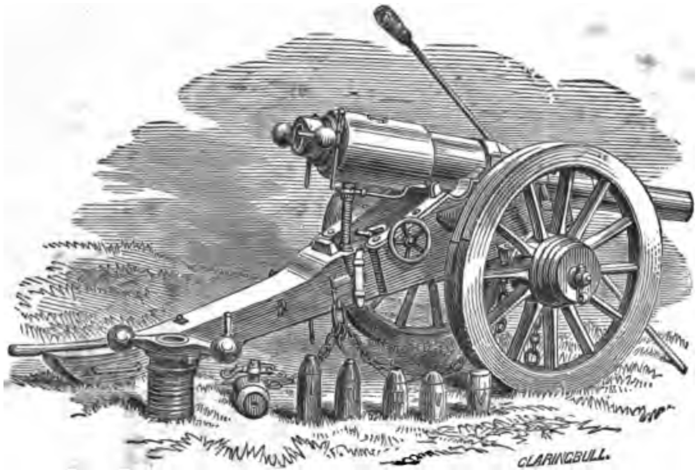
POPULAR INTRODUCTION TO RIFLED ORDNANCE

TABLE OF CONTENTS.



40-POUNDER BREECH-LOADING GUN.

A

POPULAR INTRODUCTION

TO

RIFLED ORDNANCE,

FOR THE USE OF LEARNERS OF THE ART OF GUNNERY.

BY AN ARTILLERYMAN.

WOOLWICH:

BODDY AND CO., MILITARY PRINTERS, ARTILLERY PLACE.

1871.

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BREECH-LOADING GUNS.

It would be tiresome and would answer no useful purpose to enter into a minute description of our Rifled Guns. An artilleryman is not a gun-founder. His business is more particularly with the working of the gun after it has been made. As it is impossible, however, for an engineer to be a competent workman unless he knows the names and uses of the different parts of the engine he is in charge of, so in the same manner, it is impossible for an artilleryman properly to perform his duties unless he has a general knowledge of the construction of the guns which are entrusted to his care. It is proposed, therefore, in these pages to supply such a general description of our Rifled Guns, their Projectiles and Fuzes, as shall include all the chief points which it is really necessary for an artilleryman to know, while on the other hand it should exclude all such details as appear properly to concern only the manufacturer.

We shall begin this description with our breech-loading guns, because, although it is true that muzzle-loading rifled guns are now coming much into fashion, it must not be forgotten that there are at present upwards of 3,000 breech-loading rifled guns in use in the service, and that for many years to come these will doubtless continue to form an important part of our armaments. It will be observed, moreover, that although in the one case the projectile is put in at the breech and in the other at the muzzle, the principles upon which both guns are constructed, the principles upon which they are sighted, and the leading features of their different projectiles, are in nearly all respects identical. It will be found, therefore, that when we have made ourselves acquainted with all that is necessary to be known about our breech-loading guns, we shall have comparatively little more to learn in order to be equally at home among the muzzle-loaders.

The part of the Armstrong gun which is usually most attractive to a person examining it for the first time is the breech-closing arrangement. We naturally feel curious to see how a gun can be made as open at the breech as it is at the muzzle and yet be closed again before every round so as to be almost as secure as if it had been a muzzle-loader. The way in which this is effected is very simple.

The gun, as already observed, is completely open at the breech. A schoolboy's popgun is not a more complete tube from end to end than is the Armstrong gun. To load the piece, therefore, it is only necessary to pass the bullet and cartridge in at the open end in the breech. The charge is pushed forward into its place in the barrel, and the breech is then ready to be closed up. To effect this two articles are employed. The first is the round block of metal called the vent-piece. If we examine this article we shall observe that it is bevelled off in front somewhat like the bung of a cask. It is in fact a stopper for the gun. When required for use it is dropped down through a hole or slot cut in the upper part of the breech. The bevelled side is of course turned to the front, and fits into the breech end of the barrel. When properly in its place therefore it closes up the barrel in nearly the same manner that a stopper closes up the mouth of a bottle.

It does not concern us particularly to know exactly of what material the vent-piece is made. As a matter of fact, perhaps, there may be no harm in our knowing that it was originally made of steel; then of wrought iron; then again of steel tempered in oil, and latterly of Marshall's iron. What chiefly concerns us however to know is, that the latest pattern (as shown by the date stamped upon it) should always be used in preference to any pattern of an earlier date, and that if any one of an old pattern with flat back should chance to be met with, it is on no account to be used as it does not take sufficient hold in the slot, and is liable therefore to be blown out.

Another matter which concerns us is the peculiar shape of the vent. It will be observed that it does not descend in a straight line like the vents of our smooth-bore guns. It is formed like the letter L, that is to say, it descends in a vertical line to about the centre of the vent-piece, and then turns off at right angles straight to the front. The point at which it comes out corresponds as nearly as possible with the axis of the piece. The object of making the vent in that form was to keep it near the centre of the metal so as to weaken the vent-piece as little as possible, and also to cause the cartridge to be ignited at the base so as to secure the advantage of what is called "central fire." A vent of that form, however, has the disadvantage of being very liable to become clogged up with oil, &c. A tube should therefore be fired through it to clear it before commencing practice. It is also liable to wear very much, and to gutter at the angle owing to the check which the rushing gas sustains in turning. Its condition at that point requires therefore to be occasionally ascertained by means of a small probe. If much guttered the vent-piece must be condemned, as the copper bush of the vent does not extend to that point, and there is no remedy for the weakened iron.

Another matter about the vent-piece which we have to notice is the copper ring on its face. This copper ring, it will be observed, is let into the part which presses against the edge of the barrel. It is not screwed into its place, it is only pressed in. The reason for placing a copper ring on that place is, that it is a part which is liable to become sooner worn out than the rest, and it is an advantage therefore to be able to detach and replace it when necessary. As it becomes worn or dented it can be refaced with the implements supplied to the battery for the purpose, and when no longer repairable it may be knocked off and a new ring substituted. The copper ring should at all times have a smooth surface, as any dent or bruise upon it might cause an escape of gas which would eat into the metal and speedily render the piece unserviceable. The bevelled part may be planed down until its outer edge and the edge of the iron meet; and the flat face may be planed down until it is flush with the iron. It will generally be found that the copper ring requires refacing at the end of about every 100 rounds, and that it requires to be renewed at the end of about every 300 rounds.

The back of the vent-piece is also a part which we must not overlook. It is important that it should be kept perfectly smooth and true, as any burr or upsetting of the metal on it would make the breech-screw act untruly against it, and probably cause the vent-piece to fracture. It should be occasionally tested with a straight edge to see that there are no inequalities upon its surface.

The cross-head on the vent-piece is a part with which we have more concern than may at first sight appear. It is not put on merely to give a hold for the shackle. If we examine it attentively we shall observe that its under edges have been carefully rounded off so as to form an exact fit for the edges of the slot in the gun. The object of that arrangement is that the vent-piece when dropped into the slot may be suspended by the cross-head in a true position for being screwed up. Great pains have been taken to ensure its accurate adjustment, and it is of importance therefore when working the gun to let the cross-head do its own work. If the vent-piece is allowed to drop from the hand it can sustain no damage, and will be guided by the cross-head into its proper place; whereas, if an attempt is made to guide it by hand it is liable to be improperly placed.

The second article which we have now to examine in the breech-closing arrangement is the breech-screw. This screw is merely a support for the vent-piece. It fits into the breech end of the gun and is turned by means of a lever or winch acting upon a tappet ring with projecting cams. When screwed up it presses with its face against the back of the vent-piece so as to tighten it firmly into its place, and when unscrewed it releases the vent-piece so as to allow it to be lifted out. The part of the breech-screw which requires most attention is the face which presses against the back of the vent-piece. This part requires to be frequently examined with a straight edge to see that it is perfectly smooth and true. Any roughness or unevenness on that part would of course have the same effect as irregularities on the back of the vent-piece,—it would produce an unequal pressure on the vent-piece and probably cause it to fracture.

The next object of interest about the gun is the bullet and powder chambers. If we examine the barrel we shall observe that at the end of it there is a slightly widened part, like the enlargement at the bottom of the glass chimney of a lamp. This widened part forms the chambers in which the bullet and cartridge are placed when the gun is being loaded. Now simple as this enlarged portion appears, it is in reality one of the leading features of the gun. We all know that the chief defect of our smooth-bored gun was that the bullet with which it was loaded required to be made a size smaller than the bore. It was absolutely necessary to make it somewhat smaller than the bore in order to let it pass freely up to its place in loading. The difference between the size of the bullet and the bore was not great—seldom more than one-tenth of an inch. Still the effect of that amount of windage was that when the gun was fired the bullet rebounded up and down in the bore and then left the gun, sometimes inclining in one direction and sometimes in another. Sir William Armstrong, in order to overcome that serious defect, made his gun open at the breech. He then scooped out in the end of the bore a cavity or chamber large enough to admit a bullet which should be about a tenth of an inch wider than the bore. When the gun is fired, therefore, the bullet completely fills the bore. There is no room for it to rebound in passing forward. All windage is completely done away with, and the bullet consequently leaves the bore in a true line and perfectly steadied for its flight through the air.

The part of the chambers which requires the most careful attention is the copper bush. This copper bush is the counterpart of the copper ring on the vent-piece. It is screwed into its place, and when worn may be refaced or renewed as circumstances require. It should at all times be kept smooth and free from any bruises or dents which would allow an escape of gas. When put in new it projects a little beyond the barrel so as to allow of its being planed down with the facing implements until it is flush with the face of the iron. When it has been cut down to that extent, and the breadth of the bevelled part exceeds three-eighths of an inch, it will generally be found necessary to have the copper bush renewed.

The next leading feature which attracts our attention is the rifling in the bore. This is a very interesting part of the gun. The idea of making rifled fire-arms appears to have originated nearly four hundred years ago. The grooves made at that early period, however, were not twisted grooves like those which we now use. They were straight grooves which ran parallel to the axis of the piece, and their use seems to have been merely to receive the fouling of the barrel so as to lessen the risk of the bullet getting jammed while loading. That consequently formed the first stage, or what we may call the infancy of the invention.

The second stage was reached when twisted grooves were introduced. By what means the invention passed into this second stage is still a mystery. The most probable conjecture is that owing perhaps to some of the grooves which were first made not being perfectly straight, the discovery came to be made that with twisted grooves better shooting was made than with straight ones. Whether that was really the case or not, it is tolerably certain that before the end of the sixteenth century the grooves had come to be made in a spiral form. A specimen of one of these spiral grooved pieces, dated 1588, is said to be still preserved in one of our collections in England; another specimen, dated 1610, may be seen by any one in the Tower of London, and a third specimen, dated 1623, is in the Artillery Museum in the Rotunda at Woolwich.

Even at that stage, however, the invention was only half developed. Visitors to the museum at Woolwich may perhaps remember seeing in one part of it an interesting collection of rifled firearms, manufactured in the 17th and 18th centuries. The collection includes a great variety of patterns, but it is noticeable that, as far as is known, the pieces were all made to fire only round balls. Even the first rifle introduced into the British service, viz., the Baker rifle, which was adopted for our rifle regiments in 1792, was like all the others, made to fire only a round ball. That, consequently, formed the second stage, or what we may call the youth of the invention.

The third or present stage was reached when the difficulties in the way of using elongated bullets, in as far at least as small arms were concerned, were at last overcome. This occurred in 1851, when the well-known Minié rifle was introduced. The great superiority of rifled over smooth-bored firearms was then brought prominently into notice, and since that time rifled ordnance have been rapidly taking the place of smooth-bored guns in every country in Europe.

The chief service which the rifling performs for us is that it enables us to use elongated bullets, with which we get greater accuracy of shooting, greater range, and greater penetration than it is possible to obtain with round balls.

The way in which the rifling effects this service illustrates a curious phenomenon of nature. We are all familiar with the sight of a boy's humming top. So long as the top is spinning sideways it cannot turn over lengthways. Even when it is poised on a point so fine that it would seem impossible for it not to topple over, it still appears to set the power of gravity at defiance. Now the same law, it has been discovered, applies to an elongated bullet fired from a gun. If the bullet is set spinning sideways when it leaves the gun it is prevented by that motion from turning over lengthways while it is passing through the air. This spinning motion, therefore, is exactly what the grooves in the bore impart. They give to the bullet a whirling motion round its longer axis, and so long as that whirling motion is retained the bullet travels steadily forward point foremost.

This, however, although the chief advantage which we derive from the rifling is not the only one. The advantages of greater range and of greater penetration are inseparably associated with elongated bullets, but the advantage of greater accuracy is to some extent obtainable whether we use elongated projectiles or round balls. Whatever may be the form of the projectile, the rifling, by making the bullet always rotate in one way, produces a permanent deflection in one direction which can be measured and allowed for, whereas no such allowance can be made when the direction is uncertain. Independently also of the form of the projectile, the rifling, by giving the bullet a whirling motion round its own axis, causes any defects there may be upon its surface to be presented alternately to each side, and consequently the tendency which such defects have to turn the bullet out of its true path is neutralized. This latter point is one which is much dwelt upon in theoretical lectures, but it may be doubted whether it holds good in reality to the extent that is supposed. It has been found by actual experiment at the proof butts in the Royal Arsenal that if there is even a small quantity of lubricating wax on one side of a Snider bullet more than there is on the other it will deflect the bullet considerably; and that even a very slight defect in the head of the bullet will affect its shooting. It is of course reasonable to believe that the spinning motion lessens the evil of defects in the form or construction of the bullet, but as a matter of fact it does not by any means form a complete remedy.

Let us now take a look at the way in which the gun has been put together. All our breech-loading guns are what is called "Built-up guns," that is to say, they were forged, or coiled in separate pieces, and these separate pieces were then built up one above another into the form of the gun. The inner tube of which the gun is composed is called the barrel; the second tube, which forms the breech end of the gun is called the breech piece; the broad band which encircles the gun at the trunnions is called the trunnion ring; and the other bands which are put round the outside of the gun to strengthen it, are called the coils The chief purpose which was intended to be served by making the gun in separate pieces was to increase its strength without adding to its weight. Wrought iron, it may be explained, is to some extent like wood, it is much stronger in the direction of its fibre than it is in the opposite direction. By constructing the gun, therefore, in separate pieces it was rendered practicable to arrange the fibre of the metal so that it might be in the best position for resisting either the strain which tends to blow out the sides of the piece, or the strain which tends to blow out the breech. The barrel and coils, for example, as they have to resist the strain which seeks to blow out the sides, are made with the fibre of the metal arranged round the gun. This is effected by making them of bars of iron, coiled round a mandril, on the principle of the twist barrels now so common for fowling pieces. The breech-piece, on the other hand, as it has to resist the strain which seeks to blow out the breech, is made of a forging of wrought iron with the fibre of the metal arranged lengthwise.

The separate pieces, after they had been welded into rough shape, were bored and turned to their proper dimensions. The process of boring and turning a gun is one of the most interesting sights in the Royal Arsenal. To see a huge mass of iron, many tons in weight, being bored and turned with as much ease as if it were a piece of wood in a turning-lathe, is a spectacle which strikes every one at first sight with amazement. The gun is seen fixed in a lathe and slowly turning round, while a knife ploughs into its surface and throws off the shavings in long curling ribbons.

The operation of securing the different pieces together so as to form the gun, is effected by what is called the shrinking process. The outer part, which is intended to be shrunk on, is heated until the metal becomes partially expanded, and while in that state it is placed upon the gun. It is then cooled and shrunk into its place, while the inner tube is kept from expanding by a jet of cold water which is made to play upon the interior of the barrel.

The material of which the gun is made, is, as we have already said, principally wrought iron. On the continent some of the most eminent founders make their guns entirely of steel, but our English founders have for the most part preferred to make them principally of wrought iron. The chief advantage of steel over wrought iron is that it is stronger to resist a pressure; its disadvantage is its brittleness. There is, moreover, much greater safety in working a steel gun. A steel gun when it bursts is apt to fly in destructive fragments, but a wrought iron gun only tears, and consequently seldom occasions any fatal accidents.

The only part which now remains for us to examine is the sights. This, to an artilleryman, is the most important part of the gun. There are many details about the construction of the gun which he may be ignorant of, and yet be able under ordinary circumstances to perform his duties passably well; but if he is unacquainted with the sights his ignorance must be as fatal to him as ignorance of the compass would be to a seaman. We shall endeavour, therefore, in this place to get as clear a knowledge as we can of the principle on which our sights are constructed, and of the proper method of using them.

