



The Field Gun for India

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Evening Meeting.

Monday, March 14th, 1870.

REAR-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., in
the Chair.

NAMES of MEMBERS who joined the Institution between the 7th and 14th
March, 1870.

ANNUAL.

King-Harman, M. J., Lieut., R.A.	17.	Hart, John, Lieut. 100th Regt.	17.
Baker, James, Lieut.-Col., late Cam- bridge University Volrs.	17.	Martin, G. W. T., Lieut. 46th Regt.	17.
		Maxwell, H. H., Colonel R.A.	17.

THE FIELD GUN FOR INDIA.

By Colonel H. H. MAXWELL, R.A.

1. UP to the year 1862, the armament of the Indian Field Artillery consisted of 9- and 6-pounder guns, and 24- and 12-pounder howitzers. The field-battery pieces were lighter than those in use in England, weighing only 10 cwt. The horse artillery pieces were identical with those of the home Service.

About that date the first breech-loading Armstrong battery reached India. I can tell you little from my own personal knowledge of the efficiency of the guns in that country, as the superintendence of the Indian Gun Foundry fell to my charge at the same period. Gradually I came in contact with them in another way. All sorts of strange things came into my hands, sent to me as patterns for manufacture, of whose use I had only read. But at last, a 6-pounder breech-loader Armstrong gun, split in the powder-chamber, came to me for repair, if possible. With a feeling of despair I was compelled to return it, with an intimation that its repair was beyond my power.

Chance threw in my way, in 1865, a description of the French field gun, and at the same time I learnt that it had been tried at Shoebury-ness, and that its practice was found equal to that of the 9-pounder breech-loader of the Service.

I heard, too, that the Dutch in Java had adopted the French system, and manufactured the guns and their equipments on the spot.

I came to the conclusion that a gun of this description was precisely what we wanted in India, as we had an ample stock of bronze in the country. I appealed to the powers that be; my proposals were favourably received, and were sent to England for submission to the Ordnance Select Committee, who reported not unfavourably of them.

Just at this time the Armstrong and Whitworth controversy had been fought out on the sands of Shoeburyness. Muzzle-loaders began to hold up their heads, the Navy especially objecting to breech-loaders. The next step in the history was the assembly of a Committee of superior Officers of Artillery; they reported unanimously in favour of muzzle-loading field guns.

Then followed experiments with steel-barrelled iron-coiled guns and a bronze gun of the same size and shape. The experiments were so far unsuccessful that these guns were beaten by the Service breech-loaders in accuracy. The poor bronze gun soon gave in, after having been treated to a few shells with cast-iron ribs, which struck out a line of rifling for themselves.

Finally, in December, 1868, a Special Committee was appointed under the presidency of General Eardley-Wilmot, on the Equipment of Field Artillery for India.

I feel sure, in mentioning General Wilmot's name as President, that the recommendations of the Committee will derive additional weight in the minds of those now present. After a long series of experiments, that Committee proposed the adoption of a muzzle-loading 9-pounder bronze gun of 8 cwt. as the sole gun for the Horse Artillery and ordinary field batteries in India. The gun has been so far adopted into the service, that the 9th Brigade of Field Artillery is about to be armed with it. To give you some idea of the piece and of its powers, is my object in addressing you this evening.

2. Until within the past year there existed, and perhaps exists still in the minds of many artillerymen, a somewhat ill-defined impression that a breech-loader *must* shoot better than a muzzle-loader. I, for one, hold that this is by no means the case. The muzzle-loading small-arm rifle is in nowise inferior to the breech-loader in accuracy. Why should the reverse be the case with guns?

I may be told that in the breech-loader the non-existence of windage is sufficient to demonstrate that it must shoot better than a gun with windage. I demur. I say, if I can centre a muzzle-loading projectile and keep it centred as it passes along the bore, I shall have at least as fair a chance of making a good shot as the breech-loader, which at best can only do the same.

But to quit theory and to come to facts. What is the result of actual practice? Why, simply that as regards accuracy and uniformity of range, there is little difference between the two systems.

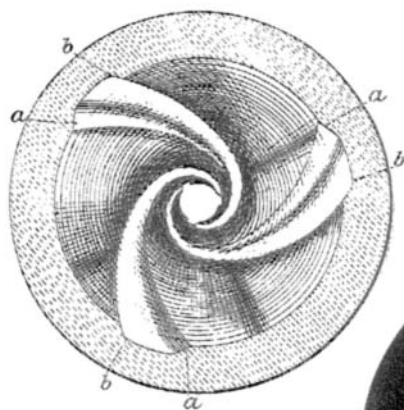
If *greater* accuracy, then, is no longer allowed to be the peculiarity of breech-loaders for field guns, that system, according to my lights, has not a leg to stand on. For we know, as regards rapidity of firing, that there is no advantage one way or the other.

I do not think I have ever seen the matter better put than in the Professional Tour Report of the Royal Artillery Officers who visited Russia in 1862; it was in these words:—

“The Russians are generally opposed to breech-loading for all services, as being unnecessary in the field, and impossible for large charges and heavy guns.”

That is, just where they would be useful they fail; and where they

Fig. 3



a . Driving side
b . Loading side

Fig. 2.

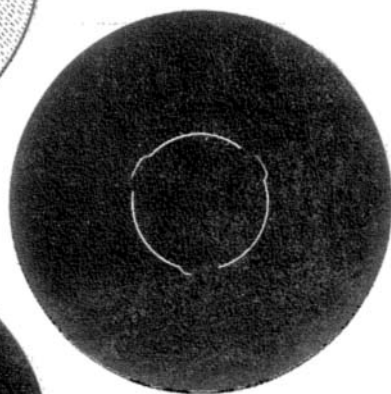


Fig. 1

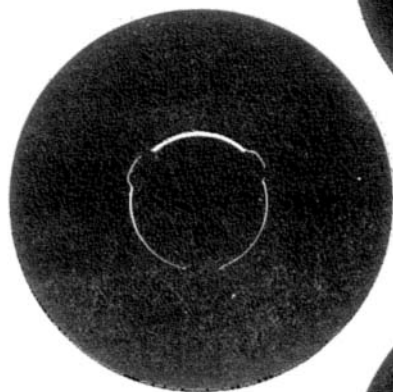
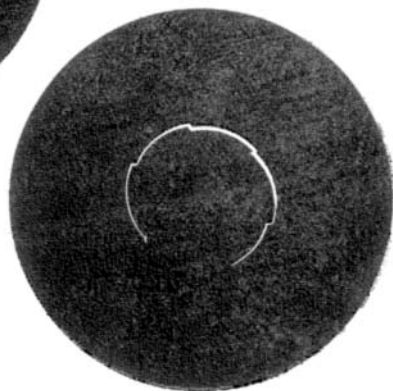


Fig. 4.



would be of no especial service, they may be used by those who like complication.

I have been told that the Russians have gone back from this wholesome doctrine, and have taken to the complications they formerly believed to be unnecessary. I confess, in one sense, I am sorry for the Russians, as I firmly believe they have some bitter experience to buy in the matter. They have been frightened by a bugbear. They held that bronze was too soft to stand the wear of rifled projectiles, and that if the metal of the studs were softer than that of the gun—perhaps the only condition upon which the guns could stand the wear—the studs would be knocked to pieces in travelling.

3. The French at the outset of their experiments got deplorable results from their bronze muzzle-loading guns. As the shell lay at the lower surface of the bottom of the bore, the cast-iron was in contact with the gun-metal; the stud was used merely to compel the shell to follow the twist of the groove, and not to protect the bronze of the bore from the cast-iron. What was the consequence? The windage or space between shell and gun being at the upper surface of the shell, on the explosion of the charge the upper edge of the base of the shell struck the top of the bore, while the shoulder of the shell was hammered down on to the lower surface. This sectional diagram will perhaps illustrate the effect. You see that the shell did its best to revolve round its shortest axis, and you may imagine how a shell thus started, behaved itself as it passed along the bore. It was about on a par with the old round shot, and some fifty rounds rendered the gun unserviceable.

Enlightened by this misconduct, they made the studs project farther beyond the surface of the shell, so that when it lay as before, at the lower surface of the bottom of the bore, there was a clearance between cast-iron and bronze.* The gun was thus subject to the friction between the zinc of the stud and the bronze of the driving sides of the grooves. Under these conditions the guns shot well and endured long.

The Austrians having suffered under these guns in 1859 in Italy, studied the matter, and in 1863 introduced a centring system applied to muzzle-loading guns. The diagram† will give you an idea of that system. The projectiles are formed of a similar figure to, but of a slightly smaller diameter than the bore of the gun, and are covered with a coating of an alloy of tin and zinc. This alloy being softer than bronze, the friction between the two metals is favourable to the latter in point of wear; but owing I suppose to the sharp angles of the surface of the alloy, each projectile has to be carried well greased in a canvas bag in the ammunition boxes. This appears to me to be the defect of the arrangement.

The French guns fire between two and three thousand rounds with satisfactory practice to the last. The Austrian guns fire some 1,500 rounds, after which service they are recast.

* Vide Fig. 1.

† Vide Fig. 4, representing a vertical cross section through the gun and shell, the latter lying at the lower surface of the bore. When centred, the windage forms six lozenge-shaped figures when seen in section.

I have thus shown you, I hope, how a projectile, composed of the hard metal, cast-iron, can by a little artifice, be fired from a gun made of a comparatively soft metal like bronze. It is, in short, by isolating the cast-iron from the bronze.

4. But the metal of the gun has more to stand than the mere friction of the studs of the projectile : it has *first* to sustain the expansive force, and *second*, the great heat of the powder gas.

