, after the gun is fired, viz., prevents the powder dust from working into the fuze.

lowed out or undercut, and the lead cup (pl. 13, figs. 13, 14) crushing outwards into this groove is securely held, and the upper part of it having contracted round the stud of the cone plug, re-action is prevented.

The lead cup in the S.S. fuze is made of a size and weight[1] to allow of the fuze acting with a very reduced charge.

Externally the sea service fuze differs in being larger, and screwed to fit the fuze holes of naval shells.[2]

The thread, instead of being carried down the whole length of the fuze, only extends three-quarters of an inch below the shoulder.

The wrench holes in the sea service fuze are further apart than in the land service fuze, being adapted to the naval wrench.

In other respects the Pettman's sea and land service fuzes are the same.

The sea service fuze is also similarly marked with the numeral number of thousand and month and year of issue,[3] and lacquered.[4]

Action.

The action of the two fuzes is the same, with the exception that in the sea service fuze, on the crushing of the lead cup the tube of the cone plug is shot forth beyond the bottom of the fuze, forcing out the card-board disc by which the fire hole is closed.[5] On the impact of the fuze against a hard substance,[6] the ball is exploded and the flame flashed through the tube into the shell.

Packing and issue.

These fuzes are used with naval spherical shells not provided with the general service fuze hole or adapter. They are available for use with muzzle-loading rifled shells,[7] but they will gradually be superseded for all services by the Pettman's general service fuze.[8]

These fuzes are issued like the L.S. fuzes, *i.e.*, wrapped in brown paper, packed 84 in deal cases; marked in red with the nature and number of fuze, date of issue; on the bottom with the number of thousand, and on the side with the words "Not to be placed in the magazine "on any pretence whatever." The larger proportion are issued to ships screwed into filled shell.

Fuzes, percussion, Pettman's general service.

3. *Pettman's General Service Percussion Fuze*[9] (pl. 44) differs from his land and sea service fuzes, mainly in an arrangement for ensuring the action of the fuze in rifled shell. It has been explained[10] that

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1 The limits are from 175 to 185 grains.

2 The thread is therefore right-handed, 16½ to the inch; and the "Moorsom gauge;" or the same as that of the 7½ and 20 seconds fuzes. See p. 259.

3 See p. 254.

4 See Table XX., p. 345.

5 The entrance of powder dust is now prevented by the cardboard disc in the tube. See p. 273.

6 See p. 277 respecting those fuzes not acting on water.

7 See latter part of following note.

8 Approved for use with M.L. rifled guns, "pending a decision as to the fuzes to be "finally adopted," 11th August 1865, *War Office Circular* 7 (new series), para. 1117. The subsequent adoption (19th May 1866, *War Office Circular* 10 (new series), § 1235) of Pettman's general service fuze practically withdrew these fuzes from use with M.L. rifled shell, for which, however, it should be noticed, they would be available on an emergency. By degrees, as stated in the text, they will be withdrawn from use for all shell, the general service fuze taking their place.

They were not recommended for use with Sir W. Armstrong's B.L. guns, because, owing to the ball lying in the axis of rotation, and to the absence of any lateral movement of the shell in the bore—any lateral concussion—it has been supposed that the steady plug and ball could not be depended upon to disengage. Sufficient experiments, however, have not been made to determine this point with any certainty, and indeed it seems probable, looking to the results of such experiments as have been made, that *in practice* the fuzes would act in B.L. rifled shells in a greater majority of cases than theoretically might have been expected.

9 Approved 16th May 1866, *War Office Circular* 10 (new series), § 1235.

10 See note 8, above.

although the sea service Pettman's fuze is available with muzzle-loading rifle shell, it cannot be depended upon to act in breech-loading rifle shell, because, owing to the ball lying in the axis of rotation, and to the absence of any lateral movement of the shell in the bore—any lateral concussion—the steady plug and ball cannot always be depended upon to disengage. The same limitation applies to the use of the L.S. fuze.

The arrangement by which the action is ensured in the general service fuze is as follows : The upper side of the steady plug and the lower side of the top plug are cupped out in the centre, (pl. 44, figs. 6 and 3) to receive a small plain ball[1] (pl. 44, fig. 4), which when situated in the cups keeps the plugs a short distance apart (pl. 44, fig. 22). The cups are made slightly larger in diameter than the ball, to diminish the liability to the latter adhering to either plug from corrosion or other cause. The ball thus touches each cup only at one point.

On the upper side of the steady plug is cut an annular groove or recess (pl. 44, fig. 5) into which is pressed detonating composition.[2] To give the composition a more secure hold the bottom of the annular recess is roughed by a number of small grooves formed in it. Over the top of the detonating composition is fixed a thin copper washer[3] sufficiently strong to prevent action taking place on the shell striking water with a high velocity, although not strong enough to interfere with the proper action of the fuze when the shell strikes a ship's side or similar hard substance with a low velocity.

Two conical fire holes pass vertically through the steady plug from the detonating composition.

The other points in which the construction of this fuze differs conspicuously from that of the other Pettman fuzes, are,—

1st. The cone plug, which is no longer coned at the top although it retains the name, has in addition to the central fire hole, two inclined fire holes passing into the tube. Its composition is otherwise the same as that of the sea service fuze.

2nd. The parts of the fuze are supported not by a lead cup, but by a copper "suspending wire"[4] which passes through the tube of the cone plug and rests upon the bottom of the fuze. No action can take place until the wire is broken. The support afforded by the wire is not ultimately greater than that which is afforded by the lead cup in the other fuzes, that is to say, no greater shock is required to shear it than is required to crush the lead cup, but the wire not being affected by the small shocks to which a fuze is subject in transport is, on the whole. more reliable than a lead cup, which being neither rigid or elastic yields little by little to a succession of such small shocks, sufficiently in the end to deprive the parts of the fuze of the necessary support.

The lower part of the central hole of the tube is enlarged sufficiently to prevent it from being closed by the suspending wire. Above the wire the hole is contracted.[5]

3rd. The support of the parts of the fuze being dependent upon the suspending wire, the lead cup which the fuze contains performs only

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[1] 70 parts copper, 30 zinc.

[2] The same detonating composition as is used for covering the balls in the land and sea service fuzes, see page 274, and table XIX., p. 344. The composition, however, is pressed dry into the plug.

[3] The copper is ·008″ thick.

[4] The wire is ·087″ thick.

[5] See page 203, respecting advantages of a small hole in a tube.

the secondary function of the same cup in the other fuzes, viz., to rivet down the cone plug and prevent re-action.[1]

4th. Externally, the general service fuze is conical without any projecting shoulder (see pl. 44, fig. 21). It is screwed to the general service fuze hole gauge[2] all the way down.

Two slots are cut in the top of the body to serve as key holes. The "key iron fuze and plug, general service"[3] is used with these fuzes.

In other respects the construction of the general service fuze is similar to that of Pettman's sea service fuze, the arrangements which have been adopted in the latter fuze for bringing the sensitiveness of the fuze within the exact limits prescribed for naval service[4] being embodied in the general service fuze. The fuze has thus the enlarged chamber, and the copper discs over the ball;[5] it has also the solid base with fire hole closed with a card board disc, and the groove round the lower part of the body for the lead cup to expand into and fix itself.

The general service fuze is stamped on the top with the numeral number of thousand and month and year of issue and is lacquered.[6]

Action

The action of the fuze fired in a spherical shell is under all circumstances the same as that of the other Pettman fuzes, except that the shock of discharge has to shear the suspending wire instead of merely crushing a lead cup.

But under the condition, which may arise in a B.L. rifle shell,[7] of the detonating ball not becoming disengaged from its supports, the special arrangement in the head of the fuze becomes *indispensable* to its action.

Under these circumstances what happens is as follows:—The plain ball having by the descent of the steady plug on the shock of discharge become thrown out of its cup supports, it occupies during the flight of the shell a position between the top and steady plugs immediately over the detonating composition of the latter. On the impact of the shell end on, the steady plug is thrown violently forward against the plain ball, the blow sufficing to explode the detonating composition in the plug, the flash from which passes through the fire holes in the steady plug to the detonating ball, or directly to the cone plug,[8] under all circumstances, however, the arrangement in the head gives an additional point of certainty to the fuze.

The general service fuze is intended for use with all naval spherical shell and M.L. or B.L. rifled shell having the general service fuze hole

[1] The form and size of the cup are slightly different from those of the land and sea service cups, it weighs from 102 to 114 grains. The considerations as to the purity of lead and the precise limits of weight of the cup, which as explained in page 273, note 10, apply to the cups of the other fuzes scarcely apply to this one, at least not to the same extent. They are, however, properly observed.

[2] 14 threads to the inch, right handed, cone increasing 1 in 9·375. The size of the frustrum is 1·95″ in length. 1·006″ in diameter at small end, 1·213″ at large end.

[3] See page 307.

[4] See page 277 for a definition of those limits.

[5] The ball is the same as that of the other Pettman fuzes, see page 277, note 4 In manufacture somewhat closer limits are observed, the limits of weight of the uncovered ball being 130 to 140 grains, instead of from 125 to 140 grains as laid down for the other fuzes. The weight of the ball covered is the same as that of the sea service fuze, viz., from 148 to 160 grains.

[6] See Table XX., page 345.

[7] See page 278, note 8. In those B.L. shells in which a lateral concussion does ake place, the condition defined in the text could not arise.

[8] Action will ensue whether the detonating ball is ignited by the flash from the steady plug or not.
The inclined fire holes in the cone plug by providing a passage for the latter, makes the ignition altogether independent of the detonating ball.

or adapter,[1] and when a sufficient number of fuzes and adapters are made it will entirely supersede the sea service Pettman fuze.[2]

These fuzes are issued wrapped each fuze in brown paper and packed 162 in a deal case, marked in black, with the nature and number of fuze, date of issue, on the bottom with the number of thousand, and on the side with the words "not to be placed in the magazine on any pretence whatever." Packing and issue.

CLASS 3.—MINING FUZES.

There are three different fuzes specially intended for mining purposes, viz. :—

1. Bickford's patent safety fuze.
2. Ord's mining fuze.
3. Abel's Electric fuze (pl. 5).

1. *Bickford's patent*[3] *fuzes* are all made of flax with a column of fine gunpowder in the centre.[4] They differ, however, in the nature and amount of protection which is afforded to the flax and powder by varnish, or coatings of various materials. Fuze, safety, Bickford's patent.

There are in all 10 different varieties of this fuze,[5] as follows :

No. 1 Common safety fuze.[6]—The flax is not protected in any way, and this fuze is accordingly " only adapted for immediate use in dry " ground, where the utmost care is taken in its application, and where " the tamping is of a soft and homogeneous character, and is cautiously " packed into the hole. In such circumstances it may be usefully " employed." Natures.

No. 2 Patent safety fuze.—The flax is protected by a coating of tar, and the fuze " is adapted for all blasting in dry ground, being made with " an ample quantity of the best materials. When kept at a moderate " temperature and carefully used, its certain operation is warranted."

No. 2* Patent safety fuze " is the same fuze as the preceding, and is " only adapted to the same kind of blasting, but is specially varnished " for any given climate. That varnish which is suitable for a cold " country becomes soft and sticky if exposed to much heat ; while that " which is suitable for a hot country becomes hard and brittle if exposed " to great cold. This inconvenience is remedied as much as possible by " the special preparation of the varnish to suit any given temperature " and which should be specified in the order."

No. 3 Patent white fuze is covered with a patented composition of whiting, china, clay, and glue. "This fuze is adapted for use in dry " ground and in close places, where there is a deficiency of pure air, or " where the smoke occasioned by the burning of the common kinds of " fuzes is found to be inconvenient. Little or no smoke is emitted by

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[1] See page 109, for adapters for naval spherical shell.

[2] See on the subject of the introduction of the fuze and the gradual supersession of the S.S. fuze, *War Office Letter*, 5th July 1866, 75/12/2852, and *War Office Circular* 10 (new series) §§ 1235, 1238.

[3] Patented by " William Bickford, of Tucking Mill, in the county of Cornwall, " leather seller," 1831. *Specification* No. 6159. This fuze is supplied by contract ; and, strictly speaking, cannot be considered a Laboratory store. It is generally inspected by the Royal Engineers or Works Departments.

[4] See description of the fuze given in *War Office Circular* 406. The specification says: "Flax, hemp, or cotton, or any other suitable materials, spun, twisted, and " countered, and otherwise twisted in the manner of twine spinning and cord " making."

[5] It is particularly enjoined (*War Office Circular* 406) that care be taken " to " demand the particular kind of fuze suited to the required purpose."

Messrs. Bickford manufacture 25 different descriptions of these fuzes (see Appendix M.), but only 10 different descriptions are recognized in *War Office Circular* 406.

[6] The description of these fuzes is mainly taken from one given in *War Office Circular* 406.

" its combustion. It is more likely to be injured by damp than the tar
" varnished fuze."

No. 4 Patent thread sump fuze " has a larger and stronger coating of " yarn and varnish." " It is adapted for use in damp ground, and is so " prepared as to resist the action of any moderate degree of humidity, " and will bear rougher treatment, both before it is used and during the " process of tamping, than the preceding kinds. It is strongly recom- " mended where the careful management of the operatives cannot be " relied on."

No. 5 Patent taped sump fuze is covered with varnished tape, twisted round the fuze over the tar. It " is adapted for use in wet ground, and " is specially protected, so as to operate efficiently even when the tamping " is saturated with water. In such cases the charge of gunpowder should " be placed in a cartridge, the end of the fuze should be inserted into " the centre of the charge, and the junction of the fuze with the car- " tridge should be properly protected with a waterproof varnish. If " employed in this manner, its certain operation is warranted."

No. 6 Patent double-taped sump fuze " is covered with a second coating " of tape and varnish, and is intended for blasting in very wet ground. " It bears just the same relation to No. 5 as No. 4 does to No. 2."

No. 7 Patent gutta-percha fuze is covered with gutta-percha, and " is " adapted to sub-aqueous blasting, where it is not liable to much motion " from waves or currents, nor subjected to much pressure. It has " answered its intended purpose after it has been under water for 24 " hours with a pressure of 40 lbs. to the inch : this is equivalent to the " weight of water at the depth of 88 feet."

No. 8 Patent double gutta-percha fuze " is superior to No. 7, being " protected and strengthened by an additional coating of gutta-percha. " It will act in a greater depth of water, and will bear a greater strain " than the preceding. It burns freely after being 24 hours under water " with a pressure of 140 lbs. to the inch : this is equivalent to the weight " of water at the depth of 300 feet."

No. 9 Patent taped gutta-percha fuze.—" This is the same fuze as " No. 7, and is adapted to the same use and duty ; but, having an ex- " terior coating of tape and varnish which delays the oxidation of the " gutta-percha, it retains its efficiency for a much longer time. It is " therefore well adapted for service in distant countries."

The descriptions of fuzes most generally used in the service are—

2*, or " dry soil fuze."
5, or " wet soil fuze."
7, 8, 9 } or " water fuze."

Use and application.

These fuzes all burn at a rate of *about* one yard in 70 seconds.[1]

Bickford's fuzes are used for military, mining, and blasting purposes generally.[2]

[1] They are, however, uncertain in their rate of burning, to what extent is indicated by the following order upon the subject. "Perfect uniformity in the rate of burning of " Bickford's fuze is not considered necessary ; when, however, the rate of burning is " so rapid as not to leave sufficient time for the men to get out of the way of danger, " or so slow as to occasion explosions long after such may reasonably be expected, " the fuze should be condemned, and fact reported to War Office."—*Order*, 30/11/63. 57/Gen. No./1274. and 57/Gibraltar/1274. The contracts for supply of these fuzes specify the following limits of burning :—Maximum rate of burning to be 6 minutes per length of 24 feet, or 45 seconds per yard. Minimum rate or burning, 10 minutes per length of 24 feet, or 75 seconds per yard ; and the contents of each cask are to burn within 5 seconds per yard, or 40 seconds per length of 24 feet, of a rate to be marked upon it by the manufacturers.

[2] Some experiments with these fuzes, and the efficiency of the " water " fuze, as No. 9 is called, is established, in *Experiments in H. M. S. "Excellent,"* pp. 67–74.

"In all sub-aqueous operations, great care must be taken that the "union of the fuze and cartridge be by a perfectly water-tight joint, and "the fuze must be strengthened as much as possible both at and near the "place of junction, else its swaying to and fro is very likely to break the "joint, which would allow the water to soak into the charge."[1]

The following directions for using Bickford's fuze are placed upon each case or cylinder containing it:

"When the fuze is required to be used in long lengths for blasting "under water, in order that the fuze be kept straight, the manufac-"turers recommend that it be fastened to a rope by strings, from two to "three feet apart; and should the current of water be strong, that a "weight be attached to the bottom end of the rope, near the surface of "the hole to be blasted.

"Before the fuze is inserted into the charge or cartridge, the ends of "it should either be opened about an inch in length, or cut in an oblique "manner, just as a quill is cut in making a pen, and one of the ends so "cut, placed about 2 inches from the bottom of the charge, this will "cause the powder to ignite more readily. The cartridge may be con-"fined in the hole by means of sand, coal, soft stone, or oakum, carefully "rammed down with an iron bar."

A proportion of Bickford's fuzes, No. 9, is always issued for boat service; and they are otherwise supplied as demanded. They form part of Engineer equipments; and have also been used for firing doubtful "rockets."[2]

Bickford's fuzes are generally issued in tin cases.[3]

Packing and issue.

The following instructions respecting the storing and care of these fuzes may be useful:

Instructions for care of Bickford's fuze.

If the first seven kinds of fuze[4] "be kept in a dry room, so that the "powder be not affected by damp, they will retain their efficiency until "the varnish has lost its essential oil and become dust. Care must be "taken that these fuzes be not touched with any greasy or oily matter, "as it rapidly penetrates through the varnish to the gunpowder, and "prevents the proper burning of the fuze.

"If through exposure to cold the tar varnish should become brittle "and crack, so that there is a danger of the column of gunpowder in the "centre of the fuze becoming damped in the hole, it may be remedied by "*very slightly* greasing the varnish of the fuze *immediately* before it is "used; and if through exposure to heat it should become soft and sticky "to the touch, this may be obviated by rubbing into it a little whiting "or any other such like powder.

"If the gutta-percha fuzes be kept in a dry room, so that the gun-"powder cannot become damp, they will retain their efficiency as long "as the gutta-percha does not become brittle by its oxidation."[5]

Fuze, mining, Ord's.

2. *Ord's Mining Fuze*[6] consists of a strand of quick-match, inserted in a case or tube a quarter of an inch in diameter, and of an indefinite length[7] of paper[8] and calico cemented together[9] with india-rubber solution;[10] the joints being fastened with the same cement, so as to render it water-

[1] *War Office Circular*, 406.

[2] The Bickford fuze was adapted by Quartermaster Behenna for this purpose, but is now no longer so employed, Congreve rockets having become obsolete.

[3] See p. 288.

[4] That is 1 to 6 inclusive, 2* making the 7th.

[5] *War Office Circular*, 406.

[6] Proposed by Col. Ord, R.E., and approved 19th April 1865.—*War Office Circular*, 6 (new series), par. 1102.

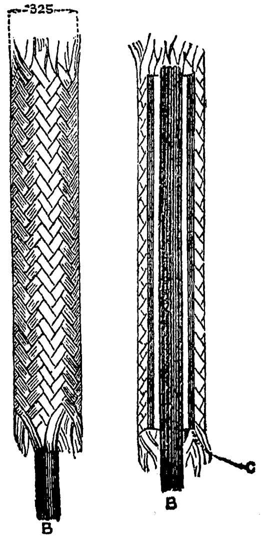
[7] It is supplied in lengths as required.

[8] "White fine paper."

[9] The paper inside the calico.

[10] India-rubber dissolved in mineral naphtha.

proof. The case is covered with plaited cotton yarn. This fuze acts instantaneously, being in fact merely a waterproof "leader." It serves to communicate the fire to a military or other mine, through a long tamp, or wherever it may be required; and has replaced, for this purpose, the "powder," or "mining-hose" which has hitherto been used.[1] It is serviceable under circumstances, such as damp ground, or firing under water, when an ordinary non-waterproof leader would be useless.



Packing and issue.

Ord's mining fuze is issued in lengths as required; packed in a zinc cylinder or any suitable case.

Fuze, electric, Abel's.

3. *Abel's Electric*[2] *fuze* (pl. 5) is on the same principle as the electric tube.[3] The head, however, is cylindro-conoidal instead of egg-shaped; but the arrangement of the head is the same as that of the tube.

The insulated wires with their covering of gutta-percha, and their ends embedded in the same priming material as is used for the electric tube,[4] extend about ·25 inch below the head, into a hollow cylinder of wood[5] (pl. 5, figs. 2, 3) about 2 inches in length[6] and ·5 inch in diameter. This cylinder is filled with about 30 grains of rifle F.G. powder, in which the lower ends of the insulated wires and the small charge of the priming material are embedded. The hole at the bottom of the wooden cylinder through which the powder charge is introduced, is plugged up securely with wood.[7] The whole fuze is varnished black.[8]

The action of the electric fuze is exactly the same as that of the electric tube,[9] with the exception that the explosion of the priming

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[1] See on the subject of the employment of the powder hose, for which Ord's fuze is now substituted, *Macaulay's Field Fortifications*, pp. 203, 204.

[2] The first issue was made 22nd May 1862, to Malta; but no pattern was approved until 27/1/66, *W.O.C.* 9 (new series), § 1201.

[3] See p. 209.

[4] See p. 210.

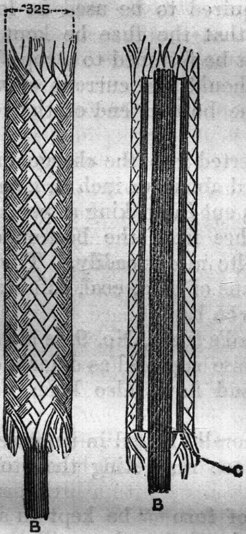
[5] Tin has also been used for this purpose.

[6] The tin cylinders were about 3 inches in length.

[7] Boxwood; in the tin-bodied fuzes the hole was closed with plaster of Paris, in some cases with gutta-percha.

[8] With the same varnish as is used for the bodies of tubes. See table XX., p. 345.

[9] See p. 211.



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materials fires, not a tube but the charge of powder contained in the wooden cylinder, which explodes the mine, or charge of powder within which it may be placed.

In future manufacture these fuzes will be made with a shorter cylinder (1·25″ in length), filled with mealed powder well rammed round the ends of the insulating wires and priming material. The ramming of the charge is effected with a view to forcing it and the priming material into close contact with the poles of the wires. The decrease in bulk which results permits of a corresponding reduction in the dimensions of the cylinder. These fuzes will be distinguished by the numeral II. Pattern II.

These fuzes are used for mining purposes.

They are issued by fifties in zinc cylinders, labelled with the nature and number of the contents. Packing and issue.

Proof of Fuzes.

The following are the rules laid down in the Royal Laboratory, Woolwich, for the proof of fuzes. They may serve as a guide at out-stations, although it will always be a matter for consideration, with reference to the special circumstances of each particular case, whether the limits and proofs herein laid down should be adhered to. The tendency of fuzes (particularly of those 20 and 7½ seconds fuzes which have not the bottom hole closed as in the present pattern) is to burn longer after being kept in store any time.

Smooth-bore Ordnance.

Time Fuzes.—2 per cent. of all time fuzes are burnt to time, the limits allowed being $\pm \cdot 2$ seconds per 5 seconds, except in the case of the common fuze when they are $\pm \cdot 3$ on the 10 seconds, and in the case of mortar fuzes where the limits are all in one direction and rather within the usual limits.

1. *Common.*—Gauged in conical gauge.
   Burnt. Correct time, 10 seconds.
   Extreme limits allowed 9·7 to 10·3.
2. *Diaphragm.*—Gauged in conical gauge.
   Burnt. Full time, 5 seconds.
   Extreme limits 4·8 to 5·2.
3. *Large Mortar.*—Gauged in conical gauge.
   Burnt. Full time, 30 seconds.
   Limits, 30 to 32 seconds.
4. *Small Mortar.*—Gauged in conical gauge.
   Burnt. Full time, 15 seconds.
   Limits, 15 to 16.
5. 20 *Seconds Fuze.*

Samples of metal selected and kept for reference (weekly): samples submitted monthly to chemist to War Department for analysis.

2 per cent gauged in screw gauge, wrench holes gauged, &c., &c.
Burnt. Full time, 20 seconds.
Limits, 19·2 to 20·8.

6. 7½ *Seconds Fuze.*

Samples of metal as above. Gauged as above.
Burnt. Full time, 7½ seconds.
Limits, 7·2 to 7·8.

7. 9 *Seconds Fuze M.L. O.*—Gauged.
   1 per cent. burnt. Full time, 10 seconds.
   Limits, 9·7 to 10·3.
   ½ per cent. fired at Shoeburyness, to test time of burning, in 64-pr. M.L. gun, 8lbs. charge, high elevation.

8. 20 *Seconds Fuze M.L.O.*—Gauged.
1 per cent. burnt.
Limits, 19·2 to 28·8.
½ per cent. fired as above.
9. *Hand Grenade.*
2 per cent. burnt. Full time, 7·5 seconds.
Limits, 7·5 to 8.
10. 10″ *Parachute.*—Gauged in conical gauge.
Burnt. Full time, 15 seconds.
Limits, 14·4 to 15·6.
11. 8″ *Parachute.*—Same as 10″.
Burnt. Full time, 10 seconds.
Limits, 9·7 to 10·3.
12. 5½″ *Parachute.*—Gauged in conical gauge.
Burnt. Full time, 7½ seconds.
Limits, 7·2 to 7·8.
13. *Manby's Shot Fuze.*—Gauged in conical gauge.
Burnt. Full time, 12·5 seconds.
Limits, 12 to 13 seconds.
14. *White Metal for Drill.*—Gauged.

Percussion.—Percussion fuzes are not only carefully gauged, a per-centage in process of manufacture and a per-centage afterwards, but are tested as to safety by dropping in shell a height of 20 feet; a per-centage of these dropped fuzes are afterwards tested for sensitiveness as below described, others are tested by firing.

The proportion of percussion fuzes tested altogether is 15 per 1,000.

1. *Pettman's L. S. Fuze.*—5 per cent. of the different parts most carefully gauged before being put together; samples of the metals are selected and put by weekly for reference, a sample submitted weekly to chemist War Department for analysis. After the fuzes are finished 15 per 1,000 are selected for examination and proof. The whole of these are carefully gauged and examined.

Ten are dropped in a 32-pr. common shell 20 feet on an iron block, in any accidental position. These should not explode. Three of the dropped fuzes are opened and the balls taken out and a weight of 7½ ounces allowed to fall upon them a height of 22 inches. These should fire.

The five remaining fuzes are fired at Shoeburyness from a 32-pr. gun, common shell, three with 10 lb. charges at about 3° elevation to ricochet on water. The object of this proof is rather to test the fuzes under a high charge than to determine whether or not they explode on striking water. As a general rule they do not explode, but they are not specially constructed to stand such a test.

The other two are fired with a 4 lb. charge from the same gun, at an oak butt, 200 yards. These should explode.

2. *Pettman's Sea Service.*—Samples of metals, gauging of parts, dropping, &c. as above. Except that owing to the diminished sensitiveness of the ball, the weight is allowed to fall 25″ instead of 22″.

In the firing test, naval instead of common shell are used, and the three fired to ricochet.

10 lbs. charge should not explode.

The other two are fired with 2½ lbs. charge at oak in the 200 yards range, and should explode.

3. *Petmann's General Service.*—Dropping test in 7″ shell. Gauging, &c., as above. Firing test, three fuzes from 7″ M.L. gun 22 lbs. ¾ elevation on water; not to explode. 2 in 40-pr. 4 lbs. charge at oak butt, 200 yards; or 5 lbs. charge, 500 yards. To explode.

Mining Fuzes.

1. *Bickford's*[1].—Maximum rate of burning, 6 minutes per length of 24 feet, or 45 seconds per yard. Minimum rate of burning, 10 minutes per length of 24 feet, or 75 seconds per yard. The contents of each cask to burn within 5 seconds per yard, or 40 seconds per length of 24 feet, of a rate to be marked upon it by the manufacturers.
2. *Ord's.*—Cannot be subjected to any test.
3. *Abel's Electric.*—Fire 2 per cent. with magnetic exploder.

MISCELLANEOUS STORES CONNECTED WITH FUZES.

The following miscellaneous stores connect themselves with this section, and are introduced accordingly :—

Bags, canvas, for fuzes - { Black. / Blue.

Boxes, tin, for fuzes - { Black. / Blue. / Boat magazine.

Cases, tin, Bickford's fuze { To hold 50 fathoms. / " 24 " / " 8 " / Boat magazine.

Shell and fuze implements.

Bags, Canvas, for Fuzes.

Bags, canvas, for fuzes are of two natures :—(*a*). Black for common fuzes; (*b*). Blue for diaphragm fuzes.

Bags, canvas, fuze, black.

The (*a*) *black bags* are made of two sizes; one size to hold 16 common fuzes, the other size to hold 10 common fuzes. They are rectangular bags of unbleached canvas,[2] lined with stout brown paper,[3] varnished with shellac. The flap of the bag ties down with twine. The expression "*black*" refers, not to the colour of the bag, which is white, but to the colour of the lettering. They are lettered with the nature and number of fuze which they contain.

Bags, canvas, fuze, blue.

The (*b*) *blue bags* are also of two sizes, to contain respectively 12 and 8 diaphragm shrapnel fuzes.

The construction is the same as that of the black bags, but they are lettered in *blue*, with the nature and number of fuze which they contain. These bags, black and blue, are used to contain fuzes, common and diaphragm respectively, in the numbers above stated for field service, as follows :—Black, to hold 16 common fuzes, to 12-pr. howitzer carriage, limber,[4] and wagon.[5]

Black, to hold 10 common fuzes to 24-pr. howitzer wagon,[6] 32-pr. howitzer limber[7] and wagon,[8] and 18-pr. gun.[9] Blue, to hold 12 diaphragm fuzes, to 6-pr. wagon,[10] 12-pr. gun carriage, and limber,[11] and wagon,[12] 12-pr. howitzer carriage, limber,[13] and wagon,[14] and 32-pr. howitzer, carriage, limber,[15] and wagon.[16]

Blue, to hold 8 diaphragm fuzes to 9-pr. wagon,[17] 24-pr. howitzer carriage limber,[18] and wagon.[19]

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[1] By W. O. Minute, 15/6/67, 75/7/173, the inspection of this fuze was ordered to be undertaken by the Royal Laboratory. It had previously been done by the Royal Engineers.

[2] "Duck" canvas. [3] Rocket paper.

[4] *Equipment of Artillery*, p. 181. [5] *Ibid.* p. 186. [6] *Ibid.* p. 189.
[7] *Ibid.* p. 191. [8] *Ibid.* p. 163. [9] *Ibid.* p. 176. [10] *Ibid.* p. 170.
[11] *Ibid.* p. 171. [12] *Ibid.* p. 179. [13] *Ibid.* p. 181. [14] *Ibid.* p. 189.
[15] *Ibid.* p. 191. [16] *Ibid.* p. 167. [17] *Ibid.* p. 184. [18] *Ibid.* p. 186.
[19] *Ibid.* p. 184.

Boxes, Tin Fuze.

Boxes, tin fuze, are of three natures—

(*a.*) Black, for common fuzes.
(*b.*) Blue, for diaphragm.
(*c.*) Boat magazine, for common and diaphragm fuze, &c.

Box, tin, fuze, common, black.

(*a.*) *Black tin boxes for common fuzes* are made of two sizes, to hold respectively 10 and 8 fuzes. They are rectangular tin[1] boxes, having a tin loop at the back for a strap, by which to buckle them to a man's waist; they are painted black, and lettered in white with the nature and number of fuze which they contain.

Box, tin, fuze, diaphragm shrapnel, blue.

The (*b*) *blue tin boxes for diaphragm shrapnel fuzes*, are made of three sizes, to hold respectively 12, 10, and 8 diaphragm shrapnel fuzes.

They are of the same construction as the black tin boxes, but are painted *blue* and lettered white, with the nature and number of fuzes which they contain.

The black and blue fuze boxes are used to contain fuzes, common and diaphragm, for field service as follows:—

Black to contain 10 common fuzes to 24-pr. howitzer carriage, limber,[2] and wagon,[3] and to 32-pr. howitzer carriage, limber,[4] and wagon.[5]

Black to contain 8 common fuzes, to 18-pr. carriage, limber,[6] and wagon,[7] to 12-pr. howitzer carriage, limber,[8] and wagon.[9]

Blue, to hold 12 diaphragm fuzes, to 6-pr. gun carriage, limber,[10] and wagon,[11] 12-pr. gun carriage, limber,[12] and wagon,[13] 12-pr. howitzer carriage, limber,[14] and wagon,[15] and to 3-pr. howitzer carriage, limber,[16] and wagon.[17] Blue to hold 8 diaphragm fuzes to 9-pr. carriage, limber,[18] and wagon,[19] 24-pr. howitzer carriage, limber,[20] and wagon.[21]

The blue box to hold 10 diaphragm fuzes is supplied for naval service.

(*c.*) *The tin fuze box for boat magazines* is of one size only. It is a rectangular tin[22] box about $8\frac{1}{2}$ inches × 3 × 3. It is unpainted.

The box is used to contain fuzes,[23] or a portion of the implements for preparing them,[24] in boat magazines. On the top are lettered in black the nature and number of the contents.

Cases,[25] tin, Bickford's Fuze.

Tin cases for Bickford's fuze are of 4 natures, viz.:—

(*a.*) To contain 50 fathoms.
(*b.*) „ 24 „
(*c.*) „ 8 „
(*d.*) Boat magazine.

Case, tin, Bickford's fuze, 50 fathoms.

The (*a*) *tin case to contain* 50 *fathoms* of Bickford's fuze is a cylindrical tin[26] case of a size to contain 50 fathoms of Bickford's fuze

[1] The tin used is "× single," except for the blue box to hold 10 diaphragm fuzes, for which "common, double" is used.
[2] *Equipment of Artillery*, p. 184. [3] *Ibid.* p. 186. [4] *Ibid.* p. 189.
[5] *Ibid.* p. 191. [6] *Ibid.* p. 174. [7] *Ibid.* p. 176. [8] *Ibid.* p. 179.
[9] *Ibid.* p. 181.
[10] *Ibid.* p. 161. [11] *Ibid.* p. 163. [12] *Ibid.* p. 170.
[13] *Ibid.* p. 171. [14] *Ibid.* p. 179. [15] *Ibid.* p. 181. [16] *Ibid.* p. 189.
[17] *Ibid.* p. 191. [18] *Ibid.* p. 166. [19] *Ibid.* p. 167. [20] *Ibid.* p. 184.
[21] *Ibid.* p. 186.
[22] The tin used is "× × × single." [23] The number varies.
[24] See page 307. [25] Sometimes called "boxes."
[26] The tin used for all cases for Bickford's fuze is "× × × single."

coiled round inside it. The lid is removable at will, and fastens by means of two hasps and staples.

Cases, tin, Bickford's fuze, 24 fathoms and 8 fathoms.

The (*b*) *and* (*c*) *cases to contain* 24 *and* 8 *fathoms* differ from the case to contain 50 fathoms only in size.

Case, tin, Bickford's fuze, boat magazine.

The (*d*) *tin case, boat magazine,* for Bickford's fuze is a rectangular tin[1] case, with the corners rounded off. The lid is hinged and fastens by means of a hasp and staple. This case will take two fathoms of Bickford's fuze. The whole of the above cases for Bickford's fuze are unpainted. On each case is pasted the following:—

" *Directions for using Bickford, Smith, and Davey's Water Fuze.*

" When the fuze is required to be used in long lengths for blasting " under water, in order that the fuze be kept straight, the manufacturers " recommend that it be fastened to a rope by strings, from 2 to 3 feet " apart; and should the current of water be strong, that a weight be " attached to the bottom end of the rope, near the surface of the hole to " be blasted.

" Before the fuze is inserted into the charge or cartridge, the ends of it " should either be opened about an inch in length, or cut in an oblique " manner, just as a quill is cut in making a pen, and one of the ends so " cut, placed about 2 inches from the bottom of the charge,—this will " cause the powder to ignite more readily. The cartridge may be con- " fined in the hole by means of sand, coal, soft stone, or oakum, carefully " rammed down with an iron bar.

" The water fuze will burn at the rate of about $2\frac{1}{2}$ feet in a minute.

" The manufacturers recommend gutta-percha as a material for " making the bag or cartridge to contain the charge.

" The boxes containing the fuze on board ship are not to be stowed in " the magazine, but between the beams of the orlop, or the beams of the " gunner's store room, and kept perfectly dry."

SHELL AND FUZE IMPLEMENTS.

History.

Since fuzes have been used for artillery purposes, instruments of some sort for preparing them have been necessary.

Formerly, saws for sawing the fuzes to length, and borers for removing the required composition, together with "engines" for extracting the fuze from the shell were employed; but on the adoption of the Boxer system of fuzes in 1850,[2] different instruments became requisite in the form of borers, bits, and braces for the preparation of the fuzes; but no formal approval of these implements can be traced until 1855,[3] when they were adopted, together with gauges and rimers for fuze holes.[4]

Shell implements, in the same way, were adopted by degrees, as the service required. For example, the present plug key was not adopted until the supersession of the white metal plug in 1858–9.[5] The hammers and punches for riveting wood bottoms were not required until 1855, when the principle of rivet attachment was adopted;[6] and similarly the partial introduction of the inclined rivet system for naval shell in 1856[7]

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[1] See note 26, p. 288.
[2] See p. 236.
[3] 27th January 1855, *Account of Alterations and Additions, &c.,* 31st January 1855, par. 29, sect. 9; see also Table C. thereto annexed.
[4] *Ibid.,* par. 28, sect. 14.
[5] See p. 99; up to 1858–9 a key with two prongs was in use.
[6] See p. 119.
[7] "Partial," because at first only one-fourth the naval shells were thus fitted.

rendered necessary the adoption of implements for fixing on the bottoms. In the same year the introduction of gutta percha wads for the fuze and loading holes of filled shells, caused the introduction of boxwood drifts.[1]

From time to time improvements were made in the nature of the implements and in the arrangement of the sets, until about 1860,[2] when a definite arrangement was adopted, which, with one or two exceptions, was retained until 1865.

Among the principal changes introduced subsequent to 1860 may be noticed the removal of mallets and setters from the field service sets in 1863, the addition of a rectifying tap and lever to the naval sets the same year, the adoption of a screw tap and key for rectifying shells prepared to receive Pettman's fuzes in 1861;[3] the incorporation of No. 7 set (for mortar shells) with No. 5; the discontinuance of the wrench for removing mortar fuze-hole plugs[4] and the introduction of a funnel for filling mortar shells in 1861.[5]

The special set for preparing shells to receive Pettman's fuzes has never been formally approved, but has been in use, more or less, since about 1861.

In May 1865[6] a considerable change was effected in the various sets; many new implements were introduced, some old ones abolished, and the sets generally reorganized, and adapted for rifled as well as smooth-bore guns. A further revision and further changes were intimated in War Office Circular, 8 (new series), par. 1166.

In September 1865[7] a new arrangement was adopted, the sets being again reorganized. Some further changes were effected in 1866,[8] owing to the introduction of Pettman's general service fuze, &c. The instructions were then printed, some on paper pasted on to cardboard, others on calico. This arrangement is now adhered to.

Natures.

By these reorganizations we obtain a total of 11 sets, not including a "special set" exclusively for rifled siege guns, a special set for 7-pr. rifled muzzle-loading guns for mountain service, or the "special set" for preparing shells to receive Pettman's fuzes.

The 11 sets are distributed as follows:—Nos. 1, 2, 3, 4, 5, and 6 are garrison sets; Nos. 1, 2, 3, and 4 being intended for common diaphragm and rifle shells and fuzes; Nos. 5 and 6 for mortar shells and fuzes.

There are four sets, numbered 1, 2, 3, and 4, for field service (smooth bore only), and one set[9] for naval service (smooth-bore and rifle).

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[1] See p. 307.

[2] The field service sets were formally approved 14th February 1860, *War Office Circular*, 551.

I have not been able to discover any formal approval of the garrison and naval sets; but lithographic drawings showing their arrangement and embodying instructions for their use were executed at the Topographical Department about this period, signed by the Superintendent, Royal Laboratory, and accepted as official.

[3] 30th October 1861, *War Office Circular*, 739, par. 429; see also on this subject, *War Office Circular*, p. 22, errata; and *War Office Circular*, 822, p. 22, errata.

[4] Mortar shells, it must be borne in mind, had metal fuze-hole plugs until 1860, when corks were substituted, see p. .

[5] *War Office Circular*, 680, par. 227.

[6] Approved 13th May 1865, *War Office Circular*, No. 6 (new series), par. 1095.

[7] 20th September 1865, *War Office Circular* 8 (new series), § 1116.

[8] 16th July 1866, *War Office Circular* 11 (new series), § 1321.

[9] Until 1865 there were two sets for naval service, but when the implements were reorganized, it was found impracticable, or at least extremely difficult and inconvenient, to subdivide the naval implements into two sets; and they were accordingly all thrown into one set, which can be demanded whole or in part.

Taking the sets in detail, they are as follows :—[1]

No. 1 Set,

S. B. GARRISON, FOR RECTIFYING FUZE HOLES OF COMMON AND DIAPHRAGM SHRAPNEL SHELL.

One set for each district in large fortresses, or one per station in small garrisons.

Blocks, wood, 10-inch 1, 8-inch 1, 32-pr. 1	3
Gauge, fuze-hole, common	1
Holder, shell	1
Instructions, printed	1
Key, iron, square	1
Lever, common	1
Rimer, common	1
Screws, coach, 4 × ½	1
Tap, screw, Pettman, common	1

Rectifying Fuze Holes of Shell.

