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PREPARED IN THE ROYAL GUN FACTORY.

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WOODCUTS.

(These accompany the respective descriptions of Stores, &c., &c., and can thus be readily ascertained by the Index.)

EXPLANATION OF ABBREVIATIONS USED IN THIS WORK.

R.M.L. - -	Rifled Muzzle-Loading.
R.B.L. - -	Rifled Breech-Loading.
M.L. - -	Muzzle-Loading.
B.L. - -	Breech-Loading.
S.B. - -	Smoothbore.
W.D. - -	War Department.
W.O. - -	War Office.
D. of A. and S. -	Director of Artillery and Stores.
L.S. - -	Land Service.
S.S. - -	Sea Service.
R.L.G. - -	Rifle Large Grain (powder).
P. - -	Pebble (powder).
P² - -	Cubical powder 1½"
R.G.F. - -	Royal Gun Factories.
O.S.C. - -	Ordnance Select Committee.
E.O.C. - -	Elswick Ordnance Company.
§ - -	This refers to the paragraph in List of Changes of War Stores.
Extracts - -	From the Proceedings of the Department of Director of Artillery.
M.V. - -	Muzzle Velocity.
f.s. - -	Feet seconds (as to velocity).
f.t. - -	Foot tons (as to energy).

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TABLES.

PREFACE.

THIS Treatise is meant more especially for use in Royal Artillery offices, by officers and others in charge of Ordnance, and also for employment in the instruction of N.C. officers and men. Theoretical matter has been, as far as possible, left out, and what remains is given briefly, and it is hoped with sufficient clearness to make it intelligible to all those who will have to use the Treatise.

The former "Text-book of Rifled Ordnance," by Major Stoney and Captain Jones, R.A., has been largely borrowed from in the preparation of this work, while the chapter on smoothbore ordnance has been taken from the work published in 1874, as revised from existing notes by Captain Molony, late R.A., and Major Stoney, R.A.

The nomenclature and pattern of the various sights and stores are given in a separate chapter, while all the necessary instructions as to examination, repair, and preservation, have also been collected in a chapter at the end. The mode of re-arrangement employed has been adopted for the purpose of simplifying reference as far as possible, and of preventing any unnecessary repetition.

In completing this work for the press, both my assistant-instructors have rendered me most valuable aid; Serg.-Major White particularly in preparing the Table of Stores, &c., and Quarter-Master-Sergt. Ashworth in collating the MSS.

J. F. OWEN, Capt. R.A.,
Capt. Instructor, R.G.F.

Instruction Branch,
Royal Gun Factories,
April 1877.

CHAPTER I.

CHAP. I.

METALS EMPLOYED IN GUN MANUFACTURE.

Properties of Metals.—Malleability.—Brittleness.—Ductility.—Tenacity.—Toughness.—Softness.—Elastic limit.—**Metals employed for Ordnance.**—Bronze; its unsuitability.—Cast Iron; properties and defects.—Wrought Iron; properties and defects.—Steel; its definition, properties, and defects.—Failures of Cast Iron and Steel Foreign Ordnance.

Properties of Metals.

Before describing the metals employed in the manufacture of Service Ordnance, it is advisable to explain the meaning of certain words used to explain their different qualities.

Malleability. Brittleness. A metal is called "*malleable*," or to have the property of "*malleability*," if it can be permanently extended in all directions without cracking or breaking (either by rolling, squeezing, or hammering). It is opposed to a "brittle" metal; lead is very malleable, but steel when hardened is brittle.

Ductility. *Ductility* is the property of permanently lengthening, when drawn or pulled out, as copper is in wire drawing. Thus wrought iron is a very ductile metal.

Toughness. *Toughness** is a quality very like tenacity, but not quite the same. It is the property of resisting extension or fracture by tearing or bending; thus a piece of copper is said to be more or less tough in proportion to its capability of being bent backwards or forwards without breaking.

Softness. A metal is said to be *soft* when it yields easily to compression without breaking, and does not return to its original form on the removal of the compressing force. It is always a comparative term; thus steel is called "*soft*" or "*hard*" according to the quality given to it by the special treatment to which it has been subjected.

When we hang a weight to one end of a bar of metal the bar stretches, but if the weight be not too heavy and we remove it, the bar goes back to its former size (or very nearly so) until as we go on adding heavier weights we come to one which will stretch the bar permanently, so that when that weight is taken off the bar remains longer than it was at first.

* Dr. Young gives the following explanation of the term toughness as applied to steel. "Steel, whether perfectly hard or of the softest temper, resists flexure with equal force when the deviations from the natural state are small, but at a certain point the steel, if soft, begins to undergo an alteration of form; at another point it breaks if much hardened, but when the hardness is moderate it is capable of a much greater curvature without permanent alteration or fracture, and this quality which is valuable for the purposes of springs (and also for gun barrels) is called toughness, and is opposed to rigidity and brittleness on the one side, and to ductility on the other."

CHAP. I.

Elastic limit.

The *elastic limit* of a metal is measured by the amount of that weight which a bar will just support without remaining permanently longer after the weight is removed. The elastic limit of any particular metal is measured by the number of tons a rod of square inch section of that metal will thus support. The greater this weight the more elastic the metal is or the greater elasticity it possesses.*

Tenacity.

Tenacity is measured by the weight a bar, wire, or rod can support without breaking. Steel is very *tenacious*.

We shall now understand what is meant by malleability, ductility, toughness, softness, and tenacity, elasticity, elastic limit when talking of metals.

These terms are only comparative; thus we say lead is a soft metal, *i.e.* it is soft compared with other metals, though hard as compared with beeswax and a hundred other things. Again wrought iron is soft as compared with steel, though it is much harder than lead.

Metals employed.

Metals employed for ordnance.

The metals employed in constructing ordnance are bronze, iron, and steel.†

Bronze.

Bronze.

Bronze is a mixture or alloy of copper and tin. That particular sort of bronze used for guns is often called gun metal, and consists of about 90 parts of copper and 10 of tin.

Bronze is a tough and tenacious metal, but when cast or founded in the ordinary way it is comparatively soft, and is easily indented and damaged by the projectile. It is also acted on by the heat caused when many rounds are fired in a short time.

For the small smoothbore guns formerly used in the field, bronze answered tolerably well, as the weight of the charge and shot were small, but with rifled guns the charges are much heavier, and bronze is not found a good material for such ordnance.‡

Unsuited for rifled guns.

There is another great fault to be found with bronze. When the copper and tin are melted together the tin is found to separate in some parts, and to form white spots or blotches called "tin spots." These spots are easily acted upon by the powder gas and are eaten away, leaving flaws or holes in the bore of the gun. In rifled guns this defect is much more serious than in S.B. pieces, for the grooves cut in the bore lay open a greater surface and expose more tin spots, while the powder gas acts with greater force (on account of the larger charges and the heavier projectiles used) and eats away the spots more quickly.

Trial of 9-pr. bronze R.M.L. guns.

In 1869 we tried bronze for 9-pr. R.M.L. guns (vide p. 34), and about 150 of these guns were made for home and Indian service. They did not answer well, and have all been returned into store.

---

* Though not strictly the case this is so in the ordinary acceptation of these terms.

† We find copper also employed for certain fittings and for the vents of guns, though not in their actual construction. The metal is very tough, and is also very ductile. It is found to withstand the action of powder gas better than others, for which reason it is used for the manufacture of vents.

‡ Some foreign nations still use bronze for their field and siege guns, but it is principally because they can make them more cheaply with that material.

The only bronze rifled guns actually in the service are a few 7-prs. (vide p.), but no more of these are to be made. We have, however, many bronze S.B. pieces (vide Table, p. 29).*

Bronze 7-prs. R.M.L.

Iron.

Although there is only one metal called iron, yet it differs so much according to what is mixed with the metal itself that the different mixtures or alloys of iron are called by various names.

Iron.

Steel is really only a mixture of the metal iron with other substances, as will be explained further on.

Steel.

Cast Iron.

To obtain iron from its ores the latter are generally melted in large furnaces with coal and other substances. The iron is run off into moulds, and is called "cast iron." It has mixed with it a great deal of "carbon" (of which coal principally consists), and also small quantities of other substances, as silicon, sulphur, phosphorus, and manganese.

Cast iron.

Any iron having more than two parts per 100 of carbon mixed with it is usually called "cast iron." This sort of iron is hard, but easily melted and cast in moulds into any shape we require. It is also cheap, but unfortunately weak and brittle, and so not suited for the manufacture of rifled guns to fire large charges.

Properties.

Defects.

The tenacity of cast iron is not high, and its brittleness makes it unsafe if strained too highly, for if a gun made altogether of this material fails, it will probably burst violently without warning.

We, therefore, make none of our service rifled ordnance entirely of cast-iron, though for economy we utilize certain old cast iron S.B. guns by strengthening them with a rifled wrought iron barrel.

Wrought Iron.

If the substance called carbon, and the other impurities mixed with the metals itself in cast iron, were altogether removed, we should have pure iron. It is difficult to remove them entirely, but by "puddling" (vide p. 38) and other processes most of the carbon, &c. can be burnt out, and when not more than 8 parts per 1,000 of carbon are left the metal is termed wrought iron.

Wrought iron.

This material differs very much from cast iron. It can be heated and then rolled out or drawn under a hammer, while if we make cast iron red hot and strike it we find that it falls to pieces.

Wrought iron cannot be melted in an ordinary furnace, and has the property of welding, which cast iron has not. By welding wrought iron we mean that if two clean surfaces of this sort of iron be brought up to a white heat placed upon one another and then pressed together by rolling or hammering, they will unite, so that the two pieces joined together will break quite as easily at any other part as at the place where they were welded together. This is a very valuable property, and is taken advantage of very largely in the manufacture of our guns.

Welding of wrought iron.

By drawing out wrought iron under a hammer or by rolling we make it fibrous, the fibres running in the direction in which the forging is drawn out. The fibre thus runs lengthways in a bar in a similar manner to the fibre in a piece of wood. Now if we take a rod of wood, for instance a small branch of a tree, we can break it easily across, but if we try to pull it in two in the direction of the fibre, we shall find it is

Properties of wrought iron.

* A large number of these bronze pieces have lately been broken up.

CHAP. I.

very much stronger, and that it takes much more power to break it in that direction.

It is the same with wrought iron, which is about twice as strong along its fibre as across; this property is also taken advantage of in using it for gun construction.

Defects of wrought iron.

Wrought iron is not very elastic, but is very ductile, malleable, and tenacious. Its tenacity is about double that of cast iron or bronze, when taken in the direction of its fibre. It is, however, comparatively soft and difficult to obtain it quite free from slight flaws caused by defects in welding, and from impurities getting mixed with the iron while it is being forged or rolled.

Steel.

Steel.

Definition of steel.

Steel is the name generally given to iron when mixed with a certain quantity of carbon, but it is more properly an alloy or mixture of iron which has certain distinguishing properties. Thus, any mixture of iron which can be melted in a furnace in large quantities, run into a mould, and afterwards, worked under a hammer or rolled out, is really steel.

We find that as a rule* iron which has with it between three parts per thousand and two per hundred of carbon can be so treated. If there is more than the higher quantity we can melt and run the iron into moulds, but we cannot hammer it afterwards. It is not malleable, but is in the state of cast iron. Should there be less than three parts per 1,000 of carbon we would on the other hand be unable to melt it in any furnaces at present practically used, but we could easily work it under the hammer while hot. It would in fact be wrought iron.

We see then that steel stands intermediate between cast and wrought iron, and has some of the properties of either. It can be melted and cast into moulds, and yet can be forged like wrought iron, and given a fibrous structure when drawn out by rolling or hammering.

TABLE I.

TABLE showing the ELASTIC LIMIT and TENACITY of Average Specimens of the Metals used in the R.G.F.

Materials.	Tons per Square Inch at		Elongation per Inch at Breaking.
	Yielding.	Breaking.	
Bronze -	6·8	14·9	0·29″
Cast iron from	about 4†	9·0	†
Cast iron to		14·0	†
Wrought iron along its fibre	11·0	22·0	0·3 ″
Steel soft	13·0	31·0	0·21″
Steel tempered in oil	31·0	47·0	0·11″

Soft steel and hard or toughened steel.

When in its natural state after casting and forging steel is nearly as soft and inelastic as wrought iron, but it may be hardened by being heated and plunged into cold water. The effect of this is to harden the material, and also to render it exceedingly brittle.

Process of toughening steel.

In order to obtain the useful properties of hardness and increased tenacity, and at the same time as far as possible to avoid the defect of brittleness, oil is sometimes used instead of water for hardening

* This is only a rough approximation.

† The specimens of cast iron tested in the R.G.F., are too short to enable the yielding point and elongation to be accurately determined.

steel. Oil is, for a liquid, a very bad conductor of heat, and does not boil under 600° F. Consequently when hot steel is plunged into it, the mass parts with its heat much more slowly than when water is used, and is toughened as well as hardened. The temperature to which the steel is heated affects the result very much.

Advantage of steel for gun barrels.

Steel when melted and cast into moulds is free from the defects common to wrought iron, due to foreign substances getting in during forging or to faults in welding, so that we can make sure of getting a smooth even surface when we use it. This is a great advantage for the inner barrel of a gun. It has a much greater tenacity than other varieties of iron, especially after forging and toughening in oil; its limit of elasticity is also high, but after that limit is past, steel will not extend much before breaking, while it is a brittle material and very uncertain* in quality. When strained suddenly it is apt to fly to pieces without any warning.

Tenacity. **Its uncertainty.**

Recapitulation.

The different gun metals, advantages and disadvantages.

To run over once more the principal qualities of bronze and of the several varieties of iron, which we term cast iron, steel, and wrought iron, as they are used in the manufacture of guns:

Bronze is the softest; wrought iron is about twice as hard as bronze, cast iron twice as hard as wrought iron, and hardened steel again twice as hard as cast iron.

Bronze and cast iron have about the same tensile strength, 12 to 14 tons per square inch, good wrought iron about 25 tons, and steel when toughened in oil about 50 tons.

Bronze is ductile and tough, cast iron is brittle, and so is hardened steel, but in its soft state steel can be drawn out as wrought iron can, so that the two latter are both ductile metals.

Steel has a high limit of elasticity, but does not stretch much after that is reached, it is uncertain in quality and apt to burst explosively; wrought iron on the other hand stretches a great deal after its elastic limit is passed, so that it does not burst violently when strained, but it is seldom free from flaws or defects and does not give us a hard, smooth, and even surface like steel.

Cast iron is too weak and bronze too soft and weak for the manufacture of rifled guns. While taken separately, neither wrought iron nor steel answer in all respects to what we require. By using the two latter in conjunction we have all that is necessary.†

Steel is admirably suited for the inner barrel of a gun, for it is very strong, and gives us a hard clean surface, while its limit of elasticity is high, so that even a heavy strain does not stretch it permanently and deform the bore. It may, indeed, split if subject to too sudden and violent a strain, but by putting a wrought iron jacket outside, we prevent any danger from that cause, for should the tube burst the wrought iron jacket will stretch and prevent any explosive rupture.

So well do these materials answer in the way we employ them, that although thousands of R.M.L. guns manufactured as described have

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* Its uncertainty is such that two specimens, even out of the same ingot, are often found not to behave exactly alike when tested, nor to possess the same structure and other physical properties. It is therefore absolutely necessary to test each individual ingot previous to putting it into a gun.

† The whole of our ordnance at present manufactured are made of these two metals, except a small 7-pr. gun, made entirely of steel, and certain second-class rifled guns converted from old S.B. pieces as before mentioned for economical reasons.

CHAP. I.

been used by us for many years past, not a single gun has burst explosively on service, nor has a single life been sacrificed by their breaking up.*

---

* We may well congratulate ourselves upon this when we think of the steel guns of Krupp and the cast iron guns of America.

As to cast iron used alone or strengthened by wrought iron superimposed rings, many such guns, R.M.L., on the Parrott construction, were used in the American war of 1860, and we find that these failed most signally; thus we are told that "In the attack on Fort Fisher all the Parrott guns in the fleet burst. By the bursting of five of these guns at the first bombardment 45 persons were killed and wounded, while only 11 were killed or wounded by projectiles from the enemy's guns during the attack." (Report on Ordnance, United States Senate, 25th February 1869.)

In France, the heavy guns constructed of cast iron, strengthened with steel hoops and barrel, have not always been successful, and only a short time ago, in 1875, a 17-cente. gun of this construction burst, it is understood, while firing service charges; killed one gunner and wounded an officer.

As to the danger and uncertainty of steel when used alone we have ample evidence, both in this and other countries, and a very long list of ordnance constructed solely of this material which have burst explosively and on many occasions caused considerable loss of life.

Some instances are given below, the greater number of which are extracted from a valuable paper by the late Lieut.-Col. Haig, F.R.S., R.A., in Proceedings R.A.I., Vol. VI. "On Heavy Rifled Guns."

In June 1860, a puddled steel 12-pr. made by the Mersey Steel and Iron Works burst at Shoeburyness at the sixth round.

In June 1861, a 7-inch steel gun by the same makers burst at the sixteenth round; while in November of the same year a 20-pr. Krupp gun burst at the second round.

In March 1862, a French 30-pr. steel gun burst at Gavres.

In August 1865, a Krupp 9¼-inch steel gun burst with a moderate charge of powder, a Prussian committee attributing the failure to inferiority of the metal. In Russia, during the same year, a 9¼-inch gun of Krupp's steel burst at the sixty-sixth round, and an 8½-inch similar gun burst at the ninety-sixth round.

In June or July 1866, a 9-inch Krupp gun burst in Russia at the fifty-sixth round; while in the same year a field gun by the same maker burst at Berlin, killing three cadets.

During the Prussian campaign against Austria in 1866, six Prussian steel field guns burst.

In January 1867, a 7-inch Krupp gun burst at the second round of proof, at Woolwich; and in the same year a 4-pr. burst at Tegel, near Berlin, killing two men.

In 1868, an 8-inch Krupp gun burst on board the Russian frigate "Alexander Newsky," in the Baltic, very destructively, killing 12 and wounding 30 men.

In 1869 (January 27th), a similar gun burst in Prussia into twenty pieces.

Besides these guns large guns constructed of steel, supplied either by Krupp or Petin and Gaudet, have burst violently at Madrid and Turin."

Again, in 1872 an 11-inch Krupp gun burst at the chase, and blew off about 3 feet of the muzzle when firing the service charge.

In an official Report, dated 1873, we have mention of two heavy steel guns bursting violently in Russia in that year.

During the Carlist War of 1874–75 several steel mountain guns burst.

In 1874 we are told that "some Krupp guns were being tested in Japan, when one of them with 15 lbs. of powder and a 70 lb. projectile, burst under the fourth round; huge pieces of metal flew in every direction, but luckily no one was injured.

CHAPTER II.

CHAP. II.

GUN CONSTRUCTION GENERALLY.

Gun Construction.—Arrangement of Material to ensure strength.—Pressure in the Bore.—Thickness of Metal.—Cast Metal insufficiently strong.—American S. B. Ordnance.—Cast Iron, why still used by some nations for Rifled Ordnance.—**Armstrong's Principles of Construction.**—Usual System of Construction.—Built up Guns.—Shrinkage.—Compression.—Tension.—Construction of our Service Ordnance.—R.B.L. Guns.—Original heavy R.M.L. Guns.—**Fraser Construction.**—Material of the Gun, how arranged.—Woolwich System.—Palliser System.—**Venting.**—Vent Bush.—Position in the Gun and Howitzers.—Through Vent.—Cone Vent.—Vents of different threads.—Exceptional 7-pr. and 80-ton Gun Vents.—**Rifling.**—Its Object.—Twist.—Wear of Grooves.—Uniform and Increasing Twists.—Rifling of B.L. Guns.—Shunt Rifling.—Plain Groove.—Woolwich Groove.—French modified.—French Groove.—Sighting.—S.B. Ordnance.—Rifled Ordnance.—Angle of Deflection.

Gun construction.

In constructing a gun we must first consider what pressure it will have to endure when fired, and then make it strong enough to ensure perfect safety. The bore also should be of such a material as to stand the wear and tear of firing a large number of rounds without being damaged so as to interfere with the shooting.

Arrangement of material.

Not only must the gun be sufficiently strong, but it must not be too costly nor too heavy, so it is important that the material should be arranged in such a manner that there should be no waste of its strength, arranged in fact so that every part should perform its own share in withstanding the strain from within.

Pressure in the bore. Greater strain on rifled than S.B. ordnance.

As the pressure inside continues to decrease as the projectile approaches the muzzle, we have to make the gun stronger about the powder chamber than towards the muzzle end, especially in rifled guns, where the strain is much greater than in S.B. ordnance, and where the shot does not move so soon.*

Strength of a cylinder to resist pressure from within.

Now, if we take a tube or hollow cylinder made of one material throughout, we find that its strength to resist a pressure from within does not depend entirely upon its thickness. We are told that in the

* The greater the weight of a projectile, the greater is the opposition from inertia which it offers in the bore to the expansion of the ignited charge, and this opposition is increased if the projectile is obliged to travel through the bore in a spiral course, so it is easy to understand why a rifled gun must be of a stronger, tougher, and more elastic material than a smoothbore gun, in which the round shot yields promptly to the first impulses of the powder gas (to which it presents half its surface), while the strain on the gun is much relieved by the comparatively great windage.

CHAP. II.

cylinder of an hydraulic press, if the thickness of its walls be equal to one half the diameter of the piston which works inside, it will be nearly as strong as if it were ten times as thick.

Strength of our S.B. mortars.

To take an instance from our own ordnance, the sides of the 13-inch S.S. mortar are twice as thick as those of the 13-inch L.S., but the former piece is not by any means twice as strong as the latter.

Strength of a cylinder limited by the tenacity of its material.

In fact, however thick we may make the sides of such a cylinder, we can only obtain a certain strength from it, depending upon the nature of the material used. It is generally agreed that "no possible thickness can enable a cylinder to bear a continual pressure from within greater on each square inch than the tenacity of a square inch bar of the material;" that is to say, if the tenacity of cast iron be 11 tons per inch, no cast iron gun, however thick, could bear a charge which would strain it beyond that point, for on the first round the interior layer would be ruptured before the outer portion could come into play, and every succeeding round would tend to make matters worse.

Guns cast of one material not sufficiently strong.

Guns made by casting iron or bronze into moulds, as S.B. pieces used to be manufactured, cannot therefore be made strong enough to stand more than a certain pressure from within for the inner portions receive the brunt of the explosion, while the outer portions are hardly affected by it at all, and consequently there is a certain amount of dead weight about every homogeneous gun. Take for example a section of a 10-inch cast iron gun where the thickness of the metal is 5 inches, and assume that the amount which the metal will stretch before it breaks is a thousandth part of its length. Now supposing a pressure could be communicated with undiminished force throughout the mass, it is plain that when the circumference of the bore would be stretched a thousandth part of its diameter, *i.e.*, the hundredth of an inch, the lamina an inch further would be only stretched $\frac{10}{12}$th of that amount, and the lamina an inch further still only $\frac{10}{14}$th, and so on to the external lamina, which would be only stretched $\frac{10}{20}$th or half the amount, that is, when the interior of 10 inches diameter would be on the point of rupture, the exterior of 20 inches diameter would have only half the strain on it which it could bear.

How to remedy this defect, and to make each layer of the metal of the gun aid in withstanding a stress from within is the problem which all gunmakers have attempted to solve.

American S.B. ordnance.

Cast iron S.B. ordnance for L.S. were manufactured in America by making a hollow casting cooled from the interior, which hardens first, and is compressed and supported by the contraction of the outer portions round it, so that the inner layers are stronger than the outer. Still however well cast iron may be disposed it is naturally too weak and brittle a metal for use with heavy rifled guns, and those nations which employ it by itself for rifled guns do so because it is cheap and easy to manufacture, and not because they consider it the best material.

Armstrong's principles of construction.

To Sir William Armstrong is due the merit of first successfully employing wrought iron coils shrunk together in gun manufacture. His construction consists essentially—

(1.) In arranging the fibre of the iron in the several parts so as best to resist the stress to which they are respectively exposed; thus, the walls or sides of the gun are composed of coils with the fibre running round the gun so as to enable it to bear the circumferential tension on discharge without bursting, whilst the breech end is fortified against the longitudinal tension, or tendency to blow the breech out, by a solid forged breech-piece with the fibre running along the gun.*

(2.) In shrinking the successive parts together so that the tension may be regulated in such a manner that the outer coils shall contribute their fair share to the strength of the gun, vide p. 10.

Usual system of construction.

Most gunmakers now either use a strong material such as steel for the inside layers, and a weaker metal, as wrought iron or cast iron, for the outer portions, or else they use some such method of construction as that employed by Sir William Armstrong described above.

Heavy rifled guns are made in France and elsewhere by fitting steel tubes into a cast iron casing, and with our Palliser guns a wrought iron barrel is used with a casing also of cast iron.

With our Woolwich guns we use both systems together. In all cases also the fibre of the metal, as already mentioned, is, when possible, disposed in the direction of the greatest tension or stress.

Built up guns.

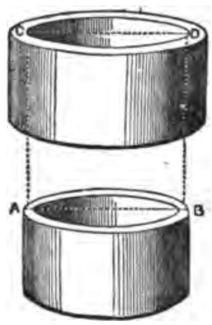
The most successful guns then are at present made by building up one coil outside another in the same manner to that introduced by Sir William Armstrong, in such a way that each outer coil compresses those inside it, and so support them while made weaker itself. This may be done by forcing on the outer tubes by hydraulic pressure as in the Whitworth guns, or by expanding them by heat, dropping them over the inner layers, and then allowing them to cool when they contract upon the parts inside. Our own guns are built in this way, as are those of Armstrong, Krupp, Vavasseur, and others.

Shrinking the parts together.

In all these cases the inside diameter of the outer tube, when cold, must be rather smaller than the outside diameter of the inner tube. This difference in the diameter is called the "shrinkage."

Shrinkage.

In the figure below, the shrinkage is the difference between AB and CD, AB being a little the largest.



Compression.

While the outer coil is cooling and contracting it compresses the inner one and makes AB rather smaller than before, the amount by which the diameter AB is decreased is termed the "compression."

Again, the outer coil itself is stretched on account of the resistance of

* A gun may be destroyed either by the bursting of the barrel or by the breech being blown off. Now, wrought iron in the direction of its fibre is about twice as strong as it is across the fibre, hence the best way to employ it to resist the circumferential tension is to wrap it round and round the piece like a rope. This is the foundation of the Armstrong coil system. For the same reason the best way to resist the longitudinal stress is to place the fibre lengthways or end on; so a breech-piece was made from a solid forging with the fibre in the required direction.

CHAP. II.

the inner one, and its diameter CD is increased, this increase in the diameter of an outer coil is called "extension."

Tension.

The shrinkage is equal to compression plus the extension, and the amount must be regulated by the known extension and compression under given circumstances.

The compression varies inversely as the density and rigidity of the interior mass, the first layer of coils will therefore undergo more compression than the second, and the second more than the third, and so on. Accordingly, in the Armstrong or original construction, a greater proportion of shrinkage was given to the inner layers than the outer, because so much of it was absorbed by compression. The shrinkage, however, never exceeded ·002 per inch of diameter. Much, too, will depend on the thickness and strength of the coil to be shrunk on; for the heavier it is, the tighter will be its grip, and the more will the inner parts be compressed and supported, whereas a thin weak coil, if shrunk on the same mass, would probably suffer from over tension. In the Fraser guns of present construction the heavy breech coil compresses the steel barrel to such an extent that the latter becomes in some instances as much as $\frac{1}{100}$th of an inch smaller in diameter during the process of shrinking, whilst one or two instances have occurred of the thin exterior coils in large guns of the original construction splitting during practice, and thus indicating that they were strained beyond their strength.

Circumstances which regulate the shrinkage.

The position of the coil must be also considered. The shrinkage over the seat of the charge is greatest of all, as that part of a gun must be the strongest, whilst the shrinkage over the muzzle is the least for an opposite reason.

The extension of a coil when shrunk on should in no case exceed that due to the elastic limit of the iron. The elastic limit of bar iron is about 12 tons per square inch and causes an extension of about $\frac{1}{1000}$th of its length, any weight beyond this would stretch the iron permanently and weaken the fibre. Hence the extension on no coil should exceed $\frac{1}{1000}$th of its diameter.

Principle of construction in our guns.

Let us now see how the principle of constructing a gun, so as to make the best possible use of the metal composing it, is carried out with our service guns.

The Armstrong construction, where the gun was built up of a number of thin coils and in which forged breech-pieces were employed, was that upon which all our R.B.L. guns were made, and also the earliest of the heavy R.M.L. guns, vizt.: 64-prs., 7-inch, 8-inch, 9-inch, and 12-inch of 25 tons, all of Mark I.

R.B.L. guns.

First heavy R.M.L. guns.

As mentioned at p. 37, although this construction gave good results it was expensive, both from the quality of iron required and from the number of pieces to be made, moved about, and put together. The large forging for the breech-piece was also very costly. Further, the thin outer hoops were not always of sufficient mass properly to compress the parts within them. For instance, a 13″ gun of original construction split some of its outer coils while the interior ones remained uninjured.

Original construction expensive.

Thin outer hoops not strong enough.

Mr. Fraser, the Deputy Assistant Superintendent of the Royal Gun Factory, therefore proposed his important modification of the system. This consists of using longer coils made of thicker bars, and so much stronger longitudinally, that the forged breech-piece becomes unnecessary. The greater weight and strength of these outer coils also allows compression to be given more certainly to the steel barrel and inner coils. In this construction, moreover, the trunnion ring which was merely shrunk on

Fraser construction.

Trunnion ring welded to breech coil.

in the Armstrong guns and occasionally slipped, is welded to the breech coil.

This Fraser construction was partly adopted in Mark II., 64-pr., 7″, 8″, 9″, and 12″, in which guns the forged breech-piece was retained. In all later marks of these guns introduced into the service since 1869 no forged breech-piece is used, but the Fraser modification is adopted in its entirety.

Forged breech-pieces in some Fraser guns.

Breech-pieces abolished in 1869.

As already stated we not only make each portion of the metal do its proper amount of work in the Woolwich guns by shrinking one coil over another, but we also use a tube of stronger material, steel, for the inner barrel. This we do because we gain by it longitudinal strength, but more especially because steel gives us a hard smooth surface, is much stronger than wrought iron, and free from flaws. Its elastic limit is also much greater than that of wrought iron, especially when toughened in oil (as 30 tons to 12 tons), so that it can stand a strain which would permanently stretch a wrought iron barrel.

Material of the gun, how arranged.

Steel barrels. Why used.

In our heavy R.M.L. guns, then, we make use of the several methods employed to make every portion of the metal do its proper amount of work. We thus avoid as far as possible extra weight, and succeed in making guns so strong that we may assert without fear of contradiction, that in the Woolwich system of construction we have the safest, cheapest, and most simple system of manufacturing heavy ordnance which at present exists.*

Woolwich system of construction.

Theoretically our converted Palliser guns are not so perfect, for the cast iron exterior is too weak, and the material (wrought iron) used for the inner barrel, though strong to resist rupture, is too soft and inelastic, and also liable to flaws. Still as an economical mode of using up old S.B. guns, and for ordnance not meant to fire large charges, it answers tolerably well. We cannot expect such pieces to be very powerful guns, but they will at any rate be much more formidable than the S.B. guns from which they are made.

Palliser guns.

An economical way of using up old S.B. guns.

Venting.

In all guns there must be some means of firing the charge, and the hole bored for this purpose through the metal of the gun itself or through the breech stopper is called the vent or vent channel. The rush of powder gas through this hole or vent wears away the metal, and it is therefore usual to bore the channel out and to fit or screw into it a vent bush, which can be removed when it gets worn, and be replaced by a new bush. As copper withstands the action of the powder gas very well, the bush is usually made of this metal.†

Vent bush.

The position of the vent in the gun may either be what is usually called axial or central, *i.e.*, when the vent channel runs through the axis of the breech and strikes the cartridge in the centre, at the bottom of the bore, as with our R.B.L. guns; or it may be such as to strike the chamber at an angle or perpendicularly to the axis, near the bottom or elsewhere, as is done in our S.B. and R.M.L. ordnance.

Position of the vent.

For convenience the vent generally opens at the top of the gun, but in 10-inch guns or upwards, the size of which render this position awkward, the bush is placed at an angle of 45° with the perpendicular, and the

10″ R.M.L. guns and upwards.

* The question of breech or muzzle loading does not affect this point, except indirectly.

† Certain bushes for S.B. guns made between 1844 and 1855 are made of wrought iron as explained in note at p. 23.

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vent hole will therefore be at the top right side in such guns for broadside and garrison service, but sometimes in turret guns on the left side.

As to the ignition of the cartridge.

It is at times important that the powder charge should be lighted in some particular part, especially if the charge be a large one.

From experiments in 1863 with heavy charges of R.L.G. powder, it appeared that when the cartridge was ignited at a distance of $\frac{4}{10}$ths of its length from the bottom of the bore, that the best results were obtained as to velocity imparted to the projectiles.* It was therefore settled that heavy guns should be vented so that the bush should strike the bore at that † distance from the bottom.

Vents of heavy guns.

Vent of small guns.

With our smaller R.M.L. guns, however, the vent strikes the bore near the bottom, in order to make certain that all the ignited portions of the cartridge bag should be got rid of, and also that when reduced charges are used whilst firing at high angles, there may be no chance of their not being exploded by the tube, which might be the case were the vent too much forward.

To recapitulate—S.B. guns are vented at a slight angle, and the powder chamber is struck close to the breech end. R.B.L. guns are vented centrally through the vent-piece (vide p. 52, for description of bush, &c.) R.M.L. guns 64-pr. and upwards are vented so that the bush strikes the surface of the bore two-fifths of the length of the cartridge from the bottom, and in 10-inch guns and upwards the bush is inclined at an angle of 45°, though it is always perpendicular to the surface of the chamber.

Converted guns.

With the converted guns, 80-pr. and 64-prs., the vent strikes the conical powder chamber at right angles to the surface, and near the bottom, and is inclined at the same angle as was the bush of the old S.B. guns, or nearly so.

R.M.L. howitzers.

With R.M.L. howitzers the vent is inclined at a certain angle so as to strike the conical chamber, also at right angles and near the bottom.

40-pr. downwards.

In the 40-pr. R.M.L. and downwards the vent is perpendicular, and strikes the bore close to the end so as to ensure complete consumption of all the pieces of the cartridge, and to ensure the lighting of the charge when the latter is reduced for the purpose of high-angle firing.

The vent bush or vent is of copper (except the few iron bushes found with some S.B. pieces), and for R.M.L. guns the metal is specially hardened. For vent bushes of R.B.L. guns, vide p. 52.

Through vent. Cone vent.

For S.B. and R.M.L. guns there are two kinds of copper vents or bushes, viz.: the "through vent" and the "cone vent."

Description of through vent.

The "through vent" is a cylinder 1¼ inch in diameter, cut with a screw thread $\frac{1}{12}$ inch deep, and having a square head by means of which the bush is screwed into the gun.

Description of cone vent.

The "cone vent" is of the same shape and size as a "through vent," except near the end where the screw thread terminates, and the cylinder merges into the frustrum of a cone 1¼ inch in length and $\frac{5}{8}$ inch in diameter at the extreme end.

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* The pressure however was greater when charges of this powder were fired in the position named, instead of in the rear.

† In the under-mentioned wrought-iron guns the vent strikes the cartridge as follows, the distance being from the end of the bore —

64-prs.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12" 23 tons	12" 35 tons	12·5" 38 tons
	[illegible]	[illegible]	[illegible]	11	[illegible]	3·5	[illegible]	12

CHAP. II.

Guns are first vented with a cone vent, the through vent is only used when the wear round the copper is so great that the cone must all be bored out to remove flaws. Cone vent first used.

The copper is 2 inches square in section. It is drawn down square while cold under a light steam hammer to the size required for the screw, the blows being as light and numerous as possible, so that the greatest amount of condensation may be effected. It is afterwards turned, a seven-thread screw cut on it, and the bottom coned in the case of a cone vent. The vents of course vary in length according to the thickness of metal of the gun.

In 18-ton guns and upwards the threads are limited to a length of 6 inches above the cone, the upper part being plain. Guns for sea service have the mouth of the vent rimed out to a depth of 1 inch, tapering from ·28 at the top to ·22 at the bottom. § 1821.

Certain S.B. bushes have a different thread, vide p. 23, Chapter III., while the converted guns are vented with a through vent to begin with, vide p. 159. Vents of different threads.

The bush of the 7-pr. steel gun is exceptional, having 18 threads to the inch and being of much smaller dimensions, 0·625 inch in diameter, in order not to weaken the gun too much. The vent bush of the 16-inch (experimental) gun of 80-tons is also exceptional, being of larger dimensions, 1·5 inch in diameter. 7-pr. gun. 16-inch gun of 80-tons.

Rifling generally.

When a gun other than S.B., has been constructed, it must in addition to being vented be also rifled, or in other words prepared in some way for the purpose of giving rotation to the projectile; if we did not make an elongated projectile rotate or spin round on its axis sufficiently as it passes through the air it would not be steady, but turn over and so spoil the shooting.* Rifling. Why necessary.

As a rule grooves are cut in the gun along which move either studs, lead coating, or copper rings attached to the shot, or cups fastened to its base which have been cut through by the lands,† save in the case of the studded projectiles. If the grooves ran straight up and down the shot would not of course rotate, but simply be driven straight along the bore by the pressure of the powder gas. Grooves cut in the bore.

As it is, however, necessary to make the projectile rotate a certain amount of twist is given to the grooves, so that as the shot moves forward it is made to move round by means of its studs, lead coating or otherwise which must run up an incline, as it were, which incline or slope is wound round the inside of the bore. The quicker the twist or the steeper this incline, with any given velocity, the more quickly the shot must rotate. Twist of rifling.

Moreover, by increasing the velocity we make the shot rotate more quickly. By changing therefore either the velocity or the twist we can alter the rate at which a shot turns round. This is irrespective of the shape or description of the groove itself, which we shall come to further on.

Let us see what we mean by the twist above mentioned. Suppose AD the length of the bore of a gun AB the length of the groove laid out in a straight line, and AC the same groove as it would appear on the inside of a gun. Meaning of the term "twist."

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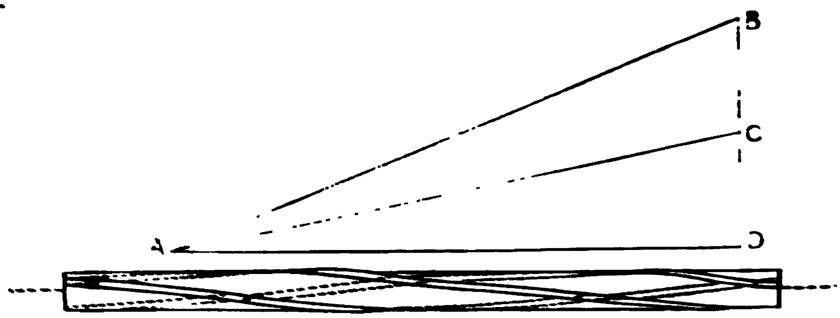
* Vide Treatise, R. L., pp.138–148.

† The *lands* stand out like ribs, being that part of the surface of the bore not termed grooves, and where a lead coating, copper ring, &c. has to be cut through these lands are usually narrower than the grooves.

CHAP. II. Then the angle of twist is BAD.



If we make the slope steeper, *i.e.*, make the length of groove in a given gun longer, we make the angle of twist greater, and increase the *twist*, as it is called.

We may also look upon the groove of a rifled gun as a part of the female thread of a screw, in which case we should talk of the "*pitch*" of the rifling. That also depends upon the length of the grooving AB in any given length of the bore AD, or which is the same thing, on the angle of rifling BAD.

Wear of grooves. The more quickly any given projectile is made to turn round, the greater is the wear of the grooves of the gun and the studs on the shot, so that only sufficient twist or pitch should be given to the rifling to keep the projectile steady during flight.

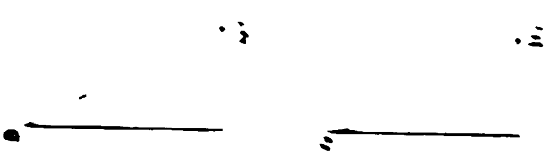
Amount of rotation. As the amount of rotation given depends on both the twist and the velocity with which the shot leaves the muzzle, in case the latter is low, as in the rifled howitzers, then the twist must be great, and vice versâ. With the service projectiles in most of our heavy guns a twist* of about 1 in 35 is found to be enough. By a twist of 1 in 35 we mean that the shot will make one whole turn while it passes along a length of 35 calibres, and similarly with any other twist.

Thus if AD = 35 calibres, then BD will = circumference of shot or bore.

Uniform and increasing twist. For instance in the 7-inch gun, where the twist is 1 in 35,

$$AD = 35 \times 7 = 245 \text{ inches}$$
$$BD = \pi \times 7 = 22 \quad "$$
$$\text{and tan BAD or tan } t = \frac{AD}{BD} = \frac{\pi}{35} = 5° 4'$$

The twist may be either "uniform" or "increasing," *i.e.*, when the groove is laid out it will appear to be either a straight line as *ab*, or a curved line as *ac*.



With the latter the studs have to move by a very slight angle to begin with, but the slope gets steeper more and more rapidly towards the muzzle. There is, therefore, less strain on the studs than with the

* The twists given to our several R.M.L. and B.L. guns are to be found in tables, pp. 55, 213.

uniform twist *ab*, where the studs have to run up a steep incline at once on starting, when the velocity is increasing very rapidly.*

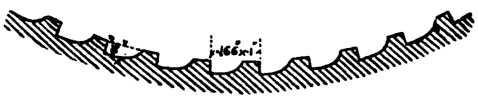
Advantages of an increasing twist.

The strain on the studs is not only much reduced by using an increasing twist, but it is also more regular throughout the bore. Another advantage is that the strain on the powder chamber is made less, for on first starting the shot has not to be forced to turn round, but only go forward, so that it is more readily moved. With our service guns the increasing twist is employed in all above the 7 inch.

When we have settled on the amount and nature of twist we intend to give to a gun, we must also decide on the size, shape, number, &c. of the grooves. This will depend on the nature of the projectile, whether lead coated, studded, or otherwise, and upon other considerations.

Rifling of R.B.L. guns.

With our service B.L. guns, in which lead coated projectiles are forced through the bore, we have a great number of grooves and narrow lands, so that the lead coating is easily cut through. On account of the number of grooves these guns are said to be many grooved, or to have polygroove rifling. The form of the groove is very simple, as shown below.



SECTION OF RIFLING (Full size).

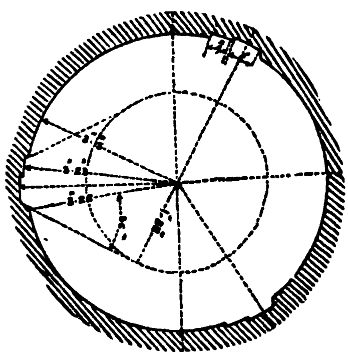
Our present R.M.L. guns use projectiles with studs to run along grooves, and the latter are comparatively few in number (vide p. 212.)

We employ five different forms of grooves, viz.:—

Shunt groove.

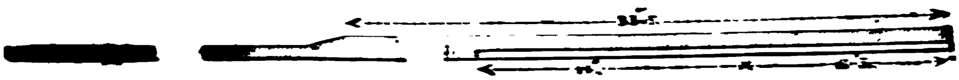
(1.) The "shunt," which is used with all 64-pr., built up guns, except such as have steel tubes (siege guns), or such guns of marks I. and II. which have been re-tubed with wrought iron, where the form of groove would be like that of the converted 64-pr.

PLAN OF MUZZLE SHOWING "SHUNT" GROOVES. Scale 3 ins. = 1 foot.



* It has been calculated by Captain A. Noble, late R.A., that the greatest pressure on the studs of a 10-inch gun, using a charge of 70 lbs., was reduced from 68 tons to 36 tons, by employing an increasing instead of an uniform twist.

The "Shunt" Groove.



Plan—Scale [illegible].

Section on AB. Scale [illegible].

Peculiarities. The peculiarity in this system of rifling is that the depth and width of the grooves vary at different parts, the object aimed at being to provide a deep groove for the studs of the projectile to travel down when the gun is being loaded, and a shallow groove through which they must pass when the gun is fired, so that the projectile may be gripped and perfectly centred on leaving the muzzle. This is attained by making one side of the groove (the driving side) near the muzzle shallow, as shown above, the unshaded portion representing the shallow part or grip. The projectiles have soft copper studs, which fit easily with a windage of 0"·025 into the deep portion of the groove; when the gun is loaded the studs travel down this deep portion until they arrive at 33"·5 from the muzzle, where they meet with an incline, by which they are "shunted" into a narrower part of the groove (still of the same depth) down which they travel to the chamber.

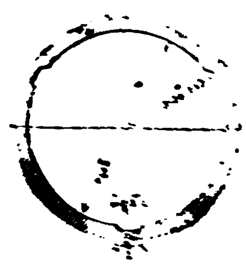
Action. On discharge the studs bear against the other side of the groove, until at 24"·5 from the muzzle they come to an incline upwards 14" long, up which they travel, the studs being thereby compressed 0"·005. With this compression they pass out through the remaining 10"·5 of the bore.

In the bottom groove at the extremity of the rifling there is an additional shunt, the object of which is to bring the studs well up against the driving edge of the grooves and thus to reduce their liability to being sheared by the shock of discharge.

Objections to shunt rifling. The principal objections which have led to the abandonment of this system of rifling are that it is complicated, that the projectile is gripped at the muzzle when at its highest velocity, and that the sharp angles at the edge of the grooves render the tube liable to split. Moreover the studs are found to be worn in steps, showing that they have over-ridden the grooves into the lands, owing to the small bearing surface on the driving side of the grooves near the muzzle. This would account for the inferior shooting of these guns compared with those rifled with the plain groove, by which the shunt has been superseded.

2. The "Plain Groove"* is really the narrow deep portion of the shunt groove.

Plain Groove. Scale [illegible].



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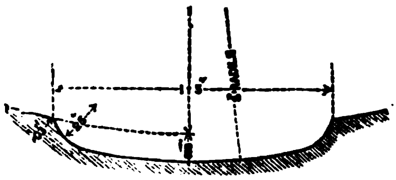
* Vide note p. 18 of this chapter.

It is employed with all the converted 64-pr. guns as well as with the re-tubed 64-pr. above-mentioned, so that they can all use the ammunition employed with the shunt rifled pieces. CHAP. II.

(3.) The so-called "Woolwich" groove (vide p. 37), is shown in diagram below, and is used with all guns above the 64-prs., as well as with the 80-pr. converted gun, 8-inch Howitzer, 40-pr. and 25-pr. guns. Woolwich groove.

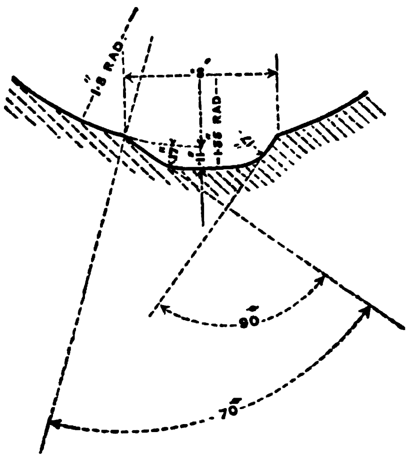
WOOLWICH GROOVE. Scale, full size.



The bottom of the groove* is eccentric to the bore, having curved edges, both of which are struck with the same radius.

(4.) The "French Modified." With 16-pr. and 9-pr. R.M.L. guns, as shown in diagram below. French modified.

SECTION OF GROOVE. Scale, full size.

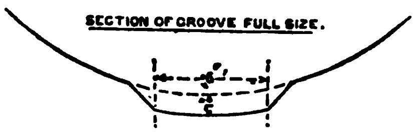


The driving edge of the groove forms an angle of 70° with the normal to the surface of the bore, and the loading side is at right angles to the driving side.

The width is 0″·8 at top, and the depth 0″·11; the bottom of the groove being eccentric to the bore, and the corners rounded off.

The object aimed at in this form of groove is that the studs may run up in incline on the driving side and thus be gripped and the projectile centred, this centring action being also assisted by the curvature of the bottom of the groove.

(5.) The "French," with 7-pr. R.M.L. guns, as shown in diagram below. The French.



SECTION OF GROOVE FULL SIZE.

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* This groove varies in width and depth according to the nature of gun, vide p. 212.

CHAP. II.

This rifling differs from the modified French system (used in the 9-pr. and 16-pr.) in not having the corners rounded and in the curve of the bottom of the groove being described concentric to the bore. The grooves are 0″·6 wide at the bottom and 0″·1 deep.*

Sighting generally.†

After a gun has been built up, vented, and (in the case of rifled guns) has also been rifled, it is useless unless we have some means of laying it correctly.

Sights supplied.

For the latter purpose a gun is as a rule provided with one or more pairs of sights which are fixed on, either temporarily or permanently.

Fore sights.

The front (fore) sight is usually placed on the gun near the muzzle, or on the trunnion ring, and the tangent or hind sight near the breech end. The line of sight passing through a notch in the latter and taking in the point of the foresight and the object aimed at.

S. B. guns. Rifled guns.

With service S.B. pieces these sights are both perpendicular,‡ but with our rifled pieces it is found that the projectiles always go to the right of the object aimed at, which is due to their having right-handed

Angle to compensate for deflection.

rifling. In order to make up for this permanent deflection, or ***derivation*** as it is sometimes called, the hind sights are inclined slightly to the left, so that the line of sight is directed somewhat to the left of the target. The quicker the twist of the rifling the greater must be this deflection.

Rifled howitzers.

With R.B.L. service guns this angle is 2° 16′ for all natures, but with R.M.L. it differs considerably in the several guns. Vide pp.133–134. The only R.M.L. service pieces of ordnance where the sight is not set at an angle are the Howitzers. With the 8-inch Howitzer a perpendicular hind sight is used, and the deviation at the several ranges made up for by means of a long deflection leaf.

Determination of angle of sights.

When a new nature of gun is introduced into the service, the angle at which the sight should be inclined is found out by experiments at Shoeburyness, and when it is finally settled for one gun, the sights for all guns of the same nature are placed at that inclination, the amount of the angle being marked upon the gun behind the sight.

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* With this nature of groove and also with the plain groove, the width is measured at the bottom, the angles being rounded off in all other grooves the width at bottom cannot be accurately measured.

† For process of sighting, &c., vide pp. 106–107.

‡ The hind sight, however, with S.B. pieces, though in the same vertical plane as the fore sight is in most cases inclined slightly to the front, so as to clear the metal of the breech, or not to weaken the breech end too much.

CHAPTER III.

CHAP. III.

SMOOTH-BORE ORDNANCE AND STORES.

Rifled Ordnance rapidly replacing Smooth-Bores.—Where S.B. are retained. —Cast iron and bronze guns.—Wrought iron S.B. guns.—**Classes of S.B. Ordnance.**—Guns, carronades, howitzers, and mortars.—Gomer and cylindrical chambers.—Registration and designation.—Length.—Weight.—Preponderance.—Windage.—Natures of cast iron ordnance in the service.—**Bronze Ordnance.**—Inspection, proof, marking before issue, &c.—Marks showing nature of vents.—Venting.—Line of metal.—Quarter-sight line.—Line of horizontal axis.—Vertical line.—Quarter-sight scale.—Millar's sights.—Wood tangent scale of L.S.—Small stores L.S. and S.S.—Tables of S.B. guns to be retained.—Table of S.B. guns to be abolished.

Rifled guns are rapidly replacing smoothbore ordnance, yet we still have so many of the latter in our armament, both at home and abroad, that it is necessary for artillerymen to be well acquainted with such ordnance and the stores belonging to them. Moreover, although for the reasons given at p. 31, it has been found necessary to adopt rifled guns for our service armament, yet for certain objects, such as the defence of short flanks where range is limited and generally speaking at close quarters, S.B. guns are still useful, and some are retained in all our large fortresses.

Rifled ordnance replacing S.B.

In certain cases S.B. retained.

S.B. ordnance, both of cast iron and bronze, were cast in moulds and afterwards bored out to the proper calibre. Cast iron ordnance were manufactured in England as early as 1545, but bronze pieces had been made in this country long before that date, for the founding of bronze was well understood prior to the art of smelting iron ores being perfected.

Manufacture of S.B.

Cast iron guns in 1545.

In 1717 the so-called brass foundry was established at Woolwich, and there our bronze ordnance have principally been made, some of the existing natures (the 4⅖ howitzer and Coehorn mortar for instance) having been manufactured from its earliest establishment.

Brass foundry at Woolwich, 1717.

Cast iron guns were supplied by contractors according to designs furnished to them, and were proved by Government officials.

The oldest pieces still in our service were made between 1780 and 1822, when Sir Thomas Blomefield was Inspector General of Ordnance. He instituted a rigorous proof, and improved the manufacture generally. Guns made after his designs may be known by the numerous architectural ornaments on the exterior.

Blomefield guns.

General Sir W. Congreve, Sir A. Dickson, and Millar, Mr. Monk, and Colonel Dundas successively introduced improvements upon the Blomefield guns, but no new nature of cast iron or bronze S.B. service gun has been made since 1859, when the supersession of our smoothbores by rifled guns commenced.

Congreve, Dickson, Millar, Monk, Dundas.

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S.B. wrought iron guns 1864.

In 1864, when guns *versus* armour plates became a serious question, the Admiralty proposed the construction of large S.B. guns of wrought iron for penetrating iron clad ships at close quarters. Two natures, 150 and 100-prs., were consequently made, being built upon the Armstrong coil system. Much more powerful results, however, than they could afford were obtained from the heavy R.M.L. guns adopted shortly afterwards, and their manufacture ceased. These two guns were the last two natures of S.B. ordnance introduced into our service and the only description made of other materials than bronze or cast iron.*

Classification.

Classes of S.B. ordnance.

Our service S.B. ordnance are classified as follows :—

$$\text{Cast iron}\begin{cases}\text{Guns.}\\ \text{Carronades.}\\ \text{Howitzers.}\\ \text{Mortars.}\end{cases}\qquad \text{Bronze}\begin{cases}\text{Guns.}\\ \text{Howitzers.}\\ \text{Mortars.}\end{cases}$$

Guns.

Guns are from 14 calibres and upwards in length, carronades about 7 calibres; they are adapted for both shot and shell.

Shell guns.

Two guns, however, the 10-inch and 8-inch, are made for shell fire only. These differ from other guns in having conical (gomer) chambers and in being shorter and lighter in proportion to their calibre.

Carronades.

Carronades have cylindrical chambers and differ much from other pieces, being short and tapering towards the muzzle, round which there is no swell, but a lip or rim projecting forward; they are without trunnions, but have a loop underneath by which they are secured to the carriage.

Howitzers and mortars.

Howitzers, 5 to 10 calibres long, and mortars from 3 to 4 calibres, are chambered and adapted solely for shells, the former for so-called horizontal and the latter for vertical fire. Their calibre is large compared with their weight.

The trunnions of mortars are, for convenience in high angle firing, placed at the breech instead of near the centre of gravity.

Gomer chamber.

All mortars and howitzers in the service have gomer chambers except the $4\frac{2}{5}$-inch bronze howitzer, which is cylindrically chambered.

Registration.

S.B. ordnance are also divided into L.S. and S.S. ; many pieces are common to both, *e.g.*, the 8-inch shell gun L.S. and S.S., others were only intended for one branch of the service. S.S. ordnance are always furnished with breeching loops, and a few also have housing blocks, otherwise they differ generally from L.S. in minor fittings only.

Difference between S.S. and L.S.

Designation.

Smoothbore pieces for firing solid shot are further designated by the weight of the shot in lbs. and the weight of the piece in cwts., as the 68-pr. of 95 cwts.; those for firing shell by the calibre in inches and weight as before, *e.g.*, the 8-inch mortar of 9 cwt. The 32-pr., 24-pr., and 12 pr. bronze howitzers are exceptions to this rule, and are distinguished like shot guns. Where there is more than one pattern of the same calibre and weight some distinction should be specified; for instance, the 32-pr. of 25 cwt., length 6 feet.

Length.

The length of all pieces, except mortars, is measured from the muzzle to back of base ring, and that of a mortar from rear of breech to face of muzzle along axis of piece.

* The 150-prs. are now obsolete. They have been returned into store, but are retained for the present. The 100-prs. are used by the Navy for drill purposes only.

The weights as given in the tables are termed nominal, because there is often a difference of two or three cwts. in pieces of the same nature. Weight.

Preponderance expresses the statical pressure on the elevating screw or coin. Preponderance.

Windage—the difference between the diameter of the bore and the diameter of the shot*—allows room for ramming home the projectile when the bore is foul, &c. In old guns the windage is $\frac{1}{20}$th the diameter of the shot; but in those of more modern date it is much less, being only ·1 inch in field guns and about ·15 inch in heavy guns. Windage should be as small as possible, for besides causing indentation of the bore and irregularity of flight, a great deal of the powder escapes and is lost. In old guns this loss was computed to be equivalent to $\frac{1}{3}$rd or $\frac{1}{4}$th of the charge. Windage.

Natures of Cast iron Ordnance in the Service.

So many different pieces had been introduced into the service up to 1864 that our armament then embraced a very great variety of ordnance. In consequence we retained in our fortresses a number of guns and a vast accumulation of small stores of an obsolete pattern. Ordnance in the service.

To remedy this, two lists, A. and B. (pp. 29, 30, Tables II. and III.), were made out in January 1864, showing the pieces to be retained in the service and those which were to be abolished. These lists continue our official guide as to S.B. ordnance absolutely in the service. We will now go through the pieces mentioned in Table II. and remark on their specialities. Table A.

There still remain some S.B. shell guns in our wooden ships and our fortressss. They have only two muzzle mouldings, while shot guns, with certain exceptions, have three. Cast iron ordnance. Shell guns.

The 10-inch shell gun weighs 86 cwts. The muzzle of this gun being too large for the ports of some ships, one of the muzzle mouldings was sometimes turned off in order to obtain a larger angle of training. Guns so treated are called L.M. (low muzzle), in contradistinction to the H.M. (high-muzzle). The 10-inch should never be double-shotted. 10-inch.

8-inch shell guns formed part of the seige train, and were much used for flanks and for permanent works. Those of 65 cwt. are now being converted into 64-pr. R.M.L. guns of 71 cwts. The 65-cwt. pattern is the one most used in both services. There are but few of the 54-cwt. pattern mounted in L.S. batteries, and none of the 60-cwt. 8-inch.

The 68-pr., of 112 cwt., was the heaviest cast iron piece in our service; of them very few are left. There are, however, many of the 95-cwt. guns. They were much used as pivot guns and for sea faces of forts, and many have been now converted into 80-pr. R.M.L. guns L.S. Shot guns. 68-pr.

42-prs. are rare; a few may yet be found mounted in out-of-the-way batteries. 42-pr.

32-prs were formerly the principal armament of all classes of vessels, and hence we have several descriptions varying in length and weight. The different amount of windage allowed from time to time has caused a considerable diversity in their calibres and ranges. The 63-cwt. gun is 32-pr. of 63, 58, and 56 cwts.

* Properly speaking "windage" is the difference between the sectional areas of the projectile and the bore of the guns.

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altogether for land service. The 58 and 56-cwt. are the patterns most commonly used in both services.*

Monk's A., B., and C. guns. 32-pr. of 48 and 50 cwts.

Monk's A., B., and C. guns still exist in Woolwich Arsenal, and in wooden ships. The A. pattern is sometimes found in garrisons, as are also the B. and C., but much more rarely. The 48 and 50-cwt. guns are issued indiscriminately, mounted on the same carriages and bracketed together in returns. The 48 and 50-cwt. guns, as well as those of 39 and 40-cwt., are to be found in inland works principally, and have been issued in large quantities to Volunteers.

The 32 and 25-cwt. guns.

The 32-cwt. gun is a bored-up gun.

The 25-cwt. gun is the light 32-pr. It can be distinguished by having two muzzle mouldings.

24-prs. of 20, 48, and 50 cwts.

24-prs. are exclusively for land service, being garrison guns. The 48-cwt. has been issued extensively to Volunteers.

18-prs. of 42 and 38 cwts.

A few 18-prs., both of the heavier natures and also bored-up guns, may still be found in the flanks of large works.

12, 9, and 6 pr.

The three small natures of cast iron guns are used for saluting and drill purposes.

Carronades.

Carronades are now to be found in flanks of a few works and utilised for drill purposes (S.S.)

Iron howitzers.

The use of iron howitzers is limited to flanks, &c., where a very short range is necessary.

Mortars.

13 and 10-inch mortars, S.S., were originally intended for mortar vessels, but are now only used for coast defences. They have narrower chambers than the L.S. mortars of the same calibres, and are very much heavier.

Bronze Ordnance.†

Bronze ordnance.

All the natures of bronze S.B. guns in the service are nearly alike, and resemble in exterior appearance the earlier cast iron guns.

Guns.

By an order, dated November 1859, a dispart patch is to be added to every bronze gun before issue.

The S.S. bronze howitzers are similar in pattern to the L.S., but the 24 and 12-pr. howitzers have a breeching loop, and the breech is rounded off, so that the breeching rope may not be cut by the end of the edge of the base ring.

Howitzers.

The 4⅖-inch howitzer still remains in the service, as well as the 3-pr. guns for colonial and mountain service. The howitzer is of exceptional construction, being very short and having a cylindrical chamber.

Mortars.

The bronze mortars may still be useful in mountain warfare and in the advanced trenches of an attack.

Inspection, Proof, Marking before Issue, &c.

The following were the tests applied in the R.G.F. to new cast iron pieces.

Fireproof.

They were examined for flaws or holes, for concentricity of bore, dimensions &c.; then two proof rounds were fired with a heavy charge

* The 58-cwt. is being largely converted, on the Palliser principle, into 64-pr. R.M.L., L.S.

† Most of the S.B. bronze guns and howitzers, until very lately held in reserve, have now been sold as old metal, but some of these pieces still exist, especially in India and in our possessions abroad.

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and generally one service shot, pressed home with a junk wad or wooden wedges. The gun was afterwards proved by water pressure, and finally examined with a lamp passed down the bore. Waterproof.

Guns which endured the test were weighed, marked, and registered. On the first reinforce were engraved the number by which the gun is registered in the R.G.F. books, the broad arrow, the exact weight of the piece in cwt. qrs. and lbs., and the year of proof, thus :— Marks on guns.

8736
↑
52–1–10
1864

On the left trunnion were already marked the manufacturer's initials or the name of the foundry, the manufacturing number, and the year of casting.* Bronze ordnance have severally a register number engraved in Roman letters on some part of the piece, the foundry number being underneath, between the trunnions.

Venting or Bushing.

Prior to issue a S.B. gun is vented, lined and sighted.

Bushing iron guns was not the rule in our service early in this century, but in consequence of the enlargement of vent of the unbushed guns used at the sieges of 1812–13, experiments were carried out at Woolwich by order of the Master General of the Ordnance in 1813 as to the advantages of different bushes. Copper bushes answered best, and the Board of Ordnance directed that for the future guns for battering purposes were to be bushed, some with iron and some with copper. Bushing or venting.

In 1844 it was directed that wrought iron bushes only should be used,† but in 1855 this order again was cancelled and copper bushes have been used since that date.

No better material for the purpose has yet been found, especially when it is hardened by hammering. Since 1855 cast iron guns (except 9-prs. and 6-prs.) have always been bushed before issue, but prior to that date, except for battering purposes, they were generally issued unbushed.‡

Bronze guns and howitzers of the present service natures have always been issued with copper bushes of different sizes and descriptions. Mortars are not bushed before issue, though some of the latter have been so subsequently.

When a gun is to be bushed for the first time, a cone vent is invariably used, but should the metal round the vent wear away in a gun so bushed, the cone vent will be replaced by a through one or otherwise according to the Regulations on that head, p. 220.

* This system of marking was not introduced until 1857, and old guns are not marked according to any regular system ; in many the weight is engraved under the cascable. On bored-up guns the new weight and year of boring up are on the first reinforce. Carronades are marked near the elevating patch.

The Royal badge is on the first reinforce of most guns of all natures below the 68-pr., and bronze guns have in addition the monogram of the Master General of the Ordnance on the chase.

† This was done because it was thought that a galvanic action was set up between the copper bush and the iron gun, which caused their corrosion. Experiments made in 1855 proved that this was not really the case, and the use of copper bushes was therefore resumed.

‡ Out of 367 pieces returned from service during the Crimean War, 256 had not been bushed at all, 107 had been bushed with iron, and four only were copper vented. —*Proceedings, O.S.C.*, Vol. I., para. 364.

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Process of venting cast iron guns.

The following is the process of venting a new gun: Throw the gun with one trunnion up to a convenient working position, and fix the drilling machine, place in the vent a stiff wire to ascertain the rake or direction of the vent. This will show the position for setting the brace and drill. Drill right through the metal with the narrow set of drills, (as guns have been frequently destroyed by false drilling, wax impressions should be taken frequently during the process, to ascertain whether the workman is drilling straight,) and then with a larger set to within an inch of the bore, viz., to the spot where the thread ends (the thickness of metal may be conveniently found by using a vent scraper). Next finish the cone with the drill for the purpose.

Remove the drilling machine and turn over the gun to prepare for tapping. In this case the seven-thread taps are always to be used. Tapping is a long and tedious process, requiring much care and skill; it is impossible to pass the first tap through, and then the second, and so on, but the thread must be brought to the right size gradually.*

Where the thread ends there is usually a little metal thrown up which would prevent the copper bush from being screwed down properly, this burr must be removed with a conical rimer.

The hole in the gun is next cleaned with tow, and the copper vent, well oiled, is screwed in. The head should not be wrenched off as a fracture might occur below the surface of the metal of the gun.

The bush when properly fixed will project about a quarter of an inch into the bore, and about two inches above the surface of the gun.

Wax composition.

Take an impression of the part in the bore with a mixture of:

Bees-wax - -	2 parts	Boiled together.
Soft soap - -	1 ,,	
Treacle - -	1 ,,	

This will show whether the cone is well home, or whether there is a space left between the copper and iron.

If the bush is home proceed to cut off the end in the bore. The instrument employed consists of a cutting tool supported by a metal head at the end of a long bar; the bar is kept in the axis of the bore by passing through a collar fitting into the muzzle, it is worked from side to side by two levers being fed up by a small screw at the end of the frame; the spiral spring against the muzzle collar makes the knife work regularly. Care must be taken not to cut into the iron of the gun. It is probable that the end of the bush will not be cut off quite flush at first, so another impression is taken, and if necessary, the knife must be fed out with a small piece of tin, and the process repeated as it is necessary that the copper and iron in the bore should be perfectly flush with each other. When this has been completed satisfactorily, remove that portion of the vent projecting above the surface of the gun by sawing it off about a quarter of an inch above the vent patch; chip a little copper away from the mouth of the vent to prevent it becoming choked when hammered, chisel it also at the edges, then hammer it well, chisel it off flush and open the mouth of the vent, then pass the set of rimers down one after the other and gauge, and if the gun is for S.S., rime out the mouth of the vent tapering it from ·28″ at the top to ·22″ in a length of [illegible] File the surface, take another wax impression of the inside, [illegible] the operation is finished.

[illegible]o men four or five hours to tap a gun.

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Cast iron ordnance are also marked over the casable according to the nature of vent they have.

Marks to show nature of vent.

$\left.\begin{matrix}\text{C V}\\ \text{N}\\ \text{C}\end{matrix}\right\}$ means copper vent, new gun, cone.

$\left.\begin{matrix}\text{C V}\\ \text{C}\end{matrix}\right\}$ indicates a cone vent, not new (gun).

C V „ a "through" vent.

The initial of the out station at which a gun is re-vented is added underneath.

I V on cascable means "iron vent."*

Lining.

The line of metal† is obtained as follows :—

Lining.

The gun being levelled across the trunnions, a wood batten is placed in the bore, so as to project some distance from the muzzle. This batten is painted white on the upper surface, and bisected by a pencil line.

The upper surface is levelled transversely, and a T square being placed upon it, the position of the pencil line is squared up against the muzzle of the gun.

A wood straight-edge is placed on the top of the gun against the T square, and the edge of this straight-edge and the centre line of the batten are brought into the same vertical plane by aid of the eye. The line thus obtained is slightly marked on the swell of the muzzle, and also on the base ring. The T square is reversed, and the same operation gone through on the other side; if there is any error there will be two lines, and the mean is taken as the true one. The line of metal thus obtained is then cut permanently on the breech and muzzle.

Line of metal.

The quarter-sight lines are next marked on both sides of the gun, at the breech and muzzle; they are parallel to the axis of the piece, but a little above it, so as to clear the trunnions and cap-squares when laying the gun.

Quarter-sight lines.

The line of horizontal axis is then cut on the breech, trunnion, and muzzle, on the right side of the gun. To obtain this line the gun is turned with the right trunnion vertical, and a similar process is repeated to that employed for finding the line of metal.

Line of horizontal axis.

Upon the right trunnion the line of horizontal axis is bisected, and a line drawn at right angles to it.

Vertical line.

Before the introduction of General Millar's sights, all cast iron guns were laid by means of a quarter-sight scale from 0 to 3° marked on the base ring on each side of the gun, starting from the horizontal line at zero. Such scales are now marked only on L.S. guns up to 32-pr. inclusive.

Quarter-sight scale.

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* Old guns may also be found marked $\begin{matrix}\text{CV}\\ \text{N}\\ \text{LC}\end{matrix}$ "copper vent; new; long cone: and TV "through vent."

† This is a line extending from the base ring to the swell of the muzzle, and represents the intersection of the surface of the metal by the vertical plane passing through the axis of the piece, when the trunnions are horizontal; iti s marked on breech and muzzle.

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Sights.

Millar's sights. The sights now used with cast iron ordnance* are Millar's sights. These consist of a fore or dispart sight of gun metal screwed on to the gun in rear of the trunnions, on what is termed the second reinforce, and of a half-round brass tangent scale† sliding in a gun metal block, which is secured to the breech of the gun by two screws.

Angle of sight. Pieces of sheet lead are placed between the foresight and the gun metal block of hindsight and the gun, to assist in adjusting the sight accurately, and also to prevent the heads of the screws being broken off. In order to clear the breech of the gun, the scale of the hindsight is at an angle of 76° and not perpendicular.

The mode of adjusting Millar's sights is given in Chapter XII.

Short radius. The distance between these sights is termed the "short radius," and is given in Table II. for each nature of gun.

Long radius. We find that at a certain point when elevating by these sights the muzzle of the gun begins to interfere with the line of sight, and it is necessary to use the muzzle notch as the foresight, and to employ another hindsight graduated for the "long radius,"‡ as the distance between the back of the hindsight and the notch on the muzzle is termed.

Wood tangent scale for L.S. Clearance angle. For L.S. this other tangent scale is made of walnut wood, and called wood tangent scale; it is graduated therefore from the clearance angle up to the extreme elevation (10° or so), the divisions being calculated to the long radius as the gun must be laid by the muzzle notch. It has also a degree scale from zero to the clearance angle, the same as that on the brass tangent scale, and there is a yard scale from pointblank to extreme range.

At the back of the scale is a brass plate which fits on the head of the brass scale when fully elevated, and at the bottom is a brass plate shaped so as to sit steadily on the hindsight block.

Long tangent [illegible] S.S. For S.S. longer scales sliding in the same block as the tangent sight are used; they are made of brass or wood,§ and are issued in sets of [illegible].

[illegible] With the [illegible] a half round brass tangent scale is used [illegible] the breech. [illegible] with a spring, and the scale has a small stud at the bottom which prevents it being removed altogether from the [illegible]. The scale is clamped by a [illegible].

[illegible] S.S. For S.S. the scale has a [illegible] so as to clear the head of the [illegible].

The [illegible] serves as a foresight with [illegible].

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* [illegible] in a similar manner to bronze guns.

† [illegible] made of gun metal.

‡ The clearance angle is the angle of elevation when the tangent sight is [illegible] and the bottom of [illegible] the brass tangent [illegible] with the line of sight. [illegible] in Appendix, Table [illegible].

§ [illegible] from the [illegible] only in the [illegible].

Quarter-sight lines are marked on both sides, and some old bronze guns have quarter-sight scales as well.

Wood side scales.

For 32-prs. of 32 cwts. and 25 cwts., and also for 24-pr. bronze howitzers mounted on S.S. carriages with elevating screws, a wood side scale is used. This is graduated from 0 to 12° downwards, and 6° upwards. Elevation and depression can be given by means of it in connexion with the ship's pendulum when smoke, &c. prevent the regular sights being used, the scale being cut so that when placed on the steps of the carriage and held upright, the zero of its graduation coincides with the axis of the gun when the latter is horizontal, the ship being on an even keel.

Graduated coins.

With other S.S. guns graduated coins are employed instead of this scale.

Small Stores.

Small stores.

In addition to sights and vents the following stores for S.B. ordnance are furnished by the R.G.F.

Priming iron or picker	Specially for land service.
Vent punches	
Lead aprons	
Bit, vent	Specially for sea service.
Priming wire	
Friction tube pins	
Guide plates	
Ships' pendulums	
Vent plugs	Common to both services.
Wrenches for sight screws and friction tube pins.	
Spikes	

L.S. stores. Priming iron or pricker.

The pricker is a rod of iron pointed at one end and with a ring at the other, for garrison service 12 inches long, and for field 7½ inches.

Vent punches.

Vent punches are for cleaning the vent from any hard substance which cannot be removed with the priming iron. They are of steel, and have a strong round head, so as to bear hammering. There are nine sizes, varying in length from 3 to 14 inches.

Lead aprons.

Lead aprons are small pieces of sheet lead for protecting the tangent scale and vent of howitzers and bronze guns when mounted or in store. There are two sizes of aprons, large for iron howitzers, and small for bronze ordnance.

S.S. stores. Priming wire, and bit.

In the Navy the pricker is termed the "priming wire." A bit is also used, but it is not connected with the priming wire.

Friction tube pin.

The head of the S.S. quill friction tube is supported by a friction tube pin, which consists of a piece of steel threaded on the lower portion and formed above into a small pin. It is screwed into the gun to the left front of the vent in cast iron, and to the right front in bronze guns.

Guide plate.

To insure direct action the lanyard passes rearwards through a *guide plate.* This is a small iron plate with cross-head on top and hole for lanyard, having also a slot near lower end for the screw which secures it to the sight block. That used with mortars is cylindrical and threaded at the lower end, and screwed into the body of the piece. The cross-head serves to loop the lanyard over.

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Ship's pendulum.

A pendulum is used to show the angle at which the vessel is heeling over on the lee side, so that the necessary allowance may be made in elevation when laying guns by the wood side scale or graduated coin.

Vent plug.

A vent plug consists of a vulcanized disc of india-rubber, with a leather stem. It is employed for protecting the vents of mounted guns.

Wrench.

The wrench for sight screw and friction tube pin is a small iron instrument with four arms, one of which is a wrench for sight screws, another a turnscrew, a third a friction tube pin wrench, and the fourth a tommy.

Spikes.

There are two sorts of spikes, common and spring.

Common spikes.

The common spike is a conical piece of hard steel about three inches long. When it is desirable to disable a gun for some time, a common spike is to be hammered into the vent, and the top broken off. For the purpose of re-venting a gun thus spiked, two hollow drills are supplied, with the venting tools.

Spring spikes.

A gun may be temporarily rendered ineffective with a spring spike, which consists of a steel rod with a flat head at the top and a spring near the bottom, so that when the end has passed into the bore the spring acts, and the spike cannot be removed till the spring is pushed back. If the gun is likely to be recaptured, the spike should therefore be inserted with the spring towards the muzzle, and on this account there is a little notch on the edge of the head to show the side the spring is on, so that it may be pressed back by the rammer.

For L.S. there are four lengths of spring spikes, 11·4, 8·5, 6·3, and 3·6 inches. The Navy are supplied only with the shorter nature for field guns.

TABLE II.

Table showing the Weights, Lengths, Calibres, Radii for Sighting, &c., of the Cast Iron and Bronze Ordnance, which, according to the O.S.C., *List A.* are to be retained in the Service.

Class	Nature and Service.	Nominal Weight.	Nominal Length.	Calibre.	Radii. Short.	Radii. Long.	Clearance Angle	By whom, and when introduced.	Remarks.
		Cwt.	Ft. In.	Ins.	Ins.	Ins.	Degs.		
Cast Iron Guns.	10-in. L.S. & S.S. -	86	9 4	10·0	56·0	114·82	5 H.M. 6¼ L.M.	Dundas, 1846 -	Two patterns.
	8-in. L.S. & S.S.	65	9 0	8·05	56·0	112·23	5¼	Millar, 1834.	
		60	8 10	8·05	56·0	110·225	5	Millar, 1831.	
		54	8 0	8·05	48·0	100·715	5	Dundas, 1840.	
	68-pr. L.S. only -	112*	10 10	8·12	59·8	132·4	4½	Dundas, 1841.	
	„ L.S. & S.S. -	95	10 0	8·12	58·0	122·1	5	Dundas, 1846.	
	42-pr. L.S. only	84*	10 0	6·97	56·5	121·5	4½	Monk, 1843.	
		67*	9 6	6·93	54·3	118·0	4	Dundas.	
	32-pr. L.S. only -	63	9 7	6·41	55·5	116·6	4	Millar.	
	„ L.S. & S.S. -	58	9 6	6·375	55·0	117·895	4	Dundas, 1847.	
	„ L.S. & S.S. -	56	9 6	6·41	55·0	112·81	4	Blomefield.	
	„ L.S. & S.S., A.	50	9 0	6·375	50·0	109·25	5	Monk, 1838.	
	„ L.S. & S.S., B.	45	8 6	6·35	48·0	103·625	5	Monk, 1838.	
	„ L.S. & S.S., C.	42	8 0	6·35	46·3	97·62	5	Monk, 1838.	
	„ L.S. only -	48 & 50	8 0†	6·41	50·0	97·0	5½	Blomefield, Millar, & Dickson.	
	„ L.S. only -	40	7 6†	6·35	40·5	85·1	7	Congreve	Bored up in 1830, from 24-pr. of 42 cwt.
	„ L.S. only -	39	7 6†	6·375	43·0	89·8	5	Blomefield -	Bored up in 1830, from 24-pr. of 40 cwt.
	„ L.S & S.S. -	32	6 6	6·3	39·0	78·0	6½	Blomefield -	Bored up in 1830, from 24-pr. of 33 cwt.
	„ L.S. & S.S. -	25	6 0	6·3	36·5	74·0	6	Dundas, 1845.	Has only two muzzle mouldings.
	24-pr. L.S. only. -	50	9 6	5·823	54·6	112·75	4	Blomefield.	
		48	9 0†	5·823	51·5	107·0	4	Blomefield.	
		20	6 0	5·823	34·0	70·75	5	Blomefield -	Bored up from 12-pr., 22 cwt.
	18-pr. L.S. only -	42	9 0	5·292	51·5	107·0	4	Blomefield.	
		38	8 0†	5·292	46·5	95·75	4	Blomefield.	
	„ S.S. drill -	20	6 0	5·17	34·0	70·75	5	Dickson -	Bored up from 12-pr., 22 cwt.
		15	5 6	5·17	30·0	65·25	5	Dickson -	Bored up from 9-pr., 17 cwt.
	12-pr. - -	34	9 0	4·623	51·0	107·5	4	Blomefield.	
		33	8 6	4·62	48·5	101·2	4	Blomefield -	For drill and saluting.
	9-pr. - -	28	8 6	4·2	48·0	101·25	4	Blomefield.	
		24	7 0	4·2	41·0	84·1	4	Blomefield -	For saluting.
	6-pr. - -	17	6 0	3·668	35·5	72·0	4½	Blomefield -	For drill or saluting.
	Carronades 68-pr.	36	5 4	8·05	30·0	—	—	1779.	
	Carronades 42-pr.	22	4 5	6·84	25·0	—	—		
	Carronades 32-pr.	17	4 0	6·25	23·0	—	—		
	Carronades 24-pr.	13	3 8	5·68	20·5	—	—		
	Howitzers. 10-in. L.S. only.	42	5 0	10·0	—	60·3	—	Millar, 1852.	
	Howitzers. 8-in. -	22	4 2	8·0	—	48·0	—	Millar, 1852.	
	Mortars. 13-in S.S.	100	5 4	13·0	—	—	—	N.P., 1857.	
		100	4 5	13·0	—	—	—	O.P. or Blomefld.	
		81	3 2	13·0	—	—	—		
	Mortars. 13-in. L.S. -	36	3 4	13·0	—	—	—	Millar.	
	Mortars. 10-in. S.S. -	52	3 10	10·0	—	—	—	Blomefield.	
	Mortars. 10-in. L.S. -	18	2 5	10·0	—	—	—	Millar.	
	Mortars. 8-in. L.S. -	9	2 2	8·0	—	—	—	Millar.	
Bronze.	Guns. 12-pr. L.S. -	18	6 6	4·623	—	78·1	—		
	Guns. 9-pr. L.S. -	13	6 0	4·2	—	71·0	—		
	Guns. 6-pr. L.S. -	6	5 0	3·668	—	59·6	—		
	Guns. 3-pr. L.S.	3	4 0	2·91	—	47·56	—		
		2¼	3 0	2·91	—	35·5	—		
	Howitzers. 32-pr L.S. -	17	5 3	6·3	—	62·5	—	Dundas, 1840.	
	Howitzers. 24-pr. L.S. -	13	4 8	5·72	—	56·0	—	Millar.	
	Howitzers. 24-pr. S.S. -	13	4 8	5·72	—	56·0	—	Millar.	
	Howitzers. 12-pr. L.S. -	6	3 9	4·58	—	45·0	—	Millar.	
	Howitzers. 12-pr. S.S. -	6	3 9	4·58	—	45·0	—	Millar.	
	Howitzers. 4⅖-in. L.S. -	2¼	1 10	4·52	—	22·5	—	1738.	Coehorn.
	Mortars. 5½-in. L.S. -	1¼	1 3	5·62	—	—	—	1742.	Royal.
	Mortars. 4⅖-in. L.S. -	¾	1 1	4·52	—	—	—	1733.	Coehorn.

* Retained only until the few that now remain are superseded by Rifled Guns.
† These guns have been issued in large numbers for the Volunteer service.

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TABLE III.

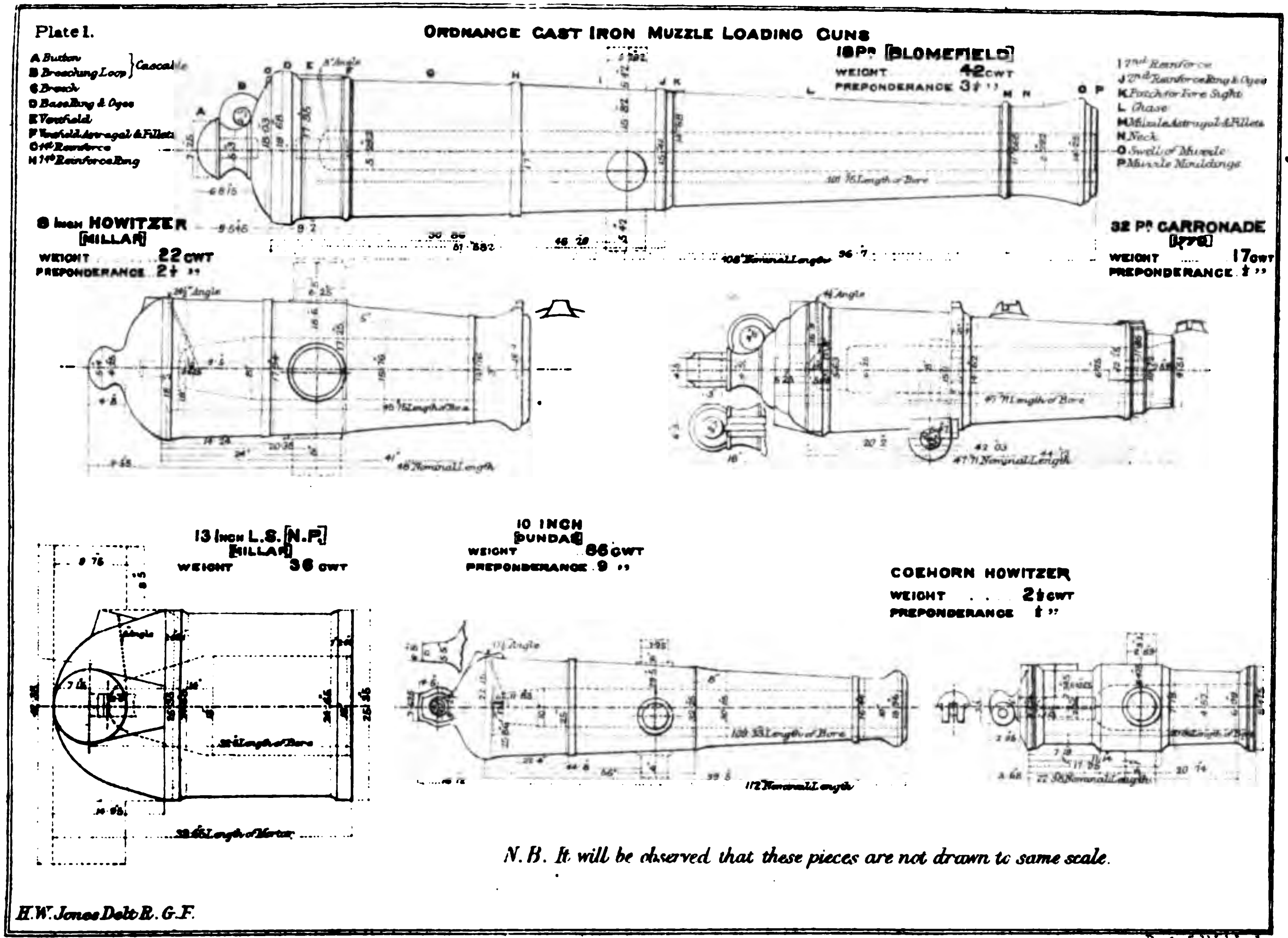
List (B.) of Cast Iron and Bronze Ordnance to be Abolished, but which are to be retained on the Works, if they are mounted at any station, until replaced by other pieces, which will be done when the carriages are worn out, if not sooner. (See par. 1,140 (*Changes in patterns*), 1st January 1866).

	Nature.		Nominal Weight.	Length. ft.	in.	Remarks.
			Cwts.	ft.	in.	
Cast Iron Guns.	10-inch		84	9	4	Millar.
			62	8	4	Millar. Only a few were made for experiment.
			57	7	6	Millar.
	8-inch		63	9	0	Millar.
			†59	6	9	Millar.
	68-pr.		88	9	6	Dundas.
	56-pr.		†97	11	0	Monk.
			†87	10	0	Monk.
	42-pr.		75	10	0	Monk. Rarely met with
	32-pr.		46	9	0	Bored up.
			41	8	0	Bored up.
			37	7	6	Bored up.
			25	6	0	Bored up.
		S.S.	25	5	4	Dickson.
	24-pr.		43	8	0	Blomefield.
			41	7	6	Congreve.
			40	7	6	Blomefield.
			38	7	6	Congreve.
			33	6	6	Blomefield.
			18	5	0	Dickson.
	18-pr.		40	9	0	Blomefield.
			32	6	10	Blomefield.
			27	6	0	Blomefield.
			22	7	0	Blomefield.
	12-pr.		29	7	6	Blomefield.
			24	6	0	
			22	6	0	Bored up from 9-pr.
	9-pr.		26	7	6	
			17	5	6	
	6-pr.		23	8	6	
			†22	8	0	
			21	7	6	
			19 or 20	7	0	
			18	6	6	
			11	4	10	
			6	3	6	
Cast Iron.	Carronades	18-pr.	†10	3	4	
		12-pr.	† 6	2	8	
		6-pr.	5	2	9	
	Howitzer, 24-pr. or 5½"		†16	3	4	Has a cylindrical chamber.
	Mortars, 8"	Eprouvette.	8½	1	5	
		O. P.	8	1	10	
			9	1	9	

* This list is based on the rarity or inferiority of the pieces it contains.

† These pieces are to be found in the vocabulary of stores published by the Ordnance Store Department, because they still exist in the armaments.

To face p.30 of Abridged Treatise



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CHAPTER IV.

CHAP. IV.

SHORT HISTORY OF OUR RIFLED GUNS FROM THEIR INTRODUCTION UP TO PRESENT DATE.

Rifled Ordnance.—When first used.—Lancaster's oval bore.—Sir W. Armstrong's R.B.L. guns.—Their superior range and accuracy.—Their adoption.—Defects.—Wedge and shunt guns.—Sir J. Whitworth's guns.—**Trials of Armstrong and Whitworth Systems.**—R.M.L. v. R.B.L. experiments.—Bronze guns.—Dartmoor experiments.—Wrought iron R.M.L. guns recommended for Home Service.—Manufacture of R.B.L. discontinued.—The effect of 9 and 16 prs.—Siege guns.—Rifled howitzers.—**Heavy rifled guns.**—B.L. system encumbrous.—100 and 150 S.B. guns.—12 and 13 inch guns.—Disadvantages of shunt rifling.—Woolwich system.—8 and 9 inch guns.—Original construction.—Fraser construction.—10 and 11 inch guns.—16 inch guns.

When rifled small arms were generally adopted about 1855, it became necessary to introduce rifled ordnance in order that artillery might still remain the most powerful arm in the field; for infantry skirmishers, armed with long range rifles could do much damage to the men and horses of smoothbore batteries, while they themselves were out of dangerous range of the guns. *Necessity for rifled ordnance.*

Since the year 1600 A.D. many rifled cannon had been tried, and it was not for lack of invention that they had not been introduced long before 1854, the date of the Crimea war, when we first used such guns.

Rifled guns to be useful must be made of strong material and very carefully manufactured, and the difficulties in the way of making them were the want of sufficient skill in the art of working metals, and also that of the necessary machinery for manufacturing, boring and rifling them, &c. with the accuracy required. Machinery has now, however, been so much improved, and we know so much better how to deal with metals, that rifled guns can be made strong enough safely to resist a pressure on the bore of 25 tons, and more per square inch, and apparently of almost any size we wish, and yet so perfect in dimensions as not to depart from the proper measurement by more than one-thousandth part of an inch.

The first rifled guns we employed were a few old S.B. 8-inch and 68-pr. cast iron pieces, made oval in the bore, and so converted into two grooved rifled guns on the Lancaster principle. They were used during the Crimean war of 1854, 1855, and 1856, but their shooting was very irregular, and the projectiles often jammed in the bore. *Lancaster's oval bore rifling. Irregularity of shooting.*

About this time a number of rifled pieces were tried in our own and other countries, and in England, Sir William Armstrong, a well known engineer, brought forward breech-loading wrought iron guns, which were officially tried in 1854 and seemed to answer very well. They were tested against bronze S.B. guns, and found to hit harder and carry further, and also to make very much better shooting. *Sir W. Armstrong's R.B.L. guns.*

The increase in range and accuracy obtained by the adoption of these rifled guns was very considerable. It has been proved by experiments *Their superior range and accuracy.*

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that whilst the 12-pr. B.L. gun could put one shot out of every two fired into a rectangular space 22 yards long (*i.e.*, in the direction of the range), by 1·3 yard wide, at the distance of a mile, the 18-pr. S.B. gun could, under similar conditions, only hit a space 121·7 yards long by 25·8 yards wide, and, in short, that the B.L. rifled gun could make better practice at a distance of two miles than the smoothbore could at one.

Adoption of Sir W. Armstrong's guns. 1859.

While these Armstrong guns were being tested "extensive experiments were carried on to try whether any safe method of strengthening cast iron guns could be found, or whether any better, speedier, or cheaper system of constructing rifled ordnance existed than that proposed by Sir William Armstrong. None such having been found within the period for inquiry, the Armstrong system was completely adopted;" and in order to obtain a supply of the guns and projectiles as soon as possible, so that we might not be behind other nations, Government not only entered into a contract in January 1859, with the newly established Elswick Ordnance Company, but commenced their manufacture in the Royal Arsenal, Woolwich.

In February 1859, Sir William Armstrong was appointed Engineer of Rifled Ordnance, and in the following November he became also Superintendent Royal Gun Factories.

Field Guns.

Our field artillery were soon equipped with these guns, and a great number of the heavier natures were made both for siege and garrison purposes, and also for the arming of our fleet.

These guns are still in the service, though most of them are kept in reserve. All the different natures are given in the Table at p. 85.

Defects of R.B.L. breech-screw guns.

This B.L. system was not so simple as the smoothbore, and required a great many implements for its repair. Further experience has shown that serious accidents were likely to take place from various causes, such as the breech-screw being improperly screwed up, the vent-piece being weak or ill fitting, &c.; and it is therefore probable that if we had been in the meantime engaged in a war, in which the B.L. guns had to be used in large numbers, such accidents would have considerably impaired their success; as it is, however, they have been only used on a small scale before an enemy, principally in China, New Zealand, and Japan.

In these wars the Armstrong B.L. guns answered very satisfactorily on the whole, both on land and at sea, and proved much more powerful than our old smoothbore field and heavy guns, but it was clear that a less complicated system would be better adapted for general service.

Wedge and shunt guns introduced. 1864.

In 1864, in consequence of the objections brought against his breech-screw guns, Sir William Armstrong introduced not only two natures of wedge guns (40-prs. and 64-prs.*) as an improvement on the breech-screw arrangement in points of safety and simplicity, but also 64-pr. *muzzle-loading* guns with *shunt* rifling, and proposed other shunt guns of larger calibre.

Many guns were proposed about the same period to take the place of the Armstrong breech-loaders for field service. None of these seemed worth further trial except a muzzle-loading system submitted by Sir J. Whitworth, and a new gun proposed by Sir W. Armstrong himself, which was a M.L. shunt.

Sir J. Whitworth's gun.

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* A small number of these guns were introduced into the service, but they are now obsolete, vide p. 84 for description.

A special committee appointed for the purpose carried on extensive trials with Whitworth 12-prs. and 70-prs., Armstrong 12-prs. and 70-prs. breech-loaders, and Armstrong 12-pr. and 70-pr. muzzle-loaders; the 12-prs. having been chosen to decide the question for field artillery, whilst the 70-prs. were the best available representatives of heavy artillery, comprising siege, garrison, and broadside guns.

Experimental trials of the Armstrong and Whitworth systems.

Both natures of the Whitworth guns were muzzle-loaders, and had his well-known hexagonal rifling, and mechanically fitting projectiles.

The 12-prs. were of solid mild steel (having trunnion rings screwed on to them), with a hoop of the same material over the powder chamber.

The 70-prs. were of the same material, but consisted of an inner tube closed by a cascable screwed in, and strengthened by hoops forced on cold by hydraulic pressure.

The Armstrong breech-loaders were constructed with steel barrels, and with wrought iron coils superimposed as usual, but the 12-prs. had the ordinary breech-screw arrangement, and the 70-prs. were upon the wedge system.

His muzzle-loaders also had inner barrels of steel; they were rifled on the shunt principle, for projectiles with soft metal studs.

The experiments conducted by the Committee were very extensive and the results showed that in construction all the guns tried were very good.*

Report of Committee. 1865.

As to range, accuracy, ease of working, endurance and cost, the Committee reported in 1865 that both Sir W. Armstrong's and Mr. Whitworth's M.L. systems, including guns and ammunition, were on the whole very far superior to Sir W. Armstrong's B.L. system.

" That the many-grooved system of rifling with its lead-coated projectiles, and complicated breech-loading arrangements, entailing the use of tin cups and lubricators, is far inferior for the general purposes of war, to both of the M.L. systems, and has the disadvantage of being more expensive both in original cost and in ammunition.

" That M.L. guns can be loaded and worked with perfect ease and abundant rapidity."†

As to the employment of steel alone or steel and wrought iron together, the Committee reported that guns fully satisfying all conditions of safety can be made with steel barrels strengthened by hoops of coiled wrought iron, and that such guns give signs of approaching rupture; whereas guns composed entirely of steel are liable to burst explosively without giving the slightest warning to the gun detachment.‡

Committee of 1866.

Another Committee, of which Sir R. Dacres was president, was appointed in 1866 to inquire into the question of M.L. and B.L.; they came to the conclusion that " the balance of advantages is in favour of M.L. for field guns," because they are equal to breech-loaders in range and accuracy, and much superior to them in simplicity both of fittings and ammunition.

At this date a few 12-pr. R.M.L. of 8 cwts. were made of wrought iron and steel, but as the expense would have been great, and there was no urgency, their manufacture was not carried out on a large scale for issue instead of the service B.L. guns.

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* Each piece after firing 3,000 rounds was only burst by using purposely abnormal charges.

† As an instance of the rapidity with which our present R.M.L. guns can be loaded and fired, it may be mentioned that four 35-ton guns on board the " Devastation " each fired 8 rounds at a target within 15 minutes. The ship was moving at a rate of 8 knots an hour and the shooting was very fair.

‡ Vide also p. 5.

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Another Committee, under the presidency of Major-General Eardley-Wilmot, R.A., was appointed in December 1868 to consider the question of "Field Artillery equipment for India." But as it was thought necessary that India should be able to produce her own guns, the Committee was restricted to bronze as a material. The Committee was also directed to adopt a muzzle-loading gun. Accordingly having satisfied themselves by experiments that bronze would answer the purpose, a 9-pr. bronze rifled gun of 8 cwt. was approved for Indian service in May 1870.

R.M.L. bronze gun for India. 1868.

A good many of these guns were made, but proving unsatisfactory, in material (vide p. 2). They are now obsolete, and have been returned into store.

Dartmoor experiments. 1869.

Meanwhile a special committee of Royal Artillery officers (Major-General C. Dickson, C.B., V.C., president) assembled at Dartmoor in June and July 1869 for the purpose of determining the best projectiles and fuzes for the B.L. guns, took occasion when writing their report to recommend a field howitzer, which would be a muzzle-loader, suitable for high angle firing and capable of throwing a common shell with a large bursting charge.

On the 25th July 1870 a special committee of Artillery officers under Major-General Sir John St. George, K.C.B., as president, was appointed to carry out comparative trials with the 9-pr. bronze rifled gun (Indian pattern) and the 9-pr. and 12-pr. B.L. guns of the home service, and to report fully on the whole subject.

In their report dated 28th November 1870, they say:—

Committee of 1870.

"The Committee have no hesitation in giving the preference to the M.L. gun, both in respect to simplicity and facility of repair.

"If, as regards the question of endurance, the Committee are called upon to select between a structure of wrought iron and steel and one of bronze, as tried by them, they unhesitatingly pronounce in favour of the former, whether the gun be a muzzle-loader or a breech-loader.

"It may be urged that considerations of manufacture favour the adoption of bronze for M.L. guns for India, but the same cannot be accepted as applying to this country, and taking weight for weight it is impossible to deny that far greater endurance will be attained by the present mode of construction than by the use of bronze.

"The service B.L. system, owing to the absence of windage, necessitates the employment of a mechanical arrangement for lighting the time fuze. This is effected by the employment of a detonator, which has proved to be highly sensible to climatic influences. The M.L. gun on the other hand has the advantage of being able to use an ordinary wood time fuze, which experience has proved to be little or not at all affected by climate.

"As regards cartridges, the B.L. guns have the great disadvantage of requiring the use of lubricators.

"In respect to other stores, such as percussion fuzes and projectiles, the Committee believe that, whether for breech or M.L. guns, there will be found little or no difference between them so far as regards their capability to bear the tests of travelling or climate.

"Judging from the results of the practice at Aldershot, the 9-pr. M.L. and the 12-pr. B.L. guns appear, in respect to shooting to be much upon a par; the former being superior in point of shrapnel shell with time fuzes, the latter in point of segment shell with percussion fuzes; the 9-pr. B.L. gun being inferior to both.

"The advantages of simplicity, facility of repair, ease of working, rapidity of fire, original cost, and cost of maintenance, are in favour of a M.L. gun, and the Committee consider that these qualifications outweigh the important advantage of the superior amount of cover given to the detachments when entrenched and in the open, which a B.L. gun affords, and are therefore of opinion that on the whole, a M.L. gun is the more efficient for war purposes; but, they recommend that, if adopted for home service, they be made of wrought iron with steel tubes."

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A wrought iron muzzle-loader with steel tube recommended for home service.

We see, then, that for field service, the first rifled service guns were the rifled breech-loader on Sir W. Armstrong's principle; that we soon found out that this system of breech-loading had faults, and in consequence made very extensive experiments between 1863 and 1870 as to the comparative value of these B.L. guns, and the various descriptions of M.L. field guns brought forward.

The Committees who carried out these trials were composed principally of distinguished artillery officers, and they all arrived at the conclusion that a M.L. gun was better than a B.L. for the reasons given above.

As regards the construction itself, which is only affected indirectly by the question of B.L. or M.L., these Committees were unanimous in recommending the built-up system of steel barrel and wrought iron jacket at present employed instead of the use of bronze or steel alone.

Manufacture of B.L. discontinued 1870.

Since 1864 no new R.B.L. guns have been made, and since 1870 we have entirely armed our mounted artillery with M.L. steel and iron guns.

9-pr. and 16-pr. R.M.L. now supplied.

The Horse Artillery are armed with 9-pr. guns of 6 cwts., while one half of the field batteries are also armed with 9-pr. guns of 6 cwts.* and the other half with 16-pr. guns of 12 cwts.

These guns proved very formidable field pieces during the experiments carried on at Okehampton in 1875; the 9-pr. up to 3,500 yards and the 16-pr. up to 4,000 yards range rendered the ground covered by them quite untenable by infantry, while at still longer ranges, cover, such as villages or houses was destroyed by their fire.

Further experiments being now carried out.

As it is thought advisable however to provide our field batteries with more powerful pieces, experiments are now being carried out with new pieces with which they will no doubt before long be armed, and which will be far in advance of our present field guns in power.

Siege Guns.

Siege guns.

As to siege guns, the same reasons which led us to discard the R.B.L. service guns for field service led us also to do so in the case of siege pieces.

Until lately the 20-pr., 40-pr., and 7-inch R.B.L. together with S.B. mortars, constituted our siege train, but since 1870 we have made 25-prs., 40-prs. and 64-prs. R.M.L. pieces for this purpose. Moreover, instead of S.B. mortars for high angle fire rifled howitzers have been introduced. These are short rifled pieces built up on the Fraser construction, for the purpose of throwing heavy rifled projectiles at high angles of elevation.

Rifled howitzers replacing S.B. mortars.

The 8-inch howitzer was introduced in 1872, and experiments are still being carried on with other natures, a 10-inch and a 6·3-inch, which latter is a service piece, though the mode of rifling, sighting, &c. have not yet been definitely settled.

* The field batteries armed with 9-prs. had at first those of 8 cwts. with which some are still equipped. These 9-prs. are being replaced by the light 9-pr. of 6 cwts.

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Heavy Guns.

Heavy rifled guns.

We have so far followed the history of our rifled field and siege pieces down to the introduction of the present R.M.L. guns, let us now see how our heavy rifled guns were brought into the service.

7-inch R.B.L. 64-pr. shunt. More powerful than the 68-pr. S.B.

The 7-inch B.L. of Sir W. Armstrong was the only heavy rifled gun in our service until 1863, when his 64-pr. R.M.L. shunt gun was found to answer well, and many of them were made both for naval and garrison service. These guns were more powerful than the 68-pr., the heaviest cast iron gun we ever had in the service, but when iron armour began to be used for ships of war, they were not able to penetrate the iron plates with which the ships sides were protected, so that it became necessary to make larger guns whose projectiles could pierce these armour plates.

B.L. system cumbrous for heavy guns.

The Armstrong and Whitworth Committees had reported in favour of muzzle-loading in 1865, and most of the leading artillerists agreed with them, especially in the case of heavy ordnance, where any B.L. arrangement with guns using very large charges must be very cumbrous if not actually unsafe, and it was consequently resolved to make our iron piercing guns muzzle loaders.

100-pr. and 150-pr. S.B. guns.

As the striking effect of a projectile depends more on its velocity than on its weight, and as a round shot fired from a S.B. gun has considerably greater initial velocity than an elongated shot fired from a rifled gun, owing to the smaller proportionate charge, the Admiralty at first proposed wrought iron S.B. guns of large calibre to penetrate armour plated vessels at close quarters. Accordingly in 1864, two natures of wrought iron S.B. guns were adopted ; these were the 100-pr. of 9″ calibre, and 150-pr. of 10·5″ calibre. They were built up on the Armstrong coil principle, but only about fifty of the former and a dozen of the latter were made, as it soon became evident that still more potent guns were necessary, and that we could make them too in the shape of wrought iron R.M.L. guns. In fact such good results were obtained from the 64-pr. M.L. shunt gun (which was approved as a sea service gun, March 10, 1865), as well as from larger experimental guns on the same system of rifling and construction, that the Ordnance Select Committee suggested that the above two natures of S.B. guns should be also rifled on the shunt system.

12-inch and 13-inch guns.

These guns were, however, of too weak a construction for that purpose,* and in 1864 it was proposed to make heavier pieces; a few 12-inch† and 13-inch guns were, therefore, ordered in 1864, and the latter were rifled with the shunt rifling.

Disadvantages of shunt rifling. Woolwich system.

The shunt system of rifling had, however, some disadvantages as pointed out at p. 16, and was soon succeeded (in 1865) by the so-called Woolwich system, which was adopted after a long series of competitive trials carried on with 7-inch built-up guns, rifled on various representative systems.

There was not much difference in the shooting qualities of the several systems, but in May 1865 the O.S.C. reported in favour of adopting the

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* They were too weak longitudinally, as pointed out by the Superintendent R.G.F. The 150-pr. are obsolete, and have been returned into store. The 100-pr. are used for [illegible] only.

† [illegible] were not tried until 1866, and were rifled with the Woolwich

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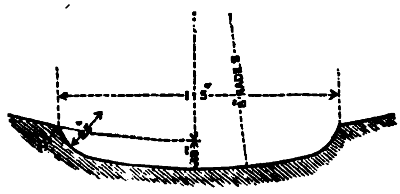
Woolwich systems of rifling* in which the groove, as shown below, is a modification of the groove then used with the French heavy guns.



Woolwich system of rifling adopted for heavy guns.

The M.L. 7-inch guns in course of manufacture were accordingly rifled on this principle, upon which all our heavy pieces since have been rifled.

The 7-inch guns referred to and introduced into the service in 1865 were the first of the so-called *Woolwich* guns, which then meant *wrought iron M.L. guns, built up on Sir W. Armstrong's principle, improved upon by hooking the coils over one another, and having solid ended steel barrels, rifled on the system shown above for studded projectiles.*

8″ and 9″ guns.

The 8″ and 9″ guns (Woolwich) were also introduced in 1865, and a few 12″ guns of 25 tons were completed by 1866, being built like the previous guns, on what was called the "original construction" or that of Sir W. Armstrong, vide Plates XI. and XII., where a forged breech-piece and a number of thin coils are used.

Original construction costly.

Decrease of cost.

This construction was an expensive one, and Colonel Campbell (now General Campbell, C.B.) who was appointed Superintendent R.G.F. in 1863 applied himself energetically to the question of reducing the cost without decreasing the strength of our guns.

A coarser and cheaper iron was obtained, and used with much success in the manufacture of the coils.

Mr. Fraser's construction.

In April 1867 Mr. Fraser, the Deputy Assistant Superintendent R.G.F., proposed a plan which was recommended by General Campbell to supersede the original or Armstrong construction.

The Fraser or cheap construction is an important modification of the Armstrong system, and differs from it chiefly in building up a gun with a few large double or treble coils made with bars of large section, vide p. 10; instead of several finely finished single ones, and also in doing away with the expensive forged breech-piece.

Solid forged breech-piece retained.

Solid forged breech-piece discontinued.

In the earlier Fraser guns the modified construction was only partially adopted, and the 64-pr., 7, 8, and 9-inch, mark II., a few of which were made in 1866, retained the forged breech-piece. Since 1867, however, our heavy guns have been made entirely on the Fraser modification of the Armstrong principle.

10″ and 11″ guns.

80-ton guns.

As necessity arose and our powder was improved heavier guns were introduced from time to time, the 10-inch in 1866, the 11-inch in 1867, 12-inch of 35 tons in 1871, 12·5 inch of 38 tons in 1873, and in 1875 was completed the experimental 80-ton gun. All of these guns are built up in the same way with the slight differences pointed out in

* The O.S.C. considered this system the best both on account of the simple form of groove, the simplicity of studding the projectile, and the advantage it offered in allowing of the use of the increasing twist.

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Chapter VIII., and as far as the mode of construction is concerned we have every reason to be satisfied with them.

As improvements in powder are made, no doubt the dimensions, &c. of our guns must undergo alteration, and our heavy guns are now made longer in the bore than the earlier natures, and other modifications will probably soon be introduced still further to increase their power.

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CHAPTER V.

MANUFACTURING OPERATIONS.