Every schoolboy who has ever thrown a stone or a cricket ball knows that if he throws low, that is to say, if he aims straight at the object he intends to hit he will not throw so far as when he gives a certain amount of upward slant. The same law holds good in the case of a bullet fired from a gun. If the gun is pointed straight at the object, the bullet will not range so far as when the muzzle is slanted upward. Some contrivance for measuring the amount of slant or elevation to be given under different circumstances was therefore necessary. In the case of our rifled guns this measurement is effected with great minuteness. The gun is supposed to be placed in the centre of a circle within which it revolves upon the axis of its trunnions, like a wheel upon its axletree. This circle in which the gun revolves is divided into 360 parts. Each of these parts or 360ths of a circle is called a "degree." Each of these degrees is then subdivided into 60 lesser parts. These lesser parts or 60ths of a degree are called "minutes." When, therefore, the gun is said to be laid with one degree of elevation it is meant that the axis of the gun is not pointed true on the object but passes through a point which is the 360th part of a circle above it. In the same manner when the gun is said to be laid with 10 minutes of elevation it is meant that the axis of the gun is not laid true on the object but passes through a point which is ten sixtieths of a degree above it.

The manner in which the sights are made to measure off these small divisions of a circle is very ingenious. The tangent scale, it will be observed, is shaped very much like the letter T, it consists simply of an upright bar with a cross-head on the top of it. The upright bar is marked off in the first place into divisions of one degree each. Each degree is then subdivided into six lesser parts of ten minutes each. It may seem at first sight that it would have been plainer if each degree, instead of being divided into only six parts, had been divided into sixty parts to represent the sixty minutes there are in a degree. Such a large number of small divisions would, however, have been indistinct, and would have confused the tangent scale. An elevating nut has therefore been added for the purpose of giving the intermediate single minutes. This elevating nut is placed on the top of the tangent bar, immediately underneath the cross-head. When turned it raises or depresses the sight in exactly the same manner that an elevating-screw, when turned, raises or depresses the breech of a gun. One revolution of the elevating nut raises or depresses the sight ten minutes. The outer edge of the nut is therefore marked off into 10 divisions. When it is turned a tenth of a revolution an arrow points to the figure 1 to show that the sight has been raised one minute. In the same manner when it is turned two-tenths of a revolution the arrow points to the figure 2, and so on. Supposing then, for example, that it is proposed to give 2 degrees and 25 minutes of elevation. The tangent bar would in that case be raised to the mark upon it for 2 degrees and 20 minutes. The remaining five minutes would then be given by turning the elevating nut till the arrow pointed to the figure 5. This would complete the elevation to 2 degrees, 25 minutes.

An easily remembered practical rule for finding the elevation which should be given for all ranges above 1,000 yards (and artillery seldom come into action at less distances than 1,000 yards, because they would then be within range of infantry arms), is to deduct 4 from the range and divide the remainder by 3. For example, if the range is 1,600 yards, deduct 4 from 16, leaving 12, which divided by 3 gives 4 degrees of elevation. This rule comes sufficiently near to answer under ordinary circumstances with the 12-pr., 40-pr., and 7-in., guns. In hardly any case will the error be greater than the difference between hitting a man on the head and hitting him on the feet.

In addition to the degree scale, however, there is now marked on the tangent bar of all our sights for rifled ordnance, another scale which is headed with the word "yards." This scale shows the elevation which should be given for each hundred yards of range without reference whatever to degree or parts of a degree.

If we wish, for example, to lay the gun at 2,000 yards, we have only, when using this scale, to raise the bar to the mark upon it for 2,000 yards, and proceed at once to lay the gun, It will be seen, therefore, that this scale is constructed on precisely the same principle as the sights for our Enfield and Snider rifles, It is a scale which is exceedingly useful for quick firing and answers for nearly all ordinary purposes. It is, moreover, in some of our tangent scales, more correct even than the degree scale. The degree scales in the barrel-headed sights of our 12 and 40-pr. guns are by no means accurate. The 12-pr. has the 10 degrees of which it is composed, divided into 10 *equal* parts; and the 40-pr. has the 12 degrees of which it is composed divided also into 12 equal parts. This error is rectified in the 40-pr. sights with sliding leaf, the first degree being, of course, shortest and the others increasing gradually in length. In the barrel-headed sights, however, which are still in general use, the original error remains, as can be seen by anyone who may take the trouble to measure them.

Let us now take a look at the cross-head on the top. This is a very useful part of the sights. Every artilleryman knows that it is often very difficult in laying a gun to make a proper allowance for a breeze blowing across the range. We cannot, of course, under such circumstances lay the gun true on the target because the breeze is carrying the bullets away to leeward. We have usually therefore no alternative but to select for our aim some new point which we imagine to be as much to windward of the target as the breeze will carry the bullet to leeward. In most cases this new point which we have to select for our aim is either dimly visible or purely imaginary. The consequence of course is, that as there is no distinct object for the eye to fix upon in taking its alignment, the difficulty of laying the gun correctly is very much increased. Now the cross-head on the sights of our rifled guns meets this difficulty to a considerable extent. The leaf on which the sight notch is cut, instead of being fixed, is made moveable. It is so adjusted that it can be made to slide along from right to left or from left to right as may be required, In the event therefore of a breeze blowing across the range, we would, instead of aligning the sights on some imaginary point to windward of the target, shift the hind sight as much to the right or left as may be necessary to produce the same result, and then take our alignment true upon the target as before. One "minute" of deflection of the sight will deflect the shot an inch in every hundred yards of range. For example, if the range is 1,000 yards, one minute deflection of the sight will carry the shot 10 inches to the right. It follows therefore as a practical rule that if we judge our shot to have fallen a certain number of feet to the right, we have only to reduce these feet to inches, and divide by the number of hundred yards at which we are firing, to find the number of minutes of left deflection necessary to be given to correct the error. If we are firing, for example, at 1,500 yards' range, and find that our shot has fallen about five feet to the right, we would reduce the five feet to inches, that is to 60, and divide by 15—the number of hundred yards at which we are firing. The result will, of course, be 4—that is, 4 minutes left deflection necessary to be given to allow for the force of the wind.

The last feature which we have to notice about the sights is one which on a cursory inspection would hardly attract our attention. If we examine the tangent scale carefully, we shall observe that it does not stand perfectly upright. It leans over a little to the left. The object of that arrangement is to allow for what is called the "permanent deflection" of the bullet to the right. The meaning of this will not perhaps at first sight be very plain. Why the bullet should have a permanent deflection to the right may not be perfectly obvious. The explanation, however, is that nearly all bodies which have a spinning motion are subject to a law which makes them incline to the side towards which they spin. If we watch a boy's humming top, for example, we shall observe that it has this tendency. It has a constant inclination to shift its ground, and always to do so in the direction towards which it is spinning. So much is this the case that we may sometimes see it describe a complete circle. Now the Armstrong gun is rifled from left to right, and the bullet which is fired from it has consequently a spinning motion from left to right. The bullet therefore inclines to the right,—that is, to the side towards which it spins.

This inclination on the part of the bullet was not of course desired, and it caused at first considerable trouble. Experiments had to be made to ascertain the exact amount of error which resulted from it, and a table had to be constructed showing the amount of deflection to the left which should be given to the hind sight at each different range in order to correct it. At a range of 2,000 yards, for example, it was found that a deflection of as much as 12 minutes to the left had to be given. To lessen, therefore, the amount of shifting of the sights to the left at long ranges, the sights were at first adjusted permanently with an error of 12 minutes deflection to the left. By that arrangement no more deflection to the left had to be given till the range was over 2,000 yards; but it became of course necessary to give for all ranges *under* 2,000 yards a deflection to the right. That plan, consequently, did not mend the matter much, and to many it was a greater puzzle than a uniform deflection to the left would have been. At last, however, an idea occurred which put an end to this troublesome difficulty. There is on the breech of all our field guns an iron ring called the "tangent ring." It takes that name because it is made to contain a pair of sockets for the tangent scales to slide up and down in. This tangent ring requires to be fixed on the gun with the utmost accuracy, as the least error in its adjustment would cause the sights to be untrue. The error might not perhaps be great at short ranges, but as the tangent scale became gradually raised the amount of error would increase and throw the bullet very much out. This circumstance may possibly have suggested the idea that if the tangent ring were put on purposely askew,—if it were put on the exact amount askew which would correct the permanent deflection of the bullet to the right,—all difficulty about adjusting the sights would be got over. The idea was speedily acted upon. A little calculation showed that in the case of all our breech-loading guns an error of 2 degrees 16 minutes in the adjustment of the tangent ring would meet the case. The right shoulder of the tangent ring is therefore, as may be observed, made higher than the left, and the sight consequently, by its increasing inclination to the left as it is raised, corrects of itself at every range the permanent deflection of the bullet to the right.

Almost all our field guns, and nearly all our 40-pounders, have been "true sighted" in this manner. There are still, however, mounted at various stations, a considerable number of 7-inch breech-loaders, which are sighted in the old inconvenient way. It has to be kept in remembrance, therefore, when using these guns, that they are only true-sighted at 2,000 yards. For all ranges below 2,000 yards a certain amount of right deflection has to be given, and for all ranges above 2,000 yards a certain amount of left deflection must be given. Below 2,000 yards the amount of right deflection increases at the rate of about 1 minute for every 300 yards. For example, 1,800 requires 1 minute right deflection, 1,500 yards requires 2 minutes, and 1,200 yards requires 3 minutes. Above 2,000 yards the amount of left deflection increases at the rate of 2 minutes for every 300 yards. For example, 2,300 yards requires 2 minutes left deflection, 2,900 yards requires 6 minutes, and 3,500 yards requires 10 minutes.

There are eight natures of breech-loading guns in the service. Four of these are field guns and four of them are heavy guns. The four field guns are the 6-pr., 9-pr., 12-pr. and 20-pr.

The 6-pr., which weighs only 3 cwt., is used chiefly for colonial service, being specially adapted, on account of its lightness, for countries difficult to traverse. It is mounted and equipped, however, in the same manner as other field guns, and should not therefore be confounded with the 7-pr. mountain gun which is carried by mules.

The 9-pr., which weighs 6 cwt., was introduced chiefly for the Horse Artillery. It was appropriated to that branch of the service because Horse Artillery require to be able to keep up with cavalry, and it was necessary, therefore, that they should be provided with a light gun for that purpose.

The 12-pr., which weighs 8 cwt., was introduced chiefly for our field batteries. It was allotted to that branch because field batteries require as a general rule to keep up only with infantry. It was practicable, therefore, to give them the benefit of a heavier gun than that used by the Horse Artillery, without detriment to their necessary quickness of movement.

The 20-pr., which weighs 16 cwt, is used chiefly as a heavy field gun, or gun of position. There are three patterns of it in the service. The 16 cwt. gun is, however, the only one used in the land service; the other two are shorter and lighter, and are for naval service only.

The heavy guns are the 40-pr. and 7-in. breech-loading (screw) guns, and the 40-pr. and 64-pr. breech-loading wedge guns.

The 40-pr. breech screw gun is usually mounted upon a travelling carriage with a limber attached. It forms consequently a light siege gun or gun of position, which may be brought up quickly and placed temporarily in position on the field, but is not intended to be manœuvred like the guns of a field battery. It is probable that it will be issued in considerable numbers to our volunteer artillery, and there can be little doubt that it is a very suitable weapon to put into their hands. In a country like England, in which there are good roads and ample means of transport, it would be unwise to restrict ourselves to very light guns. 40-prs., which can be easily drawn by farm horses, are not in the least too heavy, and when brought up a few of them would be sufficient to silence the fire of almost any number of opposing field guns.

The 7-in. breech-loading gun has been the least successful of any of our breech-loaders. When first introduced it was expected to have formed a powerful gun for our coast batteries and the naval service. About the time of its introduction, however, iron plating for ships of war began to be used. That change occasioned a call upon our rifled guns which the 7-in. breech-loader, unfortunately, could not respond to. When it was tried against a target representing one of our ordinary iron clad ships, it produced a dent of only about two inches in depth. This result was obtained with its present service charge and service projectile, and at the close range of 200 yards. Its power of penetration was in fact little, if anything, superior to the 68-pr. smooth-bored gun, which, when fired against the same target at the same range, produced a similar dent of about two inches in depth. From the navy, therefore, the 7-in. breech-loader has been almost entirely withdrawn, and replaced by muzzle-loading rifled guns, which for penetrating purposes are much superior. In the land service, however, it is still common, being retained, like the smooth-bored guns, as an auxiliary to more powerful ordnance.

The 40-pr. and 64-pr. wedge guns are very interesting pieces of mechanism. On the continent the wedge system of closing the breech has been carried out in the construction of the heaviest ordnance. The Krupp steel guns, of which we have all heard so much, are on the wedge principle, and differ from our English guns only in the method of securing the wedge in its place.

The principle of the wedge system is easy to understand. The stopper which closes up the end of the barrel, instead of being supported by a screw as in our breech screw gun, is supported by a wedge which passes crossways through the gun. The opening for the wedge is made from side to side of the breech, like the eye in the head of a needle. The wedge, therefore, when it has been pushed across the slot presses with its side against the head of the stopper and tightens it up into its place.

In addition, however, to this ready method of closing the breech, there is in our wedge guns a novel contrivance for securing the safety of the piece. This contrivance consists of a vent-cover or "locking-plate," as it is called, which is made to slide backwards and forwards over the vent. So long as the breech is open the vent-cover rests upon the top of the vent. After the gun is loaded, if the wedge has been put properly into its place and secured, the vent-cover can be pushed easily aside and the gun fired. If however, the wedge has not been put properly home and secured, then the vent-cover stands fast and refuses to let the gun be fired. In fact no sentry posted over a magazine could perform his duty in a more intelligent manner than does the vent-cover. When all is secure within, it steps aside obedient to the slightest touch; but if all is not secure within it stands immoveable over the vent and guards the gun from being fired.

The wedge system of closing the breech was proposed by Sir William Armstrong on account of the frequent complaints made against his breech screw system when extended to heavy ordnance. Its principal advantages are, that the gun is more easily worked, and that the detachment is more under cover than with the breech screw gun. It happened, however, that the service had been well stocked with breech screw guns before these pieces were introduced, and consequently the number that has been made of them is very small. All the 40-prs. made were issued to the navy, and the 64-prs., although originally intended for the navy, had their destination changed, and are now to be met with only in the land service.

MUZZLE-LOADING RIFLED GUNS.

It may seem, at first sight, a little strange that after a period of so much enthusiasm in behalf of breech-loading guns we should have returned once more to our old friends the muzzle-loaders. The explanation of this phenomenon, however, is not far to seek. The breech-loading system was adopted because at the time there seemed to be no other way of getting a gun loaded with a projectile which would completely fill the bore. A muzzle-loading gun, it was believed, required, by the nature of its construction, that the bullet should have a certain amount of play in the bore, otherwise it could not be made to pass freely up to its place in loading. On the other hand by opening the breech and scooping out a chamber in the bottom of the bore it was, of course, rendered easy to load the gun with a projectile even wider than the bore, and consequently to ensure that when the gun was fired the projectile would leave the bore with its axis perfectly steady. The muzzle-loading gun, had therefore, for the time being, to stand aside, and the breech-loading gun took its place. The progress of invention has now, however, brought them again nearly abreast, while the important advantage which a muzzle-loading gun possesses in its greater simplicity, is considered by most artillerists to have turned the tables. A gun, it has been discovered, may be loaded at the muzzle, and yet be so constructed that when fired its projectile shall pass through the bore wedged up on every side, and nearly as steady as if the gun had been loaded at the breech. The story of the way in which this has been accomplished forms one of the most interesting chapters in the history of modern ordnance.

The first successful attempt to overcome the difficulties in the way of the muzzle-loading guns was made by Sir William Armstrong when he introduced what is called the shunt system of rifling. This system may still be seen in the 64-pr. muzzle-loading gun. The shunt system, as shown in that gun, is exceedingly ingenious. The system may be compared to a railway with a double line of rails,—one of them forming an up-line and the other forming a down-line. When the bullet is put into the bore the studs which project from its sides will fit only into the grooves of the up-line. Along these grooves, therefore, the bullet travels smoothly for about three-fourths of its journey. It then, by a bend in the rifling, is shunted off the grooves of the up-line on to the grooves of the down-line, and continues on that line to the bottom of the bore. As a natural consequence, therefore, when the gun is fired the bullet makes its journey from the breech to the muzzle upon the down-line. Now this down-line has a feature in its construction which forms the key to the whole system. It is to a great extent an inclined plane, ascending gradually as it approaches towards the muzzle. As the bullet advances, therefore, towards the muzzle it rises upon the incline and becomes tightened in the bore. All room for it to sway from side to side disappears, and it consequently leaves the muzzle not only with the necessary spinning motion, but with the steadied axis which is so essential to good shooting.