"Unscrew the metal plug from the fuze hole by means of the square key and lever—[if the plug should be so firmly fixed in the shell that it cannot be unscrewed by the key, a few smart blows with the hammer will loosen it]—insert the fuze-hole gauge—if the larger end of the cone is not flush with the exterior of the fuze hole, place the shell in the holder, as shown in the drawing, and fix it by screwing up the moveable jaw—the smaller natures of shell can be supported by hand in the proper position until the jaws have a firm hold; but for the 32-prs. and heavier natures, a block of wood is necessary for the shell to rest upon; the jaws should grip the shell about halfway between the fuze hole and the bottom—insert the rimer into the fuze-hole, and turn it *gently* round with the lever, until the fuze hole is the proper dimensions, *great care being taken not to make it too large*, then perfect the thread by means of the screw tap."

Special Remarks.[2]—The instructions for this set are printed on paper mounted on mill-board and varnished. Only those shells which may have become injured in the fuze hole will require rectifying. The "tap, screw, Pettman," is not intended to *prepare* shells to receive Pettman's fuzes, but merely to rectify such shells as have been prepared for their reception. It should not therefore be used with any common shells not having a cross cut upon the plug.

The "gauge, fuze-hole, common," is to check the work of rectifying, which should not be overdone.[3]

The "screws, coach," are for attaching the shell holder to the bench or table on which it is to be fixed. It should be noticed that benches are not issued with No. 1 set, as it is presumed that means of fixing the holder would exist or could be improvised at all stations.

No. 1 set is issued in two boxes, painted grey.

The larger box contains—

Blocks, wood, 10-inch 1, 8-inch 1, 32-pr. 1	3
Holder, shell	1
Screws, coach, 4 × ½	1

[1] The details of the sets and the instructions for their use are extracted *verbatim* from the official lithographic drawings and printed instructions which accompany each set.

[2] The use of the several implements is sufficiently explained in the printed instructions which accompany the set; these "special remarks," after each set, I have introduced with a view to clearing up any points which may not be touched upon or explained in the instructions.

[3] See instructions with No. 1 set.

The smaller box contains—

Gauge, fuze-hole, common - - - -	1
Instructions, printed - - - - -	1
Key, iron, square - - - - -	1
Lever, common - - - - -	1
Tap, screw, Pettman, common - - -	1

The boxes are secured with staple and hasp and padlock.

No. 2 Set,

S. B. Garrison, for fixing Wood Bottoms.

One set for every 10 or less number of guns in each district or station, and one set spare.

Block, wood - - - - - -	1
Hammer, riveting - - - - -	1
Instructions, printed - - - - -	10
Pricker, removing wax - - - -	1
Punch, iron, riveting bottoms - - -	1
Rectifier, common, for rivet-hole - - -	1
Spanner, box - - - - -	1

Fixing Wood Bottoms.

"Remove the bottoms from the iron bar by unscrewing the nut at the end of the bar with the box spanner—place the shell on the wood block—remove the beeswax from the rivet hole with the pricker—place a rivet in the rivet-hole of the wood bottom, with the point projecting beyond the concave surface—place it on the shell, moving it about until the rivet drops into the rivet hole—place the punch on the head of the rivet, and give it a few smart blows with the hammer.

"If the rivet hole in the wood bottom is rough and jagged, pass the rectifier through it, turning it round so as to bring the hole to its proper form.

"The common shell, which are issued loose, have their fuze hole secured by a metal screw plug, and are prepared with rivet holes for fixing the wood bottoms. The wood botoms are packed by twenties on iron rods, and secured by an iron nut."

Special Remarks.—The instructions for this set are printed on paper mounted on mill-board and varnished. With regard to the "pricker" for removing wax from the rivet hole, all projectiles having rivet holes and issued "loose" have the rivet holes plugged with beeswax.[1]

In the case of shells, carcasses, &c., there will be no difficulty in finding the rivet hole, which will be opposite the centre of the fuze hole or group of vents; but in the case of solid shot it is not so easy.

The rectifier need only be applied in case of necessity.

Packing and issue. No. 2 set is issued in a deal box, painted grey, and secured with a staple, hasp, and padlock.

No. 3 Set,

R. and S. B. Garrison, for filling, securing, and preparing Common, Diaphragm Shrapnel or Rifle Shell for firing.

One set for every 5 or less number of guns in each district or station, and one set spare.

Drifts, wood	common - - - -	1
	diaphragm shrapnel, large 1, small 1 -	2

[1] See p. 29, &c.

Drivers, screw, diaphragm shrapnel, large 1, small 1		2
Funnels, leather	diaphragm shrapnel, large 1, small 1	2
	common, large	1
Instructions, printed		5
*Key, iron, adapter and plug		1
*†*Key, iron, plug and fuze, general service*		1
*Mallet, common, and diaphragm shrapnel		1

* New pattern for future manufacture. N.B.—In sets already issued, or in store, no alteration is to be made, except where there are rifle guns; these articles are then to be added or substituted, as required.

*† This key will take the place of the "key, iron, adapter and plug" in sets issued for stations supplied with the general service fuze.

Filling and Securing Shell.

"*Common Shell.*—Remove the plug from the fuze hole by means of the key—insert the funnel and pour in the bursting charge—carefully wipe every portion of powder from the fuze hole, and drive in a papier mâché wad with the drift, as far as the shoulder on the drift will allow—screw in the plug, fitted with a leather collar.

Diaphragm Shrapnel Shell.—"Remove the plug from the loading hole by means of a screwdriver—hold the shell in a position with the loading hole uppermost—insert the funnel and pour in the bursting charge—turn the shell from side to side to facilitate the filling—carefully wipe every portion of powder from the loading hole, and drive in a papier mâché wad, with the drift, as far as the shoulder on the drift will allow, and screw in the plug—unscrew the fuze-hole plug, to which is attached a wood plug covered with serge, to prevent the bursting powder from passing into the socket in sufficient quantity to cause inconvenience in fixing the fuze,—and in order to insure the small hole communicating with the powder chamber being clear, shake a few grains of powder *from the powder chamber* into the socket—then replace the fuze-hole plug.

"*Rifle Shell.*—The larger natures of common and segment shell for rifle ordnance which are fitted with the naval fuze hole require an adapter when the Boxer wood time or the general services fuzes are used.

"Remove the plug from the fuze hole and screw the adapter firmly in by means of the key—insert the funnel, pour in the bursting charge—then carefully wipe every portion of powder from the fuze hole, and from between the adapter and nose of shell.

Preparing Shell for Firing.

"*Common and Diaphragm Shrapnel Shell.*—Unscrew the plug from the fuze hole by means of the key—insert the fuze, which has been previously prepared for the required range—set the fuze home with the mallet; or against a gun carriage, or by pressing it in by hand, if more convenient.

"The fuze should not be uncapped until the shell is placed in the muzzle of the gun, this much reduces the chance of an accident, and secures the priming from injury.

"N.B.—The papier mâché wad in the fuze hole of common shell is driven into the shell in the operation of fixing the fuze.

"*Rifle Shell.*—In fixing the fuze NEITHER A MALLET NOR ANY OTHER INSTRUMENT IS TO BE USED; this operation is to be performed simply by *pressing the fuze with the hand and screwing* it at the same time into the bush or adapter.

"When the fuze cannot be screwed any farther with the *hand*, it is then properly secured."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience in rolling. This set, it will be noticed, is for use with rifle as well as smooth-bore ordnance. With regard to the instructions given for the filling of diaphragm shell, it should be noticed that the fuze-hole plug is not to be removed until the shell is filled; if this point be not attended to, a sufficient quantity of powder may work into the socket to interfere with the proper setting home of the fuze and premature explosions may result, either from the top side holes being exposed or from the fuze being loose, and the flash of discharge thus having access to the powder in the socket. Nevertheless, the instructions respecting "*a few grains*" of powder being shaken from the powder chamber into the socket must be attended to, not merely to make the action of the fuze more certain, but to ensure the fire hole being open; but in no case should this quantity be sufficient to interfere with the proper introduction of the fuze.

With reference to the fixing of the Boxer time fuzes for rifled ordnance, it is particularly to be noticed that neither mallet nor setter is to be used in this operation, as a blow upon the head of the B.L. fuze if set loose in the adapter might cause explosion;[1] and although the M.L. fuzes are not liable to be thus exploded, it is considered desirable to preserve the same manner of fixing them as is necessary for the B.L. fuzes.

The key, iron, fuze and plug, general service, is intended for use with the general service and L.S. Pettman's fuzes and adapter and plug; the old key for adapter and plug will not, however, be replaced except on demand and with new sets, or for stations where the general service fuze is supplied.

The mallet is used not for fixing the fuze but for setting home the papier mâché wad in common shell; hence no setter is required. In December 1865 the nomenclature of the mallet was changed from "$5\frac{1}{2}''$" to "common and diaphragm shrapnel,"[2] the old nomenclature having been a relic of the old system of $5\frac{1}{2}''$ and $8''$ fuze holes.

No. 3 set is issued in a box, painted grey, with a staple, hasp, and padlock.

No. 4 *Set,*

R. AND S. B. GARRISON, FOR PREPARING FUZES FOR RIFLE ORDNANCE AND FOR COMMON AND DIAPHRAGM SHRAPNEL SHELL.

One set for every 2 guns in each district or station, and 25 per cent. spare.

Bags, canvas	cylinder, wood, common - - -	2
	hook-borer - - - - -	2

[1] An accident actually occurred in 1865 at Sheerness, while one of these fuzes was being fixed into a 7″ shell; this accident led to an order being given that mallets and setters were no longer to be employed in fixing Boxer's 2″ R.O. fuze and a label to that effect fixed on the head of each fuze.

With regard to the danger being greater when the blow is struck on a fuze set loosely in the adapter, this is to be explained by the fact that the fuze then goes readily away with the blow and is brought up with a jerk on biting, this jerk being thrown upon the suspending wire. For this reason the use of papier mâché wads with the adapter was discontinued at the same time as the use of the mallet and setter. A drift for fixing the wad in the adapter was also removed for the same reason and at the same time.

See *War Office Circular*, 8 (new series), par. 1166.

[2] *War Office Minute* 7/12/65, 57/24/4114.

* Bits, hook-borer	- - - - - -	12
* Cylinders, wood, common	- - - - -	2
* Extractor, fuze, small	- - - - -	1
* Handles, hook-borer	- - - - - -	2
* Hooks, hook-borer	- - - - - -	2
* Instructions, printed	- - - - - -	2
Keys, iron { * adapter and plug	- - - -	2
Keys, iron { * Pettman L.S. fuze	- - - -	1
Keys, iron { ***plug and fuze general service*	- -	1
* Mallet, common and diaphragm shrapnel	- - -	1
Setter, common and diaphragm shrapnel	- - -	1

* New pattern. N.B.—Where there are no rifled guns the present No. 4 set viz.:—

Borer, hand	1
„ hook	1
Cylinder, wood, containg six long and six short bits	1
Instructions, printed	5
Keys, iron, for fuze-hole plug	2
Key, iron, Pettman L.S. fuze	1
Mallet	1
Sec. of fuzes	5
Setter	1

will continue in use, until the store is exhausted.—Future issues to be made in accordance with the new set, No. 4, R. and S.B.

** This key will take the place of the "key, iron, adapter and plug," and "key, iron, Pettman L.S. fuze" sets issued for stations supplied with Pettman general service fuze.

Preparing and fixing Boxer Time Fuzes for Common and Diaphragm Shrapnel Shell.

"The fuze is prepared for any desired time of flight by continuing the side hole corresponding to the required time into the composition.

Place the fuze in the hook of the hook-borer in the proper position for boring the required hole, enter the bit into the side hole and work it forward by pressing hard upon the handle, and turning it round at the same time, *until the screw takes the thread in the shank of the hook,* then screw down to the shoulder; take care not to press upon the fuze so as to prevent its bedding fairly in the hook. Unscrew till the screw is relieved from the thread in the shank, then pull straight out, until the bit is clear of the fuze; remove the fuze, and place it in the fuze-hole of the shell, and give the head of the fuze two or three smart taps with the mallet and setter, or against the gun carriage if more convenient. Before the fuze is placed in the socket of the diaphragm shell, care must be taken to remove any superfluous quantity of powder which may have passed into the socket through the communication hole. This is important, because the shell will burst prematurely if the powder in the socket prevent the fuze being securely fixed.

The length of the bit is so regulated, that when placed in the handle, as shown in the drawing, it will enter sufficiently far into the composition when screwed down to the shoulder. If the bit should become unserviceable, the handle must be detached from the shank and the tightening screw unscrewed, the square hole in the hook being made for this purpose. Care must be taken when substituting another bit, that it is properly placed in the handle, *and that the tightening screw firmly presses upon it, for if any space be left between the handle and the head of the bit, the end will not enter a sufficient depth into the composition.* The borer should be occasionally examined and cleaned. The operation of preparing the fuze and fixing it in the shell, takes on an average about 15 seconds; with a little practice these operations may be performed in a shorter time.

The fuzes for common and diaphragm must not be uncapped until the shell is placed in the muzzle of the gun. The cap is then removed by giving the tape a sharp pull. This operation not being performed until the shell is in the bore, much reduces the chance of an accident and renders the fuze less liable to injury from wet.

Preparing and fixing Boxer Time Fuze for Rifle Ordnance.

The fuze is prepared for any desired time of flight by means of the hook-borer, in the same way as the fuzes for common and diaphragm shells;[1] but in fixing the fuze *neither a mallet nor any other instrument is to be used;* this operation is to be performed simply by *pressing the fuze with the hand and screwing* it at the same time into the bush or adapter.

When the fuze cannot be screwed any farther with the *hand,* it is then properly secured.

Extracting Wood Fuzes.

Fuze for Rifle Ordnance.—Apply the fuze extractor to the head of the fuze and unscrew; if the adapter comes away with the fuze, do not remove the fuze from the adapter by striking it on the end, as a blow in that direction may weaken or break the wire which suspends the hammer in the B.L. fuze.

Fuzes for Common and Diaphragm Shrapnel.—Clear out the cup of the fuze with the projecting piece of metal on the handle of the fuze extractor; take a firm hold of the head of the fuze between the jaws of fuze extractor, and turn from left to right. The small knob between the jaws fits into the cup of the fuze and prevents the top from collapsing or giving way."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience in rolling. This set is intended for use with rifle as well as with smooth-bore guns. Particular attention should be paid to the note to the implements of this set marked (*).

The "bits, hook-borer," and the "hooks, borer," are of a very improved construction, by which the operations of preparing the fuze can be performed nearly, if not quite as quickly, with the hook, as with the hand-borer,[2] and with greater certainty of correctness.[3]

They will serve with the whole of the fuzes referred to in this set, also with the 7½" and 20" fuzes. The present bits will not serve with the old pattern hook-borer, nor the old bits with the present hook-borer.

The extractor was formerly in No. 1 set, from which it was removed on the re-arrangement of the sets in 1865.

Respecting "keys, iron, adapter and plug," see special remarks on the same under the head of No. 3 set.[4] See also special remarks on "key, " iron, plug and fuze, general service."

This set contains a mallet *and* setter for the purpose of fixing the

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[1] " [In firing against earth-works or ships it is not necessary to prepare the fuze for rifle ordnance to suit the particular range, as this fuze has been found to act in such cases as a percussion fuze, that is, to cause the shell to burst immediately after striking.]"

[2] With the old hook-borer, the average time for the *preparation* of the fuze (independently of fixing it) was about 15 to 18 seconds with instructed men; it need not now be more than from 6 to 8 seconds.

[3] Col. Boxer "thinks that the use of the hook-borer in the place of the brad awl " will give as a rule greater uniformity."—*Extracts from Reports, &c., of Ordnance Select Committee,* vol. ii., p. 275.

[4] See p. 294.

fuze, except with small shells, when it is generally more convenient and expeditious to fix it by striking it against the gun-carriage.[1]

In December 1865 the nomenclature of the mallets and setters were changed from "mallet and setter, $5\frac{1}{2}$ inch," to "mallet and setter, common "and diaphragm shrapnel."[2]

No. 5 Set,

S. B. GARRISON, FOR RECTIFYING FUZE HOLES OF MORTAR SHELLS.

One set for each district in large fortresses or one per station in small garrisons.

Blocks, wood, 13-inch 1, 10-inch 1, 8-inch 1	3
Gauge, fuze-hole, mortar	1
Holder, shell	1
Instructions, printed	1
Lever, mortar and naval	1
Rimer, mortar	1
Screws, coach, $4 \times \frac{1}{2}$	4
Extractor, fuze, large	1

Rectifying Fuze Holes of Mortar Shell.

"Remove the cork from the fuze hole, and insert the fuze-hole gauge. If the larger end of the cone is not flush with the exterior of the fuze hole, place the shell, resting on a block of wood, in the holder, as shown in the drawing, and fix it by screwing up the moveable jaw—(the jaws should grip the shell about half way between the fuze hole and the bottom ;)—insert the rimer into the fuze hole and turn it *gently* round with the lever, until the fuze hole is the proper dimensions, *great care being taken not to make it too large.* The shell holder when in use must be screwed to a bench or table.

Extracting Fuzes.

Fix the shell in the shell holder (No. 5 set)—take a firm hold of the head of the fuze, between the jaws of the fuze extractor, and turn from left to right."

Special Remarks.—The instructions for this set are printed on paper mounted on mill-board and varnished. See special remarks on No. 1 set for use of "screws, coach."

The extractor, fuze, large,[3] is of a different construction to the extractor, fuze, small, having no knob between the jaws to fit into the cup of the fuze, the sides of the mortar fuze being sufficiently strong to render such internal support unnecessary ; moreover, no projecting piece of metal is provided for clearing out the cup, an operation which the absence of the knob renders unnecessary.

No. 6 Set,

S. B. GARRISON, FOR PREPARING MORTAR FUZES.

One set for every 2 mortars, in each district or station, and twenty-five per cent. spare.

Bags, canvas, cylinder, wood, mortar	2
Bits, mortar	12

[1] Indeed, a smart tap with the hand will generally suffice, the fuze being set strongly home by the shock of discharge ; and there seems no sufficient reason for the retention of mallets and setters in this set. Even a diaphragm shrapnel fuze may be fixed by hand in such a way as to permit of an 8″ diaphragm shrapnel being lifted up by the fuze after fixing.

[2] *War Office Minute,* 1/12/65, 57/24/4114.

[3] On the reorganization of the sets in 1865 the extractor was included in No. 6 set, but subsequently in 1866 (*War Office Minute* 17/1/66, *Chatham* 5/476) it was replaced in No. 5 set.

Brace, mortar	1
Cylinders, wood, mortar	2
Funnel, leather, common, large	1
Instructions, printed	2
Mallet, mortar	1

Preparing and fixing Mortar Fuzes.

"Hold the fuze firmly in the left hand—insert the point of the bit into the required hole—place the head of the brace against the body, and turn with the right hand until the stop comes in contact with the wood—reverse the motion until the bit is clear of the fuze.

The wooden bottom of the fuze must on no account be cut off, as it supports the composition and prevents its being disarranged by the shock at the discharge.

Preparing Mortar Shell for firing.

Remove the cork from the fuze hole—insert the funnel and pour in the bursting charge—insert the fuze (which has been previously prepared for the required range) in the fuze hole, and set it home by two or three smart taps with the mallet.

The fuze must not be uncapped until the shell is placed in the bore. The cap is then removed by giving the tape a sharp pull.—This operation not being performed until the shell is in the bore much reduces the chance of an accident, and renders the priming less liable to injury from wet.

N.B.—The cork may be driven into the 13-inch or 10-inch shell, but must be taken out of the 8-inch, as it might prevent the fuze being set home."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience in rolling. See remarks on No. 5 set respecting the removal of the extractor, fuze, large, from No. 6 to No. 5 set in 1865.

The nomenclature of the mallet was changed in December 1865[1] from "mallet, 8-inch," to "mallet, mortar." A setter, mortar, was among the implements abolished on the revision of the sets in May 1865, but then called by the name "setter 8-inch," which name was officially changed by the same authority as that which changed the name of the mallet.

No. 1 *Set,*

S. B. Field, for preparing Common and Diaphragm Shrapnel Fuzes.

One set for each gun or howziter.

Bags, canvas { cylinder, wood, common	2
Bags, canvas { hook-borer	2
* Bits, hook-borer	12
* Cylinders, wood, common	2
* Extractor, fuze, small	1
* Handles, hook-borer	2
* Hooks, hook-borer	2
Instructions, printed	2
* Key, Pettman, L.S. fuze	1

* New pattern, for future manufacture. N.B.—Sets already issued, or in store, are not to be altered.

These are the implement supplied for boat service with S. B. howitzers, and are contained in the boat's magazine.

[1] *War Office Minute*, 7/12/65, 57/24/4114.

Preparing and fixing Boxer Time Fuzes.

"The fuze is prepared for any desired time of flight, by continuing the side hole corresponding to the required time into the composition.

Place the fuze in the hook of the hook-borer in the proper position for boring the required hole—enter the. bit into the side hole and work it forward by pressing hard upon the handle, and turning it round at the same time, *until the screw takes the thread in the shank of the hook,* then screw down to the shoulder—take care not to press upon the fuze so as to prevent its bedding fairly in the hook. Unscrew till the screw is relieved from the thread in the shank, then pull straight out, until the bit is clear of the fuze; remove the fuze and place it in the socket of the shell, and give the head of the fuze two or three smart taps against the gun carriage. Care must be taken that the fuze is fixed firmly in the shell, but it is on no account to be rasped.

The length of the bit is so regulated, that when placed in the handle, as shown in the drawing, it will enter sufficiently far into the composition when screwed down to the shoulder. If the bit should become unserviceable, the handle must be detached from the shank, and the tightening screw unscrewed—the square hole in the hook being made for this purpose. Care must be taken, when substituting another bit, that it is properly placed in the handle, *and that the tightening screw firmly presses upon it; for if any space be left between the handle and the head of the bit, the end will not enter a sufficient depth into the composition.* The borer should be occasionally examined and cleaned. The operation of preparing the fuze and fixing it in the shell, takes on an average about fifteen seconds; with a little practice these operations may be performed in a shorter time.

The fuze must not be uncapped until the shell is placed in the muzzle of the gun. The cap is then removed by giving the tape a sharp pull.—This operation not being performed until the shell is in the bore, much reduces the chance of an accident, and renders the fuze less liable to injury from wet.

Extracting Boxer Wood Fuzes.

Clear out the cup of the fuze with the projecting piece of metal on the handle of the fuze extractor—take a firm hold of the head of the fuze between the jaws of the fuze extractor, and turn from left to right. The small knob between the jaws fits into the cup of the fuze, and prevents the top from collapsing or giving way."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience in relling. A key, iron, Pettman's L.S. fuze, is required in this set because the L.S. fuze is issued for boat service. See special remarks on No. 4 set, rifle and smooth-bore garrison.

No. 2 Set,

S. B. FIELD, FOR PREPARING SHELL.

One set for each gun.

Drift, wood, diaphragm shrapnel, small	1
Driver, screw, diaphragm shrapnel, small	1
Funnel, leather, diaphragm shrapnel, small	1
Instructions, printed	2
Keys, iron, common plug	2
Punch, iron, riveting bottoms	1

N.B.—Sets already issued or in store are not to be altered.

Filling and securing Diaphragm Shrapnel Shell.

"Remove the plug from the loading hole by means of the screwdriver —hold the shell in a position with the loading hole upwards—insert the funnel and pour in the bursting charge—turn the shell from side to side, to facilitate the filling—carefully wipe every portion of powder from the loading hole, drive in a papier mâché wad with the drift, as far as the shoulder on the drift will allow, and screw in the plug—unscrew the fuze-hole plug, to which is attached a wood plug covered with serge, to prevent the bursting powder from passing into the socket in sufficient quantity to cause inconvenience in fixing the fuze—and in order to insure the small hole communicating with the powder chamber being clear, shake a few grains of powder *from the powder chamber* into the socket—then replace the fuze-hole plug.

Preparing Diaphragm Shrapnel Shell for firing.

Unscrew the plug from the fuze hole by means of the key—insert the fuze, which has been previously prepared for the required range—set the fuze home against a gun carriage.

The fuze should not be uncapped until the shell is placed in the muzzle of the gun; this much reduces the chance of an accident, and secures the priming from injury.

Fixing Wood Bottoms.

If the wood bottom should at any time become loose, place the punch on the head of the rivet, and give it a few smart blows with a hammer."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience of rolling. A reference to the special remarks on No. 3 set, rifle and smooth-bore garrison, will explain any points not made sufficiently clear by the instructions.

No. 3 Set,

S.B. FIELD, FOR PREPARING SHELL.

One set for each 32-pr. or 24-pr. howitzer.

Drifts, wood	common	1
	diaphragm shrapnel, large	1
Driver, screw, diaphragm shrapnel, large		1
Funnels, leather	common, small	1
	diaphragm shrapnel, large	1
Instructions, printed		2
Keys, iron common plug		2
Punch, iron, riveting bottoms		1

N.B.—Sets already issued or in store are not to be altered.

Filling and securing Common Shell.

"Remove the plug from the fuze hole by means of the key—insert the funnel and pour in the bursting charge—carefully wipe every portion of powder from the fuze hole, and drive in a papier mâché wad, with the drift, as far as the shoulder on the drift will allow—screw in the plug fitted with a leather collar.

Filling and securing Diaphragm Shrapnel Shell.

Remove the plug from the loading hole by means of the screwdriver—hold the shell in a position with the loading hole upwards—insert the funnel and pour in the bursting charge—turn the shell from side to side to facilitate the filling—carefully wipe every portion of powder from the loading hole, and drive in a papier mâché wad with the drift, as far as the shoulder on the drift will allow, and screw in the plug—unscrew the fuze-hole plug, to which is attached a wood plug covered with serge, to prevent the bursting powder from passing into the socket in sufficient quantity to cause inconvenience in fixing the fuze—and in order to insure the small hole communicating with the powder chamber being clear, shake a few grains of powder *from the powder chamber* into the socket —then replace the fuze hole plug.

Preparing Common and Diaphragm Shrapnel Shell for firing.

Unscrew the plug from the fuze hole by means of the key—insert the fuze, which has been previously prepared for the required range—set the fuze home against a gun carriage.

The fuze should not be uncapped until the shell is placed in the muzzle of the gun; this much reduces the chance of an accident, and secures the priming from injury.

N.B.—The papier mâché wad is driven into the common shell in the operation of fixing the fuze.

Fixing Wood Bottoms.

If the wood bottoms should at any time become loose, place the punch on the head of the rivet, and give it a few smart blows with the hammer."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience of rolling. A reference to the special remarks on No. 3, rifle and smooth-bore garrison, will explain any points not made sufficiently clear by the instructions.

No. 4 Set,

S.B. FIELD, FOR PREPARING SHELL.

One set for each 12-pr. howitzer.

Drifts, wood	common	1
	diaphragm shrapnel, small	1
Driver, screw, diaphragm shrapnel, small		1
Funnels, leather	common, small	1
	diaphragm shrapnel, small	1
Instructions, printed		2
Keys, iron, common plug		2
Punch, iron, riveting bottoms		1

N.B.—Sets already issued or in store are not to be altered.

Filling and securing Common Shell.

"Remove the plug from the fuze hole by means of the key—insert the funnel and pour in the bursting charge—carefully wipe every portion of powder from the fuze hole, and drive in a papier mâché wad, with the drift, as far as the shoulder on the drift will allow—screw in the plug fitted with a leather collar.

Filling and securing Diaphragm Shrapnel Shell.

Remove the plug from the loading hole by means of the screwdriver—hold the shell in a position with the loading hole upwards—insert the funnel and pour in the bursting charge—turn the shell from side to side to facilitate the filling—carefully wipe every portion of powder from the loading hole, and drive in a papier mâché wad with the drift, as far as the shoulder on the drift will allow, and screw in the plug—unscrew the fuze-hole plug, to which is attached a wood plug covered with serge, to prevent the bursting powder from passing into the socket in sufficient quantity to cause inconvenience in fixing the fuze—and in order to insure the small hole communicating with the powder chamber being clear, shake a few grains of powder *from the powder chamber* into the socket —then replace the fuze-hole plug.

Preparing Common and Diaphragm Shrapnel Shell for firing.

Unscrew the plug from the fuze hole by means of the key—insert the fuze, which has been previously prepared for the required range—set the fuze home against a gun carriage.

The fuze should not be uncapped until the shell is placed in the muzzle of the gun; this much reduces the chance of an accident, and secures the priming from injury.

N.B.—The papier mâché wad is driven into the common shell in the operation of fixing the fuze.

Fixing Wood Bottoms.

If the wood bottoms should at any time become loose, place the punch on the head of the rivet, and give it a few smart blows with the hammer."

Special Remarks.—The instructions for this set are printed on calico, with a brass edge for convenience of rolling. A reference to the special remarks on No. 3 set, rifle and smooth-bore garrison, will explain any points not made sufficiently clear by the instructions.

Implements, Naval Shell and Fuze.

Bags, canvas	cylinder, wood, common	1 for each cylinder.
	cylinder, wood, naval	1 for each cylinder.
	hook-borer	1 for each hook-borer.
Bits	hook-borer	6 per hook-borer.
	naval	6 for first 600 $7\frac{1}{2}$ and 20 seconds metal time fuzes, and for every additional 600 or less.
	rivet-hole in wood bottoms	2 per ship, where loose spherical shell are supplied.
Braces, for bits		2 per ship, where $7\frac{1}{2}$ and 20 seconds metal time fuzes are supplied.
Cylinders, wood	common	1 for every 6 hook-borer bits.
	naval	1 for every 6 naval bits and 1 brass stop.
Drifts, wood, common shell		2 per ship, where common spherical shell are supplied.
Extractors, fuze, small		2 per ship, where wood fuzes are supplied.
Funnels, leather, common large		2 per ship, where common spherical shell are supplied.
Hammers		2 per ship, where spherical shell are supplied.
Handles, hook-borer		1 per hook-borer.
Hooks, hook-borer		1 per 6 guns, and not less than 3 per ship; where wood fuzes or $7\frac{1}{2}$ and 20 seconds fuzes are supplied.
Instructions, printed		6 per ship.
Keys, iron	plug and fuze, general service.	3 per ship.
	Armstrong shell and fuze	2 per ship, where E. time fuzes are supplied, and 1, in addition, per gun, using E. time fuzes.

**Levers, mortar and naval* - -	2 per ship.
†Punches, iron, for riveting tops or bottoms.	2 per ship, where spherical shell are supplied.
Rectifiers, naval, for rivet hole -	2 per ship, where loose spherical shell are supplied.
Shields, wood, for bits, for rivet holes.	2 per ship, where loose spherical shell are supplied.
‡Spanners, uncapping $7\frac{1}{2}$ and 20 seconds metal fuzes.	1 per gun with which those fuzes are used.
Stops, brass, naval bit - - -	1 for every 6 naval bits.
**Taps, screw, naval* - - -	2 per ship.
Wires, guide - - - -	2 per ship, where loose spherical shell are supplied.
Wrenches, fixing fuze - -	1 per 6 guns, and not less than 3 per ship, where any $7\frac{1}{2}$ seconds, 20 seconds, or Pettman S.S. fuzes are supplied.
Wrenches, removing plug - -	2 per ship.

* These articles were only introduced to rectify the fuze-holes of empty shell, and are now seldom required.

† Not required for bottoms prepared with two rivet holes only.

‡ The store of old pattern spanners or wrenches for uncapping $7\frac{1}{2}$ and 20 seconds fuzes to be used up for shells riveted to wood bottoms, for which the alteration in the new pattern is not required.

All demands from out-stations for supplies of the above must be in detail, the articles in which there is no change of pattern being used up.

Fixing Wood Bottoms or Tops.

"Unscrew the plug with the wrench—place the shell on a block of wood, rivet holes uppermost—remove the beeswax or grease from the rivet holes—place the bottom or top on the shell—pass the guide wire through one of the rivet holes, and into one of the rivet holes of the shell—withdraw the guide wire—insert a rivet, and fix it slightly by a few smart blows with the hammer—bring the other holes to correspond with those in the shell—insert the remaining rivet or rivets—fix them slightly in the same manner—then rivet all firmly.

If the edges of the rivet holes in the shell are injured, so that the rivets will not enter, insert the rectifier, turning it round until the hole is of the proper dimensions. The rivet-holes in the wood bottoms will also sometimes be found to require clearing, this is done by the bit for that purpose—this bit, when not in use, should be kept in the wooden shield to protect the point.

Filling and securing Shell.

Common and Naval Shell.—Remove the plug from the fuze hole by means of the key—insert the funnel and pour in the bursting charge—carefully wipe every portion of powder from the fuze hole, and drive in a papier mâché wad with the drift, as far as the shoulder on the drift will allow—screw in the plug, fitted with a leather collar.

Diaphragm Shrapnel Shell.—Remove the plug from the loading hole by means of a screwdriver—hold the shell in a position with the loading hole uppermost—insert the funnel and pour in the bursting charge—turn the shell from side to side to facilitate the filling—carefully wipe every portion of powder from the loading hole, and drive in a papier mâché wad, with a drift, as far as the shoulder on the drift will allow, and screw in the plug. Unscrew the fuze-hole plug.

The wood plug covered with serge is attached to the metal fuze hole plug to fill up the socket, and thus prevent the bursting powder from passing into the socket in sufficient quantity to cause inconvenience in fixing the fuze—and in order to insure the small hole communicating with the powder chamber being clear, shake a few grains of powder *from the powder chamber* into the socket—then replace the fuze-hole plug.

Rifle Shell.—The natures of common and segment shell for rifle ordnance which are fitted with the naval fuze hole, require an adapter when the Boxer wood, Armstrong E metal time, or Pettman's general service fuzes are used.

Remove the plug from the fuze hole and screw the adapter firmly in by means of the key; insert the funnel, and pour in the bursting charge—carefully wipe every portion of powder from the fuze hole, and from between the adapter and nose of shell.

Preparing and fixing Fuzes.

Boxer Metal Time Fuzes.—The fuze is prepared for any desired time of flight, by continuing the side hole corresponding to the required time into the composition.

Place the fuze in the hook of the hook-borer in the proper position for boring the required hole—enter the bit into the side hole and work it forward by pressing hard upon the handle, and turning it round at the same time, *until the screw takes the thread in the shank of the hook*, then screw down to the shoulder—take care not to press upon the fuze so as to prevent its bedding fairly in the hook. Unscrew till the screw is relieved from the thread in the shank, then pull straight out, until the bit is clear of the fuze; remove the fuze and place it in the fuze-hole of the shell—then screw it home with the wrench.

The mealed powder fuze should be used when the time of flight is not required to be more than $7\frac{1}{2}$ seconds.

If the 20″ fuze be required for a time of flight less than $7\frac{1}{2}''$, the first 1·4 inch of composition at the top of the fuze should be bored through —a long bit, with a stop, is supplied for this purpose with the fuze implements.

The proper distance of the stop from the point of the bit to bore out 1·4 inch of composition, is 1·94 inch. When the 20″ fuze is prepared in the manner described, 7 must be subtracted from the numbers marked on the fuze, to determine the time of burning:—example, if required to burn 3″, the 10″ hole should be bored, as $10'' - 7'' = 3''$.

As oil cannot be applied to the bit without deteriorating the composition, the operation of boring through the 1·4 inch of composition, must be performed very slowly, and in a place apart from combustible stores. A pail of water should also be at hand in the event of the fuze igniting.

Boxer Wood Time Fuzes for Common and Diaphragm Shrapnel.—The fuze is prepared for any desired time of flight by continuing the side hole corresponding to the required time into the composition.

Place the fuze in the hook of the hook-borer in the proper position for boring the required hole—enter the bit into the side hole and work it forward by pressing hard upon the handle, and turning it round at the same time, *until the screw takes the thread in the shank of the hook*, then screw down to the shoulder—take care not to press upon the fuze so as to prevent its bedding fairly in the hook. Unscrew till the screw is relieved from the thread in the shank, then pull straight out, until the bit is clear of the fuze; remove the fuze and fix it in the fuze hole of the shell by pressing the fuze with the hand and screwing it at the same time.

Before the fuze is placed in the socket of the diaphragm shrapnel shell, care must be taken to remove any superfluous quantity of powder which may have passed into the socket through the communication hole. This is important, because the shell will burst prematurely if the powder in the socket prevent the fuze being securely fixed.

The length of the bit is so regulated, that when placed in the handle, as shown in the drawing, it will enter sufficiently far into the composition when screwed down to the shoulder. If the bit should become unserviceable, the handle must be detached from the shank, and the tightening screw unscrewed—the square hole in the hook being made for this purpose. Care must be taken when substituting another bit that it is properly placed in the handle, *and that the tightening screw firmly presses upon it, for if any space be left between the handle and the head of the bit, the end will not enter a sufficient depth into the composition.* The borer should be occasionally examined and cleaned. The operation of preparing the fuze and fixing it in the shell, takes on an average about 15 seconds; with a little practice these operations may be performed in a shorter time.

The fuzes for common and diaphragm shrapnel must not be uncapped until the shell is placed in the muzzle of the gun. The cap is then removed by giving the tape a sharp pull.—This operation not being performed until the shell is in the bore, much reduces the chance of an accident and renders the fuze less liable to injury from wet.

Boxer Wood Time Fuzes for Rifle Ordnance—The fuze is prepared for any desired time of flight, by means of the hook-borer, in the same way as the fuzes for common and diaphragm shrapnel shell;[1] but in fixing the fuze *neither a mallet nor any other instrument is to be used;* this operation is to be performed simply by *pressing the fuze with the hand and screwing* it at the same time into the bush or adapter.

When the fuze cannot be screwed any farther with the *hand*, it is then properly secured.

Armstrong E Metal Time Fuzes.—The fuze is prepared for any desired time of flight by loosening the metal cap with the iron key supplied for the purpose. The collar may then be turned round until the arrow points to the division on the paper scale corresponding to that time. The cap is then screwed tightly home. When these fuzes are used with adapters they should be first screwed tightly into the adapter, and then inserted into the shell.

Pettman Percussion Fuzes require no preparation. They must be screwed, right-handed, into the shell, by means of the keys provided for the purpose.

Armstrong Percussion Pillar Fuzes.—This fuze is used only with those rifle shells which have the naval fuze hole, and is used without an adapter. It requires no preparation, and should merely be screwed, right-handed, into the shell by means of the key, iron, Armstrong shell and fuze.

Extracting Fuzes.

Boxer Wood Time Fuzes for Rifle Ordnance.—Apply the fuze extractor to the head of the fuze and unscrew—if the adapter comes

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[1] [In firing against earth-works or ships, it is not necessary to prepare the fuze for rifle ordnance, to suit the particular range; as this fuze has been found to act in such cases as a percussion fuze; that is to cause the shell to burst immediately after striking.]

away with the fuze, do not remove the fuze from the adapter by striking it on the end, as a blow in that direction may weaken or break the wire which suspends the hammer in the B. L. fuze.

Boxer Wood Time Fuzes for Common and Diaphragm Shrapnel.—Clear out the cup of the fuze with the projecting piece of metal on the handle of the fuze extractor—take a firm hold of the head of the fuze between the jaws of the fuze extractor and turn from left to right. The small knob between the jaws fits into the cup of the fuze, and prevents the top from collapsing or giving way."

Special Remarks.—The instructions for this set are printed on calico, but not provided with a brass edge, as they are folded, not rolled. Many of the implements issued for naval service are included also in the garrison and field service sets already enumerated, and have been remarked upon in connection with those sets.

The brace is intended for use only in removing the composition of a 20 seconds fuze to enable it to act for a shorter time of flight than $7\frac{1}{2}$ seconds. The "bits, naval," are intended also for the same purpose. Formerly (until the revision of sets in 1865 [1]) short bits were provided for the preparation of the $7\frac{1}{2}$ and 20 seconds fuze by means of a hand-borer (now obselete), or, if desired, in conjunction with the brace.[2] The hook-borer is now alone used for the preparation of these fuzes.

The Armstrong shell and fuze key serves several purposes :—the curved arm is used for screwing or unscrewing the E metal time fuze; the pronged arm is used for loosening, if required, the collar of this fuze; the third arm serves to screw or unscrew the pillar fuze, the fuze-hole plug, or the adapter; the hexagonal hole in the centre of the key is for the nut of the E time fuze.

The punches, iron, for riveting bottoms are not required, as stated in a note, for bottoms attached with two rivets, for which the small end of the hammer is used. But for common and diaphragm shrapnel shells, which have their bottoms attached by one expanding rivet, the punch is used, as in No. 2 set, S. B. garrison. They are also useful for fixing or tightening the top rivets.

The bit, with shield, rivet hole, is intended for rectifying the rivet holes in the wood bottoms of naval (not other) shell. It would also, if desired, serve the same purpose as regards the tops.

The rectifiers, naval, for rivet holes are for rectifying the rivet holes in the *shell*, not in the bottom. They are serviceable with naval shells only.

The "spanner," uncapping $7\frac{1}{2}$ and 20 seconds fuzes, performs one of the functions of the "wrench, fixing fuze." The latter, however, is intended for use in the shell room, where the operations of fixing the fuze, removing the plug, &c. would be performed. The spanner is for use at the gun only, and for the single purpose of uncapping the fuze. Therefore of the latter, one per gun is supplied, of the former only one per six guns. The "taps, screw, naval," are for rectifying the bushes of such shells as may become injured.

The use of the other implements is either obvious or is sufficiently explained in the instructions.

Special attention should be paid to the note that all demands must be in detail. These implements can never be demanded or supplied in a set, as the proportion of the several implements will depend upon the equipment of the vessel.

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[1] 13th May 1865.—*War Office Circular*, 6 (new series), par. 1095.

[2] The brace, however, was rarely, if ever, used for this purpose.

The following Table shows the whole of the implements, shell and fuze, and the sets to which each implement belongs :—

Implements, parts of.