Now as to the first point—the expansive force—I believe there is no known metal or combination of metals which gives such absolute security from bursting as bronze. It is, not that an individual steel gun with or without wrought-iron coils, may not be stronger perhaps than an individual bronze gun of the same size; but take 1,000 bronze guns, and you may be perfectly certain that not one will burst. It remains to be seen if the same is the case with steel guns, with or without wrought-iron coils.

The Prussian Ordnance Committee made some interesting experiments on the resistance of bronze. The guns used were the 4-pounder and 6-pounder. The former fires a shell of about 9 lbs. weight, while the gun weighs about 6 cwt., and the latter a shell of about 15 lbs., with a weight of gun of 9 cwt.

I will confine myself to the former. They turned down the gun of 6 cwt., a small quantity at a time, until it weighed only 2 cwt., the thickness at the breech being reduced from 2·4" to 0·8", and at the muzzle from 1" to $\frac{1}{4}$ ". With this gun they made a series of experiments, firing a 9 lb. shell with a charge a little over 1 lb. After each series, the bore was examined to find out where expansion first took place. It was only after the thickness at the seat of the charge had been reduced below $1\frac{1}{2}$ inches, that expansion took place. Further, with this thickness, expansion took place after a few rounds and then ceased. When the gun was reduced to a thickness of under a $\frac{1}{2}$ of an inch, small cracks were observed through which the powder gas escaped; the gun was, however, fired with safety.

The heavier gun of 9 cwt. with a shell of 15 lbs. and a charge of $2\frac{1}{2}$ lbs. when reduced to $\frac{2}{16}$ ths inch thickness at the muzzle, burst, throwing a good large piece out of the chase with violence. Thus there was ample indication of approaching rupture.

Incidentally I may mention that as the guns were reduced in weight, the charge of powder and weight of shell remaining the same, the guns were most destructive to their carriages; a circumstance which we all could have anticipated, but one involving a true principle of construction not sufficiently borne in mind, viz., heavy gun and light carriage. I shall have occasion to allude to this further by and by.

The resistance then of pure bronze guns, much below the ordinary thickness, gives ample safety from bursting; while that of guns of the ordinary dimensions is so great, that it is almost if not quite impossible to burst them. To destroy them, the shortest plan is to heat them to redness, and then attack them with a sledge hammer. Under this treatment they tumble to pieces in a surprising manner.

This statement naturally leads us to the second point, how do bronze guns resist the great heat developed by the combustion of the powder?

On this point bronze is decidedly deficient; but fortunately in field guns the amount of powder burnt in each charge is small, and the scoring or erosion consequently of little importance. This scoring, moreover, is in no wise detrimental to the accuracy of the shooting, because the studs of the shell being locked hard against the driving sides of the grooves, there is an air-tight joint between them; hence no gas can pass. Thus, on examining the grooves of a bronze gun which has fired a large number of rounds you find the lands, loading side and bottom of the grooves, pitted by the heat burning the tin out of the alloy, and eroding the metal; the driving sides on the other hand are perfectly free from such pitting.

One more source of injury to a bronze gun consists in the effect of the accidental and premature explosion of a shell in the bore. Experiments at Shoeburyness with live common shells, having a small hole bored through the base so as to form a direct communication between the charge in the gun and that in the shell, prove that no material injury is done to the gun beyond a few unimportant scratches.

5. In the present state of our knowledge, the choice of a metal or combination of metals for a field gun, appears to lie between steel or steel protected by a wrought-iron coil and bronze. Circumstances may have unduly prejudiced me, but I confess I think there is nothing like bronze for the roughing of a long campaign, nothing like it for simplicity of manufacture nor for safety from bursting, nor, finally, for economy. It is curious to look back and to find that I am expressing an opinion held as far back as four and a-half centuries. One Capo Bianco, publishing in 1598, states that there were bronze guns in existence in 1418.

Bronze if bright from the turning-lathe, when exposed to damp air, soon oxidizes and gradually attains the green brown tint so much admired in antique statues. After the film of oxide has penetrated to a certain depth, practically the action on the metal ceases; though the oxide itself gets a deeper tint by time. This is the explanation of the perfect condition of antique bronze statues and other objects which have been found in certain soils after having been buried for centuries.

With iron or steel, on the contrary, once oxidation has set in, it goes on with increased vigour, and eats away until the whole mass is finally oxidized.

This is why I say bronze is better suited for the roughing of a campaign than steel.

As to simplicity of manufacture, nothing can be simpler than the casting of the block, once you have got apparatus suited to the size of your gun.

Recollect in making a comparison as regards manufacture between bronze and steel guns, you must not confine yourselves to what you have seen done in the Royal Gun Factories, you must go to Mr. Firth's or to Sir Joseph Whitworth's factories, and watch the processes there. I will not detain you with an attempt to describe these processes. I will confine myself to the statement that the art of casting steel in large masses is in its infancy, that it is necessarily expensive from the high melting point of the metal; and that in the present state of our

knowledge on the subject, it would not be advisable to attempt it in India.

As regards economy, the value of a new bronze gun of 6 or 8 cwt. is to the value of an old one in the ratio of 17 to 7. In other words, you recover £7 after using your bronze gun for a great number of years, out of every £17 you originally expended.

The value of a steel gun with wrought-iron coils of those weights when new is greater than that of the corresponding bronze gun; and when old, it is worthless, or the next thing to it.

6. So much for the metal; let me now turn to the nature and weight of the field gun for India, first confining ourselves to horse artillery.

The nature and weight of gun for employment in that or in any other country is best considered by first deciding on the following points:—

I. What weight can your teams draw at the pace you propose to go?

II. What is the least weight of projectile which will be efficient on explosion, and what is to be its velocity?

III. How many rounds do you want with the gun and limber?

On some, if not on all of these points, artillerymen will differ: hence the problem will have a variety of solutions. Permit me to give you my ideas on them.

In India we find that a team of six horses can draw from 30 to 32 cwt. at the pace required for horse artillery.

On the second point, I consider that an explosive projectile to be efficient, should not weigh under 9 lbs.

As to the quantity of ammunition with the gun and the limber, though opinions differ widely on the point, I think I shall not be far wrong in taking the same number of rounds as the 9-pounder breech-loading gun, viz. 34. At the same time, I should tell you that the French have lately increased the number of rounds with their gun and limber from 36 to 44, the alteration being due to the adoption of breech-loading fire-arms, by the infantry.

Then as to velocity: your 12 and 9-pounder breech-loading guns fired at Dartmoor with velocities of 1,121 and 1,058 feet per second. This pace is slow as compared with that of the round shot of the S.B. 9-pounder with its 1,614 f.s., or of the S.B. 6-pounder with its 1484 f.s.; the result is that up to 700 or 800 yards the S.B. guns have the flatter trajectory. It seems to me clear, then, that if we wish to improve on the present breech-loaders, we must increase the velocity. But as we cannot hope to fire a projectile of 9 lbs. with such a velocity as 1,600 feet from a horse artillery gun, let us see if we cannot manage to fire with 1,400 feet, a velocity rather less than that of the 6-pounder round shot of the horse artillery gun.

I have thus roughly given answers on the three points:—

I. 30 to 32 cwt. behind the gun team.

II. A 9 lb. projectile with a velocity of 1,400 feet per second.

III. 34 rounds with gun and limber.

Let us see what these answers will lead us to.

As at present constructed, the lightest limber, without load, weighs

10 cwt. We have further thirty times 9 lbs., and its charge of $1\frac{3}{4}$ lbs. for 1,400 feet velocity; this load, with fuzes, cartridge-bags, &c., will amount to 3 cwt.; the loaded limber, with its entrenching tools, and so forth, will thus weigh about 14 cwt.; deducting this weight from 30 cwt., the lowest limit of the total weight above laid down, will leave us only 16 cwt. for the gun and carriage.

Let us next compare the initial velocity of recoil of such a gun on its carriage firing a 9 lb. projectile at a rate of 1,400 feet per second with that of the 12-pounder breech-loading gun of the Service. An easy calculation gives the former as 7 feet per second, and the latter 6.2 feet per second.*

The recoil with the 12-pounder breech-loading gun at 6.2 feet per second is lively, and I think should not be much exceeded for both convenience in service and endurance of the carriage. 16 cwt. is then too light for a velocity of 1,400 feet with a 9 lb. projectile.

Taking, then, 6.2 feet per second as about the highest admissible limit, we can determine the weight of the gun and carriage which will project a 9lb. projectile with a velocity of 1,400 feet. Calculation gives us 18.0 cwt.†

This weight added to that of the loaded limber, 14 cwt., will give a total of 32 cwt.

If, then, you wish to have a gun with which errors in estimation of the distance are of less importance than with your present guns; if you want a gun which shall give you a more grazing fire than your present guns, approaching closely or being equal in this respect to the fire of the old smooth-bore guns up to 800 yards, and beyond that range much better; if, I say, you want these advantages, you must increase the velocity of your projectiles as much as possible; and this with a velocity of 1,400 feet involves a weight of gun and carriage of 18 cwt., and a total weight behind the gun-team of 32 cwt.

Cannot some of the weight of the *limber* be got rid of?

After a good deal of consideration and inquiry, I am reluctantly compelled to believe that no very great diminution is feasible without injury to the efficiency of the system.

