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Friday, April 29, 1887.

MAJOR-GENERAL W. H. GOODENOUGH, C.B., R.A., Inspector-General of Artillery, in the Chair.

ACCURACY OF ARTILLERY FIRE.

By Major G. MACKINLAY, R.A.

THE subject of good shooting has greatly occupied the attention of thoughtful Officers, and the improved matériel now at disposal demands much care in order that the greatest possible accuracy of fire may be attained. All authorities of all arms are agreed on the importance of this subject. Prince Kraft of Hohenlohe-Ingelfingen, after his experience in high command in the German Artillery during three great wars, writes that the principal requirement of good artillery may be expressed in one word thrice repeated; it must hit, hit, hit; to hitting belongs everything connected with correct handling, skilful observation, and careful correction of elevation; the mobility of artillery, absolutely necessary though it is, he considers to be of only secondary importance.

Lord Wolseley stated in his orders to the troops previous to the Ashantee War, with reference to general accuracy of fire: "Every shot that is not deliberately aimed not only encourages the enemy, who would soon learn to despise a fire that did them no injury, but it seriously affects the efficiency of the force: if ammunition were to run short, a stop would be put to our further advance."

Though all firing is essentially based on the same principles, a few features of artillery as distinguished from small-arm fire may be noticed in order that too much may not be expected from it on the one hand, or that it may not be unduly depreciated on the other hand. The advantage or facility of artillery fire is chiefly that the piece is held steadily on discharge, and it is consequently more easy to hit with an artillery gun than with a small-arm, as the latter must not only be aimed truly, but must be held steadily; it is also an advantage that the effects of artillery fire are visible at a greater distance than those of musketry, and thus the firing can be corrected; but the difficulties are numerous; several men have to co-operate in order to fire one piece in the artillery; the ranges are in general much greater and more difficult to find, and the importance of each individual round telling with effect is greater than with infantry fire, this is specially the case with the heaviest ordnance; but the chief hindrance in the attainment of accurate artillery fire is probably the small amount of annual practice ammunition, because of its expense and difficulties

connected with ranges. In horse and field artillery a *fair* amount of practice ammunition is annually fired, though four-gun batteries, with an equal number of men to be instructed, have only two-thirds of the ammunition allotted to others; and only motives of economy prevent a greater expenditure, which would doubtless give greater accuracy of fire. In siege artillery the practice firing is much less on account of increased expense; but this is not of such importance as appears at first sight, because such ordnance are fired with great deliberation at fixed targets, and the conditions are favourable to accuracy; nevertheless careful previous training is necessary in all the arrangements, but these can be rehearsed without the expenditure of a very large quantity of ammunition. When, however, we come to the heaviest land-service guns used by the garrison artillery in coast forts we meet with many difficulties; a large proportion of the guns can seldom be fired on account of danger to passing shipping, and their great expense very greatly limits the number of rounds allowed for practice, thus it is not easy to give sufficient training in the use of these weapons; on the other hand, the interests at stake are enormous, and the heavy guns of a coast fort may be directed against that most difficult target—an enemy's ship, moving at a much higher speed than any regiment of cavalry; and it may be of the utmost importance to strike her in a vital part and prevent her from running past the work; this demands great skill, as the shooting cannot so readily be corrected from observing the results of previous rounds as at sieges, because the ranges vary rapidly, and the opportunities are fleeting; we have had no practical need for the services of the artillery in the defence of our coasts for many years, but it is important that they should be able to maintain a rapid and accurate fire.

Fire discipline is just as much needed in the artillery as in the infantry; the elevation and length of fuze ordered by the Commanding Officer must be adhered to, and the fire of the guns must be directed on objects pointed out by him in order to obtain a concentrated fire and unity of action.

The utmost accuracy attainable should be sought for, but this requires constant effort; a certain measure of accuracy is easily reached, but any improvement involves labour; excellence is only obtained by those who will show an almost infinite capacity for taking trouble.

We will proceed to consider the subject in the following order:—

1. *Matériel.*
2. Range-finding.
3. Sights.
4. Training.
5. Correction of fire from observation of the effects of previous rounds.

1. *Matériel.*

Progress in the accuracy of ordnance and ammunition has been considerable of late years, and may be said to be due to three causes—

- 1st. The introduction of rifled guns.

FIG. 6. 25 P.C. VERTICAL RECTANGLES. SCALE 0 1 2 3 4 5 6 7 8 9 10 YDS. RANGE 1500 YDS. 10 ROUNDS. 9.2 INCH B.L. GUN. COMMON SHELL 320 LBS. CHARGE 140 LB. PRISM. SHOEBURNESS, 25TH APRIL, 1888. PART OF TARGET MARKED WITH SQUARES 1 FOOT SIDE.

FIG. 12. SHRAPNEL FIRE. OVER. FIG. 10. SHORT. FIG. 11. BURST OF SHELL SEEN, BUT NO INDICATIONS OF HITS OF FRAGMENTS.

FIG. 9. SCOTT'S OVER BALANCE TELESCOPIC SIGHT.

2nd. The scaling of windage either in a B.L. or by a gas-check in a M.L. gun.

3rd. The attainment of high velocity for guns, giving the advantage of a flat trajectory which aids so much in the attainment of accuracy, as not only is the dispersion less (compare diagrams of 8-inch howitzer (Fig. 1 (b)) fired with a large charge giving a comparatively flat trajectory (Fig. 1 (a)), and with a small charge giving a more bent curve), but the angle of descent being less, a target will be hit over a greater dangerous distance, and thus errors in estimating the range are rendered of less importance than would otherwise be the case; an incidental advantage of high velocity is that noticed by Colonel Maitland, R.A., in the Russo-Turkish war, when a Russian gun at Rustchuk was pointed out to him by the Turks as a particularly dangerous one, because the shell came before the warning sound of the firing of the piece; at other places where the guns had a lower velocity, the sound of their firing was heard before their shells came, the working parties of Turkish soldiers thus had good warning and had time to hide away under cover, hardly any damage was done, and the men did not fear the fire at all.

An example of good shooting of a modern high-velocity B.L. gun is given in Fig. 2 of a 9.2-inch gun fired at Shoeburyness in 1883, and laid by the experienced experimental Officer, Major O'Callaghan, R.A.

A fair comparison between the shooting of the Martini and that of the Snider is given on Fig. 3, which is the real size of parts of the target: the former rifle has the flatter trajectory, and the shot marks in its group of 20 rounds, fired from a fixed rest at 500 yards range, are seen to be close together, showing less dispersion or more accuracy than those of the Snider rifle fired on the same day under similar conditions.

With howitzers, however, it is sometimes essential to obtain a steep angle of descent in order to clear a projecting mass and breach an unseen and covered escarp, or to send a shell with a large bursting charge against an earthwork so that it will penetrate and explode in it and not ricochet off and waste its effect elsewhere; in these cases recourse must be had to a very bent trajectory, in which case, though the accuracy can never be so great as with the direct fire of guns, yet it is sufficiently so to obtain the desired effect without the employment of an excessive amount of ammunition. Another application of this nature of fire is at the decks of ships at very long ranges from large howitzers with considerable angles of descent to prevent ricochet: Krupp obtained the results shown in Fig. 4 at Meppen as long ago as August, 1879, and much interest was excited, as the descending shell of such a piece would crash through the deck of any vessel with most destructive effects; very good results were obtained last year in Russia, when an 11-inch B.L. mortar on slides inclined at 35° fired a 600-lb. shell at a range 7,500 yards with lateral errors of 15 to 30 feet, and longitudinal errors from 63 to 126 feet; Italy has adopted this nature of coast defence; steps have been taken to obtain this description of fire in our Service, and good results have been obtained

at Shoeburyness at a very long range. Commander Lindsay, R.N., and Lieutenant Stokes-Rees, R.N., H.M.S. "Cambridge," point out in a letter received this morning, that in order that this nature of fire may be effective the range must be accurately known, and large allowance must be made for the speed of the enemy, as the time of flight of the shell must necessarily be long; this is doubtless true, and it will render the value of this fire much less than would appear from practice at fixed targets, but if one shell in twenty or thirty strikes the deck of a large ship the expenditure of ammunition will probably be well worth the result.

The progress in accuracy of recent field guns is shown in Fig. 5, in which the relative sizes of the vertical targets which would be struck by 25 per cent. of the rounds fired at various ranges are drawn to scale from information given in the range tables; it is there seen that the 9-pr. R.M.L. gun is very deficient in accuracy; and it is hardly too much to say that one 12-pr. B.L. battery could generally produce at least as good an effect as two batteries of 9-pr. guns; it would appear to be a matter of great importance to replace the 9-pr. guns as soon as possible by more accurate pieces, especially in India, where the Russian Officers present at the Delhi Camp of Exercise in the cold weather of 1884-85 remarked unreservedly on the inferiority of the armament of the mounted artillery, while they praised the magnificent turnout of the batteries and the good physique of both men and horses; a 9-pr. battery is just as expensive to keep up as a 12-pr. one. These diagrams do not tell all the difference which exists between the guns, as they are compiled from practice with similar sights at Shoeburyness, and no account is taken of the more accurate Service sight of the 12-pr. B.L.; the newer pieces also hit harder and have flatter trajectories than the older ones because their shells have higher velocity, and thus their shrapnel fire is more effective at all ranges; there is consequently an increased probability of hitting with the bullets of the newest type guns. The bullets also ricochet better than those from the shells of the older pieces, because the angle of descent is smaller and the velocity higher, hence a greater distance is swept than before; the steel shrapnel shells of the newer pieces also contain many more bullets than the cast-iron shells of the old type guns, as shown by the annexed—

Table A.

Gun.	Weight of gun.	Weight of charge.	Muzzle velocity.	Number and weight of shrapnel bullets.	Total number of shrapnel bullets.	Remarks.
	cwts.	lbs. oz.	f.s.			
9-pr.	6	1 12	1,300	{ 29 of 18 to the pound 35 of 8½ to the pound	63	{ Old type R.M.L. gun. Cast-iron shells.
16-pr.	12	3 0	1,355	{ 72 of 18 to the pound 56 of 8½ to the pound	128	{ Old type R.M.L., heavy field gun. Cast-iron shells.
13-pr.	8	3 2	1,560	{ 133 of 3½ to the pound	133	{ New type R.M.L. gun. Steel shells.
12-pr.	7	4 0	1,710	{ 177 of 35 to the pound	177	{ Newest type B.L. gun. Steel shells.