Manufacturing Operations.—Wrought iron.—Puddling reverberatory furnace.—Cast iron scrap.—Slag.—Blooms.—Wrought iron scrap.—Departmental scrap.—Drumming.—Piling.—Blooms.—Rolling.—Bars.—Their shape.—Test.—**Welding.**—Use of sand.—**Coiling.**—Double coil.—Triple coil.—Welding coils.—Process of welding.—Use of water.—Solid forgings.—Trunnion ring.—Shaping.—Punching.—Shaping trunnions.—Forging cascable.—Bars for heavy guns forged.—**Uniting.**—**Shrinking.**—Its object.—The operation.—Gas and water, when used.—Manufacture of a jacket.—Manufacture and testing of steel ingots.—Casting.—Forging.—Testing.—Bending test.—Tensile test.—Centring.—Turning.—Boring.—Slotting and planing.—Broaching.—Lapping.—**Rifling.**—Drilling.—Screw cutting.—Viewing and Gauging.

Before entering upon an account of the absolute construction of our rifled ordnance, it will be well to explain the principal operations employed in preparing the several portions from the raw material, in putting them together, and completing the gun for its sights and fittings.

Manufacture of wrought iron. The wrought iron used in the R.G.F. is either puddled iron (used principally for making bars) or scrap iron.

Puddling. The puddled iron so used is the wrought iron made in the department by burning out the carbon, &c. from cast iron, old cast iron guns, carriages, shot, shell, &c. broken up being used principally for the purpose.

The operation of converting this cast iron into malleable or wrought iron is called "puddling," and is carried out in a puddling furnace. *The reverberatory furnace.* This is of the description termed a "reverberatory" furnace, that is, a furnace in which a bridge of fire-brick placed between the grate and the hearth prevents the contact of the coal and the iron which would be detrimental to the latter, while the powerful draught generated by a tall chimney at the other side of the hearth induces the flames to play upon the metal with great intensity. The chimney is provided with a damper or lid, raised and lowered by a chain attached to a lever at the top so that the draught may be regulated to a nicety, and stopped altogether when the hearth is temporarily empty.

Cast-iron scrap. *Operation of puddling.* The cast iron scrap having been broken up under a steam hammer into pieces of a convenient size, a charge of between five and six cwts. is placed in the furnace together with about one cwt. of iron scale or hammer scale which is rich in oxygen and aids in burning out the impurities.

The heat of the furnace soon melts the iron, which is well stirred by the workman, and the carbon converted into a gas (carbonic oxide), which may be known by its blue flame.

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A liquid glass or "slag" is also formed, which is tapped and run out through a hole at one side from time to time.

Slag.

As the carbon gets burnt out the iron becomes pasty, and is collected by the puddler into large balls, which look in their white hot state not unlike loosely collected masses of snow. These balls are rolled up an incline on one side of the furnace bed, and then removed from the furnace to a steam hammer where the liquid slag entangled between the particles of iron is squeezed out and the ball hammered into a rectangular block technically termed a "bloom."

Blooms.

This iron is rather hard and brittle, and has to be heated and hammered or rolled if we want to give it fibre.

Wrought iron scrap.

Departmental scrap.

Scrap iron consists either of old wrought iron articles, bolts, nuts, screws, horseshoes, &c. which are purchased by contract, or of the shavings obtained in the department from turning or boring wrought iron. The first gives the best fibre, but the latter is cleaner.

Drumming.

Piling.

To work up the first mentioned, it is drummed to get rid of rust, &c. and then piled on small pieces of board. The pile or charge is heated in a furnace to a white heat, and then hammered under a steam hammer into a bloom.

Blooms.

The Department scrap is thrown in loose instead of being piled as above, and then treated in a similar manner.

Parts of which our rifled guns are built up.

Most of the parts from which our rifled guns are built up are made by coiling a bar round a mandrel or core, and afterwards welding the folds together into a compact hollow cylinder, but certain portions, *i.e.*, the cascable and trunnion ring, are made from solid masses of iron formed by welding a number of slabs together; and the inner tube is generally made from a solid ingot of steel.

Formerly R.M.L. guns had a breech-piece made by forging, while all R.B.L. guns have such breech-pieces bored out of solid forged blocks.

We will take in order the manufacture of the several parts, beginning with that of the bar and the coil.

Manufacture of Bar.

Rolling.

Two blooms or blocks of puddled iron are heated, welded together, and then passed between two rollers or rolls which draw them out into a flat bar of about 2 cwts. Similar bars are made of scrap iron.

Bars.

These flat bars are piled or faggotted together to form a bar thick enough for the purpose required. This pile, composed partly of puddled iron and partly of scrap, the former being always placed on the outside on account of their more even surface, is raised to a white heat and rolled into a long bar about 24 feet long, and varying in section from $2\frac{1}{4}$ to 7 inches, according to the purpose for which it is intended.* Should the bar be required for the breech portion of the jacket of a gun, or for the tube of a 64-pr. gun or for guns converted on the Palliser system, it is cut into lengths, again faggotted, raised to a welding heat, and passed between the rollers. In ordinary cases one rolling is sufficient.

Rolling.

Shape of bar.

A bar is always designated by the depth of its section. The section is slightly trapezoidal in order that when the hot bar is wound round the mandrel, narrow side inwards, the spreading of the inside and the narrowing of the outside, natural to such a process, may be neutralized.

* The bars from which the breech coil of 10-inch guns and upwards are made are manufactured by forging, vide p. 42.

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Test. Samples of each week's work are tested for tenacity and elasticity, the stretching weight should be about 12 tons, and the breaking weight about 23 tons.

The bars thus made have next to be joined together to give us the bar of the length required for a coil.

Welding. To weld two bars together the ends must be scarfed down and placed from opposite sides in a furnace, from which when they arrive at a white heat, they are withdrawn and welded under a steam hammer,

Why sand is used. sand having been thrown on the hot bars (as is indeed customary in the case of all forgings) in order to clean the surface and prevent scale forming, by converting the scale into a liquid silicate which will flow off of its own accord or be squeezed out by the hammer. Another bar is welded on in a similar way, and so on, until a sufficient length is obtained for the required coil.

Coiling.

Furnace. The bar to be coiled having the ends flattened down, is placed on trestle rollers in front of a long reverberatory furnace with a chimney at the far end and fire places along its sides. A chain being hooked into an eye or hole in the far end, the bar is drawn by machinery into the furnace. When the bar arrives at a bright red heat, the end near the door is drawn out by means of the same eye, and attached to a pin, this end being cooled with water to prevent it tearing away with the weight of the bar. This pin is connected with a slightly taper iron roller or mandrel fixed across and in front of the door of the furnace. The mandrel tapers in order to make the removal of the finished coil more easy. The apparatus is then put into gear, and the mandrel

Winding bar. revolves, winding the bar around it. During the process, scales form between the folds, but they are got rid of by subsequent heating and forging, sand being used to assist in liquefying the oxide, as stated above. When the coil is formed, the fixed end is hammered off the pin and water is poured on it to cool it, in order that the folds there

Detaching coil from mandrel. may not be opened out in the taking off of the coil. If the coil be large, a short iron bar is placed with one end resting on the ground, and the other end against the extremity which has been removed from the pin. The mandrel is then turned in the same direction as that in which it revolved when the coil was being formed, and the coil, being prevented from revolving by the iron prop, is loosened, and slips down towards the narrow end of the mandrel. The mandrel is then lifted by a crane and the coil drops off. Small coils are hammered off, no water being used in this case.

Double coil. If a double or triple* coil is required, a round bar is fixed by bearings at each end through the newly made coil when cold, and placed on the supports hitherto occupied by the mandrel; the second bar is then wound round the first coil in the same way that the first bar was wound round the mandrel, but in the reverse direction to break joints. A

Triple coil. triple coil is formed by immediately winding a third bar around the second coil in the opposite direction. Thus the first coil acts as a mandrel to the second, and the second to the third, whilst the bar upon which all three revolve is easily extracted when the triple coil is completed. The inner coils project at the ends, a little beyond the outer ones in order that a close weld may be obtained at the interior of the cylinder.

* Triple coils are not employed now, and double coils but rarely owing to be greater thickness of the bars from which coils are made.

The object of welding a coil is to unite the folds so that it may withstand the longitudinal strain. The operation is generally the same for all kinds and sizes of coils, single, double, and triple. When the coil is intended for an inner barrel, as in the case of B.L. guns or cast iron guns converted on the Palliser's plan, the process must be very carefully performed; for if from the badness of the iron or from dirt or grit between the folds, or from insufficient heating, or from undue hammering the welding becomes imperfect, the barrel will of course be unsound, and the powder gas will eat its way into the defective parts.

Object of welding coils.

Great care necessary with inner barrel coil.

The coil is placed upright in a reverberatory furnace, for were it placed on its side it would have to be turned over in order to be equally heated all through, and, moreover, drippings from the fire-brick which line the furnace would probably fall from the roof in between the folds. If intended for an inner barrel, two furnaces are used; one is at a low temperature (termed a "blue light"), and when the coil arrives at a red heat it is brought out and transferred to the other, where it is brought to a welding heat. This is found to be more economical than placing the cold coil at once into a very hot furnace, and also prevents any injury to the iron which would result from so doing. In all cases of welding it is necessary to "strike while the iron is hot," and that the surface to be joined should be perfectly clean, the white hot coil is therefore transferred from the furnace to the steam hammer as quickly as possible, and sand is thrown upon it for the reason before assigned. The coil is first placed vertically under the hammer, and receives a few smart blows to weld the folds, it is then thrown on its side and being gradually turned, is hammered (or patted) all round to straighten it. It is then raised vertical again, and a punch or mandrel—rather over half the length, and a little larger than the interior diameter of the coil—is hammered down its own length, the coil is next placed on its side and hammered round, that half of its length thus being made very compact, and large enough to let the mandrel fall out. After this the coil is again raised vertical, and the mandrel is forced in the opposite end and the process repeated.

Process of welding.

The mandrels are of coiled iron and very hard.

The reason a long mandrel is not forced through the whole length of the coil is that it would tend to separate the folds.

The coil is replaced in the furnace for the second heating, and much the same process is followed to render the ring more consolidated as well as more shapely; and if intended for an inner barrel, a fine mandrel is used to make the interior more perfect. If the coil is to be "faced," a flexible steel bar is used under the hammer to flatten the ends and prevent their being bell-mouthed.

Before the coil is removed from the hammer, water is thrown over it, which forming into steam blows off the black scales and shreds when the work is good, but a black spot is left by the water if there is a bad part.

Why water is used.

Coils lose in welding from one-tenth to one-third of their length according as they are thin or thick.

Loss in length.

After welding the cylinder is inspected and tested by the gauges as to size, shape, and soundness, and unless found satisfactory in all respects is subjected to another heat.

Solid forgings.

Every large solid forging is made in the same way, namely, of slabs of iron successively welded together upon the end of a "porter bar," or carrying bar (a stout bar of wrought iron), which acts both as a lever and tongs in manipulating the work.

Solid forgings, how made.

Porter bar.

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Slabs. To form a slab, oblong blooms of scrap iron, such as already described, p. 39, are hammered into flat cakes, and several of these cakes being piled, heated, and welded together constitute a slab.

As an example of a solid forging, we will take a trunnion ring:—

Trunnion ring. The porter bar is heated and the end flattened or scarfed down on both sides, two slabs are placed on one face and the end of the porter bar with the slabs brought to a white heat and welded together; the porter bar is turned over, slabs placed on the opposite face, and the same process repeated; one slab after another is added and welded in a similar manner until we have a mass of iron of sufficient size.

Shaping a trunnion ring. This mass is roughly hammered into the shape of a trunnion ring, the porter bar being in continuation of one of the trunnions. *Punching.* This block is converted into a ring by punching a small hole (or in the case of very large guns two parallel holes) through the centre with iron wedges, and then enlarging the same by taper oval mandrels, increasing in size until the hole is sufficiently large.

Shaping trunnions. The trunnion ring has to be heated between each punching, and the trunnions are then roughly shaped. It will be seen that the fibre of the iron will run round the ring and along the trunnions exactly as we require it to do for strength.

Shaving scrap is used in making solid forgings for trunnion rings, as it gives us a good fibrous iron of uniform quality.

Forging of a cascable. When we want a solid cylinder of iron, cross or binding slabs should be welded along the sides of those first welded to the porter bar, as in the case of the forging for a large cascable.

Bars for heavy guns forged under the hammer. To form the bars from which the breech coils of heavy guns are made slabs are successively welded to the end of a porter bar scarfed to receive them, and the mass so obtained being again heated and scarfed down another slab is added and the forging drawn out to the shape and section of the bar required, and so the operation is continued until a sufficient length of bar has been made.

This mode of preparing the bars for the breech coil of very heavy guns is pursued, as by its means we obtain a denser and stronger material for that coil, where great strength is required.

Uniting two or more coils to form a tube.

[illegible] When a coiled inner barrel is required, several coils must be welded together. The B tube or chase of heavy guns is also composed of two or more coils as well as the breech coil in some cases.

Preparation. To begin with the coils must be faced (turned smooth at the ends) and [illegible] recessed; that is a projection (spigot) is formed at one end of a coil and a recess (faucet) is bored in the corresponding end of another coil. The height of the shoulder is a little greater than the depth of the recess to ensure that a close joint may be obtained on the interior. The recess is then expanded by heat and shrunk over the projection, so that the two coils are stuck sufficiently together to admit of their being put into the furnace for welding.

[illegible] In making up an inner barrel the tube is put crossways through a furnace so constructed that a close heat acts on the joint only while the two ends project outside. When the joint arrives at a welding heat a [illegible] bar is passed right through the tube; this bar is [illegible] up at one end, and by means of a screw [illegible] worked by a long lever at the other end, the two coils are squeezed or pressed together. The pressure slightly bulges the metal at the junction, so it must be straightened under a steam hammer. Another coil is then added on in a similar manner, and so on till the tube is of the required length.

B tube.

Should the uniting furnaces be required for inner barrels, the two coils for a *B* tube—being short and strong—are, when shrunk together, heated in an ordinary furnace and welded gently together under a steam hammer.

Shrinking.

Double object of shrinking.

Shrinking is employed to bind the successive coils of a built up gun firmly together, also to regulate the tension on the several layers, so that each and all may contribute fairly to the strength of the gun. Vide p. 9.

The operation.

The operation of shrinking is very simple; the outer coil is expanded by heat until it is sufficiently large (if a large mass, such as the jacket of a Fraser gun, by means of a wood fire for which the tube itself forms a flue; if a small mass, such as a coil, in a reverberatory furnace at a low temperature). It is then raised up by a travelling crane overhead and dropped over the part on to which it is to be shrunk, which is placed vertically in a pit ready to receive it.

Mode of cooling.

With respect to the mode of cooling during the process of shrinking, care must be taken to prevent a long coil or tube cooling simultaneously at both ends, for this would cause the middle portion to be drawn out to an undue state of longitudinal tension. In some cases therefore water is projected on one end of a coil so as to cool it first. In the case of a long tube of different thickness like the *B* tube of a R.M.L, gun, water is not only used at the thick end, but a ring of gas or a heated iron cylinder is applied at the thin or muzzle end, and when the thick end cools the gas or cylinder is withdrawn from the muzzle, and the ring of water raised upwards slowly to cool the remainder of the tube gradually.

Cases where gas and water should be used.

A flow of water always inside barrel.

As a rule the water is applied wherever there is a shoulder so that portion may be cooled first and a close joint secured there; and invariably water is allowed to circulate through the interior of the mass to prevent its expanding and obstructing or delaying the operation; for example, when a *B* tube is to be shrunk on a steel barrrel, the latter is placed upright on its breech end, and when the *B* tube is dropped down on it a continual flow of cold water is kept up in the barrel by means of a pipe and siphon at the muzzle. The same effect is produced by a water jet underneath, when it is necessary to place the steel tube muzzle downwards for the reception of a breech coil.

Manufacture of Jacket.

The three parts of which a jacket is composed, viz., breech coil, trunnion ring, and muzzle coil, having been separately manufactured as above described are prepared for shrinking together by heating the trunnion ring to redness, and dropping it over the shoulder of the breech coil, which is placed upright on its breech end for the purpose.

While the trunnion ring is still hot, the muzzle coil is placed down upon the front of the breech coil, through the upper portion of the trunnion ring which was left projecting. The trunnion ring thus forms a band over the joint, and in cooling contracts round the two coils, and grips them sufficiently tight to allow of the whole mass being placed bodily in a furnace, where it is raised to a welding heat.

The glowing mass is then quickly placed on its breech end under the hammer. Six or seven blows on the top suffice to amalgamate the three parts together; but to make the welding more perfect on the interior, as well as to obviate any bulging inside, a mandrel somewhat

CHAP. V. larger than the bore is forced down to within a short distance of the breech end, a series of short iron plugs being used to drive it down. The mass is then reversed, and the mandrel is driven out with the same plugs, which have fallen out in the tilting over.

Manufacture and Testing of Steel Ingots.

Casting. Steel ingots for the inner barrel of guns are supplied to the Royal Gun Factories by the contractors in the form of solid cylinders cast and afterwards forged under a heavy hammer. Casting is necessary, not only for the purpose of obtaining a sufficiently large block of steel, but also for making the block homogeneous and uniform in structure. Forging or drawing out the cast block imparts to it the desirable properties of great solidity and density.

The cylinder is manufactured thus :—A large quantity of steel having been broken up, the pieces whose fine fracture indicates a mild nature, are melted in blacklead crucibles containing about 45 lbs. each.

The metal is melted in about three hours, when the crucibles are lifted, one by one, from ths furnaces by means of tongs, and wheeled quickly to a large iron mould. An ingot for a 9-inch gun, weighs about 65 cwt., and 162 crucibles are required for it, so a large number of men are employed in rolling up and pouring in the metal. They are obliged to keep up a continuous flow of molten metal, else the casting would not be the same throughout, the operation lasting about 20 minutes.

That for the 9-inch ingot is 5 feet long and 2 feet thick. After casting, the steel is covered with ashes or other non-conducting substances, and allowed to cool very gradually; when cold a portion is cut off the top, and the lower end being the denser, is marked for the breech.

Forging. The block thus formed is drawn out by a series of heatings and hammerings which occupy several days, to a cylinder sufficiently long for an inner barrel, in which state it is sent to the Royal Gun Factories, where it is subjected to the following tests and treatment.

Testing. A slice is cut off from the breech end and divided into pieces for testing. Some of these are flat bars, 4 inches long and $\frac{3}{4}$ by $\frac{5}{8}$ in section, and others are of the shape usually tested in the machine for tensile strength and elasticity, viz., small cylinders 2″ long between breaking parts, and 0·533 in diameter, having shoulders at each end by which they are fixed in the machine.

Bending test. Three of the former are marked respectively *S*, *L*, and *H*. One end of the *S* or soft (*i.e.*, untempered) piece is gripped in a vice, whilst the other end is hammered down towards it, to ascertain that the steel, by bearing this bending without cracking, is naturally of the mild quality required. The *L* and *H* pieces are raised to a low red and high heat respectively, immersed in oil, and, when cold, treated in a similar manner. The heat is judged by an experienced workman from the colour of the specimen.

Whichever of these pieces bears the hammering best determines the heat at which the whole tube is to be toughened.* Should neither

* It may seem remarkable that the colour at which a razor, a chisel, or a watch spring must be tempered is definitely fixed, and yet that the heat for toughening a gun-barrel should vary in shade from a blood red to a bright cherry colour. Now, did the temperature depend alone on the amount of carbon in the steel, it would appear best to toughen every barrel at a bright heat, for the less carbonized, or in other words the milder the steel, the higher is the temperature at which it toughens most satisfactorily; but it is a fact that the denser the steel is—*i.e.*, the more it is hammered in the process of drawing out—the less heat does it require for successful toughening; hence, each individual barrel must be tested.

piece answer, others at intermediate temperatures are tried, and if all fail, the block is returned to the contractors; but some specimen having succeeded, as is generally the case, two of the remaining pieces—one in its soft state, and the other toughened at the ascertained temperature—are tested for tenacity and elasticity. The soft material should begin to stretch permanently at 13 tons per square inch, and break at 31 tons. The toughened piece should begin to stretch at 31 tons, and break about 50.

Test of tenacity.

The machine used for testing the tenacity consists of two levers, one acting on the other in such a manner that any weight applied to the first exerts a strain 200 times as great on the test specimen.

Ingots which pass all the foregoing tests are accepted and are toughened in oil at the approved temperature previous to being put into the gun.

Machine Operations.

After the tubes, rings, and other portions of the gun have been made as described, they have to be bored, turned, in some cases slotted, planed, and shrunk together, while the inner barrel must be bored, broached, lapped, and finally rifled. These operations are shortly described below as well as the processes of drilling, screw cutting, and gauging.

Centring.

Centring.

Previous to the first turning of any article, the axis must be found so as to centre it truly in the lathe. This is simply done in a solid cylinder by finding centres at each end with a pair of compasses; but in the case of a tube, bars of soft iron must be fixed across each end in order that the axis may be actually ascertained; the article being fixed accordingly in the lathe is turned truly cylindrical. Large masses are centred by the exterior which has been previously turned.

Turning.

Turning.

Turning means cutting off the exterior surface all round.

Boring.

Boring.

The term boring is applied either to the process of reaming out the inside of a tube, or boring one out from a solid cylinder.

Coiled wrought iron tubes for the barrels of 64-prs. and converted guns are bored before being turned, for if on examination of the bore a defect is detected which would condemn it, the labour and expense of turning is saved.

Slotting and Planing.

Slotting and planing.

When the edges or surfaces of iron work cannot be readily reduced to proper size and shape by filing, a slotting or planing machine is employed as circumstances warrant. For example, the sides of a trunnion ring are planed, but its belt or interval between the trunnions (which cannot be brought to shape in a turning lathe) is slotted, and the usual way of making any hole other than circular is first to drill one or more round holes, and then slot or pare the edges to shape.

Broaching.

A broach is the name of a tool used for making a taper hole or for perfecting a cylindrical one.

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Necessity for broaching.

During the process of boring, the cutters wear from friction, so that the tube is always slightly taper inside. This is of no consequence in an outer tube, as the interior one can be turned to suit it, but an inner barrel must of course be truly cylindrical, hence broaching is employed to remove the taper.

Broaching head.

The broaching head is round and fitted with four long cutters fixed lengthways at right angles to each other and slightly tapering.

The cutters are carried round the front of the head and are shaped so as to finish the chamber of M.L. guns to the required form.

Lapping.

When lapping is employed.

Lapping, or the process of making any hard surface smooth and accurate, or for removing a small amount of metal, is used in the Royal Gun Factories for finishing off the bore of an inner barrel, for notwithstanding fine boring and broaching some little roughness and irregularity will exist. The process of rifling also often causes some of the metal on the edge of the grooves to be burred. Lapping is therefore performed both before and after rifling.

The operation consists of working (by means of levers attached to a revolving bar) a wooden head covered with lead and smeared over with emery powder and oil, backwards and forwards in the bore wherever the very accurate gauges indicate the necessity.

Rifling.

Rifling.

This operation is performed by means of a beautiful rifling machine, which though simple in its action, is not very easy to describe without using technical terms. This machine is horizontal, and the gun to be rifled is fixed in front of it, and in line with the rifling bar, to which a stout head carrying the cutter is fixed.

One groove cut at a time.

Only a single groove is cut at a time, and that as the cutter is coming down the bore, bringing the chips of metal before it.

All the grooves in the gun are first cut out roughly in succession, and then finely. The distances between the grooves is regulated by a disc fixed to the breech of the gun, having its periphery equally divided by as many notches as there are to be grooves. The gun is fixed each time by a pawl, and when a new groove has to be cut, is turned round to the next notch.

The gun remains stationary while the head carrying the cutter works up and down the bore, so it is necessary to make the bar to which the head is attached turn round more or less at the same time that it advances and returns, otherwise we should merely have a straight groove cut along the bore, instead of the spiral we require to give rotation to the projectile.

Gun metal head.

The gun metal head in which the cutter is fixed fits the bore accurately by means of burnishers. It is fastened to a stout hollow iron bar termed the rifling bar. This bar is fixed to a saddle capable of sliding backwards and forwards.

Rifling bar.

Although the rifling bar is fixed to the saddle and moves with it, it can revolve independently of it, and near the end furthest from the gun is fixed a small pinion, which gears into a rack, sliding in the saddle at right angles to the bar itself. The outer end of this rack is fitted with two small rollers, or friction wheels, which run along a copying bar fixed to one side of the rifling machine. This copying bar is inclined at a certain angle to the side of the machine, and the greater this angle the more the rack is pulled out by the friction rollers, and the greater

Copying bar.

the twist given to the rifling bar, and so to the grooves in the gun. The angle can be altered if required, and we can also take away the straight copying bar, and use a curved one as is done when a gun is to be rifled with the increasing twist. By thus changing the copying bars only, we can use a single machine for any description of rifling.

Twist. Angle of rifling.

Cutting tool.

The cutting tool itself is of steel, and works in and out of the head. It is attached to the bar, which passes up through the hollow rifling bar, and at the outer end is fixed to an arrangement of levers and counterweights, which pushes the cutter out while the head is coming out along the bore, and draws it back while the head is going in.

Drilling.

The cutting portion of a drill is flat and shaped like a broad V.

Small holes such as those for friction tube pins, &c. are drilled by hand, the tool being turned by means of a brace or ratchet lever; but larger holes such as those for sights and vents are made with a drilling machine, the shape of the cutter is, however, the same.

Screw-Cutting.

A small internal screw thread, like that for vent bushes, is generally made by hand with taps.

A small external screw is cut by means of a screw die.

Large external and internal screw threads, such as the male and female cascable thread, are executed in screw-cutting lathes.

Viewing and Gauging.

Examinations during the stages of manufacture.

The examining or viewing is a branch in itself, with foremen for each class of work, whose constant duty it is to examine every article carefully at the close of, and sometimes during each operation, to ascertain that it is manufactured properly, and to correct the dimensions. Thus the flat bars which form a pile are examined as to manufacture and size before they are heated for rolling; the rolled bar is examined before it is welded to others; the long bar is examined before and after it is coiled; the coil after it is welded, faced, recessed, bored, turned, &c.

Every gun, &c. is made from a working drawing, which shows the dimensions of the various parts, which are exactly those of the sealed pattern for that gun or fitting as deposited in the pattern room.

Measurement of the bore.

The bore and internal surfaces which have to be shrunk together, are measured by means of gauges and Whitworth's micrometers to $\frac{1}{1000}$th of an inch, which is the smallest measurement taken in the department.

Gauging the bore.

The gauges for R.M.L. guns have studs corresponding to those on the projectiles in order that the grooves may also be tested.*

External measurements.

External dimensions are taken with callipers and measuring rods, but in this case $\frac{1}{100}$th of an inch is considered close enough.

* The dimensions of the studs being midway between the high gauge of stud on projectile, and the correct size and depth of groove.

CHAPTER VI.

RIFLED BREECH-LOADING GUNS, THEIR MANUFACTURE, FITTINGS, AND STORES.

CH. VI. S. 1.

SECTION I.—MANUFACTURE.

No. R.B.L. guns have been manufactured since 1864, but we have so many yet in the service that all gunners should thoroughly understand their mechanism and know all about their stores and the repairs at times necessary, both for the guns and their fittings.

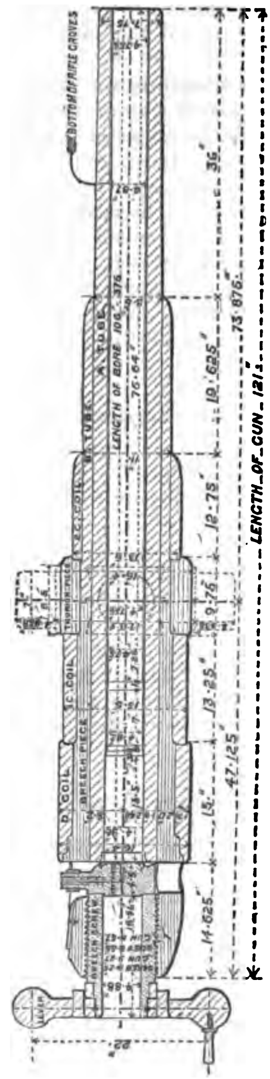
All R.B.L. service guns have been made on Sir W. Armstrong's original construction (as mentioned at Chapters II. and IV., pp. 10, 32) and are manufactured entirely of wrought iron * with the exception of a certain number having steel tubes (vide table, p. 69).

R.B.L. guns of original construction.

This original construction, as already stated, consists of an inner barrel, a forged breech-piece, a forged trunnion piece, and one or more coils, according to the size of the gun. For example, the 6-pr. has one coil, and the 7-inch of 82 cwts. has six coils.

* The 3-pr. R.B.L. gun submitted by Sir W. Armstrong in 1855 had a steel barrel, but that material was abandoned owing to the difficulty of getting it of suitable quality at that time.

As a specimen of B.L. manufacture we may take the 40-pr. of 35 cwts. as shown in the diagram below. CH. VI. S. 1.



WROUGHT IRON B.L. GUN (BREECH-SCREW) 40-PR., 35 CWT., MARK I.

Scale $\frac{1}{24}$.

The inner barrel, or A tube as it is called, was made of coils joined together lengthways in the manner explained at p. 42, but a number of guns (vide table, p. 69), especially 7-inch 20-prs. and $1\frac{1}{2}$-prs., have inner barrels made of solid forgings, *i.e.*, solid cylinders of wrought iron afterwards bored out. These were adopted owing to the difficulty at one time experienced of making a coiled barrel free from defective welds, but they were soon given up, for although they presented a clean inner surface, the fibre which ran lengthways was in the worst direction for circumferential strength.

Solid forged barrels. Why adopted.

Why discontinued.

The breech-piece and trunnion ring were forged, and the number of coils required made, and the gun then built up by skrinking these parts

Breech-piece. Trunnion ring.

CH. VI. S. 1.

over the A tube. In these guns the trunnion ring was not joined to other coils by forging, as in R.M.L. guns of present construction, but shrunk on separately.

Shrinking the parts together.

After the gun was built up it was brought to the proper size and shape by turning, boring, &c., and the piece so completed, all but the rifling, and the preparation of the gun for breech fittings.

Turning, &c.

In this stage of manufacture we might close up the open breech end and make a muzzle loader out of the built up blocks, and indeed we know that certain blocks prepared for R.B.L. guns were afterwards so used for making R.M.L., 64-pr. guns, Mark I. (vide p. 183).

Rifling.

For the service R.B.L., however, the next operation was to rifle the block. The grooves were carried right through from end to end by means of a cutter fixed to a metal head secured to a twisted bar. The bar, which was square in section, passed through a fixed nut, so that as the head and cutting tool worked up and down the bore the grooves were cut with a certain amount of twist depending upon the twist given to the bar, which varied in the different guns from 1 in 30 to 1 in 38 calibres (vide table, p. 85). Only one groove was cut at a time, as with the present rifling machines.

Twist of rifling.

Grooves.

The groove is of the simple shape shown below, the driving side being radial to the bore.

SECTION OF RIFLING (Full size).

The number of grooves is considerable, and thence the system is usually called a poly-grooved or many-grooved system.

Lands.

The lands, or portion of the bore between the grooves, were made as narrow as possible so as to cut the more easily through the lead coating on the projectile.

Preparation of Breech Fittings.

Breech fittings.

The next thing done was to prepare the piece for its breech apparatus. It is evident that in every B.L. gun we must have some method of closing the breech end of the powder chamber before the gun is fired, so as to allow of no escape of gas, for should there be any such escape, the gas rushing through the passage will soon eat out a deep channel for itself and seriously damage the gun or its fittings. This is well shown by vent-pieces which have suffered from neglect in not keeping the copper ring properly faced.

The two modes usually employed for closing the breech end are: (1) to press a block of metal firmly against the end of the barrel by means of a screw, or (2) by means of a wedge forced in behind it.

Vent piece.
Breech screw

All our service B.L. guns use the first mode where we have a metal block called a "vent-piece" and a "breech-screw."—In the wedge guns, however, which are now obsolete (p. 83), a stopper and wedge were employed instead.

In connexion with the vent-piece or stopper it is further necessary to have some arrangement for making the joint, where it meets the end of the chamber, quite gas-tight. As will be seen, we use for this purpose two copper rings (one on the vent-piece and another screwed into the gun), or in the case of the 7-inch a ring of wrought iron and a tin cup.

Copper rings.
Iron rings.
Tin cups.

CH. VI. S. 1.

After being built up, the gun was prepared for the breech apparatus by having a slot cut for the vent-piece, and underneath this a circular hole, called the "water escape" or "drip hole," was drilled through the gun. The breech end of the A tube was threaded for the breech-bush to be screwed in, while the end of the breech-piece was prepared in the same way for the breech-screw.

Vent slot.

Water escape.

Finally, the gun was chambered, *i.e.*, the powder chamber and shot chamber were bored out. The diameter of the first is greater than that of the shot chamber, which is also slightly conical. Immediately in front of the shot chamber is the "grip," which has the smallest diameter of all, in order that the projectile, which has a thin lead covering, shall, as it begins to move, have this covering compressed into the grooves of the rifling. From the grip to the muzzle the bore is slightly increased in diameter, to reduce the strain on the gun, until at the muzzle the bore is about 0·005 inch larger than the full calibre. Altogether, then, we have in the bore four different diameters.

Chambering.

Grip.

Four different diameters.

After chambering, the gun was bushed by screwing into the end of the barrel the ring or breech-bush already mentioned. This bush was faced to correspond to a ring on the vent-piece itself.

Bushing.

The breech bush can be easily repaired and refaced, and when worn out replaced by a new one, it is of copper, except in the 7-inch, which, though originally bushed with copper, are now bushed with iron.

With 7-inch guns, in order to make certain that there shall be no escape of gas when the breech-screw is home, a tin cup is used to complete the joint (vide Treatise R.L. 1874, p. 130) instead of a vent-piece copper ring. Copper bushing for these guns was not found suitable owing to liability to damage in so heavy a gun, and the copper bush was superseded by an iron bush of the same dimensions, 2″ long, ½″ thick; but as this occasionally shifted from want of sufficient bearing, a new pattern iron bush 3″ long, ¼″ thick was introduced. Guns bushed with this latest pattern* are called doubled bushed, and are marked D.B. on the right trunnion.

Why tin cups are used.

7″ double-bushed guns.

Breech Fittings.

The breech fittings for breech-screw guns are:—

Vent-piece.	Lever and keep pins.
Breech-screw.	Indicator ring.
Tappet ring.	

The Vent-Piece,†

Vent-piece.

So called because the vent‡ happens to go through it, is the block or stopper which closes the end of the breech before firing, and is in fact the breech block or stopper.

* Prior to the introduction of this new bush all 7-inch guns had been bushed either with thick iron or copper bushes. It is advisable to rebush with the thick iron bushes of O.P. any guns still having the copper bush, and should guns at out stations not be prepared for the double bush, and therefore not marked D.B. on trunnion, they must, if rebushed at an out station, be furnished with a new bush of the old pattern, as a gun can only be prepared in the first place for the latest pattern bush in an Arsenal. Vide p. 234. Guns marked D.B. would of course be rebushed with N.P. bush.

† This is not of necessity a part of this B.L. system. The fact of the vent being drilled through the vent-piece weakens the latter much, and is an expensive arrangement. At the time when R.M.L. guns were introduced experiments were being carried on as to venting R.B.L. guns through the body of the piece, with favourable results, but as shortly afterwards the manufacture of R.B.L. service guns ceased, it was not thought worth while to make any change in the system of venting, which would no doubt have otherwise been done.

‡ For weights of vent-pieces, vide p. 69.

CH. VI. S. 1.

Vent channel. Vent bushes. The vent channel passes down through the neck to the centre of the block, and this vertical portion is partially bushed with copper; from the bottom of this portion a horizontal channel allows the fire to reach the centre of the cartridge. The bottom part is not bushed, as the vent-piece would be too much weakened thereby.

Material. The material of vent-pieces has been changed frequently; wrought-iron first, then steel, then Swedish iron, then steel toughened in oil, and lastly, Marshall's refined iron, have been employed. The material of which they are made is stamped on the back.

The vent-pieces of all natures except the 7-inch and 40-pr. are lifted away from the gun after each round, while the former are placed either on the saddle or vent rest.

Component parts. A vent-piece consists of—

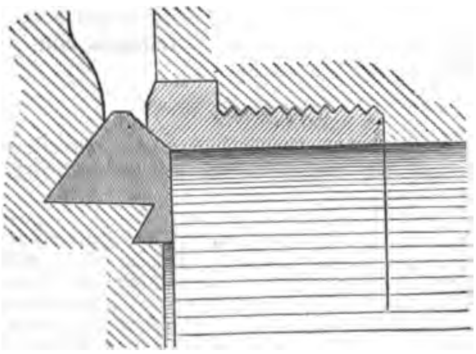
Body.
Vent bush, copper (in two parts).
Vent-piece, copper ring (except 7-inch).
Cross-head.
Shackles.

There is a "beak" on the 7-inch and 40-pr. vent-piece, to prevent thn "nose" on the face of the vent-piece being injured when the vent-piece is placed in the slot.

Bushing with copper. The vent channel is bushed with copper at the upper end. The bush formerly consisted of three or four short plain pieces and one screwed piece on the top, but now one long plain piece is used instead of the short ones.

Copper ring. The vent-piece next received the copper ring, required to give a gas-tight joint when fitted against the copper bush (vide fig. below). The face of the vent-piece itself has an annular undercut groove, into which the ring was forced.

SECTION OF RING.



Cross-head and shackles. The ring was made from pure hardened copper, and has a dovetail corresponding to the groove in the vent-piece. In order to put* it on the vent-piece it was put into a screw press and the copper ring forced on, a small amount being left projecting to allow for refacing on service (vide p. 66).

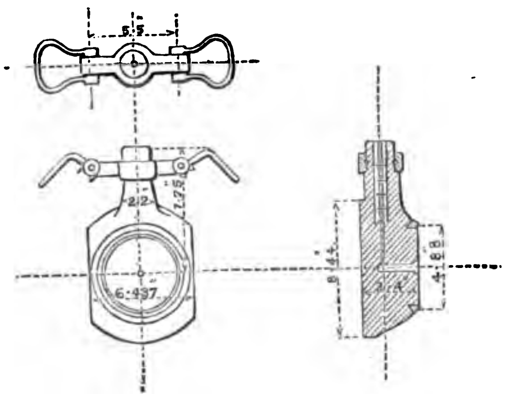
The cross-head and shackles were not put on till after proof. The

* On service, the breech-screw is utilized for this purpose, vide p. 227.

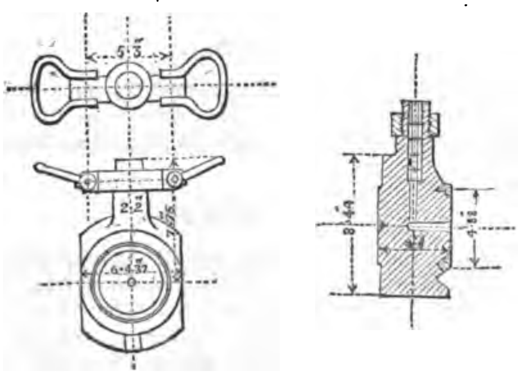
cross-head is made from a block of scrap iron, and is so shaped that its projections rest on the slot when the vent is properly placed for being screwed up. Great pains were taken to get this correct to prevent the possibility of the vent-piece going wrong, so that it should rest on the slot whilst the vent-piece was being screwed up.

The material, date of manufacture, pattern, and R.G.F. number are marked on the back; and the order is, that the latest pattern available should be used, while vent-pieces without a projection at the back should on no account be employed. Important order.

OBSOLETE VENT-PIECE. Scale 1 in. = 1 foot.



SERVICE VENT-PIECE, 40-pr. Scale 1 in. = 1 foot.



*Breech-Screw.**

Is made of steel, toughened in oil for all B.L. guns except the 7-inch, which has an iron breech-screw with a steel face 6″ long screwed into it, an iron face being liable to "set up." The thread is called the "*V* bevelled" from the shape of its section, which is less liable to be jammed by grit or dust and also more easily worked than the square thread used in the early Armstrong guns. Some of the square thread breech-screws are still to be found in use. The ends of the thread are not left sharp but cut off at about half their thickness. The 7-inch Breech-screw. Material. Thread.

* For weights, vide p. 69.

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breech-screw has a double thread; this allows of the screw being moved just twice as quickly, while giving the same amount of bearing surface.

Pitch of thread.

The pitch of thread on the 40-prs. 32 and 35 cwt. are not the same the former being 0″·9, the latter 0″·7, and consequently their breech-screws are not interchangeable for the same nature of gun.

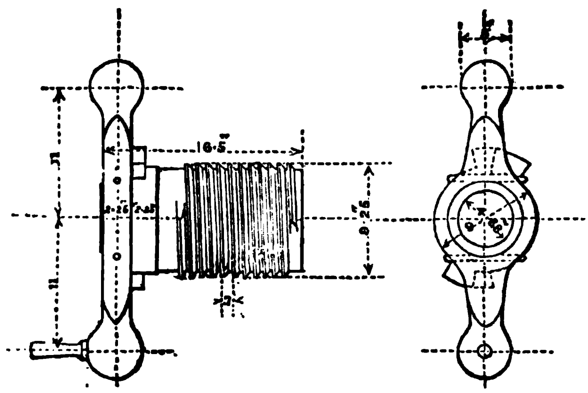
Marks.

The screws are marked with the nature of gun (but not for any individual gun), with the register number, and also with the material of which they are made.

The bore of the screw.

The bore of the screw is slightly less than that of the powder chamber, in order that the breech bush should not be damaged by the projectile when loading.

40-pr. Breech-screw, Tappet Ring, Levers, and Keep Pins. Scale ¾ in. = 1 foot.



Tappet Ring.

Tappet ring.

Is octagonal in shape in the interior, and fits on a similar octagon on the breech-screw; hence it acts as a wrench to the breech-screw, the power being communicated through its projections from the tappets of the lever.

Lever and Keep Pins.

Lever and keep pins.

The lever fits on the breech-screw behind the tappet ring; it is free to revolve round the breech-screw, but is prevented from falling off by two keep pins which work in a cannelure. The lever is fitted with weight balls or accumulators, to give power in screwing up. The levers are all of wrought iron forged, the handles and tappets being forged separately. The small natures up to the 20-pr. inclusive have one handle, one weight ball, and one projection. 40-prs. have one handle, two weight balls, and two projections. 7-inch guns have two handles, two weight balls, and two projections. The levers have all a play of ·02 inch running round the breech-screw, and as there is no particular strain on them, they are not easily damaged; they are interchangeable for guns of the same calibre.

Indicator Ring.

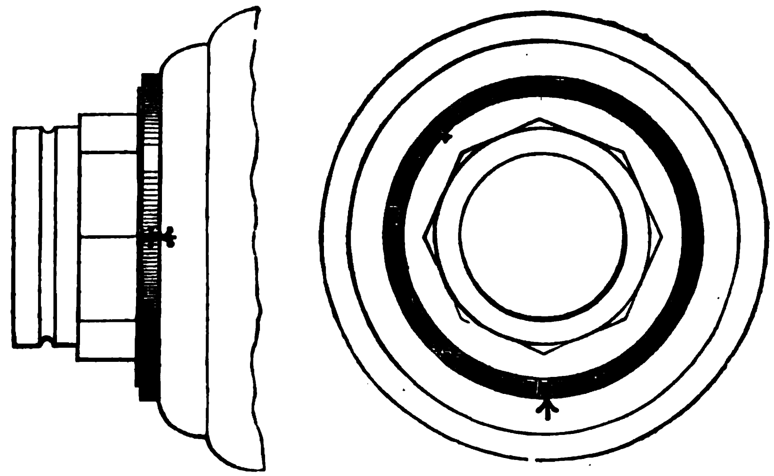
Indicator ring.

Is a thin narrow ring of wrought iron fitted on the breech-screw in front of the tappet ring; on the internal circumference there are a series of grooves or feather ways, any one of which fits a "feather" on the breech-screw; it is so adjusted on the screw that when the vent-piece is properly screwed up, the raised line of brass or arrow on the ring and on the top end of the breech-piece must coincide, and then it can be seen at a glance whether the vent-piece is properly screwed up, or should it be dark this can be ascertained by the touch. As the copper rings and breech-screw are faced on service, the position of the raised line of brass must be altered to correspond by shifting the ring round on the breech-screw.

The 7-inch and 40-pr. are the only guns with which an indicator ring is considered necessary, and some 40-prs. of 32 cwt. do not use them, not having sufficient length of breech-screw.

RINGS, INDICATOR (for 7" B.L. Gun).

The shaded portions show the indicator ring.



Top view, tappet removed. Rear view, tappet removed.

Proof of B.L. guns and fittings.

Proof. A B.L. gun was proved without its breech closing apparatus (spare being used) by firing six rounds of $1\frac{1}{2}$ the service charge, and the service shot.

Vent-pieces and breech-screws underwent two service rounds.

After Proof.

The guns having passed proof were next marked, lined, sighted, &c. prior to issue.

Marks on the gun. The weight of the gun, Royal monogram, and broad arrow are stamped in front of the vent slot, and the "mark,"* name of factory, date of proof, and register number on the left trunnion.

* R.B.L. guns may be found on service with the "mark" omitted on the trunnion; this is accounted for owing to the order not being in existence as to their being so marked at the time of issue.

CH. VI. S. 1.

Lining. Vertical and horizontal lines were marked on the breech and muzzle, for the purpose of enabling the sighting plates to be adjusted (vide p. 228). Vertical and horizontal lines were also marked on the right side of the breech and right trunnion, and right side of the muzzle; but the field guns have not these latter marks.

SECTION II.—SIGHTS, SIGHTING, AND STORES.

Sights. Our B.L. guns being sighted on both sides have four sights, viz., two tangent sights and two trunnion sights.*

Process of Sighting.

Sighting. In all natures, except the 7-inch, as the amount of metal at the breech end is small, the tangent sights work in sockets bored in a wrought-iron ring screwed on the breech of the gun, so that the sockets are inclined at an angle of 2° 16′ to the left, to compensate for the permanent deflection. (For further explanation, vide p. 18.)

Permanent deflection.

Sockets. In the 7-inch, holes are drilled in the metal of the breech of the gun itself at that angle, and in them are fixed gun metal sockets for the sights, similar to those described at p. 106 for R.M.L. guns.

The trunnion sight holes for drop sights are drilled perpendicularly, and in guns using screw trunnion sights the holes are threaded.

Tangent sights. Rectangular. Hexagonal. The sights used are as follows :—For all except the 7-inch of 72 cwt. and the 12-pr., the tangent sight consists of a rectangular steel bar with a barrel head, or, in the newer pattern (introduced in 1867), with a gun metal head and plain sliding leaf. With the 7-inch of 72 cwt. and the 12-prs. the bar is hexagonal and of gun metal. The reason of this difference is that these guns were the first B.L. guns introduced, and it was then thought that the hexagonal gun metal bars would answer best, and afterwards when the flat steel bars were preferred it was not considered worth while to alter the few 7-inch guns of 72 cwt. in the service, whilst the cost and trouble of altering the numerous 12-prs. would have been considerable.

L.S. tangent sights. L.S. sights have under the cross-head an "elevating nut," the circumference of which is graduated from 1′ to 10′, so that by turning it, any number of minutes of elevation less than 10′ can be obtained. This is considered unnecessary for S.S., which therefore have no nut; in all other respects the L.S. and S.S. tangent sights are identical.

S.S. tangent sights.

Barrel-headed sights. Many B.L. sights of the older pattern, having so-called *barrel heads* in which the deflection leaf is placed (vide diagram below), still exist. The second diagram shows the more recent pattern (according to which sights have been made since 1867), where the head is plain with a sliding leaf.

* For description of the different marks or patterns of these sights, vide table p. 71.

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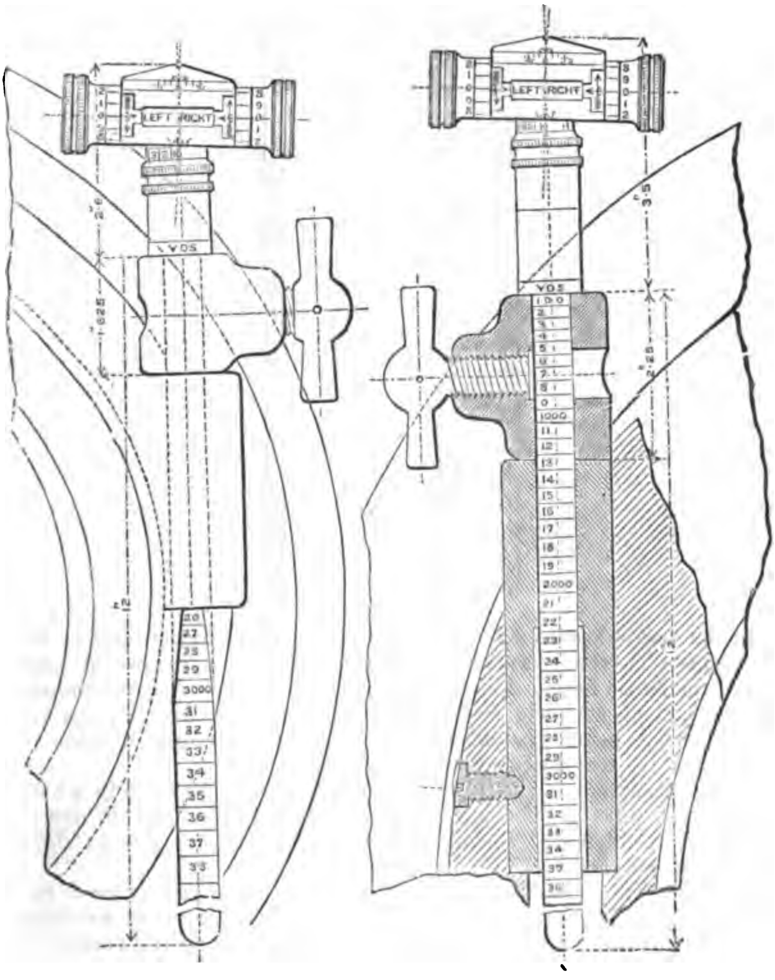
BARREL-HEADED SIGHTS, WITH MOVEABLE CLAMP.

Scale ⅜″ = 1 foot

R.B.L. (breech-screw) 40-pr., 35 and 32 cwt.

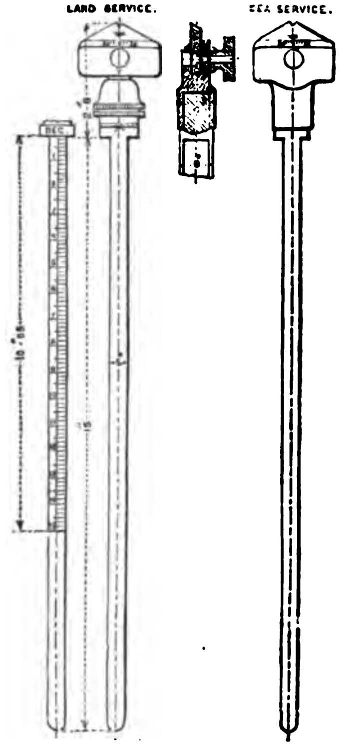
R.B.L. 7″ 82 cwt. (with gun metal socket).



CH. VI. S. 1.

SLIDING-LEAF SIGHTS.

Scale 2½" = 1 foot.



In the barrel-headed sights the leaf is traversed to the right or left by means of a screw worked by milled-headed thumbscrews at each end of the barrel head. This screw is of such a pitch that the thumbscrews make a complete revolution in traversing the leaf 10′, and the circumference being graduated from 1 to 10 any required number of minutes can be accurately given.

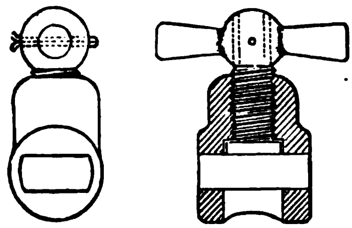
There are arrows on the barrel head showing the direction in which the screw is to be turned to give right or left deflection, and the deflection scale is graduated to half a degree (30′) on each side in three divisions of 10′ each.

Sliding-leaf sights. In the present sliding leaf pattern the leaf is traversed by hand and clamped in the required position of a milled-headed screw on the front or muzzle side, and, though not quite so accurate as the old pattern, it has the advantages of lightness and cheapness, and is not so liable to become stiff in working. It is only necessary to use the deflection scale in order to allow for wind or similar causes of irregularity.

Graduation. The steel tangent bars are graduated on one of their narrow sides in degrees, any on the other in yards. Those for the 7-inch guns of 82 cwt. have also a graduation on one of their flat sides (right), showing the number of tenths of fuze corresponding to the range scale. Each degree is divided into six divisions of 10 minutes each.

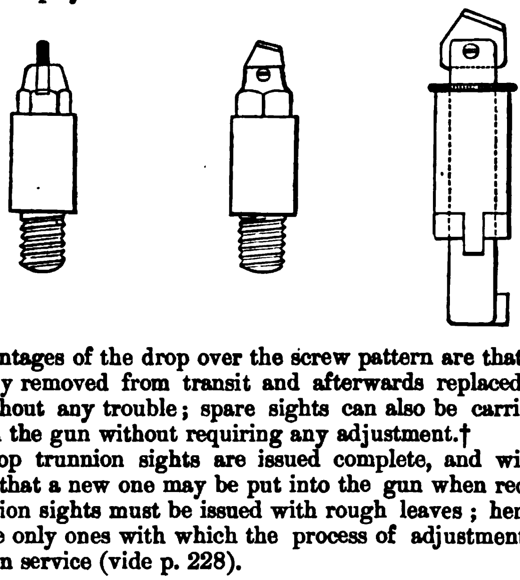
Clamping arrangements. Set s—— In the 20-pr. and lower natures the tangent sights are clamped at the proper elevation by means of a copper set screw, secured by chains to the piece. In the other two natures* the sight is fixed by a "moveable clamp," which permits of the sight being removed from the socket and taken to the light for adjustment during the operation of loading, a useful arrangement between decks or in casemates. Moveable clamp.

MOVEABLE CLAMP.



A list of different marks of sights for each nature is given at p. 71, and also in notes to the same the reasons are given on account of which alterations were made.

There are two kinds of trunnion sights, viz., the *screw* pattern and the *drop* pattern, as shown in diagram below; for description vide p. 114. The former is used with field guns, *i.e.*, 12-prs., 9-prs., and 6-prs.; they are screwed into the gun so that they may not be shaken about and loosened when moving over rough ground. The latter is used with the higher natures. With the 7-inch of 72 cwts., however, a large screw fore sight is employed. Trunnion sights. Screw pattern.



The advantages of the drop over the screw pattern are that the former can be easily removed from transit and afterwards replaced in its true position without any trouble; spare sights can also be carried ready to be placed in the gun without requiring any adjustment.† Drop pattern.

Spare drop trunnion sights are issued complete, and with the leaf finished, so that a new one may be put into the gun when required; but screw trunnion sights must be issued with rough leaves; hence the field guns are the only ones with which the process of adjustment has to be performed on service (vide p. 228). Adjustment.

* The 7-inch of 72 cwts. has its sights clamped by a fixed set screw.

† Screw trunnion sights are as far as possible made interchangeable, but on account of the great difficulty experienced in finishing off a thread with the very minute accuracy required in this case, some allowance would have to be made wherever there is a change of position. These sights can be used for either side, if circumstances should require it, only with the risk of a slight chance of error. With drop sights the case is different, there we have no screw, they can be finished off as desired, while any slight error in boring for the socket, &c., is made up for when the sockets are finally adjusted in the gun (see p. 115).

CH. VI. S. 2.

Both tangent and trunnion sights are marked for the nature of gun to which they belong, and all tangent sights (both L.S. and S.S.) are interchangeable for the same natures except between the L.S. and S.S. 20-prs.

Wood side scales.

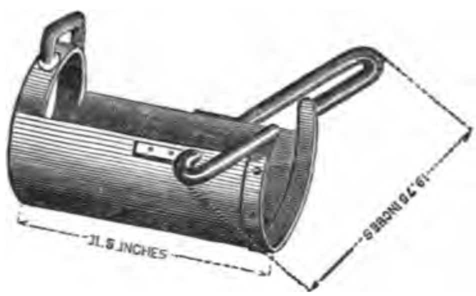
Besides tangent sights, R.B.L. guns for S.S. down to 20-pr. inclusive, are supplied with wood side scales, giving 12° elevation and 6° depression, somewhat similar to those for S.B. guns. In the case of the 20-pr. 13 cwt. gun, however, when used on the decks of iron clad ships, the wood side scale is rectangular in section and has a moveable pointer similar to those employed with R.M.L. guns, and gives 20° depression and 12° elevation.

Moveable pointer.

Stores.

The stores for R.B.L. guns made in the Royal Gun Factories are as follows. A table of the same is given at the end of this chapter.

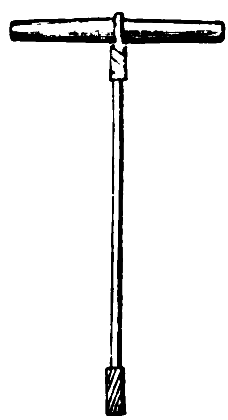
Bearers, Shot.



Shot bearer. § 919.

These shot bearers are of iron, with three handles covered with leather, and are so made that the projectile cannot be dropped from them. They are known as "Alderson's pattern." Two are issued for each 7″ gun.

Bits, Vent (Armstrong). Scale ¼.



The Armstrong vent bit is of steel, with a cross-handle of wood (similar in shape to a gimlet). It is used to clear the channel of vent-pieces, should the copper bush become burred, and there is but one pattern for all natures. One to four 7″ or 40-pr. guns. For field service 1 per division. CH. VI. S. 2. Vent bit. § 842.

Bushes.

Bushes, breech, iron, thick, 7-inch.—Two inches long, half-inch thick, and is screwed into the breech end of the A tube of 7″ guns. Breech bushes. § 399. § 467.

Bushes, breech, iron, thin, 7-inch.—Three inches long, quarter-inch thick, and is screwed into the thick bush. *Spare,* 1 per gun.

Bushes, breech, copper.—Screwed into the breech end of the A tubes of 40-pr. breech-screw guns and under, and projects ·03 inch so as to enable it to be refaced. *Spare,** 2 per gun. §§ 526, 530. See also § 1145.

Bushes, copper, vent-piece.—*Spare,** 1 to two 7″ guns; 1 to two 40-pr. for Garrison Service, and 1 for each gun for Field Service. § 1232.

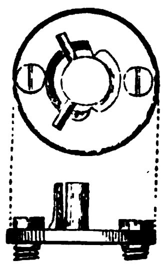
Clamps, Moveable, for Tangent Sights.

The moveable clamps are of gun metal. See page 59. Clamp for sight. §§ 1144, 1357.

Collars, Leather, for Breech-Screws.

This collar fits on the breech-screw of 12-pr. guns, in rear of the breech. When the vent slot was widened for a thicker vent-piece some of the threads of breech-screw were exposed, and this collar protects that part. It can be pared as the copper is faced away. Leather collar. § 845.

CRUTCHES, IRON. Scale ½.



The vent-pieces of 40-prs. and smaller natures for sea service not affording room for a friction tube pin are fitted with a crutch, attached round the mouth of the vent channel by two screws. A slot is cut in the horizontal part of the crutch, through which the friction bar of the quill tube passes, thus the head of the tube is supported, and the liability to its being broken off prevented when pulling the lanyard. Crutch. §§ 27, 688.

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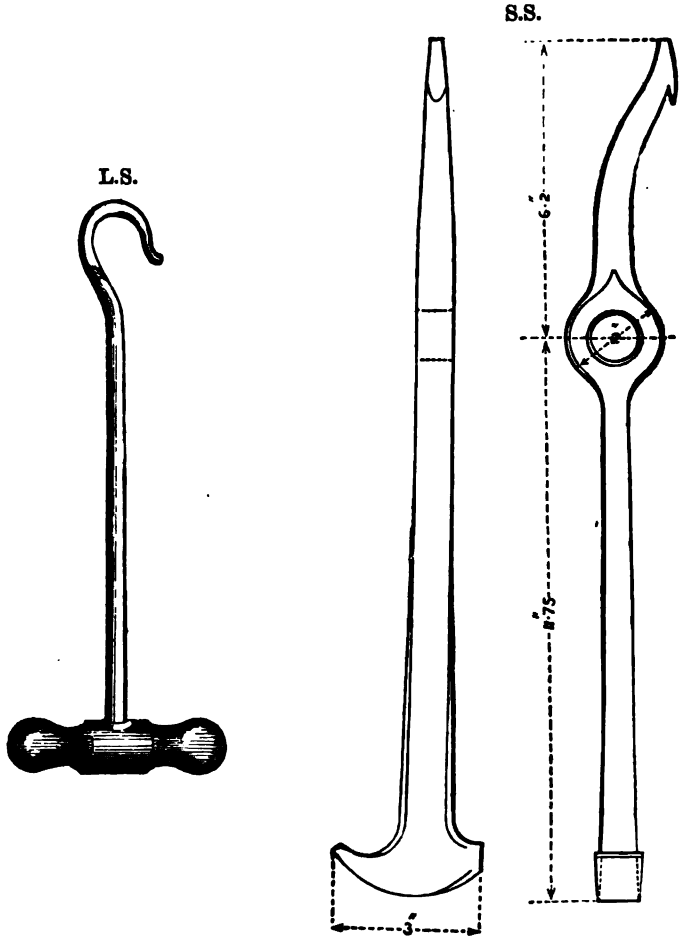
* These copper articles should be carried in some place where they would not be liable to be injured, or put out of shape.

CH. VI. S. 2. With guns used for field marine purposes the crutch has two slots so as to enable them to be fired from the left side when on land.

EXTRACTORS, TIN CUP.

Tin cup extractor.



The tin cup extractor for *L.S.* is an iron hook with a wooden cross-handle. One to each gun.

§ 738. For S.S. it is an iron lever with a barbed hook at one end to extract the tin cups, whilst at the other end it has a curved-shaped hammer, used

§ 1259. as a "lever lifting joint."

The above are only used with 7" guns.

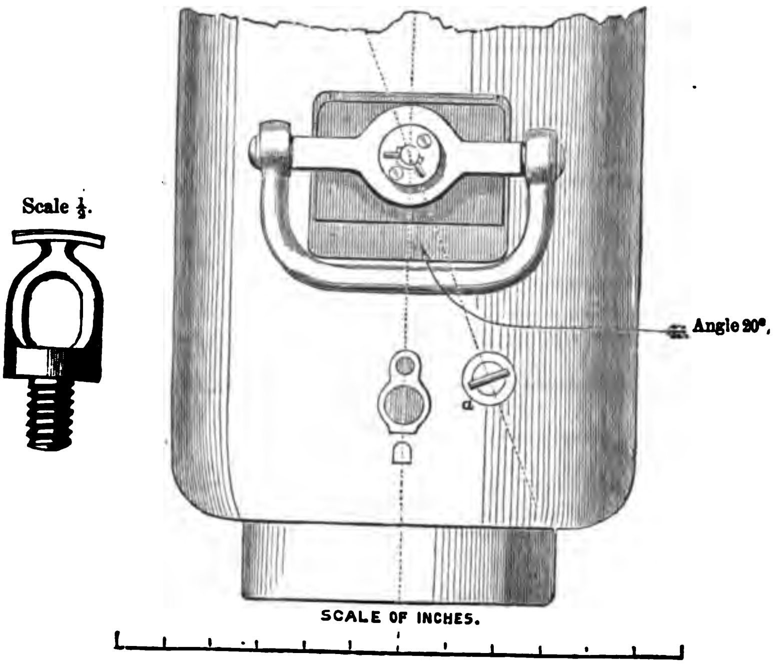
Eyes, Elevating (with Bolt, Washer, and Keep Pin).

Elevating eyes. §§ 173, 690, 717, 718, 998. See also § 102.

The elevating eyes are of iron, and are screwed underneath the breech of L.S. field guns only. The 20-pr., 12-pr., and 9-pr. are double-headed, but the 6-pr. is solid-headed; the heads of the elevating screws will therefore respectively be single-headed and double-headed. CH. VI. S. 2.

GUIDE PLATES.

Scale ½.



a Guide plate.

Guide plate. **§§ 476, 688.**

Guide plates are of steel, and one is screwed in at the right rear of the vent slot to guide the lanyard—which passes through it—direct on the quill friction tube. It has a cross-head on the top, to which a loop on the lanyard can be attached when the gun is loaded, and so prevent the gun being fired accidentally. The navy alone use it, as they fire their guns from the rear immediately the object is in line, and this guide plate enables the gunner to have a steady and direct pull on the lanyard while looking over the sights.

Implements, Facing.

Facing implements. **§§ 515, 516, 574, 575, 745, 1073.**

For detail of facing implements see *Table* p. 240.—7″ one per district, one in reserve; 40-prs. one per battery, one in reserve; other guns one per battery. The use of these instruments is described at p. 224.

Instruments taking Impressions of Bores of Guns.

Instruments for taking impressions **§ 1312. See also § 1625.**

For taking impressions of bores of guns there are two sets of instruments. The small set (No. 2) is used for guns up to 20-pr.; the other (No. 1), from 40-pr. upwards, both M.L. and B.L. A set consists of a semi-cylindrical iron frame, about 2 feet long, connected with an iron

CH. VI. S. 2. tube in such a manner that by screwing up a rod which passes through the tube the frame can be worked up or down.

Upon this frame a gun metal or iron plate, corresponding to each calibre of gun, is screwed, and when an impression is required gutta-percha is spread on the plate, and by means of the rod is pressed against the defective part.

Plates are not necessary for the 6-pr. or 40-pr. guns, as the frames answer the purpose required.

Instruments, Sighting, Set.

Sighting instruments. §§ 1061, 1096.

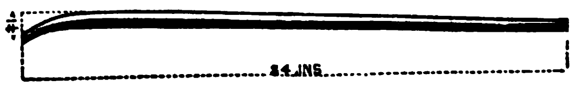
Sighting instruments are for special issue only. *See* Ordnance Select Committee Proceedings, 1867.

Levers.

Levers.

Levers, breech-screw.—See page 54.

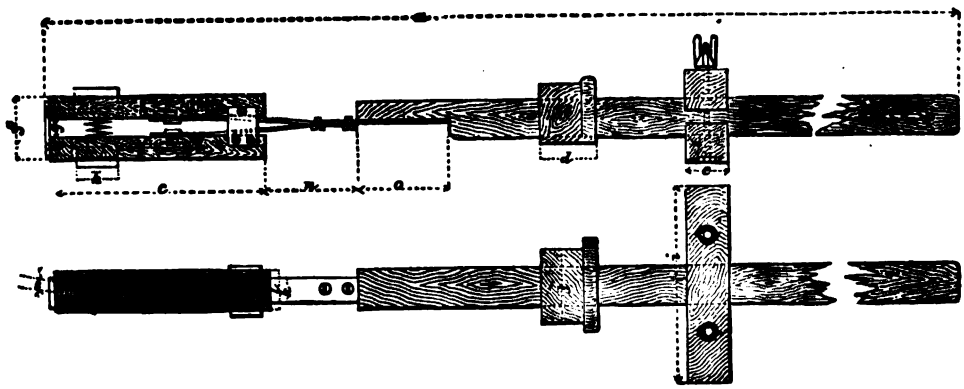
LEVER, IRON, FOR RELEASING VENT-PIECE. Scale 1 in. = 1 foot.



§ 769. See also § 1484.

Lever, iron, releasing vent-piece.—Is an iron crowbar about 2 feet 10 inches long, for prizing out the vent-pieces of 7-inch guns when they jam.—One per gun.

MACHINE, HAND-RIFLING (for 6-pr. B.L. Gun. Scale 1½ in. = 1 foot).



Hand rifling machine. §§ 973, 1096.

There is one hand-rifling machine for each nature of gun, and they are nearly all alike in patern. They are for the purpose of filing down any metal that may be turned up in the bore by the premature bursting of a shell, or other cause. The machine consists of—

1 Bar, working, (*b*) with cross-handle. (The 12-pr., 9-pr., and 6-pr. have no cross-handles.)
1 block, guide (*d*).
2 cutters, file (*h*).
1 distance piece, in halves, with bolts and nuts (*e*).
1 head, filing, with springs (*c*).
2 screws, fixing.

The filing head is of hornbeam wood, and is grooved like the barrel of the gun. The head is expanded by means of long springs, in the 7″ there are two, in the other natures one, and small files can be fitted on either side of the head which are kept up to their work in the bore by a spiral spring fixed beneath them.* One file is for the grooves and the other for the lands, and they are shaped accordingly; only one file at a time can be used. When required to be used the file for the lands or grooves (according to circumstances) is fixed and worked backwards and forwards until the bore is smooth. The guide block, which is placed in the muzzle, keeps the bar in the centre, and the distance piece is clamped on the bar at the ascertained distance of the flaw, &c. from the muzzle, thereby ensuring the action of the file on the proper place.

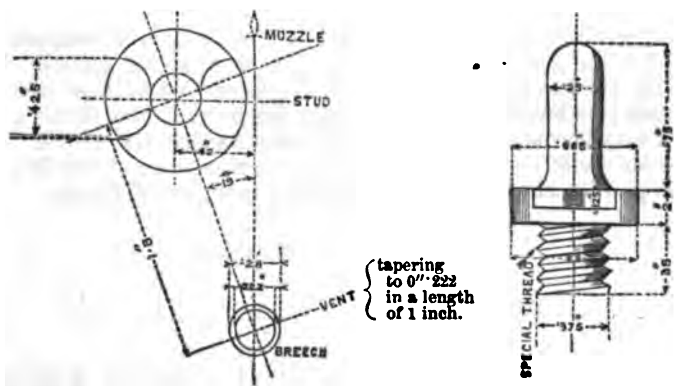
Patch, Metal, Elevating.

Elevating patch. §§ 717, 718. See also § 102.

These patches are made of gun metal, and screw into the elevating eye holes of 12-pr., 9 pr., and 6-pr., guns when fitted for sea service. The 9-pr. patch has a steel screw.

Pins.

PIN, FRICTION TUBE.



Friction tube pin.

Pins, friction Tube, are of wrought iron, case hardened, and are inserted 1″·3 to the left front of the vent channel of 7″ vent-pieces, for sea service only. The loop of the quill friction tube fits over the pin, and the mouth of the vent being rimed out to a depth of 1 inch, giving the tube a little play, ensures the pull of the lanyard acting upon the loop of the tube. The pin is now 1 inch long to prevent a liability of the loop slipping off. See *Crutches, iron.*

Lever keep pins.

Pins, keep, lever.—See page 54. *Spare,* one per 7″ and 40 pr.; two for other guns.

* The 7″ has no spiral spring, the double spring being sufficient for the purpose.

CH. VI. S. 2.

Pivot, Steel, for elevating Arcs.

Pivots.

Plates, metal, elevating (vide p. 129 for description).

Elevating plates.

These stores are only required with the 20-pr. B.L. guns of 13 cwt. S.S. when mounted on wrought iron sliding carriages and slides, which guns will be fitted on both sides of the breech with the necessary screw holes. Only one plate is used, which is triangular, as in the case of the 40-pr. R.M.L.

Rings.

Vent-piece ring. §§ 472, 526, 530. See also § 528.

Rings, copper, vent-piece.—Have a half dovetail on the inner side, which prevents the passage of the powder gas down between it and the iron of the vent-piece. It projects from the face of the vent-piece when new ″·05, so that it can be re-faced from time to time, as it is found to wear. Small channels are cut on the inside of the ring to allow the confined air to escape when placing it on the vent-piece. *Spare*, two per field gun; they should be carried in some place where they are not liable to be injured or put out of shape.

Indicator ring. §§ 790, 1033.

Rings, Indicator, for 7″ and 40-pr. B.L. Gun.—Vide diagram and description at p. 55.

Tappet rings.

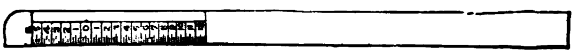
Rings tappet.—See p. 55.

Saddles, Metal.

Metal saddles.

These metal saddles form the vent rest for the 7-inch guns, and are attached to the gun in rear of the vent slot by means of screws. The saddle for the 72 cwt. gun A is about 2½ inches shorter than that for the B gun (the breech of the latter being longer than the former), and is fixed with four screws. All the other saddles have six screws. The saddles for the 82 cwt. gun are stouter made than those of the 72 cwt., and the position of the holes for fixing them is slightly different.

Scale, Wood, Side. Scale 1″ = 1 foot.



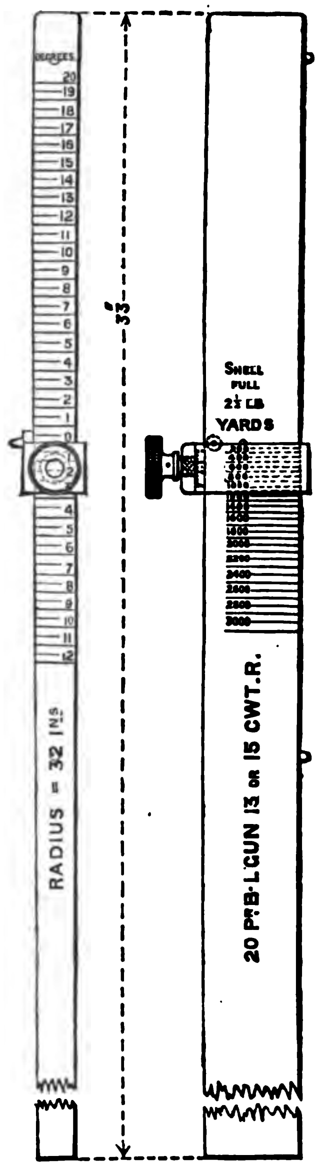
Wood side scale. § 1204.

The wood side scale is used by the navy for broadside guns independently of all other sights, when the object to be hit is obscured by smoke, &c., thereby rendering the other sights useless. It must be used in connexion with the ship's pendulum, or other means employed to show the heel of the vessel, and the number of degrees of elevation or depression to be added or deducted from the required range, *i.e.*, if firing from the windward side, and the pendulum showed 3° of heeling over, *deduct* 3° from the correct elevation for the range of the object aimed at to allow for the inclination of the ship's deck.

These side scales are adjusted to the rear chock of the carriage with the zero notch coinciding with a point on the vertical line intersected by the horizontal line cut on the right side of the breech, the gun being horizontal. They are graduated to give 6° depression and 12° elevation, the radius being the distance from the centre of the trunnion to the point of intersection on the side of the breech.

The wood side scale for the 20-pr. of 13 cwt. is rectangular in section and has a moveable pointer similar to that used with R.M.L. guns (vide p. 121). This scale gives depression down to 20°, and from 0° to 12° of elevation. CH. VI. S. 2.

20-PR. B.L.R. GUN, 13 OR 15 CWT. Scale, Wood, ¼ size.



Screws.

Screws, breech.—*See* page 54. Screws.

Screws, copper, set, right-hand and left-hand.—Are used for the purpose of clamping the tangent sight, and pass through bosses in the §§ 935, 901–906, 1034, 829.

CH. VI. S. 2. tangent sight ring. These set screws for the 20-pr., downwards, are attached to the guns by a small chain. *See* p. 58.

Screws, fixing, plates, metal, elevating. Wrought iron, and fasten the elevating plate to 20-pr. of 13 cwt. *See* p. 66.

§ 688. *Screws, fixing, crutch.*—Wrought iron, and attach the crutch to the top of the vent-piece.

Screws, fixing, metal saddle.—Wrought iron, and attach saddle to 7″ guns. *Spare* one per gun.

§ 485. *Screws, preserving.*—Wrought iron. Occupy the holes for the crutch, friction tube pin and guide plate, when the gun is used for land
§ 30. service, *and mounted*. When dismounted, those in the gun are removed and the holes filled with grease, to prevent the screw heads from being broken off.

Sights.

Sights. § 1480. *Sight, instructional, wood.*—Hexagonal in shape, and an enlarged model of the tangent sight. Rectangular are also issued on demand.

Sight, tangent.—*See* p. 58.

§§ 1143, 1476. § 872. *Sight, trunnion.*—*See* p. 59.

Sockets, Metal.

Metal sockets. § 1481. These gun metal sockets are for the hind centre sight and tangent sight.—*See* p. 106.

Straight-Edges for testing Breech-screws, &c.

Straight-edge. § 1016. The straight-edges are of steel, $18'' \times 1\frac{1}{2}'' \times \frac{3}{10}''$. *See* p. 223.

Vent-pieces.

Vent-piece. § 1185. *For vent-pieces*, see p. 53. For field batteries, two vent-pieces per gun are issued; one is carried in the gun, one at the side of the trail, and two in addition per battery. Garrison and siege batteries have three per gun.

Wrench, fixing elevating racks.

Wrench for elevating plates. Are used to attach the elevating plates and racks to the 20-pr. R.B.L. guns when mounted on the decks of iron clads. Vide p. 132 for description of this store.

TABLE IV.—Nature of Tangent Sights* and Particulars of Graduations for Rifled B.L. Guns.

Nature of Gun.	Permanent angle of Deflection of Sights.	Length of Radius in Inches.	Graduations for Degrees.		Graduations for Yards.			Remarks.
			Number.	Length in Inches.	Number.	Charge in lbs.	Length in Inches.	
7-inch B.L. 82 cwts.	2° 16′	45	15	12·057	3,600	11	8·286	
7-inch B.L. 72 cwts.	2° 16′	41·2	10	7·36	—	—	—	
40-pr. B.L., 32 and 35 cwts.	2° 16′	45	15	12·057	3,800	5	8·4319	
20-pr. B.L. 16 cwts.	2° 16′	36·2	12	7·656	3,500	2½	6·923	
20-pr. B.L. 15 and 13 cwts.	2° 16′	23·45	15	6·195	3,000	2¼	4·2373	
12-pr. B.L., 8 cwts.	2° 16′	32·375	10	5·71	3,400	1½	6·033	
9-pr. B.L., 6 cwts.	2° 16′	23·45	15	6·195	3,000	1¼	4·044	
6-pr. B.L., 3 cwts.	2° 16′	23·45	15	6·195	3,000	¾	4·506	

* Besides tangent sights, the Rifled B.L. guns for S.S. down to 20-prs. inclusive, are supplied with wood side scales (vide p. 66).

Note.—The metal heads of the sights are not to be polished, as it would eventually destroy heir accuracy.

TABLE V.—Table showing the Number of R.B.L. Guns in the Service, with the various kinds of Barrels.

Nature.		Barrels. Coiled.	Solid forged.	Steel.	Total.
Breech-Screw.					
7-inch	82 cwt.	699	179	5	883
	72 „	35	41	—	76
40-prs.	35 „	791	—	28	819
	32 „	194	—	—	194
20-prs.	16 „	83	—	6	89
	15 „	26	—	5	31
	13 „	100	187	5	292
12-pr.,	8 „	294	286	121	701
9-pr.,	6 „	261	5	—	266
6-pr.,	3 „	80	—	18	98

TABLE VI.

Weights of R.B.L. Vent-pieces and Brcech-Screws.

Vent-pieces:—	Cwt.	qrs.	lbs.
7-in.	1	0	24
40-pr.	0	2	3
20-pr.	0	0	27¾
12-pr.	0	0	15
9-pr.	0	0	14¾
6-pr.	0	0	8¼

Breech-screw complete, with lever, tappet ring, and keep pins:—

	Cwt.	qrs.	lbs.	Pitch of thread. Inch.
7-inch	5	2	18	1·4
40-pr.	2	1	13	0·9—32 cwt. gun 0·7—35 „
20-pr.	1	0	8¾	0·5
12-pr.	0	2	12	0·5
9-pr.	0	2	6¾	0·5
6-pr.	0	1	10	0·5

TABLE VII.

TABLE showing the FITTINGS and STORES for R.B.L. SERVICE GUNS.

Nomenclature of all Fittings and Stores made in the Royal Gun Factories for the RIFLED B.L. GUNS.	7-inch Gun. 82 cwt. Sea Service.	7-inch Gun. 82 cwt. Land Service.	7-inch Gun. 72 cwt. Land Service.	40-pr. Gun. Sea Service.	40-pr. Gun. Land Service.	20-pr. Gun. Sea Service.	20-pr. Gun. Land Service.	12-pr. Gun. Sea Service.	12-pr. Gun. Land Service.	9-pr. Gun. Sea Service.	9-pr. Gun. Land Service.	6-pr. Gun. Sea Service.	6-pr. Gun. Land Service.	Remarks.
Bearers, shot*	1	1	1	–	–	–	–	–	–	–	–	–	–	Issued in certain proportions as required.
Bits, vent, Armstrong*	1	1	1	1	1	1	1	1	1	1	1	1	1	
Bushes, breech, iron, thick	1	1	1	–	–	–	–	–	–	–	–	–	–	
Bushes, breech, iron, thin	1	1	1	–	–	–	–	–	–	–	–	–	–	
Bushes, breech, copper	–	–	–	1	1	1	1	1	1	1	1	1	1	
Bushes, copper, vent-piece, sets	1	1	1	1	1	1	1	1	1	1	1	1	1	
Clamps, moveable, for tangent sights	2	2	–	2	2	–	–	–	–	–	–	–	–	
Collars, leather, for breech-screw	–	–	–	–	–	–	–	–	1	–	–	–	–	
Crutches, iron	–	–	–	1	–	1	–	1	–	1	–	1	–	
Extractors, tin cup, L.S.	–	1	1	–	–	–	–	–	–	–	–	–	–	
Extractors, tin cup, S.S. with lever, lifting joint.	1	–	–	–	–	–	–	–	–	–	–	–	–	
Eyes, elevating	–	–	–	–	–	–	1	–	1	–	1	–	1	
Guide plates*	1	–	–	1	–	1	–	1	–	1	–	1	–	
Implements, facing, set	1	1	1	1	1	1	1	1	1	1	1	1	1	
Instruments, taking impressions of bore of guns. No. 1	1	1	1	1	1	–	–	–	–	–	–	–	–	
Instruments, taking impressions of bore of guns. No. 2	–	–	–	–	–	1	1	1	1	1	1	1	1	
Instruments, sighting, set	1	1	1	1	1	1	1	1	1	1	1	1	1	
Levers, breech-screw	1	1	1	1	1	1	1	1	1	1	1	1	1	
Levers, iron, releasing vent-piece*	1	1	1	–	–	–	–	–	–	–	–	–	–	
Machines, hand-rifling	1	1	1	1	1	1	1	1	1	1	1	1	1	
Patches, metal, elevating	–	–	–	–	–	–	–	1	–	1	–	1	–	
Pins, friction tube*	1	–	–	–	–	–	–	–	–	–	–	–	–	
Pins, keep, lever	2	2	2	2	2	2	2	2	2	2	2	2	2	
Pins, keep, pivot, elevating	–	–	–	–	–	1	–	–	–	–	–	–	–	For 20-pr. 13 cwt. guns when used on upper decks.
Pivots, steel, for elevating arcs	–	–	–	–	–	1	–	–	–	–	–	–	–	Do.
Plates, metal, elevating	–	–	–	–	–	1	–	–	–	–	–	–	–	Do.
Rings, copper, vent-piece	–	–	–	1	1	1	1	1	1	1	1	1	1	Some 40-prs. of 32 cwt. have no room for an indicator ring.
Rings, indicator	1	1	1	1	1	–	–	–	–	–	–	–	–	
Rings, tappet	1	1	1	1	1	1	1	1	1	1	1	1	1	
Saddles, metal	1	1	†1	–	–	–	–	–	–	–	–	–	–	
Scales, wood, side	1	–	–	1	–	-1	–	–	–	–	–	–	–	-20-pr. 13 cwt.
Screws, breech	1	1	1	‡1	1	1	1	1	1	1	1	1	1	
Screws, copper, set, right-hand	–	–	–	–	‡–	1	1	1	1	1	1	1	1	
Screws, copper, set, left-hand	–	–	–	–	–	1	1	1	1	1	1	1	1	
Screws, fixing, crutch	–	–	–	2	–	2	–	2	–	2	–	2	–	The A pattern gun of 72 cwt. has 4 fixing screws.
Screws, fixing, metal saddle	6	6	6	–	–	–	–	–	–	–	–	–	–	
Screws, fixing, plate, elevating	–	–	–	–	–	3	–	–	–	–	–	–	–	*See* Pins, pivot, elevating.
Screws, preserving, crutch*	–	–	–	–	2	–	2	–	2	–	2	–	2	
Screws, preserving, pin, friction tube*	–	1	1	–	–	–	–	–	–	–	–	–	–	
Screws, preserving, guide plate*	–	1	–	–	1	–	–	–	1	–	1	–	1	
Screws, preserving, plate, elevating	–	–	–	–	–	6	–	–	–	–	–	–	–	
Sights, instructional, wood	–	–	–	–	–	–	–	1	–	–	–	–	–	
Sights, tangent	2	2	-2	2	2	2	2	-2	-2	2	2	2	2	
Sights, trunnion	-2	-2	2	-2	-2	-2	-2	2	2	2	2	2	2	
Sockets, metal, tangent sight	2	2	-2	–	–	–	–	–	–	–	–	–	–	-With two set screws.
Straight-edges, for testing breech-screws and vent-pieces, &c.*	1	1	1	1	1	1	1	1	1	1	1	1	1	Issued in certain proportions as required.
Vent-pieces	1	1	1	1	1	1	1	1	1	1	1	1	1	
Wrench, fixing elevating racks	–	–	–	–	–	1	–	–	–	–	–	–	–	

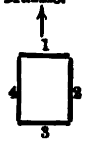
* Universal patterns.
† Different patterns for A and B guns.
‡ The breech-screws for the 40-pr. of 35-cwt. and 40-pr. of 32 cwt. have threads of different pitch and therefore are not interchangeable.

NOTE.—All the above are interchangeable with guns of the same nature, excepting † ‡.

TABLE VIII.

Tangent or Side Sights of R.B.L. Guns.

Muzzle.



Mark of Sight.	No. of Face, vide Diagram.	7-inch. 82 Cwt.	7-inch. 72 Cwt. Hexagonal Bar.	40-pr.	20-pr. 16 Cwt.	20-pr. 13 & 15 Cwt.	12-pr. Hexagonal Bar.	9-pr.	6-pr.
I.	1 2 3 4	§ 935. (2) a 0° to 11° *Blank* C.S. Yards 3,600. Time of Flight—Secs. Common Shell, 12. *Fuze Scale C.S., 2'·0* c	§ 716* (1) a 1. *Blank* 2. *Blank* 3. 0° to 10° 4. *Blank* 5. 0° to 10° 6. *Blank*	§ 901. (2) a 1. 0° to 12° 2. *Blank* 3. Yards 3,800. 4. *Blank*	§ 998. (2) a 1. 0° to 12° 2. *Blank* 3. Yards 3,500. 4. *Blank*	§ 903. (2) a 1. 0° to 15° 2. *Blank* 3. Yards 3,000. 4. *Blank*	§ 829. (1) a 1. *Blank* 2. *Blank* 3. 0° to 10° 10' 4. Yards 3,400. 5. *Blank* 6. *Blank*	§ 905, (2) a 1. 0° to 15° 2. *Blank* 3. Yards 3,000. 4. *Blank*	§ 906. (2) a 1. 0° to 15° 2. *Blank* 3. Yards 3,000. 4. *Blank*
II.	1 2 3 4	§ 1254. (4) b 0° to 15° *Blank* C.S. Yards 3,600. Fuze Scale C.S. 2'·0.	§ 1254. (4) b 1. *Blank* 2. *Blank* 3. 0° to 10° 4. *Blank* 5. 0° to 10° 6. *Blank*	§1254. (4) b 1. 0° to 15° 2. FuzeScaleC.S.2'·0 3. Yards 3,800, 4. *Blank*	§ 1254. (4) b 1. 0° to 12° 2. *Blank* 3. Yards 3,500. 4. *Blank*	§ 1254. (4) b 1. 0° to 15° 2. *Blank* 3. Yards 3,000. 4. *Blank*	§1254. (4) b 1. *Blank* 2. *Blank* 3. 0° to 10° 4. Yards 3,400. 5. *Blank* 6. *Blank*	§ 1254. (4) b 1. 0° to 15° 2. *Blank* 3. Yards 3,000. 4. *Blank*	§ 1254. (4) b 1. 0° to 12° 2. *Blank* 3. Yards 3,000. 4. *Blank*
III.	1 2 3 4	§ 1476. (5) b 0° to 15° d Shell Full 11 lbs. Fuze 24. Full 11lbs. Yds. 3,600. *Blank*		§ 1473. (5) b 1. 0° to 15° d 2. Fuze 25. 3. Shell Full 5lbs. Yards 3,800. 4. *Blank*					

a Barrel head. *b* Sliding-leaf head. *c* In 1866 the "Time of Flight" was omitted and the "Fuze Scale" substituted on Mark I. tangent sight, 7" of 82 cwt. gun.
d The fuze scale is graduated in even tenths, headings of yard scale altered, and weight of charge added. * It was *not* graduated in yards and fuze scale as stated in § 716.
(1) 1863, (2) 1864, (3) 1865, (4) 1866, (5) 1867.

CHAP. VII.

CHAPTER VII.

DIFFERENT NATURES OF R.B.L. GUNS IN THE SERVICE.

R.B.L. Guns in the Service.—7-inch of 72 cwt.—7-inch of 82 cwt.—40-pr., 32 cwt.—40-pr., 35 cwt.—20-pr., 16 cwt.—20-pr., 15 cwt.—20-pr., 13 cwt.—12-pr., 8 cwt.—9-pr., 6 cwt.—6-pr., 3 cwt.—Wedge 64-pr., 61 cwt.—**Table of Dimensions**, &c., &c. of B.L. guns.—Number in the service.

The following is a short description of each nature of R.B.L. gun in the service, a list containing the whole of which will be found at p. 85.

7-inch of 72 cwt. L.S. consists of:

§ 592. *A* tube or inner barrel.
Breech-piece and *B* tube.
Trunnion ring, and
Four coils. (See Lithograph $\frac{\text{R.G.F.}}{\text{No. 12.}}$)

Recommended in 1859 (then 100-pr.), for the navy, as a broadside or, pivot gun, to replace the 68-pr. smooth bore, but it was soon discovered that owing to the gun being so light, the recoil on board ship was excessive; hence only a few (76) of this weight were manufactured.

§ 593. There are two classes of this gun, respectively marked on the left trunnion A and B; they only differ in length of barrel and breech, A being 2″ longer in the barrel than B, and 2″ shorter in the breech.

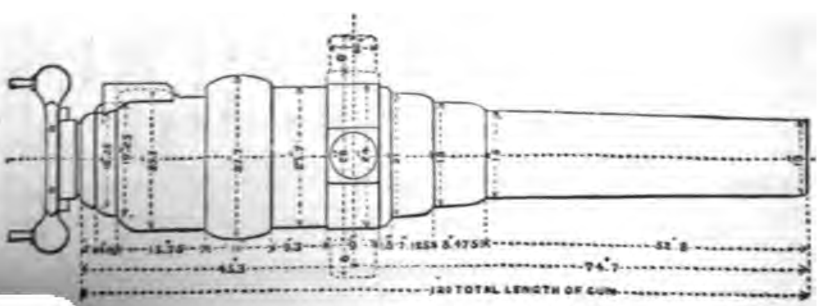
§ 666–899. In 1863 its designation was changed to "light" 110-pr., and finally, to 7-inch of 72 cwt.

This gun is only used for garrison service.

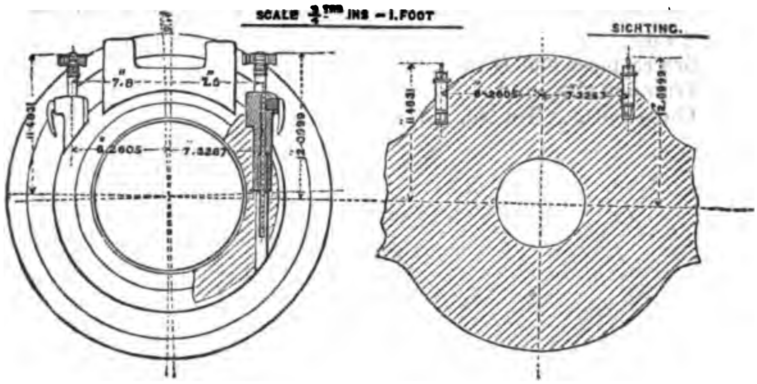
7-inch gun of 82 cwt. L.S. and S.S. consists of:—

§ 935. *A* tube. Trunnion ring, and
Breech-piece and *B* tube. Six coils. (See No. 10.)

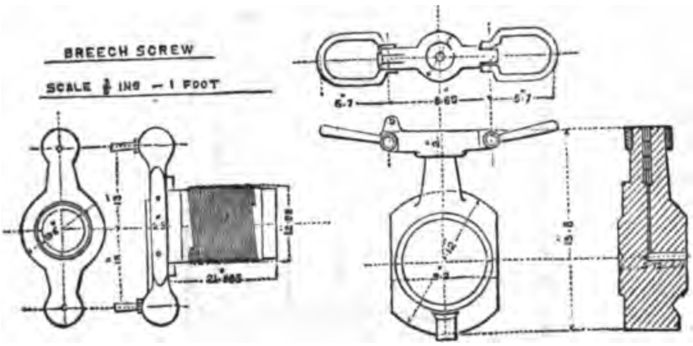
7-INCH R.B.L. GUN, 82 CWT.—Scale ⅜ in. = 1 foot.



CHAP. VII.



VENT-PIECE.†—Scale ¾ in. = 1 foot.



This gun was introduced in 1861, being a stronger gun than the 7-inch of 72 cwt. It is known from the latter by having a high coil in front of the vent slot, termed a "strengthening coil," and an additional coil in front of the trunnions.

It is used by the land and sea service, but not being sufficiently powerful for the penetration of iron plates it has been replaced in the naval service by M.L. guns.

Parliamentary Report on Ordnance, 1863, p. 250.

It was first termed "100-pr.," but afterwards in 1861, when the weight of projectile was increased to 110 lbs., it was so designated 110-pr., and lastly, 7-inch, as at present.

Report on Ordnance, 1862, p. 218. §§ 466–899.

* The sighting, as shown in the diagram, with respect to the socket and clamping, is now that of the 7″ 72-cwt. gun.

† The projection shown on top of the Vent piece is obsolete.

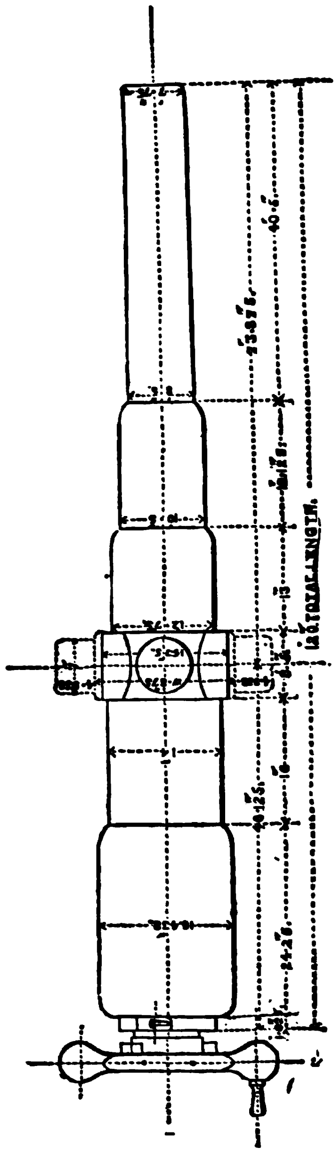
CHAP. VII.

§ 901.

40-pr. gun of 32 cwt.* cal. 4″·75 L.S. and S.S. consists of :—

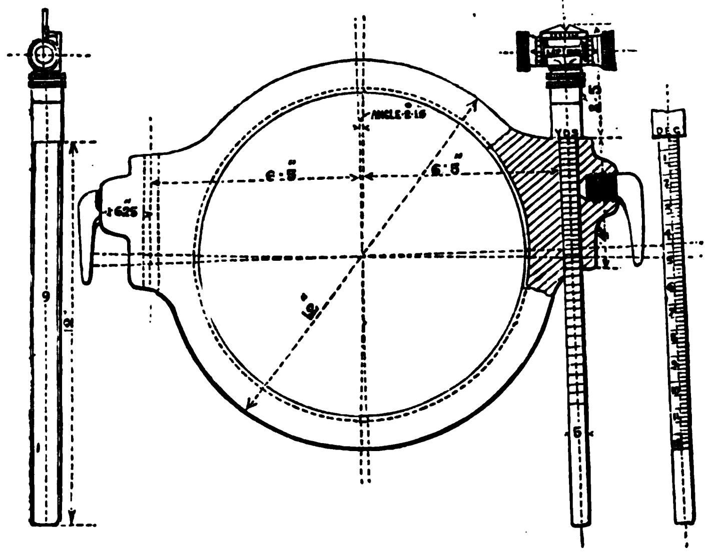
A tube.
Breech-piece and *B* tube.
Trunnion ring, and
Three coils. (See No. 13.)

40-PR. R.B.L. GUN, 32 CWT.—Scale ⅛ in. = 1 foot.

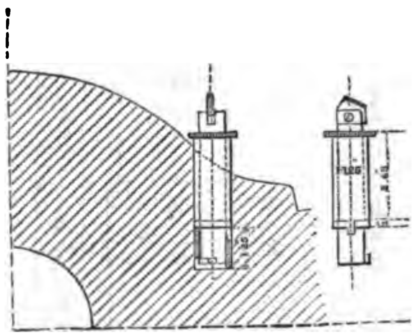


* There were in the service until lately two other B.L. guns with wedge breech-closing apparatus, which are now obsolete. The diagram at p. 84 shows the heavier nature, a 64-pr. of 61 cwts. The other gun was a 40-pr. of 32 cwt.

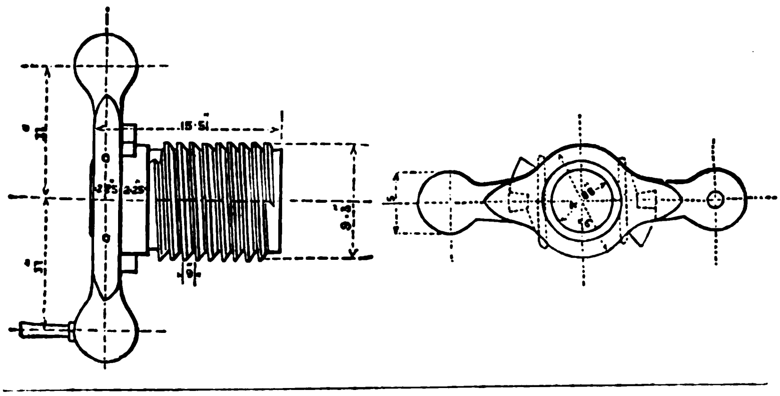
TANGENT SIGHT AND RING. Scale 2 in. = 1 foot.



DROP TRUNNION SIGHT. Scale 2 in. = 1 foot.



BREECH-SCREW. Scale ¾ in. = 1 foot.



* The clamping screws shown in the diagram are now superseded by the moveable clamp.

CHAP. VII.

Report on Ordnance, 1862, p. 176. § 902.

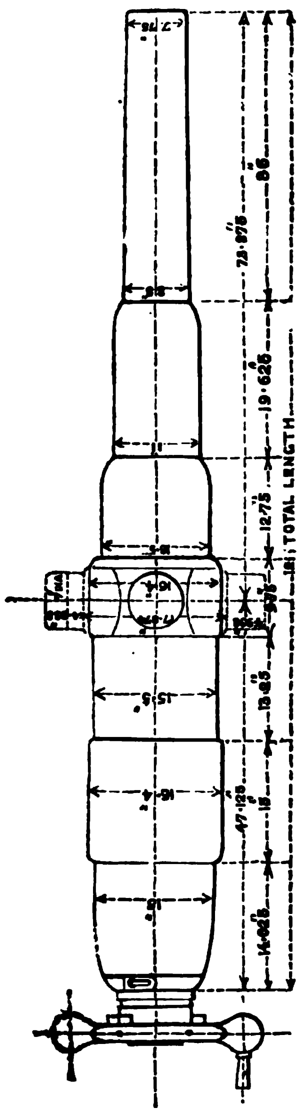
Recommended in 1859, for the navy, as a broadside or pivot gun; it is also now used by the land service for batteries of position, siege and garrison purposes.

A few of these guns have trunnions made of *cast iron*, and are known by the face of the trunnion being bored out in the centre.

This gun is sometimes termed the O.P. (old pattern) 40-pr.

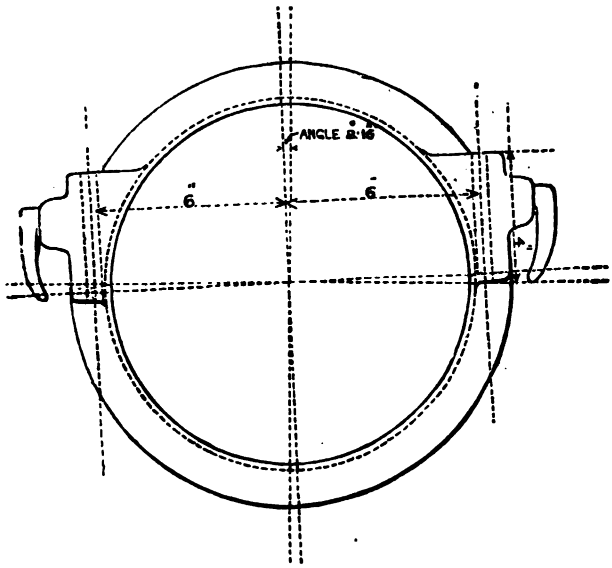
40-pr. gun of 35 cwt. cal. 4″·75 L.S. and S.S. consists of the same number of parts as the 32-cwt. gun, but has a longer and a stronger breech-piece, which is unsupported behind the vent slot and rounded off.

40-pr. R.B.L. Gun, 35 cwt. Scale ½ in. = 1 foot.

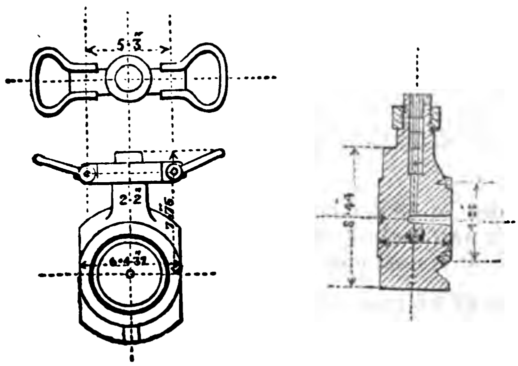


It has a raised coil in front of the vent slot, and is known as the 'G" pattern.

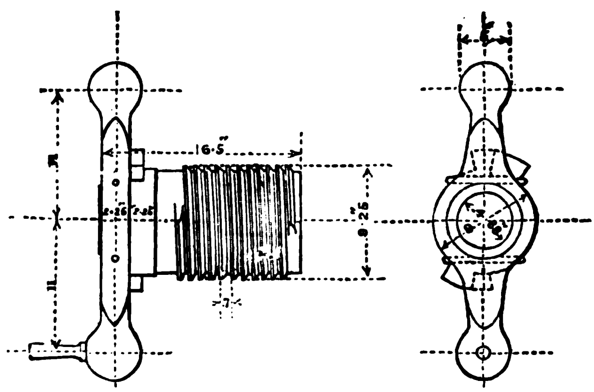
TANGENT SIGHT RING. Scale 2 in. = 1 foot.



VENT-PIECE.* Scale 1 in. = 1 foot.



40-PR. BREECH-SCREW, TAPPET RING, LEVERS, AND KEEP PINS. Scale ¾ in. = 1 foot.



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* Interchangeable for both 40-prs.

CHAP. VII.

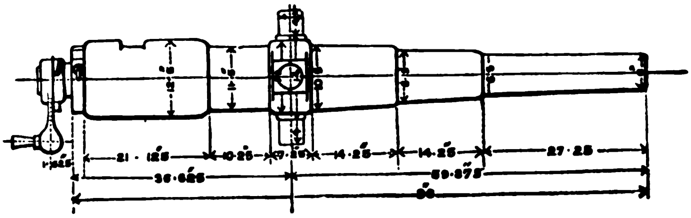
Report on Ordnance, 1862, p. 218.

This pattern was introduced in 1860, more as a matter of precaution than from any symptoms of weakness in the lighter nature. It is used for the same purposes as the 32-cwt. gun, and the fittings are interchangeable with the exception of the breech screw, which has a different shape and pitch of thread.

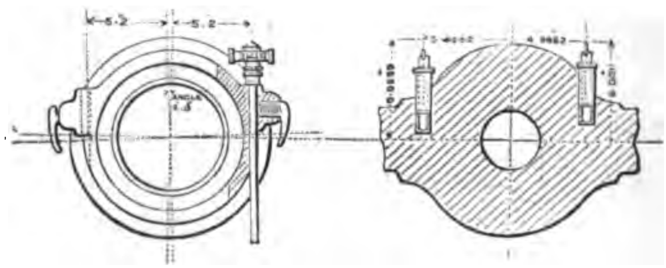
§ 998. **20-pr. gun of 16 cwt.** cal. 3″·75 L.S. consists of:—

A tube.	Trunnion ring, and
Breech-piece.*	Five coils. (See No. 14.)

20-pr. R.B.L. Gun of 16 cwt. Scale ⅜ in. = 1 foot.



Tangent and Drop Sight. Scale 1 in. = foot.



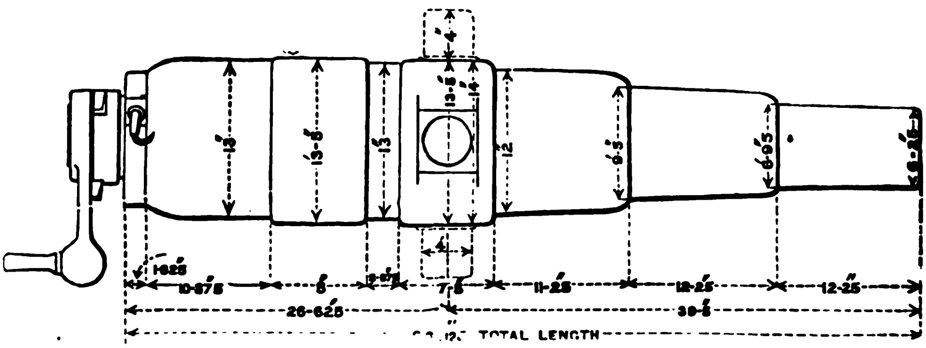
Report on Ordnance, 1862, p. 177.

Recommended in 1859 (then 25-pr.) as a light gun of position, but subsequently it was resolved to use a lighter projectile; hence its alteration to 20-pr. It is used only for heavy field batteries of reserve.

§ 904. **20-pr. gun of 15 cwt.** cal. 3″·75 S.S. consists of:—

A tube.	Trunnion ring, and
Breech-piece.	Three coils. (See No. 15.)

20-pr. R.B.L. Gun, 15 cwt Scale ⅜ in. = 1 foot.



* Guns under 40-prs. have no *B* tubes.

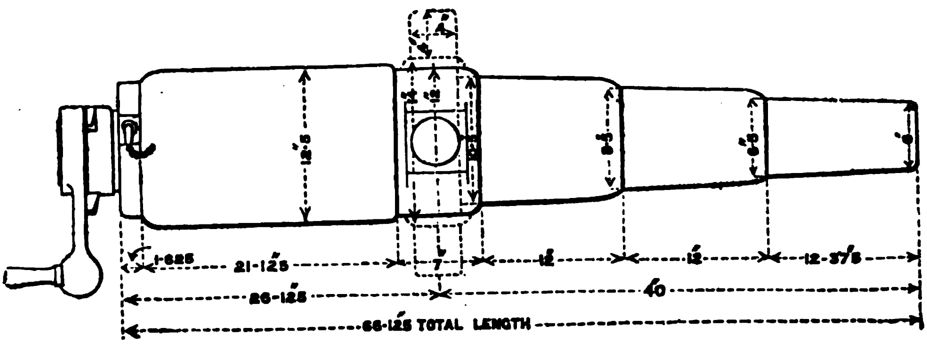
Was adopted in 1859, for the navy, as a broadside gun for ships of the sloop class, in which there is not sufficient width of beam to work the land service 20-pr. Its external appearance is entirely different from that of the land service 20-pr., as it is $2\frac{1}{2}$ feet shorter, has a raised coil in front of the vent slot, and the breech-piece is unsupported in the rear.

Report on Ordnance, 1862, p. 218.

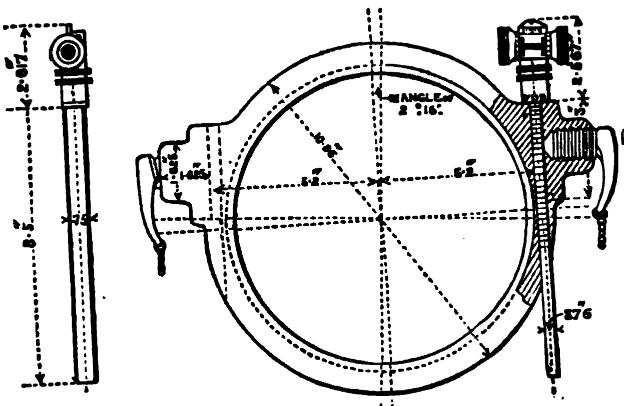
20-pr. gun of 13 cwt. cal. 3·75″ S.S. consists of :— § 903.