7. We have, then, 18 cwt. for the weight of the gun and carriage. What is to be the weight of the gun itself? It must be mainly decided by the weight of the carriage. If the latter can be brought down to 10 cwt., and yet have adequate strength, the gun may be

* 9-pr. M. L. :—

$$\begin{array}{rcl} \text{f. s. cwt.} & & \text{f. s. lbs.} \\ x \times 16 \times 112 & = & 1400 \times 9 \\ & & x = 7 \text{ feet per second.} \end{array}$$

12-pr. B. L. :—

$$\begin{array}{rcl} x \times 20\frac{1}{4} \times 112 & = & 1239 \times 11.75 \\ & & x = 6.2 \text{ feet per second.} \end{array}$$

1239 f. s. was the velocity of the 12-pr. B. L. with the slack pressed powder. Vide Handbook for Field Service, 1867, page 322.

$$\begin{array}{rcl} \text{f. s. cwt.} & & \text{f. s. lbs.} & & \text{cwt.} \\ \dagger 6.2 \times x \times 112 & = & 1400 \times 9 & & x = 18.1 \end{array}$$

8 cwt. That carriage must be strong enough to withstand the furious jolts it is subject to behind a team rushing to the front at a gallop; at the same time it must be recollected, that the heavier the gun, the less the carriage will suffer in firing. The best possible ratio of weights of gun and carriage is a nice point, which only long experience can decide. I am well satisfied so far, that in the breech-loading guns of the service, the guns should be heavier and the carriages lighter, and that the ratio I have proposed is far preferable.

8. Finally as to calibre. It has been found that to get the best shooting, the shell should be between two and three calibres long; at the same time, to be efficient when burst, it should have adequate capacity for containing bullets, segments, and powder. If you take 3 inches as the calibre for a 9 lb. projectile, you get very formidable segment and shrapnel, with, I think, sufficiently powerful common shell and case-shot. If you take a larger calibre than 3 inches, the two latter projectiles would have a larger capacity, but the shooting of the explosive projectiles would be deteriorated. If you go below 3 inches, the capacity of the explosive projectiles would be lessened with perhaps a slight gain in shooting. Small variations above and below 3 inches would probably make little difference, but if you were to go to 3·5" or 2·5" for a 9 lb. projectile, I think you would be wrong.

As an instance in point, the French field gun has a calibre of 3·4 in., and weighs 6½ cwt.; it fires with a velocity of 1,066 feet per second, and complaints are very justly made of its high trajectory.

9. The gun that I think we should adopt for the Horse Artillery in India is a gun of about 8 cwt. of 3" calibre, with 34—9 lb. projectiles, with the gun and limber, and a total weight of 32 to 33 cwt. behind the team. This is the gun recommended by the Committee on Field Artillery Equipment for India.

The main points, it appears to me, on which this recommendation should meet with the approval of thoughtful artillerymen are:—That on this system you have a sufficient number of projectiles with a gun capable of projecting them with a very high velocity, involving a total weight behind the gun-team quite within the recognized limits for horse artillery.

10. I have prepared a table from various authorities, chiefly from Major Roerdanz's* pamphlet, giving the principal weights and dimensions of various horse-artillery guns and their equipment. It is instructive to examine how the artillery of the Powers of Europe differ as to the armament of that branch. The French and Austrians agree very closely; the gun of the latter being founded on the former. The English and the Prussians are in many respects alike, but the latter carry the largest number of rounds with the limber of all the artilleries of Europe, and are therefore more independent of their wagons. The Russian and the Indian gun systems are the absolute antithesis of each other.

The Russian gun fires with a high trajectory, the Indian with a low trajectory. It appears to me that we have the best of it, on the whole.

* Das gezogene vierpfündige Feldgeschütz v. R. Roerdanz, Berlin, 1865.

TABLE OF THE PRINCIPAL DIMENSIONS AND WEIGHTS OF VARIOUS HORSE-ARTILLERY GUNS AND THEIR EQUIPMENT.*

	Prussian.	English.	French.	Austrian.	Russian.	Indian.
Weight of gun cwt.	5.4	6.5	6.5	5.2	6.4	8.1
Calibre inches	3.1	3	3.4	3.17	3.4	3
Weight of common shell } (s) lbs. }	9	8.5	8.0	8	12.5	9
Weight of charge of } gun (p) lbs. }	1.1	1.125	1.21	1.1	1.35	1.75
Ratio $\frac{p}{s}$	$\frac{1}{8.1}$	$\frac{1}{8}$	$\frac{1}{7.4}$	$\frac{1}{7.3}$	$\frac{1}{9.3}$	$\frac{1}{5.1}$
Initial velocity, feet per } second }	1184	1058	1066	1093	?	1381
Weight behind gun } team cwt. }	30.5	32.0	25.8	23.6	24.4	{ 33.5 34.1
Weight per horse in gun } team cwt. }	5.1	5.2	6.4	5.9	6.1	5.7
No. of rounds in limber } and with gun }	40	34	44	39	18	{ 34 40
No. of rounds per gun } in limber and wagon }	157	124	156	156	130	{ 124 148
Diameter of wheels . . feet	{ $\frac{4}{5}$ }	5	4.7	{ 3.5 4.4 }	4	5

COMPARATIVE PRACTICE TABLE OF HORSE ARTILLERY FIELD GUNS:

	Yards Range.	Elevation.
4-pr. French	2000	6 47
" Austrian	"	6 47
" Prussian	"	6 24
9-pr. English breech-loader	"	6 1
12-pr. ditto	"	5 20
9-pr. Indian muzzle-loader	"	4 22

11. I am aware, however, that some Officers do not appreciate the value of a great velocity, and consequently of a flat trajectory, as highly as I do; indeed, I am told it has been seriously proposed to adopt a gun, ordinarily carried on a mule's back, the 7-pounder of 146 lbs., as the armament of the horse artillery in preference to this 9-pounder of 8 cwt. This proposition needs only to be stated to an artilleryman to carry its condemnation on the face of it.

But if my hearers of the Artillery will pardon my entering into a few elementary questions of their craft, I will endeavour to put this

* A more detailed table will be found as an Appendix.

matter as clearly as I can to those who have not turned their attention to the subject.

The horse artillery gun is chiefly intended for firing at troops with projectiles, containing either bullets or segments, which are released from their envelope by the bursting of the charge. This charge is just strong enough for that purpose, and yet not strong enough to give the contents of the projectile *much* lateral spread. Further, for these bullets or segments to fly any distance and to have sufficient force to kill a man, the projectile at the moment of bursting must have considerable velocity.

Again, if projectiles would only fly perfectly horizontally through the air, there would be no difficulty in hitting an object at every round; unfortunately, that pestilent gravity persists in acting on the projectile; thus the shorter time gravity can act on the shell while it is flying from the muzzle to the point hit—that is, the greater its velocity—the closer the path of the projectile approaches the straight line, and the easier it is to hit the object aimed at.

If, now, we compare the 7-pounder gun with the 9-pounder muzzle-loader, we find that the shell of the former leaves the piece with a velocity of 672 feet per second, while the initial velocity of the latter, with R. L. G. powder, is 1,381 feet per second. The 9-pounder shell, after flying 2,000 yards will be still going at a considerably higher rate than 672 feet, the initial velocity of the 7-pounder.

It will be seen that the 9-pounder shell starts with more than twice the velocity of the 7-pounder; the shell travels faster from the muzzle to the point hit; gravity having all the less time to act on it, the chances of hitting are increased *pro tanto*. While the bullets or segments of the 9-pounder shell, when released after a flight inside the shell of about 2,400 yards, travel at the same pace as those of the 7-pounder shell if burst at the muzzle.

I need hardly remind you that a range of 2,400 yards will cover the depth of any battle field.

I think I have shown that any comparison between these guns as to efficiency, is vastly in favour of the 9-pounder of 8 cwt.; and as I have shown, its weight is quite within the power of horse artillery teams.

12. As to the field batteries, what should be the nature of the gun?

I think it a good plan to see what others have done in this matter. The Prussians have two field guns termed the 4- and 6-pounder, which fire 9 lb. and 15 lb. projectiles—I will call them by their English denominations—with charges of $\frac{1}{3}$ th and $\frac{1}{4}$ th respectively, and consequently with high trajectories as compared with the Indian gun, which fires with a charge of $\frac{1}{2}$ th. With reference to these pieces, the Prussian "Officers' Hand-book" states that:—"The 9-pounder, as regards practice, is in no way inferior to the 15-pounder; but it is obvious that an individual 15-pounder projectile must do greater damage on any fixed object which it may strike, such as a house, a wall, &c., than the 9-pounder. For this reason, to cannonade such an object, the 15-pounder would be preferable; whilst against troops, generally speaking, the one calibre has no advantage over the other. The sole advantage of the 15-pounder is the greater moral effect it

“has under certain circumstances. The advantages the 9-pounder has over the 15-pounder consist chiefly in the larger supply of ammunition, whereby the former is more independent of its wagons. Another advantage lies in the fact that its pace is faster, and can be longer kept up.”

According to this view, the Indian 9-pounder will do all that is required of a field battery gun in the way of man-killing. I am satisfied that had the Prussians introduced their 9 pounder before the 15-pounder, instead of the reverse, the 15-pounder would never have existed.

For the horse artillery and ordinary field batteries then, the Indian Committee have recommended only one gun—the 9-pounder rifled bronze gun of 8 cwt. Permit me to draw your attention to a very important bearing of this recommendation. It is the unity and simplicity of armament inherent to such a system which will facilitate the supply of stores, and render that supply economical.

13. As to facility, take the battle-field. A battery of artillery obstinately engaged is running short of ammunition, or has a shaft or wheel broken. The first wagon met with, whether belonging to the horse or field artillery will furnish exactly what is wanted. Or, to take a time of peace; two batteries relieve each other, one of horse the other of field artillery: a subtraction of stores from the one or an addition to the other will complete the equipment. The neighbouring arsenal has only one species of stores for horse and field artillery: thus there can be no confusion, no mistake. I leave you to compare such a system with the S.B. field artillery with its four calibres!