It would be well, as soon as possible, to get rid of the complication and confusion only too likely to arise on active service from the various kinds of ammunition required for the four different guns which we have at present for our small force of horse and field artillery—reduced just recently; it appears to be a most important matter to shorten the transition period through which we are now passing, and to arm the whole of our mounted artillery with the new 12-pr. B.L. and with a heavy new type field gun. The R.M.L. 9- and 16-pr. should be relegated to such duties as the auxiliary armament of coast defences for which they are well adapted for short ranges; the 13-pr. gun will probably soon disappear from our Service.

There are many other points connected with guns and ammunition which have an important influence on accuracy; they are uniformity of powder, uniformity of weights of projectiles and charges, a proper distribution of the mass of the projectile, the twist of rifling, a worn bore, the method of mounting, and accurate time fuzes, which will keep well in all climates, are a great desideratum. Progress has been made in many of these directions, but much remains to be done.

2. Range-finding.

A cause of inaccuracy on active service is that the *range* is often *unknown*; it must either be found by some instrument, which is liable to cause delay, or it must be guessed; in both cases the firing should, when possible, be corrected by noting the effects of trial rounds, generally with percussion fuzes; this becomes increasingly difficult to do at long ranges, where the effects of fire cannot readily be distinguished, even with the aid of a field-glass.

For a long time it seemed doubtful if range-finders would find a

permanent place in our field service; some Officers reported favourably, while others again found little good in them; but improvements having been made, in cheapness and portability, and more experience in their use having been gained, they are now firmly established in our own and in Continental armies, and they doubtless greatly conduce to accuracy of shooting under certain circumstances. On the strong recommendation of the Committee on Range-finders, a School of Instruction has been established at Aldershot, with a definite course, and thorough practice in the use of the Watkin instrument, as it appeared that its use was seldom properly understood, and even when that was the case the necessary facility, only developed by constant practice, was not attained. The Committee justly represented that as careful training is required to make army signallers, where those at each end of a range are trying their best to understand each other, so regular training is also necessary in range-finding, where the enemy's constant effort is to conceal what the observer wishes to find out. Care in the use and keeping of these instruments must be insisted on, as sometimes those who use them do not consider that a range-finder should be handled more carefully than a sword or a rammer.

All the systems of range-finding are based upon the principles of surveying, with the exception of the plan for finding the range by the velocity of sound, but this is very inaccurate, and it has the disadvantage that it cannot be employed until the enemy has commenced firing.

The necessary conditions are that ranges must be found with a fair approach to accuracy to be of any real value, say within 1 per cent.: this can be done with comparative ease at a short range, but it is generally more difficult to do so at a longer one, when also any error is of more importance in affecting the accuracy of shooting as the trajectory becomes more curved with increased dispersion and increased angle of descent and decreased dangerous distance (Fig. 1 (a)). On the other hand, more time can generally be given to find the longer ranges, and greater care should always then be taken.

All range-finding may practically be defined as the measurement of an unknown distance in the terms of a known one called the base: thus, when finding the distance of the earth from the sun in 1882, at the transit of Venus, a base line nearly the length of the diameter of the earth was employed; the result obtained was supposed to be accurate within about 0.12 per cent., and the ratio of base to unknown distance was about 1 to 12,000. For military range-finding the ratio of base to range should not generally be less than about 1 to 20, but it may be considerably increased if a telescope is used: the shorter the base the more quickly can a range be found, but the longer the base the greater will be the accuracy, if other conditions are the same.

Some instruments contain their own bases; they are very quick and simple in their action, and they will give good results at the shorter ranges, but they fail in accuracy at the longer ones, when the variation in the angle subtended by the base becomes too small for

accurate measurement. An exception may perhaps be made in favour of the Berdan range-finder, as it has a base line of 6 feet with well mounted telescopes at each end, but it is very expensive and awkward to transport; Mallock's range-finder on this principle may perhaps be found useful. The fixed base takes no advantage of the circumstance that a longer base can generally be advantageously employed in finding the longer ranges.

Other instruments, such as Weldon's, are arranged to take a fixed ratio between base and range, and consequently about the same percentage of accuracy is obtained at all ranges: this system has the advantage of simplicity, and is specially convenient at short ranges, but it does not readily lend itself to the circumstances which arise, as it may happen on rough ground that it is not possible to obtain the exact length of base desired, and then the range cannot be found at all.

The systems which have given best results under *all* circumstances are those which adapt themselves to the various conditions which may arise, allowing a fairly constant ratio of base to range.

Turning to the records of active service, when range-finders have been used by our troops in the field, no very satisfactory results have yet been obtained; this may perhaps be explained by the difficulties which then existed connected with the want of proper training of the observers, and the rough usage sustained by the instruments *en route* to wars, where difficulties of transport were very great; but with the lately organized system of annual inspection, periodical return of the range-finders to headquarters, and careful training of the observers in the care and employment of the instrument, the field range-finding system will now have a fair trial, and will probably give good results.

Ranges will be found at sieges by the accurate but somewhat bulky Nolan range-finder. For elevated coast defences it has been customary for many years to find the range of an enemy's ship from the battery by measuring the angle of depression to the water line of the vessel, but Major Watkin has reduced this well-known principle to a most useful and practical application in his depression range-finder, especially when it is combined with his position or direction-finding arrangement. The instrument is placed on a firmly set, well-levelled stone, isolated from the flooring to prevent vibration (as is usual with astronomical instruments), and it is in an observing station, at such a distance from the battery as to be clear of the smoke of the guns. When an observer keeps the cross-wires of the telescope of the instrument on the water line of a moving ship, the range is automatically indicated with such readiness that the probable position of the vessel some seconds in advance can be predicted, and an ingenious electrical arrangement connecting the instrument at the observing station with the battery causes dials at each group of guns automatically to record the ranges and directions of the ship from the guns; these will be different from the ranges and directions from the observing station itself. The guns can then be fired after certain scales at them have been adjusted corresponding to the indications on the dials, and accurate shooting can be carried out though the

enemy's ship may be hidden by smoke from the men actually working the guns. Fig. 6 shows results obtained by guessing the ranges and using the ordinary sights compared with those obtained by the use of the range- and position-finder; buoys fixed at known ranges will also be used to assist in range-finding from forts.

The recent adoption of range- and position-finding and of submarine mining have greatly increased the power of coast defence, and all that now seems required is a proper training and a skilful organization of the powerful means placed at our disposal.

With ships, on the other hand, I understand, a *good* range-finder is much required. An Officer sent aloft can find the angle between the water line of an enemy's ship and the horizon, and hence the range by aid of a sextant, but the steadiness of the instrument on land, which conduces so much to its accuracy, is entirely wanting, time is lost in communicating from aloft to the deck, and when a ship fires at a fort the horizon will not be visible in its direction, but in that case the range is found by cross bearings, and reference to the chart. It is possible that range-observing stations might be fitted up at each end of a ship, and thus its length might form a base, but this would present several difficulties. At the present time I believe some Officers consider it necessary that a ship should anchor for accurate fire at a fort, or else it should only fire as it passes some buoy dropped at a known distance from the hostile work; the movement of the waves renders the platform from which a ship's gun is fired unsteady, and it therefore tends to impair the accuracy of fire; naval shooting also suffers under the disadvantages that, unlike that from coast forts, it cannot continue when smoke obscures the view from the guns. At Alexandria one of the attacking ships (Admiral Le Hunte Ward's) found that more rounds could be delivered with accuracy in a given time with salvoes of four guns than when firing independently, as it was then easier to steam clear of the smoke, and aim could be taken again more easily; but I trust some naval Officers will inform us how an accurate fire is best obtained from ships.

With regard to estimating ranges by eye: distances over a level surface are generally under-estimated, and those over undulating ground are often judged to be further off than they really are. Light is often very misleading; for instance, a distant object to the west at sunrise is strongly illuminated, seems very distinct, and is judged to be nearer than it really is; but in the evening the object, as seen from the same spot, appears under the sun, is indistinct, and looks much more distant. In the French night attack on Sfax, the ships lighted up the enemy's position with the electric light; their boats advancing and firing in the dark had a good object to aim at; but they were themselves difficult to see, and consequently to hit.

When the range has been estimated, whether from the indications of a range-finder or simply by judging the distance by eye, it is most essential that it should be verified, and the shooting corrected if necessary from careful observation of the results of fire, as will be considered under the fifth heading.

3. *Sights.*

It is admitted by most Officers that a great part of the Service sights are not sufficiently accurate for the guns they are employed with. The line of sight is obtained by aligning two marks connected with the gun on to the target; the movable sight is generally that at the breech, and it is provided with a notch, the other fore sight is an apex point. In order to lay properly it is necessary to obtain a full sight (Fig. 7 (a)), i.e., the shoulders of the tangent scale should appear to be in the same horizontal line as the apex of the fore sight and the centre of the target. If a fine sight is taken, the elevation is less than is intended, and the projectile will probably fall short. The Royal Navy, however, use a half sight, and their range tables are calculated accordingly. Sometimes the notch is deep, for facility of laying, but a *shallow* notch is employed for accurate siege fire. The objections to this plan are, a certain difficulty in bringing the fore sight and target into the same horizontal with the shoulder of the tangent scale, and this becomes more troublesome to do as the depth of the notch increases; a part of the target (especially if it is a retiring one) is hidden by the sight; the aiming will not be exactly the same on a cloudy day as when the sun shines brightly with a strong glare, even though the sights are purposely kept dull; and it is not easy for the eye to focus the two sights which are near at hand and the distant target at the same instant; hence various plans have been suggested; in a French tangent sight the notch is replaced by a sort of crescent, which allows the target to be well in view between its pointed horns; in our Service rifles the notch has been given up, and a straight-edged back sight provided with a vertical line on it is used instead; a somewhat similar plan is adopted in the naval 6-inch B.L. gun, in which the tangent sight is provided with a straight horizontal wire; a vertical pointer below indicates where the notch would have been; this arrangement allows the target to be well in view.