The chief defect of this system was that the sharp angles in the rifling weakened the gun and made the tube liable to split. Not long after its adoption, therefore, our present 7-in. muzzle-loading gun, rifled upon what is called the "Woolwich system," was introduced. This system is simpler and prettier than the shunt method, and has now almost entirely superseded it. There are no up-lines and down-lines in the Woolwich system; there is no shunt, nor is there from beginning to end of the bore any difference in the form of the groove. The shunt, the incline, and the double lines are all swept away, and in their place nothing whatever is substituted excepting plain grooves hollowed out thus ⌣, like the groove on a boy's cross bow. The advantage of this simple form of groove may not at first sight be apparent. It requires a minute's thought to understand how it acts. It will be observed that when the gun is being loaded the studs on the bullet fit easily into the bottoms of the grooves, and slide along them without difficulty to the breech end of the gun. When the bullet is impelled forward, however, the twist in the rifling causes the studs to press strongly against the driving sides of the grooves. The studs under these circumstances naturally rise upon the sloping edge of the grooves and cause the bullet to become tightened up in the bore. The bullet consequently leaves the muzzle to a considerable extent centred in the bore, and steadied for its flight through the air.

Following closely upon the 7-in. gun, our present 8, 9, 10 and 12-in. guns were successively introduced. The rifling in these guns shows a still further improvement upon the system in the 7-in. gun. The spiral twist, instead of being of a uniform pitch throughout, is made to begin almost imperceptibly at the breech, and increase steadily as it approaches towards the muzzle. The advantage of this improvement is that it imparts to the bullet its spinning motion gradually, and consequently lessens the strain upon the breech of the gun at the instant of discharge.

In addition to these last-named guns, an experimental 35-ton gun has been introduced. This gun is rifled like the others, on the Woolwich increasing system. It has a calibre of 11·6 inches, and is fired with a projectile of about 700 lbs. weight. It has been stated also upon good authority that drawings have been completed of a 50-ton gun, which would be capable of firing a projectile of 1000 lbs. weight.

The method of forging, coiling, boring and turning these guns are matters with which we have little concern. It is enough for us to know that they are all made upon the built-up principle, being formed of separate forgings and coils shrunk on one above another. The inner tube in all natures above the 64-pr. is of steel, the outer parts are all of wrought-iron. The cascable, which is also of wrought-iron, is screwed into the breech. A popular and well-known method of conveying a general idea of the construction of one of our large muzzle-loading guns is to represent it as composed of an inner tube of steel covered by trousers, waistcoat and jacket. The tube which covers the part that in a smooth-bored gun would be called the chase forms the trousers; the inner breech-coil, which extends from the trousers to the extreme end of the gun, forms the waistcoat, and the outer covering for the breech, with the trunnions for sleeves, forms the jacket. It must be observed, however, that the guns are not all clothed alike. The smaller natures have not so extensive a wardrobe as the larger. The 7 and 8-in. guns, for example, have only jacket and trousers; the 9-in. gun has a jacket, waistcoat and trousers, and the 10 and 12-in. guns have jacket, waistcoat, waistband, and trousers. Most of these guns, moreover, have had to submit to important changes in the matter of their apparel. The guns of the original Armstrong construction had a much greater number of layers of clothing than are now allowed. The present cheapened and improved method was introduced by Mr. Fraser, of the Royal Gun Factory, and is called the "Fraser system" of construction.

The chief point which it concerns us as artillerymen to notice in the construction of these heavy guns is, that they are all chambered. The bore is in every instance made to narrow itself at the breech, so as to form a chamber like what there is in our smooth-bored shell guns and howitzers. It is important to keep this feature in remembrance because on account of it there would be great danger in firing any of the heavy projectiles with reduced charges. The 7, 8, and 9-in. guns have saluting charges, but these charges can only be used for blank-firing, or as reduced charges for the light case shot. They cannot be used to fire shot or shell because a space would be left between the cartridge and projectile which might cause the gun to burst. The 10 and 12-in. guns do not use saluting charges, and there is consequently not so much risk of small charges being used with them; but the objection to firing with reduced charges is, of course, as applicable to the large guns as to the smaller.

The sights used with the M.L. heavy guns differ from those used with the breech-loaders only in some slight details. In addition to the degree and yard columns, they have a third column which forms a fuze scale. This scale is very useful as showing opposite each hundred yards the length of fuze which should be given for that particular range. The guns are all sighted, like the breech-loaders, on both sides, and are provided, in addition, with a short centre sight which it was thought would be handy for close quarters and moderate ranges. Like the breech-loaders, also, they have their sights adjusted at an angle to the left, to allow for the permanent deflection of the bullet to the right. The amount of angle differs, however, in each nature of gun. In the 8-in. gun, for example, it is 28 minutes; in the 9-in. gun, 44 minutes, and in the 10-in. gun, 1 degree 10 minutes.

A practical rule for finding the elevation which should be given with the 9-in. gun at all ranges from 1,000 to 3,000 yards, when using the service charge of 30 lbs., is to deduct 2 from the number of hundred yards in the range and divide the remainder by 4. For example, if the range is 1,800 yards we deduct 2 from 18, leaving 16, which divided by 4 gives 4 degrees of elevation. At all ranges from 1,400 to 3,000 yards this rule will give the exact elevation by the latest range table within two minutes; and at ranges from 1,000 to 1,400 yards, it is in no case more than 6 minutes out.

There is a special feature about the vents of some of these guns which requires to be noticed. It will be observed that in all guns of 10 inch calibre and upwards, the vent is placed on the side of the gun instead of on the top.

It is placed at an angle of 45° so as to be more convenient for the gunner. It is usually on the right side, but in guns for turret ships it may be either on the left side or on the right, as circumstances require.

Another special feature, which it concerns us to notice, is the "tell-tale" hole in the breech. This is a small gas escape-hole which communicates with the steel tube in the gun. If the steel tube should chance to split there is a connecting channel by which the gas would find its way out through the tell-tale hole and give warning of the danger. This hole requires, therefore, to be kept clear and watched. In the event of any gas being seen to issue from it, the Practice should be stopped, as it is a sure indication that the steel tube has given way. In guns made before September 1869, the channel comes out directly under the loop, but in those since made it is placed on the left side of the loop, where it may be more readily seen.

An important and interesting question with regard to these heavy guns now naturally presents itself. What is the extent of their penetrating power? This question is almost always answered by reference to their formidable antagonists, the iron-clad ships. The 7-in. gun at a range of about 500 yards is considered capable of penetrating the "Warrior," which is cased in $4\frac{1}{2}$-inch iron plate, 18 inches of teak wood, and $\frac{5}{8}$-inch iron skin. The 9-in. gun, at a range of about 1000 yards, is considered capable of penetrating the "Lord Warden," which is cased in 6 inches of iron plate and 29 inches of wood backing. A target constructed to represent a still stronger class of vessels, and consisting of 8 inches iron plate, 18 inches teak wood, and $\frac{3}{4}$-in. iron skin, has been upon several occasions completely pierced by the Palliser 9-in. shells.

A rough practical rule among artillerists is that a large muzzle-loading rifled gun will pierce an iron plate which is not much thicker than its own calibre. For example a 7-in. gun will pierce an 8-in. plate; an 8-in. gun will pierce a 9-in. plate; a 9-in. gun will pierce a 10 or 11-in. plate; a 10-in. gun will pierce an 11 or 12-in. plate, and a 12-in. gun will pierce a 13 or 14-in. plate. This rule will also hold good in the case of targets composed partly of iron and partly of wood, if we allow 6 inches of wood to equal 1 inch of iron. The greatest penetration which has yet been obtained with any of our rifled guns was, in the case of the 12-in. gun when it pierced the Plymouth Breakwater Shield. The shield was composed of three

5-in. rolled iron plates, making a thickness of 15 inches of iron in all. A 12-in. Palliser shell passed completely through the structure and went in pieces on the other side.

It had been thought that the improvements which have of late years been made in the construction of our guns and projectiles, and also in the manufacture of the powder with which they are fired, had rendered our guns capable of even still greater performances. It would appear, however, by the results of the latest experiments at Shoeburyness, that although our guns have undoubtedly been rendered more powerful, an equally important improvement has been effected in the quality of the iron plates they are required to pierce. In May, 1871, a target, representing a section of one of our most powerful iron clad ships was erected for trial. The target consisted of 14 inches of rolled iron plate, 15 inches of wood backing, and a $\frac{5}{8}$-in. iron skin. Assuming the 15 inches of wood to equal $2\frac{1}{2}$ inches of iron, this would represent a structure equal to between 17 and 18 inches of iron plate. The gun placed in position against the target was the 12 inch gun of 25 tons, the same as that which had pierced the Plymouth Breakwater Shield. The projectile was a Palliser shot, and the charge was made up of the new pebble powder. The gun succeeded, however, in only barely piercing the 14 inches of iron plate, that is, two inches more than its own calibre. Another shot fired against a target in which the wood and iron were laid in alternate layers, gave practically the same result. It was evident therefore that while the gun, on the one hand had been rendered more powerful, as its increased initial velocity proved; the target, on the other hand, had been equally improved, as was evidenced by the fact that the iron did not star in the least. The result of the experiment therefore was that both guns and targets were left in about the same relative positions as before.

Practically the question between guns and ships, stands at present thus:—If we are required to attack a well-built iron-clad ship, such as any of those now possessed in considerable numbers by all first class powers, we should never when possible attempt it with anything of less calibre than the 9-in. gun. If we employ a lighter piece the chances except under specially favorable circumstances will be on the side of the target, but on the other hand if we employ a 9 or 10-in. gun, the chances except in a few rare instances, will be on the side of the gun.

Turning now to our field muzzle-loading guns we find that (excluding the little 7-pr. mountain gun which will be dealt with by itself) we have as yet under this head only a 9-pr. bronze gun for India and a 9-pr. wrought-iron gun for home service. Experiments are, however, being carried on with a 16-pr. and a 40-pr. muzzle loader, both of which will probably ere long be introduced into the service.

The 9-pr. bronze gun weighs 8 cwt. It was cast of bronze specially to meet the views of the Indian Government who wished to have a gun of a metal which they could cast for themselves in their foundry at Cossipore. The result of the experiment has not, however, proved satisfactory, and the manufacture of these bronze guns has, therefore, for the present been suspended.

The 9-pr wrought iron gun weighs also 8 cwt. It is now being issued in considerable numbers to the Horse Artillery, and has also been supplied to some of our field batteries. It is composed of a steel tube with jacket of wrought-iron. The rifling is a modified form of what is called the "French" system. The groove in the French system is of a different shape from that in the Woolwich system, but both act on precisely the same principle. The "French" groove, instead of being rounded is trough-shaped, thus ___/ the bottom being flat and the sides sloping outwards. When the gun is fired, the studs on the bullet are forced up the incline on the driving side of the groove, and the bullet by tightening itself up becomes steadied and centred in the bore.

The gun is sighted in the centre only, and has a dispart patch on the muzzle like the old smooth-bored field gun. It has two tangent scales, one of them graduated from 0° to 6° and the other from 6° to 12°. There is no elevating nut on the tangent bar, but each degree is marked off into 20 divisions, each 20th of a degree being of course equal to 3 minutes. The head of the tangent scale is protected from injury by being let into a recess in the breech, and the foresight is also preserved from accident by the dispart patch rising in planes on each side of it.

The extreme elevation, which is obtained when the gun is bearing on the transom, is 21½ degrees. The extreme depression which is obtained when the end of the screw is flush with the bottom of the nut is 11 degrees.

The rule for finding the elevation which should be given with the 9-pr. M.L.R. gun is to remember that 1,500 yards require 3 degrees; then for every 100 yards below 1,500 deduct ¼ degree or 15 minutes, and for every 100 yards above 1,500 add ⅓ degree or 20 minutes.

This rule answers for nearly all the ranges on the first tangent scale as will be seen by the following table.

		By Rule d.	By Rule m.	By Table d.	By Table m.
800 yards	... (Deduct 7 quarters or 1¾° from 3°)...	1	15	1	18
900 ,,	... (Deduct 6 quarters or 1½° from 3°)...	1	30	1	31
1000 ,,	... (Deduct 5 quarters or 1¼° from 3°)...	1	45	1	44
1100 ,,	... (Deduct 4 quarters or 1° from 3°) ...	2	0	1	57
1200 ,,	... (Deduct 3 quarters or ¾° from 3°) ...	2	15	2	12
1300 ,,	... (Deduct 2 quarters or ½° from 3°) ...	2	30	2	28
1400 ,,	... (Deduct 1 quarter or ¼° from 3°) ...	2	45	2	45
1500 ,,	... .	3	0	3	2
1600 ,,	...... (Add one-third or 20′ to 3°).........	3	20	3	20
1700 ,,	...... (Add two-thirds or 40′ to 3°)	3	40	3	38
1800 ,,	...... (Add three-thirds or 1° to 3°)	4	0	3	58
1900 ,,	...... (Add four-thirds or 1° 20′ to 3°) ...	4	20	4	18
2000 ,,	...... (Add five-thirds or 1° 40′ to 3° ...	4	40	4	40
2100 ,,	...... (Add six-thirds or 2° to 3°).........	5	0	5	2
2200 ,,	...... (Add seven-thirds or 2° 20′ to 3°)	5	20	5	24
2300 ,,	...... (Add eight-thirds or 2° 40′ to 3°)	5	40	5	47
2400 ,,	...... (Add nine-thirds or 3° to 3°)	6	0	6	10

On the second tangent scale which extends from 6 to 12 degrees, every degree adds 200 yards to the range.

The carriage for the 9-pr. gun is constructed entirely of wrought-iron, with the exception of the axle-tree bed which is of wood. The naves of the wheels are of gun metal but the spokes and felloes are of wood. The elevating screw is turned by a wheel and pinion arrangement, which very much facilitates the operation. The axletree boxes are much broader than those of the general service pattern and can be made available as seats for two gunners. They are fitted to carry between them 4 case shot, 4 cartridges, a set of priming irons, a tube pocket, and a range finder.

PROJECTILES FOR B.L. GUNS.

We all know that a round tub is not so well adapted for navigation as an elongated boat. Even a savage who never saw a ship learns almost by instinct to taper his canoe. He knows without any teaching that an elongated boat which will pierce the waters and part them on each side of it must be better adapted for his purpose than a round tub which has to drive the water bull-headed in front of it. Now if we think the matter over we shall see that the same principle must hold good in the case of a bullet fired from a gun. A round ball is as far from being adapted to overcome the resistance of the air as a round tub is from being adapted for navigation. A round ball is driven through the air by sheer brute force, and at an enormous waste of power. If air were visible to our eyes like water, we would see that a round ball has to drive the air in dense masses in front of it, while on the other hand an elongated bullet pierces the resisting medium like a dart. So obvious, in fact, are the advantages of elongated bullets that a wish to employ them seems to have existed from an early period, and some curious experiments with a view to getting them introduced appear at different times to have been made. In 1747, for example, Robins read a paper before the Royal Society in which, after explaining the advantages of rifling a gun, he suggested that an egg-shaped bullet should be substituted for the ordinary round ball. The egg-shaped bullet, however, when it was tried, made very inaccurate shooting. Again, in 1774, another experiment with a view to getting elongated bullets introduced was tried at Woolwich. The gun employed in that experiment was a common smooth-bored gun, and the bullet used was shaped like a pepper-box. Six rounds we are told were fired upon that occasion, at ranges of from 100 to 200 yards, and a minute of the practice is still preserved in the records of the Royal Artillery Institution. Two years later, that is to say in 1776, almost precisely the same experiment was repeated at Langard Fort. The gun used at Langard Fort was, like the one employed at Woolwich, a common smooth-bored gun, and the projectiles seem to have been shaped almost exactly like those we now use with our rifled guns. Of course, with our present knowledge, we need hardly be told how these elongated bullets acted when fired from smooth-bored guns. At all, except the shortest, ranges the bullets went tumbling through the air, over and over, in a style which showed plainly that nothing could be gained by using them in that way.

In 1851, however, the turning point in the fortunes of elongated bullets was reached. In that year the famous Minié rifle was introduced. The projectile for the Minié rifle, as we all know, was an elongated bullet made of lead and hollowed out in the base. A cup was placed in the cavity in the base, and when the piece was fired the sides of the bullet were expanded and forced into the grooves of the bore. The success of that bullet was so great that it was rapidly introduced throughout Europe, and with only slight modifications is the form of projectile still in use with all our rifled small arms.

Now it may naturally be asked, Why could not the same description of projectile have been introduced at once for our large guns? Why could not a lead bullet, hollowed out in the base and made to expand by a cup or plug being forced into it, have been provided immediately for our rifled guns? The answer is easily given. Lead is too soft a substance to serve for the bullets of a large gun. It is incapable, for example, of breeching fortifications, or of acting with effect as a shell, which has to burst and fly in a shower of fragments. It was not, therefore, until after a long struggle with formidable difficulties that the Armstrong gun, with its now well-known elongated projectiles, were introduced for the Royal Artillery. The projectiles for the Armstrong gun, as we all know, are made of cast-iron, with a thin coating of lead on the surface to enable them to take the rifling in the bore. They take the rifling, therefore, not by expansion but by being made wider than the bore, so that when the gun is fired the bullet is driven into the grooves, and then by following the twist of the rifling, acquires the necessary spinning motion.