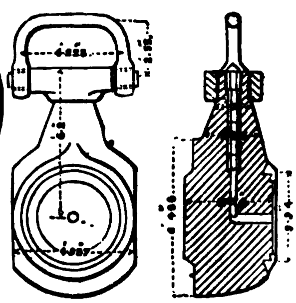
A tube.
Breech-piece.
Trunnion ring, and
Four coils. (See No. 16.)

20-PR. R.L.B. GUN, 13 CWT. Scale $\frac{3}{4}$ in. = 1 foot.



TANGENT SIGHT AND RING. Scale 2 in. = 1 foot. VENT-PIECE. *

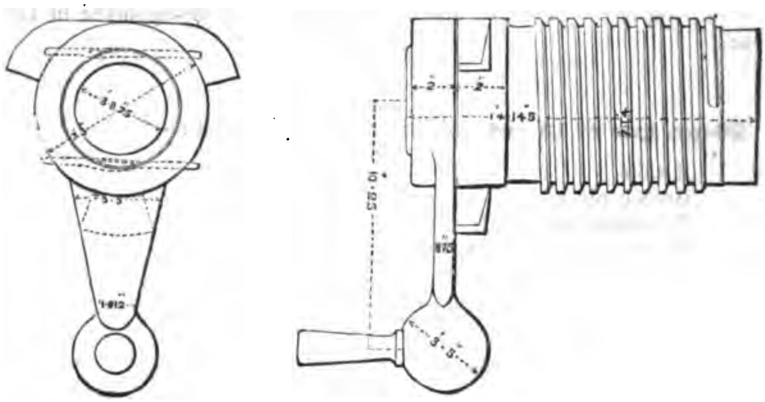




* Interchangeable for all 20-prs.

CHAP. VII.

BREECH-SCREW.* Scale 1½ in. = 1 foot.



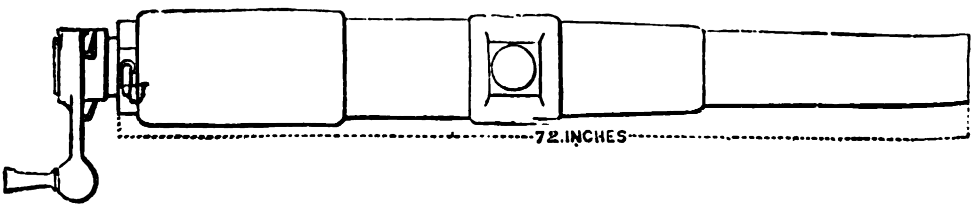
Report on Ordnance, 1862, p. 218; 1863, p. 155. Recommended in 1859, for the navy, as a boat or field marine gun, and is termed the "pinnace gun." This and the 15-cwt. gun are much alike in appearance, but differ in their construction, the heavier pattern being stronger in every respect; neither of them shoot as well as the L.S. 20-pr.

§ 1986. It is now used on the upper decks of iron clad ships for action at close quarters to repulse boarders, for firing at torpedo boats, &c., and is mounted on a carriage which allows 20° elevation or 30° depression. When so used it is fitted on the right side with a gun metal elevating plate, and steel pivot for elevating rack, similar to that used with heavy guns.

§§ 939 and 829. **12-pr. gun of 8 cwt.** cal. 3″ L.S. and S.S., and consists of :—

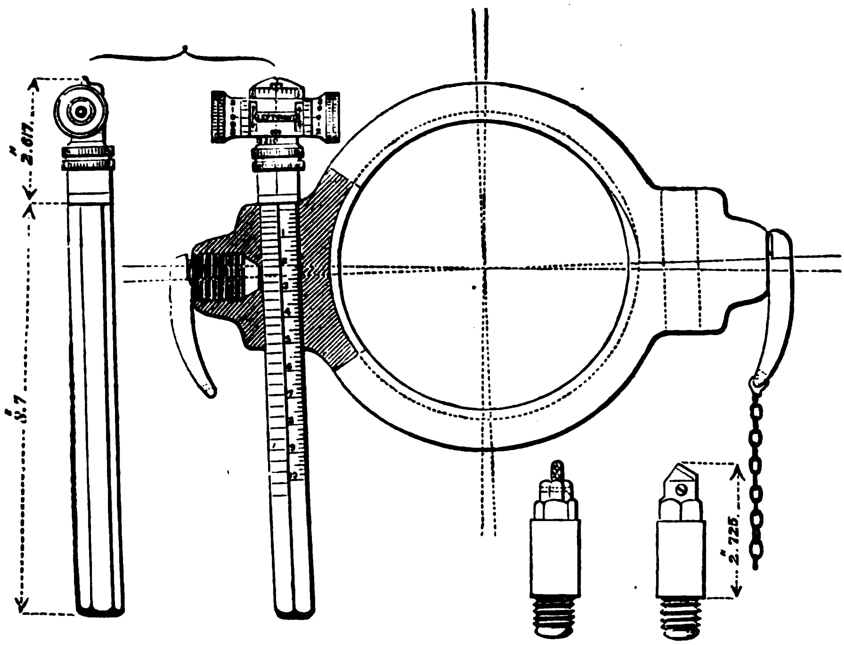
A tube.
Breech-piece.
Trunnion ring, and
Three coils. (See No. 7.)

12-PR. R.B.L. GUN, 8 CWT. Scale ¾ in. = 1 foot.



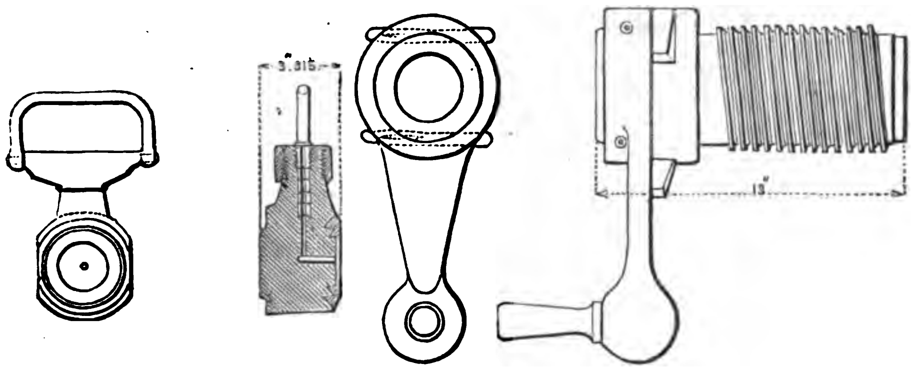
* Interchangeable for all 20-prs.

TANGENT SIGHT AND RING. Scale 3 in. = 1 foot.



SCREW-SIGHT.

VENT-PIECE. Scale 1½ in. = 1 foot. BREECH-SCREW. Scale 1½ in. = 1 foot.



This was recommended in 1858, for the land service, as a field battery gun, and subsequently adopted by the navy as a boat or field marine gun; but the naval pattern was 12 inches shorter, and without the grip at the muzzle. Report on Ordnance, 1862, p. 156. § 401.

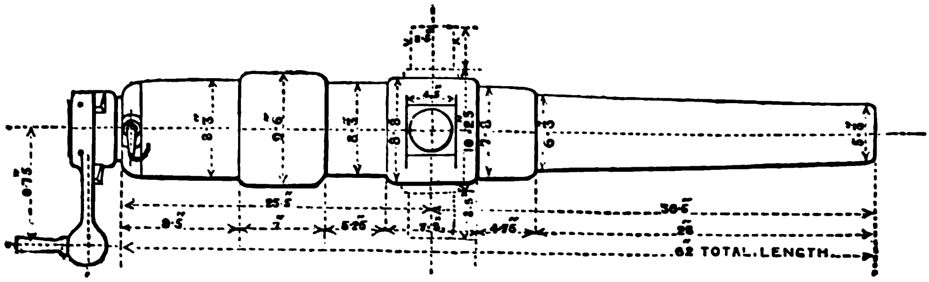
In 1863 an universal pattern was introduced for both services, the L.S. pattern being altered. This necessitated a leather collar as a special store, for the vent slot was widened at its rear part to take a thicker vent-piece, causing a portion of the breech-screw thread to project behind. The leather collar can be pared round according as the breech-screw face wears on service. § 829. § 939. § 826.

CHAP. VII. The calibre of the 9-pr. gun being the same as this gun it can, on an emergency, use the 9-pr. ammunition, but not vice versâ, the 12-pr. ammunition being longer than the 9-pr.

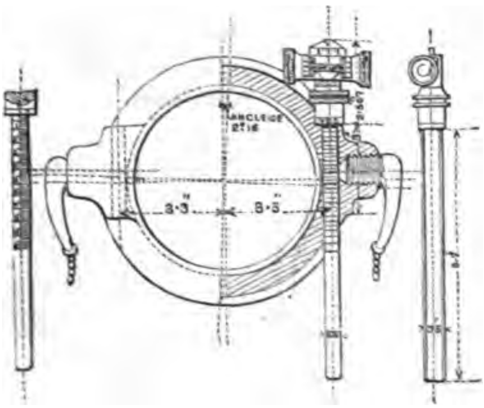
905. **9-pr. gun of 6 cwt.** cal. 3″ L.S. and S.S. consists of :—

A tube.
Breech-piece.
Trunnion ring, and
Three coils. (See No. 6.)

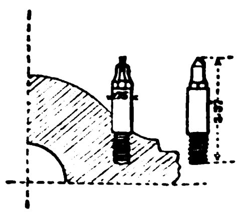
9-PR. R.B.L. GUN, 6 CWT. Scale ½ in. = 1 foot.



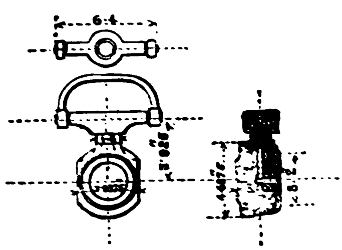
TANGENT SIGHT AND RING. Scale 2 in. = 1 foot.



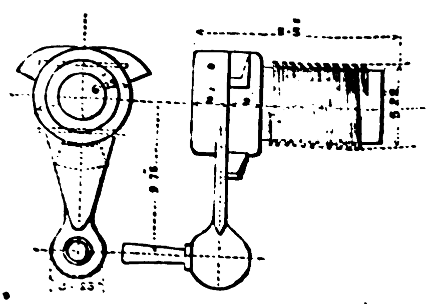
SCREW SIGHT.
Scale 2 in. = 1 foot.



VENT-PIECE. Scale 1 in. = 1 foot.



BREECH-SCREW. Scale 1 in. = 1 foot.



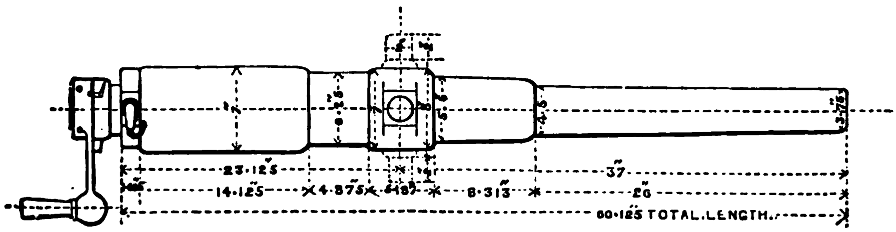
§ 474. § 539. Introduced in 1862, for the Horse Artillery. The navy use it in some cases as a boat or field marine gun.

§ 906.

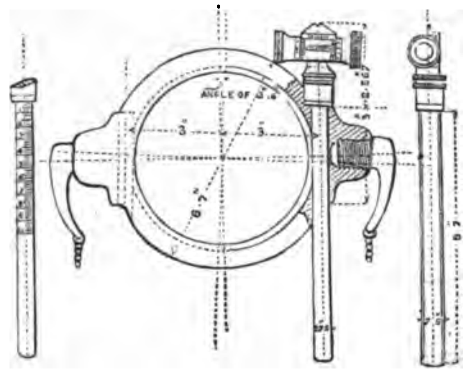
6-pr. gun of 3 cwt. cal. 2·5″ L.S. and S.S. consists of :—

A tube.
Breech-piece.
Trunnion ring, and
One coil. (See No. 5.)

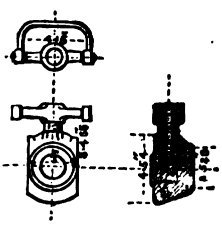
6-PR. R.B.L. GUN, 3 CWT. Scale ¾ in. = 1 foot.



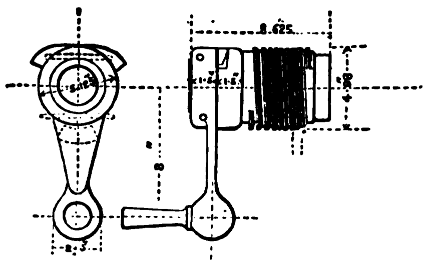
TANGENT SIGHT AND RING. Scale 2 in. = 1 foot.



VENT-PIECE.
Scale 1 in. = 1 foot.



BREECH-SCREW. Scale 1 in. = 1 foot.



Recommended in 1858, for mountain service, but, as it was considered too great a load for a mule, its use is restricted to colonial batteries; the navy employ it as a boat or field marine gun, where not replaced by R.M.L. 7-prs. Report on Ordnance, 1862, p. 156.

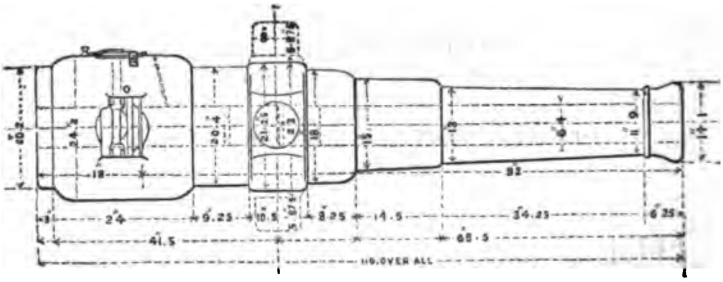
WEDGE GUNS.

§ 997. Wedge Guns.

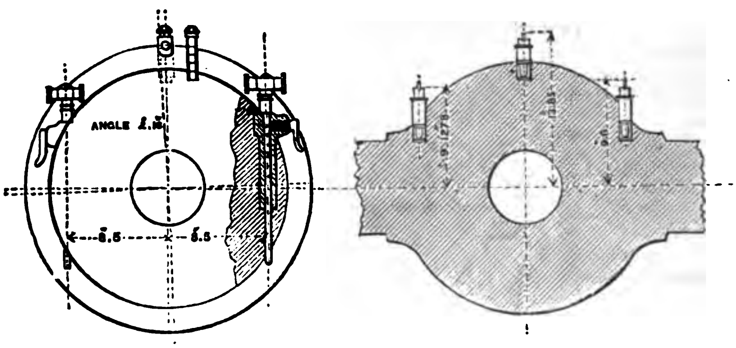
The two natures of wedge guns introduced in 1864, vide p. 32, have been withdrawn from service and placed in reserve, but in order to show the wedge system of breech-closing employed with them the diagram elow is given.

CHAP. VII.

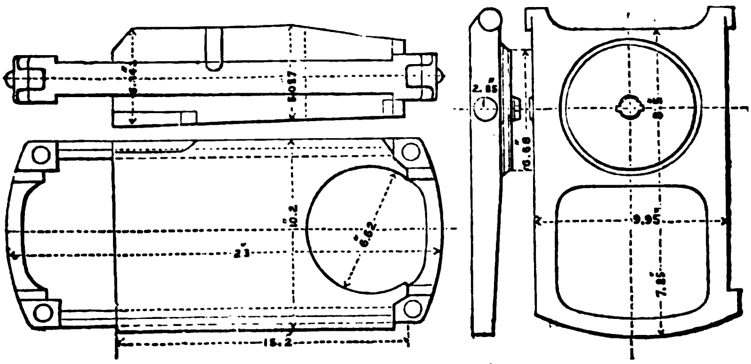
64-pr. R.B.L. (Wedge) Gun, 61 cwt. Scale $\frac{1}{8}$ in. = 1 foot.



Sighting. Scale $\frac{3}{4}$ in = 1 foot.



Wedge. Scale $\frac{1}{10}$ Stopper.



These pieces were built up and rifled like the breech screw guns, but had a horizontal instead of a vertical slot cut towards the breech end of the piece, and the breech was closed by means of a steel *stopper* supported by an iron *wedge* sliding in behind it.

Upon the face of the stopper was hung a tin cup to make the joint gastight.

TABLE IX.—Dimensions, Rifling, Service, &c. of Breech-loading Guns.

Nature, Weight, and Service.	Calibre.	Barrel, Total.	Length. Powder Chamber.	Length. Shot Chamber.*	Length. Nominal.†	Length. From muzzle to axis of trunnion.	Length. From axis of trunnion to breech.	Diameter. Greatest over charge.	Diameter. Muzzle.	Rifling (the many-grooved system). Twist.	Grooves. Number.	Grooves. Depth.	Grooves. Width.	Width of lands.	Preponderance of sealed pattern. cwt.	qrs.	lbs.	Remarks.
Breech-Screw.	"	"	"	"	"	"	"	"				"	"	"	cwt.	qrs.	lbs.	
7-inch of **82** cwt. L.S. & S.S.	**7**	99·5	16·0	9·0	**120**	74·7	45·3	27·7	13	1 turn in 37 cals.	76	·06	·166	·1236	6	3	16	The 7″ B.L. guns have been almost entirely replaced by 7″ rifled M.L. guns of 6½ tons and 90 cwt. for S.S.
7-inch of **72** cwt. L.S.	**7**	97·5	14·25	9·0	**118**	71·25	46·75	24·7	13	Do.	76	·06	·166	·1236	7	3	27	
40-pr. of **35** cwt. L.S. & S.S.	**4·75**	106·375	13·5	7·0	**121**	73·875	47·125	16·4	7·75	1 turn in 36½ cals.	56	·06	·166	·1	4	3	0	
40-pr. of **32** cwt. L.S. & S.S.	**4·75**	106·375	13·5	7·0	**120**	73·875	46·125	16·438	7·75	Do.	56	·06	·166	·1	5	1	19	
20-pr. of **16** cwt. L.S.	**3·75**	84·0	12·0	6·0	**96**	59·375	36·625	12·5	6·0	1 turn in 38 cals.	44	·06	·166	·1	2	0	11	
20-pr. of **15** cwt. S.S.	**3·75**	54·125	11·0	6·0	**66·125**	39·5	26·625	13·5	6·25	Do.	44	·06	·166	·1	1	2	0	
20-pr. of **13** cwt. S.S.	**3·75**	54·125	11·0	6·0	**66·125**	40·0	26·125	13·5	6·0	Do.	44	·06	·166	·1	1	1	24	
12-pr. of **8** cwt. L.S. & S.S.	**3**	61·375	8·5	3·0	**72**	38·75	33·25	9·75	5·75	Do.	38	·045	·148	·1	1	3		
9-pr. of **6** cwt. L.S. & S.S.	**3**	52·5	7·0	3·0	**62**	36·5	25·5	9·6	5·3	Do.	38	·045	·148	·1	0	2	26	
6-pr. of **3** cwt. L.S. & S.S.	**2·5**	53·0	7·0	2·5	**60·125**	37·0	23·125	7·0	3·75	1 turn in 30 cals.	32	·045	·148	·1	0	1	27	

* Exclusive of slopes in front and rear of shot.
† *i.e.* from face of muzzle to extreme end of breech, exclusive of breech-screw.

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CHAPTER VIII.

MANUFACTURE OF PRESENT PATTERNS OF R.M.L. ORDNANCE.

All present Pattern Service Guns built up in a similar manner.—Converted guns excepted.—Armstrong or original construction.—Fraser construction—Advantages of latter in manufacture.—**Building up of a 7-inch Woolwich Gun.**—Steel tube, operation of toughening.—B tube, how prepared.—Breech coil or jacket.—Different parts of.—Shrinking the several parts together.—8-inch gun manufactured as 7-inch.—Difference in construction of 9-inch.—Of 10-inch guns and upwards.—Of 80-ton gun.—Construction of rifled howitzers.—Manufacture of 64-pr. guns.—Siege pieces.—Construction of our field guns.—7-pr. steel guns.—**Processes after building up and before Proof.**—Forming Gas escape.—Chamber in Woolwich guns, 40-pr. and upwards.—Rifling.—Venting for proof.—**Examination and Proof.**—Proof charges for heavy guns.—**Processes after Proof.**—Lining.—Sighting.—Service venting.—Marking and adjusting fittings.—Painting and final issue.

Manufacture of latest pattern R.M.L. ordnance.

All R.M.L. pieces of the patterns now being manufactured (except converted guns) are built up* in a similar manner. That is to say, over a barrel (or A tube) of steel are shrunk a certain number of coils or other pieces of wrought iron according to the size of the gun, while a cascable is screwed into the end of the coil which comes over the breech end of the tube and fitting closely against the solid end of the barrel, supports it firmly.

Cascable screwes.

In 25-pr. guns, however, and smaller natures, the solid end of the steel tube projects beyond the breech end of the jacket and is turned down to a cascable. Such guns therefore have no cascable screw and also no gas escape. Vide p. 99.

The smallest piece we manufacture—the 7-pr.—is made out of a single block of steel and is therefore an exception to the above.

Difference between the "original" and present construction.

Until April 1867 all our rifled M.L. guns were built up like the B.L. guns—of wrought-iron coils shrunk together successively on Sir William Armstrong's original plan. The plan proposed by Mr. R. S. Fraser, of the Royal Gun Factories, was then adopted; but manufacture on the original construction did not cease altogether until March 1868.

Fraser construction.

Mr. Fraser's plan is, as stated in a previous chapter, an important modification of the original method, from which it differs principally in

* Guns of patterns made previous to 1869 were manufactured on the Armstrong or modified Armstrong construction, vide p. 8, or had some other points of difference. The details of their construction, showing how they differ from the present pattern, are given in Chapter XI., and are shown also in the Plates at the end of the book.

building up a gun of a few large and comparatively heavy coils instead of several short ones and a forged breech-piece.

Small number of parts.

For example, in addition to the steel barrel and cascable, a "Fraser" 7-inch gun has only two separate parts, viz., the breech coil or jacket and *B* tube, whereas the 7-inch gun of original construction has a forged breech-piece, a *B* tube, a trunnion ring, and six coils—nine distinct parts—which are shrunk on separately (see Mark I., Plate VIII.).

The formation of a heavy coil is a simple forge operation, but great expense is saved by its means, as there is much less surface to be bored and turned, for each coil having to be made as smooth as possible, and at the same time true to gauge (to a thousandth of an inch), it follows that it must be cheaper to have a few thick ones in lieu of many thin ones. For the same reason there is also less waste of material; for although the turnings are afterwards worked up into bars, iron in its scrap state is only worth one-third of its forged value.

Moreover, time and labour are also saved in having fewer pieces to move from workshop to workshop; for instance, in the case of a gun of original construction, when a coil was shrunk on, the mass had to be moved from the shrinking pit to the turning lathe, and turned down for the next coil, and so on, coil by coil, until the gun was built up; but in the Fraser construction only two or three separate shrinkings are required, and it is computed that where fifty tons were moved in the former case, only seven are moved in the latter.

Reduced cost of present construction.

From these circumstances, combined with the employment of cheaper iron, a Fraser gun can be made at about two-thirds of the cost of a gun of the same nature as originally manufactured, while the experiments which were carried out previous to the introduction of this construction clearly prove that guns of this pattern are at least quite as trustworthy and serviceable as those of the original pattern.

"Marks" of guns at present manufactured.

Up to 1869 Fraser guns were made on the same type as the 7-inch gun, Mark III., about to be described, which construction is still retained for 7-inch and 8-inch guns. Since that date, however, 9-inch and heavier guns have been made with the wrought iron over the breech in two layers of coils. The "Mark"* of each calibre of gun approved for future manufacture is as follows, viz.:—For 7-inch and 8-inch guns, Mark III.; 7-inch of 90 cwt. Mark I.; for 9-inch guns, Mark V.; for 10-inch, 11-inch, and 12-inch (25-ton guns,) Mark II.; and for 12-inch, 35-ton guns, Mark I.; 12·5-inch 38 tons, Mark I.; 64-pr. 64 cwt., Mark III.; 40-pr. 35 cwt., Mark II.; 25-pr. 18 cwt., Mark I.; 16-pr. 12 cwt., Mark I.; 9-pr. 8 cwt., Marks I. and II.; 9-pr. 6 cwt., Mark I. and II.; 7-pr. steel 150 lbs., Mark III.; 7-pr. steel 200 lbs, Mark IV.

Details of Manufacture of Woolwich Guns.

Manufacture of a heavy gun, 7-inch.

We will now proceed to the details of the construction of a Woolwich gun, and will, for the sake of convenience, take the manufacture of a heavy gun, and, as a good example that of a 7-inch, and then see how the manufacture of the larger and smaller natures differ slightly from the same.

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* In November 1867 the word "Mark" was substituted for "Pattern." See § 1545.

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7-inch Gun, Mark III.

This gun consists of :—

An inner barrel or tube of toughened steel (*A* tube).
A *B* tube.
A breech coil.
A cascable.

Steel tube.

A tube.

The steel for the tube is received from the contractors in the form of a solid ingot, which is rough turned, care having been taken to fix it truly central in the lathe by means of a chuck at the muzzle and the centre at the breech. In this operation a lip or collar is formed at the muzzle to facilitate the lifting of the tube in and out of the furnace and oil bath; the slice for testing is also cut off the breech end during the rough turning. The tube remains in this state until the result of the required tests (which are described in Chapter V.) are known. Should the ingot not be rejected the manufacture proceeds.

Rough boring and turning.

The block is next bored roughly from the solid. The boring head is the ordinary shaped "half-round bit" with one pointed cutter set angularly, and three steel burnishers. After this, the conical chamber (which is in all Fraser guns) is roughly formed by means of a cylindro-conoidal head with one long cutter and six steel burnishers, two on the taper part and four on the cylindrical.*

Toughening in oil.

The tube is now ready for toughening in oil. This operation consists in heating the roughly bored tube to the approved temperature in a vertical furnace, and then plunging it bodily into a bath of rape oil, in which it is allowed to cool.

The tube is lifted by a crane, and placed in a perpendicular position in an upright furnace; an iron coil, larger in diameter than the steel tube, is placed upon the fire bars at the bottom of the furnace for the tube to rest upon; beneath this iron coil is placed a piece of plate iron, to prevent the cold air coming in contact with the steel, and in order to obtain an uniform temperature at the extreme end of the steel tube the iron coil is filled with wood ashes.

After the steel has acquired the proper temperature throughout, the crane is brought over the furnace; the cover of the latter is removed, and the block of steel is drawn out and placed in a large iron tank about 20 feet deep, full of oil. The heated steel sometimes causes the surface oil to take fire, which is extinguished by closing the covers at the top of the tank. The tank has a water space around it through which a supply of cold water permeates for the purpose of keeping the oil cool.†

Effects of toughening in oil.

The process of toughening has a bad effect in two ways; it not only warps the steel a little, but frequently causes the surface to crack. The barrel must therefore be slightly turned and bored to make it straight inside and outside, as well as to remove any flaws that may have been generated. This second boring (performed with a cylindrical boring head, fitted with five long edged cutters and five wood burnishers) increases the diameter to 6·6 inches. By this the cracks are generally

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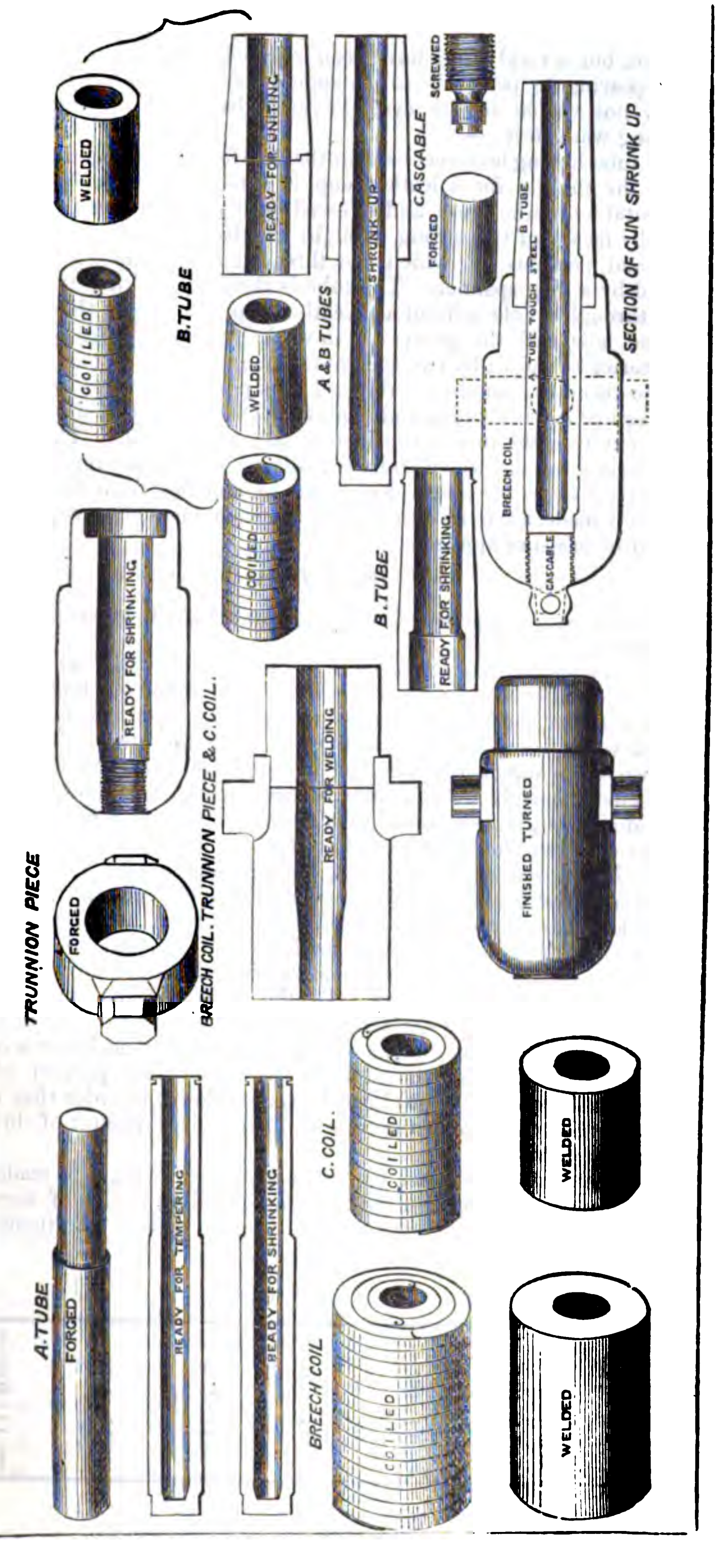
* Rough and fine boring, forming the chamber, and broaching, are all effected in the same horizontal machine, the difference being in the shape of the boring head and cutters.

† A full description of this process is given in "The Management of Steel" by Mr. George Ede of the Royal Gun Factories.

DIAGRAM ILLUSTRATING VARIOUS STAGES OF MANUFACTURE OF A 7-IN., R.M.L GUN (Mark III.)



CHAP. VIII.

removed, but several tubes have been rejected in consequence of flaws still appearing to penetrate to a dangerous depth, and lest there should be any not visible to the eye, the steel barrel is subjected to the following water test:—

Water test after toughening.

The tube having been recessed on the face for a gutta-percha ring, and inside the muzzle for a leather cup, is fitted with these, placed in a horizontal hydraulic press, and screwed tightly up between two cast iron heads by means of two strong wrought iron bars extending from head to head, and portions of which are threaded and furnished with nuts, worked by a long spanner. The tube is then filled with water from the main through a hole in head and leather cup, the pipe of the press fixed into the hole, and the pump set to work by steam. The pressure on the interior is shown by two indicators, one vertical and one horizontal, so as to check one another. When 4 tons per square inch is indicated, the pressure is withdrawn, and if no flaw has been detected by moisture on the exterior, the tube is considered safe and sound. The barrel is left in this state until the *B* tube is ready to be shrunk over it.

All steel tubes treated alike.

The steel tubes for every piece built up, and that from which a 7-pr. is entirely made, are treated in exactly the same manner, except as to the amount of pressure applied.

The B Tube.

B Tube.

The *B* tube is composed of two single and slightly taper coils united together.

Two coils welded together.

The two coils, being made and welded in the usual way, they are faced and reciprocally recessed to the depth of about one inch, and then united together endways by expanding the faucet of one coil by heat, and allowing it to shrink round the spigot of the other. This fastens the two coils sufficiently together to admit of the tube thus formed being placed upright in a furnace, whence, when it arrives, at a white or welding heat, it is removed to a steam hammer, and receives on its end six or seven blows which weld the joint completely.

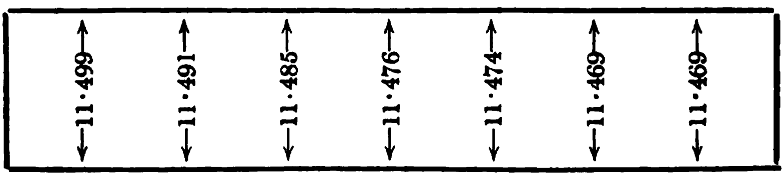
The *B* tube is next rough turned, during which process a rim is formed near the muzzle for the convenience of lifting the tube in "shrinking." After this, it is rough and fine bored in the same horizontal machine.

Measuring interior prior to shrinking.

The interior of the *B* tube having been brought to the degree of smoothness requisite for close contact with the steel barrel, is gauged every 12 inches down the bore. To the measurements thus obtained, the calculated amount of shrinkage (0″·003 at the muzzle, and increasing up to 0″·022 at the other end), is added; a plan is then made out according to which the exterior of the *A* tube (or rather that portion of it on which the *B* tube is to go) must be turned down, in order that it shall be larger than the bore of the tube by the required amount of shrinkage at the respective parts.

The plan (as illustrated by the annexed drawing), is made on a slip of paper, and together with a corresponding series of accurately measured horseshoe gauges, is furnished to the turner, who turns down the muzzle end of the *A* tube accordingly.

PLAN OF *A* TUBE.



The reason an *inner* tube is turned to suit an exterior one, instead of the latter being bored to suit the former, is, as previously stated, that it is much easier to turn than to bore to very exact dimensions, on account of the great command which the operator has over the turning lathe, and the facility he has of testing his work by gauges, and correcting it by means of emery powder and oil. CHAP. VIII.

The Breech Coil or Jacket.

Breech coil. The breech coil or jacket is composed of a triple coil, a trunnion ring, and a double coil, made and welded together as follows :—

Triple coil. The triple coil * is formed, as already described, by coiling three bars one over the other, and in order to weld its folds, is placed in a furnace for about seven hours, at the end of which time it is at a welding heat, whereupon it is rapidly transferred to a powerful hammer, and receives a few smart blows on its upper end, which close the folds longitudinally. A mandrel somewhat larger in diameter being then forced down, the coil turned on its side, and well hammered all round to make it dense, and also to weld the three layers together. It is replaced in the furnace for about four hours, and the same process repeated at the breech end, but with a smaller mandrel.

When cold, the ends are faced and the outer coil is turned down at the muzzle end to form a shoulder 10″ long for the reception of the trunnion ring.

Double coil. The double coil † being welded, as above, has a shoulder formed on the lower end about 9 inches long and ¾ inch deep, so that it may enter the trunnion ring in the after process of welding the parts of the jacket together.

Trunnion-ring. The trunnion-ring is made—as described at p. 42—like all wrought iron trunnion-rings, namely, of slabs of iron consecutively welded together on the flattened end of a porter bar, and gradually formed into a ring by means of, first, a small iron wedge, which is driven through the centre and punches an oval hole, and then by a series of taper mandrels increasing in size, which makes the hole sufficiently large and round. The trunnion-ring has to be heated for each punching, and the occasion is utilized to hammer the trunnions roughly into shape, one of them being in continuation of the porter bar. Eventually the ring is cut off from the bar by means of strong blunt hatchets of steel hammered through it. After this it is roughly bored out.

The jacket or breech coil having been built up from these three pieces (vide p. 43) is turned in a very powerful lathe.

It being impracticable to turn down the trunnion portion in a lathe, it is slotted smooth in a self-acting vertical machine with a double motion, one of which moves the jacket round for a fresh cut at every stroke of the tool which the other works up and down accordingly.‡

The trunnions themselves have yet to be turned down to shape ; so the jacket has to be moved for the purpose to another machine, a *break* lathe, in which it is made to revolve on the axis of the trunnions while the cutters act on their surface.

* In diagram called "Breech Coil." With guns such as the 9″ and upwards, having a coiled breech-piece, the jacket is termed the C coil. Iron of large section being now rolled in the R.G.F., these coils are generally made double instead of triple. Greater soundness in the interior is thereby ensured, and manufacture is facilitated.

† In diagram called "C" coil.

‡ Since 1874 the trunnion shoulders of 10-inch guns and upwards have been rounded off.

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The jacket is next rough and fine bored in a machine like that used for the *B* tube, but more powerful, and the front of the double coil is recessed on the inside to a depth of eight inches, and to a diameter sufficient to overlap the breech end of the *B* tube.

Finally, the female thread for the cascable is cut by a machine in which the jacket revolves horizontally, while the cutter is fed forward by a copying screw.*

Building up the Gun, or shrinking the parts together.

Shrinking the parts of the gun together.

The steel barrel and *B* tube being prepared for one another, as described, are shrunk together in this manner:—The *B* tube is placed on a grating, and heated for about two hours by means of a wood fire, for which the tube itself forms a flue, until it is sufficiently expanded to drop easily over the muzzle end of the steel barrel, which is placed upright in a pit ready to receive it. The *B* tube is then raised, and the ashes, &c., being brushed from the interior, it is dropped over the steel barrel by a travelling crane overhead. During the process of shrinking, a stream of cold water is poured into the steel barrel, to keep it as cool as possible, the water being supplied and withdrawn by a pipe and siphon at the muzzle. A ring of gas or a heated cylinder is placed round the muzzle or thin end of the *B* tube, to prevent its cooling prematurely, whilst a jet of cold water plays on the other end, which it is desirable should grip first; were both ends allowed to contract simultaneously, the intermediate part of the tube would be drawn out to a state of longitudinal tension, and weakened accordingly.

The *A* and *B* tubes shrunk up (see diagram, page 89), are placed in a lathe, and while one cutter fine turns the *B* tube to its proper shape and dimension, another cutter fine turns the breech end of the *A* tube according to the plan of the interior of breech coil, which has been made out according to the method already explained. The projection at the breech end is then removed and the end faced.

The shrinkage on the steel tube is 0″·01 at the extreme breech end, 0″·02 at the shoulder round the end of the bore, and gradually diminishes to 0″·017 at the point where the jacket abuts against the *B* tube, while the overlapped portion of the *B* tube is given a shrinkage of 0″·023.

The half-formed gun, composed of *A* and *B* tubes shrunk up, being next placed standing on its muzzle in the shrinking pit, the jacket is heated for about 10 hours, and shrunk on in the same manner as the *B* tube; it is, however (being nearly of the same thickness throughout), allowed to cool naturally, and, to keep the interior cool, cold water has to be forced up into the bore of the gun by a jet round which the muzzle rests.

8-inch Gun, Mark III.

Consists of same parts as the 7-inch, Mark III., and the processes in manufacture are identical.

9-inch Guns of 12 tons and 7-inch of 90 cwts.

Jackets of heavy guns.

As the guns increased in size, the jacket constructed as described for 7-inch and 8-inch guns,† became very ponderous. For theo-

* In larger natures this is cut in the breech coil instead of the jacket, vide p. 93.

† The coils would otherwise have been very thick, and the certainty not so great of ensuring throughout their thickness the soundness necessary.

retical reasons and manufacturing convenience, therefore, this portion was reduced in size in the 9-inch guns and upwards, by taking out a part of the interior and shrinking this part over the breech end of the steel tube as a separate coil, termed the breech-piece. CHAP. VIII.

By adopting this construction, which also possesses theoretical advantages,* we are further enabled to complete the rifling, &c. of the piece before the jacket is put on and the gun made so heavy as to be inconveniently moved from one workshop or machine to another. **9-inch guns and upwards rifled before the jacket is shrunk on.**

9-inch, Marks IV. and V.†

Consists of :—

A tube (toughened steel).
B tube.
Coiled breech-piece.
C coil (jacket).
Cascable.

The A tube is prepared up to the point of shrinking, as already described.

The coiled breech-piece consists of two coils united, and being finish bored, and a thread cut in the breech end for the cascable, is shrunk on the *A* tube, after which a shoulder is formed on its muzzle end.

The B tube is manufactured like that already described, except that a recess with a hook is cut in the breech end for the purpose of joining it to the coiled breech-piece.

The cascable is screwed in before the *C* coil is shrunk on in this and all guns of similar construction, the cascable thus gaining the advantage of compression due to shrinking.

The C coil or jacket is composed of a breech coil, trunnion-ring, and muzzle coil welded together, and being finish bored and turned, is shrunk on over the coiled breech-piece.

The remainder of the operations and parts are similar to those for 7-inch gun.

7-inch Gun, 90 Cwt., Mark I.

Consist of much the same parts as the 9-inch gun, Mark V.,‡ described below, viz. :—

A tube (toughened steel).
B tube.
Coiled breech-piece.
C coil (or jacket).
Cascable.

Only a few of these guns have been manufactured as new guns, but a considerable number have been made by reduction from the 7-inch S.S. gun of 6½ tons. **Reduction of 7-inch 6½-ton guns to 90 cwt.**

In both cases the jacket is made of a single coil and a trunnion-ring, but in the reduced guns the breech-piece is a part of the old jacket

* Mark I. and II., 9-inch, are of old types, one being of original Armstrong, and the other still keeping the forged breech-piece. Mark III., however, of which pattern a number were made, had its jacket formed like the 7-inch.

† Mark V. is of exactly the same construction as Mark IV., from which it only differs in the position of the axis of the trunnions being 0″·375 further back.

‡ The reduced 7-inch R.M.L. is described here as it consists of similar parts to the 9-inch R.M.L.

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which remains after removing the trunnions and turning off the outer portion.

In the new guns of this nature, on the other hand, the breech-piece consists of two coils united.

Removing the old cascable.

With reference to the reduction of these guns from 7″ of 6½ tons, it may be noted that it is not easy to get the cascable out of the latter. In order to do so advantage is taken of the expansion of the breech-piece when the new jacket is shrunk on.

10-inch Guns and upwards.

Jackets of 10-inch guns and upwards.

1 B coil or belt.

For pieces heavier than the 9-inch, the weight of the jacket is still further reduced by making it much shorter in front of the trunnions, the portion thus taken off the jacket is put on as an additional coil, over the steel tube, in front of the jacket.* This is called the 1 *B* coil or belt.

10-inch gun, Mark II., ***and higher natures of those manufactured since 1869, up to the 80-ton (Experimental) Gun,***

Consists of:—

A tube (toughened steel).
B tube.
1 *B* coil (belt).
Coiled breech-piece.
C coil (jacket).
Cascable.

The manufacture of these guns is similar to the 9-inch, Mark V., except that as mentioned above, there is an additional piece called the 1 *B* coil, or belt, shrunk over the steel tube between the *B* tube and coiled breech-piece. This is for convenience in manufacture, owing to the length of the gun. These guns are rifled, &c. before the jacket is shrunk on, to save the labour of shifting the whole weight from one machine to another.

Ring nuts.

In making, therefore, the *C* coil or jacket of such guns, a muzzle-end similar to that used with the smaller natures is not required, but a very short muzzle end, technically called a "ring nut," is screwed inside the trunnion-ring and upon the end of the breech coil, and welded with these two latter, vide p. [illegible].

The 16-inch R.M.L. Gun of 80 Tons Experimental.

This gun consists of:—

A tube (toughened steel).
B tube.
[illegible]
[illegible]
Coiled breech-piece.
[illegible]
Cascable.

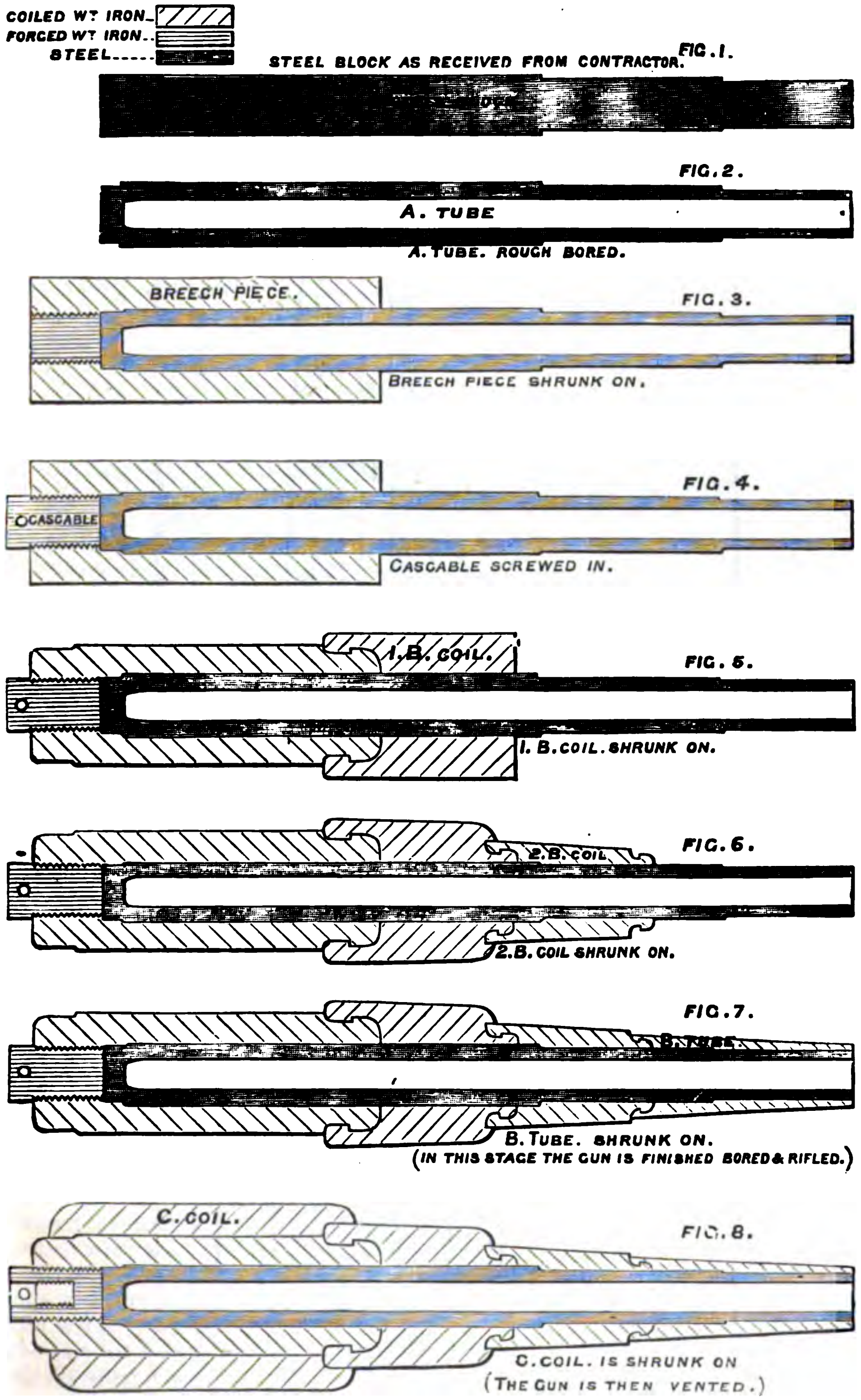
Its manufacture, as will be seen from the plate on next page, is similar to that of the 10-inch, Mark [illegible], and upwards, except in the following particulars:—

The first is that the tubes shrunk over the steel barrel consists of four

* Mark I. [illegible] were made, but their jackets [illegible] Mark II. were of original construction.

80-Ton Gun in various Stages.*

* Not exactly to scale. Shoulders much exaggerated.



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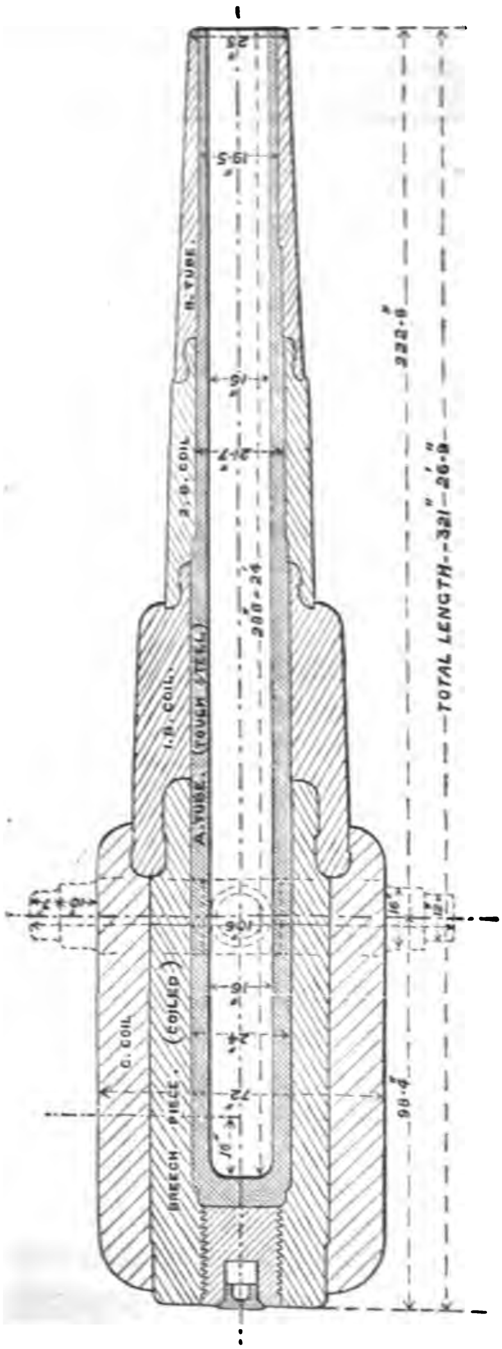
B. TUBE.
2. B. COIL.
1. B. COIL.
A. TUBE. (TOUGH STEEL.)
C. COIL.
BREECH PIECE. (COILED)
222·6
98·4
TOTAL LENGTH - 321 — 26·9

instead of three pieces, on account of the great length of the gun, an additional tube called the 2 *B* coil being placed between the 1 *B* coil or belt and the *B* tube.

2 *B* coil. 1 *B* coil. *B* tube.

C coil. As the *C* coil or jacket is of very massive proportions, it is thus constructed :—Four single coils are prepared from bars of large section and two joined together to form a tube which is turned; the other two are then shrunk over it, and the whole welded into one mass.

To the breech coil so made, the trunnion ring and short muzzle or ring coil is added as usual, and then all are welded together into the solid jacket. The section of the bar from which the coils mentioned are made, and the proportions altogether are so large that the mode of constructing the breech coil by shrinking one tube over another, as described, has been adopted both to ensure a fairly homogeneous mass and for convenience of manufacture.

The remainder of the manufacturing operations with this piece prior to proof are similar to those described in the case of smaller guns.

Cascable. The cascable will probably terminate in a plain button for L.S. like that of the 38-ton gun, but a hole will be bored in the direction of the axis of the cascable, and threaded for the reception of a strong screw bolt and shackle, the latter may be used in lifting the gun, and afterwards removed so that the total length of the gun may be as small as possible. The plate on p. 95 shows very well the various stages of manufacture of this gun.

The 80-ton gun is the heaviest gun which we have as yet made, though there appears no manufacturing reason why guns of twice or four times its size and weight should not be made in the same manner and of equal comparative strength.

Construction of Natures below 7-inch.

Construction of guns lighter than 7-inch. We will now take in detail the construction of R.M.L. pieces which are lighter than the 7-inch, and of patterns now being made.

10-inch Rifled M.L. Howitzer of 6 tons (Experimental).

The 10-inch howitzer consists of :—

A tube (toughened steel).
Coiled breech-piece and chase.
C coil (or jacket).
Cascable.

The construction of this piece is slightly exceptional, for the coiled breech-piece and that part which in most guns is termed the *B* tube, are united together before being shrunk on to the steel barrel, and so form a single tube which extends from breech to muzzle.

This mode of construction is adopted for convenience in manufacture, the two coils of which this breech-piece and chase are made being short and comparatively thick coils.

A tube. The *A* tube being prepared, the coiled breech-piece is finished bored, the thread for cascable screw cut, and a shoulder left for a corresponding shoulder on the steel tube to abut against.

Coiled breech-piece and chase. The coiled breech-piece and chase (in one) are shrunk on to the A tube, and the cascable fitted and screwed in, a gas channel being formed in the usual manner.

The exterior is next turned down for the reception of the jacket, two shoulders being left, one a little in front of the trunnions, and the other towards the breech end.

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C coil. The *C* coil or jacket is made of one single coil and a trunnion ring, manufactured and welded together as usual, and then shrunk on from the breech end. It hooks over the two shoulders left on the coiled breech-piece, so binding the gun together more firmly in a longitudinal direction. This and the remainder of the operations are similar to those described in the case of the 7-inch gun.

Cascable. The cascable terminates in a plain button having no loop.

8-inch Rifled M.L. Howitzer of 46 cwt., Mark I.

This piece consists of:—

A tube (toughened steel).
B tube.
C coil (or jacket).
Cascable.

Breech coil. It is built up and completed in the same manner as the 7-inch gun, Mark III. described in Chapter VII., but the breech coil or jacket is composed of one single coil and a trunnion ring.

A tube. *B* tube. In turning down the *A* tube a shoulder is left over which the *B* tube hooks when shrunk on.

Cascable. The cascable has no loop, but terminates in a plain button.

6·3-inch Rifled M.L. Howitzer of 18 cwt.

Construction. In construction this howitzer exactly resembles the 8-inch already described, and it consists of the same number of parts.

Rifling. The rifling is still experimental.

It is chambered like the 64-pr. R.M.L. gun, Mark III.

The 64-pr. Rifled M.L. Gun, Mark III.

This gun consists of:—

A tube (toughened steel).
B tube.
C coil (or jacket).
Cascable.

The construction of this gun is similar to that of the 7-inch gun, Mark III., already described, the jacket consists of a double coil, a trunnion ring, and a single coil welded together.

Steel barrel. Guns of this nature made since April 1871 have solid ended steel tubes and a *B* tube shrunk over the chase. Before that date 64-pr. guns had wrought iron tubes as explained in remarks on different natures, p. 186.

The 40-pr. Rifled M.L. Gun of 35 cwt., L.S., Mark II.

This gun consists of:—

A tube (toughened steel).
B tube.
B coil.
C coil (or jacket).
Cascable.

In construction this gun differs from the 7-inch in having an additional *B* coil between the jacket and *B* tube; this mode of construction is adopted as the *B* tube would be inconvenient to manufacture were it sufficiently long to extend from the muzzle to the jacket, as that part of the exterior is naturally rather thin in a gun of this size.

The 25-pr. Rifled M.L. Gun of 18 cwt., L.S., Mark I.

This gun consists of:—

A tube (toughened steel).
B coil.
C coil (or jacket).

In construction this gun is somewhat similar to the 40-pr. R.M.L. gun, Mark II., having a steel tube, jacket, and a *B* coil in front of the jacket. It has, however, no *B* tube nor cascable screw, and so stands midway in construction between the heavier guns and our field pieces, the chase consisting in part of the steel tube unstrengthened and the cascable being turned down from the projecting breech end of the steel barrel itself. Cascable.

Before tempering the inner tube of steel a hole 1 inch diameter and some inches deep is bored in its solid end (so as to reach within about 2¼ inches of the bottom of the bore), in order to obviate any chance of its splitting at that part during the operation of toughening. This hole is subsequently filled in by a screw plug when the tube has been toughened and proved. *A* tube.

16-pr. Rifled M.L. Gun of 12 cwt., L.S., Mark I.

This gun consists of :—

A tube (toughened steel).
C coil (or jacket).

This gun consists of two parts only, viz., a toughened steel tube, and a jacket, composed of two single coils and a trunnion ring welded together.

The cascable is cut out of the solid end of the steel tube, as in the 25-pr., and the chase of the gun for a distance of 30½ inches from the muzzle is entirely of steel, the tube being thicker at that part.

9-pr. Rifled M.L. Gun of 8 cwt., L.S., Mark I.

This gun consists of :—

A tube (toughened steel).
C coil (or jacket).

This gun is identical in construction with the 16-pr., except that there is a swell at the muzzle and a dispart patch. This swell is cut out of the solid steel, except in a few of the guns first made, in which it consists of a wrought iron ring screwed on. These can be known by the small fillet which runs round the chase where the iron ring ends.

The cascable is recessed to receive the head of the elevating screw, which is fastened to it by a wrought iron bolt, both secured with a steel keep pin. Cascable.

9-pr. Rifled M.L. Gun of 8 cwt., S.S., Mark II.

This gun is constructed in exactly the same manner and of the same parts as the 9-pr. R.M.L. gun of 8 cwt., L.S., Mark I., except that there is no swell on the muzzle.

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The 9-pr. Rifled M.L. Gun of 6 cwt., S.S., Mark I.

This gun is identical in construction with the 16-pr., and differs from the 9-pr. of 8 cwt. only in weight and length, and in having no swell at the muzzle.

9-pr. Rifled M.L. Gun of 6 cwt., L.S., Mark II.

In construction this gun is similar to the 9-pr. of 8 cwt., L.S., Mark I. It is, however, both lighter and longer, the bore being of greater length than that of the latter piece by $2\frac{1}{2}$ inches.

It has a swell on the muzzle and a dispart patch with recess, into which the foresight screws.

The 7-pr. Rifled M.L. Gun (steel) of 150 lbs., L.S., Mark III.

This gun is made out of a solid block of steel (see Plate I.), rough bored and shaped, then toughened in oil, and afterwards finished in the usual manner.

7-pr. rifled M.L. Gun (steel) of 200 lbs., L.S. and S.S., Mark IV.

Like the 7-pr. of 150 lbs. weight, this gun is made out of a single block of steel, which has, however, no projection at the muzzle like the block for the former, but only a slight patch to be formed into a dispart patch subsequently. This piece is a foot longer in the bore than Mark III. gun.

Processes before Proof.

Processes before proof.

We now come to the various processes which the 7-inch gun we have taken as a type undergoes after it has been built up and before it has been proved. The following are the operations:—

(1.) Screwing in the cascable and completing gas escape.
(2.) Engraving the Royal cypher.
(3.) Fine boring.
(4.) Second rough cutting of chamber.
(5.) Finished boring.
(6.) Broaching of bore, and finishing of chamber.
(7.) Lapping.
(8.) Rifling.
(9.) Temporary venting.

8-inch and smaller pieces. 9-inch and upwards.

In the case of the 8-inch and smaller guns, all of these processes are performed, as stated above, after the gun is completely built up; but with 9-inch and higher natures they are carried out before shrinking on the jacket, with the exception, of course, of the temporary venting, and engraving the royal cypher. We thus avoid having to move about from one machine to another during these processes so heavy a mass as would otherwise be the case.

Cascable.

(1.) The cascable is made of the best scrap iron. It is first forged into an oblong block, then turned cylindrical, and a bevel thread cut on it. The outer end is partially turned, and a hole is drilled for the purpose of screwing it into the gun, which hole is subsequently enlarged into the loop.

With guns not having cascable loops the portion containing the hole is cut off eventually when the button is completed.

Loop or button.

This hole is afterwards enlarged into a loop, except in the case of the 35-ton and larger guns, and with R.M.L. howitzers, where the portion containing it is subsequently cut off, and the outer end of the cascable turned into a plain button.

Screwing in the cascable.

This operation of screwing in the cascable requires great care, for the front of it must bear evenly against the end of the steel barrel, and in order that this may be the case, the end of the tube is smeared with red lead and the cascable screwed in tentatively, then unscrewed again, and filed down on the prominent parts, which are indicated by the presence of the red lead. This is repeated several times, until the equal distribution of the lead on the front shows that it bears evenly against the steel barrel.

Gas escape.

At this stage, one round of thread is turned off the end of the cascable, so that there may be an annular space there, which in connexion with a channel cut along the cascable and across the thread, will form a gas escape, or tell-tale hole, in case the steel barrel should split. The channel is about $\frac{3}{8}$th inch broad, and extends $\frac{1}{16}$th inch below the thread. In all guns made before the 1st September 1869, the channel comes out directly under the loop;* but in guns made since that date, it will be found at the right side, where it may be more easily noticed. The channel ought to be kept clear, and should the barrel split, gas would be seen issuing from the hole; it is therefore advisable, in case there should be any suspicion concerning the gun, to keep an eye on this hole, and to cease firing should it give warning.

When at length the cascable fits properly, it is finally screwed in, and to prevent its moving, a hole $2\frac{1}{4}$ inches long and $\frac{3}{4}$ inch in diameter is drilled and tapped through the jacket or breech-piece and into the cascable in a slanting direction on the left side, and a plug is screwed in to prevent any chance of the latter turning round.

Engraving.

(2.) While the cascable is being prepared, Her Majesty's monogram is engraved in front of the vent, the outline being marked on the gun by means of a perforated brass plate, rubbed over with charcoal.

Fine and finish boring.

(3.) The gun is next removed to the boring mill, where it is fine bored to 6″·9.

Chambering.

(4.) The chamber is next roughly bored out with the same boring head as before.

Shoulder on *A* tubes.

In all R.M.L. guns, 40-pr. and upwards, and also in the 8-inch and 6·3-inch howitzers, the end of the bore has a conical chamber to allow of a shoulder (as shown below) being cut on the outside of the steel tube, which abutting against the coiled breech-piece helps to distribute the longitudinal strain over the latter.

Why necessary.

With the present construction this shoulder is required, because the layer of iron next the tube is a coil, it would be necessary, in order to retain the same diameter of cascable, to make the interior of the whole coil much smaller than is now required, and afterwards to bore out a large portion of it for the reception of the steel tube. This would cause a considerable waste of labour and material, consequently in these guns the cascable screw is made nearly of the same diameter as the exterior of the tube, leaving only a small shoulder about half an inch broad.

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* As explained at p. 167, in guns having forged breech-pieces the gas escape is not cut along the cascable screw, but through the forged breech-piece, and then at right angle underneath the same, so that it opens out below instead of immediately under the cascable or at the right side of the latter.

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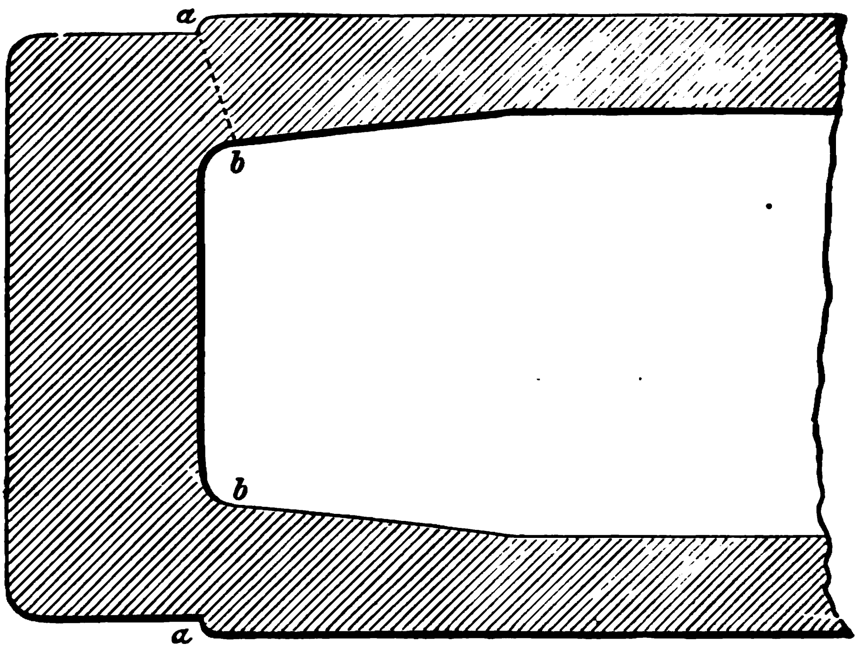
The cutting of this shoulder weakens the steel tube at that part, as shown by dotted line "*a b*."



In guns of the original construction, viz.,

7-inch,	of	6½	tons,	Mark I.
7	„	7	„	„
8	„	9	„	„
9	„	12	„	„
12	„	25	„	„

this shoulder was not necessary, as they had forged breech-pieces, and the diameter of the cascable screw was made about equal to the calibre of the gun (see 7-inch gun, Mark I., Plate VIII.), thus affording a strong shoulder in the breech-piece against which the end of the *A* tube abuts, thereby reducing the strain on the thread of the cascable screw.

In the 25-pr. and smaller natures the bottom of the bore is merely rounded off, as such a shoulder is not required, for these guns have no cascable screws, the *A* tube projecting at the breech end, and the steel tube, which is thicker at the chase than breech end, has a large shoulder abutting against a recess cut in the jacket and *B* coil, so as to take the longitudinal thrust.

(5.) The finished boring to 6″·997 is then performed.

The fine boring and the finished boring are effected with the boring head used in the second rough boring.

Finish boring.

(6.) In each boring the cutters wear a little during the operation, so that the bore becomes slightly taper towards the breech. This is of no consequence in an outer tube, as the exterior of the inner one can be turned accordingly, but the bore of the gun must be truly cylindrical, so broaching is employed; that is boring the barrel by means of a cylindro-conoidal head, fitted with four long cutters at right angles to one another, and slightly tapering. The cutters are edged on the front as well as on the side, as the chamber is also finished off at this time,

Broaching.

and for this latter purpose there is also a centre cutter for the end of the bore.

Lapping. (7.) In order to make the bore absolutely true, lapping must be finally resorted to, the bore being at the same time brought up to its correct diameter of 7 inches. In this operation no cutter is used, but a wooden head, covered with lead and smeared over with emery powder and oil, is worked up and down those portions of the bore which are indicated by the gauges as imperfect.

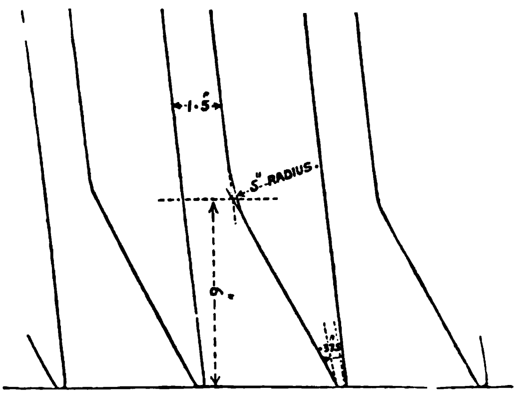
Rifling. (8.) The gun is now taken to the rifling machine, and the grooves cut as described at p. 13, the form of groove depending, of course, on the nature of the piece. With Woolwich rifling the grooves commence about an inch lower down the bore than the rear stud of projectile reaches when home, and they are so arranged that the two grooves nearest the vent are at equal distances from the latter.

Number of grooves. The number of the grooves varies. With 7-inch guns and all lower natures only three grooves are used, with 8-inch four, 9-inch six, 10-inch seven, 11-inch, 12-inch, 12·5-inch nine, and with the experimental 80-ton gun eleven.

Depth of groove. Their depth varies from 0″·1 in the smaller pieces to 0″·2 in 10-inch guns and upwards, and the width from 0″·6 in the 7-pr. to 1″·5 in the heaviest guns. Exact dimensions are given in Table, p. 212.

Width of grooves. The grooves are the same width for all natures of heavy guns, as above mentioned; they are widened at the muzzle in 10-inch guns and upwards, in order to facilitate loading, the loading side being cut away to a breadth of 2½″, tapering down to the ordinary width at 2″ from the muzzle. This change was introduced in October 1871.

Splay of grooves. According to order dated 15/1/76, in all R.M.L. guns, 10-inch and upwards, of future manufacture, and in guns of these natures which pass through the Royal Gun Factories for repair, the splay of the loading sides of the grooves will be increased, so as to remove nearly the whole of the lands at the muzzle, in order to facilitate the entrance of the projectile into the bore. The angle of splay varies slightly for each nature of the gun; that for the 12·5″ gun of 38 ton is shown in the diagram below.



As a rule, about two calibres in length is left plain or unrifled for a powder chamber. The unrifled part should be as long as possible, for grooving tends to weaken the barrel. and the seat of the charge should be the strongest part of the gun. No air space, however, must be left between the smallest charge used and the base of the projectile.

Venting. (9.) Previous to the 23rd January 1868, rifled M.L. guns were t unvented until after proof, at which they were fired by means of

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electric wires passed in at the muzzle. Since that date, all guns are drilled and tapped before proof.* and fired through a removeable cone vent,† which is unscrewed after proof and replaced by the permanent vent; the object of this is to prevent the proper vent being strained by the large proof charge.

Cone vent.

The cone of this removable vent is about 0″·025 smaller than the service pattern, but after proof the cone in the gun is broached out to the proper size.

The gun is now ready for examination and proof.

Examination and Proof.

Gutta-percha impressions taken before proof, and bore gauged.

All guns are minutely examined before proof, and gutta-percha impressions are taken of the whole length of the bore in four quarters. The bore of all guns of 9-inch calibre and upwards is also accurately gauged every three inches.

Object of testing a gun.

The object of testing a gun before issue is to make quite sure that it is strong enough to bear not only the strain caused by firing the ordinary charges, but also any unusual strain which can possibly occur caused with service projectiles and charges.

Proof.
Light guns.

For this purpose the smaller natures are proved by firing two rounds of 1¼ the highest service charge and the service projectile.‡

Heavy guns.

With guns above the 9-inch, however, the proof consists of one round, with battering charge and two rounds of proof charges which differ for each gun, but are always less than 1¼ the highest service charge. This is done because when the powder charge becomes very large, a comparatively small increase of powder gives a considerable increase of pressure upon the chamber of the gun.

Proof charges.

The proof charges of guns firing Pebble powder or cubical powder, *i.e.*, 9-inch and upwards, consists of one round with battering charge and two with proof charges; all with service weigh of shot.

The following are the proof charges for 9-inch guns and upwards, viz.:—

	Proof.	Service.
	lbs. Powder.	lbs. Powder.
38-ton gun - - - -	150 P^2	130 P^2
35 " - - -	115 P.	110 P.
25 " - - -	95 "	85 "
18 " - - -	75 "	70 "
12 " - - -	58 "	50 "

Water test.
Object.

After proof rifled M.L. guns are tested by having water force pumped into the bore, the pressure being 120 lbs. on the square inch. This test was instituted for guns with wrought iron barrels, having *loose* ends to ascertain that the breech was perfectly closed, for which purpose it is still used with the *converted* guns. It is also continued in guns having solid ended steel barrels, to make sure that the end has not been split at proof.

Impressions after proof compared with those taken before.

Gutta-percha impressions of the bore are taken after proof, and the bores of heavy M.L. guns are again gauged. The impressions taken after proof are compared with those taken previously to ascertain that whether any defect of a serious character has been developed, and whether slight ones have perceptibly increased. If such should appear to be the case,

Further test if necessary.

the gun is subjected to five more rounds with service charges, and if after that the defect appears unimportant the gun is passed.

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* As to position of vent and nature of bush, vide pp. 11–13.

† Except the 7-prs., which are proved with their service vent.

‡ 64-pr. Mark III. (with steel tubes) will be proved with 15lbs. powder and a 90lbs. projectile, to cover a charge of 12lbs. which may be exceptionally used.

The impressions of any such defects, however, are cut off, and the position in the gun marked on the back, after which they are registered and preserved for future reference.

Impressions of defects.

In addition to comparing the impressions, the expansion of the bore at the seat of the charge is ascertained by comparing the gaugings before and after proof. This expansion seldom exceeds a few thousandths of an inch, but it may be greater in guns having coiled barrels.

Should the gun pass proof it is now to be prepared for actual issue by fitting with vent, sights, &c.

It has therefore to undergo the processes undermentioned.

Processes after Proof and before Issue.

Processes after proof.

(1.) Lapping.
(2.) Obtaining preponderance and weight.
(3.) Lining.
(4.) Sighting.
(5.) Venting.
(6.) Marking, and the "marks" denoting pattern.
(7.) Fixing on elevating plates and small fittings, sloping sides of and completing cascable.
(8.) Painting and lacquering, and final inspection.

All the above processes, except the last, are performed in the same workshop (the sighting room), and generally, but not necessarily, in the exact order given.

Lapping.

(1.) Every gun is lapped after proof, for the purpose of removing any little burs which may be thrown up on the edges of the grooves by the heavy proof rounds.

Preponderance.

(2.) "Preponderance," means the pressure which the breech portion, when the gun is horizontal, exerts on the elevating arrangement.

To ascertain its amount, the gun is supported at the trunnions by steel bars placed beneath them, and is brought horizontal by means of long handspikes in the bore. A Kitchener's weighing machine (like that ordinarily used at railways for weighing luggage) is then placed under the breech, and a block of wood fixed upon it, touching the gun underneath midway between the elevating points. The handspikes being then removed from the bore, the pressure on the block is indicated on the arm of the machine, and gives the preponderance of the gun.

In 1867 it was settled that the preponderance of 7-inch guns should be 3 cwts., of 8-inch 4 cwts., and of 9-inch 5 cwts. With smaller nature it differs, the amount for each piece is given in Table, p. 212.

With 9-inch guns and upwards, anything under 3 cwts. preponderance is to be considered nil as ordered in 1869.

Actual weight.

The actual weight of each gun is taken by means of a strong steelyard to the short arm of which the gun is slung by the trunnions. But with very heavy guns the finished portions, *i.e.*, the jacket, &c. are weighed before they are shrunk together, and the weight so obtained with sufficient approximation.

Lining and sighting.

(3.) The object of lining is to enable the sights and elevating plates to be adjusted. The line of metal is the first line required, and is obtained as in cast iron guns, by finding the axis of the gun and a line in the same vertical plane along the top of the gun, but the process is much more accurate. The gun is placed on a horizontal iron table, and being levelled across the trunnions and along the bore, is carefully scotched up.

Line of metal.

Instead of using a wooden batten to find the axis, a centring block, capable of being pressed out so as to fit tightly in the bore, is pushed home

CHAP. VIII. to the breech end. From the very centre of this block, a silk thread is extended through a plate on the muzzle to an iron upright (plumbed) stand, some feet in front of the gun, which is furnished with a plumb line, so that it can be adjusted to be truly vertical. The stand is moved to the right or left until the thread passes through the centre point on the muzzle plate.

A "breech gauge," provided with a vertical slide, having been fixed horizontally on the cascable, another silk thread is stretched from the stand to the breech slide so as to pass through a point in the muzzle plate in the same vertical plane as the lower thread, and just high enough to clear the breech of the gun. This gives the position of the line of metal, which is marked for about 1½ inch in length at the extreme end of the cylindrical part of the breech.

Vertical and horizontal line. Vertical and horizontal lines are marked on the face of the muzzle along slots in the plate, and short horizontal lines are also marked on the right side of the muzzle, and on both sides of the breech, by means of a scribing block, the moveable arm of which is adjusted to the horizontal slot, the block resting on the table. These lines are useful for the purpose of adjusting the sights, elevating plates, &c.

On the right trunnion vertical and horizontal lines are also cut, except in 25-prs. and smaller natures. The vertical line on the right trunnion enables the gun to be laid point-blank (or brought horizontal) at any time without the aid of sights, while the horizontal line on the right trunnion is for use when firing at angles of depression.

Drilling for sights. (4.) The gun is placed under a radial drilling machine. The breech gauge and muzzle plate (the same as used for lining) are then attached, and the gun is levelled to the angle at which the tangent sights are to be inclined to the left, as the machine drills vertically. This brings the

Tangent sights. right sight higher than the left, and the right tangent sight socket nearer the vertical axis than the left. Two silk threads are stretched at one side of the gun from the breech gauge to the muzzle plate, and at the width of the socket apart. The given distance of the tangent sight socket from the line of metal being ascertained (by a gauge), the arm of the machine is brought over the spot and the hole drilled completely through the breech so as to allow of the water and turnings in the after processes to escape.* The drills, &c. work between the threads which answer as a check.

In subsequent borings the drills are not carried through. This operation is repeated on the other side.

The corners of the sight recesses are rounded off ⅛th inch, to prevent any injury to the thin edge when moving the gun.

Centre hind sights. The hole for the centre hind sight is drilled in the same way and at the same angle, but only of sufficient depth to admit of the sight.

Socket holes for trunnion sights. For the trunnion sights the holes are drilled in a similar manner, but as they are not to be inclined at an angle the gun must be previously re-levelled with the trunnions horizontal; the distance from the centre of the tangent sight holes to the centre of the trunnion sight holes is accurately measured (by a gauge) according to the radius at which the gun is to be sighted.

Fitting sockets. The bearing for the tangent sights in the metal of the gun being long and liable to rust, gun metal sockets are fitted in by hand and afterwards fixed by side screws. There is also a gun metal socket and clamping screw for the centre hind sight.

* With 35-ton guns and upwards, the vertical hole for the sight is drilled only to a depth of about an inch greater than the length of the tangent bar. From the bottom of this hole a channel is bored to the interior, having a slight slope downwards.

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For the drop trunnion sights, vide p. 114, gun metal sockets are fixed in the bottom of the hole. These sockets are carefully adjusted by means of gauges, &c. until a pattern drop sight fits into them accurately. This adjustment corrects any slight error due to boring or otherwise of the socket hole, and as the sockets are fixtures in the gun, it is ensured that any drop sight will answer with them when they have been so adjusted. *Trunnion sight sockets. Adjustment.*

In the howitzers, 16-pr. and smaller guns, the holes for the screw trunnion sights or fore sight are bored and threaded.

(5.) The drilling and tapping of the hole for vent bush has already been completed, as described p. 103, for the temporary vent used at proof. All that remains is to rime out the cone to the proper size, and to vent the gun with the service bush. *Venting.*

Guns below the 9-inch are vented in a similar manner to S.B. ordnance as far as the operation of venting is concerned, vide p. 11, but with the 9-inch and upwards the bush is screwed in after the cone has been cut to about the proper length in a lathe. An impression is then taken in the bore and the amount of projection marked on the part of the bush in the bore. The bush is screwed out, the bottom of cone turned off as far as necessary, and the operation repeated. When finished the bush projects in the bore about 0″·075.* *8-inch and under. 9-inch and upwards.*

(6.) In addition to the marks made in lining and the Royal cypher before mentioned, the broad-arrow and actual weight are stamped in front of the vent, and the angle of set of tangent scale is also stamped on the gun.† *Marking.*

With 9-inch guns and upwards the letter D is also stamped in front of the socket when the latter has been deepened for the lengthened centre hind sight (vide p. 113). *Set of tangent sights.*

Two parallel lines are cut across the vent field to indicate the unrifled space. That in front of the vent denotes the end of the rifling, and that in the rear of the vent the end of bore. These lines enable us to mark the sponge or rammer staves for the exact distance from the muzzle to the end of bore or rifling.

Lines are also cut on the top of the gun to denote the position of the centre of gravity and the point at which the sling must be placed in order to take half the weight, the gun being at the same time slung at the cascable.‡ *Centre of gravity. Half weight line.*

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* At present the reventing of these guns is performed as described at p. 233, with the tools issued for the purpose, the part projecting into the bore being cut off by a knife as with S.B.

† All guns made, or which have passed through the department after 24/6/75, will be found with this angle marked, but others are without it.

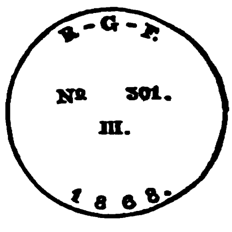
‡ See § 1936, List of Changes, 1st September 1870.

Only 8-inch guns and upwards are marked with the lines indicating centre of gravity and half weight; and as some of the following natures have been issued without these lines the respective distances are given:—

Nature of Gun.	Distance of Centre of Gravity from Muzzle.	Distance of Half Weight from Muzzle.
	″	″
8″ M.L. guns, 9 tons, Mark I.	86·45	36·4
„ „ Mark II.	87·85	39·2
„ „ Mark III.	87·75	39·0
9″ M.L. guns, 12 tons, Mark I.	90·55	34·1
„ „ Mark II.	90·5	34·0
„ „ Mark III.	90·9	34·8
„ „ Mark IV.	90·55	34·1
„ „ Mark V.	90·585	34·17
10″ M.L. guns, 18 tons, Mark I.	109·75	49·5
„ „ Mark II.	109·55	48·35

CHAP. VIII.

The material of the inner barrel (for example FIRTH'S STEEL) is stamped on the face of the muzzle, as is also the number of the barrel as entered in the registry of manufacture.



On the left trunnion are*—the initials R.G.F., or otherwise of the factory where the piece was made, the register number of the gun, the numeral signifying its pattern, and the year of proof. The register number is that by which the gun is registered in the department records; it indicates also the number of that nature manufactured.

Heel scales.

64-prs. to fire 10lb. charges as well as 7-inch and upwards (except the L.S. 7-inch of 7 tons), have a heel scale on the cascable for use with the Wood scale for S.S., as described at p. 120. This scale is marked by means of a template, and then cut by hand.

Screw holes for fittings.

(7.) Screw holes have to be bored for the screws which secure the different fittings to the gun, index plates, guide plates, &c., according to the nature of the piece.

Gun metal plates for elevating racks.

The positions for such are carefully obtained, by means of accurate gauges, from the lines already marked on the gun.

The position of the gun metal plates for the elevating racks being measured, and the holes drilled and tapped by hand, the plates are firmly attached to the gun by means of a screw at each corner. They are also marked with the number of gun to which they have been adjusted.

Until November 1871 many guns, 7-inch to 9-inch, were furnished with two studs screwed into the face of the muzzle, for supporting the shot bearer during the process of loading. At the above date, however, they were abolished, as they were found to be unnecessary and even sometimes in the way in loading; such guns are provided with preserving screws for these holes.

All heavy L.S. guns are drilled and tapped for the guide plate and friction-tube pin, the holes being filled by preserving screws: thus these guns can be made available for sea service should occasion require.

The preserving screws in the friction tube pin holes also answer the purpose of indicating the position of the vent by the touch, during night firing.

Shaping the cascable.

To bring the cascable to the approved shape, its sides are sloped towards the rear, except when it ends with a button.

To prevent the handspikes slipping when working the gun, the breech was formerly scored underneath at each side. This is no longer required, as heavy guns are now elevated by means of elevating racks.

9-inch guns and upwards must also be prepared for index plates and muzzle derricks.

Preparing for derricks.

38-ton L.S. guns are also prepared for the trunnion studs, described at p. 130.

Painting and lacquering.

(8.) The exterior of the gun being well cleaned, receives one coat of Pulford's magnetic paint, and the bore is lacquered. This only applies to 25-pr. guns and upwards; 16-pr. and smaller natures are browned (vide p. 235) and the bore left unlacquered.

The gun having been inspected, and found in exact accordance with the sealed pattern, is now ready to be issued for service; and when it has been provided with the fittings described in the next Chapter it is issued by the R.G.F. to the Commissary General of Ordnance, Woolwich, with sights, &c., complete.

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* Except with 7-prs., where these are found on the right trunnion.

CHAPTER IX.

CHAP. IX.

SIGHTS, FITTINGS, AND STORES OF R.M.L. ORDNANCE.

Sights.—Six used with 64-pr. and upwards.—Four with smaller natures, except 9-prs. and 7-prs., which have only two.—**Special Sights.**—Other means used for obtaining elevation and direction.—**Tangent Sights.**—Various natures.—Difference between L.S. and S.S.—Centre hind sights.—New pattern for 9-inch guns and upwards.—Trunnion sights and centre fore sights.—Drop pattern.—Screw.—Turret sights.—Moncrieff sights of two descriptions.—Chase sights, when used.—Telescopic sights.—Wood scales.—Index plates and readers.—Clinometer.—Quadrant.—Experimental hanging scales.

Fittings and Small Stores.—Bearers for shot.—Brackets.—Clamps.—Derricks.—Guide plates.—Pivot pieces and elevating plates.—Prickers.—Trunnion studs.—Wrenches.—Table showing different marks or patterns of tangent and fore sights for—Heavy guns, Medium, Siege, Field, and Boat or Mountain guns.—Table of wood scales.—Table of fittings and small stores.

SIGHTS.*

64-pr. guns and upwards have six sights, *i.e.*, two tangent sights or side sights, one centre hind sight, and three fore or trunnion sights. The trunnion sight used in conjunction with the centre hind sight is usually termed the "centre fore sight." Sights. 64-pr. upwards.

The 40-pr., 25-pr., and 16-pr. have two side or tangent sights and two trunnion sights; while the 9-prs. and 7-prs. are central sighted only, having one hind sight and a small screw foresight on the muzzle. 40-pr. under.

All the fore sights are of the drop pattern (p. 114), except in the case of the 16, 9, and 7 prs., with which screw fore sights of different patterns are used. Fore sights.

With the rifled 8-inch and 6·3-inch howitzer exceptional sights are employed. Exceptional sights.

Special Sights.

Besides the ordinary sights named above, we shall find that with certain guns special sights are used at times.† These are :— Special sights.

* By order dated W.O. 21/12/76, any sight passing through the Department and *altered but not brought up to the latest sealed pattern*, are to have the numeral of the mark to which they are assimilated stamped after the numeral of their original mark, thus, I. (IV.).

† Besides the special sights mentioned, it is not unlikely that telescopic sights may be furnished before long, for certain purposes.

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(1.) Turret sights.
(2.) Moncrieff „
(3.) Chase „
(4.) Telescopic (experimental) sights.

In addition to sights which can be used both for laying and giving elevation to a gun, the following arrangements are sometimes employed for giving elevation only, viz. :—

(5.) Wood scales.
(6.) Index plates and readers.
(7.) Clinometers or quadrants.

Again, guns are sometimes laid as to line of fire alone by the following * :—

(8.) Hanging scales for howitzers and siege guns.
(9.) Graduated arcs on racers used in conjunction with the index plates.

Hind Sights.

Hind sights.

All hind sights, whether side or centre, must be inclined at a certain angle, as explained in Chapter II., or else have some other arrangement by which to make up for permanent deflection, as in the 8-inch howitzer, where a long deflection leaf is employed; but the fore sights are always put in vertically.

We have already seen (p. 106) how guns are prepared for these sights, and how the sockets, &c. are fitted; we can now, therefore, go on to the description of the sights themselves and to the details of the different patterns in the service.

Ordinary Service Sights.

(a.) *Tangent Sights.*

Tangent sight.

The tangent or side sights for heavy guns consist of a rectangular steel bar rounded off on two sides and having a gun metal head, in which slides a gun metal leaf.

Slow motion screw.

Excepting L.S. sights made before 1871, which have a slow motion screw for giving minutes of elevation, as with smaller pieces,† these sights have a plain head.

For S.S. sights the slow motion screw has never been employed.

Depth of notch.

The notch in the deflection leaf through which the sight is taken is now 0″·15 deep; it was formerly 0″·06, the depth of notch still used for siege and field guns.

The diagram below represents the description of tangent sight now employed with heavy guns and also 64-pr. guns, except 64-pr. siege guns, which have L.S. slow motion screw, &c.

Graduations.

The graduations of the several faces differ in the several guns and also in the different marks or patterns, as shown in pp. 135–143, and explained in notes to the same.

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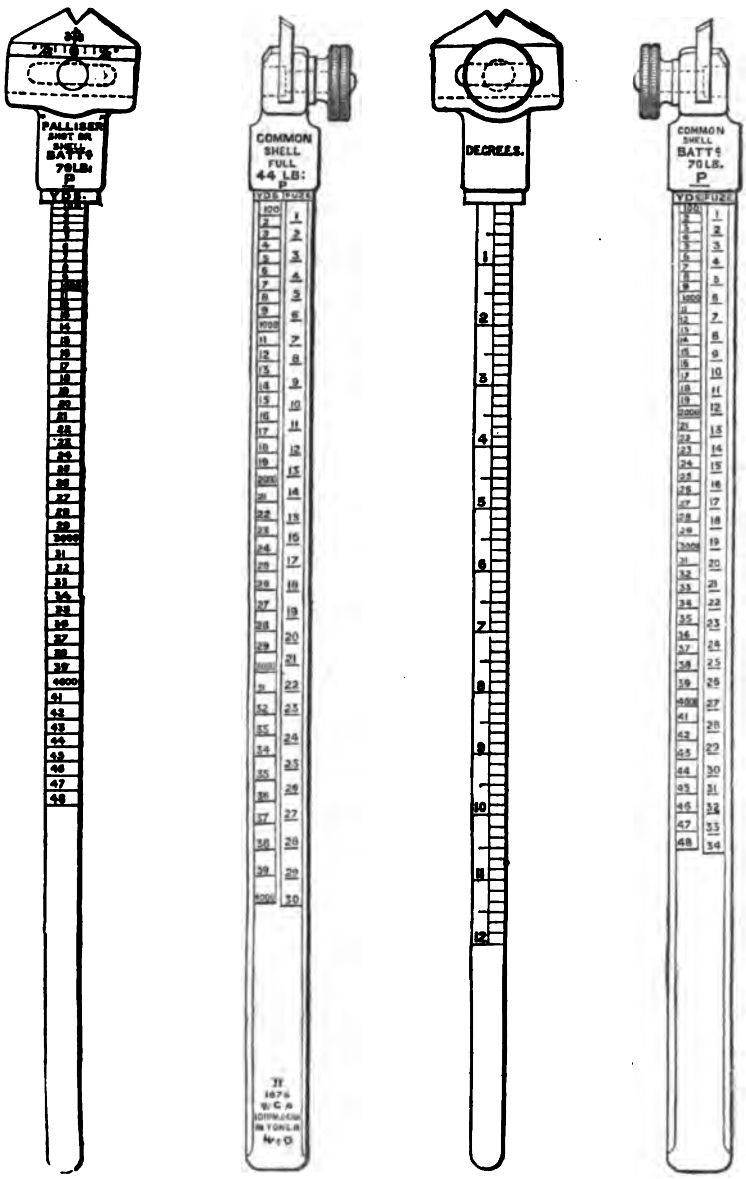
* The Collimator described in Manual of Artillery Exercises, p. 90, is practically obsolete.

† With the 38-ton gun sights, however, both the shallow notch and slow motion screw are reintroduced.

SLIDING-LEAF TANGENT SIGHT (10-inch R.M.L. gun). Scale ½. CHAP. IX.

Face next breech. Side elevation. Face next muzzle. Side elevation.



For 64-pr. guns with steel tubes, and smaller guns down to the 9-pr. (*i.e.*, all siege and field guns having side sights), the tangent sights consist of a similar steel bar with gun-metal head and sliding leaf; but in these a slow motion screw is always used, and the notch in the leaf is only 0″·06 deep as already mentioned. **64-pr. and under.**

The hind sights of 9-pr. guns consist of a bar of steel, which for L.S has a cross-head of steel and a sliding gun metal leaf, and for S.S. is quite **9-pr. guns.**

CHAP. IX.

plain, without any cross head or leaf for deflection. As these sights are graduated for the long radius—from breech to muzzle—they have no slow motion screw for giving minutes of elevation, the sights themselves being graduated for every 3 minutes.

7-pr. guns.

The hind sights for the 7-pr. are similar to those of the 9-pr. S.S.

Long and short sights.

In both 9-pr. and 7-pr. two tangent sights are provided, one long and one short. The long sights are tempered steel, and have to be employed instead of the short sights for certain elevations. If always in the gun, they would, from their length, be very liable to damage.

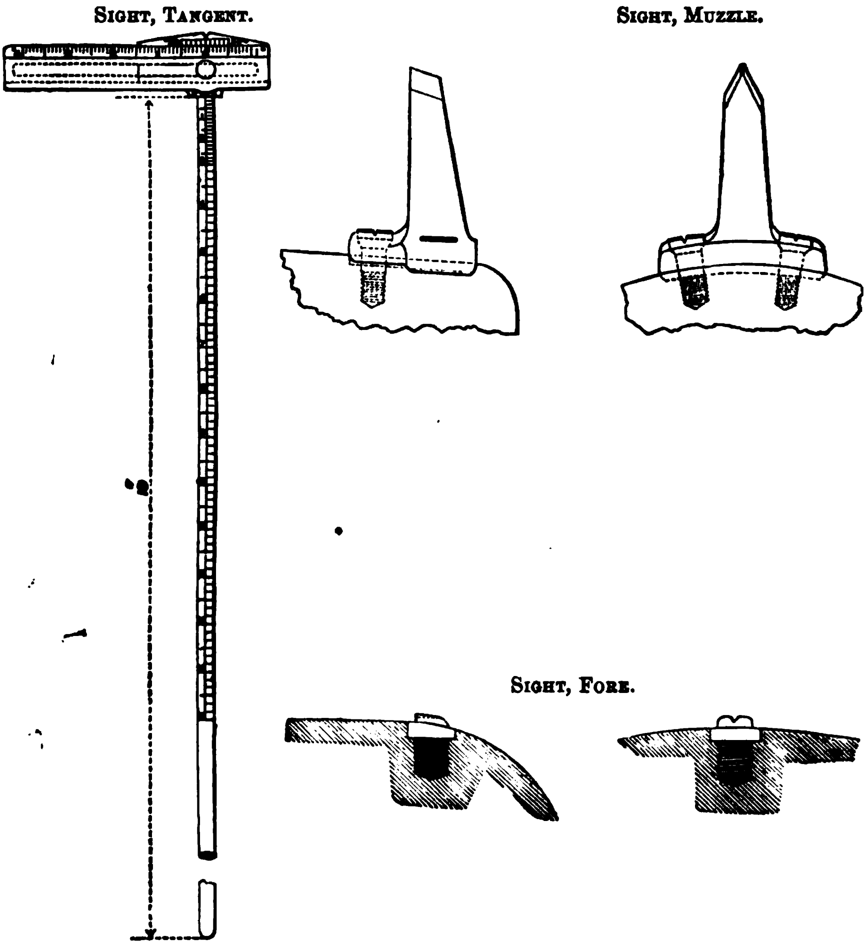
The short sight is made of a length about equal to the thickness of the gun at the breech.

The different marks or patterns of the tangent sights for siege and field guns are given at pp. 142, 143.

8-in. howitzer sight.

The 8-inch howitzer has one tangent sight placed vertically in the piece, and provided with a long steel cross-head and deflection leaf. It

8-INCH R.M.L. HOWITZER 46 CWT. ¼ Size.



is used for short ranges in conjunction with a short screw sight on the trunnion ring, and for elevation over 3° with a sight secured by screws near the muzzle, as shown above.

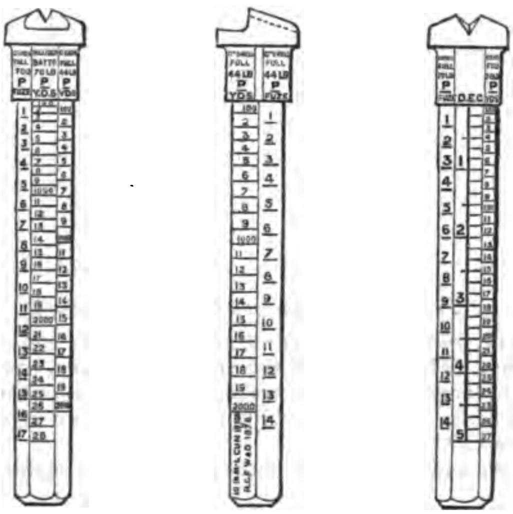
When under cover so that the mark to be hit cannot be seen, the howitzer would be laid as to elevation by the quadrant or clinometer (vide p. 122), and as to direction by the hanging scales described at pp. 123, 124.

*Centre Hind Sights.**

Centre hind sights.

A centre hind sight consists of a hexagonal bar of gun metal,† which has a plain head in all the older patterns, and also in the most recent for 8-inch guns and downwards; but 9-inch guns and upwards will for the future be provided with lengthened centre hind sights, as below. These lengthened sights are not only longer but have also a gun metal head, with a sliding leaf for giving deflection.

9-inch guns and upwards, lengthened centre hind sights.



☞ This alteration (introduced in 1874) was adopted for those heavier pieces of ordnance, 9-inch and above,‡ which at 2,000 yards and over would be formidable against iron clads.

Deepening holes, long centre hind sight.

These new sights will not be supplied immediately to all guns, but the latter will be prepared for them by deepening the hole for hind sight. Vide p. 250, Appendix for this operation, for list of tools used, and for instructions for deepening the sockets at out stations.

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* Although the tangent sights employed with 9-pr. and 7-pr. guns are central, yet this term above is not applied to them, but only to the centre hind sight used with the 64-pr. guns and upwards, which have three hind sights.

† With 12″ of 35 tons and 12″·5 of 38 tons the centre hind sight is precisely the same as the side tangent sight.

‡ When these guns are mounted behind iron shields it is not always possible to use side sights.

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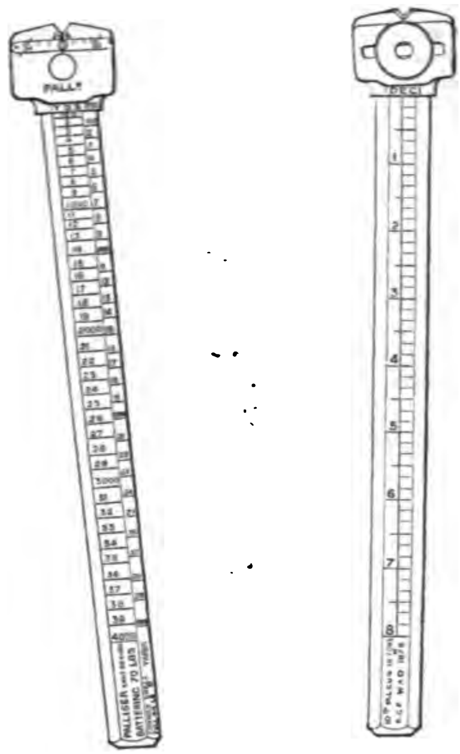


Trunnion Sights and Centre Fore Sight.

Trunnion sights.

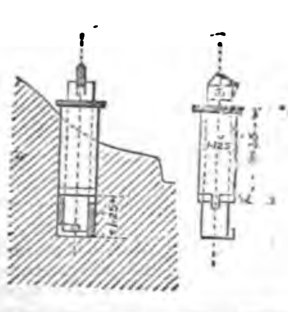
With 64-pr. guns and upwards three fore sights are secured in the trunnion ring. They are all of the same description, but the two used with the side tangent sights are usually termed "trunnion sights," and that employed in conjunction with the centre hind sight is called a "centre fore sight."*

The 40-pr. and 25-pr. also have two trunnion sights of the same description.

Drop sight.

This fore sight is termed a "drop sight," as it can readily be dropped into the socket and as easily removed. Similar sights are used with the R.B.L. guns 20-pr. and upwards (vide p. 59). The sight consists of a pillar and collar of gun metal, a small steel leaf, and a screw for fixing the leaf.

Component parts.



* The radius or distance between the centre sights is slightly greater than that between a side sight and the corresponding trunnion sight, vide Table, p. 133.

CHAP. IX.

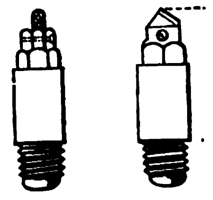
There is a socket of gun metal, into which the sight is secured by means of a double bayonet joint. This socket is permanently fixed in the gun, as explained at p. 107, and adjusted by means of a gauge sight. Sockets.

To remove the sight the collar must be raised, and then the pillar moved round a quarter of a circle. To remove a drop sight.

As the plane surfaces of the socket and sight can be very accurately fitted, these sights are made interchangeable with the sight leaves already prepared. This is not the case, as we shall see, with screw fore sights.

Screw Fore Sights.

These are always of steel, and consist of a pillar of steel threaded towards the lower end, and furnished with a steel sight-leaf secured to the top of the pillar by means of a small screw. Screw sights. Component parts.



As it is difficult to end a screw thread very accurately, these sights must be carefully adjusted in each case, and spare sights are issued with rough leaves. Why spare screw trunnion sights are issued.

The 16-pr. has two trunnion sights of this sort; the 8-inch howitzer one on the trunnion ring and one on the muzzle; the 9-pr. and 7-pr. one on the muzzle. 16-pr.

For the 9-pr. L.S. this sight is very small, and is screwed into a recess cut in a projection on the muzzle.* 9-pr. L.S.

In the S.S. 9-pr. of 8 cwts. and the 7-pr. (Mark IV.), vide pp. 99, 100, the sight is not protected in this way, but is longer, screwing into a small patch on the muzzle. 9-pr. S.S. 7-pr.

With the 9-pr. 6 cwt. S.S., however, the sight is slightly different, and is secured to the muzzle of the gun by three screws (vide p. 100), as is the muzzle sight of 8-inch howitzers.

For adjustment of the rough leaves of screw sights, vide p. 228.

Special Sights or Means of adjusting the Elevation.

1. *Turret Sights.*

Guns in moveable turrets are mounted upon carriages moving on fixed slides, so that direction must be given to them by traversing the turret itself, which is furnished with means of obtaining the correct line of sight.

Each turret has a number of "man-holes," centre, intermediate, and slide or "wing," through any one of which the captain of the turret can raise his head to look along the sights and lay the turret.

For each man-hole a fore sight and hind sight † are so adjusted that a

* So as to protect the sight from damage when the gun is being mounted.

† The hind sight is a rectangular bar of steel with a gun metal head and sliding leaf. On one side is a ratchet in which gears a small pinion worked by a hand wheel. The fore sight is of the ordinary drop pattern.

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A set of sights for each man-hole.

vertical plane through any pair of sights will be parallel to a vertical plane passing through the axis of the gun and slide. When the hind sight is at zero and the ship on an even keel, the plane passing the notch of the hind sight and the top of the fore sight is a horizontal plane. The sights are also of sufficient height to allow of the line of sight clearing the edge of the turret when the hind sight is at its maximum height. A second set of sights is provided for considerable angles of heel.

To obviate the necessity of the captain of the turret exposing himself to the enemy's fire while laying the turret, a reflecting arrangement has been fitted to the wing man-holes of some turret ships, so that he can direct the traversing and obtain the proper line of sight while under cover. This arrangement consists of two mirrors, one fixed inside the turret, the other while in use is secured upon the outside, and in rear of the man-hole. This latter mirror works on a hinge, and is readily adjusted to any required angle by a lever or hand wheel in the turret acting on a system of bell-crank levers. When not in use the mirror can be brought inside the turret and slid along the roof, where it is secured so as not to be in the way nor liable to damage.

The line of sight is reflected from the outer mirror upon that fixed in the turret, whence the captain of the turret may safely lay upon the object.

For giving the necessary elevation or depression to turret guns a wood scale is in all cases used.

Two corrections in elevation are at times required :—1st, to make up for the ship's heel, and 2nd, to make up for the gun being raised bodily from one step to another when mounted on muzzle pivoting carriages (vide Treatise R.C.D., 1874, p. 119).

The first correction is thus made :—The captain of the turret observes how many degrees above or below zero are given by the hind turret sight when laying on the object; this number of degrees is added to or taken from the proper elevation given by the wood scale as follows :— The position of the clamp on the wood scale is not altered, but the pointer on the clamp is applied to the given number of degrees above or below zero on the heel scale marked on the cascable.

The second correction is made by means of a simple arrangement in the wood scale,* so that the latter can be shortened or lengthened to correspond to the height through which the gun is lowered or lifted when placed on the several steps.

2. *Moncrieff Sights.*

In addition to the ordinary sights, two special sighting arrangements are employed with guns mounted upon Moncrieff carriages.

7-inch gun carriage, Mark I. Description of sight.

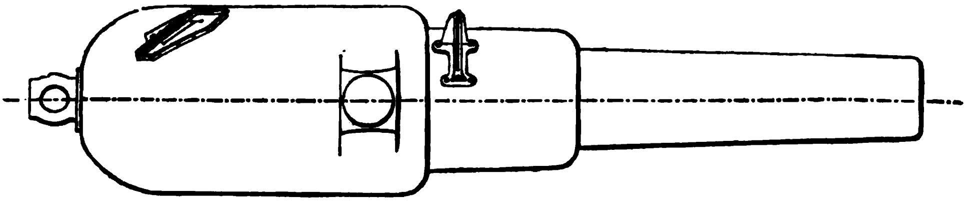
(1.) That used with 7-inch guns mounted on Moncrieff carriages, Mark I., consists of a skeleton gun metal bracket secured by screws to the trunnion ring; the sight-notch is a small V-shaped pin of metal sliding up or down in the skeleton fore sight frame, and clamped by a thumbscrew, and the graduation is in yards. To elevate the gun the V must be, of course, lowered.

The hind sight is a mirror in a gun metal bracket screwed to the top of the gun, near the breech end, as shown in Fig. below :—

* A gun metal tube with a button at the lower end slides in and out of a socket in the scale, the button resting on a small plate secured to the bottom plate of the carriage.

Wrought iron M.L. Guns, 7-inch 7 tons, R.

Sketch, showing position of Moncrieff Sights.
Scale $\frac{1}{32}$.



The woodcut shows the service position of the sights when finally adjusted on this particular gun with carriage, Mark I.

The mirror has cross lines upon it, and in order to lay the gun on an object, the V is clamped at the proper elevation and the gun traversed until the object itself and the bottom of the V are reflected together on the intersection of these cross lines.

(2.) That employed with 7-inch R.M.L. guns of 7 tons, mounted on carriages, Mark II., and for 64-pr. guns on carriages, Mark I., consist of two mirrors are used without a fore sight. One of these mirrors is secured to the end of the right trunnion of the gun by a circular bracket, and the other is fastened to a sliding bracket or frame which can be moved along a gun metal are screwed upon the lower part of the elevator, and which is graduated in degrees.

7-inch or 64-pr. gun carriage, Mark II.

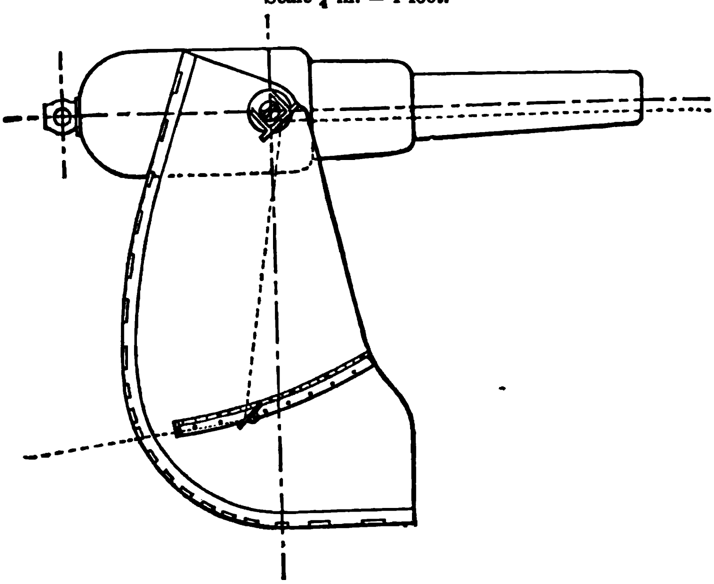
To lay the gun by these sights it is necessary that the object aimed at and the intersection of the cross lines upon the upper mirror should correspond with the intersection of the lines upon the lower mirror, the latter being clamped on the bar at the proper angle of elevation.

To fix the sights on the 7-inch gun, carriage Mark I., first take out the preserving screws and thoroughly clean the fitting surfaces of both gun and sight brackets; then screw on sights (using the thick screws

To fix the sights, Mark I. carriage.

7-inch M.L. Gun, mounted on Moncrieff Carriage (Mark II.).

Sketch showing position of Reflecting Sights.
Scale $\frac{1}{4}$ in. = 1 foot.



CHAP. IX. for the reflector), taking care that the screws are sent firmly home, otherwise the shock of firing will loosen the sights, destroy the adjustment, and perhaps break the glass.

When the sight brackets are firmly fixed, lay the gun accurately by the tangent sights (at zero) on a fixed object sufficiently far off to render the lateral distance between the two systems of sighting inappreciable; then observe whether the intersection of the cross lines (*i.e.*, the centre of the top of the T) upon the reflector is in line with the zero of the fore sight and the object, also whether the vertical line (the upright of the T) on the glass coincides with the centre line of the fore sight, indicated by the extremities of the longer line. If both these conditions are fulfilled, the sight is in adjustment; if not, the glass must be shifted.

To move the glass, unscrew the metal strips round the face of the frame, and take out the narrow frame cushions of india-rubber or other elastic material, and also the wood packing, leaving the glass in the frame; then adjust the glass by paring down the old pieces of wood, and wedging up with fresh ones, as may be required; when correctly and firmly fixed, replace the cushions, and screw in the metal strips again; the sight will then be ready for use.