Implements.	Garrison Service.	Field Service.	Naval Service.
	No. of Set.	No. of Set.	If furnished.
Bags, canvas, cylinders, wood, common	4	1	Yes.
Bags, canvas, cylinders, wood, mortar	6	—	—
Bags, canvas, cylinders, wood, naval	—	—	Yes.
Bags, canvas, hook-borer	4	1	Yes.
Bit, hook-borer	4	1	Yes.
Bit, mortar	6	—	—
Bit, naval, long	—	—	Yes.
Bit, rivet hole in wood bottoms	—	—	Yes.
Blocks, wood, 13-inch	5	—	—
Blocks, wood, 10-inch	1, 2, 5	—	—
Blocks, wood, 8-inch	1, 2, 5	—	—
Blocks, wood, 32-pr.	1	—	—
Blocks, wood, No. 2 set, siege	—	—	—
Brace, mortar	6	—	—
Brace, naval	—	—	Yes.
Cylinders, wood, common	4	1	Yes.
Cylinders, wood, mortar	6	—	—
Cylinders, wood, naval	—	—	Yes.
Drifts, wood, common	3	3, 4	Yes.
Drifts, wood, diaphragm shrapnel, large	3	3	—
Drifts, wood, diaphragm shrapnel, small	3	2, 4	—
Drivers, screw, diaphragm, shrapnel, large	3	3	—
Drivers, screw, diaphragm, shrapnel, small	3	2, 4	—
Extractors, fuze, large	5	—	—
Extractors, fuze, small	4	1	Yes.
Funnels leather, with copper spouts, common, large	3, 6	—	Yes.
Funnels leather, with copper spouts, common, small	—	3, 4	—
Funnels leather, with copper spouts, diaphragm shrapnel, large	3	3	—
Funnels leather, with copper spouts, diaphragm shrapnel, small	3	2, 4	—
Gauges, fuze hole, common	1	—	—
Gauges, fuze hole, mortar	5	—	—
Hammer, riveting	2	—	Yes.
Handle, hook-borer	4	1	Yes.
Holder, shell	1, 5	—	—
Hook, hook-borer	4	1	Yes.
Instructions, field, No. 1.	—	1	—
Instructions, field, No. 2.	—	2	—
Instructions, field, No. 3.	—	3	—
Instructions, field, No. 4.	—	4	—
Instructions, garrison, No. 1.	1	—	—
Instructions, garrison, No. 2.	2	—	—
Instructions, garrison, No. 3.	3	—	—
Instructions, garrison, No. 4.	4	—	—
Instructions, garrison, No. 5.	5	—	—
Instructions, garrison, No. 6.	6	—	—
Instructions, garrison, special	—	—	—
Instructions, garrison, naval	—	—	Yes.
Instructions, garrison, 3″ gun	—	—	—
Keys, iron, adapters and plug	3, 4	—	Yes.
Keys, iron, comman plug	—	2, 3, 4	—
Keys, iron, plug and fuze, general service	4	—	Yes.
Keys, iron, shell and fuze, Armstrong's	—	—	Yes.
Keys, iron, square	1	—	—
Keys, iron, Pettman's L.S.	—	1	—
Levers, common	1	—	—
Levers, mortar and naval	5	—	Yes.
Mallets, common and diaphragm	3, 4	—	—
Mallets, mortar	6	—	—
Pricker, removing wax	2	— 4	—
Punch, iron, riveting tops and bottom	2	2, 3,	Yes.
Rectifiers or rimers, common, fuze hole	1	—	—
Rectifiers or rimers, common, rivet hole	2	—	—
Rectifiers or rimers, mortar, fuze hole	5	—	—
Rectifiers or rimers, naval, rivet hole	—	—	Yes.
Screws, coach, 4″ × ½″	1, 5	—	—
Setter, common and diaphragm	4	—	—
Shield, wood, for bit	—	—	Yes.
Spanners, or wrench box	2	—	—
Spanners, uncapping 7½ and 20 seconds fuzes	—	—	Yes.
Stops, brass, for bits, naval	—	—	Yes.
Taps, screw, naval	—	—	Yes.
Taps, screw, Pettman's common	1	—	—
Wire, guide	—	—	Yes.
Wrenches, naval, fixing fuze	—	—	Yes.
Wrenches, removing plug	—	—	Yes.

Special Set for preparing Common Shell for Pettman's Fuzes.

The following tools are issued for this purpose:—

Brackets, iron, with bolts and nuts	1
Cutters, steel	10
Gauges, for fuze hole — recess	1
Gauges, for fuze hole — screw	1
Gauges, for fuze hole — socket	1
Levers for taps	2
Markers for plugs	1
Rimers	1
Pointers, wood	1
Sockets, iron, for braces	1
Spanners	1
Taps, screw	20
Tommies for ratchet braces	1
Braces, iron, ratchet	1
Cans, tin, for oil	1

Special Remarks.—Personal instruction in the use of these tools would generally be required, no attempt is therefore made to describe their application. It is sufficient to say generally that the object of this set is to prepare those common shells which have not the cross cut upon the plug[1] to receive Pettman's fuzes, by deepening and continuing the thread, and if required, by countersinking the fuze hole.

The following information as to the rate at which shells may be prepared with these implements will perhaps be useful.

A strong experienced labourer will screw for Pettman's fuze six shells per hour, or 60 shells in a day of 10 hours, for which he will be paid (in the Royal Laboratory at Woolwich) 4½*d.* per hour. A fair rate for the military would perhaps be four shells per hour.

If the shells are countersunk as well as screwed, the same man will do three shells per hour, for which he receives the same pay; two per hour is as much as could be expected from the military.[2]

After the shells have been altered as required, either by countersinking and screwing or by screwing only, a cross cut should be made upon the plug to indicate that the shells have been prepared.

The special sets of implements exclusively for rifled shells and fuzes are not included here, belonging more properly to Vol. II.

Cases for Implements.

The cases for packing the sets of shell and fuze implements above enumerated are as follows:—

Garrison service,	No. 1 set,	large	1[3]
,,	,,	small	1
,,	No. 2 set,	,,	1
,,	No. 3 set,	,,	1
,,	No. 4 set,	,,	1
,,	No. 5 set,	large	1[3]
,,	,,	small	1
,,	No. 6 set,	,,	1

The whole of the above cases are painted blue for Nos. 1, 2, 3, and 5 sets; red for 4 and 6; they are fitted with hinges and hasps, and closed with a padlock.

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[1] See page 25, note 11, and page 100.

[2] Memo. to Director of Ordnance by Assistant Superintendent, Royal Laboratory, 24/1/65.

[3] These two cases are the same.

Field service, No. 1 set	- - - -	1
" No. 2 set	- - - -	1
" No. 3 set	- - - -	1
" No. 4 set	- - - -	1

These cases are unpainted, and are merely rough deal boxes without hinges or hasps.

The naval implements are issued in deal packing cases as demanded.

HINTS ON THE EXAMINATION OF LABORATORY STORES.

It is impossible to give any precise or exhaustive rules respecting the examination of Laboratory stores, and the following notes on the subject do not pretend to a higher character than that of a few hints as to the leading defects, which should be looked for by those engaged in such an examination.

Moreover, when these defects have been discovered it would always be a question, which can be decided only according to the particular circumstances of each case, whether the stores should be condemned.

Obviously, the rules which apply in the Royal Laboratory at Woolwich on this subject would be of no use on active service, where a very defective article might be better than none at all; and between these extreme limits a variety of cases may be conceived, in which the circumstances being different, the steps to be taken in each must vary accordingly.

In all cases the pattern of the article under examination should be carefully noted;[1] and the question of its condemnation or preservation determined with reference to such orders as may exist on the subject.

All Laboratory stores, such as tubes, fuzes, &c., as may be considered fit for practice, although not good enough for service, are to be marked "Practice only," *War Office Order*, 22/1/64, 75/*General No.* 401. A yellow line is to be drawn across each article, and where this is not possible, *e.g.*, in the case of percussion caps, across the cylinder, &c., in which the articles are packed,[2] 24/4/64, 75/General No. 414.

Smooth-bore Ordnance.

Till within the last ten or twelve years shot and shell were always supplied by contract. The contractor was allowed larger limits of manufacture than are now permitted. Hence it is a question whether shot and shell supplied by contract should be tested by the old or new gauges; for if tested by the new gauges, a very large per-centage will be unserviceable. This question would have to be determined according to the circumstances of each case. Before examining shot and shell, the paint and dirt should be scraped off, those which are serviceable to be repainted. Shot and shell.

Shot and shell are examined with the ring gauges and rejecting wire, and also by hammering those that are freshly cast. Shells are also examined with side and bottom callipers; any that do not stand the test are condemned, in the Royal Laboratory.

All shells and shot that have been fired and subsequently recovered unburst, must be condemned, as they are frequently split.

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[1] All stores manufactured subsequent to 30th December 1865, have a Roman numeral stamped on them to indicate the pattern, in accordance with *War Office Circular* 931 (stores), and *War Office Circular* 7 (new series), para. 1126.

[2] In the Royal Laboratory a practice prevails of painting a similar blue line in the case of obsolete patterns, and this practice may be usefully adopted at out-stations

10-inch common shells must be weighed, and all *exceeding* 85 lbs. must be condemned for use with shell guns, and may be altered for mortar shells.[1]

Case and grape are gauged and examined as to external soundness. If they are worn out, the sand shot, if serviceable, are returned and re-milled. The plates, spindles, &c., of Caffin's grape will generally be repairable.

In examining a quantity of projectiles, distinguish carefully between shell and shot, they are sometimes found mixed, and even shells which have been reported empty should be carefully dealt with, as filled shells are not unfrequently found among them.

Condemned shells before being broken up *should always be drowned with water*, a wedge is then inserted into the fuze hole, and driven in with a sledge hammer.

All diaphragm shrapnel shells issued previous to 1858 to be condemned, the pattern not having been perfected until that date.

Carcasses.

The barras caps which cover the fuze holes should be perfect and secure; if the caps have been removed the quick-match should be looked to. The carcass composition is not much subject to deterioration, and new caps and quick-match (if they have become bad) will render the carcass serviceable they should pass through the gauge.

Light balls.

The woolding and canvas should be perfect, and the iron case and composition show no sign of decay or injury; they should pass through the gauge.

Cannon cartridges.

First examine the serge. If it be moth-eaten condemn it. If the serge be very black the powder has dusted and worked through, in which case the latter has probably deteriorated.

The powder should not be caked. Caking is due to two causes, damp and pressure. If it proceed from the latter cause it can be removed by rolling the cartridge by hand. If from the former the cakes will be very hard, the powder showing white crystals; the powder is then unserviceable.

A certain number should be gauged and measured. The choking, hooping, and sewing should be looked to and should be in good condition.

Empty cannon cartridges of obsolete pattern frequently admit of being cut into smaller sizes. In such cases they are repairable.

Tubes.

If tubes are bent or much indented, in all probability they will be unserviceable from the central hole having become choked. A percentage of the worst should be selected for proof.

They should be carefully examined as to the effects of damp, which will tend to make them sluggish, and in the case of friction tubes to make the bar liable to draw without firing.

If necessary, quill or common metal tubes may generally be easily repaired unless they have become oval in form.

Portfires.

A common portfire should crack crisply on being bent. The paper should exhibit no signs of damp, and should not peel off, which is a sure sign of damp. See if they are painted with oil or spirit paint. The former looks dull, the latter bright and glossy, as though varnished.

Spirit paint was introduced in 1854, as the oil worked through to the composition and injured it. If necessary they can be repainted and reprimed, when they should be bored into; observe the date stamped on them, any above 8 or 10 years of age should be carefully tested by firing.

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[1] *War Office Letter*, 21st July 1862, 75/12/1438.

The "large seam" portfires are dangerous. A certain number should be burned; the time should be from 12 to 15 minutes.

Life buoy portfires. These should be examined for injury and damp, and a proportion burned to time. Old pattern (*i.e.*, without socket for tube) to be condemned or repaired if possible. The plates are always preserved.

Long and signal lights. These should be examined as portfires for injury and damp. The cap should be examined to ascertain that it has not been eaten through by the composition or injured; verdigris is a sign of damp. The priming should not be mildewed.

Fuzes. The best test for all fuzes is to burn and time a per-centage.[1] The cases of metal fuzes are very little liable to deterioration. The quick-match and priming may be a little mildewed, in which case if they burn to time they are repairable. If condemned they are burnt out and the metal utilized.

If wooden fuzes be damp the paper will peel off. In some cases the cap will be eaten through or the tape rotten, or the priming mildewed.

At out-stations unserviceable wooden fuzes are generally burnt, composition and all.

Percussion fuzes may be tested for safety by dropping them in shells from a height, and if possible for efficiency by firing.

Quick-match. The cotton should be thickly coated with powder, stiff and crisp, some should be burned, 1 yard in 13 seconds.

PRINCIPAL SUBSTANCES USED IN LABORATORY COMPOSITIONS.[2]

Antimony, Sulphide of (SbS_3.)

Sources. Grey sulphide of antimony is the commonest ore of that metal, it is found with quartz, iron pyrites, sulphate of baryta, and carbonate of lime, containing as impurities lead and arsenic.

It may be fuzed and also volatilized unchanged in close vessels.

Preparation. The crude antimony of commerce is obtained by melting the ore covered with charcoal in a reverberatory furnace, when the earthy matters present float to the top, the sulphide being run off from the bottom into moulds and afterwards ground to powder if required.

Sulphide of antimony is also got in crystals by heating together a mixture of sulphur and ter-oxide of antimony, sulphurous acid being given off.

If sulphide of antimony be heated in air a ter-oxide and ter-sulphide is the result. Metallic antimony may be obtained at a red heat from the ter-sulphide in a stream of hydrogen.

Besides the common grey form above mentioned, sulphide of antimony exists in a hydrated state, when it is orange in colour; owing to the water present it is unsuitable for laboratory purposes.

Properties. It crystallizes in four-sided striated prisms. It dissolves when heated in hydrochloric or sulphuric acid, evolving sulphuretted hydrogen; it partly dissolves in nitric acid, leaving a white residue.

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[1] See p. 285 respecting times of burning and limits allowed in Royal Laboratory.

[2] These notes have been kindly prepared, at my request, by Capt. C. O. Browne, R.A., Capt.-Instr. Royal Laboratory, with a view to afford a ready reference, when works on chemistry, &c., are not accessible; but they make no pretence to an exhaustive character. Moreover, only the more important substances are dealt with.

The information necessary for the compilation of these notes has been drawn from various sources, among which may be named Miller's Chemistry and Ure's Dictionary, and information has been obtained verbally from Messrs. Abel and Bloxam, as well as from their work.

It plays the part of a sulphur acid, dissolving readily in solutions of alkaline sulphides; it is also soluble in those of the caustic alkalies.

It easily ignites and volatilizes, burning with a bluish white flame.

It detonates on friction or percussion with chlorate of potash.

Uses. Sulphide of antimony is supplied to the Laboratory in the crude state, and is afterwards ground to powder either to pass through the 60 or 120 mesh sieve, according to the purpose for which it is intended.

Application. It is used in—

- Carcasses,
- Stars for rockets,
- Percussion caps (A/64 pattern and Boxer B.L. ammunition),
- Detonating cross-headed tubes,
- Copper and quill friction tubes,
- Pettman's fuzes (detonating composition),
- Boxer's 2″ fuze for B.L. rifled ordnance (detonating composition),
- Pillar fuze (detonating composition).

Its flame in burning is its recommendation for carcasses and stars, and also for the new pattern A /64 caps, which from their long flash are suited to the nipples of either muzzle-loading or breech-loading small arms. The sulphide of antimony, by retarding the action of the composition, reduces its violence without affecting the strength of the cap.

With chlorate of potash it forms a detonating composition which is less sensitive than chlorate or potash and sulphur, for which reason it is preferred to the latter in the detonating compositions above mentioned.

Arsenic, Bisulphide of, Red Orpiment, Realgar (AsS_2).

Sources and preparation. This substance is found in nature crystallized in oblique rhombic prisms; it may be prepared by fusing arsenic or arsenious acid with sulphur.

In closed vessels realgar melts and distils unchanged.

Properties. It is a soft mineral of a fine brown red colour, insoluble in water and hydrochloric acid, but dissolved in nitric acid and aqua regia, also in a solution of sulphide of potassium; it is decomposed by one of caustic potash.

Uses. It burns with a bright white flame. Its chief uses are as a pigment and, in pyrotechny, in "Indian fire," &c.

In the Royal Laboratory it is used for the sake of its brilliant white flame in the Boxer parachute and long and signal lights.

Copper, Subsulphide and Subphosphide of.

Sources and preparation. Subsulphide (Cu_2S) and subphosphide (Cu_2P) of copper are both prepared in the Chemical Department, Royal Arsenal. They are obtained by heating copper in vapour of sulphur and phosphorus respectively, the masses obtained being ground to fine powder, in both cases of a grey colour.

Use. They are only used in the Laboratory in Abel's electric tube and fuze in conjunction with chlorate of potash, the subsulphide being here the combustible ingredient and the subphosphide the conducting body.

Mercury, Fulminate of.

Preparation. Fulminate of mercury ($2HgO,C_4N_2O_2$) is a salt of mercury with fulminic acid prepared as follows:—

Dissolve mercury in concentrated nitric acid (sp. gr. 1·42) in the proportion of 25 grains of the former to half an ounce of the latter, then add alcohol (sp. gr. 0·87) in the proportion of 5 drams, quickly and carefully. Almost immediately a very violent and remarkable action commences, dense clouds of nitrous ether distilling off and rolling over the edges of the vessel, giving a strong smell resembling that of Rennet apples; as this action subsides add water and finally pour off the liquid. Collect the precipitate on a filter, wash till no longer acid, and dry. It is obtained in the form of small sparkling brownish grey crystals.

Properties. It explodes on a blow, the action being very sudden and violent, though less so than that of fulminate of silver; it is rendered more sensitive by the addition of quartz or glass, and if screwed up in paper like a fulminate of silver "cracker" it forms a silent exploder or "flasher."

On explosion carbonic oxide, nitrogen, and mercury vapours are given off.

Contact with concentrated sulphuric or nitric acid causes explosion.

It is very unsafe to handle when dry.

Uses. Fulminate of mercury is used in all cap compositions and in the detonating composition for the Boxer 9 sec. and 20 sec. B.L., R.O. fuzes in conjunction with chlorate of potash, &c., on account of its detonating properties.

Potash, Nitrate of, Nitre, Saltpetre. (KO, NO_5.)

Sources and preparation. Is a natural product in some countries, as India, Arabia, and South America, where it occurs as an efflorescence on the surface of the soil, or disseminated through the superficial stratum of the earth. It is also found in the same condition in certain caverns where animal matter has decomposed in Ceylon, France, and Germany.

It is obtained in the form of "grough nitre," by lixiviating the soil and allowing the solution from it to crystallize, the chief impurities being lime, magnesia, soda, and ammonia, present as nitrates, sulphates, and chlorides.

Where there has been no supply of the natural product, as in Sweden and Prussia, it has been obtained artificially from beds formed of manure and decaying animal matter, built up with lime rubbish and ashes, moistened from time to time with urine. The impurities in the nitre thus obtained are much the same as in the natural product.

The chemical actions taking place in the formation of nitre have been explained by Davy, Kuhlmann, and others, but are still only imperfectly understood. It is sufficient here to mention that in the case of organic origin, the oxidation of the ammonia in the presence of moisture during putrefaction gives nitric acid; this action being much favoured by the presence of potash, lime, or any base (generally as a carbonate) which is predisposed to combine with the nitric acid as a nitrate.

Where there may be little or no organic matter present, as in some cases of natural formation on the soil, the action is less understood, but has been attributed to the power of the soil to condense gases in its pores, causing the oxygen and nitrogen of the atmosphere to combine as nitric acid with the strong bases present.

The various nitrates obtained by either natural or artificial means may be converted into nitre by treating the whole with lime, which takes the place of the soda, ammonia, and magnesia, leaving nitrates of potash and lime.

The addition of carbonate of potash will now give carbonate of lime as a precipitate, and a solution of nitrate of potash.

Purification. The purification of grough nitre is commonly effected by virtue of the difference of its solubility in hot and cold water being greater than that of chloride of potassium, and most of the impurities present. It is as follows :—A strong solution of nitre is evaporated down to a small bulk; while cooling, the solution is constantly stirred to obtain only small crystals, which are ladled out and drained.

Nitre crystallizes in characteristic prismatic crystals, which have a cooling saline taste; it deflagrates if heated in presence of combustible matter.

Nitre is extracted from damaged composition as follows :—100 lbs. of composition is boiled with about eight or nine gallons of water (that is, 80 or 90 lbs. of water); as soon as it boils it is filtered into pans through bags of Osnaburg, previously soaked in hot water to close the pores; the first portion coming through is discoloured, and requires to be poured back into the unfiltered liquor. When it has all run through clear it is passed into crystallizing pans, where it cools; if not strong enough to crystallize it is added in place of water to the next "boil;" the crystals finally obtained are washed with distilled water.

The mother liquor may either be reduced in bulk by evaporation, and so made to give up more crystals, until 85 or 95 per cent. of the petre in the composition be recovered, or, as is generally done, may be added to the next boil after each crystallization until it gets "high," as it is termed, and yellow coloured, when it is thrown away.

Tests for impurities.

A solution of nitre may be tested for impurities as follows :—

Chlorides give a white precipitate on adding nitrate of silver.

Sulphates, a white precipitate with chloride of barium.

Lime, a white precipitate with oxalate of ammonia.

Properties.

The value of nitre generally in laboratory compounds consists in its oxidizing power; it contains a large proportion of loosely combined oxygen, which, when brought to a certain temperature in presence of carbon, generates carbonic acid and oxide gases independently of the oxygen of the atmosphere.

This may take place so rapidly as to give explosive effects. The chief reasons for preferring it in certain preparations to similar compounds are—

1. Its gradual but rapid action.
2. It does not ignite on percussion except in the presence of phosphorus.
3. It is reasonably cheap

Saltpetre is used in the laboratory in two states:

1. Ground.
2. Pulverized.

The ground is supplied from Waltham Abbey ready for use, that is, in sufficiently fine powder to pass through an 80 mesh sieve.

The pulverized is manufactured from masses of refined saltpetre, sent also from Waltham Abbey.

The process is as follows :—

Small lumps of saltpetre, and water in the proportions of 16 lbs. of petre to one gallon of water, are placed in a copper vessel over a charcoal fire and evaporated to dryness; when at about the consistency of thick paste, wooden paddles shod with gun metal are used to stir it continually; it is removed from the fire from time to time for more thorough working with the paddles.

When dry it should be in a sufficiently fine state of division to pass through a 60 mesh sieve.

This method is obviously expensive and tedious; it was first adopted when there was no sufficient method of grinding saltpetre to fine powder of even texture; further, should any of the mother liquor be retained in any of the interstices between the large crystals adhering together, any impurities contained in it not being volatile would be retained throughout the operation, and would be present in the product; practically, however, it is pure.

Application to rockets.

The operation, in spite of its disadvantages, is still followed for the saltpetre used in rockets, because, 1st, pulverized saltpetre is given in the specification; and 2nd, owing to the ground saltpetre burning somewhat more rapidly, its substitution would possibly necessitate an alteration in the details of construction of the rocket.

Application of ground saltpetre.

Application to—

- Carcasses.
- Light balls { Ground. / Parachute.
- Smoke balls.
- Lights { Long. / Signal.
- Portfires { Common. / Blue or slow. / Miner's. / Coast-guard. / Life buoy.
- Stars for rockets.
- Fuzes.

Its use in the above is to supply oxygen, and enable the ingredients to burn independently of atmospheric action, and thus to give out the light, heat, or smoke required.

Potash, Chlorate of, (KO,ClO_5)

Preparation.

Chlorate of potash is prepared in two ways. 1st, by passing chlorine to saturation through a concentrated solution of potash or its carbonate; in cooling the chlorate of potash crystallizes out. 2nd, by passing chlorine through a damp mixture of 76 parts carbonate or sulphate of potash to 168 hydrate of lime, the mass being treated with boiling water, and chlorate of potash crystallized out.

Properties.

The crystals are anhydrous and colourless; being either thin and tabular or needle-shaped, they are unaltered by exposure to air; they have a cooling saline taste, like that of nitre.

On application of heat they decrepitate and fuze easily, evolving oxygen.

Chlorate of potash is still more powerful as an oxidizing agent than nitrate of potash; like it, deflagration occurs on heating with combustible matter, the action being still more sudden and violent; it detonates also on friction or percussion with amorphous phosphorus, but unlike nitrate of potash, it detonates with sulphur, sulphide of antimony, and various metals and metallic sulphides, besides some organic substances

Lastly, if mixed with sugar it may be ignited by sulphuric acid.

Uses.

From the above properties its suitability, or it might almost be said its necessity, as an ingredient in most detonating compositions is evident, and with reference to its use with sugar and sulphuric acid for ignition of a charge, may be instanced the fougasses used by the Russians in the defence of Sebastopol, where the acid was placed in a glass tube, contained in one of thin metal, just beneath the surface of the ground; when trodden on the metal bent, the glass broke, and the sulphuric acid running down fired the charge.

Or, as being more immediately connected with laboratory matters, may be instanced the method of ignition sometimes adopted for coast-guard portfires, and described at page 216, when a glass globule containing sulphuric acid is embedded in chlorate of potash and sugar.

In the Royal Laboratory, chlorate of potash is used for—

Quill detonating tubes.
Copper and quill friction tubes.
Pettman's fuzes.
Boxer's 2″ fuze for B.L. rifled ordnance.
Pillar fuzes.
Pellet of E time fuze.
C percussion fuzes of all patterns.
Metford's bullet.
Caps of all descriptions.
Electric tubes and fuzes.

Its detonating properties before mentioned have caused its application to the whole of the above, except in the case of electric tubes and fuzes, where it is used as an oxidizing agent to enable the subphosphide and subsulphide to burn, the peculiar balance of properties of this composition being explained at page 210, note 5.

Rosin.

The class of resinous substances is an extensive one, embracing lac-balsams, gum amber, india-rubber, and gutta-percha.

Common rosin or colophony is that particular resin which is obtained from the turpentine of the pine in which it is held in solution, by distillation with water, 75 or 90 per cent of the turpentine being left as a residue, which is the rosin, the volatile portion being the essence or oil of turpentine.

Sources.

In the market it may be obtained as brown or white rosin, each formed of two resinous acids.

It is sparingly soluble in cold and even in hot water, but is dissolved in turpentine, wood naphtha, and spirits of wine, to form various varnishes.

It is used in the Laboratory in—

Properties.

Carcasses.
Ground light balls.
Kit composition.
Lacquer for inside of shells.

Uses.

In carcasses and light balls its function is to form an inflammable cement, binding the composition into a strongly cohesive mass.

Its use in kit and lacquer is the same as in varnish, the volatile solvent passing off, and the rosin with other ingredients being left as a solid coat on the side of the shell.

Shell-lac or Shellac.[1]

Is a resin produced by a small insect about the size of a louse, called *coccus lacca* or *ficus*, from the branches of certain trees which grow in Siam, Assam, Pegu, Bengal, and Malabar.

The insects on being hatched in November or December settle upon the branches of the trees, and in time produce small nipple-like encrustations upon the twigs, their bodies being apparently glued by means of a transparent liquor, which goes on increasing to the end of March so as to form a cellular texture. At this time the animal resembles a small oval bag without life, of the size of cochineal; ultimately eggs are

[1] Shell-lac is no doubt the correct name, the prefix shell being adopted in contradistinction to stick and seed-lac. But the spelling shellac is convenient and is commonly adopted.

deposited, and when the young insects are hatched they come forth leaving empty cells upon the branches. The twigs encrusted with this cellular substance constitute the stick-lac of commerce.

In some cases, as in the stick-lac of Siam, the encrustation is sometimes a quarter of an inch thick. The Bengal stick-lac has a much thinner and less regular encrustation. But in all cases the character of the cellular substance is the same ; it is of a red colour, more or less deep, nearly transparent, and hard, with a brilliant conchoidal fracture, and is composed mainly of an inodorous common resin, a resin insoluble in ether, colouring matter analogous to that of cochineal, balsamic, and fatty matters.

When the resinous concretion is taken off the twigs, coarsely pounded, and triturated with water in a mortar, the greater part of the colouring matter is dissolved, and the granular portion which remains being dried in the sun constitutes seed-lac.

In India the seed-lac is put into oblong bags of cotton cloth, which are held over a charcoal fire by a man at each end, and as soon as it begins to melt, the bag is twisted so as to strain the liquefied resin through its substance and to make it drop upon smooth stems of the Banyan tree. In this way the resin spreads into thin plates and constitutes the substance known in commerce as shell-lac.[1]

The palest and finest shell-lac is brought from the Northern Circar.

Shell-lac[2] by Mr. Hatchell's analysis contains,—

Resin	90·5	in 100 parts.
Colouring matter	0·5	
Wax	4·0	
Gluten	2·8	
Loss	1·8	

Shell-lac dissolved in methylated spirits of wine is used extensively in the Royal Laboratory for varnishes of different descriptions, the evaporation of the spirit leaving a brown, translucent, hard, brittle resin, of a delicate character.

It is also used, dissolved in spirits, for damping various detonating compositions, and in some cases, as in the detonating balls of Pettman's percussion fuzes, acts usefully as a sort of glue (after the evaporation of the spirit) in causing the composition to adhere to the metal.

Spirits, Methylated.

Methylated spirit consists of alcohol (C_4H_5O, HO) of specific gravity ·83 mixed with 10 per cent. wood spirit or methylic alcohol (C_2H_3O, HO), which is one of the products of the destructive distillation of wood, the object of the latter ingredient being to render the spirit so nauseous as to preclude the possibility of the men drinking it who might have to deal with it in the manufacture of the compounds in which it is used, while at the same time the properties required in the alcohol were not interfered with, these properties being,—

1st. That of a volatile solvent in varnishes and shellacs.

2nd. That of a vehicle for making dry compositions temporarily into a soft cohesive paste in the Pettman and Armstrong pillar E. and C. pattern fuzes and their modifications (Freeth's C. pattern fuze excepted), and in tube compositions and primings.

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[1] Sometimes called gum shell-lac. This appears unnecessary, since the shell-lac is a distinct substance not likely to be confounded with others.

[2] Col. Boxer in his MS. notes says, "Shellac in the state of an impalpable powder "may be used with great advantage in those compositions which are employed to "produce coloured fires" (p. 6).

It is supplied to the Royal Laboratory by contract on special permission, the sale of the article, duty free, being now prohibited, owing to a plan having been discovered by a M. Eschwege of rendering the wood spirit palatable ; the spirit so treated excited much interest in the International Exhibition of 1862.

Sulphur (S.)

Is found in its purest state in Sicily as native sulphur, either crystallized (form octahedron with rhombic base) or amorphous.

It is also found in great abundance as iron pyrites and copper pyrites, from these it is difficult to obtain it free from arsenic and other impurities.

It is met with commercially in two states,—

1st. In pale yellow powder as "flowers of sulphur."

2nd. In yellow sticks, &c. as "roll sulphur" or brimstone.

Properties. Sulphur is insoluble in water, but is (generally speaking) soluble in bi-sulphide of carbon. It is tasteless. It is a non-conductor of heat and electricity.

It burns at about 450° Fahr. with a blue flame, giving off fumes of sulphurous acid (SO), it melts at 239°, and distils at about 824° Fahr. It detonates on friction or percussion with chlorate of potash.

In its combination with metals it resembles oxygen, forming sulphur bases and acids.

Extraction. Native sulphur is purified by distillation from the earthy matters found with it, first roughly before exportation, and before use, more carefully in iron retorts, the sulphur condensed slowly in a chamber at a low temperature forming "flowers" or "sublimed sulphur ;" that at a high temperature, which is allowed to run down liquid, after distillation is passed into moulds and set, becoming "roll sulphur," from which is made "ground sulphur." Of these two sorts of sulphur the sublimed is the purer but the more expensive article.

Sublimed ground sulphur.

Iron pyrites is chiefly used for manufacturing sulphuric acid.

Sulphur exists in certain solid and in one semi-liquid or viscous condition ; it will here be sufficient to mention two forms, one crystalline and the other viscous, the former being entirely and the latter only partially soluble in bi-sulphide of carbon, they are known respectively as soluble and insoluble sulphur.

General uses. The chief uses of sulphur in the Laboratory are,—

1st. To enable a composition to inflame at a lower temperature.

2nd. To give out greater heat while burning, this increased heat causing the action to be both more rapid and more powerful.

3rd. For ignition by friction or percussion in conjunction with chlorate of potash.

Ground sulphur is used in,—

- Carcases.
- Ground light balls.
- Coast-guard portfire.
- Slow composition of life buoy portfire.

Sublimed sulphur in,—

- Parachute light balls.
- Common portfire.
- Miner's portfire.
- Quick composition, life buoy portfire.
- Long and signal lights.
- Fuzes.
- Rockets, war and signal.
- Stars for rockets.
- Copper and quill friction tubes.
- Pettman's fuzes.
- Metford's percussion bullet.

In carcasses the increased heat and violence due to the presence of sulphur adds to the incendiary power, also by enabling it to burn at a lower temperature the sulphur renders it less liable to be extinguished by pouring water over it, the action of water arising from its great specific and latent heat which cause it to absorb the heat of the burning mass to such an extent as to bring its temperature below that of possible combustion.

The latter use of sulphur makes it specially valuable in the composition of the life buoy portfire.

The same recommendations apply to light balls, the first not perhaps directly, but as fitting them to some extent for incendiary purposes if required.

In lights, portfires, fuzes, and rockets, sulphur facilitates the ignition and burning, the former being its office on the wood of a lucifer match.

The use of sulphur in the detonating composition of friction tubes of Pettman's fuzes, and also in that of Metford's bullet, is mainly for ignition by friction and percussion with chlorate of potash, although the other recommendations hold good to a certain extent.

LIST OF TABLES OF DIMENSIONS.*

* These Tables do not profess to contain all the dimensions of the various Laboratory stores. A large number of dimensions are given in the plates; sometimes, as in plates 20, 21, 22, 34, 38, &c. in a tabular form; but in the majority of instances they are figured against the stores themselves.

SMOOTH-BORE ORDNANCE.

Table I.—Shot, Solid, Cast-Iron, and Steel.*

Dimensions, &c.		Nature.											
		150-pr.	100-pr.	68-pr.	56-pr.	42-pr.	32-pr.	24-pr.	18-pr.	12-pr.	9-pr.	6-pr.	3-pr.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter	Greatest - - -	10·42	8·92	7·95	7·51	6·795	6·207	5·639	5·124	4·54	4·117	3·585	2·838
	Mean - - -	10·4	8·9	7·925	7·48	9·765	6·177	5·6115	5·099	4·5225	4·1	3·568	2·823
	Leas - - -	10·38	8·88	7·9	7·45	6·735	6·147	5·584	5·074	4·505	4·083	3·551	9·808
Rejecting wire - - -		·04	·04	·04	·04	·04	·03	·03	·03	·03	·03	·03	·03
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Average weight - - -		150 3½	93 8¾	66 3½	55 8¾	41 6¾	31 6	23 8¾	17 11¾	12 4¼	9 4¼	6 0¼	2 15¾

* Steel shot are made only for the 150-pr., 100-pr., and 68-pr. guns. Their dimensions are the same as those of the cast-iron shot of these calibres.

Table II.—Smooth-bore Ordnance.—Shot, Sand.

Dimensions.		Description.														
		4 lb.	3 lb.	2 lb.	1½ lb.	1 lb.	13⅛ oz.	8 oz.	6½ oz.	6 oz.	5 oz.	4 oz.	3¼ oz.	3 oz.	2 oz.	1½ oz.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter	Greatest -	3·1	2·81	2·46	2·23	1·95	1·83	1·55	1·48	1·4	1·34	1·23	1·16	1·12	0·98	0·88
	Mean -	3·075	2·79	2·44	2·215	1·935	1·815	1·535	1·465	1·385	1·325	1·215	1·145	1·11	0·97	0·87
	Least -	3·05	2·77	2·42	2·2	1·92	1·8	1·52	1·45	1·37	1·31	1·2	1·13	1·1	0·96	0·86

TABLE III.—SMOOTH-BORE ORDNANCE.—SHOT, CASE.

Nature of Ordnance.	Shot. Weight of each.	Shot. Total No.	Top Plate. (No. 8 Plate-iron.) Diameter.	Top Plate. Thickness.	Case. Description of Metal. Tin Plate.	Case. Description of Metal. Iron Plate.	Case. Depth.	Case. Diameter.	Wood Bottom. Distance beyond the Case.	Total Weight.	Remarks.
	Oz.		In.	In.			In.	In.	In.	Lbs. oz.	
Iron Guns 100-pr.	16	91	8·7	·165	-	No. 16 W.G. ·065″	11·25	8·88	—	100 0	Iron handle.
Iron Guns 10-in. Pat. I.	16 / 13⅓	34 / 50 } 84	9·705	·165	XX D / XXXX S	—	7·05	9·82	—	80 5	Rope handle.
Iron Guns 10-in. Pat. II.	,,	,,	9·705	·165	-	No. 18 W.G.	7·4	9·82	—	82 0	Iron handle.
Iron Guns 8-in. or 68-pr. Pat. I.	8	90	7·7	·165	XX D / XXX S	—	7·6	7·82	—	48 3	Rope handle.
Iron Guns 8-in. or 68-pr. Pat. II.	8	90	7·7	·165	-	No. 18 W.G.	7·4	,,	—	50 8	Iron handle.
Iron Guns 56-pr.	16	50	7·33	·165	XX D	—	9·6	7·45	—	52 9¾	Rope handles.
Iron Guns 42-pr.	8	84	6·594	·165	XXX S	—	8·7	6·735	—	44 6½	
Iron Guns 32-pr. Pat. I.	8	66	6·02	·165	XX D / XXX S	—	8·65	6·147	—	34 13	
Iron Guns 32-pr. Pat. II.	8	66	6·02	·165	-	No. 18 W.G.	8·6	6·147	—	36 12	Iron handle.
Iron Guns 24-pr.	8	46	5·44	·165	XX D / XXX S	—	7·6	5·57	—	24 12½	Rope handles.
Iron Guns 18-pr.	6	46	4·96	·165	,,	—	7·6	5·074	—	19 0½	
Iron Howitzers 10-in.	8	170	9·705	·165	XX D / XXXX S	—	8·5	9·82	—	89 0¾	
Iron Howitzers 8-in.	2	258	7·7	·165	XX D / XXX S	—	5·3	7·82	—	34 12½	
Iron Carronades 68-pr.	8	90	7·7	·165	,,	—	7·1	7·82	—	48 1¼	
Iron Carronades 42-pr.	8	66	6·594	·165	XXX S	—	7·1	6·735	—	35 6¼	
Iron Carronades 32-pr.	8	40	6·02	·165	XX D / XXX S	—	5·7	6·147	—	22 1½	
Iron Carronades 24-pr.	8	32	5·44	·165	X D / XXX S	—	5·6	5·57	—	17 11¼	
Iron Carronades 18-pr.	6	31	4·96	·165	,,	—	5·2	5·074	—	13 3¾	
Iron Carronades 12-pr.	4	32	4·34	·165	XX S	—	4·7	4·432	—	9 2	
Bronze Guns 12-pr.	6⅔	41	—	—	X S	—	8·4	4·432	1·0	16 15¼	Without handles.
Bronze Guns 9-pr.	5	41	—	—	,,	—	7·4	4·66	0·75	13 9	
Bronze Guns 6-pr.	3¼	41	—	—	,,	—	6·5	3·532	0·75	8 5¾	
Bronze Guns 3-pr.	1⅓	41	—	—	,,	—	5·25	2·808	0·75	4 7	
Bronze Howitzers L.S. 32-pr.	3¼	105	—	—	XX D / XXX S	—	5·75	6·147	0·45	21 7	Rope handle.
Bronze Howitzers L.S. 24-pr.	2	100	—	—	X D / XXX S	—	4·25	5·57	1·175	13 13	Without handles.
Bronze Howitzers L.S. 12-pr.	2	56	—	—	XX S	—	4·15	4·432	0·9	7 13½	
Bronze Howitzers L.S. 5½-in.	2	100	—	—	X D / XXX S	—	4·25	5·57	3·0	13 15¾	
Bronze Howitzers L.S. 4⅖-in.	2	56	—	—	XX S	—	4·15	4·432	2·2	8 0¾	
Bronze Howitzers S.S. 24-pr.	8	30	—	—	X D / XXX S	—	5·55	5·57	1·2	16 9	
Bronze Howitzers S.S. 12-pr.	8 / 4	15 / 3 } 18	—	—	XX S	—	4·65	4·432	0·9	9 3¾	

Note.—The 100-pr. and Patterns II. of 10 and 8-inch and 32-pr. have both ends iron.

Table IV.—Smooth-bore Ordnance.—Shot, Grape.

Nature of Ordnance.	Shot.				Plates.				Tampion.		Case.		Total Weight.	
	Weight of each.	Number in a Tier.	Number of Tiers.	Total Number.	Number of Wrought Iron.	Number of Cast Iron.	Diameter.	Thickness.	Length.	Thickness.	Depth.	Diameter.		
	lb.						Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	lb.	oz.
Iron, Guns, *10-inch -	3	8	3	24	2	—	9·592	·165	—	—	8·1	9·82	81	7
Iron, Guns, 8-inch or 68-pr.	3	5	3	15	1	3	7·82	·5063	10·375	·75	—	—	65	9
Iron, Guns, 56-pr. -	4	4	3	12	1	3	7·45	·5063	11·25	·75	—	—	69	7
Iron, Guns, 42-pr. -	4	3	3	9	1	3	6·735	·5	10·5	·5	—	—	48	11
Iron, Guns, 32-pr. -	3	3	3	9	1	3	6·147	·5	9·37	·5	—	—	36	12
Iron, Guns, 24-pr. -	2	3	3	9	1	3	5·57	·375	8·375	·5	—	—	25	3
Iron, Guns, 18-pr. -	1½	3	3	9	1	3	5·074	·3125	7·375	·5	—	—	18	13
Iron, Guns, 12-pr. -	1	3	3	9	1	3	4·402	·3125	6·375	·375	—	—	12	15
	oz.													
Iron, Guns, 9-pr. -	13⅛	3	3	9	1	3	4·06	·25	6·127	·3125	—	—	10	12
Iron, Guns, 6-pr. -		3	3	9	1	3	3·532	·165	5·25	·3125	—	—	6	11
	lb.													
Iron, Carronades, *68-pr. -	3	5	3	15	1	—	7·7	·165	—	—	7·87	7·82	46	8¼
Iron, Carronades, *42-pr. -	4	3	3	9	1	—	6·594	·165	—	—	8·5	6·35	38	8¼
Iron, Carronades, *32-pr. -	3	3	3	9	1	—	6·02	·165	—	—	7·6	6·147	28	3¾
Iron, Carronades, *24-pr. -	2	3	3	9	1	—	5·44	·165	—	—	6·4	5·57	18	9¾
Iron, Carronades, *18-pr. -	1½	3	3	9	1	—	4·96	·165	—	—	6·0	5·074	14	6¾
Iron, Carronades, *12-pr. -	1	3	3	9	1	—	4·34	·165	—	—	5·4	4·432	10	0

* Grape for the 10-inch gun is packed in an iron cylinder, with plate-iron end and top, with an iron handle; and, for carronades in tin cylinders with a tin end, plate-iron top, and rope handle.