Endeavours have been made with the 12-pr. B.L. and 2.5-inch jointed gun to avoid the effects of glare and the focussing difficulties, by the use of cross-wires in a hooded fore sight and a pin-hole in the tangent sight (Fig. 7 (b)), the last arrangement being on the principle of the orthoptic sight used with rifles; the cross-wires being in a tunnel or hood, are always in the shade, glare is thus avoided, as they are well protected they are not liable to be broken, and if they are they can readily be replaced, and the target is but little hidden by them. The pin-hole enables the fore sight and the target to be sharply focussed by the eye at the same instant, on the principle of the small stop used by a photographer when he wishes to focus a near and a distant object at the same time, and it is easy to make the intersection of the cross-wires in the fore sight cover the desired spot on the target. As only a small field is taken in by the pin-hole, it is necessary first of all to use the ordinary sights for rough laying, on the principle of the finder attached to large astronomical telescopes, but this is readily done when time for

accurate laying is allowable. An orthoptic disc,¹ similar to that employed for rifle shooting, is used in Major Owen Hay's battery of 16-prs., which only have the old pattern sights.

A simple illustration of the principle involved may be made thus: shut one eye, look at any distant object with the other, and hold up a hand so that the top of finger is in the same line, bring the finger so close that it cannot be seen distinctly at the same instant as the distant object; now take a card with a small pin-hole in it, and look through it at the distant object and at the finger, which should not have been moved; though not so bright as before, both objects may now be seen with distinctness at the same instant, proving that the eye can focus both together by this arrangement.

When the wheels of a field gun are at a different level, one sight is more turned sideways than the other, and the projectile will fall to the side of the lowest wheel unless suitable allowance is made, dependent on a somewhat troublesome calculation. The same effect has been caused in the jointed 2.5-inch mountain gun when the junction nut has been over-screwed. In the 12-pr. B.L. Major Scott's revolving sight (Fig. 8) automatically obviates the necessity for calculating this correction, as a small screw at the side will always restore the sight to its proper inclination as indicated by an attached cross spirit level; Scott's sight has given good results, it is to be largely supplied to field guns in England, and a high authority has applied that they should be fitted to every battery sent to India. A new reciprocating sight on the same principle has been made for the 2.5-inch gun; in this case the sight bracket revolves, and is levelled by a cross level. Lateral errors of fire, noted by the observation of the effect of rounds, can also be corrected without calculation by these sights.

Deflection is not generally given for the drift of rifled projectiles, but the tangent scale is put in at an incline laterally to give an average allowance for its effects, but at long ranges it will be necessary to give further correction by the deflection leaf. No good rule exists for the necessary correction to be given for cross wind; the formulæ are complicated and not very satisfactory. It would be well to have a good wind-gauge at coast forts, as although the wind will not probably always be the same down the range as at the firing point, a wind-gauge will be more accurate than mere guess work. Mr. Brodigan, of Dublin, is constructing a sight to take the wind and other causes for deflection into account in a systematic manner without calculation, and it may become practically useful; these matters connected with deflection have not hitherto attracted much attention, as it is generally easy to correct after one round; getting the range, on the other hand, is much more difficult by observation of a round from the firing point on account of fore-shortening due to perspective. When firing, however, at a rapidly moving ship, the deflection must be carefully attended to, and it is not easy to correct for the next round from observation, as the

¹ Made by Mr. J. H. Steward, Optician, 406, Strand, London.

range and conditions vary. An effort has been made to obtain the deflection automatically in the naval "speed sights;" in any case, however, it seems important that the deflection should be given as correctly as possible for the first round.

Considerable progress has been made in the methods of laying at sieges; reflecting sights are employed, so that the No. 1 may be under cover whilst laying, and various devices have been adopted, chief among which may be mentioned Colonel French's sights, which are employed for firing at hidden targets, when the shooting should be corrected by signals from a flanking party who can see the results of the fire.

Telescopic sights have been advocated for many years, though they have generally been objected to on the score of liability to get out of order, but Scott's over-balance telescopic sight (Fig. 9) on the same principle of adjustment with a cross level as his other sight, has been tried in horse and field artillery batteries with very satisfactory results, giving greatly increased accuracy of fire. An objection to it is that it will be damaged if accidentally left on the piece when fired; but the guns are also provided with sets of ordinary sights as usual. The telescopic sight will probably be indispensable for those heavier guns which are laid by their own sights; accurate fire is much needed for them, and the sights will be less liable to damage than when constantly carried about by mounted artillery. Several Officers object to the fact that in the present construction of Scott's telescopic sight the V's bearing the pivots are too close together (Fig. 9 (b)) so that any grit or burr upon one of them will have a great effect on the sight, whereas a burr of the same size will have a less effect on the ordinary sights, as they are placed at a much greater distance from each other. There is doubtless ground for this objection, since in the astronomical transit instrument, which is also mounted on pivots resting in V's, it is well known that accuracy is obtained by putting the V's as far apart as possible and making them of considerable diameter; Scott's telescopic sight is, however, no doubt a most useful and practical one.

With regard to a telescopic sight for a machine-gun at a siege, General Gordon wrote in his diary 4th December, 1884, only a few days before the end of the siege of Khartoum, "With a good mitrailleuse and a sharp operator *with telescopic sight* no gun could be served with impunity at 2,000 yards range, though it could be served against artillery fire, for at that range there is plenty of time to dodge under cover after seeing the flash ere the shell arrives."

A minor use of a telescopic sight has been noticed by Major Marshall, R.H.A., when it is used for instructional purposes. A man lays a gun with the ordinary sight, as he thinks correctly, but when he looks through the telescope he himself finds he has made some error; he would not of necessity have been convinced of his mistake if he had been simply told so by an instructor, hence more interest is awakened and the ordinary sights are used with greater care; this leads us to the next heading of—

4. Training.

Almost any man can be trained to lay a gun with fair accuracy at a fixed target, but only a few can do so with rapidity, and the necessary facility can only be maintained by constant practice. Aiming drill is apt to become monotonous, and if a man once loses interest in his work he will not make much progress; hence every effort should be made to interest the men in aiming, on account of its great importance. In this connection, I trust I may be allowed to mention that I had the honour of receiving a private letter a few days ago from General Sir Frederick Roberts, in which he laid stress on the necessity for devoting much time to training in laying guns, and he dwelt on the need of using sights handily and properly. Some of the aids to training in accurate laying are—

(1.) Recruits should have careful aiming and firing with carbines, as this accustoms the eye to using sights. I have myself had to teach gun drill to squads of infantry soldiers in India, and the readiness and accuracy with which the laying was performed was remarkable. This was doubtless due to their previous musketry instruction.

(2.) The instructional target is useful; rivalry and interest may be kept up if the time for each man to adjust the small target three times is taken for a measure of his rapidity in laying, and the size of the corresponding triangle is systematically recorded as a test for his accuracy. A small instructional target may also be employed (as in A/A R.H.A.) to denote the position of burst of a shell; if it is placed much to one side of the target, training can be given in finding the necessary amount of deflection.

(3.) The rifle barrel attachment to a gun on the principle of Morris's tube gives variety and interest. Aim is taken with the ordinary sights of the gun at a distant object, and the rifle barrel is fired: some part of a near target will then be struck; if the aim has been good the bullet will strike an indicated mark upon it. The advantage of this plan is that direct evidence is given of the accuracy of aim by the striking of the bullets; it is a cheap substitute for the actual firing of the guns themselves; according to the testimony of Sir Frederick Roberts, Morris' tubes have worked wonders in training infantry soldiers in rifle shooting; doubtless some adaptation of the same sort to guns cannot fail to be of advantage to gunners, from the mere fact that it will induce men to lay accurately, and to use their sights intelligently. (Mr. Morris then exhibited his apparatus, explained it, and fired a small bullet from a tube such as would be fitted in a 5-inch B.L. gun at a target through an open door in an adjoining room.)

(4.) The use of good guns and matériel greatly encourages all to take an interest in shooting; on the other hand, Officers of batteries of the older guns sometimes find it difficult to interest their men when they know that their pieces are not the best.

(5.) The system of giving prizes for good shooting at the annual practice adds to the interest of the men, but it decreases the amount of ammunition available for the battery practice; the competitive

practice might perhaps be carried out with smaller guns and cheaper ammunition than at present; this would enable more rounds to be devoted to the regular practice of the battery.

(6.) The more practice there is with the guns themselves the better. The number of rounds of heavy guns fired in the garrison artillery is small—much less than in the Royal Navy; those who have had considerable experience in firing are the foremost to acknowledge its great use in training; thus a well-known gunnery Officer in the Royal Navy, Commander May, now commanding H.M.S. "Condor," writes in a letter just received from Malta, "Practice! Practice! Practice! actual shooting is the real thing, with an *accurate* record of results." The advantage of constant actual practice is well shown by the fact that the Officers in charge of experiments at Shoeburyness have always been splendid shots, due doubtless in great measure to their experience in laying and firing; a *large* floating target is now employed in the Royal Navy and only hits are scored, formerly a smaller target was used, but it was thought that sometimes rather too favourable estimates were made of the distances over or short of those rounds which did not hit.

(7.) It need hardly be said that the interest in shooting of a battery, and its efficiency and accuracy of fire, depend upon its Officers. Might not some valued recognition of shooting be instituted? Say a challenge trophy to be held annually by the best shooting battery which has made the most intelligent use of its fire, the trophy to be kept in the Officers' mess till another battery wins in a succeeding year; it might be held alternately, one year by field or horse, and the next year by garrison artillery; it is generally found that when any award depends upon the result of an exercise that it is carried out more thoroughly and with more exactness than when little notice is taken of the result; witness the care bestowed on the training for the annual competition at the military tournament.

(8.) Accuracy can only be attained by a careful attention to such matters as uniformity in the weights of the charges and projectiles. This point demands attention with filled shell; with M.L. guns care must be taken that all projectiles are rammed to the same distance.

