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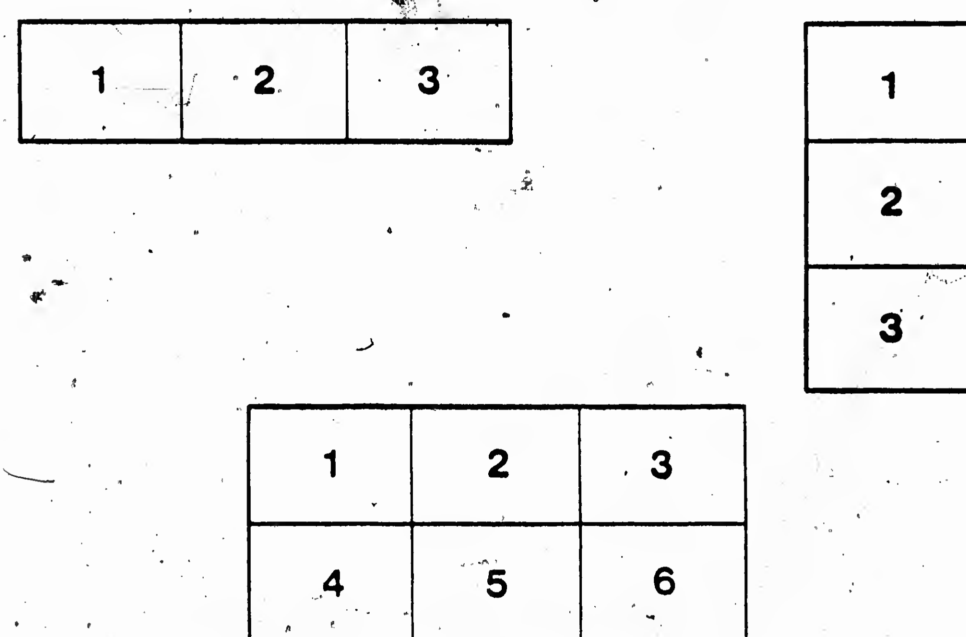
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NOTES ON ARTILLERY.

PART I.

BEING PRINCIPALLY EXTRACTS FROM ROYAL ARSENAL TEXT BOOKS,

FOR THE USE OF

THE CADETS

OF THE

Royal Military College of Canada.

BY

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CAPTAIN ROYAL ARTILLERY,

INSTRUCTOR OF MATHEMATICS AND ARTILLERY.

KINGSTON:

WILLIAM BAILIE, PRINTER.

1879.

The following notes are not intended for a text book, but have been compiled in order to bring the subject up to date, and save the time that would be otherwise occupied in dictation.

They comprise the following subjects :

Ammunition, S.B. and R.

Ordnance, S.B. and R.

Carriages, Field, Siege and Garrison.

Manufacture of ordnance and properties of materials.

S. G. F.

NOTES ON ARTILLERY.

AMMUNITION.

Ammunition, strictly speaking, includes everything connected with the firing of a gun, the powder and cartridge, wads (if used) projectiles and fittings, and also the various tubes and other means of firing a gun.

Powder will be considered separately, and it is practically the only explosive made use of to propel a projectile, gun cotton proving too violent and uncertain in its action, it is, however, under certain restrictions, used occasionally for the bursting of shell, and in minor operations, as are also detonating compositions of various kinds.

We will divide our subject into the following sections:

Cartridges.

Projectiles and their fittings.

Means of firing ordnance and sundries.

Cartridges. All cartridges till a late date were made of a sort of serge, but it has been considered advisable, for several reasons to introduce a coarse silk cloth in its place, for all charges for R. M. L. guns, and for blank cartridges for S. B.

The following qualities are necessary in a cartridge:

Qualities necessary in a Cartridge Cloth.

1. The material should be strong enough to bear reasonable knocking about when filled, and to stand the wear and tear of travel.

2. Its texture should be close enough to prevent dust from the powder working its way out, at the same time it should be permeable to the flash from the tube without its being necessary to prick the cartridge.

3. More important than all, the material should consume entirely when the gun is fired, or if this end cannot be obtained the residue should not smoulder or leave sparks in the bore.

It was chiefly on account of the third requisite that serge or "flannel", as it is often termed, was discarded for blank cartridges, for there being no resistance from a shot the material was not so completely consumed, and accidents happened from fire being left in the bore.

Again the serge was not found to be strong enough to bear the weight of heavy cartridges, especially when filled with the large grains of "P" powder, and in every way silk cloth, though more expensive, is superior to it; it is stronger, closer in texture, and not liable to smoulder. It is better therefore for heavy charges, and for field service, the knocking about does not work the dust through the material.

For service charges of R. B. L. and S. B. it has not been considered necessary to make any alteration.

Silk cloth is now to be used for all rifled R. M. L. ordnance, and also for the *blank* cartridges for S. B. and R. B. L. ordnance. However, till the large existing stock of serge cartridges have been used up, they are to be retained, except for charges of 85 lbs. and over.

4 oz. 7-pr.

There is one other exception, the 4 oz. charge for the 7-pr. is of red shalloon, a thinner material being desirable. Great care is to be taken to exclude any cotton from the material used, it being very liable to hold fire, for the same reason paint must never be used for marking cartridges, only printer's ink.

Precautions.

Before filling cartridges, care should be taken that they are sound and not moth-eaten.

All cartridges consist of a bag which is "choked" and "hooped" when filled by weight. Care is to be taken, especially with rifled cartridges, that the hooping is carefully done, so that they are the proper length and diameter, both of which are carefully guaged.

The choking closes the mouth, the hooping preserves the shape.

All S. B. serge cartridges are choked and hooped with worsted.

All S. B. silk cartridges are choked and hooped with silk twist, except the 5 lb. cartridge for 32-pr., which has silk braid.

All B. L. cartridges are choked with twine and hooped with blue worsted braid.

All R. M. L. serge cartridges are choked with worsted and hooped with blue worsted braid.

All R. M. L. silk cartridges are choked and hooped with silk hoops, twist or braid, according to size.

Marks. All cartridges are marked in black with the nature of the gun for which they are intended, the weight of their contents, &c.

S. B. cartridges are conical for gomer shaped chambers, and cylindrical for all other S. B. ordnance. The hooping is done after the choking by passing two or three loops round the cartridge, with the needle and worsted, and drawing them tight.

Charges. Shot guns, service charge about $\frac{1}{3}$ to $\frac{1}{4}$ weight of shot.

Shell guns, service charge about 1-6 to 1-12 weight of shot.

Carronades, service charge about 1-12 weight of shot.

Reduced charges. *Reduced* charges have to be used when firing at a great *depression* to avoid dismounting the gun.

From 15° to 30° $\frac{1}{2}$ charge.

" 30° to 50° $\frac{1}{4}$ "

Also for curved enfilade fire with shot (Ricochet) reduced changes are also necessary, from $\frac{1}{32}$nd to $\frac{1}{12}$th weight of projectile, and range about 400 to 600 yards.

8 in. charge. The 5 lb. charge from the 8 in. S. B. gun is too short for the chamber, and a coal dust wad in a blue serge bag is placed in it to make up length.

Gauge. These cartridges are all gauged with ring gauges, which should pass freely over them.

R. B. L. Ordnance.

The cartridges for these guns are of rather a complicated construction, and have to be more carefully made;

they have not only to fit closely into the chamber but have to entirely fill it, besides this they carry the lubricating material necessary to prevent leading of the bore.

Paper cylinder. In order that the chamber may be filled, it is necessary in the 20-pr., 40-pr. and 7 in. R. B. L. guns that a paper cylinder be placed in the cartridge to make it of proper length; this is placed in the cartridge after the first half of the powder has been put in, so as to be about the centre of the cartridge. There is one size for 7 in. 10 lb. charge, another size serves for 40-pr. and 7 in. 11 lb. cartridge, there is a small one for the 20-pr.

The cartridges for all B.L. guns are of serge, and hooped with braid. They are made in two pieces, a circular base and a rectangular piece to form the cylindrical part.

Charge. The charge is about one-eighth the weight of projectile. For the 7 in. guns there are charges of 11 lbs. and 10 lbs., for the 82 cwt. and 72 cwt. respectively, so that they are about one-ninth and one-tenth the weight.

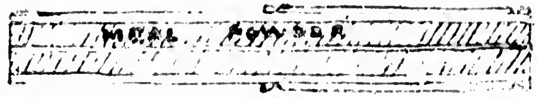
Lubricator. The lubricator consists of two thin tinned iron cups soldered together, filled with equal parts tallow and linseed oil, attached to this is a felt-wad in the form of a ring coated with beeswax, and backed by a mill-board disc; in the lower natures it is placed in the cartridge just above the powder, but in the 40-pr. for S. S. and in the 7 in. it is carried separate for convenience a wooden socket being choked into the cartridge, and a screw stalk is fastened to the lubricator proper, to fit into the wooden socket, serving at the same time to attach the three portions of the lubricator together. The lubricator is crushed up on the discharge of the gun, and the bore is cleared by the grease and the felt-wad. **40-pr. 7 in.**

Lubricators are issued, packed in wooden cases, of various sizes.

Saluting and Exercising. These cartridges are similar to the service cartridges, but contain less powder, and have no paper cylinder or lubricator, and have a becket of braid sewn on behind to facilitate unloading.

The 12-pr. and 9-pr. have a sawdust cartridge stitched

VENTPIECE PRIMER



on in front to lengthen it, to prevent its being rammed too far forward.

They are at present made of serge, but will shortly be superseded by silk cloth.

Although they have, strictly speaking, nothing to do with cartridges, still it may not be amiss to describe tin cups here, and also primers, for they are indirectly connected with them. Tin Cups.

The former are discs of tinned iron, with a rim .32 inches deep, turned in towards the bore, which is pressed back against the sides of the bore by the explosion, and the escape of gas prevented.

They have a central hole to allow of passage of flash, and to facilitate extraction.

They are always used with the 7 in., but for practice only with the lower natures, they having a copper bush, that stands the explosion well.

Primers are used for the 7 in. and 40-pr., to carry on and supplement the flash from the tube, to ensure ignition of cartridges, which, as the flame has to turn a right angle, is not otherwise very certain. They are 2½ inches long and are formed of paper made from leather pulp, and are driven with mealed powder, pierced with a small hole, to cause instantaneous explosion. They have strips of worsted attached to prevent them being blown out of vent piece before they explode. Primers.

R. M. L. Ordnance.

Field Guns have cylindrical cartridges, made of a circular and a rectangular piece, those for the 7-pr. are an exception, being made of one piece. As before stated, they will in future be made entirely of silk cloth, there being the 4 oz. charge for 7-pr. of red shalloon. Field guns.

R. L. G. is the proper powder for all except the 7-pr., but there is a large stock of L. G. to be used up. Powder used.

The guns are *undersighted* for L. G., R. L. G. giving a better velocity.

F. G. or R. F. G. is used for the 7-pr. cartridges, as, owing to the short bore a quick burning powder is necessary.

There are different charges for the steel and bronze 7-pr. guns, and a small charge of 4 ozs. for both natures, when using double shell.

Siege Ordnance and 80-pr.

These cartridges are made in the same way with circular base and cylindrical bodies, and are loaded with R. L. G. or L. G. till used up.

The cartridges for 64-pr. and 80-pr. are cylinder-conical, the silk or serge being in one piece and sewn with an overlap.

There are various reduced charges for the howitzers, a complete table of which will be given.

Heavy Ordnance.

Heavy Ordnance have generally both a "full" and a "battering" charge for each gun.

As a general rule "P" powder is used for all battering charges (except the 12.5 in. which takes "P2") and for all full charges of 40 lbs. and upwards. Battering charges are used on all occasions with Palliser projectiles, and with all projectiles when actually engaging an enemy, in firing in a casemated battery, the recoil not being sufficient with the full charge and time is lost running back.

The full charge is the ordinary charge for common, shrapnel and double shell and case shot.

Pebble powder is used with the heavy charges, as it does not stain the gun so much.

When no P. is available charges of R.L.G. may be used, but they are smaller, and the cartridge has to be more tightly drawn together to make up the proper length to fill the corrugated cases.

The battering charges of P. are generally about one-fifth or one-sixth of the weight of the projectile. That for the 25 ton 12 in. gun is only one-seventh, and that for the 7 in. is one-fourth.

For the battering charge of the 12.5 in. gun the 160 lbs. of P2 was a very awkward size, and it has been divided into two, each containing 80 lbs. and marked "Half charge."

Each cartridge has a wooden stick about 1 in. diameter down the centre, of fixed length. These touch each other when the two cartridges are rammed home, and ensure the projectile stopping at same spot each time, and the air space in each round is constant.

PROJECTILES.

These projectiles have undergone little or no alteration for many years, and are becoming obsolete; they, however, are to be met with in this country and in many outstations. S.B.

There are the following natures of shot: Solid, Case, Grape and Sand.

Solid shot are made of all calibres except the 10 in., from 3-pr. to 68-pr. inclusive. They are attached to wood bottoms for bronze guns and guns of position. 1. Solid shot.

Shot are used against masonry, wooden shipping, and masses of men.

Shot are fired from guns and carronades. They are not fired from shell guns 8 in. and 10 in.*

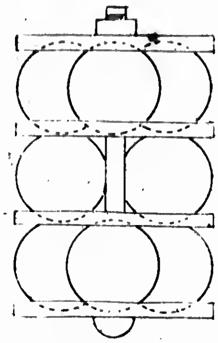
Loose for garrison service. Loose, prepared for bottoms for Indian F.S., Riveted and boxed for F.S. Issue.

2. *Case shot* are made of all calibres; they consist of sand shot made up in cylinders, and packed in wood shavings or saw dust. 2. Shot, case.

The 10 in., 8 in, or 68-pr., and 32-pr. have the cylinder made of sheet iron with iron ends and handle; the 10 in., and 8 in., or 68-pr. are rounded at the bottom to facilitate loading. The 56, 42, 24, and 18-prs. have the cylinder made of tin with an iron bottom and rope handle. The bronze guns, howitzers and iron guns of the same calibre, viz., 6, 9, and 12-pr. guns, $4\frac{2}{5}$ in., 12.pr., 24-pr., and 32-pr. howitzers have the cylinder made of tin with a wooden bottom to avoid injury to the bore of the bronze guns, and for the sake of similarity of pattern in the case of the iron guns.

*When fired under 3° of elevation, grummet wads are used, consisting of rope bent in a circle, and held in position by two cross pieces of small rope. The cross pieces go outside next the rammer head, otherwise they may be withdrawn by the rammer.

Grape Shot



The case shot for the $5\frac{1}{2}$ in. iron howitzer has also a wooden bottom.

Carronade case is not issued. Gun or howitzer case is used instead. Case for bronze howitzers has H. stencilled in white, an inch and a half long, to distinguish it.

In loading, the rule is always to put the handle away from the charge, except when it is made of rope, when the reverse is the case. The wood bottom goes next the charge.

Case shot are filled with sand shot, which vary in weight from 1 lb. to 8 oz. with heavy guns down to 32-pr., and vary from 8 oz. to 2 oz. with the smaller guns.

Case shot are fired from all natures of guns, howitzers and carronades, against troops in masses, for flanking ditches, &c., and against boats and rigging of ships. They are effective up to 350 yards. Use.

3. *Grape shot* of all calibres from 6.pr. to 10 inch inclusive, is being superseded by case. The pattern at present in use is "Caffin's" pattern. 3. Shot, grape

The sand shot are held in position by four iron circular plates pierced with holes to grip the shot, an iron spindle passes through the plates, and a nut which screws on to the head of the spindle binds the plates and shot together.

The 10 in. gun has special grape made up in cylinders like case, but has larger balls; it is known by having G. stencilled on it in white, an inch and a half long.

The sand shot vary in weight from 4 lbs. to $13\frac{1}{8}$ oz.; it will be seen that they are heavier than the sand shot used for case, and consequently there are fewer of them.

Grape was used for the same purpose as case; it is effective at rather longer ranges than case, and would probably be more destructive to boats and rigging. It may be used up to about 600 yards. Use.

4. *Sand shot* are cast-iron balls varying in weight from 4 lbs. to $1\frac{1}{2}$ oz.; their chief use is in the manufacture of case and grape and also Sharpnel for the Woolwich rifled guns. 4. Shot, sand.

Shell.

All filled shell have "filled" stencilled on them in red. Shell for field batteries are carried filled in the limbers and waggons.

Classes.

1. Common.
2. Naval.
3. Mortar.
4. Hand Grenade.
5. Diaphragm Sharpnel.

1. Common shell.

1. *Common shell*, gauge, common. Fuzes, common time and Pettman L.S. percussion. They are fired from guns, howitzers, and carronades, and $5\frac{1}{2}$ and $4\frac{2}{5}$ in. mortars, and are made of all calibres from 12-pr. to 10 in. inclusive, they are about $\frac{1}{6}$th of their diameter in thickness, and weigh empty about $\frac{2}{3}$ the weight of solid shot of the same calibre; the 10 in. is $\frac{1}{7}$th in. thickness; they have wood bottoms and have a fuze-hole of the common gauge tapped throughout so as to take Pettman's L.S. fuze, the fuze-hole is closed with a gun-metal plug marked with a × to show that the thread is tapped throughout; the plug has a shoulder fitting into a recess, a leather washer fits under the shoulder to make the joint tight, the fuze-hole is countersunk, which enables them to be used as shot without bottoms.

The 12-pr. shell has a gun-metal socket fitted into the fuze-hole extending some way into the interior of the shell. Without this the shell failed to burst as the powder was not sufficiently confined, the size of the fuze-hole being large compared to the size of the shell.

Blowing charges.

All common shell are completely filled with powder (L.G. shell). For practice in places where the full charge might be dangerous, blowing charges are used.

12 and 24-pr. common shell are used with the $4\frac{2}{5}$ and $5\frac{1}{2}$ mortars.

Use.

Common shell are used against men in masses, houses, buildings, shipping, and material generally; they may be used either by bursting them in flight, when they act both

by the velocity with which the shell is moving and by the force of the bursting charge; but they scatter too much in this way, and are not so effective against men as Shrapnel. They may also be used by bursting the shell when at rest, when they act as a mine; they are most destructive against wooden shipping; they would also be available against men in hollows or sheltered by buildings, where Shrapnel would be powerless.

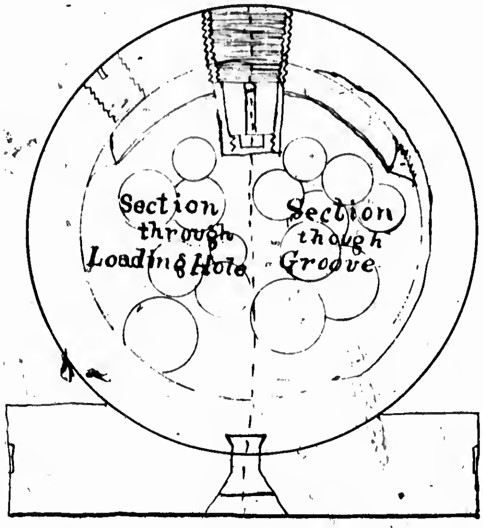
Empty loose, prepared for bottoms for garrison service. Issue.

Filled, riveted, and boxed for field or boat service. When for boat service, issued fuzed with Pettman's L.S. percussion.

Naval Shell for 32-pr. and 8 in. and 10 in. are similar to common shell, but have G.S. bush, and their bottoms are fixed by two rivets, and is hollowed out to allow double shotting. Naval shell.

Mortar Shell.—Calibres, 8 in., 10 in. and 13 in. Gauge, large mortar. Fuze, large mortar. Fired from 8 in., 10 in. and 13 in. mortars. The fuze-hole is not regularly tapped, but is roughed, except a small part at the bottom. The 8 in. is roughed throughout. The guage is much larger than the common guage. The fuze-hole of the 8 in. is a little smaller than the others, as otherwise the fuze would touch the bottom of the shell before it was fixed in the fuze-hole. Of course this makes the fuze protrude further. The 10 in. and 13 in. shell have lugs; hooks fit into the lugs to enable the shell to be carried. The 13 in. have the hooks hung by chains from a beam, and are called beam hooks. Hand hooks are used with the 10 in. In future manufacture the shell would have lewis holes. The holes incline inwards, and the iron plugs at the end of the chains bite into them, when the chain to which the plugs are attached is tight, and can be removed when the chain slackens. The advantage of lewis holes is that there is nothing projecting which is liable to be broken off in piling or transit. The 8 in. shell weighs $46\frac{1}{16}$ lbs., the 10 in., $87\frac{2}{16}$ lbs., and and the 12 in., $196\frac{3}{16}$ lbs. Mortar shell. Hooks, beam, and hand.

Diaphragm Shrapnel



Mortar shell are used for high angle fire, and employed for the bombardment of towns, forts, entrenched positions, &c. They may be employed against shipping, but are too inaccurate to give good results on a small object. The $5\frac{1}{2}$ in. and $4\frac{2}{5}$ in. mortars are used against troops under cover. For this purpose the fuze should be bored rather short to ensure the shell bursting before penetrating the earth. On the other hand, the larger shell used against material should have their fuzes bored long. **Use.**

Hand Grenades are of two sizes, 6-pr. and 3-pr. They resemble common shell, but the walls of the shell are not so thick, being about $\frac{1}{7}$th of the diameter. The fuze-hole is much smaller, and is not roughened. They are generally issued empty, loose, for L.S., and filled and fuzed for S.S., the fuze being covered with a kit plaster. These are boxed. **Hand grenades.** **Issue.**

They are used chiefly for the defence of places against assault, being thrown among the storming parties in the ditch. They are useful in the defence of houses; sometimes they are fired out of mortars instead of pound shot. They can be thrown by hand about 20 or 30 yards. **Use.**

Diaphragm Shrapnel Shell.—Gauge, common. Fuze, diaphragm. For all calibres except the 10 in. Fired from guns, howitzers, and carronades. **Diaphragm shrapnel shell**

The shell is a thin cast-iron shell, weakened by four grooves down the sides to make it open out, thickened at the junction of diaphragm and shell, as otherwise it would split into two pieces instead of four or five, as desired; thickened at the fuze-hole to support the socket, and thickened at the base in all natures above 12-pr. to withstand the shock of discharge.

A wrought-iron cup or diaphragm divides the shell into two unequal parts, the smaller forming the powder chamber, and the larger being filled with lead and antimony bullets (lead six parts, antimony one part) packed in coal dust. The antimony hardens the lead and prevents the bullets losing their form by being pressed together.

The diaphragm has a hole in the centre, through which

a gun-metal socket passes, which serves to contain the fuze. This socket is not countersunk, as is the case with common shell, but is flush with the surface of the shell. (These shell would not be used as hollow shot so countersinking is not necessary.) Through this socket the bullets are introduced and the bottom of the socket is then screwed in. The socket communicates with the powder chamber by a fire hole. The gun-metal plug which screws into it has a wooden plug covered with serge attached which prevents powder working in and filling up the space for the fuze. The powder chamber is filled with pistol, R.F.G., or F.G. powder through the loading hole. The loading hole varies in size, being smaller for the lower natures of shell up to 18-pr. inclusive.

The main advantage gained by separating the powder is to avoid premature explosions.

Use. As a small charge of powder is used merely to open the shell, the effect depends wholly on the velocity with which the shell is moving. The shell should be burst at a distance of 50 to 20 yards in front of the object. It is most destructive when used against columns, but may be used against troops in line. As the quantity of powder which the chamber holds is only just sufficient to open the shell, it is necessary to measure or weigh the charge to ensure the shell having the full amount of powder.

Issue. Empty, riveted, and boxed generally.

Filled, for field, naval, and boat service, and boxed.

Miscellaneous Projectiles.

Carcasses.
Ground light balls.
Parachute light balls.
Smoke balls.

Carcasses. *Carcasses.*—Of all calibres from 12-pr. inclusive upwards. Fired from all natures of guns, howitzers, carronades, and mortars.

They are shell with three vents rather thicker than common shell (about ⅛ diameter) to compensate for the weakness caused by the vents. They are a little heavier than common shell of the same calibre.

The composition is put in hot, and three holes made in it in prolongation of the vents. These holes are driven with fuze composition, and matched with quick match to ensure ignition. The vents are plugged with brown paper and further secured by kit plasters.

Preparation.

Before firing, the plasters and plugs must be removed and the priming exposed. They burn with a violent flame and are difficult to extinguish. Water does not put them out. Earth is the best thing to check their action.

Carcasses have been known to burst.

Use.

To fire buildings, shipping, &c. Carcasses fired from 13 in. S.S. mortar and 10 in. gun are to be fired with charges not exceeding 16 lbs. and 8 lbs. respectively, to avoid straining the pieces with such heavy projectiles.

Ground light balls.

Ground light balls.—Calibres 10 in., 8 in., 5½ in., 4⅖ in., fired from mortars only.

Construction.

They have a wrought-iron skeleton frame, partially covered with canvas, filled with composition, consisting of saltpetre, sulphur, rosin, and linseed oil, which is put in hot, and holes made in it, driven with fuze composition and matched as given above for carcasses.

The body is woolded over with twine. The 8 and 10 inch have five vents in the top; the others have four. The vents are secured with plugs and kit plaster which have to be removed before firing. The 10 in. and 8 in. have lugs to facilitate loading.

Use.

They are used at night to discover working parties, &c., of the enemy, and might, failing carcasses, be used in their place.

As they are required to remain where they fall, they are only suited to high angle fire.

The composition is not a very good one, but is hard to

extinguish, water having no effect on it. A few shovelfuls of earth will hide its light.

Sometimes shell have been placed in light balls to deter men from putting them out, therefore light balls of foreign or doubtful origin should be examined and burned with caution.

Parachute light ball.—Calibres, 10 in., 8 in., 5½ in., fired from mortars. **Parachute light ball.**

Consists of two outer and two inner tinned iron hemispheres, the two outer are lightly riveted together, the two upper hemispheres are connected by a chain, the inner upper hemisphere has a depression at the top to admit the bursting charge and fuze. A quick-match leader conducts the flash from the bursting charge to the fuze composition in the lower inner hemisphere; the inner upper hemisphere contains the parachute tightly folded up, to ensure its opening, a cord is passed between its folds and through a hole in the top of the parachute and fastened to the upper inner hemisphere, so that when the hemisphere is blown away, the cord is pulled through and the parachute expanded.

The lower inner hemisphere contains a composition. A hole is bored and driven with fuze composition and matched as usual, this hemisphere is connected with the parachute by cords and chains.

Use.

To throw light on the enemies working parties, &c., at night, it has the advantage of being out of reach, so cannot be extinguished. Careful allowance for wind must be made.

Smoke Balls.—Calibres 13 in., 10 in., 8 in., 5½ in., and 4⅖ in., may be fired out of mortars with very light charges. **Smoke balls.**

Construction. A paper shell filled with L.G. powder, saltpetre, coal dust, pitch, and tallow, the vent driven with fuze composition, and matched, and covered with kit plaster, a layer of sulphur and coal dust is sprinkled in three times during filling; in burning, this clears the vent.

These balls appear to be useless as projectiles, they are intended (1) to put in enemy's mines, (2) to conceal opera-

tions from the enemy, (3) for signals in the Arctic regions; they burn from one to eight minutes.

It is very doubtful whether smoke balls have ever been fired.

Gauges, high and low, are issued for every kind of S.B. gun, and for stations of inspection; they are simply iron rings with handles, the high gauge should pass over the shot, the low should ~~not~~. Gauges.

All S.B. projectiles are below their nominal diameter, while the gun is a little above it, thus an 8 in. shot or shell has a mean diameter of 7·85 in.

Windage is necessary not only to allow the shot to load easily, but also to allow for the increased size of the shot caused by rust, &c. With shells windage is useful by allowing the flash of discharge to ignite the fuze. Windage.

When shot are repainted it is necessary to scrape off the old paint, which can be done with knives or a piece of an old sword or cutlass.

G. S. Wad.

The *G.S. Wad* serves to prevent the powder from working up in the fuze-hole of common shell. It is made of papier mache, and has a hole in the centre covered by shalloon cemented to one side. This wad is forced in by fixing the time fuze, and does not require removing when the percussion fuze is used. The side covered with shalloon is placed downwards in the shell. Its use is confined to siege, field, and boat service. G.S. Wad.