TABLE V.—SMOOTH-BORE ORDNANCE.—SHELLS, COMMON, NAVAL, MORTAR, AND HAND GRENADES.

Description and Nature.	Diameter of Shell.			Rejecting Wire.	Thickness of Metal.			Fuze Hole.									Rivet Hole.		Average Weight.	
								Diameter.			Depth.		Screw.		Bush.					
									Below countersunk Portion.											
	Greatest.	Least.	Mean.		Greatest.	Least.	Mean.	Countersunk Portion.	Top.	Bottom.	Countersunk Portion.	Below countersunk Portion.	Depth.	No. of Threads per Inch.	Diameter (Interior).	Depth.	Diameter.	Depth.	Empty, with Gun-metal Plug.	With Wood Bottom or Top, Gun-metal Plug, and approximate bursting Charge.
	Inch.	Inch.	Inch.	In.	Inch.	Inch.	Inch.	In.	Inch.	Inch.	In.	Inch.	Inch.	In.	Inch.	In.	In.	In.	lb. oz. dr.	lb. oz. dr.
Common. 10-inch	9·88	9·82	9·85	·05	1·45	1·25	1·35	1·32	High, 1·034 Low, 1·024 (rows 10-inch to 18-pr.)	0·88	·175	1·175	1·175	14	—	—	·4	·125	77 13 5	85 7 14
Common. 8-in. or 68-pr.	7·9	7·82	7·86	·04	1·524	1·256	1·39	1·32		0·875	·175	1·215	1·215	14	—	—	·4	·125	46 13 6	50 4 2
Common. 56-pr.	7·51	7·45	7·48	·04	1·375	1·125	1·25	1·32		0·89	·175	1·075	1·075	14	—	—	·4	·125	38 15 10	42 1 10
Common. 42-pr.	6·795	6·735	6·765	·03	1·235	1·029	1·132	1·32		0·902	·175	0·957	0·957	14	—	—	·4	·125	28 12 15	31 1 2
Common. 32-pr.	6·207	6·147	6·177	·03	1·137	0·931	1·034	1·32		0·913	·175	0·859	0·859	14	—	—	·4	·125	21 14 14	23 11 11
Common. 24-pr. or 5½-in.	5·62	5·57	5·595	·03	1·029	0·843	0·936	1·32		0·925	·175	0·761	0·761	14	—	—	·4	·125	16 1 15	17 6 15
Common. 18-pr.	5·124	5·074	5·099	·03	0·938	0·768	0·853	1·32		0·937	·175	0·628	0·628	14	—	—	·4	·125	12 5 8	13 8 1
Common. 12-pr. or 4⅖-in.	4·476	4·432	4·454	·03	0·82	0·672	0·746	1·32	1·225*	1·225*	·175	0·571	0·571	14	H. 1·024 L. 1·023	1·6	·4	·125	8 0 12	8 14 14
Naval. 150-pr.	10·42	10·38	10·4	·05	1·75	1·65	1·7	1·6	1·45*	1·35	·185	1·515	1·04	16½	1·23	1·0	·25	·3	104 8 0	114 10 11
Naval. 100-pr.	8·92	8·88	8·9	·04	1·54	1·46	1·5	1·6	1·45	1·35	·185	1·315	1·04	16½	1·23	1·0	·25	·3	66 3 0	72 8 3
Naval. 10-in.	9·88	9·82	9·85	·05	1·45	1·25	1·35	1·6	1·45*	1·35	·185	1·65	1·04	16½	1·23	1·0	·25	·3	77 1 8	54 12 5
Naval. 8-in. or 68-pr.	7·95	7·9	7·925	·04	1·45	1·25	1·5	1·6	1·45*	1·35	·185	1·65	1·04	16½	1·23	1·0	·25	·3	47 1 11	50 17 15½
Naval. 32-pr.	6·207	6·147	6·177	·03	1·137	0·931	1·034	—	1·45*	1·35	1·034 §		0·85	16½	1·23	0·85	·25	·3	21 10 2	23 7 2
Mortar. 13-in.	12·88	12·8	12·84	·05	2·36	1·932	2·146	—	1·484†	1·25	2·146 §		Roughed with a screw tap of 14 threads to the inch. (rows 13-in. to 8-in.)						196 9 0	‖207 1 0
Mortar. 10-in.	9·88	9·82	9·85	·05	1·81	1·482	1·646	—	1·484†	1·309	1·646 §								88 9 0	‖93 9 0
Mortar. 8-in.	7·9	7·82	7·86	·04	1·524	1·256	1·39	—	1·411†	1·259	1·39 §								45 11 0	‖47 15 0
Hand grenades land or 3-pr.	2·778	2·738	2·758	·03	·399	·359	·379	—	·6775‡	·634‡	·445 ‡								1 10 0	‖1 11 12
Hand grenades sea or 6-pr.	3·496	3·456	3·476	·03	·485	·445	·465	—	·6775‡	·634	·515 ‡								3 9 0	‖3 13 0

*** 10-inch common shell in store which do not *exceed* 85 lb. may be admitted for service, and all which are 85 lb. and upwards to be altered to mortar shells.—*War Office Letter*, 21st July 1862, 75/12/1438.

* Before bushing. † Not countersunk, but finished diameter of fuze hole. ‡ Mean measurement, fuze hole neither roughed nor countersunk.

§ Not countersunk, but total depth of fuze hole.

‖ The weight of filled mortar shells and hand grenades is of course given without wood bottom or metal plug, which are not used with these projectiles.

TABLE VI.—SMOOTH-BORE ORDNANCE.—SHELL, DIAPHRAGM SHRAPNEL.

Nature.	Diameter of Shell.		Rejecting Wire.	Thickness of Metal.				Socket Hole screwed.		Socket.					Distance between Bottom of Socket Hole and Top of Diaphragm.	Loading Hole.		Rivet Hole.		Bullets, Number of.					Weight, filled with Ball.	
				At Bottom.		At Side.				Interior Diameter for Fuze.			Length (Interior).	Screw												
										Top.		Bottom.		No. of Threads per Inch (Interior.)												
	Greatest.	Least.		Greatest.	Least.	Greatest.	Least.	Diameter.	Depth.	High.	Low.					Diameter.	Distance from Fuze Holes.	Diameter.	Depth.	Musket.	Carbine.	Pistol.	Buck.	Total.	Without Metal Plug, Wood Bottom, or Burster.	With Metal Plug, Wood Bottom, and Burster.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.						lb. oz. gr.	lb. oz.
150-pr. - -	10·42	10·38	·05	1·24	1·22	1·18	1·16	1·1	1·325	1·034	1·024	·9	2·92	14	·09	·4	1·7	0·25*	·25	30	254, 2 oz. sand shot.			284	120 0 0	122 0
100-pr. - -	8·92	8·8	·04	1·11	1·09	1·03	1·01	1·0	1·125	1·034	1·024	·9	2·87	14	1·65	·4	1·25	0·348	·13	484	—	–	–	484	84 10 0	86 0
8-in. or 68-pr.	7·95	7·9	·04	1·02	0·96	1·18	1·12	1·24	·94	1·034	1·024	·9	1·86	14	·393	·4	1·45	·447	·13	338	1	1	1	341	59 12 10	60 13
56-pr. -	7·51	7·45	·04	0·87	0·81	1·08	1·02	1·24	·84	1·034	1·024	·9	1·86	14	·375	·4	1·45	·447	·13	284	1	1	1	287	50 14 0	52 5
42-pr. - -	6·795	6·735	·04	0·82	0·77	0·98	0·92	1·24	·81	1·034	1·024	·9	1·86	14	·34	·4	1·35	·447	·13	210	1	1	1	213	37 2 0	38 5
32-pr. - -	6·207	6·147	·03	0·77	0·71	0·88	0·82	1·24	·77	1·034	1·024	·9	1·86	14	·31	·4	1·35	·447	·13	151	1	1	1	154	28 0 0	28 15
24-pr. - -	5·62	5·57	·03	0·68	0·63	0·79	0·74	1·24	·715	1·034	1·024	·9	1·86	14	·284	·4	1·25	·447	·13	110	1	1	1	113	20 8 0	21 5
18-pr. - -	5·124	5·074	·03	0·62	0·57	0·67	0·62	1·24	·735	1·034	1·024	·9	1·86	14	·256	·3	1·25	·348	·13	77	1	1	1	80	15 4 0	15 5
12-pr. - -	4·476	4·432	·03	0·47	0·43	0·57	0·53	1·24	·7	1·034	1·024	·9	1·86	14	·297	·3	1·15	·348	·13	—	72	1	1	74	10 3 0	10 12
9-pr. - -	4·1	4·06	·03	0·42	0·38	0·52	0·48	1·24	·65	1·034	1·024	·9	1·86	14	·273	·3	·95	·348	·13	—	52	1	1	54	7 5 0	7 14
6-pr. - -	3·568	3·532	·03	0·37	0·33	0·46	0·42	1·24	·57	1·034	1·024	·9	1·86	14	·237	·3	·95	·348	·13	—	29	1	1	31	5 5 0	5 13

* Naval rivet holes and bottom.

TABLE VII.—SMOOTH-BORE ORDNANCE.—MARTIN'S SHELL.

Nature.		Extreme Diameter.	Thickness.							Filling Hole, Diameter at	
			Interior Coating of Loam.	At Side.		At Bottom.		At Filling Hole.			
				Metal.	Metal and Loam.	Metal.	Metal and Loam.	Metal.	Metal and Loam.	Top.	Groove.
		Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
10″	high	9·88	0·34	0·96	1·3	1·82	2·16	1·32	1·66	1·2	1·4
	mean	9·85	0·30	0·90	1·2	1·7	2·0	1·2	1·5	—	—
	low	9·82	0·26	0·84	1·1	1·58	1·84	1·08	1·34	—	—
8″	high	7·9	0·28	0·55	0·83	1·1	1·38	1·1	1·38	—	—
	mean	7·86	0·25	0·5	0·75	1·0	1·25	1·0	1·25	—	—
	low -	7·82	0·22	0·45	0·67	0·9	1·12	0·9	1·12	—	—

TABLE VIII.—SMOOTH-BORE ORDNANCE.—CARCASSES.

Nature.	Diameter.			Thickness.			Diameter of Vents.	Weight filled.
	Mean.	Limit of Deviation.		Mean.	Limit of Deviation.			
		Greatest.	Least.		Greatest.	Least.		
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	lb. oz. about
13-inch - -	12·84	12·88	12·8	2·9	2·96	2·84	2·38	234 0
10-inch - -	9·85	9·88	9·82	2·11	2·17	2·05	1·9	105 0
8-inch, or 68-pr.	7·86	7·9	7·82	1·68	1·73	1·63	1·52	53 0
56-pr. - -	7·48	7·51	7·45	1·6	1·65	1·55	1·44	*
42-pr. - -	6·77	6·795	6·745	1·45	1·5	1·4	1·3	30 8
32-pr. - -	6·177	6·207	6·147	1·32	1·36	1·28	1·19	26 12
24-pr., or 5½-inch	5·595	5·62	5·57	1·2	1·24	1·16	1·08	19 4
18-pr. - -	5·099	5·124	5·074	1·09	1·13	1·05	0·98	14 12
12-pr., or 4⅖-inch	4·454	4·476	4·432	0·95	0·99	0·91	0·85	9 8

* None of this nature have been manufactured.

TABLE IX.—SMOOTH-BORE ORDNANCE.—GROUND LIGHT BALLS.

Nature.	Mean.		Weight.		
	Diameter.	Length.	Empty.	Composition.	Total filled.
			lb. oz.	lb. oz. dr.	lb. oz. dr.
10-inch - - -	9·51	14·3	31 8	32 2 8	63 10 8
8 „ - - -	7·6	12·0	16 8	16 7 0	32 15 0
5½ „ - - -	5·48	8·2	1 12	8 13 8	10 9 8
4⅖ „ - - -	4·36	6 5	1 4	3 14 0	5 2 0

Table X.—Smooth-bore Ordnance.—Projectiles.

Table showing the Greatest, Least, and Average Weights of 100 of each nature, weighed in the Royal Laboratory, July 1865.

Nature and Description.		Mean.	Greatest.	Least.	Greatest Difference from Mean.	Remarks.
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	
Shells, common, empty, riveted to elm bottoms, and plugged.	10-inch	79 4½	80 1½	78 11½	0 13	
	8-inch	47 4¼	48 15	46 5	1 10¾	
	56-pr.	40 2	—	—	—	Weight of one shell only.
	42-pr.	29 11	—	—	—	None in store.
	32-pr.	22 5¼	22 12½	21 15	0 7¼	
	24 pr.	16 11¾	17 2¼	16 3	0 8¾	
	18-pr.	12 10¼	12 14½	12 5¾	0 4½	
	12-pr.	8 9½	8 11	8 7½	0 2	
Shells, diaphragm, shrapnel, empty, fitted to elm bottoms, and plugged.	150-pr.	140 8	—	—	—	One shell only.
	100-pr.	86 7	87 3	85 6	1 1	
	8-inch	60 5	61 0	59 8	0 13	
	56-pr.	51 7	52 0	50 14	0 9	
	42-pr.	37 14	38 4	37 7½	0 6½	
	32-pr.	28 3½	28 10½	27 12½	0 7	
	24-pr.	21 0	21 5	20 9½	0 6½	
	18-pr.	15 15½	16 4½	15 11½	0 5	
	12-pr.	10 2¾	10 5¾	9 15	0 3¾	
	9-pr.	7 12½	7 14½	7 10¼	0 2¼	
	6-pr.	5 0½	5 2½	4 15¼	0 2	
Shell, hand grenade, empty.	Sea Service 6-pr.	3 9¼	3 12	3 5¼	0 4	
	Land Service 3-pr.	1 11¼	1 11¾	1 10¾	0 0½	
Shell, Martin, empty, riveted and plugged.	10-inch	68 9	70 13½	67 4	2 4½	
	8-inch	28 3¼	30 1	27 4	1 13¾	
Shell, mortar, empty, loose.	13-inch	195 3	199 15	188 1	7 2	
	13-inch	195 6	199 15	191 0	4 9	3 shells under 191 lb. left out.
	10-inch	87 2	88 10	85 14	1 8	
	8-inch	46 1	46 8½	45 12½	0 7½	
	5½-inch	16 3	16 6¾	16 0	0 3¾	
	4⅖-inch	8 5	8 6¾	8 3	0 2	
Shell, naval, empty, riveted, and plugged.	top, 150-pr.	107 10	—	—	—	Single shell.
	bottom, 10 in.	79 13	83 6	76 9	3 9	
	top, 100-pr.	67 6	68 0	66 14	0 10	
	bottom, 8-in.	47 13¼	49 6	46 9	1 8¾	
	bottom, 32-pr.	22 6¼	23 0½	21 12	0 10¼	
Shot, case, gun.	10-in., Patt. II.	79 3¼	79 12	77 15	1 4¼	
	100-pr.	99 12	—	—	—	Single shot, case, grape.
	8-in., Patt. II.	47 4	48 9	46 14	1 5	
	56-pr.	52 5	54 10½	50 9	2 5½	
	42-pr.	45 5	47 14	43 14	2 9	
	32-pr., Patt. II.	34 11½	35 9	34 0	0 13½	
	24-pr.	24 2¼	25 4¾	23 1½	1 2½	
	18-pr.	19 3	20 5	18 11½	1 2	
	12-pr.	16 11¾	18 1½	16 2	1 5¾	
	9-pr.	13 6	13 12½	12 14	0 8	
	6-pr.	8 11¾	9 3½	8 2½	0 9¼	
	3-pr.	4 5	4 7½	4 3½	0 2¼	

TABLE X. *continued.*—SMOOTH-BORE ORDNANCE.—PROJECTILES.

TABLE showing the Greatest, Least, and Average Weights of 100 of each nature, weighed in the Royal Laboratory, July 1865—*continued.*

Nature and Description.		Mean.		Greatest.		Least.		Greatest Difference from Mean.		Remarks.
		lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	
Shot, case, howitzer.	10-inch	89	7½	90	8	88	0	1	7½	
	8-inch	34	0½	34	13	32	12½	1	4	
	32-pr.	22	5½	23	6¼	20	8½	1	13	
	Sea Service. 24-pr.	15	14¾	16	15½	14	8¼	1	6½	
	Land Service. 24-pr.	13	8½	14	8¾	13	1½	1	0¼	
	5½-inch	13	13¼	14	3	13	7	0	6¼	
	Sea Service. 12-pr.	8	15½	9	4	8	11	0	4½	
	Land Service. 12-pr.	7	14¾	8	3¼	7	12	0	4½	
	4⅖-inch	8	1¼	8	4½	7	13	0	4¼	
Shot, grape, Caffin.	10-inch	82	12¾	85	15	80	8½	3	2¼	Iron case.
	10-inch	82	12¼	84	9¾	80	8½	2	3¾	Do. one shot left out.
	68-pr.	67	0½	68	3	65	11	1	5½	
	56-pr.	69	8¾	72	2	68	4	2	9¼	
	56-pr.	69	8½	71	5½	68	4	1	13	1 shot left out.
	42-pr.	48	10¾	49	9	47	8	1	2¾	
	32-pr.	37	8½	37	12¾	37	3	0	5½	
	24-pr.	26	2½	26	6½	25	14¾	0	4	
	18-pr.	18	13¾	19	5	18	8	0	7¼	
	12-pr.	12	11½	12	14¼	12	8	0	3½	
	9-pr.	10	7	10	11¼	10	4¼	0	4¼	
	6-pr.	6	9½	6	11¾	6	7¾	0	2¼	
Shot, solid, loose.	150-pr.	150	3½	150	15¾	149	1	1	2½	
	100-pr.	93	8¾	94	3½	92	11½	0	13¼	
	68-pr.	66	3¼	66	10	65	12½	0	6¾	
	56-pr.	55	8¾	56	6	54	7	1	1¾	
	42-pr.	41	6¾	41	11½	40	15½	0	7¼	
	32-pr.	31	6	31	15½	30	13½	0	9½	
	24-pr.	23	8¾	23	11½	23	4½	0	4¼	
	18-pr.	17	11¾	17	13	17	10¼	0	1½	
	12-pr.	12	4¼	12	6¼	12	1¾	0	2½	
	9-pr.	9	2	9	5	8	15½	0	3	
	6-pr.	6	0¼	6	1¼	5	14½	0	1¾	
	3-pr.	2	15¾	3	0¼	2	15	0	0¾	
Shot solid, riveted.	18-pr.	18	3½	18	9	18	0¾	0	5½	
	12-pr.	12	8	12	10¾	12	5¾	0	2¾	
	9-pr.	9	5½	9	9½	9	4	0	4	
	6-pr.	6	3	6	5¾	6	1	0	2¾	
	3-pr.	3	1½	3	2	3	1	0	0½	
Carcasses, empty, loose.	13-inch	220	15	222	14	218	1	2	14	
	10-inch	98	10½	99	4½	97	11½	0	15	
	8-inch	49	15½	50	6½	49	7	0	8½	
	32-pr.	24	3¾	24	7	23	13	0	6¾	
	24-pr.	18	0¼	18	4	17	13½	0	3¾	
	18-pr.	—		—		—		—		None in store.
	12-pr.	8	15¾	9	1½	8	14½	0	1¾	
Carcasses, filled, loose.	13-inch	234	0	235	10	232	5½	1	10½	
	10-inch	103	1	104	7	100	13¾	2	3¼	
	8-inch	52	12	—		—		—		
Carcasses, filled, riveted.	32-pr.	28	8	—		—		—		Average of a number taken some time ago.
	24-pr.	16	11	—		—		—		
	18-pr.	14	2	—		—		—		
	12-pr.	9	1	—		—		—		

TABLE XI.

AVERAGE WEIGHT OF SHOT AND SHELL BOTTOMS, PLUGS, &c.

Nature and Description.		Average Weight. lb.	oz.
Bottoms, Wood, Elm.	150-pr. diaphragm	1	12·37
	10-inch common and naval	1	2·96
	100-pr. diaphragm	1	8·13
	8-inch common, diaphragm, and Martin	1	0·89
	8-inch naval	0	13·44
	56-pr. common and diaphragm	1	1·69
	42-pr. ,, ,,	0	14·50
	32-pr. common, diaphragm, and Martin	0	10·06
	32-pr. naval	0	6·82
	24-pr. common	0	7·14
	24-pr. diaphragm, tin strapped	0	9·00
	18-pr. common and shot	0	7·77
	18-pr. diaphragm, tin strapped	0	9·69
	12-pr. common and shot	0	4·60
	12-pr. diaphragm, tin strapped	0	5·50
	9-pr. shot	0	4·42
	9-pr. diaphragm, tin strapped	0	5·70
	6-pr. shot	0	3·20
	6-pr. diaphragm, tin strapped	0	4·15
	3 pr. shot	0	2·17
Tops, wood, elm, with rope beckets.	150-pr. naval	2	12·55
	100-pr. ,,	1	13·97
Rivets, naval.	Long	0	0·42
	Medium	0	0·28
	Short	0	0·23
Rivets, common and diaphragm.	All common shell and shot, and diaphragm, down to 24 pr.	0	0·38
	Diaphragm 18 to 6-pr.	0	0·22
Plugs, fuze-hole.	Common	0	2·20
	Diaphragm	0	2·54
	Martin	0	3·22
	Naval	0	4·08
	General service	0	2·75

Table XII.—Smooth-bore Ordnance.—Boxes for packing Projectiles.

No. of Box.	Ordnance. Nature.	Projectile. Description.	No. in each Box.	External Dimensions. Length.	Width.	Depth.	Weight.* Boxes.	Projectile.	Total.	Tonnage in Inches.	Remarks.
				In.	In.	In.	In.	lbs. ozs. drs.	cwts. qrs. lbs. ozs.		
1	13-inch mortar -	Shell - - -	1	16·5	15	15·5	23·12	206 0 11	2 0 5 $5\frac{3}{4}$	3836·25	Filled.
2	10-inch gun - -	„ common - -	1	13·5	11·75	12·75	16·8	85 8 0	0 3 18 4	- -	Filled.
„	„ „ - -	„ Martin - -						68 9 0	0 3 1 5	2022·468	
„	„ „ - -	„ naval - -						86 0 13	0 3 18 13	- -	Filled.
3	„ „ - -	Grape - - -	2	23·5	12·25	12·25	23·4	82 12 12	1 2 21 0	3526·468	
„	„ „ - -	Case - - -						79 3 4	1 2 13 $12\frac{3}{4}$		
„	„ howitzer -	„ - - -						89 7 8	1 3 6 $5\frac{1}{4}$		
4	8-inch or 68-pr. gun -	Shell, diaphragm -	1	11·5	9·875	10·75	10·4	60 10 0	0 2 15 $0\frac{1}{4}$	1220·796	Filled.
„	„ „ -	„ naval - -						50 4 6	0 2 4 $12\frac{3}{4}$		Filled.
5	8-inch gun - -	„ common -	2	20·125	10·125	10·75	16·6	49 12 13	1 0 4 $3\frac{1}{4}$	- -	Filled.
„	„ „ - -	„ Martin - -						28 3 4	0 2 17 $0\frac{1}{8}$	2217·523	New.
„	„ „ - -	Case - - -						47 4 0	0 3 27 $1\frac{5}{8}$		
„	„ howitzer -	„ - - -						34 0 8	0 3 0 $10\frac{5}{8}$		
„	68-pr. carronade -	„ - - -						48 7 3	1 0 0 15		
„	„ „ -	Grape - -						48 12 0	1 0 1 5		
6	68-pr. gun - -	„ - - -	2	20·125	10·25	13	20·12	67 0 8	1 1 14 2	2681·656	New.
7	56-pr. gun - -	„ - - -	2	19·5	9·75	14	16·15	69 8 12	1 1 15 4	2661·75	New.
„	„ „ - -	Case - - -						52 5 0	1 0 8 $12\frac{1}{4}$		
8	42-pr. gun - -	„ - - -	4	31·25	8·75	13	30·8	45 5 0	1 3 16 $0\frac{3}{4}$	3554·687	
„	„ „ - -	Grape - - -						48 10 12	2 0 1 $7\frac{3}{4}$		
„	„ carronade -	„ - - -						38 5 9	1 2 15 6		
9	„ gun - -	Shot - - -	4	31·25	8·75	9·5	21·4	41 6 12	1 2 19 $1\frac{3}{8}$	2597·655	Filled.
„	„ „ - -	Shell - - -						31 5 10	1 1 7 14		
„	„ carronade -	Case - - -						35 2 0	1 1 21 12		
10	„ gun - -	Shell - - -	1	10·25	8·75	9·5	7·7	31 5 10	0 1 10 $0\frac{13}{16}$	852·031	Filled.

* The weight of the projectiles and the total weight in this table differ from those in General Regimental Order 461, par. 9, because in this table the mean weight of the projectile accurately determined by an experiment in the Royal Laboratory in 1865 (see table X., page 328), has been taken.

Table XII.—Smooth-bore Ordnance.—Boxes for packing Projectiles—*continued.*

No. of Box.	Ordnance, Nature.	Projectile, Description.	No. in each Box.	External Dimensions. Length.	Width.	Depth.	Weight.* Boxes.	Projectile.	Total.	Tonnage in Inches.	Remarks.
				In.	In.	In.	In.	lbs. ozs. drs.	cwts. qrs. lbs. ozs.		
11	32-pr. gun	Grape	4	28·625	8·125	12·125	21·1	37 8 8	1 2 3 5	2820·	New.
„	„ „	Case						34 11 8	1 1 19 15		
„	„ carronade	Grape						29 4 0	1 0 26 1		
12	„ gun	Shot	4	28·75	8·75	9·375	19·0	31 6 0	1 1 4 8	- -	
„	„ „	Shell, common						23 9 4	1 0 1 5	2358·398	Filled.
„	„ „	Shell, diaphragm						28 6 10	1 0 20 $10\frac{1}{2}$		Filled.
„	„ carronade	Case						21 14 8	0 3 22 10		
„	„ howitzer	„						22 5 8	0 3 24 6		
13	„ gun	Naval shell	1	10	8·25	8·75	6·10	23 8 12	0 1 1 $9\frac{3}{4}$	721·875	Filled.
14	24-pr. gun	Grape	6	21	13	10·625	26·8	26 2 8	1 2 15 $11\frac{3}{4}$	2900·625	
„	„ „	Case						24 2 4	1 2 3 $10\frac{1}{4}$		
15	„ „	Shell, diaphragm	6	20·75	13	9·5	20·12	21 0 0	1 1 7 $0\frac{11}{16}$	2562·625	Filled.
„	„ „	Shell, common						17 9 15	1 0 14 $2\frac{1}{4}$		
„	„ „	Shot	6	20·75	13	9·5	20·12	23 8 12	1 1 21 6	2562·625	
„	24-pr. carronade	Grape						18 11 12	1 0 21 $2\frac{1}{2}$		
„	„ „	Case						17 9 12	1 0 14 6		
„	24-pr. howitzer	„ L.S.						13 8 8	0 3 17 $4\frac{3}{4}$		
„	„ „	„ S.S.						15 14 12	1 0 3 $10\frac{1}{4}$		
„	$5\frac{1}{2}$-inch „	Shell						20 10 0	1 1 4 8		
„	„ „	Case						13 13 4	0 3 19 $1\frac{1}{4}$		
16	18-pr. gun	Grape	8	24·75	12·5	10·25	18·10	18 13 12	1 2 0 16	3171·093	New.
„	„ „	Case						19 3 0	1 2 3 9		

* The weight of the projectiles and the total weight in this table differ from those in General Regimental Order 461, par. 9, because in this table the mean weight of the projectile accurately determined by an experiment in the Royal Laboratory in 1865 (see table X., p. 328), has been taken.

Table XII.—Smooth-bore Ordnance.—Boxes for packing Projectiles—*continued.*

No. of Box.	Ordnance, Nature.	Projectile, Description.	No. in each Box.	External Dimensions. Length.	Width.	Depth.	Weight.* Boxes.	Projectile.	Total.	Tonnage in Inches.	Remarks.
				In.	In.	In.	In.	lbs. ozs. drs.	cwts. qrs. lbs. ozs.		
17	18-pr. gun	Shell, diaphragm	8	24·5	12	8·25	20·12	15 15 8	1 1 8 13	-	Filled.
„	„ „	Shell, common						12 10 4	1 0 14 7¾	-	Filled.
„	„ „	Shot						18 3 8	1 1 25 14	2425·5	
„	18-pr. carronade	Grape						14 6 0	1 0 23 12		
„	„ „	Case						13 9 0	1 0 17 4		
18	12-pr. gun	„	12	31	11	12	24·7	16 11 12	2 0 1 8¼	4092·	New.
19	„ „	Grape	12	31·25	11	9	21·10	12 11 8	1 2 5 11	3093·75	
„	12-pr. carronade	„						10 4 0	1 1 4 10		
„	„ „	Case						8 15 0	1 0 16 14		
„	12-pr. howitzer	„ L.S.						7 14 12	1 0 4 2		
„	„ „	„ S.S.						8 15 8	1 0 16 11		
„	4⅗-inch „	„						8 1 4	1 0 6 0		
20	12-pr. gun	Shell, diaphragm	12	31·25	10·75	7·5	17·13	10 4 4	1 1 0 5	Filled.	New, reduced ⅝ inch in depth.
„	„ „	Shell, common						8 15 0	1 0 12 6	Filled.	
„	„ „	Shot						12 8 0	1 1 27 2	2519·531	
„	4⅗-inch howitzer	Shell						10 1 0	1 0 26 9		
21	9-pr. gun	Case	12	28·875	10·125	10·875	22·12	13 6 0	1 2 9 10	3179·408	
22	„ „	Grape	12	28·875	10·125	8·375	17·6	10 7 0	1 1 2 13½	2448·509	New.
23	„ „	Shell, diaphragm	12	28·375	10·25	7·25	18·4	7 13 10	1 0 0 10	-	Filled.
„	„ „	Shot						9 5 8	1 0 18 8½	2108·617	
24	6-pr. gun	Shell, diaphragm	24	26·25	9·25	11·75	23·8	5 1 2	1 1 5 7¾	-	Filled.
„	„ „	Shot						6 3 0	1 2 4 4¾	2853·046	
25	„ „	Case	12	24·625	9·25	9·75	14·14	8 11 12	1 0 6 15	2220·867	
26	„ „	Grape	12	24·5	9·25	7·875	13·10	6 9 8	0 3 4 3	1784·671	New.
27	3-pr. gun	Case	30	32	10·25	9·375	18·0	4 5 0	1 0 25 6	3075·0	
„	„ „	Shot	60					3 1 8	1 3 7 7		
28	„ „	Grape	60	32·125	10·125	10·375	21·15	2 9 0	1 2 3 12	3374·63	
	13-inch mortar	One pound shot	100	23·5	8·5	9·25	12·8½	- -	1 0 0 8½	1847·687	

* The weight of the projectiles and the total weight in this table differ from those in General Regimental Order 461, par. 9, because in this table the mean weight of the projectile accurately determined by an experiment in the Royal Laboratory in 1865 (see table X., p. 328), has been taken.

Table XIII.—Ring Gauges for Projectiles* (W.O.C. 11, New Series, § 1,314).

SMOOTH BORE.

Calibre of 13-inch Mortar, 13·0 Inches.

H.G. 13-inch	12·88
L.G. 13-inch	12·8

Calibre of 150-pr. Gun, 10·5 Inches.

H.G. 150 pr.	10·42
L.G. 150-pr.	10·38

Calibre of 10-inch Gun, Howitzer, and Mortar, 10·0 Inches.

H.G. 10-inch	9·88
L.G. 10-inch	9·82

Calibre of 100-pr. Gun, 9·0 Inches.

H.G. 100-pr.	8·92
L.G. 100-pr.	8·88

Calibre of 68-pr. Gun, 8·12 Inches; 8-inch Gun, 8·05 Inches; 8-inch Howitzer and Mortar, 8·0 Inches.

H.G. 68-pr.	7·95
L.G. 68-pr.	7·82

Calibre of 56-pr. Gun, 7·65 Inches.

H.G. 56-pr.	7·51
L.G. 56-pr.	7·45

Calibre of 42-pr. Gun, 6·97 Inches.

H.G. 42-pr.	6·795
L.G. 42-pr.	6·735

Calibre of 32-pr. Gun, 6·41, 6·375, 6·35, and 6·3 Inches; 32-pr. Howitzer, 6·3 Inches.

H.G. 32-pr.	6·207
L.G. 32-pr.	6·147

Calibre of 24-pr. Gun, 5·823; Howitzer, 5·72; 5½-inch Howitzer, 5·68; 5½-Inch Mortar, 5·62 Inches.

H.G. 24-pr.	5·639†
L.G. 24-pr.	5·57

Calibre of 18-pr. Gun, 5·292 and 5·17 Inches.

H.G. 18-pr.	5·124
L.G. 18-pr.	5·074

Calibre of 12-pr. Gun, 4·623; 12-pr. Howitzer, 4·58; 4⅖-inch or Coehorn Howitzer and Mortar, 4·52 Inches.

H.G. 12-pr.	4·54
L.G. 12-pr.	4·432

Calibre of 9-pr. Gun, 4·2 Inches.

H.G. 9-pr.	4·117
L.G. 9-pr.	4·06

Calibre of 6-pr. Gun, 3·668 Inches.

H.G. 6-pr.	3·585
L.G. 6-pr.	3·532

Calibre of 3-pr. Gun, 2·913 Inches.

H.G. 3-pr.	2·838
L.G. 3-pr.	2·808

Sea Service Hand Grenade.

H.G. hand grenade, S.S.	3·496
L.G. hand grenade, S.S.	3·456

Land Service Hand Grenade.

H.G. hand grenade, L.S.	2·778
L.G. hand grenade, L.S.	2·738

* "The issue of low gauges is to be restricted to stations of inspection," *W.O.C.* (New Series), § 1314. "It is not intended to interfere with the limits of manufacture at present allowed in spherical projectiles, but merely to simplify the regulations for their inspection at out stations." *W.O.O.* 31st Dec. 1866, being errata on Circular 11 (New Series.)

† For future manufacture this gauge will be 5·64″.—W.O. Letter, 29/9/66, 75/12/2914.

RING GAUGES FOR SAND SHOT.*

H.G. 4 lb. sand shot	3·1
L.G. 4 lb. sand shot	3·05
H.G. 3 lb. sand shot	2·81
L.G. 3 lb. sand shot	2·77
H.G. 2 lb. sand shot	2·46
L.G. 2 lb. sand shot	2·42
H.G. 1½ lb. sand shot	2·23
L.G. 1½ lb. sand shot	2·2
H.G. 1 lb. sand shot	1·95
L.G. 1 lb. sand shot	1·92
H.G. 13⅛ oz. sand shot	1·83
L.G. 13⅛ oz. sand shot	1·8
H.G. 8 oz. sand shot	1·55
L.G. 8 oz. sand shot	1·52
H.G. 6½ oz. sand shot	1·48
L.G. 6½ oz. sand shot	1·45
H.G. 6 oz. sand shot	1·4
L.G. 6 oz. sand shot	1·37
H.G. 5 oz. sand shot	1·34
L.G. 5 oz. sand shot	1·31
H.G. 4 oz. sand shot	1·23
L.G. 4 oz. sand shot	1·2
H.G. 3¼ oz. sand shot	1·16
L.G. 3¼ oz. sand shot	1·13
H.G. 3 oz. sand shot	1·12
L.G. 3 oz. sand shot	1·1
H.G. 2 oz. sand shot	0·98
L.G. 2 oz. sand shot	0·96
H.G. 1½ oz. sand shot	0·88
L.G. 1½ oz. sand shot	0·86

* These gauges are enumerated, but they are not now supplied except to stations of inspection.

Table XIV.—Wads.

Nature.	Junk.						Grummet.			
	Mould.		Gauge.	Thickness of finished Wad.		Nature of Yarn for Woolding.	Gauge.	Rope.		
	Interior.								Circumference.	
	Diameter.	Depth.	Diameter.	Proof.	Service.		Diameter.	Length.	For Grummet.	For Cross Pieces.
	Inches.	Inches.	Inches.	Inches.	Inches.		Inches.	Ft. In.	Inches.	Inches.
150-pr.								8 6	3·5	2·5
100-pr.								7 3	3·5	2·5
0-inch	9·4	6	9·91	6·5	3·5	3-strand spun yarn.	9·91	7 0	3·5	2·5
8-inch or 68-pr.	7·52	6	8·03	5·75	3·25		8·03	6 6	3·5	2·0
56-pr.	7·02	6	7·53	4·75	2·75		7·53	6 0	3·5	2·0
42-pr.	6·31	6	6·81	4·25	2·5		6·81	5 10	3	2·0
32-pr.	5·95	4·5	6·32	3·5	2·5	common yarn, single.	6·32	5 0	3	2·0
24-pr.	5·37	4·5	5·63	3·25	2·5		5·63	4 9	3	1·5
18-pr.	4·81	4·5	5·1	3·125	2·5		5·1	4 9	2½	1·5
12-pr.	4·22	4·5	4·51	2·75	2·25		4·51	4 1	2½	1·5
9-pr.	3·81	4·5	4·16	2·75	2·125		4·16	3 6	2	1·5
6.pr.	3·22	4	3·54	2·5	1·75		3·54	3 3	2	1·0
3-pr.	2·48	4	2·85	2·25	1·625		2·85	3 0	1·5	1·0

Table XV.—Smooth-bore Ordnance.—Charges, Firing, with Dimensions of Cartridges.

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended. Land Service.	Purpose for which each Charge is intended. Sea Service.	Cartridge. How marked.†	Pattern. Length.	Pattern. Width. Top.	Pattern. Width. Bottm	When Sewed. Length.	When Sewed. Width. Top.	When Sewed. Width. Bottm	No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
		lbs.				Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Guns,	150-pr.	40	- - - - -	Battering - -	**150-pr. 40 lb.** -	28	30	—	27·4	14·37	—	3	‡4	—
		35	- - - - -	Full - - -	**150-pr. 35 lb.** -	25·25	30	—	24·65	14·37	—	3	‡3	—
		20	- - - - -	Reduced and saluting -	**150-pr. 20 lb.** -	20	31	—	19·4	14·875	—	3	‡1	—
	100-pr.	25	- - - - -	Battering - -	**100-pr. 25 lb.** -	25	25·5	—	24·65	12·125	—	3	‡3	—
		20	- - - - -	Full - - -	**100-pr. 20 lb.** -	22·5	25·5	—	21·9	12·125	—	3	‡2	—
		12	- - - - -	Reduced and saluting -	**100-pr. 12 lb.** -	18	27¼	—	17·4	13	—	3	‡1	—
	10-in.	12	Service* - - -	Full* - - -	**10-in. 12 lb.** - -	17	15	12	16	14	11	3	3	19
		8	Martin shell,* carcass, saluting, or exercising.	Martin shell, carcass, and reduced.	**10-in. 8 lb.** - -	14½	15	12	13½	14	11	3	1	19
	8-in.	10	Service, 65 and 60 cwt. gun -	Distant, 65 and 60 cwt. gun.	**8-in. 65 or 60 D 10 lb.**	19	13¼	9½	18	12¼	8½	3	3	17
		8	Service, 52 or 50 cwt. and Martin shell.	Full and Martin shell -	**8-in. 8 lb.** - -	17	13¼	9½	16	12¼	8½	3	2	17
		5	Saluting or exercising -	Reduced, with coal-dust wad.	**8-in. 5 lb.** - -	15	13¼	9½	14	12¼	8½	3	2	17
	68-pr.	18	Service, 113 cwt. gun -	- - - - -	**68-pr. 18 lb.** -	24	23¾	—	23	11¼	—	3	3	19
		16	Service, 95 cwt. gun - -	Distant, 95 cwt. gun -	**68-pr. 16 lb.** -	22	23¾	—	21	11¼	—	3	3	19
		14	Service, 87 cwt. gun - -	Distant, 87 cwt. gun -	**68-pr. 14 lb.** -	20½	23¾	—	19½	11¼	—	3	3	19
		12	- - - - -	Full, 95 cwt. gun -	**68-pr. 12 lb.** -	19	23¾	—	18	11¼	—	3	2	19
		10	Martin shell* - - -	Full, 87 cwt. gun, and Martin shell.	**68-pr. 10 lb.** -	17¼	23¾	—	16¼	11¼	—	3	2	19
		8	Saluting or exercising -	Reduced 95 cwt. gun -	**68-pr. 8 lb.** - -	15½	23¾	—	14½	11¼	—	3	1	19
		6	- - - - -	Reduced, 87 cwt. gun -	**68-pr. 6 lb.** - -	14	23¾	—	13	11¼	—	3	1	19
	56-pr.	14	Service - - -	- - - - -	**56-pr. 14 lb.** -	20	22¼	—	19	10½	—	3	3	17
		8	Saluting or exercising -	- - - - -	**56-pr. 8 lb.** - -	15	22¼	—	14	10½	—	3	2	17
	42-pr.	14	Service, 84 cwt. gun - -	- - - - -	**42-pr. 14 lb.** -	22½	21	—	21½	10	—	3	3	17
		12	Service, 75 cwt. gun - -	- - - - -	**42-pr. 12 lb.** -	20	21	—	19	10	—	3	3	17
		10½	Service, 67 cwt. gun and hot shot, 84 cwt. gun.	- - - - -	**42-pr. 10½ lb.** -	18	21	—	17	10	—	3	3	17
		8	Saluting or exercising* -	- - - - -	**42-pr. 8 lb.** - -	16	21	—	15	10	—	3	2	17

* Where weight of gun is not mentioned that charge is used with all guns of that nature.

† All cannon cartridges, both for smooth-bore and rifled guns, issued from store filled, are to have the initial letter of the station at which they are filled stamped on the bottom end, see p. 154. The cartridges filled by the Royal Artillery will be distinguished by having no initial letter stamped on them. Approved 28th May 1863; War Office Circular No. 835, Stores; Paragraph 763.