Constant firing practice at one fixed target is uninstructional. After the range has been found and verified, only a small group should be fired; another target should then be selected, and its range should be found and tested. Practice at moving targets is most necessary in the garrison artillery, and steam launches should be employed to tug a target at high speed in a tideway; this firing is difficult, and Officers, both in the Royal Navy and in the Royal Artillery, who have devoted much attention to it are the most ready to acknowledge that great skill is required. Some plan or general idea should be formed when battery practice is carried out; it will give interest to it, and will be suggestive of what may occur on active service; for instance, in the garrison artillery so many guns should be told off to hit targets towed at speed, representing an enemy's ships trying to run the gauntlet, a gun or so in the fort should be put out

of action on the supposition that it is struck by an enemy's shell, and several of the men might be withdrawn during the exercise under the idea that they are wounded; the firing should, however, be carried on accurately, and without confusion or delay.

Coming now to larger questions of training, considerable advance has been made of late years. Formerly India had an advantage over England in having land ranges available at most stations for horse, field, and garrison artillery, while it was often difficult to find a suitable range at a home station; but of late years excellent arrangements have been made at the practice camps at Hay and Okehampton, where special attention is devoted to the development of accurate field artillery fire. Twelve batteries of horse and field artillery will carry out their full practice at those camps this year, and it is believed that Officers will be attached from other batteries for instruction. A portion of the garrison artillery has during the past few years had valuable training for a few weeks each year at Chatham in siege works and practical firing at Lydd; six batteries will take part this year. The progress in firing garrison guns from coast forts, however, has not been great; but progress will probably soon be made when the Watkin range- and position-finders are generally used. Shoeburyness, excellent as it is, does not fulfil all the requirements of the garrison artillery, for it is a place devoted to experiments in matériel, and endeavours are made to teach *all* artillery drills and exercises there, so that the special duties of the batteries of garrison artillery do not receive very full attention, nor can they in a place which is not a fort, and which is not a part of the regular system of the coast defence of a harbour or estuary. Colonel Lyons, R.A., has suggested the formation of a summer camp, which seems very desirable, for the garrison artillery, at the western forts, Isle of Wight, to which garrison batteries might be sent in turn for organized practice, on the system of the present camps at Hay, Okehampton, and Lydd; the garrison artillery would then have the opportunity of firing at targets moving in a rapid tideway from forts which form part of the defence of the Solent, and valuable training could be carried out in the combined action of several forts under one Commanding Officer, and the organization could be tested. Coast defence has attracted much attention of late, and the need for the combined action of artillery, submarine mines, and torpedo-boats is now apparent; it is believed that combined practice will take place this year from several batteries at Devonport.

The efficient and accurate working of heavy guns has also been thought out by Colonel Oldfield, R.A., when in command of the Royal Artillery at Malta; he caused a book to be compiled for each district, showing the position of the magazines, number of rounds for each piece, bearing of the guns, support afforded by the fire of neighbouring works, &c.; he also insisted on arranging all the store-rooms on the same plan, so that any R.A. Officer in Malta would know where to find anything on first entering a fresh fort: at a time when local knowledge is insisted on as a desideratum in Officers engaged in coast

defence, it seems advisable to simplify and classify as clearly as possible all the arrangements of the forts themselves.

5. *Corrections of Fire from Observation of the Effects of Previous Rounds.*

Telescopes or field-glasses are indispensable for making good artillery practice, except at the shorter and decisive ranges. General Gordon remarked in his diary, "Certainly every fortified place ought to be provided with a hundred good telescopes." The eye should be trained to observe, and the mind to understand the meaning of various often minute distant appearances after firing; thus the practised artilleryman knows that a cloud of smoke from a bursting shell on impact hiding any part of his target, indicates that a shell has burst short (Fig. 10), and when firing at an escarp wall hidden by a covering glacis, if a flattened cloud of smoke slowly rises and fragments of masonry are seen to fly into the air, he knows that the unseen wall has been hit low down.

The hiding of these indications from any cause will prevent an accurate fire from being attained; for instance, when firing from machine-guns at a long range at the bombardment of Alexandria, the splashes of the bullets could not be distinguished in the broken water near the shore, and there was no means of knowing whether the correct range had been obtained. Again, if a target is on the top of a hill (Fig. 17) the cloud of smoke of a trial shell may easily be hidden if it falls into the valley on either side of it, and it is then most difficult to correct the elevation.

It is evident that difficulties may arise with trial shots, and this is more particularly the case at the longer ranges, when the result of firing can hardly be seen; this has led to the adoption of flanking parties when possible, pushed well forward to some position where the result of the firing can be seen and signalled to those at the guns; this is absolutely necessary at sieges when the object fired at will often be invisible from the firing point, and cases will arise on field service when it can be advantageously employed.

The following is the approved method of finding the range by trial shots:—First estimate the range, and then fire a shell with 200 or 300 yards less elevation with percussion fuze to burst on impact and a little to windward of the line of fire, so that the smoke of the bursting shell may be blown across the range; if, as is expected, the shell strikes and bursts short, as indicated by the smoke of the shell obscuring the target (Fig. 10), fire the next round also with a percussion fuze with say 400 yards more elevation—a bold difference from the previous round; obtain a burst *over* as indicated by the target standing out of a background of smoke produced on the bursting of the shell (Fig. 11); then, in imagination, construct a zone to include the target, the outer lines being at right angles to the line of fire and at the distances of the points of impact of the two shells from the gun (Fig. 12). As the difference of elevation for the two rounds corresponded to 400 yards, it may be assumed that the zone is about 400

yards wide; consider by estimation, having regard to perspective and the lie of the ground, the position of the target with relation to the two sides of the zone, we will suppose it is judged to be at a relative distance of 1 from the further burst and 3 from the nearer one; this would mean that the first shell was 300 yards short, and the second one was 100 yards over. A third shell should be fired (Fig. 12), but the firing should also be tested by others with percussion fuzes if possible; shrapnel shell with time-fuzes may then be fired to burst in the air, but it is generally useless to begin with shrapnel and time-fuzes, as a shell which appears to burst in the air short of the target may really be a long way beyond it (Fig. 16). However, under the conditions of a very short range or when firing over water or hard ground, when the splashes or dust raised by the bullets and fragments of a shell can be seen, the firing can be corrected from observation of shrapnel with time-fuzes (Figs. 13, 14, and 15, each of which represents the target as seen from the gun, and also from the position of the range party). Colonel Nicholson, R.A., Commandant of the School of Gunnery, Shoeburyness, has studied shrapnel shell fire in a most practical manner, and has recorded the results. As previously noted, increase of velocity in modern guns increases the efficiency of shrapnel to a great extent, but the adjustment of the time-fuze, which is always a troublesome matter, is rendered rather less accurate.

A broad question of tactics comes before us, as to whether horse and field artillery should advance to a comparatively short range before beginning to fire, or whether they should commence at a longer distance. Some Officers advocate the shorter range from the success of the bold measures taken by the German artillery in their war with France, but a blind following of the letter of that which led to success in the past is not always wise, particularly as in the case before us accuracy of fire has increased with the adoption of range-finding and high-velocity guns, and the efficiency of infantry fire will increase with the general adoption of small-bores and magazine rifles. Of course the artillery should be brought up and employed at the very beginning of an action, and towards the decisive periods of the fight they must engage at a short range; but the question is, at what range should they generally begin to open fire? This paper does not, however, propose to go into field artillery tactics—but this question comes up, because if field guns are *never* to fire at a long range it is of no use to teach the men to fire in that manner. Long-range artillery fire has always the advantage that it can be carried on with deliberation, and it can be employed out of range of infantry and machine-gun fire, but unless conducted with great care it leads to waste of ammunition, and in many cases when folds of the ground intervene and the effects of fire cannot be noted (Fig. 17), it will be very difficult to attain satisfactory results. Over the sea, however, from coast batteries it is probable that very long ranges will be employed, for a very accurate range-finder can be used from a carefully prepared position, and the splash in the level water, which can generally be seen, indicates whether the shell has struck over or

short. Ships will also probably fire at fairly long ranges, being then beyond the range of torpedo action.

Provision is made to indicate the necessary alterations in the elevation, to alter the range, or change the height of impact on a vertical target at any range in the more modern range tables (see Table B); and it is fully recognized that range tables are not infallible, but are only to be regarded as indications or guides, as the conditions of fire may differ from those under which the data were obtained for their compilation; for instance, if a range is known to be 1,500 yards, and the elevation is given correctly according to the table, if several projectiles average 120 yards over, it would be folly not to lessen the elevation and also to make a corresponding deduction at all other ranges, because it is evident that the powder is stronger than is expected, or some other cause is at work to increase the range.

The subject of accuracy of artillery fire is a wide one, but I believe the points most needing attention are the following:—The immediate introduction of new type high-velocity field guns, one of them to throw a heavy projectile, and the rapid withdrawal of the present 9- and 16-pr. R.M.L. guns; sustained training in range-finding for both field and coast firing; further improvements in sights; the use of the rifle attachment to train in aiming; further organization in the firing of the garrison artillery, especially at moving targets; more rounds to be fired annually by them; and the establishment of an annual practice for the combined action of garrison artillery with submarine mining and torpedo-boats in the defence of a harbour or estuary; further development of the system of observing and signalling the result of fire from advanced flanking parties to the firing point; and the establishment of a valued challenge trophy to be held annually by the battery which makes the most intelligent use of its annual allowance of ammunition.

The CHAIRMAN (General Goodenough, R.A.): I may state that His Royal Highness the Duke of Cambridge expressed his intention of being present at the lecture this afternoon, but I received, just before the lecture began, a letter from his Aide-de-Camp, stating that he was unable to come. I am sure you will be glad to know that His Royal Highness was so kind as to have been desirous of coming if he possibly could. We have had a very interesting lecture from Major Mackinlay, and I now call upon gentlemen who have any remarks to make on the subject of the lecture to give us their opinions. The questions of artillery fire and inventions appertaining to sights are very much common property, and I have observed in my experience that a vast number of people take an interest in them; in fact, I think, the Italian saying is very applicable, "Auch' io son pittore!" Therefore I expect we shall have many gentlemen who will wish to make observations on the lecture.

Major ORDE BROWNE: I believe that firing has been carried on at targets representing ships in motion automatically, on Major Watkin's system, by tracing the course of the ship on a diagram, and laying on a point in the production of the line that is in advance of the ship. I was curious to know whether we could have any relative statistics as to such firing automatically and firing by judgment; also whether we could have any statistics as to the measure of accuracy that can be got with rapid machine-firing guns.