Copper scrapers are used in removing any powder from filled shell. In future the sizes will be manufactured large for rifled B. L. and M. L. shell 7 in. and upwards, and for S. B. 13 in. Small for B. L. and R. M. L. 9-pr. to 64-pr., S. B. 12-pr. to 10 in. These scrapers will supercede those at present in use for S. B. shell, when the store is used up. Copper scrapers.

Wood Bottoms.—Used with shot fired from bronze guns to save the guns, with shot carried with iron guns of position, to steady them in the limbers, also used with all shells

(except mortar shell) and with carcasses except when fired from mortars. They are necessary with shell to keep the fuze, and with carcasses to keep the vents in the proper position. They are shaped so as to fit the pieces of ordnance for which they are intended.

They are made of well seasoned elm or alder, or teak for tropical climates. The grain runs plankways, except for shrapnel up to 24-pr., where the grain runs endways, and tht bottom is carried higher up on the shell, and is secured from splitting by a tin strap, this ensures the bottom breaking up, and so there is less risk when firing over troops in front, also the shooting is said to be improved by the bottom quitting the shell readily. **Common and Shrapnel bottoms.**

Bottoms for land and boat service are fastened by a single expanding gun-metal rivet. **Rivets.**

When not issued fastened to the shell, they are strung by 20 on an iron rod. **Issue.**

Solid Shot are used against masonry, wooden shipping, and masses of men. Hot shot and Martin's shell are obsolete. **Solid shot.**

Case Shot are fired from all natures of guns, howitzers, and carronades, against troops at close quarters, in masses, for flanking ditches, and against boats and the rigging of ships, effective to about 350 yards. **Case shot.**

In loading, the handle is always put away from the charge when of iron, towards it when of rope. **Loading case**

Grape.—Used for the same purpose as case, but to longer ranges, that is to about 600 yards. **Grape.**

It is more effective against boats and rigging.

Sand Shot.—Used only in the construction of case and grape, and heavy shrapnel for Woolwich rifled guns. **Sand shot.**

Common Shell.—Used against houses, shipping, buildings, earthworks, men in masses or sheltered by woods or hollows, where shrapnel would be useless, or when beyond the effective range of the latter. **Common shell.**

Also against material generally, or at rest, using them as a mine.

Common shell scatters too much when burst with a time

fuze to be very effective against men, they are more useful when burst on impact.

Diaphragm Shrapnel.

Diaphragm Shrapnel.—The effect of these shells is entirely dependent on the velocity with which they travel, the exploding force being merely enough to open the shell. They are of great use against men in column or in line. They should be burst from 20 to 50 yards in front of the object, and about 10 or 15 feet above plane. They are very effective when burst at the head of a column.

Carcasses.

Carcasses.—Used to fire buildings and shipping, they burn from 3 minutes with the 12-pr. to 12 minutes with the 13 in. They cannot be put out with water. Dig a hole and bury them.

Ground light balls.

Ground Light Balls.—Used to discover the working parties, &c., of the enemy, they might be used as carcasses.

Parachute light balls.

Parachute Light Balls.—Parachute lights are more effective than above, when properly burst, especially as they cannot be put out.

Smoke balls.

Smoke Balls are not used as projectiles, they are used to put in the enemy's mines, and to conceal operations from the enemy.

Hand Grenades.

Hand Grenades are used for repelling storming parties. They ought to be well lighted before they are thrown.

Rifled Projectiles.

To ensure good shooting all elongated projectiles should be at least two calibres in length, the length being limited by the twist of rifling, the quicker the twist the longer can be the shell. Thus the 12 in. 25 ton gun has a very slow twist, consequently its common and shrapnel shell cannot be brought up to the weight of its Palliser projectiles.

In the Armstrong B. L. system a soft-coated projectile, larger than the bore, is forced through it, the lands cutting their way through the soft coating. There is no windage, so that special time fuzes are necessary.

The strains on the gun for a given charge are great in proportion to that on a R.M.L. gun.

More attention may be paid to these projectiles, as the B.L. guns, notably the 7 in. and 40-pr., are still used in large numbers, and seem to be increasing in favour, especially for land fronts, and experiments are being carried on with lead-coated Palliser shells fired from the 7 in. gun with 20 lbs. of P. powder.

In the Woolwich system there are studs pressed into the various projectiles (case excepted) which are in some cases of copper, in others of gun metal; these fit into corresponding grooves in the gun, and thereby rotation is given to the projectile.

All R.M.L. projectiles have two rings of studs, except the last mark of projectiles for the 12 in. 35 ton and the 12.5 in. 38 ton, which have three rings. **No. of Studs, &c.**

The 64-pr. has three rings of small studs of pure copper, so as to be used with the shunt gun or with those with plain groove. The three are necessary to give a large bearing, the metal being soft to enable it to be compressed in the shunt groove.

The front ring in all guns with increasing twist has smaller studs than the rear ring, to accommodate themselves to the increasing twist.

The front studs of the 80-pr. are also small, but that is to reduce the strain required in pressing them in, the twist being uniform.

On account of the serious effects of the rush of gas over the upper surface of the projectile, when firing the heavy battering charges, a copper gas check has been devised; it is fastened to the base of a projectile by a screw plug, and effectually prevents the rush of gas by expanding and filling up the grooves and windage. **Gas check.**

During the experiments to determine the best form of the above, it was found that they added considerably to the accuracy of the firing, at the same time not increasing the strain of the gun to any great amount, and in consequence have been approved for the 40-pr. common and 64-pr. battering shell, 8 in. howitzer common shell, and 9 in. to 12.5 in.

Palliser projectiles and common shells, and 7 in. double shell; also, 12.5 in. shrapnel. They will probably be extended to other natures.

Used in connection with projectiles on the Woolwich system, they are discs of copper, cupped in front and slightly overlapping the base of the shell. They are fixed by a double screw and nut, their concave side being next the shell.

There are two descriptions of gas checks. The one as above for all battering charges, and in fact all projectiles except shrapnel, for the above natures; and another which has projections fitting the grooves, and has fire holes to allow enough fire to pass to light the fuze, and is used for the 8 in. howitzer and for the 40-pr. common shells.

As yet there are no gas checks for shrapnel, the present pattern being probably too weak to bear the boring for the plug in base.

The 12.5 in. shrapnel is an exception.

There is yet another mode of giving rotation that has been found very satisfactory, that is by means of a driving gas check. Driving Gas check.

The system is an old one, but the difficulty of fixing the cup to base was very great, and but for the absolute necessity of some means of checking the evils of erosion it probably would have remained in abeyance.

During the experiments with a gas check the difficulty was overcome and the old idea again came to the front, and its advantages, mentioned in the chapter on Rifling, are so great that there is an almost certainty that it will be adopted for all new natures of ordnance.

The 6.3 in. howitzer is the only service gun on this principle at present, but there will soon be a 13-pr. field gun, also the 80 and 100 ton guns, probably soon a 160 ton gun, and some other howitzers. The gas check in this case has projections punched in it to fit radial grooves in base of projectile, and it is cupped to rear in place of front, and is of

sheet copper for the 6.3 in. howitzer. It has five fire holes in rim to allow of ignition of fuze.

It is attached by a screw plug with loose gun metal nut.

All Woolwich guns have Palliser projectiles, except 7 in. R.M.L. guns of 90 cwt. (S.S.) **General notes on R. Projectiles.**

The 64-pr. has a battering shell.

The 11 in. 25, the 12 in. of 35, and the 12.5 in. of 38 tons have Palliser shells only. No shot.

The 80-pr. common shell has an interior belt under front stud for strength.

All common shell and Palliser projectiles are lacquered with red lacquer internally.

The 7 in. and 40-pr. B.L. segment shell are also lacquered. The segment of 20, 12, and 9-pr. have a gas pipe burster. The 6-pr. has a peculiar shaped one, larger at top than bottom. **Segment.**

Shrapnel exists but are not issued yet for the 7 in. and 40-pr. B.L. guns. **Shrapnel.**

Shrapnel for 7 in. R.M.L. guns and upwards contain iron, sand shot. The lower natures are of mixed lead and antimony.

The 64-pr. and 80-pr. shrapnel have a thin wood tube round centre iron tube, to make them long enough without being too heavy. **64-pr. & 80-pr.**

Shrapnel for 64.pr. guns and upwards are weakened by grooves in the body as well as in the base.

The 16-pr., 25-pr., and 40-pr. have no grooves.

The same case serves for 64-pr., 80-pr. guns, and 6.3 in. howitzer, also the same is used for 8 in. gun and howitzer. **Case shot.**

Up to 7 in. they are about the weight of the other projectiles; above that calibre they are about the same weight as a spherical shot for gun in question.

In future the following shell will be cast to gauge, and so save turning, which destroys the hard outer crust. **Shell cast to gauge.**

Common shell for 6.3 in. howitzer, 64-pr., and 9-pr. gun, also 40-pr., mark II., and 38 ton projectiles generally;

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these latter have two bands in front and base, ground or turned down, of slightly larger dimensions, also shrapnel for 64-pr., 40-pr., 25-pr., 16-pr., 9-pr.

In time, doubtless, others will be so constructed. Heavy common shell that have been altered to take the gas check and consequently marked * beside the numeral, are too weak in base to be fired with battering charges.

Paint. All service projectiles are painted black.

The heads of field service shrapnel and M.L. 40-pr. are red, and the tips of palliser shell are white.

Various Projectiles. The following are the various projectiles for rifled guns:

Palliser shot—For all natures of M.L. above 7 in., except 11 in., and 35 and 38 ton guns.

Palliser shell—All natures of M.L. above 7 in., and perhaps for 7 in. B.L.

Battering shell—64-pr. siege gun, perhaps for 8 inch howitzer.

Common shell—All natures except 6-pr. of B.L.
All natures of M.L.

Double shell—For 7 in. and 7-pr. R.M.L.

Segment shell—B.L., all natures.

Shrapnel—B.L., issued for 9-pr. and 12-pr., but patterns exist for 40-pr. and 7 in. if required.
M.L. All guns, but as yet not for howitzers. One for the 8 in. has been made but not sealed.

Case—All natures.

Solid shot—Exist for all natures of B.L. guns except 7 in. They are only used for practice.

Star shell—For purposes of lighting up enemy's position. Is issued for 7-pr., and probably will soon be for 8 in. howitzer, and 6.3 howitzer. The star shell for 7-pr. is something like a shrapnel, but contains 13 stars in paper cylinders; the bursting charge only enough to blow off head.

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Carcasses will also probably be introduced for the howitzers, similar to common shell, filled with carcass composition.

Palliser Projectiles.

Palliser projectiles—These projectiles are specially intended to pierce the thickest armour plates. The successful attainment of this result depends on—

1. The metal used.
2. The mode of casting.
3. The form of projectile, or the arrangement of the metal.

1st. Metal is a carefully selected sample of white iron, that possesses the curious property of forming "White" iron when cooled quickly or chilled, and "Mottled" iron, a softer nature, when cooled gradually.

"White" iron is extremely hard and brittle, and difficult to cut. "Grey" iron is easily cut, though still comparatively hard. "Mottled" iron is intermediate.

They are all natures of cast iron, and only vary in the form in which the carbon, which is mixed with all cast iron, is found. In "Grey" iron it is in great part simply mixed mechanically, in "White" iron; the bulk is chemically combined.

2nd. The mode of casting. The projectiles are cast head downwards, to ensure its density and soundness, the head being in an iron mould or "chill". The body is cast in sand. The mass of cold iron rapidly cools the head, the result is an intensely hard head of white iron, supported by the body of mottled iron, slowly cooled by the bad conducting sand; but the body is more tenacious and supports the head, which is extremely hard and brittle, better than if it was cast in a chill as well.

3rd. As to the form. The metal is got as well forward as possible to prevent much strain coming on the walls of the projectile, and the head is an ogival in form, struck with a radius of 1½ diameters, that form being found best all round for flight and penetration.

Studs.

The studs are swedged into undercut holes cast in the metal of the gun.

The metal of which they are composed is so hard that it cannot be turned, so that when not cast to finished dimensions, and the bands of those projectiles that are, have to be ground to required size.

For the above reason a cast iron bush is cast into the metal of the base of the shells and later patterns of shot, to enable a screw to be cut for the gun metal plug to attach the gas check.

Lacquer and bag. All palliser projectiles are lacquered with red lacquer, and the charge is contained in a bottle shaped bag in order to lessen the friction and so avoid premature explosions.

Shell. Made for 7 in. to 12.5 in. Their length varies from a little over 2 calibres to a little over $2\frac{1}{2}$.

They are similar but contain a rather larger bursting charge than the shot.

Shot. The shot are made for all heavy guns, excepting the 11 in. and 25 in. 35 ton and 38 ton guns.

The earlier natures had merely a small core down the centre, and had a plug hammered in to close base.

Defects occurred from the form of the cavity, and it was increased in size. The base closed the same as the shell, so that it can be filled with powder if necessary.

Use. Both these projectiles are used for penetrating armour plates, and the shot is found to penetrate better than the shell in oblique firing.

These projectiles explode on striking armour plates, without a fuze, but it is doubtful if they would on striking an iron vessel not armour plated, and they would fail entirely on striking a wooden one.

The powder is exploded by its friction against the sides on impact.

Testing. They are tested at a pressure of 100 lbs. on square inch by water, and the base is hammered with a pointed hammer to find any defects.

The points are liable to chip when struck sideways, and it depends on the extent of the practice whether they be used or not.

The shell are lacquered while cooling, and pieces of iron from the bush sometimes stick to the sides, and increase the friction so much that the powder is contained in serge bags, and all powder taken out of them is to be destroyed as unsafe. All powder to be destroyed.

All are filled with "L. G. shell" powder. Powder.

Are similar to palliser projectiles, but are not chilled to such an extent, and have a large bursting charge in proportion. Battering Shell.

They are chiefly for siege purposes for breaching masonry, and are used in connection with a fuze, with delay action, inserted in the base. They have a gas check attached, and are at present made for the 64 M.L. pr. only.

Are used for all natures of ordnance B.L. and M.L., except the 6-pr. B.L. Common Shell.

They are used the same as S.B. common shell, whenever a powerful explosion is wanted, or for incendiary purposes.

B.L. common shell are divided into two classes, viz.: Garrison and Field. B.L. Common Shell.

The garrison are 7 in. and 40-pr. Gauge G.S.

The fuzes in use are Pettman's G.S. and R.L., Mark II. and sometimes B.L. 9 seconds and 20 seconds time.

They are cylindrical, with ogival head radius 1.5 diameters; they are about 2½ calibres long.

A specially light shell is used with 7 in. in S.S.

The field calibres are 9, 12, 20 pr. gauge Armstrong F.S. fuzes. L.S., B.L. plain percussion. Field.

They have a flanged socket to take the fuze in the proper position, and the plug screwed in on the top.

The Navy use the Armstrong E. time fuze for firing over water, and the 9 sec. and 20 sec. for the 20-pr. only. These shell have a papier mache wad fitted into the socket to prevent the powder working up, the flash blows it down.

Common shell exist for all natures from the 7-pr. to the 80 ton gun; the latter is, however, not yet in the service. M. L. Ordnance.

They are about three calibres long, except that for the Heavy Guns.

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12 in. of 25 tons which, as stated before, is only about $2\frac{1}{2}$ calibres.

Thickness.

The thickness of walls vary from about $\frac{1}{8}$th in the larger to $\frac{1}{6}$th of the diameter in the smaller shells.

In the 11 in. 25ton, 12 in. 35, and 12.5 in. 38, the walls are thicker at base than top, and also in Mark II. for 10 in. All the later marks have bases rounded off to facilitate loading. They are all to be fitted with gas checks, but the *altered ones* are not strong enough to stand a battering charge.

Use.

They are used against material generally and are especially destructive to wooden ships. They use only a fuze to act on direct impact, Pettman's G.S. However in the attack on a fortress it might be well if they would burst or graze.

Siege Guns.

80-pr., 64-pr., 40-pr., 25-pr., 8 in. and 6.3 in. howitzer,

80-pr.

The common shell for 80-pr. is peculiar in having a ring of increased thickness cast under the front studs, to bear the pressure of forcing them in, and it increases in thickness towards the rear. It has studs of copper and zinc, to fit Woolwich grooves. This gun is L.S. only; fuze Pettman's G.S. and R.L. Mark II.

64-pr.

Common shell fuzes, Pettman's G.S. and R.L., Mark II. Beyond the three rings of studs there is nothing peculiar in this shell, the studs being small and of copper.

8 in. howitzer 40-pr. and 25-pr.

These common shell are of the ordinary form, the 25-pr. not having a copper bush.

The 40-pr. and 8 in. howitzer have gas checks on their shells.

6.3 in. howitzer has no studs, rotation being given by a driving gas check.

Field Guns.

The common shell is similar in each one. They have no copper bush, and take the R.L. fuzes, Marks I or II for the 7-pr. full charges and the 9-pr., the 16-pr. takes Mark II. only, and the 7-pr. is best used with the sensitive fuze.

Double Shell are similar to common shell, but are nearly 4 calibres long. The 7 in. is strengthened by 3 ribs inside.

They are chiefly used in the 7 in. against wooden ships, and in the 7-pr. against houses, &c.

The 7 in. is accurate up to 2000 yards; the 7-pr. to about 1600 yards.

Segment Shell—Used with percussion fuzes, from B.L. guns.

Segment Shell are of two classes—garrison and field.

The shell is of thin cast iron, cylindro-conoidal in shape, cast without a base and weakened by four grooves in the head. It is weakened by grooves in the body. Segments of cast iron are built up in arches or layers on a cast iron disc, having a hollow space in the centre; these segments are introduced into the shell, forming an interior lining to it; the lead and antimony in the operation of coating is allowed to flow into the shell through a hole near the shoulder (the powder chamber being closed by a core or mandril); the lead flows between the segments, binding them together; the base is also fastened on to the body by the lead coating, which seals the joint between base and body; this construction is very strong against external pressure, but opens readily when acted on by the bursting charge.

Garrison Segment Shell, 7 in., and 40-prs. G.S. gauge. Fuzes, 9 seconds or 20 seconds B.L., Pettman's G.S. percussion, and R.L. percussion fuze, Mark II. These shell have their powder chambers coated with red lacquer, and are a little over two calibres long.

Field Service Segment Shell.—Field service gauge, fuze B.L. plain percussion, (Navy, E. time in addition.) Calibres 20, 12, 9 and 6-prs. In the shell, the powder "shell F.G." is contained in wrought-iron gas pipe bursters, the pipe is dropped into the powder chamber which is of the same diameter as the fuze-hole; the brown paper cover in which the burster is issued is retained, the top end being torn off to allow ignition; the ends of the burster are closed by serge and paper discs fastened to metal rings.

Field service shell are now carried filled, over the burster

is placed a wooden plug, covered with serge to keep it steady.

All segment shell are about two calibres in length.

U. on the lead coat signifies that they are attached by the old means of undercut grooves.

The coating has been attached in three ways:

1st. Tin solder and square grooves.

2nd. Mechanical means, viz.: undercut grooves.

3rd and best, by zinc solder, no grooves.

The zinc amalgamates strongly with both iron and lead.

Chiefly useful against troops in column when burst or graze close to them, they scatter too much if burst in front. Use.

They are very effective when burst through a thin wall.

The whole subject of "segment versus shrapnel" is a very vexed one and cannot be gone into fully here.

The form of the segments are bad for flight and they have to be very accurately burst, and used on hard level ground, to get full effect.

Are made for the 7 in. and 40-pr., 12-pr. and 9-pr, B. L. guns, and also for all R. M. L. guns, except, as yet, the howitzer. Shrapnel.

The general idea is the same all through, we will describe the B. L. first.

They are always, if possible, to be used with time fuzes, and their effect is entirely dependant upon the correct estimate of range, and proper setting of fuze; their penetration is proportional to their velocity.

The heavy shrapnel from Woolwich guns are effective at long ranges, as they maintain their velocity and the balls are large, they could be burst within 300 yards of object, and used at say 4500 yards for the largest natures. But for field service 2000 yards is the outside, and burst from 20 to 50 yards short, about 15 feet above plane.

The largest size projectiles will all be fitted for gas checks in the new patterns, but they are not strong enough to alter, to take them in the existing natures.

The body is of cast iron coated with lead as before Construction.

SHRAPNEL PRIMER

described, containing a powder chamber at base, and is weakened by 6 grooves along the sides. Into the powder chamber, fits a tin cup to contain the bursting charge, over the cup resting on a shoulder in the shell is a wrought-iron disc or diaphragm into which, for the smaller shells up to the 12-pr. inclusive, a gun-metal pipe is screwed, tapped in the top for the primer. A tin socket is soldered on to the gun-metal pipe, and this in conjunction with the gun-metal bush in the head receives the fuze; lead and antimony balls are placed over the diaphragm, imbedded in rosin, the shell being lined with brown paper to prevent the rosin from adhering too firmly. A kamptulicon or felt disc soaked in kit composition goes over the balls. The head is made of Bessemer steel, ogival in shape, lined with wood, and having a gun-metal socket soldered in, it is fastened to the body by rivets and screws, and further secured by soldering.

There is a little difference in the construction of the garrison shrapnel, the tin cup and diaphragm in future manufacture would be coned to allow of the shell being unloaded more easily, a wrought-iron pipe of larger diameter screwed into the diaphragm, and the gun-metal socket fitted into the pipe, and sufficiently large to hold the fuze, and tapped to take the primer, so that no tin socket is required. The shell hitherto made differ slightly in details, the cup not being coned, they have a smaller iron pipe and tin socket.

The projecting socket of shrapnel shell has been found liable to injury in transit; it has been replaced by a socket flush with the head of the shell.

The charge for these shell is measured, and pistol R.F.G. or F.G powder is used, when the charge has been inserted a gun-metal primer is screwed by a screw-driver into the top of the wrought-iron tube.

Primer, Shrapnel shell.

Mark II. primer consists of a gun-metal cylinder, having a screw thread, and two slots cut in the head to enable it to be screwed into the shell. A cup-shaped recess in the head is pierced with three holes, leading into a chamber

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filled with L.G. powder; the bottom being slightly closed by a brass ring and a disc of shalloon.

The primer serves to carry the flash of the fuze to the charge, and also prevents the powder from working up.

Field M. L. Shrapnel.

Resemble those previously described for B.L. guns, F.S., page 28, as to their internal arrangements; lead and antimony balls are used. The latest patterns, however, have flush sockets, and there are no internal grooves in Mark II., 16.pr., and Mark V., 9-pr., except in the powder chamber of the latter; the tin cup and diaphragm in the 16-pr. are coned.

The studs are pure copper, and the last patterns of 16-pr., Mark III., and 9.pr., Mark VIII., are cast to finished dimensions.

Heavy Woolwich guns.

The shrapnel for those guns is similar to above. The body of shell being nearly as thick as the common shell, which it resembles in studding and exterior dimensions.

The walls are slightly thicker towards the base. The tin cup and disc are coned to facilitate unloading. The balls are sand shot for economy.

The 64-pr. 80-pr.

Differ from above in having balls of the mixed metal, and round the central iron tube is a wooden one to fill up space and bring shell to proper weight without unduly increasing its weight.

The 64-pr., as usual, has the three rings of studs, and has three extractor holes.

40-pr. & 25-pr.

Are similar to the shrapnel for field service, have thin walls, gun metal tube, and composite socket of tin and copper.

Case shot.

Are made for all rifled guns; they are cylinders of thin iron tinned, containing balls of different natures and size, according to calibre, packed in clay and sand.

Up to 7 in.

Up to 7 in. inclusive, the case shot have a body of tin, in three pieces, soldered longitudinally together. The bottom is of tin soldered to body, and has an iron ring riveted on outside. The top end is fringed, and the fringes bent down and soldered unto a tinned iron top.

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Above 7 in., the case shot has the body made of one piece of tinned iron fringed at both ends. The bottom is an iron *disc*, the top is as above. Above 7 in.

The 6, 9, 12, and 20-pr. B.L. have a tin top, covering a piece of wood with rounded edges. Exceptions.

The 9-pr. M. L. has a tin top, covering a thin disc of wood.

The 7-pr. has a plain tin top.

All case shot contain three loose wrought-iron segments as a lining, placed upon a loose iron disc at bottom. The exception is the 64-pr. and 80-pr. case, which also serves for the 6.3 in. howitzer, it has six segments; 32-pr. case cannot be used for 64-pr., as it scores the bore. Contents.

All case shot have their contents packed in clay and sand.

For R. M. L. the balls are mixed metal up to 40-pr. inclusive.

For R. B. L. they are mixed metal up to 20-pr. inclusive.

Higher natures contain 8 oz. sand shot.

Up to the 16-pr. inclusive they have no handle.

From 25-pr. to 8 in. they have one handle.

Above 8 in. they have two handles.

The same case serves for 7 in. B. L. and M. L.

The same case serves for 64-pr., 8 in. and 6.3 in. howitzer.

B. L. case differ from M. L. in having solder studs at or near base, to prevent them being rammed too far home, not to take the riflings. Solder Studs

In the case for 7 in., the studs are placed so as to fit the grooves, when used with the Woolwich gun.

For field service, case can be used up to about 300 yards, when the ground is soft or uneven 1°. elevation ought to be given, but when hard and even, point blank is best. Use.

In the large guns they are effective up to 600 yards, and cause great destruction to boats and are very useful to repel a boat attack, especially by torpedo boats.

Means of Firing Ordnance, &c.

Friction tubes are almost invariably used, made of copper for L.S., and quill for S.S.

Electric tubes are often used on board ship, and will be used in casemated batteries. There are also make-shift tubes of paper, but these and the electric are seldom met with.

Friction tubes of copper about ·2 in. diameter are used for firing guns in the L.S. **Tubes, copper friction.**

There are three sizes, viz., the short friction tube about 3 in. in length for guns in general, a special tube about 2 in. long for the 7-pr., and the long friction tube about 5 in. long for 10 in. R.M.L. guns and upwards in L.S. There is a special 5 in. tube, with a wire attached to keep it from flying, issued for all the Woolwich guns in the navy when waterproof cartridges are used; a small lanyard is hooked on to the wire and hitched on to the gun carriage.

The friction tube consists of a copper tube driven with mealed powder and pierced with a central hole, the top stopped with shellac putty and the bottom with a disc of varnished paper; a hole is bored through near the top of the tube, and at right angles to it, and over this hole is secured a cylinder or "nib-piece," containing a copper friction bar, roughened, and slightly turned up at one end, with a small patch of detonating composition of chlorate of potash, sulphur, and sulphide of antimony placed above and below the bar; the nib-piece is pinched down so as to press on the friction bar, the projecting part of which has an eye into which the hook of the lanyard fits.

On pulling the lanyard (which should be stretched and then sharply pulled) the friction bar is pulled out, igniting the composition and firing the tube. **Action.**

The central hole in the tube is important, it gives passage for the flash, and causes the tube to act instantaneously, without it the mealed powder would burn like a squib and fail to ignite the cartridge.

Friction tubes are issued in tin cylinders, containing 25. **Issue.**

Friction tubes are on no account to be placed in a magazine.

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Quill friction tubes.

Quill friction tubes of two sizes, about 2¼ in. and 4 in. long are used by the navy. The general principle of construction is the same, but they differ slightly in details; a little mealed powder is added to the detonating composition which is put on one side only of the friction bar; the bar passes through the tube. To support the tube when the lanyard is pulled, a leather loop is attached which fastens on to a crutch or pin screwed into the gun near the vent; the long tube is used for guns of 8 in. calibre and over, when firing reduced charges, and also for use with 24-pr. Hale's rockets S.S.

Issue.

In tin cylinders, same as copper friction tubes.

Lanyards.

Friction tubes are fired by means of lanyards. They differ chiefly in length.

Garrison lanyard short, 7 ft. 6 in. long, having a loop at one end and a hook spliced on at the other.

Garrison lanyard, service, for guns under 7 in., length 12 feet. This will supersede the short one for all guns.

Garrison lanyard, Mark I., has been approved to guide local alteration of existing store, and for future manufacture. It has a line, with a loop at the end, spliced on about 3 feet from the hook; this line is made fast, so as to prevent the hook flying back when the gun is fired. It is for use for with 7 in. guns and over.

Field service lanyard, length 5 ft. 4 in.

Common Port fire.

When friction tubes are not available the gun must be fired by means of a port fire, consisting of a cylinder of paper about 16 in. long and half an inch in diameter, filled with a burning composition, they burn from 12 to 15 minutes.