Then think of the distances we have to deal with in India. As the crow flies it is about 1,800 miles from Peshawur to Cape Comorin, and about 1,300 to Calcutta; while from Cape Comorin to Kurachee is about 1,400 miles. Now if you will recollect that roads and rivers do not run as the crow flies, you may form some idea of the distances stores have to travel. I think then, that in India of all countries, unity and simplicity of armament are most desirable, and we have both, on the proposed system, developed in a very high degree.

Unfortunately, however, I am obliged to confine these advantages to the horse artillery and *ordinary* field batteries.

14. There remains the want of ordnance for the attack of fortified villages, entrenchments and the like. For this purpose I would have a 20-pounder howitzer and a 20-pounder mortar, both rifled. Neither of these pieces are yet in existence; but the S.B. 9-pounder can easily be converted for the one, and I see my way pretty clearly to the other with a weight of $2\frac{1}{2}$ cwt. The latter piece, if it can be got to shoot well—and I believe this to be quite feasible—would likewise be invaluable towards the end of a siege.

I would arm a few batteries with the howitzers. They *must* move slowly; owing to the weight of the equipment; but they would not be wanted until a fight was well developed, and they would rarely change position. I would further arm a few garrison batteries with rifled field mortars at the opening of a campaign.

The remainder of the field batteries I would arm with the 9-pounder M.L.R. gun.

15. To the advocates of a 12-pounder I would commend the words I have quoted from the Prussian Hand-book.

Perhaps some of my hearers who may have been in the Mutiny in India may object to me, that this 20-pounder howitzer will not replace the 8-inch mortar or howitzer of the Indian heavy field batteries. I do not pretend for one moment that it will; but it will handsomely replace the 24-pounder howitzers of the light field batteries: it will do more than this—I speak advisedly—it will be at least as efficient as the 18-pounder gun of the Indian heavy field batteries in opening a breach. It will thus compensate for the somewhat deficient common shell power of the 9-pounder M.L.R. batteries.

It will be recollected that no army goes a-field in India without a siege train of some sort. Let that siege train have the best and most powerful guns, howitzers, and mortars that you can give them, with a maximum weight in the largest gun of 50 cwt.—the weight of the 24-pounder siege gun. If you have a small fort to take, detach a portion of your siege train. But dragging about 18-pounder guns, 18-inch howitzers, and 8-inch mortars over a parade ground by elephants, drilling the battery as you would a field battery with all its minutiae, appears to me to be an exhibition calculated to raise a smile.

Again, many would have a couple of howitzers with each field battery, for they say that just when you want your howitzers, they would be miles away. You would be in the position I once had the misfortune to be in, when we unlimbered our 6-pounder horse artillery smooth bores against the stout stone-walled fort of Wudnee, at the opening of the Sutlej campaign. I am happy to be able to add that we judiciously refrained from firing, and that the fort was evacuated during the night when we were all in bed.

16. But to return to the howitzers: there are, I think, insuperable difficulties in the way of mixing up the howitzers with the 9-pounder rifled guns. We all agree, I think, that we cannot have a really efficient common shell for field purposes much smaller than a 20-pounder with a bursting charge of about $1\frac{1}{3}$ lbs. The piece must really be a howitzer, not a mortar on wheels, for it must do a little in the way of homicide as well as fire into or over parapets, at houses, &c. We must consequently have some segment and Shrapnel shells. For these to be efficient, we must fire with a charge of at least from $\frac{1}{3}$ to $\frac{1}{10}$ of the weight of the shell. Such a charge behind a 20-pounder shell involves considerable weight in the piece—I think not much under 10 cwt.—as it is to fire at high angles, lest we smash our carriages to pieces.

But this is not all. You must recollect that this 20-pounder shell weighs more than two of your 9-pounder shells; and thus, if we associate the 20-pounder howitzer with the 9-pounder, we can only carry with it less than half the number of rounds that we do with the latter. This would be a serious loss to suffer, and in a long campaign I think you would regret your reduced supply of ammunition. I think most of my hearers will allow that the association is unadvisable.

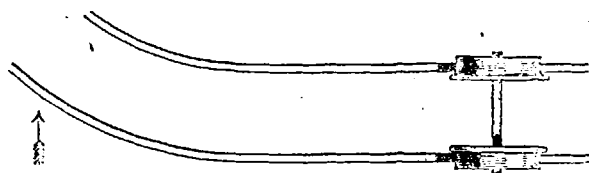
But has the reverse no advantages? Prussia, when armed with smooth-bores had distinct howitzer batteries, and within my own ser-

vice, I recollect all the 24-pounder howitzers in the Army of the Sutlej being collected into one battery at Sobraon in 1845. I merely throw out the thought for your consideration.

17. I must now return to the 9-pounder, and will say a few words about its rifling and the fit of the projectile. You will recollect that I mentioned that the cast-iron of the projectile should not come in contact with the gun-metal of the bore. The depth of the groove of the Indian gun is $\frac{1}{100}$ ths of an inch, and the projection of the stud is $\frac{1.3}{100}$ ths; deducting one from the other, we have a clearance of $\frac{2}{100}$ ths of an inch between cast-iron and bronze.* Up to about 2,500 rounds fired from one gun tried by the Indian Committee, the impressions show that there has never been any contact between the hard and the soft metal. When, however, the grooves at the seat of the shell have been burnt out by the powder to such a depth that the top of the stud can no longer touch the bottom of the groove before the projectile is centred, then, of course, contact takes place between cast-iron and bronze, and the gun soon becomes unserviceable.†

Before a single round was fired, I convinced myself that what was clear in the afore-mentioned figures as to the isolation of the cast-iron from the bronze, was carried out in fact. A lamp was put into the bore, and then a shell. On looking into the bore I saw a circle of light all round the shell, saving where it was interrupted by the studs. I know then that all was clear. The drawing will give you some idea of the appearance.‡

As to the centering. Supposing you are watching a railway train going away from you along a line of rails perfectly straight for a cer-



tain distance, and then curving away to the right. The most ordinary observation or thought would convince you that when the train comes to the curve, the flanges of the near or left wheels will rub against the inner edge of the rail they run on; thus the *near* rail will divert or drive the train to the *off* side.

Now, turning to guns, suppose you cut the breech off a rifled gun, so as to be able to look through the bore;‡ that the rifling has a right-handed twist, and that the lowest groove, as in the Indian gun, is immediately below the axis of the piece at the bottom of the bore; if you follow the course of this groove, you will see it ascend the left

* Vide Figs. 1 and 2 where the shell is shown in section in the gun, 'excentric after being rammed home, and centred as it passes along the bore on its exit, the gun metal of the bore being in neither case in contact with the gun-metal of the piece.

† Vide Fig. 2.

‡ Vide Fig. 3.

side of the bore, advance round over the top, and make its exit at the muzzle on the right side, after having made in the Indian gun, two-thirds of a revolution. The groove, you observe, has been constantly turning in the same direction as the hands of a clock. Now, if we put a studded shell into the bore, the grooves will of course force the shell to revolve in the same direction. But if you could watch more closely, you would see that it is the side of the groove which is opposite to the direction of revolution which drives the stud round, just as the *left* rail, in the illustration I have taken, drives the train to the *right*, where the line of rails curves in that direction. We see, then, that one side of the groove does all the work in driving the shell round. Now, if that side were perpendicular to the bottom of the groove, it is true it would drive the shell round; but as the studs to enter the grooves must have some play—that is, the diameter over the studs must be less than the diameter over the grooves—there is no reason whatever why the shell should not be hard jammed towards one stud, the whole of the play being over the others. Instead, however, of the driving side being perpendicular to the bottom of the groove, if we make it oblique to the radius, and if we make the driven edge of the stud to conform to it, the rotation of the shell, or rather the force which causes it to rotate, will compel the studs to ascend the inclined planes of the driving sides of the grooves until the shell is firmly centred. If we could only centre the shell after loading and before firing, that is to say, bring all the driven sides of the studs against the inclined driving planes of the grooves, there would be much less damage done to the first foot or so of the grooves than actually takes place. For observe, on this system when the shell is loaded, it is loose in the bore and grooves; but when the powder explodes behind it, the shell is sent forwards by a tremendous force impelling the studs against the driving sides of the grooves. This causes considerable wear for some short distance in front of the shell; but as there are some three or four feet of grooving uninjured in this way, the shooting is unimpaired for a great number of rounds.

In the Austrian system,* which is in principle precisely like that I have described, the whole of the groove is a curved inclined plane. And by way of locking them into a central position, the shells have warts or drifts at the nose which fit into a bayonet-joint on the sheet-iron flange of the rammer-head. As soon as the shell is set home on the powder, the loadsman turns the staff of the rammer to the right and thus centres the projectile.

I am by no means satisfied that this centering before firing could not be managed with our muzzle-loading shells. But the endurance of the guns is already so great, that it seems hardly necessary to complicate the loading with even this trifling addition. The truth is that, thanks to the admirable workmanship in the Royal Arsenal, the shells are now made with a clearance between the sides of the studs and the grooves of only $\frac{1}{100}$ th of an inch; thus the driven side of the stud must be brought in contact with the driving side of the groove almost instantaneously.

* Vide Fig. 4.