Major WATKIN: In answer to Major Orde Browne's enquiry I may state that

there have been two practical trials of the system within the last year at a towed target, both of which have been very successful. At the first practice the target was hit five times out of eleven rounds with the 10-inch R.M.L. gun, and this by what is called predicted firing. As the instrument traces the course of the vessel, it is easy to predict her position sufficiently in advance to allow ample time to the gunner to carefully lay the guns. Position-finding is being gradually applied to our forts as means are available.

Lieutenant-Colonel HUGHES, 2nd Kent Artillery Volunteers: I was desirous to mention the practice at stations where Volunteers undergo their annual practice of firing with reduced charges. My brigade practised, and we were firing at about 1,800 yards actually, but we had to use the sights for about 300 yards in excess, because we were firing with reduced charges. I should like to say I do not think that a kind of practice which is as good as if we were firing with the proper charge. It may save a little, no doubt, as far as powder is concerned, but for actual experience it is not so good. As of course we shall fire under other circumstances with proper charges, I might say, for the information of those who have an opportunity of correcting these things, that I think we ought to practise with the same ammunition we should be required to fire with if we were engaged in actual warfare, otherwise I think our experience, to a great extent, is thrown away. I have been greatly interested in the lecture, and I think I understand it, but the point with regard to firing at moving objects has always been a great difficulty. The difficulty which we have had to contend with many years ago, right up to the present, is allowing for the time of the flight of the projectile; there does not appear to me any other way now than by allowing for it by aiming in front of the object, or by putting on a sufficient quantity of deflection to cover the length of time. The tendency of a rifle-shot to go to the right is arranged for by the tangent scale inclining to the left. On the Armstrong and other rifled guns, certainly, I wanted to submit to the lecturer whether the time of flight could not be arranged for on the same system of an inclined tangent scale. Of course it would vary in reference to the speed at which the moving object was going, but still if you had a sight so arranged on the system that the speed would be twelve miles an hour it would help. It would be much better to be able to fire a gun when you were actually laying it on the object itself than laying it so much in advance of the object, and thereby perhaps lessening the accuracy of the range. I have noticed with regard to all our tangent sights on guns that they have not sufficient length of deflection-bar to allow for all these things. You get a degree, in some cases only half a degree, on the deflection bar, but if you have to allow for wind, for time of flight, the moving object, and the distance that it will get during the time of flight of the shot, you have not a sufficient number of degrees or minutes on the deflection-bar to allow for all that. The result is you have to go into guesswork, and the accuracy of the fire is very much lessened. I put these in the form of questions, because I really myself, although I have some ideas on the subject, should like those more experienced to solve that problem, which has already been alluded to, in referring to speed sights, but it has not been said which is the best plan. With regard to the Watkin's depression range-finder, I have seen it at Sheerness, and I entertain a very high opinion of it. If the inventor be present, as I am told that he is, I congratulate him indeed upon having perfected a very splendid instrument; but it requires watching, and that those who use it should know how to set it right before they start with the two cross spirit levels. Another thing is that it should be firmly set in the bed, and that the bed itself should be previously prepared, so that when you get the training on the plate, which you do get from the depression range-finder, that training may be coincident with the training required for the gun for which it is supposed to be used. At Sheerness, having given from the instrument the arc training for the gun, in order to lay it on a particular object which the glass pointed at, on going down to examine it I found that the gun had been laid three degrees differently. Somebody had gone down and told them that the red buoy was what we wanted to get, and they all laid it on the red buoy, disregarding the arc training from the Watkin's finder, and it was ultimately found that the bed on which the zero of the Watkin range-finder had been laid was at least three degrees different to

the zero of the arc training of the gun which was underneath. That should not have been. It was said that the engineers had improperly placed the stone bed on which the instrument was fixed, which shows, to my mind, that the relative accuracy of the range-finder and the gun is not often examined to see whether they really are in accord, and of course it all depends upon that. It should not only be examined when the instrument is first fixed, but also frequently afterwards, to see that it does not get out of order, or that there is not anything altered in any shape or form. I mention this specially, as the inventor of the instrument is here, because any error with regard to firing might have been laid to the fault of the instrument, when, in reality, it was the fault of the application of the instrument.

The CHAIRMAN: With reference to one remark made by Colonel Hughes I think I might give an explanation. His statement about the reduced charge would seem so extraordinary to some people that perhaps it may be worth while at once to endeavour to put it right. I would ask him whether he was made aware at the time in question that the term "reduced charge" was a new term in the nomenclature introduced; that it does not imply that the charge is not a service charge, but it simply is a new name for an old thing. Formerly we used to have two charges for the heavier armour-piercing guns, designed to penetrate armour-clad vessels. They were called the "battering charge" and the "full charge." In course of time it came to be considered as rather ridiculous that the "full charge" was not the full, that is to say that it was not the larger charge of the two: the "battering charge" was the larger. The terms were therefore altered, and they are now called "full" and "reduced," and those names are now printed upon the tangent scale. It is just possible that this being a new thing might not have been fully represented to Colonel Hughes, and he might have gone away with the impression that they were firing a charge less than the service charge, which I hardly think can have been the case.

Colonel HUGHES: It is a fact that we were firing at 1,800 yards with a 2,100 yards' sight, because the charge was less than the service charge, and it was so reduced, as I understand, to save expense.

The CHAIRMAN: I was not aware of that fact.

Colonel SCOTT, R.A.: The lecturer talked about horse and field artillery having a "fair" amount of ammunition for practice. I do not consider the amount we at present get as being quite fair, and if you will allow me I will presently tell you why. I agree that it would be very desirable to establish some method of commending such battery or batteries as achieved the best practice. In India, I understand, the result of shooting is made public each year; at home it is not, and many Majors often complain that they do not know whether they are considered to have fired well or not, or whether the Adjutants-General or other authorities were satisfied, which of course it would be very desirable that they should know. There are many reasons why the matter is much more easily done in India. First of all, the whole of the horse and field artillery are armed with the same gun, the 9-pounder; and, secondly, the batteries have all, I believe, the same quantity of ammunition each year; thirdly, the batteries are all of six guns; and, fourthly, the weather is nearly always fine. At home we have six-gun batteries and four-gun batteries. There are four different guns in use, and the batteries have different scales of ammunition, consequent on (1) whether for triennial or ordinary practice, and (2) whether possessing four or six guns. I am speaking solely, of course, of horse and field artillery; there is no doubt that batteries cannot be made to shoot without a *good* amount of ammunition, not a *fair* amount—a really *good* amount; and I think the quantity at present allotted, even for the triennial practice, can only be called *fair*. It is for a six-gun battery 510 rounds, but from that has to be deducted 60 rounds for the ten selected competitors, and six for their trial shots, or $510 - 66 = 444$ rounds, whilst a four-gun battery in a non-triennial year has only 60 rounds altogether, or deducting the amount required for their eight competitors, viz., $48 + 6 = 54$, only 26 rounds for the whole of the rest of the battery of sixty men, so that you may say that such a battery has virtually no practice at all. Before triennial practice was introduced there used to be 300 rounds annually, and there were no competitors to cause any deduction. I happened to be one of the first to go to Hay in 1876 in command of my battery B/1 R.A. The late Colonel Fox Strangways was

the Commandant. That was the first practice camp. I remember pointing out to Colonel Strangways at the time that we should lose a considerable amount of ammunition by the new triennial system. We had before 300 rounds in each of three years, that is 900 rounds; now we have 441 in the triennial year, and 54 only in each of the other two years,¹ being equal to 552, making the total loss in three years 348, which is a most considerable one. Colonel Strangways said to me at the time, "Let us establish the principle, and more ammunition will undoubtedly follow; if we ask for too much at first we shall get nothing. You may rely upon me to advocate more ammunition when the system has made its mark and the beneficial results have been fully appreciated." I maintain that the shooting at the close of a triennial year's practice has most materially improved, but that the interval is too long between what we may call the "service practices." Unfortunately for us all, the originator and advocate of this step in the right direction has passed away from amongst us, and therefore it is the duty of those who remain to do their utmost to obtain a sufficiency of ammunition to ensure their men being properly trained to shoot. How would a rifleman keep up his proficiency if he had only ammunition once in three years? When opportunity has offered I have advocated the issue of further supplies. A very few thousand pounds would, I fancy, be all that would be required, and if horse and field artillery are to be kept up at all, it would seem worth while to maintain them in a condition to shoot with effect when called upon, especially as now there are fewer guns. Some of the money saved by the reduction of guns might advantageously be expended in providing more ammunition for those that remain. Campaigns now-a-days are short and sweet, and there is no going into winter quarters and pulling yourself together and preparing for the next. Again, since triennial practice was introduced the period of service has been reduced from twelve to seven years, so that a gunner (unless he chancies to be a competitor) has only an opportunity of firing some 21 rounds in his service. On a previous occasion I have advocated the additional supply of ammunition as follows:—For the triennial year 600 rounds, including ammunition for competition, and for the other two years 200 rounds each, making the total in three years 1,000 rounds. On thinking this over since I have, however, come to the conclusion that a biennial practice would be better, and no practice at all on the "off year," except for the recruits and competitors, who could be removed if necessary by rail to Shoeburyness or other suitable place. I should then advocate the following practice:—Ammunition: for the first, third, and fifth years 666 rounds; for the second, fourth, and sixth years, for competitors only, 66 rounds, making the total in six years 2,196 rounds. That is only an increase (over the old system of 300 rounds annually) of 396 rounds, or, to put it in another way, *the same amount as formerly* + ammunition for the ten competitors. I think the few rounds now given on "off years" are virtually useless, also that 12 case-shot are more than enough to show the men the effect; one per gun would be ample, and thus supplement a little the other ammunition. I think a recruit should have at least six rounds, the same as a competitor, to test his capabilities. I do not see how a recruit can learn to handle the two different sorts of ammunition unless he has them. It is marvellous how batteries at Hay and Okhampton improve in their shooting after a time, and the practice in driving and getting quickly into and out of action, &c., is worth anything. At first the tendency is to be slow in firing, doubtless from over-anxiety to make good practice; but as a rule the batteries that fire quickest also shoot the best. I have been five years at the Okhampton and Hay camps, and have had a good opportunity of observing this. When I speak of slow firing I refer entirely to service practice under the Commandant's own direction. Of course elementary practice is necessarily slow and deliberate. Coming to the proposal in the lecture, I am of opinion, on the whole, that as matters stand, namely, with first, triennial practice, secondly, with so many different sorts of guns in the Service, and, thirdly, with an insufficiency of ammunition, especially on off years, that it is undesirable at present to attempt to compare the shooting of the batteries, but that when these objections are overcome it would be very desirable to have two challenge cups or