Slow Port fire.

Is made of common blue porous paper, soaked in a boiling solution of 3 oz. saltpetre dissolved in 1 or 2 quarts of water; the more porous the paper, the more water required.

Quick Match.

Is made of cotton wick boiled in a solution of mealed powder and gum, and dry powder dusted over it.

When unenclosed it burns at the rate of about 1 yard in 13 seconds, enclosed in a tube of any kind, it burns much

more rapidly, the pressure causing the gas to rush forward and fire the mass explosively.

Is made of pure hemp boiled in water and wood ashes, ashes about one bushel, water about 50 gals. **Slow Match.**

ROCKETS.

Rockets have long been used as fireworks for signalling purposes, in fact they were known to the Chinese long before the introduction of gunpowder. **Rockets.**

It is known that they used them for offensive purposes in the 13th century, and they were used in Europe in the 15th century, and they were used against us with great effect in India in 1799; it is impossible to say at what remote period they were first invented.

They have many advantages in use; they carry their own projectile force, they have considerable velocity, and are extremely effective as incendiary projectiles, and have an alarming effect on savage nations and on animals.

Sir W. Congreve was the first to bring them prominently forward in our service, but the long stick or tail of his rockets, on the pattern of the ordinary sky-rockets was very inconvenient, and increased the irregularity of their flight on grazing any object.

In 1867 Hale's rockets, called after their inventor, superseded the Congreve pattern. **Hale's Rockets.**

In these the escaping gas passes through three vents in the tail piece; these vents have one side cut away, so that the escaping gas finds no resistance on that side, and as the three are so arranged as to assist each other, rotation is given to the rocket, and the necessity of a stick obviated.

The head is of cast-iron, plugged with wood, and riveted on to the body, at one time the head was filled with powder and used as a shell, but they were found dangerous to handle.

The body is of steel, lined inside with brown paper and calico, to prevent contact between the composition and metal, as consequent deterioration of the former, the base is secured

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by an iron disc, into which screws the tail piece, with its three conical vents, cut away on one side, as described above.

Composition

The composition, consisting of saltpetre, sulphur, and charcoal, is driven into the case under a pressure of from 8 to 10 tons per square inch.

The composition is then bored out to a considerable amount, so as to ensure a large volume of gas to start the rocket.

Action.

When a rocket is fired, there is generated a large volume of gas, and consequently a pressure in all directions, inside the case, the pressure on the sides balance, and that on the head would be equal to that on the base, but for the three vents, through which the gas escapes and reduces the pressure on the bar, that on the head is in consequence the greater, and the rocket is impelled forward, the action being exactly similar to the recoil of a gun.

Sizes, 9-pr., 24-pr.

The service sizes are 9-pr. and 24-pr.; they are of several patterns. Mark I. is dangerous, and is on no account to be used.

The outside of the rocket is painted red.

Besides these, experiments are being carried on with rockets containing an incendiary composition in the heads, rockets of 6 in. diameter and 100 lbs. weight, carrying 13 lbs. of gun cotton in head, and a fuze resembling the R. L. fuze, *ready to strike*.

Several of these have been sent to India.

A 24-pr. with 3 lbs. of gun cotton has been tried.

Life-Saving Rocket.

There is also a life-saving rocket to carry a rope to a stranded ship, which is actually a double rocket, when one is burnt out the other comes into play.

They have a stick, as also have the several varieties of signal rockets in use.

Hale's rockets are fired from angular troughs.

Disadvantages

The "glorious uncertainty" of the range and direction of all rockets is their great drawback, otherwise they are the perfection of artillery, no heavy guns being required to fire them.

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Fuzes.

Fuzes are divided into two distinct classes, "time" and "percussion," each being used for well defined purposes.

Time fuzes are sub-divided into those for S. B., M. L. R., and B. L. R., and with few exceptions they are not interchangeable.

Percussion fuzes cannot be so divided.

They may, however, be considered as those to act on graze and those to act on direct impact.

There has been of late years a considerable advance made in the manufacture and accuracy of fuzes of all sorts, brought about chiefly by the increased accuracy of rifled guns, and the deadly effects of shrapnel when properly burst.

Prior to the Crimean war, fuzes were rough cones of wood, filled with a composition that burst more or less irregularly, and the necessary "length of fuze" was obtained by *sawing* off pieces of the end of the core; as the fuze-holes in the shells were of all sizes, the fuze had then, in many cases, to be rasped down to the necessary size.

Percussion fuzes were, I believe, hardly known.

To General Boxer, R.A., is chiefly due the great improvements in the time fuzes of the present day, for these fuzes for rifled guns are essentially the same as the "common" time fuze he brought out about that period.

Fuze composition is now a well defined and carefully made mixture, and it is driven into the fuze by a regular hydraulic pressure, so that there is great regularity in the time of burning in any *given gun*, allowances being necessary for increase or decrease of velocity, and particularly for increase of elevation of gun *above sea level.*

The greater the velocity the quicker would a fuze burn, provided that the fuze kept point foremost.

It was found in Abyssinia that the time fuzes burnt much slower at Magdala than at the sea level; and it is found that as a general rule each diminution of atmospheric pressure to the extent of one mercurial inch, which is equal to a rise of 1000 feet, increases the time of burning $\frac{1}{30}$th,

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thus at 5000 feet elevation the large mortar fuze that burns 30 seconds at sea level would burn 35 seconds, and so in proportion for others. Again, any considerable fall or rise in the barometer would increase or diminish the average time of burning, an important consideration when firing shrapnel.

A fuze that has been kept for a considerable time is also irregular in its burning, generally burning slowly.

Hence all tables of lengths of fuze for range can only be approximate.

Fuze Compositions.

Fuze Compositions Ordinary.

(1) Ordinary fuze compositions consists of—

Ground Saltpetre	46.4	100 parts.
Mealed Pit Powder	39.3	
Sublimed Sulphur	14.3	

And when driven at regulated pressure burns at the rate of 1 inch in 5 sec.

Special 15 sec

(2) Special, burning 1 in. in $7\frac{1}{2}$ sec.

Special 30 sec

(3) Special, burning 1 in. in 10 sec.

The above special differ only from ordinary in the quantities of ingredients.

Mealed Powder.

(4) Ordinary mealed powder is also used alone, and it burns at double the rate of ordinary, viz., at 1 in. in $2\frac{1}{2}$ sec. It can easily be seen that by using fuze composition or mealed powder the same length of fuze can be graduated at *equal* distances, so that in one case it will be graduated to $\frac{1}{2}$ seconds and in the other to $\frac{1}{4}$ seconds.

Proof of fuzes

A proportion of fuzes in every 1000 are sent to and fired from the same gun, *bored* at same length to test regularity of burning, and others are burned at rest to test length of time, $\pm$·2 in every 5 seconds of time is allowed to new fuzes, but old fuzes are not condemned unless they burn 10 per cent over their proper time. Thus the 5 sec. fuze would be condemned if at any time it was found to burn 5.5 sec.

The wood time fuzes are all made from the same cone, different portions being cut off as necessary.

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TIME FUZES.

Time fuzes consist of a hollow cone filled with composition, and in most cases containing powder channels, parallel to the central composition; they are graduated at sides generally to 10ths of fuze, burning either ½ sec. or ¼ sec. as the case may be. They are ignited at head either by flash of gun or by a detonating arrangement when there is no windage. Time fuzes

We have first, fuzes for S.B. ordnance, consisting of: S B. fuzes.

Diaphragm, fitting shells with } Common gauge
Common, " " } fuze holes.
Small Mortar, " " }
Large Mortar, " " Large Mortar gauge.

Diaphragm may be used with common shell at short ranges, also *Common* with 5.5 and 4.4 mortar shells at short ranges.

The small Mortar fuze may be used with common shell for long ranges, when the metal of the shell would not interfere with the passage of the flame.

1st. Diaphragm Fuze. For use with diaphragm shell. Diaphragm.

This is a short fuze, containing only 1 inch composition, for, from the construction of the shell, a longer one could not be used, neither would it be desirable to do so, if it were possible, from the fact that the effect of shrapnel shell depends entirely upon the velocity at the moment of rupture, and the velocity of an S.B. shell after 1200 yards, diminishes very rapidly. The arrangements of this fuze is the type, however, of many others.

It consists of a wooden core, and has three channels driven excentrically through it, one larger than the other two. The large one is driven with fuze composition, and the powder channels are filled with pistol powder, and the powder in each channel is supported by a piece of quick match, passing through the lowest hole, by means of which the flame explodes the shell if the fuze is not bored. A groove cut in the bottom of the fuze, with a piece of quick match in it, unites the two powder channels, holes are bored

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through into the powder channels, filled with powder protected by clay and varnished paper. These holes are $\frac{2}{10}$ in. apart and serve to direct the bit in boring the fuze. They are marked externally in alternate $\frac{1}{10}$ths, odd Nos. on one, even on the other; in all it is marked to 10 half seconds.

The fuze composition is continued ·6 in. above the highest side hole, it is bored into to the depth of ·4 in. in order to give a large surface to the action of the flash from the quick match.

The highest side hole is therefore ·2 in. below the zero of the fuze.

4 holes are bored through the head to fix the quick match that is used as priming, and the whole is covered by a tin cap, and a piece of tape attached.

Powder channels have several advantages.

Advantages of Powder channels.

1st. In case of the hole bored coming in contact with the metal, they carry the flash into the body of the shell.

2nd. By having odd $\frac{1}{10}$ths on one and even $\frac{1}{10}$ths on the other, it enables the fuze to be bored to smaller dimensions, in the 15 sec. fuze are 6 powder channels, in order to give the necessary graduations; the 30 sec. has 8.

3rd. An increased flash is given, which is especially useful, indeed necessary, with shrapnel of all sorts.

Preparation.

These fuzes are covered with varnished paper. The fuze is prepared by boring to required length, and tearing off cap when shell is in gun.

Common fuze.

Common Fuze. For common shell is identical with above except that it contains 2 in. of composition, and burns 10 sec., and also the powder channels are not connected with quick match.

It may be used in $5\frac{1}{2}$ and $4\frac{2}{5}$ mortars, when the ranges are short.

Large mortar fuze.

Large Mortar Fuze is used with 8 in., 10 in., 13 in. mortar shell.

The length of composition is 6 in., burning 30 seconds. There are no powder channels or side holes, and the composition is in the centre of the cone. The head is primed

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with quick match, and a hole is bored for a short distance into the composition. The first mark for boring is at 2 in. from top of composition, and the remaining 4in. are divided spirally into $\frac{2}{10}$th inches, burning seconds. The cone is bored through at 6 in., and has a mealed powder pellet placed in it to ensure ignition in case fuze is not bored. It is covered by tin cap as before.

There are two rings on fuze besides those marking inches, the first marks the depth to which it will enter the fuze hole of 13 in. and 10 in. shell, below this at ·9 in., another line shews where it is gripped by 8 in. shell.

The first hole only acts in a 10 in. shell falling against the metal in 13 in. and 8 in.

Small mortar fuze.

The small mortar fuze is of the same gauge as the common fuze, only 1 in. longer, having 3 in. of composition. It is similar in marking and construction to the large mortar fuze; the first mark for boring is at 1 in., it burns 15 sec. When used with 12-pr. common shell something must be wrapped round it.

Special fuzes.

Special fuzes are made for *Hand Grenades*, which are nearly obsolete.

Parachute light fuzes are also different, they are painted blue, and are different for 10 in., 8 in., and 5½ in. The first two *might* be used with common shell on an emergency, the third is too small. They burn 15 min., 13 min., and 10 min. respectively.

Manby's life-saving fuze is nearly obsolete, the life-saving rocket taking the place of the Manby shot.

Time Fuzes for R. Ordnance.

We now come to the consideration of time fuzes for rifled ordnance, first for muzzle loading guns, &c.

The general construction of these fuzes is the same as the fuzes for S.B. ordnance, making certain allowances for the peculiar circumstances under which they are used.

Frst we have to consider that a rifled projectile always travels point first, so that if the top of the fuze was exposed

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as in the S.B. fuzes, the rate of burning would be greatly increased, and again it would be very likely to be extinguished on grazing. Again, some few alterations are made to ensure greater accuracy in the burning of the fuze and greater strength.

The general arrangements of powder channels and fuze composition is the same, the chief difference being that the head is closed with a gun-metal plug, containing a pin in its centre, round which strands of quick match are passed through two fire holes at side, thence round a groove cut in head of fuze, covered and secured by a copper strip covered with tape. A brown paper lining is also introduced between the wood and the composition, to prevent the latter shrinking, and the consequent premature action of the fuze. The clay stopping is dispensed with, varnished paper only being used.

In preparing fuzes for R. guns the tape is torn off.

The following is a table of fuzes at present in use for R.M.L. guns.

5 sec. used for shrapnel or common shell up to 1500 yds.
9 sec. for common shell or shrapnel for long ranges.
15 sec. to supersede 5 sec. and 9 sec., when used up.
20 sec. for common shell, long ranges.
30 sec. to supersede the 20 sec.

5 sec. Varnished paper, Drab & Red.

The 5 sec. fuze is used for shrapnel having G.S. gauge, up to 80-pr. inclusive; it contains 2 inches of mealed powder and burns 5 sec., its general construction has been described; it can be used for common shell for short ranges.

9 sec. used with S.B. [illegible] shell, common and shrapnel, of G.S. gauge, up to 80-pr. inclusive.

It is identical with the 5 sec. fuze in construction, only fuze composition is used, it consequently burns (at rest) 10 seconds.

9 sec. Varnished paper. Black & Drab.

In this fuze, above the fuze composition, ·4 in. of mealed powder is driven, to prevent risk of splitting the column of composition when boring at top hole, it is consequently longer.

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These two fuzes, how[illegible] distinguished, one being painted *drab and re*[illegible] *black and drab.*

Also, the marking of side ho[illegible] one case is in ½ tenths or ½ sec., in the other in tenths or ¼ sec.

All other fuzes take their name from the time of burning when *at rest*, this takes its name from the time when fired from a certain gun.

On account of the inconvenience of having the two fuzes the same size, viz., 5 sec. and 9 sec., in a field equipment, the 15 sec. was introduced on the 8th Feb'y., 1878, to take the place of either and eventually to supersede both.

15 sec. fuze.

Its construction differs from the preceding fuzes inasmuch as it has 6 powder channels and is driven with a *slow* burning composition, burning 2 in. in 15 sec., or half as long again as the old composition.

For convenience of reference to old tables, &c, the division on the fuze read *nominal*, $\frac{1}{10}$ths and $\frac{1}{20}$ths of fuze corresponding to ½ and ¼ seconds of time. It is spirally graduated 1, 1.5, 2, 2.5, &c., on to 30.

The figures 1 to 10 corresponding to and giving same times of burning as those on the 5 sec. fuze, and on to 20 those on the 9 sec.

30 sec. fuze.

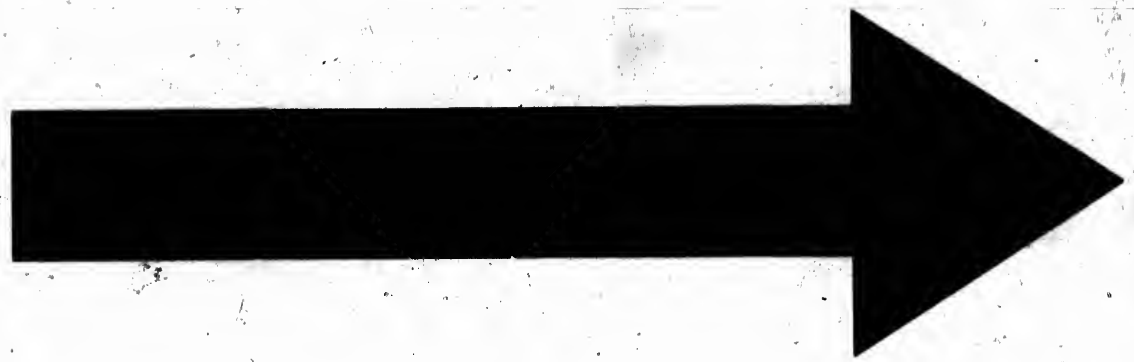
This fuze resembles above in general construction, it has, however, a still slower composition, burning 1 in. in 10 sec., it has 8 powder channels, and is graduated as above, commencing at 30 in. nominal lengths to represent ¼ sec. The lower portion is cylindrical to give room for the powder channels. It is to be bored by gimlet borer only.

20 sec. fuze.

This fuze is used for R.M.L. common shell, G.S. gauge, up to 30-pr. inclusive, and also for 7-pr. guns.

It will be superseded by above 30 sec. fuze.

In general construction and action it resembles a mortar fuze, having no powder channels, but the arrangements as to head, priming, paper lining, &c., are the same as other M.L.R. fuzes. It has a pellet of mealed powder pierced, placed in a hole bored through end of composition to carry flash if not bored.



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The marking begins at 20 and reads only ½ in., running on 20, 22, 24, &c.

It contains 4 in. composition.

The latest pattern of all these fuzes, 5, 9, and 20 sec., Mark III., differ from earlier makes slightly.

(1) The head projects a little more from shell, and has a larger groove containing more quick match, protected with copper and tape band.

(2) The paper lining is reduced to half its thickness, and is coated with varnish.

(3) The powder channels are nearer the centre and slightly reduced in length, and the side holes are not bored beyond powder channels, increasing the strength of the fuze.

R. B. L. Fuzes.

There being no windage in B.L.R. guns there is no flash to ignite the fuze, hence it is necessary to add some arrangement to start the action in a time fuze.

A detonating arrangement is therefore fixed into the head of time fuzes for these guns.

A cylinder of an alloy resembling gun metal is secured into the head of the fuze. This cylinder contains a hammer supported by a copper wire, below the hammer is a hollow in the cylinder containing the detonating composition of—

Chlorate Potash, 6 parts.
Fulminate Mercury, 4 parts.
Sulphide Antimony, 4 parts.

A hole is bored through cylinder for passage of flame.

The hammer is also supported by a safety pin, which is withdrawn by tape just before putting into gun.

There are three escape holes for the gas to escape by, protected by papier maché wads and thin copper discs.

The head is woolded with copper wire to prevent its being split when detonator is being screwed in. The Mark (I.) of these fuzes had kamptulicon discs at top and bottom, but no safety pin.

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They are never to be struck, always screwed in by hand. The fuzes used are 5 in., 9 in. and 20 in.

They are, with the exception of the head, identical with the M.L.R. fuzes. The 15 sec. will be made if necessary, which is not at present.

Armstrong breech-loading guns are still largely used by the Navy for boat service, on account of their great convenience in a cramped place.

E. time fuze.

The chief Armstrong shell for use against troops and boats, is the segment shell, and although a percussion fuze gives the best results with this shell still the Navy are not able always to rely on a percussion fuze acting properly over water, and a shell exploded by a time fuze over water gives better effects than when exploded by percussion fuze on water.

The E. time fuze is still made and issued for S.S. field guns, partly because it was the original fuze proposed for the Armstrong F. service, and it would cause some confusion and trouble to change the gauge to the G.S. Moreover the E. time fuze is better adapted to boat service, it has not to be bored before use, it can be much more accurately set, which is of importance with segment shell especially, it is also less liable to injury through damp; the fuze can be readjusted at any time, and is always open to inspection.

Advantages.

Both body and nut of the last pattern, E. III., are made of gun-metal, and the graduations for length of fuze in inches and tenths are marked on the metal rim instead of on paper, as in former patterns. The pellet, which is supported by a brass cup, is filled with R.F.G. powder, secured by thin paper fastened on its base; the detonator in the head consists of a cap composition (fulminate of mercury, chlorate of potash, and sulphide of antimony), instead of the amorphous phosphorus composition which deteriorated in damp climates. In those lately made, a disc of brass ·001 in. thick covers the detonating composition. The word "cap" is stamped on the base of the fuze.

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The channel by which the flash from the hammer reaches the ring of fuze composition is enlarged in this pattern, and a little hole is bored in the ring of fuze composition to ensure its lighting. The fuze composition is pit mealed powder, pressed into a ring or groove which runs round close to the exterior of fuze body; this composition burns at the rate of 1 in. in 2 sec., and owing to a metal stop can only burn in one direction, *i.e.*, from left to right.

A leather washer and movable gun-metal collar cover the ring of composition. At one part of the collar, a channel (primed with mealed powder driven and pierced), communicates with a groove round the neck of the fuze which contains mealed powder, this groove is connected by a channel with the blowing chamber which is primed with mealed powder, driven and pierced; a small brass disc closes the chamber.

The movable collar is kept in its place by a nut which screws on to the neck. The body has a small hole in the side to fit a projection in the Armstrong key used in screwing in the fuze.

Action

On firing the gun, the brass cup is crushed in, the hammer strikes the needle, which explodes the detonating composition, the ring of fuze composition is ignited by the flash and burns till it comes to the channel, marked by the arrow head, leading to the groove in the neck primed with mealed powder, the flash is then instantaneously conveyed into the blowing chamber, and thence into the shell.

The changes recently introduced, particularly the cap composition and the ensuring ignition by piercing a hole in the ring of fuze composition, have greatly improved this fuze.

Issue

1 in a waterproof bag placed in a cylindrical tin box, wrapped in brown paper, 72 boxes in a deal case, placed on the sides or heads, the bottom of each tin box is marked "top" to prevent it being placed downwards.

All wood time fuzes can be depended on to act as

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percussion fuzes on *direct* impact, but not on graze, the fuze being broken up and driven into the shell.

Gun cotton priming.

When firing with reduced charges, notwithstanding the increased priming of Marks II. and III., the fuze often fails to ignite, also this is the case when gas checks are used; to counteract this, strands of gun cotton are issued in tin boxes, so that pieces 4 or 5 inches long may be wrapped round their heads.

Short Rule for getting Length of Fuze.

Time fuzes generally.

Divide the number of hundreds of yards in the range by 2 and add 1 up to 1000 yards, 2 up to 2000 yards, and so on for length of fuze in tenths of inches; this will be found nearly correct with rifled ordnance. Example. To find length of fuze at 2600 yards for 16-pr. gun, $\frac{26}{2}+3=16$.

Shrapnel require to be bored a little shorter.

N.B.—Blind shell are frequently due to the fuzes being bored too long. If old fuzes, which burn long, are bored according to the range table, blind shell may be expected; hence, if blind shell occur, try a shorter fuze.

Short Rule for getting Length of Fuze for Mortars.

Mortar fuzes.

Add 17 to the number of hundreds of yards in the range for the length of fuze in tenths of inches, thus the fuze for 1700 yards will be 3.4 in.

E. time fuze.

Divide number of hundreds of yards in range by 6 for length in inches, thus for 1200 yards, length of fuze=2 in.

All time fuzes are now issued in tin cylinders, containing 5 and have the top soldered on.

Percussion Fuzes.

We now come to the consideration of percussion fuzes. It will be easily seen that some material stronger and less liable to alteration in form than wood is necessary for these fuzes.

Iron was first tried, but its chemical effect on the powder was such that it had to be discontinued; finally, a nature of gun metal, which is a sort of bronze, composed of copper

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and tin, was used, a small portion of lead or zinc is added to make it more easily turned. The main parts then of all service percussion fuzes are of gun metal, various portions, however, being of lead; copper and brass wire is also used.

I have before said that percussion fuzes may be classed as those for field and garrison service. Perhaps a better division will be into those designed to act on direct impact only and those designed to act on graze.

It is a comparatively simple matter to make a fuze that will act with certainty in a S.B. shell only, or in a rifled shell only, but it is a much more difficult matter to arrange one so that it will act equally well in both. Pettman's G.S. fuze very ingeniously fulfils both conditions.

The first fuzes we will consider are those that are to act on direct impact only, there are three of these.

Pettman's Land Service. S.B. only.

Pettman's General Service. S.B. and all rifled shell except Armstrong.

Special Fuze for 64-pr. battering shell. 64-pr. M.L.R. Wrought Iron.

As it is necessary that a fuze to act on direct impact should not be so sensitive as to explode on mere graze or on passing through a wave. This is generally managed by covering the detonating arrangements with thin copper, or by diminishing the sensitivenes of the composition.

Pettman's Land Service Fuze is used with common shell of common gauge, the fuze hole being through tapped to receive this fuze; common shell with a cross cut on the plug, indicates that this has been done.

The fuze is composed of the following parts:

A—Body.
B—Top Plug.
C—Steady Plug.
D—Detonating Ball.
E—Cone Plug.
F—Lead Cup.
G—Bottom Plug.

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The body is gun-metal, the ball, cone plug, and steady plug are of a harder alloy to strengthen them. The remaining parts are of gun-metal, excepting the lead cup.

The ball is covered with a detonating composition, which is also in a groove cut round it; it is protected by varnished gut and varnished silk, from damp and premature explosion. A strand of quick match closes the fire hole in bottom plug.

Deton. comp.
Chlt. Pot. 6oz.
Sul. Ant. 6oz.
Sulphur ½oz.
Meal Pr. ½oz.
Made into paste, Spirit and Shellac.

Action—On firing, the shock of discharge crushes up the lead cup, the ball, cone and steady plugs set back, the lead cup firmly dovetailing the cone plug and bottom plug together and preventing rebound. The steady plug prevents the ball striking the sides of the fuze on discharge, the irregular motion, however, of the S.B. shell through the air disengages it, and on striking, it is dashed violently forward or against the sides, and the fuze exploded.

This fuze was introduced for garrison or siege purposes, as it does not act well on graze.

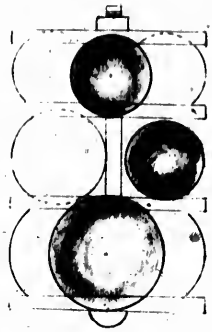
Pettman's General Service Fuze.

It was found that the even regular motion of the projectile from a B. L. R. gun, often failed to release the detonating ball, and consequently did not fire the shell.

For rifled guns only, a much simpler action would do for both M.L. and B.L. guns, but as it was thought desirable to have a fuze certain in its action for all natures, "Pettman's G.S." fuze was brought out, which included an extra action, available, however, only when the shell struck point first, which is almost invariably the rule in a rifled shell.

This fuze is moreover *specially* designed not to act on graze.

It was no easy matter so to balance things that the fuze would not act on graze, and would act on direct impact, with practical certainty in each case; this, however, was got over by casing the detonating ball with thin copper hemispheres and extra layers of silk and gut, the extra rim of detonating composition is also covered with thin copper.



So accurately has this been adjusted that they will not act on water with heaviest charges, but do on striking thin wood directly.

The composition of the various parts of the fuze is the same as the L.S., but it has an extra "plain ball" of brass, and a copper supporting wire.

The fuze consists of:

Body.
Top Plug.
Plain Ball.
Steady Plug.
Detonating Ball.
Cone Plug.
Lead Cup.
Supporting Wire.

The body of the shell is conical and tapped to screw into the G.S. gauge and can be used with all shells of that gauge. It is tapped throughout. It will only screw about half way into a common S.B. shell (land service.)

The steady plug has a ring cut on upper surface, to receive the detonating substance, and has a cup cut to receive the plain ball.

The cone plug (so called from its shape in the L.S.) is larger than the L.S., and contains a chamber filled with mealed powder driven like a tube.

The detonating ball, of the latest patterns, with the composition on it, is first covered with gut, then two layers of silk, then two copper hemispheres, then more gut, then three layers of silk, each layer of gut and silk is varnished. The ring of composition is also covered with copper and lacquered. The whole fuze is carefully lacquered and cemented to keep out damp, which, acting with the copper and gun-metal of the hemispheres and ball on the composition, was found to deteriorate.

The cone plug is supported by a copper wire.

The action from a S.B. gun is the same as the L.S. Action

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In a rifled gun, if the motion is not sufficient to disengage the large ball, the set back of cone plug, ball, and steady plug, releases the plain ball, which is thrown by centrifugal force over some part of the ring of detonating composition, and on striking point first cannot fail to ignite the fuze. The copper protection to the detonating composition causes its inaction on graze. So nicely has this been adjusted that it explodes when fired against wood from a B.L. gun, but will not explode on graze from a 7 in. with battering charge.

Special Fuze.

Special fuze. 64-pr. Battering Shell.

Lately a modified palliser shell under the name of a "Battering shell" has been approved for the wrought iron 64-pr. M.L.R. siege gun, for the purpose of destroying escarp walls or masonry generally.