The batteries which were first armed with breech-loading rifled guns had only one description of projectile, viz., segment shell. The segment shell, it was thought, could be made to answer all the purposes of shot, shell, and case. That opinion has since been considerably modified, and a proportion of shrapnel shells, common shells, and case shot is now supplied to all our field batteries. We shall therefore take a look at these different projectiles, and without entering into minute details about their construction, endeavour to ascertain how each is prepared for use, and under what circumstances each may be employed with the best effect.

Segment shells are used with all natures of breech-loading guns, whether field, siege, or garrison. As the name implies, it is composed principally of a number of separate pieces called segments. These segments are made of cast-iron, and are built up into the form of the shell in exactly the same manner that a round tower of masonry is built up of separate stones. The segments are, of course, previously cast of a size to fit accurately into their places, and when put toge

take the form of the shell as if the whole were a single piece. An iron frame encloses the segments, and the usual lead coating is then placed on the outside to make the projectile take the rifling. A special feature in the construction of the segment shell is its happy adaptation to answer two entirely opposite purposes. Each segment, it will be observed, is slightly wedge-shaped to adapt it to the form of the shell; it is in fact shaped almost exactly like the keystone of an arch. When put into its place, therefore, the narrow end is turned inwards, and the broad end is turned outwards. The effect of this arrangement is that, on the principle of the arch, any pressure acting against the outside of the shell only drives the wedge-shaped segments more firmly together, while on the other hand, any pressure which is within the shell, such as the bursting charge, causes the segments to separate immediately.

A special feature in the action of the segment shell is that owing to its bursting charge being in the centre of the shell it opens rapidly into a wide cone of dispersion. The fragments scatter, in fact, more than is generally desirable, and owing to their angular form they do not retain their velocity long. Segment shell, therefore, should be made to burst closer upon the object than is necessary in the case of shrapnel shell. They produce their greatest effect when made to burst on graze either close upon or in the midst of a column of troops. In such cases their destructive power is very great. At Dartmoor 15 rounds fired at a group of dummies representing a column of troops, produced an average of 80 hits to each round. The gun used upon that occasion was the 12-pr., the range was nearly a mile, and the shells were all exploded with percussion fuzes. The most effective rounds were those in which the shell burst almost close upon the head of the column.

Another special feature in the action of the segment shell is, that as it is most effective when used with percussion fuzes only, it can be quickly and easily prepared on emergency. This is a more important point than may at first sight appear. Some officers, it must be remembered, laugh at the idea of boring or setting time fuzes in action in the field. They think that men in action cannot reasonably be expected to have the coolness and presence of mind necessary for preparing a time-fuze to the proper range. There are others, however, who think differently. They think that English soldiers do not so easily loose their heads, and that they may safely be trusted to bore or set their time fuzes when necessary. The truth probably is that circumstances greatly vary. Occasions must doubtless frequently present themselves even in action, in which a time fuze can be prepared with almost as much deliberation as at ordinary practice. On the other hand, however, occasions are just as likely to arise in which the proper preparation of time fuzes would almost be impracticable. In these latter cases, therefore, the segment shell, which does not require its fuzes to be either bored or set, comes readily to hand, and meets the necessities of the moment.

The bursting charge for the 9, 12 and 20-pounder segment shells is contained in a piece of iron gas piping. It is of no consequence which end of the burster is put first into the shell, but care should be taken when inserting it, that the brown paper in which it is wrapped is not removed. The wrapper should be inserted with it, and only the end torn off to allow a passage for the flame from the percussion fuze. Care should also be taken that the small lead disc, supplied for the purpose, is placed in the shell, immediately underneath the burster. This little article is very necessary, as without it the screw-plug in the head of the shell will not fit down with sufficient tightness to steady the percussion fuze, and prevent premature explosion. When the shell is not for immediate use a serge plug is inserted in it above the burster to fill up the space required for the percussion fuze. The bursting charge for the 40-pr., 64-pr., and 7-in. shells is only nominal, It is poured in loose and if the ordinary quantity is not sufficient, more powder is to be used until the shell is full.

The only fuze now used with the field segment shells is the C cap percussion fuze. The fuzes used with the 40-pr., 64-pr., and 7-in. segment shells, are, Boxer's 9 and 20 seconds wood time-fuzes for B.L. rifled guns, and Pettman's general service percussion fuze.

Shrapnel shells are used with the 9 and 12-pr., field guns, and with the 40-pr., 64-pr., and 7-in. heavy guns. The special feature in the construction of the shrapnel shell is that the bursting charge is placed in the bottom of the shell underneath the lead balls, with which the shell is filled. An iron partition or diaphragm separates the powder from the bullets. In the first pattern of these shrapnel shells (called mark I.) the partition was made of cast-iron and the only lining which the powder chamber had, was a coating of marine glue. It was found, however, that these shells were liable to premature explosion, owing, it was supposed, to the diaphragm being too weak, or to grains of powder getting into crevices and being ignited by concussion. In the present pattern (called mark II.) these defects have been remedied by making the partition of wrought iron and introducing a tin lining into the powder chamber. It may be useful to remember this circumstance because in the event of its being necessary to fire over one's own troops, the shells of mark II. should, if available, be preferred, as being less likely to burst prematurely. The interstices between the balls are filled with rosin, and the top of the shell is closed by a wooden head covered with Bessemer metal. This wooden head has a conical-shaped cavity in it, which is fitted with a gun metal bush for the reception of the wood time fuze. A hollow tube, which answers as a fire-hole, passes down through the centre of the shell, from the head to the bursting charge in the base.

The special feature in the action of the shrapnel shell is that the bursting charge in the bottom of the shell acts, when ignited, as a second impulse to the bullets, increasing their penetrating power while at the same time it lessens their lateral spread. The cone of dispersion of the shrapnel shell is consequently a long narrow one, the bullets keeping well together and retaining their velocity for a considerable time. The round form of the bullets and their comparatively heavy weight cause them moreover, to ricochet well upon hard ground. A shrapnel shell will therefore generally be effective even when burst as much as 80 or 100 yards from the object. When fired against troops in column, however, it gives the best results if the burst is within 30 or 40 yards of the head of the column, and from 6 to 8 feet above the plane, while against troops in line it acts best when burst about 60 or 80 yards in front of them.

The bursting charge for shrapnel shells is a fixed one. It should be poured into the shell gradually, as the narrow tube through which the powder has to pass is very easily choked. The metal primer which closes up the top of the tube should be screwed in tightly and kept permanently in its place as it not only assists to carry the flame from the fuze to the bursting charge but also prevents the loose powder from working up into the fuze-hole.

The field shrapnel shells all take Boxer's 5 and 9 seconds B.L.O. fuzes, and the heavy shrapnel shells all take the 9 seconds B.L.O. fuze. The 5 seconds fuze would, of course, fit the fuze-hole of the large shells, but would seldom suit their ranges.

The *Common shell* is merely an elongated bullet, cast hollow like a bottle, and filled with as large a bursting charge as it can be made to contain. In the case of the larger common shells, such as the 40-pr., which have a bursting charge of $2\frac{1}{4}$ lbs., and are capable, at 1,000 yards, of penetrating solid earth to a depth of 15 feet, their effect as a mine is very considerable. Their smashing powers are not so easily measured. There have been few experiments in this country to show the effect of any particular projectile in disabling and dismounting an enemy's guns. The cost of such an experiment would perhaps be too great. It is probable, however, that in an artillery duel, in which the object is to silence the opposing guns, the common shell, if fired from such ordnance as the 40-pr., would be as effective a projectile as could possibly be employed. On the continent the common shell is a great favourite. In the Prussian service it forms the chief projectile of all their field and siege equipments. It has, of course, the recommendation that it is always effective as a shot, and that in addition it generally follows up its first blow by bursting destructively as a shell. It has also the recommendation, which is probably regarded as of even still greater importance, that it acts best with percussion fuzes, which do not require to be bored or set to time.

The bursting charge for common shells is only nominal. The shells are always to be filled till they can hold no more. In filling the field shells there are three things which require specially to be attended to. The first is to shake them well during the operation, so as to give them the greatest possible bursting charge. The second is to close up the hole in the bottom of the socket by inserting in it the papier-mâchè wad supplied for the purpose. The use of this wad is to prevent any grains of powder from working up into the fuze-hole. The third thing to be attended to is to place in the socket, immediately above the wad, the perforated lead disc which is necessary to keep the percussion fuze firm, and prevent it from being exploded by the shock of discharge. The 9 and 12-pr. shells, which are marked III. on the lead coating, have had the internal depth of their sockets made less, so as to render the use of the lead washer unnecessary. With shells so marked, therefore, the lead washer is not used. In filling the 40-pr., 64-pr., and 7-in. shells, the chief points to be attended to are to fill them with as large a charge as possible, and to see that there are no loose grains of powder left about the fuze-hole. There are no wads or washers used with these large shells.

The only fuze used with the field shells is the lately-introduced C. cap percussion fuze. The fuzes used with the 40-pr., 64-pr. and 7-in. shells are the 9 and 20 seconds B.L.O. fuzes, and the general service percussion fuze.

Case shot is now used with all our breech-loading rifled guns. It is a more interesting projectile than its familiar name would lead us to suspect. There were, it must be remembered, difficulties in the way of using case shot with rifled guns, which do not exist in using it with smooth-bored guns. The tin cylinder, filled with iron balls, which is fired from our smooth-bored guns, was unsuitable for a rifled gun, because the breaking up of such a projectile in the bore was likely to injure the rifling. Then again, lead balls could not well be substituted for iron ones on account of their liability to conglomerate or adhere together in lumps.

In 1866, however, there was introduced into the service a case shot (invented by the late Lieutenant Reeves, of the Royal Artillery,) in which these difficulties were very ingeniously met. Reeves's case is a tin cylinder filled with a pile of wooden discs, which take up all the space within the cylinder, and lie as flat one above another as if the whole were a solid block. Room is then found for the balls with which the cylinder has to be filled by making in each of the wooden discs a group of holes exactly like the group of holes in a bagatelle board. These holes are filled, in the 7-in., with sand shot, and in all other natures with lead balls,—one-half of each ball in the lower disc, and the other half in the upper disc. The balls are, in fact, recessed both above and below, like the jewels in a lady's jewel case. The effect of this arrangement is that the cylinder is prevented from breaking up until it actually leaves the muzzle. There is consequently no chance of the bullets being conglomerated, and there is no flying asunder of balls in the bore to injure the rifling. The shock of discharge only presses the wooden discs more firmly together, and it is not until they come asunder at the muzzle that the balls are released and begin to spread.

A slight defect was, however, discovered in the action of this case shot. It was found that the breaking up of the wooden discs among the balls had a tendency to scatter them more than is generally desirable. In 1868, therefore, another pattern was adopted. This pattern, which is generally known as the Laboratory pattern, consists of a tin cylinder filled with loose balls. Its special features are that the cylinder is lined with thick sheet iron, cut lengthwise into three segments, and that the interstices between the balls are filled with coal-dust. When the gun is fired the segmental lining passes along the bore in company with the bullets, and keeps like a wall between them and the rifling. At the muzzle of the gun the lining is, of course, blown away, but being in no way mixed up with the bullets it goes off without any scattering effect upon them. Practically, therefore, the case shot of the Laboratory pattern carries closer than the case shot of Reeves's pattern, and would therefore be more effective against a compact body of troops. The balls in the Laboratory case were until lately, made of iron (called sand-shot), but they are now made of mixed metal (lead and antimony), and have the interstices filled with clay and sand rammed firmly in. The charge used for case shot is the ordinary service charge of the gun, and the range up to which it is effective is rather more than with smooth-bored guns. It is effective up to about 400 yards for the smaller natures and to about 500 yards for the larger. Rapidity of fire rather than accuracy of laying is required when using case shot. Three or four rounds of case can be fired in a minute from a field gun, and it has been calculated that at this rate from three to four rounds could be fired at a body of cavalry in the time they would pass over the last 300 yards of a charge.

Solid Shot is used with the 6, 9, and 12-pr. guns for practice and exercise only. It forms no part of their service equipment, and is retained merely for the sake of economy. For the 20-pr. it is still retained as a service projectile. For the 40-pr., also, when mounted as a gun of position (but not when mounted as a garrison gun), solid shot is still retained as part of the service equipment of the gun. There is no solid shot for the 64-pr. and 7-in. guns. The 64-pr. was originally provided with hollow-headed shot, and the 7-in. with a hollow-bodied shot, but these projectiles are now no longer supplied, and the existing store of them has been ordered to be used up for practice.

A very useful thing for an artilleryman to be able to do is to distinguish readily these different projectiles one from another. Perhaps the best and pleasantest way of learning to do so is to pay a visit either to the sealed pattern rooms in the Royal Arsenal, or to any lecture room in which the different projectiles may be seen side by side. The distinguishing features of each can then be readily noted, so that when any one of them is afterwards met by itself it may be at once recognised. It will be observed, for example, that the shrapnel shell can be readily distinguished from any of the other projectiles by the circumstance that it has a projecting socket in the head, and a projecting shoulder between the head and body like the shoulder formed by the different widths of an Armstrong gun. It will be observed, also, that segment shell may be distinguished from common shell by the circumstan--

that it is generally shorter, being usually only about 2½ calibres in length, while the common shell is about 3 calibres in length; that its head is shorter and more rounded; and that its base has the lead coating carried much further inward in order that it may overlap the plug which closes up the bottom of the shell. Reeves's case have all the numeral I. stamped on the top, while the Laboratory case have all the numeral II., III., or IV. stamped on the top, except the 40-prs, which are all marked I. All case shot for breech-loading guns is distinguished by the circumstance that it has either a belt of studs, or a lead ring on the outside of the cylinder near the base to prevent the projectile from being pushed beyond the bullet chamber in loading; the muzzle-loading case has no such belt. The only exception to that rule is the 64-pr. case, which has the studs on the outside, but is used indifferently with either muzzle-loaders or breech-loaders. In the wood-cut, facing the title-page, the different projectiles are indicated by being numbered thus—common shell I., shrapnel shell II., segment shell III., solid shot IV., and case shot V.

PROJECTILES FOR M.L. RIFLED GUNS.

All our muzzle-loading rifled guns which are heavier than the 64-pr. are provided with Palliser chilled or cored shot, and Palliser chilled shell. They are also all provided with common shells, shrapnel shells, and case shot.

The most interesting of these projectiles are the Palliser chilled shot and shell. In that long battle between guns and targets, which was contested at Shoeburyness, it was these chilled projectiles that so often gave the guns the victory. It was with them that the Gibraltar shield and the Chalmer's target, dense iron structures which had been deemed almost impenetrable, were reduced to ruins; and it was owing almost entirely to them that our 9-in. gun, when it was matched at Berlin against the Krupp steel gun of the same calibre, put daylight at every round through an iron target which its rival had been hammering against in vain. It was with the Palliser projectiles also, that the Plymouth Breakwater shield, consisting of 15 inches iron plate, was pierced by our service 12-inch gun, and that in July of the present year, a target consisting of 13 inches iron plate, 12 inches wood, and 1½ inch iron skin, was pierced by an experimental 11-inch gun, of 25 tons, a feat which it was thought could only have been performed by the experimental 35-ton gun.

The special feature of the Palliser shot is, of course, its intense hardness. This hardness is obtained by rapidly cooling or chilling the iron from a molten state. The effect of thus rapidly cooling the projectile is that for penetrating purposes it becomes more effective even than steel, while on the other hand it is only about one-fourth the cost of steel. A considerable number of the Palliser shot, at present in the service, have been chilled over their entire body, but latterly it has been found best to chill them only in the head. The advantage of chilling them only in the head is, that the body of the shell is left in a natural state which renders it less liable to crack.

In addition, however, to this feature of intense hardness, the Palliser shot possesses another advantage in the peculiar form of its head. The head, it will be observed, is not rounded off like those of our other projectiles. It is tapered to a sharp point. The advantage of this form of head is, that the sharp point which in any other projectile would probably be shattered at the instant of striking, is kept whole by the hardness of the metal, and pierces the resisting medium like a dart. The shot is cast with a hollow up the centre which is closed at the base by an iron plug. The hollow core renders the shot less liable to split in store, and allows it to be brought up to length without increasing its weight. It is on account of this core that the projectile is usually designated "cored shot."

The Palliser chilled shell is manufactured on the same principle as the chilled shot. A peculiar feature of the chilled shell, however, is that although filled with a bursting charge and intended to explode in the object struck, it requires no fuze. The heat generated by impact (that is by passing through the object struck) is so great that it is sufficient of itself to ignite the bursting power. The head of the shell is therefore entirely closed, and the powder with which the shell is charged, is poured in through a loading hole at the base.