There are four fine lines on the edges of the mirror, and four on the frame; the relative positions of these should be accurately noted after the final adjustment of the sight, so that any shifting may be readily detected.

Mark II. carriage.

The same course should be pursued with carriages Mark II. as to cleaning the fitting surfaces, &c., and fixing the sights to the gun and elevator, as in the case of Mark I., already described.

Run the elevator up to its firing position, set the lower sight at zero on the curved bar and clamp it. After this lay the gun by the ordinary tangent sights, also at zero, upon a distinct object, and observe whether the object itself and the intersection of the cross lines on the top mirror coincide with the intersection of the similar lines upon the lower one, also whether the vertical and horizontal lines on the one mirror strictly coincide with those on the other. If these conditions are ~~fulfilled~~ the sights are in adjustment, if not, the glasses must be shifted as described in instructions given for sights with Mark I. carriage.

3. *Chase Sights.*

Chase sight.

When guns of 25 tons and upwards are mounted behind shields originally intended for 10-inch or 9-inch guns, it is found that the ports foul the ordinary sights when the guns are traversed.*

Various modes of getting over this difficulty have been proposed by placing sights on the chase of the piece, and in June 1874 it was approved of that for such guns a mode of sighting should be adopted which had been brought forward by Colonel Inglis, R.E.

The system embraces a fore sight and a tangent sight with reflector. Both are fixed on the chase of the gun at a distance apart of 30 inches, and a set being furnished for each side of the gun.

Fore sight.

The fore sight is an ordinary drop sight, fitting into a gun-metal socket let into the chase.

Hind sight.

The hind sight consists of a rectangular steel bar, graduated in degrees on its rear face, and fitting into a socket in the chase. Upon this bar slides up and down a cross-piece of steel, the direction of which is parallel to the axis of the gun; upon the muzzle end of this cross-piece is a vertical sight-leaf with a notch for use as a back sight, the leaf being

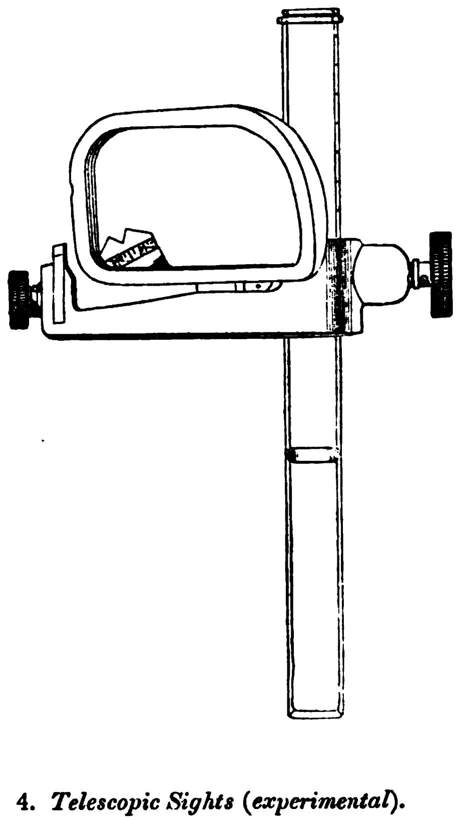
* *i.e.* For guns mounted on "small port" carriages.

capable of sliding laterally to give deflection up to 30′ R. or L.; it can be clamped as usual by a set screw.

Between this leaf and the tangent bar there is a vertical axle on the cross-piece (the axis of which is in line with the sights), and upon this axle a mirror is fixed which can revolve freely in a horizontal plane and partially in the vertical plane also. The cross-piece carrying the back sight leaf and mirror can be clamped at any required elevation on the tangent sight bar by means of a powerful set screw.

To use this sight the man laying the piece stands in front of the trunnions with his back to the port, and having clamped the cross-bar at the necessary elevation, lays the gun by traversing until the object, the notch on back sight, and point of fore sight are reflected together upon the mirror, which he can adjust to suit his own position, or else the mirror can be clamped at an angle of 45°, when the person laying will have to shift position.

CHASE SIGHT FOR HEAVY GUNS.



4. *Telescopic Sights* (*experimental*).

As the range of guns became greater, and the accuracy of their fire increased, attempts were naturally made to aid the eye by artificial means when laying upon distant objects, and we find that so long ago as 1857 a telescopic sight was proposed by Captain (now Colonel) Younghusband, R.A., which was tried at Shoeburyness.

CHAP. IX.

Since that date, although the subject has been frequently mooted, no new sight of this description has been definitely brought forward for employment in the service until of late years.

Alterations in Colonel Younghusband's telescopic sight above mentioned were designed in the R.G.F., and this sight has been used with the experimental 80-ton gun, and with the 12-pr. field guns.

It consists of a telescope with cross wires, mounted upon a quadrant, the supports of which have concave feet on the under side; these feet fit upon a rounded bar secured to the side of the gun, in a position parallel to the axis af the piece. The sight is furnished with a small cross level at right angles to the telescope, and can by this means be properly adjusted, so that the line of sight shall always be parallel to the axis of the piece, whether the trunnions are level or otherwise. When this adjustment is made the sight is fixed to the bar by a clamp, and the piece laid by means of the telescope.

In 1875, also, Lieut. (now Captain) Scott, R.E., proposed a "pendulous telescopic sight," which was very similar in construction to that of the ordinary theodolite. The sight was fitted below with knife edges fitting into slots in a gun metal bracket secured to the side of the gun at the breech end; this sight was tested at Shoeburyness in 1875, and also in February and March 1876, and gave fair results, but proved delicate and difficult to read.

5. *Wood Scales.*

Wood scale.

For naval service a *wood scale* is used in connexion with the ship's pendulum or director, for giving elevation or depression when the object aimed at cannot be seen from the gun. The scale is square in section, and is graduated for degrees and yards, both for full and battering charges.

Adjustment.

When it arrives on board, it is cut so that when placed upright on the naval slide, the zero of the scale corresponds to the zero of the graduations ($3\frac{1}{2}°$ elevation or depression), on the rear face of the cascable, the gun being parallel to the deck. It is provided with a moveable slide, fitted with a pointer and clamping screw; this can be set at the required
§§ 1477–8. elevation or depression, and must be made to coincide with the degree on the cascable which corresponds with the heel of the ship, in order to give the necessary elevation to the gun.*

Those used with heavy guns mounted on muzzle pivoting carriages have also an arrangement by which they can be lengthened or shortened (vide p. 116).

The graduations on this scale are computed with a radius equal to distance between the rear face of cascable and the axis of the trunnions.

When the radius is above 40 inches the graduations on the tangent scales are calculated for each degree, and therefore increase in length for the higher elevations. Under 40 inches radius the scale is calculated for the highest elevation and divided into degrees of equal length.

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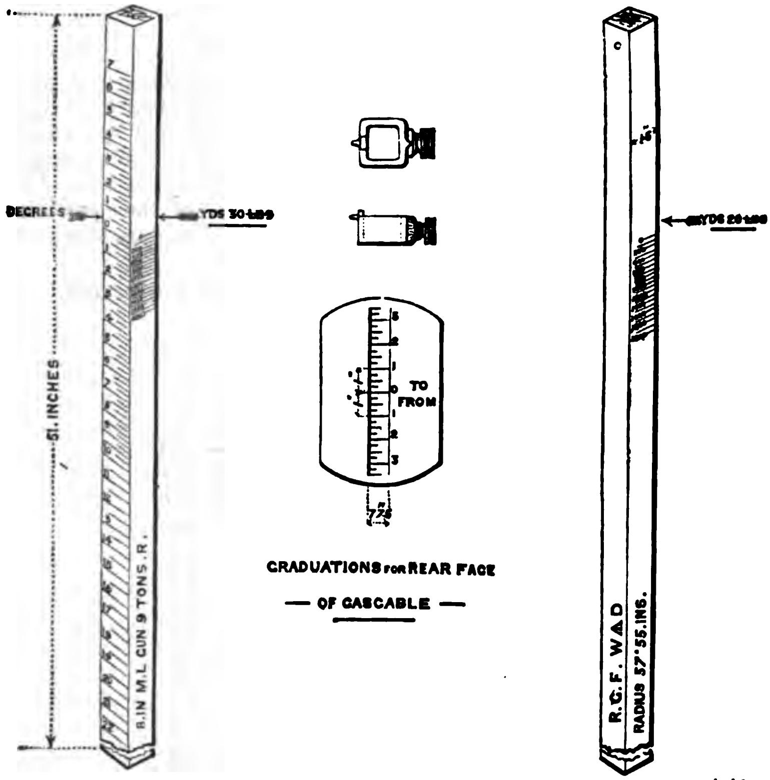
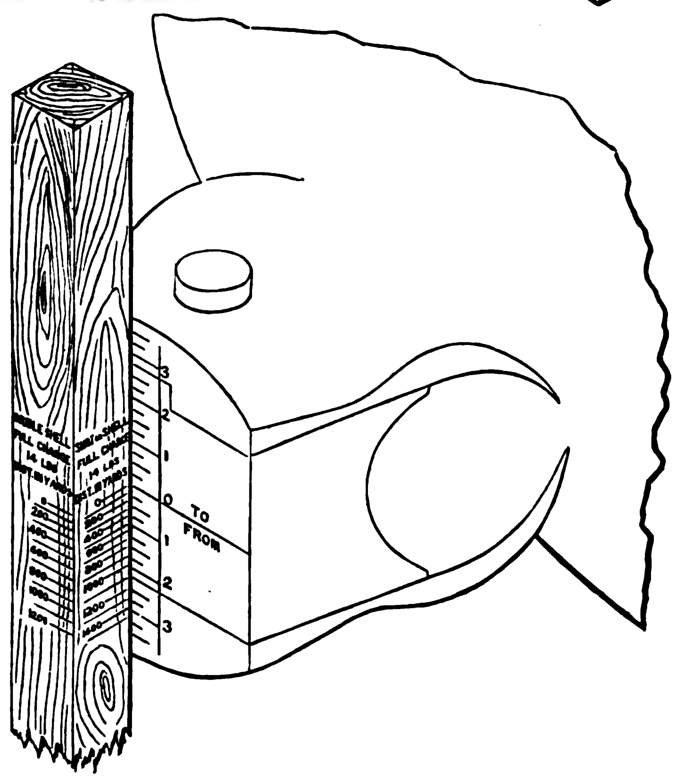
* The various marks, &c. of these scales are given in Table at pp. 150, 151.

Wood Scale (8-inch R.M.L. Gun). Scale $\frac{1}{8}$.



Manner in which the Wood Scale is used.*



* The scale shown in this drawing is not fitted with the moveable slide and clamping screw used in the latest patterns, which is shown in the preceding woodcut.

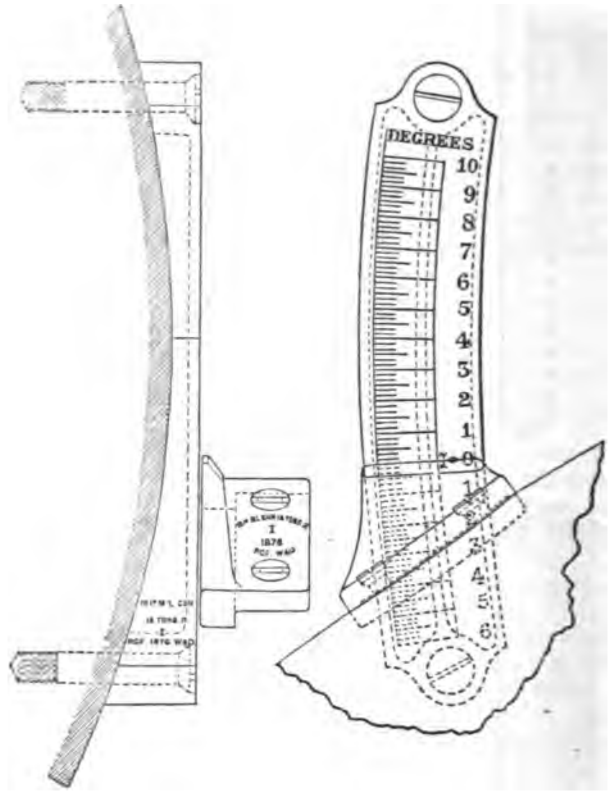
CHAP. IX.

6. *Index Plates and Reader.*

For 9-inch guns and upwards.

In order to facilitate the elevating of 9-inch guns and upwards mounted on casemate platforms, a gun-metal arc termed an "index plate" is secured to each side of the gun near the breech end by two screws. These arcs are graduted for 10° elevation down to 6° depression, and a gun-metal pointer termed "reader for index plate" is secured to the carriage, so that the number working the handle of the elevating gear can see when the required elevation is given. There are two patterns, Marks I. and II. See table, p. 152.

10-INCH R.M.L. GUN, 18 TONS. INDEX PLATE AND READER.
¼ Size.



7. *Clinometer.**

§ 1444. This instrument, which was introduced into the service in 1867, can be used for giving the angle of elevation. It is issued as part of the equipment for field guns.

It consists of a 12-inch boxwood rule, with a quadrant marked on tbe joint and a spirit level set in one edge.

A few useful scales and memoranda are marked on the faces.

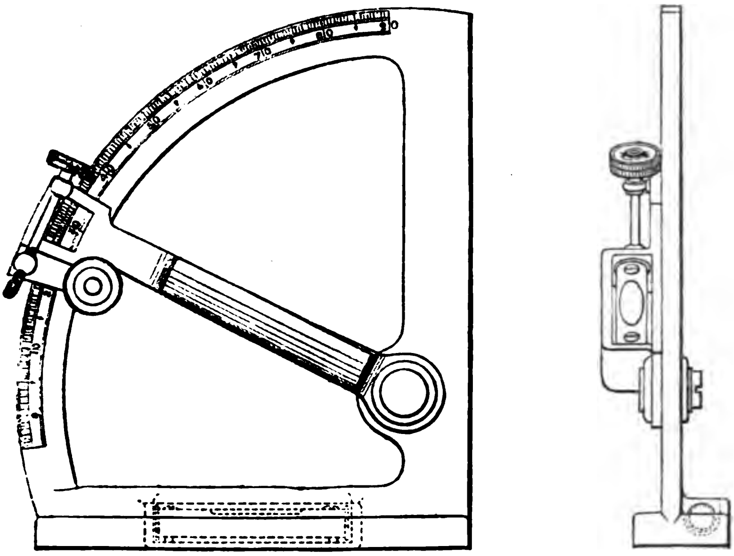
8. *Quadrant.**

Quadrant. A quadrant of the description shown on next page was also introduced for the same purpose in 1867. This pattern was introduced to replace an older one which had previously been employed for these pieces of ordnance.

* These stores are not made in the R.G.F., but obtained by contract.

For the rifled howitzer lately adopted a new and improved form of quadrant will (probably) be employed, with a spirit level showing, in addition, whether the trunnions are horizontal or otherwise.

NEW QUADRANT FOR LAYING HOWITZERS.
½ Full Size.

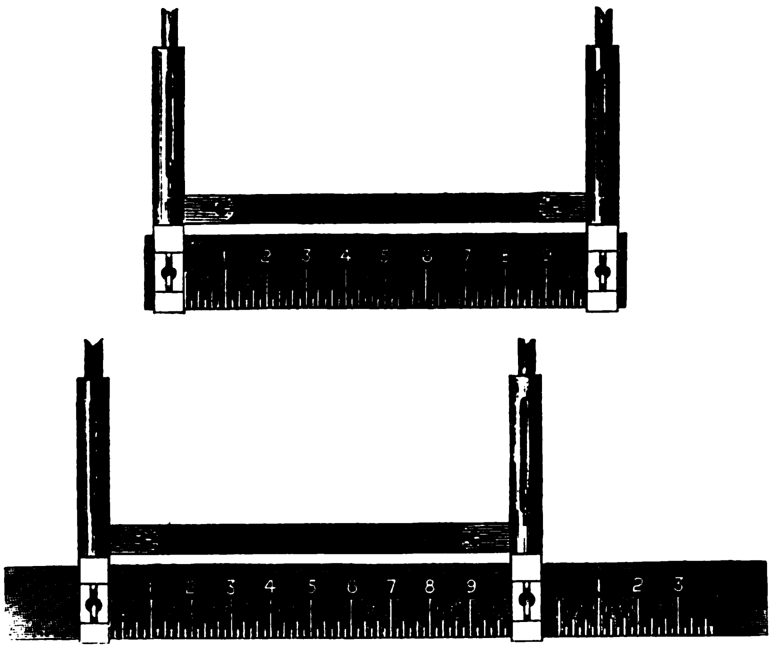


☞ This instrument will be applied to steps cut on the surface of the piece.

9. *Hanging Scales* (*Experimental*).*

This is a special arrangement employed for laying siege pieces when

Laying apparatus for siege ordnance. § 3070.



* Although still experimental, scales of this description are to be adopted with some modifications.

CHAP. IX. under cover, so that the object to be aimed at cannot be seen. The elevation in such case is given by means of (a clinometer or) quadrant, as before explained.

Hanging scales. The scales consist of two frames, one hanging from the axletree of the gun, and a second parallel to the former hanging from the trail, the frames being at right angles to the axis of the gun and swinging freely on the supporting hooks and eyebolts, so that they always assume a vertical position when in use.

When the piece is in action and the frames hanging down, the distance between their lower edges varies with the nature of carriage measured in the vertical plane passing through the axis of the gun.

Front frame. Suspending rods. For the front frame two eyebolts are screwed into the underside of the axletree at equal distances from the centre. Two suspending rods of iron are hung by hooks on their upper ends from these eyebolts. Each rod slides in a gun metal socket, and has a scale of three inches at its lower end, and a set screw, by means of which the rod can be clamped to length required.

Distance piece. A "distance piece" is secured to the rods above the caps, completing a rigid frame, the upper portion of which is the axletree itself, the sides being the two suspension bars and the lower side the "distance bar."

The frame swings freely on its upper side in a vertical plane, the bearing surfaces of the suspension bar hooks and the eyebolts in the axletree being knife-edged.

Scale bars. The front "scale bar" fits through the lateral slots in the caps, and is therefore parallel to the distance bar. It is capable of lateral movement in the frame to the right or left, and can be clamped by a thumbscrew in each cap.

The scale bars are rectangular and of gun metal. They are graduated in degrees from 0° to 10°, each of which is subdivided into smaller parts corresponding to 10 minutes. The scales are enamelled and fixed to the bars by means of screws.

How the scales are prepared for use. When required for use the hooked end of the suspension bars are inserted into the eyebolts under the axletree, and adjusted so that the scale bar when passed into the caps may nearly touch the platform with its lower edge.

The lower ends of the suspension bars are thus connected by the distance bar, and the scale bar placed in the caps.

Rear frame. For the rear frame two eyebolts are screwed into the side of the trail, to which the frame is suspended.

This rear frame consists of the same parts as the front frame, but the suspension bars are of course shorter.

The scale bar is rather longer than that of the front frame, and in addition to being graduated like the latter has a scale on the rear face for giving deflection up to 4°.

Deflection scale. How to use the scales. In order to use the scales, obtain the line of fire in direction (by pointing rods or otherwise), and mark its prolongation along the length of the platform. The division on the first scale cut by this line is noted, and the piece traversed until the same line cuts a division on the rear scale equal to that on the front.

Deflection is given by pushing the rear scale to the left, the number of degrees being given by the graduation on the right end of the rear face.

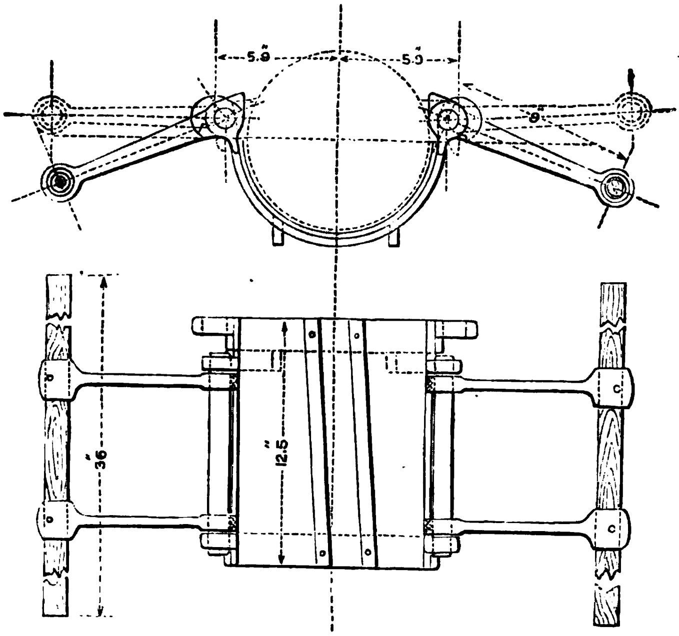
FITTINGS AND SMALL STORES.

§ 1320. We now come to the other fittings and stores for R.M.L. guns, besides their sights. These are all shown in Table p. 152, in alphabetical order.

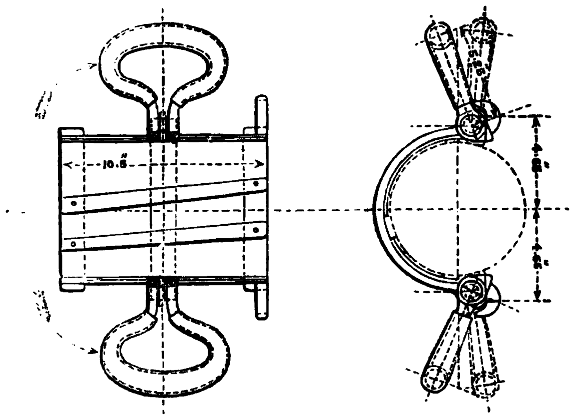
Bearers, shot or shell. CHAP. IX.

These are for use with the L.S. 9-inch, 7-inch, and 80-pr. guns, and the 8-inch howitzer.

SHOT BEARERS, L.S. 9-inch R.M.L. Gun.



7-inch R.M.L. Gun.



The hooks on the shot bearers shown in the cut have been removed. § 2207.
The handles of the 9-inch are now made of iron tubing.

Studs to support the shot bearer were formerly screwed into the muzzle of heavy guns before issue, vide p. 108.

Bolt iron, elevating eye complete.

For 25, 16, and 9-pr. guns, and consists of a bolt, washer, and keep pin, and are interchangeable, except the 9-pr. 6 cwt. bolt, which is shorter than the others.

CHAP. IX.

Brackets, metal.

§§ 1752, 2066, 2220. Attach the trunnion and centre fore sight sockets to the converted cast iron guns. See p. 164.

Clamps, metal, for wood scales.

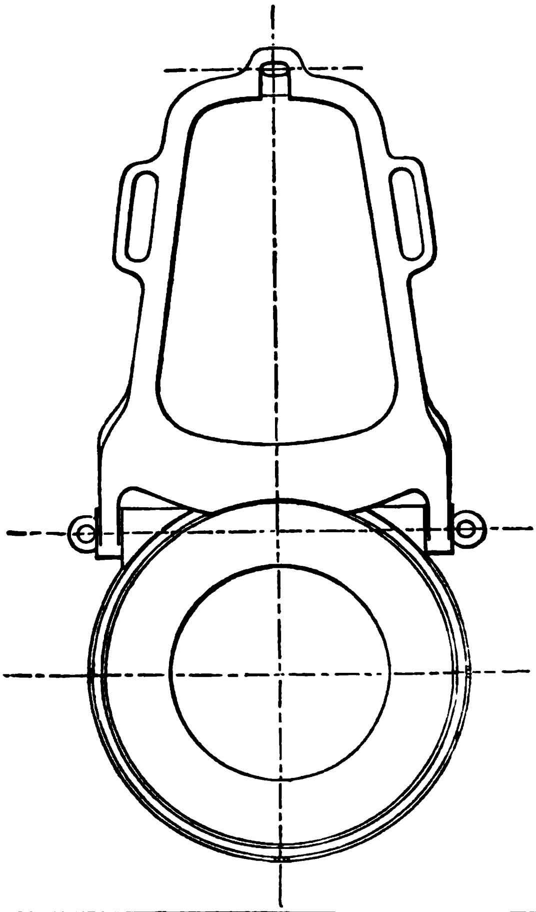
§ 1478. Are used with R.M.L. heavy guns for S.S. and slides on the wood scale. It has a pointer and is used to give elevation or depression in connexion with the heel scale on the cascable. See p. 120.

Clamps, moveable for Tangent Sights.

§§ 1144–1357. Are of gun metal and clamp the side sights at the required elevation, see p. 59. They are used with 25-pr. R.M.L. guns and upwards.*

ORDNANCE WROUGHT IRON R.M.L. 12·5-Inch 38 Tons.

MUZZLE DERRICK. Scale 1 inch = 1 foot.



* These clamps are only interchangeable for certain natures of guns, viz.:
1 is 2·25 inches in height for 7″ B.L., 82 cwt.; 100-pr. S.B. 9″ of 12 tons, 11″ and 12″ of 25 tons R.M.L.

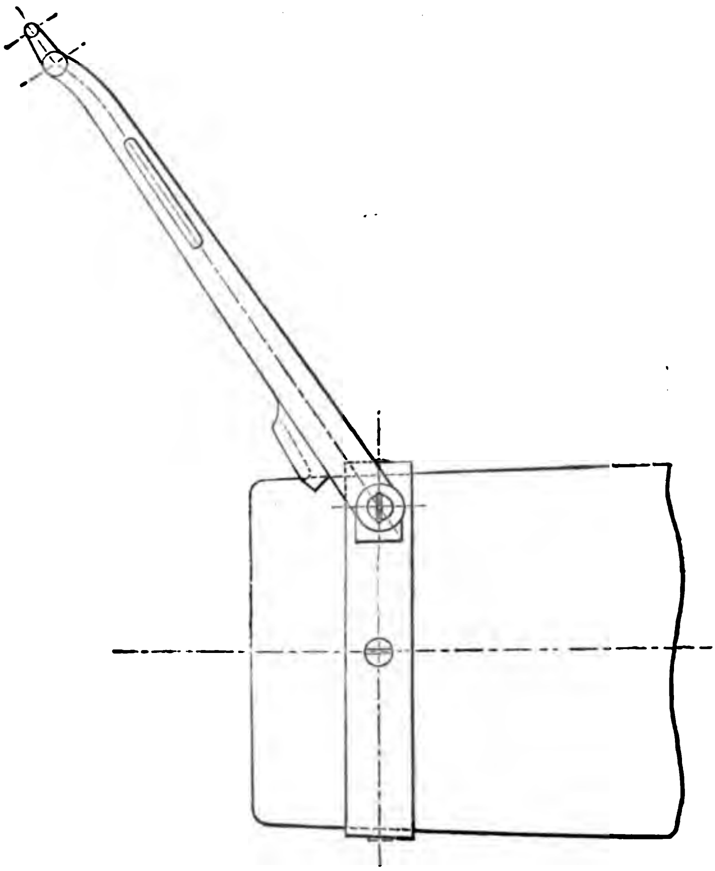
2 is 1·625 inches in height for 64-pr. 64 and 71 cwts. R.M.L., and $\frac{80}{68}$-prs.

3 is 1·425 „ for all other R.M.L. guns except,—
4, the 40-pr., and 25-pr. R.M.L., for which the clamps are 1″·125 high.
5, 8-inch and 6·3-inch howitzers.

Derricks.

This fitting is now provided* for 9-inch L.S. guns and upwards, for the purpose of raising the projectile to the muzzle of the piece.

It is made of bronze, and consists of a *band* (A) and *derrick* (B), as shown by the drawing below. The band is fixed round the chase of the gun at a distance of from seven to twelve inches from the muzzle, according to the nature of gun, and the derrick is secured to it by two



screw bolts, The derrick has a "bridge piece" (*b*) which rests on the top of the chase, supporting the fore part of the derrick, which projects over the muzzle the amount required for convenience of loading. To the loop (*c*) would be hooked the single block of the small tackle by means of which the projectile is raised.

The band when adjusted in the proper position is secured to the gun by four screws. Instructions for adjusting and securing these derrick bands are given at p. 251, Appendix II.

Guard, metal, vent.

For S.S. 10-inch guns when mounted on gun boats of the "Blazer" class, to prevent injury to the men from the flash of the vent when the gun is fired.

These are issued to the navy and are fitted by their artificers to the guns.

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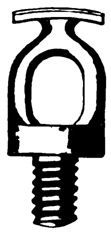
* Trials with various experimental derricks have been carried out from time to time since 1866, when the O.S.C. proposed such stores for the 13″ gun.

CHAP. IX.

Guide plates.

§§ 476–688. Guide plates are of steel, and one is screwed in at the right rear of the vent to guide the lanyard—which passes through it—direct on the quill friction tube. It has a cross-head on the top, to which a loop on the lanyard can be attached when the gun is loaded, and so prevent the gun being fired accidentally. The navy alone use it, as they fire their guns from the rear immediately the object is in line, and this guide plate enables the gunner to have a steady and direct pull on the lanyard while looking over the sights.

Scale ½.



Patch, preserving, muzzle sight.

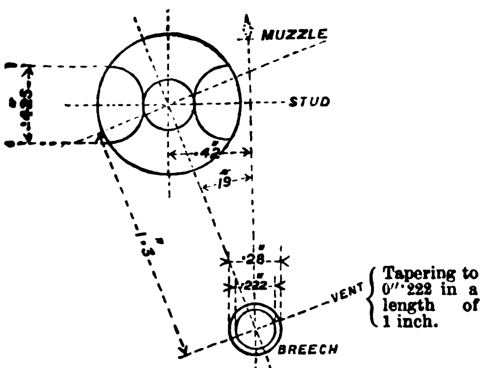
This covers the screw holes for the muzzle sight of the 9-pr. 6-cwt. S.S gun and the 8″ and 6·3″ howitzers, when the sight is not on the piece.

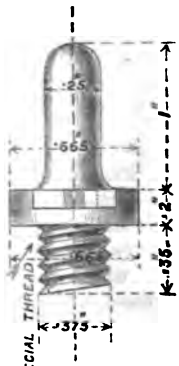
§ 1435. *Plate, metal, elevating.*

See Pieces, pivot.

§ 1141. *Pin, iron, friction tube.*

The friction tube pin is screwed in 1·3 inch to the left front of the vent and a spare hole is made adjoining it, lest the pin should be broken off, leaving its stump in the first hole. The leather loop of the S.S. quill friction tube is placed over this pin, to prevent the tube coming out or breaking when the lanyard is pulled, whilst to ensure direct action, the lanyard is passed through the *guide plate*, which is screwed into the gun in rear.





§ 1435. *Pins, iron, keep, pivot, elevating.*

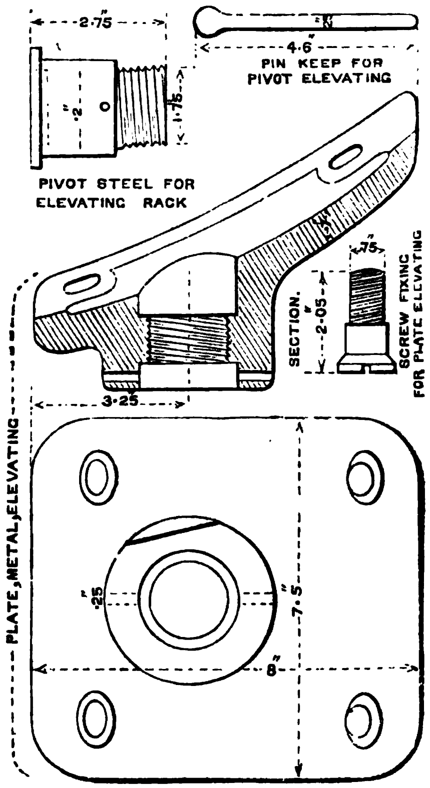
See Plate, metal, elevating.

§ 1435. *Pivots, steel, for elevating arc.*

See Pieces, pivot.

Pieces, pivot.

DETAILS OF A PIVOT PIECE FOR 9-IN. R.M.L. GUNS, 12 TONS.
See § 1435.



Scale ¼ size.

A pivot piece consists of the following parts : a metal plate, steel pivot for elevating rack, keep pin for pivot, and four screws for fixing the plate.

The metal plates are right and left handed (excepting 38 and 35-ton guns which have also two plates, both attached to one side of the breech of the gun by six screws each and termed top and bottom).

Pivot pieces serve to connect the gun to the elevating racks on the carriage ; they are attached to the guns by means of a wrench, vide p. 132.

To fix the elevating rack (vide p. 113, Treatise R.C.D., 1874) the keep pin is removed, the steel pivot unscrewed, passed through the hole in the elevating rack, and once more screwed into the plate, after which the keep pin is again inserted.

Plates, index.

These plates are of gun metal and for use with L.S. 9-inch guns and upwards, and are right and left handed, being attached to the side of the breech of the gun.

They are used in conjunction with a pointer or reader attached to the carriage, vide p. 122. See Table, p. 152.

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* The latest pattern for 10" and upwards are termed "countersunk." They have a square projecting boss fitting into a recess cut in the metal of the gun.

CHAP. IX. Mark II. is used with 10″ guns on low carriages Mark II. and low platforms, vide Treatise R.C.D., 1874, p. 216.

Prickers, priming.

§§ 1212, 1575. They are to prick the cartridge and are of four different lengths, viz., 29-inch, 23-inch, 17-inch, and 7½-inch. Most of the existing prickers are made of iron except the 29-inch pricker which is of steel. For the future, however, all to be made of steel. R.C.D., 1874, p. 116.

Reader for index plate.

§§ 1306, 1478. See Index plate. Are of gun metal and attached to the carriage, and are right and left handed.

Scales, wood.

§§ 1204, 1752. Are used in connexion with the heel scale for S.S. guns, vide p. 120

Scales, wood, side.

The 64-pr. guns for S.S. are provided with these scales, and are used in a similar manner to those for smoothbore guns.

Screws, copper, set.

Right and left hand for 16-pr. guns, and serve to clamp the tangent sight.

Screws, fixing and preserving.

All fittings, &c. are attached to the guns by means of "fixing screws," and when such fittings, &c. are removed, the holes are filled up by "preserving screws."

Sights.

See pp. 109 to 124, and Table, pp. 133 to 151.

Sockets, metal.

§ 1481. The centre, hind, and tangent sights work in these sockets which are let into the gun.

Studs, trunnion.

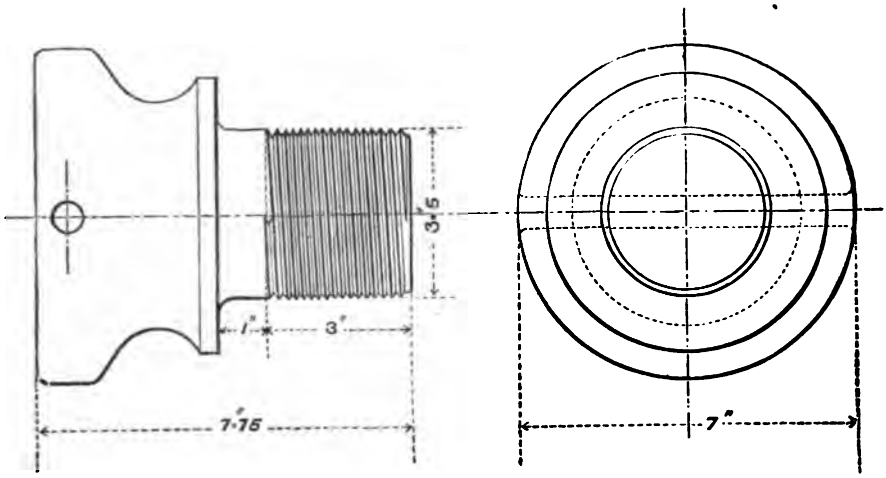
In order to facilitate the mounting and dismounting of very heavy guns in casemates, Colonel Inglis, R.E., proposed in 1874 that studs should be screwed into the trunnions of 38-ton guns, which would afford points by means of which the gun could be raised with the aid of powerful hydraulic jacks and a beam with wrought iron loops fitting over the studs. These studs were tried that year and found to answer well, in consequence of which their employment for 38-ton guns for L.S. was approved of in 1875.

The gun is prepared for them by boring into the face of each trunnion, the holes being about 4 inches in depth and 3·5 inches in diameter, and tapped for about 3 inches. The studs themselves are of wrought iron of the shape shown below, and when screwed home project 3·75 inches.

20-ton hydraulic jacks would be used in conjunction with them.

As the studs are interchangeable, only a certain proportion require to be issued, and not a pair for each gun.

TRUNNION STUDS.

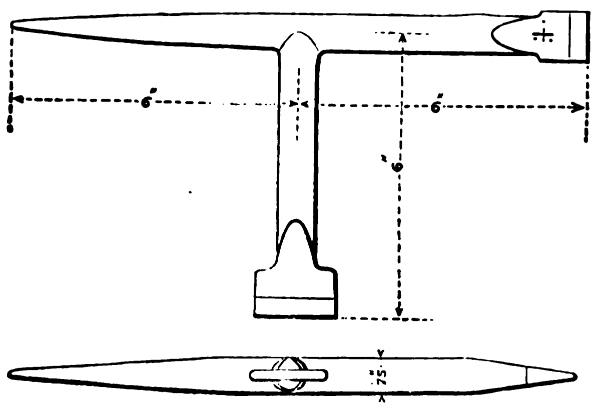


Wrench, Box, Fore Sight.

In case the fore sight of the L.S. 9-pr. guns becomes damaged or § 2078.
requires removing, this wrench is issued for the purpose of effecting this removal.

WRENCH FOR FIXING ELEVATING RACKS. 7, 8, and 9-inch R.M.L. Guns.

MARK II.



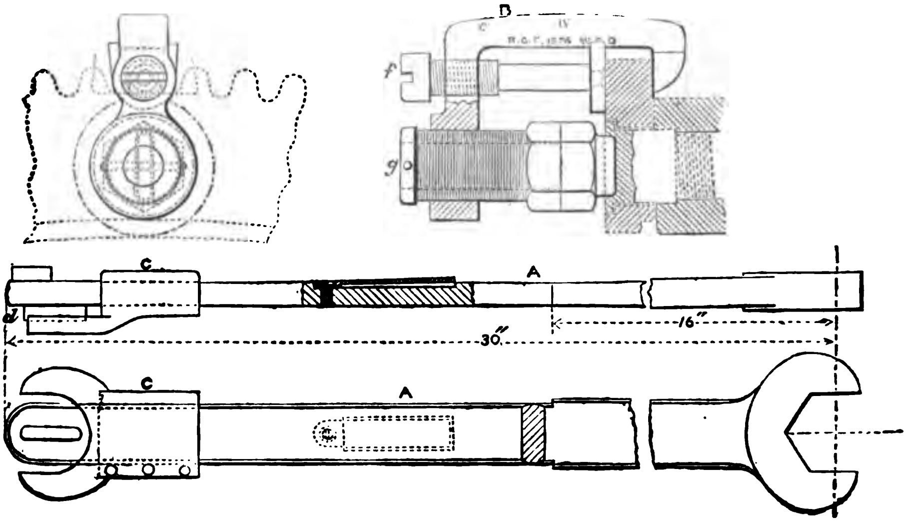
This wrench (Mark II.) is for the purpose of attaching the elevating § 1365.
plates to the above guns; but as they were not found to answer, a bent screw-driver (Wrench, Mark III.) was adopted for 10-inch guns and upwards, while those of Mark II. were to be utilised for smaller natures until the stock was exhausted.

Mark III. proved not powerful enough, and will be superseded by a new and much more powerful instrument, Mark IV., shown below.

CHAP. IX. WRENCH, MARK IV., WITH CLAMP COMPLETE, FOR REMOVING ELEVATING PIVOTS.

¼ size.

MARK IV.



This consists of two separate pieces, one only (A) of which need be employed to remove the pivot piece when the elevating arc is not secured to the gun, but both (A and B) are necessary should the arc be attached.

Part A is a strong wrought iron bar with a wrench at one end, and at the other a projecting stud to fit into the slot in the face of the pivot piece. Upon it slides a jaw (*c*) (kept in the centre by a spring when not required).

To use the wrench in removing a pivot piece preparatory to fixing on the elevating rack, place the stud (*d*) into the slot on the pivot piece, slide the jaw (*c*) over the pivot piece behind the head, and then unscrew.* The jaw prevents any slipping and keeps the stud firmly fixed in the pivot piece.

To remove the pivot piece when the elevating rack is attached by it to the gun, we must use A and B. B is also of wrought iron, and has a bent portion (*e*) to fit over the elevating arc, the screw (*f*) securing it firmly in position; the screw (*g*) has a spindle passing through its centre, on the end of which is a stud for fitting into the pivot piece.

§ 1213. On the screw and spindle where they meet are cut hexagonal faces, and the wrench fits over both together.

To remove the pivot piece, fix B to the arc, screw up (*g*) until the stud is well home in the slot of the pivot, then apply the wrench (A) to the hexagonal surfaces, and unscrew the stud.

Wrench, Pin, Friction Tube.

This wrench has four arms, which are used for the following purposes :—

Box wrench for friction tube pin.
Spanner for sight and fixing screw.
Tommy for guide plate.
Screw-driver for sight screw.

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* The keep pin being of course removed.

TABLE X. CHAP. IX.

NATURE of LATEST PATTERNS of TANGENT and CENTRE SIGHTS* and particulars of GRADUATIONS for RIFLED M.L. GUNS.

Nature of Gun.	Pattern of Sight.	Permanent angle of Deflection of Sights.	Length of Radius in Inches.	Graduations for Degrees. Number.	Graduations for Degrees. Length in Inches.	Remarks.
16-inch, 80 tons	—	-	-	-	-	——
12·5-inch, 38 tons	I.	2° 10′	72	10	12·695	Side or centre.
12-inch, 35 tons	I.	1° 25′	72	10	12·695	Side.
				10	12·695	Centre.†
13·05-inch, 23 tons	—	Nil.	45	13	10·388	Side } No yard graduations.
			45·1	5	3·936	Centre } No yard graduations.
12-inch, 25 tons	II.	30′	54	12	11·478	Side.
			59·95	5	5·249	Centre.
	III.	30′	59·95	10½	13·5	Long centre hind sights.‡
11-inch, 25 tons	I.	2° 26′	54	12	11·478	Side.
			59·95	5	5·249	Centre.
	II.	2° 26′	59·95	10½	13·5	Long centre hind sights.‡
10-inch, 18 tons	II.	1° 10′	54	12	11·478	Side } The side sights of L.S. guns are placed 3″ nearer the vertical axis than S.S. guns.
			60	5	5·249	Centre
	III.	1° 10′	60	8	10	Long centre hind sights.‡
9-inch, 12 tons	III. IV.	44′	45	15	12·057	Side } Existing sights to be altered for P. powder according to instructions below.§
			45·1	5	3·936	Centre
	V.	44′	45·1	7½	8	Long centre hind sights.‡
8-inch, 9 tons	II.	28′	38	15	10·05	Side
			38·1	5	3·35	Centre
7-inch, 7 and 6½ tons	III.	3°	38	15	10·05	Side
			38·1	5	3·35	Centre }
7-inch, 90 cwt.	I.	44′	38	15	10·05	Side.
			38·05	5	3·35	Centre.
80-pr. (converted) 5 tons	I.	19′	38	15	10·05	Side.

* Besides tangent sights, the Rifled M.L. guns for S.S. have wood scales used in conjunction with heel scales on the cascable, whilst 64-pr. M.L. are supplied with wood side scales (giving 12° elevation and 6° depression) similar to those for S.B. guns.

† This is a third tangent sight with steel bar.

‡ Vide p. 113.

§ The face of 7-inch sights graduated for yards with battering charges R.L.G. will be planed down, and a fresh scale showing yards for battering charges P. powder engraved instead. The faces of 8-inch and 9-inch sights graduated for yards with battering charges of R.L.G. powder will be cancelled by two lines drawn across the scale, and a fresh scale showing yards with battering charges P. powder will be engraved on the blank face opposite.

NOTE.—The metal heads of the sights are not to be polished, as it would eventually destroy their accuracy.

CHAP. IX.

TABLE X.—*continued.*

Nature of Gun.	Pattern of Sight.	Permanent angle of Deflection of Sights.	Length of Radius in Inches.	Graduations for Degrees. Number.	Graduations for Degrees. Length in Inches.	Remarks.
64-pr. 64 cwts.	V.-VI.	2° 16′ / 2° 50′*	38	15	10·05	Side.
64-pr. 64 cwts.	IV.	2° 16′	38·1	5	3·35	Centre.
64-pr. converted 71 cwts.	IV.	2° 16′	38	15	10·05	Side.
64-pr. converted 58 cwts.	III.	2° 16′	38·1	5	3·35	Centre.
40-pr. 35 cwt.	I.	1° 20′	36	12	7·651	Side.
40-pr. 34 „	I.	1° 20′	30	12	6·376	Side.
25-pr. 18 cwt.	I.	0° 53′	30	12	6·376	Side.
16-pr., 12 cwt.	I.	1° 50′	24	12	5·101	Side.
9-pr. Wrought Iron 8 cwt.† Mark I.	II.	1·30	66	6	6·936	Short } Central sighting.
				12	14·028	Long
9-pr. Wrought Iron 8 cwt. Mark II.	I.	1° 30′	65	6	6·831	Short } Central sighting.
				12	13·815	Long
9-pr. Wrought Iron 6 cwt. Mark I.	I.	1·30	54·6	7	6·703	Central sighting.
9-pr. Wrought Iron 6 cwt.† Mark II.	III.	1° 30′	68	5	5·946	Short } Central sighting.
				12	14·458	Long
7-pr. 150 lbs. (Steel)	II.	3°	24·2	10	4·28	Central sgihting.
				20	8·81	Do. Wood.
7-pr. 200 lbs. (Steel) Mark IV.	I.	3°	36·4	8	5·116	Short } Central sighting.
				12	7·736	Long
7-pr. 200 lbs. (Bronze)	I.	3°	33·5	8	4·708	Central sighting.
				17	10·241	Do. Wood.

* Those with steel tubes firing 10 lb. charges.
† A brass plate showing the range table is attached to left bracket of carriage.

TABLE XI.

TANGENT OR SIDE SIGHTS OF HEAVY R.M.L. GUN.

CHAP. IX.

TABLE XI.

Tangent or Side Sights of Heavy R.M.L. Gun.

Muzzle.

Mark of Sight.	No. of Face. Vide Diagram.	—	80-Ton.	12″·5 38-Ton.	12″ 35-Ton.	12″ 25-Ton.	11″ 25-Ton.	10 18-Ton.	9″ 12-Ton.	8″ 9-Ton.	7-inch. 7 or 6½ Tons.	7-inch. 90-Cwt.
I.	1	—	—	0° to 10°.	0° to 10°.	0° to 12°.	§ 2198.* 0° to 12°.	0° to 12°.	0° to 15°. *a*	§ 1477.† 0° to 15°.	§ 1281.‡ 0° to 15°.	§ 2540.§ 0° to 15°.
	2	—	—	—	C.S. Full, 85 lbs. P. Yds. 4,500.	C.S. Full. Fuze 24	C.S. Full. 60 lbs. P Yds. 4,500	S.Full. 40 lbs. Fuze30	Fuze 2·65	Shell Full. 20 lbs. Fuze 30.	Fuse.	*Blank.*
	3	—	—	—	Pal. S. or S. Battg. 100 lbs. P. Yds. 4,800.	„ Yds. 4,000	Pal. S. or S. Battg. 85 lbs. P. Yds. 4,800	Full.40lbs. Yds.4,000	S. or S. 30 lbs. Yds. 4,000	Full. 20 lbs. Yds.4,000	C.S. 14 lbs. Yds.4000	C.S. Full. 14 lbs. Yds. 4,000
	4	—	—	—	*Blank.*	C.S.Battg. „ 4,000	*Blank.*	Battg. 70 lbs. P. Yds. 4,800	*Blank.*	Battg. 35 lbs. P. Yds. 4,800.	*Blank.*	C.S. Full. Fuze 20.
II.	1	—	—	—	—	§ 2198.* 0° to 12°. *d*	—	§ 2198.* *d* 0° to 12°.	§§ 1254, 1476.† *b* 0° to 15°.	§ 2198.* *d* 0° to 15°.	§ 1487.† *c* 0° to 15°.	—
	2	—	—	—	—	C.S.Full 55 lbs. P. { Yds. 4,000 Fuze 24	—	C.S.Full. 44 lbs. P. { Yds.4,000 Fuze 30	Shell Full. 30 lbs. Fuze 27.	C.S.Full. 20 lbs. { Yds. 4,000 Fuze 30	C.S. Full. 14 lbs. Fuze 20.	—
	3	—	—	—	—	Pal. S. or S. Battg. 85 lbs. P. Yds.4,800	—	Pal. S. or S. Battg. 70 lbs. P. Yds.4,800	Full. 30 lbs. Yds.4,000	Pal. S. or S. & C.S. Battg., 35 lbs. P. Yds. 4,800.	C.S. Full. 14 lbs. Yds. 4,000.	—
	4	—	—	—	—	C.S. Battg. 85 lbs. P. { Yds.4,800 Fuze 32	—	C.S. Battg. 70 lbs. P. { Yds. 4,800 Fuze 34	Battg. 50 lbs. P. Yds. 4,800.	C.S. Battg. 35 lbs. P. Fuze 33.	Battg. 30 lbs. P. Yds. 4,800.	—

III.	1	–	–	–	–	–	–	–	§ 2198.* *d* 0° to 15°.	–	§ 2198.* *d* 0° to 15°.	
	2	–	–	–	–	–	–	–	C.S. Full 30 lbs. { Yds. 4,000 Fuze 27	–	C.S. Full. 14 lbs. { Yds. 4,000 Fuze 20	
	3	–	–	–	–	–	–	–	Pal. S. or S. & C.S. 50 lbs. P. Yds. 4,800	–	Pal. S. or S. & C.S. Battg. 30 lbs. P. Yds. 4,800.	
	4	–	–	–	–	–	–	–	C.S. Battg. 50 lbs. P. Fuze 32.	–	C.S. Battg. 30 lbs. P. Fuze 27.	
IV.	1											
	2											
	3											
	4											
V.	1											
	2											
	3											
	4											

a. Barrel head sight. * Introduced in 1871. † 1867. ‡ 1866. § 1873.
b. Has sliding leaf head, fuze scale in even tenths, headings of yard scale altered, and weight of charge added. In 1865 this system was adopted.
c. Fuze scale in even tenths, and projectile and charge added.
d. Owing to the introduction of P. powder regraduation was necessary; the depth of notch increased, and the graduations made uniform.

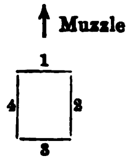
CHAP. IX.

TABLE XI.—Tangent or Side Sight of Heavy R.M.L. Gun—*continued.*

Mark of Sight.	No. of Face. Vide Diagram.	—	80 Ton.	12″·5 38 Ton.	12″ 35-Ton.	12″ 25-Ton.	11″ 25-Ton.	10″ 18-Ton.	9″ 12-Ton.	8″ 9-Ton.	7-inch. 7 or 6½ Tons.	7-inch. 90 Cwt.
VI.	1											
	2											
	3											
	4											
VII.	1											
	2											
	3											
	4											
VIII.	1											
	2											
	3											
	4											

TABLE XII.

TANGENT OR SIDE SIGHTS OF MEDIUM R.M.L. GUNS.



Mark of Sight.	No. of Face on Diagram.	64-pr. (Built-up Gun.)	$\frac{80}{68}$ pr. 5 tons. (Converted.)	Remarks.	Should be issued with
I.	1	§ 1032. 0° to 15°. *a*	§ 2220. 0° to 15°.	*a* Barrel head. No yards graduation owing to range not having been determined. Introduced in 1865.	Nil.
	2	*Blank.*	S.F. 10 lbs. Fuze 20.		
	3	*Blank.*	Full do. Yd. 3,500.		
	4	*Blank.*	*Blank.*		
II.	1	§ 1143. § 1254. 0° to 15°. *b*		*b* Sliding leaf head, 1866 - -	Nil.
	2	Fuze scale, F. 2·0.			
	3	Yards, 3,600.			
	4	*Blank.*			
III.	1	§ 1476. § 1752. 0° to 15°. *c*		*c* Fuze scale graduated in even tenths, heading of yard scale altered, and weight of charge added. 1867. Adopted for the converted 64-pr. 8-inch gun, 1869.	Nil.
	2	S. Full, 8 lbs., fuze 27.			
	3	Full „ Yds. 3,600.			
	4	*Blank.*			
IV.	1	§ 2198. 0° to 15° *d*		*d* Owing to the introduction of P. powder, regraduation was necessary, and the depth of notch increased, and the graduation made uniform. 1871. It is also now used for the converted 64-pr. 8-inch gun.	A.B. E.
	2	S. F. 8 lbs. Fuze 27.			
	3	Full „ Yds. 3,600.			
	4	*Blank.*			
V.	1	§ 2842. 0° to 15°. *e*		*e* Has a slow-motion screw for giving minutes of elevation being required for L.S. 64-pr. with steel tubes for siege purposes, and has also the shallow notch. 1875.	D.
	2	*Blank.*			
	3	Full, 10 lbs. Yds. 5,000.			
	4	„ „ Fuze 34.			
VI.	1	§ 2993. 0° to 15°. *f*		*f* Has no slow-motion screw, being used by the S.S., has the deep notch, and graduated for reduced charges. 1876.	A. B.C. E.
	2	Red^{d}. 8lbs. { Yds. 3,600. Fuze 27.			
	3	Full, 10 lbs. Yds. 5,000.			
	4	„ „ Fuze 34.			
VII.	1				
	2				
	3				
	4				

TABLE XII.—Tangent or Side Sights of Medium R.M.L. Guns—*continued.*

Mark of Sight.	No. of Face on Diagram.	64-pr. (Built-up Gun.)	$\frac{80}{68}$ pr. 5 tons. (Converted.)	Remarks.	Should be issued with
VIII.	1				
	2				
	3				
	4				
IX.	1				
	2				
	3				
	4				
X.	1				
	2				
	3				
	4				

Note.—§ 2993 (1.) There are at present six classes of the above-mentioned guns, viz.:

A. 64-pr. of 64 cwt., Mark I. (S.S.)
B. „ „ „ II. (S.S.)
C. „ „ „ III. (S.S.)
D. „ „ „ III. (L.S. siege train).
E. „ 71 cwt. converted, Mark I. (L.S. and S.S.)
F. „ 58 cwt. „ „ I. (L.S.)

(2.) From 1865 to the present date there have been introduced into the service for these natures of guns six patterns of tangent sights and five patterns of centre hind sights.

(3.) Tangent sights of Mark I. when returned into store from H.M. ships now in commission will be condemned, together with those in store at home and abroad, and sent to Woolwich as opportunities offer.

(4.) Tangent sights of Marks II. and III. at present on board H.M. ships will remain as they are until the vessels are paid off. Those in store, together with those returned from ships from time to time, will be sent to Woolwich for alteration to suit the guns for which sights of Mark IV. can be issued. The altered sights will resemble those of Mark IV., but will not be brought in all respects to pattern. They will be distinguished by having the Mark "IV." within parentheses, added to their original numeral; thus II. (IV.) and III. (IV.).

TABLE XIII.

Tangent or Side Sight, Siege, Field, Mountain, and Boat Guns.

CHAP. IX.

TABLE XIII.—Tangent or Side S

Mark of Sight.	No. of face on diagram.	64-pr. 64. cwt. Mark III. (steel tubes).	40-prs. 1.	40-prs. II.	25-pr.	16-prs.	* 9-pr. 8 cwt. L.S.I. Short.	* 9-pr. 8 cwt. L.S.I. Long.	*9-pr. 8 cwt. Short.	*9-pr. 8 cwt. L
I.	1	*a*	§ 2478. *b* 0° to 12°	§ 2854, *b* 0° to 12°	0° to 12°.	§2221. 0° to 12°.	§1920. §2067. *Blank.*	*Blank.*	§2743. 0° to 6°.	[illegible]
	2	—	Fuze 26	Fuze 26	*Blank.*	Fuze 28.	*Blank.*	*Blank.*	Fuze 17.	[illegible]
	3	—	Charge 7 lbs. Yds, 4,000	Charge 7 lbs., Yds. 4,000.	Yds. 4,000.	Yds. 4,000.	*Blank.*	*Blank.*	Yds. 2,600.	[illegible]
	4	—	*Blank* [3]	*Blank.* [3]	*Blank.* [1]	*Blank.* [5]	0° to 6°. [6]	6° to 12°.	*Blank.* [7]	[illegible]
II.	1	*a*	—	—	—	—	§ 2352. § 2636. *Blank.*	*Blank.* *c*	—	-
	2	—	—	—	—	—	Yds. 2,400.	Yds. 3,500.	—	-
	3	—	—	—	—	—	0° to 6°.	0° to 12°.	—	-
	4	—	—	—	—	—	Fuze 16. [5]	Fuze 20.	—	-
III.	1	*a*	—	—	—	—	—	—	—	-
	2	—	—	—	—	—	—	—	—	-
	3	—	—	—	—	—	—	—	—	-
	4	—	—	—	—	—	—	—	—	-
IV.	1	*a*								
	2	—								
	3	—								
	4	—								
V.	1	§ 2842. 0° to 15°.								
	2	*Blank.*								
	3	Full 10 lbs. Yds. 5,000.								
	4	Do. Fuze 34. [1]								
VI	1	*a*								
	2	—								
	3	—								
	4	—								

[1] Introduced in 1875; [2] 1873; [3] 187

a. See table of sights for medium guns.

b, These sights are not interchangeable, owing to the different radius with which these guns are sighted.

This pattern differs from Mark I. in having a yard and fuze scale, and the degrees on the long bar read from 0° to 12.

flection head on the short sight gives 30′ right and left, and the long bar is ½″ shorter than the long bar of Mark I.

Muzzle.
1
2
3

8 cwt. L.S. II.		*7-pr. 150 lbs. (steel) II. and III.		*7-pr. 200 lbs. (steel) IV.		7-pr. 200 lbs. Bronze. II.		* Howitzers.		9-pr. 6 cwt. S.S. I.	
.	Long.	Short.	Long.	Short.	Long.	Short.	Long.	8-inch.	6·3 inch.	Short.	Long.
.	Nil.[d]	§ 1506.[g] 0° to 10°.	—	§ 2498, 0° to 8°.	0° to 12°.	§ 1935.[i] 0° to 8°.	§ 1943.[i] 0° to 17°	Blank.[e]	—	0° to 7°.	0° to 12°.
.	Nil.	Blank.	—	12 oz. { Yds. 1,800. Fuze 13.	Yds. 2,400 Fuze 19.	D.S. { Y. 700. F. 9.	Ys. 1,200[h] Fuze 17.	Blank.	—	F. 15.	F. 20.
.	Nil.	Blank.	—	8 oz. { Yds. 1,700. Fuze 14.	Yds. 2,200 Fuze 19.	C.S.Y. 1,700.	Ys. 2,800[h]	0° to 15°.	0° to 15°	Yds. 2,400	Yds. 3,300
7	Nil.	Blank.[9]	—	D. shell 4 ozs. { Yds. 700. Fuze 9.[8]	Yds. 900. Fuze 12.	C.S.F. 14.[6]	Fuze 26.[h][6]	Blank.[8]	—	Nil.	Nil.
k.	Blank.	§ 1717. 0° to 10°.	0° to 20°								
100	Yds. 3,500	Blank.	Blank								
5°.	5° to 12°.	Blank.	Blank.								
13.	Fuze 20.	Blank.[8]	Blank.								
nk.	Blank.[f]										
,100	Yds. 3,500										
5°.	5° to 12°.										
12.	Fuze 20.										

[4] 1869; [5] 1872; [6] 1870; [7] 1874; [8] 1868; [9] 1867.
d. No sight of this pattern has been sealed or issued.
e. The deflection head on the sight gives 1° left and 4° right.
f. This pattern sight has its fuze graduation longer than the previous pattern.
g. This was for Mark II. gun which was side sighted.
h. These graduations added in November 1871.
i. A number of these sights have been issued marked only for degrees; these should be completed as occasion offers.
* These tangent sights are central though not termed central hind sights.

CHAP. IX.

TABLE XIII.—Tangent or Side Sight, Siege, F

Mark of Sight.	No. of face on diagram.	64-pr. 64 cwt. Mark III. (steel tubes).	40-prs.		25-pr.	16-prs.	* 9-pr. 8 cwt. L.S.I.		* 9-pr. 8 cwt.	
			I.	II.			Short.	Long.	Short.	Lo
VII.	1									
	2									
	3									
	4									
VIII.	1									
	2									
	3									
	4									
IX.	1									
	2									
	3									
	4									
X.	1									
	2									
	3									
	4									
XI.	1									
	2									
	3									
	4									
XII.	1									
	2									
	3									
	4									

…ntain, and Boat Guns—*continued.* CHAP. IX.

…r. 6 cwt. L.S. II.		* 9-pr. 6 cwt. S.S. I.	*7-pr. 150 lbs. (steel) II.		*7-pr. 200 lbs. (steel) IV.		7-pr. 200 lbs. Bronze.		* Howitzers.		
…rt.	Long.		Short.	Long.	Short.	Long.	Short.	Long.	8-inch.	6·3 inch.	

Mark of Sight.	No. of Face, vide Diagram.	7-Inch. ...ns.	7-Inch. 90 Cwt.	64-Pounder. 64 Cwt. (Wrought iron.)	64-Pounder. 64/32 Converted.	Should be issued with (See note p. 140.)
I.	1		§ 2549. (4) 0° to 5°	§ 1032. (7) 0° to 5°	—	Nil.
	2	. 1,200.	*Blank.*	*Blank.*	—	
	3	22 lbs.	*Blank.*	*Blank.*	—	
	4	. 2,200.	C.S. Full, 14 lbs. Yds. 2,200.	*Blank.*	—	
	5	e 1·5.	„ Fuze 15.	*Blank.*	—	
	6	e 8.	*Blank.*	*Blank.*	—	
II.	1	(3) a d	—	§ 1476. (3) 0° to 5° d	§§ 1476, 2066. 0° to 5°	
	2	. Yds.	—	*Blank.*	*Blank.*	
	3	.2,700. *C. S.* *. Yds.*	—	*Blank.*	*Blank.*	
	4	Yds.	—	Full, 8 lbs. Yds. 2,000.	Full, 8 lbs. Yds. 2,000.	
	5	Fuze	—	S. Full, 8 lbs. Fuze 13.	S. Full, 8 lbs. Fuze 13	
	6	Fuze	—	*Blank.*	*Blank.*	
	1	b Yds	—	§ 2198. (2) b 0° to 5°	§§ 2066, 2198. (2) e 0° to 5°	A. B.

a The graduations are carried as far as the shape of the gun will permit, as

The heads are fitted with deflection leaves like those of the tangent sight, as

b Has the deep notch being required for S. S.

tinued.

	7-Inch.		64-Pounder.		
n.	6½ and 7 Tons.	90 Cwt.	64 Cwt. Wrought iron.	$\frac{64}{32}$ Converted.	Should be issued with (*See* note p. 140.)
	—	—	§ (3) *b.* 0° to 5°		
	—	—	{ Reduced, 8 lbs. Fuze 13.		
	—	—	„ Yds. 2,000.		
	—	—	Full, 10 lbs. Yds. 2,500.		
	—	—	„ „ Fuze 16.		
	—	—	*Blank.*		
			Should be issued with A. B. C. F. (*See* note p. 140.)		

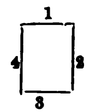
TABLE XV.

Wood Scales for R.M.L. Guns.

CHAP. IX.

TABLE XV.—Wood Scales for R.M.L. Guns.

Muzzle.



Mark of Scale.	No. of Face, vide Diagram	80 Ton.	12"·5 38 Ton.	12" 35 Ton.	12" 25 Ton.	11" 25 Ton.	10" 18 Ton.	9" 12 Ton.	8" 9 Ton.	7-Inch. 6½ Tons.	7-Inch. 90 Cwt.	64-pr. 64 Cwt. g	64-pr. 71 Cwt., converted.
I.	1	—	—	—	—	—	* §1757. (4) 7° D. to 12° E.	§1360. (1) 7° D. to 22° E.	§1479. (2) 7° D. to 22° E.	§1204. (1) 6° D. to 20° E.	§ 2635. (4) 7° D. to 22° E.	§1204. (1) e 6° D. to 12° E.	§ 1752. (4) 6° D. to 12° E.
	2	—	—	—	—	—	Blank.	S. or S. Full 30 lbs. Yds. 2,000.	S. or S. Full 20 lbs. Yds. 2,000.	This was a side scale.	Shell Full 14 lbs. Yds. 3,000.	This is a side scale.	This is a side scale.
	3	—	—	—	—	—	Blank.	Blank.	Blank.	—	Blank.	—	—
	4	—	—	—	—	—	Blank.	S. or S. Battg. 43 lbs. Yds. 2,000.	S. or S. Battg. 30 lbs. Yds. 2,000.	—	Blank.	—	—
II.	1	—	—	—	—	—	(5) c 7° D. to 12° E.	§1478. (2) a 7° D. to 22° E.	(5) c 7° D. to 22 E.	§1306. (1) b 7° D. to 22° E.	—	(7) f 8° D. to 13° E.	—
	2	—	—	—	—	—	S. or S. Full, 44 lbs. P. Yds. 2,000.	S. or S. Full 30 lbs. Yds. 2,000.	S. or S. Full 20 lbs. P. Yds. 2,000.	S. or S. Full 14 lbs. Yds. 1,500.	—	Shell 6 lbs. Yds. 3,600.	—
	3	—	—	—	—	—	C.S. Battg. 70 lbs. P. Yds. 3,000. d	Blank.	Blank.	D.S. Full 14 lbs. Yds. 1,200.	—	Shell 8 lbs. Yds. 4,000.	—
	4	—	—	—	—	—	S. or S. Battg. 70 lbs. P. Yds. 3,000.	S. or S. Battg. 43 lbs. Yds. 2,000.	S. or S. Battg. 35 lbs. P. Yds. 2,500.	S. or S. Battg. 22 lbs. Yds. 1,600.	—	Shell 10 lbs. Yds. 5,000.	—

a Has a sliding gun metal clamp and two small studs. b Square in section and yards graduations added. c Graduation for P. powder, and head of scale painted in different colours. d C.S. is cut on the top of this face. *D. depression, E. elevation. (1) 1866, (2) 1867, (3) 1868, (4) 1869, (5) 1872, (6) 1874, (7) 1876. e For guns mounted on wooden carriages. f Guns mounted on iron carriages. g 64-pr. firing 10-lb. charges have a cascable scale and use wood scale Mark II., vide p. 120.

TABLE XV.—Wood Scales for R.M.L. Guns—*continued.*

Mark of Scale.	No. of Face, vide Diagram.	80 Ton.	12"·5 38 Ton.	12" 35 Ton.	12" 25 Ton.	11" 25 Ton.	10" 18 Ton.	9" 12 Ton.	8" 9 Ton.	7-Inch. 6½ Tons.	7-Inch. 90 Cwt.	64-pr. 64 Cwt.	64-pr. 71 Cwt.
III.	1	—	—	—	—	—	—	(5) c 7° D. to 22° E.	—	§1587 (3) a 7° D. to 22° E.			
	2	—	—	—	—	—	—	S. or S. Full 30 lbs. Yds. 2,000.	—	S. or S. Full 14 lbs. Yds. 1,500.			
		—	—	—	—	—	—	*Blank.*	—	D.S. Full 14 lbs. Yds. 1,200.			
	4	—	—	—	—	—	—	S. or S. Battg. 50 lbs. P. Yds. 3,000.	—	S. or S. Battg. 22 lbs. Yds. 1,500.			
IV.	1	—	—	—	—	—	—	—	—	(5) c 7° D. to 22° E.			
	2	—	—	—	—	—	—	—	—	S. or S. Full 14 lbs. Yds. 1,500.			
	3	—	—	—	—	—	—	—	—	D.S. Full 14 lbs. Yds. 1,200.			
	4	—	—	—	—	—	—	—	—	S. or S. Battg. 30 lbs. P. Yds. 3,000.			

a Has a sliding gun metal clamp and two small studs. c Graduation for P. powder, and head of scale painted in different colours. (3) 1868, (5) 1872.

CHAP. IX.

TABLE

TABLE OF SMALL STORES

—	16" of 80 Tons.	12·5" 38 Ton. L.S.	12·5" 38 Ton. S.S.	12" 35 Ton. L.S.	12" 35 Ton. S.S.	12" 25 Ton. L.S.	12" 25 Ton. S.S.	11" 25 Ton. L.S.	11" 25 Ton. S.S.	10" 18 Ton. L.S.	10" 18 Ton. S.S.	9" 12 Ton. L.S.	9" 12 Ton. S.S.	8" 9 Ton. L.S.	8" 9 Ton. S.S.
Band, bronze, derrick, with four fixing screws and two bolts, complete.	–	1	–	1	–	–	–	1	–	1	–	–	–	–	–
Bearers, shot or shell	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–
Bolts, eye (*see* Band, bronze, derrick).															
Bolts, iron elevating eye	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brackets, metal, trunnion sight, right-hand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brackets, metal, trunnion sight, left "	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Brackets, metal, centre fore sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Clamps, metal, for wood scales	–	–	1	–	1	–	1	–	1	–	1	–	1	–	1
Clamps, moveable for tangent sights	–	2	2	2	2	2	2	2	2	2	2	2	2	–	2
Derricks, bronze, muzzle	–	1	–	1	–	–	–	1	–	1	–	–	–	–	–
Guard, metal, vent	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
Guide plate	–	–	1	–	1	–	1	–	1	–	1	–	1	–	1
Patch, preserving, muzzle sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pieces, pivot (for elevating arc, complete)	–	2	2	2	2	2	2	2	2	2	2	2	2	–	2
Pins, iron, friction tube	–	–	1	–	1	–	1	–	1	–	1	–	1	–	1
Pins, iron, keep, pivot, elevating	–	2	2	2	2	2	2	2	2	2	2	2	2	–	2
Pivots, steel, for elevating arcs	–	2	2	2	2	2	2	2	2	2	2	2	2	–	2
Plates, metal, elevating, right-hand	–	2	2	2	2	1	1	1	1	1	1	1	1	–	1
Plates, metal, elevating, left "	–	–	–	–	–	1	1	1	1	1	1	1	1	–	1
Plates, metal, elevating, right " Mark II.	–	2	2	2	2	1	1	1	1	1	1	–	–	–	–
Plates, metal, elevating, left " "	–	–	–	–	–	1	1	1	1	1	1	–	–	–	–
Plates, index, right-hand, Mark I. or II.	–	1	–	1	–	1	–	1	–	1	–	1	–	–	–
Plates, index, left " " "	–	1	–	1	–	1	–	1	–	1	–	1	–	–	–
Prickers, priming, steel 29-inch	–	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	–	–	–	–
Prickers, priming, iron 23 "	–	1	1	1	1	1	1	1	1	1	1	–	–	–	–
Prickers, priming, iron 17 "	–	–	–	–	–	–	–	–	–	–	–	1	1	–	1
Prickers, priming, iron 7½ "	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Reader for index plate, right-hand, Mark I. or II.	–	1	–	1	–	1	–	1	–	1	–	1	–	–	–
Reader for index plate, left " " "	–	1	–	1	–	1	–	1	–	1	–	1	–	–	–
Scales, wood	–	–	1	–	1	–	1	–	1	–	1	–	1	–	1
Scales, wood, side	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, copper, set, right-hand	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, copper, set, left "	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: Band (*see* Band, bronze, derrick).															
Screws, fixing: bracket, trunnion sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: do. centre fore sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: centre muzzle sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: elevating plate, I. or II.	–	12	12	12	12	8	8	8	8	8	8	8	8	–	8
Screws, fixing: guard, vent	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–
Screws, fixing: plates, index	–	4	–	4	–	4	–	4	–	4	–	4	–	–	–
Screws, fixing: reader for index plate	–	6	–	6	–	4	–	4	–	4	–	4	–	–	–
Screws, fixing: sights on counterweight 7" carriages, Mark I., forescale	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: sights on counterweight 7" carriages, Mark I., hind bracket reflecting sight.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: do. Mark II., trunnion reflecting.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: do. Mark II., graduated arcs with reflectors.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: sockets for tangent sight*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, fixing: sockets for centre hind sight	–	1	1	1	1	1	1	1	1	1	1	1	1	–	1
Screws, Preserving: bracket, trunnion sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, Preserving: bracket, centre fore sight	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Screws, Preserving: centre, fore, muzzle sight	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –	– –

XVI.

AND FITTINGS, R.M.L. GUNS.

7-inch. 7 Ton. L.S.	7-inch. 6½ Ton. S.S.	7-inch. 90 Cwt. S.S.	64-pr. 64 Cwt. L.S.	64-pr. 64 Cwt. S.S.	Converted. 80-pr. L.S.	Converted. 64-pr. 71 Cwt. S.S.	Converted. 64-pr. 58 Cwt. L.S.	40-pr. 35 Cwt. L.S.	25-pr. 18 Cwt. L.S.	16-pr. 12 Cwt. L.S.	9-prs. L.S.	9-prs. S.S.	7-prs. 200 lbs. L.S.	7-prs. 200 lbs. S.S.	Howitzers. 8" L.S.	Howitzers. 6·3" L.S.	Page and Price in Vocabulary of Stores, 1875.	Page in this Book.	Remarks.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	126	For guns mounted en barbette—12·5" gun, Mark I., 12" 35 tons I., 11" II., 10" I. and II., 9" I. and 9" II., III., IV. and V.
1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	203	124	
-	-	-	-	-	-	-	-	-	1	1	1	1	-	-	-	-	209	125	
-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	213	164	
-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	213	164	
-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	—	164	
-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	243	120	
2	2	2	2	2	2	2	-	2	2	-	-	-	-	-	1	-	243	126	For guns mounted en barbette.—*See* Band, bronze.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	126	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	257	127	When mounted on gun boats of the "Blazer" class.
-	1	1	-	1	-	1	-	-	-	-	-	1	-	1	-	-	285	127	
-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	1	1	—	128	* 9-pr. 6 cwt. S.S. Mark I.
2	2	2	1	1	-	-	-	1	1	-	-	-	-	-	1	1	281	129	
-	1	1	-	1	-	1	-	-	-	-	-	1	-	1	-	-	282	128	* When usea as siege ordnance. † For Mark III. gun.
2	2	2	1*	1†	-	-	-	1*	1*	-	-	-	-	-	1*	-	282	129	
2	2	2	1*	1†	-	-	-	1*	1*	-	-	-	-	-	1*	-	284	129	* When used for siege ordnance. † For Mark III. gun.
1	1	1	1*	1†	-	-	-	1*	1*	-	-	-	-	-	1*	-	285	129	* When used for siege ordnance. † For Mark III. gun.
1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	285	129	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	129	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	129	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	129	*Mark I. is for high carriage and low platform; II. for low carriage and high platform.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	122	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	289	130	* Are of steel, toughened in oil.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	289	130	
1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	289	130	
-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	-	-	289	130	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	122	* *See* Plates, index.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	122	
-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	295	120	
-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	296	164	
-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	—	130	
-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	—	130	
-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-	299	164	
-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	—	164	
-	-	-	-	-	-	-	-	-	-	-	-	3*	-	-	3	3	—	112	* 9-pr. 6 cwt. S.S. Mark I.
8	8	6	4*	4†	-	-	-	3*	3*	-	-	-	-	-	3*	3	300	129	* When used as siege ordnance. † For Mark III. gun.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	122	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	122	
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	315	117	
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	315	117	
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	117	
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	117	* 16-pr. guns and upwards have two of these screws, but being fixed in the gun are considered part of it.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
1	1	1	1	1	-	-	1	-	-	-	-	-	-	-	-	-	—	130	
-	-	-	-	-	4	4	-	-	-	-	-	-	-	-	-	-	300	130	
-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	—	130	* 9-pr. 6 cwt. S.S. L. and attaches the preserving patch.
-	-	-	-	-	-	-	-	-	-	-	-	2*	-	-	2	2	—	130	
-	-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	—	130	* 9-pr. 8 cwt. SS.

TABLE XVI.—Table of Small Stores

—	80 Ton.	12·5" 38 Ton. L.S.	12·5" 38 Ton. S.S.	12" 35 Ton. L.S.	12" 35 Ton. S.S.	12" 25 Ton. L.S.	12" 25 Ton. S.S.	11" 25 Ton. L.S.	11" 25 Ton. S.S.	10" 18 Ton. L.S.	10" 18 Ton. S.S.	9" 12 Ton. L.S.	9" 12 Ton. S.S.	8" 9 Ton. L.S.	8" 9 Ton. S.S.
Screws, preserving: elevating plate	-	12	12	12	12	8	8	8	8	8	8	8	8	-	8
Screws, preserving: friction tube pin	-	2	2	2	2	2	2	2	2	2	2	2	2	-	2
Screws, preserving: guard, vent	-	-	-	-	-	-	-	-	-	-	4*	-	-	-	-
Screws, preserving: guide plate	-	1	1	1	1	1	1	1	1	1	1	1	1	-	1
Screws, preserving: plates, index	-	8	-	8	-	8	-	8	-	8	-	8	-	-	-
Screws, preserving: sights on counterweight 7" carriages, Mark I. – fore scale	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Screws, preserving: sights on counterweight 7" carriages, Mark I. – hind bracket reflecting light.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Screws, preserving: do. Mark II. – trunnion reflector.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Screws, preserving: do. Mark II. – graduated arcs with reflectors.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: centre, fore – drop	-	1	1	1	1	1	1	1	1	1	1	1	1	-	1
Sights: centre, fore – drop, chase	-	1*	-	1*	-	1*	-	1*	-	-	-	-	-	-	-
Sights: centre, fore – muzzle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: centre – hind, hexagonal gun metal	-	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	1*	-	1
Sights: reflecting – mounted on counterweight carriage 7" Mark I. – Fore scale, with thumb screw.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: reflecting – mounted on counterweight carriage 7" Mark I. – hind bracket with glass reflector and frame.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: reflecting – do. Mark II. – graduated arc with reflector and clamping screw.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: reflecting – do. Mark II. – trunnion reflector.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights, reflecting. – rectangular steel, chase, with reflector and set screws (sliding leaf head).	-	1*	-	1*	-	1*	-	1*	-	-	-	-	-	-	-
Sights: tangent – rectangular steel, with sliding leaf head.	-	2	2	2	2	2	2	2	2	2	2	2	2	-	2
Sights: tangent – long do.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: tangent – short do.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: tangent – rectangular steel plain head – long	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: tangent – rectangular steel plain head – short	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: tangent – rectangular steel, with sliding leaf and small elevating nut.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sights: trunnion – drop	-	2	2	2	2	2	2	2	2	2	2	2	2	-	2
Sights: trunnion – screw	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sockets, metal for – centre hind sight with set screw	-	1	1	1	1	1	1	1	1	1	1	1	1	-	1
Sockets, metal for – tangent sight*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sockets, metal for – tangent sight with set screw	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Studs, trunnion, for Colonel Inglis' lifting apparatus.	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Wrench – box, fore sight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wrench – iron, for elevating plate, II., III. do. IV: with clamp complete	-	1	1	1	1	1	1	1	1	1	1	1	1	-	1
Wrench – pin, friction tube	-	1	1	1	1	1	1	1	1	1	1	1	1	-	1

nd Fittings, R.M.L. Guns—*continued.* CHAP. IX.

7-inch.			64-pr. 64 Cwt.		Converted.			40-pr. 35 Cwt.	25-pr. 18 Cwt.	16-pr. 12 Cwt.	9-prs.		7-prs. 200 lbs.		Howitzers.		Page and Price in Vocabulary of Stores, 1875.	Page in this Book.	Remarks.
7 Ton.	6½ Ton.	90 Cwt.			80-pr.	64-pr. 71 Cwt.	64-pr. 58 Cwt.								8″	6·3″			
L.S.	S.S.	S.S.	L.S.	S.S.	L.S.	S.S.	L.S.	L.S.	L.S.	L.S.	L.S.	S.S.	L.S.	S.S.	L.S.	S.S.			
8	8	8	4*	4†	-	-	-	3*	3*	-	-	-	-	-	3	3	300	130	* When used as siege ordnance. † For Mark III. gun.
2	2	2	2	2	2	2	2	2	2	-	-	2	2	2	-	-	300	130	* When mounted on gun boats of the "Blazer" class.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
1	1	1	1	1	1	1	1	1	1	-	-	1	1	1	-	-	300	130	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	315	130	
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	315	130	
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
1	1	1	1	1	-	-	1	-	-	-	-	-	-	-	-	-	315	114	
-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	—	118	* When mounted behind shields originally intended for 9″ or 10″ guns.
-	-	-	-	-	-	-	-	-	-	-	1	1*	1	1	-	-	315	115	* 9-pr. 6 cwt. I. is attached by 3 screws. 9-pr. 8 cwt. II. is screwed into a muzzle patch.
1	1	1	1	1	-	-	1	-	-	-	-	-	-	-	-	-	315	113	* Have sliding leaf heads.
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	315	117	
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	127	
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	117	
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	117	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	118	* When mounted behind shields originally intended for 9″ or 10″ guns.
2	2	2	2	2	2	2	-	-	-	-	-	-	-	-	-	-	315	111	
-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	-	316	112	* The mark of gun must be stated owing to difference of radius.
-	-	-	-	-	-	-	-	-	-	-	1*	-	-	-	-	-	316	112	* Do. do.
-	-	-	-	-	-	-	-	-	-	-	-	1*	1*	1*	-	-	316	112	* Do. do.
-	-	-	-	-	-	-	-	-	-	-	-	1*	1*	1*	-	-	316	112	* Do. do.
-	-	-	2*	-	-	-	-	2	2	2	-	-	-	-	-	-	315	111	* Mark III., steel tubed guns.
2	2	2	2	2	2	2	-	2	2	-	-	-	-	-	-	-	316	114	
-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	—	115	
1	1	1	1	1	-	-	1	-	-	-	-	-	-	-	-	-	322	130	* See remarks to screws, fixing for sockets, tangent sight.
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	130	
-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	-	-	—	130	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	—	131	
-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	346	131	
1	1	1	1	1*	-	-	-	1	1	-	-	-	-	-	-	-	346	131	* For Mark III. gun.
1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	-	-	346	133	

CHAPTER X.

CHAP. X.

MANUFACTURE OF R.M.L. CONVERTED GUNS; THEIR SIGHTS AND STORES.

Early attempts to convert S.B. into Rifled Guns.—Palliser method preferred and adopted in 1863.—Nature of S.B. pieces converted.—**Mode of conversion,** taking the 8-inch S.B. as an example.—Boring out the S.B. piece.—Manufacture of wrought iron barrel.—A tube, B tube, gas escape, how formed.—Insertion of barrel into casing.—Securing the same in its place.—Completion of gun.—Rifling with plain groove.—**Venting,** different from that of built up guns.—Operation of venting.—Proof and examination.—$\frac{64}{32}$-pr. of 58 cwts. converted.—Conversion of 68-pr. S.B. into $\frac{80}{68}$-pr. R.M.L. of 5 tons.—**Sighting of converted Guns.**—The two heavier natures side sighted.—Wood scales used.—Fittings and small stores. —Brackets for side and centre fore sights.

Conversion of S.B. into Rifled Guns.

Conversion of S.B. into rifled guns.

When rifled guns came into use there existed in the armament of all nations a number of S.B. cast iron guns, and, for the sake of economy, it was attempted to turn them into rifled pieces. The material, however, was found too weak of itself, and different modes of strengthening the guns were tried.

Early experiments.

Palliser's system.

As early as 1855 attempts were made to strengthen such guns by encasing them in rear of the trunnions with a wrought iron or other jacket, and between that date and 1863 various plans of this and other descriptions were tried unsuccessfully. In that year Captain (now Colonel Sir William) Palliser proposed to line cast iron guns with coiled iron barrels, fitting comparatively loosely into the casing until expanded by the heavy proof rounds. This method appeared to be more promising than any previously tried, and was moreover founded upon correct principles, the stronger material being placed next the charge.

Palliser principle.

Several guns converted on the Palliser principle gave very fair results upon trial, and showed themselves more powerful pieces than the smoothbores from which they were made. It was consequently determined to convert a large number of S.B. ordnance in this way, for although such pieces would be much inferior to built up Woolwich ordnance, yet where the range was limited and there were no iron plates to pierce they would prove useful.

Natures of S.B. proposed for conversion.

The O.S.C. proposed several natures for conversion, but it was finally decided that only the following natures of S.B. guns should be converted. They are, as will be seen, those of the newest and best construction amongst S.B. cast iron guns, viz.:

68-pr. of 95 cwts., S.B.,	into	80-pr.	R.M.L., of	5 tons.
8-inch of 65 „ „ (throwing 50 lb. shell)	„	64-pr.	„	71 cwts.
32-pr. of 58 cwts., S.B.	„	64-pr.	„	58 „

CHAP. X.

The mode of conversion consists in boring out the old gun and making a wrought iron tube to fit the casing thus prepared; this tube is slightly smaller than the bore of the casing, and is pushed into it without much force being necessary.* When fitted into its place it is secured there by means of a cast iron collar screwed into the muzzle end of the casing over a shoulder on the end of the tube; a wrought iron plug is also screwed through the casing underneath and into the barrel, preventing any chance of the latter shifting round. Mode of conversion.

The principles of conversion are identical in all cases, though the dimensions differ somewhat; we will therefore describe in detail the conversion of an 8-inch gun.

Conversion of 8-*inch S.B. of* 65 *cwt. into* 64-*pr.*, 71 *cwt.*

The cast iron gun is rough, second and finished bored to 10″·5 diameter, gauged, and horseshoe gauges prepared for turning the *A* tube. A variation of $\pm$ 0″·1 is allowed in the diameter of the bore of the cast iron casing, but should there be any difference in the diameter at one § 1752.
part or another it must result in a taper from muzzle to breech. The play between the tube and the casing is not allowed to exceed 0″·007 for a length of 24″ from the breech end, and 0″·015 for the remainder of the length. The cast iron gun.

The muzzle is recessed and threaded for the cast iron collar (the use of which is to keep the tube in position), and the gas channel is bored through the breech. This is under the cascable in the first 212 guns converted at Elswick, and in all the others is to the right top of the cascable so as to be clear of the breeching rope.

The coils for the tube are made entirely of departmental bar iron specially prepared by being put three times through the roughing rolls. The tube is formed of five coils united together in the usual manner, and is rough and fine bored to 6″·238 diameter, and the recess in the breech cut and tapped for the wrought iron cup. The cup for closing the breech end of the barrel is forged and stamped into shape under a steam hammer. It is turned inside and out and a screw cut on the exterior with a thread of five to the inch. It is then screwed tightly home. *A* tube of wrought iron.

The tube in this state is proved with water pressure of 120 lbs. on the square inch to ascertain that the cup fits tightly and that there is no leakage. The breech end of the *A* tube is then turned over a length of 32″ for the *B* tube † previously bored, and a spiral gas channel 0″·05 deep and 0″·1 wide is cut round its exterior communicating with the star grooves cut in the end of the barrel, and the gas escape through the cast-iron breech. Gas channel.

The *B* tube consists of two coils united, and being rough turned to 10″·75 and finished bored to 8″, it is shrunk on with 0″·003 shrinkage in the diameter. The tube is made double at this part in order that the gas may escape through the gas channel without bursting the gun in the event of the inner layer splitting.‡ The whole tube is then rough turned and the bore broached to 6″·29 and examined, after which the *B* tube.

---

* After proof, however, the barrel being permanently expanded, fits tightly against the interior of the casing. This is clearly shown when it is attempted to force out of its casing a tube condemned at proof, which is done by hydraulic pressure applied from breech end.

† This must not be confounded with the "*B* tube" of a wrought iron gun which forms the chase, while in converted guns it goes over the breech end of the *A* tube.

‡ The permanent expansion of the bore caused by firing heavy proof rounds brings it up to the proper calibre of 6″·3.

CHAP. X.

exterior is fine turned to fit the cast iron casing with the requisite amount of play.

Putting the gun together.

The tube is now fitted into the casing, the greatest care being taken that the breech end bears fairly against the cast iron ; the curved part of the end of the barrel is described with a longer radius than the corresponding curve in the cast iron so as not to be in contact with it at that part. The space thus left between the two prevents the tube acting as a wedge to split open the cast iron.

Cast iron collar.

When the tube is properly adjusted a cast iron collar is securely screwed into the muzzle end of the casing and over a shoulder of the tube.

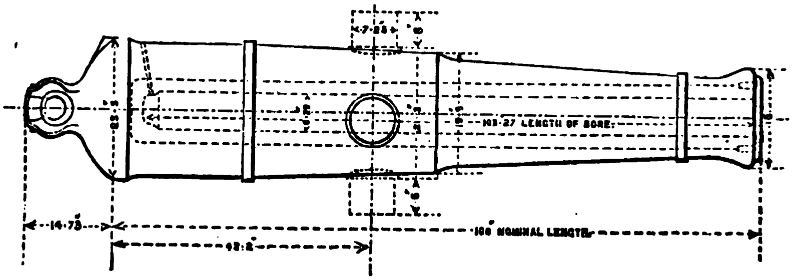
Wrought iron pin.

A hole 1″·25 in diameter is drilled through the cast iron, and a short distance into the tube at 29″ from the trunnions under the chase, and, being tapped, a wrought iron pin is screwed in to prevent the tube from shifting round.

The muzzle of the gun is then cut and faced, and the bore lapped and rifled.

§ 1752. $\frac{\text{64-pr.}}{\text{8-inch}}$ *M.L. Converted Gun, of* 71 *cwts. L.S. and S.S.*

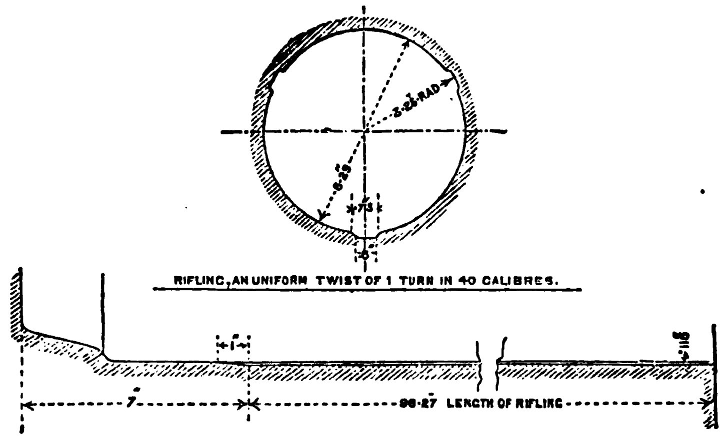
Scale $\frac{1}{12}$nd.



Plain groove.

The gun is rifled in the same machine, and in a similar manner to other R.M.L. guns, but the groove is the plain groove of section below, as mentioned at p. 16.

RIFLING. Scale $\frac{1}{12}$th.

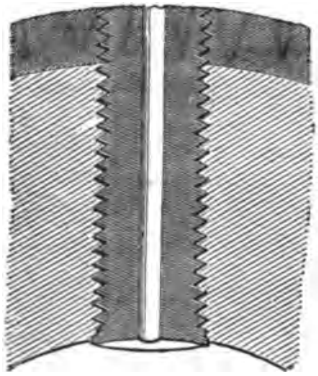


Venting.

Venting.

The vent patch is removed, as it would interfere with the lanyard when used through the guide plate on S.S., and the old vent closed with a wrought iron screw plug, a new vent being drilled a little from the breech end. This is bushed permanently before proof with a "through vent" (seven threads to the inch) of hardened copper screwed through the barrel into the breech cup, and perpendicular to the surface of the cup, *i.e.*, at an angle of 12° 25′ to the vertical.* The lower thread of the screw in the gun is cut away and the end of the vent is set up into the recess thus formed.† CHAP. X.

64-PR. CONVERTED M.L. GUNS, VENTING. Scale ½.



The process of venting is as follows (vide Plate on next page for tools mentioned) :—‡

The thread of the through bush is turned off for a length of about ¼ inch, and the bush is then screwed in by hand by means of a lever wrench. To insure that only the required amount projects into the bore, an "*adjusting block*" is passed into the chamber. This is an iron block attached to an iron bar, and having a portion slotted away of the depth sufficient for projecting part of the bush to fit into; the bar is kept in centre of the bore by means of two wood discs. A Gauge for copper vent. A¹.

When the end of the bush comes in contact with the bottom of the slot on the "adjusting block," the operation of screwing is discontinued, and the projecting copper "upset" into the recess as follows.

A split head or "*upsetting block*" of wrought iron, fitting the shape of the chamber, is pushed up into the latter by means of an iron "*extracting rod;*" into that part of the block immediately under the copper bush a piece of hard steel is dovetailed. An iron *tube*, the inner end of which fits over the "upsetting block," is next passed up the bore, and through this guiding tube is passed a solid iron *wedge*, which being forced into the "split head" or "upsetting block" presses out the sides of the latter, and so sets up the copper into the recess in the cup. The wedge is at one end of a stout iron bar, the outer end of which is struck by a "*monkey*" worked by two or three men, as a considerable amount of power is required for the setting up of the hardened copper bush. B¹ and B². C. D. E. H.

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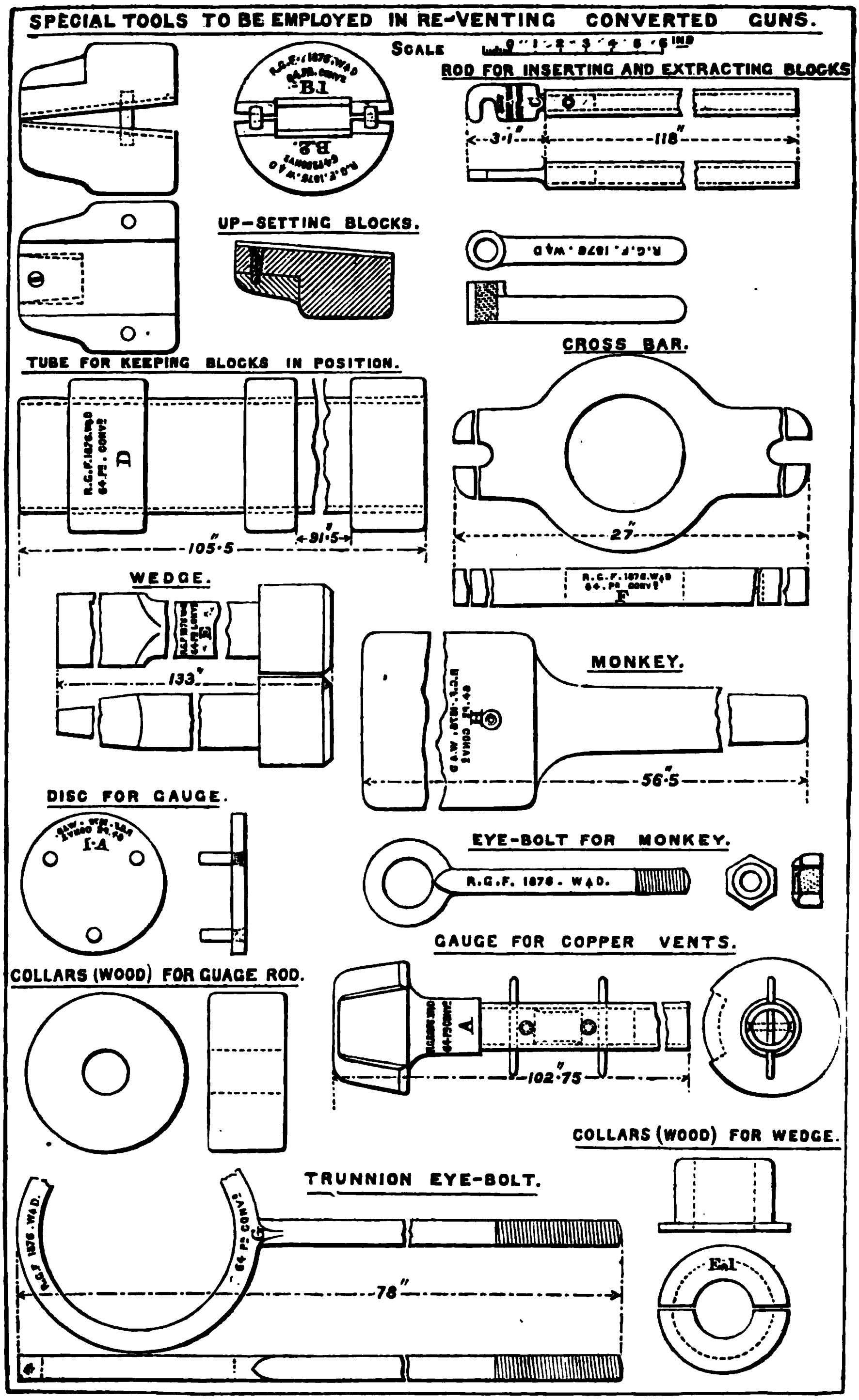
* With $\frac{64}{32}$-pr. and $\frac{80}{68}$-pr. the hole used for the old vent bush is used for venting, and the vents are therefore inclined at the same angle (from 9½° to 10°) as in the S.B. guns from which they were converted.

† The first 207 guns converted at Elswick had a vent bush 1″ diameter, 12 threads to the inch, but when they require re-venting it will be with the service bush.

‡ A list of the special tools required for this operation and that of re-venting is given at p. 241, Chapter XII. At present such sets of special tools have only been issued to Portsmouth, Malta, Hong Kong, and Esquimalt, and also to the Flagship of our Mediterranean Squadron.



SPECIAL TOOLS TO BE EMPLOYED IN RE-VENTING CONVERTED GUNS.
SCALE
ROD FOR INSERTING AND EXTRACTING BLOCKS
3·1"
118"
UP-SETTING BLOCKS.
B1
B2
R.G.F. 1876. W&D
CROSS BAR.
27"
TUBE FOR KEEPING BLOCKS IN POSITION.
D
105·5"
91·5"
WEDGE.
E
133"
F
MONKEY.
H
56·5"
DISC FOR GAUGE.
I·A
EYE-BOLT FOR MONKEY.
R.G.F. 1876. W&D.
GAUGE FOR COPPER VENTS.
A
102·75"
COLLARS (WOOD) FOR GUAGE ROD.
COLLARS (WOOD) FOR WEDGE.
E1
TRUNNION EYE-BOLT.
G
78"

To keep the bar to which the wedge is attached in the centre of the bore it passes through a "*wood collar*," and also through the centre of a "*cross bar*" in front of the muzzle, which is retained in position by a frame consisting of two rods with loops fitting over the trunnions and secured by nuts and screws to the ends of the collar. E. F. G.

When the copper is sufficiently "set up," the bars are loosed from the collar and the latter removed. The wedge and guilding tube are then withdrawn and the upsetting block removed by the extracting rod, after which a gutta-percha impression is taken of the bottom of the vent to ascertain if the operation has been performed completely; in that case the copper should still project into the bore for about 0·05 inch.

Proof and Examination.

These guns are proved like other R.M.L. ordnance with two rounds, $1\frac{1}{4}$ service charge and service projectile, and the expansion caused by proof must not exceed certain limits. No part of the bore before proof is allowed to be more than 0″·02 under the gauge (6″·29) nor 0″·04 over that gauge after proof. After proof the guns are gauged, examined with gutta-percha, and again tested with water pressure of 120 lbs. on the square inch to to see that the breech is still perfectly tight. Proof and examination. Fire-proof. Waterproof.

Owing to the defects inherent to wrought iron as a material for the inner barrel of a gun, converted guns not unfrequently fail at proof, generally speaking through defects in the wrought iron cup which closes the end of the breech, though sometimes the tube itself splits. Wrought iron cup.

Should a tube fail it is forced out of the casing by hydraulic pressure applied to the breech end; the nozzle of the hydraulic apparatus being passed through the gas escape channel, which is enlarged for this purpose. Removing a tube from its casing.

If the gun pass proof, however, it has now to be lined* and sighted. Lining and sighting.

These operations are performed as in the case of other R.M.L. guns (vide pp. 105–6), except that the sockets for the fore sights are not fitted into holes bored in the metal of the gun but into gun metal brackets which are themselves secured to the piece by two screws.

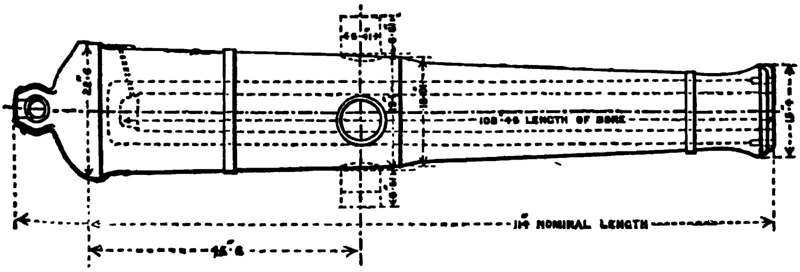
$\frac{64}{32}$-*pr. R.M.L. Gun L.S., of* 58 *cwts.*

The method of conversion of these guns is identical with that just described. They are, however, only sighted centrally. § 2066.

They are vented in the original position, and those guns which had six thread bushes as S.B. pieces are re-vented with bushes of the same thread, this divergence from the pattern being stamped on the vent field. Venting.

The vent patch is not removed, these guns being intended for L.S. only.

Scale $\frac{1}{32}$nd.



* The vertical line on muzzle is extended over the cast iron casing, so as to show any shifting of the tube.

CHAP. X.

$\frac{80}{68}$-*pr. R.M.L. Gun L.S., of 5 tons.*

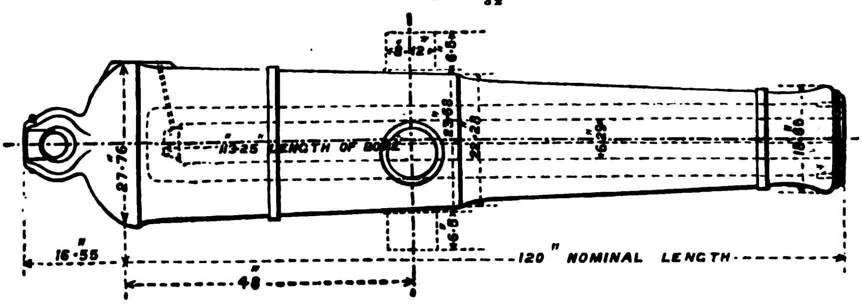
§ 2220. The conversion of these guns is identical with that of the 64-pr. of 58 cwts., but the rifling is on the "Woolwich" system, the width of the groove being 1·3″ and depth 0·145″.

Sighting. They are side-sighted, and have drop trunnion sights and sockets fitted to the gun by gun metal brackets similar to those of the 71-cwt. 64-pr.

Venting. They are vented the same as the 58-cwt. gun, and guns having six-thread bushes are re-bushed with the same.

They are for L.S. only.

Scale $\frac{1}{32}$nd.



Sights.

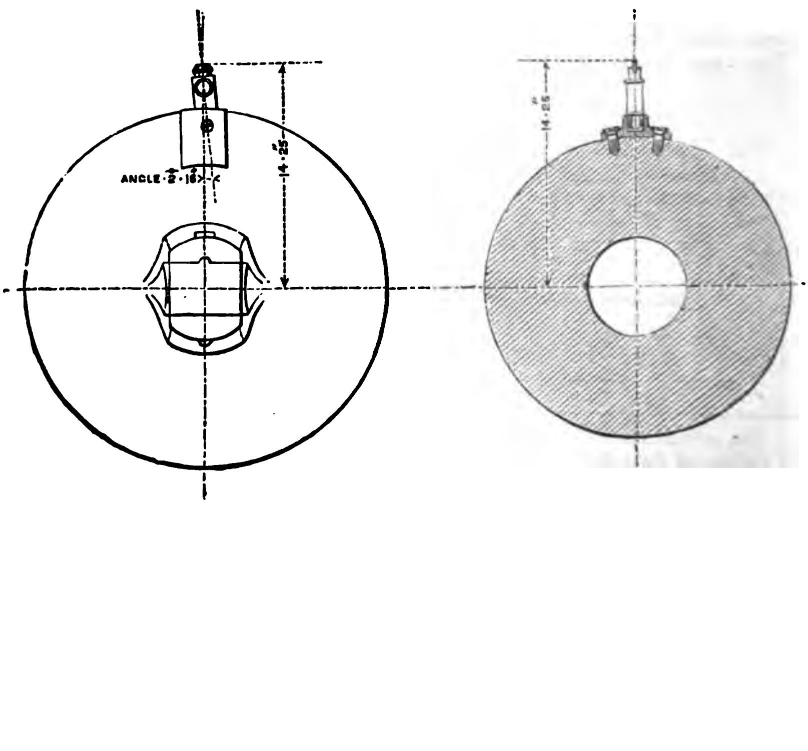
As already mentioned, the 64-pr. of 58 cwts. has only two sights, a centre hind sight and drop trunnion sight, while the 64-pr. of 71 cwts. and the 80-pr. of 5 tons have two hind sights and two fore sights, as shown below.

The tangent sights used for the 80-pr. and 64-pr. of 71 cwts. are similar to those described for other R.M., of 5 tons and upwards, p. 110, while the 64-pr. of 58 cwts. has a centre hind sight similar to the centre hind sights of the built up R.M.L. 64-pr. of 64 cwts.

They are all set at an angle of 2° 16′ to make up for permanent deflection, and are graduated as shown in Table X., pp. 133–4.

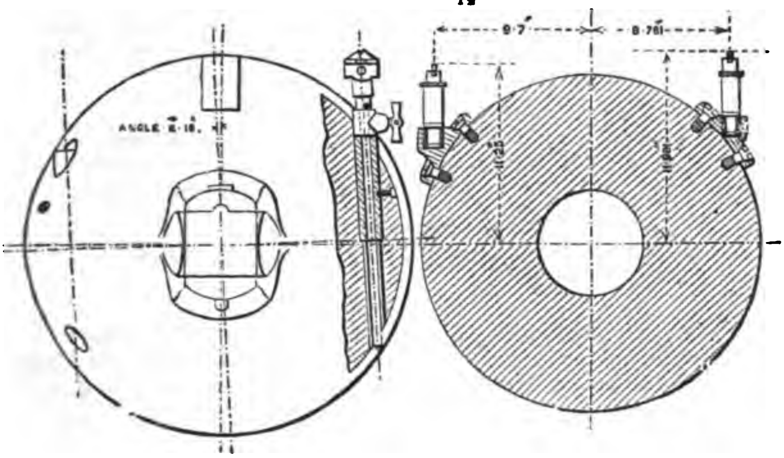
Sighting 64-pr. of 58 cwts.

SIGHTING. Scale $\frac{1}{12}$th.



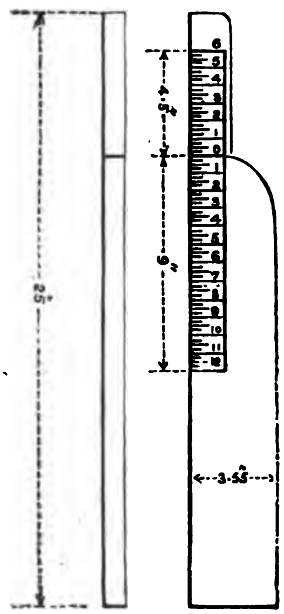
Sighting of 64-pr. of 71 cwts. and 80-pr. of 5 tons.

SIGHTING. Scale $\frac{1}{12}$th.



Besides these sights the 64-pr. of 71 cwts. S.S. is supplied with the wood side scale shown below.

WOOD SIDE SCALE. Scale $\frac{1}{8}$th.



Small stores and fittings.

The following are the stores belonging to these guns as mentioned in Table XVI., p. 152.

Bearers, shot and shell.

For the 80-pr. guns only.

CHAP. X.

Brackets, right and left hand.

These are of gun metal and attached to cast iron casing of the gun by two screws, and contain the socket for the drop trunnion sights. To bore holes in the cast iron casing for these sockets would weaken it §§ 1752, 2066, 2220. too much. They are for the 80-pr. 5 tons and 64-pr. 71 cwts., and must be removed when the gun is required for transport.

Bracket, centre fore sight.

§ 2066. This is similar to the above bracket, but only for the 64-pr. 58 cwt. for its centre fore drop sight, and attached to the second reinforce by two screws. It must be removed when the gun is required for transport.

Clamps, moveable for tangent sight.

§§ 1144, 1357. Are of gun metal and are for the 80-pr. 5 tons, and 64-pr. of 71 cwt., see p. 59.

Guide plates.

§ 688. Are of steel, attached to the right rear of the vent, and the pattern is universal for all S.S. guns, see p. 128. The 80-pr. 5 tons and 64-prs. of 71 and 58 cwts. are prepared for the reception of this fitting in the event of the guns being required for S.S.

Pins, iron, friction tube.

§ 1141. This is attached to the left front of the vent, and is of wrought iron case, hardened, and the pattern is universal for all S.S. guns. For further remarks see heading above.

Pricker, priming iron.

§ 1212. 17 inches long and serve to prick the cartridge. All the converted guns use it.

Scales, wood, side.

§ 1752. Is a S.S. store for the 64-pr. 71 cwt., and the pattern is identical with that used by S.S. smoothbore guns, see p. 27.