The resistance of masonry not being sufficient to explode the shell like an ordinary palliser against iron, it was found necessary to devise a fuze to be placed in the rear of the shell, so as to keep the pointed head intact. It had to be strong enough to resist the direct effects of the explosion, and to firmly close the base of the shell. It was, moreover, found convenient to modify its external form so as to make it answer the purpose of a nut to fix on the gas check.

As it is important that a shell should penetrate to its extreme distance before bursting, in order to get the full effect for breeching purposes, a delay arrangement consisting of about ½ an inch of a species of fuze composition has to be burned through before the fire reaches the powder in the shell. An air space allows a little room for the products of combustion.

The fuze consists of:

Body.

Percussion arrangement of pellet with detonator, guard, suspending wire and steel pin.

Air space.

Delay arrangement of fuze composition.

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On striking, the wire is sheared off, the guard and pellet are set back to dash powder impact, unto the steel needle, the detonating composition lights the fuze composition, which burns for about 5 sec., then it ignites the mealed powder, and passes into the shell.

FUZES THAT ACT ON GRAZE.

We now come to fuzes designed to act on graze. The smaller the charge the less the velocity and the greater the difficulty of making a fuze to act with certainty. Thus the ordinary percussion fuzes, issued for field service, do not act well with the small charges of the 7-pr. or with the reduced charges of the rifled howitzers.

Again a short range from an ordinary gun is trying to a fuze, for the traject is flat and the shell receives but slight check on grazing; the softer the ground the greater the chance of failure.

The ordinary fuzes, however, act well at 400 yards and even under.

Quickness of action is imperative in these fuzes, or the effects of a good burst on graze would be lost if the shell had time to rise.

The first we come to is the

B.L. Plain Percussion Fuze. This fuze was known as the "C. Cap", and is almost identical in action with the Marks I. and II. R.L. fuzes and also the before mentioned "special fuze." The whole internal arrangement is much simpler than in the Pettman G.S. fuze, and they are less liable to deterioration from damp and, as the detonating composition is contained in a copper cap into which it is placed under great pressure and well varnished.

The fuze is used with segment and common shell from field service, Armstrong guns, it fits into a place prepared for it in the shell, and is generally used in connection with the E time fuze, it has a projecting rim at top to prevent it going too far into the shell.

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The fuze consists of

Body and top.
Guard.
Pellet.
Cap.
Bottom:
Safety Pin.

The *Pellet* is made of lead and tin in equal parts; it is hollowed out at the head and receives the copper cap, filled with ordinary cap composition, pressed in under 600 lbs. to area of cap, covered with very thin brass and varnished paper. The lower part of the pellet is hollowed out and filled with pressed powder, driven like a tube. It has four flanges or feathers on which the guard rests. The remainder of the fuze is gun metal; the *top* has four holes in it covered inside with thin discs of brass, which allow the passage of the flame from the E time fuze, if used with it. A *steel* point is fastened to the underside of the top, point down. Two holes for the safety pin are bored through the body.

The guard is also pierced with holes for the safety pin; it fits inside next the top, and is recessed inside to receive the head of the pellet. There is a slight undercut at top of recess to receive the head of pellet when it sets back.

The *cap* has three holes in it to allow the flash to pass through it to the powder in the pellet, thence to the shell.

A gun metal disc, with a hole in it, driven as usual with powder and closed at base with a brass disc, forms the *bottom*, which is screwed in. The *safety pin* is of twisted brass wire, with a piece of braid to it, by which it is withdrawn; it is placed through the holes prepared for it and luted with beeswax.

Preparation

The fuze is prepared by withdrawing the safety pin and dropping it into the shell, replacing the plug or screwing in the E. time fuze, if on sea service.

Action

The *action* is as follows. The guard sets back on discharge, and dovetails into the pellet, having sheared off the

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feathers. On striking or grazing they fly forward in one mass, and the cap striking the needle the fuze is exploded.

Before the safety pin was added the soft leaden feathers were jolted off in the limber boxes, and the fuze made dangerous, the safety pin now takes all weight off them when in its place.

This fuze may be depended on to act on water, even at 400 yards, where case ceases to be effective.

R. L. fuzes

We now come to the R.L. fuzes, designed to use with R.M.L. guns.

There are two "Marks" of this fuze; the original "Mark I." though excellent in its action with 7-pr. full charges, and with the 9-pr. gun, was found not to be strong enough in construction for use with the 16-pr. and higher natures.

The "Mark I" is no longer made, but will be used up with equally good results with the 7-pr. and 9-pr., while the "Mark II" can be used with all common shell up to the 80-pr. M.L., and with the 7 in. R.B.L. gun.

Mark I. R.L.

Mark I., in its internal arrangements and action, exactly resembles the "B.L. Plain" fuze, but the body and top are cast in one piece; there is a square hole in head to screw it in by. The fuze is tapped to fit the G.S. gauge, and has a projecting rim round the top secured to hold a brass ring fastened to the safety pin.

The hole where the safety pin comes out being outside the shell, the flash might pass in and cause a premature, but to guard against this a small lead pellet slides freely in a recess cut for it in head of fuze; when the shell is rammed home the pellet sets back and closes the hole.

The safety pin is of single wire.

Mark II. R.L.

"Mark II" differs from "Mark I" in the following particulars:

(1). The pellet and guard are of smaller diameter, to admit of the walls being of greater thickness and of a deeper screw thread in the bottom, thereby giving the base a greater power to support the shock of the pellet and guard.

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(2). The pellet has no powder in it, and there is an increased quantity of detonating composition in the cap, the action is therefore quicker.

(3). The safety pin is of double twisted wire, and the ends are opened out so as to bind themselves in a conical cap. The head of the safety pin has a loop of string; there is no brass ring or recess round the head of the fuze.

The above fuzes were not found to act well with the reduced charges of the howitzers and the 7-pr., and a fuze was required that would do this and at the same time stand the shock of their heaviest charges.

This lead to the introduction of a fuze resembling the Prussian percussion fuze, and called the sensitive fuze.

Sensitive fuze.

The sensitive fuze consists of

- Body.
- Hammer or Pellet.
- Steel Needle.
- Thimble.
- Detonating Cap.
- Safety Pin.
- Outside Primer of Quick Match.
- Band.

The body, hammer and cap are of gun-metal.

Hammer.

The hammer tapers slightly from top to bottom in order to move forward freely on striking, a thin steel plate the centre of which forms the *needle*, fits into a slot in top of hammer, and a hole bored through centre of latter allows flash to pass on both sides of the steel plate into the shell.

Needle.

The Thimble.

The thimble is a thin brass cylinder, flanged at bottom, and encloses the hammer, and moving with it prevents the hammer being impeded with dirt that might enter through the safety pin hole on graze.

The Cap.

The cap is screwed into the head of fuze and secured by a small stop screw; it contains about 7½ grains of pressed meal powder, covered with a perforated copper disc; below this is pressed 3½ grains cap composition, protected by varnished paper and a thin brass disc.

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The meal powder ensures a sufficient flash to explode the shell.

Safety Pin consists of a brass pin with a heavy head of gun-metal; it is secured by a strand of thread quick match or gun cotton, coated with meal powder. **Safety Pin.**

The whole is covered by tape and a copper band. The pin fits easily through the body into a recess in opposite wall.

The fuze is uncapped like a time fuze when shell is in the bore, the flash of discharge burns up the quick match or gun cotton, and the heavy headed pin is free to whirl out by centrifugal force, when clear of gun. The hammer is then free to move forward on slightest graze, the steel pin is dashed into the detonating composition and explodes the shell. **Action.**

Gunpowder.

Gunpowder has been composed of the same ingredients for many years, viz.:

Saltpetre, 75 parts,	100 parts.
Charcoal, 15 parts,	
Sulphur, 10 parts,	

Roughly speaking the charcoal is the fuel, the saltpetre supplys the necessary oxygen to ensure the rapid combustion necessary to evolve large quantities of heated gas, and the sulphur enables this to be done at a comparatively low temperature, and also chemically assists the action.

The qualities which most influence gunpowder, as regards its use in rifled guns, are its density, size, and shape of grain, and the condition of the charcoal. **Qualities.**

The denser the powder is the slower it will burn, the dense powder offering *a smaller surface to ignition* than an equal weight of a less dense nature. **Density.**

For a similar reason a large grain will burn slower than a number of small grains making up the same weight, but exposing a much larger surface. **Size of grain.**

Again, a regular shape, such as a sphere or cube, will offer less surface than an irregular one of same mass; a

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flakey form of grain indicates a very violent powder.

If the charcoal is imperfectly charred, the oxygen and hydrogen retained in it, cause a more rapid combustion than when it is reduced to nearly pure carbon, and also, it is more "hygroscopic," or liable to absorb moisture. **Effect of Charcoal.**

Thus a large grain, dense powder will burn slower and with less violent results than a small grained powder of less density, always supposing that the grain is not too small to allow the passage of the flame amongst it, which, however, is only the case when it is reduced to *meal.*

On account of the extra strain on rifled guns, it was found advisable to introduce a slower burning powder than had been in use with S.B. guns, and a powder called "Rifle Large Grain," or shortly "R.L.G.," was introduced, of larger grain and denser than the old "L.G." **R. L. G.** **L. G.**

This R.L.G. is too violent for the largest guns, and "Pebble" powder in two sizes is now in use, called "P" and "P2". Pebble is still denser than R.L.G., 125 lbs. occupying much the same space as 100 of L.G.

There are other powders for small arms, &c., the following being a complete list:

P2 P2 grains about 5 to 7 to lb., length of side of rough cube about $1\frac{1}{2}$ inches; it will probably be used for all heavy guns, from the 10 in. upwards; at present it is used for the $12\frac{1}{2}$ in. gun and upwards. Density not less than 1.75.

P. P. grains about $\frac{5}{8}$ in. side. Density about 1.75.

It is used at present for all battering charges, and for service charges of 40 lbs. and upwards, except the $12\frac{1}{2}$ in. gun.

* The above powders give less strain on the gun, but greater velocities than R.L.G., for the reason that though the pressure on the powder chamber is less, it is kept up longer in the bore, on account of the slow burning, and the velocity depends on the *total* pressure exerted on the shot in the bore.

Advantages of P. over R.L.G.

The recoil is greater when P. is used than when R.L.G. is used, but this shews that the actual strain on gun is less, the force of the powder has *time* to make the gun recoil in

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place of having to expend itself on trying to tear apart the particles of metal.

When gun cotton or other violent explosive is used, we have the contrary result, the recoil being slight, in proportion to that when gunpowder is used, but the strain on the metal is very great; in fact a certain amount of energy has to be expended somewhere, the gun has not *time* to recoil before it is all over, consequently the metal has to take the strain. The more freely a gun can recoil, the less will it be strained.

Will pass through a sieve having 4 divisions in a linear inch, or a 4-mesh sieve, and will rest on an 8-mesh, this determines its size, its density is 1.65.

R.L.G. is intended for use with all R.M.L. guns for charges under 40 lbs., except battering charges and the charge for the 7-pr. R.M.L. gun. As it is, there is a large quantity of L.G. to be used up, so at present R.L.G. or indeed L.G. *may* be used for battering charges of 7, 8, and 9 inch guns, but the charge is not so heavy. R.L.G.

L.G. is at present used for S.B. and B.L. guns, and till *used up* for full charges of R.M.L. guns *under* 10 inch (except R.M.L. field guns and the 7-pr.) L G.

This powder passes through an 8-mesh and rests on a 16-mesh sieve. The density varies. It is easily known from R.L.G. by the absence of glaze. Unglazed.

R.F.G. used for small arms (except Martini-Henry, Gatlins and Pistols) and the 7-pr. R.M.L. guns. It passes through a 12-mesh and rests on a 20-mesh sieve. R.F.G.

R.F.G.2 used for Martini-Henry, and Gatlins. Is same size as last, but of greater density. R.F.G.2

F.G. no longer made. Used for S.B. small arms and for 7-pr. and for bursting charge of shrapnel. F.G.

Pistol for Colt's and Adams' Pistols. It passes through a 44 and rests on a 72-mesh. Pistol.

Siftings of R.F.G.2 has been approved for Adams' revolvers. It passes an 18-mesh and rests on a 44-mesh sieve. Adams' Pistol

Mealed powder is ordinary powder reduced to impalpable dust by means of a revolving barrel and gun metal balls. Mealed Powder.

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It is used in various ways, when easy ignition is required, but no great regularity in burning.

Pit Mealed Powder.

Is made from powder specially prepared, the charcoal being charred in pits in place of cylinders. It is used in fuze composition, when great regularity is required. It burns quicker than ordinary mealed powder.

Precautions.

Gunpowder explodes when heated to about 600° F., but will also explode either by a blow or on friction, the harder the surface and the thinner the layer of the powder, the more likely is explosion to take place; the dust from powder escaping from barrels, would be very apt to explode on a stone floor, if walked over with nailed boots; hence in all cases when powder is moved, the men work in their stockings or in shoes for the purpose, and the floors are invariably covered with hides or woolen cloths called wad-mill tilts.

Copper tools are alone used in operations with powder, being a soft metal, and all loose grains must be immediately swept up and destroyed, all grit and dust also must be carefully cleared away.

Saltpetre must be pure.

Gunpowder stands climate well if the saltpetre is pure; in very damp climates, however, the powder is kept in metal lined cases. It must never be left in direct contact with metal, as, if there is the least damp, the powder attacks the metal, and also, the powder deteriorate.

Classification.

The following are the classes into which powder is divided, the first three being "serviceable" powders.

Class.	*Designation.*	*Description.*
1	Service.	1. All new powder. 2. All returned powder found uninjured on examination.
2	Blank.	1. Powder from broken up cartridges too dusty for Class I. 2. Powder from broken up S.A. ammunition. 3. Service powder found on return or on examination to have become too dusty.
3	Shell.	Powder too dusty for Class II.
4	Doubtful.	All powder (except new) returned to Store to await examination.
5	Condemned for sale.	Powder too bad for any of above classes.
6	Condemned for extraction.	Powder from shells, and B.L. S.A. cartridges, that contain their own means of ignition, or too much damaged to use as powder.

A better class of powder is required for blank than for shells, for dusty powder would work through the cartridge. If "shell" powder cannot be obtained a better class must be used.

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Gun cotton is now manufactured at the Government works, and is largely used for torpedoes and for general purposes of demolition. Gun Cotton.

Its explosive power when strongly confined is very great, but when fired loose it burns quietly without explosion. It can, however, be violently exploded loose, either in a wet or dry state, by means of a detonator of fulminate of mercury; this property is one of its most valuable, as it does away with the necessity of tamping mines, and a few discs or slabs hung on a gate, stockade, or the pier of a bridge and detonated have a tremendous effect.

Non-commissioned officers of cavalry now carry a certain amount, to enable them to destroy bridges or railways.

A valuable property is that it can be kept in tanks in a wet state, when it is perfectly safe and cannot be exploded by fire; a quantity thrown into the fiercest fire simply smoulders away, it can be dried as required or *detonated* in the wet state. Gun cotton may ignite at 277° F., it must ignite at 400° F., its average being about 340°; it is much more inflammable than gunpowder, and hence is used to prime fuzes when low charges are used.

Without going into chemical details, it may be said that it is produced by the action of the strongest nitric acid on pure cotton, sulphuric acid being added to absorb water, which is a product of the process, if the water was not absorbed the cotton would decompose. Manufacture.

After a short time the cotton is taken out and very thoroughly washed, it is then pulped and is moulded or pressed into any required form. It is generally used in discs of from 1 to 9 ounces, and in slabs of $1\frac{1}{2}$, 2 and $2\frac{1}{2}$ lbs.

Detonators are used to fire it, consisting of a tin tube containing about 20 grains fulminate of mercury; to this is attached an electric arrangement of some nature and the whole is inserted in a hole in the slab to be exploded. Detonators.

One detonator will explode any number of slabs, if they are nearly touching each other.

Other compositions are used in laboratory work, but it is hardly necessary to describe them here.

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DEFINITIONS

OF VARIOUS TERMS USED IN GUNNERY.

Axis of piece is an imaginary line passing down centre of the bore. — Axis of piece.

Axis of trunnions is an imaginary line passing through the centre of the trunnions, at right angles to the axis of the piece. — Axis of trunnions.

Line of sight is an imaginary line passing through the sights of the piece and the object aimed at. For practical purposes this may be termed the *line of fire*. — Line of sight.

Plane of sight is the vertical plane passing through the *line of sight*. — Plane of sight.

The angle of sight is the line which the line of sight makes with the horizontal plane. — The angle of sight.

Angle of elevation is the angle which the line of sight makes with the axis of the piece. — Angle of Elevation.

The quadrant angle is the angle which the axis of the piece, when laid, makes with the horizontal plane, and is termed *quadrant elevation* or *depression*, according as the axis of the piece is laid above or below the horizontal plane. — The quadrant angle.

The trajectory is the curve described by the projectile in passing from the muzzle of piece to the first point of impact. — The trajectory.

The line of departure is the direction in which the projectile is moving on leaving the piece; or, in other words, a tangent to the trajectory at the muzzle. — The line of departure.

The plane of departure is the vertical plane passing through the line of departure and the axis of the piece when laid. — The plane of departure.

The angle of departure is the angle between the line of departure and the horizontal plane. The excess of the angle of departure above the quadrant angle is commonly called the jump. — The angle of departure. — The jump.

The angle of projection is the angle between the line of departure and the line of sight. — The angle of projection.

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The angle of descent is the angle which a tangent to the trajectory at the first point of impact makes with the horizontal plane. The angle of descent.

The range is the distance from the muzzle to the intersection of the trajectory with the line of sight. The Range.

The lateral deviation is the perpendicular distance of the point of impact of the projectile right or left of the plane of sight. The lateral deviation.

The drift is the constant deflection of a projectile from the plane of departure due to the rotation imparted by the rifling of the piece. It is also called derivation. The drift.

Dispart is, generally speaking, half the difference of the diameters of those parts of the gun on which the sights are placed. Dispart.

Line of metal is an imaginary line joining two notches on the upper surface of the gun, one at the highest part of the breech, the other the highest part of muzzle, the axis of trunnions being level. Line of Metal

A gun is said to be laid point blank when the line of sight is parallel to the axis of the piece, that is, when the "angle of elevation" is 0°. The quadrant elevation or depression may be considerable. As in the case of a tower on shore, firing on boats within 100 yards or so. Point blank.

The point blank range is the range attained by a shot when the axis is laid parallel to the horizontal plane. The point blank range.

The range generally depends upon the initial velocity of projectile; its form and density, the range of elevation, and the height of gun above plane. The range.

In using the ordinary sights of a S.B. gun at a certain angle of elevation the muzzle interferes with the line of sight, that angle is called the clearance angle. Clearance angle.

The calibre of a S.B. gun is the diameter of its bore. The calibre of a rifled gun is measured across the lands. Calibre.

The windage of a S.B. gun is strictly the difference in area between a section of the projectile and of the bore, but is practically measured by the linear difference between the diameters. In a rifled M.L. gun it is taken as the Windage.

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difference in diameter of the projectile and the bore of the gun taken between the "lands."

Clearance. Clearance is the difference between the height of a stud above the body of a projectile, and the depth of the groove into which the stud fits. If the depth of groove is *less* than height of stud the shell will rest entirely on the studs, and there will be an interval called "clearance" between the projectile and bore. This is important in bronze guns, in order to keep the hard metal off the soft bore.

Advantages and disadvantages of Windage. The advantages of windage are, easy loading, ignition of time fuze by flash of discharge, slightly reduced strain on gun, and it makes allowance for expansion of projectile by heat, rust or paint.

The disadvantages are, loss of power from escape of gas, scoring of bore when heavy charges are used, and means have to be taken to centre the projectile.

VARIOUS KINDS OF FIRE, &c.

The terms distinguishing the various natures of artillery fire, have reference

(1) To the conditions within the vertical plane.

(2) To the conditions within the horizontal plane.

Vertical plane. The terms denoting the conditions within the vertical plane are,

Direct fire. *Direct fire*, which is the fire from guns with *service* charges at all angles of elevation up to 15°.

Indirect or curved fire. *Indirect or curved fire* is the fire from guns with reduced charges, and from howitzers and mortars at all angles not exceeding 15°.

High angle. *High angle* fire is the fire from guns, howitzers and mortars, at all angles of elevation exceeding 15°.

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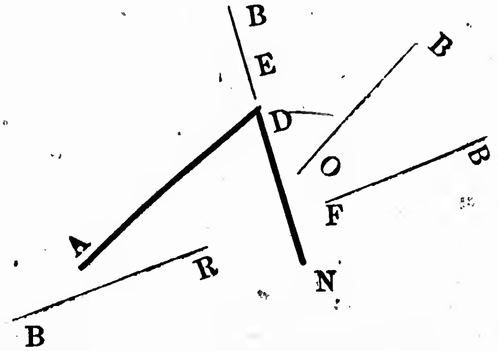
The terms denoting the conditions within the horizontal plane are, *front*, *oblique*, *enfilade*, and *reverse* fire. **Horizontal.**



Let A D N be the work attacked, B B B the attacking batteries, then,

B. F. ⊥ to face of work D N represents the general direction of *front fire*; B O oblique to D N represents the general direction of *oblique* fire; B E parallel to the face; D N represents the general direction of *enfilade* fire; and B A perpendicular to the reverse slope of D N, represents the general direction of *reverse* fire. **Front fire.** **Oblique fire.** **Enfilade fire.** **Reverse fire.**

A combination of these terms accurately describes the various natures of artillery fire, *e. g.*, direct front fire means that the fire is direct in the vertical plane, and front in the horizontal.

With S.B. guns *Ricochet* fire would still be useful. It is according to above definitions "indirect" or "*curved*" *enfilade* fire, but from S.B. guns only. **Ricochet fire.**

It is intended with round shot, to just clear the various traverses, and in several bounds dismount guns, &c. Rifled projectiles are uncertain after first graze in their direction to make *Ricochet* fire of much use.

Direct fire hardly needs description. It is used on all occasions when possible and convenient, for it alone developes the full powers of a gun, apart from the effect peculiar to its projectile. Hence it is used against shipping, troops **Direct fire**

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in the open, breaching earth works or *visible* revetments, and destroying cover generally. Greater ranges are of course obtained.

Indirect or curved fire.

Indirect or curved fire, by means of which the projectile descends at a greater angle than in direct fire, that is the *angle of descent* is greater, has long been used, with S.B. ordnance, from guns and *Howitzers* to dislodge troops under cover of a parapet. Its use is now more important than ever, since in all modern defences the revetments are more or less under cover, of glacis, &c., and could not be reached by direct fire, but are easily breached by modern curved fire, which every day becomes more accurate as our knowledge of the correct path of a projectile, and its true angle of descent, increases. Curved fire was very much used during the French war by the Prussians, who have given great attention to it. It is quite possible now to make equally good practice by night or day at an unseen object once the proper elevation and line of fire has been obtained, from observation or actual measurement on a plan. The line of fire would then be marked on the platfrom, and direction given by "hanging scales," and elevation by quadrant. Every shot is then bound to go to the exact same spot. The axis of piece being parallel to, or in, its original direction every time.

Ricochet fire.

Ricochet fire, as previously remarked, is a species of this fire, but would seldom be used even with S.B. guns, the effect of a shell bursting just within a battery being greater than a round shot in its bounds. If advisable the elevation should not be over 10o, or shot is liable to bury itself, and the charges about $\frac{1}{30}$ to $\frac{1}{20}$ weight of shot, according to range.

The modern rifled howitzers are particularly designed for this species of fire, and are extremely accurate in practice, and they consequently form a large proportion of a modern seige train. The general accuracy of rifled guns have to a very great extent increased the utility of this nature of fire.

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High angle fire is employed when the angle of descent is required to be abnormally large, as in penetrating the "bomb proof" roofs of magazines, casemates, &c., and perhaps in breaching, when the distance between the object and its guard is very small, or the distance very short.

High angle fire.

It is also useful in throwing shell on to the decks, which are the weakest part of ironclad vessels, and for this purpose a 10 sec. rifled mortar (at present it is called a howitzer, but from its dimensions it is more correctly a mortar) has been designed. This fires a shell about the same weight as a 10 in. R.M.L. gun of 18 tons, and only weighs 6 tons.

In this fire, it is generally most important to obtain the largest angle of descent possible, which is a simpler matter than calculating the exact angle required to just clear a given object, and to strike a given point considerably below it further on. In the latter problem there are many variables, for the range has to be considered as well as the distance of point fired at from its counter guard, so that elevation and charge have both to be varied till the proper angle is arrived at. For this purpose, by no means sufficient data have been collected.

Various charges.

For both curved and high angle fire from rifled ordnance certain *fixed* reduced charges are issued for each gun, and any further alteration is made by giving more or less elevation generally by quadrant, as the object is usually invisible, and, moreover, the angles beyond those conveniently marked on tanjent scale. Again, for this practice it is important that the axis of piece should always be inclined at the same angle to horizontal plane, when firing at the same object, and this can, in all cases, be more accurately done by quadrant.

It is also important that the plane of sight should be perpendicular to the horizontal plane, that is, the trunnions level, or allowances made for difference in level.

With S.B. ordnance, except mortars, the charges may be varied and the elevation also.

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With S.B. mortars, the elevation is practically for all purposes fixed at 45° and the charges are varied as required.

It is very important, therefore, to see that the axis of the mortar is inclined at 45° to horizontal plane, and that the axis of trunnions is parallel to it.

With reference to the horizontal plane it can be seen that for penetrating purposes, such as breaching a revetment, or penetrating an armour plate, front fire is more effective than oblique. **Horizontal plane.**

Again in enfilade fire, being in the prolongation of a work or line of men, there is more chance of hitting, for if the object fired at is missed there are more beyond.

Reverse fire, when possible, generally takes a work or position at a great advantage. The main defences being towards the front there is probably little protection to the defenders from this nature of fire.

Smooth Bore Ordnance.

Smooth bore guns have altered but little as regards size and general construction for upwards of 300 years.

In olden times there was a great variety of guns of all sizes. The weight, size and calibre depended chiefly on the ideas of the manufacturer.

Of later years, however, the varieties were greatly reduced, and S.B. ordnance was divided into guns, howitzers, mortars and carronades.

Guns are divided into two classes, shot guns and shell guns.

Shot guns are the strongest in construction, and are meant for heavy charges and all projectiles. **Shot guns.**

They are made of bronze for field service, and of iron for the heavier natures.

The bronze guns are 12, 9, 6 and 3-prs., and are used for field service. **Bronze guns.**

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Iron guns are 68, 56, 42, 32, 24, 18, 12, 9 and 6-prs. The 12, 9 and 6 are scarcely ever met with. *Iron guns.*

The 18 and 24-prs. were guns of position and siege guns.

The 32 and 68-prs. were the most useful and best known garrison and naval guns. There are various natures of the 32-pr. and other guns, varying in weight, &c.

The 42 and 56-prs. are practically obsolete, there being only one 56-pr. in Canada, and the 42-pr. was a naval gun.

10 in. and 8 in. shell guns are really long howitzers, and are used only with shell and light charges, being much lighter than the shot guns. They are of iron. *Shell guns.*

Howitzers are of iron for garrison service; of bronze for field service. There were two bronze howitzers in each field battery. *Howitzers.*

The 12-pr. batteries had the 32-pr. howitzer.

The 9-pr. " " " 24-pr. " for horse or field artillery.

The 6-pr. batteries had the 12-pr. howitzer for horse artillery.

The 3-pr. batteries had the $4\frac{2}{5}$ in. howitzer for mountain service.

The garrison howitzers were of iron, and of 8 in. and 10 in. calibres, and 22 and 42 cwt. respectively. *Iron Howitzers.*

They were generally mounted on travelling carriages for ricochet fire, but are also used for defence of places were the range is limited.

Howitzers resemble guns in greneral form, but are much shorter and lighter for their calibre.

Mortars are short and heavy pieces of ordnance, used to throw shells for high angle fire. They are generally fixed in their beds to fire at 45° only, and their charges vary with the range. *Mortars*

They are distinguished by the diameter of their bore.

They are of cast iron and of bronze.

The cast iron mortars are:

13 in., 10 in. and 8 in. for land service, and for sea service, the 13 in. and 10 in of nearly 3 times their weight. *Cast Iron.*

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Mortars were excellent for bombarding a town, but they are very uncertain as to range and direction.