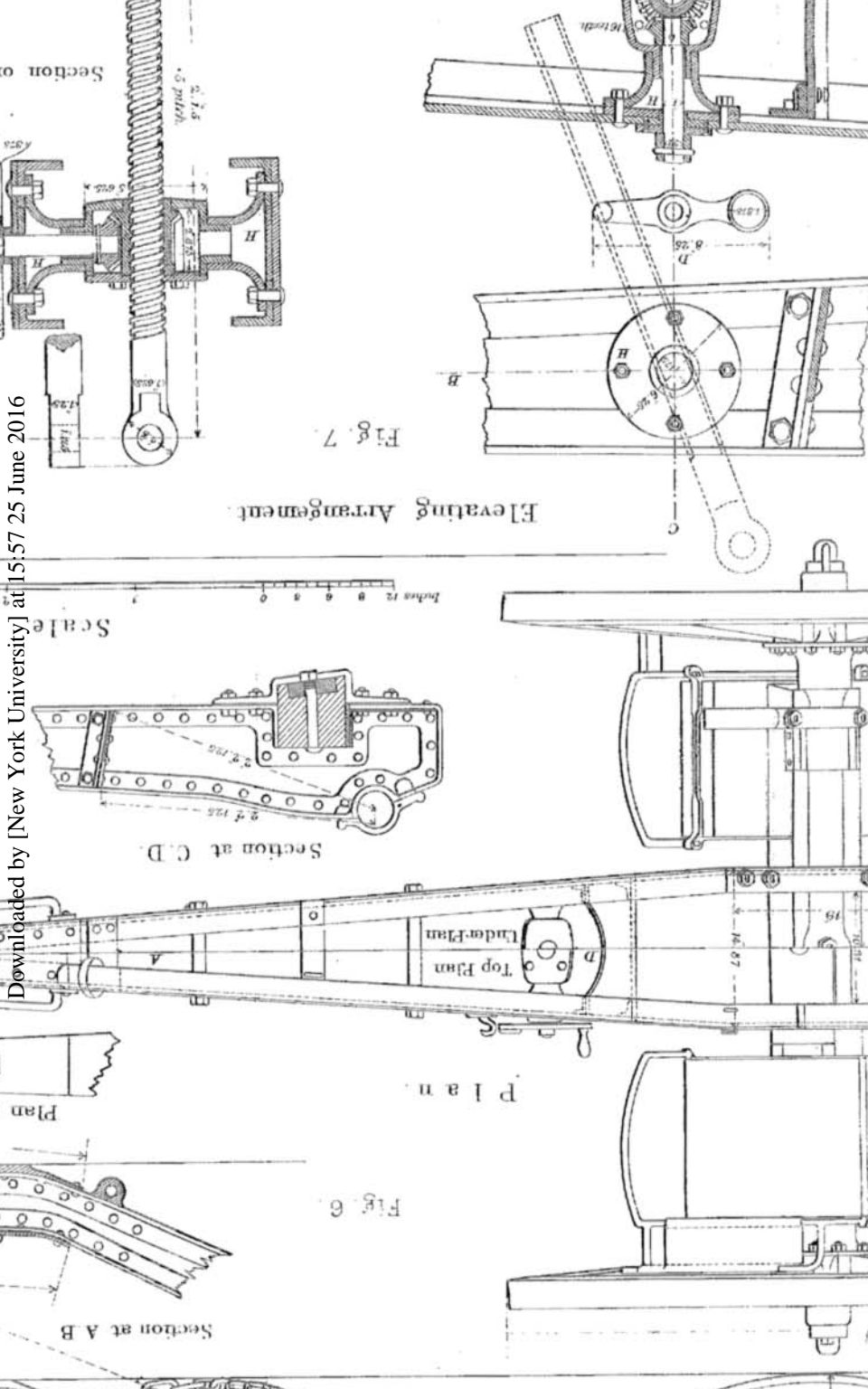


Fig. 6. Plan. Section at A B. Section at C D. Scale. Elevating Arrangement. Fig. 7.

18. Let me now give you a few details of the bronze muzzle-loading field 9-pounder gun adopted for India.

The gun weighs about $8\frac{1}{2}$ cwt.* Its length of bore is 63·5 inches, its calibre 3"; its breech preponderance is about 8 lbs. The rifling is of the French form, slightly modified in size but not in principle; the oblique inclined plane forming the driving side of the groove is at 110° to the radius. The projectiles weigh 9 lbs. They are three in number. I. Shrapnel containing 63 bullets of 18 and 34 to the lb. II. Common shell, containing $7\frac{1}{2}$ oz. of powder. III. Case-shot, containing 113 one-ounce hardened lead bullets. A segment-shell of the same weight is to form part of the equipment as soon as a trustworthy concussion-fuze can be produced. This matter is left in such good hands, that there can be no doubt we shall shortly be in possession of a projectile for long ranges which can be fired as readily as case-shot.

The charge of powder is 1 lb. 12 oz.; the nature of the powder being as yet undecided. The initial velocity with R.L.G. powder is 1,381 feet per second, and with a special powder made at Waltham Abbey, it is within one or two feet of 1,400 feet per second.

The accuracy and uniformity of shooting of this gun is, I think, remarkable. This short table will give you a fair notion of it:—

Elevation.	Mean Range.	Mean Difference of Range.	Mean Reduced Deflection.
Degrees.	Yards.	Yards.	Yards.
2	1176	14·2	0·5
3	1552	17·1	0·9
7	2665	18·9	0·8

This means that at 3° of elevation if you were to fire 100 rounds, 50 shells would be found to have fallen 17 yards short of or beyond the mean range of 1,552 yards, and $\frac{9}{10}$ ths of a yard in width right or left of the line of fire.

As to rapidity of firing, 50 rounds have been fired in seven minutes; and as to rapidity combined with accuracy, 50 rounds were fired in 13 minutes, making 27 hits in a 9-foot target at 1,000 yards. Further, 140 rounds were fired from one gun without stopping, at the rate of three rounds a minute, that is continually for three-quarters of an hour. The metal became so hot as to boil water.

The shrapnel shell, fired at a column of troops, represented by targets 54 feet wide by 9 feet high, in four ranks 20 yards apart, made 48 hits *through* 2" boards at 1,200 yards, 40 through at 1,600 yards, and 10 through at 2,000 yards. The case shot, fired at two rows of the same targets, 50 yards apart, at 300 yards, gave 6·5 hits through 2-inch boards; 11·9 lodged, and 3·3 struck, in total 21·7 hits per round.

* Vide Fig. 5.

The sighting of the gun is central, and both muzzle and breech sights are completely protected against injury. The plate carrying the notch in the breech-sight is capable of lateral deflection. This refinement will scarcely be necessary in firing at troops; but it may be required in certain cases where great accuracy is desirable, such as firing at a single gun, at the pillars of a house, or the voussoirs of an arch, &c. The tangent scale is set in at an angle of $1^{\circ} 30'$ to the left of the vertical to correct the deflection or drift up to 1,500 yards due to the pitch of rifling and velocity.

The venting is that of the smooth-bore guns, excepting that the vent is vertical, striking the axis of the piece at 0.6" from the bottom of the bore. The object of a return to the old venting is to ensure the whole of the cartridge bag being blown out at each discharge. The Indian Committee tried several patterns of sponges calculated to fetch out *débris* of cartridge; but this venting left them nothing to do in this respect.

19. The gun-carriage is chiefly of iron;* the trail is composed of two plate-iron brackets, stiffened with angle-iron, connected by through bolts, and ending in the trail-eye. The axle-arm is not steeled so as to be suited to the gun-metal pipe-box of the nave.

The wheels are of the Madras pattern, so well known as not to need description.

The fittings of the ammunition boxes are of the simplest nature, and are so contrived that when the lid is closed, each shell is held fast in its place by wooden compressors in contact with the lid.

Right and left of the gun are two boxes, the lids of which can be made available as seats for two gunners with the *field* batteries, while two are carried on the limber, and two more on the off horses of the team; so that the gun can go into action independently of its wagon, with its gunners fresh for their work.

In the near box are three case-shot and three charges, with priming irons and tube-pouch. In the off box it is proposed to place a range-finder and one round of case-shot. The limber contains 30 rounds, but accommodation is provided for 36.

The weight dragged by the gun-team, with men dismounted, will be about $33\frac{1}{2}$ cwt.; that is one and a-half cwt. heavier than the Royal Horse Artillery 9-pounder breech-loader, and about the same weight as the 6-pounder smooth-bore of Royal Horse Artillery in India.

The wagon and limber contain 96 rounds, or 128 filled up, the latter being interchangeable at will with the gun-limber. The weight behind the team is about the same as with the gun, 33 cwt.

The forge wagon differs little from that formerly in the service, with the exception that iron is brought into use as much as possible.

With regard to the endurance of the carriages in firing, one has had fired from it some 4,000 rounds. For 500 rounds, the wheels were lashed to posts to stop the recoil. The carriage at this moment appears to be as good as when new.

The gun-carriage has met with the highest approbation of all who have used it, and I believe all who have seen it. It was designed in

* Vide Fig. 6.

the Royal Carriage Department at Woolwich, and appears to me to reflect the greatest credit on its designer.

The adoption of this carriage for India relieves us from a very great difficulty. We have magnificent wood in that country, but it is getting scarce, the scarcity being due to the introduction of railways and to the forests having been neglected. The timber for the manufacture of the carriages had to be stacked in covered sheds for several years before use. Of the timber thus stored a great deal split in drying to such an extent as to be useless for the larger portions of the carriage, viz., the trail-beam and naves. Thus, when a stress came as in and after the Mutiny, the main difficulty in equipping the batteries with their carriages was the want of seasoned wood.

With the new carriage, the largest piece of wood required is for the axle-bed, which acts as a mere cushion: its soundness is not vital to the efficiency of the carriage. The spokes, felloes, and the slight wood-work of the limber will not be, under almost any circumstances, difficult to supply in India; for it is easy to get a small piece of sound wood, when it might be impossible to find a large piece of the same quality.

Again, the open trail of the iron carriage permits of the passage of Sir Joseph Whitworth's* admirable elevating-screw. With the wooden carriage you were compelled to bore an oval hole of very considerable size through your beam, at the very point where it was weakest. Around this lamentable hole, you bored four smaller holes for the holding-down-bolts of the socket of the ball-nut of the elevating-screw. This defect of construction is avoided in the bracket-trail.