In preparing the shell for use it is necessary before pouring in the bursting charge to insert in the shell a serge bag. The use of the serge bag is to prevent premature explosion which might arise from the friction of the powder against the metal. The shell should be completely filled. The plug which closes the loading-hole is special for *each shell* and is not therefore interchangeable. These shells are almost exclusively for use against armour-clad ships, as it is doubtful if they would burst on striking wooden ships. In moving Palliser shells or shot especial care should be taken that the sharp points are not injured, as although it is almost impossible to crush them by direct force, they are easily broken off by a side blow.

The other projectiles fired from our muzzle-loading rifled guns are in their main features the same as those used with the breech-loaders, excepting, of course, that instead of being coated with lead they are provided with metal studs which project from their sides and fit into the grooves of the gun.

The shrapnel shells are constructed internally in exactly the same manner as those for the breech-loaders, except that the large shells (from the 64-pr. and upwards) are now all filled with sand-shot instead of mixed metal bullets. The field shells take the 5 and 9 seconds M.L.O. fuze, and the large shells (from the 64-pr. and upwards) take the 9 seconds M.L.O. fuze. Like their comrades for the breech-loading guns, none of them take the 20 seconds fuze, as their socket is too short to receive it, and none of them use percussion fuzes. It is not improbable, however, that percussion fuzes may yet be introduced for the shrapnel shells of our M.L. field guns, as experiments with that view have for some time been carried on.

The common shells for field service take the 5 and 9 seconds M.L.O. fuze, and the heavy gun shells (from the 64-pr. and upwards) take the 9 and 20 seconds M.L.O. fuze. These large shells can be fitted with the 5 seconds fuze, but the range at which they are usually fired is beyond the limits for which that fuze is available. The field shells do not use percussion fuzes, but the heavy gun shells (from 64-pr. and upwards) take Pettman's general service percussion fuze.

The case shot are all of the Laboratory pattern, except those of mark I. for the 7 and 9-in. guns, which are of Reeves's pattern. The Laboratory case for the muzzle-loading heavy guns is a comparatively short and light projectile, being usually only about the weight of a round shot of the same calibre. The 8-in. case, for example, weighs only 68lb., the 9-in. case 100lbs., and the 10-in. 130lbs. Of course, when necessary, more than one may be inserted in the gun. The field case, like those for the breech-loaders, are filled with mixed metal bullets, but the heavy case from the 64-pr. and upwards) are filled with sand-shot.

The 64-pr. gun, as already observed, is not provided with Palliser shot or shell. The gun is not sufficiently powerful to render these projectiles effective. The 7-in. gun, on the other hand, possesses not only all the ordinary projectiles, but has been provided in addition with what is called a double shell,—that is a shell constructed on the same principle as the common shell, but made nearly double the ordinary length to give it increased effect. This shell is strengthened internally by three longitudinal ribs. The fuzes used with it are Boxer's 9 seconds M.L.O. fuze, and Pettman's general service percussion fuze. It does not take the 20 seconds fuze, because it flies rather wild at long distances, and is therefore restricted to moderate ranges.

In distinguishing these different projectiles one from another, it will be observed, that the nature of gun for which each is intended may be discovered by remembering that as a 7-inch gun has three grooves in the bore, so its projectiles have three longitudinal rows of studs to correspond; that, as the 8-inch gun has four grooves, so its projectiles have four rows of studs to correspond; that, as the 9-inch gun has six grooves, so its projectiles have six rows of studs, and so on. It is true that the 64-pr. muzzle-loader has the same number of grooves in the bore as the 7-inch gun, but then their projectiles may be at once distinguished by the circumstance, that the studs of the 64-pr. projectiles are only about the size of a sixpence, while the studs on the 7-inch projectiles are as large as a crown piece. Palliser projectiles are, of course, easily recognised by their sharp-pointed heads. Palliser shells are distinguished from Palliser shot by the circumstance that the shells are painted white at the points, while the shot are painted entirely black. If the paint happens to be removed, the shell may be recognised by the key-hole in its base-plug, there being no key-hole in the shot plug. The shrapnel shells are distinguished from the common shells in the same way as in the case of the breech-loaders, viz.: by the shrapnel shells having a projecting fuze-socket, and a shoulder between the head and body.

FUZES FOR BREECH-LOADING GUNS.

We all know that when a railway train starts suddenly the passengers who may be seated in the carriages are thrown violently backward. A power which they cannot resist, seems to hold them to the spot, and the consequence is that they come with a shock against the back of the carriage. Now, if we keep this phenomenon in mind, we shall have no difficulty in understanding how the time-fuze for our breech-loading guns is ignited. The head of the fuze is constructed with a small chamber in it, which may be taken to represent the compartment of a railway carriage. Inside this compartment a pellet is placed, which may be taken to represent the passenger in the train. When the shell is suddenly started by the explosion of the powder, the pellet in the inside of the fuze comes back with a blow against the end of its chamber, just as the passenger in the railway carriage is thrown back by the sudden starting of the train. To take advantage of this effect, the point of the pellet is made to strike against a patch of an explosive substance, called detonating composition. This composition is ignited by the blow, and the flame thus produced sets the fuze composition burning.

All the time-fuzes for our breech-loaders are ignited in this manner. There are three of them in use in the service, viz.: Boxer's 5 seconds, 9 seconds, and 20 seconds B.L.O. fuzes. The best known, and most frequently used of these, is the 9 seconds fuze. In its main features, it is merely the well-known wood time-fuze, for spherical shells, with the detonating arrangement of which we have spoken, in the head. The detonator is made of gun metal, and is permanently screwed into the head of the fuze. The technical name of the little pellet, inside the detonator, is the hammer. The hammer is suspended in its chamber by a copper wire, which passes crosswise through it. The strength of this copper wire is proportioned, so that it may be strong enough to resist any accidental blow, but not strong enough to resist the shock of discharge, which snaps it asunder. In the latest pattern of the fuze, there is also another safeguard against accidents. A safety-pin is introduced, which should not be withdrawn until the fuze has been fixed in the shell. The wood body of the fuze contains 2 inches of fuze composition, which burns 9 seconds in an elongated shell, and 10 seconds in a spherical.

Vent is given to the flame from the composition by three fire-escape holes, made in the sides of the fuze, near the head. These escape-holes are plugged, but the first rush of the gas from within throws them open. The fuze is bored with a bradawl, in the usual manner. The figures opposite the side holes are so arranged, that any one of them, if divided by 2, will give the number of seconds time of burning. For example, if we take the figure 12 and divide it by 2, we have 6; consequently, if we bore at the figure 12, the fuze will burn 6 seconds before causing the shell to explode. The fuze, after it has been bored, is set in the shell by being screwed in with the hand. When it cannot be screwed any further by hand it is sufficiently set.

The 9 seconds fuze is used with the 40-pr., 64-pr., and 7-inch shells of all descriptions. It is also used for times of flight above 5 seconds, with the field shrapnel shells, but not with any of the field common or segment shells, as it does not fit their fuze-hole. There are two patterns of the 9 seconds B.L.O. fuze in the service, the latest pattern having the safety pin, which is not in the first.

For times of flight exceeding 9 seconds, the 20 seconds wood time-fuze is used. This fuze is constructed on the same principle as that of the 9 seconds fuze. It has the same detonating arrangement in the head, and its composition burns at the same rate. As it is used, however, only at long ranges, the ordinary powder channels are dispensed with, and the side holes are arranged spirally, like those on a mortar fuze. The 20 seconds fuze is used with the 40-pr., 64-pr., and 7-inch common and segment shells, but not with any of the shrapnel shells, as their sockets have not been made long enough to receive it. It is not used with any of the field shells. There are two patterns of the 20 seconds B.L.O. fuze in the service, the latest pattern, like that of the 9 seconds, having the safety pin, which is not in the first pattern.

The 5 seconds fuze has only lately been introduced into the service. It is intended, chiefly, for the field shrapnel shells. It is distinguished, externally, by being painted red, like the heads of the field shrapnel shells, with which it is most frequently used. It has the same detonating arrangement in the head as the 9 seconds fuze, but instead of containing the ordinary fuze composition, it is pressed with 2 inches of mealed powder. This mealed powder burns at the rate of 2 inches in 5 seconds, or twice as quick as ordinary fuze composition. The special feature of the 5 seconds fuze, therefore, is that it can be bored to *quarter* seconds of time of flight. This is a more important advantage than may at first sight appear. In our ordinary time-fuzes, the shortest periods represented by the side-holes are *half* seconds. Each of these half seconds of time generally represents about 140 yards range. Practically, therefore, it is in many cases almost impossible to bore a fuze so as to make it act at the proper distance in front of the object. By reducing the divisions to quarter seconds, however, we get much nearer to what we require, as a scale which increases only 70 yards at each step is sufficiently minute for all practical purposes. It is important to observe in connexion with this fuze, that, although it actually burns twice as quick as an ordinary fuze, the figures opposite the side-holes are so arranged that any one of them, if divided by 2, will give the number of seconds time of burning, the same as in the case of the 9 seconds fuze. The figures, therefore, still read *tenths*, but tenths of the whole length of the fuze, instead of *tenths* of an inch. For example, the figure 6 means 6-tenths of the whole length of the fuze, and represents 3 seconds time of burning. In the same manner, the figure

7	represents	$3\frac{1}{2}$	seconds	time of	burning.
7-50	,,	$3\frac{3}{4}$	,,	,,	,,
8	,,	4	,,	,,	,,
8-50	,,	$4\frac{1}{4}$	,,	,,	,,

In field equipments, the 5 seconds fuze is used with the shrapnel shells only. It does not fit the fuze hole of the field common or segment shells. It fits the fuze holes of the 40-pr., 64-pr., and 7-inch shells of all descriptions, but could not often be used with them, as their practice is generally at longer ranges than those for which it would be available. There is only one pattern of the 5 seconds fuze in the service.

The 5, 9, and 20 seconds B.L.O. fuzes, are all bored in the usual manner, and are screwed into the shell by hand. The safety-pin should not be removed until the fuze is fixed in the shell. A handy practical rule for finding the length of fuze which should be given, under different circumstances, is to take two-thirds the range. For example, if the range is 1,800 yards, we take two-thirds of 18, which is 12; we then bore the fuze at the figure 12. This rule holds equally good with the 5 seconds, 9 seconds, and 20 seconds fuzes, and applies in the case of the 12-pr., 40-pr., and 7-inch guns. It answers best, however, with common shells, which are intended to burst after striking. With shrapnel and segment shells, which are intended to burst short of the object, it is necessary to deduct 1 from the range, and then take two-thirds of the remainder. For example, if the range is 1,600 yards, we call it 15, and then bore the fuze at the hole opposite 10. Another thing which it may be useful to remember, in connexion with these wood time-fuzes, is that in all cases of *direct impact* they usually act as percussion fuzes as well as time fuzes. It has been found by experience, that when the shell strikes fully against any object, the fuze is usually driven in among the bursting powder, causing an immediate explosion.

Let us now take a look at our percussion fuzes. A percussion fuze, as we all know, is intended to cause the shell to burst either on graze or on striking the object aimed at. It ignites, therefore, entirely without reference to the time it may have taken in its journey through the air. The principle upon which it is made to act is exactly the converse of that by which the time-fuze is ignited. We all know that if a railway train travelling at full speed is suddenly stopped the passengers who may be seated in the carriages are thrown violently forward. An irresistible force seems to impel them onward, and the consequence is that they come with a shock against the front of the carriage. Starting with this idea a chamber which may be taken to represent the compartment of a railway carriage, is constructed in the interior of the fuze. A pellet, which may be taken to represent the passenger in train, is then placed in the interior of the chamber. When the shell is suddenly stopped by striking any hard substance the pellet in the interior of the fuze, like the passenger in the railway carriage, comes with a shock against the front of its chamber. In anticipation of this effect the pellet is faced with detonating composition. This composition is ignited by the blow and the flame thus produced lights a train of powder which leads to the bursting charge in the shell and causes it to explode. Our field service percussion fuze, and Pettman's general service percussion fuze, are both ignited upon this principle.

The only percussion fuze now used with our field-service shells is the one called the Armstrong C. cap percussion fuze. It is merely a modification of the old C. percussion fuze, introduced for our field shells by Sir William Armstrong. The pellet in the interior of the fuze is made of slightly hardened lead, and is suspended in its chamber by projecting arms or feathers of the same metal. The detonating composition is the same as that used in our copper caps—hence the name C. cap percussion fuze. It has a safety-pin which passes through the pellet from the outside. The safety-pin forms both a support and a guard for the pellet, as it prevents the projecting feathers from being worn down by the constant jolting in the limber boxes. The safety-pin is, of course, withdrawn before inserting the fuze in the shell, and care should be taken to screw the plug in the head of the shell tightly down upon the top of the fuze, as any play left to the fuze would be likely to cause premature explosion. The C. cap percussion fuze is used only with the field common and segment shells. It is not used with field shrapnel shells, nor with any shells above the 20-pr. It is very sensitive and will act on grazing either ground, water or sand.

Pettman's general service percussion fuze may be employed with the 40-pr., 64-pr., and 7-in. common and segment shells. It is not used with shrapnel shells, nor with any of the field shells. It is chiefly used with muzzle-loading shells, and a description of it will therefore be found in connexion with the muzzle-loaders.

FUZES FOR MUZZLE-LOADING RIFLED GUNS.

The only fuzes now used with the muzzle-loading rifled guns, are Boxer's 5, 9, and 20 seconds M.L.O. fuzes and Pettman's general service percussion fuze.

With regard to Boxer's wood time fuzes a word of explanation is necessary. There is sufficient windage in the muzzle-loading rifled guns to allow the flame to pass round the shell and ignite the fuze. It would seem therefore at first sight, that our well-known wood time fuze for spherical shells should answer for the elongated shells of the muzzle-loaders also. Such in fact was at first believed to be the case, and it was not until after some experience that the difficulties in the way of using the common fuze for elongated shells were discovered. An elongated shell, it must be remembered, travels constantly point foremost, like a ship going end on, and the open head of the fuze being therefore the part which comes first to the ground, there was more than the usual amount of risk of the fuze being prematurely extinguished. Another obstacle to the use of the common fuze with elongated shells was, that the pressure of the air being constantly exerted on the head of the fuze affected materially its time of burning. This will be obvious enough when we consider how much a strong current of air quickens the burning of a fire. To test the difference an experiment was made when it was found, that a fuze, which in a spherical shell burns 20 seconds, lasted only 17 seconds when fired in an elongated shell. To get rid of these difficulties, therefore, it was decided to construct a fuze on the same principle as the wood time fuze for spherical shells but with the head completely closed. This alteration is effected by means of a metal plug which is screwed permanently into the head of the fuze. The first rush of the air as the shells passes forward in its flight is consequently met by the closed head of the fuze, and the composition is sheltered behind it. To allow the fuze, however, to be still ignited by the flame from the charge of the gun a narrow neck is cut round the outside of the fuze, a little below the head, and a piece of quick-match wrapped round it, like a cravat round a person's neck. The ends of the quick-match are passed in through the neck to the fuze composition, so as to establish a train of communication between them. The quickmatch round the neck is covered, until required for use, by a thin band of tape and copper, but when the shell is placed in the bore the band is stripped off and the quickmatch thus left exposed,

The 5 seconds fuze is pressed with mealed powder like the 5 seconds B.L.O. fuze. It is painted red like the heads of the field shrapnel shells with which it is chiefly used. The figures marked upon it when divided by 2 give the number of seconds time of burning, the same as in the case of the B.L.O. fuze. It may be used for short ranges with the field shrapnel and common shells. It also fits the fuze-hole of all the large common and shrapnel shells but could not often be used with them as their practice is generally at longer ranges than those for which it would be available.

The 9 seconds M.L.O. fuze is used with all our muzzle-loading common and shrapnel shells, and also with the 7-inch double shell.

There are two patterns of the 5 and 9 seconds M.L.O. fuzes in the service. The only difference between them, however, is that the fuzes, which are marked II., have a little more priming round the head, as the fuzes of mark I. were found liable to uncertainty of ignition.

The 20 seconds M.L.O. fuze is an almost exact counterpart of the 20 seconds B.L.O. fuze, except that it is without the detonating arrangement in the head. Both fuzes burn the same period, both are alike without any powder channels, and both have their side-holes arranged spirally, like those in a mortar fuze. The 20 seconds M.L.O. fuze is used only with muzzle-loading common shells. It is not used with shrapnel shells as their socket is not long enough to receive it, and it is not used with the 7-in. double shells, as they are too wild at long ranges.

The rule for finding the length of fuze with the 9-pr. M.L.R. shells is to remember that 800 yards requires 4-tenths, and that every additional tenth up to 2000 yards, adds 150 yards of range. Thus—

800	yards	requires	4	-tenths	of fuze.
950	,,	,,	5	,,	,,
1100	,,	,,	6	,,	,,
1250	,,	,,	7	,,	,,
1400	,,	,,	8	,,	,,
1550	,,	,,	9	,,	[illegible]
1700	,,	,,	10	,,	,,
1850	,,	,,	11	,,	,,
2000	,,	,,	12	,,	,,

Another rule is to deduct 2 from the range and take two-thirds of the remainder. This gives exactly the same result. Thus—

If the range is 800 yards, two-thirds of 6 is 4.
,, 1100 ,, ,, 9 is 6.