The bronze mortars are the Royal 5.5 in. calibre, and the the Coehorn of 4.4 in.

These small mortars were used in the advanced trenches to annoy the besieged.

Carronades.

Carronades are short pieces of ordnance, called after the Carron foundry, where they were first made. They have less thickness of metal than guns of the same calibre, and have no trunnions, being secured to the carriage by a loop and bolt underneath. They were used chiefly for sea service and the defence of ditches.

They were made of all calibres, and threw shot and shell at short range very accurately and with small expenditure of powder. They were light and required but few men to work them.

For calibres, &c., see Table.

Rifled Ordnance.

Up to the year 1855 there had been but little real progress in the architecture of artillery, with the exception perhaps of the 68-pr. and the 8 in. and 10 in. shell guns. The different piece ordnance in the service were the same in general form and dimensions as in the days of the Tudors. They were not so ornamental either in their forms or their designations as the old ones, yet otherwise, in many cases, there was little to choose between them.

Although every nation still adhered to S.B. guns, it was not from ignorance, for at least several of the more important advantages of rifling, or at any rate of giving rotation to a projectile, were known to artillerists and scientific men for many years prior to their introduction. In fact, any one who had seen the steady flight of an arrow must have been impressed with its value.

In fact, as far back as 1615 a gun now in St. Petersburg was made rifled with 9 grooves; and again in 1661 the

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Prussians experimented with a gun rifled with 13 shallow grooves.

During the next two centuries in England and in various other countries, numerous experiments were undertaken with the object of giving rotation to the projectile, either by means of grooves in the gun or projection to act as feathers on the shot.

Thus, for a long time, the advantages of rifling, at anyrate as regards accuracy, was well known; but the backward state of metallury and mechanism was, till lately, the stumbling block to all inventors, amateur and professional.

It was in 1854 then that the great want was felt of rifled guns, and several 8 in. and 68-prs. were rifled on Lancaster's system and sent to the Crimea. However, through defects in the shape of the shell they turned out failures, still they are the first rifled guns actually in our service, or, I believe, in any service.

The French next, in 1859, employed rifled field guns with great effect at Magenta and Solferino. Thus the ball was set rolling, who can say where it will stop?

Rifled ordnance may be divided into several classes, viz:

1. *Field guns*, including mountain and boat guns.
2. *Guns of position* and *siege pieces.*
3. *Converted guns*, for secondary purposes of defence.
4. *Heavy guns.*

First, field guns.

Though the Prussians from the first adopted Krupp's steel, and the French bronze for their field guns, we, considering the softness of bronze and the uncertainty of steel, took to wrought iron as the best material, and Sir W. Armstrong having invented a breech loading system that gave excellent results when compared with S.B. guns, his system was adopted in our service to meet the urgent demand for rifled field guns.

His system was tried at the time against many others, and held its own. Our Field Artillery was equipped with them, also our siege train, and many larger ones were made.

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They had wrought iron inner tubes, but steel would now be used. Their manufacture was discontinued in 1866, but we now have, chiefly in reserve, some 3,500 of these excellent guns of all sizes, that would do good work if required. The following natures were made for field service:

B.L. Field guns.

NAME.	WEIGHT.	CALIBRE.	USE.
6-*pr. gun of*	3 *cwt.*	2.5 in.,	*a mountain* and boat gun.
9-*pr.* "	6 "	3 in.,	*Horse Artillery* and boat gun.
12-*pr.* "	8 "	3 in.,	*Field Battery* and boat gun.

The two last have the same calibre—3 ins.—and both could use the 9-pr. ammunition on emergency, but *not vice versa.*

The above system was found to be both complicated, expensive and dangerous, besides being difficult to keep in repair, and it was felt that for our varied requirements a simpler system was necessary; although, apart from various accidents from breech piece flying out, &c., these guns were found to be in many ways very satisfactory; in fact, a committee reported that there was little to choose in effect between the 12-prs. B.L.R. and the 9-pr. M.L.R., the 9-pr. B.L.R. being inferior to both.

R.M.L. Field guns

Between 1863 and 1870 very extensive experiments were carried out on the rival merits of various guns B.L. and M.L., and the various committees reported strongly in favour of M.L. guns, and those to be constructed of wrought iron coils shrunk over a steel tube; they reported that they considered the advantages of simplicity, facility of repair, ease of working, rapidity of fire, small original cost, and cost of maintenance, to be in favour of the M.L. gun, and outweigh the important advantage of the protection to the detachment from the superior cover afforded by a B.L. gun.

In 1871 our M.L. field guns were commenced, and our artillery is now entirely equipped with them. A few, almost experimental guns, were made at first, but finally the following were fixed upon for L.S.:

NAME. WEIGHT. CALIBRE. USE.

9-pr., 3 in., calibre; 8 cwt.; lately introduced for H.A.
9-pr., 3 in., calibre; 8 cwt.; light field batteries.
16-pr., 3 in., calibre; 12 cwt.; heavy field batteries.
*13-pr., 8 cwt.; field batteries.

*Experimental as yet, 1878.

There are also,

Steel.	7-pr., 3 in., calibre 200 lbs., the latest pattern; mountain and boat.
	7-pr., 3 in., calibre 150 lbs., an earlier pattern; mountain and boat.

There a[illegible] few 7-pr. of same weight of *bronze*, but no more are [illegible] made. The above are the only guns in our service of steel. All four natures fire the same ammunition.

The above guns are all rifled on the French system, except the 13-pr. experimental gun.

The 7-prs. are cut out of a solid ingot of steel.

The 9 and 16-prs. are composed of A tubes of toughened steel, strengthened by a *breech* coil, composed of a single coil, a trunnion ring, and a coil in front of the trunnions, all welded together and shrunk over the tube.

The heavy 9-pr. will ultimately become a S.S. gun.

The 16-pr. is identical in construction.

The 13-pr. is rifled on the poly-groove system, with several shallow grooves, and rotation is given to the projectile by means of a driving gas check. This gun will be very shortly adopted as the field gun. It is much larger than existing natures, and embraces all the modern improvements of enlarged chamber, &c. It will use a special powder. Very great velocities have been obtained with it.

Siege Guns and Guns of Position.

The history of these guns is very similar to that of the field guns, and consequently we first have a large number of R.B.L. guns of Sir W. Armstrong's construction, of the following varieties:

20-pr., 16 cwt.; light gun of position, and siege gun.
40-pr., 35 cwt.; heavy " " " "
7 in., of 72 and 82 cwt.; heavy siege gun.

There are other lighter natures of all three of these guns, but are used only at sea for boat work.

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The 20-pr. was the heavy field battery of reserve gun.

The 7 in. would only be used in the batteries of an attack.

There were also a 64-pr. and 40-pr. on the *wedge* system. They were entirely withdrawn some time ago.

For exactly similar reasons as in field guns these were withdrawn from L.S., though the great convenience of B.L. ordnance in boat work, render them still favourites with the navy.

There are also considerable numbers of 40-pr. on travelling carriages in every large garrison both at home and abroad, and they have been largely issued to the Reserves.

They are, however, being gradually superseded by the following:

25-pr., 4 in., calibre of 18 cwt.
40-pr., 4.75 in., calibre of 34 cwt.
64-pr., 6.3 in., calibre of 64 cwt.

Also the following rifled howitzers. Those marked * are at present experimental, but will, in all probability, be adopted, when the present ones will probably be termed rifled *mortars* which they most resemble in their proportions.

6.3 in.	howitzer,	18 cwt.
*6.6	" "	36 "
8	" "	46 "
*8	" "	70 "

The 25-pr. and 40-pr., and 64-pr., are built on the Frazer construction, and are the guns now used in the siege train, together with the rifled howitzers.

The following are the proportions for the 30 pieces in a light and heavy siege unit, respectively:

Light.	25-prs	10	Also 6, 7-pr. guns, 200 lbs., in place of bronze mortars.
	40-prs	10	
	6.3 in. howitzers	10	
		30	
Heavy.	40-prs	8	Also 6, 7-pr. guns, 200 lbs., in place of bronze mortars.
	64-prs	8	
	8 in. howitzers	14	
		30	

There would probably be a few Gatlins or machine guns.

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The above guns are all rifled on the Woolwich or French system.

They differ from the field guns in having a *B coil.*

The howitzers are also of the usual Woolwich construction, and the rifling of the 8 in. is the Woolwich, with a very rapid twist.

The 6.3 in., however, and the two experimental ones are poly-groove, and the rotation is given by a driving gas check.

Medium and Heavy Guns.

Medium.	64-pr., converted from 32 and 8 sec.
	80-pr., " " 68-pr.
	7 in. sea service only.

Heavy or armour piercing.	7 in., of	7 tons.	
	8 " "	9 "	
	9 " "	12 "	
	10 " "	18 "	
	11 " "	25 "	
	12 " "	25 "	
	12 " "	35 "	
	12.5 " "	38 "	
	16 " "	80 "	
	17.72 in., of	100 tons.	

When the necessity for rifled guns was felt, there were quantities of smooth bore guns in the service, and the question arose as to whether these could be utilized for the purpose. After various trials it was found that by boring out the old guns to a certain extent, and inserting a coiled wrought iron tube, which was then rifled, a very cheap and serviceable gun was the result, as long as the charge was not too heavy.

Large numbers of the old 32-prs. and 8 in. guns have been converted to 64-prs. of the same calibre and weight as the 32-pr., and many 68-prs. to 80-pr.

The calibre of the latter is the same as the former, but it is a stronger and more powerful gun.

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These guns are still made, and are very useful for garrison guns for the purpose of land defence, but are not strong enough to penetrate armour.

Probably large numbers of the S. B. guns in this country will be converted on this system, most likely in the country.

The 7 in. and upwards are considered as armour piercing guns, and in general will pierce an armour plate about 2 ins. thicker than their calibre at 200 yards.

In the larger natures this is exceeded. Thus the 11 in. gun pierces about 14 ins, while the 12 in., 35 tons, has pierced $18\frac{1}{4}$ ins. iron, and 12 ins. teak, and the $16\frac{1}{2}$ in., 80 tons, about 30 ins.

These guns are used on board ship, and for coast defence, in the forts, protecting the dockyards of Portsmouth, Plymouth, Sheerness, and the principal harbours in Great Britain and her colonies. There are great numbers of 7, 9 and 10 in. guns mounted, besides 11 in., of 25 tons. The 12 in. and $12\frac{1}{2}$ in. guns, of 35 and 38, are chiefly used afloat, but they are to be mounted in several of the latest forts at Plymouth, Portsmouth, &c.

One fort alone at the former place is to have about 10 of them.

The 80 ton gun is at present designed for sea service only.

The chief difficulty with respect to these heavy guns is that of getting carriages and platforms strong enough to stand the shock of recoil, and at the same time bring them to rest, within the cramped space available in turrets and casemates, which were, in many cases, designed for smaller guns.

As the palliser shell or shot almost always breaks up on impact, experiments are being carried on with steel projectiles. Their expense is greater, but it is expected that their effect will be much increased.

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RIFLING.

The chief object of rifling a gun, is to obtain great range and accuracy combined.

This result is obtained almost entirely by the use of elongated projectiles, which can only be used from a rifled gun, for without rifling we could not give a "spin" to the projectile, and if it had no spin or rotation round its longer axis it would be inclined to turn over in its flight and become unsteady, and its range limited.

Sufficient spin must, therefore, be given to counteract this tendency, and to make the projectile travel point foremost throughout the entire range.

By this means the resistance of the air to a projectile of given weight is greatly reduced, for the area presented to its action is much smaller.

The muzzle velocity is not nearly so quickly reduced as in the case of a spherical projectile of equal *weight* fired under similar circumstances, and the difference is much greater if we take a spherical projectile of the same calibre. The result of this power of keeping up velocity is increased *range* and increased power of *penetration*, or of doing work at a given range.

As to accuracy. Inaccuracy in a S.B. gun is chiefly due to the bounding of the shot more or less in the bore, and to the fact that, in consequence of this the shot leaves the bore rotating on an accidental axis. Again, all projectiles are more or less "eccentric," and this again makes them inaccurate in flight, the centre of gravity describing a different path to the centre of the projectile.

In the case of a projectile fired from a rifled gun, it is given a rotation round an axis practically coincident with that of the bore, that is to say, the projectile is centred, and thus the effects of irregularities of either mass or surface are equalized, and revolution upon an accidental axis is prevented and ensures accuracy.

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A certain regular deviation or drift is caused by this rotation, but it can be allowed for, being constant for the same gun.

A rifled gun does not *necessarily* entail the use of elongated projectiles; but the collateral advantages are so great that they are universally used.

A spherical shot fired from a rifled gun, so as to have rotation imparted to it, would be *accurate* in its flight but limited in range.

The following are the principle advantages attained by the use of elongated projectiles:

1. Diminished surface for the resistance of the air to act on, and thus we obtain greater *range*, and greater power at a given range.

2. The trajectory is flatter, and thus we have more chance of hitting an object.

3. The head may be of any required form or weight, as in the case of palliser and shrapnel shell.

4. By varying the length, different kinds of projectiles for the same gun can be made the same weight; thus complications in range tables are avoided.

5. On the contrary, if desirable, a specially heavy (or light) projectile may be fired, as in the case of double shell.

6. The capacity of a shell for powder or bullets is increased, and consequently its power.

7. Great saving is effected in powder, the charge being from $\frac{1}{8}$ to $\frac{1}{6}$ weight of projectile, in place of $\frac{1}{3}$, as in S.B.

Besides above, two important properties are common to both spherical and elongated rifled projectiles, viz.:

A simple percussion fuze can be used, and the bursting charge of a shrapnel can be kept *behind* the bullets, which is the most advantageous position.

Systems of Rifling.

This all important rotation is given to projectiles in various ways, and accordingly there are several well known "systems of rifling."

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A system of rifling is, strictly speaking, the means of giving rotation to a projectile, and has nothing to do with the form or number of the grooves or studs, or with the vexed subject of B.L. *versus* M.L. guns.

The following are the best known systems:

1. A breach loading system, in which the projectile has a soft coating slightly larger than the bore of the gun, into which it is forced by the explosion, and made to take the rifling, which usually consists of a large number of shallow grooves cut spirally in the gun.

The best examples are the Armstrong and the Prussian systems, varying in details but not in principle.

2. A muzzle loading system, using projectiles with projecting studs or ribs of soft metal, shaped to the general form of the grooves, but with sufficient play to make loading easy. The grooves are fewer in number and larger than in the previous system. The British Woolwich system is the best known. It is modified from the French.

3. Muzzle or breech loading guns having projectiles of hard metal accurately made to fit the peculiar form of bore mechanically. Whitworth's and Lancaster's guns are on this system.

4. Last, but by no means least, a muzzle loading system, in which rotation is given by means of an expanding cup or disc of soft metal fastened to the base of the projectile, which is "set up" by the explosion into a number of small grooves, and rotation thereby given to the projectiles.

This system is in use for the 80 ton gun, the 100 ton do., the rifled howitzers, and the new field gun. As will be shown this system has many advantages and few defects, so that probably all new natures of guns will be rifled on this system, and in due time *the whole* of the service guns.

Defects, &c., of various systems.

We must first point out defects that are common to several systems, then those peculiar to each.

In every case where they exist, grooves cut in the bore of a gun greatly weaken it, according to their depth.

Again, to a much greater degree, do the holes cut in the projectiles and the subsequent pressures in fixing the studs, weaken the shell. In almost every case it is found that a shell breaks up at a stud.

Rifling is a necessary evil in every system but one, and till lately studs were considered practically necessary wherever grooves existed in a muzzle loading gun.

Studs, besides weakening the projectile, are costly in manufacture, and are very liable to damage from rough usage; and every projectile requires careful gauging before use.

1. The drawbacks peculiar to the first system were cost and complication of ammunition; and as the coating had to be compressed into the grooves, the strain on the gun for a given charge was very great. Small charges could only be used. The lead coating, if the twist was quick, was inclined to strip. Also the time fuze had to be lighted by a detonating arrangement.

Advantages. The projectile was, however, accurately centred, and consequently very steady and accurate in its flight. Also there is no windage and consequent loss of power.

The grooves are very shallow, and do not weaken the bore much.

2. In this system the gun is weakened by grooves, and the projectile by studs, and unless means are taken to prevent the rush of gas over the projectile the bore suffers severely, especially with high charges from scoring. The windage also means loss of power.

On the other hand, the gun is easily loaded, and latterly, the escape of gas has been entirely controlled by means of a copper gas check fixed to the base of the shell, enough flame being allowed to pass to ignite the fuze, but in no degree to damage the bore; and as there is no *compression* of the shot, but rather expansion, the strains on the gun are hardly increased at all.

Advantages. 3. In the third system we have in the Whitworth a large bearing surface, small windage, an absence of studs, and

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practically of rifling; in the Lancaster, the entire absence of grooves.

In both these, the projectile being made to fit the bore, no holes have to be bored for studs, so that the projectile is stronger and not so complicated.

Disadvantages

The machinery and workmanship must be of the best, otherwise the projectiles will not fit the bore accurately, and being of hard metal, will jam and break up, probably severely injuring the bore of the gun.

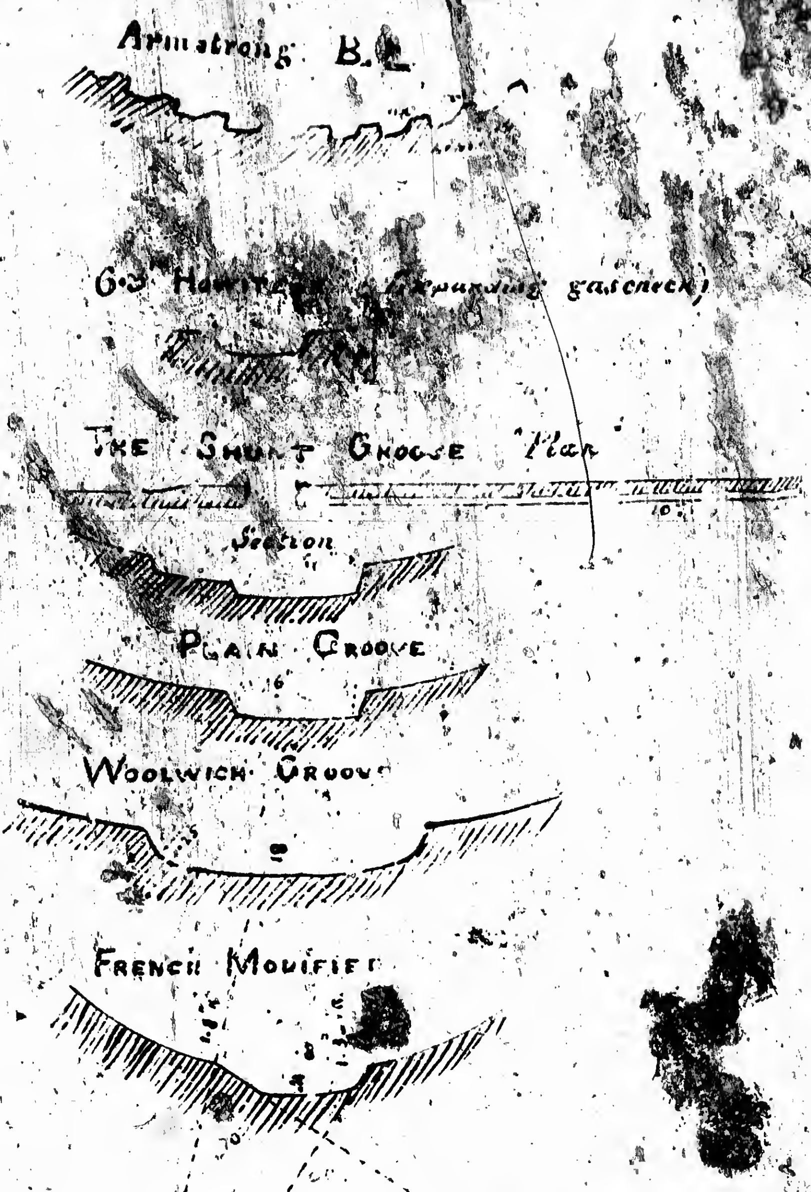
4. The fourth class has the advantages of the shallow grooves. The projectile is easily rammed home, and its manufacture is very simple. Moreover, it is not weakened by having studs, and is cheaply made, and sufficient gas passes to ignite the fuze.

The separate gas check slightly complicates matters, and is liable to damage, otherwise this system combines most of the advantages, and has few of the defects, common to other systems.

It had often been considered and was actually in use in the Confederate army, and is very similar to Mr. Britten's, but the mechanical difficulty in fixing the driving gas check to the base of the shell, so as to stand the heaviest charges, was long in being satisfactorily overcome, indeed it was brought out partly by accident. The gas checks were first used solely to prevent the scoring in the bores of the guns with large charges, and it was found at last that they could be fixed securely enough to give rotation to the projectile.

Grooves.

There are various forms of grooves used in these different systems. Those with studs requiring large and comparatively deep grooves, while guns rifled on either of the systems where the rotation is given by means of a soft coating or base ring will be found to possess a large number of small shallow grooves. The actual form and size of the groove depends upon the nature and size of the gun. As a general rule the simpler the form of the groove and the less sharp its angles the less chance is there of the barrel splitting along the groove; again the bore is less weakened



Armstrong B.L.
6.3" Howitzer (expanding gascheck)
The Shunt Groove Plan
Section
Plain Groove
Woolwich Groove
French Modified
French

by a number of shallow grooves than by a few deeper ones. There are several natures of grooves in use with our service ordnance.

1. The small grooves of the Armstrong and the 4th system.

2. The *shunt* used with all the early natures of 64-pr. built-up guns, and, in fact, all the 64-prs., except those with steel tubes, and marks I. and II. that have been re-tubed with wrought iron, and the converted guns.

The peculiarity of this gun was that the depth of groove varied at different parts of the bore, to enable the studs of the projectile to travel down a deep groove in loading, and to be *shunted* into a shallower portion when the gun is fired on the passage up the bore, so that the projectile may be gripped and perfectly centred on leaving the muzzle. There were several objections to this form of groove. (1.) It is complicated. (2.) It was not found to answer well in practice, probably for the reason that the compression took effect generally on one row of studs only, so that the centring action did not work, or that the groove was so shallow that the studs over-rode the groove. (3.) The projectile is gripped at the muzzle when at its greatest velocity, and the muzzle is thus unduly strained. (4.) The sharp angles of the grooves render the tube liable to be split.

The plain groove.

The *plain* groove is really the narrow deep portion of the *shunt* groove. It is used for all the converted 64-prs. and mark I. and II. re-tubed guns, so that they can use the same ammunition as the shunt gun. The results of the shooting with this groove are very good.

Woolwich groove.

The Woolwich groove is used for all guns above the 64-pr., including the 80-pr. converted gun; also the 8 in. howitzer, the 25-pr. and 40-pr. siege guns. The bottom is eccentric to the bore, having curved edges, both struck with same radius. The dimensions differ slightly for each nature of gun.

The modified French.

The modified French is used for the 16-prs. and 6-pr. field guns.

The driving edge is at a gentler slope than the loading edge, and the stud slightly mounts the slope and centres the projectile. The angles are rounded off and the bottom is eccentric with the bore. The loading and driving edges make an angle of 70° with each other.

The French.

The French is used for the 7-pr. It has not got its corners rounded off, and its bottom is concentric with the bore.

The form of the grooves having been discussed we will now consider the twist of the rifling, &c.

[illegible] of [illegible]g.

It is necessary, in order to make the projectile rotate, that a certain twist should be given to the grooves, so that as a shot moves forward it is made to twist round by means of its studs, lead coating, or cup, which must run up an incline, as it were, which incline 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.

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 the shot turns round.

Angle of twist

With regard to the actual twist, let us suppose a right-angled triangle. Let the base be equal to the length of the gun and the hypothenuse to the length of the groove in the given gun, then the angle of twist is $\cos^{-1}\frac{\text{base}}{\text{hypot.}}$

The longer the groove in a given length of gun the steeper becomes the angle of twist.

The greater the angle of twist, or the pitch of the rifling, the greater the strain on studs and grooves, hence only sufficient twist should be given to keep the projectile steady in flight.

As the amount of rotation depends both on the twist and on the velocity, when the latter is low we require a quick twist; so in the rifled howitzers the velocity is low, therefore the twist is quick.

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In our heavy guns a twist of about 1 in 35 is found sufficient. That is, a shot will take an entire turn in the length of bore equal to 35 times the calibre, therefore, in the above triangle, the perpendicular is equal to the circumference of the bore, and

$$\tan \theta = \frac{\text{perpendicular}}{\text{base}} = \frac{\text{Circumference of bore.}}{\text{Length of bore due to one turn.}}$$

In a 7 in. gun where twist is 1 in 35.

$$\tan \theta = \frac{7 \times \pi}{7 \times 35} = \frac{\pi}{35} \quad \therefore \theta = 5^{\circ}\ 4'$$

The twist may either be uniform or increasing. In a uniform twist the hypothenuse is a straight line. In an increasing twist it is a curved line. The incline is slight to begin with, but gets steeper towards the muzzle, so that the strain on the studs is much reduced and is more regular throughout the bore.

With our service guns, all over 7 in. have increasing twists.

The size, shape, number, &c., of the grooves, will depend on the nature of the projectile, whether lead coated, studded or otherwise, and on other considerations.

CARRIAGES.

Principles of Construction of Field Artillery Carriages.

The following qualities are necessary in a field artillery carriage:

First, and most important, is "mobility," for without this, in a high degree, field artillery would be of little use.

"Stability," so that in any movement required, even on rough ground, it may not overturn.

"Strength," "durability" and "simplicity," are, of course, of great importance; and convenience of transport is peculiarly necessary for British artillery, that has to be sent to each and every quarter of the globe.

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Mobility is influenced by several things, viz.: Mobility.

By the "traction" or "draught," that is, the power requisite to put it in motion and keep it in motion, by its capability of reversing, and by its power of passing objects.

It is necessary then to have the draught as light as possible, therefore the load must be as light as possible, that is, the gun and ammunition being fixed, the carriage must be as light as possible; and also the load must be properly distributed over the axles. The fore carriage having, as it were, to make the track, is hardest to drag, therefore the load ought to be rather less on it than on the rear axle. At the same time, if too much weight is thrown on to the rear wheels they will sink, and thereby increase the weight on the whole. The two axles must be long enough to make both tracks exactly the same, so that the front wheel prepares the track for the rear.

The diameter of the wheels must be a maximum, and the diameter of the axle a minimum. In order to increase the leverage over friction; 5 feet has been selected as the most suitable.

Lastly, the angle of traction must be as favourable as possible.

The height of a horse's collar being practically fixed, the only thing we can vary is the height of the point of attachment of traces to the carriage. We find about 6½° the best.

The carriage must also be capable of reversing very sharply, therefore it must be a minimum length, and the angle through which the fore carriage can sweep a maximum.

The mobility of a carriage is also influenced by its power of passing obstacles. The size of wheels and inclination of traces influence this, but more properly considered under the head of lightness of draught. The mode of attachment of fore and hind carriage materially affects this power. The fore carriage should be able to move vertically about

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the point of attachment, so that it may move in that direction, to some extent, independent of the hind carriage.

Mobility must be accompanied by stability.

Stability is influenced by the number of points on which the carriage rests, and the position, vertical and horizontal, of the centre of gravity with regard to those points.

The carriage being level, the vertical distance should be a minimum, and the other a maximum, that is, the S.G. should be as low as possible.

Stability.

Stability in reversing is influenced by the height and mode of connection of fore and hind carriages, and the height of traces. When advancing, the vertical from S.G. should always fall within the figure joining the points of support. The upsetting angle for the carriage packed is about 35°.

Strength. Durability.

The material used must be the strongest consistent with lightness. It must stand well the effects of shot striking or rough usage, the action of climate, and must not deteriorate in store. Wrought iron has superseded wood, being much more durable, and scarcely any heavier, for a given strength. It is not so elastic, and hence does not absorb so much of any strain put on it as wood, and also it is easily put out of shape; and hence there is a loss of strength through change of form, therefore stronger iron is used than is absolutely necessary to resist a particular stress.

Simplicity.

The carriage should have as few parts to get out of order as possible, and any part should be easily repaired if necessary, and all parts and fittings should, as far as possible, be interchangeable with other carriages.