¹ Deducting the amount required for competitors.

trophies for horse and field artillery, one for batteries armed with the 12-pr. B.L., and the other for those having the 13-pr. M.L. I take it for granted that these two guns will be some time yet in the Service; also, if it can be arranged, for the garrison artillery at home to fire a fair proportion of their ammunition from one and the same sort of gun, a similar cup or trophy should be provided for them. Of course, in each case programmes would have to be laid down by the D.A.G.R.A., as to placing and firing at certain targets, and in the case of horse and field artillery the competition might perhaps extend over two years, supposing my idea of biennial practice were introduced, or it might be awarded annually to such batteries as had practised. In the latter case no battery would have a chance of winning on two consecutive years, which would be a pity, as I think any battery winning three times in succession should retain the trophy. Batteries would have to take their chance of weather, as the time in camps is limited, and as long as it is fairly fine practice must go on; besides which, it is an advantage to fire as on service in various states of the atmosphere. There is another advantage in using a good amount of ammunition at practice, namely, to prevent any stores getting too old to be reliable, which is now often the case. I think it was last year or the year before that one battery had time-fuzes to fire, the date of manufacture ranging over as many as ten years, and it was impossible for the Officer commanding the battery to know what he was about with his fuzes, some burnt so very much longer than others. If the fuzes, owing to age, cannot be depended upon, the gunners are apt to lose all confidence in them. I think if a practice ground near Aldershot could be found, say on Chobham Ridges or Common, it would be a very great advantage, so that the Aldershot Batteries could shoot there. It is most inconvenient sending them away in the thick of the drill season, as they lose the advantage of the combined operations carried on at that time of the year, whereas if there were a range near, half of the batteries for practice could shoot in May before the big field days commenced, and the rest in August after the season is over. Land ranges in Ireland are much needed.

General SUTTON, R.A.: I have, for the most part, only concurrence to express with regard to the statements and prescriptions of the lecturer. I should, however, like the last speaker, have been glad if he had proposed additional practice for the field artillery as well as for the garrison. I well remember how our dear friend Colonel Strangways hoped that after we had made a beginning with triennial practice camps, and shown what satisfactory results they afforded, we must shortly succeed in getting annual ones. Since that time, I have been under the impression that one of the first batteries that went into our triennial practice camps was Major Borradaile's, which so shortly afterwards had the opportunity of convincing Lord Wolseley, and also the Egyptian Army, of the superiority of our current artillery practice. I always have taken that rather as a consolation for the loss of practice for two years, that we thus evidently made a really good thing of the third year. This rate of provision did very well for the Egyptian War, but of course if we come to a larger war we shall not have enough batteries prepared for it on the triennial system. With the whole of the remaining prescriptions of the lecturer I likewise concur, but I have to object most absolutely to one of his diagrams. I am sorry to see an old friend (or enemy) of mine up there on the wall, entitled "Results of Practice, under Service Conditions, and with a Position-finder" (Fig. 6). Now it is well that the point should be brought out, as so many enquiries are asked about firing on ships in motion, and especially with this beautiful instrument, the position-finder; but that diagram, I will undertake to convince anybody by a simple reference to the official record, should not be headed "results," but rather "extracts" or "selections"; inasmuch as the practice really included nearly twice the number of rounds there shown. I also object to the title for its misapplication of the term "Service conditions." In the two series thus referred to, the ranges were guessed independently by non-commissioned Officers, which is not a Service condition with heavy guns; moreover, during one of these series, the target was practically invisible most of the time, being laid over by the strength of the tide, but the guns were fired at objects mistaken for it, sometimes here and sometimes there; in the other, the view of the target was only intermittent, being constantly cut off by large masses of smoke made by blank firing from adjacent guns. I have also to remark that the red

spots are beautifully grouped there about the target; they almost look to the casual observer as if they were all hits; but there were no hits made during the whole practice; and that is what we can very rarely say of any practice, whether with the aid of the new machines or without it. Inasmuch as the talk is now of the impossibility of adequately training the men to the use of the complicated machines which heavy guns have come to be, and as here was an instrument devised which almost seemed to do away with the necessity of training the gunners, I think it well to remind you that you must not found your expectations on that diagram. Let us rather base our calculations always, if possible, on the authentic records of actual practice. I wish absolutely to absolve the lecturer from the slightest imputation of having prepared the diagram himself, but wherever I meet it—and I have seen it years ago—I know it to be fallacious.

Mr G. F. LOWE: Mr. Chairman and gentlemen, during the Crimean War Colonel Davidson, an Officer of the Indian Army, perfected a system of telescopic sights for cannon and for night firing. A series of experiments were tried at Woolwich, and a number of these telescopic sights were made and purchased by the Government, but the operations were brought to a close in consequence of the peace, and apparently matters rested *in statu quo* for many years, until the question was taken up by Major Scott. Colonel Davidson used telescopic sights on sporting rifles in India for game shooting as long ago as 1834, and this last autumn, at the age of 76, he bowled over stags on the moor in Scotland with one of his favourite weapons. The principle which he introduced is applicable apparently to sporting rifles, military rifles, machine-guns, and big guns, and there is a general improvement in the standard of accuracy all round if the telescope is used. An article was published in the year 1864, which appears in the Journal of this Institution, in which a description is given of a telescopic sight as applicable to military rifles adjustable to various distances. One hundred military rifles were made by Whitworth, and fitted with telescopes of this pattern, ran the blockade and were distributed to the picked marksmen in the Confederate Army, and I have here a letter which was written in July, 1863, by a Confederate marksman who carried one of these rifles through the whole of the war, and he describes the marvellous practice that was made. I also have a letter, which recently appeared in "The Rifle," an American paper, published at Boston by a Staff Officer of the Confederate Army. He said, "I recollect that General Cleburn was greatly pleased with the work of these sharpshooters, and spoke himself of witnessing through his field-glass the unhorsing of a mounted man at 1,500 yards." Numerous instances occurred during the war of the marvellous power which telescopic sights gave to individual firing. A squad of skilled marksmen with telescopic rifles were able to silence a battery and keep it silent for a long period, and when the battery was captured it was found that no less than fifty of the gunners had been hit in the head and shoulders by their fire. So much for the question of telescopic sights as regards military rifles. I will venture to read an extract from a letter which Colonel Davidson wrote me about a year ago. "In regard to telescopes for great guns I was also early in the field. I send you an account of my invention for laying guns and mortars for night-firing by means of a telescope and the collimator, and you will see that the same telescope that is used with the collimator is available for laying guns with direct fire. I have tried it on a gun at Woolwich, and in the presence of the late Major Vandeleur made splendid practice with it, he happening to require to fire a great many rounds to test the bushing of vents, and not wishing the shots to hit one another in the butt; a line of pegs was stuck in the butt, and we nipped them over at 300 yards with great precision." He also gives further details which I do not think I need trouble you with, and then says, "I remember when my telescope was tried at Woolwich, when the gunner was sighting with the open sight I was watching him with my telescopic one. I could see what a time he took, and how he dodged about before he was satisfied, while with the telescope it could be done in a moment and more accurately." He also told me he could lay the sights of a gun in one-third the time and ten times as accurately as a gunner could with the open sight. Another important point is that by means of the apparatus accurate firing can be carried on during the night or during the day if the smoke or fog is in the way by the use of an instrument called the collimator. The gun itself being fitted with a telescopic

sight, an auxiliary telescope is mounted in a box immediately in rear of the gun, beyond the recoil. The box is steadied by several cannon-balls, and is mounted on a pillar formed by a gabion or heap of stones, and the cross-hairs of this instrument are brought in a line with the cross-hairs of another telescope mounted on the gun, so that as long as the collimator remains in position the gun can be readjusted after every shot until the cross-hairs of the two telescopes again intersect one another, and firing can be carried on during the whole night just as accurately as during the day. I am glad to see that the gallant lecturer has also brought forward the suggestion made by poor General Gordon in his diary at Khartoum, that telescope sights are also available for use with machine-guns. I brought that forward myself about a year ago at Major Armit's lecture, and I trust we may see the use of these improved instruments in Her Majesty's Service, both for small arms, machine-guns, and great guns.