‡ Blue braid, about ·334 inches broad; each hoop 40 inches long.

Table XV. *cont.*—Smooth-bore Ordnance.—Charges, Firing, with Dimensions of Cartridges.

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended. Land Service.	Purpose for which each Charge is intended. Sea Service.	Cartridges. How marked.*	Pattern. Length.	Pattern. Width. Top.	Pattern. Width. Bottm	When Sewed. Length.	When Sewed. Width. Top.	When Sewed. Width. Bottm	No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
		lbs.				Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Guns—*cont.*	32-pr.	10	Service, 63, 58, and 56 cwt. guns.	Distant, 58 or 56 cwt. guns.	**32-pr. 58 or 56 D 10 lb.**	18	19⅜	—	17	9⅛	—	3	3	7
		8	Service, 50 to 48 cwt. guns -	Full, 58 to 48 cwt. guns -	**32-pr. 8 lb.** - -	16	19⅜	—	15	9⅛	—	3	2	7
		7½	Hot shot, 63 to 56 cwt. guns	Hot shot, 58 or 56 cwt. guns.	**32-pr. 7½ lb.** - -	16	19⅜	—	15	9⅛	—	3	2	7
		7	Service, 45 cwt. gun - -	Full, 45 cwt. gun -	**32-pr. 7 lb.** - -	15	19⅜	—	14	9⅛	—	3	2	7
		6	Service, 46, 42, 41, 40, and 39 cwt. guns.	Reduced, 58 or 56 cwt. guns; full, 42, 41, 40, 39 cwt. guns.	**32-pr. 6 lb.** - -	14	19⅜	—	13	9⅛	—	3	2	7
		5	Service, 32 cwt. gun - -	Reduced, 50, 48, and 45 cwt. guns; full, 32 cwt. gun.	**32-pr. 5 lb.** - -	13	19⅜	—	12	9⅛	—	3	2	7
		4	Saluting or exercising 39 cwt. and upwards. Service, 25 cwt. gun.	Reduced, 42 to 39 cwt. gun; full, 25 cwt. gun.	**32-pr. 4 lb.** - -	12	19⅜	—	11	9⅛	—	3	1	7
		3	Saluting or exercising 32 cwt. gun.	Reduced, 32 cwt. gun -	**32-pr. 3 lb.** - -	12	19⅜	—	11	9⅛	—	3	1	7
		2½	Saluting or exercising 25 cwt. gun.	Reduced, 25 cwt. gun -	**32-pr. 2½ lb.** - -	10½	19⅜	—	9½	9⅛	—	3	1	7
		2	- - - - -	Saluting - - -	**32-pr. 2 lb.** - -	10	19⅜	—	9	9⅛	—	3	1	7
	24-pr. -	8	Service, 50 and 48 cwt. guns	- - - -	**24-pr. 8 lb.** - -	17½	17¾	—	16½	8⅜	—	3	3	16
		6	Service, 41 cwt. gun an hot shot, 50 and 48 cwt. gun.	- - - -	**24-pr. 6 lb.** - -	14¾	17¾	—	13¾	8⅜	—	3	2	16
		5	Saluting or exercising 50 and 48 cwt. guns.	- - - -	**24-pr. 5 lb.** - -	13½	17¾	—	12½	8⅜	—	3	2	16
		4	Service, 33 cwt. gun, saluting or exercising 41 cwt. gun.	- - - -	**24-lb. 4 lb.** - -	12½	17¾	—	11½	8⅜	—	3	2	16
		3	Saluting or exercising 33 cwt. guns.	- - - -	**24-pr. 3 lb.** - -	11¼	17¾	—	10¼	8⅜	—	3	1	16
		2½	Service, saluting or exercising 20 cwt. guns.	- - - -	**24-pr. 2½ lb.** -	10½	17¾	—	9½	8⅜	—	3	1	16
	18-pr. -	6	Service, 42 to 38 cwt. guns -	- - - -	**18-pr. 6 lb.** - -	18	16½	—	17	7¾	—	3	3	15
		4½	Hot shot, 42 to 38 cwt. guns	- - - -	**18-pr. 4½ lb.** - -	15¾	16½	—	14¾	7¾	—	3	2	15
		4	Saluting or exercising 42 to 38 cwt. guns.	- - - -	**18-pr. 4 lb.** - -	15	16½	—	14	7¾	—	3	2	15
		3	Service, saluting or exercising 22 to 20 cwt. guns.	Full, 22 or 20 cwt. guns -	**18-pr. 3 lb.** - -	13	16½	—	12	7¾	—	3	1	15
		2	Service, saluting or exercising 15 cwt. guns.	Reduced, 22 or 20 cwt. guns; full, 15 cwt. gun,	**18-pr. 2 lb.** - -	11	16½	—	10	7¾	—	3	1	15

* All cannon cartridges, both for smooth-bore and rifled guns, issued from store filled, are to have the initial letter of the station at which they are filled stamped on the bottom end, see p. 154. The cartridges filled by the Royal Artillery will be distinguished by having no initial letter stamped on them.—Approved 28th May, 1863; War Office Circular No. 835, stores; Paragraph 763.

Table XV. *cont.*—Smooth-bore Ordnance.—Charges, Firing, with Dimensions of Cartridges.

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended. Land Service.	Sea Service.	Cartridge. How marked.†	Pattern. Length.	Pattern. Width. Top.	Pattern. Width. Bottm	When Sewed. Length.	When Sewed. Width. Top.	When Sewed. Width. Bottm	No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
		lbs.				Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Guns—*cont.*	12-pr.	4	Service, iron and bronze	-	**12-pr. 4 lb.**	14¾	14¼	—	13¾	6⅝	—	3	3	6
		3	Saluting or exercising bronze and 34, 33, 29½ cwt. iron guns.	-	**12-pr. 3 lb.**	12½	14¼	—	11½	6⅝	—	3	2	6
		2½	Saluting or exercising 21 cwt. iron guns.	-	**12-pr. 2½ lb.**	11½	14¼	—	10½	6⅝	—	3	2	6
	9-pr.	3	Service iron guns	-	**9-pr. 3 lb.**	13½	12¾	—	12½	5⅞	—	3	3	13
		2½	Service bronze guns	-	**9-pr. 2½ lb.**	12	12¾	—	11	5⅞	—	3	2	13
		2	Saluting or exercising iron guns.	-	**9-pr. 2 lb.**	10	12¾	—	11	5⅞	—	3	2	13
		1½	Saluting or exercising bronze guns.	-	**9-pr. 1½ lb.**	9	12¾	—	8	5⅞	—	3	1	13
	6-pr.	2	Service iron guns*	-	**6-pr. 2 lb.**	12	11½	—	11¼	5⅜	—	2	3	12
		1½	Service, bronze guns, saluting or exercising, iron guns.*	-	**6-pr. 1½ lb.**	10¼	11½	—	9½	5⅜	—	2	2	12
		1	Saluting or exercising bronze guns.	-	**6-pr. 1 lb.**	8¾	11½	—	8	5⅜	—	2	1	12
		¼	-	Practice	**6-pr. 4. oz.**	5½	9	—	4¾	4⅛	—	2	—	5
	3-pr.	12oz.	Service, saluting or exercising, bronze 3 cwt. gun.	-	**3-pr. 12 oz.**	8½	9	—	7¾	4⅛	—	2	1	5
		10	Service, saluting or exercising, bronze 2¼ cwt. guns.	-	**3-pr. 10 oz.**	7¾	9	—	7	4⅛	—	2	1	5
	1-pr.	6	Service	-	**1-pr. 6 oz.**	8	6⅜	—	7	2¾	—	2	1	4
Howitzers,	10-in.	7lb.	Service	-	**10-in. how. 7 lb.**	13½	11½	12	12½	10½	11	3	1	17
		4	Saluting or exercising	-	**10-in. how. 4 lb.**	11¼	11½	12	10¼	10½	11	3	1	17
	8-in	4	Service	-	**8-in. how. 4 lb.**	13	12	8	12	11	7	3	1	16
		3	Saluting or exercising	-	**8-in. how. 3 lb.**	12½	12	8	11½	11	7	3	1	16
	32-pr	3	Service	-	**32-pr. how. 3 lb.**	12½	14¼	—	11½	6⅝	—	3	2	6
		2	Saluting or exercising	-	**32-pr. how. 2 lb.**	10¼	14¼	—	9¼	6⅝	—	3	1	6
	24-pr.	2½	Service	-	**24-lb. how. 2½ lb.**	11	9½	7	10	8½	6	3	1	14
		1½	Saluting or exercising	-	**24-pr. how. 1½ lb.**	9	9½	7	8	8½	6	3	1	14
	5½-in.	2	Service, saluting or exercising, 15 cwt. iron.	-	**5½-in. how. 2 lb.**	10½	13¾	—	9½	6⅜	—	2	1	14

* Where the weight of the gun is not mentioned that charge is used with all guns of that nature.

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Table XV. *cont.*—Smooth-bore Ordnance.—Charges, Firing, with Dimensions of Cartridges.

Nature of Ordnance.		Charge.	Purpose for which each Charge is intended. Land Service.	Sea Service.	Cartridges. How marked.*	Pattern. Length.	Pattern. Width. Top.	Pattern. Width. Bottm.	When Sewed. Length.	When Sewed. Width. Top.	When Sewed. Width. Bottm.	No. Rows of Stitches.	No. of Hoops.	No. Paper Cover.
						Inch.	Inch.	Inch.	Inch.	Inch.	Inch.			
Howitzers—*cont.*	12-pr.	2	-	Service, 10 cwt.	**12-pr. how. 2 lb.**	11½	8	5½	10½	7	4½	2	2	12
		1½	Service 6½ cwt.	-	**12-pr. how. 1½ lb.**	9½	7½	5½	8½	7	4½	2	1	12
		1	Saluting or exercising 6½ cwt.	-	**12-pr. how. 1 lb.**	9	7½	5½	8	7	4½	2	1	12
	4⅗-in.	8oz.	Service 2½ cwt., coehorn	-	**4⅗-in. how. 8 oz.**	8¾	7¼	—	7¾	3⅛	—	2	1	4
		4	Saluting or exercising 2½ cwt., coehorn.	-	**4⅗-in. how. 4 oz.**	6½	7¼	—	5½	3⅛	—	2	1	4
Mortars,	13-in.	20lb.	-	Service	**13-in. mor. 20 lb.**	25	18	11½	24	17	10½	3	3	18
		16	-	Carcass	**13-in. mor. 16 lb.**	21½	18	11½	20½	17	10½	3	3	18
		9	Service	-	**13-in. mor 9 lb.**	15½	16½	13	14½	15½	12	3	1	19
	10-in.	9½	-	Service	**10-in. mor. 9½ lb.**	18½	13	10	17½	12	9	3	3	17
		4	Service	-	**10-in. mor. 4 lb.**	13	14	10		13	9	3	1	17
	8-in.	2	Service	-	**8-in. mor. 2 lb.**	10	11	7½	9	10	6½	3	1	14
	5½-in.	7oz.	Service, Royal	-	**5½-in. mor. 7 oz.**	7	7½	6	7¼	6½	5	2	1	5
	4⅗-in.	5	Service, coehorn	-	**4⅗-in. mor. 5 oz.**	6	7	5	5¼	6	4	2	1	5
Carronades,	68-pr.	5lb.	-	-	**68-pr. carde. 5 lb.**	14½	21	—	13½	10	—	3	2	—
	42-pr.	3½	-	-	**42-pr. carde. 3½ lb.**	12½	19	—	11½	9	—	3	2	—
	32-pr.	2$\frac{11}{16}$	-	-	**32-pr. carde. 2$\frac{11}{16}$ lb.**	12½	17½	—	11½	8¼	—	3	2	—
	24-pr.	2	-	-	**24-pr. carde. 2 lb.**	11	16	—	10	7½	—	3	2	—
	18-pr.	1½	-	-	**18-pr. carde. 1½ lb.**	10¼	13¾	—	9¼	6⅜	—	3	2	—
	12-pr.	1	-	-	**12-pr. carde. 1 lb.**	9	13¼	—	8	6⅛	—	3	2	—
	6-pr.	10oz.	-	-	**6-pr. carde. 10 oz.**	7	10¼	—	6	4¾	—	2	2	—

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Table XVI.—Smooth-bore Ordnance.—Charges, Bursting, approximate.*

Nature of Shell.	Description of Shell. Common.	Naval.	Mortar.	Shrapnel improved. Charge.	Shrapnel improved. Bullets.† Size.	Shrapnel improved. Bullets.† No.	Shrapnel Diaphragm. Charge.	Shrapnel Diaphragm. Bullets.† Size.	Shrapnel Diaphragm. Bullets.† No.	Hand Grenades. Sea Service.	Hand Grenades. Land Service.	No. of Calico and Paper Bags. Common Mortar and Hand Grenades.	No. of Calico and Paper Bags. Diaphragm.
	lb. oz. dr.	lb. oz. dr.	lb. oz. dr.	dr.	Size.	No.	dr.	Size.	No.	oz.	oz.	No.	No.
13-inch	—	—	10 15 0	—	—	—	—	—	—	—	—	7	—
150-pr.	—	6 14 0	—	—	—	—	128	Sand shot 2 oz Musket	254 30	—	—	6	4
100-pr.	—	3 13 0	—	—	—	—	—	do.	484	—	—	6	4
10-inch	6 12 0	6 5 0	5 4 0	—	—	—	96	do.	—	—	—	7	—
8-inch, or 68-pr.	2 9 0	2 9 0	2 9 0	67	Musket	370	80	do.	341	—	—	6	4
56-pr.	2 7 0	—	—	66	do.	—	70	do.	287	—	—	5	3
42-pr.	1 12 0	—	—	44	do.	—	60	do.	213	—	—	5	3
32-pr.	1 5 0	1 5 0	—	40	do.	170	50	do.	154	—	—	5	3
24-pr., or 5½-inch	1 0 0	—	1 0 0	25½	do.	119	40	do.	113	—	—	4	3
18-pr.	0 12 0	—	—	24	do.	90	30	do.	80	—	—	4	2
12-pr., or 4⅖-inch	0 7 0	—	0 7 0	16½	Carbine	80	24	Carbine	74	—	—	4	2
9-pr.	—	—	—	14	do.	34	18	do.	54	—	—	—	1
6-pr.	—	—	—	9½	do.	25	10	do.	31	5	—	3	1
3-pr.	—	—	—	—	—	—	—	—	—	—	3	2	—

* Shells, with certain exceptions, are now filled by capacity instead of by weight, and the charges here given except in the case of shrapnel, are taken from W.O.C. No. 7 (new series), par. 1116, the shells being filled in accordance with W.O.C. No. 3 (new series), par. 954; also, W.O.C. 884; and Royal Artillery Circular *Memo.*, 13th December, 1864, par. 3; "the shell being tapped with a mallet during the process."

The approximate amount of powder required was determined by an experiment in the Royal Laboratory in 1865, when 10 shells of each nature were filled, and the quantities given above are slightly in excess of the mean result of this experiment, to give even weights; and "it is assumed that as shells of small and large capacity " are supplied in about equal proportions, the powder saved in the one case will suffice to make up the deficiency in the others."—*War Office Circular*, 927.

An allowance must be made for displacement by the fuze as follows:—

Nature of Shell.	Powder displaced.	Nature of Fuze.
Mortar 13 and 10 inch	Half an ounce.	Wood.—Mortar.
Mortar 8-inch	One ounce.	Do. do.
Common, 32, 24, 18, and 12 pr.	Half an ounce.	Wood.—Common.
Naval 10-inch	Half an ounce.	Metal.—Time.
Naval 8-inch 56, 42, and 32 pr.	One ounce.	Do. do.
Hand grenade	Half an ounce.	Wood.

No allowance required in other shells or for other fuzes.

Thus the 13-inch mortar shell will take approximately 10 lb. 15 oz. of powder without a fuze, and 10 lb. 14 oz. 8 dr. with a fuze. In the case of the shrapnel shell the charge is the minimum sufficient to open them.

† The total number of bullets here given is not always composed entirely of musket or carbine balls; in each shell a few bullets of a smaller nature, pistol or buck shot, are generally added, to bring the shell up to the weight; and these, for convenience, are included in this table among the number of musket or carbine balls. For details as to actual number of each nature of bullet *vide* table of "Boxer Diaphragm Shrapnel Shell."

Table XVII.—Table of Filled Cannon Cartridges.—Smooth-Bore.

Nature.	Charge.—L.G. Powder. lb.	oz.	Diameter of Cartridge Body. In.	Diameter of Ring Gauge. In.	Length of Cartridge. From In.	Length of Cartridge. To In.	Number of Hoops. Braid.	Number of Hoops. Worsted.	Barrel Whole. Number.	Barrel Whole. Weight. lb.	Ammunition Box. Number.	Ammunition Box. Weight. lb.	Case, Powder, Copper-lined. Whole. Number.	Whole. Weight. lb.	Half. Number.	Half. Weight. lb.	Quarter. Number.	Quarter. Weight. lb	Case, Powder, Brass. Pentagon. Number.	Pentagon. Weight. lb.	Sectional. Number.	Sectional. Weight. lb.	Rectangular. Plain. Number.	Plain. Weight. lb.	Corrugated. Number.	Corrugated. Weight. lb.	Remarks.
150-pr.	40	0	9·6	9·6	16·0	17·0	4	..	1	74	..	..	..	..	..	..	..	..	..	..	..	..	2	151			These cartridges are too large in diameter to be packed in a corrugated brass case.
	35	0	9·6	9·6	14·5	15·5	3	..	2	104	..	..	..	..	..	..	..	..	..	..	..	..	3	176			
	20	0	9·6	9·6	9·0	9·5	1	..	4	114	2	62	..	..	..	..	..	..	..	..	..	..	6	191			
100-pr.	25	0	8·25	8·25	13·5	14·5	3	..	3	109	1	47	3	124	..	..	..	..	3	137	..	..	4	171	4	151	
	20	0	8·25	8·25	12·0	12·5	2	..	4	115	2	62	4	129	..	..	..	..	4	142	..	..	5	171	6	171	
	12	0	8·25	8·25	8·0	8·5	1	..	7	119	4	70	9	158	..	..	..	..	8	159	..	..	9	168	9	160	
10-inch	12	0	7·75	9·76	8·5	..	..	3	7	119	4	70	9	158	..	..	..	..	9	171	..	..	10	192	12	196	A conical papier mâché gauge is used in the Royal Laboratory.
	8	0	7·4	9·76	7·0	..	..	1	12	132	5	63	14	162	6	78	..	..	14	175	..	..	15	192	17	188	
8-inch (with coal dust wad).	10	0	7·0	7·2	10·2	..	..	3	9	125	4	62	11	160	4	70	..	..	11	172	..	..	12	192	14	192	Do.
	8	0	6·65	7·2	9·2	..	..	2	12	132	5	63	14	162	6	78	..	..	14	175	..	..	16	200	18	196	
	5	0	6·9	7·2	9·5	..	..	2	10	109	5	59	13	146	5	67	..	..	12	152	..	..	14	176	17	180	
68-pr.	18	0	7·55	7·76	12·8	..	..	3	5	125	2	58	6	158	..	..	..	..	6	171	..	..	6	180	7	177	
	16	0	7·55	7·76	11·5	..	..	3	6	131	3	70	6	145	2	62	..	..	6	158	..	..	7	183	8	179	
	14	0	7·55	7·76	10·3	..	..	3	6	119	3	65	8	161	3	71	..	..	8	174	..	..	9	198	10	192	
	12	0	7 5	7·76	9·5	..	..	2	8	132	4	70	9	158	4	78	..	..	9	171	..	..	10	192	12	196	
	10	0	7·4	7·76	8·3	..	..	2	9	125	4	62	11	160	4	70	..	..	11	172	..	..	12	192	14	192	
	8	0	7·3	7·76	7·4	..	..	1	12	132	5	63	14	162	6	78	..	..	14	175	..	..	16	200	17	188	
	6	0	6·9	7·76	6·4	..	..	1	16	131	8	71	19	164	8	78	..	..	19	177	..	..	21	198	24	196	
56-pr.	14	0	7·0	7·4	11·6	..	..	3	6	119	3	65	8	161	3	71	..	..	8	174	..	..	9	198			
	8	0	6·9	7·4	7·2	..	..	2	12	132	5	63	14	162	6	78	..	..	14	175	..	..	16	200			
42-pr.	14	0	6·6	6·675	12·3	..	..	3	6	119	3	65	8	161	3	71	..	..	8	174	..	..	9	198			
	12	0	6·6	6·675	11·2	..	..	3	8	132	4	70	9	158	4	78	..	..	9	171	..	..	10	192			
	10	8	6·6	6·675	10·2	..	..	3	9	130	4	64	11	164	4	72	..	..	11	177	..	..	12	198			
	8	0	6·5	6·675	8·0	..	..	2	12	132	5	63	14	162	6	78	..	..	14	175	..	..	16	200			
32-pr.	10	0	6·0	6·087	10·75	..	..	3	9	125	4	62	11	160	4	70	..	..	11	172	..	..	12	192	14	192	
	8	0	6·0	6·087	9·2	..	..	2	12	132	5	63	14	162	6	78	..	..	14	175	..	..	16	200	18	196	
	7	8	6·0	6·087	8·5	..	..	2	12	125	6	68	15	162	6	75	..	..	15	175	..	..	16	192	19	195	
	7	0	6·0	6·087	8·0	..	..	2	13	126	7	72	16	162	7	78	..	..	16	175	..	..	18	198	21	199	
	6	0	5·9	6·087	7·5	..	..	2	16	131	8	71	19	164	8	78	..	..	19	177	..	..	21	198	24	196	
	5	0	5·8	6·087	6·5	..	..	2	19	130	10	73	22	160	10	80	..	..	22	173	..	..	26	202	30	202	
	4	0	5·8	6·087	5·75	..	..	1	25	136	12	71	27	158	13	82	..	..	27	171	..	..	32	201	36	196	
	3	0	5·3	6·087	5·2	..	..	1	32	132	18	77	37	161	17	81	..	..	37	174	..	..	43	202	50	202	
	2	8	5·1	6·087	5·0	..	..	1	38	132	20	74	44	161	19	77	..	..	44	174	..	..	51	201	60	202	
	2	0	4·8	6·087	4·3	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202	—	—	

Table XVII.—Table of Filled Cannon Cartridges.—Smooth-bore—*continued.*

Nature.	Charge.—L.G. Powder.		Diameter of Cartridge Body.	Diameter of Ring Gauge.	Length of Cartridge.		Number of Hoops.		Number packed and Weight of Package.																		Remarks.
									Barrel Whole.		Ammunition Box.		Case, Powder, Copper-lined.						Case, Powder, Brass.								
													Whole.		Half.		Quarter.		Pentagon.		Sectional.		Rectangular. Plain.		Rectangular. Corrugated.		
					From	To	Braid.	Worsted.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	
	lb.	oz.	In.	In.	In.	In.				lb.		lb.		lb.		lb		lb.		lb.				lb.		lb.	
24-pr.	8	0	5·5	5·52	10·5	..	..	3	12	131	5	63	14	162	6	78	..	..	14	175	..	..	16	200			
	6	0	5·5	5·52	8·3	..	..	2	16	131	8	71	19	164	8	78	..	..	19	177	..	..	21	198			
	5	0	5·5	5·52	7·5	..	..	2	19	130	10	73	22	160	10	80	..	..	22	173	..	..	26	202			
	4	0	5·4	5·52	6·5	..	..	2	25	136	12	71	27	158	13	82	..	..	27	171	..	..	32	201			
	3	0	5·2	5·52	5·2	..	..	1	32	132	18	77	37	161	17	81	..	..	37	174	..	..	43	202			
	2	8	5·1	5·52	4·7	..	..	1	38	132	20	74	44	161	19	77	..	..	44	174	..	..	51	201			
18-pr.	6	0	5·0	5·024	9·0	..	..	3	16	131	8	71	19	164	8	78	..	..	19	177	7	85	21	198	25	202	
	4	8	5·0	5·024	7·5	..	..	2	20	125	10	68	25	163	10	75	..	..	25	176	10	88	28	199	34	205	
	4	0	5·0	5·024	6·75	..	..	2	25	136	12	71	27	158	13	82	..	..	27	171	12	91	32	201	32	200	
	3	0	4·9	5·024	5·75	..	..	1	32	132	18	77	37	161	17	81	..	..	37	174	17	94	43	202	52	202	
	2	0	4·6	5·024	4·8	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202	75	202	
12-pr.	4	0	4·35	4·388	8·6	..	..	3	25	136	12	71	27	158	13	82	5	39	27	171	12	91	32	201			
	3	0	4·3	4·388	6·8	..	..	2	32	132	18	77	37	161	17	81	7	40	37	174	17	94	43	202			
	2	8	4·3	4·388	6·0	..	..	2	37	130	18	69	44	161	20	81	8	39	44	174	20	94	51	201			
9-pr.	3	0	3·9	4·02	8·2	..	..	3	32	132	18	77	37	161	17	81	6	37	37	174	17	94	43	202			
	2	8	3·9	4·02	6·7	..	..	2	38	132	18	69	44	161	20	81	8	39	44	174	20	94	51	201			
	2	0	3·9	4·02	6·0	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
	1	8	3·8	4·02	4·9	..	..	1	58	124	30	69	74	162	35	83	12	37	74	175	35	96	84	199			
6-pr.	2	0	3·4	3·496	7·0	..	..	3	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
	1	8	3·35	3·496	5·5	..	..	2	58	124	30	69	74	162	35	83	12	37	74	175	35	96	84	199			
	1	0	3·35	3·496	4·4	..	..	1	94	134	42	65	110	162	50	81	20	39	110	175	50	94	125	199			
	0	4	2·5	3·496	2·5	..	..	0	350	126	..	..	400	154	200	83	70	37	400	168	200	96	470	195			
3-pr.	0	12	2·75	2·778	4·6	..	..	1	120	129	60	69	135	154	60	73	25	38	..	..	..	..	..	..			
	0	10	2·75	2·778	4·2	..	..	1	130	121	72	69	160	153	72	76	30	38	..	..	..	..	..	..			
1½-pr.	0	6	2·1	..	4·0	..	..	1	..	..	125	71	..	..	..	..	..	..	..	..	..	..	..	..			
13-inch mortar	20	0	8·35	..	12·75	..	..	3	4	115	2	62	5	150	..	..	..	..	4	142	..	..	5	172			
	16	0	8·2	..	12·0	..	..	3	5	115	3	70	6	145	..	..	..	..	6	158	..	..	7	183			
	9	0	7·85	..	7·3	..	..	1	10	125	5	67	12	158	..	..	..	..	11	162	..	..	12	180			
10-inch "	9	8	6·5	..	9·7	..	..	3	10	131	4	60	12	164	5	78	..	..	11	167	..	..	12	186			
	4	0	6·0	..	5·5	..	..	1	25	136	12	71	27	158	13	82	..	..	27	171	..	..	32	201			
8-inch "	2	0	4·9	..	5·0	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
5½-inch "	0	7	3·1	..	3·1	..	..	1	220	135	120	77	240	157	120	84	50	40	240	170	120	96	280	197			
4⅖-inch "	0	5	2·6	..	2·9	..	..	1	260	122	160	76	300	147	160	82	70	41	300	160	150	91	350	184			

Table XVII.—Table of Filled Cannon Cartridges.—Smooth-bore—*continued.*

Nature.	Charge.—L.G. Powder.		Diameter of Cartridge Body.	Diameter of Ring Gauge.	Length of Cartridge.		Number of Hoops.		Number packed and Weight of Package.																		Remarks.
									Barrel Whole.		Ammunition Box.		Case, Powder, Copper-lined.						Case, Powder, Brass.								
													Whole.		Half.		Quarter.		Pentagon.		Sectional.		Rectangular. Plain.		Rectangular. Corrugated.		
					From	To	Braid.	Worsted.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	
	lb.	oz.	In.	In.	In.	In.				lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.	
Cochorn - -	1	0	2·3	2·4	10·5	..	..	3	..	..	42	67	100	153	..	..	..	..	..	..	..	..	..	..			A conical papier mâché gauge is used in the Royal Laboratory.
10-inch howitzer	7	0	7·15	9·4	6·3	..	..	1	13	126	7	72	16	162	7	78	..	..	16	175	..	..	18	198			Do.
	4	0	6·25	9·4	5·3	..	..	1	25	136	12	71	27	158	13	82	..	..	27	171	..	..	32	201			
8-inch „	4	0	5·75	7·2	6·0	..	..	1	25	136	12	71	27	158	13	82	..	..	27	171	..	..	32	201			
	3	0	5·2	7·2	5·1	..	..	1	32	132	18	77	37	161	17	81	..	..	37	174	..	..	43	202			
	2	0	4·8	7·2	4·6	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
5½-inch „ -	2	0	4·15	5·1	5·2	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
4⅖-inch „	0	8	2·2	4·2	4·6	..	..	1	200	136	110	78	230	167	110	86	40	39	..	..	..	..	..	..			
	0	4	2·2	4·2	3·5	..	..	1	350	126	180	70	400	154	200	83	70	37	..	..	..	..	..	..			
32-pr. „	3	0	4·3	4·388	6·8	..	..	2	32	132	18	77	37	161	17	81	7	40	37	174	17	94	43	202			
	2	0	4·3	4·388	5·4	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
24-pr. „	2	8	4·75	5·1	5·6	..	..	1	37	130	18	69	44	161	20	81	8	39	44	174	20	94	51	201	60	202	A conical papier mâché gauge is used in the Royal Laboratory.
	1	8	4·2	5·1	4·6	..	..	1	58	124	30	69	74	162	35	83	12	37	74	175	35	96	84	199	96	197	
12-pr. „	2	0	3·9	4·2	6·6	..	..	2	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			Do.
	1	4	3·5	4·2	5·3	..	..	1	77	134	38	71	88	161	40	81	16	39	88	175	40	94	102	201			
	1	0	3·4	4·2	4·5	..	..	1	94	134	42	65	110	162	50	81	20	39	110	175	50	94	125	199			
68-pr. carronade -	5	0	6·3	..	6·3	..	..	1	19	130	10	73	22	160	10	80	..	..	22	173	..	..	26	202			
42-pr. „ -	3	8	5·7	..	5·3	..	..	1	27	131	13	69	32	163	14	79	..	..	32	176	..	..	36	199			
32-pr. „ -	2	11	5·15	..	5·2	..	..	1	33	126	18	72	42	164	18	79	..	..	42	177	..	..	45	195			
24-pr. „ -	2	0	4·7	..	4·6	..	..	1	48	133	24	72	55	161	25	81	10	39	55	175	25	94	64	202			
18-pr. „ -	1	8	4·1	..	4·4	..	..	1	58	124	30	69	74	162	35	83	12	37	74	175	35	96	84	199			
12-pr. „ -	1	0	3·8	..	3·4	..	..	1	94	134	42	65	110	162	50	81	20	39	110	175	50	94	125	199			
6-pr. „ -	0	10	3·1	..	3·4	..	..	1	130	121	72	69	160	153	72	76	30	38	160	166	70	88	190	195			
Bags, 15lb. Rifle, L. G.	..		..	..	..	..	..	..	8	155	4	83	8	170	4	90	..	..	8	183	..	..	9	208			
Bags, 15lb. L. G. -	..		..	..	..	..	..	..	8	155	4	83	8	170	4	90	..	..	8	183	..	..	9	208			
Bags, 15lb. F. G. -	..		..	..	..	..	..	..	7	140	4	83	8	170	4	90	..	..	8	183	..	..	9	208			

10.—Stone Colour for Brass Pentagon and Rectangular Powder Cases:—

	lb.	oz.
Lead, white	28	0
Copperas	0	12
Umber	0	8
Varnish, copal	3 qts.	
Gold size	2 ,,	
Turpentine	2 ,,	

11.—Black for Bodies of Paper, Quill, and Copper Friction, Cross-headed and Electric Tubes:—

	lb.	oz.
Black, vegetable	1	0
Litharge	0	8
Varnish, copal	3 qts.	
Turpentine, spirits	2 ,,	
Gold size	1 ,,	

12.—Red for head of Cross-headed Tubes:—

	lb.	oz.
Vermilion	2	0
Shellac	6	8
Spirits, methylated	1 gall.	

13.—Thick Brown Varnish:—

	lb.	oz.
Shellac, gum	16	0
Spirits, methylated	2 galls.	

14.—Thin Brown Varnish:—

	lb.	oz.
Shellac, gum	8	0
Spirits, methylated	2 galls.	

15.—Shellac Putty:—

	lb.	oz.
Whiting	6	0
Shellac, gum	2	0
Spirits, methylated	1 quart	

16.—Paste:—

	lb.	oz.
Flour	2	0
Alum, pounded	0	1
Water	1 gall.	

17.—Flesh Colour for Common Portfires:—

	lb.	oz.
Lead, white, ground	10	0
Lead, red, dry	0	4
Shellac, gum	10	0
Spirits, methylated	3 galls.	

18.—French White for Coast-guard Portfires:—

	lb.	oz.
Lead, white, ground	10	0
Lead, sugar of	0	10
Blue, Prussian	0	2
Turpentine, spirits	1½ pints	
Oil, linseed, raw	2 qts.	

19.—Black for Plates of Life-buoy Portfires:—

	lb.	oz.
Black, lamp	1	0
Litharge	0	2
Oil, linseed, boiled	1 quart	
Turpentine, spirits	1 pint	

20.—Drab for Long and Signal Lights:—

	lb.	oz.
Lead, white, ground	10	0
Shellac, gum	10	0
Spirits, methylated	3 galls.	

21.—Black for Life-buoy Portfires, and Body of Wood Fuzes:—

	lb.	oz.
Black, lamp	2	0
Shellac, gum	10	0
Spirits, methylated	3 galls.	

22.—Drab-white for Body of Wood Fuzes:—

	lb.	oz.
Lead, white, ground	10	0
Shellac, gum	10	0
Spirits, methylated	3 galls.	

23.—Yellow for Side-holes of Wood Fuzes:—

	lb.	oz.
Lead, white, ground	3	0
Lead, sugar of	0	3
Yellow, chrome	0	1
Varnish, copal	1 quart	
Turpentine, spirits	½ pint	

24.—Black for Side-holes of Wood Fuzes:—

	lb.	oz.
Black, lamp	3	0
Litharge	0	4
Varnish, copal	1 quart	
Turpentine, spirits	½ pint	

25.—Red for Figuring the Side-holes of Wood Fuzes:—

	lb.	oz.
Vermilion	3	0
Oil, linseed, raw	1 quart	
Turpentine, spirits	½ pint	

26.—Thick Black Paint for Ring round Cap of Wood Fuzes:—

	lb.	oz.
Shellac, gum	1	0
Black, lamp	½	0
Spirits, methylated	1½ pints	

27.—Blue for Parachute Fuzes:—

	lb.	oz.
Ultra-marine	0	4
Lead, white, ground	3	0
Shellac, gum	1	0
Spirits, methylated	½ gall.	

28.—Anti-corrosive for fuze caps, &c.:—

White lead	8 oz.
Copal varnish	½ gill
Turpentine	1 „
Sugar of lead	1 oz.

29.—Varnish for the Gut and Silk over Detonating Ball of Pettman Fuzes:—

	lb.	oz.
Shellac, gum	0	8½
Spirits, methylated	1 quart	

30.—Lacquer for Brass Fuzes and other Brass Work:—

	lb.	oz.
Seedlac	5	0
Turmeric	2	8
Spirits, methylated	5 galls.	

31.—Lacquer for inside of 100 and 150-pr. S.B. and of Rifle Shells:—

	lb.	oz.
Rosin	12	0
Brown, Spanish	2	0
Plaster of Paris	1	0
Turpentine	½ pint	

TABLE XXI.—LIST OF PAPER USED IN THE ROYAL LABORATORY, WOOLWICH, FOR MANUFACTURING PURPOSES, AS SPECIFIED.[1]

Description.	Use.
Brown, 29 × 22½, 100 lb.	Cases, Portfire, Common. Life-buoy. Lights, long and signal. Cylinders and sockets for Armstrong cartridges. Lining for Boxer naval fuze and pellet for Boxer ammunition for Snider rifles.
Brown, 24 × 19, 45 lb.	Lining of cartridge barrels, boxes, and general packing.—*See* Wrapping. Linings for Boxer wood fuzes for rifled ordnance and Manby shot. Boxer ammunition for Snider rifles. (Pattern V.)
Cannon cartridge, 9-pr.	Covers for cannon cartridges. Cylinders for Armstrong cartridges. Smoke balls.
White demy, 18 × 22½, 21 lb.	Labels for S.A. cartridges, &c. Belts, Whitworth cartridges.
Blue, 23 × 36	Labels for practice, S.A. ammunition.
White, 20 × 32	Slips for linings for naval metal fuzes.
Fine. Green, 24⅜ × 19¼, 12–13 lb.	Cartridges and wrappers for Brunswick rifle. Bands, Whitworth, 1864, rifle.
Fine. Purple, 24 × 19½, 12–13 lb.	Bands for Long and signal lights. Terry blank. Blank cartridges and wrappers.
Fine. Blue	Gum bands, Deane and Colt, skin cartridge covers.
Fine. Red, 24⅜ × 19¼, 12–13 lb.	Cartridges, rifle musket /51.
Fine. White, 24⅜ × 19¼, 12–13 lb.	Cartridges and slips for: Artillery, Paget, C.B., M.B., and Victoria carbines. /53 service, /53 proof, Lancaster D.B. Terry, Whitworth, W. Richards muskets. Common and ordnance muskets. Buck shot. Common and rifle pistol and Boxer ammunition for Snider rifles. (Patts. I., II., III., IV.) Bands and circles for signal rockets. Do. for C G. portfires. Capping life-buoy portfires. Covering side-hole and bottom of wood fuzes; and ends of copper tubes. Capping hand-grenade fuzes.
Fine. Yellow, 24⅜ × 19¼, 12–13 lb.	Cartridges and slips for /42 rifle musket, and W. Richards carbine.
Portfire, 24 × 18, about 60 lb. per ream	Caps and collars for C.G. portfires.
Rocket, 28½ × 23, 168 lb. per ream	Cases for C.G. portfires. Signal rockets. Cones, cylinders, and circles for signal rockets. Linings for Congreve rockets and bags, canvas fuze. Circles for Terry cartridge, and tin caps for wood fuzes.

[1] This table is not meant to include all the uses to which the different papers are put, but merely the principal uses.

Description.		Use.
Tissue		Covering end of tube of long and signal lights. Discs, E-time and other fuzes.
Waterproof		Bags for ball cartridges, diaphragm and rocket bursters, cannon cartridges. Armstrong time and Dyer percussion fuzes. Circles for covering composition, lights parachute. Fuzes for firing Hale and life-saving rocket.
Wrapping.	Brown, 24 × 19, 45 lb.	Wrappers for: Artillery, C.B., M.B., Paget, and Victoria carbines. Buck shot. /53 rifle. Common and ordnance musket. Colt, Deane, common, rifle, and C.B. pistols. WestleyRichards musket, and S.S. pistol 1 dram. Boxer ammunition for Snider rifles. Armstrong bursters. E-time and Dyer fuzes.
	Red, 24 × 19·5, 45 lb.	Powder cylinder and wrapper for /51 pattern rifle.
	White, 24 × 19, 45 lb.	Covers for W. Richards carbine. Powder cylinder for artillery and Paget carbines. Covers and wrappers for Terry carbine, W. Richards, and Whitworth musket. Powder cylinder for /53, Lancaster, Whitworth, and /53 proof rifles. Powder cylinder for rifle pistol. Cases for miner's portfire. Coverings for cones and cylinders for signal rockets. Covers for Deane and Colt cartridges. Wrappers for 2nd proof rifles.
	Yellow, 24 × 19, 45 lb.	Powder cylinder and wrappers for '42 rifle. Wrappers for Westley Richards carbine.

Table XXII.—Dimensions of Copper Hoops and Rivets for Powder Barrels.

Description.			Hoops.								Rivets.	
			Length in Inches.		Width in Inches.		Thickness in Inches.		Weight of Hoops.	Limits.		
			Mean.	Limits.	Mean.	Limits.	Mean.	Limits.	Mean.		Length.	Diameter.
									lbs. oz.	oz.		
Departmental Manufacture.	Whole	Bilge	56·125	+·125 −·125	1·265	+·015 −·015	·0925	+·0075 −·0075	2 2½	+½ −½	5	·25
		Chime	52·6	+·1 −·1	1·265	+·015 −·015	·0925	+·0015 −·0015	2 0½	+½ −½		
	Half	Bilge	43·5	+·05 −·05	1·65	+·10 −·10	·08	+·01 −·01	1 6	+½ −½	·45	·26
		Chime	41·5	+·05 −·05	1·65	+·10 − 10	·08	+·01 −·01	1 5	+½ −½		
	Quarter	Bilge	37·5	+·05 −·05	1·	+ 10 −·10	·08	+·01 −·01	0 15½	+¼ −¼	·45	·2
		Chime	35·5	+·05 −·05	1·	+·10 −·10	·08	+·01 −·01	0 15	+¼ −¼		
	Eighth	Bilge	28·0	+·05 −·05	·91	+·10 −·10	·08	+·01 −·01	0 10½	+¼ −¼	·45	·2
		Chime	26·5	+·05 −·05	·91	+·10 −·10	·08	+·01 −·01	0 10	+¼ −¼		
Repairs	For Whole		—	—	—	—	—	—	—	—	·65	·29
	" Half		—	—	—	—	—	—	—	—	·55	·26

APPENDIX.

APPENDIX A.

On the VALIDITY of GENERAL SHRAPNEL'S CLAIM to the INVENTION of SHELLS in which the true principle of shrapnel fire was first enunciated and applied.[1]

In spite of the overwhelming mass of evidence which might be produced to show that the large majority of authors and others have unhesitatingly accorded to General Shrapnel the credit of the invention,[2] two distinct claims have been put forward on behalf of other nations. The first is a claim which has been preferred by General Bormann of the Belgian army, on behalf of the Germans of the 16th century; the second is a claim preferred by the celebrated Piobert on behalf of the French artillerists of the the 17th century. The validity of these claims I shall proceed to investigate in succession.