If the range is	1400	yards,	two-thirds of	12 is 8.
,,	1700	,,	,,	15 is 10.
,,	2000	,,	,,	18 is 12.

The lengths of fuze here given refer to shrapnel shell. With common shell it is necessary to add a tenth or a half tenth, as may be required, to let the shell lodge in the object before bursting.

Pettman's general service percussion fuze is the prettiest fuze in the service. A section of one looks more like a piece of elegant jewelry than a fuze for a shell. It contains within itself two arrangements for effecting its ignition—one of them being adapted for muzzle-loading shells and the other for breech-loading shells.

In the arrangement for igniting it when used with muzzle-loading shells the railway passenger, who is the type and emblem of nearly all our fuzes, is represented by a round ball called the detonating ball. This ball is coated with detonating composition, and is then suspended in the centre of its chamber, like a globe between two points. When the gun is fired the ball is thrown back, but the two plugs between which it is suspended, come back at the same time, and still keep the ball as a prisoner between them. Like the boy, however, who lost his support by sawing off the branch on which he was sitting, the ball and plugs in coming back have destroyed their only support by crushing up a lead cup which, until then, was keeping them together. The vibration of the shell as it passes forward then causes the plugs to come asunder and release the ball. As a natural consequence, therefore, when the shell is suddenly stopped by striking the object aimed at, the ball dashes against the sides of its chamber and is immediately ignited. The flame from the ball then rushes down through prepared fire-holes to the bursting charge in the shell and causes it to explode.

The arrangement for causing the fuze to ignite when used with breech-loading shells is somewhat different. The action of the fuze, when used with muzzle-loading shells depends, it will be observed, upon there being an amount of vibration in the shell sufficient to shake the plugs asunder, and let the ball free. A breech-loading shell, however, passes forward through the bore with so much smoothness and steadiness that it was found the fuze did not act; to meet this difficulty, therefore, a simple and, at the same time, most effective expedient is adopted. The uppermost of the two plugs, between which the ball is suspended, has a ring of detonating composition placed upon it. A brass pea is then recessed in the centre of the ring, between the plug and the head of the fuze. On the gun being fired, the brass pea drops down, so as to come opposite the composition, and when the shell is suddenly stopped by striking any hard substance, the plug is flung forward against the pea. The detonating composition on the surface of the plug is ignited by the blow, and the flame rushes down through prepared channels to the bursting charge in the shell.

The general service percussion fuze is used with all our heavy muzzle-loading common shells, from the 64-pr., and upwards. It is also used with the 7-inch double shells. It is not used with shrapnel shells because, as already mentioned, the method of igniting by percussion was considered inconsistent with the principle of a shrapnel shell, and it is not used with any field shells, as it does not act on graze. It is important to remember that the general service fuze, valuable as it is in its own department, is not sufficiently sensitive to act on graze, either on land or water. One of the essential conditions which it was required to fulfil before being adopted by the navy was, that it should not act on striking water, even with a high velocity, while, on the other hand, it should be sufficiently sensitive to act on striking the sides of a ship with even a low velocity. It can only be used with effect, therefore, against an object which is exposed to direct impact, such as a wooden ship, or a raised earthwork. It is in fact only available for cases in which the shell is intended to act as a mine. It could not be used, like our field percussion fuze, to make a shell burst on graze in front of an object, and go forward in a shower of fragments.

DETAILS ABOUT THE GUNS AND THEIR PROJECTILES.

The following are the details about the guns in most common use in the service.

The 9-*Pounder B.L. Gun.*—The weight of the gun is 6 cwt.; its length is 5 feet 2 inches, and its calibre 3 inches. There are 38 grooves in the bore. The twist of the rifling is one turn in 38 calibres, or 1 turn in 9½ feet. The service charge of the gun is 1 lb. 2 oz. This charge answers for all descriptions of projectiles fired from the gun. The lubricator is choked inside the cartridge. The saluting or exercising charge is 1 lb. The saluting cartridge is provided with a sawdust wad to lengthen it. There are four descriptions of projectiles fired from the gun; these are, segment shell, shrapnel shell, common shell, and case shot. The segment shell contains 42 segments, the weight of each segment being about 1½oz.; its bursting charge is 300 grains, or about ¾oz. The common shell has a bursting charge of 6 oz. The shrapnel shell contains 42 mixed metal bullets, 21 of them 18 to the lb., and 21 of them 34 to the lb.; the bursting charge is 12 drachms. The case shot, of mark I. is Reeves's pattern and contains 77 mixed metal bullets of 7 to the lb. This pattern has been ordered to be withdrawn from the land service. The case shot marked II. on the top is Laboratory pattern, and contains 35 sand shot, of 2 oz. The case shot marked III. on the top is also Laboratory pattern, and contains 101 mixed metal bullets, at 16½ per lb.

The 12-*pr. B.L. Gun.*—The weight of the gun is 8 cwt. Its length is 6 feet, and its calibre 3 inches. The rifling is on the Polygroove system. There are 38 grooves in the bore. The twist of the rifling is one turn in 38 calibres, or one turn in 9½ feet. The service charge of the gun is 1 lb. 8 oz. This charge answers for all descriptions of projectiles fired from the gun. The lubricator is choked inside the cartridge. The saluting or exercising charge is 1 lb. The saluting cartridge is provided with a sawdust wad to lengthen it. There are four descriptions of projectiles in the equipment of the gun. These are segment shell, shrapnel shell, common shell, and case shot. Solid shot is used only for practice and exercise. The segment shell contains 48 segments, the weight of each segment being about 1¼ oz. The bursting charge is 550 grains or about 1¼ oz. The shrapnel shells contain 42 bullets, 18 to the pound, and 14 bullets of 34 to the pound. The bursting charge is 12 drachms. The common shell has a bursting charge of 9½ oz. The case shot marked I. on the top is of Reeves's pattern, and contains 77 mixed metal bullets, 7 to the pound. The case shot marked II. on the top is of the Laboratory pattern, and contains 70 mixed metal bullets of 1½ oz. The case shot of mark I. and II. have been ordered to be withdrawn from the land service. The case shot marked III. on the top is also Laboratory pattern, and contains 48 sand shot of 2 oz. The case shot marked IV. on the top is likewise Laboratory pattern, and contains 132 mixed metal bullets of 16½ to the pound.

The 40-*pr. B.L. Gun.*—There are two patterns of the 40-pr. breech-screw gun in the service. One of these is a 35-cwt. gun, and the other a 32-cwt. gun. The 35-cwt. gun is the one in most common use. Its length is 10 feet, and its calibre 4¾ inches. The rifling is on the Polygroove system. There are 56 grooves in the bore. The twist of the rifling is one turn in 36½ calibres, or one turn in 14½ feet. The service charge of the gun is 5 lbs., and its exercising or saluting charge 3 lb. 4 oz. The service charge answers for all descriptions of projectiles fired from the gun. A paper cylinder is placed inside the cartridge to bring it up to length. The exercising or saluting cartridge is marked with the word "Blank." There are five descriptions of projectiles fired from the gun. These are segment shell, common shell, shrapnel shell, case shot and solid shot. The segment shell contains 72 segments, the weight of each segment being about 2½ oz. The bursting charge is 13 oz. The common shell has a nominal bursting charge of 2¼ lbs. The shrapnel shell contains 162 mixed metal bullets, 16 to the lb. The bursting charge is 3 oz. The case shot is of the Laboratory pattern, and contains 37 sand shot of 8 oz. Solid shot is supplied to the gun as part of its service equipment, when mounted as a gun of position; when mounted as a garrison gun the solid shot is used only for practice and exercise. Primers, to assist in carrying the flame from the friction tube to the cartridge, are used with this gun.

The 7-in. B.L. Gun.—There are two patterns of the 7-in. breech-loading gun in the service. One of them is an 82-cwt. gun, and the other a 72-cwt. gun. The 82-cwt. gun is the one in most common use. Its length is 10 feet and its calibre 7 inches. The rifling is of the Polygroove description. There are 76 grooves in the bore. The twist of the rifling is one turn in 37 calibres, or one turn in 21½ feet. The service charge of the gun is 11 lbs., and its exercising or saluting charge 7 lbs. There are four descriptions of projectiles fired from the gun. These are common shell, segment shell, shrapnel shell, and case shot. The common shell marked I. on the coat weighs empty about 98 lbs., and has a bursting charge of 7 lbs. 10 ozs. The common shell marked II. on the coat weighs 83 lbs. empty, and has a bursting charge of 6½ lbs. The segment shell contains 112 segments, the weight of each segment being nearly 3½ oz. It weighs empty about 98½ lbs. Its bursting charge is 3 lbs. 2 ozs. The shrapnel shell marked I. on the coat weighs 96 lbs., and contains 360 mixed metal bullets, of 14 to the lb. The shrapnel shell marked II. on the coat weighs 97 lbs., and contains 305 mixed metal bullets of 14 to the lb. The bursting charge of both patterns is 8 oz. The case shot marked I. on the top is of Reeves's pattern, and contains 87 sand shot, of 1 lb. each. The case shot marked II. on the top is Laboratory pattern, and contains 112 sand shot, 23 musket balls, and 22 pistol balls. Only a small number of this pattern were made. The case shot marked III. on the top is also Laboratory pattern, and contains 74 sand shot of 8 oz. each.

The 7-pr. M.L. Gun.—In 1867, when the Abysinnian expedition was determined on, it was decided to construct a 7-pr. muzzle-loading mountain gun specially for that expedition. The gun was made of steel and rifled on the French system. Its length is 26½ inches; its weight 150 lbs., and its calibre 3 inches. There are three grooves in the bore. The twist is uniform, one turn in 20 calibres. The ordinary service charge of the gun is 6 oz., but with the double shell it is only 4 oz. There are four descriptions of projectiles fired from the gun. These are common shell, double common shell, shrapnel shell, and case shot. The common shell weighs filled 7 lbs. 5 ozs., and has a bursting charge of 7 ozs. There are three rows of zinc studs on it, two in each row. The double shell weighs 12 lbs. filled, and has a bursting charge of 1 lb. The shrapnel shell weighs 7 lbs. 5 ozs., and contains 42 mixed metal bullets, 21 of them 18 to the lb., and 21 of them 34 to the lb. The bursting charge is 8 drachms. The fuzes used with common, double and shrapnel shells are special. They are of three lengths, viz., a 5 seconds, 10 seconds, and 15 seconds fuze. The case shot contains 82 mixed metal balls of 1 oz.

The 9-pr. M.L. Gun.—The weight of the gun is 8 cwt., its length 5 ft. 8½ in., and its calibre 3 inches. There are three grooves in the bore. The twist of the rifling is uniform, 1 turn in 30 calibres. The rifling is a modification of the French system. There are, as yet, only three descriptions of projectiles approved for the gun. These are shrapnel shell, common shell, and case shot. The shrapnel shell contains 63 mixed metal bullets, 28 at 18 per lb. and 35 at 34 per lb. The fuze-hole is the general service bush. The studs are in three rows, two in each row. The bursting charge is 12 drachms F.G. powder. The common shell has a bursting charge of 8 ozs. The fuze-hole is the general service bush. The studs are in three rows, two in each row. The case of mark I. contains 110 mixed metal bullets, at 16½ per lb. The case of mark II. contains 108 mixed metal bullets at 16½ per lb. The interstices in the first pattern were filled with rosin and sand; in the second pattern they are filled with sand and clay. There are no segment shells or percussion fuzes used with this gun; but the question of their introduction is under consideration.

The 9-inch M.L. Gun.—The 9-inch M.L. gun weighs 12 tons. Its length is 12¼ feet. It is rifled on the Woolwich increasing system. There are 6 grooves in the bore. The twist of the rifling increases from 0 to 1 turn in 45 calibres. The battering charge is 43 lbs., the service charge is 30 lbs., and the saluting or exercising charge 15 lbs. There are five descriptions of projectiles fired from the gun, viz.: Palliser cored shot, Palliser chilled shell, common shell, shrapnel shell, and case shot. The Palliser cored shot weighs 250 lbs. The Palliser chilled shell has a nominal bursting charge of 2 lb. 13 oz., and weighs filled 250 lbs. The common shell has a nominal bursting charge of 18 lbs., and weighs filled 250 lbs. The shrapnel shell contains 564 2-oz. sand shot, and has a bursting charge of 12 oz.; it weighs filled 250 lbs. The case shot of mark I. is of Reeves's pattern. Its length is 24 in., its weight 190 lbs., and its contents 87 balls; the weight of each ball being 2 lbs. The balls are made of lead and antimony, and are recessed in 12 wooden discs. The case shot, of mark II., contains 168 6-oz. sand-shot, 50 musket balls, and 58 pistol balls. Only a small number of this pattern were made. The case shot of mark III. is 9 inches in length; its weight is 100 lbs., and its contents 113 8-oz. sand-shot. It is of Laboratory pattern, the interstices between the balls being filled with coal dust.

SERVICE OF M.L. FIELD GUN.

Strength of the Detachment.—A detachment for the service of a M.L. field gun consists of one non-commissioned officer and eight gunners.

Formation of the Detachment.—The detachment is formed up two deep, two yards in rear of the muzzle of the gun; the non-commissioned officer, who is called No. 1, on the right of the front rank and uncovered.

Telling off the Detachment.—At "tell-off" from the instructor, No 1 takes a pace to his front, turns to his left, and numbers himself off 1. The man on the right of the rear rank then numbers off 2; the man in his front 3, and so on to the left; all the even numbers in rear, the odd numbers in front. No. 1, when he sees that his detachment is numbered off correctly, resumes his place on the right of the front rank.

Unlimbering.—If the detachment is composed of recruits the ordinary way of commencing their instruction is to unlimber the gun, and make them take post in action, as follows :—

Posts of the Detachment in action.—No. 1 stands at the end of the handspike ; No. 2 stands in line with the front of the right wheel ; No. 3 stands in line with the front of the left wheel No. 4 stands in line with the breech on the right side of the gun ; No. 5 stands in line with the breech on the left side of the gun ; No. 6 stands five yards in rear of the left wheel ; No. 7 stands in rear of the off (or right) limber box ; No. 8 stands in rear of the near (or left) limber box ; No. 9 stands four yards in rear of the limber. All the numbers face the gun.

Action, by numbers.—At the word "action," No. 1 repeats the command and ships his handspike. No. 5 (who has the tube pocket on his right side) takes the lanyard from his tube pocket, folds it and places it in his belt. No. 4 steps in to the trail, unbuckles the spunge, seizes the staff with his right hand at the centre, the back of the hand down, places the left hand under the rammer head, advances his right foot towards the axletree, with the right shoulder thrown forward, and holds the spunge at an elevation of about 45°. *Two.* No. 4 keeps the spunge-head well up, pitches the spunge neatly over the axletree to No. 2, and immediately resumes his place. No. 2 turns his head, looks over his left shoulder so that he may see No. 4, and receives the spunge in both hands, the right hand being about the centre of the staff, and the left about half way between the right and the rammer-head; he passes it in front of him and brings it down as smartly as possible to his right side, holding it with the right hand at the centre, and trailed at an angle of about 45°.

Serving the Vent.—At "load," No. 4 steps up to the breech and wipes the vent-field across from right to left with the ball or thick part of the left thumb, turns to his right and places the flat of the thumb of the left hand firmly on the vent; extends the fingers down the vent-field on the left side of the gun, keeps the left elbow well up (so as to allow No. 1 to lay the gun); takes the priming irons from the loop, selects the pricker, and stands holding it in his right hand. No. 5 takes the lanyard from his belt, hooks a tube to it, and holds the lanyard in the left hand, and the tube in the right hand, standing outside the wheel.

Serving ammunition.—At "load," No. 7, assisted by 8, prepares a shell. No. 8 takes the cartridge in his right hand and the shell in his left, back of both hands down, the bottom of the shell and the choked end of the cartridge next to each other, and hands them to No. 6. No. 6 runs back to No. 8, and receives the ammunition with the back of both hands up, the projectile in his right hand and the cartridge in his left, carries them up and delivers them to No. 3. He then immediately returns to 8 for another round, and halts at his own station till the gun is fired, with his arms crossed, the cartridge covered by the right arm. No. 3 slews his body to his right, brings his hands together to receive the ammunition from 6, the cartridge in his right, the projectile in his left, backs of both hands down.

Stepping in by numbers.—At "load," No. 2 raises the spunge perpendicular, takes an oblique pace to the right with his right foot, and brings the right elbow close to the hip. *Two.* He takes a step to his left front with his left foot, pointing the toes towards the breast of the carriage, and carries the spunge perpendicularly opposite the centre of the body, at the same time seizing it with the left hand close above the right. *Three.* He takes a step to his right with the right foot, separating the feet about thirty inches, and turns the toes of his right foot outwards; at the same time he brings the spunge to a horizontal position, in line with the axis of the piece, and slides the left hand to the spunge-head with the back down, and with the right hand he retains a firm hold of the stave at the centre.