Once more, we are subject to the most dreadful pest of white ants in India, against which there is only one effective precaution: it is to move all articles made of wood every day. With an equipped battery this amounts to mere inconvenience; you have to look after your wagons in your sheds. But in arsenals and manufactories, the difficulty is a very serious one. In our new carriages, iron being largely used, those who have charge of stores will have all the less to fear.

20. Let me now succinctly compare this muzzle-loading 9-pounder with the breech-loaders of the service.

I have no doubt in the world, that a gun on the Armstrong breech-loading system, firing 9-pounder shells with a charge of $1\frac{3}{4}$ lb., and weighing 8 cwt., could be made, which would equal the 9-pounder muzzle-loader bronze gun in accuracy, and in flatness of trajectory; but there can be no manner of doubt that the breech-loaders of the service are on both points inferior to it.

The adoption of the latter system entails the following heavy list of complications:—

1. Detonators to the fuzes, which are liable to injury by climate or jolting, despite elaborate packing arrangements.
2. Breech-screw, with tappet lever and keep pins with reserve.
3. Vent-pieces with reserve.
4. Facing implements.

* Vide Fig. 7.

5. Armourers and special tools.
6. Lubricators and tin cups.
7. Lead-coating to shells involving India-rubber discs in the boxes.
8. Browning and greasing the gun.

These complications may or may not form serious objections to the breech-loading gun in Europe; but for India, in my opinion, there is no doubt in the matter. There we have an atmosphere which in a short space of time alternates between that of a heated oven and a steam-bath. Expansion, contraction, rust, mildew, and so forth, try war stores by tests ten fold as severe as any they are subject to in Europe. Again, the source of supply is so distant—if we were to rely on England, as perforce we must with the breech-loading system—that the country might well be lost before fresh supplies could reach us, even supposing them unintercepted on the high seas. On the other hand, large stores might be laid in, in fortified arsenals, so as to meet all possible wants.

Independent of the consideration of the effect of the climate on such stores, the recollection of Delhi in 1857 reminds us that we might again be putting arms into the hands of our domestic enemies for our discomfiture; as the first process in every rebellion or revolution is to seize a *dépôt* of arms. A country is thus all the safer the fewer arms she has in dangerous districts beyond her own immediate wants.

Manufacture in the country is then the best security. I shall probably be told that for a campaign you must trust to your stock in hand and not to manufactories. I reply that a campaign such as we had in India during the Mutiny, would denude most of your arsenals, and that while the troops are fighting in the field your manufactories, working night and day, should, if properly organized, be able to supply the arsenals nearly, if not quite, as fast as they issue stores. Thus, instead of being exhausted at the end of a campaign, you would be nearly as strong as ever in *matériel*.

On the other hand, what advantages does the breech-loading system hold out to us in India? I confess that the only one that I can see is assimilation with the Royal Artillery at home; and this advantage I humbly hope and trust we shall soon have by the universal adoption of the muzzle-loading system.

21. Let me now give you in two words a *per contra* list of the advantages of that system:—

1. Simplicity throughout the equipment, involving the possibility of manufacture in India.

2. Stores little liable to injury from the climate of that country.

3. Economy.

These are the main advantages, though there are many others of a minor and less general nature.

22. Before concluding, I do not think it out of place now that we have got a gun for India, to direct your attention to the question of keeping it. Let me give you an idea of how guns are taken in action in these days of breech-loading small arms.

“At Lipa, near Sadowa, 10 Austrian guns fell into the hands of the

“ Prussians, their teams having been shot down from a distance almost entirely by a section of the Fusiliers of the Guards.

“ Out of the 113 pieces taken from the Austrians in actual fight, 108 were taken by infantry, and almost all by swarms of skirmishers. The method of attack was always the same. The skirmishers got under cover within range of their rifles, and thus knocked over men and horses; they then charged the battery, generally speaking abandoned by its infantry escort, and with three-fourths of its horses down, the battery fell an easy prey.”

Now this Austrian artillery behaved heroically, it fired case-shot to the last, and covered the retreat of the army.

That is to be our field artilleryman's fate, unless we are better backed than were the gallant Austrian gunners!

But how is this backing to be managed?

The fire of modern small-arms is deadly at 500 yards; at 800 yards it is formidable; and even at 1,200 yards with the Martini Henry it is something serious.

A flat trajectory will avail you much; but if your opponents of the infantry are under cover, even at these short distances your guns will do so little, that the expenditure of ammunition would not be justifiable.

What is to be done then with these skirmishers?

Every battery when engaged should have a permanent escort—not only theoretically as at present, but practically—and that escort must on no pretence whatsoever abandon its charge as was the case with the Austrians.

If the enemy's skirmishers advance against a battery, they must be met by skirmishers, especially on their flanks. If men and horses are being shot down by light infantry, one of two things must be done: the battery must retreat at once, or the escort, strengthened if necessary, must drive back the skirmishers.

Thus far I am clear; but suppose the battery has to advance 1,000 yards at a trot and gallop, where would be your infantry escort?

I see nothing for it; but, to detail a cavalry escort to cover the advance in extended order and to retire by the flank as soon as the battery has got into action, the cavalry being relieved by the infantry escort. This is complicated, but something of the sort appears inevitable.

It would seem that now more than ever, a battery in action must be dry-nursed. That the General under whose orders it acts, should be impressed with the indubitable fact, that a battery of field artillery is, like gold, a very valuable possession; and that in proportion to its value, it is all the more likely to be robbed from him, unless he guards it with all the care that he bestows on his purse.

In my own experience of service, escorts to batteries were often told off, but they invariably were left behind on the advance of the battery, and rarely came up to it again, being ordered off elsewhere and otherwise employed. This must no longer be permitted, on pain of the loss of our guns.

23. In conclusion, casting a glance back at our smooth-bore field

artillery and to its advantages in ricochet, I cannot regret it in any respect but one, viz., its more powerful case-shot fire. In all other respects, the rifled gun has the advantage. When the smooth-bore round-shot hit an object 100 feet long by 6 feet high once in every four rounds at 1,000 yards, one-half of which was by ricochet, the Indian gun would hit *at least* three times out of four rounds. It is very well to say the round-shot will go bowling on and hit half-a-dozen objects before it comes to rest. I ask, is it better to hit the object aimed at three times out of four, than to miss it as many times, and to trust to chance that something else may be in its way before its course is finished?

I have thus given you some idea of the field gun for India, and in taking leave of the subject, venture to express before you my fullest confidence in the system which has been adopted. As far as my lights go, the gun compares favourably with any existing field gun; its endurance ample, its uniformity of range and accuracy of direction admirable; its simplicity great, and its trajectory, the flattest that has come to my cognizance. The bronze gun and its iron carriage are suited to India, and their manufacture to the artificers we have at our disposal. They have, however, two great tests to undergo, more severe than any they have been put to at Shoeburyness, viz., time and actual employment on the battle-field. I have no doubt of their successfully enduring both those tests.

I beg to thank you for the attention you have been good enough to pay to my feeble exposition of "The Field-gun for India."

APPENDIX.

Principal Dimensions and Weights of various Horse Artillery Guns and their Equipment.	Breech-loaders.		Muzzle-loaders.		Breech-loader.	Muzzle-loader.
	Prussian.	English.	Austrian.	French.		
	4-pr.	9-pr.	4-pr.	4-pr.		
TIRE GUN.						
Calibre	3·089	3	3·17	3·41	3·42	3
Number of grooves	12	38	6	6	12	3
Depth "	0·051	0·015	0·175	0·113	0·051	0·11
Width "	} in front 0·6		1·51	0·67	{ 0·61	0·8
	} in rear 0·71				{ 0·77	
Length of bore rifled	59·6	.....	42·2	49·4	47	63·5
Pitch-angle	3°15'	4°13'	8°30'	6°53'	4°35'	5°59'
Length of bore	22·5	17·5	15	16	17	21·2
Weight of piece	5·413	6·5	5·177	6·5	6·43	8·1
AMMUNITION.						
Diameter of common shell	3·059	3·02	3·089	3·305	{ 3·413	2·91
Length of nose of do.	3·192	3·07			{ 3·522	
Length of cylinder of do.	1·86	.....	3·19	2·83	2·08	3·13
Total length of do.	4·47	.....	3·91	3·47	4·83	4·8
Weight of common shell filled	6·33	.....	7·10	6·30	6·91	7·33
Weight of common shell bursting charge	5·9	8·5	7·99	8·9	12·5	9
Number of balls in strapnel .....	.....	5	7	7	7·9	7·5
Weight of strapnel .....	.....	42	80	85	.....	63
Number of balls in case-shot .....	.....	9	8·03	9·72	.....	9·25
Weight of case-shot	48	.....	56	41	40	108
Service charge of powder	1·1	1·125	7·91	9·73	8·43	9
Ratio of weight of charge to shell	1	1	1·1	1·21	1·35	1·75
Initial velocity	8·1	8	7·3	7·4	9·3	5·1
..... feet per second	1184	1058	1093	1066	?	1381

Principal Dimensions and Weights of various Horse Artillery Guns and their Equipment.	Breech-loaders.		Muzzle-loaders.		Breech-loader.	Muzzle-loader.
	Prussian.	English.	Austrian.	French.		
	4-pr.	9-pr.	4-pr.	4-pr.		
GUN CARRIAGE.						
Track.....	60·24	62·	59·7	56·3	58·	62·
Diameter of wheel.....	61·	60·	52·5	56·29	48·	60·
Weight of gun-carriage, equipped, but without gun.....	9·35	10·5	8·6	8·42	8·39	10·5
Weight of gun-carriage, equipped, but with gun.....	14·04	17·0	13·78	13·88	14·07	18·75
Rounds carried on gun.....	1	....	3	4	....	4
LIMBER.						
Diameter of wheel.....	48·6	60·	43·2	56·3	48·	60·
Weight of limber, packed.....	15·75	15·	9·86	10·1	8·95	{ 14·0 14·6
Number of rounds in limber.....	48	34	36	40	18	{ 30 36
Proportion of ammunition in limber.....	40	6	20	32	8	8
{ common shell.....	4	....	....	....	....	....
{ carcass.....	....	....	10	5	6	16
{ shrapnel.....	....	18	....	....	....	....
{ segment.....	4	10	6	3	4	6
{ case-shot.....	....	....	....	....	....	....
MISCELLANEOUS.						
Weight of gun behind team.....	30·5	31·5	23·63	25·76	24·4	{ 33·5 34·1
Number of horses in team.....	6	6	4	4	4	6
Weight for each horse in draft, men dismounted.....	5·1	5·2	5·9	6·4	6·1	5·7
Number of rounds per gun, limber, and one wagon.....	157	124	156	156	130	{ 124 148
Number of men carried.....	2	2	1	....	2	2
{ on limber.....	3	....	3	3	3	....
{ on gun.....	....	....	....	....	....	....