Screws, fixing.

See Brackets and Sockets.

Screws, preserving.

These fill up the holes occupied by the brackets for the sights when the guns are dismounted, and also the holes for the friction tube pin and guide plate when the piece is in use by the L.S.

Sights.

Centre, fore, of the drop pattern 64-pr. 58 cwt. is similar to that used by the 64-pr. wrought iron guns, vide p. 114.

Centre, hind, hexagonal, 64-pr. 58 cwt., same as 64-pr. wrought iron guns, vide p. 113.

Tangent, for 80-pr. 5 tons, and 64-pr. 71 cwt. is the usual rectangular steel bar with sliding-leaf head, vide p. 111.

Trunnion, drop, 80-pr. 5 tons, and 64-pr. 71 cwt., they are of the usual pattern, that for the 64-pr. 71 cwt. being the one also used by the wrought iron 64-pr.

Sockets, metal.

§ 1481. Centre hind sight with set screw for 64-pr. 58 cwt. and let into a hole being fixed by a screw. It must be removed when the gun is required for transport.

Wrench, pin, friction tube.

§ 1213. This wrench for the converted guns is required to screw or unscrew the friction tube pin, guide plate, and the fixing and preserving screws.

CHAPTER XI.

RECAPITULATION OF ALL NATURES OF R.M.L. GUNS IN THE SERVICE.

CHAP. XI.

Different Classes of R.M.L. Ordnance.—Mountain or Boat, Field, Siege Medium, and Heavy.—General remarks as to employment.—Marks or patterns.—Gas escapes.—Exterior form.—Mountain or boat guns in the Service.—7-pr. of five different patterns.—**Field Guns.**—Four natures of 9-prs., 16-pr. guns.—**Siege Pieces.**—Light and Heavy 6·3-inch and 8-inch howitzers, 25-pr., 40-pr., and 64-pr. guns of latest pattern.—**Medium Guns.**—Converted and other 64-pr. and 80-pr. guns.—7-inch of 90 cwts.—**Heavy Guns.**—Different natures of, 7-inch, 8-inch, and 9-inch; two patterns of 10-inch and 11-inch guns.—12-inch guns of 25 and 35 tons.—12·5-inch of 38 tons.—13·05-inch gun practically obsolete.—**Experimental Pieces.**—16-inch gun of 80 tons.—Rifled howitzers.—12-pr. field gun.—Table of R.M.L. Ordnance, with dimensions, rifling, &c.

Classes of R.M.L. Ordnance.

The general mode of construction of the guns now manufactured has been explained in Chapter VIII., and in the following chapter will be given the details of construction of all our existing R.M.L. pieces, including some natures which are still in the service but of which no more will be manufactured. R.M.L. ordnance.

Our R.M.L. ordnance* may be divided into— Classification.

(1.) *Mountain or Boat Guns.* Mountain or boat.
7-prs. of 150 to 224 lbs.

(2.) *Field, Boat, or Field Marine.* Field, boat, or field marine.
9-pr. of 6 or 8 cwts.
16-pr. of 12 cwts.

(3.) *Siege or Position.* Siege or position.
25-pr. of 18 cwts.
40-pr. of 34 or 35 cwts.
64-pr. (Mark III. with steel tube) of 64 cwts.
6·3-inch howitzer of 18 cwts.
8 „ „ 46 „

* Vide table, p. 212, for list with dimensions.

CHAP. XI.

Medium.

(4.) *Medium.*

64-pr. built up (except Mark III. with steel tube) of 64 cwts.
64-pr. converted of 58 cwts.
80-pr. „ 5 tons.
7-inch of 90 cwts.

Heavy.

(5.) *Heavy.*

7-inch of 6½ and 7 tons.
8 „ 9 tons.
9 „ 12 „
10 „ 18 „
11 „ 25 „
12 „ 25 and 35 tons.
12·5 „ 38 tons.
16 „ 80 „

General Remarks.

Before entering into the details of the various natures it may be well to make some general remarks as to R.M.L. service ordnance.

Nomenclature.

(1.) *As to Use.*—All heavy guns, except the 7-inch of 7 tons and the 8-inch, which are L.S. and S.S. guns only, are used for either L.S. or S.S.

§§ 899, 1081.

For S.S. we have also the 7-inch of 90 cwts. and* $\frac{64}{\text{8-inch}}$ converted gun, as well as the 64-pr. built up guns, except such as are appropriated for siege purposes.

The $\frac{80}{68}$-pr. 5 tons, and $\frac{64}{32}$-pr. 58-cwt. converted guns are meant for L.S. only.

Siege ordnance.

All the siege pieces or guns of position are L.S. Where guns of that size would be employed for S.S. as deck guns or otherwise, 20-pr. and 40-pr. R.B.L. are generally used.

Boat or field marine.

For field marine, or heavy boat service we have two 9-prs. of 6 cwts. and 8 cwts. respectively,† while the 16-pr. is for L.S. alone, as is the 9-pr. of 6 cwts. L.S.

Boat or mountain.

For boat or mountain service we have the small 7-pr. guns, which are L.S. and S.S.

(2.) *Marks or Patterns of Guns.*—As explained at p. 87, all built up Woolwich guns below the 9-inch are now made on the Fraser construction, with one layer of metal over the breech end in the shape of the jacket, the reduced 7-inch of 90 cwts. alone excepted (vide p. 93). The different marks of such guns, therefore, only differ in the manner in which the B layer of metal is put on, as in the 40-pr., or in length or other dimensions, as in the 9-pr.

Patterns of guns.

In the case of the heavier guns, however, where there is more than one construction on which the guns were formerly manufactured, the following table may be useful, as it shows in a condensed form the various patterns of guns in use. All these guns, it will be seen, are now made on the Fraser principle, with either one or two layers of iron over the steel tube.

* The $\frac{\text{64 pr.}}{\text{8-inch}}$ of 71 cwt. is also used for L.S. for certain land fronts.

† Many of these have been altered from the L.S. Mark I. 9-pr. of 8 cwts.

TABLE XVII.

TABLE showing the CONSTRUCTION of the VARIOUS MARKS of BUILT UP M.L. GUNS, 64-prs. and upwards.§

Nature.	Original Construction, pp.	Fraser Modification with Forged Breech-piece, pp.	Fraser Modification with One Layer, pp.	Fraser Modification with Two Layers. pp.	Remarks.
	Mark.	Mark.	Mark.	Mark.	
64-pr., 64 cwt.	I.‖	II.‖	III.*†¶	—	* These are now the service patterns for future manufacture. ‖ Iron tubes. ¶ Steel tubes.
7-inch, 90 cwt.	—	—	I.	—	
7 „ 6½ or 7 tons	I.‖	II.‖	III.*¶	—	
8 „ 9 tons	I.‖	II.‖	III.*¶	—	
9 „ 12 „	I.‖	II.¶	III.¶	IV., V.*¶	
10 „ 18 „	—	—	I.¶	II.*¶	
11 „ 25 „	—	—	I.¶	II.*¶	
12 „ 25 „	I.¶	—	—‡	II.*¶	
12 „ 35 „	—	—	—	I.*¶	
12 „ 38 „	—	—	—	I.*¶	
16 „ 80 „	—	—	—	I.¶	

Gas escapes.

(3.) *Gas escapes.*—As a precaution against accident in case the inner tube should split, most R.M.L. guns are furnished with gas escapes, *i.e.*, with a channel through which, should the inner barrel crack, the gas will escape and give warning that firing should be stopped.

All guns having cascable screws, *i.e.*, the R.M.L. howitzers as well as the 40-pr. guns and upwards, have gas escapes except Mark I. 64-pr. wrought iron guns, which have none, being manufactured before their introduction; but any of these latter guns that may require re-tubing would of course be furnished with such an escape.

The converted guns are also furnished with gas escapes, as explained in Chapter X., p. 157.

In the 25-pr. and downwards no such escape exists, as in these pieces the steel tube projects beyond the breech end of the jacket.

To form the gas escape in the built up guns, 40-pr. and upwards, a part of the thread of cascable screw is turned off, so that when the cascable is home against the end of steel tube an annular space is left; this is made to communicate with the outside of the gun by means of a channel cut through the cascable itself or through the metal of the gun, so that in the event of the tube splitting in the vicinity of the chamber the gas escaping through the channel would indicate the fact to the detachment at the gun, when firing should immediately cease.

In heavy guns of original construction.

With 7, 8, 9, and 12-inch guns Mark I., which have a forged breech-piece, a hole 0″·3 diameter was drilled through the breech-piece, at right angles to the cascable screw, so as to meet the annular space on the cascable, a groove also being cut along the outer edge of the breech-piece so as to meet this hole. In this pattern the gas escape comes out underneath the cascable, between the breech-piece and the coil overlapping it.

† Those manufactured after April 1871 have steel tubes, former guns wrought iron.

‡ There are two 12-inch 25-ton guns on this construction similar to Mark I. 11-inch, but they do not constitute a separate pattern, being known by their Nos. (20 and 21).

§ Guns marked F. or F.I. are of Mark II. construction.

„	„	F. II.	„	III.	„
64-pr. guns	„	B.	„	II.	„
„	„	D.	„	III.	„

CHAP. XI.

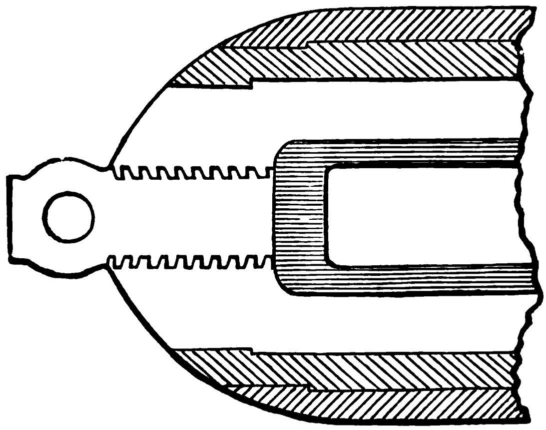
In other marks the channel is cut along the cascable screw and comes out at the right side of the cascable.

Exterior form.

(4.) *Exterior Form.*—It is convenient sometimes to know at a glance the nature and pattern of a gun. As to howitzers and the smaller guns, no remarks are required, but the following may be useful in the case of the heavier natures, of which there are several marks or patterns:—

§ 1385.

Exterior Form.



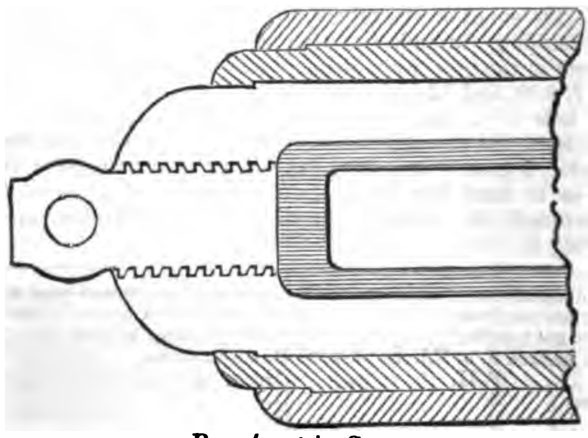
Breech rounded.

Original construction, breech rounded off.

Mark I. 64-pr., 7-inch, 8-inch, and 9-inch.—Are rounded off at the breech, because at the time of their introduction the breeching rope was used through the breeching loop, which was provided with a moveable block and pin, and consequently this shape of breech was adopted to save the rope from wear. They have also several steps in front of the trunnions.

Mark I. 12-inch and 13-inch are stepped at the breech.

Mark II. 64-pr., 7-inch, 8-inch, and 9-inch.—The curve at the breech is broken by the breech-piece which forms a step; the breeching rope being carried through the carriage, the moveable block in the breeching loop was abolished, and the thin edges of the layers of coil caused by the rounded outline was considered objectionable owing to the liability of the edges setting up. This and all future patterns have but two steps in front of the trunnions.



Breech cut in Steps.

Mark III. 64-pr., 7-inch, 8-inch, and 9-inch, and Mark I. 10-inch and 11-inch.—Having but one layer at the breech it is rounded off. CHAP. XI. Fraser modification, with one layer.

Marks IV. and V. 9-inch, and Mark II. 10-inch, 11-inch, and 12-inch, Mark I. 12·5-inch, Mark I. 16-inch.—As a rounded outline in this pattern would introduce the objectionable thin edge, the breech is cut in steps, corresponding to the layers of coals. Fraser modification, with two layers.

(5.) *Steel Tubes.*—The maximum thickness of these inner barrels varies from about 0·25 of a calibre in the larger guns to 0·33 of a calibre in the smaller pieces. This greatest thickness is naturally given at the breech end over the powder chamber, except in some of the field pieces where the barrel is not supported towards the muzzle by any coil shrunk on, and in which the tube is consequently thicker in the chase than at the breech end. Steel tubes.

The thickness of the tube is not uniform in the heaviest guns of latest pattern; in all pieces above the 7-inch gun (excepting the 10-inch of 18 tons) it decreases towards the muzzle, and in the 35-ton, 38-ton, and 80-ton gun this is readily seen.

A thinner chase is quite strong enough to withstand the strain, which decreases rapidly towards the muzzle.

Mountain or Boat Guns.

7-pr Rifled M.L. Guns.

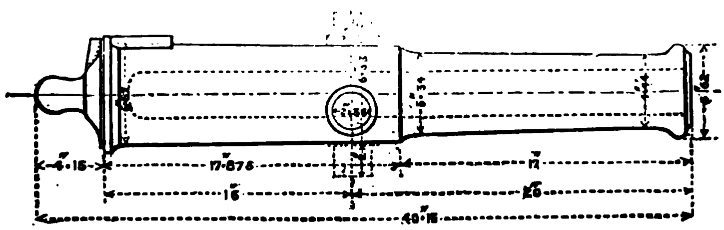
There are seven patterns of this gun in the service, three of bronze and four of steel, but the number of any one pattern made is very small, with the exception of Marks III. and IV., steel, of which many have been made. 7-pr. guns.

The rifling of the whole of these guns (both bronze and steel) is identical, and they fire the same ammunition.

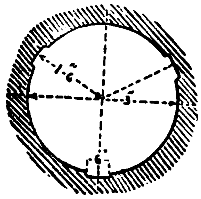
Bronze. Mark I. Weight, 224 lbs.
Calibre 3″.

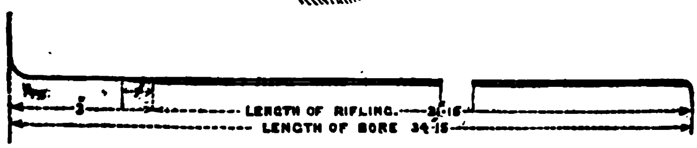
Scale 1 inch = 1 foot.

7-pr. bronze, Mark I.



Rifling. Scale 3 inches = 1 foot.





CHAP. XI.

§ 1146. O.S.C. Proceedings, 1865, pp. 212, 303, 304; and 1866, p. 233.

In 1865 some mountain guns were required on an emergency by the Indian Government to accompany the expedition to Bhootan, and 10 steel guns were demanded by the late Ordnance Select Committee, five of 190 lbs. weight and five of 150 lbs. As these guns could not, however, be supplied in time for Bhootan, six bronze 3-pr. S.B. guns of 2¼ cwt. were turned down to a weight of 224 lbs., bored to 3", and rifled on the French system with a twist of one turn in 20 calibres, this rifling having been adopted after a long series of experiments in competition with the Shunt and Lancaster (oval) systems.

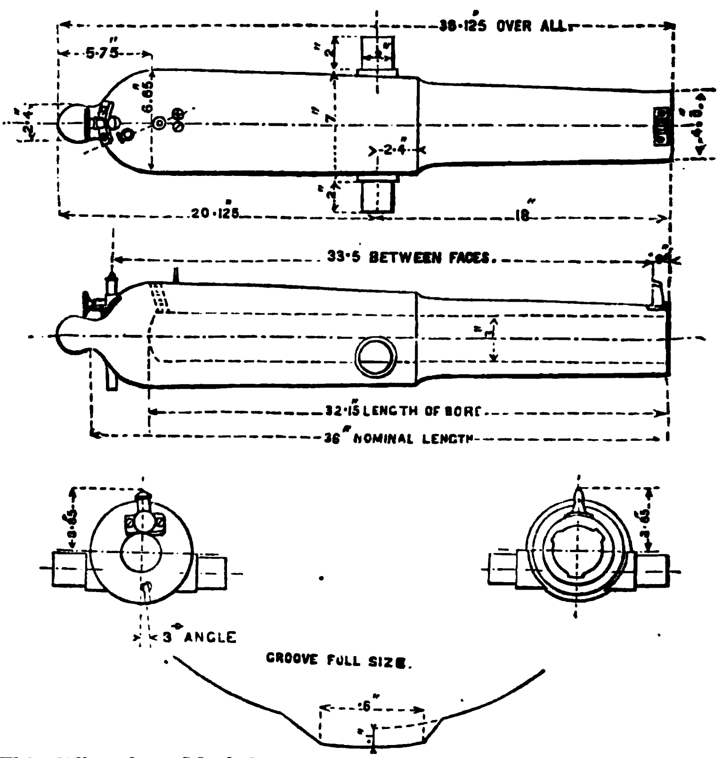
This gun was found to be too heavy for the mules in India, and a gun of 200 lbs. weight was asked for.

In order therefore to utilize the existing stock of bronze 3-prs., a gun was reduced to the required weight and adopted in 1866 as Mark II.

7 pr. Bronze. Mark II. Weight, 200 lbs.

Scale 1 inch = 1 foot.

7 pr. bronze Mark II.



§ 1985. O.S.C. Proceedings, 1866, p. 107.

This differs from Mark I. gun in having the exterior turned perfectly plain, and being 2" shorter in the bore. The swell of the muzzle is removed and a dispart sight screwed on the gun.

A pattern of this gun was sent to India in 1866 to govern manufacture and in 1867 twelve were sent to Ireland during the Fenian disturbances. In 1870 six were sent to Canada for the Red River Expedition, and being also approved of for boat service, it was then definitely adopted into the service.

The form and preponderance of this gun (being only a conversion) are not satisfactory, and experiments were carried out with a view to the adoption of a new bronze gun of better construction, but intended to fire the same ammunition with a heavier charge. The gun recommended is shown at Plate I. CHAP. XI.

Mark III., bronze.

On 21/1/73 it was ordered that no more bronze 7-pr. R.M.L. were to be made. Only two of this Mark III. pattern have been manufactured. 7-pr. bronze, Mark III.

Steel. Mark I. 190 lbs.

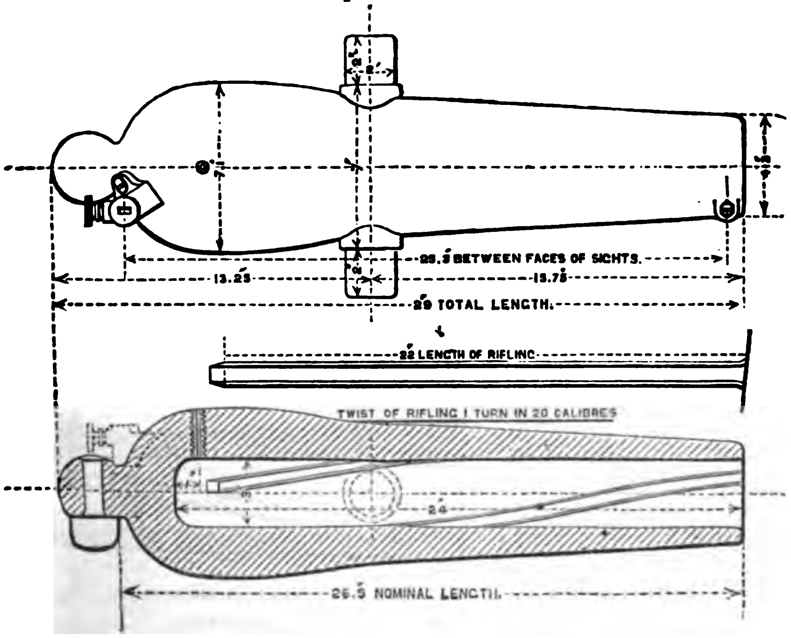
This was the first steel gun adopted, and five were made in 1865 and sent to Bhootan. The pattern is obsolete, and no more are made, but those already issued are retained in the service in India. 7-pr. steel, Mark I.

Steel. Mark II. 150 lbs.

This is the piece commonly known as the Abyssinian gun, twelve having been sent with that expediton. They were sighted on the right side only, the tangent sight working in a gun metal socket screwed to the breech, and the dispart sight screwed into the side of the muzzle. § 1506. 7-pr. steel, Mark II.

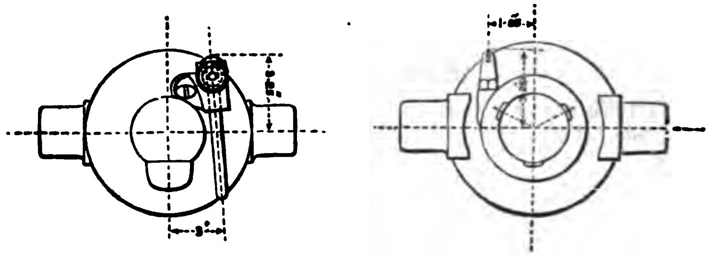
The cascable had a projection underneath, which fitted into a slot in the elevating screw. A pattern of this gun was never sealed, and the gun was altered on the experience gained in Abyssinia into the present system. Thirteen manufactured.

Scale 1½ inch = 1 foot.

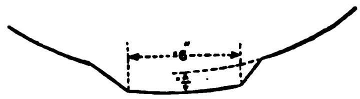


CHAP. XI.

SIGHTING. Scale 1½ inch = 1 foot.



GROOVE, full size.



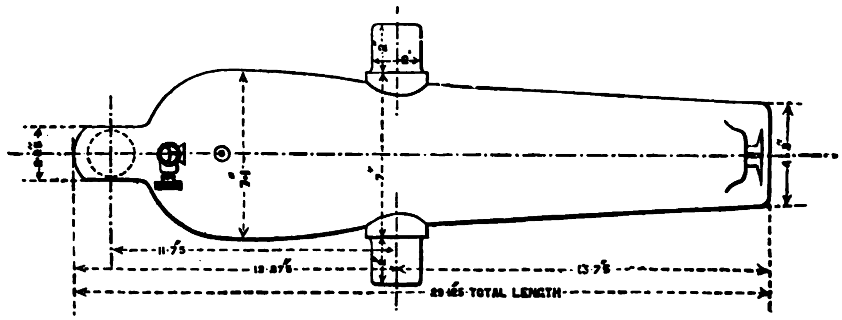
Steel. Mark III. 150 lbs.

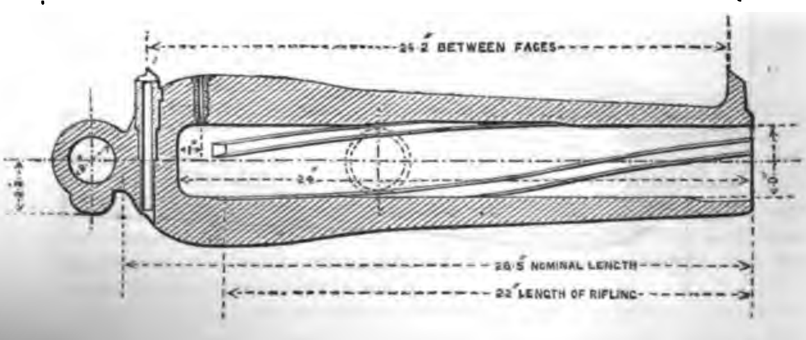
(See Plate I.)

§ 1717. 7-pr. steel, Mark III.

This gun differs from Mark II. in being centre sighted (see page 171, as the side sights were found to be liable to injury), and also in having a horizontal hole bored through the cascable, through which a rod can be passed, so as to facilitate loading or unloading, and also to enable the gun to be readily carried by men over country impassable for animals.

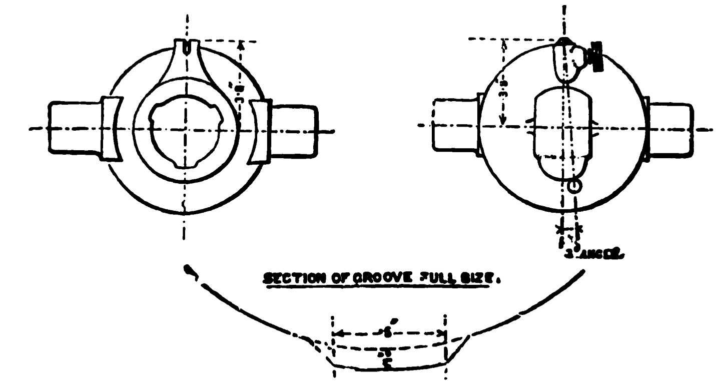
Scale 1½ inch = 1 foot.





SIGHTING. 1½ inch = 1 foot.

CHAP. XI.



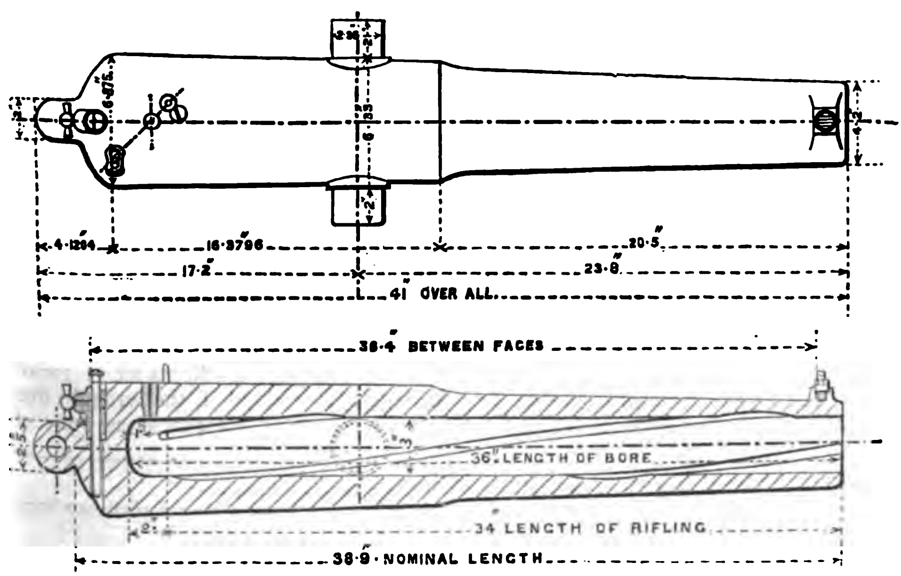
Steel, Mark IV., 200 lbs., L.S. and S.S.

(See Plate I.)

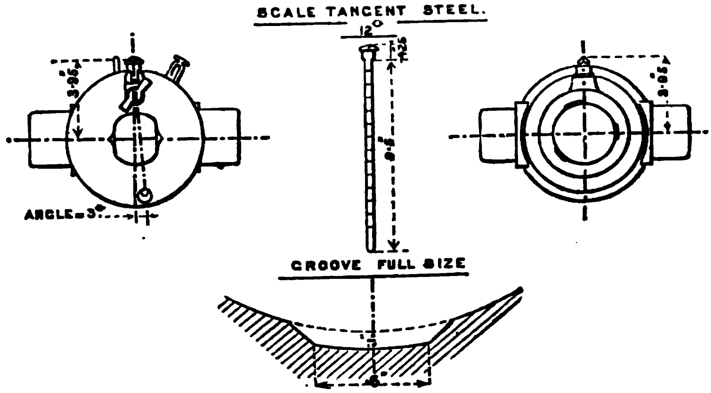
This gun was introduced into the service in July 1873; it is much longer than Mark III., and externally resembles the bronze, 7-pr. Mark II. It is made out of a solid block of steel, and has no swell at the muzzle, but a small dispart patch into which the fore sight screws. It differs in this from Mark III., and also in having two steel tangent sights, one graduated up to 8° and the other up to 12°. § 2498. 7-pr. steel, Mark IV.

The hole through the cascable is here small, this piece being intended for mule carriage if employed for L.S.

This piece would be used in the siege train to take the place of the old S.B. bronze mortars.



CHAP. XI.



TWIST OF RIFLING. 1 TURN IN 20 CALIBRES.

FIELD GUNS.

9-pr. Rifled M.L. Guns.

(See Plate II.)

9-prs. of four natures.

We have four different natures of 9-prs. in the service; two for L.S. and two for S.S. They all have the same calibre and rifling.

The L.S. are	9-prs.	of 8*	cwts.	Mark	I.
"	"	of 6	"	"	II.
Those for S.S.	"	of 8*	"	"	II.
"	"	of 6	"	"	I.

It will be seen that the 6-cwt. gun Mark I. is the shortest of all. It is meant for boat service.

O.S.C. Proceedings, 1866, p. 201.

The 8-cwt. gun will be boat and field marine; and the 6-cwt. Mark II., which has the greatest length of bore, will be the Horse Artillery and light field battery gun.†

O.S.C. Proceedings, 1868, p. 384.

O.S.C. Proceedings, 1866, p. 328; 1867, p. 71.

In 1866 the late Ordnance Select Committee suggested the adoption of rifled M.L. guns of a pattern equally suitable for field or boat service. The gun suggested for the Horse Artillery was a 9-pr. of 6-cwt., and that for field batteries a 12-pr. 8 cwt., both having a calibre of 3".

In 1866–7, 50 of the former and 48 of the latter were asked for by the navy, but it was decided, 21/1/67, "that for the present no alteration was to be made in the construction of rifled field guns for land service." Subsequently 20 12-prs. and 45 9-prs. were manufactured for the Navy up to the point of rifling only, the system of rifling to be adopted being undesided.

Bronze 9-pr.

Withdrawn 1874.

In 1869 a bronze 9-pr. gun of 8 cwts. was introduced for Indian service, with the calibre rifling, &c. of our present 9-prs. Several batteries of these pieces were issued, but as the material of which they were made proved unsatisfactory, their manufacture soon ceased, and they have now all been withdrawn from the service.‡

Upon the recommendation of the committee of officers who reported in favour of the bronze 9-pr. for India, the whole of the wrought iron and steel guns above mentioned were, in 1870, completed as 9-prs. of

* L.S. of 8 cwt. will be all altered and become S.S. guns.

† For light field batteries we shall soon have a more powerful piece now being experimented with.

‡ Vide also p. 2. A number of these bronze guns were rendered unserviceable for ordinary practice firing in peace time.

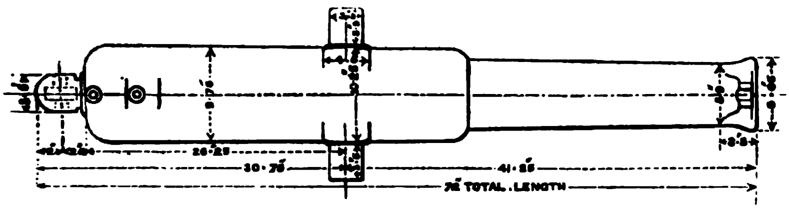
6 cwts. and 8 cwts., and rifled with the same form of groove as that adopted for the bronze guns, so as to fire the same ammunition. CHAP. XI.

Since that date all our Horse Artillery have been armed with 9-prs. of 6 cwts., and half of the field batteries with 9-prs. of 8 cwts. The latter, however, are being now altered for sea service, and the field batteries having 9-prs. will be equipped entirely with those of 6 cwts. for the present, to be superseded shortly by 12-pr. guns.

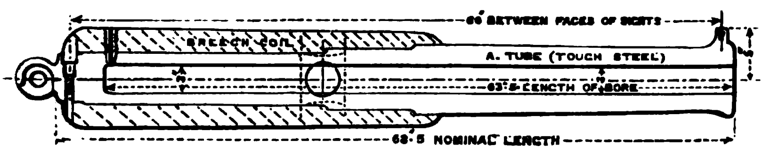
The following diagrams, &c. give the details of construction of the 9-prs.

Mark I. 8 cwt.

Scale ⅜ inch = 1 foot.



9-pr.
Mark I.
L.S.



Consists of:— § 2067.

A tube (toughened steel).

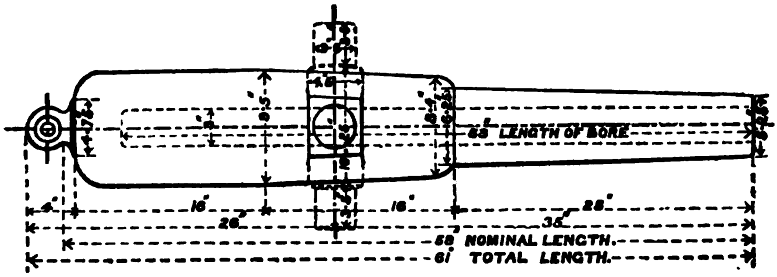
Breech coil, composed of a single coil, trunnion-ring, and a coil in front of the trunnions welded together.

Rifling, modified French, 1 turn in 30 calibres.

Length of bore, 21 calibres.

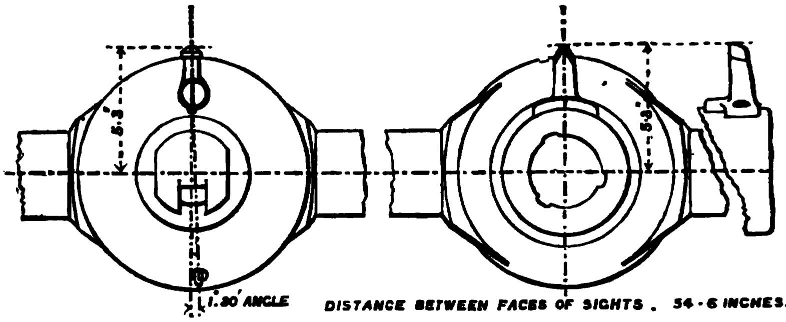
These guns are being altered to S.S. by turning off the projection at muzzle and providing the S.S. sights mentioned at pp. 111–112.

Mark I., S.S., 6 cwt. § 2674.



9-pr.
Mark I.
S.S.

CHAP. XI.



The 6-cwt. gun, Mark I., S.S., is used by the Navy ; some of the pattern have been ordered for the Indian Naval Service.

Its construction is identical with that of the 8-cwt. gun. Only a small number (45) of these have been made, as the Navy prefer the 9-pr. of 8 cwt. Mark II.*

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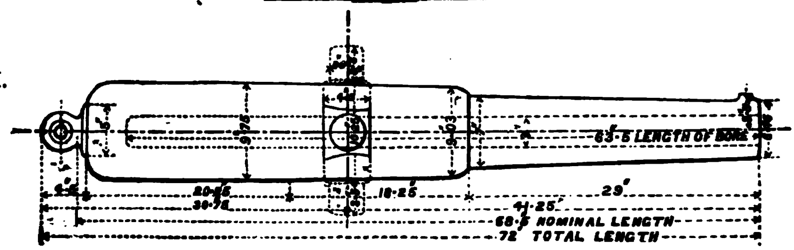
§ 2599.

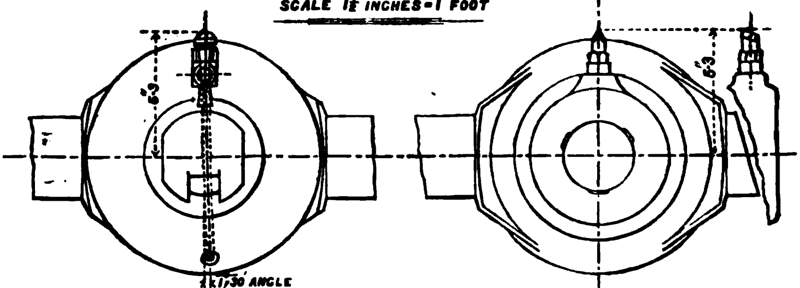
Mark II., S.S., 8 cwt.

SCALE ¼ INCH TO 1 FOOT.

9-pr. Mark II. S.S.



SIGHTING
SCALE 1½ INCHES = 1 FOOT



DISTANCE BETWEEN FACES OF SIGHTS = 66 INCHES
" " CENTRES OF HOLES = 65·325 "

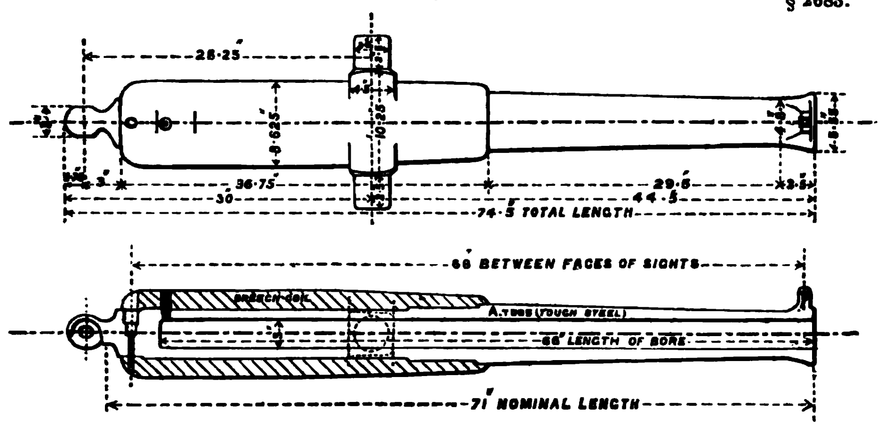
In 1873 a pattern gun of 8 cwt., Mark II., was sealed for S.S. It is the same generally as the L.S. 9-pr. of 8 cwt., and uses the same ammunition. It differs from the latter gun in having no swell on the muzzle, and also in its sights, which are adapted for sea service.

* It will be seen that the fore sight of this piece is exceptional. It is secured to the gun by three screws.

CHAP. XI.

§ 2683.

Mark II., L.S., 6 cwt.



This 9-pr. R.M.L. gun of 6 cwt., L.S.. Mark II., was introduced in September 1874. It only differs from the 9-pr. of 8 cwt., L.S., in weight, length, and dimensions generally, being of precisely similar construction and using the same ammunition. 9-pr. Mark II. L.S.

Its rifling and sighting are also similar, but the sights of the two pieces are not interchangeable, as they have different radii, and those of the lighter natures are of smaller section.

As the muzzle velocity of this gun is not much greater than that of the 8-cwt. gun, the yard scale corresponds to the same elevation.

We now come to the heavy field guns with which the greater portion of our field batteries are armed.

16-*pr. Rifled M.L. Gun of* 12 *cwt. Calibre* 3″·6.

(See Plate III.)

In 1869, the Special Committee on Shrapnel *v.* Segment Shell stated:—"These experiments showed very conclusively the little value there is in the present 12-pr. and 9-pr. common shell against earthworks, two having burst in the parapet of a gun pit without doing more damage than the displacement of a couple of spadesfull of earth;" and again: "of so little value (common shell) either for field purposes or the attacks of entrenchment, owing to the smallness of their capacity, that the Committee recommend their withdrawal from the service;" and thus, owing to the inefficiency of the 12 and 9-pr. common shells, they recommended "the introduction of a field howitzer which should be a muzzle-loader suitable for high angle firing, and capable of throwing a common shell with a large bursting charge like the howitzers in smoothbore batteries." 16-pr. of 12 cwt.

In 1870 this question was referred to a Special Committee, who recommended the adoption of a rifled gun of about 12 cwt. having a calibre between 3″·5 and 3″·7. Report of Experimental Department of D. of A., 1870, p. 341.

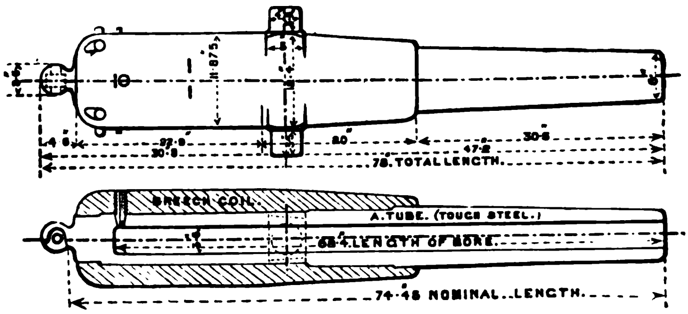
Two guns were made, one with 3″·6 calibre and the other 3″·3, and the former was ultimately adopted for the armament of a portion of our field batteries.

Preponderance 7½ lbs.

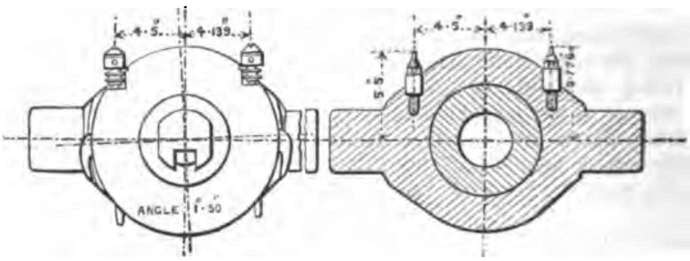
CHAP. XI.

Mark I. L.S.

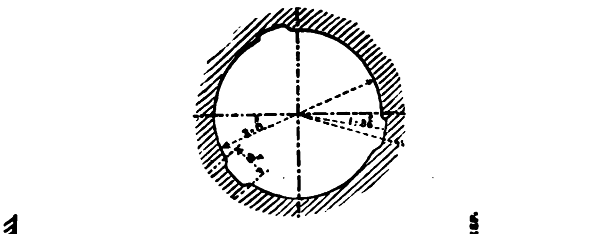
Scale ½ inch = 1 foot.



SIGHTING. 1 inch = 1 foot.



RIFLING. 3 inches = 1 foot.



§ 2221. Consists of:—

A tube (toughened steel).

Breech coil, composed of a single coil, trunnion ring, and a coil in front of the trunnions welded together.

The form of groove is the "modified French," as in the 9-pr. guns, and the twist 1 in 30 cals.

This gun is side-sighted and has screw trunnion sights, and the tangent sights are clamped in position by fixed copper set screws.

GUNS OF POSITION AND SIEGE ORDNANCE. CHAP. XI.

Siege ordnance.

The siege train will consist of the following proportions to each section of 30 pieces.*

† Light section	25-prs. -	10
	40-prs., Mark II. -	10
	6·3-inch howitzers -	10
† Heavy section	40-prs., Mark II. -	8
	64-prs., " III., with steel tube	8
	8-inch howitzers -	14

Light.

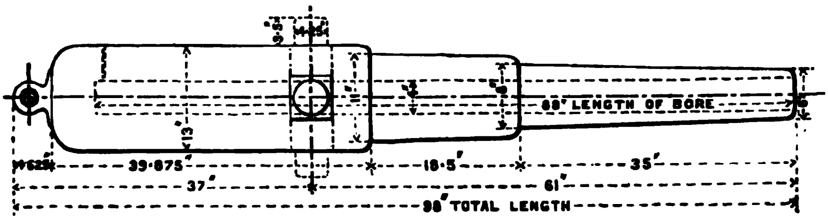
Heavy.

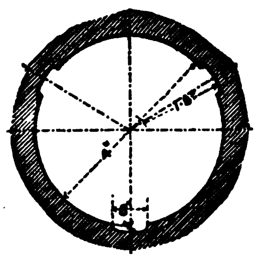
25-pr. Rifled M.L. Gun of 18 cwt. Mark I. L.S.
Calibre 4".

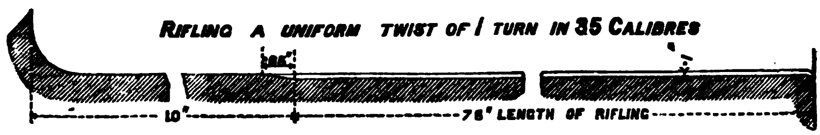
This gun was proposed in January 1871, by the Superintendent, R.G.F., as a light siege gun and gun of position, intermediate between the 16-pr. and 40-pr. (See Plate III.) § 2673. 25-prs. of 18 cwt.

Its introduction was decided on in April 1874.

Length of bore, 22 calibres.







Consists of:—

A tube (toughened steel).
B coil.
Breech coil, composed of a single coil, trunnion ring, and coil in front of trunnions welded together.

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* According to that laid down in the Regulations for Equipment of the Army, 1876.
† With each unit there will also be six 7-pr. guns of 200 lbs.

CHAP. XI.

40-*pr. Rifled M.L. Gun. Calibre* 4″·75.

§ 2478. 40-prs. It was at one time proposed to convert the B.L. 40-pr. guns into muzzle-loaders, but it was decided in preference to make new guns, first, because the B.L. guns as they exist are excellent weapons, and the cost of converting and re-tubing them would be little less than that of new guns; secondly, if converted without being re-tubed the guns would have to be weakened by being bored out.

Introduction of Mark I. In 1871, therefore, a R.M.L. 40-pr. was designed, Mark I. This gun is 18 calibres in length of bore.

During further experiments carried on after a few of these guns had been manufactured, some irregularity of velocity, &c. appeared to be due to the incomplete burning of the charge; a longer gun of the same weight and calibre was therefore tried with such satisfactory results that its introduction into the service was approved in March 1874. The bore of the gun is 22 calibres in length.

Mark II. Only 20 Mark I. have been made, and no more will be manufactured; for the future all will be of Mark II. pattern.

These guns have the same nature of rifling, and are side-sighted only, not having any centre sights. Their sights are not interchangeable.

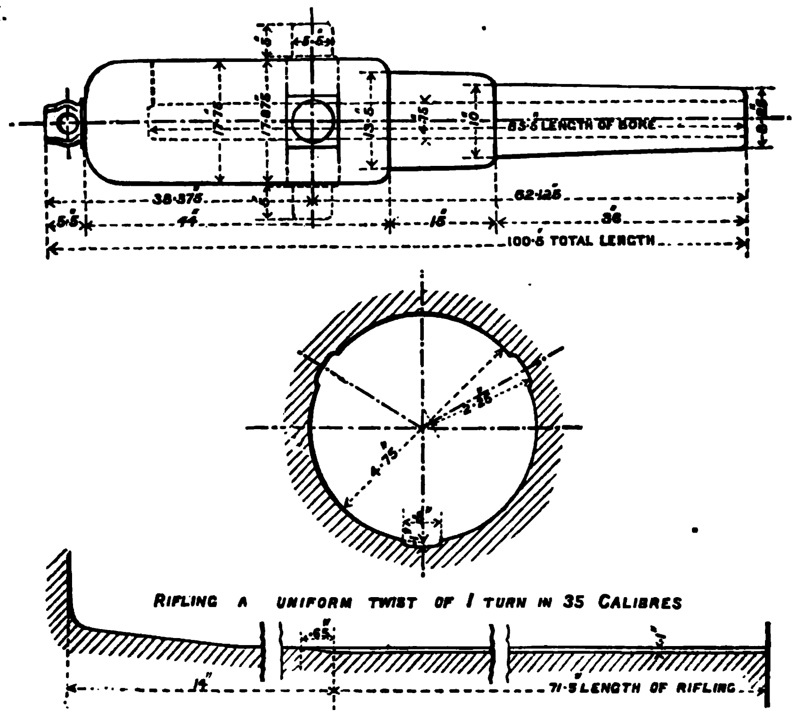
They have rear vents striking the bore near the bottom.

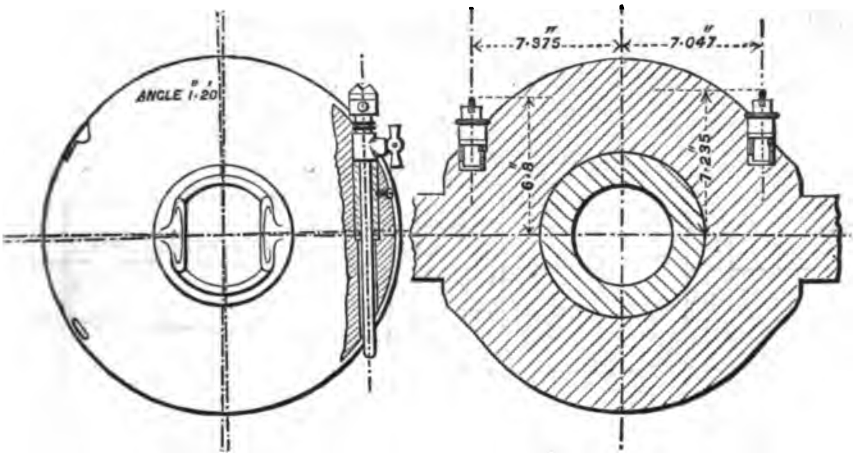
Mark I., L.S., of 34 cwt.

(See Plate IV.)

§ 2478.

40-pr. Mark I. L.S.





Consists of—

A tube (toughened steel).

B tube.

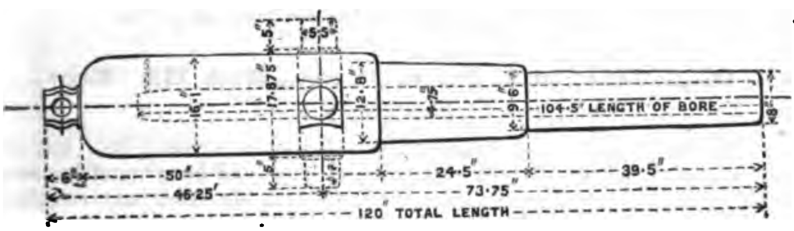
Breech coil, composed of a single coil, trunnion ring, and coil in front of trunnions welded together.

Cascable.

Mark II., L.S., of 35 cwt.

§ 2672.

40-pr. Mark II. L.S.



Its construction differs slightly from that of Mark I., and it consists of:—

A tube (toughened steel).

B tube.

1 *B* coil.

Breech coil, composed of two single coils and a trunnion ring.

Cascable.

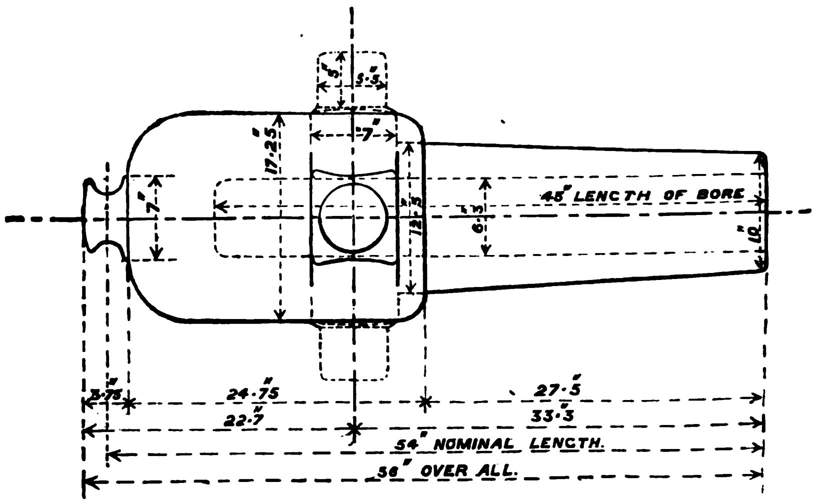
6·3-inch Rifled M.L. Howitzer of 18 cwt.

Having in view the success of the 8-inch howitzer (vide next page,) and being anxious to try a lighter nature of rifled howitzer to fit the 40-pr. carriage, and to fire a shell of about 60 lbs. weight, the Committee on High Angle fire proposed in March 1874 that howitzers should be constructed of 6·3-inch calibre. 6·3-inch howitzer.

The rifling is polygrooved, and consists of 20 grooves, the spiral being an increasing twist from 1 in 100 to 1 in 35 cals.

CHAP. XI.

Scale ¼ in. = 1 foot.



This howitzer consists of:—

A tube (toughened steel).
B tube.
Breech coil, composed of a single coil and a trunnion ring.
Cascable.

The vent bush is of the service pattern, placed in the piece vertically so as to strike the bore at a point just in front of the chamber.

The mo·· of sighting is similar to that described at p. 112

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§ 2084. **64-pr. Rifled M.L. Gun of 64 cwt., Mark III. (Siege).**

(See Plate V.)

Siege 64-pr.

The 64-pr. siege gun is the Mark III. pattern (vide p. 98), but all those employed for this service have steel tubes, and have therefore been either manufactured as new guns since 1871, or else have been re-tubed with steel.

The several parts are—
A tube (toughened steel).
B tube.
Breech coil or jacket.
Cascable.

The guns have their sights graduated for 10 lb. charges, and have also the shallow notch of leaf and slow motion screw used for siege and field guns.*

---

§ 2507. **8-inch Rifled M.L. Howitzer of 46 cwt., L.S., Mark I.**

(See Plate VII.)

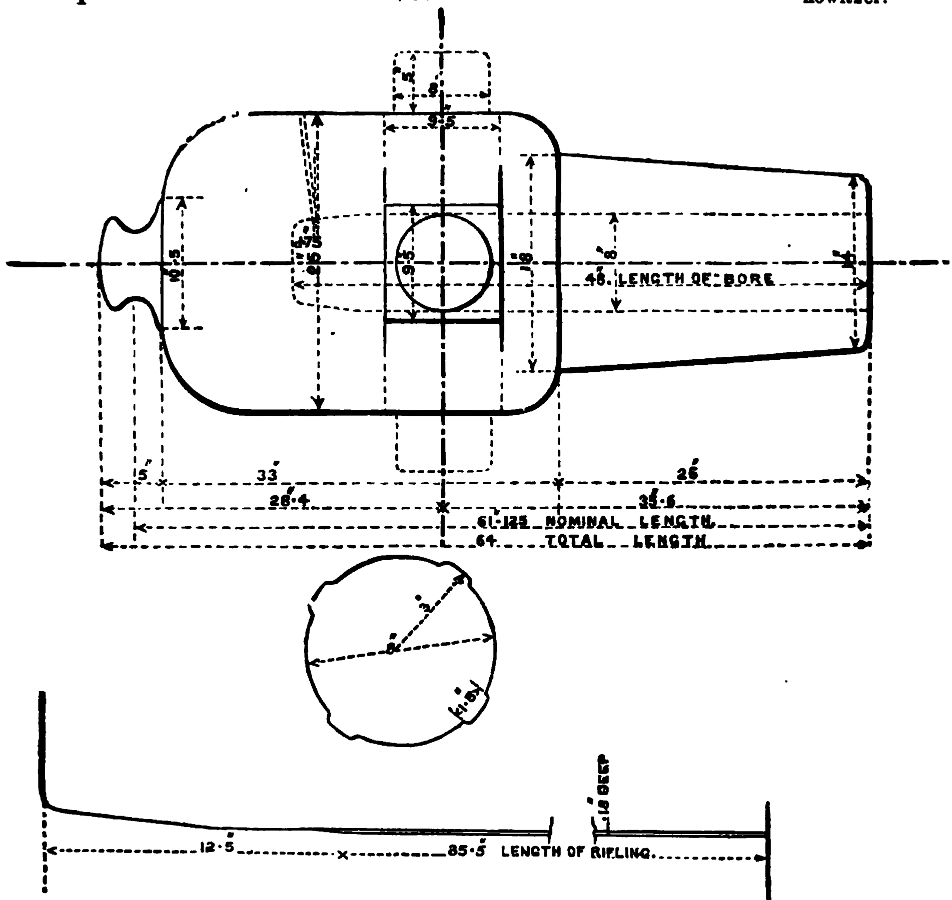
The 8-inch howitzer was the first piece of ordnance introduced into our service to supersede S.B. mortars for high angle fire.

Towards the close of 1872 it was ordered that S.B. mortars should no longer constitute a part of the siege train, and that 8-inch howitzers should be substituted in their place.

* They are, however, proved for 12-lb. charge with a 90-lbs. projectile, which charge they can fire when required.

8-inch howitzer.

Several of these howitzers were therefore estimated for in 1873–4, and up to this date a number have been manufactured.



This howitzer consists of—

A tube (of toughened steel).
B tube.
Breech coil (or jacket), composed of a single coil and trunnion ring.
Cascable.

It has the Woolwich rifling, with four grooves of the same size as the 8-inch R.M.L. gun. The sighting is central, as described p. 112, and the vent strikes the chamber near the bottom at right angles. A levelling plane and a plane for elevation are cut on the surface of piece, as well as on the 6·3 inch howitzers for use with quadrant.

Medium Guns.

We may term the 64-prs., other than siege pieces, the three natures of converted guns, and the 7-inch of 90 cwts., medium guns.

Medium guns, 64-prs.

64-*pr. Rifled M.L. Guns of* 64 *cwt. L.S. and S.S. Calibre* 6″·3.

There are three patterns of this gun. (See Plate V.)

The 64-pr. was the R.M.L. gun first introduced, so that we find a number of these pieces built up on the old method of construction. Indeed the construction and external appearance of Mark I. of these guns

CHAP. XI.

O.S.C. Proceedings, 1864, pp. 98, 255.

is identical with that of the 64-pr. wedge, for which they were originally intended. They were adopted in 1864 for the Navy as a broadside or pivot gun to replace the 64-pr. wedge gun (vide p. 83), which was objected to, as its use would have necessitated a store of special ammunition being kept at all out stations. The calibre of 6″·3 was chosen to permit of firing 32-pr. smoothbore spherical projectiles in cases of emergency.

Those tubed or re-tubed with steel, and also such of Marks I. and II. as have been re-tubed with iron, have the plain groove. The remainder have the older shunt groove. Vide also pp. 15, 16.

O.S.C. Proceedings, 1866, p. 246.

In 1866 it was recommended and approved that this nature should replace the 7″ B.L. guns in the Navy, in cases in which the latter were found too heavy.

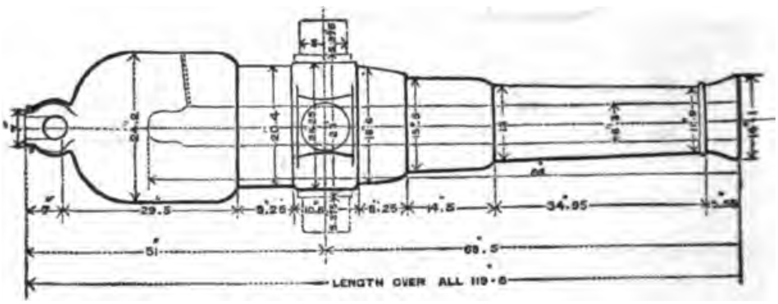
§ 1113. O.S.C. Proceedings, 1865, p. 217.

These guns are used solely as shell guns, not being sufficiently powerful against iron clad ships.

§ 1062.

Mark I.

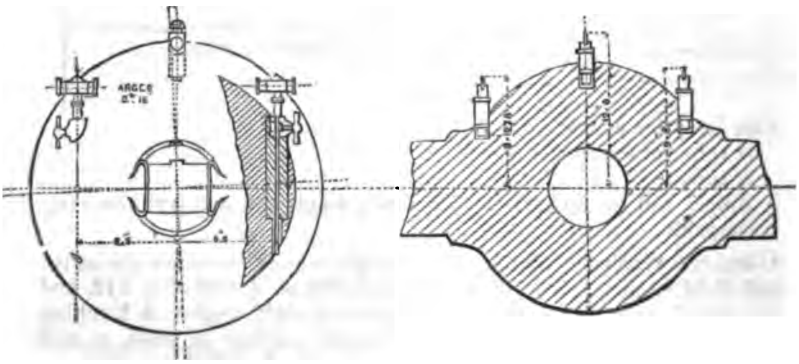
Scale ⅜ inch = 1 foot.



64-pr. Mark I.

The end of the bore is closed by a copper cup, backed up by the cascable.

SIGHTING. Scale ¾ inch = 1 foot.



§ 1032.

MARK I. consists of :—

A tube (coiled iron).	4 coils.
Breech-piece and *B* tube.	Cascable.
Trunnion ring.	

Mark II.

O.S.C. Proceedings, 1866, p. 287.

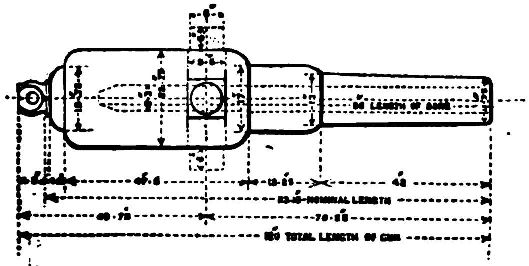
Guns of this nature were recommended for manufacture in 1866 being less expensive than Mark I., and equally efficient. The end of the bore is closed by a wrought iron plug, a copper disc intervening between it and the cascable.

These guns differ entirely in exterior appearance from Mark I., the swell at the muzzle is dispensed with, and the gun is cylindrical from the breech to a little in front of the trunnion, the curve of the breech is also broken so as to form a step. CHAP. XI.

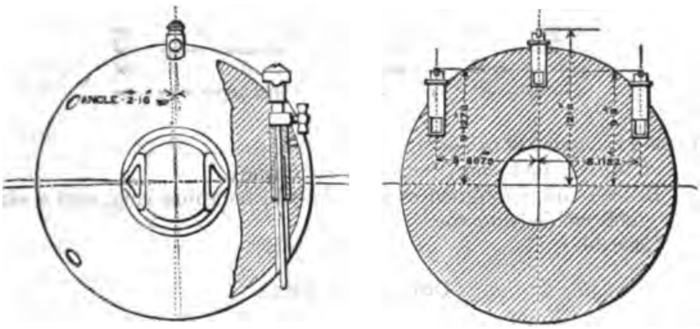
They are marked B on the left trunnion, that being the designation of this pattern when introduced into the service. § 1608.

64-pr. Mark II. or B pattern.

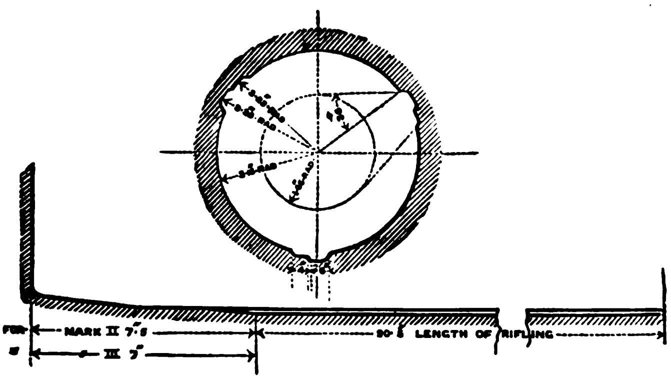
Scale ¼ inch = 1 foot.



SIGHTING. Scale ¾ inch = 1 foot.



RIFLING. Scale 2 inches = 1 foot.



MARK II. consists of:— § 1608.

A tube (coiled iron), double at the chase.
Breech-piece.
Breech coil, composed of a double coil and trunnion ring welded together.
Coil in front of the trunnions.
Cascable.

CHAP. XI.

Mark III.

64-pr. Mark III. or D pattern. O.S.C. Proceedings, 1867, p. 11. O.S.C. Proceedings, 1866. p. 852. § 1608.

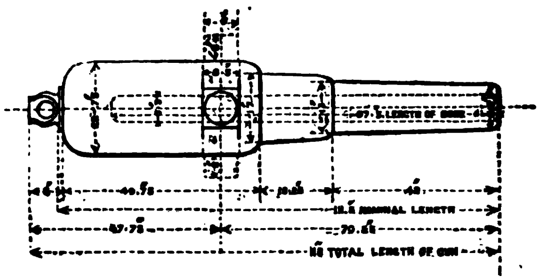
The manufacture of Mark III. was approved in 1867, experiments having proved that this construction is stronger than that in which the solid forged breech-piece is used.

Its external appearance is the same as Mark II., excepting that the breech is rounded off.

Guns of this pattern issued prior to March 1868, have D stamped on the left trunnion; that being its designation when introduced.

Those made since April 1871 have solid ended steel tubes, and a *B* tube shrunk over the chase. Most of the guns made with steel tubes are for the siege train, as explained at p. 182, the guns having iron tubes are employed as S.S. guns.

Scale ½ inch = 1 foot.



§ 1608.

Mark III. consists of :—

A tube, coiled iron (double at the chase).

Breech coil, composed of a triple coil, trunnion ring, and a single coil welded together.

Cascable.

Converted guns.

(See Plate VI.)

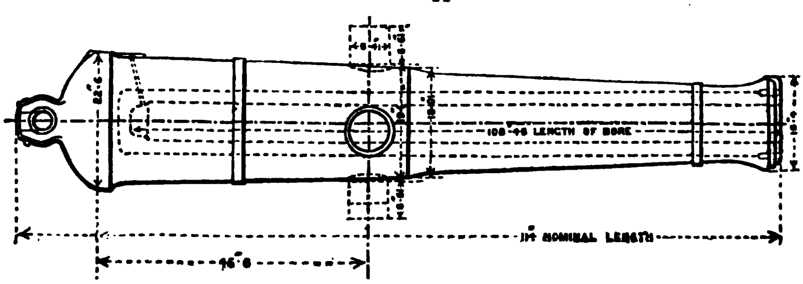
Converted guns.

As described in Chapter X., the manufacture of converted guns on the Palliser principle, where a wrought-iron barrel is inserted into a cast iron casing, was commenced in 1863. Some of these converted guns were made by contract, but most of them in the R.G.F.

$\frac{64}{32}$-pr. (converted) 58 cwt. L.S.

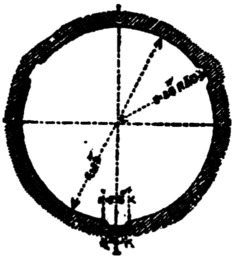
A number of these guns have been made for land and sea fronts where range is limited. The construction is described at p. 161.

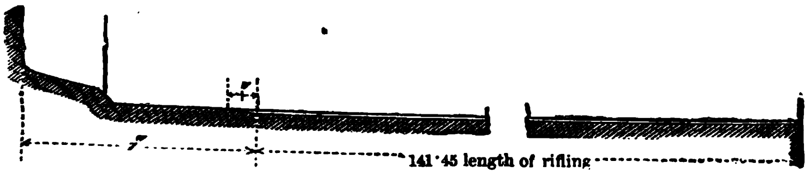
Scale $\frac{1}{12}$nd.



RIFLING. Scale ⅛th. CHAP. XI.

$\frac{64}{32}$-pr. of 58 cwt.





This 64-pr. of 58 cwt. consists of:— § 2066.
Cast iron casing.
Barrel { *A* tube, coiled iron.
B " " "
Cast iron collar.
Wrought iron screw plug.

$\frac{\text{64-pr.}}{\text{8-in.}}$ R.M.L. (converted) of 71 cwts. L.S. and S.S.

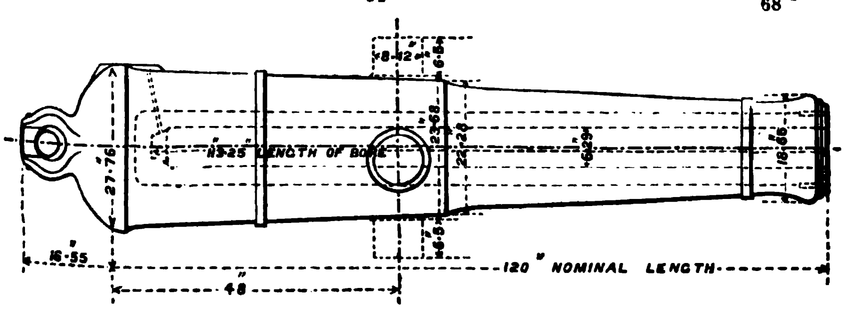
This gun is meant for the armament of unarmoured ships and land fronts of fortifications. Vide, for description, pp. 157–163, where a diagram of the sights, &c. will also be found. § 1752.

This 64-pr. of 71 cwts. consists of:— $\frac{\text{64-pr.}}{\text{8-inch.}}$ of 71 cwt.
Cast iron casing.
Barrel { *A* tube, coiled iron.
B " " "
Cast iron collar.
Wrought iron screw plug.

$\frac{80}{68}$-pr. R.M.L. converted Gun of 5 tons. L.S.

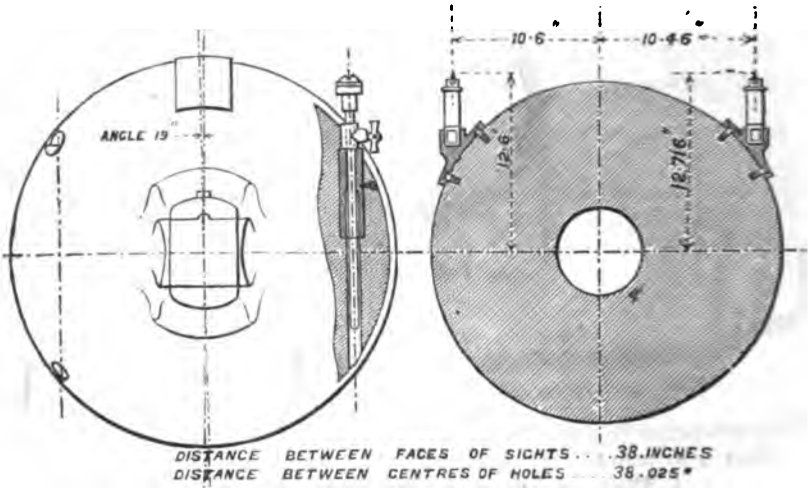
This our heaviest converted gun is a L.S. gun and would be employed for the same purpose as the $\frac{64}{32}$-pr. 58 cwt. where a somewhat more powerful piece is wanted. § 2220.

Scale $\frac{1}{32}$nd. $\frac{80}{68}$-pr. of 5 tons.

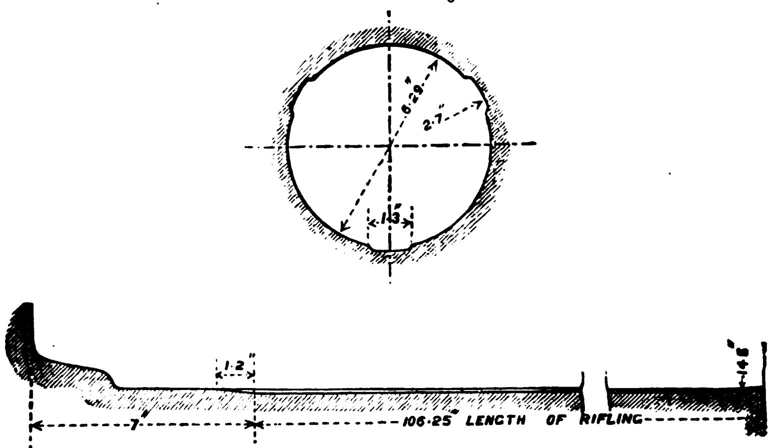


CHAP. XI.

SIGHTING. Scale $\frac{1}{12}$th.



RIFLING. Scale $\frac{1}{6}$th.



Parts the same as for the two preceding guns.

7-inch R.M.L. Gun of 90 cwts. Mark I. S.S.

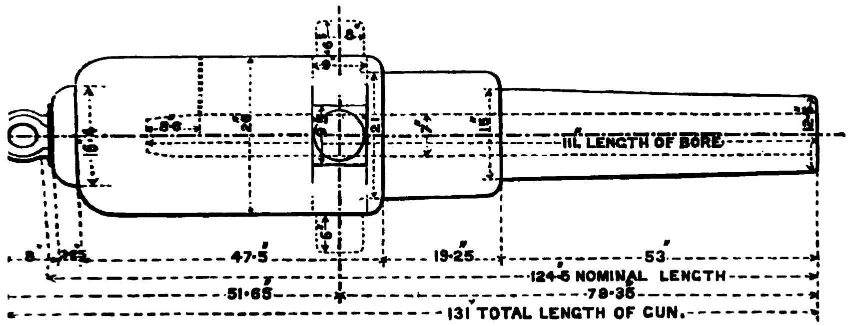
(See Plate X.)

§ 2363. At the request of the Admiralty some 7-inch 6½-ton guns under manufacture were completed in 1874 as 90-cwt. guns for the armament of unarmoured vessels. The bore of the piece remains the same, but the exterior is turned down all over and slightly shortened. In order to rectify the preponderance and the position of the trunnions, a large part of the jacket is also turned off and a new jacket shrunk over the breech, where a portion of the old jacket forms a breech-piece as in the 9″ guns and upwards.

Many service 6½-ton guns have since been reduced to 90-cwt. guns as described, and a few new guns have been made of similar construction the coiled breech-piece in the latter case being made of two coils united, which together resemble the breech coil and 1 B coil of 10″ guns and upwards.

CHAP. XI.

7-inch of 90 cwts. Mark I. reduced from those of 6½ tons.



Consists of :—

A tube (toughened steel).
B tube (chase).
Coiled breech-piece.
C coil or jacket :—A single coil and trunnion ring welded together.
Cascable.

HEAVY GUNS.

Employment of heavy guns.

We now come to guns which might be employed against armour plates with fair effect from ranges of 1,000 up to 3,000 yards. Their powers increase very much as they become larger until in the 80-ton gun we have a piece of ordnance which can pierce with ease the thickest armour at present afloat (24 inches) up to a range of about 1,000 yards.

All these pieces have three sets of sights. They all have the Woolwich rifling with increasing twist, except the 7-inch where it is uniform. In all of them also the vent strikes the bore at right angles, and at a distance of $\frac{4}{10}$ the length of the cartridge from the bottom of the bore.*

7-inch Rifled M.L. Guns of 6½ tons, S.S. only.

There are three patterns of this gun. (See Plate IX.)

7-inch guns of 6½ tons, Mark I.

It is built on the original construction, the coils being separate and hooked. It was adopted in 1865 as a broadside or pivot gun for frigates, to replace the 7-inch B.L. and 68-pr. S.B. guns, and is now very extensively used, 331 having been made.

Externally the breech is rounded off, giving the gun somewhat the shape of a soda-water bottle, and it has several steps in front of the trunnions.

O.S.C. Proceedings, 1865, pp. 227, 317.

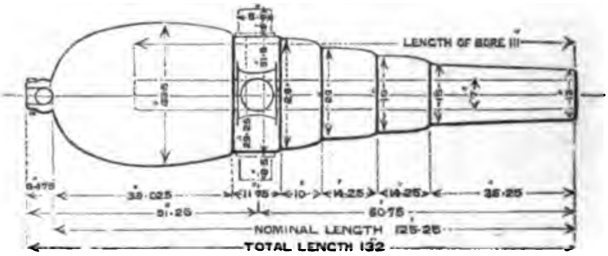
These guns are in total length 18 inches shorter than the land service 7-inch gun, being a length more suited to the requirements of the Navy.

* With the 80-ton gun it is possible that an axial vent may be employed.

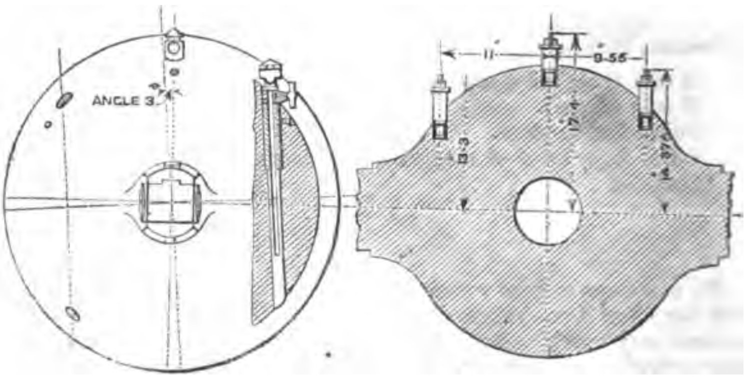
CHAP. XI.

Mark I.

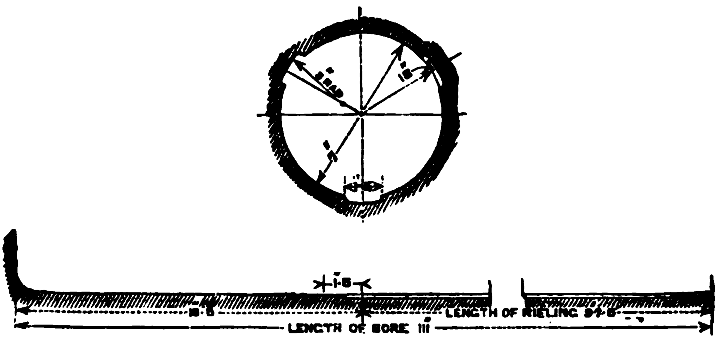
Scale ¼ inch = 1 foot.



SIGHTING. Scale ⅝ inch = 1 foot.



RIFLING. Scale 1½ inch = 1 foot.



§ 1231. MARK I. consists of :—

A tube (toughened steel).
Breech-piece and *B* tube.
Trunnion ring.
Six coils.
Cascable.

CHAP. XI.

Mark II.

7-inch $6\frac{1}{2}$ tons, Mark II.

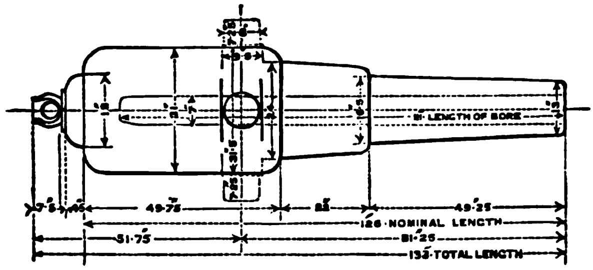
Very few of this pattern were manufactured. They were introduced in 1866 and then designated and marked on the left trunnion F. I. (Fraser construction); guns of this pattern issued prior to 31st March 1868, are thus known.

§§ 1462, 1596, 1644.

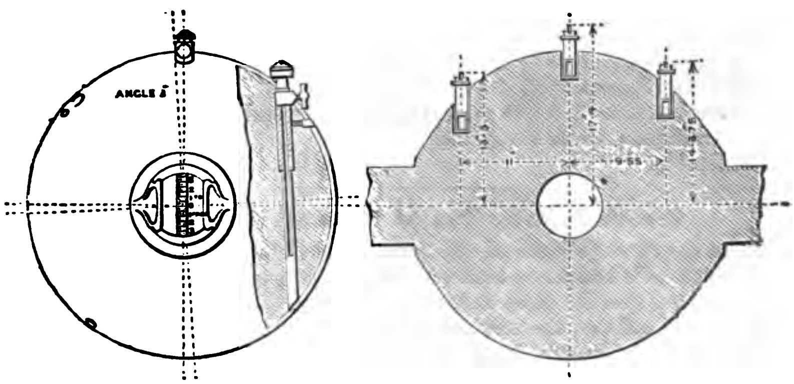
They had coiled iron barrels closed by an iron plug, as steel was not then finally adopted as the material for inner barrels. Any of them, however, which have since been re-tubed have solid ended steel barrels.

Their external appearance is similar to that of Mark II., 64-pr.

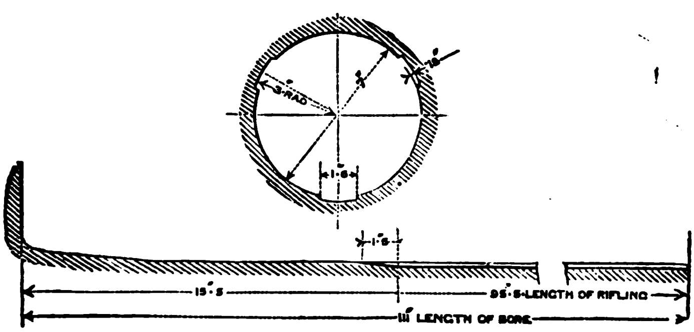
Scale $\frac{1}{4}$ inch = 1 foot.



SIGHTING. Scale $\frac{3}{8}$ inch = 1 foot.



RIFLING. Scale $1\frac{1}{2}$ inch = 1 foot



CHAP. XI.

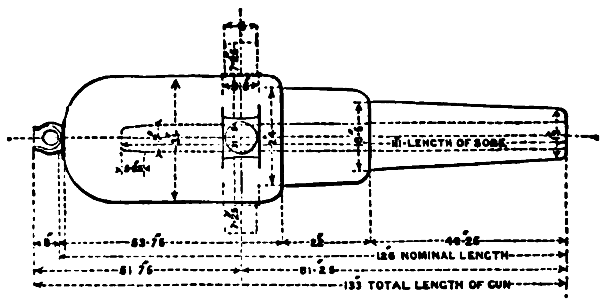
§ 1644. MARK II. consists of:—
A tube (coiled iron).
Breech-piece.
B tube (the coil in front of the trunnions, and chase).
Breech coil:—a double coil and trunnion ring welded together.
Cascable.

Mark III.

7-inch 6½ tons, Mark III. This construction adopted in 1866 superseded Mark II., the solid forged breech-piece being abandoned, and the metal over the breech being put on in one thickness. Those issued prior to March 1868 have F. II. stamped on the left trunnion.

§ 1462–1596. Its external appearance is similar to Mark III., 64-pr.

Scale ½ inch = 1 foot.



§ 1644. MARK III. consists of:—
A tube (toughened steel).
B tube (chase).
Breech coil:—a triple coil, trunnion ring and coil in front of the trunnions, welded together.
Cascable.

7-inch R.M.L. Gun of 7 tons. L.S. only.

7-inch 7 tons, Mark I. There are three patterns of this gun. (See Plate VIII.)

This nature is entirely a land service gun, and was introduced in 1865 as a battering gun for coast defence.

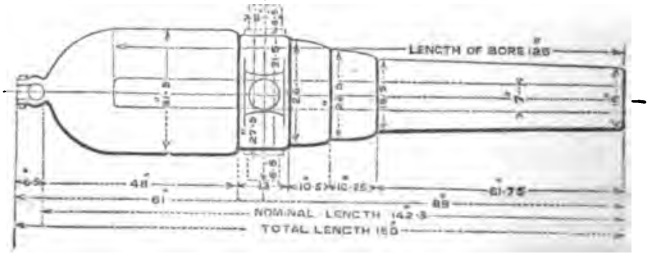
Mark I. is built on the original construction, and externally is similar to the 7-inch 6½-ton gun, Mark I. The *B* tube of this pattern is covered by an additional thin coil so as to reduce the preponderance, which was found to be excessive. 51 were manufactured.

Mark I.

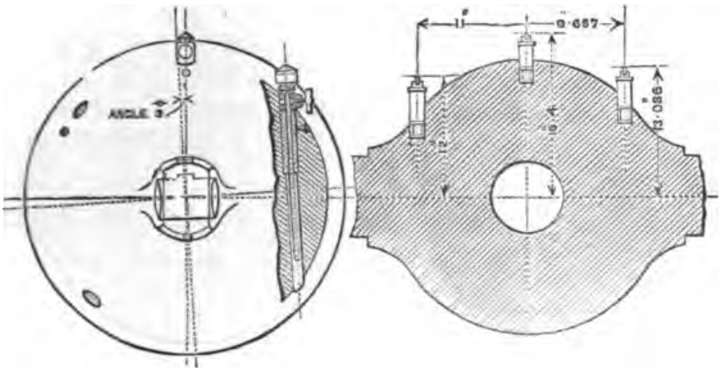
O.S.C. Proceedings, 1865, p. 316.

O.S.C. Proceedings, 1866, p. 119.

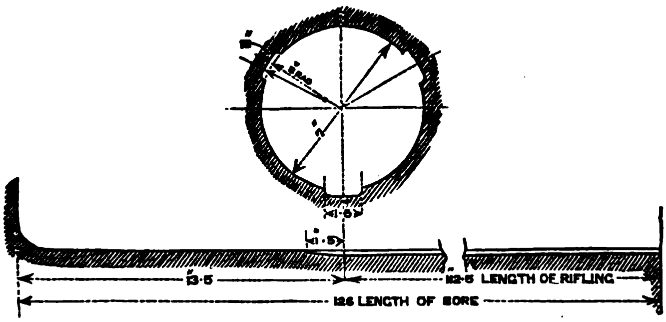
Scale ½ inch = 1 foot.



SIGHTING. Scale ⅜ inch = 1 foot. CHAP. XI.



RIFLING. Scale 1½ inch = 1 foot.



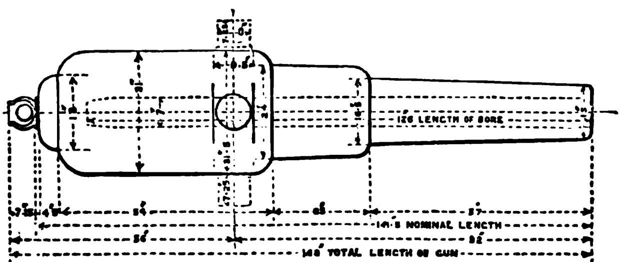
MARK I. consists of:— § 1230.

A tube.
Breech-piece and *B* tube.
Trunnion ring.
Five coils.
Cascable.

Mark II.

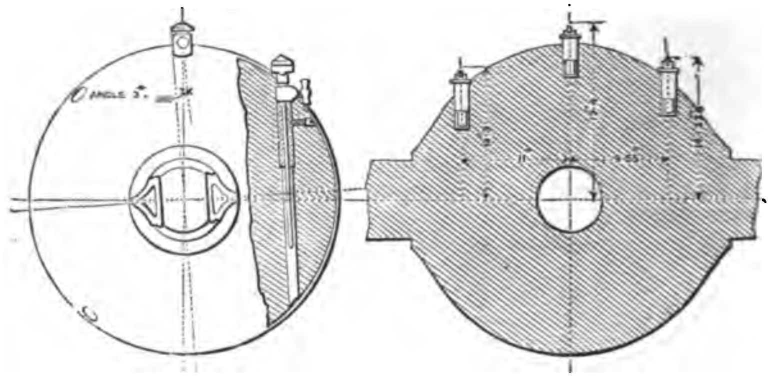
Introduced in 1866, consists of same parts as Mark II., 7-inch 6½-ton gun, and differs from it only in length. There were only two made, and they are marked F. I. on the left trunnion. 7-inch 7 tons; Mark II.

Scale ¼ inch = 1 foot. 1607.

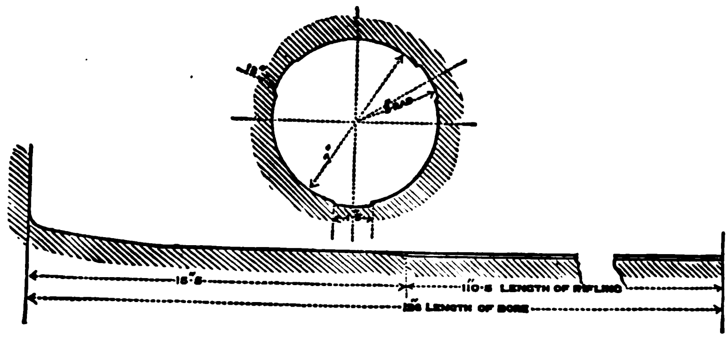


CHAP. XI.

SIGHTING. Scale ⅝ inch = 1 foot.



RIFLING. Scale 1½ inch = 1 foot.

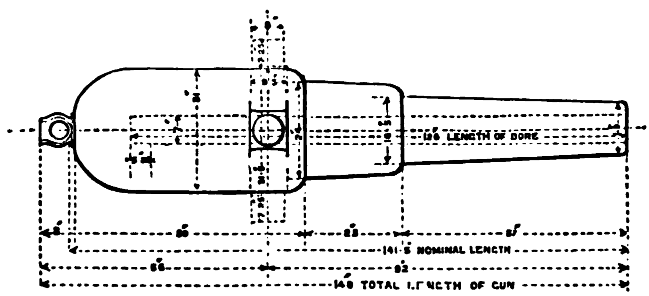


7-inch of 7 tons. Mark III.

MARK III., introduced in 1866, differs only in length from Mark III., 7-inch 6½-ton gun. Previous to April 1868 these guns were marked F. II. on the left trunnion.

Mark III.

Scale ½ inch = 1 foot.



§ 1607. The several parts are as in Mark II.

8-inch Rifled M.L. Gun of 9 tons, L.S. and S.S.

There are three patterns of this gun. (See Plate XI.) CHAP. XI.

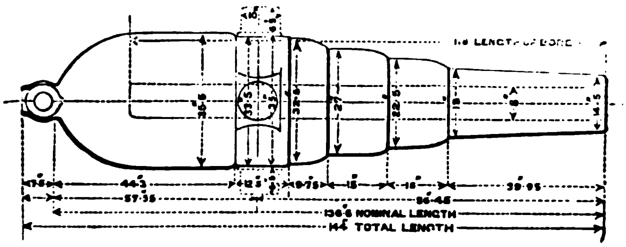
These guns were introduced in 1866 for S.S., and a few have since been made for L.S. They are used by vessels not sufficiently heavy to carry 9-inch guns. 8-inch of 9 tons Mark I.

Its exterior is similar to Mark I. 7-inch $6\frac{1}{2}$-ton gun.

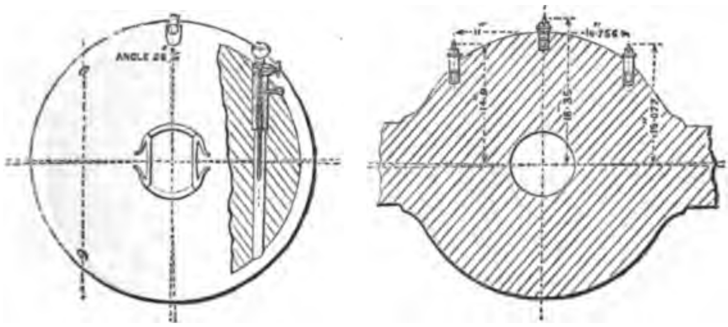
The number made of this pattern is 76.

Mark I.

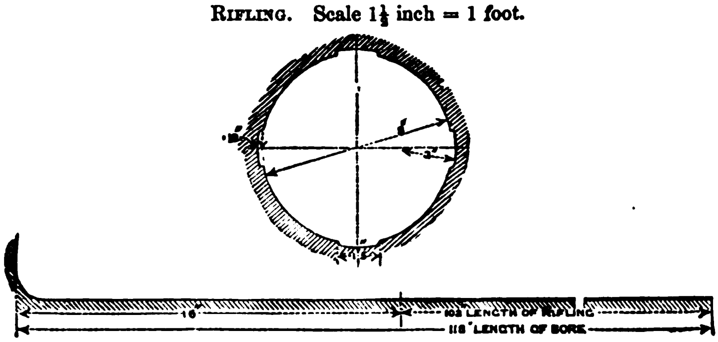
Scale $\frac{1}{4}$ inch = $\frac{1}{4}$ foot.



SIGHTING. Scale $\frac{1}{2}$ inch = 1 foot.



RIFLING. Scale $1\frac{1}{2}$ inch = 1 foot.



MARK I. consists of :— § 1289.

- *A* tube.
- Breech-piece and *B* tube.
- Trunnion-ring.
- Five coils.
- Cascable.

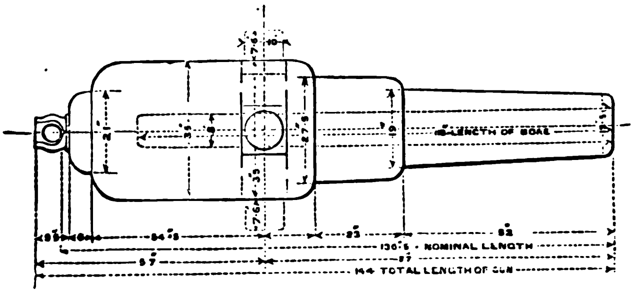
CHAP. XI.

Mark II.

8-inch of 9 tons, Mark II.

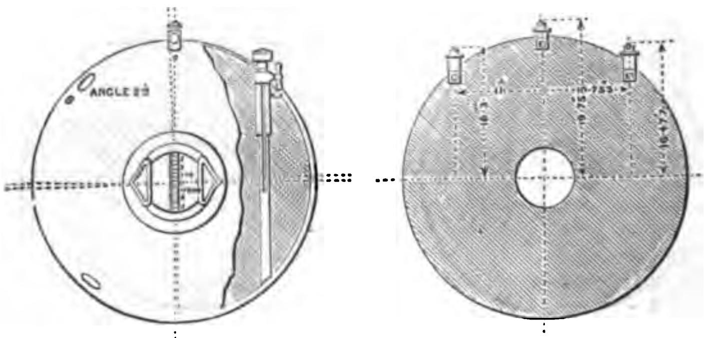
This gun, introduced in 1866, consists of same parts as Mark II. 7-inch 6½-ton gun, and the exterior form is similar. Only six were made, and they are marked F. I.

Scale ¼ inch = 1 foot.

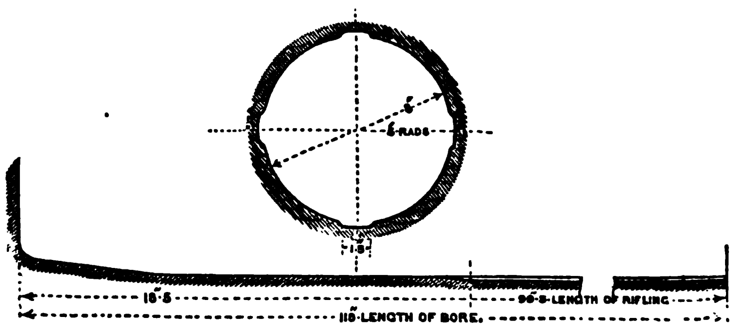


§ 1643.

SIGHTING. Scale ⅛ inch = 1 foot.



RIFLING. Scale 1½ inch = 1 foot.

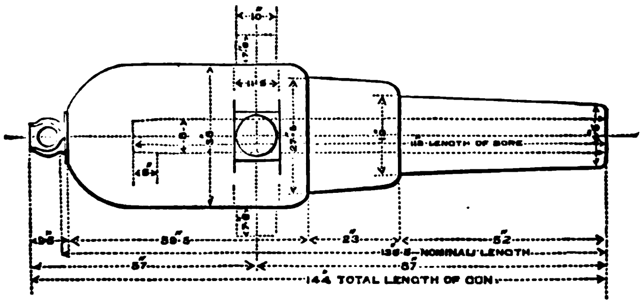


Mark III.

8-inch of 9 tons, Mark III.

MARK III., introduced in 1866, consists of same parts as Mark III. 7-inch 6½-ton guns, and the exterior form is similar. Those made previous to April 1868 were marked F. II.

Scale ¼ inch = 1 foot.



§ 1643.

9-inch Rifled M.L. Gun of 12 tons, L.S and S.S.

There are five patterns of this gun. (See Plate XII.)

Mark I.

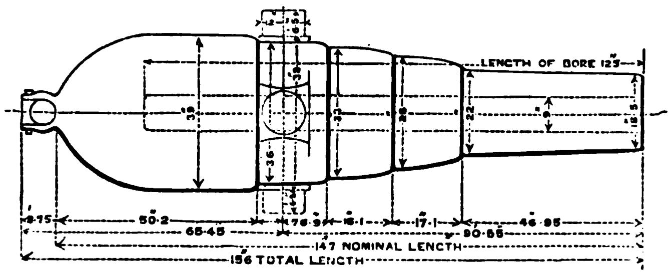
9-inch of 12 tons, Mark I.

Introduced in 1865 as a broadside gun for heavy iron clad ships, and also for the defence of harbour and sea fronts. 190 were made.

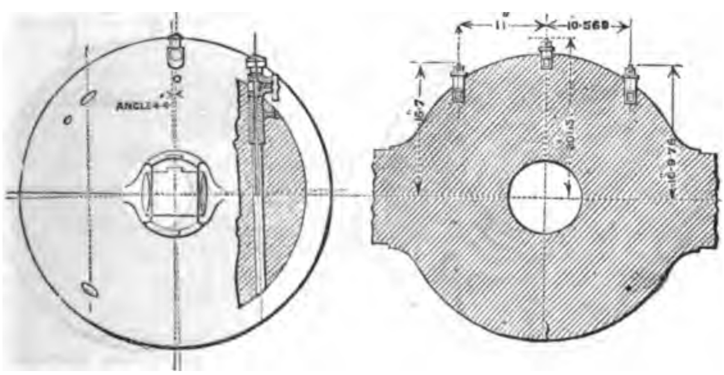
It is a very powerful gun for its weight.

Externally it has several steps in front of the trunnions, and is rounded off at the breech.

Scale ¼ inch = 1 foot.

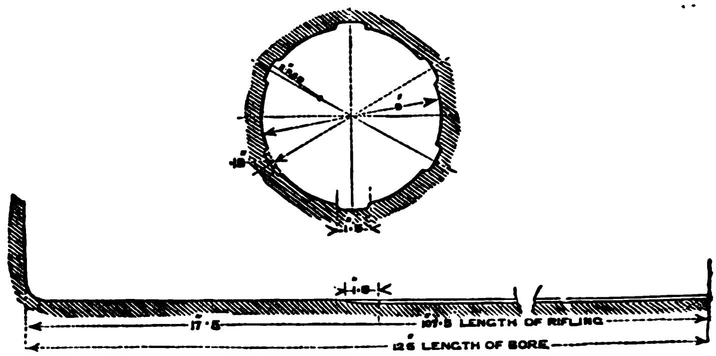


SIGHTING. Scale ⅛ inch = 1 foot.



CHAP. XI.

RIFLING. Scale 1½ inch = 1 foot.



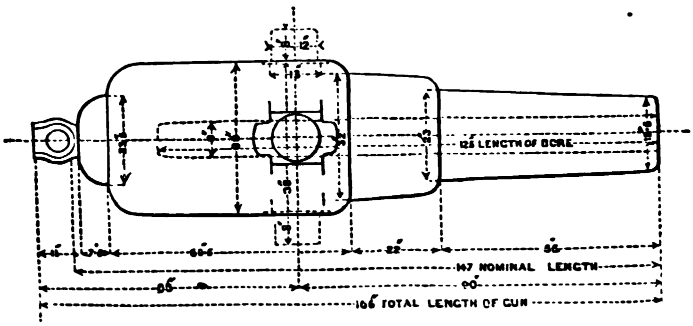
MARK I. consists of:—
- *A* tube (toughened steel).
- Breech-piece.
- *B* tube.
- Trunnion ring.
- Seven coils.
- Cascable.

Mark II.

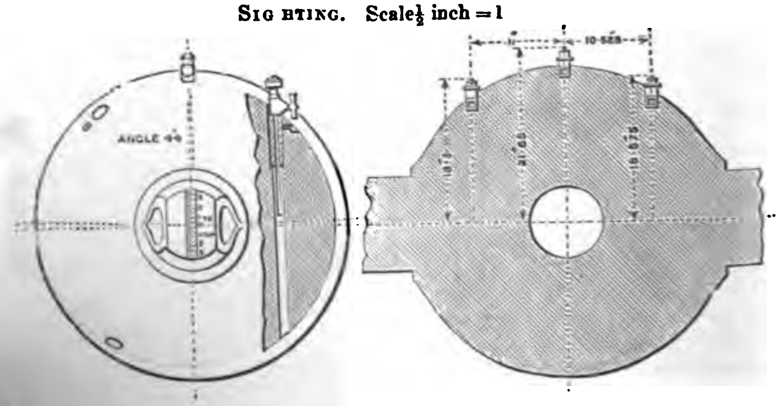
9-inch of 12 tons, Mark II.

Introduced in 1866, only 26 being made. They differ from Mark II. 7-inch and 8-inch in having steel barrels, but the external appearance is the same. They are marked F. I. on the left trunnion.

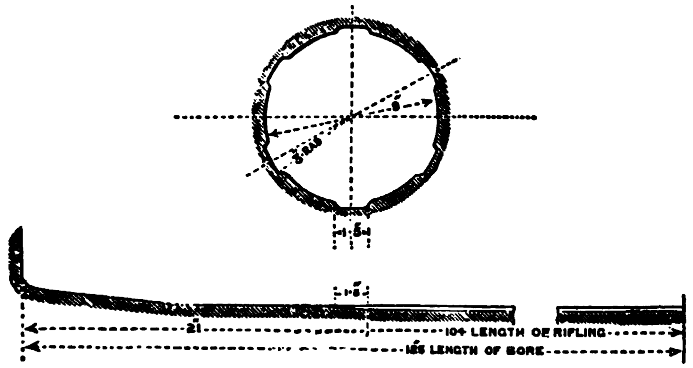
Scale ¼ inch = 1 foot.



SIGHTING. Scale½ inch = 1



RIFLING. Scale 1½ inch = 1 foot.



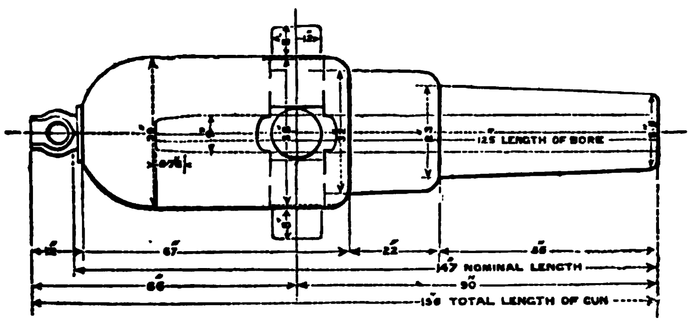
MARK II. consists of:— § 1642.

A tube (toughened steel).
Breech-piece.
B tube.
Breech-coil:—Double coil, trunnion ring, and a coil in front of the trunnions welded together.
Cascable.

Mark III.

Was introduced in 1866, and is similar in construction and exterior form to Mark III. 7-inch. Those manufactured previous to April 1868 are marked F. II. 136 of this pattern were manufactured. 9-inch of 12 tons, Mark III.

Scale ¼ inch = 1 foot.



MARK III. consists of:— § 1642.

A tube (toughened steel).
B tube.
Breech coil:—Triple coil, trunnion ring, and a double coil in front of the trunnions welded together.
Cascable.

Marks IV. and V.

Mark IV. pattern was adopted in 1869, and its external appearance is the same as Mark II. Mark V. differs from IV. in preponderance only, the trunnions being placed ⅜″ further to the rear. 9-inch of 12 tons, Marks IV. and V

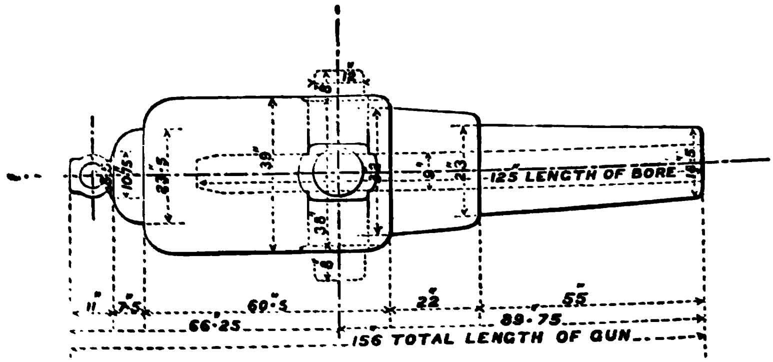
These pieces, as well as all those of higher natures now manufactured have two layers over the breech, *i.e.*, a coiled breech-piece covered by a breech coil, this construction being considered preferable to the

CHAP. XI.

Mark III. for very heavy guns, on account of the difficulty of ensuring the soundness of the interior of a large mass of iron.

§ 1906.
O.S.C. Proceedings, 1869, p. 172.

Scale ¼ inch = 1 foot.



Marks IV. and V. consist of :—
A tube (toughened steel).
B tube.
Coiled breech-piece.
Breech coil :—double coil, trunnion ring, and single coil in front of the trunnions welded together.
Cascable.

10-inch Rifled M.L. Gun of 18 tons, L.S. and S.S.

There are two patterns of this gun. (See Plate XIII.)

Mark I.

10-inch of 18 tons, Mark I.

Mark I. was proposed by Commodore Heath, R.N., in 1865, owing to the success of the 9-inch gun, and introduced in 1868 for the Navy as a most powerful broadside gun, H.M.S. "Hercules" being armed with it. These guns at 2,000 yards strike nearly as hard a blow as the 9-inch does at the muzzle, and their power of penetration at 1,500 yards is nearly equal to the 9-inch at the muzzle.

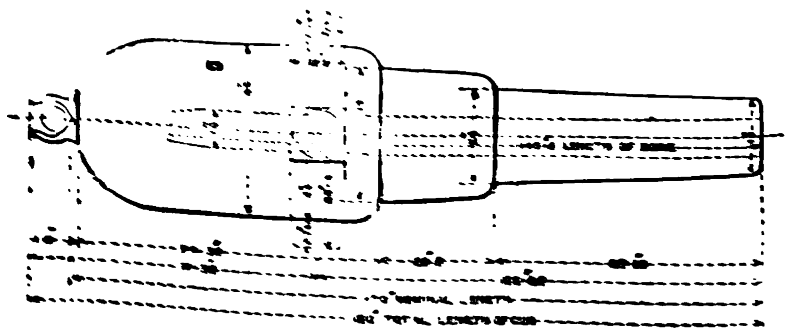
The 10-inch is now used by the land service for coast defence.

Its external appearance is similar to Mark III. 9-inch.

There are 18 guns of this pattern.

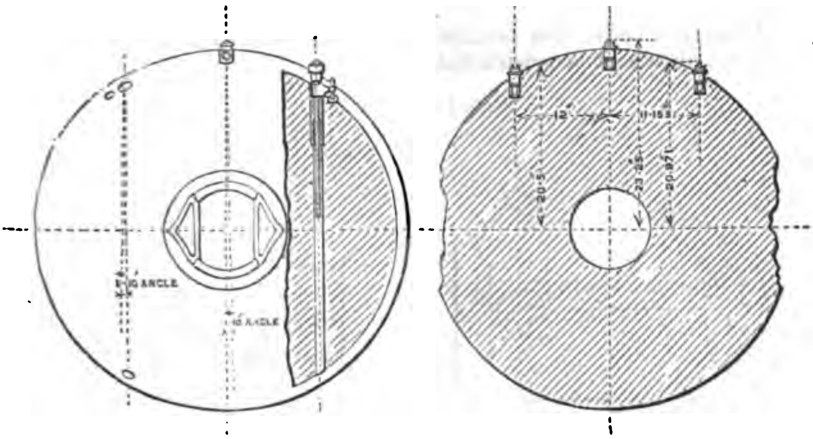
O.S.C. Proceedings, 186[illegible], p. [illegible].
O.S.C. Proceedings, 186[illegible], p. [illegible].

Scale ¼ inch = 1 foot.

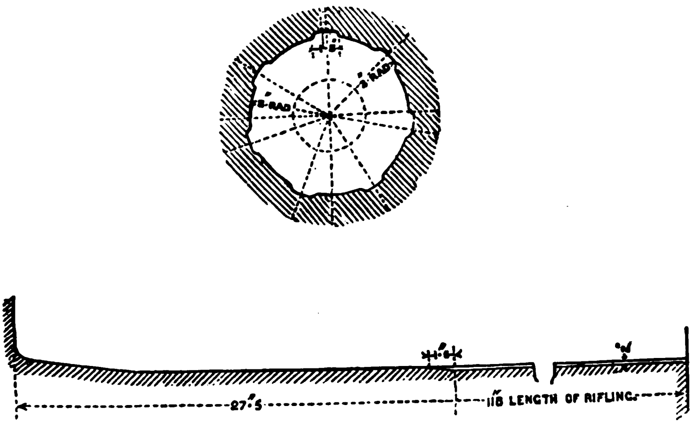


10-inch of 18 tons, Mark I.

SIGHTING. Scale ½ inch = 1 foot.



RIFLING. Scale 1 inch = 1 foot.



MARK I. consists of:— § 1688.

- *A* tube (toughened steel).
- *B* tube.
- Breech coil:—triple coil, trunnion ring, and a triple coil in front of the trunnions welded together.
- Cascable.

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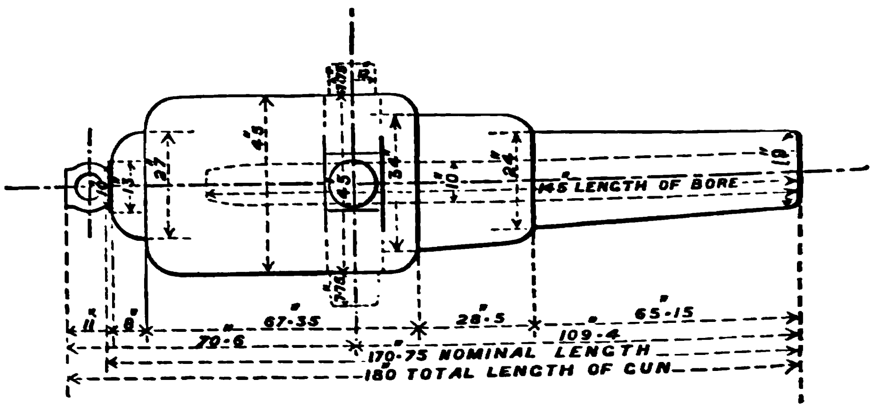
Mark II.

10-inch of 18 tons, Mark II.

Adopted in 1869. Its exterior form is the same as Mark V. 9-inch, upon which type it is constructed.

Scale ¼ inch = 1 foot.



O.S.C. Proceedings, 1869, p. 122. § 1905.

Mark II. consists of :—

A tube (toughened steel).
B tube.
Triple coil in front of the trunnions. (Belt.)
Coiled breech-piece.
Breech coil :—double coil, and a trunnion ring welded together.
Cascable.

11-inch Rifled M.L. Gun of 25 tons, L.S. and S.S.

There are two patterns of this gun. (See plate XIV.)