Transport.

Carriages should take to pieces and stow away conveniently on board ship, and the length of carriage should be a minimum, not only for mobility but to make a column of route as short as possible.

The Gun Carriage and Limber.

The gun carriage.

The present form has been arrived at as fulfilling the foregoing conditions; as convenient for bringing the gun

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into action; as furnishing a stable carriage for the gun when in action; as allowing a supply of ammunition to be carried with the gun; and as admitting of a portion of its detachment being carried on it if necessary.

We will now investigate, as shortly as possible, the various strains exerted on a gun carriage when the gun is fired.

We may consider the discharge as simply producing a strain on the bottom of the bore acting along the axis of the piece.

We will also consider the gun is standing on the level, and at any elevation.

The gun and carriage being symmetrical with regard to the vertical plane through the axis, we can consider all forces to be spoken of as acting in that plane.

The single force can be resolved into a vertical and a horizontal force. Only portions are transmitted to the carriage depending, in amount, on the weight of the gun.

A small part of these is transmitted to the ground, depending on its nature.

These forces we can see will act at the points of attachment of the gun to the carriage, viz.: Trunnion holes, and head of elevating screw.

The horizontal component decreases as the angle of elevation or depression increases.

It exerts itself in two ways, viz.: In recoil, and also in giving a tendency to twist about the point of the trail. Hence, to render this component as harmless as possible, the opposition to this motion should be as slight as possible; that is, the weight should be a minimum; also to reduce the twisting strain the trunnion holes should be as low as possible.

The vertical component acts in an upward or downward direction, the former tending to rend the carriage apart when fired at an angle of depression, and the latter to crush it when fired at an angle of elevation. This tells most on the carriage, especially on hard ground.

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In addition to this, it will, as well as the horizontal component, have a tendency to twist the carriage round the point of the trail, either upward or downward, according to the direction of the force.

The body of the carriage being supported by the wheels and the trail, the brunt of this vertical component, if downward, is borne mainly by the axletree, because the axis of the trunnion holes lies vertically very near the axis of the latter.

If the vertical component acts upwards, the resistance of the ground is not felt, but the weight of the carriage acting downward at its centre of gravity, tends to tear the carriage apart.

When it acts downward, the resistances of the ground being called into play, they will, in general, be less in total amount than the component itself, the difference varying with the nature of the ground, and being expended on it. In the same manner the ground, by its nature and slope, will influence the recoil, and therefore the amount of the horizontal component spent on the carriage.

Sometimes, it is necessary to check recoil, resulting in an extra strain on the carriage.

The trunnions have some play in the holes, and consequently the gun rests on points lower than the axis of the piece; and, consequently, the force of discharge has a moment with regard to the bearing points, which is borne by the screw, and through it to the trail. This portion of the trail has to be extra strong.

The screw has also a strain thrown on it, by the tendency of the whole system to twist round the centre of gravity, and to the reaction.

In guns, such as the cast iron or bronze guns, that have the axis of the trunnions below the axis of the piece, there is a greater strain thrown on the screw and trail, for the blow on the bottom of the bore acting along the axis has a greater moment round the bearing points of the trunnions.

Wooden Carriages.

Up to a recent date all carriages were of wood, of the form known as block trail, previously they had bracket trails, but they were more clumsy.

There are many wooden carriages both field and siege at present in the service, the Armstrong R.B.L. guns being mounted on them.

The following, a 12-pr., is a type of them all, there are 6-pr., 9-pr., 12-pr., 20-pr., 40-pr. and 64-pr. carriages, also mortar beds of a different construction.

The 12-pr. gun carriage consists of the following principal parts, namely: the trail, two brackets, the axletree, axletree bed, and wheels. **12-pr. B.L.R. gun carriage.**

The trail is of oak, usually in one piece, but sometimes in two joined longitudinally; it is fitted with a trail plate with steeled eye for attachment to the limber. The brackets are of oak or elm, attached to the trail by dovetailed housings and by three bolts. The axletree bed of oak is housed both into the trail and brackets, and is secured by axletree bands, which, together with yoke bands and coupling plates, also hold the axletree in the bed. The axletree is the field axletree, giving the wheels, which are the O.P. light field, a track of 5 ft. 2 in.

The carriage is fitted with a traversing arrangement, which consists of a metal saddle carrying the gun in trunnion holes, and secured by capsquares. This saddle slides in dovetailed slots in the trunnion plates, and is traversed by means of an iron lever pivoted upon the trail. The lever is worked by a traversing screw resting in bearings on the brackets, and fitted with a hand wheel. Iron cleats or stops are fixed upon the trail, and allow of $1\frac{1}{8}^{\circ}$ right or left deflection being given to the gun.

The other fittings of the carriage are a socket or pan for the elevating screw, a chain with hook for securing the gun in travelling, breast chains, trail handles, locking plates,

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jack plates, and also fittings for carrying side arms, axletree boxes, drag shoe, and small stores.

The articles belonging to the carriage are an elevating screw, side arms, axletree boxes, and a drag shoe with chain. The screw is that known as the "ball and socket" pattern; it is attached to the gun by a bolt and pin, and worked by handles on a wrought-iron collar fixed to a metal nut, which is in the form of a ball.

The axletree boxes are fitted to carry each two rounds of case and some small stores.

The field limber.

The limber for the gun carriage consists of a framework formed by an axletree bed and block of elm, a splinter-bar and three futchells of ash. A platform board of ash, and footboard of elm are secured over the front of the futchells, and a slat of ash to fill the space between the splinter-bar and the footboard. To the back of the block a limber hook is bolted. The axletree and wheels are the same as in the gun carriage, the former being secured in the bed by bolts and by yoke bands with coupling plates. The limber is fitted for draught, for carrying ammunition boxes, entrenching tools, &c.

The articles belonging to the limber are three ammunition boxes, "near," "off," and "centre," with a canvas cartouch for each of the two first mentioned. The near and off boxes carry each 17 rounds of ammunition.

12-pr. B.L.R. ammunition waggon.

The ammunition waggon consists of a perch, two sides, and three platform boards of ash, two footboards and an axletree bed of elm, two fluted boards of teak, together with axletree and wheels, the same as in the gun carriage.

The perch and sides, each of the latter strengthened by an iron plate along its outer surface, and the former fitted with a nose plate with steeled eye for attachment to the limber hook, are housed across and bolted to the axletree bed. The axletree is secured in the bed by bolts and by yoke bands with coupling plates. The boards are fitted across the perch and sides, the fluted boards being placed

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between the platform boards for the ammunition boxes to rest upon.

The waggon is fitted with an axletree arm block of sabicu, shod with iron over the front footboard and front platform board, together with an elm block on the perch for carrying a spare wheel; the fittings for securing the boxes are similar to those on the gun limber.

The articles belonging to the waggon are six ammunition boxes, four canvas cartouches, four under boxes, a drag shoe with chain and spare lashings. The ammunition boxes are identical with those of the gun limber, except the centre are shorter and of slightly different shape to the centre box of the limber. The under boxes are one for grease and four for horse shoes.

The waggon limber is the same as the gun limber; it has the letter "W" painted upon it for distinction.

The 9-pr. gun carriage is not fitted with a traversing arrangement. **9-pr. B.L.R. gun carriage, &c.**

The carriages, limbers and waggons for the 9-pr. and 20-pr. differ only in details from above, the 20-pr. taking the heavy wheel.

The 6-pr. had a service carriage similar to above, but wheels only 4 ft. 2 in. in diameter, track 3 ft. 10 in., the limber and waggon matched.

It had also a carriage of usual height called the Kaffraria, for use in the high grass in those parts.

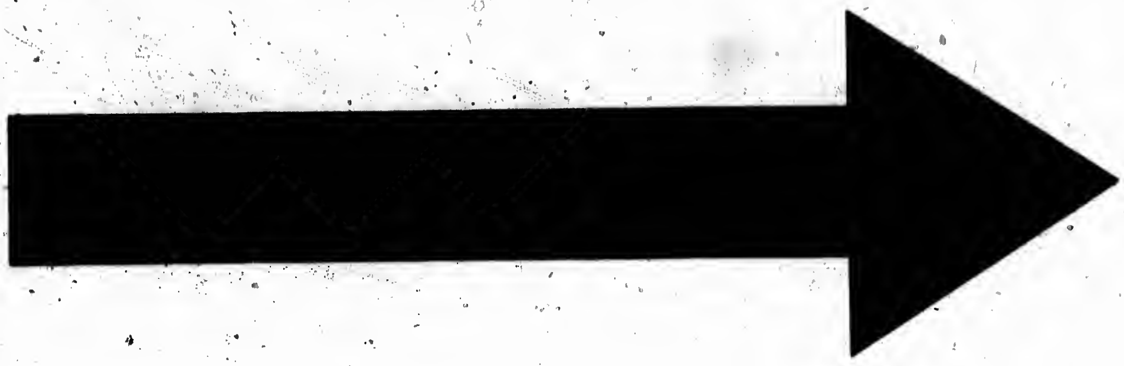
The 40-pr. and 64-pr. carriages are heavier and have two setts of trunnion holes and no axletree boxes, it and its limber have the heavy siege wheels.

Iron Carriages.

Iron carriages have taken the place of wooden, both for field and siege guns.

For field service there are three natures, the 7, 9 and 16-prs., with their limbers and wagons. **Field 7, 9, & 16-prs.**

For siege guns, there are carriages for the 25, 40 and 64-prs. The carriage for 40-pr. takes the 6.3 howitzer, but

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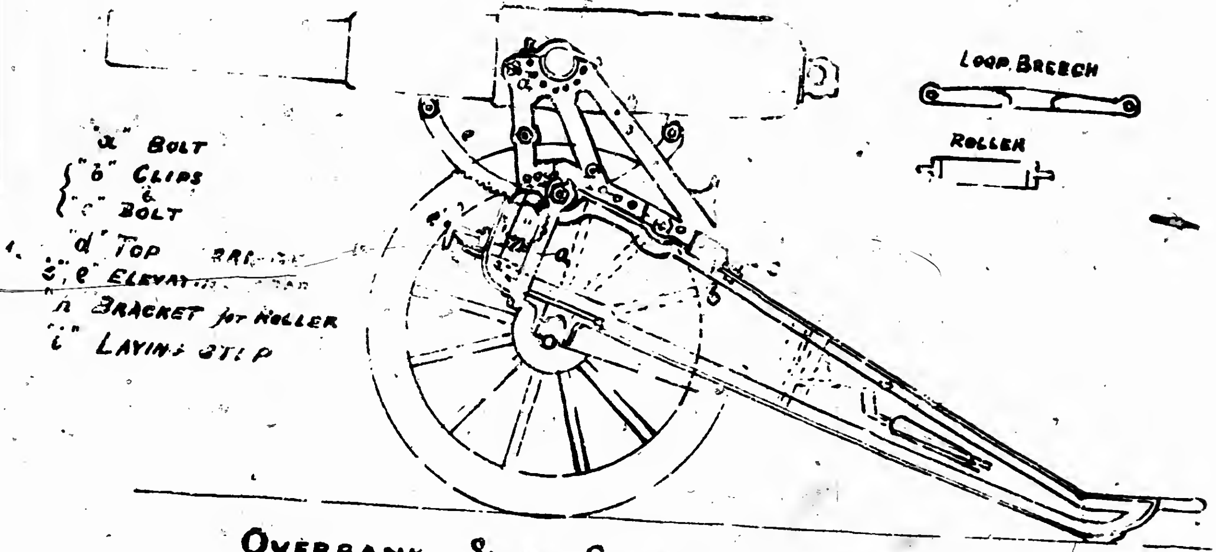

OVERBANK SIEGE CARRIAGE

for

64 PR. 40 PR. 25 PR. M.L.R.

the 8 in. howitzer has a separate carriage, and also a "bed" for high angle firing.

Besides these, there are various ammunition, forge and store waggons and carts.

For firing over a parapet without an embrasure, which is now necessary, in order that the men may be protected from small arm fire at medium ranges, greater height is required than is obtained with the ordinary siege carriages. A moveable top, consisting of two brackets, each formed of three iron stays supporting trunnion holes, has been introduced. **Overbank fire**

They are fastened to the ordinary carriage by means of nuts, long bolts and clips, and the gun is then mounted on the top, and in this position will easily clear an 8 foot parapet.

This upper carriage can be fixed, with a little practice, but without skilled labour, and the gun remounted in about five minutes.

There are travelling trunnion holes, but the gun must never be taken over rough ground when in them, the centre of gravity being too high. In fact, there is always a danger of them tipping to the front when limbering up or unlimbering.

We will now describe the latest pattern of the 9-pr. carriage, as a type for the rest.

Mark II. is the last pattern. It will take either the 6 or 8 cwt. gun. It is formed of two bracket sides, connected by two transoms, two collar bolts, and a trail piece; an axle-tree bed with axle-tree, and field wheels of latest pattern, with gun metal naves.

The brackets are formed of iron plate riveted to the inner side of a frame of angle iron of the required form, specially strong at the trunnions.

The transoms are of plate iron. They have angle iron riveted to them, by which they are riveted to sides and bed.

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The collar bolts connect the brackets between the transoms and trail, their collars keeping it rigid.

The trail piece lies between the brackets at the point, and rivets pass through the whole. This piece ends in an eye, to go on to the limber hook, and is steeled to prevent wearing.

A bearing piece of steel is bolted under the end, and a plate is bolted above to prevent damage, if the limber is driven over it.

The axle-tree bed is of wrought iron, and forms, with the axle, a beam of box-girder section.

The axle-tree forms the bottom of the box, a piece of angle iron riveted along each side of the body the sides, while the top is formed by a plate riveted along the upper sides of the angle iron pieces. The whole is fixed into recesses in the brackets, where it is secured by being riveted, to the frames of the latter, by angle iron stays riveted to itself in rear and to the frames, and by tensile stays, from the shoulders of the axle-tree, to the same.

A strengthening plate is riveted on the inside of each bracket, extending from the bed to the rear transom.

The carriage is fitted with capsquares and keys, metal sockets to receive the trunnions of the elevating gear, a handspike ring, trail handles, range plate, and a lot of other small ones.

The elevating screw, which is known as the Whitworth pattern, Plate VIII., is attached to the gun in the usual way by a bolt and is worked by a metal nut through which it passes. Bevel teeth are cut upon the lower part of the nut, into which a bevel wheel upon a horizontal spindle gears. The nut and bevel wheel are contained in a wrought-iron box, having a trunnion upon each side, by which it is supported and can oscillate between the brackets. The lid of the box is secured to the bottom by four long screws and has a lubricating hole in it for oiling the bevel wheels through, which hole is filled by a metal screw to keep dust and grit out; a drip hole is made in the bottom and the

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interior is coated with red lead. The spindle of the bevel wheel passes through a metal bearing or bouch in the right trunnion of the box and upon its extremity outside the right bracket of the carriage has a metal hand wheel by which it is worked. To remove the box from the carriage the lid has to be taken off, the pin holding the spindle pulled out, and the spindle withdrawn. The second transom of the carriage has then to be removed, after which the bolts of the sockets being taken out, the box with the sockets can be moved to the front, and the former freed from the latter.

The axle-tree boxes are arranged to carry two rounds of case and small stores. The lid serves as a seat when required. The boxes form seats, with back and foot rests.

Limber Mark II.

The limber is also chiefly of iron. It is formed of three futchells, a splinter bar with two stays, a platform board, a slat, an axle-tree bed with limber hook, axle-tree and wheels.

The splinter bar is of plate iron, bolted to the futchells, and strengthened by a stay of round iron from the extremities to the axle-tree bed.

The axle-tree bed is deeper, but of lighter construction than that for the gun. The futchells of tee iron are let into the bed, below the top plate.

The limber hook has three long arms, by which it is riveted to and also held at the proper distance from the rear of the bed. It is steeled.

The platform board of ash, and foot board of elm, are placed on top, and fastened to the futchells. The slat is placed in front, between the splinter bar and foot board.

The shafts are the field shafts off and near, of ash. The off shaft has the part between splinter bar and axle-tree, of iron, to give room for the wheel to work, it being fastened for ordinary draught outside the wheel.

The limber is fitted for either single, double, treble or bullock draught.

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The shafts are placed in the centre for single and treble draught, swingle-trees being used in the latter case. A pole is used for bullock draught, fixed in the centre.

The three limber boxes, "off," "near" and "centre," are fastened to the frame by straps. The off and near are similar; each contain 18 projectiles standing in trays, their heads fitting into blocks in the lid. The 18 cartridges are in the centre in a canvas cartouch. Four extra projectiles can be carried under the trays, and 4 cartridges in the cartouch. The lids have small stores fitted into straps.

The centre box contains fuzes and tubes. Each box has a hand strap for a gunner to hold on by, and outside there are iron guards for the same purpose.

Ammunition Waggon, Mark II.

The waggon consists of perch, sides, two platform plates, axle-tree, &c., as above.

The perch is formed of two brackets, in a somewhat similar manner to the trail of a gun carriage, connected by a perch piece with steeled eye and collar bolts.

The brackets are of channel iron, the channel being turned outwards.

The perch lies across the top of the bed, each bracket being riveted to it by angle iron.

The sides of the waggon are of angle iron resting on the bed, to which they are riveted.

The platform plates are riveted to perch and sides.

The boxes are similar to those of limber.

The limber is identically the same as the gun limber.

The waggon is fitted to carry a spare wheel.

The other limbers and waggons differ only in detail.

16-pr.

The 16-pr. carriage is stronger and wider in the brackets than the 9-pr. The limber and waggon is the same, each box carrying 12 rounds of ammunition.

25-pr.

The carriage is similar in construction, but the elevation is given by an arc secured to side of gun, connected with gearings on the bracket of carriage.

A stool bed and quoins are issued, and can be used in case of gear breaking.

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The limber and waggon are the same as before, but the boxes only carry 9 rounds.

40-pr. and 6.3 inch howitzer.

The 40-pr. carriage is constructed on the same pattern as the 9-pr. There are three transoms, secured more strongly than in the other carriages, in order that the carriage may take the 6.3 inch. howitzer.

The wheels are N.P. siege. There are firing and travelling trunnion holes.

The elevating gear is similar to the 25-pr., and it is also fitted with gear for the 6.3 in. howitzer.

There are attachments for hanging scales.

The limber is similar to above, and each box carries 6 rounds.

64-pr.

64-pr. carriage is similar, but stronger and larger. It has but two stays, the height of axis of trunnions being as in the 40-pr., 4 ft. 6 in. The carriage admits 40° elevation, and 10° depression being given the gun.

The 25, 40 and 64-pr. carriages are fitted to take the overbank top, and for special elevating gear to work with the long arc.

8 in. howitzer carriage.

8 in. howitzer carriage has double plate brackets, and the axle-tree bed is formed of angle iron along each side of the axle-tree; and there is a bottom plate from front of brackets to transom. It was intended to fire either off or on its wheels. A bed is now made for it.

When fired from its wheels, the elevation must not exceed 15°, and the charge 5 lbs.

8 in. howitzer bed.

The bed has double plate brackets, and rests on six rollers, always in action, over a guide bar that is fixed by a hinged flap to a pivot in front.

There are two compression bars on each side; corresponding plates hanging from the carriage proper. A lever at side works the compression.

The bed has the usual elevating gear.

7-pr. bed.

This bed consists of two brackets of plate iron, secured to a bottom plate; has a transom in front and angle iron in rear.

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Upon each bracket there is a handle.

It is elevated by quoin. For use the carriage is secured by bolts to a small tee shaped platform.

Mountain Carriages.

The ordinary carriage is formed of two single plate brackets, strengthened by angle iron along the outside top edge, and secured to axle-tree by clip plates and bolts. The brackets are connected by two transoms, and trail eye piece. 7-pr. ML. Service pattern.

The elevating arrangement consists of a sliding quoin, worked by a hand wheel and screw. It rests between the brackets, and can be lowered to three separate heights. The wheels are ordinary make, 3 feet in diameter. Check ropes are supplied to fix round trail eye, and wheels to check recoil.

This carriage is similar in height and track to the 9-pr., but of much lighter construction. Kaffraria.

The elevating is done by an arc attached to cascable.

The limber, when used, is of light construction, and carries two leather limber boxes. Limber.

The Kaffraria pattern is similar to 9-pr., and each box carries 30 rounds.

The Gatling gun carriage is similar in make to the 9-pr. but much lighter, and there is no axle-tree bed.

The axle-tree boxes each hold a drum of cartridges, and the lids covered with Bessemer steel, bullet proof, form a protection for the detachment. The limber is as usual, and carries two boxes, protected top and front with steel. One box carries 4 drums, the other two, a S.A. ammunition box.

The numerous other field and siege carriages of all sorts need not be mentioned here.

Wheels and Axle-trees.

The travelling crrriages having been described, it is necessary to give a brief account of their different wheels and axle-trees.

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A wooden wheel of ordinary construction has a stock or *nave* of elm, 12 *spokes* of oak, and 6 *felloes* of ash. A cast iron *pipe-box* is fitted into the nave, and the hollow passing through it is enlarged in the middle to hold grease, so that the bearing surfaces extend only to 3 inches from each end; the nave is strengthened by two *nave hoops*.

Wheels are made with a *dish* or inclination of the spokes outwards, to enable them to withstand the lateral thrust that they may be subjected to in passing over uneven ground, when one wheel is often much higher than the other, in which case a pressure is exerted on the nave of the lower wheel, tending to force it outwards; the dish is usually about ½ in. for 1 ft. in length of spoke.

The tire of the wheel of the wooden artillery carriage now in the service is composed of 6 short pieces of iron called *streaks*, each of which is placed over the junction of 2 felloes, and secured with 4 bolts and 2 nails; by using a *streak* instead of a *ring* tire a wheel can be repaired in the field, for as the streaks are of small size, they can be transported with a battery, and heated in the ordinary field forge.

The wheels of all carriages liable to come under fire are, however, to have gun-metal naves and ring tires. The nave consists of three separate pieces—two flanges and a pipe-box, the latter being prevented from turning by a projecting feather, fitting into a slot cut in the inner flange; the flanges are connected by 12 boss-headed triangular iron bolts, passing between the spokes, and secured by nuts on the outside of the inner flange. The spokes are of oak and the felloes of ash.

In the *field* wheel, the ring tire is 3 in. wide, and ⅝ in. thick, and is secured by six bolts, with nuts and collars, one bolt passing through the middle of each felloe. In the *siege* wheel the tire is formed of two rings of the same size as that on the field wheel, shrunk on side by side, and each ring is secured to the felloes by six bolts, the bolts being placed diagonally across the felloes.

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The wheels of carriages for all services, not exceeding 3 in. in breadth across the sole of the felloe, will in future manufacture be shod with ring instead of streak tires.

The *track* of wheels is the distance from the outside of one to the outside of the other; it is 5 ft. 2 in. for the wheels of field carriages.

Wheels are divided into four classes, termed *siege*, *field*, *general service*, and *naval* wheels; there are several wheels in each class differing in weight and diameter, but all in a class have the same *pipe-box*, and will therefore fit on the same axle-tree arm.

Wooden travelling carriages hitherto made for our service have wrought iron axle-trees let into wooden beds; the axle-tree bed is fitted underneath the brackets and trail by *housings*, and is attached to the carriage by two axle-tree bands, having bolts passing through them and the brackets. The axle-tree is also secured at each end of the bed by a *yoke-hoop* and *coupling plate;* the hoop can be tightened by screwing up the coupling plate, in case the wook shrinks. The axle-tree beds for iron carriages have been described. The axle-tree arms have a slight inclination downwards termed the *hollow* of the arm, so that the lowest spoke of each wheel may be vertical; if a wheel has no *dish* the *hollow* of the arm is not required. The arm has also a very slight inclination forwards called the *lead;* the hollow and lead together are termed the *set* of the arm. The bearing surfaces of the arms of axle-trees for wheels having cast-iron pipe-boxes are *steeled*, to prevent wear.

Axle-trees are, like wheels, divided into four classes, named respectively *siege*, *field*, *general service*, and *naval* service axle-trees; each class contains several natures of axle-tree, but all those in a class have *arms of the same size*, and only differ in the amount of metal between the arms; the similarity in the arms allows of an interchange of wheels when required.

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Standing and Sliding Carriages, Beds, and Platforms.

The carriages for garrison ordnance have no wheels, and are not therefore adapted to the transport of the guns, for which a separate class of carriages, including sling and platform waggons, &c., is employed. There are three descriptions of garrison carriages, viz.:—

Common standing, Rear chock, Sliding.

The first and last are made both of wood and wrought iron, the rear chock of wood.

The following principles should be observed in the construction of a garrison carriage:—

(1.) The height of the carriage must depend upon the efficient working of the gun.

(2.) The carriage must be so constructed that it may be easily run up or back, traversed, or moved from one embrasure to another near it.

(3.) The carriage should occupy as little space as possible, for it may be exposed to enfilade or ricochet fire; and, moreover, it is desirable to have all the available space that can be obtained within the battery and under cover for the conveyance of ordnance, stores, &c., from one part of the works to another.

The material of which the carriage is composed must be capable of withstanding the exposure to the various changes of the atmosphere for a considerable period, as, except when in casemates, the carriages are not under cover.

With guns of over 4 tons, the slope of the platform is not alone sufficient to limit the recoil, and it has been found necessary to check the motion of the carriage by means of a *compressor*, which by acting against the platform causes the resistance requisite to absorb the recoil. As will be seen, there are various patterns of compressors.

The *common standing carriages* when made of wood are composed of two *brackets*, connected together by a *transom*, two *bolts*, one passing through the transom, and two *wooden axle-trees;* they are not mounted on wheels, but

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on four small iron *trucks*, the two front being of larger diameter than the two rear trucks; elevation is given to the gun by means of *quoins* and *elevating screw*, the latter supporting the *stool-bed* upon which the quoins and breech of gun rest; the front of the stool-bed fits on to the rear bolt. These carriages have no capsquares, as the guns mounted on them are very heavy, and consequently have not such violent action when discharged as lighter pieces.

In consequence of the rapid decay of wood in some climates, especially in the tropics, a certain number of carriages are made of cast iron with open brackets, but these have the following disadvantages, viz.: that they weigh two-thirds heavier than wooden ones, that if struck by a shot they would be easily damaged, the splinters from them would be very destructive, and if fractured they are difficult to repair.

A rear chock carriage is similar in construction to a garrison standing carriage, except that it has only the two front trucks, and instead of a rear axle-tree, it has a block of wood which rests upon the platform. Rear chock.

The *howitzer* (*rear chock*) *carriages* are of similar general construction to the gun carriages, but are strengthened with iron to a greater extent.

Sliding carriages are mounted on traversing platforms, and are used in coast batteries where rapidity of traversing is required, the objects fired at from such batteries being seldom stationery. A sliding carriage for a dwarf traversing platform is similar in construction to the garrison standing carriage, but instead of axle-trees it has two blocks upon which it rests on the platform, the part of the block between the cheeks being deeper, and passing between them so as to keep the carriage in its place. A pair of *cheek plates* are attached to the front of each bracket, in which works a gun metal truck that comes into play when the rear of the carriage is hoisted up by the *truck levers.* It recoils on the blocks, but can be easily run up after loading by using the truck levers, which raise the carriage on Sliding carriage.

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to four trucks; its forward motion can be checked at any time by means of the *preventor rope*, which is attached to the rear black of the carriage, and, being twisted round the *bollard* of the platform, it is held by one of the gun detachment. The carriage is run back at drill by means of tackle, the levers also being used to raise the carriage off the blocks; a wood *compressor*, worked by an iron handle, fits in between the blocks, and also between the side pieces of the platform, against which it presses in checking the recoil.

The *casemate sliding* is similar to the dwarf sliding carriage, except that it has two lower brackets.

Wt. Iron Standing carriage.

Two patterns of wrought-iron *garrison standing carriages* have been approved for service in climates where wood is liable to rapid decay. They are of similar construction, but the brackets of (2) are four inches closer together than those of (1).

The carriages are constructed of open or *skeleton brackets*, each bracket consisting of three *stays* of double plate iron, ⅜ in. thick, bolted to a *tie beam* of **T** iron at the lower ends at such intervals as to afford the greatest strength to the carriage.

The axle-trees are made of 7 in. girder iron (**I**), and two blocks of sabien are screwed underneath the rear axle-tree, to enable it to be used as a rear chock carriage by removing the rear trucks.