Lieutenant TUPPER, R.N.: I am afraid the Navy is in a very small minority here this afternoon. I have been waiting for some other naval Officer to get up and speak; but apparently none are willing to do so, I have therefore to intrude with a few remarks upon this very interesting subject. First, as regards matériel, I agree with Major Mackinlay in saying that the Navy much fear high-angle fire from howitzers. Of course that fear is much increased by the accurate range-finders possessed by the forts. Without those range-finders, the firing would not be likely to do much damage, because the 75 feet beam of the largest ship is rather a small target to hit, with a high angle of descent. The idea is mentioned in the lecture of anchoring your ship, whilst attacking forts, and also of having buoys placed to steam past at fixed distances from the fort. I do not think it would be possible to carry out either of these plans of attack. With the excellent range-finders now in use, the only chance would be for a ship to be constantly on the move whilst attacking a fort, so as to puzzle the range-finder as much as it could by constantly varying the range. It must be remembered that at Alexandria there were no range-finders in the forts, and the practice from the forts was not very good. Also with regard to matériel, I am rather an enemy of the great number of fuzes we now have in the Service. In the German Navy they have but one fuze, a percussion fuze, for every description of projectile in their Service, thus doing away with complications in supply. I always have thought the percussion fuze alone is the right fuze to adopt generally. As a Gunnery Lieutenant, I always find that it is very difficult to get the men to fit their time fuzes properly; and also in action, particularly on board ship, your range is so constantly altering, that by the time you have your shell fitted with the time fuze and rammed home you find the range has altered again, and if you have not that time fuze properly fitted there is at once a waste of ammunition; whereas with a percussion fuze it will burst when it hits the object; and for shrapnel shell, of course, you can burst your shell effectively by using 100 yards less range. As regards range-finding in the Navy, I do not think any instrument could be devised for accurate range-finding; it is only by constant practice and trial shots that you can get that range. I know from constantly firing outside Plymouth Breakwater, I got pretty well accustomed to all the changes of weather, light, and that sort of thing, and I became so accustomed to the different aspects of our targets at different distances that we very often shot away the target during the day's practice. As regards range-finding by trial shots for the Naval Service, it would not be a bad plan to have some special shells fitted for, say, the 6-pounder Q.F. gun, containing a very small bursting charge, a lot of phosphide of calcium, and a very sensitive percussion fuze, so that when the shell reached the water it would burst at first graze, the phosphide of calcium would rest on the sea, and would at once ignite. We can see the smoke from our life buoys at a distance of one or two miles easily through a glass. Of course with trial shots as now carried out, you seem to forget exactly where the splash has been; it dies away so soon, but if this phosphide of calcium were used, it would make a smoke and flame on the water for some minutes, and would thus give you some sort of idea where your trial shots had struck, and how far from the target it was. As regards sights, the 6-inch B.L. gun sight on the table is the sight originally brought out in the "Excellent," and generally called the "H" sight, it gives very good results. The fore-sight has a deflection leaf for the speed of the ship, which is a fixed quantity; the tangent sight has a deflection leaf for the speed of the enemy,

and the deflection due to wind across range. At the same time that that sight was tried, another kind was also tried, consisting of two circles, one on the fore-sight and one on the hind-sight, the circle on the hind-sight being the smaller of the two, and of such a size that at the extent of the tubelanyard one would exactly cover the other, when the sights were aligned for the object. This sight was very good for direction, but the men who used both concluded that the "H" sight was the better of the two. Since that we have gone in for night firing with electric sights. Lieutenant Hewett, late of the "Cambridge," was one of the first to bring them out. He sent them to the Admiralty, and I believe they are now being improved on board the "Vernon." To illuminate these sights there is a local battery on the gun-carriage, and there is a little coil of P.S. wire on your tangent sight, very similar to the carbon thread in the Swan lamp, and a similar coil on your fore-sight. No. 1 has a little key which he presses when he wants to illuminate his sights, and then you just have sufficient battery power to make the wires a dull red heat, so as not to make them too brilliant. Telescope sights have at present only been used in turrets and barbettes in the Service, but I hope before long to see them introduced more generally; they can be very easily fitted to all Vasseur mountings on the same principle as the automatic turret sight. As regards training, I feel sure that all Gunnery Lieutenants want to have a great deal more gunnery training practised in our fleets. I deplore deeply the great waste of time and money that continues to go on by keeping masts and sails in ships, in which they are ABSOLUTELY USELESS. The first thing one would do, on preparing for action, is to get them out, and send them on shore or throw them overboard, and I am sure a great many Gunnery Officers would agree with me in being very glad when we do really get rid of masts and sails in those ships, in which they are absolutely useless. Of course I am not referring to ships which depend upon sail, or in which sails help their propulsion. It is not only the time occupied by sail drill, but you lose all your time when you come into port; you are always refitting useless rigging, sails, &c., at the expense of your real fighting efficiency. Your gunnery drill, which ought to be constantly carried out, is sacrificed to hauling taut ropes, unbending sails, and refitting, and the cost of maintaining these relics of the past is enormous. There is an aiming apparatus in use in the Navy which might be worth the consideration of some artillery Officers. We have them on the "Cambridge" and the "Excellent." Instead of having an aiming disc moved by hand and stopped by word of command, as shown by the lecturer, it is stopped by a rather ingenious little arrangement of electro-magnets. No. 1 has an ordinary tube lanyard and tube, and as he fires the tube with the lanyard, he completes an electric circuit, which stops a little pencil that is revolving round a white disc. The pencil is pressed against the white disc by means of an electro-magnet acting behind it, and that shows the exact spot where that pencil was on the target when No. 1 fired. The application of electricity to this aiming target is better than when the disc is moved by hand. If any Officers wish to see this aiming target, I am quite sure that the Officers on board the "Excellent" and "Cambridge" would be very pleased to show the working of it. As regards tube cannons, we use them extensively in the Navy, and with very good results. The idea of practice from forts at moving targets I think a capital one, but I certainly hope they won't try to tow a moving target with a steam launch, because I should be very sorry to be in that steam launch. If you are to have a moving target you must tow it with a long scope of rope, and at a good speed. The only thing that would be of any use in my opinion would be a powerful tug-boat, towing a large raft, and on the raft a light framework and canvas in the shape of a boat, but the use of steam launches for this purpose is I think utterly inadequate.

Major DOUGLAS JONES, R.A.: I am very glad that the lecturer referred to the very inferior gun still in the possession of our mounted branches of artillery, for I feel that it cannot be dinned too often and too loudly into the ears of those who have to vote the money that our field artillery has for many years been armed with the worst gun in Europe, and although for a long time we have had a promise of receiving the "best gun in the world," it has not yet come to pass. All I can say is, "that hope deferred maketh the heart sick." What is the present state of affairs? We have no less than four patterns of guns in our field batteries. In case of war it is frightful to contemplate the confusion that would arise in supply-

ing those four descriptions of guns with the ammunition required, besides which most of our batteries would be unable to cope upon equal terms with the batteries brought against them by the enemy. With regard to the general suggestions made by the lecturer, I will only touch upon two. I do hope that the suggestion of the Morris tubes being attached to the guns may be introduced and a good deal of practice allowed with them, in addition to the annual practice, because the present number of rounds allowed is not nearly sufficient for efficient training. I also think his idea of a challenge trophy a most excellent one, and I hope it will be carried out. We have been told it would be difficult to do so on account of the different descriptions of guns in the Service, but still I think that difficulty might be overcome by a competent Committee who could decide upon the best use that has been made of the annual practice. I would, however, suggest that there should be one trophy for the mounted branches and one for the garrison artillery. There is only one more point I desire to remark upon, and that is one on which I do not agree with the lecturer. It is with regard to the warning against any blind following of the tactical employment of field artillery by the Germans in 1870. I am an advocate for the bold handling of guns in action and in intimate co-operation with infantry. It is as much a question of taking warning how not to do it from the way in which the Russian artillery was employed in 1877, as a question of following the example set by the Germans in 1870. The Russian artillery in 1877 failed utterly, except in a very few instances, as when under the direct supervision of that bold leader of men, the late General Skobelev, when the guns did good service. After all it is the infantry on which devolves the main fighting, and I am convinced that we shall never be able to support infantry effectively in action if we rely upon the results of our practice Returns obtained at long ranges with the new modern guns. In the din of battle, with the smoke of advancing infantry, and so on, we shall be unable to support them efficiently unless some of our batteries are close at hand. In the case of an attack, for instance, the infantry first advances rapidly, then there comes hesitation and a tendency to lie down and fire. The supports and even local reserves become absorbed in the firing line which is carried forward a little farther, but comes to a halt again, and the time may come when the attack wavers between success and failure. What a grand opportunity for a mobile battery, such as a battery of horse artillery, which should be at hand to move forward on the flank of the wavering infantry and pour a withering fire into the enemy, drawing on itself the fire of the enemy, and even sacrificing itself, if needs be, in order that the infantry may live to win the day.

Major WHITE, R.A.: The lecturer suggested that a challenge trophy should be started for good gunnery. Now, as I have the honour of conducting the School of Range-finding, I should much like to see a substantial prize given annually for the best range-finding. I wish someone would put his hand in his pocket and give us a nice prize; it would be a great encouragement, and instead of wrangling about the merits of rival instruments we should get some good field range-finding under Service conditions. There is another point I must refer to, though I am rather sorry to do so, because, for once in my life, I have the misfortune to differ from my honoured friend General Smyth, who was President of the Committee on Range-finders, when I was the Secretary. He has found great fault with the diagram representing a particular practice at a trial of the Watkin position-finder, at which we were both present with the rest of the Committee.¹ It is all an old story now, and a great deal has been done in position-finding since then, so that the matter is not of very much consequence, but I can only say that great pains were taken at the time to ensure a conclusive experiment, and as far as possible to imitate Service conditions. The smoke that General Smyth complained of is just what you will have when a fort is engaged, and as to non-commissioned officers laying the guns, why they are the very men who do lay guns in action. There are only two subalterns in a whole garrison battery, so clearly the Officers cannot be expected to lay each gun. I believe that all the members of the Committee, which

¹ I was not a member of the Committee till a month later, but was deputed to act as Secretary on the occasion.

included some very able and distinguished Officers, Royal Artillery and Royal Engineer, were well satisfied as to the accurate practice that was carried out by the aid of the position-finder. It is not the position-finder we are going to have now, but the principle is much the same, and I should be sorry that it should be imagined that the authorities were introducing a new system based upon an imperfect trial. I remember, however, we made a mistake. When the practice was over and the target *hors de combat*, someone said, "Fire at a buoy for a target." There were two buoys exactly alike, and a wrong message was wired down, the result being that one operator aimed at one buoy and the other operator at another, so that there was one very bad round—that I must own—but it was an accident not likely to recur.¹ I should like to say something on one other subject mooted—whether field artillery should come to close quarters or not. It is a point we often discuss at Aldershot. Of course one would always like to push up close, but for guns to get very near to infantry these days of good range-takers (that, for example, Colonel Weldon has introduced) may be easier said than done. I am sure that to advance openly within effective fire of batteries possessing the Watkin range-finder would be impracticable. Give me the guns in position, and I would engage to say in an open country we should have half the enemy's horses down before they got within 2,000 yards of us. In a close country they might creep up by the roads, but, once caught sight of, it would only be necessary to bring down the leading teams, and so cause a delay which might perhaps be prolonged indefinitely.