Spunging by numbers.—At "One," No. 2 enters the spunge-head its own depth into the bore, shifts his left hand to his right, bends the right knee, and draws the left hip in, keeping the body well up, the head erect, and shoulders square to the front. *Two.* He forces the spunge in until his hands meet the face of the piece: at the same time he straightens the right knee, and bends over the left, draws in the right hip, and keeps the shoulders square to the front. *Three.* He shifts the hands out to the rammer-head, bends over the right knee, and straightens the left. *Four.*

He forces the spunge-head ***hard home*** to the bottom of the bore, straightens the right knee, bends the left, and draws the right hip in so as to preserve the squareness of the shoulders to the front. *Five.* He loosens his grasp of the spunge, sinks the wrists downwards, keeping the elbows close to the sides; he then grasps the stave firmly, presses the spunge-head against the bottom of the bore and raises the wrists. He repeats the motion, thus giving the spunge two "half turns." *One.* He draws the spunge out half its length, bends the right knee and straightens the left. *Two.* He shifts his hand from the rammer-head to the centre of the stave. *Three.* He withdraws the spunge with the right hand only, keeping the left hand at the muzzle of the piece, meets the spunge with the left hand back down close to the spunge-head, and smartly turns it, catching the stave with the left hand back up close to the rammer-head. No. 3, as soon as the spunge is withdrawn, steps up to the muzzle and puts in the ammunition, taking care that the choked end of the cartridge is next the projectile, and that the seam does not come under the vent; then uncaps the fuze if firing shell, and steps back to his former position.

Ramming home by numbers.—At "*One,*" No. 2 places the rammer-head in the bore, shifts the left hand to the right and takes a firm grasp of the stave. *Two.* He forces the rammer-head into the bore, until the left hand touches the face of the piece, bends the left knee, straightens the right, keeps the shoulders square to the front, and the head well up. *Three.* He slides both hands to the end of the stave, takes a firm hold near the spunge-head (the back of the right hand down and the back of the left up), straightens the left knee and bends the right. *Four*. He rams home, throwing his body strongly towards the carriage, both arms extended as far as possible so as to keep the body from the muzzle. He then quits the stave and springs up to his left clear of the muzzle, while No. 4 pricks the cartridge. No. 4, after pricking the cartridge to see if it is home, replaces his thumb on the vent, and returns the priming irons to the loop. *Five*. Directly the cartridge is pricked, No. 2 springs the rammer by jerking it out with his right hand back down; he steps to the right and allows the stave to slide through his hand; he grasps it firmly in the middle with the right hand, and at the rammer-head with the left, both knees straight. No. 4 quits the vent, runs to the end of the handspike and stands ready to traverse.

Stepping back by numbers.—At "*One*," No. 2 takes a pace to his rear with his right foot, brings the spunge upright, and seizes it with his left hand close above the right. *Two*. He takes a pace to his rear with his left foot. *Three*. He brings his right foot to his left, quits the stave with his left hand, and remains facing the gun with the spunge at the slope of 45° as before.

Laying the Gun.—As soon as the gun is loaded No. 1 steps in and lays it. He first raises the tangent scale to the proper elevation and clamps it. He then lays hold of the elevating wheel and looks over the sights, elevating or depressing the gun as may be required. He directs No. 4, who is at the handspike, to traverse the gun, giving the word "trail right" or "trail left," as may be necessary.

Ready.—No. 1, as soon as the gun is laid, puts down his tangent scale, gives the word "ready," and steps out clear of the recoil, taking up a position where he can best see the effect of his shot. No. 4, at the word, resumes his place outside the wheel. No. 5, at the word, steps up to the gun, and presses the tube into the vent with his right thumb; steps outside the wheel, takes the lanyard in the right hand and extends it, looking towards No. 1, with the right hand as high as the vent.

Fire.—No. 5, at the word "fire," draws the lanyard strongly out, without a jerk, towards his body, on a level with the vent, and replaces the lanyard in his belt. No. 4, when the gun has recoiled, steps in and drifts the vent.

Running up.—As soon as the gun is fired and the vent drifted, No. 1 directs the gun to be "run up" to its former place if necessary. In running up, Nos. 2, 3, 4 and 5 man the carriage wheels, while No. 1 lifts at the handspike. At "halt" they all resume their posts.

Cease Firing.—At the word "cease firing," No. 1, replaces his handspike; 5 places the lanyard in his tube pocket; 6 carries the round of ammunition back to 8, who places it in the box and shuts down the lid. No. 2 raises the spunge and points the rammer-head over the breast of the carriage, his left hand, back down, about the centre of the stave, and his right hand near the spunge-head, then throws the spunge over the axletree to 4, who catches it, and buckles it to the trail.

NOTE.—For the sake of simplicity, the drill for this gun has been given by numbers, but these numbers are used only with beginners, and should in all cases be dispensed with as soon as possible.

SERVICE OF THE 12-PR. B.L. GUN.

The method of loading the Armstrong field gun is very simple, and may be learned with ease in a few hours.

A man of the detachment, who is called No. 2, is posted on the left side of the gun, near the breech. At the command "load," he opens the breech for the reception of the charge by unscrewing the breech-screw, and taking out the vent-piece. Another man of the detachment, who is called No. 3, is posted on the right side of the gun, near the breech. His duty is to put in the projectile and the cartridge. The next man of the detachment, who is called No. 4, stands on the left side of the gun, a little in rear of the breech. His duty is to spunge the gun out, and then to ram home the projectile and cartridge. No. 2, as soon as the charge is home, closes up the breech again, by replacing the vent-piece and screwing up the breech-screw. This completes the loading. No. 1, as usual, lays the gun. The remaining numbers of the detachment, viz: 5, 6, 7, 8, and 9, merely supply ammunition from the limber and waggon.

The following is the detailed explanation of the drill.

Strength of the Detachment.—A detachment for the service of an Armstrong field gun consists of one non-commissioned officer, and eight gunners.

Formation of the Detachment.—The detachment is formed up two deep, two yards in rear of the muzzle of the gun, the non-commissioned officer, who is called No. 1, on the left of the front rank, and uncovered.

Telling off the Detachment.—At "tell off," from the instructor, No. 1 takes a pace to his front, turns to his right, and numbers himself off "one." The man on the right of the front rank then numbers off 2, the man in his rear 3, and so on to the left; all the even numbers in front, the odd numbers in rear. No. 1, when he sees that his detachment is numbered off correctly, resumes his place on the left of the front rank.

Getting out Stores.—The squad is next usually ordered to "stand at ease," while No. 6 gets a limber key and opens the limber boxes. No. 2 gets a tube pocket, lanyard and tubes. He straps the tube pocket round his waist, pocket on the right side, and supplies himself with oil and tow to clean the vent-piece. The squad is then called to attention. If the detachment is composed of recruits, the ordinary way of commencing their instruction is to unlimber the gun, and make them take posts as follows:—

Posts of the Detachment.—No. 1 stands on the right side of the gun, between the breech and wheel, facing to the front. No. 2 stands on the left side of the gun, between the breech and wheel, facing to the front. No. 3 stands one yard in rear of and covering the right wheel. No. 4 stands one yard in rear of and covering left wheel. No. 5 stands five yards in rear of the the right wheel. No. 6 stands in rear of the off or right limber box. No. 7 stands ten yards in rear of No. 5. No. 8 stands in rear of the near or left limber box. No. 9 stands four yards in rear of the limber.

At "Action," No. 2 *gets out his lanyard,* 3 *his handspike,* 4 *his spunge,* 6 *a round of ammunition.*—At "action" No. 1 repeats the command and turns to his left. No. 2 turns to his right, and puts the lanyard in his belt; then, when water is used, takes the plug out of the spunge bucket. No. 3 turns to his left, ships the handspike, and remains facing the trail, one pace to the left of No. 1. No. 4 turns to his right, unbuckles the spunge, and remains facing the trail, with the spunge at an angle of 45 degrees, the rammer head on the ground, to his rear. No. 6 prepares a shell, assisted by 8, and then takes out a cartridge.

At "Load," No. 1 *adjusts his sights,* 2 *takes out the vent-piece,* 4 *spunges out the gun,* 7, 5, *and* 3, *get a round of ammunition.*—At "with—load," No. 1 repeats the command, and adjusts his scales of elevation and deflection.

No. 2 unscrews the breech-screw with his right hand, back down, forcing the lever from him, takes out the vent-piece with his left hand, steps out clear of the wheel, and cleans the vent-piece if necessary, resting it on the nave of the wheel.

No. 4 brings the spunge horizontal, the left hand back under, the right hand back up, the spunge-head towards the front, takes a pace to the left with his left foot, puts the spunge into the bucket, if water is used, spunges out the gun thoroughly, and withdraws the spunge, keeping it horizontal, while No. 1 examines the bore.

No. 7 doubles to No. 6, gets a round of ammunition from him, and returns with it to his post.

No. 5 doubles to No. 7, gets a round of ammunition from him, and then places himself on the left of 3, ready to hand it to him.

No. 3 takes a shell from 5 and stands ready to place it in the bore.

At "Shell," No. 3 *puts the projectile in the bore,* 4 *sets it home.*—No. 1, as soon as the gun is spunged out, looks up the bore, to see that it is clean, and gives the word "shell;" No. 3, at the word, puts the projectile in the bore, and takes a cartridge from No. 5. No. 4 places the rammer head against the base of the projectile, slips his left hand to his right, and, with a sharp motion, forces the projectile quickly into the chamber. He then remains steady till the word "cartridge" is given.

At "Cartridge," No. 3 *puts the cartridge in the bore,* 4 *sets it home.*—No. 1 looks down the slot, and when he sees that the shell is home, gives the word "cartridge." No. 3 then places a cartridge in the breech, falls back to the end of the handspike, and traverses the gun roughly into the line of fire. No. 4 presses the cartridge gently home, and waits for the word "home" to spring the rammer.

At "Home," No. 2 *closes up the Breech.*—No. 1, as soon as the cartridge is in its place, gives the word "home"; No. 4 then springs his rammer, steps back clear of the wheel, and brings the stave to the slope as before. No. 2 drops the vent-piece into the slot, screws up the breech-screw, right hand back up, giving the cam two taps with the lever; he then steps clear, and hooks a tube to the lanyard.

No. 1 *lays the Gun.*—No. 1, as soon as the gun is loaded, steps in and lays it. No. 3 traverses for him, if necessary. The final adjustment is given with the traversing bar.

At "Ready," No. 2 *makes ready,* 1 *and* 3 *step clear.*— No. 1, as soon as he has laid the gun, puts down his tangent scale, gives the word "ready," and steps clear of the wheels, to a position where he can best see the target. No. 2, at the word, presses a tube into the vent, steps back clear of the wheels, and holds the lanyard in his right hand. No. 3 steps back clear of the wheels, but still facing the trail.

At "Fire," No. 2 pulls the lanyard.—At "fire," No. 2 pulls the lanyard towards him, and replaces it in his belt.

At "Run up," Nos. 1, 2, 3, 4 *and* 5, *run the Gun up.*—At "run up," Nos. 1 and 2 place themselves between the breech and the wheels; 4 and 5 man the wheels with their inner hands, 3 places himself at the point of the handspike. They run the gun up into its former place, and No. 1 gives "halt." All then resume their places.

At "Cease Firing," the stores are replaced, and the detachment turn to the front.—At "cease firing," No. 1 places the traversing bar in the centre of the carriage, and the scales at zero. No. 2 replaces, if necessary, the plug in the spunge bucket, and puts the lanyard in his tube pocket; 3 unships the handspike and replaces it; No. 4 buckles the spunge on to the trail, 5 and 7 return their ammunition; 6 replaces the ammunition in the limber-box, taking care, however, to remove the fuzes if the shell has been prepared. All the numbers turn to the front.

Telling off Posts and Duties.—Each man in succession may now be called upon to tell off his post and duties as follows: No. 1 stands on the right side of the gun, between the breech and the wheel, points and commands. No. 2 stands on the left side of the gun, between the breech and the wheel, takes out and puts in the plug of the spunge-bucket, screws up and unscrews the breech, puts in and takes out the vent-piece, makes ready and fires. No. 3 stands one yard in rear of and covering the right wheel, ships and unships the handspike, puts in the projectile and cartridge, and traverses with the handspike. No. 4 stands one yard in rear of and covering the left wheel, spunges and rams home. No. 5 stands five yards in rear of the right wheel, and supplies No. 3 with ammunition from No. 7. No. 6 stands in rear of the off limber-box, prepares and serves out ammunition to No. 7. No. 7 stands ten yards in rear of No. 5, and supplies him with ammunition from No. 6. No. 8 stands in rear of the near limber-box, and assists No. 6. No. 9 attends the ammunition waggon.

Changing Rounds.—At "change rounds," when the detachment is in action, No. 1 becomes 3; 3, 5; 5, 7; 7, 9; 9, 8; 8, 6; 6, 4; 4, 2; 2, 1.

NOTE.—When 5 or 7 have sent forward their ammunition, they invariably supply themselves with another round. When case shot is used No. 3 supplies himself from the axletree box.

SERVICE OF THE 40-PR. B.L. GUN.

The method of loading the 40-pounder breech-screw gun is nearly the same as that of the 12-pr. field gun. The only alterations are such as are obviously called for by the heavier nature of the gun and projectile.

At the command "load," Nos. 2 and 3 open the breech for the reception of the charge, by unscrewing the breech-screw and taking out the vent-piece. No. 5, as soon as the gun is ready for loading, puts in the projectile, which 4 and 5 ram home. No. 5 then puts in the cartridge, which 4 and 5 also ram home. No. 6 has to assist 4 and 5 in this part of their duty by handing them sidearms, and taking them back when no longer required; 2 and 3 then close up the breech again by replacing the vent-piece and screwing up the breech-screw. This completes the loading. No. 1, as at the 12-pr., steps in and lays the gun; No. 7 fires. The remaining numbers of the detachment, viz., 8, 9 and 10, supply ammunition.

The following is the detailed explanation of the drill.

Strength of the Detachment.—A detachment for the service of the 40-pr. B.L. gun, consists of 1 N.C. officer and 9 gunners.

Formation of the Detachment.—The detachment is formed up two deep, on the left rear of the gun to be served, the non-commissioned officer, who is called No. 1, on the left of the front rank, and uncovered.

Telling Off.—The detachment is told off for drill as with field guns.

Taking Post.—At "take post under cover," from the commander, No. 1 gives the word "right turn," turns with his detachment, and gives "double march." The detachment wheel to their left, open out, and file along the opposite sides of the gun to their places under cover; 2 and 3 halt at the parapet, near the mouth of the embrazure; 4 and 5 come up on the outer flanks of 2 and 3; 6 and 7 come up on the outer flanks of 4 and 5; the whole turn to the right about together; 8, 9 and 10, fall to the rear. No. 1 remains on the left rear of the platform, but has no fixed place, as he is responsible that all the numbers perform their duties correctly.

At "Prepare for Action," all the numbers get out their stores, and place them at the Gun.—At "prepare for action," No. 1 brings his sights and a common handspike; No. 2 a priming pocket, with primers, oil and tow for cleaning the vent, a bit for the vent, and a common handspike. No. 3 a common handspike, and removes the muzzle fid. No. 4 a spunge and a common handspike. No. 5 a rammer and a common handspike. No. 6 a water bucket, containing water, and a support for head of side-arms. No. 7 a tube pocket, tubes and lanyard. No. 8 a cartridge, in a cylinder, places it on No. 7's left, close under the parapet, and then assists 9 to prepare a shell. No. 9 sees that the shell and implements for preparing shell at the limber are ready for use. No. 10 goes to the magazine to serve out ammunition.

At "Examine Gun," the gun and sights are inspected, and No. 7 fires a tube through the vent.—At "examine gun," No. 1 examines his sights and traversing bar, and looks through the bore to see that it is clear. Nos. 2 and 3 unscrews the breech-screw and lift out the vent-piece, 2 cleans it, and 2 and 3 then replace it, and screw up the breech-screw. No. 6 examines the elevating screw and slightly depresses the gun. No. 7 fires a tube through the vent to clear it, when the vent-piece has been replaced.

At "Load" from the commander, No. 1 *gives the word, "run up."*—The commander names the object to be fired at and range, and gives the word, "with—load." No. 1 immediately gives the word "run up," when the gun is run up as with smooth-bored guns. No. 1 then repeats the command, "with—load" and sends to 9 by 7 the nature and length of fuze required.