(1.) *The Germans' claim to the Invention.*

General Bormann's work on *The Shrapnel Shell in England and Belgium* commences with the following passage:—"The English were the first nation who, " in modern times, employed the projectiles known in England more under " the name of 'spherical case shot,' than under that of shrapnel; hence gene- " rally, though erroneously, as we shall see hereafter, its invention is believed " to be of English origin."—*Shrapnel Shell in England and Belgium*, p. 1.

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[1] This paper originally appeared in the *Proceedings*, Royal Artillery Institution, vol. iii., p. 398.

[2] It may be interesting to quote some of the testimonies, which I have culled from different works, in General Shrapnel's favour. I have selected those which are concise and best adapted for quotation, and which appear to me to be the most weighty; to these a large number of other quotations of a similar nature might be added, but those I have given will suffice for my purpose:—

"This invention has universally been accorded to General Shrapnel, of the British Artillery."—*Ordnance Select Committee Report on Shrapnel Shells*, p. 5.

"Shrapnel shells . . . . . . take their name from that of the inventor, the late General Shrapnel, of the Royal Artillery."—*Observations on Shrapnel Shells*, p. 9.

"Shells originally introduced by General Shrapnel."—Owen and Dames' *Lectures on Artillery*, p. 69.

"Although General Shrapnel's invention of spherical case shot dates from the beginning of the present century," &c.—*Report of American Ordnance Commission to Europe*, p. 716.

"Shrapnel's shells, or spherical case.—The author of the *British Gunner* has very justly observed that the latter term is given to the prejudice of the ingenious inventor Major General Shrapnel."—*Aide Memoire to the Military Sciences.* (See *The Britishe Gunner*. Introductory Remarks.)

General Foy in his *Histoire de la Guerre de la Peninsule*, vol. i., p. 298, speaks of "Shrapnel spherical case shot from the inventor's name, Col. Shrapnel.—*Observations on Shrapnel Sheels*, p. 71.

Paixhans in his *Constitution Militaire de la France*, p. 248, speaks of them as having been "proposed by Shrapnel, an English Artillerist."—*Ibid.*, p. 70.

"Colonel Shrapnel, of the Royal Artillery, has an exclusive merit of having added this formidable weapon to those already in use," &c.—James' *Military Dictionary*, p. 813.

"The military weapon, which, as I have said, my father had for some time patronized, and endeavoured to introduce, was a kind of shell, invented by an ingenious officer of Artillery, Lt.-Col. Shrapnel, and now familiarly known by the name of *Spherical case shot.*"—*Memoirs of Sir John Sinclair*, by his son, the Rev. John Sinclair, M.A., vol. ii., p. 243.

"To that able and distinguished officer (Major-General Shrapnel) is due the credit of the invention which has made his name so justly celebrated."—*Naval Gunnery*, p. 425.

See also opinions of Decker and Meyer quoted further on.

The ground upon which General Bormann disputes General Shrapnel's claim to the invention is, that the shrapnel shell was merely, as he believes, the application of a principle perfectly well known to the German artillerists of the 16th century, and applied by them in the form of a projectile termed, *hagel kügel* (hail shot). This is what General Bormann says upon the subject:—"The "shrapnel shell is a German invention of the 16th century, as has lately been "discovered. For this discovery the Germans are indebted to a distinguished "officer of the Royal Prussian Artillery, Captain Toll, who in his historical "researches found in the library of the Heidelberg university, a MS. of the "year 1573, which incontestably proves that the German artillerists of that "epoch knew perfectly well the principle upon which the present shrapnel fire "is founded, and that notwithstanding their limited means, they had even "succeeded in the application of this projectile, which was then called *hagel* "*kügel* (hail shot)."—*Ibid.* pp. 59, 60.

Artillerymen, however, will probably not think the proof as "incontestable," as General Bormann appears to consider it, when they read the description which he gives of the projectile in question. "This *hagel kügel consisted of a* "*leaden shell, or rather box, of cylindrical form;* its fuze was the old common "fuze placed in the axis of the shell and at one end of the cylinder; the burst- "ing powder surrounded and covered the fuze in the interior of the shell; the "rest of the empty space of the shell was filled up with 'hail,' pieces of iron, "bullets, or even pebbles; and lastly, the shell was suitably closed at the "other end. This projectile was introduced into the gun so that its fuze "was turned towards the charge of the piece; the fire with it seems to have "been successful to such a degree that it was employed in action."—*Ibid.* p. 61.

It is perfectly evident from this description that the *hagel kügel* was merely a clumsy description of case, only adapted for short ranges; for it would of course be impossible to project a *cylindrical* leaden box to any considerable distance from a smooth-bore gun.[1]

It is possible, therefore, that the *hagel kügel* may have had something to do with the introduction of case, but that it gave any hint as to how case might be made effective at *long ranges* cannot be conceded; and it has already been explained that *it is only at long ranges that shrapnel is superior to case; herein alone the great advantage claimed for it lies—that it enables a fire similar to that of grape or case to be delivered at distances beyond the ranges of those projectiles.*

It is difficult, therefore, to see how the principle of the Shrapnel shell, much less the application of the principle, can be fairly said to have been derived from the *hagel kügel*, when the characteristic feature of the former—the great advantage upon which its claims to notice were founded, viz., that it enabled case effects to be produced *at long ranges*, was necessarily, from its form and construction, absent in the latter.

(2.) *The French claim to the Invention.*

Piobert says:—"Les projectiles creux ont été employés, notamment à Lille "en 1672 a lancer des balles de plomb en grande nombre et à grandes "distances. Pour cela on introduit dans leur intérieur une certaine quantité "de balles indépendamment de la charge qui doit produire l'éclatement, et l'on "place dans l'œil une fusée d'une longuer telle que le feu ne se communique "à la charge qu'un peu avant l'arrivée au but."—*Traité d'Artillerie, Théorique et Pratique*, p. 253.

Piobert does not, it is true, say in so many words that the true principles of shrapnel fire were understood by those who proposed and employed these

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[1] It might appear at first sight to the modern artilleryman that the fact of the fuze and bursting charge of the projectile being "turned towards the charge of the piece," affords an additional reason for supposing that the projectile was intended to burst soon after quitting the gun. I have not overlooked this consideration, but I do not think it *proves* anything; for there is no doubt that in those times the fuzes of *shells* were frequently turned towards the charge, and clearly, *shells* could not have been intended to burst invariably on quitting the muzzle. The explanation of this arrangement is probably to be found in the fact that the artillerymen of those days did not know that the flash of the discharge would ignite the fuze if placed away from it.—See *Le Passe et l'Avenir de l'Artillerie*, vol. iii., p. 342, *ante, et seq.*

projectiles in the 17th century, but he implies it. He implies it by the bare fact of introducing a description of this projectile in connexion with his account of shrapnel shells; and he implies it more pointedly by the very precise description which he gives of the action of these shells and of their bullets;[1] this description being surely intended to convey two things to the mind of the reader,—the first, that the action of the projectiles was the same as that of the modern shrapnel shell (and we *now* know that fired and exploded *under the same conditions* it must necessarily in its main effects have been the same),—the second, and the more important, that the inventors of the shell and the artillerymen who used them thoroughly understood their action, and the principle upon which that action depended;—in short, that *theoretically* and *practically*, spherical case shot were understood more than a century before General Shrapnel proposed them; and that the credit of the invention belongs not to that officer, but to the artillerists of the time of Louis XIV.

Piobert's statement has been adopted by some other authors. Thiroux says, "*Des Schrapnells* ou *obus à balles:* Ces projectiles, essayés en France, " dès le temps de Louis XIV., au siége de Lille."—*Instruction d'Artillerie*, p. 299; and Captain Brenton in his course for the American cadets, in the same way, dates the first employment of these projectiles as far back as the time of Louis XIV.: "Projectiles similar to spherical case shot were used in " France as early as the time of Louis XIV."—*American Artillery Course*, p. 77.

Now with regard to Piobert's statement (upon which apparently the other two that I have quoted are built), I would first observe that I have been unable to trace the authority upon which it rests. Ordinarily Piobert is very particular in supporting his statement by references to the authors from whom his authority is borrowed; in this instance he fails to do so. In the absence of any such references I have searched a number of other works upon the history of artillery, particularly the admirable *Le Passé et l'Avenir de Artillerie*, perhaps the most correct and authoritative work upon the subject which has ever been published; neither this work, nor, with one exception, any of the others which I have consulted, make any mention of such a projectile as Piobert describes.

The one exception is Decker, who in a note says "Dans l'ouvrage de " Geissler (Curiose und Volkommene artillerie) de 1718, on lit, page 90, que " Geissler a tiré ces bombes, le 20 Novembre 1642, à la citadelle de Lille, en " présence de Louvois et du Grand-Maître de Lude."—*Expériences sur les Shrapnels*, p. 13. It is probably, then, upon *Geissler's* authority that Piobert's statement is founded; but that this authority rests upon no very solid or well-established basis may be concluded from the remark made by Decker a little further on: "*Il n'y a que l'expérience de Geissler . . . . : mais qui en garantit l'authenticité?*"[2]

But supposing it could be incontestably established that "des bombes " remplies de balles de plomb" *were* fired at the siege of Lille, does this fact of itself deprive General Shrapnel of the credit of the invention? In my opinion certainly not. To my mind the absence of any mention of these projectiles in the numerous works treating of the history of artillery (with the exceptions I have mentioned) is convincing proof that although projectiles resembling Shrapnel shells may have been used in the 17th century they were not intended to serve the same end as General Shrapnel's shell *and were constructed on a different principle.*

I believe that the bullets were placed inside to act merely as so many additional splinters, the effect of which, according to the idea of the inventor, would depend upon the same causes as the ordinary splinters of ordinary shells, viz., upon the bursting charge of the shell, and in no way upon the communicated motion of the projectile, and the velocity with which it might be travelling at the moment of rupture; while, doubtless, in addition, their weight was thought advantageous as increasing the density of the projectile.

My reason for holding this opinion are as follows:—

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[1] I have not thought it necessary to quote this description; it is exactly the description which the modern artilleryman would give of the action and principle of the shrapnel shell.

[2] *Expériences sur les Shrapnels*, p. 14.

1st. The first appreciation and application of so important a principle in gunnery as that involved in the proper action of the shrapnel shells, would surely not have been passed over without remark by the authors of the military histories of those times.

2ndly. If the principle had been known to the artillerists of this epoch, it seems strange that no further efforts should have been made to apply it more successfully than in these first rude attempts, and that a century and a quarter should have elapsed before the subject was again practically, or, for aught we know, theoretically, taken up.

3rdly. All difficulty in accounting for the disappearance of projectiles of the nature described by Piobert, and for the absence of any mention of them in the works to which I have alluded, vanishes if we adopt the explanation suggested above, that the bullets were placed inside to increase the weight of the projectile and to act as so many additional splinters, for a very slight experience, the experience which one siege may have afforded, must have served to show that shells of this construction, and intended to act on this principle, were of little real service. And the complete failure which must have speedily followed any attempt to introduce shells constructed on these erroneous principles would sufficiently account for the absence of any general mention of them, and of any attempt to improve upon them—facts which I know not how to account for in any other way.

4thly. There is no doubt that shells have been thus constructed,—constructed, that is to say, with a number of bullets added to them with the object of increasing the number of splinters, for the following passage occurs in an old work written sometime in the 17th century, by Caismir Simienowicz, a Polish officer, and called *The Great Art of Artillery*:[1] "This grenado is most fre-" quently armed with leaden bullets; that is the outside of it is covered with " them, that it may do the greater execution. In order to this, you must first " coat the grenado with melted wax, which must have a certain quantity of " colsphone[2] mixed with it; into which you may sink as many musquet balls " as you please whilst it is cooling; then wrap the whole up in a cloth and " bind it well round with packthread."—*The Great Art of Artillery*, p. 212.

This passage removes all doubt as to the fact that shells have been constructed upon the erroneous principle which I have explained, for, in the first place, the "grenados" in question were *hand* grenades, and as these could not have been thrown with sufficient velocity to communicate an effective forward velocity to the bullets after rupture, clearly the bullets must have derived their effect from another agency, and that agency must have been the bursting charge of the shell; and, in the second place, the fact of the bullets being placed *outside* the shell seems to point towards the same conclusion, for by placing them outside the whole of the interior of the shell became available for the reception of the bursting charge, and as, according to my view, the effect of the bullets depended upon the bursting charge, by this arrangement that effect would be proportionally increased.

5thly. That the leading principle of shrapnel fire—the theory of the projectile, if I may so designate it—had not made a very permanent impression on the minds of the French artillerists of the 17th century, if it *had* ever been known to them, must be concluded from the fact that it was *unknown* to French officers of the highest rank and experience in the 18th and the beginning of the 19th centuries! That this was the case is placed beyond all doubt by a note appended to Decker's *Traité Elémentaire d'Artillerie*, by the French translators, Colonel J. Ravichio de Peretsdorf and Capt. A. P. F. Nancy: "Ces " projectiles ne peuvent pas être, à beaucoup près, aussi terribles qu'on les " représente. Les balles n'étant point serrées sur la petite quantité de poudre " renfermée dans l'obus, *celle-ci ne peut leur communiquer, par suite de l'explo-" sion, une quantité de mouvement capable de les porter assez loin et avec assez " de force pour les rendre vraiment meurtrières.* Des expériences faites à Vin-" cennes sont venues à l'appui de ce raisonnement, et ont démontré que les " *schrapenschels* étaient réellement de fort peu d'effet. Pour les rendre plus

[1] This work is, I believe, very rare. I am indebted to Colonel Lefroy for the loan of a copy of the English translation (the original work was in Latin), published in 1729. There is a copy of the work in the Royal Artillery Library at Woolwich.

[2] Powdered rosin.

" meurtriers, un officier Français a proposé de les composer de deux enveloppes " concentriques en fer coulé, entre les quelles seraient placées les balles, et dont " celle de l'intérieur contiendrait la poudre. Il n'est pas douteux que de cette " manière la force de l'explosion ne communiquât aux balles une quantité de ' mouvement beaucoup plus considérable, et ne les rendit par conséquent " beaucoup plus meurtrières; mais aussi la fabrication en deviendrait certaine- ' ment beaucoup plus difficile et plus coûteuse." I think I am justified in concluding from this passage that the theory of the projectiles " was unknown " to French officers of the highest rank in the 18th and the beginning of the " 19th centuries," when it is remembered that Colonel Peretsdorf was a " chevalier des ordres royaux a Saint-Louis et de la Légion d'Honneur, archi- " viste des bureaux de l'artillerie et du génie au ministère de la guerre, &c.," and who has served, he tells us, " en Piémont, puis en Autriche, et enfin en " France, et ayant, dans sa longue carrière militaire, occupé tous les grades " depuis celui d'élève d'artillerie, et rempli presque tous les emplois, soit en " paix, soit en guerre, soit dans le personnel, soit dans le matériel;" while Captain Nancy was " ancien élève de l'école polytechnique, de la société des " lettres, sciences, et arts, de Metz." &c.

This passage also conclusively proves that the idea of those officers respecting these projectiles was exactly the idea which I have attributed to the French artillerists of the 17th century, viz., that the bullets were intended to act as so many splinters, to which force and movement would be communicated *by the bursting charge, and without reference to the velocity of the shell.* This seems to me to be very strong presumptive evidence in support of the theory which I have advanced.

From these considerations I have concluded that the principle of the shrapnel shell had not been perceived, and still less appreciated, as Piobert would have us suppose, by the artillerists of the 17th century. Those to whom my reasoning upon this subject does not carry conviction I would refer to the following extract from Decker respecting the history of these projectiles, and I must congratulate myself in being able to quote so distinguished an author in support of my views. " Quant à ce qui concerne les shrapnels, on rencontre bien dans " l'ancienne artillerie quelque chose de semblable *mais fondé sur un tout autre " principe;* ce qu'il ne faut pas confondre.

" On s'est servi de cylindres remplis de charges explosives et de petites " balles ' non pas probablement, d'après le principe des shrapnels, mais comme " ' une sorte de pétards; toutefois, nous connaissons aussi peu l'usage spécial " ' de ces projectiles que la matière des petites balles.'

" On dit qu'au siege de Rhodes, en 1522, les Turcs, se sont servis de bombes " remplies de grenades; c'est là l'exemple le plus ancien d'un projectile, qui a " une affinité éloignée avec les shrapnels modernes.

" Dejà le célèbre Furtenbach propose, en 1629, de placer sur les fusées un " pétard ou une grenade, et de les remplir avec des balles de fer ou de plomb " pour leur donner l'effet destructif d'un tir à mitraille.

" Dans l'année 1697, le Colonel Geisler a tiré à Telle, devant le ministre " Louvois, des bombes remplies de balles de plomb; et, dix ans plus tard, il " s'est servi de bombes remplies avec des grenades à main.

" En 1774, on rencontre dans l'artillerie Prusienne, parmi les projectiles à " obus, des *boulets explosifs,* qui contenaient de petites grenades; on dit que " ces grenades, après l'explosion du boulet, étaient lancées à 80 pas et faisaient " explosion à leur tour.

" Il est vraisemblable que ces projectiles étaient les mêmes que ceux qu'on " a depuis nommés *perdreaux.* En l'année 1806, un grand nombre de ces " projectiles tomba dans les mains des Français à Magdebourg, et en 1813, " lorsque les munitions devinrent rares, ils nous ont canonnés avec, probable- " ment sans en connaitre la construction; j'y étais, et j'ai souvent été interrogé " par les camarades sur ce fait singulier.

" Si on voulait se donner beaucoup de peine pour faire des recherches ulté- " rieures, on rencontrerait probablement plusieurs faits qui rentreraient dans " le domaine des shrapnels; mais quelques expériences que l'on eût faites dans " les temps passés avec des projectiles simulant des shrapnels, elles sont in- " différentes pour notre but; il n'y a que l'expérience de Geisler qui puisse faire " exception; mais qui en garantit l'authenticité? *Tous les projectiles creux " avaient cela de commun que leur effet devait dépendre de la charge explosive,*

" *et le Colonel Shrapnel fut le premier qui s'attacha à la vitesse initiale du*
" *projectile, et la prit pour base des obus à balles. Cette seule circonstance*
" *suffit pour lui assurer la priorité de l'invention, et le mettre à l'abri de toute*
" *contestation.*

" 'Tous les projectiles remplis de balles de plomb et de poudre, jusqu'au
" 'temps de Shrapnels,' dit le Capitaine Meyer, 'ressemblaient aux shrapnels
" 'seulement dans leur composition générale, mais non dans leur compo-
" 'sition spéciale, *et moins encore dans leur but;* car tous les projectiles creux
" 'des temps anciens ne devaient avoir de l'effet *qu'après avoir touché le sol,*
" '*tandis que ce qu'il y a de caractéristique dans les shrapnels consiste dans*
" '*l'explosion du projectile en avant de l'ennemi. Les anciens projectiles pro-*
" '*jetaient leurs balles par la force de la charge d'explosion, tandis que les*
" '*shrapnels les projettent par la charge de la pièce;* les premiers ne sont
" 'que des projectiles creux dont le nombre des éclats est augmenté, et
" 'les derniers sont des balles devant agir au loin. L'effet des anciens pro-
" 'jectiles de cette espèce devait être faible; de là leur emploi rare. Avant
" 'que les fuseés n'eussent atteint assez de perfection pour être réglées avec
" 'précision, à quoi l'on est parvenu seulement vers la fin du dernier
" 'siècle, il ne pouvait pas être question de produire l'effet que Shrapnel avait
" 'en vue; et c'est là le mérite incontestable de Shrapnel d'avoir tiré parti du
" 'perfectionnement des fusées pour utiliser un effet de cartouches non connu
" 'jusque-là.' "—*Expériences sur les Shrapnels*, pp. 12–14.

Major Seton, in his little work upon the shrapnel shell, also has a passage upon the subject, which I shall do well to quote. " It may be stated, how-
" ever, that these shells were filled with leaden bullets at the early periods
" above mentioned, under an erroneous notion that, on the shell bursting, the
" contained bullets would scatter with force and produce an effect similar to
" that of splinters of the shell. The dynamical fact, however, of the bullets
" continuing to pursue the course the shell was moving in when it burst, and
" that they derive their effect rather from the charge of the piece than from
" that of the shell—the leading principle in the shrapnel fire—appears, no
" doubt, to have been first clearly perceived, as well as distinctly enunciated,
" by Colonel Shrapnel."—*Observations on the Shrapnel Shell*, p. 10, *note.*

See also *British Gunner*, Introductory " Notes, Explanatory of the several
" subjects to which they relate."

The conclusions to which I have come, then, after a careful investigation of the facts of the case, are that General Shrapnel's invention had not, either in theory or practice, been anticipated by either the Germans or the French, or, that I can discover, by any nation in any age.

It is not enough, as I have before said, that General Shrapnel should merely be spoken of as having " improved upon," " re-introduced,"[1] or " perfected,"[2] a shell invented by Germans or French some hundred of years back. I desire to see his claim to the *invention* universally and unhesitatingly conceded.

Appendix B.

Some Considerations respecting the Practical Value of Shells of the Shrapnel Class.[3]

There has always existed, and still exists, much difference of opinion as to the practical value of shrapnel shell; but it appears to me that the testimony borne to their efficiency on their first introduction, and during their employment in the Peninsula campaign is so overwhelming as to admit of no doubt on the subject on the part of those who choose to examine this testimony carefully and dispassionately; my chief difficulty in dealing with the matter consists in the selection of authorities in support of my views, from the large

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[1] "Remit en usage."—*Piobert*, p. 253.
[2] " Perfectionnés."—*Thiroux*, p. 299.
[3] This paper originally appeared in the *Proceedings*, R.A. Institution, vol. iii., p. 4.

mass at my disposal.[1] The Duke of Wellington in a letter to Sir John Sinclair, dated 18th October 1808, says, "I shall have great pleasure in testifying at any " time to the great benefit which the army lately under my command derived " from the use of the spherical case shot in two actions with the enemy, a " benefit which I am convinced will be enjoyed wherever they will be judiciously " and skilfully used."

Colonel Robe, commanding the Royal Artillery, says, in a letter to General Shrapnel, "It is admirable to the whole army . . . . its accuracy perfect and " its effect dreadful, *as acknowledged by the French officers themselves at a con-* " *ference with ours after the action of the 21st* . . . . the artillery has been " complimented both by them and by all our own general officers in a way " highly flattering to us, and I should not do my duty to the service were *I not* " *to attribute this good fortune to a good use of that weapon with which you have* " *furnished us.* I told Sir Arthur Wellesley I meant to write to you, and asked " if it might be with his concurrence, his answer was, 'You may say anything " 'you please, you cannot say too much.'"[2]

"D'après le Général Foy, les Anglais se seraient servis avec beaucoup " d'avantage contre nous de ce projectile à la bataille de Vimiera en " Portugal."[3]

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

It would be easy to multiply authorities to prove that the effect produced by these shells at Vimiera, and subsequently throughout the Peninsula campaign, was very great, and to those who would wish to investigate the subject more at length I would recommend a persual of Major Seton's *Observations on Shrapnel Shells,* particularly chapters i. and iii. Major Seton is one of those who think the effect of shrapnel very questionable, and that although on their first employment they seemed to have done good service, this service was rather apparent than real, the novelty of the projectile contributing in no small measure to increase the admiration with which it was first regarded, and to cause its effect to be exaggerated. Now respecting this and other adverse opinions which have been expressed upon the subject, I must remark that no case against these shells seems to me to have been made out.[4]

It appears to me in the first place, on weighing the favourable against the unfavourable opinions as collected and recorded by Major Seton and some few others whieh I have met with elsewhere, that the balance is largely in favour of the shells, and this any reader who chooses to take the trouble may determine for himself by referring to Major Seton's work, and to sources referred to in note 1, below.

In the second place it is certain that many of the adverse opinions prove upon investigation to be much less formidable than they at first sight appear. For instance, when the Duke of Wellington states, as he did in 1812, that his opinion in regard to these shells had been much shaken,[5] he explains wherein he thinks the shells defective, "that they inflict trifling wounds and kill " nobody," and in the following month we find him not proposing to discontinue the supply of the shells or condemning the principle, but suggesting

1 The appendix to the memorial presented by General Shrapnel's son, and his petition to the House of Commons, bearing date 1846 and 1847 respectively, contain no less than 55 independent testimonies to the great efficiency and merits of these projectiles in battles, sieges, &c. These testimonies are extremely interesting, but as they occupy some 16 folio pages any attempt to quote them here is obviously out of the question. It may be desirable, however, to state that the testimonials are given, among others, by the Duke of Wellington, Colonel Sir W. Robe, Lord Howe (Lieut.-General of the Ordnance), the Marquis of Anglesea, Lord Combermere, Duke of Cumberland, Admiral Sir Sydney Smith, Lieut.-General Lord Keane (Commander-in-Chief in India), Sir Robert Sale, and 22 artillery officers.

2 *Ordnance Select Committee Report on Shrapnel Shells,* p. 14.

3 *Instruction d'Artillerie,* p. 299.

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

5 *Gurwood's Despatches,* vol. viii., p. 659.

"a remedy" for this "material defect" by the employment of larger bullets than those which had previously been placed in the projectile,[1] a fact which in itself is strong proof that he thought the projectile only needed *improvement* to make it formidable. That this increase in the size of the bullets proved an effective remedy can hardly be doubted when we read the accounts given by the French of the effect which these projectiles produced when employed against them at St. Sebastian in 1813: "Ces projectiles nous causèrent beau- "coup de mal"; "Nous ne pumes lutter longtemps contre une masse aussi "formidable d'artillerie"; "Ce projectile, que l'ennemi a trouvé le moyen de "faire éclater à volonté, nous fait beaucoup de mal."[2] Such are the terms in which these projectiles are spoken of by those who certainly did not want for opportunities of noticing their effects.

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

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

Much stress has also been laid by the opponents of the shell on the difficulty of judging correctly where the shell should be exploded; and though I believe that the force of this objection has been much over-estimated,[3] I am quite

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1 *Gurwood's Despatches*, vol. ix., p. 281.

2 *Observations on Shrapnel Shell*, pp. 16, 17.

3 By General Shrapnel, indeed, it was affirmed that shrapnel shell have an *advantage* over other projectiles in this respect. He says, "The great advantage which pertains to spherical case shot over all other modes of firing is, that it is calculated and best adapted for unfixed distances and ranges merely estimated, or which cannot be correctly ascertained; the reason of which is self-evident from its covering or spreading over so much ground, that one and the same elevation will answer for a considerable number of contiguous ranges."—*Ordnance Select Committee Report on Shrapnel Shells*, p. 16. I do not quite hold with General Shrapnel in this matter; but I go to the length of saying that the importance of the objection which has been urged against shrapnel shells on this account has been much overrated.

prepared to assign to it a place in an investigation of the merits of this description of projectile. But this objection, and others, such as the liability to premature explosion, and the comparatively short range at which they were effective, which held good against the original shrapnel shell, can scarcely now be urged against the diaphragm pattern.

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

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

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

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

"There is a point of much importance, which has been well established by " the results of the experiments lately carried on with diaphragm shells at " Woolwich, namely, that if the *elevation* be correct it matters little whether " the shell burst at 100 yards or 20 yards from the object fired at, so that, " when the corresponding lengths of fuze and elevations have been determined " by experiment the practice with shrapnel will become very simple."[1]

Doubtless it is necessary to the full development of their efficiency that they should burst with tolerable correctness as regards the object aimed at; but it must not be supposed that their effect will be nullified if they do not burst at the *exact spot* required; no doubt their effect will be lessened in proportion as they explode further from the required spot (may not this be said in a greater or less degree of all other projectiles?), but the limits of error in this respect are very large, larger, perhaps, than with any other projectile, except a solid shot, and have been still further extended (see Appendix C.) by the adoption of the diaphragm pattern. There is a passage in Col. Boxer's *Remarks on the Diaphragm Shrapnel Shell* which has a very direct and practical bearing on this subject as showing the margin of error allowable with shells of this class; it is quoted in the text, p. 253, "There is a point of much importance, &c." . . . . . down to end of quotation.

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

It will probably, however, always be a moot point as to whether the physical effects of shrapnel fire are very great, and shells of this class will probably always have their opponents, but mainly, I believe, from the reason that men are apt to draw their conclusions hurriedly, and without perfectly knowing or sufficiently weighing *all* the circumstances of the cases on which these conclusions are founded.[1] For my own part, I must say that the solution of the question which a careful and dispassionate examination of the available data upon the subject has afforded me, is that which the foregoing pages have indicated, and which admits of a concise and general expression in the following terms: Certain conditions are necessary to the proper development of the efficiency of every missile; doubtless these conditions are somewhat more numerous in the case of shrpanel shells than of other projectiles, but with the improvements which have been effected in these shells and their fuzes they are far from being impracticable or even difficult of fulfilment, while the effects, both physical and moral, of the shells are, under favourable conditions, probably greater than those of any other projectile.

It will be observed that I have attempted to deal with the objections which have been urged against the shrapnel class of shells in the aggregate, rather than separately and in detail, and this paper makes no pretence to the character of an exhaustive investigation of the subject; but perhaps the considerations and arguments which I have set forth, general though they be, may serve to guide officers to the salient points of a question which it is important every artilleryman should understand, and may help to clear away the doubts which embarrass the minds of some as to the practical value of shrapnel fire.[2]

Appendix C.

On the Objections which have been urged against the Diaphragm Shrapnel Shells, and on the General Merits of this Construction.

Upon careful consideration it appears to me that of the various objections which have been urged against the diaphragm construction, only two are sufficiently grave, or sufficiently precise to necessitate a careful examination. These two objections may be stated as follows:—

(1.) That from the relative positions of the bullets and powder, the shell is necessarily eccentric, and that great irregularity of flight does, and must, result from this eccentricity.

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

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

[3] This paper originally appeared in the *Proceedings,* R.A. Institution, vol. iii., p. 234.

(2.) That the bullets are acted upon by the bursting charge in a way and to an extent highly injurious to the efficiency of the shell.

1. *With respect to the eccentricity of the shell and the consequent inaccuracy of flight which it is stated must and does result therefrom.*—This objection appears first to have been raised by the Inspector General of Ordnance in Calcutta, in 1857,[1] but it can be shown, to quote Col. Boxer's words, to have "no foundation in fact or in theory,"[2] and that, far from this shell being necessarily inaccurate in its flight, it should theoretically "be even more regular "than an ordinary shot of the same weight."[3]

First, then, as regards the facts of the case: An immense number of references might be made to practice reports, and to the reports of the various committees which have deliberated from time to time to prove that the opinion as to the eccentricity of this projectile affecting injuriously its accuracy "has no "foundation in fact;" the following, however, will perhaps be sufficient for this purpose:—

On the 5th October 1852, Col. Robe reports to the Director-General, "The "results as to *deviation*, range, and velocity have been most satisfactory. . . . . "At 900 and 950 yards five shells out of six went through the target, and the "sixth was five yards to the left of the centre line . . . . At 1,600 yards five "shells were fired and grazed at 3, 4, 5, 6, and 7 yards to the left of the line."[4] At the foot of the same report Col. Robe writes, "The *direction* of these shells "were remarkably good."[5]

Again, the Committee report 18th April 1853. "The results" as to *direction*, range, and velocity were very satisfactory.[6]

On the 15th August 1853, Col. Lake, R.A. reports: "I beg to state that "these shells appear to answer most effectually, *and the direction was very* "*exact.*"[7] Again, on the 22nd August 1853, with reference to further experiments, Colonel Lake reported: "I beg to observe *that the direction is very* "*good,* &c."[8] On the 23rd September 1853 the same officer reports; "The "experimental practice with Capt. Boxer's diaphragm shells being completed, "I have the honour to inform you that they appear to me to be very effective ". . . . *The direction was good.*"[9] On the 1st October 1853 the Committee report, "With the diaphragm shrapnel shell . . . . *the direction is good.*"[10]

Such are a few of the many positive testimonies which might be quoted to prove the accuracy of the practice which was made with these shells,[11] to which

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[1] "The centre of gravity of the shell is not in the centre of figure, and experiments made with eccentric shot and shells in 1850 proved that such projectiles cannot be depended upon for accurate practice."—Report of Inspector General of Ordnance in Calcutta, 21st December 1857. See *Supplement to Synopsis of Ordnance Select Committee Reports*, p. 16.

See also Committee's Memorandum on Diaphragm Shrapnel Shell, p. 3. Colonel Boxer's *Remarks on Committee's Memorandum on Diaphragm Shrapnel Shell*, p. 3.

The Inspector General of Ordnance at Calcutta, however, was not the only officer who held this opinion, nor, indeed, the only one who urged it, for in Colonel Boxer's *Remarks upon Diaphragm Shrapnel Shell*, p. 17, the following passage occurs:—"*It has been often stated*, and it is, I believe, *the opinion of many* even at the present time, that as the centre of gravity in the diaphragm shell does not coincide with the centre of figure . . . . great irregularity in flight must result."

See also *Supplement to Ordnance Select Committee Report on Shrapnel Shell*, p. 18; *Synopsis of Ordnance Select Committee Report on Shrapnel Shell*, p. 295. Also, *The Shrapnel Shell in England and Belgium*, pp. 48, 49; and *Revue de Technologie Militaire*, vol. ii., p. 390.

[2] *Remarks on Diaphragm Shrapnel Shell*, p. 17.

[3] Colonel Boxer's *Remarks upon Committee's Memorandum on Diaphragm Shrapnel Shell*, p. 4.

"In fact the flight of these projectiles should be theoretically more accurate than ordinary round shot of the same weight, and I am quite satisfied that in practice it will be found quite as accurate."—*Remarks on Diaphragm Shrapnel Shell*, p. 23.

[4] *Synopsis of Ordnance Select Committee's Report on Shrapnel Shell*, p. 276.

[5] Colonel Boxer's *Remarks on Committee's Memorandum on Diaphragm Shrapnel Shell*, p. 4.

[6] *Synopsis of Ordnance Select Committee's Reports on Shrapnel Shell*, p. 281.

[7] *Ibid.*, p. 281. [8] *Ibid.*, p. 283. [9] *Ibid.*, p. 285. [10] *Ibid*, p. 288.

[11] I might perhaps also quote a passage from a report of the late Sir George Barker, R.A., in positive proof of what I am seeking to establish; the passage is as follows:—"The objection referred to by Colonel Abbott, that the centre of gravity is not in the centre of the figure, has been found *by experiment* not to affect the flight of the projectile to a perceptible degree."—*Supplement to Ordnance Select Committee Reports on Shells*, p. 23.

may be added that the whole tenor of the reports of the Committee,[1] and the teaching of some 50 pages of practice reports,[2] go to prove that the practice with these shells as regards accuracy of flight was at least up to the average of practice with spherical projectiles of the same weights.

As regards the negative evidence available for the same object, the following appears to me sufficiently conclusive: I can discover only two unfavourable opinions *professing to be based upon practice or experiment*[3] respecting the accuracy of flight of these projectiles.

The two unfavourable reports are as follows:—

(*a*) A report made in 1857, which says: "The weight of the bullets being " all on one side of the shell causes an irregular motion, and consequently " great inaccuracy in the flight of the projectile."[4] And (*b*) a report made by another officer in 1858, to the same effect: "With the same charge and eleva- " tion, and only a few ounces difference in the weight of the shells, the range " of one would exceed that of the other by 200 or 300 yards, while also, owing " to their eccentricity, the lateral deviation was very great."[5]

These, then, are the two, and, as far as I can discover, the only two, instances in which officers *speaking from practice and experience, and not merely on theoretical grounds*,[6] have reported unfavourably of the accuracy of flight of the diaphragm shell; and the case against the projectile in this respect rests therefore solely upon these two reports.[7]

This is not a very strong case, and when we take into consideration the mass of evidence pointing to a different conclusion, hardly strong enough to make it necessary to do more than prove that supposing great inaccuracy of flight *did* occur with these projectiles, the effect could not possibly have proceeded from the cause so confidently assigned. I prefer, however, before I proceed to the theoretical aspect of the question, and with a view to rendering my vindication of the diaphragm shell more complete, to endeavour to account for the only two exceptions to the generally favourable testimony borne to the accuracy of flight of these projectiles by officers who have actually experimented with them. The following explanation suggests itself:—

In speaking of the accuracy of these shells it is necessary carefully to distinguish between accuracy of fire and accuracy of flight. By accuracy of fire is meant the accuracy, with respect to the object fired at, at which the shells burst; and this will depend upon a variety of conditions, chief among which may be named an accurate estimate of the range, correctness of line and elevation, accuracy of direction of the projectile, and correct adjustment and action of the fuze; by accuracy of flight is meant only accuracy of direction up to the bursting point: accuracy of flight is, in fact, only one of many elements necessary to secure accuracy of fire. Now it is evidently quite possible that the accuracy of fire at some particular practice may be very inferior, while the accuracy of flight is all that can be desired; for accuracy of flight being, as has just been pointed out, only one of the elements of accuracy of fire, the failure may arise from any other of those elements which I have enumerated.

In this way much confusion and difference of opinion may exist as to the proper application of the term "accurate" and "inaccurate" to any particular

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I do not, however, quote this passage in my text for the reason that I cannot discover to what particular experiment Colonel Barker referred; and I think that I may very well afford to dispense with a piece of evidence which is not as precise as I wish all the evidence which I make use of to be. At the same time I give the passage in a note, that it may not be supposed that I have overlooked it, and because it shows what this distinguished artillery officer thought upon the subject.

[1] See *Synopsis*, &c., also Committee's *Memorandum on Diaphragm Shrapnel Shell*, pp. 3, 4, &c.

[2] *Ibid.*, pp. 9–58.

[3] The opinion of the Inspector General of Ordnance at Calcutta was entirely theoretical, r the Select Committee says:—"It does not appear from the correspondence that any bxperiments were made at Dum Dum to prove the correctness of the opinions entertained y the Ins pector General of Ordnance."—*Committee's Memorandum on Diaphragm Shrapnel Shell*, p. 4s

[4] *Synop is, &c.*, p. 295.

[5] *Supplement to Report of Ordnance Select Committee on Shrapnel Shell*, p. 18.

[6] I have already pointed out (*see* note [3]) that the opinion expressed by the Inspector of Ordnance at Calcutta was a purely theoretical one.

[7] See P.S. appended to this paper respecting reports made in 1863 from 30 artillery stations, *in* NONE *of which the shells are stated to be inaccurate in flight.*

practice with this class of shells; while even with the best intentions, and the clearest and most correct views upon the subject, the distinction is not an easy one to make *practically* with shells which generally burst, it must be remembered, before they graze.

The proper way to determine the accuracy of flight of diaphragm shells is to fire a number of them blind, but neither of the two officers from whose reports I have quoted make any mention of having done this.[1]

I observe also on examining the practice reports upon which the second of the two unfavourable reports is based, and other practice reports given in the *Committee's Memo. on Diaphragm Shrapnel Shells*, pp. 9 to 58, that where the shells failed to burst the accuracy of flight seems to have been very good; generally the shells which so failed went through the target, in the majority of the other cases they were "in the line," and when not in the line the deflection right or left is generally inconsiderable. I think this is very strong proof that inaccuracy of flight and inaccuracy of fire were not always carefully distinguished from one another, and that the former term was often misapplied.

I may now pass on to the theory of the question, and prove that even if the testimony to inaccuracy of flight been universal, and the fact been placed beyond all possibility of doubt, the defect could not properly be assigned to the cause from which the officers who reported upon the subject believed it to proceed, prove, in short, *that any observable inaccuracy of flight on the part of these projectiles could not be in any way connected with their eccentricity.*

In the case of all spherical projectiles fired from smooth-bored guns there is a certain rotation generated in the bore, arising, when the projectile is concentric, principally from the windage,[2] and where the projectile is eccentric, and the line joining the centres of gravity and figure is not in, or parallel to, the axis of the bore, from the powder acting upon a larger surface on one side of the centre of gravity than on the other, and so producing a rotation about the centre of gravity.[3] Now the direction of the rotation which arises from these causes affects very appreciably the flight of the projectiles;[4] and as in the case of eccentric projectiles the direction of this rotation will vary according to the relative positions of the line joining the centre of figure and gravity, and the axis of the piece,[5] so also will the flight of the projectile vary from the same

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1 It is worthy of observation that there is no record of any such experiments having been made; and this may fairly be accepted as a sort of negative proof that those who practised and experimented with the shells were generally well satisfied with regard to their accuracy of flight. Otherwise it is reasonable to suppose that so grave a defect would have been tested by an experiment specially calculated to expose it.

2 "There is a considerable degree of friction between the bore and the projectile . . . where there is windage, the direction of the force being opposite to that of the gunpowder, and upon the surface of the ball. It will therefore tend to give rotation to the shot."—*Treatise on Artillery*, Section 1, Part I., p. 158.

"Friction . . . is the only immediate cause of deflection in a projectile whose centres of figure and gravity are coincident."—*Ibid.*, p. 166.

3 *Motion of Projectiles*, p. 125, par. 19.

"Suppose the ball to be perfectly round, but its centre of gravity not to coincide with the centre of figure. In this the impelling force passes through the centre of the ball, or nearly so, and acts in a direction parallel to the axis of the piece; but if the centre of gravity of the ball be out of the line of direction of the force of the powder, the shot will be urged to turn round its centre of gravity."—*Treatise on Artillery*, p. 158.

4 "A ball leaving the bore of a gun rotating on any axis, except one parallel to that of the bore, will deviate accordingly to the direction of the rotation."—*Motion of Projectiles*, p. 26.

"If the anterior part of the shot turn from below to above there will be a force tending to raise the centre of gravity, and the range will be increased; if from above to below, it will be diminished. Should the rotation be from left to right the shot will be thrown to the right."—*Treatise on Artillery*, Section 1, Part I., p. 166.

"To our countryman Robins is due the credit of first pointing out the great change which the rotation of a shot would produce in the path of its flight."—*Ibid.*, p. 159.

See Robins' experiments and remarks upon this subject embodied in *Ibid.*, p. 159–165.

5 "The direction of rotation will depend upon the position of the centre of figure with regard to that of gravity."—*Treatise on Artillery*, Section 1, Part I., p. 159.

"If a spherical eccentric projectile be placed in the gun, so that the line joining it centres of gravity and figure form an angle with the axis of the bore . . . . the line representing the sum of all the forces resulting from the explosion of the charge will not pass through the centre of gravity, as it passes through, or nearly so, the centre of figure; and the result will consequently be . . . . a motion of rotation round an axis at right angles to the axis of the bore."—*Remarks on Diaphragm Shrapnel Shell*, p. 18.