11-inch of 25 tons.

This gun was introduced in 1867 on account of the great penetration obtained with the 10-inch gun, and also to try it in comparison with the service 12-inch gun of the same weight and length of bore, in order "to determine what calibre and proportional length of bore were best adapted to a gun of from 23 to 25 tons weight, or in other words, what calibre in a given weight and length of gun are best adapted to the profitable consumption of the powder charge."

O.S.C. Proceedings, 1867, pp. 15, 94.

In the meantime, manufacture of these guns of 25 tons weight proceeded as if for 12-inch, but they were only bored up to 11 inches and left unrifled, until the question was decided 1st October 1870, in favour of the smaller calibre.

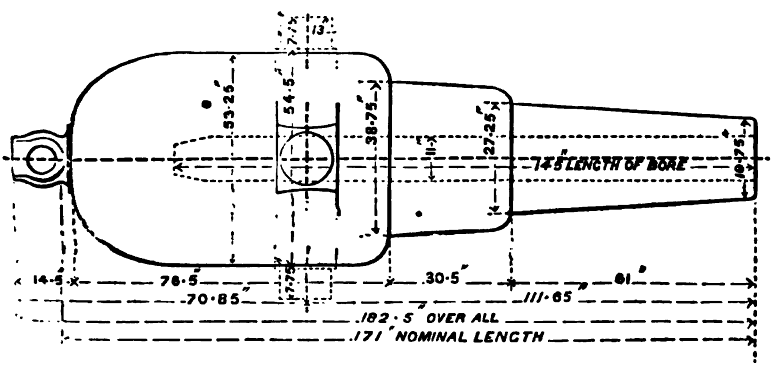
It is for use occasionally in the Navy and by L.S. for coast defence.

Mark I.

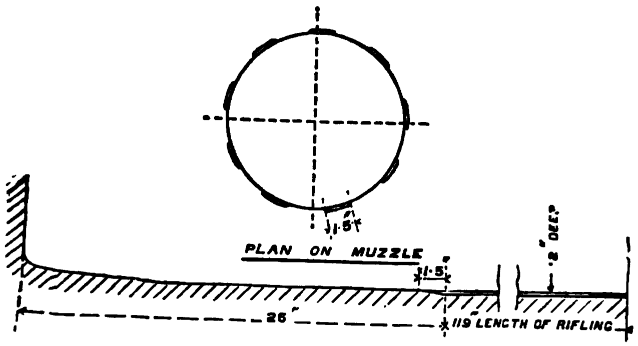
Externally it has a step in front of the trunnions, and is rounded off at the breech. 11-inch of 25 tons, Mark I.

Only 7 of this pattern have been made.

Scale $\frac{1}{48}$.



RIFLING. Scale $\frac{1}{12}$.



MARK I. consists of :—

A tube (toughened steel). § 2102.

B tube.

Breech coil :—triple (or quadruple) coil, trunnion ring, and triple coil in front of the trunnions welded together.

Cascable.

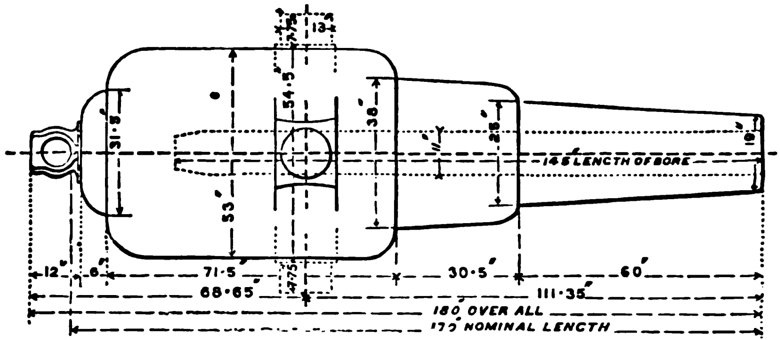
CHAP. XI.

Mark II.

11-inch of 25 tons, Mark II.

This gun was adopted in 1871 for the same reasons as to manufacture as already mentioned in the case of 9-inch guns Mark IV., vide pp. 199–200.

Scale $\frac{1}{48}$.



§ 2102.

Mark II. consists of:—

A tube (toughened steel).
B tube.
Triple coil in front of the trunnions.
Coiled breech-piece.
Breech coil:—double coil and a trunnion ring welded together.
Cascable.

12-inch Rifled M.L. Gun of 25 tons, L.S. and S.S.

There are two patterns of this gun. (See Plate XV.)

Mark I.

12-inch of 25 tons, Mark I.

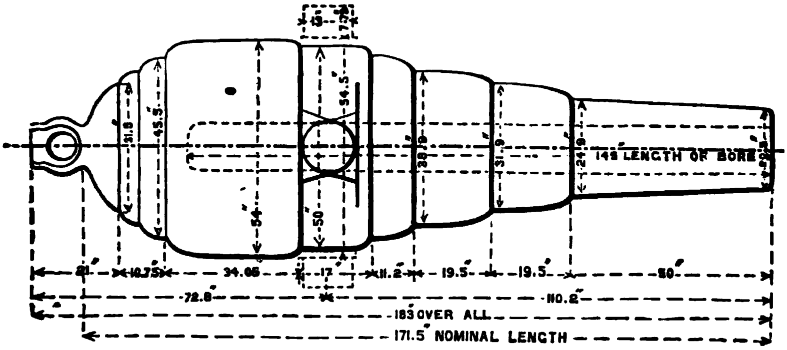
This gun was recommended in 1864 on the belief that it would give higher initial velocity than the 13-inch gun, but the trial was not carried out till 1866.

It is known externally by having steps in front of the trunnion, and also at the breech. There are only four of this construction in the service, and their weight is 23½ tons, but by an order of 3rd July 1868, to avoid confusion and the necessity of separate series on account of weight it was approved that they all should bear the same designation, viz., Ordnance, Rifled M.L. 12-inch of 25 tons, this being the weight of the later patterns.

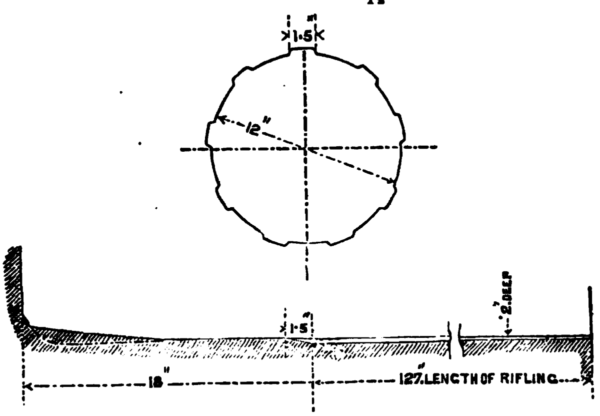
O.S.C. Proceedings, 1864, p. 190.

12-inch guns are used for turret ships and coast defence.

Scale $\frac{1}{48}$.



Rifling. Scale $\frac{1}{12}$.



Mark I. consists of:— § 2022.

- *A* tube (toughened steel).
- Breech-piece.
- *B* tube.
- Trunnion ring.
- 7 coils.
- Cascable.

Mark II.

This pattern was introduced in 1866, but the first gun made in that year (No. 5) is exceptional in having a coiled iron tube and also a solid forged breech-piece. 12-inch of 25 tons, Mark II.

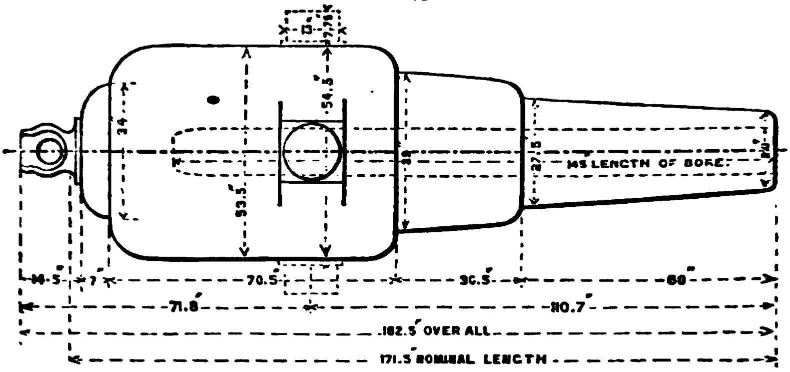
Externally they are known by the step at the breech. They weigh about 25 tons (see Mark I.).

The number of 12″ 25-ton guns manufactured up to June 1871 is 15. Of these 4 are on the original or Mark I. construction, and 9 on the Mark II. pattern (including the exception noted above).

The remaining two guns, Nos. 20 and 21, are of the same construction as the 11″ gun Mark I., but they do not form a distinct pattern, and are known by their numbers. The breech of these two guns is rounded. O.S.C. Proceedings, 1866, p. 256.

CHAP. XI.

Scale $\frac{1}{48}$.



§ 2022. MARK II. consists of :—

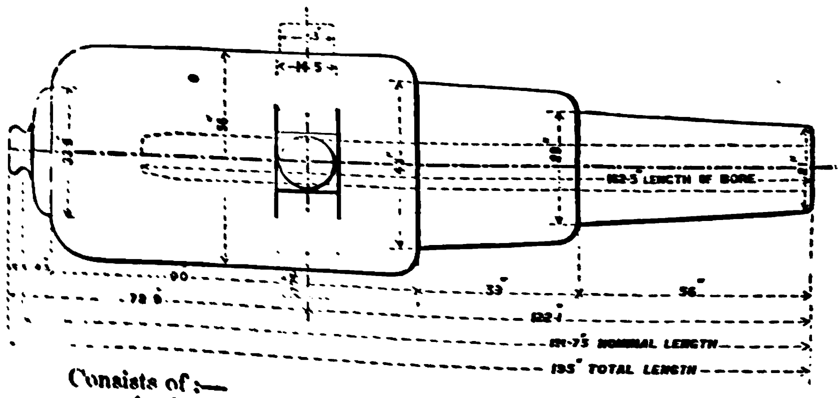
A tube (toughened steel).
B tube.
Triple coil in front of trunnions.
Coiled breech-piece.
Breech coil :—double coil and trunnion ring welded together.
Cascable.

12-inch Rifled M.L. Gun of 35 tons. Mark I. S.S.

There is only one pattern of this gun. (See Plate XVI.)

12-inch of 35 tons, Mark I. The first of these guns was completed in February 1871 as a 700-pr. of 11"·6 calibre, but experiments having proved that this calibre is not suitable for the efficient combustion of 120 lbs. of "P" (Pebble) powder, the proposed battering charge of the gun, it was decided to bore it out experimentally to 12".

This calibre was finally adopted for guns of this weight, of which only 15 have been made. The cascable terminates in a plain button instead of a loop.



§ 2440. Consists of :—

A tube (toughened steel).
B tube.
Triple coil in front of the trunnion.
Coiled breech-piece.
Breech coil :—double coil and a trunnion ring welded together.
Cascable.

12·5-inch Rifled M.L. Gun of 38 tons, Mark I.

12·5-inch of 38 tons, Mark I.

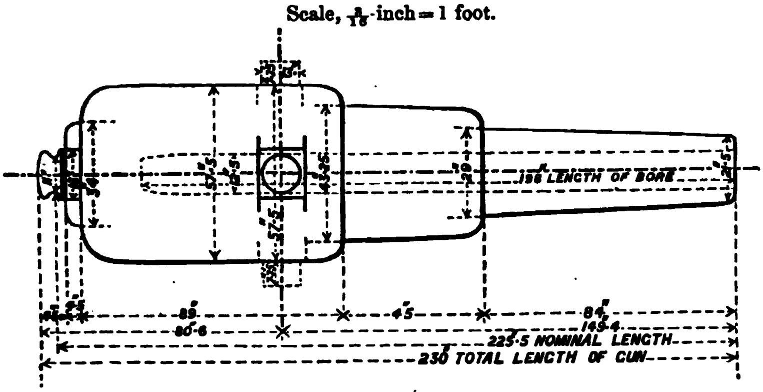
The 12-inch gun of 35-tons being rather short for its other dimensions, a pattern for a 38-ton gun about three feet longer in the bore was provisionally approved of in 1873. (See Plate XVII.)

Experiments made by the Committee on Explosives with such a gun, bored out first to 12 inches and then to 12·5 inches, showed that the latter calibre was the most suitable of the two. It was consequently approved in November 1874, that the calibre of this piece should be 12·5 inches the charge and projectile being provisionally 110 lbs. P. powder and an 800 lb. shell.*

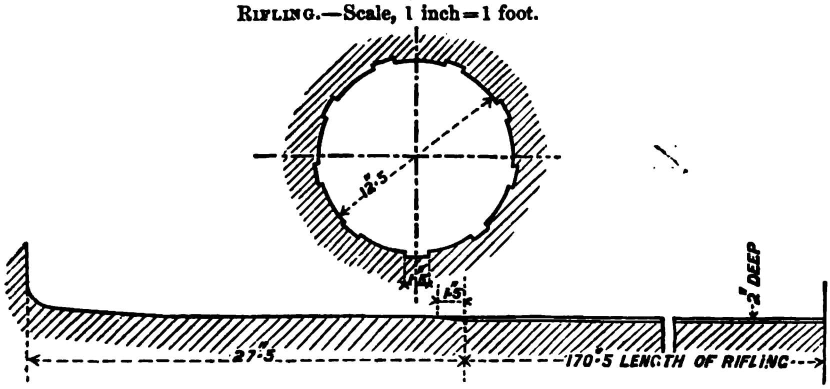
Further experiments made by the committee enabled them to report that with an 800 lb. shot, and 130 lb. of P² powder no excessive strain was thrown upon the gun at any point in the bore when these charges were employed with the curve of rifling of the experimental gun. They therefore recommended that the parabolic curve of rifling (increasing twist) with a twist of from 0 at the breech to 1 in 35 at the muzzle should be adopted. This was finally approved of in January 1875, since which date a number of these guns have been made. §2792.

In construction this gun exactly resembles the 35-ton gun, already described, from which it differs in dimensions only.

Scale, $\frac{1}{16}$-inch = 1 foot.



RIFLING.—Scale, 1 inch = 1 foot.



13″·05 Rifled M.L. Gun of 23 tons. Mark I. L.S. only.

There is only one pattern of this gun, which was brought forward in 1862 as a 600-pr., to have a calibre of 13·3 inches. In 1864 four of 13·05 inch of 23 tons, Mark I.

* Two 38-ton guns Nos. 2 and 3 on board H.M.S. "Thunderer" retain the calibre of 12″ temporarily.

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these guns were ordered having a calibre of 13 inches, shunt rifling, uniform spiral and A tubes of untempered steel, closed by the Elswick loose end similar to that in the 64-pr., Mark II. (see Plate V.). Of these four, by March 1867, two were rendered unserviceable during experimental practice at Shoeburyness by splitting their A tubes and some of the coils, and another by splitting its outer coil. The latter was repaired with a new outer coil shrunk on, and is now serviceable, and the fourth having passed proof is serviceable.

O.S.C. Proceedings, 1867, pp. 98–102.

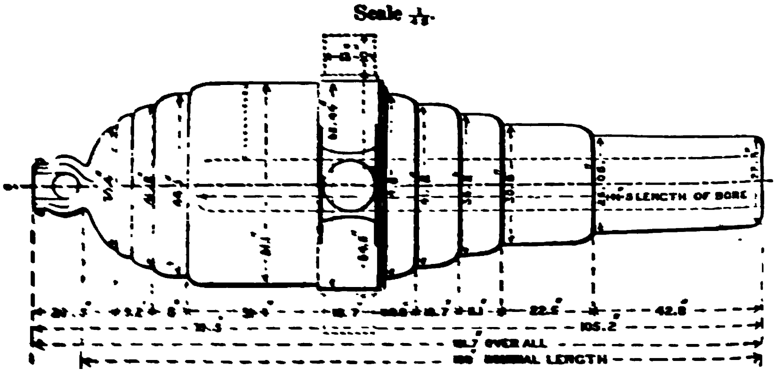
In the meantime the 12″ calibre had been adopted, and it was decided that the rifling of the two guns which remained should be converted to the "Woolwich" form of groove, the calibre being increased to 13·05 inches, a manufacturing necessity owing to re-rifling.

O.S.C. Proceedings, 1867, p. 101.

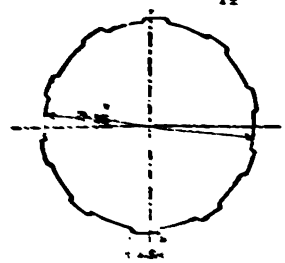
Thus it is that these two guns have an exceptional calibre, uniform twist, and 10 grooves.

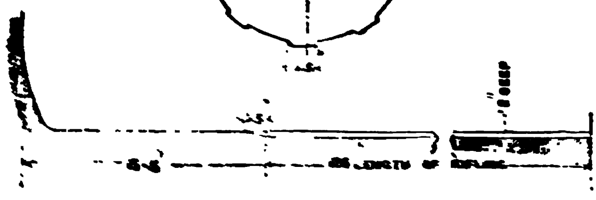
Indeed we may look upon them as obsolete, for no ammunition is made for these guns, one of which is in the Royal Military Repository, and the other in Woolwich Arsenal.

Scale 1/12.



Rifling. Scale 1/12.





Consists of:—

A tube, untempered steel, with loose end.	Trunnion ring.
Breech-piece.	15 coils.
B tube.	Cascable.

Experimental Guns.

16-inch of 80 tons.

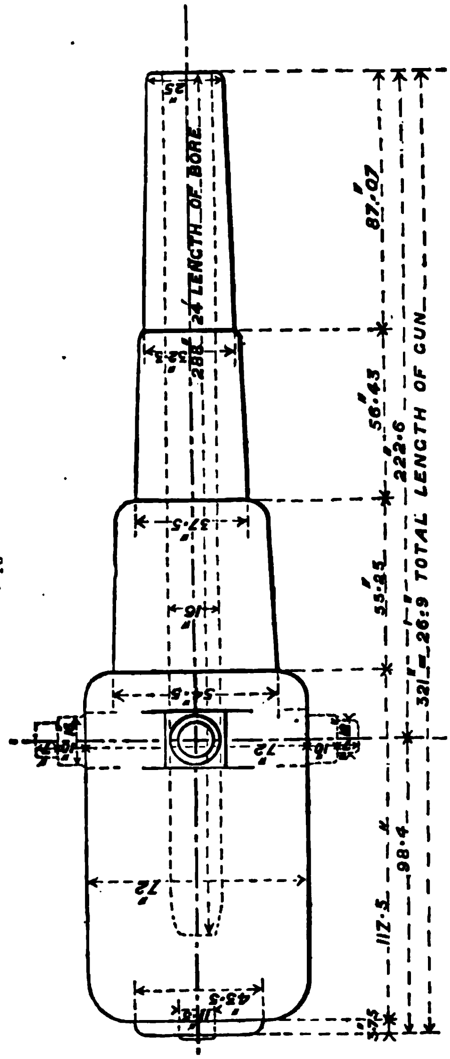
[illegible] ordnance is introduced into the service, a [illegible] trials are carried out to settle the various questions as to calibre, rifling, &c., &c., and so long as these points are not definitely settled, the pieces are termed experimental, although it may frequently happen that up to a certain point, such as the rifling or sighting, a number of the nature may be manufactured. Thus at present (1877) we continue the manufacture of four 16-inch guns of 80 tons, though the first made is still in the experimental stage.

16-inch Rifled M.L. Gun, L.S. and S.S., of 80 tons.

16-inch guns proposed in 1873.

In 1873 it was proposed to construct a more powerful gun than any of the service ordnance, and the heads of departments recommended that an experimental gun should be manufactured to weigh about 75 tons, and to be 24 feet long in the bore, with a calibre of 14 inches. This calibre to be subsequently bored up to 15 inches and 16 inches

Scael, 1/16-inch = 1 foot.



successively in order to determine the proper calibre, rifling, charge, &c., &c.

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In the early part of 1874, the Admiralty acquiescing in the suitability of such a gun, the Secretary of state for War ordered its manufacture, the cost of the piece being estimated at about 8,000*l*., and its weight 80 tons.

Experimental calibres of 16-inch gun.

It was intimated at that time by our naval authorities that they intended to arm the "Inflexible," now building, with guns of this size.

Some idea of the dimensions of this piece may be gained from the fact that it is 27 feet in total length, 24 feet long in the bore, and that its diameter at the breech is 6 feet.

It was completed in 1875, being bored up to 14·5 inches, and in September of that year was fired at the Proof Butts, giving very satisfactory results.

The gun was subsequently bored up to 15 inches, and a number of rounds fired with shot of 1,265 and 1,465 lbs., and charges up to 300 lbs.

Since then it has been bored up to its final calibre of 16 inches, and fired with most satisfactory results at Shoeburyness.

It consists of:—

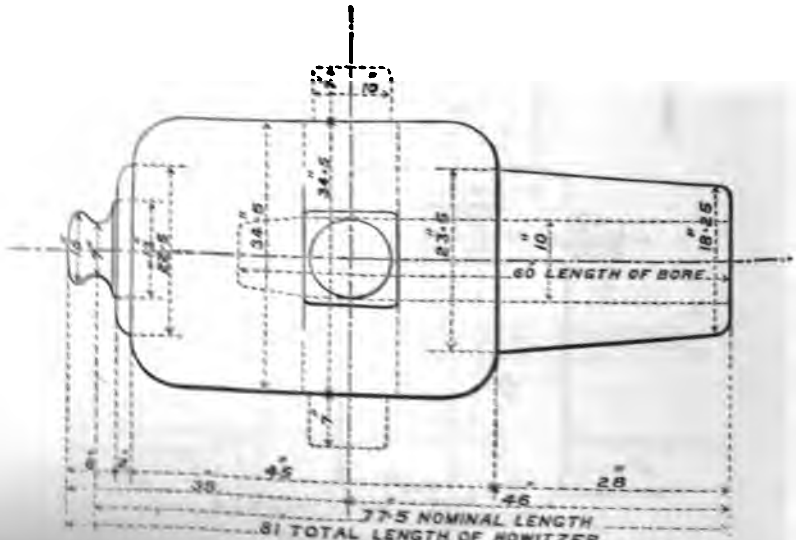
A tube (toughened steel).
B tube.
2 *B* coil.
1 *B* coil (or belt).
Coiled breech-piece.
C coil (or jacket) made of 4 single coils, a ring coil, and a trunnion ring.
Cascable.

The rifling, sighting, venting, &c. of this gun are not yet finally settled upon.

Experimental 10-inch howitzer of 6 tons.

10-inch Rifled M.L. Howitzer of 6 tons (Experimental).

Scale ½ inch = 1 foot.



Should this howitzer be introduced into our service it will probably take the place of the 13-inch S.S. mortar in coast defences and other positions in which these mortars are now employed.

The present experimental construction consists of:—

A tube (toughened steel).
B tube and coiled breech-piece united into one tube.
Breech coil (or jacket).
Cascable.

In external appearance it resembles the 8-inch R.M.L. howitzer, but having two layers of iron over the breech it is stepped, showing the end of the coiled breech-piece, the cascable also terminating as in that piece with a plain button.

9-inch R.M.L. Howitzer of 5 tons.

The same remarks as apply to the 10-inch experimental howitzer will also apply to the 9-inch. Experimental 9-inch howitzer of 5 tons.

12-pr. R.M.L. Gun of 8 cwts.

Three guns of the above weight are now under trial, rifled upon different systems. By certain alterations in the bore it is hoped to make these very powerful field pieces. Experimental 12-pr. field guns.

TABLE XVIII.—Dimensions, Rifling, &c. of Muzzle-Loading Guns.

Nature, Weight, and Service.	Length. Gun.*	Length. Bore.	Length. Rifling.	Rifling. System.	Rifling. Spiral.	Grooves. Number.	Grooves. Depth.	Grooves. Width.	Preponderance.
	ft. in.	in.	in.				in.	in.	cwt.
16″ of **80** tons.—L.S., & S.S., I, Exp.	26 9	288	—	Woolwich	——	—	—	—	—
12·5′ of **38** tons.—L.S. and S.S., I.	18 9½	198	170·5	Do.	Increasing, from 0 to 1 in 35.	9	·2	1·5	Preponderance of guns of 18 tons and upwards not to exceed 8 cwt.
12″ of **35** tons.—S.S., I.	15 11¾	162·5	135	Do.	Do.		·2	1·5	
13·05″ of **23** tons.—L.S. Mark I.	14 1	141·5	126	Do.	Uniform, 1 turn in 55 calibres of 13″.	10	·2	1·5	
12″ of **25** tons.—L.S. and S.S., I. & II.	14 3½	145	127	Do.	Increasing, from 1 in 100 at breech to 1 in 50 at muzzle.	9	·2	1·5	
11″ of **25** tons L.S. I.	14 3	146	119	Do.	Increasing, from 0 to 1 in 35.	9	·2	1·5	
11″ of **25** tons L.S. II.	14 2								
10″ of **18** tons L.S. and S.S. I.	14 2	145·5	118	Do.	Increasing, from 1 in 100 to 1 in 40.	7	·2	1·5	
10″ of **18** tons L.S. and S.S. II.	14 2½								
9″ of **12** tons L.S. and S.S. I.	12 3	125	107·5	Do.	Increasing, from 0 to 1 in 45 calibres.	6	·18	1·5	Nil.
9″ of **12** tons L.S. and S.S. II., III., IV., & V.†	12 3	125	104‡	Do.	Do.	6	·18	1·5	5
8″ of **9** tons S.S. I.	11 4½	118	102	Do.	Increasing, from 0 to 1 in 40 calibres.	4	·18	1·5	Nil.
8″ of **9** tons S.S. II. & III.	11 4½	118	99·5‡	Do.	Do.	4	·18	1·5	4
8″ Howitzer of **46** cwt. L.S., I.	5 1	48	35·5	Do.	Uniform, 1 turn in 16 calibres.	4	·18	1·5	2
7″ of **7** tons L.S. I.	11 10·8	126	112·5	Do.	Uniform, 1 turn in 35 calibres.	3	·18	1·5	4·5
7″ of **7** tons L.S. II. & III.	11 9½	126	110·5	Do.	Do.	3	·18	1·5	3
7″ of **6½** tons S.S. I.	10 5½	111	97·5	Do.	Do.	3	·18	1·5	5·5
7″ of **6½** tons S.S. II. & III.	10 6	111	95·5	Do.	Do.	3	·18	1·5	3
7″ of **90** cwt. S.S., I.	10 4½	111	95·5	Do.	Do.	3	·18	1·5	5
80-pr. 6·3″ of **5** tons L.S., I.	10 0	113·25	106·25	Do.	Uniform, 1 turn in 40 calibres.	3	·145	1·3	9·75
64-pr. 6·3″ of **64** cwt. S.S. and L.S. I.	9 3½	98	90·5	Shunt §	Do.	3	·11 & ·08	·6 & ·4	7
64-pr. 6·3″ of **64** cwt. S.S. and L.S. II.	9 5	98	90·5	Do.‖ or plain.	Do.	3	·11 & ·08	·6 & ·4	3
64-pr. 6·3″ of **64** cwt. S.S. and L.S. III.	9 3½	97·5	90·5	Do.‖ or plain.	Do.	3	·11 & ·08	·6 & ·4	3·75
64-pr. 6·3″ of **71** cwt. L.S. & S.S., I.	9 0	103·27	96·27	Plain groove.	Do.	3	·115	·6	6·375
64-pr. 6·3″ of **58** cwt. L.S., I.	9 6	108·45	101·45	Do.	Do.	3	·115	·6	—
									lbs.
40-pr. 4·75″ of **34** cwt., L.S., I.	8 0	85·5	72·5	Woolwich	Uniform, 1 turn in 35 calibres.	3	·1	·8	28
40-pr. 4·75″ of **35** cwt., L.S., II.	9 6½	104·5	90·5	Do.	Do.	3	·1	·8	26
25-pr. 4″ of **18** cwt., L.S., I.	7 10½	88	78	Do.	Do.	3	·1	·8	14
6·3″ howitzer of **18** cwt., L.S., I.	4 6	45	42·5	Poly-grooved.	Increasing from 1 turn in 100 to 1 in 35.	20	0·5	·5	—
16-pr. 3·6″ of **12** cwt., L.S., I.	6 2·45	68·4	58·04	Modified French.	Uniform, 1 turn in 30 calibres.	3	·11	·8	7·5
9-pr. 3″ Wrought iron of **8** cwt. L.S. I.	5 8½	63·5	59·8	Do.	Do.	3	·11	·8	7
9-pr. 3″ Wrought iron of **8** cwt. S.S. II.	5 8½	63·5	59·8	Do.	Do.	3	·11	·8	7
9-pr. 3″ Wrought iron of **6** cwt. S.S. I.	4 10	53	49·3	Do.	Do.	3	·11	·8	3
9-pr. 3″ Wrought iron of **6** cwt. L.S. II.	5 11	66	62·3	Do.	Do.	3	·11	·8	10
7-pr. 3″ of **150** lb. steel (mountain).¶—I., II., & III.	2 2½	24	22	French	Uniform, 1 turn in 20 calibres.	3	·1	·6	3 lbs. III. 5 lbs. I. II.
7-pr. 3″ of **200** lb. steel—IV.	3 2 3/16	36	34	Do.	Do.	3	·1	·6	5
7-pr. 3″ of **200** lb. bronze (boat).**—II.	3 0	32·15	29·15	Do.	Do.	3	·1	·6	45
7-pr. 3″ of **224** lb. bronze, Mark III.	3 0	34	32	Do.	Do.	3	·1	·6	5

* The length of a Rifled M.L. gun is measured from the face of the muzzle to the smallest diameter of the cascable, excepting those having base rings, from behind which to the muzzle constitutes their nominal length.
† Mark V. differs from IV. only in preponderance, the trunnions being placed ¾″ further to the rear.
‡ Those made before 1st January 1868 have length of rifling same as Mark I.
§ Those hereafter re-tubed or manufactured will have same rifling as the 64-pr. converted gun.
‖ As explained at p. 184, all 64-prs. having steel tubes, whether originally or re-tubed Mark III. guns, and also all of Marks I. and II. re-tubed with iron, have the plain groove.
¶ These differ in the method of sighting, and the size and shape of cascable.
** Mark I. was 24 lbs. heavier than 2″ longer in bore. A few (seven) were issued to India.
Note. For charges, &c. see table, p. 264.

CHAPTER XII.

CHAP. XII.

EXAMINATION, PRESERVATION, AND REPAIRS OF ORDNANCE AND STORES.

Examination of Ordnance.—Memorandum of examination issued with every gun.—Periods at which different natures of ordnance must be examined.—Mode of examination.—How to examine the bore.—When impressions should be taken. —Mode of taking gutta percha impressions with B.L. and with M.L. guns.—Natures of defects usually found in bore.—How the vent should be examined.—Natures of defects in or near vent.—As to sentencing for re-venting.—**Examination of B.L. Fittings.**—Defects on exterior of gun of little importance.—**Repairs.**—What can be performed in the field.—Re-coppering, adjusting new fore sights or clamping screw for hind sights.—Re-venting.—Repairs at certain stations.—Adjusting Millar's sights to a S.B. gun.—Re-venting heavy guns.—Re-bushing 7-inch R.B.L.—Repairs to be carried out in an arsenal.—**Preservation of Guns and Fittings.**—Painting, browning, lacquering bore.—Vent plugs.—Sights, how preserved.—Blueing.—Bronzing.—Preserving screws should be used.—**Tables.**—Cleaning and examining tools for S.B. Ordnance.—Rifled Ordnance.—Venting tools.

Examination.

Every artilleryman should know how to examine the weapons with which he works, and should understand what defects in guns are serious and what defects may be disregarded, while it is of great importance that the examination of both guns and fittings should be very searching and exact, otherwise a small flaw left unnoticed may endanger the life of the gun in the future.

Importance of examination.

Guns must therefore be frequently examined at out-stations,* but as it requires great practice and experience in order to become a competent judge of the various conditions of all the different natures of guns in the service, it has been directed that *final* condemnation shall be pronounced only by the authorities of the Royal Gun Factories.

Final condemnation.

In all cases, however, where there are sufficiently serious defects (p. 218), or if there be any doubt as to the serviceable state of the gun, it must be provisionally condemned and a report made of the same as mentioned in Appendix, p. 243.

Provisional condemnation.

* This will be done by the Inspector of Warlike Stores or other competent person, as mentioned Appendix, p. 243.

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Guns examined, &c. before issue.

As described at p. 104, every gun before being passed into the service is carefully examined after proof, and in the case of R.B.L. guns, with reference also to its breech fittings.

It is then marked with the broad arrow in front of the vent, and if it be a rifled gun a memorandum of examination is filled in, which is in fact a register sheet for that particular piece.

Memorandum of examination.

This memorandum of examination always accompanies the gun and is in possession of the officer in whose charge the piece may be. In it is given the information required by any one who has to examine a gun, viz., the material of the bore, and, in the case of the muzzle-loading ordnance, a short description of the construction, with a wood cut showing the gun in section. The defects in the gun at the time of *its issue,** the number of rounds it has fired, and the subsequent examinations are also stated. When a gun is returned to the R.G.F. for repairs, a new memorandum of examination is made out after the repairs are completed and sent out with the gun on re-issue.

Periods of Examination.

Periods of examination.

With regard to the periods of examination the following rules are laid down :—

Every gun must be examined after firing a given number of rounds with projectile as under :—

			Rounds.
S.B. guns.	S.B. Cast iron guns	Firing 10 lbs. charges † and upwards	100
		Under 10 lbs. charge - -	200
Rifled guns.	Rifled guns B.L. and M.L.	9-inch guns and upwards -	50
		8″, 7″, and 64-prs. - -	100
		40-prs. and under - -	150

Mode of Examination.

Preparing a gun for examination.

The bore should be thoroughly cleaned, as it is not possible to detect small defects, which may sometimes be of importance, if the bore be in a rusty or very greasy state. If care has previously been taken in keeping a gun tolerably clean, it will probably be sufficiently prepared for examination by washing, brushing, and drying with tow or a clean sponge head. If, however, there be hard rust which will not yield, or a thick coating of lacquer or grease, the bore may be cleaned either by firing, if circumstances admit, one or two scaling charges, about one-third the full service charge, without projectiles, which will usually loosen the scale, or by the use of hot water and potash, in the following manner :—

Cleaning with potash water.

About a gallon of boiling water is poured on one pound of black American potash, and an old sponge covered with a canvas cap, or some substitute to make it tight to the bore, is dipped into the solution. The bore is then rubbed till the dirt is loose, when the hard brush will remove it ; it is then wiped dry with tow, &c., and slightly oiled. The

* *See* p. 217. The position of defects developed on service are noted in a similar manner.

† 68-pr. | 32-pr., 63 cwt.
56-pr. | 32-pr., 58 cwt.
42 pr. | 32-pr., 56 cwt.

potash water must be used very hot, and the sponge must be very tight, or the process is ineffectual. If the dirt be very thick in the small grooves of the Armstrong guns, a common pricker with the point filed flat is useful. No sharp edged or pointed scrapers should be employed for cleaning the bores of rifled guns; they are unnecessary, and are liable to injure the rifling.

Examination by means of lamp.

The bore, being thus cleaned, should be examined by aid of a lamp; if the surface is slightly wet the detection of defects by this means is greatly facilitated. A sharp pointed pricker is used to ascertain the extent and position of any flaw, the stave being graduated in inches so that the distance from the muzzle may be readily ascertained. A spring searcher is also used to detect defects, and with B.L. guns in such a manner that each groove shall be traversed in succession by one of the points. A pricker with "blunted point," or rather a flat edge, is also supplied, and is useful in searching the defects in coiled barrels.

Spring searcher.

Blunted pricker.

Moreover, should there arise any doubt as to the state of the bore, or should there be any appearance of fissures about the vent, the gun would of course be examined at the discretion of the officer in whose charge it is.

As to taking impressions generally speaking: With S.B. guns it will usually be only necessary to take one of the vent and that portion of the bore immediately adjoining it. With R.B.L. pieces impressions would only be taken when flaws were seen, and as a rule of the breech bush in the gun and of the face of the vent piece. With converted guns impressions of the whole of the powder chamber showing also the joint where the cup closes the end of the bore should be taken. With R.M.L. steel-lined guns, unless scoring, damage by shell, or incipient cracks are thought possibly to exist, an impression of the vent would very often be sufficient.

Examination of Bore.

Bore.

For the purpose of this examination tools are provided for S.B. and Rifled guns respectively as shown in Tables, pp. 236, 7, 8.

Defects in S.B. guns.

Should any defects be discovered they need not be taken notice of, in the case of S.B. guns, unless they are 0″·1 deep in rear of, or 0″·2 deep in front of the trunnions, or unless they have jagged edges likely to retain pieces of cartridge; and in the case of rifled guns, unless they are new defects not shown on the memorandum of examination, or old ones which have materially increased. If the defects however, be of the natures mentioned, impressions must be taken of the bore.

Defects in rifled guns.

Impressions to be taken.

Temporary impression.

For S.B. guns an impression of the defect will be taken by means of a pricker having a copper pan attached to it below. This impression is only a temporary one taken with a mixture of soft soap, bees-wax, and treacle.* With rifled guns a special instrument is issued for the purpose, vide p. 63, or should that not be available, wood blocks such as those shown below for taking impressions of the whole length of the bore may be used. They can be made by any carpenter,† but it requires some practice to take good impressions with them. It is therefore advisable to take impressions of the powder chamber if possible with the special instrument provided with examining tools.

Of powder chamber.

Long impressions. § 1625.

In all cases where there is any doubt as to the state of the bore, in the case of rifled guns, impressions should be taken of the whole length by means of these blocks.

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* Should a permanent impression be required it must be taken with gutta-percha with whatever means may be available.

† These blocks are therefore not issued.

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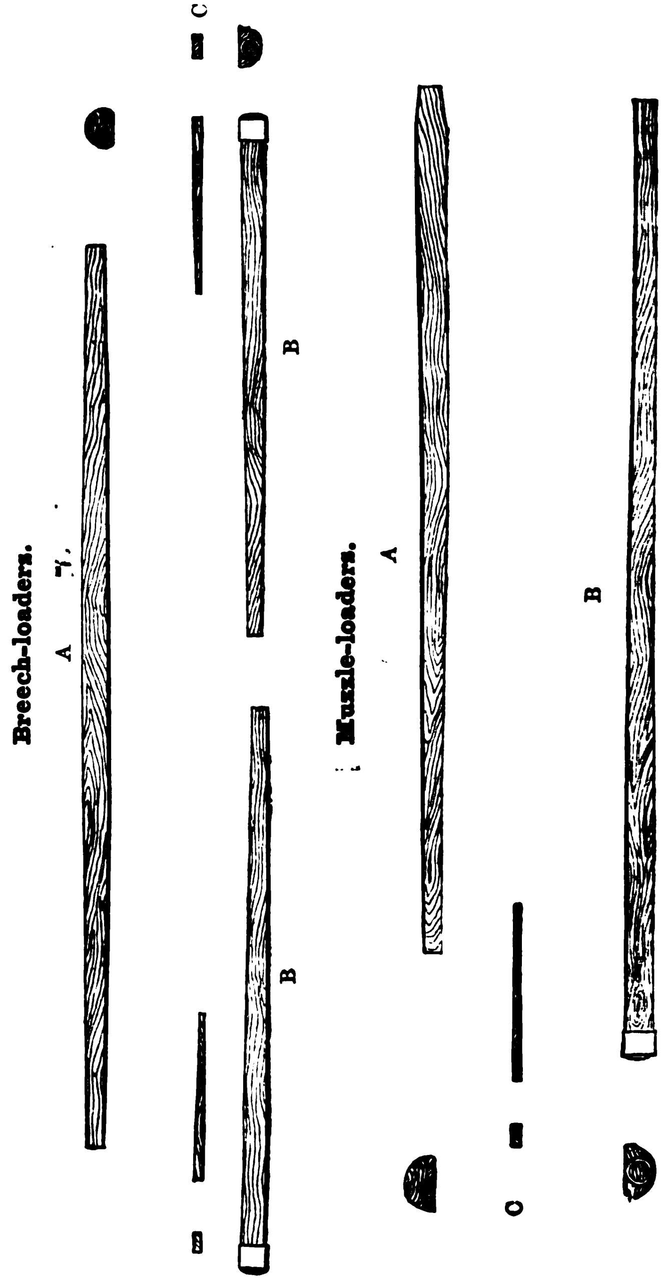
Wood Blocks for taking Impressions of the Bores of Guns. Scale ½ inch = 1 foot.



The wood blocks are thus used:—

Method of using wood blocks.

Blocks A (tapering from the centre for B.L. guns, and from the breech for M.L. guns) with their wedges B should be made to suit the diameter of the bores to be taken, leaving room for about 0·25 inch of gutta-percha when the wedge or wedges are driven home, and proceed as follows:—

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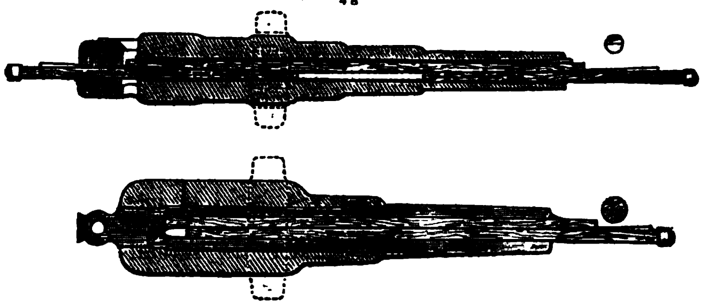
Preparation of the gutta-percha.

A sufficient quantity of gutta-percha, having been softened in water just under the boiling point, is well kneaded and worked to expel the air and water, and is laid along the block A, which has been previously prepared by rubbing it over with a little soft soap. The gun is so placed that the impression required will be taken upwards, the block A is inserted into the bore, and the wedge B (if a B.L. gun by simultaneous blows at both ends) is driven well home with mauls; a small wedge C is then forced between the ends of the blocks A and B.

METHOD OF USING THE WOOD BLOCKS FOR TAKING GUTTA-PERCHA IMPRESSIONS OF THE BORES OF GUNS.

Scale $\frac{1}{48}$ size.



This can easily be withdrawn in about 10 or 15 minutes, according to the temperature, when the impression has become cold, and thus gives slackness to the wedge B and the block A, which are withdrawn in the order named together with the impressions, which can be readily removed from the block, being prevented from sticking by the soft soap.

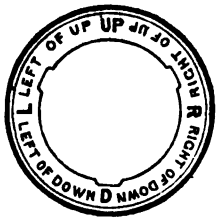
Before impressions are taken the bore should be quite clean but slightly greasy; if quite dry the gutta-percha will adhere to it, and the impression be damaged in removal.

Instruments for taking impression of vents.

To use the "instrument for taking impressions of vents" gutta-percha prepared as above is laid on a gun metal plate secured by screws to a frame. The frame is attached to a long hollow handle, and is so made that the upper portion * can be raised or lowered by bell-crank levers worked by a right and left-hand screw. This screw forms part of a rod passing through the frame handle, and to the outer end of the bar, &c. is attached a cross handle by working which the plate carrying the gutta-percha can be forced up against the surface of the bore or powder chamber when required, and lowered when the gutta-percha is sufficiently hardened.

Position of flaws, &c., how noted in returns.

In order to note in returns † the position of any flaw, &c. upon an impression, their distance from the muzzle is measured in inches and noted as up, right of up, &c., as the case may be. ‡



* The upper part of the frame itself answers as a plate for some natures.

† Vide Appendix p. 245.

‡ Defects in powder chambers of R.B.L. guns are measured from the breech end, and noted in a similar manner to defects in the bore.

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Defects in Bore.

S.B. guns. Corrosion of bore.

In S.B. guns the bore is liable to be much corroded if exposed to the action of salt water, and occasionally a flaw in the metal leaving a hole may also occur. Generally speaking, however, the defects which condemn such pieces will be found at or about the vent, vide p. 221–2.

Rifled guns.

With rifled guns the following defects are likely to be found.

Tool marks.

(1.) "Tool marks," or slight irregularities and scratches caused in manufacture during the boring and rifling.*

With steel tubes, on account of the hard smooth surface, these are more apparent and have been at times mistaken for fine cracks when running along the bore. To an experienced eye, however, the difference is easily perceptible.

Wearing of the grooves.

(2.) Slight wear of the sides of the grooves from the friction and over-riding of the studs of projectile is also found at times, but this takes place as a rule only in guns having iron tubes, or when with steel tubes a uniform twist is employed with a heavy gun.

Defects in wrought iron barrels.

(3.) With wrought iron "A" tubes † imperfections of weld always exist, and scarcely any are quite free from them; they are, however, of little consequence as a rule, unless they are found to increase very much when the gun is used.

The following are the technical names of the several defects likely to be found in wrought iron barrels :—

"Coil marks," where the line of coil running round the barrel is visible, the weld not being quite perfect; but in this case the defect has no appreciable depth, and is of little consequence.

"Defective welds," the same sort of defect as "coil marks," but deeper and more important; they run round the bore in coiled barrels, and along it in solid forged barrels.

"Specks," small spots and pin holes in the metal, caused by dirt in iron, blisters, &c. These sometimes occur in clusters.

"Flaws," larger defects of the same nature.

"Longitudinal cracks" are also found in solid forged barrels, caused by the gas eating into the defective welds and splitting the barrel lengthways.

"Scoring" or "Guttering" about the seat of the projectile, caused by the rush of gas through the windage in M.L. guns, occurs in the coiled barrels of heavy guns (few of which have been made), and "longitudinal cracks" are also sometimes developed.

Certain defects of little importance in coiled barrels.

The experience of years has proved that flaws, coil marks, and even defective welds are of little importance in guns not exceeding the size and power of the 7-inch B.L. gun. The importance of a defect depends in a great measure on its position in the gun, one in rear of the trunnions, especially if in the powder chamber, being more dangerous than one of the same nature and extent in front of the trunnions, as the powder gas acts much more rapidly upon it, and it is liable moreover in M.L. guns to hold a piece of ignited cartridge. Few instances have occurred in which defects in coiled barrels have caused accidents or have increased in any material degree after issue, unless they exist in the powder chamber, and for this reason no guns have been issued for some years past with any defect except of the most trifling character in that part of the bore.

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* A chip or grain of sand getting between boring or rifling head will cause such tool marks, while the emery powder used in lapping leaves very fine marks on the hard surface of the steel tubes.

† The material of which the barrels are made has for some years past been stamped [illegible] muzzle, and is also entered in the "memorandum of examination."

It has been found that in M.L. guns having coiled iron barrels (64-prs. and a few of the heavier natures, *see* p. 167), the tube is liable to split in the chamber in continuation of the edge of one of the grooves. This, together with the difficulty of getting the material sound, has led to the abandonment of coiled iron for the barrels of all, except the converted guns, in which there is a peculiar gas escape to indicate when the breech portion of the inner tube is split. Longitudinal cracks in barrels.

(4.) Steel barrels are fortunately free from the defects so inherent to wrought iron, and generally show us a beautifully smooth and even surface, very slightly scored by a number of very minute tool marks. Occasionally a small piece is found chipped out as it were, but leaving a smooth hollow behind it, which if small is quite an unimportant defect. Defects in steel barrels.

Longitudinal cracks at times occur which develope into splits. When such are found they are of far more importance than similar cracks in a wrought iron tube. Longitudinal cracks.

A few instances have occurred in which steel tubes have split on service from the bursting of a shell inside the bore; in some of these the tube split at the muzzle. In cases where steel barrels have split in M.L. experimental guns when being tested for endurance, the crack has commenced at the edge of one of the grooves (as in coiled barrels) and extended into the powder chamber; as a crack in the chamber, should it exist, might be so fine as not to be visible from the muzzle, it is essential that impressions in gutta-percha should in all cases be taken of the chamber of rifled M.L. guns, as before stated, and care must be taken to discriminate between a crack and a superficial streak or tool mark. Splitting of steel barrels, how caused.

(5.) Scoring or guttering was caused by the rush of gas round* the projectile in R.M.L. guns due to windage, and was common to both iron and steel barrels. In small guns this was very slight, but when very heavy charges were used the surface of the bore was gradually eaten away to a considerable extent, but even in extreme cases scoring has not caused the destruction of a gun, though in some instances acting on the corner of a groove it has tended to split the tube. Fortunately we may now look upon this species of defect as a thing of the past, for by the new mode about to be adopted of closing the windage upon firing, scoring will be entirely prevented. Scoring or guttering. Prevention of scoring by gas checks.

Thus, upon examination of the 80-ton gun after firing 94 rounds of charges of 370 lbs. powder, copper gas checks having been employed with all the projectiles fired, the surface of the tube showed hardly the least trace of scoring. Gas checks to prevent scoring.

(6.) Again, we have sometimes "dents" or "abrasions" caused by the bursting of a shell in the bore; these are as a rule of very little importance. In one or two instances muzzles have been blown off from this cause; but generally the only result is to cut up and graze the bore more or less. It is found that such injuries seldom interfere with the efficiency of the piece, and an armourer can generally file down any metal set up in the bore. Dents or abrasions due to shell bursting.

Sentence as to bore.

In sentencing a gun according to the state of the bore, it is essential to discriminate between defects which are characteristic of the material, and cannot wholly be avoided in manufacture, and those which are created or developed on service, such as cracks in a steel tube. In Sentence as to bore.

* This wear is principally over the top of the projectile where windage is greatest owing to projectile resting on its lower studs.

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coiled barrels defects are often numerous and generally of little importance, while in steel barrels the case is reversed; defects seldom occur, but when they do they are of great importance.

It is almost impossible to lay down any definite rules as regards the extent or depth of a defect which should necessitate the condemnation of a barrel; a great deal must be left to the judgment and experience of the inspector.

Sentence on coiled barrels.

Unless there is reason to believe that there has been some material change from the former state of the defects, a gun with a coiled barrel need not be condemned. Speaking generally, the depth of a defect is of more importance than its extent, but, should a defective weld run *right round* the bore, the gun would be liable to part at that point, and must be considered unserviceable. The best method of testing a gun is to take an impression of the defect, then to fire a few rounds and take another impression; if on comparing these impressions the defect does not appear to have increased, the barrel may be considered as serviceable.

Solid forged.

In solid forged barrels a flaw running lengthways has a tendency to develop into a crack, especially if it occur in the powder chamber. If the inspector finds a case of this kind he will put the gun aside, but he will endeavour to discriminate between this and a mere streaky line, which is unimportant.

Steel barrel.

As to steel barrels, any crack, however fine, would necessitate the provisional condemnation of the gun.

Examination of Vent.

Examination of vent.

Gauging.

Besides examining the bore of a gun it is necessary especially to examine the vent-bush itself, and that part of the chamber or bore of the piece where it enters. For this purpose in S.B. and R.M.L. guns,* the vent channel is thoroughly cleared and scraped, and then gauged by means of a set of gauges issued for the purpose.

It is not uncommon to find a "choke" where the metal has been set up near the bottom of the vent; this should be removed by a drill or rimer before the gauge is taken.

Impressions of vents.

A clean impression of the bottom of the vent must also be taken, this will be taken with the improved instruments for taking impressions of bores, the plates for which are now fitted with ends to suit the chambers of guns (*see* § 2032), or they may be taken with the instrument provided among the tools for venting ordnance, if this latter and the proper blocks are at hand.

Defects as to vent, and sentence.

Effect of firing on vents of rifled M.L. guns.

The effect of service on a vent is seen either by a gradual increase to the channel of the vent itself, by an irregular wearing away of the bottom, by the metal of the vent setting up, and the gas forming a hollow ring round it, or by fissures or hair lines radiating into the metal of the bore from the edge of the vent bush.

The following are the existing regulations as to sentencing guns, either for re-venting † or condemnation, according to the state of their vents.

Re-venting.

(1.) S.B. and Rifled.—To be re-vented if $0''\cdot 3$ gauge passes down.

(2 *a*.) S.B. unbushed ‡ guns.—Should there be a cavity at the

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* R.B.L. guns being vented through the breech-block or vent-piece, vide p. 223 for mode of examining the same.

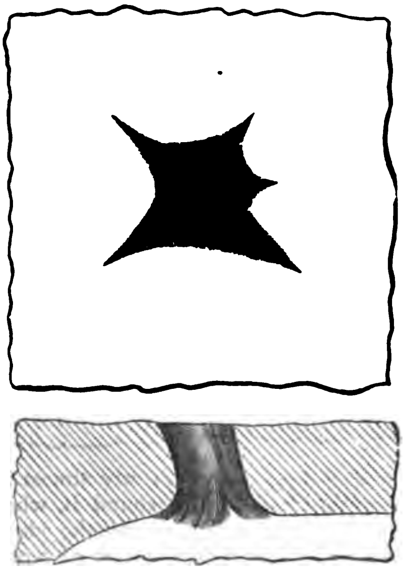
† For re-venting, vide p. 233.

‡ Very few of such guns would now be found, as all guns issued from R.G.F. since 1855 have been bushed, vide p. 12. Still S.B. guns might have to be drawn from stores abroad where unbushed guns are occasionally on charge.

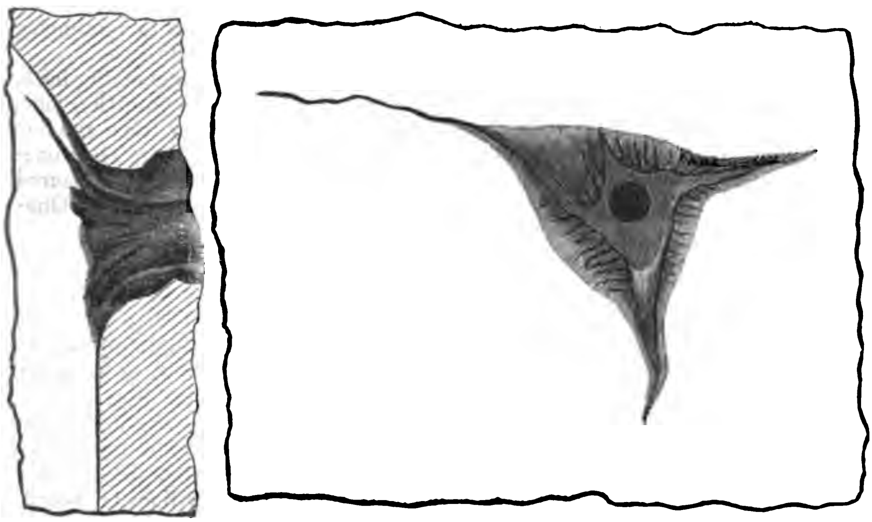
Unbushed guns.

bottom, or any hair lines or fissures, the extent of the defects will be measured on the impression. If they be of a length beyond ·2-inch, but not exceeding ·35-inch from the original centre, the gun will be sentenced for cone venting; if ·35-inch, but not 5-inch, for through venting; if beyond that limit, the gun will be reported provisionally as unserviceable.

UNBUSHED GUNS.—Fig. 1.



UNBUSHED GUNS.—Fig. 2.



Bushed guns.

(2 *b.*) S.B. Bushed guns. The defects usually found round the vent of bushed guns, are the giving way of the iron round the bush, from the gas getting in between the two metals (*see* Fig. 2), and the fissures or

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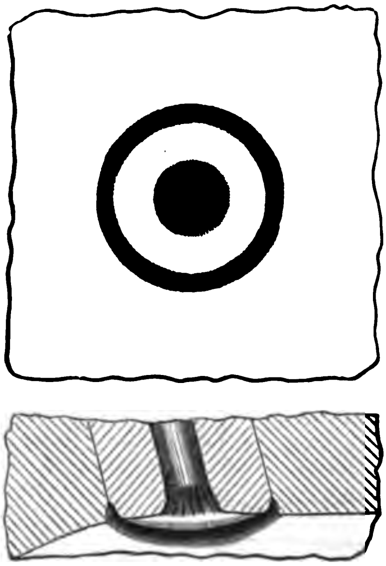
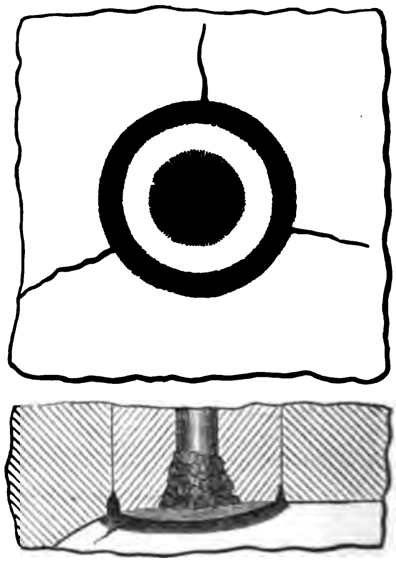
hair lines, which radiate in the iron, from the edge of the vent bush (*see* Fig. 3).

Bushed Guns.—Fig. 2.



Bushed Guns.—Fig. 3.



Ring worn round bush.

The metal round a bush begins to give way almost immediately after a gun is vented, forming a hollow ring round it, which gradually increases. So long as this wear is uniform, and the edges are not jagged it is not of importance; and guns will not be re-vented or condemned for this cause until the ring has become 0·1-inch deep, or 0·1-inch wide. If, however, the edges are ragged, or if one side has given way much more than the other, so as to be likely to hold a piece of unconsumed cartridge, the examiner must use his discretion as to sentencing the gun, it being impossible to lay down fixed rules for all cases.

Fissures, or hair lines.

Fissures or hair lines, radiating in the iron from the edge of the bush, will be found in bushed guns. There will often be one on either side, and a third to the front. The examiner will carefully trace the fine lines on the gutta-percha impressions, and if they extend more than one-tenth part of the circumference of the bore in any direction, measured from the original centre, he will provisionally condemn the gun. One-tenth may be taken as—

68-pr.	- - -	2¼ inches.
32 „	- - -	2 „
24 „	- - -	1¾ „

Vents of R.M.L. guns.

(3.) R.M.L. Should the ring (Fig. 2) above, worn away round bottom of bush, be 0″·1 wide or deep, or jagged and irregular, so as to be in the opinion of the examiner likely to retain a piece of cartridge, the gun would be condemned for re-bushing and if possible with a cone bush (vide p. 233). If already through bushed the gun must be condemned. In case of hair lines radiating from the edge of the vent in steel lined pieces the gun must be provisionally condemned should the hair lines be 1-inch in length, unless when directly to the front or rear, when the limit of condemnation is smaller, ½ inch, owing to that position being the worst for the development of a crack. The measurements are taken from the edge of the bush.

Examination of R.B.L. fittings.

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We next come to the fittings of R.B.L. guns.

Examination of breech-screw, lever, tappet, and keep pins.

(1.) The breech-screw will be examined with the straight-edge, in order to ascertain that the face is quite flat and true; if it be not, it will be filed; the thread should be examined by tapping with a wood mallet, and should not be broken or burred, but a considerable portion may be removed, if injured, without destroying the efficiency of the screw.

The lever and tappet should be sound; the lever handles of naval guns are sometimes broken off, but the lever can still be used in this state, though not so conveniently. The keep pins must be sound.

Vent-piece and breech bush.

(2.) The vent-piece is the most important fitting, and should be perfectly sound, neither cracked nor bulged. The back and sides when tested by the straight-edge, should be quite flat and true; the fracture of vent-pieces is frequently owing to the back not being true to the face of the screw. The copper ring on the vent-piece, as well as the breech bush at the end of the barrel, must be sufficiently high to prevent the action of the gas on any part of the iron.* The angle face of the 7-inch vent-pieces should be flat, and should work truly against the end of the barrel, and the "nose" should fit closely, but not too tightly, into its place. The bush of a breech-loading gun will be sentenced to be renewed if found to be so much expanded that the gas could escape between it and the tin cup or vent-piece, and when it is not possible to remedy the same by facing. The copper bushes in the neck of the vent-piece should be in good order; if they are so much worn that a 0·3-inch gauge can pass through, the friction tube is liable to be pulled out without being fired, and the bushes will be renewed from the spare sets issued for the purpose. A cavity frequently forms at the angle of the vent channel, but this (which should be examined with a probe) does not entail the immediate condemnation of the vent-piece, unless the examiner considers it dangerously large.

Cross head.

The cross-head should not be loose, as instances have occurred of its being broken off whilst firing.

Examination of Exterior.

Defects on exterior of guns.

In examining the exterior of a cast iron gun the points to pay attention to are the soundness of the trunnion and cascable loop.

Very considerable defects may exist on the exterior of a wrought iron gun, without the strength being affected. Hardly an instance has yet occurred, with the present class of rifled ordnance, of the exterior of a gun failing, unless the interior has first shown signs of weakness, or been strained in an extraordinary manner.

Defective welds on the exterior near the muzzle are sometimes developed in the B tube; these are of no practical importance, and a gun should not be condemned on such grounds alone, though it should be exchanged when an opportunity offers.

If it be found that a shell has burst in the bore, the exterior will be thoroughly scraped with old swords, and cleaned (with potash water, if necessary), in order to ascertain whether it is perfectly sound.

Rifled guns.

It occasionally happens with wrought iron guns that on firing the outer coils shift; if on examination the shifting is found considerable, the gun will be provisionally condemned, but a slight shift, which is sometimes perceptible when the gun is first used, and which has gone no further afterwards, may be disregarded. Unless there be reason to suspect damage on the exterior, it will not be necessary to scrape the whole of the paint off the exterior whenever a gun is examined.

* Particular attention should be paid to the fitting and facing of vent copper ring and breech bush, especially with the 40-pr. R.B.L., where they should be frequently faced.

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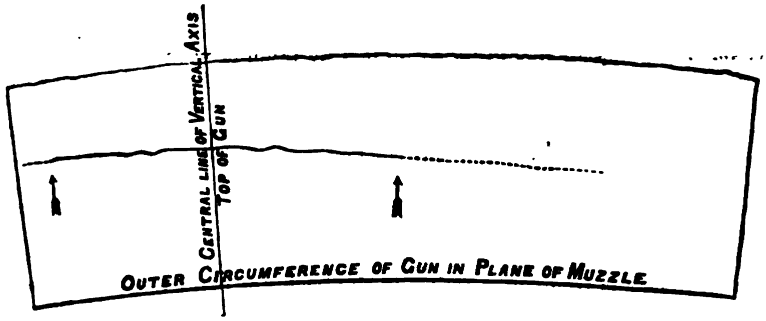
Large defects on the exterior are noted on the "Memorandum of Examination."



The above sketch represents a defective weld in the exterior of the "B" tube of a 9-inch R.M.L. gun. The opening, after 7 rounds (2 battering, 5 full), extended 30″·5 round the chase at about 12″ from muzzle. The gun was then sent to the Royal Gun Factory for examination and repair. It was submitted to the test of firing 40 battering rounds, and the crack then extended 16″·5 farther, but no other alteration took place.

This result shows that defective welds near the muzzle are of no practical moment, and that no gun should be condemned on such grounds alone, although it should be exchanged when opportunity offers.

Repairs.

The repairs of guns and fittings may be divided into:—

Repairs in the field. I. Repairs which can be carried out in the field with the stores issued for the purpose, or such as can be improvised.

Repairs at stations. II. Such as can be carried out at certain stations provided with special means.

Repairs in an arsenal. III. Those which must be performed in a large arsenal.

I.—Repairs in the Field.

(a.) R.B.L. Coppering, i.e., replacing or repairing breech bush copper or vent-piece copper ring, as the case may be.*

Coppering B.L. guns. Detailed instructions are contained in the boxes of implements † issued for refacing and renewing both the vent-piece copper ring, and the breech bush copper. In the operation of refacing, only just sufficient copper must be removed to render the angle face quite smooth and true.

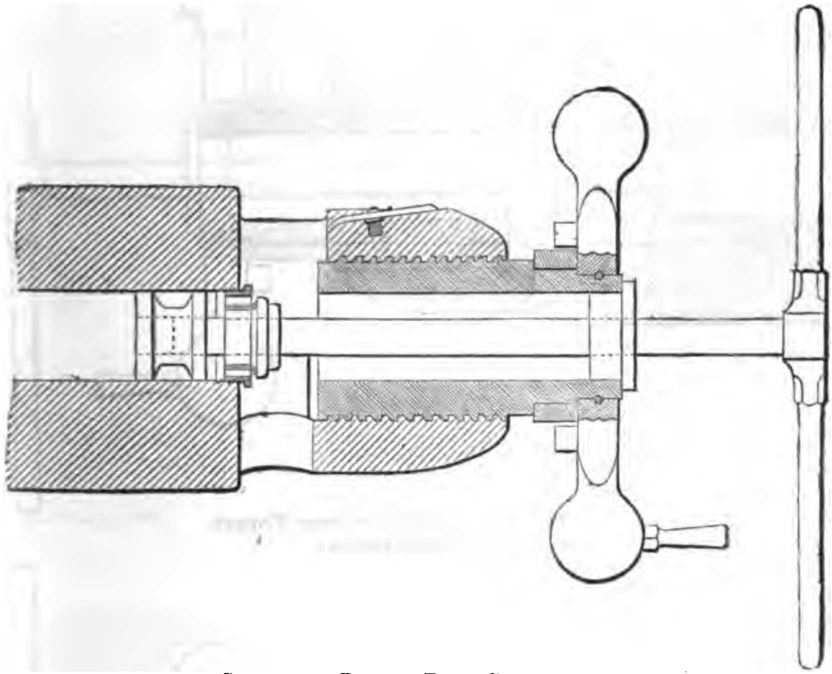
Inserting a breech bush copper. A bearing is put into the bore in front of the bush for the boring spindle to work upon and the face of the breech bush which is to fit against the A tube being red-leaded, the bush is screwed into the gun as a trial, and on being unscrewed, if the red lead shows it does not fit all round, it is scraped or filed down on the high parts. It is important that the face should fit perfectly tight to the barrel, for if the slightest space be left, the powder gas would eat into it. On being screwed in finally it is sent well home by striking the lever with a handspike. The ring is then upset with the upsetting block; it is next bored out, the spindle is introduced through the breech screw, there being two bearings

* As to 7-inch bush, vide p. 234.

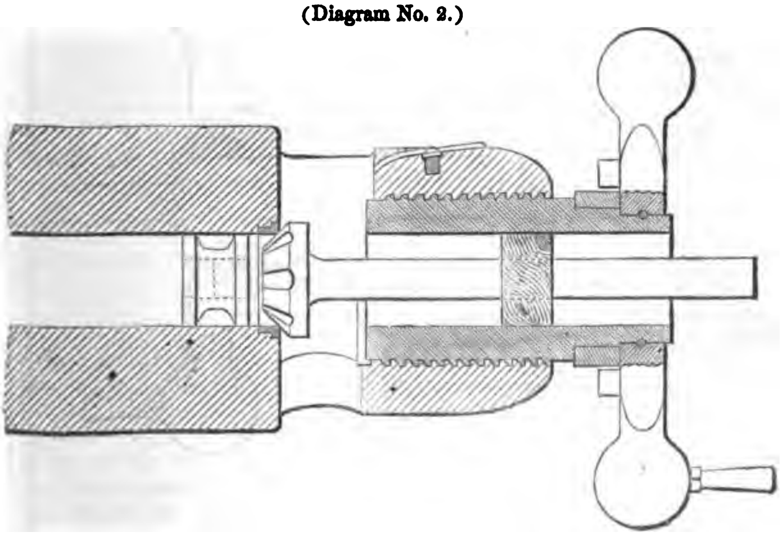
† Each B.L. battery, in addition to spare articles connected with the breech-loading apparatus, is supplied with a box of facing implements weighing 105 lbs., and containing 25 articles required for refacing the vent-pieces and bush rings, and with a set of special tools in two boxes, together weighing 83 lbs.

in the breech-screw, one in front and one behind, and the knife is fixed through the spindle in the vent chamber; the spindle is turned by a wrench and fed to its work by means of the breech-screw. After boring, a different tool is fitted through the spindle, and the copper is faced to within ·03 of an inch of the face of the A tube, the cone part being left ·15 broad.

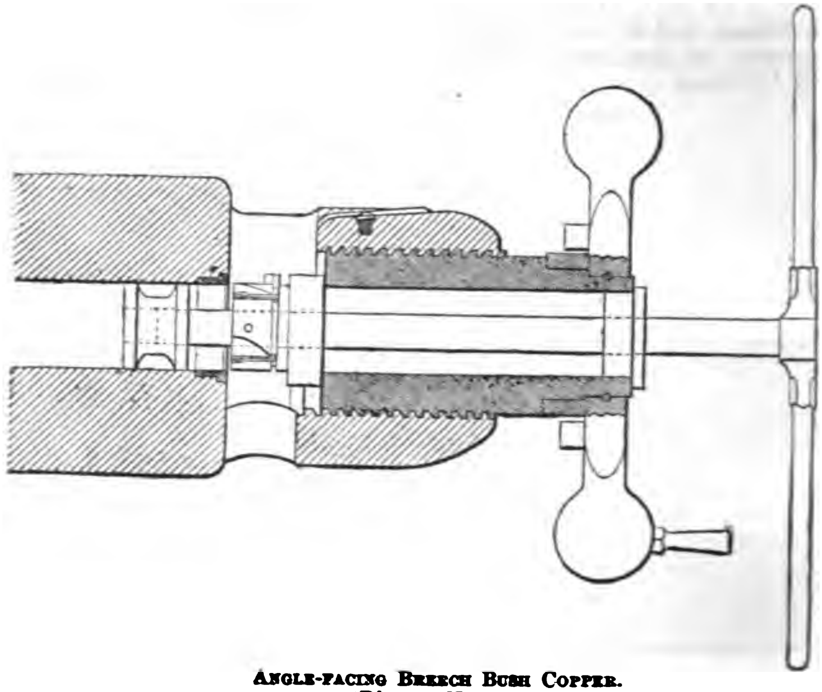
Screwing in Breech Bush Copper.
(Diagram No. 1.)



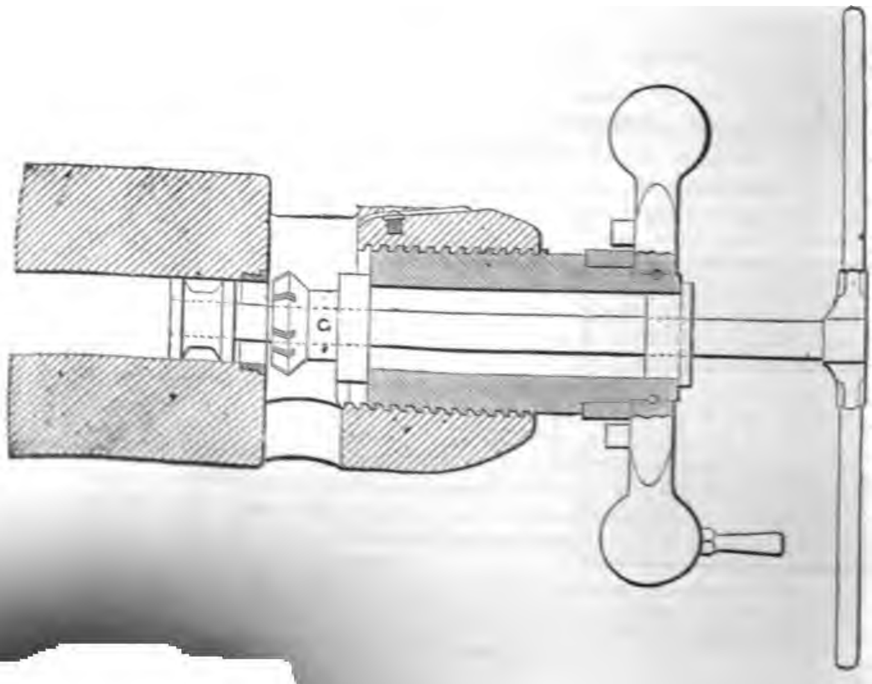
Setting-up Breech Bush Copper.
(Diagram No. 2.)



BORING AND FACING BREECH BUSH COPPER.
(Diagram No. 3.)



ANGLE-FACING BREECH BUSH COPPER.
(Diagram No. 4.)

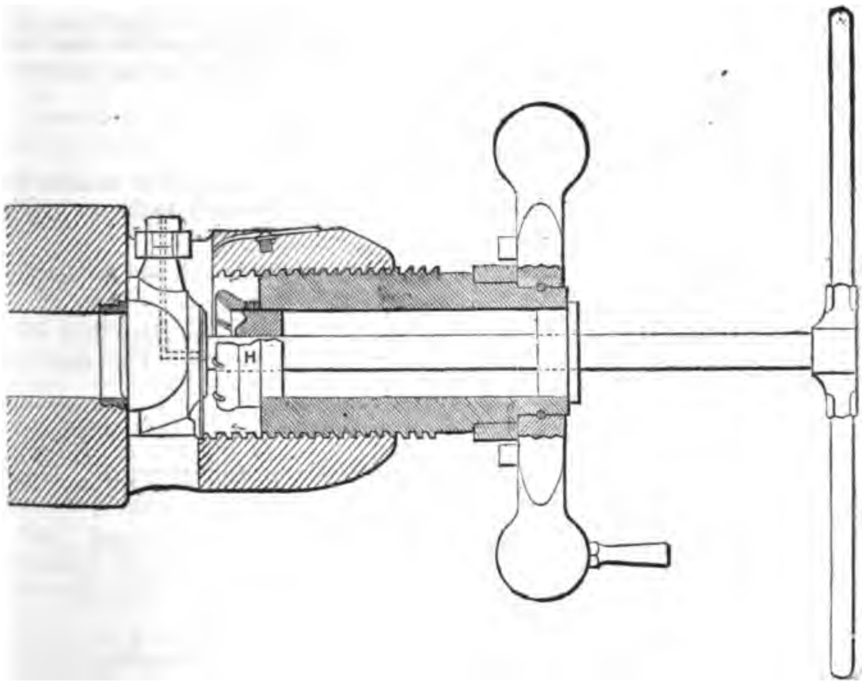


The vent-piece copper ring can be repeatedly refaced until the angle face and the back edges meet. After this it can be removed by striking it a few smart blows with a hammer on the cone face, when it is so expanded that it flies off. The new one is put on by hand, and the vent-piece having been placed in the gun front to the rear, the ring is forced on by screwing up the breech-screw. It is well to place one of the guide blocks in the face of the breech-screw to prevent its injuring the copper.

Refacing vent-piece.

The operation of refacing is shown in the diagram below; the facing tool forming a conical face exactly fitting into the hollow made in breech bush.

ANGLE-FACING VENT-PIECE RING. (Diagram No. 5.)



(b.) *Re-venting a Vent-piece.*

To re-vent R.B.L. in the field.

In boring out the old bush a bearing can be obtained for the drill by lashing a handspike across the wheels and performing the operation with the vent-piece placed in the gun. Care must be taken to drill right down to the bottom of the copper before removing the screwed piece at the top, otherwise some difficulty will be found in removing the lower piece (or pieces). The bush is to be renewed from the spare ones issued for the purpose in the manner described at page 52.

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(c.) *Adjusting New Trunnion Sights.*

Adjusting new trunnion sights.

Fore-sights, whether on the trunnion ring or elsewhere, are liable to get damaged on service, and as the spare sights are issued with rough leaves, some simple mode of adjusting a new fore sight should be known.

Re-adjusting Trunnion Sights of B.L. Field Guns on Service without the aid of Sighting Instruments.

As sighting instruments are no longer issued to batteries and only to some stations, it may be found necessary to adjust damaged trunnion sights on service without them, this may be done in the following manner, viz., by making wooden copies of the proper instruments.

Requisite materials.

The requisite materials are :—

Two blocks or discs of wood to fit into breech and muzzle.

Two rectangular pieces of wood long enough to project beyond the tangent sights on each side, and of such width that the upper edge shall be level with the top of the right tangent sight, when the lower edge coincides with the line of horizontal axis marked on the breech and muzzle.

Four screws to fasten these pieces together.

Two silk or fine thread lines.

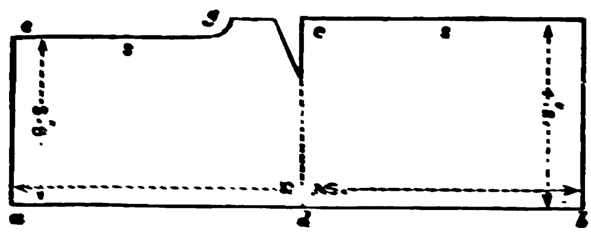
Operation.

The object of the following operation is to obtain a line on each side of the gun through the tangent sight notch parallel to the axis of the bore.

(1.) Remove the breech-screw and fasten the breech and muzzle discs in the gun securely by wedges.

(2.) Fasten the two rectangular pieces together and plane their lower edges *a b* (see Fig.) level, treating them as one piece. Then square up

FOR 12-PR., BREECH-SCREW GUN.



a line *c d* at the centre of each at right angles to *a b*, and cut away the wood on one side of *c*, in order that *c d* may be brought against the vertical line on the face of the breech or muzzle.

(3.) Now bring *a b* against the horizontal line, and *c d* the vertical line marked on the breech, and fasten the boards by two screws to the disc in the breech of the gun.

(4.) Cut away the top until it is level with the *bottom* of the notch of the tangent sight on each side, the left side *e g* will require to be cut away more than the right.

(5.) Then with a rule brought by eye parallel to the axis of the gun, mark lines *s s* on the top of the boards opposite the tangent sight notches on each side; this can be done sufficiently accurately by eye, as any error is corrected in the after operations.

(6.) Remove the boards from the gun and separate them, fastening one at the breech and the other at the muzzle, taking care to adjust them to the horizontal and vertical lines on the gun.

(7.) Stretch silk lines on each side of the gun from the marks *s s* on the breech and muzzle board; they should pass exactly through the bottom of the notch of the tangent sights. If they do not they must be moved to the right or left until they do, but care must be taken always *to move the line the same amount both at breech and muzzle*, so as to keep it parallel to its original position. These lines are parallel to the axis of the gun.

Adjusting new trunnion sights.

(8.) The leaf is filed down to the right height, *i.e.*, the level of the silk line. In doing this it is usual to raise the silk both at breech and muzzle by the thickness of a piece of paper, when it should just clear the leaf, and when the paper is removed it should touch the same.

(9.) The position for the apex on the trunnion sight is then ascertained by the length of radius for each nature of gun (see table, p. 69), measured from the notch on the tangent sight. The apex is not in the axis line of the sight, except in 6-prs. and 9-prs.

In 12-prs. it is	0″·05 to the rear.
„ 20-prs. „ 40-prs. „ 7-inch	0″·2 „

(10.) Remove the sight from the gun, place it in a vice, and file down the front and back slopes. The slopes should be sufficient to form a point when the gun is at its highest elevation.

(11.) Replace the sight in the gun and file down the lateral slopes, so that a true edge is obtained under the silk line, care being taken that the top of the leaf is not made too sharp, as it would be liable to injury. In the case of a screw trunnion sight, a curved line is marked by a scriber, to show the position of the metal surface of the trunnion when the sight is screwed home.

(12.) The trunnion sight is again removed and the back slope is roughed, so that in laying a gun there may not be too bright a reflection presented to the eye.

(*d.*) *R.M.L.—Replacing a broken Clamping Screw, 9-pr. L.S.*

Replacing broken clamping screw.

The mill-headed screw employed to clamp the tangent sight of the 9-pr. R.M.L. guns, Mark I. and II., L.S., is occasionally broken off near the head, and can be replaced as follows:—

Remove the screw (A) which secures the steel projecting patch (B), drive out the latter in the direction of the breech by means of a copper set.

With a piece of hard wood applied through the hole bored in the gun for the reception of the sight, drive out the gun metal sight socket.

Take out the broken clamping screw through the hole in the back of the socket, replace it by a new one, and put the socket back into its place, securing it there by reversing the foregoing operations.

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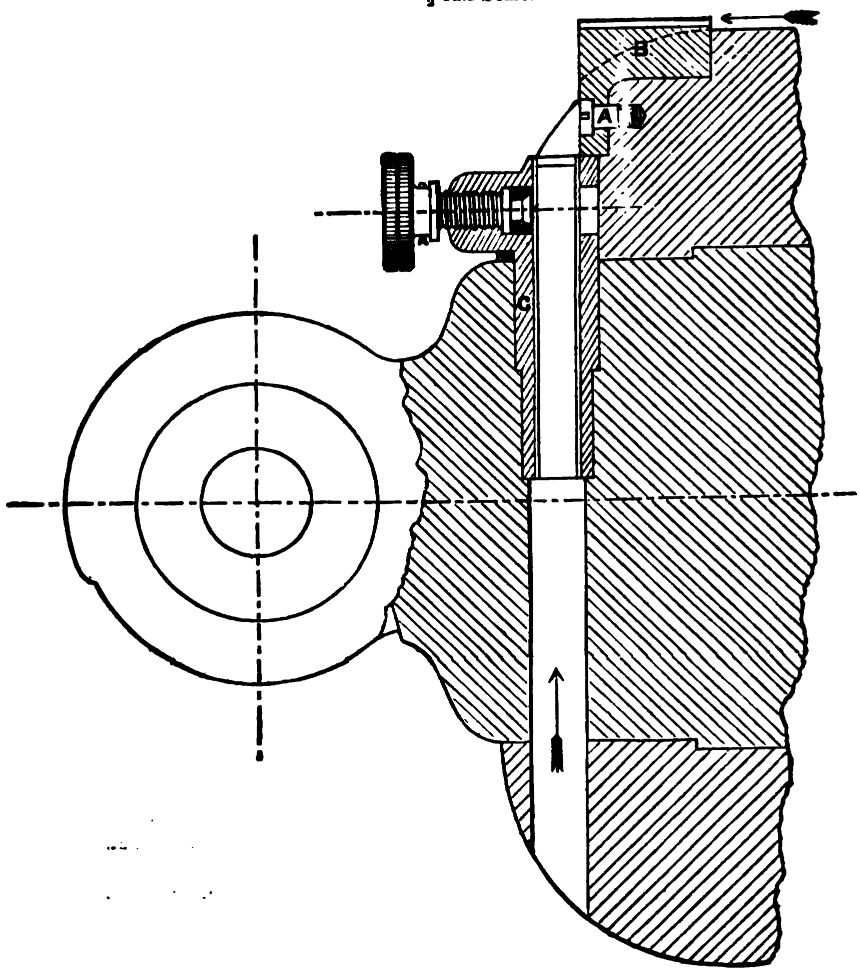
9-PR. WROUGHT IRON R.M.L. GUN OF 8 CWT.

Diagram illustrating the replacing of a broken Clamping Screw.
½ full Scale.



(e.) *Adjusting new Fore Sight.*

Adjusting R.M.L. fore-sights on service.

7-pr. or 9-pr.—Spare dispart sights are issued rough, in case the sight in the gun should get broken, and a wrench is supplied for removing and replacing it. To fit the new one it will be necessary to level the gun longitudinally along the bore, and to screw the rough sight home into the dispart patch, bringing its leaf parallel to the axis. Then file the top down until it is level with the bottom of the notch on the tangent sight. This can be done by placing a piece of metal the thickness of the depth of notch on the top of the fore sight. Measure the radius also from the back of the tangent sight, and file the back and front slopes. With a rule or straight-edge mark the centre line on the top of the leaf opposite the line of vertical axis engraved on the dispart patch and muzzle of the gun, and file up the front side slopes to this line. Remove the sight from the gun, rough the back slope, clean

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and blue it (as described at p. 249), and replace it in the gun in the same position.

Adjusting a new trunnion sight for a 16-pr. R.M.L. gun.

16-pr.—To adjust a new screw trunnion sight for a 16-pr. R.M.L. gun, proceed as follows:—

Screw in the new sight with rough leaf, then place the gun upon level ground and lay with an undamaged sight upon some distant object (not less than 2,000 yards away), the tangent sight being at zero. File down the top of the leaf of the new sight until it is in a line with the bottom of the notch of its tangent sight and the object.

Mark the length of the radius from the back of the tangent sight, mark the muzzle direction on the sight leaf, then remove the sight and file up the front and back slopes.

Replace the sight and file down the side slopes until the gun is accurately laid on the same object by both sights.

Rough the back slope, polish and blue the sight, and so complete it.

N.B.—There is a slight error in this method, for the line of sight will cross at the distance of the point upon which the gun was laid

The following is another method which may be adopted, but which is less accurate than the foregoing in some points and requires more time and material.

It is less accurate in some cases because the sights are not interchangeable in reality (as mentioned at p. 115), and they are here treated as though they were.

1. Place a block of wood in the muzzle of the gun, and on its face pivot a piece of wood, having an oblong slit cut in it through which a screw passes forming the pivot, and also serving to tighten it against the disc in the bore.

2. Stretch a silk line from the bottom of the tangent sight notch across the top of the undamaged trunnion sight, and attach it to the piece of wood pivoted on the muzzle disc, which must then be screwed up tightly. The silk line will give us a line parallel to the axis of the piece, and passing just over the centre of the leaf of the fore sight.

3. Remove undamaged sight, and in its place screw that which is to be adjusted (with a rough leaf), file its leaf down until level with the silk line, mark the apex by measuring the length of radius, also muzzle direction of leaf, remove the sight and file down the front and back slopes, then replace it in the gun and file the side slopes, using the silk line as a guide.

4. Take out the sight so adjusted, and screw it into the hole on the other side of the gun, replacing it by the one originally removed.

(6.) *Venting.*

Venting tools for siege ordnance.

With a siege train a set of tools (vide p. 241) will be supplied in the proportion of one set to 30 guns, for the purpose of re-venting according to the operation described at p. 232.

The tools are of a light description and will not occupy much room.

II.—Repairs which can be performed only at certain Stations or on board certain Ships.

(1.) *Adjusting Millar's sights of a S.B. Gun.**

Adjusting sights, S.B. guns.

(1.) The gun having been carefully levelled laterally across the trunnions, and longitudinally in the bore, the fore and hind sights are to be adjusted so as to fulfil the following conditions:

* The necessary implements for the performance of this adjustment are given in table, p. 239.

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1st. They are to be the exact distance apart, according to the short radius given in No. II. Table, p. 72.

2nd. When the scale is at zero, the line joining the top of hind and the top of fore sight must be parallel to the axis.

3rd. When the scale is raised to the full elevation marked on it,—that is, the "clearance angle,"—the top of the scale, the apex of the fore sight, and the highest point on the muzzle of the gun, must be in the same line.

4th. The line of sight must be made to coincide exactly with the same vertical plane as the line of metal.

An old fore sight is placed loosely on the gun over the second reinforce ring. This and the hind sight are adjusted by hand in the first place until the conditions are fulfilled.

The angular level is used to bring the scale to the angle of 76°. The position for the hind sight screw holes are then marked with a scriber on the gun through the holes previously drilled and punched through the sight block and lead packing.

The holes are drilled by aid of the instrument called "machine drilling hind sight," and care must be taken to drill the holes perpendicular to the face of the sighting block, so that the heads of the screws may rest fairly on it; the holes are then tapped.

The hind sight being fixed, the scale is raised to a little more then the clearance angle, and a silk cord stretched from the notch on it to that on the muzzle. The real fore sight is now adjusted so as to bring its top under the silk cord at the proper distance from the tangent sight.

The position of the fore sight screw holes being marked, they are drilled and tapped, and the sight screwed on. The head of the sight is then filed down to the proper height, and the position of the ridge being marked, it is unscrewed, and the side slopes filed down. When again screwed on, the sighting is tested to ascertain whether the whole of the conditions are fulfilled.

The sights and lead packing are then marked with the number of the gun to which they have been fitted, and the screws are also marked for their particular holes.

When guns are mounted, the sight screw holes are filled with preserving screws, but these are to be removed when the guns are shifted, as the screw heads are liable to be broken off; the holes are then filled with tallow and white lead composition.

(2.) *Re-venting S.B. and R.M.L. Guns.*

S.B. ordnance.

(*a.*) The operation for S.B. can be carried on, wherever the set of tools at p. 241 exist, and is performed by R.G.F. Artificers or Armstrong Armourers at home, and by the latter abroad. Vide Appendix, p. I., for Regulations.

Heavy R.M.L. guns.

(*b.*) In the case of heavy R.M.L. guns the necessary tools are only supplied to the following stations,—Woolwich, Malta, Gibraltar, Bermuda, Devonport,* Hong-Kong, and Esquimault, and also to some men-of-war where qualified engineers are present who have been especially instructed for the purpose.

Special tools for converted guns.

(*c.*) Special tools, p. 241, being required for re-venting converted guns, this service can only be carried out at Portsmouth,* Malta, Hong-Kong, or Esquimault.

* To other stations at home, qualified artificers with the necessary tools are sent from time to time.

(*a & b.*) With regard to re-bushing a S.B. or R.M.L. gun proceed as follows :— CHAP. XII.

Re-venting with Cone Vent.

Re-venting with cone vent.

Proceed as if venting a gun for the first time, p. 24, using the narrow drill (B) ; when the hole is some four or five inches deep, turn up the gun and make the hole square with the gravers' chisel hammer into it one of the shortest of the square drifts, and try to unscrew the old bush with a wrench. Sometimes the whole of the copper vent will come out, but if the copper has been much set up in firing it will be much tighter and probably break ; the drilling must then be repeated until the whole is removed.

When the old copper vent is taken away, ascertain, either by measuring it or taking an impression of the thread in the gun, whether it is a six or seven thread pitch ; then use the corresponding set of taps commencing with the lowest number to clear the thread. If the wrong set of taps be used the damage will be irreparable.

The hole in the gun is next cleaned with tow, and the copper vent, well oiled, is screwed in with as much power as three men can bring to bear upon it. The head should not be wrenched off, as a fracture might occur below the surface of the metal of the gun.

The new bush when properly fixed will project about a quarter of an inch into the bore, and about two inches above the surface of the gun.

Take an impression of the part in the bore with wax composed of

Bees-wax - - -	2 parts	Boiled together.
Soft soap - - -	1 „	
Treacle - - -	1 „	

This will show whether the cone is well home, and that there is no space left between the copper and iron.

If the bush is home proceed to cut off the end in the bore. The instrument consists of a cutting tool supported by a metal head at the end of a long bar ; the bar is kept in the axis of the bore by passing through a collar fitting into the muzzle, it is worked from side to side by two levers being fed up by a small screw at the end of the frame ; the spiral spring against the muzzle collar makes the knife work regularly. Care must be taken not to cut into the iron of the gun. It is probable that the end of the bush will not be cut off quite flush at first, so another impression is taken, and, if necessary, the knife must be fed out with a small piece of tin, and the process repeated.

It is necessary that the copper and iron in the bore should be perfectly flush with each other, the action of the powder being much greater on anything projecting, however slightly, into the bore.

Saw off the outside end of the vent to within about a quarter of an inch of the patch ; chip a little copper away from the mouth of the vent to prevent it becoming choked when hammered, chisel it also at the edges, then hammer it well, next chisel it off flush and open the mouth of the vent, and pass the set of rimers down one after the other, and gauge. File the surface, take another wax impression of the inside, and if all is right the operation is finished.

Re-venting with Through Vents.

Re-venting with through vents.

This is precisely the same operation as venting with cone vents, except that the thread is carried right through to the bore. The chief precaution to be taken in venting with a through vent is not to make the hole too wide at the bottom, and not to break away the last thread.

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Re-venting Converted Guns.

Venting converted guns.

Regarding (*c.*) for converted guns* proceed as above as to removing old bush.

A hole being drilled through the old bush, and then enlarged for a depth of about 2 inches, the corners are squared, a drift driven in, and the vent screwed out, it will eventually break away from the portion "set up" from the interior of the chamber, which can be driven down into the bore, and so taken out.

The thread having been cleaned out, the new bush is screwed in, set up, and completed as described in the case of first venting such a gun, vide p. 159.

In case, however, of re-venting one of the guns mentioned in note, p. 159, which were originally vented with cone vents of exceptional diameter and thread, the old bush is removed as usual, but when that operation is completed the gun must be prepared for a new bush as follows:—

Drill out the hole to proper size for through bush of service pattern and tap the thread for the same as usual.

Then cut out the last thread of female thread in the cup by means of a "rose cutter," take an impression to see if this is properly removed, and then re-vent as already described.

(3.) *Re-bushing 7-inch R.B.L.*

Re-bushing 7" R.B.L. guns.

As the re-bushing of 7-inch R.B.L. guns is a more difficult operation than that of copper bushing the smaller natures, it would be performed only where the necessary tools are provided, which is at all large stations and sub-arsenals at home and abroad.

The set of facing implements is given at p. 240. The tools are of course much stronger than those in the smaller set.

(4.) *Adjustment of Sights.*

Adjusting sights and sight sockets.

Sights, sight sockets, &c. can also be adjusted and repaired at most of our large stations wherever there is a fire-master, as well at some others.

III.—Repairs to be performed in an Arsenal.

Important repairs.

All important repairs, such as re-tubing, re-sighting, &c., must be performed at Woolwich Arsenal.

To re-tube a built-up R.M.L. gun, the usual practice is to cut the chase through in front of the trunnion coil or 1 B coil in heavy guns; to bore out the steel tube in breech portion, and to use the latter as a jacket for a new gun which would be otherwise built up as usual.

Re-tubing.

A converted gun can be prepared for re-tubing by removing the cast iron collar and screw plug, stopping up the vent after removing the bush, and then forcing out the tube by hydraulic pressure, the gas escape hole being enlarged for that purpose to admit the nozzle of the tube through which the water is forced.

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* For set of tools required, vide table, p. 241.

Preservation of Guns and their Fittings.

In order to preserve guns from atmospheric influences, the larger natures down to 20-pr. R.B.L. gun inclusive, as well as all S.B. guns, are painted on exterior with two coats of Pulford's magnetic paint; but the smaller natures are browned, as paint would be removed by the usage such guns are exposed to. The operation of browning is described in Appendix II., p. 249. It can be carried out by the batteries in whose charge the guns are. Painting. Browning.

The bores of S.B., R.B.L., and R.M.L. guns, when not in use, should be lacquered; but when in frequent use they will be kept clean and slightly oiled instead. The lacquer can be removed in a few minutes by brushing the bore with hot potash solution. For composition and proportions of lacquer, vide p. 242. Lacquering.

The breech-screw and light parts of R.B.L. guns in store or mounted, where rarely or never used, will be coated with the composition given at p. 242.* Fittings of B.L. guns.

The parts which can be removed being laid up in store.

The muzzles of guns are stopped with tampions, and those of mortars covered with wooden cups to keep out moisture, while vent plugs are used with mounted guns. Muzzles and vents to be stopped, and guns depressed.

Guns, whether mounted or lying on skidding, should be depressed at the muzzle to prevent rain or moisture lodging inside.

A vent plug consists of a vulcanised disc of india rubber, with a leather stem. It is employed for protecting the vents of mounted guns. Vent plug.

The exposed portions of the sights are "bronzed" if made of gun metal, and "blued" if of steel. This is done to preserve them from corrosion, and on no account are these parts to be burnished or cleaned in such a manner as to remove the bronzing or blueing more than it is of necessity worn off by fair wear, the mode of performing these operations is given at p. 249, Appendix II.

When mounted in exposed positions the whole of the sights should be removed from the guns and kept in store, the holes in the guns being filled with a plug of greased tow to keep out the rain and dirt. These plugs can be readily removed when it is required to fit the sights to the guns, and particular attention should be paid to the prevention of rust or grit accumulating in the sight recesses. Preservation of sights.

The set screw for clamping the centre hind sight, not being removeable from the gun, should be tested to see that it works freely.

The sight themselves should be kept clean, free from grit, and oiled; the "sliding leaf" and "elevating nut" of the tangent sights, as well as the "collars" of the drop centre fore and trunnion sights, should have free play.

Elevating plates are removed for transport, and the holes in the gun fitted with preserving screws.

Guns fitted for land service have also the "friction tube pin" holes and the "guide plate" hole filled by preserving screws, and it is advisable that these and all other preserving screws should be occasionally removed and oiled to prevent their becoming fixed by rust. Preserving screws.

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* A new preserving mixture of powdered chalk and cocoa nut oil seems to promise good results and has been ordered to replace the composition mentioned when the store of the latter has been used up, vide § 3041.

CHAP. XII.

TABLE XIX.

List of Tools required for the Cleaning and Examination of the various Natures of Cast Iron and Bronze Ordnance.

—	Calibre. 10-in.	68-pr. and 8-in.	56-pr.	42-pr.	32-pr.	24-pr.	18-pr.	12-pr.	9-pr.	6-pr.	3-pr.
Bit, vent, 12-in.	1	1	1	1	1	1	1	1	1	1	1
Brace, armourer's	1	1	1	1	1	1	1	1	1	1	1
Brushes, hard, round, 10-in.	1	–	–	–	–	–	–	–	–	–	–
Brushes, hard, round, 68-pr. and 8-inch	–	1	–	–	–	–	–	–	–	–	–
Brushes, hard, round, 56 "	–	–	1	–	–	–	–	–	–	–	–
Brushes, hard, round, 42 "	–	–	–	1	–	–	–	–	–	–	–
Brushes, hard, round, 32 "	–	–	–	–	1	–	–	–	–	–	–
Brushes, hard, round, 24 "	–	–	–	–	–	1	–	–	–	–	–
Brushes, hard, round, 18 "	–	–	–	–	–	–	1	–	–	–	–
Brushes, hard, round, 12 "	–	–	–	–	–	–	–	1	–	–	–
Brushes, hard, round, 9 "	–	–	–	–	–	–	–	–	1	–	–
Brushes, hard, round, 6 "	–	–	–	–	–	–	–	–	–	1	*
Brushes, Turk's head, large	1	1	1	–	–	–	–	–	–	–	–
Brushes, Turk's head, small	–	–	–	1	1	1	1	1	1	1	1
Drill, vent, 15-in.	1	1	1	1	1	1	1	1	1	1	1
Gauges, vent, set of 4	1	1	1	1	1	1	1	1	1	1	1
Instrument, taking impressions of vents complete with blocks and pans	1	1	1	1	1	1	1	1	1	1	*
Knives, cleaning, ordnance, pairs, 10-in.	1	–	–	–	–	–	–	–	–	–	–
Knives, cleaning, ordnance, pairs, 68-pr. and 8-inch	–	1	–	–	–	–	–	–	–	–	–
Knives, cleaning, ordnance, pairs, 56 "	–	–	1	–	–	–	–	–	–	–	–
Knives, cleaning, ordnance, pairs, 42 "	–	–	–	1	–	–	–	–	–	–	–
Knives, cleaning, ordnance, pairs, 32 "	–	–	–	–	1	–	–	–	–	–	–
Knives, cleaning, ordnance, pairs, 24 "	–	–	–	–	–	1	–	–	–	–	–
Knives, cleaning, ordnance, pairs, 18 "	–	–	–	–	–	–	1	–	–	–	–
Knives, cleaning, ordnance, pairs, 12 "	–	–	–	–	–	–	–	1	–	–	–
Knives, cleaning, ordnance, pairs, 9 "	–	–	–	–	–	–	–	–	1	–	–
Knives, cleaning, ordnance, pairs, 6 "	–	–	–	–	–	–	–	–	–	1	–
Knives, cleaning, ordnance, pairs, 3 "	–	–	–	–	–	–	–	–	–	–	1
Lamp, tin, with rod	1	1	1	1	1	1	1	1	1	1	1
Pot, for softening gutta-percha	1	1	1	1	1	1	1	1	1	1	1
Prickers, common, with pan	1	1	1	1	1	1	1	1	1	1	1
Prickers, common, without pan	1	1	1	1	1	1	1	1	1	1	1
Rimer, vent, 15-in.	1	1	1	1	1	1	1	1	1	1	1
Scale, diagonal, brass	1	1	1	1	1	1	1	1	1	1	1
Scrapers, balloon, large	1†	–	–	–	–	–	–	–	–	–	–
Scrapers, balloon, medium	–	1†	–	–	–	–	–	–	–	–	–
Scrapers, balloon, small	–	–	–	–	1†	1†	–	1†	–	–	–
Scrapers, fore-right	1	1	1	1	1	1	1	1	1	1	1
Scrapers, half-round	1	1	1	1	1	1	1	1	1	1	1
Scrapers, vent, half-round	1	1	1	1	1	1	1	1	1	1	1
Scrapers, vent, spring	1	1	1	1	1	1	1	1	1	1	1
Searchers, spring, 8-prong	1	1	1	1	1	–	–	–	–	–	–
Searchers, spring, 6 "	–	–	–	–	–	1	1	–	–	–	–
Searchers, spring, 4 "	–	–	–	–	–	–	–	1	1	1	*
Springs for knives, 10-in., 8-in., and 56-pr.	1	1	1	–	–	–	–	–	–	–	–
Springs for knives, 42 and 32-pr.	–	–	–	1	1	–	–	–	–	–	–
Springs for knives, 24 " 18 "	–	–	–	–	–	1	1	–	–	–	–
Springs for knives, 12 " 9 "	–	–	–	–	–	–	–	1	1	–	–
Springs for knives, 6-pr.	–	–	–	–	–	–	–	–	–	1	–
Springs for knives, 3 "	–	–	–	–	–	–	–	–	–	–	1
Swords, old	2	2	2	2	2	2	2	2	2	2	2
Tongs for grinding knives	1	1	1	1	1	1	1	1	1	1	1
Tool for grinding searcher points	1	1	1	1	1	1	1	1	1	1	1
Wire, lacquering vents	1	1	1	1	1	1	1	1	1	1	1
Wrench for knives	1	1	1	1	1	1	1	1	1	1	1

* There is no hard brush for the 3-pr., the small Turk's head is used instead; and the instrument for taking impressions is too large for use with this gun, the pricker with pan, or a piece of wood being used; the smallest spring searcher is also too large, the common pricker taking its place.

† Only required for shell guns, howitzers, and mortars, having gomer chambers.

Note.—13-inch mortars are cleaned with the same articles as 10-inch, except that the bore is scraped [illegible], instead of with the spring knives.

TABLE XX.—LIST of TOOLS required for the CLEANING and EXAMINATION of the various Natures of RIFLED ORDNANCE.

—	Muzzle-loading.														Breech-loading.						Remarks.
	12·5-in.	12-in.	11-in.	10-in.	9-in.	8-in.	7-in.	80-pr. & 64-pr. convd.	64-pr.	40-pr.	25-pr.	16-pr.	9-pr.	7-pr.	7-in.	40-pr.	20-pr.	12-pr.	9-pr.	6-pr.	
Bits, vent — Armstrong	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1	1	
Bits, vent — 23-in.	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	
Bits, vent — 12 ,,	—	—	—	—	—	—	—	1	1	1	1	1	1	1	—	—	—	—	—	—	
Brace, armourers'*†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Brushes, gun, piassaba with staves — 12·5-in.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
12 ,,	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
11 ,,	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
10 ,,	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
9 ,,	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
8 ,,	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
7 ,, *	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	
80-pr. and 64-pr. converted.	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	
64-pr.*	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	
40 ,,	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	
25 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
20 ,,	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	
16 ,,	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	
12, 9, and 7 pr.	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	1	1	—	
6-pr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	
Compasses†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Gauges, vent, set of 4 — long†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	The "long" set for 9-in. guns and upwards.
Gauges, vent, set of 4 — short*†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Instruments, taking impressions of bores — No. 1†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	For 40-pr. guns and upwards.
Instruments, taking impressions of bores — No. 2†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	For guns below the 40-pr.
Lamp, tin, with rod*†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	

* Articles marked thus *, being among the tools for examining cast iron ordnance, should not be demanded by officers applying for tools for examining wrought iron ordnance, if they have already been supplied with a set for examining cast iron ordnance. † 1 for each set of tools.

Table XX.—List of Tools, &c.—*continued*.

	Muzzle-loading.														Breech-loading.						Remarks.
	12½-in.	12-in.	11-in.	10-in.	9-in.	8-in.	7-in.	80-pr. & 64-pr. convd.	64-pr.	40-pr.	25-pr.	16-pr.	9-pr.	7-pr.	7-in.	40-pr.	20-pr.	12-pr.	9-pr.	6-pr.	
Plates for instruments taking impressions of bores. 12·5-in.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Plates are not required for the 40-pr. or 6-pr., as the frames answer the purpose.
12 "	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
11 "	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
10 "	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
9 "	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
8 "	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
7 "	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	
80-pr. and 64-pr. convd.	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	
64-pr.	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	
40 "	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
25 "	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	
20 "	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	
16 "	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	
12, 9, and 7 pr.	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	1	1	—	
6-pr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Pot, softening gutta percha*†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Pricker, common, with pan*†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Ditto (with blunted point)†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Rimers, vent { 22-in.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	The 22-in. for 9-in. guns and upwards.
Rimers, vent { 15 " *	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Scales, diagonal, brass, 12-in.†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Scrapers, vent, half-round { 24-in.†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Scrapers, vent, half-round { 14 " *†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Straight-edge, testing breech-screws†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	For B.L. guns only.
Swords, old*	2	2	2	2	2	2	2	2	2	2	2	2	1	1	2	2	1	2	2	1	

* Articles marked thus *, being among the tools for examining cast iron ordnance, should not be demanded by officers applying for tools for examining wrought iron ordnance, they have already been supplied with a set for examining cast iron ordnance. † 1 for each set of tools.

TABLE XXI.

SET of SIGHTING TOOLS for SMOOTH-BORE ORDNANCE.

Articles.			No. to a set.	Remarks.
Battens, wood	inside	large	1	
		small	1	
	outside	large	1	
		small	1	
Braces	armourers		1	
	drilling, hand	medium	1	
		small	1	
Cases, wood, spirit level			1	
Chisels	hand, flat		2	
	graver's		6	
Drills	carronade fixing screws		3	3 sizes.
	gun fixing screws		3	Do.
Hammers, hand, small			1	
Levels	spirit	angular	1	
		with bar	1	
	steel for battens		1	
	wood for trunnions	large	1	
		small	1	
Machine, drilling, with chains complete		fore sight	1	
		hind sight	1	
Plummets	brass		2	
	lead		1	
Punches, steel	centre		1	
	lead		1	
Scribers			6	
T-square, steel			1	
Taps	carronade fixing screws		3	3 sizes.
	gun fixing screws		3	Do.
V set			1	
Wrenches	socket		1	
	tap		1	

CHAP. XII.

TABLE XXII.

DETAILED LIST of FACING IMPLEMENTS for RIFLED B.L. (BREECH-SCREW) GUNS.

6-PRS.

In a box, with hinges and hasps, and padlock with two keys.

	Letter.	No. of each.
Blocks, breech bush copper, angle facing	L	1
Blocks, breech bush copper, finish boring	K	1
Blocks, breech bush copper, screwing in	H	1
Blocks, breech bush copper, upsetting	I	1
Blocks, vent-piece ring, angle facing	N	1
Guard, wood, for vent-piece	Q	1
Guides, in breech-screw	D	2
Guides, in powder chamber	E	1
Guides, wood (block upsetting), two parts	O	1
Key, for fixing knives	F	1
Knives, breech bush copper, cutting out	G	1
Knives, breech bush copper, facing	M & M1	2
Knives, breech bush copper, rough boring	J	1
Lever	B	1
Punch, for pin in spindle	R	1
Spanner, for stop washers	P	1
Spindle	A	1
Washers, stop	C	2

12 & 9-PRS.

In a box, with hinges and hasps, and padlock with two keys.

	Letter.	No. of each.
Blocks, breech bush copper, angle facing	I	1
Blocks, breech bush copper, finish boring, 3·125 diameter	F1	1
Blocks, breech bush copper, finish boring, 3·2 diameter	F2	1
Blocks, breech bush copper, screwing in	D	1
Blocks, breech bush copper, upsetting	C	1
Blocks, vent-piece ring, angle facing	J	1
Guard, wood, for vent-piece	S	1
Guides, in breech-screw	M	2
Guides, in powder chamber, 3·125 diameter	N1	1
Guides, in powder chamber, 3·2 diameter	N2	1
Guides, wood (block upsetting), two parts	R	1
Key, for fixing knives	O	1
Knives, breech bush copper, cutting out	K	1
Knives, breech bush copper, facing	G & G1	2
Knives, breech bush copper, rough boring	E	1
Lever	B	1
Punch, for pin in spindle	P	1
Spanner, for stop washers	Q	1
Spindle	A	1
Washers, stop	L	2

20-PRS.

In a box, with hinges and hasps, and padlock with two keys.

	Letter.	No. of each.
Blocks, breech bush copper, angle facing	K	1
Blocks, breech bush copper, finish boring, 3·875 diameter	I1	1
Blocks, breech bush copper, finish boring, 3·94 diameter	I2	1
Blocks, breech bush copper, screwing in	G	1
Blocks, breech bush copper, upsetting	M	1
Blocks, vent-piece ring, angle facing	L	1
Guard, wood, for vent-piece	P	1
Guides, in breech-screw	C	2
Guides, in powder chamber, 3·875 diameter	D1	1
Guides, in powder chamber, 3·94 diameter	D2	1
Guides, wood (block upsetting), two parts	Q	1
Knives, breech bush copper, cutting out	F	1
Knives, breech bush copper, facing	J & J1	2
Knives, breech bush copper, rough boring	H	1
Key, for fixing knives	N	1
Lever	B	1
Punch, for pin in spindle	R	1
Spanner, for stop washers	O	1
Spindle	A	1
Washers, stop	E	2

40-PRS. (*See* NOTE.)