The trucks are of elm, bouched with gun-metal, and shod with iron ring tires; each carriage has an iron stool bed, ratchet-headed elevating screw, and two quoins. When not in use the carriage is to be mounted on cast-iron trucks, and the wooden ones placed in store.

No. 1 *carriage* takes the 64-pr., B.L. or M.L.R. gun without fittings, and the 8 in. (65 or 54 cwt.) either as S.B. or as palliser converted M.L.R. 64-pr. gun with a trunnion plate in each trunnion hole.

No. 2 *carriage* mounts the 32-pr. of 58 cwt. either as S.B. or as palliser converted M.L.R. 64-pr. gun, with a

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trunnion plate in each trunnion hole, and the 32-pr. of 56 cwt. with a collar on each trunnion, in addition to the plate in trunnion hole. For the 40-pr. B.L.R. gun there are special trunnion plates.

Carriages for guns weighing 6 tons or more are made of wrought iron. These carriages for different natures of guns are similar in construction, but differ in dimensions and in the substance of the iron employed.

A wrought iron gun carriage consists of the following parts, viz.:—

2 Brackets.	4 Gun metal trucks.
1 Transom.	Elevating gear.
1 Bottom plate.	Compressor.

There are two constructions of these carriages, the *single plate* and *double-plate*, and there are several patterns of each construction.

Single-plate carriage.

The bracket of a *single-plate* carriage is made of *plate iron* riveted to a frame of *angle iron*, and strengthened with a centre stay of **T** iron, riveted diagonally across the plate from the rear of the trunnion hole to the bottom of the frame. Four holes are cut through the bracket:—

(1.) For the breeching.
(2.) " compressor screw.
(3.) and (4), For the spindles of elevating gear and friction roller.

These and the trunnion holes are lined with gun-metal.

The transom is made of plate iron, riveted to angle iron.

The bottom is of plate iron, to the under surface of which are riveted 2 *guides* of angle iron, intended to fit in between the sides of the platform or slide, and keep the carriage from running off. An aperture is cut in the bottom for the plates and levers of the compressor, and a stay of angle iron is riveted across the bottom in rear of the aperture, to strengthen the plate and prevent its buckling.

A stay of **T** iron is bolted to the inside of the rear of the bracket, and to the bottom on each side, to secure rigidity in the carriage.

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The trucks work in iron *flanged feet*, bolted to the brackets; the rear trucks have eccentric axles.

Elevating gear.

The *elevating gear* may be thus described:—The breech of the gun is fitted with a *segmental arc* on each side, and elevation is given by an iron spindle working through each bracket, and having an iron *pinion-wheel* inside the bracket, the teeth of which work into those of the segmental arc. On each spindle outside the bracket is an iron *drum*, having a number of holes in its circumference to receive the point of the lever used to work it; the drum can move laterally on the spindle, but is prevented from turning round it by a projection on the axis of the drum, fitting into a slot in the spindle. The elevation given by turning the drum can be preserved by a *screw-lever clamp* outside each drum, the clamp, when turned pressing the drum and pinion tightly against the bracket between them. A *friction roller*, attached to the inside of each bracket in front of the pinion, keeps the teeth of the arc, which is not rigidly attached to the gun, in gear with those of the pinion.

Double-plate carriage.

The *double-plate* differs from the single-plate carriages in the following respects, viz.:—

The brackets are made of two plates with a frame of *flat iron* between them, the whole riveted together, instead of a single plate riveted to an angle iron frame. The plates extend beyond the frame at the bottom in the front and rear, so as to form flanges for the trucks.

Instead of sockets for the rear trucks a *connecting bar* joins the axles of the trucks, and has a socket hole at each end for the point of the shod levers; the trucks must therefore always move together.

Elevating gear.

The *elevating gear* of the carriages for the 9 in. gun and under is the same as described above, but for 10 in. and heavier guns the arrangement is somewhat different. Instead of capstan and levers, a *worm-wheel* and *worm* are used for elevating, the worm being on a shaft attached to the inside of the bracket, but projecting beyond so as to be

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worked by a hand-wheel on the end of the shaft in rear of the carriage.

When the carriage is run up, it comes into contact with four gutta-percha buffers on the inside of the front of the platform or slide. There is also a buffer on each side of the platform or slide inside the girder, to receive the rear of the carriage in the recoil.

Compressor. The compressor of the single-plate carriage consists of a number of iron plates suspended through the bottom of the carriage, between which are others attached to the platform or slide; these plates, being jammed together, check the recoil of the carriage. The compressor plates of the carriage hang through the aperture in the bottom plate, being suspended by slots cut on each side, fitting on to the angle iron of the transom, and to a bar bolted to the bottom plate.

On each side of the plates is a *rocking lever* pivoted on a stay bolted to the bottom plate; the lower arms of these levers bear respectively against the outer plates of the carriage, and on the upper arms of the levers are *slotted screw nuts* to receive the screw shafts, which, passing through the brackets are worked by two *lever handles*. By pressing down the handle on either side, the lower arm of the rocking lever connected with it presses the plates towards the opposite lever arm. The screw on the shaft on the left side is only half the pitch of the other, and is termed the *adjusting screw*; the other is called the *compressor screw*.

The *compressor shaft* of the double-plate carriage differs slightly.

Should the gun detachment omit to press down the handle of the compressor screw, a metal *tripper* attached to the platform or slide will catch the short arm of the handle and force it down through the whole arc.

The *hydraulic buffer*, intended to replace the compressor, is simple in construction and entirely self-acting. It consists of an iron cylinder with rod and piston, the latter, which is 8·04 inches in diameter, having four holes about an inch in diameter to allow of the passage of the fluid in

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the cylinder from one side of the piston to the other when moving. The cylinder is attached to the platform or slide by two bands, and has a filling hole at the top in rear, and an emptying cock at the bottom in front. The piston rod is connected to a bracket attached to the carriage above, and the carriage is provided with *clips*, to prevent its rising on recoil. The buffer is adapted to use with all the heavy M. L. R. gun carriages, the only difference being in the size of the holes.

The cylinder can be filled with water, or Field's oil, which is non-freezing. The cylinder holds 12 gallons of water, or about 1 more of oil. When the gun recoils, the piston, being forced rapidly back, is resisted by the fluid, which can only pass through the holes at a certain rate, depending upon their diameter. The buffer does not interfere with the running up of the gun, for, the velocity being then low, the fluid can easily pass through the holes from one side of the piston to the other.

Moncrieff carriage.

The principal parts of the *Moncrieff carriage* are, the *carriage*, the *elevators*, and the *platform*. The *carriage*, consisting of iron brackets with stool bed and elevating screw, is supported between the elevators on a strong bolt or shaft passing through them from side to side; each bracket has a truck in rear to run upon the inclined frame of the platform.

The *elevators* are merely two very large iron brackets, with a box between them to hold the *counterweight*, which is rather heavier than the gun; they are curved in rear and provided with teeth to run in rolling back upon the horizontal side-pieces of the platform, which have corresponding teeth.

The *platform*, consisting of iron side-pieces and frame above, traverses round a central pivot by means of four trucks running on racers. A self-acting break wheel, with a pinion inside working into a *cycloidal arc* on the elevator, is attached to the platform, to hold the elevators down and to check them in rising when necessary.

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In later constructions (for the 7 in. guns) the carriage has been dispensed with, the trunnions are held by the elevators, and the breech of the gun is supported and can be elevated or depressed by an arrangement for the purpose.

The purpose of the carriage is to protect the gun from direct fire, and to obtain security for the gunners when loading. Its working is as follows:—When the gun is fired, the recoil of the carriage forces the elevators to roll backwards upon the platform, the gun therefore descending and the counterweight rising. The weight of the latter gradually checks the motion, and brings the gun to rest when below the parapet; the break preventing the gun being again raised by the fall of the counterweight, the piece can be loaded under cover of the parapet, but, by releasing the break, it can be quickly raised for firing. With this carriage it is obvious that no embrasure is required.

Mortars are not, like guns and howitzers, mounted upon carriages, for, being fired at very high angles of elevation, a carriage having wheels or trucks would not be capable of withstanding the shock of the discharge, the vertical strain from which is so very great. *Beds* of wood or iron of simple construction are therefore employed, the whole length of the bed resting on and being supported by the platform. A mortar bed is provided with a quoin, upon which the piece rests, usually at an angle of 45°, and also with bolts on each side, both in front and rear, for the convenience of running the mortar up or back; for siege purposes they have a short trail, and are placed on wheels.

Traversing platforms are of three kinds, viz.: *common*, *dwarf*, and *casemate*.

Common traversing platforms are employed to raise guns sufficiently high to enable them to fire over a parapet, and they are made of either wood or iron. The wooden platforms consist of two long side pieces placed upon four legs, having trucks, which run upon circular racers let into the ground, and on the top of each side-piece is a plank for the trucks of the carriage to run upon; there is also a riband of wood inside each side-piece to keep the trucks from

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running off. These platforms can be made to traverse either in front, centre, or rear, the central pivot being only employed when guns are mounted on circular towers; they have a slope of 1 in 12, to check the recoil, and facilitate the running up of the gun. The ordinary garrison carriage is used with this platform, the hind trucks being removed, and a block of wood substituted for them.

The advantages obtained by the use of these platforms are, (1) that the gun can traverse through a much greater angle than an embrasure will admit of; (2) that the parapet is much strengthened; and (3) that there is more cover for the interior of the work. There are, however, the following disadvantages, viz.: (1) that guns mounted on them could be easily dismounted by ricochet or cross fire, in consequence of the large object they present above the parapet; (2) their great height above the ground renders the mounting guns upon them a comparatively difficult operation; (3) also the men working the guns are very much exposed.

Wooden *dwarf traversing platforms* have almost entirely superseded the common traversing platforms, to which they are similar in general construction, and guns mounted upon them can fire through embrasures. The chief parts of this platform are,

Two side-pieces.
One head block.
Two transoms (middle and rear.)
One cross block under rear transom.
Two footboards outside of side-pieces.
Four battens between side-pieces and transoms.
Four cast-iron flanges.
Four wrought-iron hollow soled trucks.

Along the top of each side-piece is a wrought-iron plate for the truck of the carriage to run upon, and two flanges with their trucks are bolted to each side-piece underneath, one in front and the other under the cross block.

A *bollard* is attached to the left side-piece for the *preventor rope*, and at the end of each side-piece is a *stop iron* to

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prevent the carriage running off the platform. The carriage can be transported by two wheels and a *dilly*, as shown in the axle-tree for the former passing through two bands bolted under the side-pieces just behind the middle transom.

There is only one nature of wood dwarf platform, which is suitable for all the heavy S.B. cast-iron guns and B.L. rifled ordnance; the platform has a slope of 5°, the distance between the side-pieces is 21 in. Both these and the casemate platforms used to traverse on a pivot fixed in the ground, but the pivot was liable to fracture or displacement from the strain of the recoil, which is now distributed over the lengths of the two curved racers upon which the *hollow soled* trucks run. By varying the positions of the racers, the gun can be made to traverse round several different centres as required: when arranged for *muzzle pivoting* the (imaginary) centre from which the curves of the racers are described, and round which the gun moves in traversing, being at the muzzle, only a small embrasure is required.

The *casemate* is the same platform as the dwarf, only lowered by substituting the front flanges and trucks for the rear ones, which are removed, and supplying the place of the front trucks with two very small trucks or rollers in flanges let into the side-pieces.

Wrought iron platforms are made for the heavy M.L.R. ordnance, from 7 to 12 in. calibre. The first, made for the 7 and 9 in. single-plate carriages, had the same width between the sides, and were suited to either carriage; but the platforms for double-plate carriages differ in width according to the nature of gun mounted on them.

An iron platform consists of—

Two sides.	Diagonal stay.
Two transoms, front and rear.	Four flanged feet.
Head plate.	Four trucks.
Bottom plates.	

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and is fitted with—

Compressor bars. Tripper. Loops for tackle. Axle-tree bands. Eye-plate for limber. Front buffer. Rear stops, with buffer. Bollard. Foot planks.

The platforms provided with hydraulic buffers have no compressor bars. Those for guns of 10 in. and over are of the built-up (fish-belly) girder pattern. The dwarf and casemate are of the same construction, but the former has higher trucks and a loading stage hinged to the front. All platforms for guns of 9 in. and over are to be provided with *traversing gear*, which gives greater facility and rapidity in training than tackle and ring bolts. The racer is generally smooth, a rack racer being objectionable for land service; the rear trucks have toothed wheels fixed to them, so that they can be driven by the gearing.

MANUFACTURE OF ORDNANCE.

METALS.

It is purposed in the following pages to go briefly into the manufacture of the service ordnance, both S. bore and rifled, and also a few of the more important stores connected with the various pieces, as far as is possible, without being able actually to see the different operations performed.

Before touching on the matter of actual manufacture of ordnance, it is well to have some idea of the properties of the various metals used in their construction. If we then consider the conditions that the material a gun ought to fulfil, we can then have a good idea as to what metal, or combination of metals, will best suit our purpose.

Physical properties of Metals.

We will first discuss briefly those physicial properties of metals that bear more directly on our subject. These are: *Malleability*, *ductility*, *hardness*, and its converse *softness*, *toughness*, *elasticity*, and *tensile strength*.

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We must also understand what is meant by *tenacity* and *elastic limit* as applied to metals.

Malleability is the property of being permanently extended in all directions without rupture, either by hammering or rolling. It is the converse of *brittleness* which is the tendency to break under pressure more or less sudden. Malleability. Brittleness.

Ductility is the property of being permanently elongated by traction, as in wire drawing. Ductility.

Softness. A metal that easily yields to pressure without breaking, and does not regain its original form on the pressure being removed is said to be *soft*. Softness.

The converse is hardness. These terms are naturally all comparative. Hardness.

Toughness is easily understood, but is very difficult to define. It is resistance to a tearing force. Toughness.

Elasticity is the property of a metal to resist permanent alteration in its shape when subject to a stress. Elasticity.

The *Elastic Limit* of a metal is the tension which causes permanent elongation. Elastic Limit

Tenacity is the tension required to produce rupture. Tenacity.

Tensile strength denotes the work done on a metal to produce fracture by traction. Tensile Strength.

Metals Used.

The metals used in constructing ordnance are: Bronze (a compound of two metals,) and iron, in its three forms, *cast* iron, *wrought* iron and *steel*, each of the greatest use, and possessing very different qualities. Metals, Bronze, Iron.

First, *bronze*, or rather a particular sort called "*gun metal.*" Bronze.

Bronze is composed of a mixture of copper and tin in various proportions. *Gun metal*, containing 90 parts copper to 10 of tin. Bronze is a tough, tenacious metal harder than either zinc or copper, and easily cast, but when it is cast in the ordinary way in a mould of loam and sand it is too soft for the manufacture of rifled ordnance. Also, when

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heated it becomes softer, and is more easily injured by rapid firing. A further drawback to its general use is its great cost, although, as a counterbalance, old bronze ordnance is readily re-cast.

Bronze.

The chief cause of the failure of bronze guns when rifled, was the impossibility, in casting, of getting a perfectly homogeneous mass. The tin used has a lower melting point than the copper, and consequently in the setting the copper would set first; and, in spite of every care in mixing, the tin would form what are known as "tin spots," and these being softer than the rest of the metal, were easily eaten out by the gas, more especially in rifled pieces, where the strains are greater, and where the cutting of the rifling discloses fresh tin spots. The bore becoming both indented and fissured.

Phos. Bronze.

Attempts have been made by mixing other substances, as manganese and phosphorus, with bronze to obtain greater hardness, while not sacrificing, to any great extent, the valuable properties of toughness and tenacity.

Phosphor bronze is of great use for small objects, such as the pullies of blocks, &c., but the difficulty of ensuring the phosphorus being in exact proportion, bars its use for large castings.

Manganese has also been mixed in small quantities, with doubtful success.

General Uchatius, of the Austrain service, found that by casting bronze in iron and cooling the interior of the gun at the same time by a metal core, the metal was greatly improved, possessing, in fact, many of the properties of steel.

The difficulty, however, of getting rid of the tin spots still remains.

Iron.

Iron.

Iron, although when perfectly pure, is a well defined elementary metal. Yet, when *mixed* (or alloyed) with a very small quantity of various other elements, changes its

properties to such an extent as to form other virtually distinct metals, differing from one another in their characters more than many actually different elements.

The treatment of iron during manufacture has, in some cases, more to do with the variation of its properties than any chemical change that takes place in its structure.

Iron is found in nature in the form of its ores, and is extracted from it in large blast furnaces with various fluxes, according to the nature of the ore, in order to carry off earthy matter. Limestone is generally used as a flux. Clay and limestone, though separately very infusible, readily fuse when mixed.

Alternate layers of coal for fuel, and lime and iron, are placed in the furnace. When the iron is melted, it is run out into moulds of sand and forms *pig iron*.

In this form it contains a quantity of sulphur and other impurities from the coal: Also contains *carbon*, *silicon*, and *phosphorus*, in small quantities. **Pig Iron.**

Sulphur, Ph. and Si., are all injurious, as they decrease strength and increase brittleness. In the quantity of the *carbon*, however, and in the manner in which it is combined with the iron depends in a very great measure the various qualities of the iron.

The iron is refined by smelting, and a quantity of the impurities are got rid of, but from 2 to 5 per cent. of carbon remains, either chemically combined or in a mixed state with the iron. Cast iron is divided into several grades according to the quantity of carbon in it, in the *mixed* state. *Grey or mottled* iron contains the greater part of the carbon in a free state, as graphite. **Mottled Iron.**

White or bright iron contains most of it, chemically combined. The extreme qualities can readily be distinguished by their fracture, even by an unpractised eye. **White Iron.**

"Cast iron" is readily fused and cast into a homogeneous mass. It is cheap and easily turned and cut, so that we can obtain a firm hard surface. **Qualities. Good.**

Though comparatively *hard*, it is very brittle, and its

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limit of elasticity is very low and ductility small. It cannot be hammered either when hot or cold, therefore cannot be used to "build up" the monster ordnance of the present day.

Bad.

Though on account of its hardness it was a good metal for S.B. guns where the strains were slight. It is too weak for rifled guns, and was certain to give way explosively—a serious defect in a gun metal.

For economy, we use a quantity of cast iron rifled guns, but they are strengthened by an inner tube of wrought iron.

Wrought Iron.

If we remove the carbon still more from cast iron till there is less than 2 per cent. left, we obtain either wrought iron or steel, according to the amount removed, or to the subsequent process of manufacture, or both.

Wrought iron is obtained from cast iron by puddling or otherwise, and is then worked up by hammering or rolling into the necessary convenient forms, hence the name of *wrought* iron.

Puddling.

Cast iron, in the form of scrap, and to the amount of 5 or 6 cwt., is placed in a puddling furnace with about 1 cwt. of iron scale, which, being a high *oxide* of iron, supplies the oxygen to combine with the carbon to form carbonic oxide, that is seen to burn with a blue flame. The mass, when melted, is continually stirred by the workman.

Oxide of Iron.

A liquid slag or glass is also formed of the various impurities, and portions of the brick furnace, which is drawn off.

As the carbon burns off, the mass becomes pasty, and is collected by the puddler into large balls. These are brought under the steam hammer, and all liquid slag entangled in its mass is squeezed out, and it is left in a rectangular form.

In this state it is rather hard and brittle. Slight impurities affect it considerably. A very small quantity—25 per cent.—of phosphorus will make wrought iron *cold*

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short or brittle when cold, while a little sulphur will make it *red short* or brittle when heated. — Cold Short. Red Short.

This puddled iron has now to be drawn out and worked over, under the hammer or by rolling, and is thereby given a regular fibre, like that in wood, in the direction in which it is drawn.

Its strength is thereby much increased in that direction, just as wood is much stronger across the grain than in the direction of it. It takes about twice the force to break it in one direction as in the other.

Unfortunately, the above processes do not entirely remove impurities, and it is difficult to obtain a uniform surface free from flaws.

Properties.

Perhaps the most valuable property of wrought iron is that of "welding," at a white heat—3,000° F.—that is, if two clean surfaces of wrought iron are brought together at a red heat and hammered, they will unite as strongly as the rest of the mass.

This is the property that has enabled us to make our large wrought iron guns; for long bars of iron are coiled and then welded into compact masses to form the several portions of a gun.

Wrought iron is practically infusible at any ordinary temperature, and therefore cannot be cast.

It is, however, very malleable and ductile, two properties that are very similar to each other; and it is of very great tensile strength, though its tenacity is much below most natures of steel, being about 25 tons per square inch, in place of from 30 to 60 tons.

A very valuable property of wrought iron is, that though its *elastic limit* is low—that is, the pressure at which it becomes permanently elongated is not large, only about 12 tons—yet it is so ductile that it stretches to such an amount as to give a large margin of safety.

So that in a service gun of Frazer construction—that is, one with wrought iron coils over a steel tube—if the steel tube splits, the gun can still be used with safety, if neces-

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sary. And, moreover, a wrought iron gun, except under extraordinary circumstances, would not give way explosively, the stretching of the metal giving warning.

It is possible, however, that repeated firing might alter the formation of the iron, and it might in time lose its fibrous construction. Cases of wrought iron railway bridges have been known where the continuous jarring of passing trains has so altered the form of the iron.

In our service no heavy guns are entirely made of wrought iron, the inner tubes being made of toughened steel, on account of the comparative softness of wrought iron and of the difficulty of forming a surface free from flaws.

At first we used it, and the B.L.R. guns have wrought iron barrels. We still use it in the palliser converted cast iron guns, in order to give sufficient safety to guns made of such weak metal as cast iron. The palliser converted gun is a very safe gun for its detachment, for before the inner tube of wrought iron burst, it would stretch to such an extent as to split the cast iron casing.

Wrought iron does capitally for the exterior portions of guns, as it is not only cheap but easily worked, and from its ductility gives a large margin of safety.

Testing Iron.

In the Royal gun factories all iron used is carefully tested, both as to the *distance* to which it will draw out before breaking, and as to the *weight* required to break it; for the former shews its *ductility* and the latter its *tenacity*. Its fracture is also examined. A good tough wrought iron ought to present a fracture of irregular silky appearance, light grey in colour, and of well defined fibre.

Steel.

Steel has, till lately, been defined according to its supposed chemical constitution as a form of iron containing from 3 to 2 per cent. of carbon. According to this definition, when the carbon is present in certain proportions—the limits of which cannot be strictly defined—we have the various kinds of steel, which are highly elastic, malleable,

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ductile, forgable, weldable, capable of receiving very different degrees of hardness by tempering, and fusible in furnaces.

Owing, however, to the gradual development of new modes of manufacture, and in the enormous increase of late years in the production of cast steels of all sorts, this definition leads to much confusion, and often to serious mistakes.

A simpler definition of steel is becoming general, which possesses the advantage of precision, and is in harmony with the current modes of manufacture. It is this:

Definition.

Steel is an *alloy of iron and carbon, cast, when in a fluid state, into a malleable ingot.*

It is held by this nomenclature, that steel and wrought iron cannot always be distinguished by chemical analysis (for the same proportions of carbon, manganese, silicon, &c. may exist in any malleable alloy of iron,) but that the fundamental and essential difference between *steel* and compounds of iron merely worked or "wrought," is a *structural* difference easily determined.

Advantage of this definition

Piled iron.

All *malleable* products of iron, that is, all iron except cast iron, may be divided into what is technically called *piled* metal (or wrought iron) and *ingot* metal (or steel.)

Ingot metal.

The former, including all malleable forms of iron produced without fusion of the metal, *when in the malleable state.*

The latter, including all irons however produced, which are *cast* into a malleable ingot.

These two classes differ more widely from each other in appearance, and many important properties, than the varieties amongst themselves, and form two distinct parallel series, chemically identical, differing only in the mode of production and in mechanical structure, rising in each series from the purest and softest iron to the hardest and most highly carbonated varieties.

Production of steel.

Steel is produced in several ways, in each case by getting

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rid of a portion of the carbon from cast-iron, under such conditions as to obtain a melted product.

It is generally done by dissolving wrought iron or scrap steel in molten cast iron.

By the direct melting of puddled or other iron of proper hardness (the hardness referring to the amount of carbon); also by melting a mixture of soft wrought iron with carbon or cast iron, and several other modes.

Practically the melting is carried out in crucibles, giving pot or crucible steel; on the open hearth of a reverberatory furnace, giving Siemens steel; or by blowing air through molten cast iron, producing Bessemer steel. Crucible steel Siemens Bessemer.

The results are similar, but being perfectly homogeneous they have very different properties to wrought iron.

Steel, though apparently homogeneous in structure, is not necessarily so in tensile, strength, tenacity, &c., and this is the weak point at present in steel.

MANUFACTURE OF S.B. ORDNANCE.

Till the introduction of rifled guns all natures of ordnance were made of bronze for the small, and cast iron for the large size.

No more will be made, so the operations may be very shortly referred to.

A model of the form of the gun required, allowing for turning and shrinking, and also for a large *dead head* at the muzzle end was first prepared.

The dead head was extra metal at muzzle end, so that the impurities might float up to top, and be cut off in it; its weight also compressed the metal. A gun jacket of iron was then made, in two longtitudinal pieces, for the bronze guns, and in several sections of convenient size for the large iron guns. Dead head.

There was sufficient space left between the model and jacket to contain a mixture of loam and sand, which was well rammed in; the model was then removed and the

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mould well dried, and numerous holes were pierced in it to allow of escaping gas and steam.

The parts of the jacket containing the mould were then fastened together and placed in a pit, breech downwards.

The metal was melted in a reveratory furnace and run into the mould; when cool, the dead head, 2 or 3 feet long in the case of a bronze gun, was cut off, and the gun turned, bored and finished pretty much the same way as the rifled guns.

All guns were cast solid, breech downwards, so that, the impurities rising to the top, it should be the best and densest part of the gun.

Manufacturing Operations.

We will first give a short description of the various operations employed in preparing the several portions of a gun from the raw material, in putting them together, and completing the gun.

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

The former is made, as has already been described, from old cast iron, generally shot, shell, guns or carriages. It is formed in blooms, which are then hammered or rolled when hot, to give fibre.

Scrap is made from either old wrought iron articles, bolts, nails, nuts, horseshoes, &c., which are freed from rust, piled on boards, heated and hammered together, or from the shavings from turning and boring in the Department. The former is called wrought iron scrap, the latter departmental scrap, which is thrown loose into the furnace in place of being piled. **Scrap.**

Most of the parts of a gun are formed by coiling a wrought iron bar round a mandrel, and then welding it into a compact cylinder, but certain parts, *i. e.*, the trunnion ring and cascable screw are formed by welding slabs together; and the inner tube is made from a solid ingot of **Parts of which a gun are built.**

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steel. All R.B.L., and formerly all R.M.L. guns, had a forged breech piece.

Manufacture of bar.

Two "blooms" of puddled iron are welded together and rolled into a flat bar weighing about 2 cwt.

Similar bars are made of scrap iron.

These are piled alternately to make a bar thick enough for purposes required, the outside bars being always puddled iron, it presenting a more even surface.

Rolling.

This pile is then heated to white heat and rolled into a long bar about 24 feet long, varying in section from 2½ to 7 inches, according to the purpose for which it is intended.

10 in. and upwards.

The bars for the 10 in. gun and upwards are made by forging.

Should the bar be required for the breech portion of the jacket of a gun, or for the tube of a 64-pr. or Palliser gun, it is cut into lengths, again faggotted and rolled, a finer and stronger iron being the result.

Shape of bar.

A bar is designated by depth of its section. It is slightly trapezoidal in section in order that when wound round the bar, narrow side inwards, the spreading of inside and narrowing of outside, usual in such a process, may be avoided.

Welding.

These bars are tested, and then a sufficient number are joined together to give a bar of the necessary length.

Use of Sand.

The ends are scarped down and heated, and hammered under a steam hammer, sand being thrown, as in all cases of forgings, on to the weld, to prevent scale forming, by converting the scale into a liquid silicate, which is easily squeezed out by the hammer.

Coiling.

The bar to be coiled is heated in a long reverberatory furnace, in front of which is fixed a slightly tapered mandrel or roller. It is tapered so that the coil can easily be removed.

This mandrel can be revolved on its axis.

When the bar is red hot the end is drawn out and cooled to make it hard, and is then hooked on to a pin, there being an eye for the purpose. The pin is connected with

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the mandrel, which is then set in motion, the bar is gradually drawn out and coiled round it.