"The shot . . . . is found to deviate according to the position of the centre of gravity when the ball is placed in the bore of the gun."—*Motion of Projectiles*, p. 26.

cause, and depend upon the angle which the line joining the centres of figure and gravity happens to make with the axis of the piece.

But when an eccentric projectile is so placed in the bore that this line does *not* make an angle with the axis of the piece, but lies parallel to or in it, then no rotation will be generated, and no deflection from the natural line of flight be produced, *except from those causes which produce rotation and deflection in a concentric projectile, i.e.,* those resulting from windage,[1] and an eccentric projectile thus situated may therefore be practically considered as a concentric projectile, being under these circumstances subject in respect to its rotation and deflection to similar laws and influences. Now the diaphragm shell is, from its construction, and from the fact of its having a wood bottom attached, a projectile of this nature, that is to say, although eccentric it is always necessarily placed in the bore with the line joining its centre of gravity and figure parallel to the axis of the piece, and thus no rotation is generated in it which would not be generated in a concentric projectile,[2] *and therefore no deflection or inaccuracy of flight results from its eccentricity.*

But more than this, it may be shown, as already stated, that "these shells "should theoretically be even *more* regular in their flight than an ordinary "shot of the same weight."[3] This is not difficult to prove, for it will be apparent to any one who has followed the above remarks carefully, that "if "eccentric projectiles be always placed in the gun in similar positions as regards "the lines joining their centres of gravity and figure, *whatever that position "may be,* their path will be more regular than that of ordinary round shot "placed accidentally in the bore,"[4] because in the one case the direction of rotation is known and determined, in the other, the case of ordinary round shot, it is uncertain and variable, owing to the fact of nearly all ordinary round shot being more or less eccentric,[5] and the position of their centres of gravity and figure undetermined. It follows, therefore, that the practice with ordinary round shot will be theoretically less accurate than the practice with diaphragm shell, the line joining the centres of gravity and figure of which always occupies, as has been explained, a known and uniform position in the bore. And how much more must the advantage incline to the side of that projectile of which the eccentricity is, so to speak, neutralized by its always occupying a position in the bore which prevents any deflection due to eccentricity being produced. In other words, the comparison lies between projectiles more or less eccentric, and

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1 "The experiments in 1850 with shot purposely made eccentric and placed in the bore, with the centre of gravity in various positions . . . proved . . . that if the centre of gravity was placed in the centre of the piece, the eccentric lump being towards the charge, the range and deflection were about the same as those with concentric shells."—Committee's *Memorandum on Diaphragm Shrapnel Shell*, p. 4.

"If the direction of the force be through the centre of gravity it causes a progressive motion only. . . . . If the body, besides its progressive motion, had a motion of rotation likewise, this last will not be changed by the action of a new force, whose direction passes through the centre of gravity."—*Treatise on Artillery*, Section 1, Part I., p. 157.

In other words, if the force act through the centre of gravity, as it does in the case of a spherical concentric projectile, and in the case of an eccentric projectile the line joining the centres of gravity and figure of which lies in or parallel to the axis of the piece, a progressive motion only, and no rotation, will be communicated to the projectile,—although such a projectile may have a motion of rotation *from other causes,* such as windage. Therefore, whether the projectile be concentric or eccentric, *so that it be situated with its centre of gravity in the axis of the piece, and with the line joining its two centres in or parallel to that axis,* it matters not; the same motion will be the result, and the eccentric projectile under these circumstances becomes *virtually,* and for all practical purposes, a concentric one.

2 "Although the diaphragm shrapnel shell, when prepared for service, is from the relative positions of the bullets and powder, what is termed eccentric, still no rotation will be generated in the bore from this arrangement, as the wood bottom which is firmly riveted to the shell always ensures the straight line which joins its centre of gravity and centre of figure being in a position parallel, or very nearly, to that of the axis of the bore, or the line representing the direction of the propelling force."—*Remarks on Diaphragm Shrapnel Shells*, pp. 22, 23.

3 Colonel Boxer's *Remarks on Committee's Memorandum on Diaphragm Shrapnel Shell*, p. 4.

4 *Remarks on Diaphragm Shrapnel Shells*, p. 22, Colonel Boxer adds:—"The results of the experiments which were made in 1850 and in 1851 at Shoeburyness, notwithstanding the imperfect mode adopted to secure the proper position of the eccentric shot, confirms this view."—*Ibid.*, p. 22.

5 From the difficulty, almost amounting to an impossibility, of casting a perfectly concentric sphere of iron, or any other metal.

which occupy accidental positions in the bore, on the one hand, and projectiles which are virtually concentric, on the other; there can hardly be much difficulty in determining which of the two should theoretically be most accurate in flight.

2. The second objection which has been urged against the diaphragm shell is, *that the bullets are acted upon by the bursting charge in a way and to an extent highly injurious to the efficiency of the shell.*[1]

The answer to this objection is fourfold.

1st. That a special arrangement was made by Col. Boxer to preserve the balls from the direct action of the bursting charge, this arrangement consisting in the four grooves in the inside of the shell and in the thickening of the metal round the line of junction of the diaphragm;[2] and unless it can be proved that this arrangement has failed, it is fair to conclude that it has answered the end required of it.

2nd. In examining unfavourable reports respecting the failure of the shell in respect to this arrangement, particular attention must be paid to the date of such reports, and whether they were made before or after 1858, for, as has been explained, the details of the arrangement by which the balls are preserved from the direct action of the bursting charge, and upon which the proper opening and action of the shell depends, were not perfected until 1858.[3] Consequently no unfavourable reports upon this subject which bear date previous to 1858, or which are urged against shells manufactured before that date, can be received in evidence against shells of the 1858 pattern; *and the only unfavourable reports upon this subject which I have been able to discover bear date* 1857,[4] *and are therefore of no account in dealing with shells of the present pattern.*

3rd. There is positive evidence that even with shells which were manufactured before the adoption of the 1858 pattern this defect was by no means universal; indeed, it seems certain, from the following extracts, that with *shells which were correctly manufactured*[5] the defects complained of were not generally apparent:—Letter from Col. Robe, 5th October 1852.—"The results "as to direction, range, and velocity have been most satisfactory. The shells "*break into very large fragments*, which range to great distances; *they appear "to break in the direction marked by the construction.*"[6] On the 22nd August 1853, Col. Lake writes, "I beg to observe that the direction was very good, "*also the force of the balls, and spread.*"[7] In a report from Col. Boxer to the Director-General of Artillery, 27th September 1853, he says: "The spread of "the balls has been *symmetrical with regard to the trajectory.*"[8] Surely, therefore, it may fairly be conceded that the *principle* of construction was not at fault, but that the defects arose in part from the details of construction being *at that date* slightly imperfect, and in part from bad workmanship.

4thly. There can be no doubt that the defect was entirely remedied by the improvements introduced into the 1858 pattern shells, and that with shells correctly manufactured on this improved design no further failures in respect to the proper action of the balls took place. This fact seems to be established, (1) by the negative evidence borne by the absence of any unfavourable reports against the shells on this score subsequent to 1857;[9] and (2) by the positive and very strong evidence afforded by the following table of practice carried on in 1858, with diaphragm shells of the improved construction. The table is epitomized from a table given at length at page 46 of *Remarks on Diaphragm Shrapnel Shell.* The targets were arranged in eight rows, each row 15 yards behind the one in front, except the two last intervals, which were 30 yards, so as approximately to represent a battalion in column at half intervals. The frontage of each row was 80 feet, the height 8 feet. The whole of the targets were made of 1-inch boards, except the first row, which was *originally* of 1-inch boards, but for which 2-inch boards were afterwards substituted. It should be noticed that these shells were fired in one important respect under unfavourable circumstances, for the most suitable elevation and length of fuze were not

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1 See *Ordnance Select Committee Report on Shrapnel Shell*, p. 192–297.

2 See pp. 51, 52.

3 See pp. 47, 48.

4 The Reports given in *Ordnance Select Committee Report on Shrapnel Shell*, p. 223–297. These reports, with one exception, almost entirely have reference to these two defects—want of velocity on the part of the balls, and the splitting of the shell into two hemispheres round the junction of the diaphragm with the shell. See P.S. respecting Reports made in 1863.

5 *See* p. 155, note 17.

6 *Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, p. 276.

7 *Ibid.*, p. 283. 8 *Ibid.*, p. 216.

9 *See* P.S. respecting Reports made in 1863.

previously determined.[1] *It will be observed that out of* 9,600 *no less than* 9,346 *bullets took effect, and of these* 6,299 *went through the targets.*[2]

TABLE showing the Penetration of Bullets, the Result of 180 Rounds with diaphragm Shrapnel Shells, from 12, 9, and 6-pr. Guns, 60 Rounds per Gun, at the following Ranges, viz. :—

Range.	No. of Rounds per Gun.			Total No. of Rounds.
	12-pr.	9-pr.	6-pr.	
Yards.				
1,200	10	10	10	30
1,100	20	20	20	60
900	20	20	20	60
650	10	10	10	30
Total	60	60	60	180

—	Total Distance from No. 1 to No. 8, 135 Yards.									Total.
	2-inch Boards.	1-inch Boards.								
	1	1	2	3	4	5	6	7	8	
Bullets through	845	530	1,079	704	699	743	894	464	341	6,299[3]
Penetration :—										
lodged ·2-inch	3	—	—	—	—	—	—	—	1	4
·3 ,,	8	21	49	42	17	21	28	15	9	210
·4 ,,	7	9	17	23	8	13	15	8	6	106
·5 ,,	21	10	21	18	19	22	20	9	11	151
·6 ,,	46	23	59	42	41	17	58	21	21	328
·7 ,,	37	12	24	19	23	24	23	21	20	203
·8 ,,	28	5	15	9	18	8	12	3	2	100
·9 ,,	24	2	5	8	2	—	1	1	—	43
1·0 ,,	47	—	—	—	—	—	—	—	—	47
1·1 ,,	26	—	—	—	—	—	—	—	—	26
1·2 ,,	62	—	—	—	—	—	—	—	—	62
1·3 ,,	42	—	—	—	—	—	—	—	—	42
1·4 ,,	31	—	—	—	—	—	—	—	—	31
1·5 ,,	34	—	—	—	—	—	—	—	—	34
1·6 ,,	47	—	—	—	—	—	—	—	—	47
1·7 ,,	14	—	—	—	—	—	—	—	—	14
1·8 ,,	14	—	—	—	—	—	—	—	—	14
1·9 ,,	3	—	—	—	—	—	—	—	—	3
struck ·0 ,,	5	20	55	17	33	16	39	51	40	276
·05 ,,	13	45	84	53	46	60	51	29	37	418
·1 ,,	20	29	94	49	46	52	60	50	55	455
·15 ,,	1	—	—	—	—	8	4	3	2	18
·2 ,,	28	24	69	45	28	38	39	23	39	333
·25 ,,	1	—	1	—	—	—	2	1	1	6
·3 ,,	15	5	12	6	7	12	9	4	6	76
Total through	854	530	1,079	704	699	743	894	464	341	6,299*
lodged	494	82	190	161	128	105	157	78	70	1,465
struck	83	123	315	170	160	186	204	161	180	1,582
took effect	1,431	735	1,584	1,035	987	1,034	1,255	703	591	9,346*

Number of bullets in the 180 shells, 9,600.

I have now dealt with the only two objections which appear to me to demand a special and careful investigation, and I trust it will be considered that my remarks have vindicated the character of the diaphragm shrapnel shell in these respects.[4] A number of minor objections were urged against these shells on

[1] Colonel Boxer's *Remarks on Diaphragm Shrapnel Shell*, p. 42.

[2] I shall be happy to afford any officers who may desire it occular proof that the shells do really burst in the directions indicated by the grooves, and that this arrangement answers the end required of it, if they will call at my office in the Royal Laboratory, where they may see a number of burst shells; or, should they call on a day when shells are being burst for proof (a per-centage of all diaphragm manufactured are tested in this way) they may themselves see them burst in the bursting cell belonging to the department.

[3] There is a mistake in these figures in the original table, which I have corrected.

[4] The following passage from a letter addressed by the Secretary of State for War to Colonel Boxer shows what was the opinion entertained by the authorities respecting the objections which were urged against the shell after these objections had been fully

their first introduction, the fallacy of most of which has been exposed by time and practice and experience, and they therefore are not likely now to find many, if any, supporters. Among objections of this class may be noticed the following:—That a complete separation of the powder and bullets could not be effected by the diaphragm arrangement; that the shells would not continue for any length of time in store in a serviceable condition; that the effect caused by the jolting action in travelling in limber boxes would render the shells inefficient; that owing to the skill and care requisite to cast the shell correctly being so great, the expense of manufacture would be very considerable, and that there would be little guarantee that the projectiles supplied were of the proper quality.[1] Other objections, such as that the shell is generally of too complex a character, have been raised, but these are of so vague and intangible a character, and where not vague and intangible so often afford unmistakeable indication of having been put forward by those who are unacquainted with the details and objects of the diaphragm construction, that it is unnecessary to attempt to reply to them categorically.[2]

Of course the diaphragm shell will always be open to those objections which some hold to be common to all shells of the shrapnel class.[3]

The general conclusion to which the present considerations seem to me to lead, and I believe that those who are at the trouble of investigating the subject carefully will agree with me, is that General Shrapnel's object in introducing this class of shell, viz., to provide the service with an effective long range case shot, is attained in a most remarkable manner by Col. Boxer's diaphragm arrangement, and that while by this construction the defects of the original shrapnel have been removed, no fresh ones have been originated; and while the principle has been preserved in more than its original integrity,[4] the advantages have been multiplied and developed.[5]

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discussed:—"Major General Peel has observed with great satisfaction *that the various objections urged against this construction have proved to be groundless;* that its efficiency against targets has been amply established; and that its success in obviating premature explosions is fully recognized by the committee."—*War Office Letter*, 19th January 1859, 75/12226.

1 *Remarks on Diaphragm Shrapnel Shells*, pp. 27, 28.

2 As an example of the class of objection to which I refer, I give the following passage from a report of some American officers:—"Some objections present themselves in examining this arrangement, viz., the complicated construction of the shell, the great reduction of its capacity for balls, the peculiar boring instrument required for piercing the fuze, and the time required for performing this operation and adjusting the fuze in the shell in the field."—*Report of American Commission to Europe*, p. 140.

By two foreign authors, General Bormann and Colonel Delobel, the diaphragm system has been subjected to vigorous criticism; but I believe that an attentive perusal of the objections urged by them (see *The Shrapnel Shell in England and Belgium*, pp. 47-57, *et seq.*, and *Revue de Technologie Militaire*, vol. ii., pp. 329-405) will satisfy any one well acquainted with the construction of the projectile that neither to General Bormann nor to Colonel Delobel were the details of this construction thoroughly familiar. It is, of course, impossible for me to quote their objections at length,—I have given references to the works in which they may be found; but one objection appears to me so good an illustration of the way in which the indictment against the diaphragm is sometimes made up that I extract it entire. The objection is urged by Colonel Delobel, and quoted approvingly by General Bormann, who, indeed, adduces it in his Appendix, p. 126, on his own account:—"The series of operations necessary at the very moment of the fire for the preparation of the shrapnel, the regulation of the fuze, and the driving it into the *ampoulette* (socket), will require too much time; without taking into account that, if all this may be done properly and without error on the practice ground, it would not be the same on the field of battle, for the complete boring of the regulating hole up to the column of fusing composition, the introduction of the fuze into the ampoulette, SO THAT THE ROW OF CYPHERS CORRESPOND TO THE GROOVE AND ITS HOLE OR VENT (*lumière*), *and especially the driving home of the fuze into the ampoulette,* are things very difficult to do rapidly and well during the excitement of battle and amidst a thick smoke, and which will certainly occasion a great number of failures in igniting and premature burstings."—*The Shrapnel Shell in England and Belgium*, pp. 55, 56.

To the practical and well instructed artilleryman this objection will suggest its own comments.

3 These objections I have discussed in Appendix B., where the practical value of shells of the shrapnel class is considered.

4 I refer to the principle of preserving the bursting charge from the direct action of the bullets, and allowing their effect to depend entirely upon their communicated velocity. I say that in the diaphragm this principle has been preserved "in more than its original integrity," because I believe the bullets to be less affected by the action of the bursting charge in the diaphragm than they were in the original shrapnel shell.

5 Owing to the fact that full service charges may be used with the diaphragm shell, they are available at longer ranges than the original shrapnel, while their velocity will be

P.S.—Since the foregoing paper was written I have had an opportunity of examining the reports furnished in 1863 by 30 commanding officers of Royal Artillery at different stations, at home and abroad;[1] and through the kindness of General Lefroy I have obtained permission to make use of the Ordnance Select Committee's Abstract of these reports. From this abstract, it will be seen that out of the 30 reports one only is condemnatory,[2] three are unsatisfactory,[3] three are only *moderately* favourable,[4] *and* 23 *are highly satisfactory.*

In none of the above reports are the shells stated to be inaccurate in flight, and in three only is it affirmed that the flight of the bullets is affected by the bursting charge, or that the shells have failed to open properly,[5] and in these three cases this effect is spoken of as exceptional.

ORDNANCE SELECT COMMITTEE'S ABSTRACT of REPORTS received in 1863 from the several Stations abroad and at home, upon the Practice made with Diaphragm Shrapnel Shell.[6]

FOREIGN STATIONS.

Stations.	Results of Practice.	Premature Bursts.	Spread on Targets.	Remarks.
Barbadoes	No practice.	—	—	—
Bermuda	Inferior to improved shrapnel.	- - -	Effect inferior to improved shrapnel.	The only advantage of the diaphragm is in facility of loadloading.
Cape of Good Hope.	Most satisfactory in all respects.	—	—	—
Colombo	Several shell fell in a lump, like round shot.	- - -	- - - -	Practice from 8-inch and 32-pr. guns.
Corfu	Most satisfactory	- - -	- - -	Practice from 8-inch, 32-pr., 24-pr., 9-pr., and 6-pr. guns.
Gibraltar	Satisfactory, *from heavy guns.*	- - -	Penetration good at 1,200 yards, and effect much more destructive than common shell.	—
Halifax	No practice (*see* Remarks).	- - -	- - - -	Previous local records show that results have been satisfactory.
Hong Kong	Satisfactory	- - -	- - - -	From range reports in March 1863, and former experience.
Jamaica	Good as to the onward velocity of the balls.	4 out of 43	Lateral spread very uncertain.	Practice from 8-inch and 32-pr. guns.
Kingston	Satisfactory	Very rare; 1 out of 100.	- - - -	Instances of blind shells more frequent than with common shell.
Do. (*2nd report included in Montreal*).	Satisfactory	2 out of 113	- - - -	5 out of 113 blind.

greater at short ranges. Therefore whoever admits the advantages of shrapnel fire must admit that these advantages have been "multiplied and developed" by the diaphragm construction. Moreover, the diaphragm shell may be more safely carried filled.

[1] In all 35 reports were furnished, but at five stations there had been no practice with the diaphragm shell, and the reports from these stations accordingly embodied no opinion.

[2] Devonport.

[3] Colombo, Bermuda, and Leith Fort. In the last of these cases (Leith Fort) the opinion expressed in the Report is formed from "a few rounds fired by militia artillery regiments when undergoing their annual course of training."

[4] St. Helena, Jamaica, and Shoeburyness (Colonel Taylor's). Perhaps it may be thought that the Report from the Mauritius should be included among the "moderately favourable;" but as it pronounces the diaphragm pattern to be "a great improvement upon either the old or improved shrapnel," I have thought that it might fairly be included among the "satisfactory" Reports.

[5] Colombo ("several shells fell in a lump, like a round shot"); Jamaica ("lateral spread very uncertain"); and Shoeburyness, Colonel Taylor's Report ("generally effective, although SOMETIMES not ALTOGETHER satisfactory as regards breaking up of the shell").

In one other case, Mauritius, it is stated that *beyond* 1,200 *yards* "the bullets *appear* to strike the water in one solid mass."

[6] See *Extracts from Reports and Proceedings of Ordnance Select Committee,* vol. i., p. 386.

Foreign Stations—*continued.*

Stations.	Results of Practice.	Premature Bursts.	Spread on Targets.	Remarks.
Malta - -	Satisfactory - -	Per-centage small.	Effect good, judging from spread on water.	Blind shells; per-centage small.
Mauritius -	Great improvement -	Per-centage small.	Effect certain at 1,200 yards, but beyond that distance the bullets appear to strike the water in one solid mass.	Practice from 8-inch. 68-pr., 32-pr., and 9-pr. guns, and 8-inch and 24-pr. howitzers. Blind shells frequent.
Montreal - -	Most satisfactory.	——	——	——
Quebec - -	Very satisfactory -	Nil out of 62	Effect on target not ascertainable.	5 blind out of 62.
St. Helena -	32-pr. favourable, 24-pr. unfavourable.	——	——	——
St. John's, N.B	No practice.	——	——	——
Toronto -	Highly satisfactory -	Nil out of 50.	——	——

Home Stations.

Stations.	Results of Practice.	Premature Bursts.	Spread on Targets.	Remarks.
Alderney - -	Very satisfactory, and superior to all former shrapnel.	Very rare -	Very satisfactory -	Practice confined to firing at a mark on the water, when shells are often blind, either from fuze or elevation.
Aldershot -	No opinion.	——	——	——
Ballincollig -	No opinion.	——	——	——
Colchester -	Very satisfactory -	- - -	- - - -	No Royal Artillery practice, experience of Norfolk militia.
Devonport -	Feeble and harmless, as a shell.	- - -	Effects nil - -	An unfavourable opinion of the diaphragm construction is expressed as far inferior to the old shrapnel.
Dover - -	Extremely satisfactory, *from heavy guns.*	- - -	Floating targets unsuitable for judging effect.	——
Dublin - -	No practice.	——	——	——
Guernsey - -	Most satisfactory -	- - -	- - - -	Experience based on former local practice reports, and personal experience elsewhere.
Jersey - -	Most satisfactory.	——	——	——
Leith Fort -	Unsatisfactory as regards the splinters striking the target.	——	——	——
Manchester -	Very satisfactory -	- - -	- - - -	Local practice very limited.
PembrokeDock	Highly satisfactory -	Very rare; 1 out of 75.	——	——
Portsmouth -	Very satisfactory -	- - -	Spread on water, good.	——
Sheerness -	As perfect as diaphragm shells can be.	- - -	- - - -	Experience considerable.
Woolwich -	No results noted -	Reduced to a minimum.	- - - -	From 13th brigade only.
Shoeburyness School of Gunnery:				
1. Colonel TAYLOR's Report.	Generally effective, although sometimes not altogether satisfactory as regards breaking up of the shell.	- - -	Very good from 24-pr. and 32-pr.; not much lateral spread with 9-pr.	Practice confined to firing at a mark on water.
2. Colonel GARDNER's Report.	——	——	——	——

Col. Gardner classifies the usual complaints under four heads.

(1.) *Blind Shells.*—They are chiefly due to want of skill, in boring or fixing the fuze, or its extinction on graze. The former is remedied by instruction, the latter incidental to all shells.

(2.) *Uncertain burst and dispersion of bullets.*—He does not allow that this complaint is well founded.

(3.) *Premature explosion.*—It is very rare, and has been traced in some recent instances to the fuze having been split by the rammer.

(4.) *Inaccuracy of flight.*—He affirms that they are much more accurate than common shells, and scarcely, if at all, inferior to round shot.

Col. Gardner gives six examples of actual practice.

——	Range.	Rounds.	Target.	Hits.
	Yards.			
25/5/60—32-pr., 50 cwt. - -	1,200	15	9 ft. × 18 ft. -	1,087
„ 8-in., 52-cwt. - -	„	15		
19/3/61—24-pr. howitzer - -	800	16	6 ft. × 6 ft. 10 in. column 15 yards apart	464
„ 9-pr. „ - -	„	16		
20/3/61—24-pr. howitzer - -	1,000	22	6 ft. × 72 ft. -	806
„ 9-pr. „ - -	„	22		
20/4/63—24-pr. howitzer - -	800	27	10 ft. × 60 ft. -	1,372
„ 24-pr. „ - -	„	27		
24/4/63—24 pr. howitzer -	700	20	6 ft. × 12 ft. -	196*
„ 24-pr. „ - -	„	20	6 ft. × 12 ft. -	98
28/5/63—68-pr., 95 cwt. - -	900	10	6 ft. × 12 ft. -	517
„ 32-pr - - -	„	10	6 ft. × 12 ft. -	708

During this practice, which was as rapid as possible, the guns were dismounted and mounted, limbered up and unlimbered, wheels were shifted, and the detachments changed round, each operation four or five times.

APPENDIX D.

EXTRACT from REPORT of COMMITTEE on ORDNANCE (1858) on SUBJECT of REDUCTION of WINDAGE.

" 29. The important subject of windage has much engaged the Committee's attention, and though there is no doubt that a diminution of windage gives greater accuracy of direction and increase of range, yet there are other questions which must be well considered before deciding on a reduction of windage.

The following are, perhaps, the most important points to be kept in view, viz.,—the expansion of shot by heating, the effects of rust, increase of diameter by painting, the foulness of the piece (which after repeated firing becomes very considerable), and the probability of the enduring power of the gun, as well as that of the carriage, being affected by the increased strain to which they would be subjected by any diminution of windage.

31. It has been proposed to have low gauge shot for the purpose of heating, and that they should be painted some particular colour, and were the expansion of shot by heating the only objection to the diminution of windage it might be deemed desirable to try such a scheme, but this not being the case, and the introduction of two descriptions of that shot for the same gun being very objectionable, on account of the confusion likely to occur therefrom, the Committee do not recommend this proposition.

* And two shells through.

32. The Committee with reference to the increase in the diameter of shot by painting deem it desirable that efforts be made to obtain a substitute for paint for lacquering shot and shell, of a thinner and more durable form.

33. The Committee propose a slight reduction in windage to be carried out by a diminution in the bores of the guns which the Committee consider a preferable method to that of increasing the diameter of the shot, as the latter plan if adopted would necessitate the re-casting of all the shot and shells at present in the service to bring the change into effect.

But by an alteration in the bore of the gun the present store of shot and shell can be used both with guns of the present calibre and also with those to be hereafter constructed of diminished calibre.

* * * * * *

35. The Committee recommend as a principle that the windage be calculated from the high gauge of the shot in place of the mean, between the high and low gauges, the founder receiving directions to adhere to the high gauge as closely as possible.

By this method the windage will more nearly represent the difference between the diameter of the bore and the shot, and thus will be a safer guide than the present method; for example the windage of a 68-pr. gun measured from the present mean gauge (7·925) is ·195; but should a shot be used which is of the high gauge (7·95) the windage is reduced to ·17, whilst a shot of the low gauge would give a windage of ·22. By the method recommended of calculating the windage from the high gauge greater uniformity will be obtained and the least possible windage at once known.

36. The Committee in proposing the amount of windage to be allowed have been governed by the expansion of shot by heating, and the gun founders' limits; thus take a 68-pr. shot of the high gauge 7·95 inch, add ·12 for heating, gives 8·07. The diameter of the gun is 8·12; deducting for founders' limits leaves 8·105, subtracting 8·07 from 8·105 there will only remain ·035, and the Committee, in the absence of any recorded experiments within reference to firing 68-pr. guns with red hot shot, deem it desirable that the windage for 68-pr. and 32-pr. guns should not be finally decided until the experiments suggested in the conclusion of this report be carried out."

Appendix E.

Experiments by Ordnance Select Committee with R. L. G. and L. G. Powder.

Minute 16,686.—1641. Gunpowder.

Proposal to substitute rifle L. G. (A^4) for L. G. in smooth-bore ordnance.

1. Lieut. Noble, R.A., 25/3/65. Submits, with reference to Minute 15,717, the following abstract showing the velocity of projectiles fired from various natures of ordnance with L. G. powder in comparison with rifle L. G.

It appears that a greater velocity is obtained by the use of the latter powder in every instance with *guns* except one, viz., the 10-inch gun, in which the velocity is slightly less; this result is probably owing to the charge in this case being relatively smaller than in any other. It appears, as might have been expected, that the smaller grained powder gives greater velocity in the case of mortars. The 8-inch mortar was not used, as the results with the 10-inch and 13-inch were considered sufficiently conclusive.

This experiment proves that rifle L. G. powder can be substituted for L. G. in all those natures of smooth-bore guns which will probably enter into future armaments.

Brands of powder { L. G., 20/11/63. Lot 674. Rifle L. G., 1/4/64. Lot 754.

Date of experiment, 7, 8, 9/8/65. No wads used.

Gun.	Charge.	Cartridge. Length.	Cartridge. Diameter.	Brand of Powder.	Projectile. Nature.	Projectile. Mean Weight.	Projectile. Mean Diameter.	Observed Velocities at 40 Yards. 1.	2.	3.	4.	5.	Mean Observed Velocity at 40 Yds.	Calculated Mean Initial Velocity.
	lbs.	ins.	ins.		Steel.	lbs.	ins.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
10·5-inch wrought iron gun of 12 tons	50	- -	- -	L. G.	●	168·0	10·4	- -	- -	- -	- -	- -	- -	1669·0
" " " -	50	- -	- -	Rifle L. G.	"	168·0	10·4	- -	- -	- -	- -	- -	- -	1710·0
100-pr. wrought iron gun of 6¼ tons -	25	- -	- -	L. G.	C. iron	94·0	8·87	1668·6	1641·3	1672·3	1674·2	1666·8	1664·6	1697·0*
" " " -	25	- -	- -	Rifle L. G.	"	94·0	8·87	1687·7	1703·0	1699·1	1704·9	1693·4	1697·6	1731·0
10-inch gun of 87 cwt. - - -	12	10·25	7·15	L. G.	○	92·625	9·86	1238·1 1237·0	1221·0 1243·5	1236·0 1216·8	1221·0 1210·5	1209·5 1234·9	1226·8	1251·0
" " - - -	12	10·25	7·15	Rifle L. G.	"	92·625	9·86	1194·0 1227·4	1185·8 1201·2	1185·8 1185·0	1196·1 1227·4	1175·9 not observed	1197·6	1222·0
8-inch gun of 65 cwt. - - -	10	11·0	6·5	L. G.	"	49·625	7·86	1432·8 1425·8	1431·4 1404·9	1427·2 1442·8	1425·8 1410·5	1394·1 1434·2	1422·9	1463·0
" " - - -	10	11·0	6·5	Rifle L. G.	"	49·625	7·86	1476·2 1435·7	1434·3 1434·3	1427·3 1437·1	1450·0 1428·7	1471·8 1426·0	1442·1	1482·3
68-pr. gun of 95 cwt. - - -	16	12·0	7·0	L. G.	●	66·5	7·92	1529·8 1531·3	1541·0 1531·4	1571·7 1533·0	1529·8 1552·2	1520·3 1552·0	1539·3	1574·0
" " - - -	16	12·0	7·0	Rifle L. G.	"	66·5	7·92	1557·1 1541·0	1571·9 1544·2	1533·0 1581·9	1571·9 1541·0	1541·0 1533·0	1551·6	1586·5
32-pr. gun of 56 cwt. - - -	10	11·0	5·75	L. G.	"	31·5	6·16	1590·5 1635·7	1609·3 1642 8	1621·5 1670·1	1675·6 1662·7	1639·2 1662·7	1641·0	1689·0
" " - - -	10	11·0	5·75	Rifle L. G.	"	31·5	6·16	1684·9 1657·2	1675·6 1675·6	1660·9 1662·7	1662·7 1675·6	1677·5 1681·2	1671·4	1720·5
13-inch sea service mortar of 103 cwt.	10	- -	- -	L. G.	○	204·5	12·8	654·6	649·3	651·7	647·0	640·8	648·7	657·0
" " " -	10	- -	- -	Rifle L. G.	"	204·5	12·8	574·5	580·2	582·7	575·4	570·7	576·7	584·0
10-inch land service mortar of 18 cwt.	4	- -	- -	L. G.	"	91·437	9·83	522·0	517·1	511·6	516·8	520·1	517·5	524·0
" " " -	2	- -	- -	"	"	91·437	9·83	331·6	335·5	318·6	331·2	332·7	329·9	333·0
" " " -	4	- -	- -	Rifle L. G.	"	91·437	9·83	420·6	432·7	422·0	418·4	412·5	421·2	426·0
" " " -	2	- -	- -	"	"	91·437	9·83	292·2	292·2	297·3	302·2	299·5	296·7	300·0

—	L. G.	Rifle L. G.
Density - - - - - - -	1·710	1·710
Number of grains in 50 grains' weight -	525	48

* Minute 14,749.

Appendix F.

Circular No. 674.

Home and Foreign.

War Office, Pall Mall, 5th April 1861.

1. The Secretary of State for War, considering it desirable to establish a greater uniformity in the proof report of gunpowder forwarded to the Superintendent of Royal Gunpowder Factories, at Waltham Abbey, from the several stations at home and abroad, as well as to render the proof results a more certain criterion of the general state of powder in charge, has been pleased, with the concurrence of His Royal Highness the General Commander-in-Chief, to approve of the annexed Forms, War Office No. 1517 and War Office No. 1518, being used by the Inspector of Warlike Stores and other proof officers, in lieu of the various forms which have hitherto been furnished.

2. Form No. 1517 is to be filled in by the Military Storekeeper and Inspector of Warlike Stores as far as practicable when the directions in Circular No. 541, for the arrangement of the store have been carried into effect, and sent to the Superintendent Royal Gunpowder Factory, Waltham Abbey, who will cause the original proof of other several lots at Purfleet to be traced and inserted. The form will then be returned to the respective stations for the information of the storekeeper and proof officer, and constitute the basis of a record of the powder in charge; and the subsequent proofs at the stations as they take place being inserted the state of powder in store will always be known.

3. In order that this record of the powder in charge may be kept up at the several stations, the storekeeper at Purfleet will in future send with the delivery voucher a memorandum of the Purfleet proof of the lot or lots issued, and this information should be recorded at once on the receipt of the powder.

4. Form No. 1518 is the report of proof to be forwarded annually to the Superintendent of Royal Gunpowder Factories, Waltham Abbey.

5. When the store of powder has been properly arranged as directed by Circular No. 541, and the form No. 1517 completed, the following mode of proceeding with the periodical proof will probably be found convenient, and sufficient to secure an accurate knowledge of the condition of all the powder in charge.

6. Ten barrels of powder may be selected indiscriminately from each of the different lots, which together constitute about *one-third* part of the whole quantity in store, when samples taken from each and mixed together will form the sample to be fired the *first* year. In the *second* year the same course may be pursued by testing samples from other barrels taken out of the lots composing one-third part of the total store; and the remaining third portion would undergo proof in like manner in the *third* year.

7. In the succeeding year the time will have again come round for proving those lots of powder which underwent the test in the first year, and so on.

8. The barrels from whence the samples are drawn should in each case be marked with the date of proof, and other barrels taken when the same lot is again proved.

9. The Inspector of Warlike Stores or other proof officer will, however, carry on the proof by sight and hand as much further as he may think necessary, and even resort to proof firing should it be desirable from the magazines being damp or defective, or the condition of the powder doubtful from any other cause, since it is to be clearly understood that these general arrangements are not intended to relieve Inspectors of Warlike Stores or others upon whom the duty may devolve from the responsibility of satisfying themselves that the powder at their respective stations is always in good condition.

(Signed) B. Hawes.

To Military Storekeepers,
Inspectors of Warlike Stores, &c.

W.O. Form 1517.

Appendix F. *cont.*—A REGISTER of GUNPOWDER in Store at .

Purfleet Proof.							Proofs at this Station.								Number of Lot.	Sort of Grain.	Number of Barrels.	Lbs. of Powder in each Barrel.	When received at this Station.	Placed in		Shifted to						Issued.		Quantity —lbs.
Date of Second Proof.	Cube. lbs. ozs.	Range in Feet obtained with 68 lbs. Solid Shot fired with 2 ozs. Charges of Powder from 8-inch Iron Mortars.				Remarks.	Date.	Range in Feet with 68 lbs. Solid Shot, &c. &c.		Remarks.	Date.	Range in Feet with 68 lbs. Solid Shot, &c. &c.		Remarks																
		First Proof.		Second Proof.																										
		Each Shot.	Means.	Each Shot.	Means.			Each Shot.	Means.			Each Shot.	Means.							Magazine.	Bay.	Magazine.	Bay.	Magazine.	Bay.	Magazine.	Bay.	Date.	To	

Appendix F. *cont.*—A Report of the Proof of Gunpowder in charge of W.O. Form 1518.

Description.			Sort of Grain.	Date of Receipt at the Station.	Number of Barrels in Lot.	Lbs. of Powder in each Lot.	Number of the Sample.	Number of Barrel from which the Samples are taken.	Range in Feet obtained in firing a 68-lb. Solid Shot, with 2 oz. Charges from an 8-inch Gomer Mortar.				Remarks.
Maker's Name.	Date.	No. of Lot.							1	2	3	Average.	

Appendix G.

Circular No. 892.—(*Gunpowder.*)

HOME AND FOREIGN.
(Exclusive of India.)

War Office, 9th January 1865.

The Secretary of State for War desires, with a view to the avoidance of errors in describing gunpowder, that instead of the existing marks on the barrels, viz.:—

Powder.							
Common.		Exercise.		—		Shell.	—
L. G.	F. G.	L. G.	F. G.	A. 4	E. R.	L. G.	M. R. A.

The following marks shall, for the future, be adopted, viz.:—

Powder.									
—		Exercise.		Rifle.		Shell.		Redusted.	
L. G.	F. G.	L. G.	F. G.	L. G.	F. G.	L. G.	F. G.	L. G.	F. G.

The other marks on the barrels will be regulated accordingly.

Edward Lugard.

Appendix H.

Result of Experiment, filling Cannon Cartridges with Caffin's Machine, and weighing the Charges with Scales.

—	Machine.			Scales.		
	68-pr., 16 lbs.; Two Measures of 4 lbs. each, twice filled.	32-pr., 10 lbs.; Two Measures of 5 lbs. each.	7-inch A, 12 lbs.; Two Measures of 6 lbs. each.	68-pr., 16 lbs.	32-pr., 10 lbs.	7-in., A, 12 lbs.
Bringing powder from magazine -	1 man	1 man	1 man	1 man	1 man	1 man
Unheading barrels and suppling hopper.	2 men	2 men	3 men	1 man	1 man	1 man
Filling - - - - -	1 man	1 man	1 man	1 man	1 man	1 man
Hold - - - - -	- - -	- - -	- - -	1 boy	1 boy	1 boy
Removing filled cartridges from machine to table.	1 man	1 man	1 man	- -	—	—
Total -	5 men	5 men	6 men	3 men 1 boy	3 men 1 boy	3 men 1 boy
Number filled per hour - -	202	222	331	160	190	
Number one man can make up per hour - - - - -	Skilled men 10 Unskilled men 6	10 6	8	10 6	10 6	
Total number of men making up to keep the machine or scales fully employed - - -	Skilled men 20 Unskilled men 34	22 37	41 110	16 27	19 32	
Variations in the charges of powder. New L.G., W.A.	16 lbs. 10 ozs. to 16 lbs. 5 ozs.	10 lbs. 8 ozs. to 10 lbs. 3 ozs.	—	—	—	—
Variations in the charges of powder. Started L.G. -	17 lbs. to 16 lbs. 3 ozs.	- - -	—	—	—	—
Variations in the charges of powder. Rifle L.G., W.A.	- -	- - -	13 lbs. 6½ ozs. to 13 lbs. 1 oz.	—	—	—

The difference in the number of cartridges filled of rifle L.G. powder as compared with L.G. is in consequence of the powder running more freely.

The measures, when using rifle L.G. powder, delivered a greater charge than when L.G. is employed, this is due to the freedom with which this powder runs.

It is found impracticable to use the machine for filling those cartridges which have a paper cylinder.

In measuring the 10 lbs. charges L.G. three were found to weigh respectively 6 lbs. 8 ozs., 7 lbs. ¾ ozs., and 7 lbs. 5 ozs., caused by the powder clogging in the hopper; this will frequently occur if the powder is only slightly caked.

Appendix I.

III.—Experiments on the Application of Permanent Magnets to the Explosion of Charges and to Submarine Operations.

"The ignition of gunpowder by the direct magneto-electric current, though well known to be practicable, has never yet been applied to military or industrial operations, and no satisfactory experiments appear to have been made, before those undertaken at Woolwich, showing its practical applicability to these purposes.

In the first experiments on this application of the magneto-electric current, a very large powerful magneto-electric machine was employed, which had been constructed by Mr. Henley (and had been exhibited by him at the Paris Exhibition in 1855). The principle of this instrument was precisely the same as that of the machine devised by Mr. Wheatstone, for ringing magneto-electric bells. Its armature, instead of rotated, was suddenly detached from the magnet by means of a lever. It was soon established by a few experiments, that even with this instrument gunpowder itself could be ignited with any degree of certainty. Results obtained with Statham's and other fuzes, though superior to those furnished by gunpowder alone, were still far from satisfactory. The first efforts were therefore directed to the discovery of a suitable agent to serve as a perfectly certain medium (or priming material) for effecting the ignition of charges by means of the magneto-electric machine. For this purpose, a variety of compounds and mixtures of a more or less sensitive character, were prepared for trial with the magnet. The following were the principal tried :—mixtures of meal powder with powdered coke, with sulphur, with sulphur and iron filings, with iron filings and carbon, with fulminate of mercury, and with the latter in addition to iron filings and to coke; fulminate of mercury, percussion-cap composition, alone and with coke; detonating composition (sulphide of antimony and chlorate of potassa); the same mixed with iron filings and with coke; gun cotton, alone and mixed with some of the above; amorphous phosphorus, in admixture with oxidizing agents. It will be observed that the nature of the above materials was varied so as to test the sensitiveness of readily ignitable substances, both alone and when mixed with bodies which would serve as electrical conductors.

Many of these compositions furnished results to a certain extent favourable, a number of fuzes, primed with them, having been fired in succession with the magnet, and from two to four charges in one circuit having been ignited, in a very few instances. But no perfect certainty of discharge was attained with any one of the above materials; the attempt to fire a fuze being frequently unsuccessful, while no difference between it and a successful fuze, containing the same composition, could be detected by careful examination. These preliminary trials, however, established the fact that the sensitiveness (ready explosiveness) of a priming material was not alone sufficient to determine its success, but that those which possessed a certain though not too considerable degree of conducting power were more readily and certainly ignited than others of a more sensitive character.