N.B. The numbers bracketed in the column referring to the Indian gun are to be taken according to whether each ammunition box contains 15 rounds only, or is filled up with 18.

The CHAIRMAN: Has any gentleman any observations to make on this elaborate paper?

Captain HEATHORN, h.-p., R.A. : I have an observation which I hope you will allow me to make. Being an Indian gunner myself, I am very much interested in this able lecture on the new Indian gun, and there is one point in the Indian gun carriage that I should like to refer to: it is the elevating-gear, which I hear has been presented by Sir Joseph Whitworth. In the early part of 1867, before the French Exhibition, I prepared a model of a similar elevating gear, which I submitted to the Ordnance Select Committee, which afterwards went to the French Exhibition, which returned, and which is now in the Museum of this Institution. The principles of that elevating-gear are these, and they are the same as those of the Indian gun:—A vertical screw is driven up and down by a cog-wheel nut, which is made to revolve by a mitre-wheel. This nut is supported by a cradle, which swings on the carriage by shoulders or trunnions; the centres of the spindle of the mitre-wheel driving the cog-wheel nut and of the trunnions of the cradle, coincide; therefore, whatever motion the cog-wheel nut is constricted to take by the oscillating movement of the screw up and down is at once communicated to the mitre wheel, then to its spindle, which, as I have said before, has its centre coincident with the centres of the trunnions of the cradle that bear the nut; therefore nothing gets out of gearing. This, I believe, is the first time that such an arrangement was ever submitted for driving a screw at all, at least in gunnery. Mr. James, a very well-known mechanic in Lambeth, made the model, and he told me this elevating gearing was a new thing. If anybody would like to see it, the model is in the Museum. To that particular circumstance, viz., the coincidence of these centres, is due that very easy motion which is found to answer so well in the Indian elevating screw. I have tried to explain my claim to Government, but have met with no success. I have no doubt mechanics, if they will take the trouble, will see that what I say is true. An Institution of this kind is no place for inventors to come to with their claims, at least if they are claims, for reward. But if a man like myself, who all the time he has been in the Service has given his attention to the development of his profession, claims an invention, he claims something more than money, he claims the honour of that invention, if it turns out well, and I wish everybody to know that I make that claim distinctly. There is one more point which I should like to mention, alluding to the necessity for protection to horse artillery and field artillery in meeting an adverse force. I do not think Colonel Maxwell told us how horse artillery is to be provided to meet infantry skirmishers. I think it was in the Prussian campaign, to which Colonel Maxwell alluded, that the Prussian gunners were shot down to a man by the infantry skirmishers; therefore the field artillery ought to be accompanied by an infantry force. But I do not imagine that horse artillery guns could be accompanied by an infantry force, and as they will, by turning the flanks of armies, have at times to meet infantry, I shall be glad if Colonel Maxwell will tell us how those guns are to be protected.

Colonel MAXWELL: As no one seems inclined to get up, I should like to say one word upon the subject of the elevating screw. I saw it in Sir Joseph Whitworth's office in London; there was nothing new in it; I knew the whole thing perfectly. I had seen the thing in various applications dozens of times. Go down to Woolwich Arsenal, or to any factory in England, and you will see the same principle applied. In the gun carriage of Captain Scott it is applied. Sir Joseph Whitworth, I should think, would never have dared to go to the Patent Office and take out a patent for such a thing; nor can I conceive that any man would dare to do such a thing. I might as well take out a patent for putting fire under water to make it boil. I do not know who originated the idea, but I have been familiar with it for years and years.

Captain HEATHORN: May I answer that. It is not a novelty to use mitre wheels to drive a screw. It is the particular coincidence of the centre of the spindle of the mitre-wheel and centre of the trunnions of the cradle bearing the nut, that is a novelty. Captain Scott's gun carriage uses a vertical screw with bevelled wheels. That is very well. But where you constrict the nut of the lower wheel to a certain necessary movement by a screw which oscillates in a vertical plane, you must provide

that those mitre-wheels do not get out of gear. My invention is that the centre of the mitre-wheel is in coincidence with the centres of the trunnions of the cradle bearing the nut, therefore it is not like Captain Scott's method of raising and depressing his gun by a fixed vertical screw. That does not oscillate; his is a standing arrangement; there is no oscillation at all about it.

The CHAIRMAN: I am afraid if we are to go into these elaborate details, and into questions that are always extremely difficult as to priority of inventions, we shall be straying away from what is more interesting, the "field gun of India." Without a model, the question raised by Captain Heathorn is almost unintelligible.

Captain HEATHORN: The model is in the next room.

The CHAIRMAN: I know, but I would rather keep to what we have before us, the field gun of India. General Eardley Wilnot, who is here, will, perhaps, be kind enough to say a few words.

General EARDLEY WILNOT, R.A.: I should like to say a word with regard to the elevating arrangement for the gun, because I am to a certain extent responsible. I saw this arrangement in Sir Joseph Whitworth's office, and having a long acquaintance with him, I asked him if we might apply it, as it stood, to the gun under our consideration. He very kindly put it at our disposal. I submit that the Indian Field Artillery Committee is not constituted the arbiter as regards inventions. It is nothing to us whether this arrangement was invented in the time of Adam; all we know is that it was ready made to our hand, and we gladly adopted it. We do not say it was Sir Joseph Whitworth's invention, or Mr. Anybody's; all we say in our report is that we had been permitted by Sir Joseph Whitworth to adopt the elevating arrangement which was in use on one of his guns.

Colonel SMYTHE, R.A.: There is one remark I would make about Captain Heathorn's suggestion about escorts. If we have a war, I think we shall find it absolutely necessary to protect field artillery by riflemen, who shall accompany the guns in cars; there is no other way, I am certain, that field artillery can be properly used in a campaign without their escorts are carried in that way.

General EARDLEY WILNOT: I wish to add a few words with regard to the paper that has just been read. I feel a certain amount of delicacy in saying anything, having been President of the Committee of which Colonel Maxwell has been so able a member. My principal object in rising at the present moment is, that I may convey to this meeting a feeling which we all feel towards Colonel Maxwell, for the great zeal, energy, and intelligence which he has brought to bear on this question. I am aware that, to a certain extent, I am taking this duty out of the Chairman's hands, but having been cognizant of the matter from the beginning, and having had the pleasure of Colonel Maxwell's acquaintance, I cannot on this occasion help bearing my testimony to his labours; I believe no Committee has ever worked more harmoniously, or in a more friendly manner. To me, at the close of my services—for you know that when an artilleryman becomes a General, he has very little more to do, except to hide himself—it has been a pleasure to become acquainted with Colonel Maxwell and the other Officers of the Indian service. There are some points mentioned by Colonel Maxwell to which I may refer. With regard to the gun, there are many of us who for many years have considered that a muzzle-loading gun for field service is the best weapon, and who think that the *onus probandi* ought to be thrown on those who advocate breech-loading, to show in what the muzzle-loading gun fails. I am thankful, after many years' of discussion and experiment, to see that the feeling is gradually coming round to our position, not only on the grounds which Colonel Maxwell has so ably set forth, but also from the growing conviction that there is no necessity for a breech-loader for field service, either as regards rapidity of fire, accuracy, simplicity, shell power, and high angle firing. I think the artillery has gone rather in the wrong direction; in seeking for a breech-loading gun for field artillery, they were seeking for a thing for which there was no necessity; not that there is an objection to breech-loading, as such, because if a heavy breech-loading gun could be found, it might be made a valuable weapon. How far we are from it remains to be seen. At the same time a muzzle-loading gun for general purposes, being so simple and so comparatively easily made, is far preferable; and if you can by some means introduce a carriage which can assimilate itself to the result gained