Any scales that form are got rid of in forging.

A small coil is hammered off and a larger one is removed by fixing on end and revolving the mandrel the contrary way.

Double coils. Double coils are made by using the first coil, when cool, as a mandrel, and coiling the second bar the contrary way round it.

These are seldom used as the bars are now made of greater thickness when necessary.

Welding coils. The coil is now placed upright in a reverberatory furnace. If it were on its side, it would be unequally heated, and drippings from the roof would get between the coils.

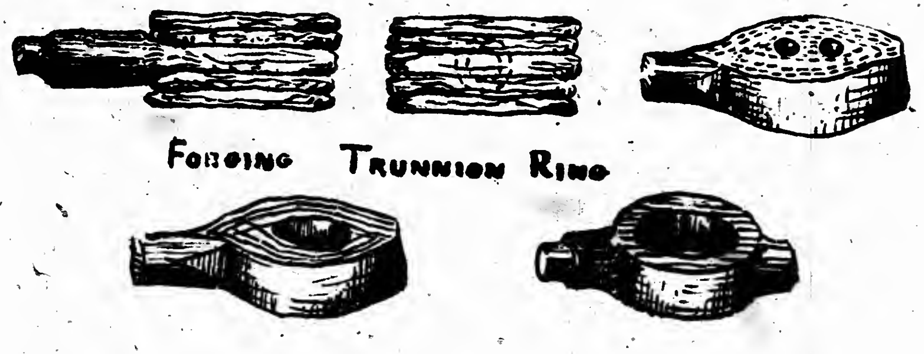
If it is necessary to be very careful about the heating, it is done in a cool furnace first, and then the coil is transferred to a hotter one. When white hot it is placed under a hammer by means of gigantic tongs. Sand is thrown on it as before. It is first given a few great blows in a vertical position to weld the coils. It is then thrown on its side and gradually hammered all round to straighten it. It is again placed vertical, and a mandrel or punch, a little longer than the interior diameter, is then hammered half way down the coil; again placed on its side, and this end hammered very compact. The mandrel is then forced into the other end, and the operation repeated.

The mandrels are of coiled iron and very hard.

The coil is replaced in the furnace for the second heating, and much the same process is gone through to make the coil more solid and shapely; and, if intended for an inner barrel a fine mandrel is used to make the interior more perfect.

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

After welding, the cylinder is gauged and inspected, and if found unsatisfactory is re-heated.



Forging Trunnion Ring

Solid forging.

Every large forging is made in the same way, viz.:

Slabs.

"Slabs" of iron are successively welded together upon the end of a "porter bar," or carrying bar, which acts as a lever and tongs in manipulating the work.

Slabs are formed by hammering together several blooms of scrap iron.

Trunnion ring.

To form a trunnion ring, the porter bar is heated, and slabs are welded on it, two at a time, till a mass of the required size is formed.

This is roughly hammered into shape, the porter bar being in the continuation of one of the trunnions. This block is converted into a ring by punching a hole in the centre (in the case of large guns, two holes.) These are then enlarged by driving oval shaped mandrels through it, increasing in size till the hole is large enough.

Shaping trunnions.

The trunnion ring has to be heated between each punching, and the trunnions are then roughly shaped.

It will be seen that in this case the fibre will run along the trunnions, and round the ring as described.

Scrap from turnings is used, as it gives a good fibrous iron of good quality.

Forging 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 cascabel.

Bars for heavy coils.

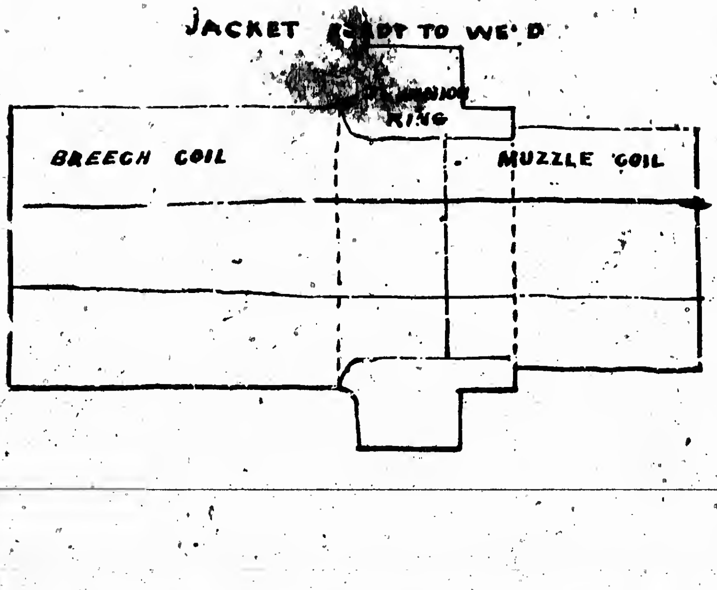
The heavy bars for the breech coils of heavy guns are made by welding successive slabs to the end of the porter bar till sufficient length is obtained. By this means we get a denser and stronger material for the breech coil, where great strength is required.

Uniting two coils.

When an inner barrel is required, several coils must be welded together.

The B tube, or chase, of heavy guns, is also composed of two united coils, as well as the breech coil, in some cases.

To begin with, the coils are turned smooth at ends, and reciprocally recessed, that is, a projection is formed on one and a corresponding recess is formed on the end of the other.


JACKET
BREECH COIL
MUZZLE COIL

The recess is then expanded by heat, and shrunk over the projection, so that the coils are stuck together enough to be heated for welding.

Inner tubes.

The coils are then placed crossways through a furnace, so that the ends project, and the intense heat only acts at the joint. A long bar is passed through when heated sufficiently. This is keyed up at one end, and at the other is a strong lever and screw nut, by which means the coils are pressed and welded together. The slight bulge at joint is straightened by steam hammer.

B. tube.

The coils for a B tube are short and strong. They may be heated in an ordinary furnace and welded by steam hammer.

Shrinking.

Shrinking is employed to bind the successive coils of a gun together, and also to regulate the tension of the various layers, so that each may contribute to the strength of the gun.

The outer coil is expanded by heat. In the case of the large coils, a wood fire is lighted inside it, the tube forming the flue, and it is then dropped over the part on which it has to be shrunk.

Mode of cooling.

Care must be taken to prevent a long tube cooling at both ends at once, for in that case the middle part would be unduly strained in a longitudinal direction. It is usual, therefore, to pour water on one end to cool it first; and in the case of a very thick coil, a ring of gas jets is used to keep up the heat at the other end, or a heated iron cylinder is applied to the thin end. As the other end cools, the heat is withdrawn, and the ring of water gradually raised.

Water is always kept flowing in the barrel to prevent its expanding and delaying the operation.

When a steel tube is placed muzzle downward to receive a breech coil, a jet of water is thrown up from below.

Manufacture of Jacket.

The three separate parts of a jacket, viz.: Breech coil, trunnion ring, and muzzle coil, being prepared as above, are united by the trunnion ring being heated and dropped over a shoulder on the breech coil, and then the muzzle

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coil is placed down upon the breech coil through the ring, which contracting, forms a band over the joint. The whole is then heated, and welded under the steam hammer, a mandrel being driven down inside to preserve the shape.

Steel ingots. Steel ingots for the inner barrels are received in R. G. Factory by contract. They are solid cylinders, cast and afterwards forged.

Casting is necessary to obtain the block large enough and homogeneous. Forging makes it solid and dense.

Casting. A large quantity of steel of a "mild" nature, that is, not too hard and brittle, is broken up and melted in black-lead crucibles, about 45 lbs. at a time. They are then emptied one by one, but in a *continuous flow*, into an iron mould. The least check in the flow spoils the casting. About 162 crucibles are required for a tube for a 9 in. gun.

After casting it is allowed to cool as slowly as possible. When cold a portion is cut off from the top, and the lower end, being densest, is marked for the breech.

Forging. This block is then heated and hammered several times, till of proper shape.

The block is tested when received, for elasticity and tensile strength.

Toughening. Pieces are bent over and hammered cold, and also raised a low and high temperature, and tempered in oil, and when cold, treated as above. An experienced workman can then tell what heat is best to temper the whole at. The soft untempered piece should stretch permanently at 13 tons per square inch, and break at 31. The toughened piece should stretch at 31, and break about 50.

Machine Operations.

Machine Operations. The tubes, rings, &c., have now to be bored, turned, in some cases, slotted, planed, and shrunk together. The inner barrel must be bored, broached, lapped and rifled.

Turning. Turning, means cutting off the exterior surface all round.

Boring. Boring means either reaming out the inside of a tube, or boring one out from a solid cylinder.

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Slotting and planing are much the same, only different actions are required in the machine. It is used for parts that cannot be turned, as the shoulders are slotted. Slotting and planing.

A broach is a tool used for making a taper hole, or for perfecting a cylindrical one. Broaching.

During boring the cutters wear away, and the hole is in consequence taper, hence the necessity of broaching.

Lapping is the final smoothing by means of a bar with a wooden head covered with lead, and is used with oil and emery powder. Lapping.

The rifling is done one grove at a time by means of a very simple machine, though difficult to understand without drawings. The rifling bar moves in and out, and at the same time revolves enough to give a twist to the rifling, the twist being regulated by what is called a copying bar, which can be changed as required, and the same machine used for any rifling. Rifling.

Drilling is done in case of a large hole, by machine. Drilling.

Small screws are made by hand with stocks and dies, but large ones are made in screw-cutting lathes. Screw cutting

A most thorough system of examination and gauging is carried out in every case, in every stage of the operations. Viewing and gauging.

Every portion is made strictly to sealed pattern, and the bore and internal surfaces that have to be shrunk together, are measured to $\frac{1}{1000}$ part of an inch.

Externally, $\frac{1}{100}$ of an inch is considered close enough.

R.B.L. guns have not been made for many years. They are all on Armstrong's original construction, with many small coils of wrought iron, with a forged breech piece and a coiled wrought iron barrel. R.B.L. guns.

Having no cascable screw, they were fitted with a hollow breech screw, and a slot was cut for a vent piece.

The breech fittings consist of—

Vent piece, breech screw, to fix latter in its place; *tappet ring,* by means of which the *lever* acted upon the *breech screw,* the latter having an octagonal head, on which the

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tappet ring fits. An *indicator ring* shews if the breech piece is screwed up enough.

Vent piece, so called because the vent goes through it, is the stopper that closes the end of the bore. The vent passes vertically to the centre of block, and then turns at right angles to allow the fire to strike the centre of the cartridge. The vertical part is bushed with copper. The bottom part is not bushed, as it would weaken it too much. Vent piece.

Various kinds of iron have been used for this purpose.

They are all faced with a copper ring except the 7 in., and have two shackles to lift them up by. The 9 and 12-pr. have only one shackle.

The breech screw is made from steel toughened in oil, except that for 7 in., which is of iron, with 6 inches of steel face screwed in. A strong "V bevelled" thread is cut on it to fit that in breech of gun. The 7 inch has a double thread, and is thus screwed in twice as quickly, and has a good bearing. Breech screw

The tappet ring is octagonal in shape inside and fits on to a similar octagon on breech screw. It has two projections, by which the power of the lever is communicated to it so that it acts as a wrench to screw up or unscrew breech screw. Tappet ring.

The lever fits on the breech screw behind the tappet ring. It is free to work round the breech screw but is prevented by two keep pins, which work in a canelure. The lever is fitted with heavy balls or accumulators, to give power in screwing up. Lever and Keep pins.

The smaller natures have only one ball and handle.

The indicator ring is a narrow thin ring fitted on breech screw in front of tappet ring. It is arranged so that when the breech screw is tight home, an indicator mark corresponds with one on the breech. The 7 in. and 40-pr. guns only have them. Indicator ring.

The gun and fittings are proved, and the gun afterwards marked, lined, sighted, &c. Proof, &c.

The weight, royal monogram, and broad arrow are Marks.

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stamped in front of slot, and the "mark", name of factory, date of proof, and register number on left trunnion.

Lines.

Vertical and horizontal lines are marked on breech and muzzle, to enable sighting plates to be adjusted; and also on the right side of breech, right trunnion and muzzle.

Sighting.

The process of sighting cannot be described unless the actual operations can be witnessed.

Sights.

The guns are supplied with two tangent and two trunnion sights. The former have revolving barrel heads, by means of which they can be accurately set to each minute of elevation and deflection.

The latter pattern, however, have only a sliding leaf; they are cheaper, and practically as good.

R.M.L. Ordnance.

All our R.M.L. guns are, with the exception of the steel and bronze 7-prs., built up on Sir. W. Armstrong's system, as modified by Mr. Frazer.

Original construction.

The original construction consisted of an inner barrel of coiled iron—steel could not then be made with sufficient certainty—supported by a forged breech piece over the breech, and by numerous coils of wrought iron, shrunk over all, with a forged trunnion ring and cascable.

Frazer's first modification.

Frazer's first modification consisted in doing away with the numerous coils, and using two or three heavy ones; but at first the heavy forged breech piece was retained, and the barrels were of steel.

Second modification.

The forged breech piece was next done away with, and one massive double or triple coil was used for the breech, and the parts of the gun reduced in number to an A tube, a B tube, a breech coil and a cascable.

Third modification.

It has been found more convenient, and stronger, to divide the breech coil into two heavy coils, finished separately. The strain is better distributed, so that from the 7 in. upwards the guns consist of an A tube, a B tube, a coiled breech piece, and over it a C coil or jacket, which carries the trunnions.

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The A tube is prepared as previously described, from a solid ingot. It is heated, when turned and rough bored, to the proper heat, and is plunged into a bath of rape oil.

Manufacture generally of a heavy gun.

Toughening strengthens the steel very much, but it warps it a little, and frequently causes the surface to crack, so it has to be turned and bored true after the operation.

Effects of toughening.

The B tube is composed of two single and slightly taper coils, united as before described. It is then turned; the *inside* is then gauged so that the steel tube may be finished to correct size, allowing ·003 ins. at muzzle, and ·002 at other end, for shrinkage.

The B. tube.

It is easier to turn to gauge than bore to gauge, hence the reason the inside of a coil is carefully measured.

The coiled breech piece consists of two united coils. The breech end has a screw, cut for the cascable.

Coiled breech piece.

C coil consists of a breech coil, trunnion ring and muzzle coil, united as before described.

C Coil.

N.B.—Double and treble coils are not now used, the bars being made of much larger section.

The coiled breech piece is first shrunk on to the A tube. A shoulder is formed on its muzzle end to receive a similar recess, cut in the B tube, which is then shrunk on.

Putting together.

The cascable is now screwed in, so that it gets compressed by the C coil, which is now shrunk on over all, and the gun is ready for (1) gas escape being made, engraving, finishing bore and rifling, venting and (2) sighting, marking, &c.

The gas escape is cut through the threads of the cascable.

The other operations cannot be, with advantage, described, we not being able to see the actual operations.

The gun is supplied with two tangent sights, a centre hind sight and three trunnion sights.

Larger natures of guns are made on similar principles. The cast patterns of the 18 ton and larger guns, have "muzzle" coil shrunk on separate from the jacket, to which it is not welded, and it becomes the 1 B coil.

Larger natures.

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The 80 ton gun has the "B" tube proper, divided into two, forming a "2 B" tube, so that it consists of, — 80 ton.

A tube.
B 2 tube.
B 1 tube.
Breech piece.
C coil.
Cascable.

The 64-pr. wrought iron gun consists of A tube, B tube and breech coil or C coil (composed of two coils and trun nion ring.) — 64-pr.

6.3 in. and 8 in. howitzers consist of A tube, B tube, C coil or jacket, cascable. — 6.3 in. & 8 in. Howitzers.

40-pr. consists of A tube, B tube, B coil, C coil or jacket, cascable. The B tube is in two parts, the B tube and B coil, it not being easy to manufacture so long and thin a coil in one piece. — 40-pr.

25-pr. consists of A tube, B coil, C coil or jacket. No cascable screw. — 25-pr.

16-pr. and 9-pr. consists of A tube strengthened at breech end by a C coil or breech piece. — 16-pr. 9-pr.

7-pr., 150 and 200 lbs., is made out of a solid block of steel, toughened in oil. It has a fore and hind sight. — 7-pr., 150 & 200 lbs.

Palliser Converted Guns.

When the necessity arose for rifled guns there were large numbers of cast iron S.B. guns in the service, and the question naturally presented itself, was it possible to make satisfactory rifled guns out of them?

The metal unsupported was too weak to stand the greatly increased strain when rifled, and several methods were tried as early as [illegible] to strengthen them. The general idea being to strengthen them by hammering or shrinking wrought iron or steel rings on to the parts that most required strenghtening. These were, however, of but little avail, as we can see from the known properties of wrought and cast iron. Cast iron stretches but little be-

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fore rupture, and wrought iron considerably, as does steel. These latter then easily yielded to the slight expansion of the inner cast iron, and supported it but little.

Sir W. Palliser in 1863 proposed that this method should be reversed, and that the softer and more elastic metal should be inside, and supported strongly by the outer casing of hard unyielding cast iron.

Great numbers of 68-prs., 32-pr. and 8 in. S.B. guns have been converted on his principle, and have proved highly satisfactory, forming a valuable gun where great penetration, and consequently great strains are not required; greatly superior to the S.B. guns from which they were converted, and moderate in price.

These guns are also peculiarly safe, for when the inner barrel is strained beyond its elastic limit and becomes permanently stretched, it still has a large margin of safety before actual rupture, and if the strain is too great for the cast iron, the latter splits, and warns the gunners that it is dangerous to go on. This property of wrought iron is a very valuable one.

Guns converted.

The 68-pr. of 95 cwt. is converted into an 80-pr. R.M.L. of 5 tons.

The 8 in. of 65 cwt. is converted into a 64-pr. R.M.L. of 71 cwt.

The 32-pr. of 58 cwt. is converted into a 64-pr. R.M.L. of 58 cwt.

Mode of conversion

The mode of conversion consists of boring out the old gun and inserting a wrought iron tube, which is rifled. When in its place it is secured 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, to prevent the latter slewing round.

Operations in an 8 in. gun.

The old gun is first bored out to 10½ in. bore. The muzzle is recessed and threaded for the cast iron collar, and

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the gas channel is bored in the breech at the right top of the cascable.

The coils for the A tube are made of the finest iron, called "departmental bar," and it is specially prepared by being thrice rolled. A tube wrought iron

The tube is formed of 5 coils, united as usual, and is bored to about 6.2 in. diameter, and a recess is cut in breech end and tapped for wrought iron cup.

The cup for closing the breech end is forged and stamped into shape, and a screw cut on it, and it is then screwed firmly home.

The A tube is now tested under hydraulic pressure to see if cup fits and that there is no leakage.

The breech end is now turned over to the length of 32 in., for the B tube (in these guns the *breech* coil is called the B tube,) previously made of two coils, and a gas channel $\frac{1}{10}$ in. wide is cut spirally round the A tube, communicating by star grooves at the end, with the gas escape. If anything gives way about the breech end, the gas escapes and gives warning. B tube.

The tube is made double at this part, so that if the inner layer gives way the gas may escape without bursting the gun; and also it enables, by the shrinking on of the B tube, greater strength to be given to this part. The whole tube is then fine turned to proper dimensions, allowing a little play between it and the casing, so that it can be easily forced in. Great care is taken that the breech end of tube bears fairly against the bottom of the bore. The curved part of the end of the barrel is made with a longer radius than the corresponding curve in the cast iron, the space between preventing a wedge-like action, tending to split the casing.

When the tube is adjusted, the collar is screwed in at the muzzle, and the hole bored under the trunnions; and a wrought iron pin screwed in. The bore is then rifled, with three small grooves.

The old vent is closed by a wrought iron screw plug, and the new vent drilled a little from the breech end. A Vent.

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"through" vent is permanently screwed in before proof, and when the heavy proof rounds have been fired, the strains exerted being over the elastic limit of wrought iron, the barrel is permanently expanded and made to fit tightly into the casing.

Two rounds of 1¼ service charges are used.

The guns are then sighted and lined.

The vertical line at muzzle is extended over tube to shew any shift.

The light 64-pr. has only a centre hind sight and a drop trunnion sight. Sights.

The heavy 64-pr. and the 80-pr. have two hind and two fore sights.

The tangent scales are all set at an angle of 2° 16', to allow for permanent deflection.

MATERIAL USED IN THE R.C.D.

First, wood. When a tree is cut across we see the woody fibre arranged round a centre in regular rings, each representing a years growth, the more solid interior portion is known as heartwood, the younger portion, next the bark, is sapwood. Wood.

Timber should be free from the following defects, viz.: "shakes" radiating from the centre; "cup shakes" or cracks between the annular rings; "upsets" where the fibres have been crushed by compression. Defects.

"Rind Galls" or wounds received in one of the older layers when young, and grown over in subsequent years.

"Dead knots" where a branch has been cut off and its root decayed. "Hollow or spongey" places proceeding from decay. Timber, especially elm and ash, is apt to be "doated" from lying in wet; this defect shews as yellow spots in the wood when sawn.

In good timber as a rule the fibre will adhere firmly together and will not look wooly or clog the saw when cut. When freshly cut it ought to look firm and glistening, a dull chalky look is a sure sign of bad timber. Good timber.

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The closer the annular rings are together the better as a rule will the timber be.

Warping. Planks cut from a log will always warp away from the centre of the original tree.

The plank cut exactly through the centre will shrink but not warp.

British Woods. The chief British woods used in the R.C.D., are oak, ash, elm and beech.

Oak. Oak is the strongest, toughest and most lasting. It, however, contains an acid, which corrodes iron in contact with it.

Ash. Ash is tough and remarkably elastic. It is used for shafts, handspikes, felloes, &c. It does not stand weather well, and is very liable to suffer from worm.

Elm. Elm is a very cross-grained tough wood, therefore it does not splinter. It is also very durable under constant wet.

Beech. Beech is a hard, strong wood, but does not stand exposure.

Foreign Woods. The following foreign woods are used:

African Oak. African oak, is stronger, heavier and darker than English oak, for which it is used as a substitute.

Sabicu. Sabicu, is exceedingly strong, heavy and durable. It is used for parts where rubbing action may be expected and weight is no object, such as the blocks in a rear chock carriage, bollards, &c. It is grown in the West Indies.

Teak. Teak, an East Indian and African timber. It possesses great strength, toughness and durability, but splinters readily.

It contains an essential oil that keeps off insects.

It is used for work for foreign stations.

Mahogany. Mahogany, is of two kinds, "Honduras," from Central America, and "Spanish," from Cuba and other West Indian Islands.

It is strong in all directions, and keeps its shape under trying circumstances, as to heat and moisture.

Honduras is lighter and inferior to Spanish.

Pine. Pine is soft, light and elastic, and is of several kinds.

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Pine proper, from the Scotch fir grown in Norway, Sweden and North America. It is red, yellow or white. Yellow alone is used for the interior fittings of waggons.

Deal. "Deal" is either white or yellow. It is the produce of the Scotch fir, and is used for ammunition boxes and the boarding of waggons.

Larch. Larch, a strong and durable but knotty timber. It is only used "uphers," or small trees for ladders, &c.

Deal, sawn up, is classed as "planks," "deals," and "battens," according to width, viz.: 11, 9 and 7 in.

Measurement The contents of a log are computed, if of oak, elm, or foreign wood, by square measure; if of ash or beech, by round measure; because in these the outer layers are sounder and better than the inner.

Round measure is thus taken $\left\{\frac{\text{mean girth in feet}}{4}\right\} \times$ length in feet = contents in cubic feet.

Square measure. Mean width $\times$ mean depth $\times$ length, (in feet in each case) = contents in cubic feet.

Seasoning. Seasoning timber is expelling, as far as may be, the natural moisture in its pores, this is done either naturally or artificially.

In natural seasoning the wood is cut into planks and exposed to the air, sheltered from rain and high wind. The time required in England is one year for each inch in thickness.

Artificial seasoning is done by subjecting the timber in a chamber to a current of hot-air or steam.

This is a much quicker process but it makes the wood more brittle and less durable than if naturally seasoned.

Metals.

Iron. Iron is received by contract in the form of girder **I**, tee **T**, angle **L**, round, square, flat, and plate iron. It is tested in various ways, as to its power of being bent into various shapes, both when hot and when cold.

Round, square and flat is bar iron of that section.

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Plate iron has to stand bending when cold, through certain angles, according to its thickness and whether it is bent with or across the grain.

Plate of any thickness must stand bending, when hot, 120° with grain, and 90° across it.

Both bar and plate iron must stand a strain with the fibre of 22 tons (English) per square inch, and of 18 tons (English) against the fibre.

Malleable cast iron is a term applied to castings of certain iron, which, by an after process of annealing, become a sort of steel. It is very tough, and refuses to weld. **Malleable cast iron.**

Steel is received as "blister," "shear," or cast steel, and tested practically as to its qualities. **Steel.**

There are three principal alloys made use of, all technically known as metal. **Metal.**

(1)	Copper,	86.8	For pipe boxes and sheaves of blocks. This is the hardest, as it contains most tin.
	Tin,	12.4	
	Zinc,	.8	
(2)	Copper,	86.5	For rollers.
	Tin,	10.83	
	Zinc,	2.68	
(3)	Copper,	84.2	For bearings and nuts of elevating screws, &c.
	Tin,	7.9	
	Zinc,	5.24	
	Lead,	2.62	

The usual method of preparing the alloy is to melt all the tin, zinc and lead, with a small proportion of copper, and cast this into ingots. These ingots are broken up and melted, and the rest of the copper added.

Leather, Rope, &c.

The leather used is tanned with oak bark, and not by chemicals. To prove this, cut a small piece and moisten the edge; a black mark down centre of edge denotes chemical tanning; a brown colour shews oak tanning. **Leather.**

Well tanned leather must not crack when doubled up.

Leather must be periodically dubbed, being first well cleaned. If in use, every three months. If in store, once in two years. **Preservation.**

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Dubbing consists of, train oil, one quart; neatsfoot oil, 4 quarts; olive oil, 2 quarts; tallow, 13 lbs. This is a most useful receipt. Dubbing.

The chief descriptions of leather are: "Hides," from oxen or cows; "strapback," for strapping; "bellows," for bellows of forges (these are dressed in oil;) "mill band backs," for bands of machinery. Also "basils," from sheep skin, for the inside strapping of boxes.

Rope.

A rope is formed of three strands, each strand of a number of yarns, and each yarn of a number of fibres of hemp. Rope is either white or tarred, and of different sizes, according to the number of yarns. The size is expressed by the circumference in inches. Rope.

The strength of rope when new, *i. e.*, the number of tons it will bear, is found approximately by squaring the circumference and dividing by 6. Strength.

Rope is issued in coils of 113 fathoms, marline and Hambro' line (lighter natures) in skeins, and spun yarn (tarred yarn) in lbs.

Government rope has a coloured thread running through it.

The following are the principal ropes and their uses:

12	inch,	white,	slings of sheers.
9	"	"	straps of sheers.
6	"	"	main tackle of sheers, guys and slings.
5	"	"	gun falls (heavy.)
4	"	"	light gun falls.
3	"	"	heavy gun tackles and drag ropes.
2½	"	"	light " "
4½	"	tarred,	guys of derricks, slings.
4	"	"	parbuckle ropes, lashings.
3	"	"	straps, lashings.
2½	"	"	luff-tackles lashings.
2	"	"	lever ropes, lashings.

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PAINT.

Paint. Lead paint is used for woodwork, as it gives a better body than zinc.

For iron carriages Pufford's black is used, painted over in field carriages with lead.

All new articles receive three coats.

Iron must be cleaned before painting.

Hard stopping. Hard stopping is used to stop "shakes"; is made by mixing dry white lead with gold size, 1 lb. of former to 1 gill of latter. It is better than putty for large cracks.

Putty. Putty for cracks is made of 1 cwt. of common whitening with 2½ gals. raw linseed oil.

Varnish. Varnish, made of equal parts of boiled oil and copal varnish; is used for the heads of side arms, for rifled ordnance, &c.

Water proof composition. Ordinary composition is made of lamp-black 24 lbs., litharge 13 oz., boiled linseed oil 74½ lbs., beeswax 11 oz.

To preserve bright iron work. To preserve bright iron work, mix 3 lbs. tallow and 1 lb. white zinc, and it will preserve bright iron from rust.