Some successful results, obtained accidentally with one of the experimental compositions, which had become damp by exposure to air, led to a trial of the effect of moisture in promoting the ignition of but slightly sensitive compositions, and it was ultimately found that the impregnation of ordinary gunpowder with a small amount of moisture (by an expedient similar in principle to one adopted with considerable success by Captain Scott, R.E., in connexion with charges to be fired by the induction coil machine) rendered its ignition by means of the magnet a matter of certainty.

Some important precautions were, however, indispensable to the attainment of this definite result. If the slightly damp powder was employed in a finely divided condition, it very frequently became caked between the wire terminals in the fuze, and the current would then pass through the composition without igniting it. This was found to take place occasionally, even when the powder was employed in its original granular condition. Several attempts were made to overcome this difficulty by modifying the form and position of the terminals or poles in the fuze, and I at last contrived a perfectly successful arrangement in which only the *sectional surfaces* of the terminals, consisting of fine copper wire (0·022 inch diameter) were exposed in the interior of the fuze, so as not to project at all. The prepared gunpowder, therfore, simply *rested* upon the surfaces, and a perfect uniformity in the action of the fuze was attained. The priming composition consisted of fine grain gunpowder, which had been soaked in an alcoholic solution of chloride of calcium, of a strength sufficient to impregnate the grains with from one to two per cent. of that salt. The prepared powder was exposed to the air for a short time, to permit of a sufficient absorption of moisture by the deliquescent salt. Upwards of 500 quill fuzes (of the description employed for firing guns), primed with the prepared gunpowder, and fitted with the arrangement of the terminals above referred to, were fired with the larger lever magnet. The failures did not amount to more than 3 per cent., and were all proved to be due to defective manufacture. In the experiments with these fuzes, one or two simple rheotomic arrangements, such as that referred to in the first part of this memoir, were successfully employed for effecting the rapidly successive discharge of a series of fuzes.

The above fuze was found to be easy of manufacture and permanently effective. While, however, it presented a certain means of effecting the ignition by the aid of a powerful magnet of single charges, or of a large number to be fired in moderately rapid succession, it was inapplicable to the ignition with certainty of more than one charge in circuit. After a great number of experiments I at length succeeded in the production of a priming material for the fuze, which greatly exceeded in sensitiveness any of the other compositions hitherto tried. A very gradual separation of the armature from the large magnet sufficed to effect the ignition of the fuzes primed with this material, and the induced current obtained by means of a very small magnet, with a rotatory armature, such as employed in Wheatstone's magneto-electric telegraph was sufficiently powerful to produce the same result. I have recently found that the currents obtained from magnetic instruments of inferior power and less perfect construction, such as the small American magneto-electric medical apparatus, readily ignite this priming material, and that fuzes primed with it are fired with certainty, by the smallest electro-magnetic apparatus, with the employment of one moderate-sized cell of Smee's battery.

The new priming composition consisted of a very intimate mixture of sub-phosphide of copper, chlorate of potassa, and levigated coke, the latter substance being employed to add to the conducting power of the mixture, which was found otherwise insufficient.

In the course of experiments subsequently carried on with fuzes which contained this composition, it was found that a slight residue, consisting principally of the coke employed, occasionally remained on the surfaces of the terminals in the fuze after its discharge, and, by forming a good conducting link between them, interfered with any future effects of the magnetic current in other directions by the establishment of a complete circuit. This obstacle to the perfect success of the composition was entirely removed by the substitution, for the coke, of another material, more easily acted on by the chlorate of potassa, and answering equally well as a conducting medium; namely, the sub-sulpide of copper. No instance has occurred in the discharge of several thousand fuzes, primed with the mixture of sub-phosphide and sub-sulphide of copper with chlorate of potassa, in which the terminals have not been found quite free from adherent residue after the ignition. The sub-phosphide of copper, which is produced at an elevated temperature, is a compound of very stable character, and the mixture of the three constituents is quite as unalterable as the explosive mixtures which are in general use for the preparation of percussion caps, &c. The stability of the mixture has already been submitted to very satisfactory tests. Fuzes primed with it have been found to have lost none of their delicacy and certainty when tried more than two years after preparation.

Before passing to a statement of the results obtained by the aid of this priming composition in investigating the extent to which magneto-electricity could be applied with certainty to the simultaneous ignition of a number of fuzes, some little account must be given of the properties of the priming material itself, and of the results which regulated the proportions in which its ingredients were employed.

The sub-phosphide of copper, intimately blended with chlorate of potassa, forms a mixture in a high degree sensitive to the effect of heat, and possessed at the same time of some power of conducting electricity. With the employment, however, of magneto-electric machines of comparatively low power, and in cases where the resistance to be overcome by the current is considerable, this conducting property is not sufficient to ensure the ignition of the mixture of assisting the passage of the current across the interruption in the metallic circuit (*i.e.*, across the small distance between the terminals of the wires in the fuze). It must be borne in mind that the striking distance, or the space between the terminals across which the current from even a powerful magneto-electric machine will leap, is very small. With the large lever magnet the spark could only be produced when the wires were almost in contact. Since, however, it is indispensable to the proper insulation of the wires in the fuze arrangement that the terminals should be at least one-sixteenth of an inch apart, it will be readily understood how essential to success, in operations with these machines, it is that the priming material should possess considerable conducting power. Hence the necessity of increasing the conducting power of the mixture of sub-phosphide of copper and chlorate of potassa; a result which, it has been already stated, was obtained in the first instance by the employment of finely levigated coke, and afterwards by the sub-sulphide of copper for that substance. Many experiments were of course required to determine the proportions in which it was advisable to employ the conducting constituent so as to facilitate the passage of the current through the mass as far as possible without interfering too much with the sensitiveness of the explosive mixture, or producing an almost perfectly continuous connexion between the two poles in the fuze, and thus promoting the passage of the current so greatly as to prevent the ignition of the composition.

Considerable difficulties were encountered in the endeavours properly to balance these conditions when attempts were made, which will presently be mentioned, to apply the mixture in question to the ignition of several charges in circuit. The increase in the resistance of the current, consequent on the introduction of more than interruption in the metallic circuit, necessitated an increase in the conducting power of the mixture which it was difficult to attain, unless at a considerable sacrifice of the sensitiveness of the composition. It was consequently found that, when the proper conditions had been attained for ensuring the passage of the current through several (five or six) fuzes in circuit, the absolute certainty of the fuze when applied in this manner had been sacrificed. Thus out of several fuzes tried together, which had been most carefully prepared, so as to be as far as possible perfectly alike, the current would ignite a few passing through the others without affecting them; and would thus point to minute differences in the conducting powers and sensitiveness of different portions of one and the same quantity of the mixture which, it is almost needless to observe, was prepared in such a way as to insure the greatest possible uniformity.

By a large number of careful experiments the proportions of ingredients were at length determined, which furnished a mixture possessed of high conducting power, attainable without detriment to the sensitiveness (ready explosiveness) of the material. The perfect certainty of its action, when applied in the fuze, to the explosion of a single charge by means of magneto-electric machines, has been proved by the ignition of at least 5,000 fuzes without failure.

A large number of these have been fired by means of the smaller machines already referred to."—*Abel on Recent Application of Electricity*, pp. 16 to 21.

APPENDIX K.

On the INFLUENCE of ATMOSPHERIC PRESSURE upon some of the PHENOMENA of COMBUSTION.*—By Dr. EDWARD FRANKLAND, F.R.S.

Although *the rate of burning* of candles and other similar combustibles, whose flames depend upon the volatilization and ignition of combustible matter in contact with atmospheric air, is not perceptibly affected by the pressure of the supporting medium, yet this is not true of all combustibles. The rate of burning of self-supporting combustibles, like the time-fuzes of shells, depends essentially upon the pressure of the medium in which they are deflagrated. Attention was first called to this fact by Quarter-master Mitchell,* who found that the fuzes of shells burnt longer at elevated stations than when ignited near the level of the sea. The results of the author's experiments with six-inch or thirty-seconds fuzes burnt in artificially rarefied air are embodied in the following table:—

Average Pressure of Air in Inches of Mercury.	Average Time of Deflagration of 6-in. Fuze.	Increase of Time of Burning over preceding Observations.	Reduction of Pressure corresponding with Increase of Time.	Increase of Time of each Diminution of 1-in. Pressure.
	seconds.	seconds.	inches.	seconds.
30·40	30·33			
28·25	32·25	1·92	2·15	·893
25·70	34·75	2·50	2·55	·980
22·45	34·75	3·00	3·25	·925
19·65	41·50	3·75	2·80	1·339
15·95	45·50	4·00	3·70	1·081

There are here evident indications of the rate of retardation being somewhat greater at low than at comparatively high pressures; but, neglecting these indications, the above numbers give 1·043 second as the average retardation in a six-inch or thirty-seconds fuze for each inch of mercurial pressure removed. This result agrees closely with that obtained by Quarter-master Mitchell, if we except those fuzes which he burnt at the greatest altitude; and in reference to which some error must obviously have crept in. The following table shows Mr. Mitchell's results uniformly with those in the last table. The fuzes which he employed were 15 seconds or three inch ones, and their times of combustion have therefore been multiplied by two in order to bring them into comparison with the six inch fuzes which were used in the author's experiments:—

Pressure of Air in Inches of Mercury.	Average Time of Combustion of 6-in Fuze.	Increase of Time of Combustion over last Observation.	Reduction of Pressure corresponding to Increase of Time.	Increase of Time for each Diminution of 1-in. Pressure.
	seconds.	seconds.	inches.	seconds.
29·61	28·50			
26·75	31·56	3·06	2·86	1·070
23·95	34·20	2·64	2·80	·943
22·98	36·25	2·05	·97	2·113

Here, omitting the last determination as abnormal, we have the average retardation, in the combustion of a six inch fuze, for each diminution of one

* Proceedings Royal Society, Vol. XI. p. 137.

inch mercurial pressure, equal to 1·007 second, which coincides almost exactly with the number (1·043) deduced from the author's experiments.

The results of both series of observations may therefore be embodied in the following law:—*The increments in time are proportional to the decrements in pressure.* For all practical purposes the following rule may be adopted:—*Each diminution of one inch of barometrical pressure causes a retardation of one second in a 30 seconds fuze;* or, *each diminution of atmospheric pressure to the extent of one mercurial inch increases the time of burning by one-thirtieth.*

This retardation in the burning of time-fuzes by the reduction of atmospheric pressure will probably merit the attention of artillery-officers. Up to the present moment these fuzes have been carefully prepared so as to burn, at Woolwich, a certain number of seconds; but such time of combustion at the sea-level is no longer maintained when the fuzes are used in more elevated localities. Even the ordinary fluctuations of the barometer in our latitude must render the time of the combustion of these fuzes liable to a variation of about 10 per cent. Thus a fuze driven to burn 30 seconds when the barometer stands at 31 inches, would burn 33 seconds if the barometer fell to 28 inches. Even the height to which a shell attains in its flight must exert an appreciable influence upon the burning of its time-fuze; to a still greater extent, however, must the time of combustion be affected by the position of the fuze during the flight of the shell. If it precede the shell, the time of burning must obviously be considerably shorter than if it follow in the comparatively vacuous space behind the shell.

The apparently opposite conclusions to which we are led as regards the influence of atmospheric pressure upon the *rate* of combustion, by the experiments upon candles on the one hand and upon time-fuzes on the other, are by no means irreconcileable; in fact, an examination into the conditions of combustion in the two cases scarcely leaves room for the expectation of any other result. In the combustion of a candle, the author proves that, at all pressures, there is a sufficient supply of melted combustible matter kept up at the base of the exposed portion of the wick; the capillarity of the latter is not affected by pressure, and as the temperature of the flame is also proved to remain practically constant, effecting the evaporation of the same amount of combustible matter under all pressures, it follows that the rate of consumption of a candle must be nearly or quite independent of the pressure of the surrounding medium. In the deflagration of time-fuzes, the conditions are obviously very different. Here the combustible matter never comes into contact with atmospheric oxygen until it has been ejected from the fuze-case. Unlike the candle, the composition contains within itself the oxygen necessary for combustion, and a certain degree of heat only is necessary to bring about chemical combination. If this heat were applied simultaneously to every part of the fuze composition, the whole would burn almost instantaneously. Under ordinary circumstances, however, the fuze burns only at a disk perpendicular to its axis; and the time occupied in its deflagration necessarily depends upon the rapidity with which each successive layer of composition is heated to the temperature at which chemical combination takes place. This heat, necessary to deflagration, is evidently derived from the products of the combustion of the immediately preceding layer of composition; and the amount of heat thns communicated to the next unburnt layer must depend, in great measure, upon the number of particles of these heated products which come into contact with that layer. Now, as a large proportion of these products are gaseous, it follows that, if the pressure of the surrounding medium be reduced, the number of ignited gaseous particles in contact at any one moment with the still unignited disk of composition will also be diminished. Hence the slower rate of deflagration in rarefied air.

Appendix L.

On the Use of Metal Time Fuzes.

It is worth while to consider whether the reasons originally urged for the employment of metal time fuzes for naval service are really as valid as *primâ* *facie* they appear, and whether they are applicable to the existing order of things.

The decision of 15th November 1865,[1] that "all shells issued filled for naval "service are to be fuzed with percussion fuzes," materially affects the position of the advocates of metal naval *time* fuzes, since the two first and principal reasons alleged in favour of the employment of such fuzes [2] fall to the ground now that this practice has been discontinued. These two arguments hinge upon the storing of shells filled and fuzed with time fuzes, and have no independent force or meaning; and it might therefore be sufficient to dispose of them by pointing out that whatever force they may at one time have possessed they no longer apply.

It will, however, be worth while[3] to inquire whether they ever really had that force which has been claimed for them; whether, in fact, it was necessary or even desirable that filled naval shells should be kept fuzed? As regards percussion fuzes, it may be at once conceded that as such fuzes require no preparation, and have not therefore to be removed from the shell and replaced before loading, a material saving of time and a somewhat diminished chance of accidents, such as might under rare circumstances arise in exchanging a plug for a fuze, does result from storing the filled shells with percussion fuzes in them in place of plugs; and the arguments in favour of the employment of metal *percussion* fuzes therefore hold good.

But when we turn to time fuzes,[4] which, if intended to be used as such, must be removed from the shell on going into action, prepared for the required range and replaced in the fuze hole, it does not appear that any saving of time or any increase of convenience results from the present practice; indeed, it is probable that of the two a shell with a plug and wad or with a percussion fuze in it could be prepared more rapidly, the preparation of the time fuze going on simultaneously with the removal of the plug or percussion fuze; while in the case of the (time) fuzed shell the removal of the fuze must precede its preparation. And when we consider that the abandonment of the practice of keeping shells (time) fuzed admits of the adoption of *wooden* time fuzes—of fuzes, that is to say, which require no *screwing into the shell*, but which can be prepared and fixed in about six or seven seconds, and which can be uncapped in a shorter space of time than metal fuzes, the balance as regards saving of time inclines still more strongly to the side of the plugged or percussion-fuzed as against the time-fuzed shell. It may be urged that naval shells which were fitted with *time* fuzes were always stored with the 7½-seconds and not the 20-seconds fuze in them, and that this short range fuze was, as a general rule, not prepared at all, and that the loss of time indicated above is therefore imaginary. To this it may be answered that such an argument, instead of being favourable to the present practice, furnishes a strong condemnation of it: no one would advocate the non-preparation of the fuze, or contend that such non-preparation is in any way desirable; the fuze is *intended* to be prepared and is specially constructed with side holes, and implements are specially provided with this object,[5] and if advantage is never taken of this construction, and of these implements they are unnecessary. Why, then, is the fuze which is intended to be prepared not prepared? Because *of the loss of time which such an operation would involve.*

What part of the operation is it which entails the loss of time? Surely not the simple preparation, the simple boring of the fuze, which is the work of two or three seconds, but the operations of unscrewing and refixing the fuze, the operations, in short, which are inherent in and peculiar to a system of fuzed shells and metal fuzes. Surely, therefore, the argument respecting the non-preparation of the fuze tells forcibly not for but against a system by which such loss of time is entailed that it is considered necessary or desirable to sacrifice in a measure the effects of the shell and practice, and, so to speak, to throw away the fuze to avoid it?

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[1] *War Office Circular* 8 (new series), 1151.

[2] See pp. 263, 264.

[3] As establishing the comparative wisdom of our present arrangements.

[4] It must be recollected that time fuzes are supplied with, but not in, naval shells in the proportion of 75 per cent.

[5] It is perhaps worthy of notice that the white drill fuze, specially issued for the instruction of the navy in the manner of the *preparation* of the service fuzes, is a dummy representation of the 7½-seconds fuze.

As regards the 20-seconds fuze, which *is* usually prepared, the preparation can go on simultaneously with the removal of the 7½-seconds fuze from the shell which is about to be used, just as the preparation of a wooden fuze could go on simultaneously with the removal of the plug. In this case, however, the keeping of a shell (time) fuzed effects no saving of time, but the contrary, as the wooden *time* fuze, which is used when the shells are *not* kept fuzed, can be fixed more rapidly than the metal fuze can be *screwed in*. In no case, therefore, does it appear that any *saving of time* resulted from the practice of keeping shells fuzed with the *time* fuzes, but rather that more or less loss of time, according to the circumstances of the case, was occasioned.

We turn then to other considerations for arguments in favour of such a system. Is it safer, for example, than the alternative of issuing the shells filled and plugged or percussion-fuzed and employing wood time fuzes? Accidents may arise from three causes,—1st, the accidental ignition of the bursting charge or fuze by a neighbouring explosion, either in (*a*) the shell-room or (*b*) on deck during the service of the gun; 2nd, from the falling out of the fuze; and 3rd, from the manipulation of the fuze.

Under the first head, the accidental ignition of the bursting charge in the shell-room, a shell secured with a gun-metal plug and papier mâché wad is *perfectly* safe,[1] so also is a shell fitted with an efficient percussion fuze, and a shell fitted with a metal time fuze can therefore be no safer. As regards the accidental ignition of the bursting charge on deck during the service of the gun, so long as a shell with a plug remains plugged it will be no more liable to accidental explosion than the (metal) fuzed shell. But no doubt, of two *live fuzed* shells, the one with a metal and the other with the present *common* fuze, the latter will be more liable to accidental ignition from a *neighbouring explosion* than the former, and as the practice of storing shells on deck in action, particularly when attacking land forts, is considered by naval officers to be one which cannot be conveniently given up,[2] the metal time fuze may under these circumstances be regarded as safer and better than the service wooden one.

But the comparison, which was originally made with the common wooden fuze, only holds good against that fuze, and a modification of the head of the fuze, such as has been actually adopted in the B. L. and M. L. time fuzes, alone is required to make it under such circumstances as safe as a metal one.[3] Even if the "common" wood fuze were used, and the plug removed and the shell fuzed at the gun,[4] the danger of accident at the moment, or in the infinitely

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[1] See *Synopsis of Ordnance Select Committee Reports on Shrapnel Shells*, p. 233, where this point is fully established.

[2] "It is necessary that a supply of shells should be on deck when going into action." —*Experiments in H.M.S. "Excellent,"* p. 96.

[3] The Boxer (wooden) time fuze for breech-loading rifled ordnance was tested before its introduction into the service, as follows:—

"1st trial. Four 40-pr. shells with fuzes fixed were placed round a 10-lbs. cartridge, two of them leaning upon it, and the other two standing fuze uppermost. The charge was exploded and none of the fuzes ignited.

"This experiment was repeated five times.

"2nd trial with fresh fuzes.

"3rd trial with fresh fuzes.

"4th trial, with fuzes of 3rd trial.

"5th trial, with fuzes of 2nd and 4th trials.

"None of the fuzes exploded, or were blown out of the shell, or loosened in any way." —*Extracts from Reports and Proceedings of Ordnance Select Committee*, vol. ii., p. 62.

The Committee reported in unqualified terms as to the safety of these fuzes; they "believe that it would be hardly possible that the fuze should light under such circumstances."—*Ibid.*, ii., 62.

"That they are not liable to ignition by the bursting of a charge of powder in close proximity to them. The Committee consider the results of the experiments made by Col. Boxer (as detailed above), are so conclusive that they see no necessity for carrying out the experiments which they themselves proposed."—*Ibid.*, ii., 62.

"The Committee regard the result as conclusive proof of safety under trying circumstances."—*Ibid.*, ii., p. 133.

These experiments may therefore be regarded as completely establishing the safety of a wooden fuze, of the common fuze, in fact, slightly modified; and similar experiments justify the belief that the Boxer time fuzes for muzzle-loading rifled ordnance are not less safe. (See p. 265, note 3).

[4] This practice it is understood is considered by naval officers to be inadvisable. See *Extracts from Reports, &c. of Ordnance Select Committee*, vol. ii., p. 281.

short space of time during which the plug is out and before the fuze is driven in, is so slight as to be hardly appreciable.

And it must be borne in mind that whether metal or wooden time fuzes be used, if the fuzes are prepared at all, the preparation and fixing must be done somewhere, whether in the shell-room, or between the guns, or elsewhere on board the ship, and of the different parts of the vessel which are available for this purpose one is scarcely less vulnerable or less liable to the accidental explosion of an enemy's shell than another. Nor must it be supposed that shells fitted with metal fuzes are perfectly safe against accidental explosion, such as might be produced by the entry of another shell into the shell-room, for it resulted from some experiments conducted in 1853 under the direction of Captain Chads, C.B., R.N., that of 82 shells fitted with Moorsom's fuzes and piled in a mass on the orlop deck of the "*York*," and fired into by a 32-pr. shot with a 4 lbs. charge at 25 yards, four shells were broken and exploded, while of 82 shells fitted with metal time fuzes, and arranged and fired into in the same way, two shells were broken and exploded, and *two were exploded by the caps of the fuzes being knocked off* and the fuzes ignited by the explosion of the bursting charges of the two shells that were broken.[1]

Now the circumstances under which at any rate a metal fuze may be expected to afford protection, are when the fuze itself is struck (for evidently a shell is as liable to be *broken* and exploded by a shot striking it whether it contains a wooden or metal fuze); and yet it appears from the experiment above recorded that the protection which a metal fuze does afford under such circumstances is at least uncertain.

Therefore the protection afforded by a metal fuze to the bursting charge of a shell is certainly not necessarily safer than that which may be afforded by the wooden fuze properly arranged as the present breech-loading and muzzle-loading rifled ordnance *wood* time fuzes, with a view specially to security against accidental ignition; while even in comparison with the common wood fuze the superior safety of the metal fuze cannot be accepted as established, if the fuzes are to undergo the preparation which they are intended to undergo, and which entails removal and refixing on board the ship.

As regards, 2nd, the accidents likely to result from the falling out of the fuze, whereby the powder would be spilt or exposed. Such an accident is scarcely likely to occur under any circumstances, and the plugged or percussion-fuzed shell is as free from the chance of it as the metal (time) fuzed shell. Nor is a wooden fuze specially open to this objection, unless the shells were stored fuzed, and the fuzes were to shrink, in which case it might take place; but the present arguments are specially directed against the storing of shells time fuzed, and this may be accepted as an additional reason against that practice if wooden time fuzes be adopted, while it is no argument for it so long as metal fuzes are retained.

With respect to, 3rd, accidents which may arise in the manipulation of the fuze, there can be no doubt that if the practice of keeping shells fuzed *necessitated* the employment of metal time fuzes; that practice gave rise to a greater chance of such accidents, inasmuch as metal time fuzes may be considered as more dangerous in this respect than wooden ones.

Sir Howard Douglas lays down that, "Fuzes should be frequently examined "to see that their caps have not become so corroded as to be immoveable, but "the danger attending this operation when the fuze is in the shell is such that "this can be safely done only by putting the shell, whose fuze is to be so examined, "into a gun previously loaded with a small charge of powder, the range to the "front, right and left, being clear."[2]

Here distinctly is an admission of the danger inherent in the manipulation of metal fuzes, taken in conjunction with a system of filled and fuzed shells.

But officers may differ with Sir Howard Douglas as to the necessity for such examination; they cannot, however, differ as to the necessity of ultimately removing the cap before the shell is rammed home, and here the manipulation of the metal fuze is decidedly more dangerous than that of the wooden fuze.[3]

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[1] *Experiments in H.M.S. "Excellent,"* 1852 *to* 1854, pp. 104, 5, 6.

[2] *Naval Gunnery*, pp. 327, 8.

[3] I take no account of the injunction not to uncap the fuze until the shell is in the gun, because this very excellent precaution is also taken with the wooden fuze, and does

And, as regards the fixing of the fuze in the shell, so long as time-fuzed shells and metal time fuzes were used (the one as a consequence of the other), so long was the double operation of unscrewing and screwing in the fuze necessary, and if this operation is attended by *any* danger that danger will be exactly doubled by a system in which such a twofold operation is involved.[1]

It would appear, therefore, from the foregoing considerations that the old practice of keeping naval shells fuzed with metal time fuzes neither increased the facility of preparation of the fuze, but rather retarded the operation, nor did it apparently conduce to the safety of the shells. It is difficult to see in what other respects it could be considered as advantageous. No saving of storage was thereby effected; the fuzes were not better preserved from the effects of damp or climate, but the reverse, as will presently be shown; the bursting charge was not better secured against damp than by a gun-metal plug and papier mâché wad or by a percussion fuze;[2] and it is not easy to suggest any other possible advantages resulting from such a system. If, therefore, the system of keeping naval shells time fuzed carries with it no recommendations, neither is the employment of metal time fuzes, *so far as it may be connected with and result from that system,* desirable.

We proceed now to the consideration of the question—whether the other advantages claimed for metal fuzes—those advantages which do not connect themselves simply with the question of storing the shell filled and fuzed—the intrinsic advantages of a metal time fuze, so to speak, have sufficient force to justify their retention. And this inquiry is the more important because, if this side of the argument ever had any force, it will not have been weakened or affected by the recent decision respecting the fuzing of all filled shells with percussion fuzes. The first of these alleged advantages is stated (p. 264) as follows:—3rd. A metal fuze is less liable than a wooden one to deterioration from the effects of damp or " climate, or to injury from the effects of violence."

As the case stood when this argument was first urged, the metal fuze being in a large number of cases *in* the shell, the wooden fuze being packed in a waterproof cylinder, there can be no doubt that the metal fuze was *more* subject to deterioration than the wooden one, since the former was in contact with the powder with which the shell is filled, and "we find that where gunpowder " is in contact with metal that there is a great deterioration both of the metal " and of the gunpowder."[3] But now that the practice of keeping the filled shells fuzed with time fuzes has been given up, and the metal and wood fuzes are packed with equal care, the question to be determined is whether a wooden fuze is inherently more liable to deterioration than a metal fuze. It will be said that a wooden fuze is liable to shrink or expand, which the metal fuze is not, but to this objection it may be answered that such shrinking or expansion is of no consequence, and does not in any way affect the efficiency of the fuze,[4] nor does

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not, therefore, imply an admission of danger *peculiar* to the metal fuze. But while two accidents are on record of explosions resulting from the ignition of a metal fuze in unscrewing the cap, (*Naval Gunnery*, pp. 280, 288, 316); Sir Howard Douglas also speaks distinctly of "the danger arising from unscrewing the cap of a metal fuze," p. 288), I have not been able to discover that any such accident has ever occurred with wooden fuzes, and indeed it is difficult to imagine how it could occur; moreover, it stands to reason that the operation of unscrewing a metal cap must be less safe than that of pulling off the cap or covering of the wooden fuze.

1 Since only the operation of unscrewing the plug or percussion fuze, and not the second operation of screwing in the time fuze, is necessary under the opposite system.

2 " A 24-pr. common shell with plug fixed was kept 24 hours under water; its interior was then found to be perfectly dry."—*Synopsis of Ordnance Select Committee Reports on Shrapnel Shell*, p. 233. Shell with Pettman's general service fuze in have also been kept for two or three tides under water in the Thames, without injury to their charge.

3 *Colonel Boxer's Evidence before Armstrong and Whitworth Committee*, Question 1714.—"Do you suppose it is the saltpetre that is in the composition that attacks the metal?—Yes, and the sulphur. Q. Is not each piece of brass lacquered before it is put in?—Yes; and still, notwithstanding that, the action still goes on. It preserves the metal to a certain extent, but not sufficiently. We find, even when lacquered, that deterioration takes place."—*Ibid.*, questions 1718, 1719.

4 I am here supposing the fuzes to be lined (as Boxer's time fuzes for rifled ordnance and the Manby fuze) with a paper cylinder, by which the prevention of a cavity between the composition and the inside of the bore (due to alteration in the wood of the fuze) is avoided; the universal application of this improvement has for some time

it appear that in other respects the wooden fuze is more susceptible to deteriorating influences than the metal one.

Practically, then, the wooden fuze is as little liable to be injuriously affected or deteriorated by damp or climate as the metal fuze, and the argument in favour of the latter, which is based upon the assumption of the inferiority of the wooden in this respect is therefore inadmissible.[1]

We have now to consider whether the metal fuze is, as alleged, less liable to injury from the effects of violence. It is not easy to understand what description of violence is contemplated. One writer speaks of the wood fuzes being "liable to be broken by the collision of the projectile with the bore."[2] Such collision must be of rare occurrence with the present system of wood fuzes, which project but slightly, have no heads, and are used only in shells riveted to wood bottoms. The very slight injury (to the screw) which suffices to interfere with the metal fuze being screwed into the shell at all, or the slight corrosion which fix it there immovably, are probably stronger and more valid objections to the metal fuze than is the one above referred to, the wood fuze.

Another argument in favour of metal fuzes is that—"4th, it is less likely "than a wooden one to be broken or knocked out on striking a ship's side or "other hard substance." As regards the breaking of the fuze, this can only result in either case from actual impact of the fuze on a hard substance, and although the metal fuze is doubtless less liable to be broken by such impact, it is not less liable to be extinguished,[3] and thus rendered inefficient, than the wood fuze. It matters little, therefore, if the fuze be broken or not, if its effect as a fuze is destroyed; and the metal fuze has therefore no superiority in this respect.

The argument respecting metal fuzes being less liable than wooden ones to be *knocked out* on striking a hard substance, if it has any force at all, would apply rather in favour of the introduction of metal fuzes for land than for sea service, since it is on land rather than at sea that such an accident is likely to occur. "Although the wood fuze is liable," says Col. Boxer, "to be knocked "out by repeated ricochetting, it is not subject to this defect in passing "through a material."[4] And as naval shells are not generally exposed to such repeated ricochetting on a hard substance, the fuzes of such shells, whether

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been under consideration; the effects of *external* alteration of form alone have to be considered, and such alteration will only cause the fuze to descend further or less far, as it expands or contracts, into the fuze hole. In extreme cases it may loosen the index paper, but this "may be overcome without difficulty."—Mr. Abel's *Report to Armstrong and Whitworth Committee*, p. xliii). And, "there would then be no part vital to the efficiency of the fuze likely to suffer deterioration."—(*Ibid.* xliii.)

[1] I have not here taken into account an argument which suggests itself as to the proportion which the amount of deterioration to which the two fuzes are respectively subject bears to their cost, but it is evident that if the one fuze is not more liable to be affected by damp or climate than the other, *cæteris paribus*, the wood fuze, which costs *2d.*, is superior to the metal fuze, which is not produced under 1*s.* 11*d.*. At the same time, this argument, although admissible in a general survey of the relative value of the two fuzes, is scarcely so at that part of the argument in which the relative *efficiency* of the two fuzes, independently of other considerations, is being considered, unless it can be clearly established that they are equally efficient, or that the less efficient is the dearer of the two. For example, supposing the wooden fuze to deteriorate three times as fast as the metal fuze, the fact that the cost of these wood fuzes would be only one-fourth that of one metal fuze could not be put forward as an argument in favour of the wood fuze, the more rapid deterioration of which would very much more than counterbalance its great comparative cheapness.

In fact the question of cost is so entirely subordinate to that of efficiency that the intrinsic value of any two war stores can hardly be taken into account where there is any material difference in the excellence of the two, the inefficient article being under almost all circumstances the dearer. In proportion, however, as the two articles approach one another in efficiency, the question of cost assumes a more important character.

These considerations have induced me to postpone the arguments as to cost until it could be more legitimately and effectually employed,—thus avoiding pressing it, as it were, into the service of efficiency.

[2] *Shells and Shell Guns*, p. 149.

[3] "Time fuzes, which are essential to enable a shell to act as a mine, are very inefficient in horizontal shell firing. *It is found that four fuzes out of five are extinguished on striking the water, and about one in three on striking a ship.* If the shell strikes with the fuze end forward, which is generally the case, it is found that the timber, by its resistance, forces itself into and effectually plugs the fuze."—*Naval Gunnery*, p. 281.

[4] Colonel Boxer's MS. *Notes*, p. 81.

wood or metal, are not liable to be knocked out. This argument, therefore, can scarcely be urged specially in favour of metal fuzes for *naval* service, and as regards land service the defect was remedied in 1854 (since Col. Boxer's notes, from which the above extract is made, were written) by the removal of the projecting head,[1] and the present fuzes are not liable to it. The argument about the knocking out of the fuze holds good, therefore, neither for land nor sea service.

There remain only to be noticed the relative explosive effects of shells fitted with metal and wood fuzes. The prevailing opinion as to the relative superiority of the metal fuzed shells in this respect is founded on experiments made prior to the reduction in the size of the fuze holes of the wood fuzed shells.[2]

Now the fuze holes of the 8-inch and 32-pr. naval shells used in these experiments had a diameter of 1·2″, while the present fuze holes of these shells are (taken at their smallest) ·913″ and ·875″ in diameter respectively,[3] and the area through which the gas could escape in the old shells was therefore in round numbers about double that of the present shell.

But a reference to an actual experiment instituted in the Royal Laboratory in 1865, specially with a view to determine whether the force of explosion of a metal fuzed shell was much in excess of that of a wood fuzed shell, will perhaps be the most satisfactory argument on this point.

32-pr. spherical shell were taken as being the most unfavourable to the wood fuze,[4] and it was assumed that the number of fragments into which the shell broke would give a fair rough expression of the relative force of the explosion.[5]

Five naval shells were burst with metal fuzes screwed into them; three common shell with common fuzes in, and two common shell with no fuze or plug of any description in the fuze hole.

The total number of pieces from the first five shells was 112; the total number from the common shell 96; showing but a slight and scarcely appreciable advantage on the side of the metal fuzed shell.

The details of the experiment are given in the following table:—

Fuze.	Shell.		Actual Number of Fragments.												Mean of Number of Pieces per Shell.
	Nature.	Number burst.	2 lbs. and upwards.	1 lb. to 2 lbs.	½ lb. to 1 lb.	6 oz. to 8 oz.	5 oz. to 6 oz.	4 oz. to 5 oz.	3 oz. to 4 oz.	2 oz. to 3 oz.	1 oz. to 2 oz.	½ oz. to 1 oz.	Under ½ oz.	Total.	
20 seconds, metal fuze	32-pr. Naval	5	14	30	31	3	3	1	–	8	9	6	7	112	22·4
Common, wood fuze	Common	3	11	16	9	4	3	–	–	1	4	5	3	56 } 96	18·66 } 19·2
Without fuze or fuze hole plug	Common	2	9	10	8	4	2	–	2	1	1	1	2	40	20·0

An experiment of a similar character was made by the Ordnance Select Committee in 1864, taking 40-pr. B.L. shells and using E time fuzes and Boxer's wood time fuzes respectively.

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1 "By this arrangement the fuze will not be so liable to be knocked out on ricochetting."—*Synopsis of Ordnance Select Committee Report on Shrapnel Shell*, p. 201.

The change was approved 13th March 1854.

2 The grounds upon which Capt. Key chiefly based this opinion as to the relative bursting power of shells fitted with metal and wooden fuzes were the experiments made prior to 1854 with 32-pr. and 8-inch spherical shells having fuze holes of the original 8-inch size.—*Extracts from the Reports, &c. of Ordnance Select Committee*, ii., 132.

Sir Howard Douglas' opinion is also founded upon (probably the same) experiments with the old large fuze hole, the third edition of his work, from which I have quoted, having been published in 1851.

3 The diameters of the fuze holes of the shells with metal fuzes need not be taken into account, since they may be regarded as a closed issue. But these holes were smaller than at present, being the old naval time-fuze hole ·9 inch diameter.

4 Most unfavourable as compared with larger shells, because evidently the loss of explosive force due to escape of gas from a hole of fixed size will be less felt in proportion as the size of the shell and the consequent capacity for powder increases.

5 On the argument that the smaller the charge of a shell and the less the expression of force the larger and consequently less numerous will be the fragments. See p. 170.

The result was as follows:—"Omitting fragments of half an ounce and
" under, and taking into account pieces weighing from 1 oz. to 2 lbs. and up-
" wards, the mean number of pieces into which the shells broke up was as
" follows:—

" With E time fuze - - 372 pieces.
" With Boxer's time fuze - - 341 ,,

" or 31 pieces in favour of the shells fitted with the Armstrong (metal) fuze, a
" difference which is hardly appreciable, and might even be reversed if the
" experiment were repeated."[1]

This subject might be pursued further, but enough has been said to show that even under the unfavourable circumstances of small shells (such as the 32-pr. and 40-pr.), the difference of explosive effect of a metal fuzed shell is practically inapplicable.

And having said this much on behalf of wood as opposed to metal time fuzes; having shown that the reasons originally urged for their adoption were of insufficient force even at that time, and are now inadmissible, and that the metal fuze, in fact, presents no advantages over, and in some respects is distinctly at a disadvantage compared with, the wood fuze, it may be well, with a view to completing the argument in favour of the change which has recently been effected, by the adoption of wood time fuzes for naval use, to state briefly what difference of expense results from the employment of the existing metal time fuze for naval shell.

The expense must be considered not merely with regard to the fuze itself, but with regard also to the stores, which are accessory to the system—to the plugs and bushes.

The following table shows the comparative cost of 100 8-inch naval and common shells and fuzes respectively:—

——	Naval.	Common.
	£ s. d.	£ s. d.
Bushes - - - - - -	1 9 6	Nil.
Plugs - - - - - -	1 5 6	0 15 2½
Preparing fuze hole - - -	0 14 9	0 7 2
Cost of fuze per 100 - - -	11 7 8	1 7 4
	14 17 5	2 9 8½

or a difference of 11*l.* 7*s.* 8½*d.* in favour of the wood system per 100 shell.

The other objections to metal fuzes have been indicated, although their force has been by no means fully expressed, in the former part of this paper. Such objections, for example, as the loss of time which necessarily results from the employment of a *screwed* time fuze.

Other objections of a minor character have been urged against these fuzes by Dahlgren[2] and other writers, and the recent adoption of wood time fuzes for our heavy rifle guns, to be ultimately extended to naval spherical shells, indicates a satisfactory change of feeling upon a subject which has too long been allowed to rest upon a basis of tradition and specious reasoning, and which on examination crumbles to pieces.

[1] *Extracts from Reports, &c. of Ordnance Select Committee*, ii., p. 132.
[2] *Shells and Shell Guns*, p. 142.

Appendix M.

Safety Fuzes for conveying Fire to the Charge in Blasting Rocks, manufactured by Bickford, Smith, and Co., Tuckingmill, Cornwall.

No. on Descriptive List, W.O. Cir. 406.	No.	—	Per Coil of 24 Feet.
No. 1	1	Bickford's Patent Small Fuze, for immediate use in dry ground	3*d.* and 3½*d.*
No. 2	2	" Patent Fuze, for use in dry ground	4*d.*
No. 3	3	" Patent White Fuze, for use in dry and close places	4*d.*
	4	" Patent Red Fuze, for use in very damp and close places	4½*d.*
	5	" Patent Yellow Fuze, for use in damp and close places	4½*d.*
No. 4	6	" Patent Thread Sump Fuze, for use in wet ground	5*d.*
	7	" Patent Small Tape Sump Fuze, for immediate use in wet ground	5½*d.*
No. 5	8	" Patent Tape Sump Fuze, for use in wet ground	6½*d.*
No. 6	9	" Patent Double Tape Sump Fuze, for use in very wet ground	8½*d.*
	10	" Patent Treble Countered Fuze, for use in very wet ground; will bear rough treatment	7½*d.*
	11	" Patent Thread Countered Tape Fuze, adapted for very wet ground; strong and tough	8*d.*
	12	" Patent Small Gutta Percha Fuze, for use in very wet ground, or for immediate use in water	8*d.*
No. 7	13	" Patent Gutta Percha Fuze, for use in 40 feet of water	9½*d.* to 1*s.*
No. 8	14	" Patent Taped Gutta Percha Fuze, for use in 60 feet of water	From 1*s.* to 1*s.* 6*d.*
No. 9	15	" Patent Double Gutta Percha Fuze, for use in 300 feet of water	From 1*s.* 2*d.* to 2*s.*
	16	" Patent Large Sub-aqueous Fuze, for use in any depth of water for any length of time; will bear any pressure, and very great strain	From 8*s.*
	17	" Metallic Fuze, for use in wet ground	1*s.*
	18	" Patent Double Countered Metallic Fuze (White), for use under water	1*s.* 6*d.*
	19	" Patent Double Countered Metallic Fuze (Black), for use in deep water	1*s.* 6*d.*
	20	" Patent Treble Countered Metallic Fuze, for use in 40 feet of water when immersion for a considerable time is necessary	2*s.*

No. on Descriptive List, W.O. Cir. 406.	No.	——	Per Coil of 24 Feet.
	21	Bickford's Patent Gutta Percha Countered Metallic Fuze, for use in any depth of water, and will bear immersion any length of time - - -	
	22	" Patent Treble Wove Fuze, a very superior fuze, adapted to almost every mining requirement - - -	6*d.*
	23	" Patent White Tape Fuze, for use in wet and close places, and for exportation into warm climates - - -	7*d.*
	24	" Patent White Double Tape Fuze, for use in very wet and close places, and for exportation into hot climates - -	9*d.*
	25	" Patent "Quarry" Fuze, for use where very deep holes are required in slate quarries and elsewhere; warranted to carry the fire to the bottom of the charge before causing explosion - - -	10*d.*

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