In a box, with hinges and hasps, and padlock with two keys.

	Letter.	No. of each.
Blocks, breech bush copper, angle facing	G	1
Blocks, breech bush copper, cutting out	D	1
Blocks, breech bush copper, finish boring, 4·91 diameter	F1	1
Blocks, breech bush copper, finish boring, 4·96 diameter	F2	1
Blocks, breech bush copper, screwing in	E	1
Blocks, breech bush copper, upsetting	M	1
Blocks, vent-piece ring, angle facing	H	1
Collar, for feed motion	B	1
Guides, in breech-screw	A1	1
	A2	1*
Guides, expanding, in powder chamber	C	1*
Guides, wood (block upsetting), two parts	N	1
Handle to hold blocks in vent chamber	P	1
Lever	J	1
Punch, for knives in blocks	K	1
Punch, for pin in spindle	L	1
Spanner, for stop washers	R	1*
Spindle	I	1
Washers, feed	O	1*
Washers, stop	Q	1*

7-INCH.

In a box, with tray, hinges and hasps, and padlock with two keys.

	Letter.	No. of each.		Letter.	No. of each.
Blocks, breech bush iron, cutting out, boring, facing, tapering, and angle facing.	G	1	Handle to hold blocks in vent chamber	P	1
			Knives, cutting out, breech bush, thick iron	E2	2
			Knives, cutting out, breech bush, thin iron	E1	2
Blocks, breech bush iron, screwing in, and rough boring.	F1	1	Lever	B	1
Blocks, vent-piece, angle facing			Punch, for pin in spindle	N	1
Guard, wood, for vent-piece	K	1	Spanner, for stop washers	M	1
Guides, in breech-screw	O	1	Spindle	A	1
Guides, expanding in powder chamber	C	2	Washers, stop	J	2
	D	1			

E.—This set of 40-pr. Facing Implements is the new pattern; the old pattern, which is not to be considered
, consists of the same articles, with the omission of those marked *, and the insertion instead of the
expanding," Guides in powder chamber {4·91 diameter — C 1 — 1. / 4·96 diameter — C — 1.} See "Changes in Patterns," § 1073, No. 5.

TABLE XXIII.

CHAP. XII.

TABLE of VENTING TOOLS.—S.B. AND RIFLED GUNS.

Description.	Smooth Bore.	Rifled Ordnance. No. 1.	Rifled Ordnance. No. 2.	Siege Train. No. 3 set. Heavy.	Siege Train. No. 3 set. Light.	Siege Train. No. 3 set. Common to both.	Special in addition for converted Guns.	Remarks.
Bar, iron, with spring and metal collar	1	1	1	–	–	1	–	
Blocks, wood, for taking impressions of vents. 7", 8", 9", 10", 11", and 12" (one to each calibre).	–	6	–	–	–	–	–	
Blocks, wood, for taking impressions of vents. 64-pr., Mark I.	–	1	–	–	–	–	–	
Blocks, wood, for taking impressions of vents. „ „ II. & III.	–	1	–	1	–	–	–	
Blocks, wood, for taking impressions of vents. „ and 80-pr. converted	–	1	–	1	–	–	–	
Blocks, wood, for taking impressions of vents. 8-inch howitzer	–	–	–	1	–	–	–	
Blocks, metals, do. 40-pr.	–	–	1	–	–	1	–	
Blocks, metals, do. 16 and 25 pr. The same block answers for these two guns.	–	–	1	–	1	–	–	
Blocks, metals, do. 6·3-inch howitzer	–	–	–	–	1	–	–	
Braces, iron – armourers'	1	1	1*	–	–	–	–	
Braces, iron – drilling, large	1	1	–	–	–	1	–	
Braces, iron – ratchet, 12-inch	–	–	1	–	–	1	–	
Brushes, gun – gun, soft	–	1	1*	–	–	1	–	
Brushes, gun – Turk's head	1	–	–	–	–	–	–	
Burnishers, spare	3	–	–	–	–	–	–	For 42-pr. S.B. guns.
Chisels, hand – flat	5	5	5*	–	–	5	–	
Chisels, hand – gouge	1	1	1*	–	–	1	–	
Chisels, hand – graver's	3	3	3*	–	–	3	–	
Collars, cast iron, for muzzles of guns, 3' and upwards	7	7	4	–	–	–	–	One for each nature.
Collars, wood, for wedge, E 1.	–	–	–	–	–	–	1	
Cross bar, F.	–	–	–	–	–	–	1	
Cutters for metal heads. 13-in., 10-in. 8-in., 68-pr., 32-pr., (7), 24-pr. (2), 18-pr., 12-pr.	15	–	–	–	–	–	–	
Cutters for metal heads. 7", 8", 9", 10", 11", and 12" (one to each calibre).	–	6	–	–	–	–	–	One for each nature.
Cutters for metal heads. 64-pr. wrought iron guns	–	1	–	–	–	–	–	
Cutters for metal heads. 40-pr. and 25-pr.	–	–	2	–	–	–	–	
Cutters for metal heads. 16-pr. and 9-pr.	–	–	1	–	–	–	–	
Cutters for metal heads. 7-prs. 224 lbs. and 200 lbs. (bronze)	–	–	1	–	–	–	–	
Cutters for metal heads. 7-prs. 150 and 200 lbs. (steel)	–	–	1	–	–	–	–	
Drifts for taking out old vents	4	5	2	–	–	3	–	
Drills – cone	1	2	2	–	–	1	–	
Drills – hollow	2	2	2	–	–	1	–	
Drills – venting – drifting	3	5	2	–	–	2	–	
Drills – venting – tapping	3	5	2	–	–	2	–	
Files, bastard, flat, taper, 16-inch with handle	1	1	1*	–	–	–	–	
Frame, iron, for cutting off the ends of vents, with adjusting bar and extenders.	1	1	1	–	–	1	–	
Gauge – vent 22"	1	2	1	–	–	1	–	
Gauge – for copper vents (with wood collars), A.	–	–	–	–	–	–	1	
Gauge – disc for A1	–	–	–	–	–	–	1	
Hammers, hand – large	1	1	1*	–	–	1	–	
Hammers, hand – small	1	1	1*	–	–	1	–	
Heads, metal, for cutters. 13-in., 10-in., 8-in., 68-pr., 32-pr., 24-pr., 18-pr., and 12-pr., S.B.	8	–	–	–	–	–	–	
Heads, metal, for cutters. 7", 8", 9", 10", 11", and 12" (one to each calibre).	–	6	–	–	–	–	–	One for each nature.
Heads, metal, for cutters. 64-pr. with extra stop	–	1	–	–	–	–	–	
Heads, metal, for cutters. 40-pr., 25-pr., and 16-pr. (one to each calibre).	–	–	3	–	–	–	–	
Heads, metal, for cutters. 9-pr. and 7-pr.	–	–	1	–	–	–	–	
Instruments for taking impressions of vents	–	1	1	–	–	1	–	
Instruments for taking impressions of vents with wax, complete with six blocks and two pans.	1	–	–	–	–	–	–	
Levers, iron, for working bar	2	2	2	–	–	2	–	
Machine, drilling, with chain, complete	1	1	1	–	–	1	–	
Monkey (with eye bolts), H.	–	–	–	–	–	–	1	
Pans for instruments for taking impressions of vents – A.—large	–	1	–	–	–	–	–	
Pans for instruments for taking impressions of vents – B.—small	–	1	–	–	–	–	–	
Pans for instruments for taking impressions of vents – C.—converted guns	–	1	–	–	–	–	–	
Pans for instruments for taking impressions of vents – 40-pr.	–	–	1	–	–	–	–	
Rimers – cone (letter H.)	1	–	–	–	–	–	–	
Rimers – vent (letter E.)	3	–	–	–	–	–	–	
Rimers – for mouth of vent, S.S.	1	1	1*	–	–	1	–	
Rimers – cone	–	2	2	–	–	1	–	
Rimers – long, 22-inch	–	1	–	–	–	–	–	
Rimers – short	–	3	1	–	–	1	–	

N.B.—Those marked * are identical in both 1 and 2 sets.

CHAP. XII. TABLE XXIII.—Table of Venting Tools—*continued.*

Description.	Smooth Bore.	Rifled Ordnance. No. 1.	Rifled Ordnance. No. 2.	Siege Train. No. 3 set. Heavy.	Siege Train. No. 3 set. Light.	Siege Train. No. 3 set. Common to both.	Special in addition for converted Guns.	Remarks.
Rod for inserting and extracting blocks, C.	–	–	–	–	–	–	1	
Saw with frame, 14-inches	1	1	1*	–	–	1	–	
Spanner for nuts on frame	–	–	1	–	–	1	–	
Stave for brush, Turk's head and fitting	–	1	1	–	–	–	1	
Tube for keeping blocks in position	–	–	–	–	–	–	1	
Trunnion eye-bolt (with nuts)	–	–	–	–	–	–	1	
Taps — 1¼" new thread	–	3	3	–	–	–	–	
Taps — ¼" fine "	–	–	3	–	–	–	–	
Taps — New thread (letter C.)	5	–	–	–	–	–		
Taps — Old " (" D.)	3	–	–	–	–	–	–	
Upsetting blocks B1	–	–	–	–	–	–	1	
Upsetting blocks B2	–	–	–	–	–	–	1	
Wire, directing	1	1	1	–	–	1	–	
Wrenches — cutter	1	1	–	–	–	1	–	
Wrenches — socket	1	1	1	–	–	1	–	
Wrenches — tap	1	1	–	–	–	–	–	
Wrenches — vents	1	1	–	–	–	–	–	
Wrenches — taps and vents — large	–	–	1	–	–	1	–	
Wrenches — taps and vents — small	–	–	1	–	–	1	–	
Wedge, E.	–	–	–	–	–	–	1	

N.B.—Those marked * are identical in both 1 and 2 sets.

The quantity of grease allowed for breech-screws, &c., for every ten guns is—

7-inch	20 lbs.
40-pr.	15 "
20 "	10 "
12 "	7½ "
9 "	7½ "
6 "	7½ "

The breech screw and bright parts about the guns will be coated with a composition of—

Tallow	3 parts.
Oil, lard	1 part.

Lead, white, about 1 lb. to a gallon.

The parts which can be removed being laid up in store.

The lacquer composed of—

	lbs.	ozs.
Black, lamp, dry	0	12
Lead { black, dry	24	8
Lead { red, dry	6	12
Oil, linseed, raw	9	0

And the quantity of lacquer authorised to be used for every six guns is—

	lbs.	ozs.
7-inch	3	0
40-prs.	2	4
20-pr. and 12-prs.	1	2
9-pr. and 6-prs.	0	12

APPENDIX.

APPENDIX I.

Returns and Examination of Ordnance.

(1.) Rules for Furnishing Annual Returns.

Annual return.

Returns according to the accompanying forms, p. 247, for S.B., W.O. 1475, and for rifled guns W.O. 1476, will be sent yearly, by Officers of Artillery in command of districts, except in North America, to the Director of Artillery and Stores, on the 1st of June. Those from the North American Artillery stations will be furnished on the 1st November. Officers commanding vessels of war of every description having guns on board, and likewise the Royal Marines, Royal Naval Reserve, and Coast Guard, having ordnance in their charge will furnish returns on 1st January, through the Admiralty, to the Secretary of State for War. These annual returns are forwarded to Superintendent R. G. F. for report and record.

Date for furnishing.

It is necessary for the identification of guns that the descriptive marks should be accurately entered in the return.

The weight of the gun is marked on the top of the gun in front of the vent.

The initial of the factory* will be found on the left trunnion in all cases, and on rifled guns the numeral of pattern or mark is also on that trunnion.

The date of proof is marked on the reinforce in S.B. guns, and on the left trunnion with rifled guns.

The register number and year of proof† will be found on the reinforce in S.B. cast iron guns, and on the left trunnion in the case of rifled ordnance.‡

Under the head of "Nature," the proper name of the gun, with its nominal weight, will be entered; as for instance, "32-pr. of 56 cwts.," "9-inch R.M.L. of 12 tons," "40-pr. R.B.L. of 35 cwt." The correct designation of S.B. guns is given, and that of all rifled guns will be taken from the official list of changes of ordnance, published with the Monthly Army Circular, in which a description of every gun appears when finally approved.

Date of last examination.

The column headed "Date of last examination" will be filled in from the date of the last inspection, made in accordance by an Inspector of Warlike Stores, or other qualified person.

Condition of bore and Sentence.

The "Condition of bore" and "Sentence" will be taken from the last report made by the Inspector of Warlike Stores, or other examiner conducting the periodical or special examinations ordered; but if the gun has not been examined, owing to only a few rounds having been fired from it, these columns may be left blank, unless the commanding officer should see cause to call special attention to the gun.

Number of rounds fired.

The "Number of rounds fired" at the date of making the return, will be very carefully entered under the several headings; it is exceedingly important, for sake of the record, that the number should be given correctly. The number of rounds fired with projectiles since previous examination should also be given.§

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* With S.B. ordnance this would of course denote the foundry where the guns were cast.

† On all guns proved since September 1857.

‡ Except in the 7-pr. R.M.L., where this information is found on the right trunnion.

§ The number of rounds fired with projectiles at the time of making the annual returns will be very carefully recorded from year to year. All the older cast iron guns which were in the service previous to records being kept, have had a number of rounds "assumed" from the size of the vent, in accordance with the instructions of previous circulars. The number of "assumed rounds" will be entered every year in red ink, and the actual number of rounds in black ink. In the column in middle of return should be inserted the number of rounds fired with projectiles since last examination.

Condition of fittings, B.L.

The columns regarding the condition of the fittings of the breech-loading guns, and the vents of muzzle-loading guns, will be filled in from the reports of the Inspector of Warlike Stores, or other examiner.

Column "Remarks."

Particulars of any special defect on the exterior or other part of the gun will be noted in the column of "Remarks," if not entered in any other part of the return; as also, any peculiar circumstance, such as the re-venting of a muzzle-loading gun, the bursting of a shell in the bore, the fracture of fittings, &c. Reference will be made, when necessary, to explanatory documents.

Guns which have not been fired since the previous return will be entered in the return; but the columns headed "Condition of bore," "Sentence," "No. of rounds fired," and condition of fittings, need not be filled in, the remark "Not used since 18 " being entered against them.

(2.) Rules as to Examination of Guns.

Examination of guns in Royal Artillery charge at home.

For home service the following arrangements will be carried out for guns in Royal Artillery charge:—

As soon as a gun has fired the number of rounds, since previous examination, laid down in the regulations, vide p. 214, a notification of the circumstance (see Form, p. 248) will be sent to the Director of Artillery,* or in the case of S.B. guns, direct to the Superintendent, R.G.F., by the officer commanding the district, and practice from the gun will cease until its condition has been reported upon. At the end of every quarter an examiner and an artificer from the Royal Gun Factories will visit each district, and examine those guns which have fired the prescribed number of rounds and perform such repairs as may be required.† Should there be no guns in a district requiring such examination or repair, the district will not be visited in that quarter.

Naval reserve batteries.

Officers in charge of Royal Naval Reserve batteries will apply to the Commissary of Ordnance Stores, to have such of their guns as may require it placed on the list for the next quarterly inspection of the district in which the port they are stationed at may be situated.‡

In case of emergency they will apply through the same channel for the immediate services of examiners and artificers from the Royal Gun Factories.

Inquiry to be made immediately into the cause of accidents.

When any accident occurs either at home or abroad, such as the bursting of a shell in the bore, the splitting of a breach-loading vent-piece, &c., immediate inquiry will be made into the circumstance, and the gun examined. If the commanding officer considers the damage to be of importance, he will send without delay a report of the circumstances through the same channel as his annual return, forwarding, if necessary for the illustration of his report, gutta-percha impressions of the damage done to the gun. A similar course will be pursued in regard to naval guns.

Foreign Stations.

Examination of guns in Royal Artillery charge abroad.

At all foreign stations the examination will be made under the direction of the officer commanding the Royal Artillery in the district, by an Inspector of Warlike Stores, should there be one at the station, or, if not, by some other competent person. A report of the examination will be made on W.O. form 1475 or 1476,† and forwarded through the same channels as laid down for the annual return. Impressions will not be sent with the report unless there is any doubt as to the serviceability of the gun or guns; but should any gun appear to be in an unserviceable state, or to require re-venting or other repairs beyond what can be effected on the spot, impressions will be forwarded with the report, for the information of the Director of Artillery and Stores, who will give such directions as he may think desirable.

If guns found unserviceable, or requiring re-venting or repair, as above, be mounted in an important position, or if local circumstances render their immediate exchange necessary, they will at once be exchanged, if practicable,

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* If possible a gutta-percha impression of vent should accompany the return, as the Director of Artillery, after its inspection, may be able to allow of continuance of practice from the gun without waiting for quarterly inspection.

† A copy of the Examiner's report, upon W.O. Form 1476, will be furnished by him to the officer commanding the R.A. District, or H.M. Ship, where the guns are mounted, to enable him to complete his Annual Return as prescribed.

‡ In such case the word "Special" will be substituted for "Annual" in the heading of the form.

by requisition on the Commissary of Ordnance Stores, approved by the general officer commanding. In such cases the requisition, after being complied with, will be forwarded by the Commissary to the Director of Artillery and Stores.

Examination of naval guns.

Officer commanding Her Majesty's ships will, from time to time, as exigencies of the service permit, apply to the Commissary of Ordnance Stores at the station to cause their rifled guns to be examined, unless they themselves have at disposal the means of effecting the service. The Commissary, on receipt of such demand, will, if abroad, send a requisition to have the service performed to the officer commanding the Royal Artillery, and, if at home, to the Controller, Royal Arsenal, Woolwich, except in the Southern or Western districts, in which the demand will be dealt with at Portsmouth or Devonport Gun Wharf, and the examination will be carried out in the manner laid down for Garrison Ordnance, by the Inspector of Warlike Stores, if there be one, or otherwise by some competent person. On the completion of the examination, the result will be notified to the Commissary on W.O. form 1475 or 1476, and will be forwarded by him to the officer commanding the vessel, who will take such steps as he may deem necessary, under the orders of the senior naval officer. All requisitions from officers commanding Her Majesty's ships for the re-venting or exchange of guns will be made through the Commissary of Ordnance Stores, and will be complied with under the rules laid down for supplying warlike stores to Her Majesty's vessels. The Commissary will report his proceedings to the Director of Artillery and Stores.

(3.) Instructions for the Guidance of Examiners in the Inspection of Rifled Ordnance.

Preparing a gun for examination.

When a gun is to be examined, the bore will be thoroughly cleaned, as described at p. 214, the inspector having the memorandum of examination.

How bores are to be examined and defects noted.

The barrel being in a fit state, the Inspector will proceed to examine it by aid of a lamp and a sharp pointed pricker. The stave of the pricker should be graduated in inches for measuring the distance of the defect, which is recorded in inches from the muzzle, except when one occurs in the powder chamber of a breech-loader, when the distance of the defect is measured from the breech end of the barrel. The position round the gun is recorded in all cases as "up," "down," "right," "left," or in intermediate positions, as "right of down," &c., &c., looking from the muzzle.

When impressions are to be taken.

The Examiner should in all cases take gutta-percha impressions in cases where it is necessary, vide p. 215.

In cases when an impression is sent away for decision or preserved for record it should be carefully labelled.

(4.) Method of taking Impressions in Gutta-percha and Wax.

Gutta-percha.

The common kind of gutta-percha used for the soles of boots is suitable for the purpose. It can be used over and over again, and need never be thrown away if a little fresh material be added from time to time, to prevent it from becoming brittle. It should not be allowed to become mixed with dirt or grit, and it should be kept in water when not in use.

How prepared.

The method of applying the gutta-percha is as follows: A sufficient quantity having been softened by being put into boiling water, is worked and kneaded on a smooth board, until the air and water are expelled, and a smooth surface obtained. A small lump is then placed on the pan of the instrument (which should have been previously fitted with a pad of gutta percha) and screwed up against the vent, or other part of the bore, of which an impression is to be taken. It is there left till cold, about 10 or 20 minutes, according to the weather; then the instrument is withdrawn.

How used.

A little soft soap, or, if that be not available, common soap and water, oil or grease, will prevent the impression sticking to the pad. The bore of the gun should be slightly greased. Too much pressure must not be applied, otherwise the impression will be very thin, and if the defect be deep it will be difficult to remove the gutta-percha. A good deal of practice is required to get good, smooth impressions; and several impressions of the vent have sometimes to be taken before one is obtained which can be relied on to show any hair lines.

Labelling impression.

When an impression is forwarded with a return, for report or decision a label will be gummed to the back, showing the name of the station, the date of taking the impression, the direction of the muzzle, the nature and number of the gun, and the position of the fissure (if it be in any part but the vent), defined according to the directions. The impression should be reduced to the smallest dimensions compatible with showing the whole of the defect.

Wax composition.

Wax composition, which may be used instead of gutta-percha, for taking temporary impressions for examination on the spot, is made of beeswax two parts, treacle one part, soft soap one part. The wax should be melted over a slow fire in an iron pot, the treacle being first added and mixed well by stirring; and lastly the soft soap, a little at a time. The mixture must be kept in motion, and when thoroughly mixed poured out, and made into balls when cool. This composition being soft, is always ready for use, but is easily destroyed by handling. The cushion or pad of gutta-percha will be removed from the pan of the instrument before the wax composition is applied.

W.O. Form 1475.

An Annual Return of the State of Cast Iron and Bronze Ordnance, showing the Condition of the Vent and Bore, and the Number of Rounds fired from each Gun.

________________ 18____.

Descriptive Marks.					Actual Weight.			Length.				Condition of														
Foundry.												Vent.				Bore.		Sentence.	Number of Rounds fired with Projectiles.				Received from		Returned or issued to	
													Diameter.													
Number on Trunnion.	Letters.	Date.	Register Number on Reinforce.	Cypher or Badge, if any.	Cwt.	Qrs.	Lbs.	Feet.	Inches.	Nature.	Date of last Examination.	Iron, Copper, or not bushed.*	Through gauge.	At bottom.	Extent of Fissures in the Cast Iron round the Vent, measured from the original centre of the Vent.	Examiner's Remarks.	No. of Rounds with projectiles fired since last Examination.	↑ = Serviceable. C = For cone-venting. T = Through-venting. + = Unserviceable.	Previously reported.	Since last Report.	Total.	In Store, or whether mounted, and where placed, in Ship or Fortress.	Station, &c.	Date.	Station, &c.	Date.	Remarks.†

* The letters (if any) on the cascable or loop to be inserted in this column.
† If any gun has been re-vented at the station since the last return, the date of venting and description of vent will be inserted in this column.

W.O. Form 1476.

An Annual Return of the State of Rifled Ordnance, and of the Number of Rounds fired from each Gun.

_______________ 18____.

Description. Register Number.	Description. Mark.	Description. Initials of Factory, and Date.	Weight.* Tons.	Weight.* Cwt.	Weight.* Qrs.	Weight.* Lbs.	Nature. (See para. 12 of Regulations for Inspection.)	Date of last Examination.	Condition of Bore, specifying any important defects not noted in Memo. of Examination.	Size of Vent. Through Gauge.	Size of Vent. Size at Bottom.	General state of Vent, and of adjoining part of Bore.	Sentence. A Serviceable.	Sentence. R ‡Repairable.	Sentence. + Unserviceable.	Number of Rounds fired at Date of Return. With Projectile. Battering. Previously reported.	Battering. Since.	Battering. Total.	Full. Previously reported.	Full. Since.	Full. Total.	Reduced. Previously reported.	Reduced. Since.	Reduced. Total.	Number of Rounds with Projectiles fired since last Examination.	In Store, or whether mounted, and where placed, in Ship or Fortress.	Received from Station, &c.	Received from Date.	Returned or issued to Station, &c.	Returned or issued to Date.	Condition of Breech-screw.	Condition of Vent-piece.	Remarks.†

N.B.—Duplicate copy of this return not required. * Under 100 cwts. give the full weight in cwts.; 5 tons and over in tons. See § 1081, Changes in Ordnance, &c.

† If any gun has been re-vented at the station since the last return, the date of venting and description of vent should be inserted in this column.

‡ If repairable, give nature of repair required.

Royal Artillery _______________ District _______________ Station _______________, 1875.

Return of Ordnance which have fired the prescribed Number of Rounds since previous Examination.

Nature.	Descriptive Marks. Number on Trunnion.	Descriptive Marks. Letter.	Descriptive Marks. Date.	Weight. Tons.	Weight. Cwt.	Weight. Qrs.	Weight. Lbs.	Number of Rounds fired. Since last Examination.	Number of Rounds fired. Total.	Name of Battery where mounted.	When next required for practice.	Remarks.*

* State if any impression is sent, or if there is no person at hand to take one.

† In the case of smooth bore guns this return should be sent direct to the Superintendent, Royal Gun Factories.

†*The Director of Artillery, War Office, Pall Mall, S.W.* _______________ *In Charge of Guns at Battery.*

APPENDIX II.

INSTRUCTIONS FOR BLUEING AND BRONZING SIGHTS AND FITTINGS, BROWNING GUNS, DEEPENING CENTRE HIND SIGHT HOLES, FIXING DERRICKS, &c.

Blueing.

(1.) The steel tangent bar, screw trunnion sight, and all trunnion sight leaves are blued. Blueing steel sights.

Blueing consists simply in covering the surface with a thin film of oxide sufficient to give the article a deep blue colour and to prevent further oxidation from exposure to the atmosphere. This is easily effected by polishing bright the surface of the article, and heating it to about 550° until it assumes a blue colour, and then allowing it to cool gradually. A sand bath is generally used in order to obtain a uniform heat, and the bar, &c. is taken out from time to time to watch the change of colour and to prevent its going too far.*

Bronzing.

(2.) The exposed gunmetal portions of all the tangent and drop sights are protected from the influence of the atmosphere by "bronzing" as follows:— Bronzing drop sights, &c.

1st. Polish the parts well and heat them over a spirit lamp or gas.

2nd. Polish with a brush and black lead, to remove all grease, &c.

3rd. The bronzing mixture is then applied to the heated metal. It consists of—

Bichloride of platinum - - -	2 parts.
Corrosive sublimate - - -	1 ,,
Vinegar - - - - -	1 ,,

4th. The parts are next dipped into boxwood sawdust to dry them, and then again polished with black lead to give a body to the colour. The figures, which are left bright, are rubbed with emery cloth, and the whole is finally varnished with shellac and methylated spirits,

Browning.

(3.) 9 and 16-pr. guns are browned, the operation is as follows:— Browning.

1. Steam the gun for 10 hours, then wash with a lye of potash (1 lb. black potash to 1 gallon of water); repeat until the grease is thoroughly eradicated.

(A.) If there be no convenience on service for the performance of the steaming process, simple washing may have to be employed instead. The whole object is to get rid of oil which may remain on the surface of the iron, and hence the water should be as hot as can be borne by the operator, who will rub vigorously all over the exterior surface with a clean hard brush; a little hard soap should be used, and the water should be frequently changed so as to ensure its perfect cleanness. This washing and scrubbing with soap and

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* The temperature may be judged by the colours, which successively appear on the surface of the steel at various low temperatures, viz.:—

At 450° F. the steel becomes a straw colour, 475° an orange or gold, 500° brown, 530° purple, 550° violet, 580° blue, 610° white, and at 625° red.

hot water must be repeated at least three times; then wash the gun with the lye of potash as aforesaid. (B.) Repeat the process A, consisting of three washings and scrubbings with soap and water, and of one washing with the lye of potash several times; to obtain perfect cleanness may require many repetitions of the whole process, and care must be taken not to touch the gun with any fatty matter, or even with the hand, as it may take hours of washing to wholly remove the effect.

2. Wash with hydrochloric acid and water (equal parts) to remove oxide, then wash with clean water and wipe dry. 3. Apply browning mixture with a sponge, and let stand for 12 hours in a temperature not less than 60° or more than 100°; then rub off rust with scratch-card and brush. The browning mixture is composed of the following:—

Tincture of steel	2	parts	Spirts of nitre -	$1\frac{1}{2}$	parts.
Nitric acid -	1	"	Spirits of wine -	$1\frac{1}{2}$	"
Blue vitriol -	1	"	Soft water -	32	"

4. Apply mixture, let it stand six hours, rub off rust. 5. Repeat No. 4. 6. Apply mixture, let it stand six hours, then boil five minutes in a lye of potash (1 lb. potash to 2 gallons of water), then rub off rust. 7. When cold, repeat No. 4. 8. Repeat No. 4. 9. Apply mixture. stand six hours, then boil as in No. 6 operation, rub off rust, then coat with olive oil.

Care to be taken to well sponge and dry the bore and chambers after each operation of washing, steaming, or boiling.

Stores required for browning a battery.

The following is a detail of the stores and quantities of ingredients allowed per battery biennially required for browning a battery of six 9-pr. guns, or six 16-prs.,* viz.:—

Tincture of steel - - -	4 ozs.	To be mixed in 2 quarts of soft water.
Nitric acid - - -	2 "	
Blue vitriol - - -	2 "	
Spirits of nitre - - -	2 "	
Spirits of wine - - -	3 "	
Hydrochloric acid - - - - - -		6 lbs.
Earthenware pan to hold 6 quarts, for hydrochloric acid		1
American potash - - - - - -		6 lbs.
Wooden pail for do. - - - - - -		1
Oil - - - - - - - -		1 gill.
Sponge cloth for do. - - - - - -		1
Sponge to apply the browning mixture - - -		1
Flat brush to apply the hydrochloric acid - -		1
Scratch-card to rub the surface of the gun between the coatings - - - - - -		6 ins.
Coals - - - - - - -		335 lbs.
Brush, hard - - - - - - -		1

Preparing Guns for long Centre Hind Sights.

Preparing gun for lengthened hind sight.

(4.) As mentioned at p. 113, lengthened centre hind sights are to be supplied eventually for 9-inch guns and upwards, and for that purpose the socket hole has to be deepened.

The tools required are mentioned below, as well as the necessary instructions regarding their use.

Tools for deepening holes for lengthened Centre Hind Sights, 9-inch R.M.L. Guns and upwards:—

Brace, ratchet, 20″ - - - -		1
Drill -	16″ - - - -	1
	$22\frac{1}{2}$″ - - - -	1
Guide, steel - - - - -		1
Stamp, D. - - - - -		1

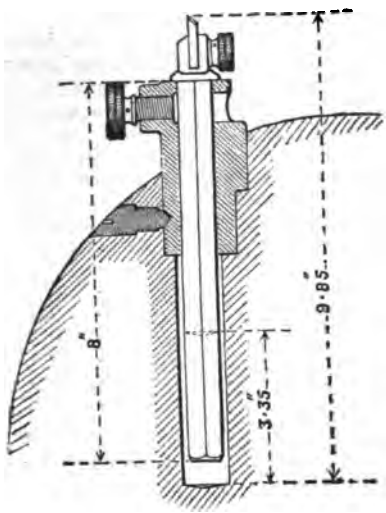
* Half as much again for 16-prs. as to proportion of stores.

Instructions for deepening the centre hind sight holes for 9", 10", 11", and 12" guns:—

Take out the metal sight socket and put the steel guide in its place. Erect the sighting machine drill frame (marked L in the tools for sighting ordnance), placing the drill in the steel guide and bringing the feed screw exactly to it. The drill and feed screw will not be quite perpendicular, but will be inclined at the correctional angle for the gun's deflection. Fasten the frame securely by a strong chain or rope to the gun, placing a block of hard wood under the tail.

The holes in the 12 and 18-ton guns can be sufficiently deepened with the shorter drill alone, but for those in the 25-ton guns it will be necessary to extend the hole farther, and the longer drill must be substituted, when the shorter one has drilled as deeply as the feed screw will drive it. It will be found convenient to mark the proper depth on the drill.

To use the machine, insert the drill, attach the ratchet brace, gently tighten up the feed screw, lubricate with oil, and turn the handle.



When the proper depth has been attained, remove the apparatus and steel guide, thoroughly clean out the hole and replace the socket; a small D will then be stamped in front of the hole.

Fixing Bronze Derricks.

(5.) The following instructions apply to the fixing on the guns of the muzzle derricks described at p. 126, Chapter IX.

Instructions to be observed in fixing bronze derricks to muzzles of heavy rifled guns:—

1st. Scribe a line upon the top of the chase from the vertical axis line on muzzle for a distance of about 12 inches towards the fore sight. Fixing derricks.

2nd. Remove the fixing screws and then try on the band; there may be a slight variation in the diameter of the muzzles of guns of the same nature, but if they are correct the bands would be seated as follows, viz.:—

Distance from face of muzzle to front edge of band - - - } for 9" M. L. guns $5\frac{1}{2}$"; or 10", 11", 12", and $12\frac{1}{2}$" guns, 6".

Should the band not reach its seat, it will be necessary to ease it inside with a half-round file until it attains the required position. If, on the other hand, the muzzle of the gun be small, the band must be pushed on as far as it will go.

3rd. When the band has been placed roughly in its position, turn it round until the vertical lines cut on the front and rear faces agree with the scribed line on muzzle mentioned in § 1. When properly adjusted give the front edge a few gentle taps round with a piece of wood to drive it on to the chase, and thus fix it temporarily in position, but the relations of the lines must not be disturbed in so doing.

4th. Now mark off upon the chase the positions of the holes by means of a steel scriber carefully guided around the interior of the screw holes, and then remove the band. Special attention must be paid to this operation.

5th. Dot round with a centre punch the circles just described, and centre each as nearly as possible ready for drilling.

6th. Erect the drilling apparatus and drill very carefully four holes, each $\frac{5}{16}$ in diameter and $1\frac{1}{4}$ deep, to correspond with the plain points of fixing screws.

Judgment must be exercised in drilling the holes if required, so that they may be perfectly concentric with the dotted circles previously marked off.

At the chief stations, where artificers are at hand, drills can readily be prepared on the spot for this purpose, but in localities where these conveniences do not exist the drills can be supplied on demand.

7th. After the holes are completed, remove the drilling tackle, clean the surface of the chase, take off all "burrs" from the holes, and place the band in position; then insert the screws and send them home firmly and securely.

8th. In the event of the band being fitted to a gun with small muzzle, as named in § 2, it will be necessary to adjust the bridge piece which supports the derrick when erected, so that the latter may be brought forward in order to maintain the required relation with the muzzle of the piece. It will be requisite first to level the gun, and then to drop a plumb line from the centre of the hook seat at the top of derrick, and the distance measured from the face of muzzle to this line should be—

	"	
For 9″ M.L. gun - - - -	7·4	Limits of error, one inch minus or plus.
,, 10″ ,, - - - -	9·4	
,, 11″ ,, - - - -	10·3	
,, 12″ 25-ton ,, - - - -	10·45	
,, 12″ 35 ,, ,, - - - -	11·5	
,, 12½″ ,, - - - -	12·35	

Where the measurement does not comply with the above dimensions, the lower side of bridge piece must be cut away and relieved until the proper overhang has been obtained.

APPENDIX III.

Mitrailleur or Machine Guns.

Mitrailleurs or machine guns* of some description now exist in limited numbers in the armament of most great powers.

With regard to the raison d'etre of these weapons, it appeared on the introduction of rifled field guns that the smaller charges used with and motion imparted to the projectile somewhat decreased the effect of case shot,† while shell fire (until fuzes are much improved) at short ranges must always be more or less uncertain. Mitrailleurs were therefore made with a view to their affording a fire like that of case (*mitraille*), or a hail of bullets, for ranges up to 1,000 or 1,200 yards. Use of mitrailleurs.

In 1869 the question of such weapons was seriously taken up by different nations. The United States Government ordered 100 Gatling guns to be used for flank defences, and occasionally as field artillery; while several European states had one or two Montigny mitrailleurs manufactured for trial. In 1867, our Ordnance Select Committee tried a Gatling gun against a 9-pr. R.B.L. gun, with very fair results for the former; while in 1869, as Major Fosbery had reported favourably to the India Office upon the Montigny, and the French Government were making a similar weapon in considerable numbers, it was decided to carry out further trials, both with the Montigny and the Gatling gun, which latter had been much improved by Mr. Broadwell since the experiments of 1869. United States, 1869. Montigny mitrailleurs. Ordnance Select Committee, 1857.

In August, 1870, a Special Committee‡ carried out these further trials, which resulted in the preference being given to the Gatling gun, a small number of which the committee recommended should be at once purchased. Special Committee, 1870. "Gatling" preferred.

Their report was made in November 1870, at which date a full knowledge had not been obtained of the effect of the mitrailleurs used in the Franco-German war of that year. Twelve Gatling guns, however, of small calibre, for land service, and 24 of medium, together with 12 of small size for sea service, were ordered as a tentative measure, until further experience was gained. Gatling guns introduced 1870.

In November 1871, the Special Committee above mentioned having prosecuted further inquiry as to the intentions of foreign governments regarding machine guns, and having examined a number of officers who were present with French or German armies during the war, made a second report, in which they adhered to their former opinion, recommending the adoption of the larger Gatling gun of 0·65-in. bore for coast defences and naval service, and the smaller of 0·45-in. calibre for field purposes. Adoption recommended of the 0·65″ and 0·45″ Gatling.

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* Fire-arms having many barrels, intended either to be fired together or in rapid succession, are however, by no means a modern conception; although the introduction of rifling and metallic cartridges has of course revolutionised their nature and manufacture.

In the earliest days of artillery, we find machines used under the names of ribaudequins, orgues, orgels, organ or tube guns, &c., in which several barrels of small callibre were united in a single mass, or on a rigid framework.

These weapons were originally of clumsy construction, and could not be discharged with rapidity. Towards the end of the 15th century, however, more efficient organ guns were taken into the field; but wheeled carriages strong enough to resist the recoil of a field piece, and yet fairly mobile, were constructed about this period, so that Francis I., when invading Italy in 1515, though he carried organ guns with him, also took a number of field pieces. As the latter improved in mobility, the use of tube guns was gradually given up, and after the 16th century their employment in war seems to have been exceptional.

† The effective range is supposed to have retrograded from 100 to 150 metres, or between 340 and 500 feet. Vide also Proceedings, R.A.I., Vol. IX., No. 4.

‡ President, Colonel Wray, C.B., R.A.

Finally approved of in 1874 by § 2647.

As already mentioned, a small number of these guns had been ordered in 1870, and it was thought advisable, before manufacturing any more, that these should be thoroughly tried in the service. A number of 0·45-in. calibre, and of 0·65-in. calibre, have been made for S.S., and lately some smaller 0·45-in. Gatlings have been ordered for Indian service. All the Gatlings we have have been manufactured by the E.O.C. These Gatling guns were finally approved of as service pieces in 1874.*

Prussia, 1869 and 1871.

In Prussia, both Montigny and Gatling mitrailleurs were tried in the year 1869, in the presence of the king; but as it was thought that the results gained by their use were not adequate to "the *personnel* and *matériel* required in serving them," they were not approved of.

With the exception of one battery of revolver cannon on the Feldl system, made during the war, no machine guns have been made for this power; but we must remember that large numbers of the French mitrailleurs captured in 1870 are in her possession. Some of these, were tried, indeed, at Berlin, in 1871, and pronounced superior both to the Gatling and Montigny guns.†

Russia, 1873. Austria. Turkey. America.

Russia, in 1873, had as many as 300 Gatling guns, but since that date has adopted the Nobel machine gun, a species of Gatling, with certain alterations on the plan of General Gorloff. Austria has adopted the system of Christophe and Montigny in her mitrailleuses. She has added many of these weapons to her armament. Turkey possesses a number of machine guns made, like our own, on the Gatling principle. America, as we have seen, also uses the Gatling (which, indeed, owes its origin to that country) both for fortress defence and for field service.‡

So much as to the history of mitrailleurs and Gatling guns; let us now turn to their probable employment and advantages as a gun or fire-arm.

The experience which was gained during the war of 1870, and careful official investigations made since that time by the War Departments of various powers, enable us now to form a fair estimate as to the value of such guns, and to see more plainly the uses to which they should be applied, and it is evident that their employment will be limited, and will be restricted in general to the following:—

Field service.

i.—*For Field Service.* An addition of a light nature in small numbers to the reserve artillery of an army, for increasing the fire of infantry at critical moments,‖ and for the *defence* of bridges, villages, field entrenchments, &c.

Fortresses or siege works.

ii.—*For Fortresses or Siege Works.* In caponnières, têtes du pont, breaches, and flank defence generally, and for use in advanced trenches.

Naval purposes.

iii.—*For Naval Purposes.* Firing from ships' tops, and in boat operations.

* "It is proposed to keep in store in reserve a few Gatling guns (made by contract), in case they should be required, and also to issue a limited number to ships of war.

"As these weapons, however, are considered complicated and of limited power, it is not contemplated that they will be much employed on active service, and no troops are armed with them. The ammunition, being of a special nature, is also purchased as required, by contract."—*Proceedings, D. of A., Vol. XII., p.* 321.

† This conclusion is scarcely borne out by unprejudiced evidence.

‡ In the kingdom of Sweden and Norway a Commission has lately investigated the subject, and according to their report a species of machine gun invented by Messrs. Winborn and Palmcrantz is likely to be adopted there.

According to the Report of a French Commission this weapon has certain defects as to the complication of its mechanism, &c.

A six barrelled machine gun, termed the "Hotchkiss revolver cannon," has lately been experimented with in Germany. It is meant to fire small shells weighing, when full, about 1½ lb., with percussion fuze. It outwardly resembles a Gatling, but has only one lock, opposite to which each barrel is brought in turn.

‖ It must be remembered, however, that great care and caution have to be exercised in the introduction into our field equipment of an arm of such limited use. If we do employ any, they should be the very best obtainable; so that the wisest policy is not to manufacture many till greater mobility than our service Gatling possesses, as well as the other essentials required have been attained. As soon as this is the case, the necessary number for the reserve of our army can, with the manufacturing capabilities of this country, be produced at very short notice.

i.—*Employment in the Field.*

Field guns *v.* mitrailleurs.

In the field, mitrailleurs would have to oppose either artillery, cavalry, or infantry. To be effective against field guns they must have long range, be comparatively heavy, and carry such a weight of ammunition that the number of horses required would be almost the same as that used with a field gun; while for many purposes they would be quite powerless,—for instance, against walls, stockades, entrenchments, or cover of almost any kind. Against the horses and men of artillery exposed within the range such mitrailleurs might indeed be formidable; but that would not make up for their impotence in shell fire for destroying villages or *matériel*, blowing up ammunition wagons, driving troops out of cover, &c.

Franco-German war.

General Walker, who accompanied the Prussians, states that "the French mitrailleurs were invariably driven off the field the moment they showed themselves so that the Prussian artillery could get at them." (The best range for the Prussian guns was 1,800 yards.)

Captain Gurdon, R.N., who was with the French army of the Loire, says that, when opposed to artillery, mitrailleurs always had the worst of it. He only saw one case when they had any effect upon the former, "at the battle of St. Jean-sur-Eroe, where three Prussian 12-prs. came down a road and opened fire upon us at a distance of 2,400 yards. We brought," he says, "four mitrailleurs against them, and after a quarter of an hour the guns limbered up, evidently having some of their horses and guns disabled, and retired another 300 yards to the rear."

Colonel Wray's Committee.

At times, however, mitrailleur fire has proved more destructive than that of guns,* and the evidence taken by Colonel Wray's Committee of Officers who had seen these weapons largely used in the field was thus summed up by Colonel Fletcher, Scots Fusilier Guards, one of the Committee.

1. The French officers, and those who witnessed the campaign from the French side, were generally in favour of the employment of mitrailleurs in the field.
2. The Prussian staff disapproved of their introduction into the service.
3. English officers who were present with the German army, with one exception, considered that for certain purposes they might prove useful adjuncts to field artillery.†

Colonel Wray's Committee carried on exhaustive trials between the 9-pr. R.M.L. gun, firing shrapnel, a small (0·45-in. bore) Gatling gun, and six Guardsmen armed with the Martini-Henry rifle. In a series of eleven trials where the firing took place at ranges from 300 to 1,200 yards, and under various conditions as to time and distance, the Gatling made 2,699 hits, the 9-pr. gun 1,620, and the Martini-Henry 718. (Vide tables of practice, p. 261.)

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* Captain H. Brackenbury, R.A., mentions several instances:—"At the battle of Rezonville," he says, "we have very plain evidence as to whether the French considered the mitrailleuses to be more effective than guns in certain positions, by this fact, that Marshal Bazaine, who was there on the spot himself (near a ravine close to the Bois de Oignons), had plenty of guns under his hand, but had only two batteries of mitrailleuses. To defend the head of this ravine (and this was after having seen previous battles) he brought up his mitrailleuses. Any one who has seen that battle-field, who has seen the way in which the graves are at this point piled almost one upon another, will see how awful the slaughter must have been; and it was due, practically, entirely to these mitrailleuses."

"There is," he also says, "another peculiar case, and that is on the western side of the battle field of Sedan. On the heights close to Floeing, there was placed a battery of mitrailleurs. There is, opposite to that, a round hill with wood on the top, and out of this wood and from behind this hill came the Prussian columns. As they came out they were swept down by these mitrailleuses, and they did not succeed. They could not make any progress, but were obliged to go back again, and go round on the reverse slope of the hill, checked by the mitrailleuse."

† As the mitrailleur can only be used advantageously for defensive tactics, and that on exceptional occasions, when the ground in front is clear of cover, it is generally agreed that the reserve of a division is the proper place for batteries of this arm, if it be taken into the field.

This, of course, merely proved that under certain circumstances the fire of a mitrailleur would be very deadly beyond the range of case shot; but it must also be borne in mind that with known short ranges the fire is certain, while shell fire is always more or less uncertain.

Recommended for weapons of defence.

With these facts and this evidence before them, the Committee, in their final report, laid down distinctly "that the mitrailleurs should be treated purely as defensive weapons, and that they should in general be entrenched, and kept as far as possible masked from artillery fire; that the so-called small Gatling of 0·45-in. calibre—of which the destructive effect against troops in the open, at ranges up to 1,400 yards, is estimated at being nearly three times that of the 9-pr. field gun—should be lightened, so as to be easily drawn, with its carriage and ammunition, by two horses, and on an emergency by one." Also "that the field artillery should not be reduced by a single man or horse for the sake of substituting mitrailleurs."

To assist in defending such positions as villages, field entrenchments, &c., the Committee considered that the small Gatling would be found valuable.

ii.—*Employment of Machine Guns for Fortresses or Siege Works.*

Where space is limited, the front clear, and range known—as in permanent works—these weapons would probably be most useful in caponniéres, counterscarp galleries, &c., for the defence of ditches, as well as of the short flanks of works,* while in a breach their effects would be most formidable.

iii.—*Employment of Machine Guns for Naval Purposes.*

The advantages of using mitrailleurs for ships' tops, to repulse boarders, and for boat service in certain cases are generally recognised.

Boat or field marine purposes.

They have not actually been used in naval warfare, so we have nothing but experimental data to go upon.

For covering a landing they would no doubt be useful, should the beach and adjoining country be open—as would usually be the case; though even then they should supplement, and not supersede, the heavier natures of guns used for boat or field marine service. Notwithstanding that great advantage, in a boat, of absence of recoil, their manifold disadvantages must not be lost sight of.

* The Swedo-Norwegian Committee report that "in warfare of position, or fortresses, these arms have so great and so evident an importance that opinions cannot differ thereon." The Americans carried on exhaustive trials last year between Gatling guns, field guns, and 8-inch siege howitzers; and the report of the board of officers concerned was strongly in favour of using some of these weapons for flanks of works. In consequence, the Secretary of State for War has recommended to Congress the appropriation of 292,600 dols. for the immediate purchase of 209 Gatling guns and carriages, to be in position by the 1st July 1874. Another special board, U.S. Army, reporting as to advantages of mitrailleurs in defending short flanks, say:—"There can be no question that the great volume of fire of the 8-in. howitzer (1,173 balls discharged in one minute, or double that number if necessary), would prove irresistible on the short lines of our permanent fortifications. Besides, these guns admit of the use of shells when needed." In cases, however, of a simultaneous attack on the curtain and faces of adjacent bastions, they go on to say, "It would be impossible to serve the opposite howitzers with the freedom a good defence would require," on account of the risk to gunners in opposite casemate. The board therefore recommended one Gatling gun "for each flank of casemated forts, even to the displacement of the howitzer when there is but one flank embrasure, if the scarp can be readily approached and if there be a line of embrasures raised but a few feet above the ground."

The TABLE below gives some data as to the MITRAILLEUR or GATLING GUNS used by different Nations.

Nation.	Nature of Mitrailluse.	1 Nominal Rapidity of fire. Rounds per Minute.	2 Mechanism is capable of greater Rapidity.	3 Weight. Gun complete.	Carriage complete.	Limber empty.	4,000 Rounds (about).	Total.	4 No. of Men to carry when dismounted.	5 If capable of lateral Spread.	6 Ammunition used.	7 No. of Men for Service in Action.	Range up to	Remarks.
				cwt.qr.lb.	cwt.qr.lb.	cwt.qr.lb.	cwt.qr.lb.	cwt.qr.lb.					yds.	
England	Gatling, 0·65-in. bore	—	—	7 2 14	7 2 13	—	—	—	?	Yes	Special	?	—	For naval and coast service.
„	„ 0·45-in „	300 to 400	No.	3 3 24	5 2 10	7 0 3	4 0 0	20 2 9	?	Yes	Special	2	2,400	Up to 1,200 yds. produces maximum effect.
Russia	„ ? „	—	No.	1 0 0	12 1 10	9 2 10	?	?	?	Yes	—	—	—	360 or over in their service for fortresses.
„	Nobel	About 300	No.	1 0 0	2 1 8	5 1 4	3 0 8	11 2 20	?	Yes	Special	?	1,870	For service in the field.
France	The French	100 to 150	No.	?	?	?	?	?	?	?	Special	?	?	„ „
Austria	Montigny and Christophe	200	No.	3 2 5	9 3 4	9 1 20	?	?	?	?	Werndl. S.A.A.	?	1,000	„ „
Prussia	The French	As above	No.	—	—	—	—	—	—	—	—	—	—	„ „
Turkey	Gatling	„	No.	—	—	—	—	—	—	—	—	—	—	?
America	„ 0·45-in. bore	—	No.	?	?	?	?	?	?	?	Berdan.	—	—	For flank defence, and frontier war.
Sweden and Norway	Palmorantz	400 to 500	No.	2 2 6	2 2 2	?	3 0 0	?	2	?	Special as yet.	1	1,400	Only proposed, not adopted.

NOTE.—Spain also employs mitrailleurs with her field artillery, each brigade of which contains one mitrailleur battery of six pieces. For field service, Russia has Gatling batteries of eight pieces employed in certain proportions in the Reserve Field Artillery of each Division.

Construction of Service Gatling.

§ 2642.
§ 2647.
The following are the details of construction of our service Gatling, which belongs to the description of mitrailleurs where the barrels revolve, and are charged simultaneously. Each barrel has its special lock, which accompanies it during revolution, and is also capable of motion backwards and forwards. It pushes the cartridge into its barrel, then serves as a breech, and afterwards extracts the empty cartridge. Each lock has a striker with spiral spring, and an extractor.

Scattering arrangement. The system is caused to revolve by means of a crank fixed on the right side of the piece, and an automatic "scattering" arrangement has been added, which can be put in gear or not, as required, and which is worked by the crank which moves the system. Each lock can be taken out separately, and replaced by a new one.

300 to 400 rounds per minute can be fired from this mitrailleur, and two men are sufficient to serve one in action.

We have three natures in our service, the 0·65-in. and two of 0·45-in. bore of 3 cwts. and 200 lbs. weight respectively.

	cwt.	qrs.	lbs.
Weight of gun - - - - - -	3	3	24
„ carriage and limber (empty) - -	12	2	13

Barrels. The gun has 10 steel barrels, rifled on the Henry principle, fixed in a circle round a centre shaft of steel. To this shaft are keyed two gun metal discs, through one of which the muzzle ends of barrels pass, while their breech ends are screwed into the other. Vide Plate, page 259.

Shaft. The shaft itself is fixed in a "gun frame" (*aa*, Fig. 1) of wrought iron, made of two bars connected in front of muzzles by a curved cross-piece (*n*, Fig. 1). The rear ends of this gun frame are connected by screws to a cast iron box, or "breech casing" (*C*, Fig. 1), which contains the mechanism.

Breech casing. In this casing is a vertical diaphragm, through which the shaft passes towards the breech, and the breech end of the casing is closed by a "cascable plate"

Cascable plate. (*D*, Fig. 1) of cast iron.

Inside the casing, upon the rear of the shaft, is a small (pinion) worm-wheel (*W*, Fig. 2), which gears into a worm (*f*, Fig. 2) on a crank shaft or spindle (*gg*, Fig. 2), which passes into the breech casing on the right side, and at right angles to the main shaft. By turning a crank handle secured to this spindle, the main shaft and barrels are caused to revolve. When not in use this handle is pushed in out of the way.

Fastened by screws to the gun frame, is a "pivot block" of gun metal (*p*, Fig. 3); a pivot (*P*, Fig. 3) passes through this, and into an iron trunnion plate (*ee*, Fig. 3), and upon it the system turns when lateral spread of bullets is required.

The trunnion plate has projections, or trunnions, on which the system revolves for elevation, and is secured at the rear end by a bolt and nut to a locking bolt plate which fits into an undercut slot in bottom of breech casing.

Scattering fire. When a scattering fire is required, the frame, barrels, &c., turn on this "block" through the required arc by means of an automatic arrangement (*AF*, Fig. 2) worked by the crank handle before mentioned.

Concentrated fire. When such is not required, the fire is concentrated by putting this arrangement out of gear, and preventing any transverse movement by means of a "locking bolt"

Locking bolt. (*l*, Fig. 2) let down into a slot in trunnion plate at the rear.

Cartridge carrier. On the main shaft in rear of the barrels a cast iron cylinder, or "cartridge carrier" (*M*, Fig. 4) is fixed. This has 10 longitudinal grooves, corresponding with the 10 barrels.

Hopper. A gun metal cover, or "hopper" (*B*, Fig. 4), hinged at one side, drops over it. The cover has a longitudinal slot, corresponding to the opening in the "feed drum"* (*T*, Fig. 1), which rests upon

Feed drum. the upper surface of the "hopper." As each column is exhausted, the drum is turned round by hand until the next one corresponds with the opening in the

* This drum is of metal, fits on a pin (*b*, Fig. 4) in centre of hopper, and contains 240 cartridges, in 16 perpendicular columns or channels. It weighs, when full, 50lbs

Service Gatling Gun, 0·45 Bore.

Fig. 1.

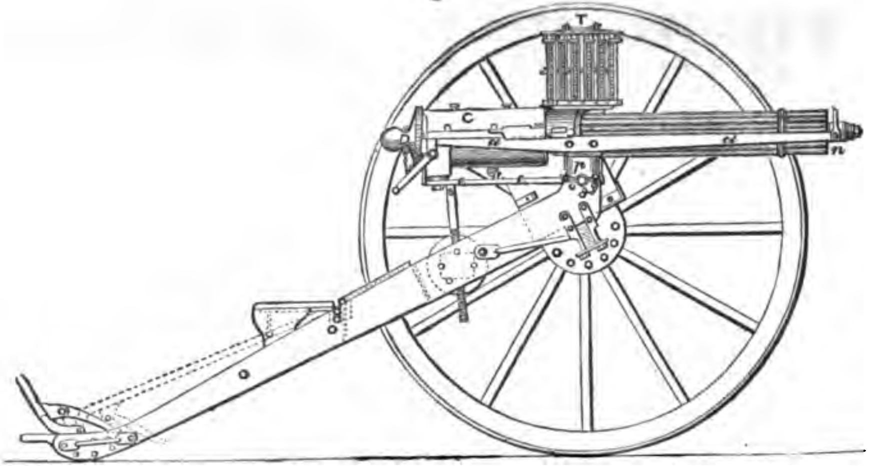


Fig. 3.—Section through Trunnion-Plate, Trunnions, and Pivot Block.

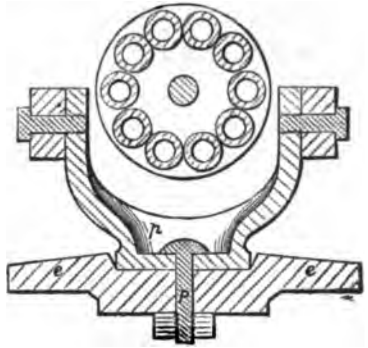


Fig. 2.—Elevation of Breech End with Cascable Plate removed.

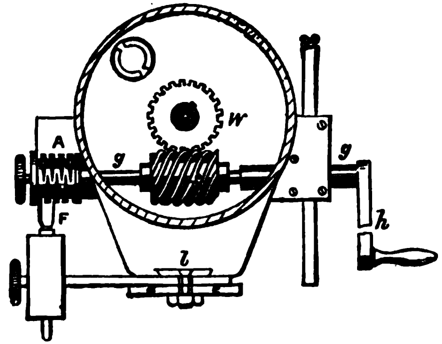


Fig. 5.—Plan, Bottom of Drum.

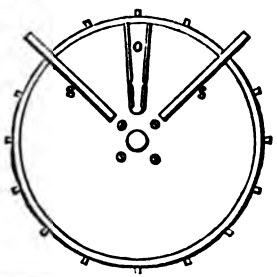


Fig. 6.—Horizontal Section through Drum.

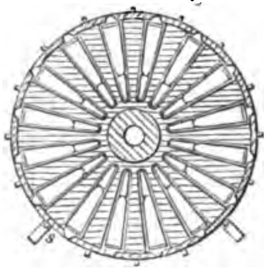
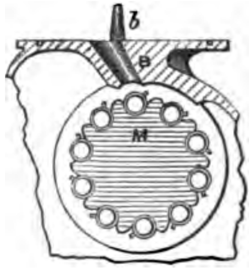


Fig. 4.—Section through Hopper and Cartridge Carrier



hopper. Through this slot the cartridges drop (as the shaft revolves) into the several grooves, ready to be pushed by the lock plungers into the barrels corresponding.

Lock chamber. In rear of this, and inside the breech casing, is placed the "lock chamber," which is keyed to and revolves with the main shaft. It is a cylinder of cast-iron, having longitudinal channels through which the "locks" pass.

Locks. Rear guide nuts. Upon the main shaft, again, and against the back of the "lock chamber," is secured a cast iron "rear guide nut," which keeps the parts firmly together. The locks rest partly upon the outer circumference of this nut; and in the grooves on which they fit, as well as in the channels in the lock chamber, are small slots, in which run studs on the locks, in order to prevent the latter revolving save with the shaft.

Cam. Inside the "casing" is a curved gun-metal plate, or cam, by means of which, as the shaft and lock chamber revolve, the locks themselves are pushed forward or back. A piece of steel is let into the front of this cam, against which the butt of each lock bears at the moment the barrel is fired.

Cocking ring. Firing pin. There is also a steel cam, called a cocking ring, which, as the lock chamber revolves, draws back and then releases a spiral spring acting on the "firing pin" or needle of each lock.

The Lock.

Lock. The lock consists of a steel tube or "plunger," about 11¼ ins. long, the front end of which, for about 4 ins., is smaller in diameter, and has only a pin hole running through it.

Butt. The remainder is hollow, and slotted out on one side. Its breech end is closed by a steel plug or "butt," screwed in.

Inside is a steel bolt or "hammer," having a projection at the side which passes through the slot in the tube, while to the front part of it is attached a firing pin or "striker," of steel.

A spiral spring is placed over the hammer, being retained by the "butt."

Extractor. To the outside of the tube or lock is fixed a steel extractor, having a hook, which seizes the rim of the cartridge and draws it out as the lock is being withdrawn.

Sighting.

Sights. There are two sights, a foresight and tangent sight. The former is a plain steel sight attached to the gun frame on the right side at the muzzle, and the latter is a plain steel bar graduated in degrees and yards, working in a socket on the right rear side of the breech casing, and clamped by means of a milled head thumb screw.

The 0·45-in. gun is sighted with a tangent and fore sight up to 2,400 yds. (8° 23′ elevation).

Action.

(Vide Plate facing p. 262.)

Action. When the gun is in action five cartridges are always in process of loading, and five are in different stages of extraction. Thus, as the system revolves, cartridges drop from the feed drum through slot in the hopper, successfully, on the 10 grooves in cartridge carrier; as each lock comes in contact with the cocking ring, the hammer is drawn back and spring compressed; further rotation brings the lock against the gun metal cam, which pushes it forward, driving before it a cartridge from the carrier into its particular barrel. The breech is thus closed, and as the butt comes opposite the steel plate in the cam, the cocking ring releases the spring, and the needle fires the cartridge. The system continues to revolve, and the lock now being drawn back within the chamber, extracts the empty cartridge case while retreating, and the latter falls to the ground.

The following table gives a summary of the results obtained from firing, in competition, the pieces mentioned. The practice was carried on by Colonel Wray's Committee in August and September 1870:—

1st Experiment.—At a line of targets 9 feet by 9 feet, representing 90 Cavalry or 150 Infantry. Shrapnel shell only used with the field guns. Firing against time, 2 minutes.

Range, 300 Yards.	Weight of Ammunition.	No. of Hits.	Range, 400 Yards.	Weight of Ammunition.	No. of Hits.	Range, 600 Yards.	Weight of Ammunition.	No. of Hits.	Range, 800 Yards.	Weight of Ammunition.	No. of Hits.	Range, 1,000 Yards.	Weight of Ammunition.	No. of Hits.
	lbs.			lbs.			lbs.			lbs.			lbs.	
Small Gatling.	53	369	Small Gatling.	39	310	Small Gatling.	56	522	Small Gatling.	30·5	229	9-pr. M.L.	86	294
12-pr. B.L.	121·5	268	9-pr. M.L.	118	236	9-pr. M.L.	75	283	Mitrailleur	25	154	12-pr. B.L.	94·5	218
9-pr. M.L.	107	208	Mitrailleur	30	178	12-pr. B.L.	94·5	142	12-pr. B.L.	82	152	Small Gatling.	41·5	62
Mitrailleur	25	171	12-pr. B.L.	121·5	166	Mitrailleur	30	127	9-pr. M.L.	53	118	Martini-Henry.	9	47
Martini-Henry.	15	74	Snider	9	77	Snider	9	63	Martini-Henry.	10	66	Mitrailleur	30	33
Snider	8	63	Martini-Henry.	17	68	Martini-Henry.	11	52	Snider	10	48			

2nd Experiment.—At similar targets. Firing deliberate. Shrapnel used with field guns.

Range, 300 Yards.	Weight of Ammunition.	No. of Hits.	Range, 400 Yards.	Weight of Ammunition.	No. of Hits.	Range, 600 Yards.	Weight of Ammunition.	No. of Hits.	Range 800 Yards.	Weight of Ammunition.	No. of Hits.
	lbs.			lbs.			lbs.			lbs.	
Mitrailleur	25	172	Mitrailleur	25	177	12-pr. B.L.	60	164	12-pr. B.L.	60	208
9-pr. M.L.	45	162	Small Gatling.	16	169	Mitrailleur	25	107	Small Gatling.	16	183
12-pr. B.L.	60	138	12-pr. B.L.	60	118	9-pr. M.L.	45	78	9-pr. M.L.	45	124
Martini-Henry.	14	83	9-pr. M.L.	45	110	Martini-Henry.	12	74	Mitrailleur	25	106
Snider	9	74	Martini-Henry.	13	90	Snider	9	63	Martini-Henry.	12	85
			Snider	8	61				Snider	8	62

3rd Experiment.—At three rows of targets, 20 yds. apart. Shrapnel and segment shell with field guns. Firing against time, 2 minutes.

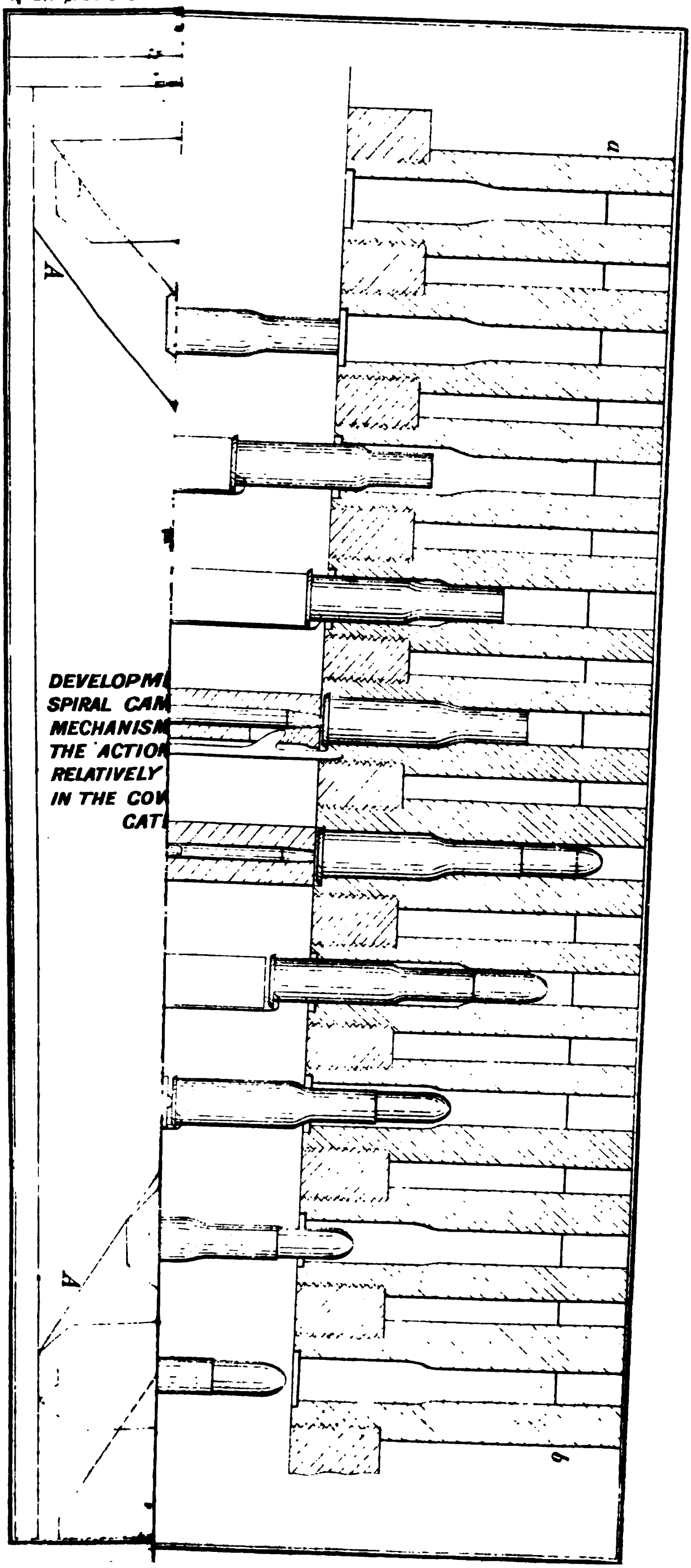
Range, 1,200 Yards.	Weight of Ammunition.	No. of Hits.	Range, 1,400 Yards.	Weight of Ammunition.	No. of Hits.	Range, 2,070 Yards.	Weight of Ammunition.	No. of Hits.	Range, 2,100 Yards.	Weight of Ammunition.	No. of Hits.
	lbs.			lbs.			lbs.			lbs.	
Small Gatling.	28	204	Med. Gat. 0·65-in.	89	236	Med. Gat. 0·65 in.	127	164	12-pr. B.L. seg.	108	73
Mitrailleur	50	201	12-pr. shrap. B.L.	60	224	12-pr. B.L. seg.	72	115	9-pr. M.L. shrap.	63	72
12-pr. seg. B.L.	72	173	9-pr. shrap. M.L.	54	178	Large Gatling.	198	99	9-pr. M.L. seg.	54	52
9-pr. seg. M.L.	54	99	Small Gatling.	47	104	9-pr. M.L. seg.	54	60	Med. Gat. 0·65-in.	114	45
9-pr. shrap. M.L.	54	92	12-pr. seg. B.L.	84	102	12-pr. B.L. shrap.	72	41	12-pr. B.L. shrap.	60	29
Martini-Henry.	12	84	Large Gatling.	212	99	9-pr. M.L. shrap.	54	35	Large Gatling.	100	12
12-pr. shrap. B.L.	60	78	9-pr. seg. M.L.	63	70						
			Mitrailleur	37	68						

4TH EXPERIMENT.—At 134 dummies, in loose order, representing infantry retiring. Front 98 yds., average depth 35 yds. Firing in three positions, with unknown ranges. Shrapnel shell only used with field guns.

First Position.	Weight of Ammunition.	No. of Hits.	Second Position.	Weight of Ammunition.	No. of Hits.	Third Position.	Weight of Ammunition.	No. of Hits.
	lbs.			lbs.			lbs.	
Small Gatling -	39	312	Small Gatling -	63	162	Small Gatling -	63	177
Mitrailleur - -	45	122	Mitrailleur -	45	83	9-pr. M.L. -	53	47
9-pr. M.L. - -	53	74	12-pr. B.L. - -	67·5	82	12-pr. B.L. - -	67·5	39
Martini-Henry -	16	65	Martini-Henry -	14	49	Martini-Henry -	12	33
Snider - - -	5	51	9-pr. M.L. - -	53	34	Mitrailleur -	55	9
12-pr. B.L. - -	67·5	29	Snider - - -	2	24	Snider - - -	·687	7

Note.—Six Guardsmen, armed with the Martini-Henry rifle, and a similar number with the Snider, were pitted against the guns.

To face p. 262 of AB



DEVELOPM
SPIRAL CAM
MECHANISM
THE ACTIO
RELATIVELY
IN THE COV
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rvice Ordnan

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Fuze.

vice Ordnance.*

...ment. Fuze.	Shrapnel, Boxer. Weight, empty.	Bursting Charge. F.G. or Pistol Powder.	Fuze.	Proof. Charge. P.	R.L.G.	Projectile	Nature of Ordnance.
	lbs. ozs.	lbs. ozs.		lbs. ozs.	lbs. ozs.	lbs. ozs.	R. Muzzle Loaders.
- - - -							16-inch, 80 tons (Exp[tal]).
- - - -			9 sec. M.L.	130 / 50	- -	800 0	12·5-inch, 38 tons.
- - - -	610 6	1 15	Do.	10 / 15	- -	700 0	12-inch, 35 tons.
- - - -	494 13	1 15	Do.	- - -	87 8	600 0	12-inch, 25 tons.
- - - -			Do.	85 0 / 95 0	- -	530 0	11-inch, 25 tons.
- - - -	403 0	1 9	Do.	70 0 / 75 0	- -	400 0	10-inch, 18 tons.
- - - -	254 0	1 5	Do.	50 0 / 58 0	-	250 0	9-inch, 12 tons.
- - - -	179 0	1 0	Do.	-	37 8	180 0	8-inch, 9 tons.
- - - -	115 10	0 12	Do.		27 8	115 0	7-inch, 7 tons.
- - - -	115 10	0 12	Do.		27 8	115 0	7-inch, 6½ tons.
- - - -	115 10	0 12	Do.	- -	17 8	115 0	
- - - -	77 6	0 9	R.L. Percussio[n] / 9 sec. M.L. / 5 do.	-	12 8	80 0	80-pr., 5 tons converted.
- - - -	65 10	0 9	Do.	-	10 0	64 0	64-pr.: 64 cwt., Mark I., II., and III. -
- - - -	65 10	0 9	Do.	- -	15 0	90 0	64-pr.: 64 cwt., Mark III., with steel tube -
- - - -	65 10	0 9	Do.	- -	10 0	64 0	64-pr.: 71cwt. converted
- - - -	65 10	0 9	Do.	- -	10 0	64 0	64-pr.: 58cwt. converted
- - - -	65 10	0 9	Do.	- -	12 0	64 0	64-pr., 64 cwt., Mark III., with steel tube.
- - - -	39 5¼	0 5	Do.	- -	8 12	40 0	40-pr., 34 cwt., Mark I.
- - - -	39 5¼	0 5	Do.	- -	8 12	40 0	40 pr., 35 cwt., Mark II.
- - - -	25 0	0 3	Do.	- -	5 0	25 0	25-pr., 18 cwt., Mark I.
- - - -	17 3	0 1½	Do.	- - -	3 12	16 0	16-pr., 12 cwt., Mark I.
- - - -	9 12	0 0¾	Do.	- - -	2 3	9 0	9-pr.: L.S., Mark I. 8 cwt.
- - - -	9 12	0 0¾	Do.	- - -	2 3	9 0	9-pr.: S.S., " II 8 cwt.
- - - -	9 12	0 0¾	Do.	- - -	2 3	9 0	9-pr.: S.S., " I. 6 cwt.
- - - -	9 12	0 0¾	Do.	- - -	2 3	9 0	9-pr.: L.S., " II. 6 cwt.
- - - -	7 8½	0 0½	Do.	- - -	0 8 (F.G.)	7 0	200 lbs. (bronze) -

APPENDIX V.—Range Tables.

*** Range Table for 12·5-inch Rifled M.L. Gun of 38 Tons.**

Based on Practice of 20th April 1876.
Minutes
Charge, 130 lbs. P. powder.
Projectile, Palliser shell, with gas-check. Weight 810 lbs. 6 oz.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 8	0·23		2,600	4 18	6·46		5,100			
200	0 17	0·46		2,700	4 30	6·74		5,200			
300	0 26	0·69		2,800	4 42	7·02		5,300			
400	0 35	0·92		2,900	4 54	7·30		5,400			
500	0 44	1·15		3,000	5 6	7·58		5,500			
600	0 53	1·38		3,100	5 18	7·86		5,600			
700	1 1	1·61		3,200	5 30	8·14		5,700			
800	1 10	1·85		3,300	5 42	8·42		5,800			
900	1 19	2·09		3,400	5 54	8·70		5,900			
1,000	1 28	2·33		3,500	6 6	8·98		6,000			
1,100	1 38	2·47		3,600	6 18	9·26		6,100			
1,200	1 48	2·81		3,700	6 31	9·54		6,200			
1,300	1 58	3·05		3,800	6 44	9·82		6,300			
1,400	2 8	3·29		3,900	6 57	10·10		6,400			
1,500	2 18	3·53		4,000	7 10	10·39		6,500			
1,600	2 28	3·78		4,100	7 23	10·68		6,600			
1,700	2 38	4·03		4,200	7 36	10·97		6,700			
1,800	2 48	4·28		4,300	7 49	11·26		6,800			
1,900	2 59	4·54		4,400	8 2	11·55		6,900			
2,000	3 10	4·80		4,500	8 15	11·84		7,000			
2,100	3 21	5·07		4,600	8 29	12·13		7,100			
2,200	3 32	5·34		4,700	8 43	12·42		7,200			
2,300	3 43	5·62		4,800	8 57	12·71		7,300			
2,400	3 54	5·90		4,900	9 11	13·00		7,400			
2,500	4 6	6·18		5,000	9 25	13·29		7,500			

* For the two 12-inch guns of 38 tons (vide p. 207) special range tables exist.

*Range Table for 12-inch Rifled M.L. Gun of 35 Tons.

Based on Practice of 10th December 1872 and 27th February 1873.

Minute 30,658.

Charge, 85 lbs. Pebble.

Projectile, common shell, weighted and plugged. Weight 618 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								Corresponding Range to Tenths of Fuze			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.		yds.	° ′	secs.			yds.		yds.
100	0 9	0·24		2,600	4 58	6·80		1	200	17	2,780
200	0 19	0·48		2,700	5 12	7·09		1·5	300	18	2,915
300	0 29	0·72		2,800	5 26	7·38		2	395	19	3,045
400	0 39	0·96		2,900	5 40	7·68		2·5	490	20	3,170
500	0 49	1·20		3,000	5 54	7·98		3	585	21	3,295
600	0 59	1·45		3,100	6 8	8·28		3·5	680	22	3,415
700	1 10	1·70		3,200	6 23	8·58		4	770	23	3,535
800	1 21	1·95		3,300	6 38	8·88		4·5	860	24	3,655
900	1 32	2·20		3,400	6 53	9·18		5	950	25	3,775
1,000	1 43	2·45		3,500	7 8	9·49		5·5	1,040		
1,100	1 54	2·70		3,600	7 23	9·80		6	1,125		
1,200	2 5	2·96		3,700	7 38	10·11		6·5	1,210		
1,300	2 16	3·22		3,800	7 53	10·42		7	1,295		
1 400	2 27	3·48		3,900	8 8	10·74		7·5	1,380		
1,500	2 39	3·74		4,000	8 24	11·06		8	1,460		
1,600	2 51	4·00		4,100	8 40	11·38		8·5	1,540		
1,700	3 3	4·27		4,200	8 56	11·71		9	1,620		
1,800	3 15	4·54		4,300	9 12	12·04		9·5	1,700		
1,900	3 27	4·81		4,400	9 28	12·38		10	1,780		
2,000	3 40	5·09		4,500	9 45	12·72		11	1,930		
2,100	3 53	5·37		4,600				12	2,080		
2,200	4 6	5·65		4,700				13	2,225		
2,300	4 19	5·93		4,800				14	2,370		
2,400	4 32	6·22		4,900				15	2,510		
2,500	4 45	6·51		5,000				16	2,645		

* Vide note as to exceptional 12-inch guns, p. 207.

RANGE TABLE FOR 12-INCH RIFLED M.L. GUN OF 35 TONS.

Based on Practice of
Minutes
Charge, 110 lbs. Pebble.
Projectile, Palliser shell, weighted. Weight, 700 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 10	0·25		2,600	4 28	6·32		5,100			
200	0 19	0·47		2,700	4 40	6·60		5,200			
300	0 28	0·69		2,800	4 52	6·88		5,300			
400	0 37	0·91		2,900	5 4	7·17		5,400			
500	0 46	1·14		3,000	5 16	7·46		5,500			
600	0 55	1·37		3,100	5 28	7·75		5,600			
700	1 4	1·60		3,200	5 40	8·04		5,700			
800	1 14	1·83		3,300	5 52	8·33		5,800			
900	1 24	2·06		3,400	6 4	8·62		5,900			
1,000	1 34	2·29		3,500	6 16	8·91		6,000			
1,100	1 44	2·52		3,600	6 28	9·20		6,100			
1,200	1 54	2·96		3,700	6 40	9·49		6,200			
1,300	2 4	3·00		3,800	6 52	9·78		6,300			
1,400	2 15	3·24		3,900	7 4	10·07		6,400			
1,500	2 26	3·48		4,000	7 17	10·36		6,500			
1,600	2 37	3·72		4,100	7 30	10·66		6,600			
1,700	2 48	3·96		4,200	7 43	10·96		6,700			
1,800	2 59	4·20		4,300	7 56	11·26		6,800			
1,900	3 10	4·44		4,400	8 9	11·56		6,900			
2,000	3 21	4·69		4,500	8 22	11·86		7,000			
2,100	3 32	4·95		4,600	8 35	12·16		7,100			
2,200	3 43	5·21		4,700	8 48	12·46		7,200			
2,300	3 54	5·48		4,800	9 1	12·76		7,300			
2,400	4 5	5·76		4,900				7,400			
2,500	4 16	6·04		5,000				7,500			

Range Table for 12-inch Rifled M.L. Gun of 25 Tons.

Charge, 50 lbs. R.L.G. or 55 lbs. P. powder
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 12	0·28		2,100	4 43	5·94	*13*
160	—	—	*1*	2,200	4 57	6·25	
200	0 24	0·56		*2,255*	—	—	*14*
300	0 36	0·83		2,300	5 13	6·56	
325	—	—	*2*	2,400	5 29	6·87	
400	0 48	1·10		*2,410*	—	—	*15*
490	—	—	*3*	2,500	5 45	7·18	
500	1 0	1·37		*2,560*	—	—	*16*
600	1 13	1·64		2,600	6 1	7·50	
655	—	—	*4*	2,700	6 17	7·82	
700	1 26	1·91		*2,710*	—	—	*17*
800	1 39	2·18		2,800	6 33	8·14	
820	—	—	*5*	*2,860*	—	—	*18*
900	1 52	2·45		2,900	6 50	8·46	
985	—	—	*6*	3,000	7 7	8·78	
1,000	2 5	2·72		*3,005*	—	—	*19*
1,100	2 18	3·00		3,100	7 24	9·10	
1,150	—	—	*7*	*3,150*	—	—	*20*
1,200	2 32	3·28		3,200	7 41	9·43	
1,300	2 46	3·56		*3,295*	—	—	*21*
1,310	—	—	*8*	3,300	7 59	9·76	
1,400	3 0	3·85		3,400	8 17	10·09	
1,470	—	—	*9*	*3,440*	—	—	*22*
1,500	3 14	4·14		3,500	8 35	10·43	
1,600	3 28	4·43		*3,580*	—	—	*23*
1,630	—	—	*10*	3,600	8 54	10·77	
1,700	3 42	4·72		3,700	9 13	11·11	
1,790	—	—	*11*	*3,720*	—	—	*24*
1,800	3 57	5·02		3,800	9 32	11·45	
1,900	4 12	5·32		3,900	9 52	11·80	
1,945	—	—	*12*	4,000	10 12	12·16	
2,000	4 27	5·63					

Range Table for 12-inch Rifled M.L. Gun of 25 Tons.

Charge, battering, 67 lbs. R.L.G. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 10	0·25		2,100	4 12	5·7	
140	—	—	*1*	*2,170*	—	—	*14*
200	0 21	0·5		2,200	4 26	6·0	
300	0 32	0·8		2,300	4 40	6·3	
310	—	—	*2*	*2,320*	—	—	*15*
400	0 43	1·0		2,400	4 54	6·6	
480	—	—	*3*	*2,470*	—	—	*16*
500	0 54	1·3		2,500	5 9	6·9	
600	1 5	1·5		2,600	5 24	7·2	
640	—	—	*4*	*2,620*	—	—	*17*
700	1 16	1·8		2,700	5 39	7·5	
800	1 27	2·1	*5*	*2,770*	—	—	*18*
900	1 39	2·3		2,800	5 54	7·8	
960	—	—	*6*	2,900	6 9	8·2	
1,000	1 51	2·6		*2,915*	—	—	*19*
1,100	2 3	2·9		3,000	6 24	8·5	
1,120	—	—	*7*	*3,060*	—	—	*20*
1,200	2 15	3·1		3,100	6 40	8·8	
1,270	—	—	*8*	3,200	6 56	9·1	
1,300	2 27	3·4		*3,205*	—	—	*21*
1,400	2 40	3·7		3,300	7 12	9·4	
1,420	—	—	*9*	*3,350*	—	—	*22*
1,500	2 53	4·0		3,400	7 28	9·7	
1,570	—	—	*10*	*3,495*	—	—	*23*
1,600	3 6	4·3		3,500	7 45	10·0	
1,700	3 19	4·5		3,600	8 1	10·3	
1,720	—	—	*11*	*3,640*	—	—	*24*
1,800	3 32	4·8		3,700	8 17	10·7	
1,870	—	—	*12*	3,800	8 34	11·0	
1,900	3 45	5·1		3,900	8 51	11·3	
2,000	3 58	5·4		4,000	9 9	11·7	
2,020	—	—	*13*				

Range Table for 12-inch Rifled M.L. Gun of 25 Tons.

Charge, battering, 85 lbs. P. powder.
Projectile, Palliser.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′			yds.	° ′		
100	0 7			2,500	4 58		
200	0 15			2,600	5 12		
300	0 23			2,700	5 26		
400	0 31			2,800	5 40		
500	0 39			2,900	5 54		
600	0 48			3,000	6 8		
700	0 58			3,100	6 22		
800	1 9			3,200	6 36		
900	1 20			3,300	6 50		
1,000	1 32			3,400	7 4		
1,100	1 44			3,500	7 19		
1,200	1 57			3,600	7 34		
1,300	2 10			3,700	7 49		
1,400	2 24			3,800	8 4		
1,500	2 38			3,900	8 19		
1,600	2 52			4,000	8 34		
1,700	3 6			4,100	8 49		
1,800	3 20			4,200	9 4		
1,900	3 34			4,300	9 19		
2,000	3 48			4,400	9 34		
2,100	4 2			4,500	49		
2,200	4 16			4,600	10 4		
2,300	4 30			4,700	0 19		
2,400	4 44			4,800	10 34		

RANGE TABLE FOR 12-INCH RIFLED M.L. GUN OF 25 TONS.

Charge, battering, 85 lbs. P. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.	
100	0 5	0·23	
185	—	—	*1*
200	0 11	0·45	
300	0 18	0·67	
375	—	—	*2*
400	0 26	0·89	
500	0 35	1·11	
560	—	—	*3*
600	0 45	1·33	
700	0 56	1·56	
740	—	—	*4*
800	1 7	1·80	
900	1 18	2·04	
915	—	—	*5*
1,000	1 29	2·29	
1,085	—	—	*6*
1,100	1 40	2·54	
1,200	1 51	2·79	
1,255	—	—	*7*
1,300	2 2	3·04	
1,400	2 14	3·29	
1,425	—	—	*8*
1,500	2 26	3·55	
1,595	—	—	*9*
1,600	2 38	3·81	
1,700	2 50	4·07	
1,760	—	—	*10*
1,800	3 2	4·34	
1,900	3 14	4·61	
1,920	—	—	*11*
2,000	3 26	4·88	
2,080	—	—	*12*
2,100	3 38	5·15	
2,200	3 51	5·42	
2,240	—	—	*13*
2,300	4 4	5·69	
2,400	4 17	5·96	*14*
2,500	4 30	6·24	
2,560	—	—	*15*

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.	
2,600	4 43	6·52	
2,700	4 56	6·80	
2,715	—	—	*16*
2,800	5 9	7·08	
2,865	—	—	*17*
2,900	5 23	7·36	
3,000	5 37	7·65	
3,015	—	—	*18*
3,100	5 51	7·95	
3,160	—	—	*19*
3,200	6 5	8·25	
3,300	6 19	8·55	*20*
3,400	6 34	8·85	
3,440	—	—	*21*
3,500	6 49	9·16	
3,580	—	—	*22*
3,600	7 4	9·47	
3,700	7 19	9·48	
3,715	—	—	*23*
3,800	7 35	10·09	
3,850	—	—	*24*
3,900	7 52	10·40	
3,980	—	—	*25*
4,000	8 9	10·71	
4,100	8 26	11·03	
4,110	—	—	*26*
4,200	8 43	11·85	
4,235	—	—	*27*
4,300	9 0	11·67	
4,360	—	—	*28*
4,400	9 17	12·00	
4,480	—	—	*29*
4,500	9 34	12·33	
4,600	9 51	12·66	*30*
4,700	10 8	13·00	
4,720	—	—	*31*
4,800	10 25	13·34	
4,835	—	—	*32*

Range Table for 11-inch Rifled M.L. Gun of 25 Tons.

Based on Practice of 28th May 1872.
Minute, 30,325.
Charge, service, 60 lbs. P. powder.
Projectile, common or shrapnel shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Tenths of Fuze.
yds.	°	′	secs.		yds.	°	′	secs.	
100	0	13	0·28	—	2,600	6	19	7·56	17
200	0	26	0·56	1	2,700	6	35	7·87	18
300	0	39	0·84	1·5	2,800	6	51	8·18	18
400	0	53	1·12	2	2,900	7	7	8·50	19
500	1	7	1·40	2·5	3,000	7	23	8·82	20
600	1	21	1·68	3·5	3,100	7	39	9·14	
700	1	35	1·96	4	3,200	7	56	9·46	
800	1	49	2·24	5	3,300	8	13	9·79	
900	2	3	2·53	5·5	3,400	8	30	10·12	
1,000	2	17	2·82	6	3,500	8	47	10·45	
1,100	2	31	3·11	6·5	3,600	9	4	10·78	
1,200	2	45	3·40	7·5	3,700	9	21	11·11	
1,300	3	0	3·69	8	3,800	9	38	11·44	
1,400	3	15	3·98	9	3,900	9	56	11·78	
1,500	3	30	4·27	9·3	4,000	10	14	12·12	
1,600	3	45	4·56	10	4,100	10	32	12·47	
1,700	4	0	4·85	11	4,200	10	50	12·82	
1,800	4	15	5·14	11	4,300	11	8	13·17	
1,900	4	30	5·43	12	4,400	11	26	13·53	
2,000	4	45	5·73	13	4,500	11	44	13·89	
2,100	5	0	6·03	13	4,600	12	2	14·25	
2,200	5	15	6·33	14	4,700	12	21	14·61	
2,300	5	31	6·63	15	4,800	12	40	14·97	
2,400	5	47	6·94	15	4,900	12	59	15·35	
2,500	6	3	7·25	16					

Range Table for 11-inch Rifled M.L. Gun of 25 Tons.

Based on Practice of 27th June 1871.
Minute, 29,397.
Charge, battering, 85 lbs. P. powder.
Projectile, Palliser cored shot.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Tenths of Fuze.
yds.	°	′	secs.		yds.	°	′	secs.	
100	0	12	0·24		2,500	4	43	6·61	
200	0	22	0·49		2,600	4	56	6·91	
300	0	32	0·74		2,700	5	10	7·21	
400	0	42	0·99		2,800	5	24	7·51	
500	0	52	1·24		2,900	5	38	7·81	
600	1	2	1·49		3,000	5	52	8·11	
700	1	12	1·74		3,100	6	6	8·41	
800	1	22	1·99		3,200	6	20	8·72	
900	1	32	2·24		3,300	6	34	9·03	
1,000	1	43	2·49		3,400	6	48	9·34	
1,100	1	54	2·74		3,500	7	3	9·65	
1,200	2	5	2·99		3,600	7	18	9·96	
1,300	2	16	3·25		3,700	7	33	10·28	
1,400	2	27	3·51		3,800	7	48	10·60	
1,500	2	38	3·78		3,900	8	3	10·92	
1,600	2	50	4·05		4,000	8	19	11·24	
1,700	3	2	4·32		4,100	8	35	11·57	
1,800	3	14	4·60		4,200	8	51	11·90	
1,900	3	26	4·88		4,300	9	7	12·23	
2,000	3	38	5·16		4,400	9	23	12·56	
2,100	3	51	5·44		4,500	9	40	12·89	
2,200	4	4	5·72		4,600	9	57	13·22	
2,300	4	17	6·01		4,700	10	14	13·55	
2,400	4	30	6·31		4,800	10	31	13·88	

Range Table for 10-inch Rifled M.L. Gun of 18 Tons.

Charge service, 40 lbs. R.L.G. or 44 lbs. P. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 13	0·26		2,200	5 13	6·56	
160	—	—	*1*	*2,205*	—	—	*15*
200	0 24	0·54		2,300	5 30	6·89	
300	0 36	0·82		*2,335*	—	—	*16*
320	—	—	*2*	2,400	5 47	7·22	
400	0 48	1·10		*2,465*	—	—	*17*
480	—	—	*3*	2,500	6 5	7·56	
500	1 1	1·38		*2,595*	—	—	*18*
600	1 14	1·67		2,600	6 23	7·90	
635	—	—	*4*	2,700	6 42	8·24	
700	1 27	1·86		*2,725*	—	—	*19*
785	—	—	*5*	2,800	7 1	8·58	
800	1 41	2·25		*2,850*	—	—	*20*
900	1 55	2·54		2,900	7 21	8·93	
930	—	—	*6*	*2,970*	—	—	*21*
1,000	2 9	2·83		3,000	7 41	9·29	
1,080	—	—	*7*	*3,090*	—	—	*22*
1,100	2 23	3·12		3,100	8 1	9·65	
1,200	2 37	3·42		3,200	8 21	10·02	
1,225	—	—	*8*	*3,210*	—	—	*23*
1,300	2 51	3·73		3,300	8 42	10·39	
1,370	—	—	*9*	*3,330*	—	—	*24*
1,400	3 6	4·04		3,400	9 3	10·76	
1,500	3 21	4·35		*3,445*	—	—	*25*
1,515	—	—	*10*	3,500	9 25	11·14	
1,600	3 36	4·66		*3,560*	—	—	*26*
1,655	—	—	*11*	3,600	9 47	11·52	
1,700	3 51	4·97		*3,675*	—	—	*27*
1,795	—	—	*12*	3,700	10 9	11·90	
1,800	4 7	5·28		*3,790*	—	—	*28*
1,900	4 23	5·60		3,800	10 32	12·29	
1,935	—	—	*13*	3,900	10 56	12·68	*29*
2,000	4 39	5·92		4,000	11 21	13·08	
2,070	—	—	*14*	*4,010*	—	—	*30*
2,100	4 56	6·24					

Range Table for 10-inch Rifled M.L. Gun of 18 Tons.

Charge, battering, 60 lbs. R.L.G. powder.

Projectile, Palliser.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	°	′	secs.		yds.			
100	0	9	0·20		2,100			
200	0	18	0·43		2,200			
300	0	28	0·67		2,300			
400	0	38	0·91		2,400			
500	0	48	1·15		2,500			
600	0	58	1·40		2,600			
700	1	8	1·65		2,700			
800	1	18	1·91		2,800			
900	1	29	2·17		2,900			
1,000	1	40	2·43		3,000			
1,100	1	51	2·69		3,100			
1,200	2	2	2·96		3,200			
1,300	2	13	3·23		3,300			
1,400	2	25	3·50		3,400			
1,500	2	37	3·77		3,500			
1,600	2	49	4·05		3,600			
1,700	3	1	4·33		3,700			
1,800	3	13	4·61		3,800			
1,900	3	25	4·90		3,900			
2,000	3	38	5·19		4,000			

Range Table for 10-inch Rifled M.L. Gun of 18 Tons.

Charge, battering, 70 lbs. P. powder.
Projectile, Palliser.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′			yds.	° ′		
100	0 6			2,500	4 27		
200	0 13			2,600	4 40		
300	0 22			2,700	4 54		
400	0 31			2,800	5 8		
500	0 40			2,900	5 22		
600	0 49			3,000	5 36		
700	0 58			3,100	5 50		
800	1 7			3,200	6 4		
900	1 16			3,300	6 18		
1,000	1 26			3,400	6 32		
1,100	1 36			3,500	6 46		
1,200	1 47			3,600	7 0		
1,300	1 58			3,700	7 14		
1,400	2 9			3,800	7 28		
1,500	2 21			3,900	7 42		
1,600	2 33			4,000	7 56		
1,700	2 45			4,100	8 10		
1,800	2 57			4,200	8 24		
1,900	3 9			4,300	8 38		
2,000	3 22			4,400	8 52		
2,100	3 35			4,500	9 6		
2,200	3 48			4,600	9 20		
2,300	4 1			4,700	9 34		
2,400	4 14			4,800	9 48		

RANGE TABLE FOR 10-INCH RIFLED M.L. GUN OF 18 TONS.

Charge, battering, 70 lbs. P. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.	
100	0 9	0·25	
170	—	—	*1*
200	0 18	0·50	
300	0 27	0·75	
345	—	—	*2*
400	0 36	1·00	
500	0 46	1·25	
515	—	—	*3*
600	0 56	1·50	
685	—	—	*4*
700	1 6	1·75	
800	1 16	2·00	
855	—	—	*5*
900	1 26	2·25	
1,000	1 37	2·51	
1,025	—	—	*6*
1,100	1 48	2·77	
1,195	—	—	*7*
1,200	1 59	3·03	
1,300	2 10	3·29	
1,355	—	—	*8*
1,400	2 21	3·55	
1,500	2 32	3·81	
1,515	—	—	*9*
1,600	2 44	4·07	
1,675	—	—	*10*
1,700	2 56	4·33	
1,800	3 8	4·60	
1,825	—	—	*11*
1,900	3 20	4·87	
1,975	—	—	*12*
2,000	3 32	5·15	
2,100	3 44	5·43	
2,125	—	—	*13*
2,200	3 56	5·71	
2,275	—	—	*14*
2,300	4 9	5·99	
2,400	4 22	6·27	
2,425	—	—	*15*
2,500	4 35	6·55	
2,570	—	—	*16*
2,600	4 48	6·85	
2,700	5 1	7·15	
2,715	—	—	*17*
2,800	5 15	7·45	
2,855	—	—	*18*
2,900	5 29	7·75	
2,995	—	—	*19*
3,000	5 43	8·05	
3,100	5 57	8·35	
3,130	—	—	*20*
3,200	6 12	8·66	
3,265	—	—	*21*
3,300	6 27	8·98	
3,400	6 42	9·30	*22*
3,500	6 57	9·62	
3,530	—	—	*23*
3,600	7 12	9·94	
3,660	—	—	*24*
3,700	7 28	10·27	
3,785	—	—	*25*
3,800	7 44	10·60	
3,900	8 0	10·94	
3,910	—	—	*26*
4,000	8 16	11·29	
4,030	—	—	*27*
4,100	8 32	11·64	
4,150	—	—	*28*
4,200	8 48	11·99	
4,270	—	—	*29*
4,300	9 5	12·35	
4,385	—	—	*30*
4,400	9 22	12·71	
4,500	9 39	13·07	*31*
4,600	9 57	13·44	
4,615	—	—	*32*
4,700	10 15	13·81	
4,725	—	—	*33*
4,800	10 33	14·18	
4,835	—	—	*34*

Range Table for 9-inch Rifled M.L. Gun of 12 Tons.

Charge, 30 lbs. R.L.G. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Tenths of Fuze.
yds.	°	′	secs.		yds.	°	′	secs.	
100	0	11	0·30		2,200	5	0	6·07	
165	—		—	*1*	*2,290*	—		—	*14*
200	0	23	0·57		2,300	5	15	6·37	
300	0	35	0·84		2,400	5	30	6·68	
335	—		—	*2*	*2,435*	—		—	*15*
400	0	47	1·11		2,500	5	45	6·99	
500	1	0	1·38	*3*	*2,580*	—		—	*16*
600	1	13	1·65		2,600	6	0	7·30	
670	—		—	*4*	2,700	6	15	7·62	
700	1	26	1·92		*2,720*	—		—	*17*
800	1	39	2·19		2,800	6	30	7·94	
835	—		-	*5*	*2,860*	—		—	*18*
900	1	52	2·46		2,900	6	46	8·26	
1,000	2	6	2·73	*6*	3,000	7	2	8·58	*19*
1,100	2	20	3·00		3,100	7	18	8·90	
1,170	—		—	*7*	*3,140*	—		—	*20*
1,200	2	34	3·27		3,200	7	34	9·23*	
1,300	2	48	3·54		*3,280*	—		—	*21*
1,335	—		—	*8*	3,300	7	51	9·56	
1,400	3	2	3·81		3,400	8	8	9·90	
1,500	3	16	4·08		*3,410*	—		—	*22*
1,505	—		—	*9*	3,500	8	25	10·24	
1,600	3	30	4·35		*3,540*	—		—	*23*
1,665	—		—	*10*	3,600	8	42	10·58	
1,700	3	45	4·63		*3,675*	—		—	*24*
1,800	4	0	4·91		3,700	8	59	10·92	
1,825	—		—	*11*	3,800	9	16	11·26	
1,900	4	15	5·20		*3,805*	—		—	*25*
1,980	—		—	*12*	3,900	9	34	11·63	
2,000	4	30	5·49		*3,930*	—		—	*26*
2,100	4	45	5·78		4,000	9	52	12·01	
2,135	—		—	*13*	*4,045*	—		—	*27*

* Limits of present fuze.

Range Table for 9-inch Rifled M.L. Gun of 12 Tons.

Charge, battering, 43 lbs. R.L.G. powder.
Projectile, Palliser or Common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 9	0·22		2,000	3 41	5·22	
200	0 18	0·45		*2,035*	—	—	*11*
205	—	—	*1*	2,100	3 55	5·51	
300	0 28	0·68		2,200	4 9	5·81	*12*
400	0 38	0·92		2,300	4 24	6·11	
410	—	—	*2*	*2,370*	—	—	*13*
500	0 48	1·16		2,400	4 39	6·41	
600	0 58	1·40		2,500	4 55	6·72	
620	—	—	*3*	*2,530*	—	—	*14*
700	1 8	1·65		2,600	5 11	7·03	
800	1 18	1·90		*2,685*	—	—	*15*
820	—	—	*4*	2,700	5 27	7·35	
900	1 28	2·16		2,800	5 43	7·67	
1,000	1 39	2·43		*2,835*	—	—	*16*
1,005	—	—	*5*	2,900	5 59	7·99	
1,100	1 50	2·70		*2,990*	—	—	*17*
1,185	—	—	*6*	3,000	6 15	8·31	
1,200	2 1	2·97		3,100	6 31	8·63	
1,300	2 12	3·24		*3,140*	—	—	*18*
1,360	—	—	*7*	3,200	6 47	8·95	
1,400	2 23	3·52		*3,290*	—	—	*19*
1,500	2 35	3·80		3,300	7 3	9·28	
1,530	—	—	*8*	3,400	7 19	9·61	
1,600	2 48	4·08		*3,435*	—	—	*20*
1,700	3 1	4·36		3,500	7 35	9·94	
1,790	—	—	*9*	3,600	7 52	10·27	
1,800	3 14	4·64		3,700	8 9	10·61	
1,870	—	—	*10*	3,800	8 26	10·95	
1,900	3 27	4·93		3,900	8 43	11·31	
				4,000	9 0	11·67	

RANGE TABLE FOR 9-INCH RIFLED M.L. GUN OF 12 TONS.

Charge, battering, 30 lbs. P. powder.

Projectile, Palliser or common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 6	0·23		2,600	4 39	6·90	
185	—	—	*1*	2,700	4 53	7·22	
200	0 13	0·46		*2,765*	—	—	*16*
300	0 21	0·69		2,800	5 8	7·54	
370	—	—	*2*	*2,850*	—	—	*17*
400	0 29	0·92		2,900	5 23	7·86	
500	0 37	1·15		*2,970*	—	—	*18*
550	—	—	*3*	3,000	5 38	8·18	
600	0 46	1·39		3,100	5 53	8·50	*19*
700	0 55	1·63		3,200	6 8	8·82	
730	—	—	*4*	*3,230*	—	—	*20*
800	1 4	1·87		3,300	6 23	9·15	
900	1 13	2·11		*3,360*	—	—	*21*
910	—	—	*5*	3,400	6 39	9·48	
1,000	1 23	2·36		*3,490*	—	—	*22*
1,090	—	—	*6*	3,500	6 55	9·81	
1,100	1 33	2·61		3,600	7 11	10·14	
1,200	1 44	2·87		*3,620*	—	—	*23*
1,270	—	—	*7*	3,700	7 27	10·47	
1,300	1 55	3·13		*3,750*	—	—	*24*
1,400	2 6	3·40		3,800	7 43	10·81	
1,440	—	—	*8*	*3,850*	—	—	*25*
1,500	2 17	3·67		3,900	8 0	11·15	
1,600	2 28	3·95		4,000	8 17	11·50	
1,610	—	—	*9*	*4,010*	—	—	*26*
1,700	2 40	4·23		4,100	8 34	11·85	
1,780	—	—	*10*	*4,140*	—	—	*27*
1,800	2 52	4·51		4,200	8 51	12·20	
1,900	3 4	4·80		*4,265*	—	—	*28*
1,945	—	—	*11*	4,300	9 9	12·55	
2,000	3 17	5·09		*4,390*	—	—	*29*
2,100	3 30	5·38	*12*	4,400	9 27	12·91	
2,200	3 43	5·68		4,500	9 45	13·27	
2,260	—	—	*13*	*4,515*	—	—	*30*
2,300	3 57	5·98		4,600	10 3	13·63	
2,400	4 11	6·28		*4,640*	—	—	*31*
2,410	—	—	*14*	4,700	10 21	13·99	
2,500	4 25	6·59		*4,765*	—	—	*32*
2,560	—	—	*15*	4,800	10 39	14·36	

Range Table for 8-inch Rifled M.L. Gun of 9 Tons.

Charge, 20 lbs. R.L.G. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 10	0·27		2,200	4 58	6·64	
170	—	—	*1*	*2,255*	—	—	*15*
200	0 21	0·55		2,300	5 15	6·98	
300	0 33	0·84		*2,385*	—	—	*16*
330	—	—	*2*	2,400	5 32	7·32	
400	0 45	1·13		2,500	5 49	7·66	
485	—	—	*3*	*2,520*	—	—	*17*
500	0 57	1·42		2,600	6 7	8·00	
600	1 9	1·71		*2,655*	—	—	*18*
640	—	—	*4*	2,700	6 25	8·35	
700	1 21	2·01		*2,780*	—	—	*19*
795	—	—	*5*	2,800	6 43	8·70	
800	1 33	2·31		2,900	7 2	9·05	
900	1 46	2·61		*2,910*	—	—	*20*
945	—	—	*6*	3,000	7 21	9·41	
1,000	1 59	2·91		*3,035*	—	—	*21*
1,095	—	—	*7*	3,100	7 40	9·78	
1,100	2 12	3·21		*3,160*	—	—	*22*
1,200	2 26	3·51		3,200	7 59	10·15	
1,245	—	—	*8*	*3,280*	—	—	*23*
1,300	2 40	3·81		3,300	8 19	10·53	
1,395	—	—	*9*	*3,395*	—	—	*24*
1,400	2 54	4·11		3,400	8 39	10·92	
1,500	3 8	4·41		3,500	8 59	11·31	
1,550	—	—	*10*	*3,515*	—	—	*25*
1,600	3 23	4·72		3,600	9 19	11·70	
1,695	—	—	*11*	*3,680*	—	—	*26*
1,700	3 38	5·03		3,700	9 39	12·09	
1,800	3 54	5·35		*3,745*	—	—	*27*
1,835	—	—	*12*	3,800	9 59	12·48	
1,900	4 10	5·67		*3,860*	—	—	*28*
1,975	—	—	*13*	3,900	10 20	12·88	
2,000	4 26	5·99		*3,975*	—	—	*29*
2,100	4 42	6·31		4,000	10 42	13·26	
2,115	—	—	*14*	*4,085*	—	—	*30*

Range Table for 8-inch Rifled M.L. Gun of 9 Tons.

Based on Practice of 1867.
Minutes 21,734 and 21,795.
Charge, battering, 30 lbs. R.L.G. powder.
Projectile, Palliser or common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 9	0·25		*2,015*	—	—	*12*
190	—	—	*1*	2,100	3 46	5·83	
200	0 18	0·51		*2,175*	—	—	*13*
300	0 27	0·77		2,200	4 0	6·14	
360	—	—	*2*	2,300	4 16	6·45	
400	0 36	1·03		*2,320*	—	—	*14*
500	0 45	1·30		2,400	4 28	6·77	
530	—	—	*3*	*2,465*	—	—	*15*
600	0 55	1·57		2,500	4 42	7·10	
700	1 5	1·84	*4*	2,600	4 57	7·43	
800	1 15	2·11		*2,605*	—	—	*16*
880	—	—	*5*	2,700	5 12	7·76	
900	1 26	2·39		*2,745*	—	—	*17*
1,000	1 37	2·67		2,800	5 27	8·10	
1,040	—	—	*6*	*2,880*	—	—	*18*
1,100	1 48	2·95		2,900	5 42	8·45	
1,200	1 59	3·23		3,000	5 58	8·80	
1,210	—	—	*7*	*3,010*	—	—	*19*
1,300	2 10	3·51		3,100	6 14	9·15	
1,380	—	—	*8*	*3,150*	—	—	*20*
1,400	2 21	3·79		3,200	6 30	9·50	
1,500	2 33	4·07		3,300	6 47	9·86	
1,550	—	—	*9*	3,400	7 4	10·22	
1,600	2 45	4·35		3,500	7 21	10·59	
1,700	2 57	4·63		3,600	7 38	10·96	
1,715	—	—	*10*	3,700	7 55	11·33	
1,800	3 9	4·91		3,800	8 12	11·70	
1,870	—	—	*11*	3,900	8 30	12·08	
1,900	3 21	5·21		4,000	8 12	12·48	
2,000	3 33	5·52					

Range Table for 8-inch Rifled M.L. Gun of 9 Tons.