in the turn-table of the service, that is to say, if the muzzle of the gun, in the act of recoil, be brought round to a convenient loading position, you would get almost everything you want. The only advantage of breech-loading is the supposed facility, not rapidity, of loading, without having to push the rammer through the port of the ship or the casemate. The Navy, we all know, have expressed themselves rather strongly with regard to the breech-loading gun. The same difficulty they find of clearing the deck or turret from smoke when the breech-piece is taken out, would be found also in casemates. When you take out the breech-piece the whole of the casemate is filled with smoke instantly, so that the gunners cannot see. With regard to bronze, there is no doubt that the present system of casting bronze, which was introduced in the year 1853, is very favourable, for it produces a metal of a much harder character than the old bronze. There is at Shoeburyness a specimen of a bronze muzzle-loading smooth-bored 9-pounder gun. This gun has fired at least 1,666 rounds. That return was taken in August, 1869; since then I have no doubt it has fired a good many more. The life of bronze muzzle-loading guns was said formerly to be 300 to 400 rounds at the most. One reason given was that the gun drooped at the muzzle, on account of the heat from firing. A long argument among artillerymen on that subject was terminated satisfactorily by an experiment which was made in the Arsenal some years ago. A bronze gun was heated up to a glowing heat in the furnace; it was taken out, balanced on a knife edge, and left there to cool. If the softness of the metal was so great that the heat of it would put it out of form, you would think that in a 13½ cwt. gun, balanced on a knife edge, there would be some deviation of the bore when the gun was cold. It was found there was nothing of the kind. The drooping and destruction of the bore entirely arose from windage. It is a curious circumstance in our service that so many were averse then to a diminution of windage. The gun at Shoeburyness was made in the Arsenal, under a certain order; it was sent there, and fired an unusual number of times. The believers in "drooping" began to wonder why this gun was not destroyed; and on examination of the papers it was found that it was made with diminished windage. But the gun was there, and those who were interested in it said, "You had better go on firing the gun." The gun is still as good as ever, and is in constant use; therefore it is clear, if the bronze will stand a charge of powder for a 13 cwt. gun, it will stand the charge of powder for a rifled gun, because the charge for a rifled gun is less. Colonel Maxwell has said something about the introduction of mortars. I confess to a particular objection to mortars. The shape is an absurd one, fit only to be seen in a museum, because mortars are inapplicable to horizontal fire. With the same weight you might have a short Howitzer, which could be applied to vertical fire just as well as a mortar. Unfortunately, up to the present moment nothing has been done in the way of howitzers, of which Colonel Maxwell has spoken. I have long advocated the use of heavy shells with field howitzers. But to return to the subject of the Committee, it is a subject of congratulation that such a Committee as this was appointed, with Indian officers upon it, and to a certain extent under the superintendence of the India Office, because, by that means the whole question has been looked at in an entirely independent manner, and we have come to conclusions perfectly independent of any preconceived notions. The Committee has been engaged rather a longer time, perhaps, than the authorities have liked; but I am sure every Officer will be satisfied that the time has not been long in which to produce an equipment almost entirely new, a gun entirely new, a carriage entirely new, ammunition, small stores, and everything connected with the gun, almost entirely new. The period occupied by the Committee was about a year and a quarter, or nearly a year and a half; not extraordinarily long, particularly when you consider how many years the whole question of field artillery has been on the *tapis*, and does not seem to be in a permanent position yet. The whole cost has been comparatively small, not exceeding £3,000 in the whole, that of the Whitworth and Armstrong Committee having been £30,000. The experiments have been kept down to the smallest number compatible with a satisfactory result. I join with Colonel Maxwell in hoping, most heartily, that what has been done for the field artillery of India will be the initiation for British artillery generally.

Major-General BOILEAU, F.R.S: Before the discussion closes I should wish to address a few observations to the meeting, not in the sense of an artillery Officer, for I would not presume to give an opinion of the qualities of the gun in that sense. But there is a point of view which I think I may be privileged to notice. It is that the introduction of this bronze gun into India will enable the Government of India to make their own artillery on the spot. That is a point of very great importance. There may arise circumstances in which it may be of the greatest importance that we should be able to manufacture guns in India, which I have no doubt, from the description given, are entirely suited to the country in which they will be employed. I may add, if the artillery service in India is not very much changed from what it was when I was there, that the gun will have on service the best possible application that a gun can have. That the gun and its carriage and ammunition can be made with ease in India, is a point the importance of which cannot be over-estimated. There is only one other point I would mention before I sit down. It is this, that in the theatre of this Institution, improvements in artillery and projectiles have been brought forward which are of the greatest interest and value. I allude to Palisser's system of guns and ammunition, to Moncreiff's gun carriage, and to Heathorn's muzzle-pivoting carriage. I can only hope, as there seems to be a certain amount of good luck attending the reading of papers in this Institution, that Colonel Maxwell, who has read a most interesting and instructive paper this evening, will also reap the benefit of this *prestige*, if there be any, and that the future will show that his ideas are sound and have been considered worthy of an extended adoption.

Major TESCHEMAKER: I should like to ask one question with regard to the material for the gun carriage. Colonel Maxwell says they are relieved from a great deal of difficulty in India by the introduction of iron. Though wood is getting scarce in India, I think iron is still scarcer.

Colonel MAXWELL: In explanation I would say at once, that what I mentioned just now was, that the adoption of iron relieves us from a very great difficulty. If you recollect, I distinctly said that wood had to be seasoned for a long period of time, to be kept in covered sheds, and that in the process of seasoning a great deal of the wood became injured. If, then, we can get out angle iron, bars, bolts, and so forth, put them into a shed, and let them be there for a dozen years, no seasoning will be required, no white ants; nothing will injure them. In a time of emergency, you cannot get seasoned wood, as we found in India, towards the end of the mutiny, when the stock began to run low. Endeavours were made on all sides to procure seasoned wood, but it was not to be had. Now, iron can be had at any time.

Colonel FLETCHER: There is a question I would like to ask, although I do so with great diffidence, not being an artillery Officer, and consequently not well acquainted with the subject. It is with regard to the composition of service batteries, whether it would not depend upon the nature of the country in which the campaign would take place. I remember in 1862 the American artillery Officers were very much in favour of the Napoleon 12-pounder gun, because they found that it was much more effective in the wooded country in which they were campaigning than the rifled field gun. Therefore I would ask Colonel Maxwell, supposing we were to have a campaign in a very wooded country, whether it would not necessitate an increase of the number of our howitzers, or the adoption of a gun somewhat similar to that used in the American campaign, namely, the Napoleon 12-pounder?

General EARDLEY WILMOT: That question would have been gladly entertained by the Indian Committee, but on referring to the Indian Government we were distinctly told that we were not to trouble ourselves about it. We were all anxious to go into that very question which Colonel Fletcher has spoken of, being fully alive to the importance of it.

Colonel E. B. JOHNSON, R.A.: I should like to answer General Boileau, and I think Colonel Maxwell will endorse what I say. The first ground on which the bronze muzzle-loader was taken up was the capabilities which India possesses of making that gun, compared with the impossibility of making the breech-loader. (Colonel MAXWELL: Quite so.) As for iron, there is as much iron to be found in India as there is anywhere else.

Mr. E. J. REED, C.B., Chief Constructor of the Navy: Although it is very late, I will

venture to say one or two words upon the subject, though I am afraid that what I say on such a subject will not be considered important. It seems to me that if the discussion were to close at this point, the paper would scarcely have justice done to it, inasmuch as Colonel Maxwell has, in the course of his paper, enunciated several propositions which appear to be of very great moment, and which I probably, in common with other mechanical persons, have listened to with great satisfaction. One is, that Colonel Maxwell has exemplified a preference for weight of gun instead of a preference for weight of carriage. My own opinion is, that the principle has to be much more developed than it has been, not only in field artillery, but in heavy artillery; and that the time is fast coming when we shall distress our carriages a great deal less than we at present distress them, by putting a great deal more weight into the gun, and making the carriage lighter. Another point that I have listened to with peculiar gratification is, that in the production of this system of field artillery for India very great importance has been attached to a low trajectory. I am almost afraid to say that, in my opinion, that question has been too much passed by in certain quarters. I view with the greatest apprehension a preference shown by any gunnery Officer whatever for a gun with a high trajectory; and I think the effort of every person concerned in the construction of guns should be directed towards the production of guns with a low trajectory. I know it is said that, for naval purposes, the unsteadiness of the gun platform is an argument against any great attempt at accuracy of fire at considerable ranges. But I think, on the contrary, that while the naval architect has the most solemn obligations laid upon him to produce the steadiest possible gun platform, that a like obligation ought to be laid upon the gunner and upon the gun manufacturer to produce the lowest trajectory, and to give the gun the best possible aim. I might possibly differ in a slight degree from the gallant Officer who read the paper in one point, because, for my own part, I should like to see a low trajectory obtained, with less dependence upon a high initial velocity. I am in favour of a somewhat smaller bore, with great velocity at great range, rather than in favour of a high initial velocity with a larger bore. If you look at the table you will see that that system of designing ordnance has not been lost sight of even in this case, because, as compared with all European systems of artillery, the accuracy and success of this gun has been secured by means of the smallest calibre, and, therefore, the lowest trajectory with regard to the powder used. I view that with the greatest satisfaction, because I am sure in field artillery, as in naval artillery, and in all other classes of artillery, there is too great a tendency to disparage the small bore, and the accuracy which results from that with proportionate charges. I think it is only fair to Sir Joseph Whitworth, into whose system I have been lately looking, to point out that, with regard to the small bore rifle, he unquestionably led the way, and I believe honestly he is no less unquestionably leading the way in artillery likewise. Nor is this true of the small bore only; on looking at the system of centring the shot, of which Colonel Maxwell gave us a lucid explanation, I always fancy that I see in that stud, with its inclined surface, tending to the centring of the shot after a certain motion has taken place, the rudimentary form of Sir Joseph Whitworth's system of polygonal bore and projectiles. I will say no more upon the paper. I thought it due to the gallant Officer who has read it to take advantage of your kindness, sir, in allowing me to say a word or two, to point out that his paper does involve a recognition of these very important principles. I for one, as a mechanical person, have listened to him with very great satisfaction on that account.

The CHAIRMAN: I will now close the discussion by asking you to give a vote of thanks to Colonel Maxwell for his very interesting and valuable paper. We have heard to-night the testimony of the gallant Officer who was President of the Committee on the Field Gun for India; and I am sure that any words that I can add would be superfluous, as that gallant Officer has had the best opportunities of judging of Colonel Maxwell's knowledge of the subject, which I am sure you must all agree with me is most minute and most elaborate. I beg to return to Colonel Maxwell our best thanks.