Nos. 2 *and* 3 *unscrew the breech-screw and lift out the vent-piece.*—Nos. 2 and 3, at the word "load," unscrew the breech-screw, lift out the vent-piece, and place it on the flat surface in rear of the slot. No. 2 cleans the vent-piece with his oil and tow, and inserts a priming tube, head downwards, in the priming chamber.

Nos. 4 *and* 5 *spunge out the gun, if necessary;* 6 *hands them sidearms.*—Nos. 4 and 5, at the word "load," place themselves at the centre of the trail in a position for spunging. No. 6 takes up the spunge as at smooth-bored gun drill, and passes it horizontally between 4 and 5. He then takes up the rammer with his right hand at the centre, meets it with his left hand at the rammer-head, and lays it on the trail with the head towards the breech, and stands behind 4 to receive the spunge. Nos. 4 and 5 spunge out the gun, withdraw the spunge and hand it back to 6, No. 4 canting it over his head to him. No. 6 receives the spunge and lays it down. No. 4 then picks up the rammer and stands ready to ram home. If spunging is not required the rammer is handed at once to 4 horizontally.

No. 9 *brings up a shell,* 5 *puts it in the bore,* 4 *and* 5 *ram it home.*—No. 9, at "load" (if time-fuzes are used) bores the fuze to the required length, and fixes it in the shell by screwing it in firmly with his hand. He then brings up the shell, and hands it to No. 5. No. 5 places it in the bore, and 4 and 5 ram it home with their utmost force.

No. 7 *brings up a cartridge,* 5 *puts it in the bore,* 4 *and* 5 *press it home.*—No. 7, at "load," brings up the cartridge in its cylinder and places himself near 3's left, ready to hand it to him. As soon as the projectile is rammed home, 5 puts the cartridge in the bore, and 4 and 5 press it home; 4 then hands the rammer vertically to 6 who turns right-about and lays it down. 4 and 5 then pick up their hand-spikes, turn to the rear, and stand ready to traverse. 8 keeps 7 supplied with cartridges, and takes away the cylinders as they become empty.

Nos. 2 *and* 3 *replace the vent-piece, and screw up the breech-screw.*—Nos. 2 and 3, as soon as the cartridge is home, replace the vent-piece in the slot, screw up the breech-screw as rapidly as possible, and give two taps to ensure the screw being home. They then double under cover, as all elevating of the 40-pr. is done with the elevating screw.

No. 1 *lays the gun.*—No. 1, as soon as the breech is screwed up, steps in and lays the gun. No. 6 elevates and

4 and 5 traverse for him as may be required. The final adjustment is given with the traversing screw. Nos. 4 and 5, when No. 1 begins to work the traversing screw, step off the platform so as to be under cover.

No. 7 makes ready and fires.—As at smooth-bored guns.

Telling off the duties.—Each man in succession, as he is proved, may be called upon to tell off his duties as follows. No. 1 points and commands, and guides the gun into the line of fire when running up. No. 2 attends to the vent-piece and breech-screw, primes and runs up. No. 3 assists 2 and runs up. No. 4 spunges, if necessary, rams home, runs up, and traverses. No. 5 spunges if necessary, loads, rams home, runs up and traverses. No. 6 hands spunge and rammer to 4, runs up and elevates. No. 7 supplies 5 with cartridges, runs up and fires. No. 8 supplies cartridges from magazine, and assists 9 to prepare shell. No. 9 bores and fixes fuzes, prepares and brings up shell, and gives them to No. 5. No. 10 serves out ammunition from the magazine.

Replacing stores.—At "cease firing, replace stores," No. 1 gives the command, "examine gun," and if the gun is not clear the numbers spunge out as before. The stores are then replaced by the numbers who brought them up.

Changing rounds.—At "change rounds" 3 becomes 5; 5, 7; 7, 1; 1, 10; 10, 9; 9, 8; 8, 6; 6, 4; 4, 2; 2, 3.

NOTE.—Before the gun is examined the elevating screw should be put in by 7, No. 1 giving the word, "bear down;" 2 places a handspike in the bore, 4 one over it; then 2, 3, 4 and 5 bear down.

LIMBERING UP AND UNLIMBERING THE 40-PR.

The 40-pr. breech-loading gun, when mounted on a travelling carriage, is limbered up and unlimbered in nearly the same manner as the field gun. Seven men instead of three, however, are required to raise and lower the trail, and three men instead of two are required to bring up and withdraw the limber. The first seven numbers, viz., 1 to 7, are the numbers who raise and lower the trail, and the last three numbers, viz., 8, 9 and 10 bring up and withdraw the limber. The limber when withdrawn is not reversed but only halted at a convenient distance from the gun. The following is the detailed explanation.

Limbering up.—At "limber up" from the commander, No. 1 gives, "prepare to limber up," 10 goes to the limber and places himself between the shafts; 8 and 9 go to the splinter-bar; they back the limber to within three feet of the trail-eye. No. 1 goes to the extreme end of the trail-eye; 6 and 7 place themselves next him, then 4 and 5, and then 2 and 3; all as far from the gun as possible, and grasping the trail handles ready to lift. No. 1, as soon as the trail is brought up gives "limber up;" the men at the trail then throw the trail up till the muzzle strikes the ground; they all move forward towards the gun and the limber is backed. At "lower" from No. 1, the eye is placed on the pintail and No. 1 keys up. If the carriage

SERVICE OF THE 7-INCH B.L. GUN.

The 7-inch B.L. gun is served in almost exactly the same manner as the 40-pr. At the command "load," 2 and 3 open the breech for the reception of the charge by unscrewing the breech-screw and taking out the vent-piece. No. 3, in performing his part of this duty has to use an iron lever to loosen the vent-piece in the slot.

As soon as the vent-piece is taken out, No. 5, assisted by 4 and 6, puts in the projectile, which 4 and 5 ram home; 5 then puts in the cartridge, which 4 and 5 ram home. No. 6 has to assist 4 in performing his part of this duty by handing him the rammer, and taking it from him again when he is done. No. 3, as soon as the cartridge is home, places a tin cup in the bottom of the bore, and 2 and 3 then close up the breech again by replacing the vent-piece and screwing up the breech-screw. This completes the loading. No. 1, as soon as the gun is loaded, steps in and lays it. No. 7 fires. The remaining numbers, viz., 8, 9, and 10, supply ammunition in the same manner as with smooth-bore guns.

The following is the detailed explanation.

Strength of the Detachment.—The same as with the 40-pr.

Formation of the Detachment.—The same as with the 40-pr.

Telling off the Detachment.—The same as with the 40-pr.

Taking Post Under Cover.—The same as with the 40-pr.

Preparing for Action.—At "prepare for action," No. 1 brings sights, hammer, files, and preventer rope. No. 2 a priming pocket with primers, oil-can, vent-bit, a 7-feet handspike, and a truck lever. No. 3 a cup extractor and cups, an iron lever, a 7-feet handspike, and a truck lever. No. 4 a spunge, shod lever, and luff tackle. No. 5 a rammer, shod lever, and luff tackle. No. 6 a spunge, bucket filled with water, and support for head of side-arms. No. 7 a tube pocket, tubes, lanyard, and elevating screw. No. 8 two cartridge cases. No. 9 two shell bearers, and shell and fuze implements. No. 10 goes to the magazine.

Examine Gun.—The same as with 40-pr.

At "Load," No. 1 gives the word "Run up."—When the commander gives the word "with—load," No. 1 gives the word "run up," and the detachment run the gun up, as with smooth-bored guns. No. 1 then repeats the command "with—load."

No. 2 and 3 unscrew the breech-screw and lift out the vent-piece.—Nos. 2 and 3 at the word "load," unscrew the breech-screw, lift out the vent-piece and place it on the saddle; 2 cleans the vent-piece, and inserts a priming tube head downwards in the priming chamber; No. 3, if there is a tin cup in the slot, removes it.

Should the vent-piece jam, No. 7 hand the iron lever to

No. 3, who will prize it out. No. 1 will then make a careful examination, to discover, if possible, the cause of the jamming, and take immediate steps to have the defect removed.

Nos. 4 *and* 5 *place themselves in position for ramming home. No.* 6 *hands them side-arms.*—Nos. 4 and 5 at the word "load," mount up on the side pieces, and place themselves in position for ramming home; No. 6 hands the spunge to No. 4, and places the rammer on the platform.

Nos. 9 *and* 8 *bring up the shell,* 5 *and* 6 *raise it,* 4 *pushes it into the bore, and* 4 *and* 5 *ram it home.*—No. 9, at "load," bores the fuze to the required length, and fixes it by screwing it with the hand into the shell; 8 and 9 bring up the shell and place it on the platform on its base; 5 and 6 raise the shell in its bearer to the breech, and 4 pushes it into the bore with the reverse end of the rammer; 4 and 5 then run the shell home with their utmost force.

No 7 *brings up a cartridge;* 5 *puts it in the bore;* 4 *and* 5 *press it home.*—No 7 at "load," brings up the cartridge on its cylinder, and places himself near the left of 5, ready to hand it to him. As soon as the shell is rammed home, 5 puts the cartridge in the bore, and 4 and 5 press it home; the rammer is then returned to 6, and 4 and 5 jump down, take up their shod levers, and stand ready to traverse.

Nos. 2 *and* 3 *replace the vent-piece, and screw up the breech-screw.*—Nos. 2 and 3, as soon as the cartridge is home, mount up on the steps of the carriage, 3 puts a tin cup in the bore, edges to the front; 2 and 3 then replace the vent-piece and screw up the breech-screw. They then step down and pick up their handspikes ready to elevate.

No. 1 *lays the gun.*—No. 1, as soon as the gun is loaded, mounts up and lays it; 2 and 3 elevate for him, 4 and 5 traverse, and 6 works the elevating screw, as may be required.

Ready.—As at smooth-bored guns.

Fire.—As at smooth-bored guns. The gun is run back at drill in the usual manner, without any word of command.

Telling off the Duties.—The detachment may here be proved and called upon to tell off their duties as follows: No. 1 points and commands. No. 2 attends to the vent-piece and breech-screw, runs up, elevates with a handspike and primes. No. 3 asists 2 with vent-piece and breech-screw, runs up, elevates with a handspike, primes, and attends to tin cups. No. 4 spunges, rams home, runs up, and traverses. No. 5 spunges, loads, rams home, runs up, and traverses. No. 6 hands spunge and rammer to 4, attends to the elevating screw, and assists to load. No. 7 supplies 5 with cartridges and fires. No. 8 brings up carttidges (with lubricators attached) to No. 7, assists No. 9 in preparing and bringing up shells. No. 9 bores and fixes fuzes, assists to prepare and bring up shells. No. 10 fixes lubricators to cartridges and serves out ammunition from the magazine.

Changing Rounds.—At "change rounds," 3 becomes 5; 5—7; 7—1; 1—10; 10—9; 9—8; 8—6; 6—4; 4—2; 2—3.

Cease Firing; Replace Stores.—The gun is examined, as at the 40-pr., and the stores replaced by the numbers who brought them up.

Forming Detachment Rear.—Detachment rear is formed in exactly the same manner as at smooth-bored guns, except that No. 1, after he has given "halt, front, dress," changes his flank by the rear.

Note.—No. 7 is kept supplied with cartridges by No. 8, who brings up a cartridge in his right hand each time he comes up with a shell, and then takes away the cylinders and shell-bearers as they become empty.

SERVICE OF 7, 8, AND 9-INCH M.L. RIFLED GUNS.

The drill for the 7, 8, and 9-inch Muzzle-Loading Rifled Guns is almost exactly the same as that for the 68-pr. and other heavy smooth-bored guns. The only difference of any consequence is that the cartridge and projectile are rammed home separately instead of together, and that two additional numbers are required to bring up shells. The gun is supposed to be mounted in a specially constructed work, with the shell room underneath, and a "lift" provided for raising the shells from the shell-room, as soon as they have been prepared. The two additional numbers, viz., 10 and 11, stand at the mouth of the lift, to receive the shells as they are sent up by No. 9; and Nos. 5 and 6 then assist 10 and 11 (if necessary) to raise the shells and place them in the bore.

The following is the detailed explanation of the drill.

Strength of the Detachment.—One N.C. officer and 11 men.

Formation of the Detachment.—The detachment is formed up two deep on the left rear of the gun to be served, the same as with smooth-bored guns.

Telling off the Detachment.—As with smooth-bored guns.

Taking Post under Cover.—As with smooth-bored guns.

Preparing for Action.—No. 1 provides sights and preventer rope. No. 2 a spunge and an iron-pointed lever. No. 3 a shell extractor and an iron-pointed lever. No. 4 a rammer and priming irons. No. 5 two iron-shod levers and wads. No. 6 spunge bucket with water, support for heads of side-arms, and brush for cleaning spunge. No. 7 tube pocket, tubes, lanyard, and searcher. No. 8 two cartridge cases. No. 9 fuzes, and fuze and shell implements. No. 10 two shot bearers, and two shot brushes. Nos. 10 and 11 bring also a set of tackle each (double and triple blocks), for traversing and running back. No. 12 goes to the magazine.

The stores are arranged as for smooth-bored guns.

Elevate, clear the vent, search the gun.—At the command, Nos. 4 and 5 elevate; No. 1 drifts the vent;

2 and 3 search the gun; 6 hands the wadhook to 2 and takes it from him again when he is done. As soon as the gun is sufficiently elevated No. 1 gives the word "clamp,"

Load.—The gun is loaded as at smooth-board guns except that the cartridge is rammed home first, and then the projectile No. 10 and 11 bring up the shell in its bearer and place it in the bore, 5 and 6 assisting them with 8 and 9 inch guns.

Run up,—Nos. 2 and 3 put their levers in the sockets and bear down; 1 and 7 hold on the preventer rope, 4 stands to the compressor. When the gun is sufficiently run up No. 4 hauls back the lever and stops the gun.

Laying the Gun.—No. 1 lays the gun, and 2 and 3 work the elevating gear. When the traversing is with shod levers it is done by 4 and 5, when with tackle all the numbers except 9 and 12 man the tackle.

Ready.—As at smooth-bored guns.

Fire.—As at smooth-bored guns.

Cease Firing, Replace Stores.—As at smooth-bored guns.

Changing Rounds.—2 becomes 4; 4—6; 6—1; 1—12; 12—11; 11—10; 10—9; 9—8; 8—7; 7—5; 5—3; 3—2.

General Duties.—No. 1 points, commands, adjusts the compressor and holds on to the preventer rope. No. 2 searches, spunges, rams home, runs up, and elevates. No. 3 puts in cartridge and wads, assists to spunge and ram home, runs up, elevates, and uncaps the fuze when in the bore. No. 4 serves the vent, drifts it, pricks the cartridge, attends to the compressor, and traverses with lever or winch. No. 5 supplies wads, assists to ram home, and to raise the 9 and 8-inch projectiles at the muzzle, traverses with lever or winch. No. 6 supplies side arms, assists to ram home, and to raise the 9 and 8-inch projectile, at the muzzle, cleans and damps the spunge when necessary, using the brush. No. 7 supplies 3 with cartridges, makes ready, fires, and holds on preventer rope. No. 8 supplies 7 with cartridges. No. 9 prepares shells and fuzes in the shell room. No. 10 and 11 bring up projectiles and assist to put them in the bore. No. 12 issues cartridges from the magazine.

ADDENDA.

The following are the details about the New 16-pr. Muzzle-Loading Rifled Gun, referred to at p. 37, and now about to be issued to the Field Batteries :—Matériel, wrought iron jacket, with steel barrel. ; length of gun, 6 ft. ; weight, 12½ cwt. ; calibre, 3·6 inches ; system of rifling, modified French ; No. of grooves, 3 ; twist of rifling, uniform, 1 turn in 30 calibres ; sights adjusted at angle of 1° 30′ to left, to allow for deflection of shot to the right. The gun is sighted on both sides in almost exactly the same manner as the breech-loading field guns. The service charge is 3 lbs, and the saluting or exercising charge is 1½ lbs. The projectiles are not yet decided on, but will probably consist of common shell, shrapnel shell, and case shot. The gun-carriage is made of wrought iron, and is of similar construction to that of the new 9-pr. carriage.

To complete the account given at p. 35 of the penetrating powers of our large muzzle-loading rifled guns, it is now necessary to add that an experimental 11-inch gun of 25 tons has lately been tried at Shoeburyness, and has given results exceeding that of any gun at present in the service. The target against which it was tried, consisted of 13 inches of iron, 12 inches of wood-backing, and 1½-inch iron skin. Assuming the 12 inches of wood to equal 2 inches of iron, the entire thickness would represent about 16½ inches of iron. This structure was completely pierced, a large day-light hole being left after each round. The penetration obtained with this gun was consequently equal to about 1⅔ times its own calibre, while the penetrating power of our service guns is at most only about 1¼ times their own calibre. It is probable, moreover, that even this penetration will soon be exceeded.

The 35-ton gun referred to at p. 31, has been re-bored up to a calibre of 12 inches, and when tested, will probably give a penetration exceeding that of any gun yet in existence.

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