Charge, battering, 35 lbs. P. powder.
Projectile, Palliser or common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.	
100	0 6	0·23		2,600	4 52	7·07	
180	—	—	*1*	*2,610*	—	—	*16*
200	0 13	0·46		2,700	5 7	7·38	
300	0 22	0·69		*2,745*	—	—	*17*
360	—	—	*2*	2,800	5 22	7·69	
400	0 31	0·92		*2,875*	—	—	*18*
				2,900	5 38	8·00	
500	0 40	1·16					
540	—	—	*3*	3,000	5 54	8·32	
600	0 49	1·40		*3,005*	—	—	*19*
700	0 59	1·65		3,100	6 10	8·64	
715	—	—	*4*	*3,135*	—	—	*20*
800	1 9	1·90		3,200	6 26	8·97	
885	—	—	*5*	*3,265*	—	—	*21*
900	1 19	2·15		3,300	6 42	9·30	
				3,395	—	—	*22*
1,000	1 29	2·41		3,400	6 58	9·63	
1,055	—	—	*6*				
1,100	1 39	2·67		3,500	7 14	9·96	
1,200	1 50	2·94		*3,525*	—	—	*23*
1,225	—	—	*7*	3,600	7 30	10·29	
1,300	2 1	3·21		*3,655*	—	—	*24*
1,395	—	—	*8*	3,700	7 46	10·62	
1,400	2 12	3·49		*3,785*	—	—	*25*
				3,800	8 2	10·95	
1,500	2 23	3·77		3,900	8 18	11·29	
1,555	—	—	*9*	*3,915*	—	—	*26*
1,600	2 34	4·05					
1,700	2 46	4·34		4,000	8 34	11·63	
1,715	—	—	*10*	*4,045*	—	—	*27*
1,800	2 59	4·63		4,100	8 51	11·98	
1,875	—	—	*11*	*4,170*	—	—	*28*
1,900	3 12	4·92		4,200	9 8	12·33	
				4,295	—	—	*29*
2,000	3 26	5·22		4,300	9 25	12·68	
2,030	—	—	*12*	4,400	9 42	13·04	
2,100	3 40	5·52		*4,420*	—	—	*30*
2,180	—	—	*13*				
2,200	3 54	5·83		4,500	9 59	13·40	
2,300	4 8	6·14		*4,545*	—	—	*31*
2,330	—	—	*14*	4,600	10 17	13·76	
2,400	4 22	6·45		*4,665*	—	—	*32*
2,470	—	—	*15*	4,700	10 35	14·13	
				4,785	—	—	*33*
2,500	4 37	6·76		4,800	10 53	14·50	

Range Table for 7-inch Rifled M.L. Gun of 7 Tons.

Charge, 14 lbs. R.L.G. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.
100	0 11	0·28	0·05	2,500	5 46	7·32	1·70
200	0 21	0·56	0·15	2,600	6 3	7·64	1·75
300	0 32	0·84	0·20	2,700	6 20	7·96	1·85
400	0 43	1·12	0·25	2,800	6 38	8·28	1·90
500	0 54	1·40	0·30	2,900	6 56	8·60	2·00
600	1 5	1·68	0·40	3,000	7 14	8·93	
700	1 16	1·96	0·45	3,100	7 32	9·26	
800	1 28	2·24	0·50	3,200	7 50	9·59	
900	1 40	2·52	0·60	3,300	8 8	9·93	
1,000	1 53	2·80	0·65	3,400	8 26	10·27	
1,100	2 6	3·08	0·70	3,500	8 44		
1,200	2 20	3·37	0·80	3,600	9 2		
1,300	2 34	3·60	0·85	3,700	9 20		
1,400	2 49	3·95	0·90	3,800	9 38		
1,500	3 4	4·24	1·00	3,900	9 57		
1,600	3 20	4·53	1·05	4,000	10 16		
1,700	3 36	4·83	1·10	4,100	10 35		
1,800	3 52	5·13	1·20	4,200	10 54		
1,900	4 8	5·44	1·25	4,300	11 14		
2,000	4 24	5·75	1·30	4,400	11 34		
2,100	4 40	6·06	1·40	4,500	11 54		
2,200	4 56	6·37	1·45	4,600	12 15		
2,300	5 12	6·68	1·55	4,700	12 36		
2,400	5 29	7·00	1·60	4,800	12 57		

Range Table for 7-inch Rifled M.L. Gun of 7 Tons.

Charge, 22 lbs. R.L.G. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.
100	0 5	0·25	0·05	2,500	4 16	6·50	1·55
200	0 11	0·47	0·10	2,600	4 30	6·81	1·65
300	0 18	0·69	0·15	2,700	4 45	7·13	1·70
400	0 25	0·91	0·20	2,800	5 0	7·45	1·80
500	0 33	1·14	0·25	2,900	5 15	7·77	1·85
600	0 41	1·37	0·35	3,000	5 30	8·09	1·95
700	0 49	1·60	0·40	3,100	5 45	8·41	2·00
800	0 58	1·84	0·45	3,200	6 0	8·73	
900	1 7	2·08	0·50	3,300	6 15	9·05	
1,000	1 16	2·32	0·55	3,400	6 30	9·37	
1,100	1 26	2·57	0·60	3,500	6 46	9·69	
1,200	1 36	2·82	0·70	3,600	7 2		
1,300	1 46	3·08	0·75	3,700	7 18		
1,400	1 57	3·34	0·80	3,800	7 35		
1,500	2 8	3·60	0·85	3,900	7 52		
1,600	2 19	3·87	0·95	4,000	8 9		
1,700	2 30	4·14	1·00	4,100	8 27		
1,800	2 42	4·42	1·05	4,200	8 45		
1,900	2 55	4·70	1·15	4,300	9 3		
2,000	3 8	4·99	1·20	4,400	9 22		
2,100	3 21	5·28	1·25	4,500	9 41		
2,200	3 34	5·58	1·35	4,600	10 0		
2,300	3 48	5·88	1·40	4,700	10 20		
2,400	4 2	6·19	1·50	4,800	10 40		

RANGE TABLE FOR 7-INCH RIFLED M.L. GUN OF 6½ TONS.

Charge, 14 lbs. R.L.G. powder.
Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.
yds.	°	′	secs.	ins.	yds.	°	′	secs.	ins.
100	0	10	0·30	0·05	2,100	4	43	6·20	1·45
200	0	21	0·55	0·15	2,200	5	0	6·55	1·50
300	0	31	0·80	0·20	2,300	5	18	6·90	1·60
400	0	42	1·10	0·25	2,400	5	36	7·20	1·65
500	0	54	1·40	0·30	2,500	5	54	7·55	1·75
600	1	6	1·65	0·40	2,600	6	12	7·90	1·85
700	1	18	1·90	0·45	2,700	6	31	8·25	1·90
800	1	31	2·20	0·50	2,800	6	50	8·60	2·00
900	1	44	2·50	0·60	2,900	7	9	8·95	
1,000	1	57	2·80	0·65	3,000	7	29	9·30	
1,100	2	10	3·10	0·70	3,100	7	48	9·65	
1,200	2	24	3·40	0·80	3,200	8	8	10·00	
1,300	2	38	3·70	0·85	3,300	8	28	10·40	
1,400	2	52	4·00	0·95	3,400	8	48	10·75	
1,500	3	7	4·30	1·00	3,500	9	8	11·10	
1,600	3	22	4·60	1·05	3,600	9	29	11·50	
1,700	3	37	4 90	1·15	3,700	9	49	11·90	
1,800	3	53	5·25	1·20	3,800	10	10	12·25	
1,900	4	9	5·60	1·30	3,900	10	31	12·60	
2,000	4	26	5·90	1·35	4,000	10	52	13·00	

Range Table for 7-inch Rifled M.L. Gun of 6½ Tons.

Charge, 14 lbs. R.L.G. powder.

Projectile, double shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.*	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.			
100	0 14	0·30		1,700			
155	—	—	*1*	1,800			
200	0 28	0·60		1,900			
300	0 42	0·90		2,000			
315	—	—	*2*	2,100			
400	0 56	1·20		2,200			
470	—	—	*3*	2,300			
500	1 10	1·50		2,400			
600	1 25	1·80		2,500			
630	—	—	*4*	2,600			
700	1 41	2·15		2,700			
785	—	—	*5*	2,800			
800	1 57	2·45		2,900			
900	2 14	2·75		3,000			
940	—	—	*6*	3,100			
1,000	2 31	3·10		3,200			
1,080	—	—	*7*	3,300			
1,100	2 50	3·40		3,400			
1,200	3 9	3·75		3,500			
1,235	—	—	*8*	3,600			
1,300				3,700			
1,400				3,800			
1,500				3,900			
1,600				4,000			

* These Tenths of fuze apply equally to the L.S. 7-inch gun of 7 tons when firing double shell. Charge, 14 lbs.

RANGE TABLE FOR 7-INCH RIFLED M.L. GUN OF 6½ TONS.

Charge, battering, 22 lbs. R.L.G. powder.
Projectile, Palliser or common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.*	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.*
yds.	° ′		ins.	yds.	° ′		ins.
100	0 6		0·05	2,400	4 18		1·55
200	0 13		0·10	2,500	4 33		1·60
300	0 21		0·15	2,600	4 48		1·70
400	0 30		0·25	2,700	5 3		1·75
500	0 38		0·30	2,800	5 19		1·85
600	0 47		0·35	2,900	5 35		1·95
700	0 56		0·40	3,000	5 51		2·05
800	1 5		0·45	3,100	6 7		
900	1 14		0·55	3,200	6 24		
1,000	1 24		0·60	3,300	6 41		
1,100	1 34		0·65	3,400	6 58		
1,200	1 45		0·75	3,500	7 15		
1,300	1 56		0·80	3,600	7 32		
1,400	2 7		0·85	3,700	7 49		
1,500	2 19		0·90	3,800	8 6		
1,600	2 31		1·00	3,900	8 24		
1,700	2 43		1·05	4,000	8 42		
1,800	2 56		1·10	4,100	9 0		
1,900	3 9		1.15	4,200	9 18		
2,000	3 22		1·25	4,300	9 36		
2,100	3 35		1·30	4,400	9 55		
2,200	3 49		1·40	4,500	10 14		
2,300	4 3		1·50	4,600	10 34		

* Boxer's 2-inch wood time fuze for rifled M.L. and smooth-bore guns.

Range Table for 7-inch Rifled M.L. Gun of 6½ Tons.

Charge, battering, 30 lbs. P. powder.

Projectile, Palliser or common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° '	secs.		yds.	° '	secs.	
100	0 4	0·20		2,500	3 49	6·23	
190	—	—	*1*	2,600	4 2	6·52	
200	0 10	0·42		*2,605*	—	—	*16*
300	0 16	0·64		2,700	4 15	6·81	
380	—	—	*2*	*2,745*	—	—	*17*
400	0 23	0·86		2,800	4 28	7·11	
500	0 30	1·08		*2,880*	—	—	*18*
565	—	—	*3*	2,900	4 41	7·41	
600	0 37	1·30		3,000	4 54	7·72	
700	0 44	1·53		*3,015*	—	—	*19*
745	—	—	*4*	3,100	5 8	8·03	
800	0 51	1·76		*3,150*	—	—	*20*
900	0 59	1·99		3,200	5 23	8·34	
920	—	—	*5*	*3,280*	—	—	*21*
1,000	1 7	2·23		3,300	5 38	8·66	
1,090	—	—	*6*	3,400	5 53	8·98	
1,100	1 16	2·47		*3,410*	—	—	*22*
1,200	1 25	2·72		3,500	6 9	9·30	
1,260	—	—	*7*	*3,535*	—	—	*23*
1,300	1 35	2·97		3,600	6 24	9·62	
1,400	1 45	3·22		*3,660*	—	—	*24*
1,420	—	—	*8*	3,700	6 40	9·94	
1,500	1 55	3·47		*3,785*	—	—	*25*
1,580	—	—	*9*	3,800	6 56	10·26	
1,600	2 5	3·73		3,900	7 13	10·59	
1,700	2 15	4·00		*3,905*	—	—	*26*
1,735	—	—	*10*	4,000	7 30	10·93	
1,800	2 26	4·27		*4,025*	—	—	*27*
1,885	—	—	*11*	4,100	7 47	11·28	
1,900	2 37	4·54		4,200	8 4	11·63	
2,000	2 48	4·82		4,300	8 21	11·98	
2,035	—	—	*12*	4,400	8 39	12·34	
2,100	3 0	5·10		4,500	8 57	12·70	
2,180	—	—	*13*	4,600	9 15	13·07	
2,200	3 12	5·38		4,700	9 33	13·45	
2,300	3 24	5·66		4,800	9 51	13·83	
2,325	—	—	*14*				
2,400	3 36	5·94					
2,465	—	—	*15*				

Range Table for 7-inch Rifled B.L. Gun of 82 Cwt.

Charge, 11 lbs. R.L.G. powder.

Projectile, common shell of 90 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.
yds.	°	′	secs.	ins.	yds.	°	′	secs.	ins.
100	0	9	0·26	0·05	2,100	5	27	6·62	1·35
200	0	21	0·56	0·10	2,200	5	47	6·97	1·40
300	0	33	0·86	0·15	2,300	6	7	7·30	1·50
400	0	45	1·16	0·20	2,400	6	27	7·65	1·55
500	0	58	1·46	0·30	2,500	6	47	7·97	1·65
600	1	11	1·77	0·35	2,600	7	7	8·31	1·70
700	1	25	2·08	0·45	2,700	7	27	8·65	1·75
800	1	40	2·39	0·50	2,800	7	47	9·00	1·85
900	1	55	2·71	0·55	2,900	8	7	9·36	1·90
1,000	2	10	3·03	0·60	3,000	8	27	9·71	2·00
1,100	2	26	3·34	0·70	3,100	8	47	10·06	
1,200	2	43	3·66	0·75	3,200	9	7	10·42	
1,300	3	0	4·00	0·80	3,300	9	27	10·80	
1,400	3	17	4·30	0·90	3,400	9	47	11·17	
1,500	3	34	4·61	0·95	3,500	10	7	11·63	
1,600	3	52	4·93	1·00	3,600	10	27	12·00	
1,700	4	11	5·29	1·10	3,700				
1,800	4	30	5·61	1·15	3,800				
1,900	4	49	5·93	1·20	3,900				
2,000	5	8	[illegible]	1·30	4,000				

Range Table for 80-pr. Converted Rifled M.L. Gun of 5 Tons.

Charge, 10 lbs. R.L.G.

Projectile, common shell 80 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								—			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Corresponding Range.	Tenths of Fuze.	Corresponding Range.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.		yds.		yds.
100	0 11	0·28	0·05	2,100	4 52	6·32	1·35	1	260	12	2,470
200	0 23	0·57	0·15	2,200	5 9	6·65	1·45	1·5	390	13	2,630
300	0 35	0·86	0·20	2,300	5 27	6·98	1·50	2	520	14	2,775
400	0 47	1·15	0·25	2,400	5 46	7·32	1·55	2·5	630	15	2,915
500	0 59	1·44	0·30	2,500	6 5	7·66	1·65	3	750	16	3,055
600	1 12	1·73	0·40	2,600	6 25	8·00	1·75	3·5	860	17	3,190
700	1 25	2·02	0·45	2,700	6 45	8·35	1·80	4	980	18	3,320
800	1 38	2·31	0·50	2,800	7 6	8·70	1·90	4·5	1,080	19	3,445
900	1 51	2·61	0·55	2,900	7 27	9·05	1·95	5	1,190	20	3,570
1,000	2 4	2·91	0·65	3,000	7 49	9·41	2·05	5·5	1,290		
1,100	2 18	3·21	0·70	3,100	8 11	9·77	2·10	6	1,400		
1,200	2 32	3·51	0·75	3,200	8 34	10·13	2·20	6·5	1,495		
1,300	2 46	3·82	0·80	3,300	8 57	10·50	2·30	7	1,595		
1,400	3 0	4·13	0·90	3,400	9 20	10·87	2·35	7·5	1,695		
1,500	3 15	4·44	0·95	3,500	9 44	11·25	2·45	8	1,785		
1,600	3 30	4·75	1·00					8·5	1,880		
1,700	3 46	5·06	1·10					9	1,970		
1,800	4 2	5·37	1·15					9·5	2,060		
1,900	4 18	5·68	1·20					10	2,145		
2,000	4 35	6·00	1·30					11	2,235		

Range Table for 8-inch Howitzer of 46 cwt.

Based on Practice of 14th, 15th, 20th, and 25th March 1872.
Minutes 30,083.
Showing ranges with constant charge and variable elevations.
Charge, 10 lbs. Projectile, shell, 180 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.											
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 18	0·37		2,600	13 50	11·68		5,100			
200	0 39	0·77		2,700	14 31	12·21		5,200			
300	1 4	1·17		2,800	15 14	12·75		5,300			
400	1 33	1·57		2,900	15 59	13·30		5,400			
500	2 3	1·97		3,000	16 44	13·85		5,500			
600	2 33	2·38		3,100	17 29	14·40		5,600			
700	3 3	2·79		3,200	18 14	14·95		5,700			
800	3 33	3·21		3,300	18 59	15·52		5,800			
900	4 3	3·63		3,400	19 45	16·10		5,900			
1,000	4 33	4·05		3,500	20 32	16·70		6,000			
1,100	5 3	4·48		3,600	21 20	17·30		6,100			
1,200	5 34	4·92		3,700	22 10	17·90		6,200			
1,300	6 6	5·36		3,800	23 2	18·50		6,300			
1,400	6 38	5·80		3,900	23 55	19·15		6,400			
1,500	7 10	6·25		4,000	24 49	19·85		6,500			
1,600	7 43	6·71		4,100	25 44	20·60		6,600			
1,700	8 17	7·18		4,200	26 44	21·40		6,700			
1,800	8 52	7·65		4,300	27 54	22·30		6,800			
1,900	9 28	8·14		4,400	29 16	23·30		6,900			
2,000	10 5	8·63		4,500	30 52	24·40		7,000			
2,100	10 42	9·12		4,600	32 44	25·50		7,100			
2,200	11 19	9·62		4,700	34 55	26·70		7,200			
2,300	11 56	10·13		4,800	37 28	28·05		7,300			
2,400	12 33	10·64		4,900	40 26	29·55		7,400			
2,500	31 11	11·15		5,000				7,500			

Range Table for 8-inch Rifled M.L. Howitzer of 46 cwt.

Based on Practice of
Minutes
Charge, 8 lbs.
Projectile, common shell, 180 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuse.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuse.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuse.
yds.	° '	secs.		yds.	° '	secs.		yds.			
100	0 34	0·42		2,600	17 2	12·68		5,100			
200	1 7	0·83		2,700	17 54	13·26		5,200			
300	1 40	1·25		2,800	18 47	13·86		5,300			
400	2 14	1·68		2,900	19 41	14·48		5,400			
500	2 48	2·12		3,000	20 36	15·12		5,500			
600	3 22	2·57		3,100	21 32	15·76		5,600			
700	3 56	3·03		3,200	22 30	16·42		5,700			
800	4 32	3·50		3,300	23 30	17·09		5,800			
900	5 8	3·97		3,400	24 30	17·76		5,900			
1,000	5 44	4·44		3,500	25 30	18·44		6,000			
1,100	6 21	4·91		3,600	26 32	19·14		6,100			
1,200	6 58	5·38		3,700	27 35	19·86		6,200			
1,300	7 35	5·86		3,800	28 39	20·60		6,300			
1,400	8 12	6·34		3,900	29 45	21·40		6,400			
1,500	8 50	6·83		4,000	31 10	22·40		6,500			
1,600	9 29	7·33		4,100	32 50	23·75		6,600			
1,700	10 9	7·83		4,200	35 25	25·60		6,700			
1,800	10 50	8·34		4,300				6,800			
1,900	11 32	8·86		4,400				6,900			
2,000	12 15	9·39		4,500				7,000			
2,100	13 0	9·92		4,600				7,100			
2,200	13 46	10·46		4,700				7,200			
2,300	14 33	11·00		4,800				7,300			
2,400	15 21	11·55		4,900				7,400			
2,500	16 11	12·11		5,000				7,500			

Range Table for 8-inch Rifled M.L. Howitzer of 46 cwt.

Based on Practice of
Minutes
Charge, 5 lbs.
Projectile, common shell, 180 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuse.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuse.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuse.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 54	0·74		2,600	34 27	20·45		5,100			
200	1 43	1·33		2,700				5,200			
300	2 33	1·92		2,800				5,300			
400	3 24	2·52		2,900				5,400			
500	4 16	3·12		3,000				5,500			
600	5 10	3·72		3,100				5,600			
700	6 5	4·32		3,200				5,700			
800	7 1	4·92		3,300				5,800			
900	7 58	5·52		3,400				5,900			
1,000	8 57	6·13		3,500				6,000			
1,100	9 59	6·75		3,600				6,100			
1,200	11 3	7·37		3,700				6,200			
1,300	12 11	7·99		3,800				6,300			
1,400	13 22	8·63		3,900				6,400			
1,500	14 36	9·29		4,000				6,500			
1,600	15 53	9·98		4,100				6,600			
1,700	17 19	10·72		4,200				6,700			
1,800	18 49	11·50		4,300				6,800			
1,900	20 25	12·33		4,400				6,900			
2,000	22 2	13·22		4,500				7,000			
2,100	23 39	14·19		4,600				7,100			
2,200	25 19	15·29		4,700				7,200			
2,300	27 3	16·46		4,800				7,300			
2,400	29 0	17·70		4,900				7,400			
2,500	31 21	19·02		5,000				7,500			

RANGE TABLE FOR 8-INCH RIFLED M.L. HOWITZER OF 46 CWT.

Based on Practice of
Minutes
Constant elevation of 20°
Projectile, common shell, 180lbs.

Charge.	Range.	Time of Flight.	Lengths of Fuze.	Charge.	Range.	Time of Flight.	Lengths of Fuze.	Charge.	Range.	Time of Flight.	Lengths of Fuze.
lb. oz.	yds.	secs.		lb. oz.	yds.	secs.		lb. oz.	yds.	secs.	
1 8	470	6·17		4 0	1,483	10·78		6 8	2,436	13·67	
9	497	6·30		1	1,508	10·88		9	2,458	13·72	
10	523	6·43		2	1,533	10·97		10	2.480	13·77	
11	549	6·56		3	1,558	11·06		11	2,502	13·82	
12	575	6·69		4	1.583	11·15		12	2,524	13·87	
13	601	6·82		5	1,608	11·24		13	2,546	13·92	
14	627	6·95		6	1,633	11·33		14	2,568	13·97	
15	653	7·08		7	1,658	11·42		15	2,590	14·02	
				8	1,683	11·51					
2 0	697	7·21		9	1,708	11·60		7 0	2,611	14·07	
1	705	7·33		10	1,733	11·69		1	2,632	14·12	
2	731	7·45		11	1,758	11·77		2	2,653	14·17	
3	757	7·57		12	1,783	11·85		3	2,674	14·22	
4	783	7·69		13	1,808	11·93		4	2,695	14·27	
5	808	7·81		14	1,833	12·01		5	2,716	14·32	
6	833	7·93		15	1,858	12·09		6	2,737	14·37	
7	858	8·05						7	2,758	14·42	
8	883	8·17		5 0	1,883	12·17		8	2,779	14·46	
9	905	8·29		1	1,908	12·25		9	2,800	14·50	
10	933	8·41		2	1,933	12·32		10	2,821	14·54	
11	958	8·53		3	1,958	12·39		11	2,842	14·58	
12	983	8·64		4	1,982	12·46		12	2,863	14·62	
13	1,008	8·75		5	2,006	12·53		13	2,884	14·66	
14	1,033	8·86		6	2,030	12·60		14	2,905	14·70	
15	1,058	8·97		7	2,054	12·67		15	2,925	14·74	
				8	2,078	12·73					
3 0	1,083	9·08		9	2,102	12·79		8 0	2,945	14·78	
1	1,108	9·19		10	2,125	12·85					
2	1,133	9·30		11	2,148	12·91					
3	1,158	9·41		12	2,171	12·97					
4	1,183	9·52		13	2,194	13·03					
5	1,208	9·63		14	2,216	13·09					
6	1,233	9·74		15	2,238	13·15					
7	1,258	9·85									
8	1,283	9·96		6 0	2,260	13·21					
9	1,308	10·07		1	2,282	13·27					
10	1,333	10·18		2	2,304	13·33					
11	1,358	10·28		3	2,326	13·39					
12	1,383	10·38		4	2,348	13·45					
13	1,408	10·48		5	2,370	13·51					
14	1,433	10·58		6	2,392	13·57					
15	1,458	10·68		7	2,414	13·62					

RANGE TABLE FOR 8-INCH RIFLED M.L. HOWITZER OF 46 CWT.

Based on Practice of .

Mixtures .

Constant elevation of 40°.

Projectile, common shell, 180 lbs.

Charge.	Range.	Time of Flight.	Lengths of Fuze.	Charge.	Range.	Time of Flight.	Lengths of Fuze.	Charge.	Range.	Time of Flight.	Lengths of Fuze.
lb. oz.	yds.	secs.		lb. oz.	yds.	secs.		lb. oz.	yds.	secs.	
1 8	715	11·33		4 0	2,154	19·71		6 8	3,554	25·39	
9	751	11·57		1	2,189	19·87		9	3,589	25·52	
10	787	11·81		2	2,224	20·03		10	3,624	25·65	
11	823	12·05		3	2,259	20·19		11	3,659	25·78	
12	859	12·29		4	2,294	20·35		12	3,694	25·90	
13	895	12·53		5	2,329	20·50		13	3,729	26·02	
14	931	12·77		6	2,364	20·65		14	3,764	26·14	
15	967	13·01		7	2,399	20·80		15	3,798	26·26	
2 0	1,003	13·25		8	2,434	20·95		7 0	3,832	26·38	
1	1,039	13·49		9	2,469	21·10		1	3,866	26·50	
2	1,075	13·72		10	2,504	21·25		2	3,900	26·62	
3	1,111	13·95		11	2,539	21·40		3	3,934	26·74	
4	1,147	14·18		12	2,574	21·55		4	3,968	26·86	
5	1,183	14·41		13	2,609	21·70		5	4,002	26·98	
6	1,219	14·64		14	2,644	21·84		6	4,036	27·10	
7	1,255	14·87		15	2,679	21·98		7	4,070	27·22	
8	1,291	15·10		5 0	2,714	22·12		8	4,104	27·34	
9	1,327	15·32		1	2,749	22·26		9	4,138	27·46	
10	1,363	15·53		2	2,784	22·40		10	4,172	27·58	
11	1,399	15·74		3	2,819	22·54		11	4,206	27·70	
12	1,435	15·94		4	2,854	22·68		12	4,239	27·82	
13	1,471	16·14		5	2,889	22·82		13	4,272	27·94	
14	1,507	16·34		6	2,924	22·96		14	4,305	28·06	
15	1,543	16·54		7	2,959	23·10		15	4,338	28·18	
3 0	1,579	16·74		8	2,994	23·24		8 0	4,371	28·30	
1	1,615	16·94		9	3,029	23·38					
2	1,651	17·14		10	3,044	23·52					
3	1,687	17·34		11	3,099	23·66					
4	1,723	17·54		12	3,134	23·80					
5	1,759	17·74		13	3,169	23·94					
6	1,795	17·93		14	3,204	24·08					
7	1,831	18·12		15	3,239	24·22					
8	1,867	18·31		6 0	3,274	24·35					
9	1,908	18·50		1	3,309	24·48					
10	1,989	18·69		2	3,344	24·61					
11	1,975	18·87		3	3,379	24·74					
12	2,011	19·05		4	3,414	24·87					
13	2,047	19·22		5	3,449	25·00					
14	2,083	19·39		6	3,484	25·13					
15	2,119	19·55		7	3,519	25·26					

Range Table for 64-pr. R.M.L. Gun of 64 Cwt.

Based on Practice of 4th and 5th May 1874.
Minutes 31,833.
Charge, 10 lbs.
Projectile, common shell; weight, 64·5 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuse.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuse.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuse.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 7	0·25	—	2,600	5 23	7·36	16	5,100			
200	0 16	0·48	1	2,700	5 40	7·7	17	5,200			
300	0 25	0·72	1·5	2,800	5 58	8·04	17	5,300			
400	0 34	0·96	2	2,900	6 16	8·39	18	5,400			
500	0 43	1·21	2·5	3,000	6 34	8·74	19	5,500			
600	0 52	1·46	3·5	3,100	6 53	9·09	19	5,600			
700	1 2	1·72	4	3,200	7 12	9·44	20	5,700			
800	1 12	1·98	4·5	3,300	7 32	9·8	21	5,800			
900	1 22	2·25	5	3,400	7 52	10·16	22	5,900			
1,000	1 33	2·53	6	3,500	8 12	10·53	23	6,000			
1,100	1 44	2·81	6·5	3,600	8 32	10·9	23	6,100			
1,200	1 56	3·09	7	3,700	8 53	11·27	24	6,200			
1,300	2 9	3·38	7·5	3,800	9 14	11·65	25	6,300			
1,400	2 22	3·67	8·5	3,900	9 35	12·04	25	6,400			
1,500	2 35	3·96	9	4,000	9 57	12·43	26	6,500			
1,600	2 48	4·25	9·5	4,100	10 19	12·83	27	6,600			
1,700	3 2	4·55	10	4,200	10 41	13·23	28	6,700			
1,800	3 17	4·85	11	4,300	11 3	13·64	29	6,800			
1,900	3 32	5·15	11	4,400	11 25	14·05	29	6,900			
2,000	3 47	5·46	12	4,500	11 48	14·46	30	7,000			
2,100	4 2	5·77	12	4,600	12 11	14·87	31	7,100			
2,200	4 18	6·08	13	4,700	12 34	15·28	31	7,200			
2,300	4 34	6·39	14	4,800	12 57	15·69	32	7,300			
2,400	4 50	6·71	15	4,900	13 21	16·1	33	7,400			
2,500	5 6	7·03	16	5,000	13 45	16·51	34	7,500			

RANGE TABLE FOR 64-PR. RIFLED M.L. GUN OF 64 CWT., AND 64-PR. CONVERTED GUNS OF 71 AND 58 CWT.

Charge, 8 lbs. R.L.G. powder.

Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.
yds.	°	′	secs.	ins.	yds.	°	′	secs.	ins.
100	0	10	0·25	0·05	2,100	4	48	6·16	1·40
200	0	21	0·50	0·10	2,200	5	6	6·51	1·50
300	0	32	0·75	0·15	2,300	5	25	6·87	1·60
400	0	43	1·02	0·25	2,400	5	44	7·23	1·65
500	0	55	1·29	0·30	2,500	6	4	7·59	1·75
600	1	7	1·57	0·35	2,600	6	24	7·96	1·85
700	1	19	1·86	0·45	2,700	6	45	8·32	1·90
800	1	32	2·15	0·50	2,800	7	6	8·70	2·00
900	1	45	2·42	0·55	2,900	7	28	9·09	2·05
1,000	1	58	2·72	0·60	3,000	7	50	9·47	2·15
1,100	2	12	2·99	0·70	3,100	8	13	9·87	2·25
1,200	2	26	3·29	0·75	3,200	8	36	10·27	2·30
1,300	2	40	3·58	0·80	3,300	9	0	10·68	2·40
1,400	2	55	3·89	0·90	3,400	9	24	11·09	2·50
1,500	3	10	4·20	0·95	3,500	9	49	11·51	2·60
1,600	3	25	4·51	1·05	3,600	10	14	11·93	2·70
1,700	3	41	4·81	1·10	3,700	10	40	12·35	2·80
1,800	3	57	5·15	1·20	3,800	11	6	13·77	2·90
1,900	4	14	5·48	1·25	3,900	11	33	15·19	3·00
2,000	4	31	5·82	1·35	4,000	12	0	16·61	3·10

Range Table for 40-pr. R.M.L. Gun of 35 Cwt. Mark II.

Based on Practice of 30th January and 5th February 1874, also 15th April 1873.
Charge, 7 lbs. R.L.G. powder.
Projectile, common shell; weight 38·5 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 9	0·23	-	2,600	5 38	7·52	14	5,100			
200	0 17	0·47	1	2,700	5 56	7·88	15	5,200			
300	0 26	0·71	1·5	2,800	6 14	8·24	16	5,300			
400	0 36	0·96	2	2,900	6 33	8·61	17	5,400			
500	0 46	1·21	2·5	3,000	6 52	8·98	17	5,500			
600	0 56	1·47	3	3,100	7 12	9·35	18	5,600			
700	1 6	1·73	3·5	3,200	7 32	9·73	19	5,700			
800	1 17	1·99	4	3,300	7 52	10·11	19	5,800			
900	1 28	2·25	4	3,400	8 13	10·49	20	5,900			
1,000	1 40	2·52	4·5	3,500	8 34	10·88		6,000			
1,100	1 52	2·79	5	3,600	8 55	11·27		6,100			
1,200	2 4	3·07	5·5	3,700	9 17	11·67		6,200			
1,300	2 17	3·35	6	3,800	9 39	12·07		6,300			
1,400	2 30	3·64	6·5	3,900	10 1	12·48		6,400			
1,500	2 43	3·94	7	4,000	10 23	12·89		6,500			
1,600	2 57	4·24	7·5	4,100				6,600			
1,700	3 11	4·55	8	4,200				6,700			
1,800	3 26	4·86	9	4,300				6,800			
1,900	3 41	5·17	9·5	4,400				6,900			
2,000	3 56	5·49	10	4,500				7,000			
2,100	4 11	5·81	11	4,600				7,100			
2,200	4 27	6·14	12	4,700				7,200			
2,300	4 44	6·47	12	4,800				7,300			
2,400	5 2	6·81	13	4,900				7,400			
2,500	5 20	7·16	14	5,000				7,500			

RANGE TABLE FOR 40-PR. RIFLED B.L. GUN OF 32 CWT.

Charge, 5 lbs. R.L.G. powder.

Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.
100	0 10	0·35	0·05	2,100	5 27	6·60	1·35
200	0 21	0·65	0·10	2,200	5 45	7·00	1·40
300	0 33	0·95	0·15	2,300	6 4	7·35	1·45
400	0 45	1·25	0·20	2,400	6 24	7·70	1·55
500	0 58	1·55	0·25	2,500	6 44	8·05	1·60
600	1 12	1·85	0·35	2,600	7 5	8·45	1·70
700	1 27	2·15	0·40	2,700	7 27	8·80	1·75
800	1 42	2·45	0·50	2,800	7 49	9·20	1·85
900	1 57	2·75	0·55	2,900			
1,000	2 13	3·05	0·60	3,000			
1,100	2 29	3·35	0·65	3,100			
1,200	2 46	3·70	0·75	3,200			
1,300	3 3	4·00	0·80	3,300			
1,400	3 21	4·30	0·85	3,400			
1,500	3 39	4·65	0·95	3,500			
1,600	3 57	4·95	1·00	3,600			
1,700	4 15	5·30	1·05	3,700			
1,800	4 33	5·60	1·10	3,800			
1,900	4 51	5·95	1·20	3,900			
2,000	5 9	6·30	1·25	4,000			

Range Table for 20-pr. Rifled B.L. Gun of 16 Cwt.

Charge, 2 lbs. 8 ozs. R.L.G. powder.

Projectile, shot or shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.
100	0 11	0·30	0·15	2,100	5 58	7·10	3·80
200	0 25	0·60	0·30	2,200	6 19	7·50	4·00
300	0 39	0·90	0·50	2,300	6 40	7·85	
400	0 53	1·25	0·65	2,400	7 1	8·20	
500	1 8	1·60	0·85	2,500	7 22	8·60	
600	1 23	1·90	1·00	2,600	7 43	8·95	
700	1 38	2·25	1·20	2,700	8 4	9·30	
800	1 53	2·60	1·35	2,800	8 25	9·70	
900	2 9	2·90	1·55	2,900	8 46	10·05	
1,000	2 26	3·25	1·75	3,000	9 7	10·40	
1,100	2 44	3·60	1·90	3,100	9 28	10·80	
1,200	3 3	3·95	2·10	3,200	9 49	11·20	
1,300	3 22	4·30	2·30	3,300	10 10	11·55	
1,400	3 41	4·65	2·50	3,400	10 32	11·90	
1,500	4 0	5·00	2·70	3,500	10 54	12·35	
1,600	4 19	5·35	2·85	3,600			
1,700	4 38	5·70	3·05	3,700			
1,800	4 57	6·00	3·25	3,800			
1,900	5 16	6·35	3·45	3,900			
2,000	5 37	6·70	3·65	4,000			

Range Table for 25-pr. Rifled M.L. Gun of 18 Cwt.

Based on Practice of February and July 1875.
Minutes 32,768, 33,604.
Charge, 4 lb. R.L.G.
Projectile, common and shrapnel shell, 25 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Tenths of Fuze.
yds.	° ′	secs.		yds.	° ′	secs.		yds.			
100	0 8	0·23	—	2,600	6 12	8·12	15·5	5,100			
200	0 18	0·47	1	2,700	6 33	8·50	16	5,200			
300	0 28	0·71	1·5	2,800	6 54	8·88	17	5,300			
400	0 38	0·96	2	2,900	7 17	9·26	18	5,400			
500	0 49	1·22	2·5	3,000	7 40	9·64	18·5	5,500			
600	1 0	1·59	3	3,100	8 3	10·03	19	5,600			
700	1 12	1·86	3·5	3,200	8 26	10·42	20	5,700			
800	1 24	2·14	4	3,300	8 50	10·82		5,800			
900	1 36	2·42	5	3,400	9 15	11·23		5,900			
1,000	1 49	2·71	5·5	3,500	9 42	11·65		6,000			
1,100	2 3	3·00	6	3,600	10 9	12·07		6,100			
1,200	2 16	3·30	7	3,700	10 36	12·49		6,200			
1,300	2 30	3·61	7·5	3,800	11 4	12·92		6,300			
1,400	2 45	3·92	8	3,900	11 32	13·35		6,400			
1,500	3 1	4·25	8·5	4,000	12 0	13·78		6,500			
1,600	3 17	4·58	9·5	4,100				6,600			
1,700	3 33	4·91	10	4,200				6,700			
1,800	3 49	5·25	10·5	4,300				6,800			
1,900	4 4	5·60	11	4,400				6,900			
2,000	4 20	5·95	11·5	4,500				7,000			
2,100	4 37	6·30	12	4,600				7,100			
2,200	4 55	6·65	13	4,700				7,200			
2,300	5 13	7·01	13·5	4,800				7,300			
2,400	5 32	7·38	14	4,900				7,400			
[illegible]	[illegible] 52	7·75	15	5,000				7,500			

Range Table for 16-pr. R.M.L. Gun of 12 Cwt.

Charge, 3 lbs.

Projectile, common or shrapnel shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								—			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.		yds.		yds.
100	0 0	0·25	0·05	2,100	4 33	6·25	1·25	1	200	11	1,875
200	0 0	0·50	0·10	2,200	4 51	6·60	1·30	1·5	295	12	2,020
300	0 7	0·76	0·15	2,300	5 10	6·96	1·40	2	390	13	2,165
400	0 19	1·03	0·20	2,400	5 30	7·32	1·45	2·5	485	14	2,305
500	0 31	1·30	0·25	2,500	5 50	7·69	1·55	3	575	15	2,445
600	0 44	1·58	0·30	2,600	6 10	8·06	1·60	3·5	665	16	2,580
700	0 57	1·86	0·35	2,700	6 30	8·44	1·70	4	755	17	2,715
800	1 10	2·15	0·40	2,800	6 51	8·82	1·75	4·5	840	18	2,845
900	1 24	2·44	0·50	2,900	7 12	9·21	1·85	5	925	19	2,975
1,000	1 38	2·73	0·55	3,000	7 33	9·60	1·95	5·5	1,010	20	3,100
1,100	1 52	3·02	0·60	3,100	7 55	10·0	2·00	6	1,095	21	3,220
1,200	2 6	3·32	0·65	3,200	8 17	10·41	2·10	6·5	1,175	22	3,335
1,300	2 21	3·63	0·75	3,300	8 39	10·83	2·15	7·	1,255	23	3,450
1,400	2 36	3·94	0·80	3,400	9 1	11·26	2·25	7·5	1,335	24	3,565
1,500	2 51	4·26	0·85	3,500	9 23	11·70	2·35	8	1,415	25	3,680
1,600	3 7	4·58	0·90	3,600	9 46	12·14	2·45	8·5	1,495	26	3,790
1,700	3 23	4·90	1·00	3,700	10 9	12·59	2·55	9	1,575	27	3,895
1,800	3 40	5·23	1·05	3,800	10 33	13·04	2·60	9·5	1,650	28	3,995
1,900	3 57	5·56	1·10	3,900	10 57	13·50	2·70	10	1,725		
2,000	4 15	5·90	1·20	4,000	11 22	13·96	2·80				

Range Table for 12-pr. Rifled B.L. Gun of 8 Cwt.

Charge, 1 lb. 8 ozs. R.L.G. powder.

Projectile, segment shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze. E. Time.	Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze. E. Time.
yds.	°	′	secs.	ins.	yds.	°	′	secs.	ins.
100	—		—	—	2,100	5	36	6·95	3·50
200	0	10	0·60	0·25	2,200	5	57	7·40	3·70
300	0	18	0·90	0·45	2,300	6	19	7·80	3·90
400	0	27	1·15	0·60	2,400	6	43	8·25	4·00
500	0	42	1·45	0·70	2,500	7	9	8·75	
600	0	58	1·75	0·85	2,600	7	36	9·25	
700	1	14	2·05	1·05	2,700	8	4	9·75	
800	1	32	2·40	1·20	2,800	8	33	10·25	
900	1	50	2·75	1·40	2,900				
1,000	2	8	3·05	1·55	3,000				
1,100	2	26	3·40	1·75	3,100				
1,200	2	44	3·70	1·90	3,200				
1,300	3	2	4·05	2·05	3,300				
1,400	3	20	4·40	2·20	3,400				
1,500	3	39	4·75	2·35	3,500				
1,600	3	58	5·10	2·55	3,600				
1,700	4	17	5·45	2·75	3,700				
1,800	4	36	5·80	2·95	3,800				
1,900	4	56	6·20	3·15	3,900				
2,000	5	16	6·60	3·30	4,000				

Range Table for 9-pr. Rifled M.L. Gun of 8 Cwt.

Charge, 1 lb. 12 ozs. R.L.G. powder.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								Fuze Scale.			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.		yds.	° ′	secs.			yds.		yds.
100	0 0	0·25		2,100	5 2	6·50		0	0	11	1,835
200	0 6	0·50		2,200	5 24	6·90		1	200	12	1,965
300	0 14	0·80		2,300	5 47	7·30		1·5	300	13	2,095
400	0 26	1·05		2,400	6 10	7·70		2	400	14	2,225
500	0 39	1·35		2,500	6 34	8·10		2·5	500	15	2,355
600	0 52	1·70		2,600	6 59	8·50		3	600	16	2,475
700	1 5	1·95		2,700	7 25	8·90		3·5	700	17	2,595
800	1 18	2·25		2,800	7 52	9·30		4	800	18	2,705
900	1 31	2·55		2,900	8 20	9·80		4·5	880	19	2,810
1,000	1 44	2·85		3,000	8 48	10·30		5	960	20	2,910
1,100	1 57	3·20		3,100	9 18	10·80		5·5	1,035		
1,200	2 12	3·55		3,200	9 49	11·40		6	1,110		
1,300	2 28	3·85		3,300	10 21	12·00		6·5	1,185		
1,400	2 45	4·15		3,400	10 53	12·70		7	1,260		
1,500	3 2	4·45		3,500	11 27	13·45		7·5	1,335		
1,600	3 20	4·75		3,600				8	1,410		
1,700	3 38	5·10		3,700				8·5	1,485		
1,800	3 58	5·45		3,800				9	1,555		
1,900	4 18	5·80		3,900				9·5	1,625		
2,000	4 40	6·15		4,000				10	1,695		

Case shot, 300 yards = 1°.

Range Table for 9-pr. Rifled B.L. Gun of 6 Cwt.

Charge, 1 lb. 2 ozs. R.L.G. powder.

Projectile, segment shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.		Time of Flight.	Lengths of Fuze.
yds.	°	′	secs.	ins.	yds.	°	′	secs.	ins.
100	—		—	—	2,100	6	25	7·40	3·65
200	0	15	0·65	0·25	2,200	6	50	7·80	3·85
300	0	25	0·95	0·40	2,300	7	17	8·25	4·00
400	0	41	1·25	0·55	2,400	7	47	8·70	
500	0	59	1·60	0·75	2,500	8	19	9·15	
600	1	18	1·95	0·90	2,600	8	52	9·65	
700	1	37	2·25	1·05	2,700				
800	1	56	2·60	1·25	2,800				
900	2	15	2·95	1·40	2,900				
1,000	2	34	3·25	1·55	3,000				
1,100	2	53	3·60	1·75	3,100				
1,200	3	12	3·95	1·90	3,200				
1,300	3	31	4·30	2·10	3,300				
1,400	3	51	4·65	2·25	3,400				
1,500	4	12	5·05	2·45	3,500				
1,600	4	33	5·40	2·65	3,600				
1,700	4	54	5·75	2·80	3,700				
1,800	5	15	6·15	3·00	3,800				
1,900	5	38	6·55	3·20	3,900				
2,000	6	1	7·00	3·45	4,000				

Range Table for 7-pr. Rifled M.L. Steel Gun, 150 Lbs.

Charge, 4 ozs. F.G. powder

Projectile, double shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								Fuze Scale.			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.	in.	yds.					yds.		yds.
100	1 18	0·76	0·15	2,100				1	75	12	825
200	2 45	1·50	0·25	2,200				1·5	110	13	885
300	4 12	2·25	0·40	2,300				2	150	14	940
400	5 47	3·04	0·55	2,400				2·5	185	15	995
500	7 26	3·84	0·70	2,500				3	225	16	1,050
600	9 12	4·67	0·85	2,600				3·5	260	17	1,100
700	11 4	5·52	1·00	2,700				4	300	18	1,150
800	13 6	6·40	1·15	2,800				4·5	335	19	1,200
900	15 14	7·35	1·35	2,900				5	370	20	1,250
1,000	17 25	8·30	1·50	3,000				5·5	405	21	1,295
1,100	19 42	9·33	1·70	3,100				6	440	22	1,340
1,200	22 10	10·42	1·90	3,200				6·5	475	23	1,385
1,300	25 0	11·60	2·10	3,300				7	510	24	1,425
1,400	27 55	12·86	2·35	3,400				7·5	545	25	1,465
1,500	30 55	14·23	2·60	3,500				8	575	26	1,505
1,600	34 7	15·72	2·85	3,600				8·5	605	27	1 540
1,700	37 37	17·33	3·15	3,700				9	640	28	1,575
1,800				3,800				9·5	670	29	1,610
1,900				3,900				10	705	30	1,645
2,000				4,000				11	765	31	1,680
										32	1,710

Range Table for 7-pr. Rifled M.L. Steel Gun, 150 Lbs.

Charge, 6 ozs. F.G. powder.

Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								Fuze Scale.			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance o Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.	ins.	yds.					yds.		yds.
100	0 26	0·4	0·05	2,100				1	130	11	1,215
200	0 50	0·9	0·15	2,200				1·5	190	12	1,305
300	1 19	1·3	0·25	2,300				2	250	13	1,395
400	1 54	1·8	0·30	2,400				2·5	310	14	1,475
500	2 29	2·3	0·40	2,500				3	370	15	1,555
600	3 5	2·8	0·50	2,600				3·5	425	16	1,635
700	3 44	3·3	0·60	2,700				4	480	17	1,715
800	4 25	3·8	0·70	2,800				4·5	535	18	1,795
900	5 9	4·3	0·80	2,900				5	590	19	1,875
1,000	5 54	4·9	0·90	3,000				5·5	645	20	1,950
1,100	6 41	5·4	1·00	3,100				6	700	21	2,025
1,200	7 30	6·0	1·10	3,200				6·5	755		
1,300	8 21	6·6	1·20	3,300				7	810		
1,400	9 15	7·2	1·30	3,400				7·5	865		
1,500	10 14	7·9	1·45	3,500				8	915		
1,600	11 15	8·6	1·55	3,600				8·5	965		
1,700	12 21	9·3	1·70	3,700				9	1,015		
1,800	13 30	10·0	1·80	3,800				9·5	1,065		
1,900	14 44	10·7	1·95	3,900				10	1,120		
2,000	16 0	11·4	2·05	4,000							

Range Table for 7-pr. Rifled M.L. Bronze Gun, 200 Lbs.

Charge, 4 ozs. F.G. powder.
Projectile, double shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								Fuze Scale.			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.	ins.	yds.					yds.		yds.
100	0 26	0·65	0·15	2,100				1	85	15	1,090
200	1 24	1·29	0·25	2,200				1·5	130	16	1,150
300	2 30	1·96	0·35	2,300				2	170	17	1,205
400	3 36	2·69	0·45	2,400				2·5	210	18	1,260
500	4 44	3·43	0·60	2,500				3	255	19	1,310
600	6 3	4·20	0·75	2,600				3·5	295	20	1,360
700	7 27	4·97	0·90	2,700				4	335	21	1,405
800	8 58	5·77	1·05	2,800				4·5	375	22	1,445
900	10 36	6·61	1·20	2,900				5	415	23	1,485
1,000	12 31	7·48	1·35	3,000				5·5	455	24	1,520
1,100	14 31	8·38	1·50	3,100				6	490	25	1,555
1,200	16 44	9·34	1·70	3,200				6·5	530	26	1,585
1,300	19 18	10·42	1·90	3,300				7	565	27	1,615
1,400	22 6	11·59	2·10	3,400				7·5	600	28	1,645
1,500	25 14	12·96	2·35	3,500				8	635	29	1,670
1,600	28 53	14·62	2·65	3,600				8·5	670	30	1,695
1,700	33 16	16·76	3·05	3,700				9	705	31	1,720
1,800	39 15	19·62	3·55	3,800				9·5	740	32	1,740
1,900				3,900				10	775	33	1,760
2,000				4,000				11	840	34	1,780
								12	905	35	1,795
								13	970	36	1,810
								14	1,030		

Range Table for 7-pr. Rifled M.L. Bronze Gun, 200 Lbs.

Charge, 8 ozs. F.G. powder.

Projectile, common shell.

Mean Elevation due to each 100 Yards of Range, by Interpolation.								Fuze Scale.			
Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Tenths of Fuze.	Range.	Tenths of Fuze.	Range.
yds.	° ′	secs.	ins.	yds.	° ′	secs.	ins.		yds.		yds.
100	0 13	0·36	0·05	2,100	10 49	10·02	1·80	1	150	12	1,510
200	0 29	0·76	0·15	2,200	11 40	10·63	1·90	1·5	220	13	1,615
300	0 47	1·17	0·20	2,300	12 33	11·26	2·00	2	290	14	1,715
400	1 6	1·58	0·30	2,400	13 27	11·90	2·15	2·5	355	15	1,815
500	1 26	2·00	0·35	2,500	14 23	12·54	2·25	3	420	16	1,915
600	1 48	2·42	0·45	2,600	15 21	13·20	2·35	3·5	485	17	2,015
700	2 11	2·85	0·50	2,700	16 21	13·88	2·50	4	550	18	2,110
800	2 36	3·30	0·60	2,800	17 23	14·58	2·60	4·5	615	19	2,200
900	3 3	3·76	0·65	2,900	18 27	15·30	2·75	5	680	20	2,290
1,000	3 31	4·23	0·75	3,000	19 32	16·04	2·85	5·5	745	21	2,380
1,100	4 0	4·70	0·85	3,100	20 39	16·80	3·00	6	810	22	2,470
1,200	4 31	5·18	0·95	3,200				6·5	875	23	2,555
1,300	5 5	5·67	1·00	3,300				7	935	24	2,640
1,400	5 41	6·17	1·10	3,400				7·5	995	25	2,720
1,500	6 19	6·68	1·20	3,500				8	1,055	26	2,800
1,600	6 59	7·20	1·30	3,600				8·5	1,115	27	2,875
1,700	7 41	7·74	1·40	3,700				9	1,175	28	2,950
1,800	8 25	8·30	1·50	3,800				9·5	1,230	29	3,025
1,900	9 11	8·86	1·60	3,900				10	1,285	30	3,100
2,000	9 59	9·43	1·70	4,000				11	1,400		

RANGE TABLE FOR 7-PR. STEEL RIFLED M.L. GUN OF 200 LBS.

Based on Practice of 25/8/76.
Minutes,
Charge, 12 ozs.
Projectile, common shell. Weight, 7¼ lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.
yds.	° ′	secs.		yds.	° ′	secs.		yds.	
100	0 18	0·31		2,600	11 30	11·05		5,100	
200	0 36	0·62		2,700	12 13	11·65		5,200	
300	0 54	0·93		2,800	12 56	12·25		5,300	
400	1 12	1·24		2,900	13 43	12·85		5,400	
500	1 30	1·57		3,000	14 30	13·46		5,500	
600	1 49	1·90		3,100	15 21	14·09		5,600	
700	2 9	2·26		3,200	16 12	14·74		5,700	
800	2 30	2·62		3,300	17 8	15·46		5,800	
900	2 51	2·98		3,400	18 4	16·14		5,900	
1,000	3 13	3·34		3,500	19 4	16·84		6,000	
1,100	3 36	3·71		3,600	20 4	17 54		6,100	
1,200	4 0	4·08		3,700	21 8	18 24		6,200	
1,300	4 24	4·52		3,800	22 12	18 94		6,300	
1,400	4 48	4·96		3,900	23 18	19 66		6,400	
1,500	5 16	5·40		4,000	24 24	20 40		6,500	
1,600	5 44	5·84		4,100				6,600	
1,700	6 14	6·32		4,200				6,700	
1,800	6 42	6·80		4,300				6,800	
1,900	7 14	7·30		4,400				6,900	
2,000	7 46	7·80		4,500				7,000	
2,100	8 19	8·31		4,600				7,100	
2,200	8 52	8·82		4,700				7,200	
2,300	9 30	9·35		4,800				7,300	
2,400	10 8	9·88		4,900				7,400	
2,500	10 49	10·46		5,000				7,500	

Tenths of Fuze.	Range.
1	160
1·5	240
2	320
2·5	400
3	475
3·5	550
4	625
4·5	700
5	770
5·5	840
6	910
6·5	975
7	1,040
7·5	1,105
8	1,170
8·5	1,230
9	1,290
9·5	1,350
10	1,410
11	1,530
12	1,640
13	1,750
14	1,860
15	1,960
16	2,060
17	2,160
19	2,260
19	2,350
20	2,440

Range Table for 7-pr. Steel Rifled M.L. Gun of 200 Lbs.

Based on Practice of 25/8/76.
Minutes,
Charge, 4 oz.
Projectile, double shell, 12 lbs.

Mean Elevation due to each 100 Yards of Range, by Interpolation.

Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Time of Flight.	Lengths of Fuze.	Distance of Object.	Elevation.	Tenths of Fuze.	Range.
yds.	° ′	secs.		yds.				yds.			
100				2,600				5,100		1 1·5	160 240
200				2,700				5,200		2 2·5	320 400
300				2,800				5,300		3 3·5	475 550
400				2,900				5,400		4 4·5	625 700
500				3,000				5,500		5 5·5	770 840
600				3,100				5,600		6 6·5	910 975
700				3,200				5,700		7 7·5	1,040 1,105
800				3,300				5,800		8 8·5	1,170 1,230
900				3,400				5,900		9 9·5	1,290 1,350
1,000	13 0	7·05		3,500				6,000		10 11	1,410 1,530
1,100	14 48	7·93		3,600				6,100		12 13	1,640 1,750
1,200	16 36	8·85		3,700				6,200		14 15	1,860 1,960
1,300	18 38	9·77		3,800				6,300		16 17	2,060 2,160
1,400	20 48	10·60		3,900				6,400		18 19	2,260 2,350
1,500	23 10	11·70		4,000				6,500		20	2,440
1,600	25 48	12·80		4,100				6,600			
1,700	28 50	14·0		4,200				6,700			
1,800	32 26	15·40		4,300				6,800			
1,900	36 24	17·0		4,400				6,900			
2,000	44 0	18·6		4,500				7,000			
2,100				4,600				7,100			
2,200				4,700				7,200			
2,300				4,800				7,300			
2,400				4,900				7,400			
2,500				5,000				7,500			

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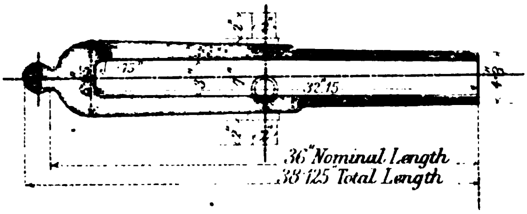
[6527.—550.—8/77.]
[6638.—1000.—8/77.]

ORDNANCE BRONZE R.M.L. 7-PR. 200 LBS.

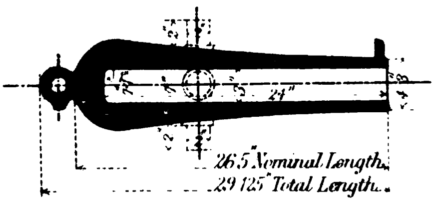
Scale 3/4 inch - 1 foot.

MARK III.



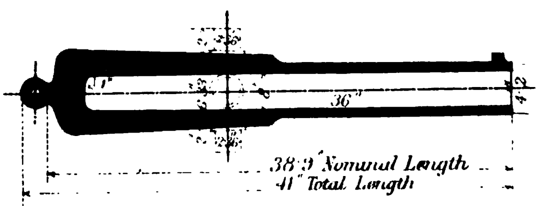
ORDNANCE STEEL R.M.L. 7-PR. 150 LBS.

MARK III.



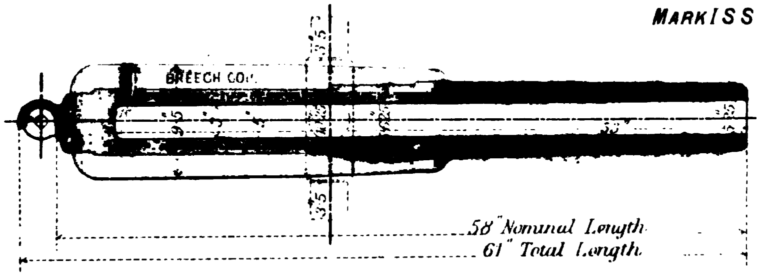
ORDNANCE STEEL R.M.L. 7-PR. 200 LBS.

MARK IV.

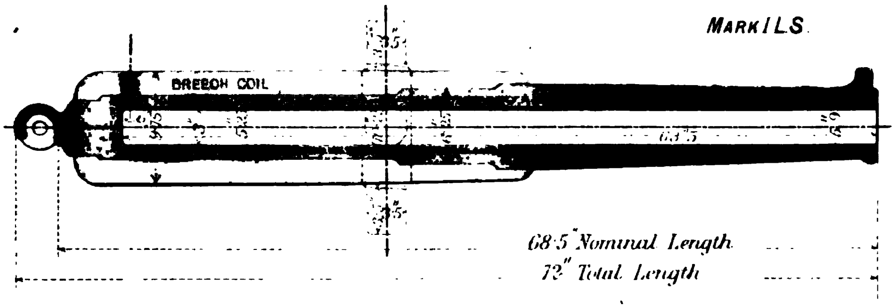


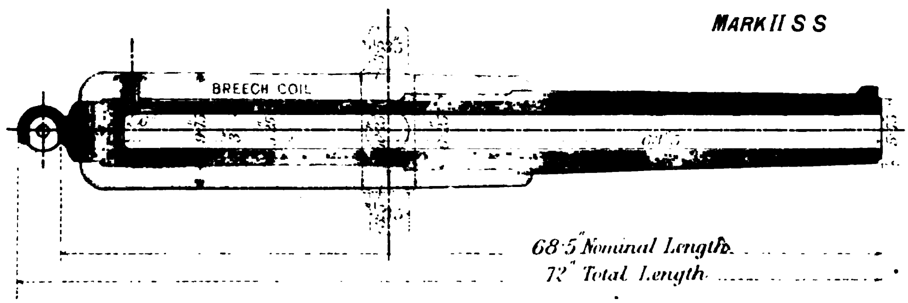
ORDNANCE WROUGHT IRON R.M.L 9-Pr 6 CWT.

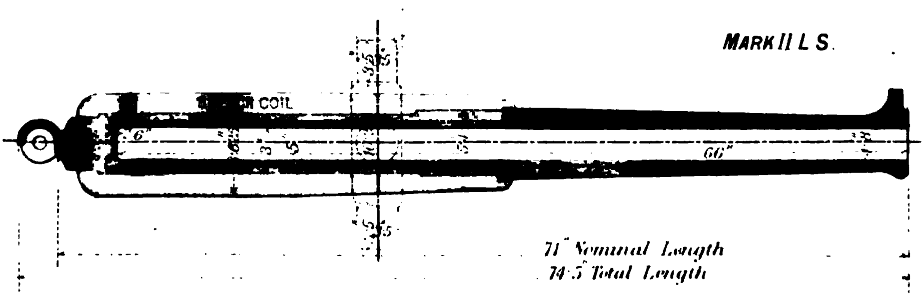
Scale ¾ inch = 1 foot



ORDNANCE WROUGHT IRON R.M.L 9-Pr. 8 CWT.



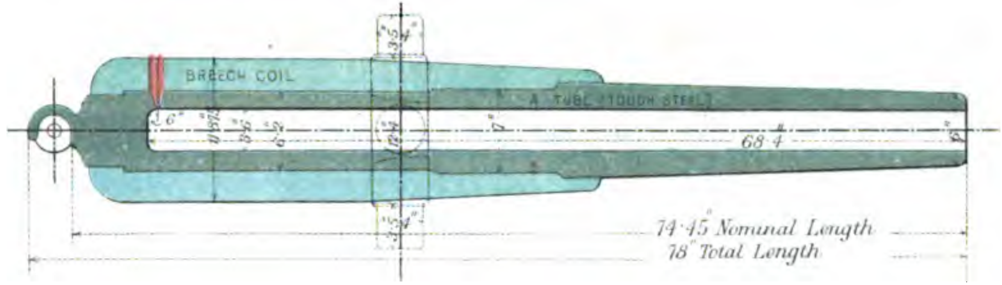




ORDNANCE WROUGHT IRON R. M. L. 16-Pr. 12 CWT. L. S.

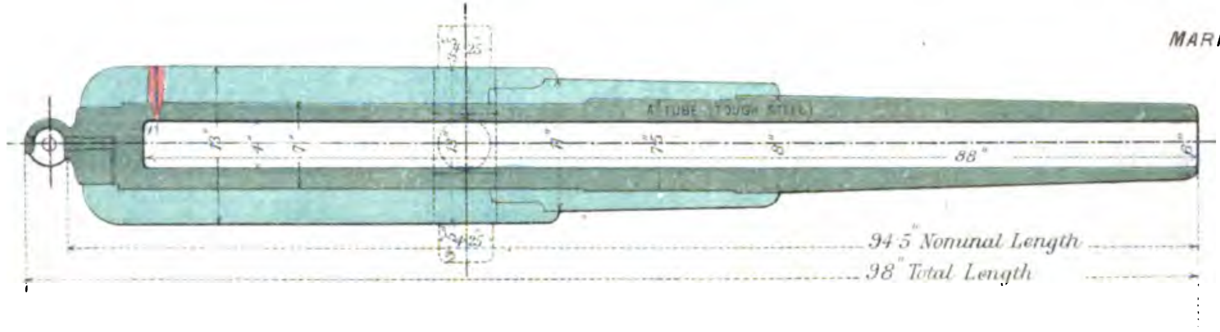
Scale ¾ inch = 1 foot

MARK I



ORDNANCE WROUGHT IRON R. M. L. 25-Pr. 18 CWT.

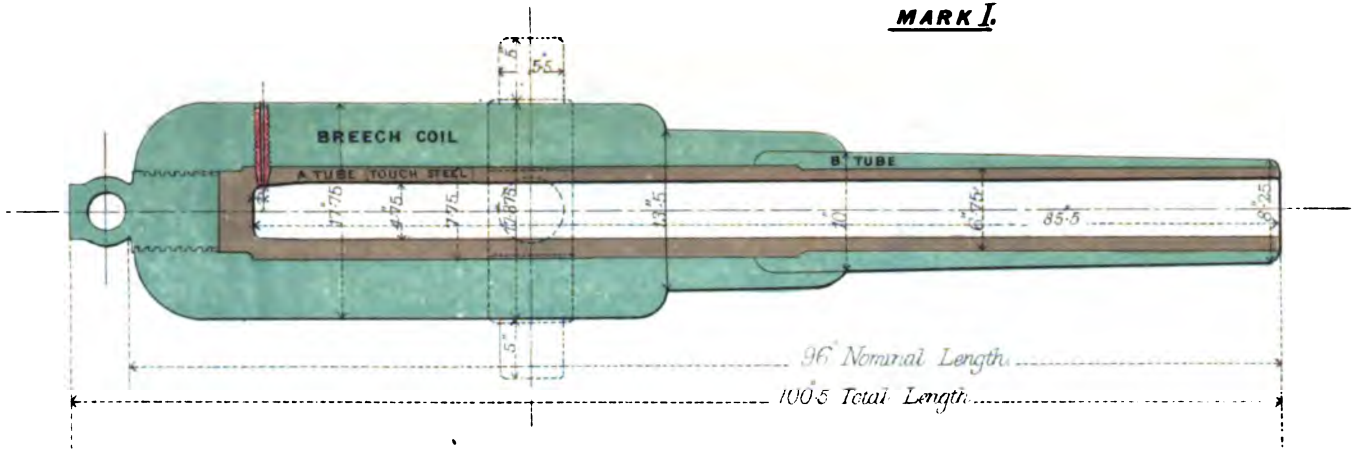
MARK II



Pl. IV.

40 PR. WROT. IRON GUN 34 CWT.

MARK I.



40 PR. WROT. IRON GUN 35 CWT.

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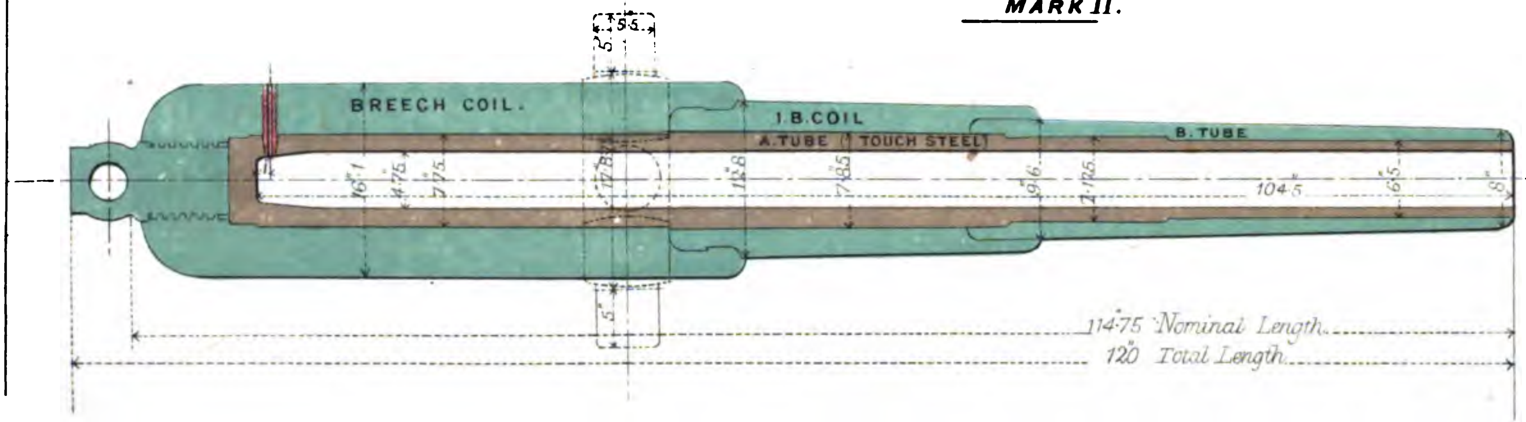
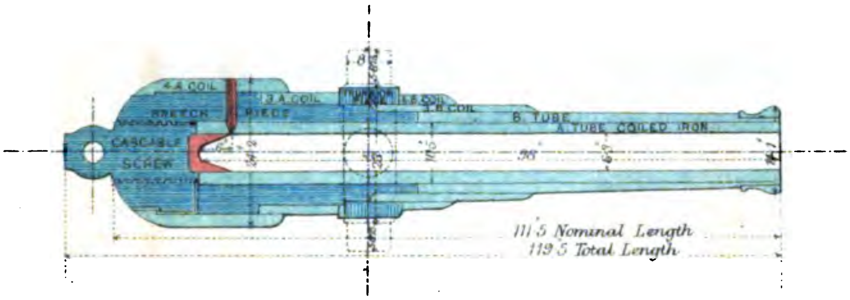


Dangerfield 22 Bedford St. Covent Garden

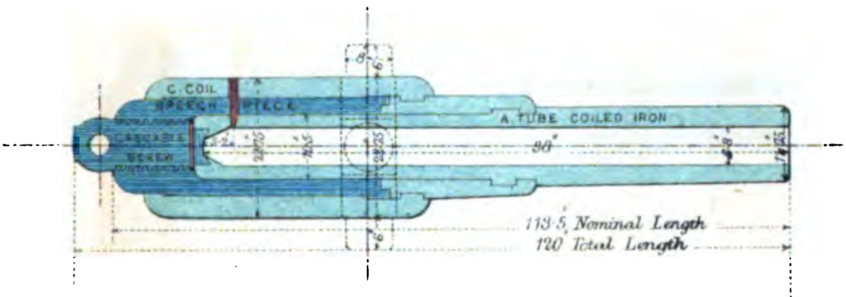
WROT IRON RIFLED MUZZLE LOADING 64 PR. GUNS OF 64 CWT.

Scale 3/8 Inch – 1 Foot.

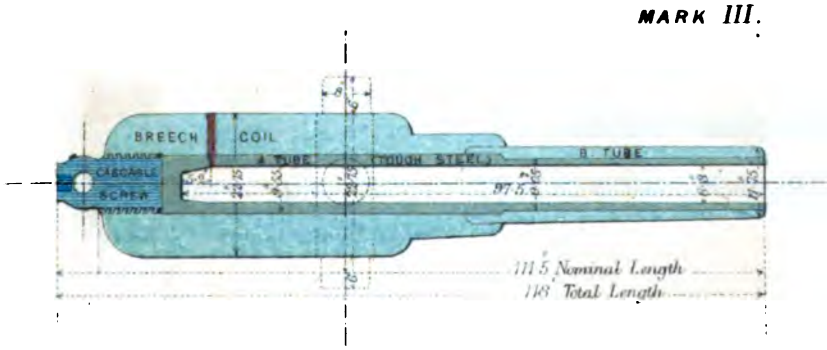
MARK I.



MARK II.



MARK III.

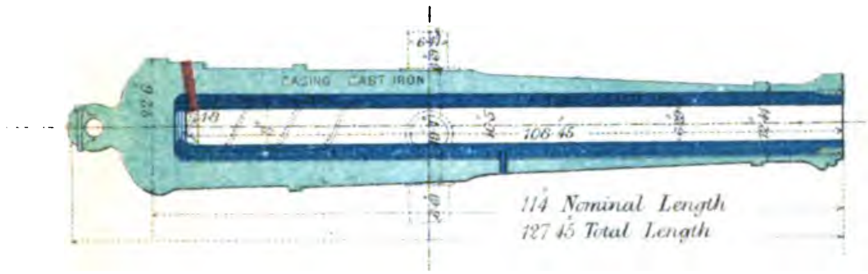


Spangerfield 22 Bedford St Covent Garden.

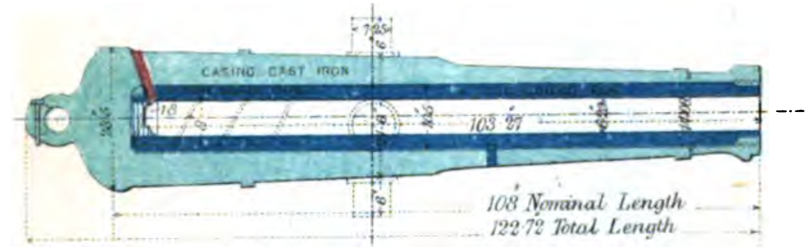
CONVERTED RIFLED M. L. GUNS.

Scale 3/8 Inch - 1 Foot.

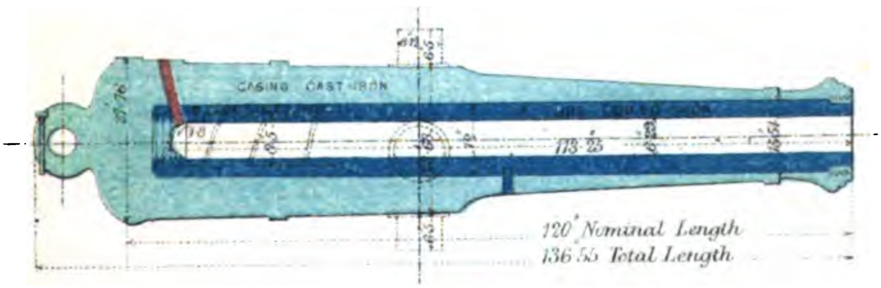
64 PR 58 CWT. FROM 32 PR 58 CWT.



64 PR 71 CWT. FROM 8 IN. 65 CWT.



80 PR 5 TONS FROM 68 PR 95 CWT.



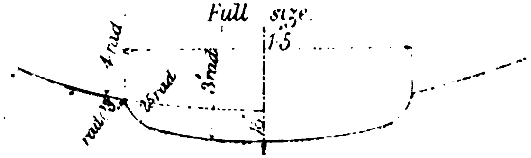
Dangerfield 22 Bedford St Covent Garden

ORDNANCE WRO! IRON MUZZLE LOADING HOWITZER 8 INCH 46 CWT. R. MARK I.

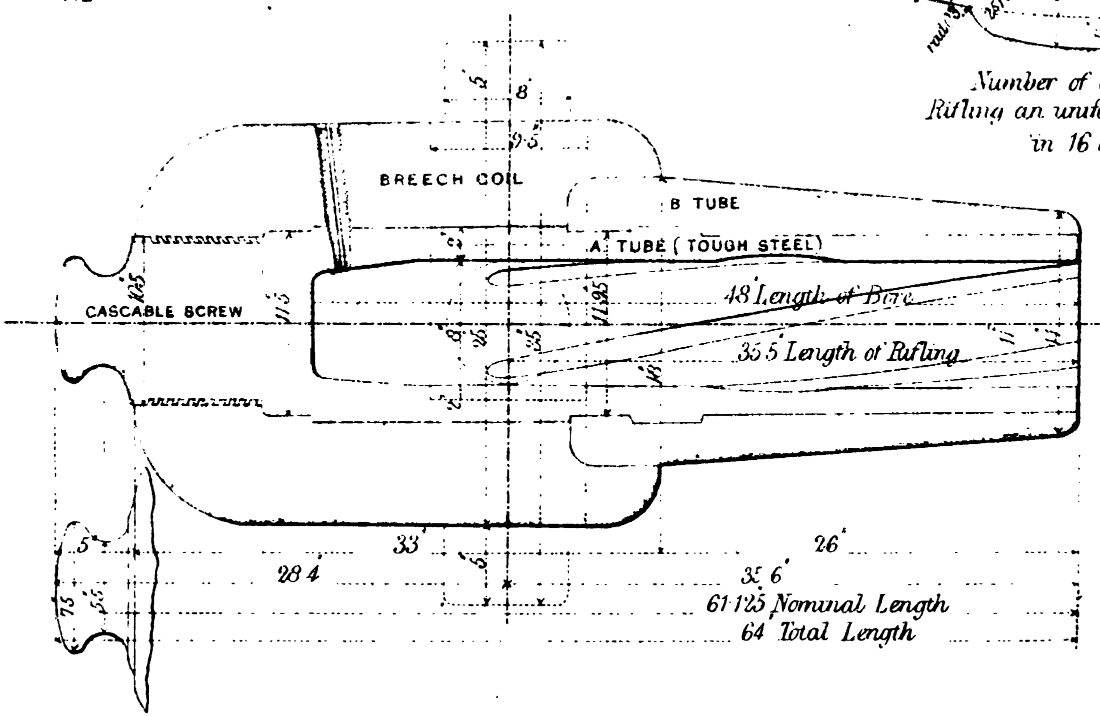
WEIGHT.. .. .. 46 CWT. 0 QR 12 LB.
PREPONDERANCE.....2 0. 12.

9.12.72 $\frac{73}{\frac{3}{4\cdot12}}$

SECTION OF GROOVE.
Full size.



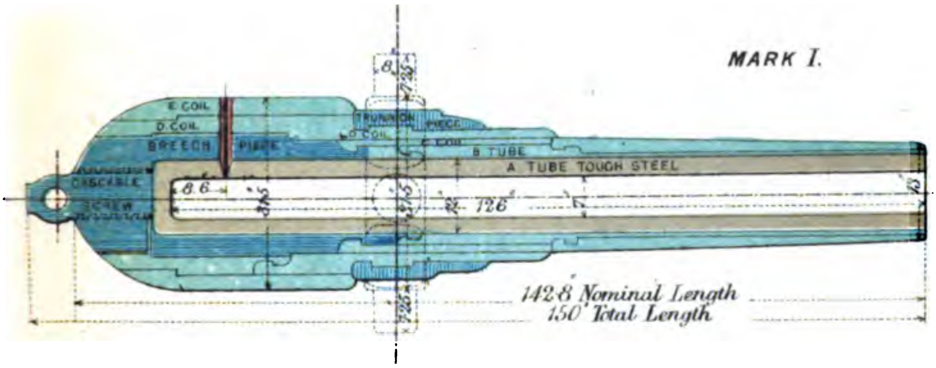
Number of Grooves 4
Rifling an uniform twist of 1 turn in 16 calibres.

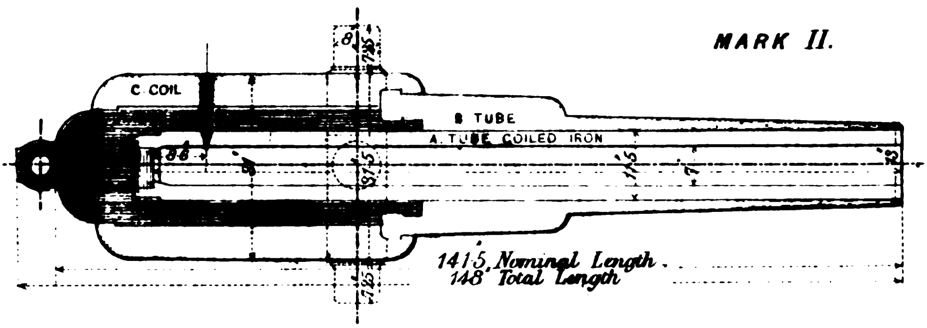


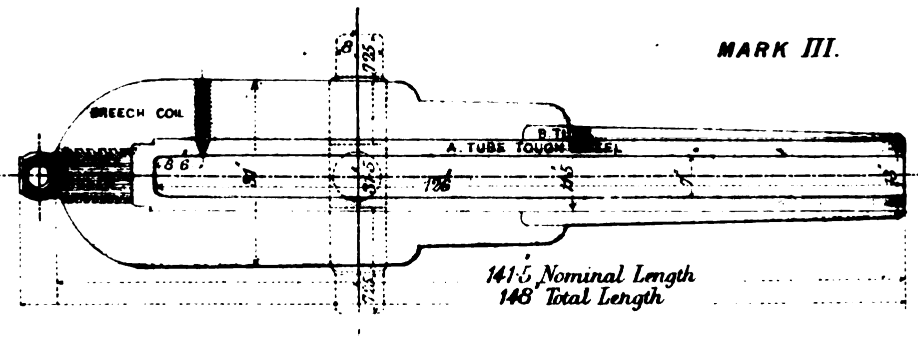
Pl. VII.

WROT IRON RIFLED MUZZLE LOADING 7 INCH GUNS OF 7 TONS.

Scale, ⅜ Inch – 1 Foot.





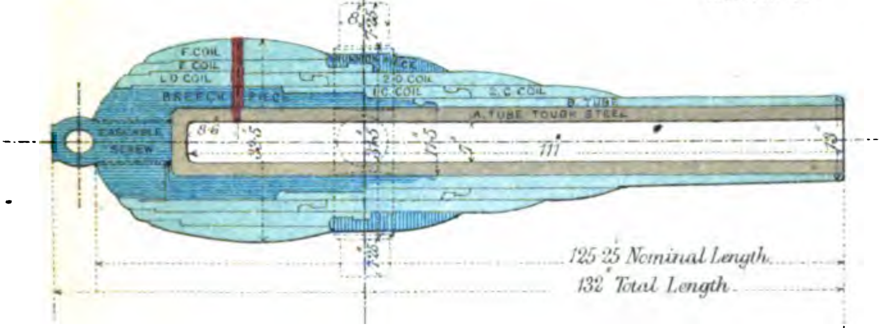


Dangerfield Lith. Bedford St Covent Garden

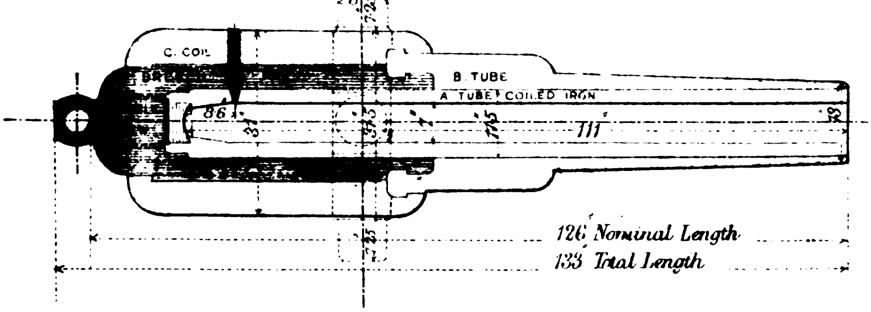
WROT IRON RIFLED MUZZLE LOADING 7 INCH GUNS OF 6½ TONS.

Scale ⅜ Inch – 1 Foot.

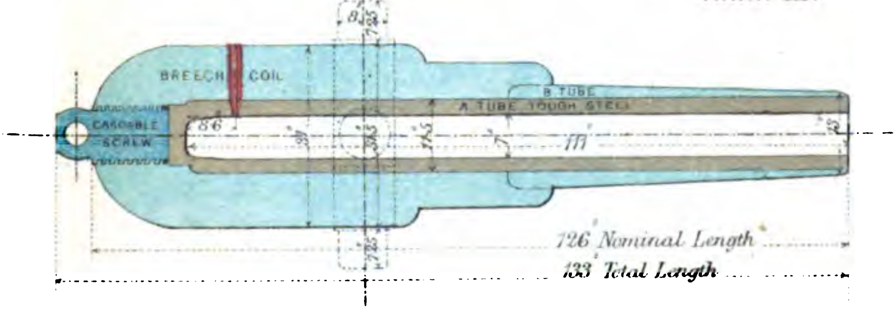
MARK I.



MARK II.



MARK III.



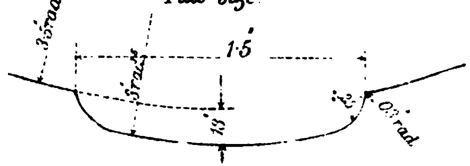
ORDNANCE WROT IRON RIFLED MUZZLE LOADING 7 INCH 90 CWT. MARK I.

§ 2363

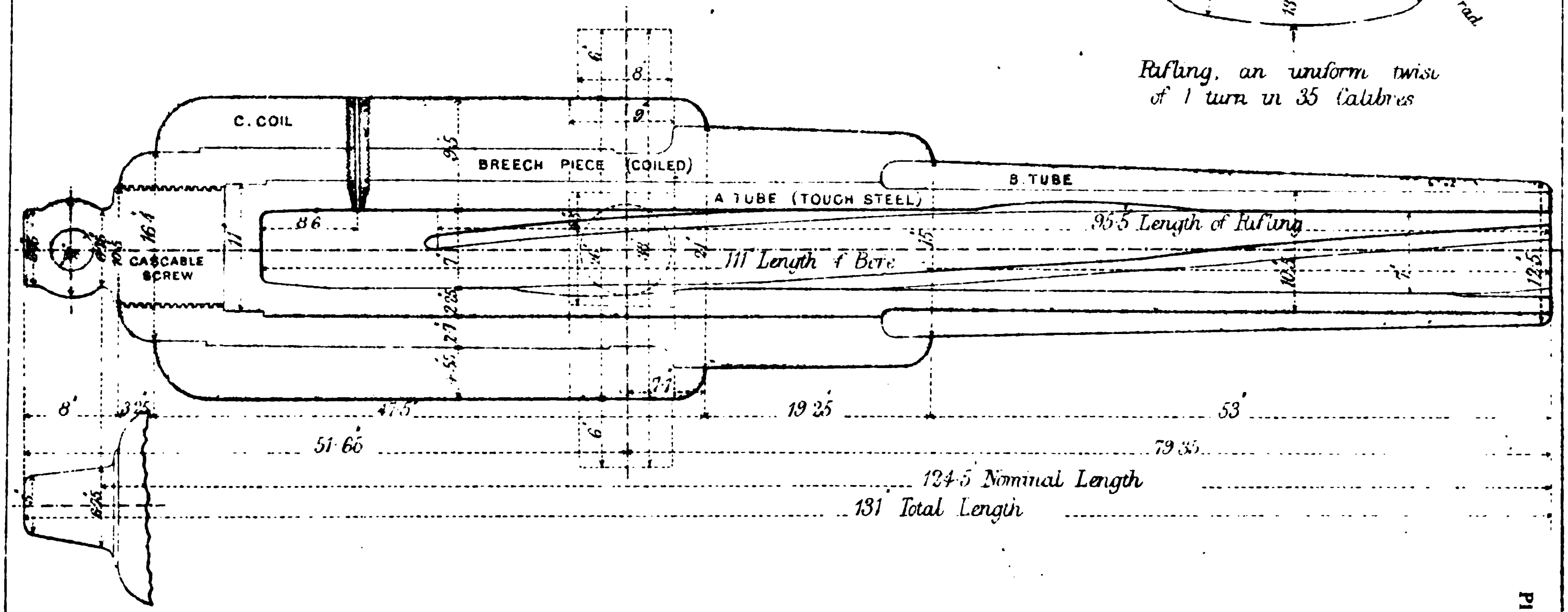
WEIGHT	89 CWT	1 QR	14 LB.
PREPONDERANCE	2.	1.	22.

5 . 10 . 72 $\frac{57}{\frac{2}{1427}}$

SECTION OF GROOVE.
Full size.



Rifling, an uniform twist of 1 turn in 35 Calibres

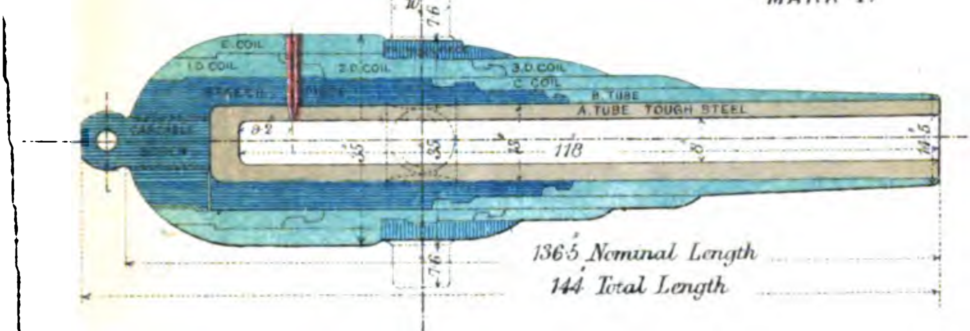


Pl. X.

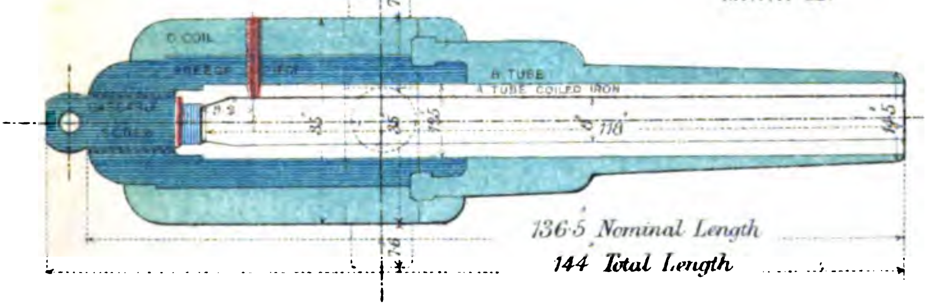
WROᵀ IRON RIFLED MUZZLE LOADING 8 INCH GUNS OF 9 TONS.

Scale ⅜ Inch – 1 Foot.

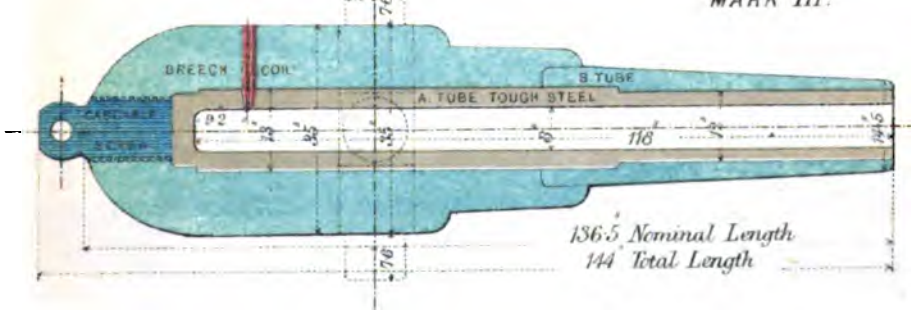
MARK I.



MARK II.



MARK III.

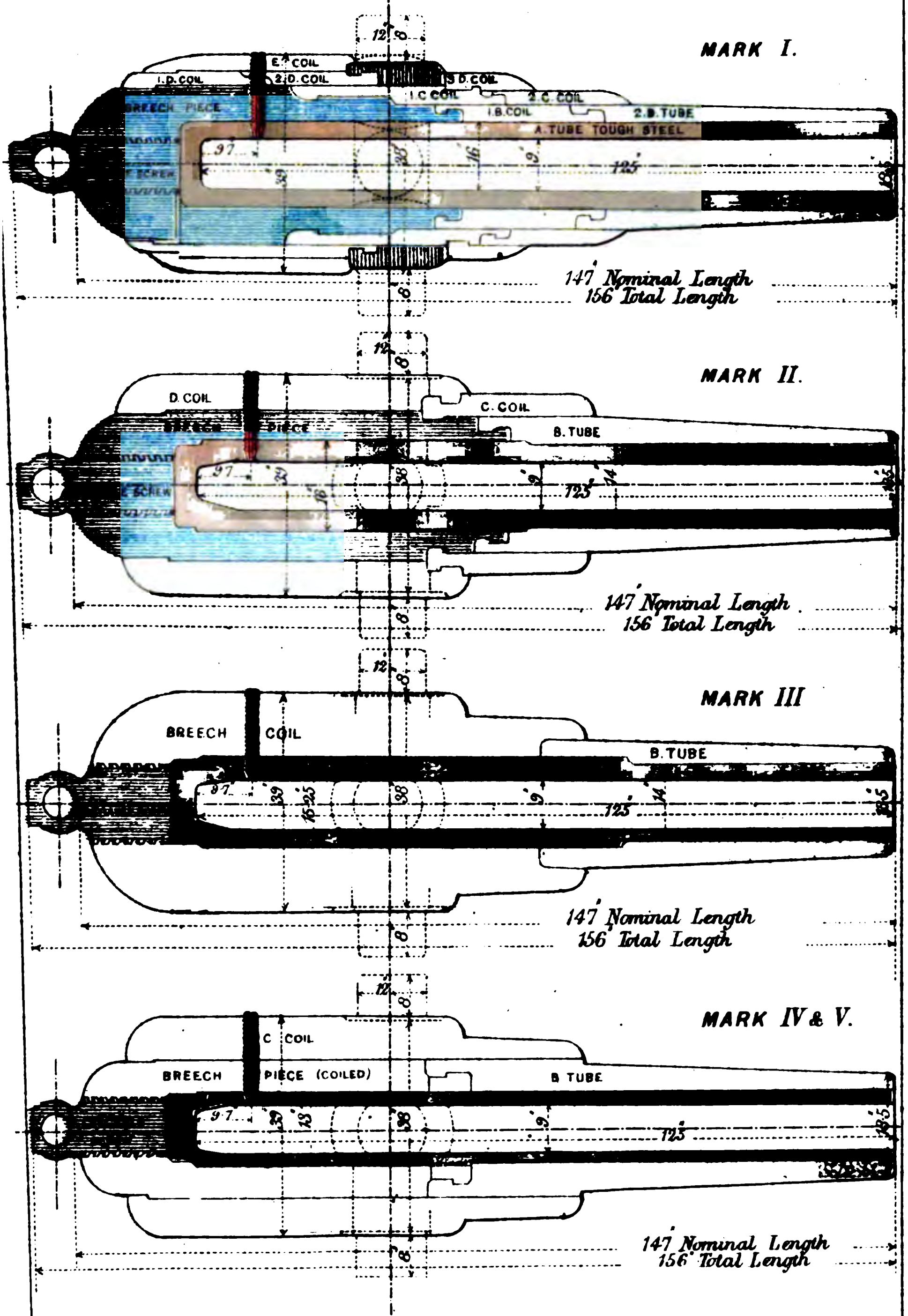


Hangerfield 22 Bedford Sᵗ Covent Garden

Pl. XII.

WROT IRON RIFLED MUZZLE LOADING 9 INCH GUNS OF 12 TONS.

Scale 3/8 Inch – 1 Foot.

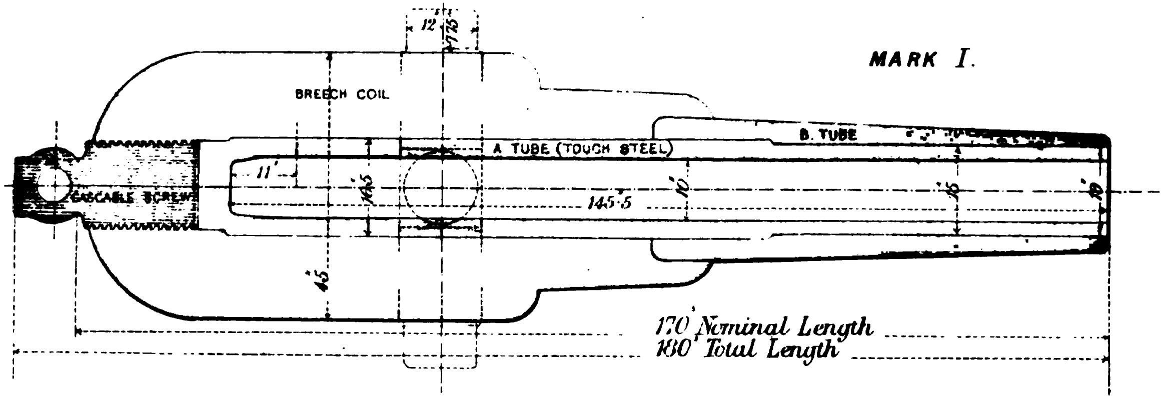


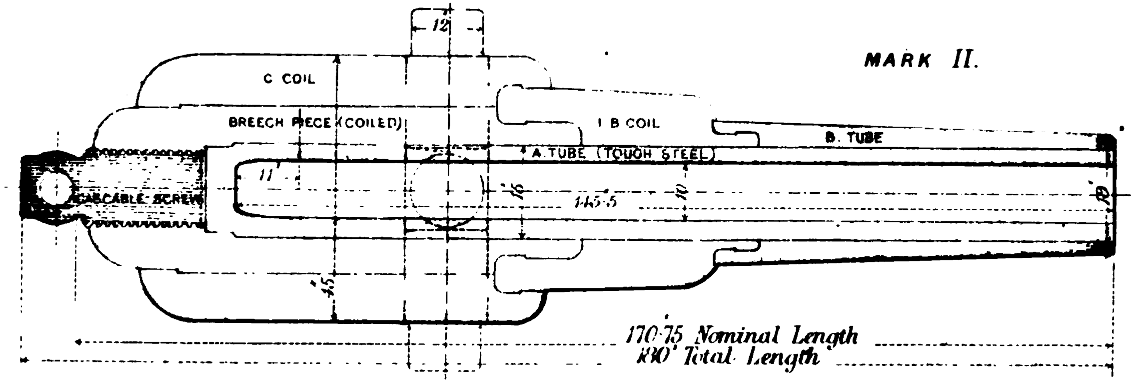
Dangerfield 22 Bedford St Covent Garden

Pl. XIII.

WROUGHT IRON RIFLED MUZZLE-LOADING 10 INCH GUN 18 TONS.

Scale 3/8 inch - 1 Foot.





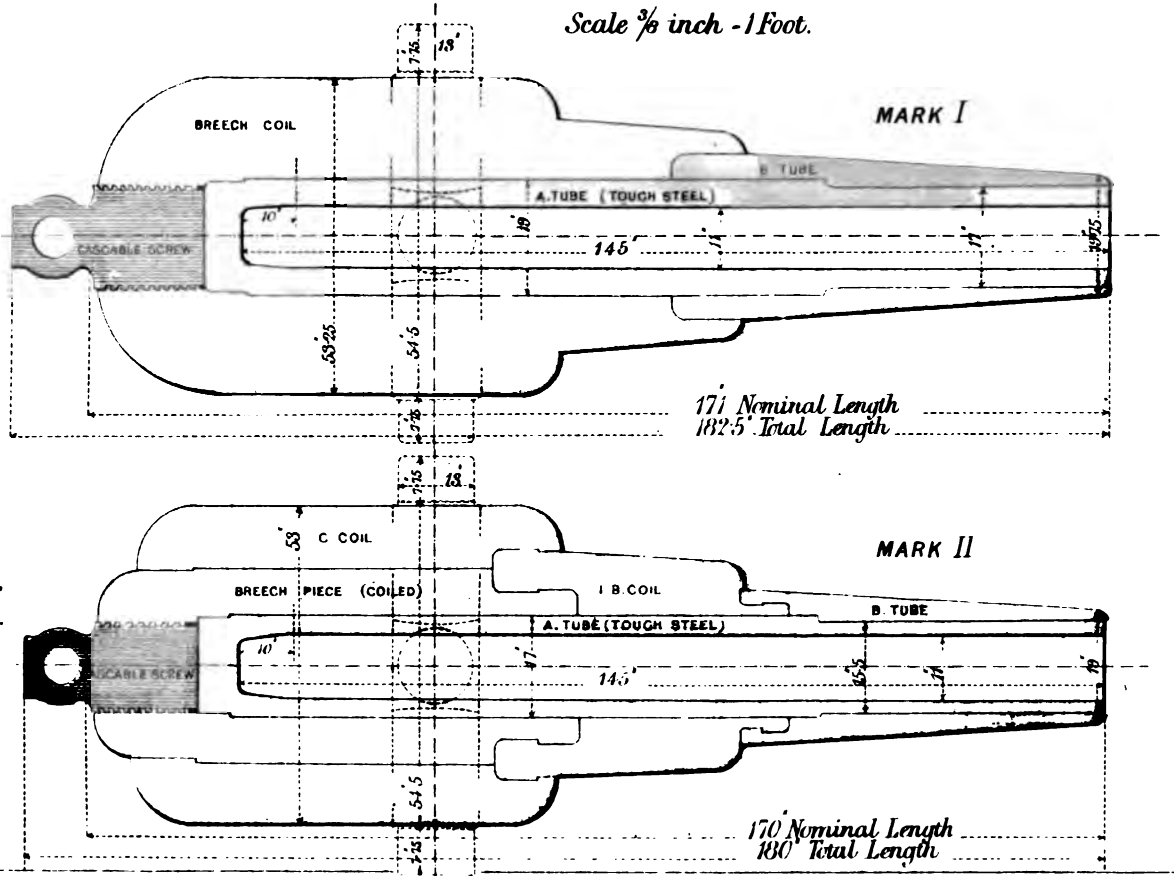
Note. These Guns when intended for Broadside use in the Navy and for Land Service are vented upon the right hand side at an angle of 45° with the vertical axis of gun. But when employed in double gun turrets are vented right and left i.e. upon the outsides of their respective positions.

Darlfield 26 Bedford St Covent Garden

Pl. XIV.

WROUGHT IRON RIFLED MUZZLE-LOADING 11 INCH GUN 25 TONS.

Scale 3/8 inch - 1 Foot.



Note. These Guns when intended for Broadside use in the Navy and for Land Service are vented upon the right-hand side at an angle of 45° with the vertical axis of gun. But when employed in double gun turrets are vented right and left i.e. upon the outsides of their respective positions.

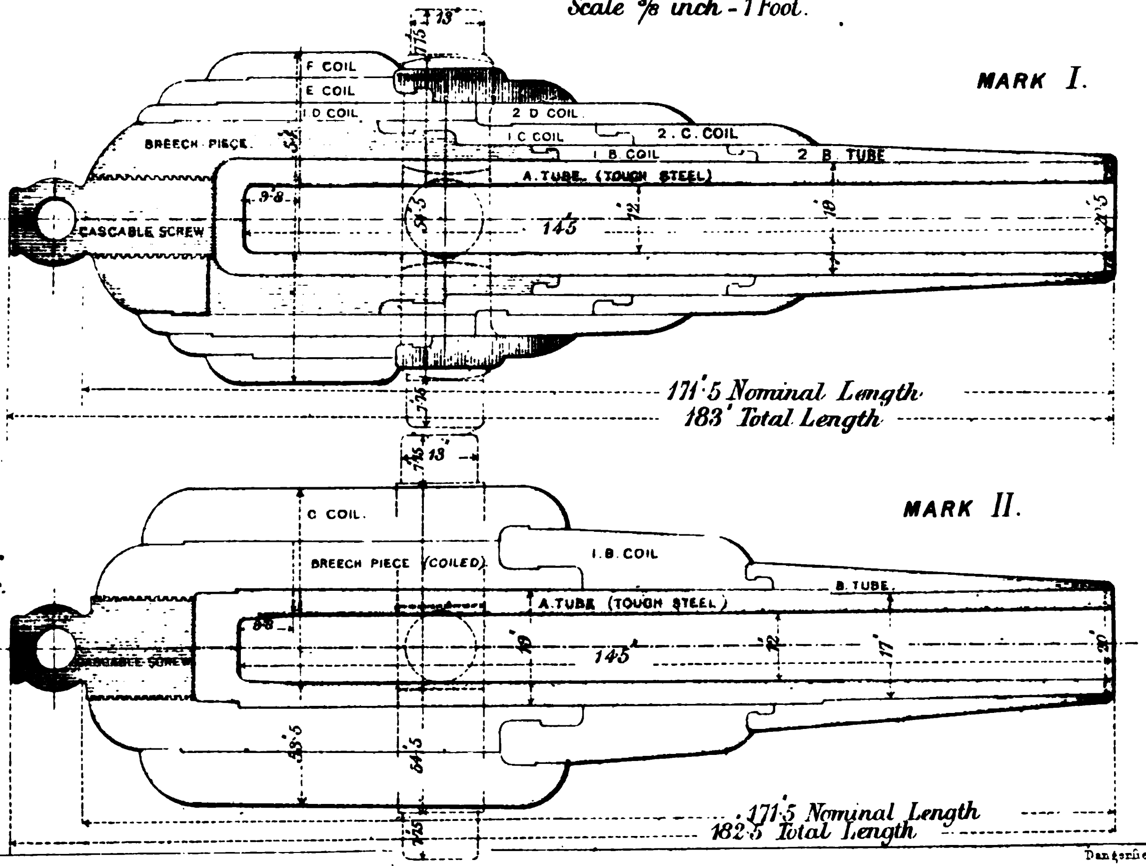
Hangerfield [illegible]

PI. XV.

WROUGHT IRON RIFLED MUZZLE-LOADING 12 INCH GUN 25 TONS.

Scale 3/8 inch - 1 Foot.

Note. These Guns when intended for Broadside use in the Navy and for Land Service are vented upon the right-hand side at an angle of 45° with the vertical axis of gun. But when employed in double gun turrets are vented right and left i. e. upon the outsides of their respective positions.

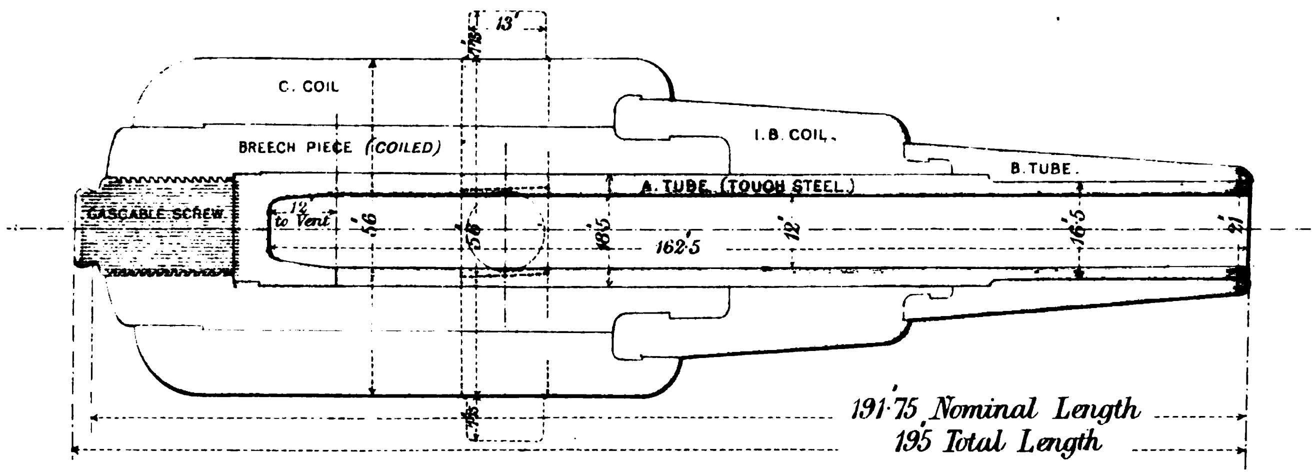


Dangerfield 22 Bedford S^t Covent Garden

PL. XVI.

WROUGHT IRON RIFLED MUZZLE-LOADING 12 INCH GUN 35 TONS.

Scale 3/8 inch – 1 Foot.



Dangerfield 22 Bedford St Covent Garden

ORDNANCE WROUGHT IRON RIFLED M. L. 12·5 INCH 38 TONS MARK I.

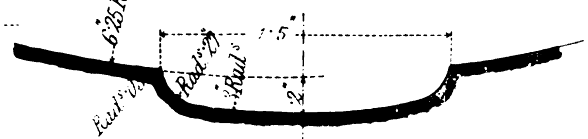
§ 2792.

7, 11, 74 $\frac{74}{2}$ 3259

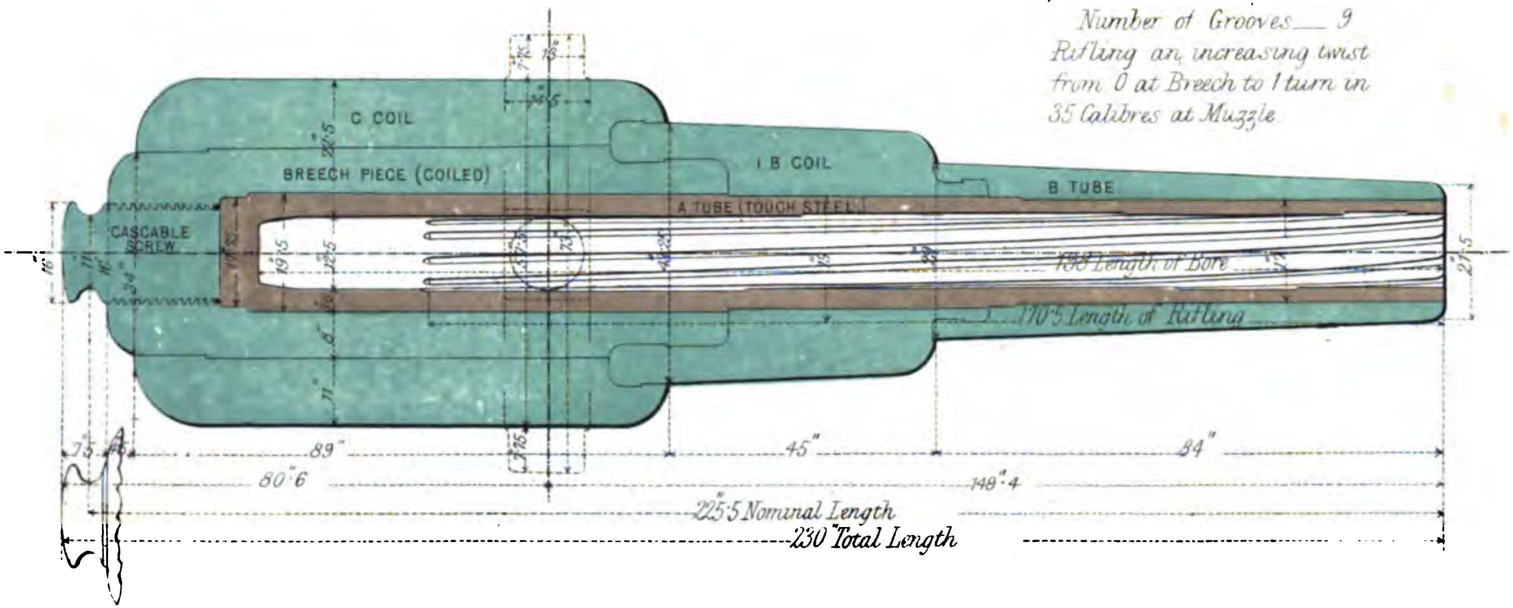
	TONS	CWT	QR	LB
WEIGHT	38	0	0	0
PREPONDERANGE	NIL			

SECTION OF GROOVE

Full size.



Number of Grooves — 9
Rifling an increasing twist from 0 at Breech to 1 turn in 35 Calibres at Muzzle



Pl. XVII.

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