Captain WALTER JAMES, late R.E.: You were good enough, Sir, to say that there might be other Officers in the room who take an interest in the subject of artillery. I have done so personally for some years past, and there are one or two points on which I should like to remark. First, as to the question of the gun, as shown in Table A. It always has seemed to me a most remarkable fact that although the field artilleries of Europe have for many years been re-armed with weapons which I will typify as equal to the 13-pr., we have at the present moment our artillery armed with weapons which are most distinctly inferior. It may be the fault of the British taxpayer or of somebody else, but whose ever fault it is, it is a very grave one. At the present moment the 12-pr. gun is being introduced into the Service, but I do not think there is a new type of heavy field gun settled on. The heavy field gun is represented at present by the 16-pr., which is about as comparable to the heavy field gun of France as is the old Armstrong to the 13-pr. As to there being a number of types in the Service, that is a thing we are not unused to. I remember in 1872 I was at Secunderabad. There was there a horse artillery battery, two field batteries, and a heavy battery. The horse artillery battery had 6-pr. Armstrongs. One field battery had the 9-pr. bronze gun; the other field battery had the 12-pr. Armstrong, and the heavy battery had smooth-bores. There would have been made a slight complication, as you might suppose, in serving out ammunition from the ammunition column. I may also add that the British infantry in those days had been used to the Snider, but the 76th and the 24th were armed with weapons

¹ I find that, speaking from memory, eight years after the time, I did not state quite precisely what actually occurred. Referring to my notes, I see that there were no bad rounds when the apparatus was used as a position-finder, that is to say, when the laying was purely mechanical. There were, however, some rounds wasted when the apparatus was tried as a range-finder, thus—

4.3.79. 2nd Series. First Day.

Round 1,	{	Target had sunk out of sight, and another object was
500 yards, short.		mistaken for it.
Rounds 8 to 12	{	The target having sunk, and the two operators being
fired as one set.		directed to observe a buoy described to them as the
500 to 600 yards		"further buoy," they directed their pointers on two
short.		different but similar buoys, causing a false intersection.

It was this mistake that led to the introduction of the single observation method now commonly adopted.

which were courteously termed Enfields, but which were really in a large number of cases mere gas pipes, because all the rifling had been really rubbed out of them by an excellent machine that the arsenal was in the habit of using for the purpose of removing rust from the barrel. There is one point about which I have a great deal of curiosity, namely, as to what are considered to be artillery ranges. If I look to the tactical authority of the British Army, Colonel Clerj's work on Minor Tactics, I find that 2,500 yards is laid down as the extreme range of field artillery. If I look to another book, which is not yet to be obtained in an English form, Prince Hohenlohe Ingelfingen's "Letters on Artillery," I find that he has very considerably enlarged views on the system of artillery ranges. I cannot help thinking that at the time the former work was written there was in existence a book by one Hoeffbauer, taking us back to the battle of Gravelotte, giving the ranges used by the German artillery, which ranges were certainly in excess of what is laid down by our present tactical authority. I think therefore that a slight revision in this particular item of the authority in question might well be made, so that we should have it fairly and authoritatively laid down what artillery ranges really are under modern conditions. When I was in Zululand I had the pleasure of using the Watkin range-finder as a surveying instrument. The range-finder belonged to a battery (Lieut.-Colonel Owen's); I do not know what the pattern was, but after we had jolted up and down five or six miles of hilly country, when I came to measure the ranges, I often found that the results were not gratifying from a surveying point of view. It has always seemed to me, with the greatest respect for the Watkin, that it is not an instrument which can stand the rough handling on service. I am also informed that the range measured by the battery before going into action at Laing's Nek was considerably in excess of what it was found to be when the trial shots were made, and however good the range-finder, you are almost sure when you come to fire your trial shots to find that there is an error, and it therefore comes to this, that if your artillery is to shoot accurately, it must practise constantly. As with artillery so with infantry, it is practically impossible that they can either of them carry out what is their chief *raison d'être*, namely, to shoot well, unless they have constant practice.

Colonel RICHARDSON, R.A.: Major Mackinlay compared the shooting of the modern gun with the performance of the modern rifle, and said there was no reason that the gun should not shoot better than the rifle, or rather he implied that there were reasons why it should do so. I think there are reasons why it should not in spite of that pretty diagram; first, that the projectiles are not of the same specific gravity; secondly, that in the new gun the centering of the projectile is not satisfactory. The projectile of the rifle is soft-coated, that of the big gun is hard and imperfectly centered, and that is a good reason why the large gun should not be as perfectly accurate at its own ranges as the rifle is at its. We have already been asked "what artillery ranges are?" but, taking the range for the gun as double that of the rifle, I have given a reason why the big gun, in spite of its steady platform, deliberation of laying, and to a certain extent lack of personal error, should not shoot as well as the rifle, taking two to one as the proportion of range that the artilleryman would be shooting at. I think the feats performed at Wimbledon by riflemen will never be equalled by artillerymen with their own weapons, unless we get very much better guns. Even supposing that a perfectly accurate gun is evolved, I think it extremely unlikely that the artilleryman of that day will equal the rifleman in his performances, because it is hardly likely that an artilleryman, firing at the most two or three rounds a year, will equal a man firing probably thousands of rounds. Therefore, the Queen's prizeman of artillery will be a very poor shot compared with the Queen's prizeman at Wimbledon. Of course we know that great practice will produce beautiful shooting with big guns, but the ordinary artilleryman getting, it may be said, no practice, will always make very bad shooting, from a Service point of view. Unless the fire of artillery does become accurate from continued practice, I think the whole of the Service practice should be devoted to perfecting some system of group firing if the greatest effect from a given amount of fire is to be produced, and that probably both in field and garrison artillery. I think, under any circumstances, there is not a doubt that a good position-finder must make artillery fire far more accurate than the sight

shooting of men who practically have never laid guns at all. Mechanical laying will be the most accurate; but whether it is capable of accuracy or not it will not prove of the slightest use in war unless much studied and practised in time of peace. I am confident of that, but the artillery as a body have no practice with, or even knowledge of, any position-finder. Its use is confined to a few selected positions, it has been very seldom used, and it is a great pity that we do not know a little more about it. With regard to the expense of artillery fire, in siege practice it is certain that under nearly all circumstances, and it is probably the case in all sorts of firing, that where anything like accuracy is obtainable the most expensive ammunition to make is by far the cheapest to use. This seems a paradox, but a large shell will do more execution than four or five times the amount of smaller ammunition, costing more in the aggregate. This is certainly the case with garrison artillery, and probably would be in all branches. One plea for more ammunition for garrison gunners has been omitted, and that is the necessity for testing the mounting of the guns. I have seen guns in positions where they could not ordinarily be fired in peace time because of breaking windows, &c., and which, when they were fired, were found totally unserviceable. Guns may look very pretty and serviceable on their mountings, but there is no real test for them but actual firing. Some time ago I suggested that it might not be difficult to invent a projectile capable of raising the pressure in the gun to Service conditions and giving the proper recoil to its system, but which would nevertheless break up into harmless fragments, or be consumed in flight, at a short distance from the muzzle. I believe that an attempt is being made to supply the want, and this will enable all guns to be worked. It is improbable that sufficient ammunition will ever be granted to make any considerable number of garrison artillerymen very first class shots, and it is a question whether it would not be best to give up the attempt and devote all our energies to the development of accurate mechanical laying, which is comparatively simple with heavy guns. Whether Major Watkin's system, or any simpler one, is adopted, I question whether it would not be at once better to give up trying to make garrison artillerymen good shots. It is a very difficult thing even to make them so, and they never will be unless they get a very considerable amount of practice ammunition allowed. Major Mackinlay has told us that no very satisfactory results have been obtained by range-finders in the field, but in Afghanistan, I am told, the Weldon range-finder was used by the artillery with very good results, as regards good shooting at an enemy, in spite of rough usage and still rougher ground, by men with little training. With regard to sights, it appears to me that for years we have been spending an enormous amount of time and labour unnecessarily in teaching our gunners to lay with a sight that presents great difficulties to a great majority of eyes. A gun can no doubt be laid with considerable accuracy with our notched full sights, but to do so requires an enormous amount of practice. Many years ago, as a Brigade Instructor, a great many men passed through my hands, all of whom I tested in laying with Service sights, both at standing and moving objects. I kept a record of the results, which, as far as I recollect, showed that about 5 per cent., probably from defective eyesight, were incapable of recognizing whether a gun was well laid or not; 10 per cent. were very good from start to finish; 30 per cent. improved to good or moderate shots, and the rest were always untrustworthy. One has only to work with the instructional target to see how inaccurate is the laying with our notched sights. For the average eyesight the pinhole and cross wire is preferable where it can be used. One great difficulty in accurate firing, using the position-finder and mechanical system of laying, will be found in the variations of the wind. Fortunately, a really windy day would be worse for ships than for fort guns; but if, as Major Mackinlay indicates, the elevation, direction, and fuze ordered from the position station under Major Watkin's system is to be strictly followed, great accuracy will be impossible. With the instructional target, there is a difficulty in bringing time to bear as an element of competition. Speed depends on the proper manipulation of the triangle over which the man laying has really very little control. If he has got a good man at the triangle to help him, you will find his speed in laying improves very materially. One point omitted in the lecture is the organization of personnel as an element in accuracy, and I think that garrison

battery practice, as at present carried on, hardly represents Service practice. Owing to the very small numbers of garrison artillery, there would probably be never more than two Royal Artillery men at a gun, and a proportion of even these would be recruits or very partially trained men; therefore, for conditions at all resembling Service conditions, it is necessary to know who are to be the bulk of the workers. It seems to me that organization is an unknown quantity, which would prove a most important factor in accurate artillery fire.

Lieutenant-General Sir M. A. S. BIDDULPH, R.A., K.C.B.: In India considerable steps were taken by Colonel Adye, now General Sir John Adye, G.C.B., when the Armstrong gun first came out, to introduce competitive practice, and afterwards, under my directions as Deputy Adjutant-General, these operations were continued. I might give you an illustration of what was done during a camp of exercise under Lord Napier of Magdala. At the close of the camp we had targets placed on the River Indus, which floated down with the current, advancing at a pace of about 5 to 7 miles an hour, so that we got a very fair exhibition of an advance of troops, and batteries were brought into action at the targets at varying distances. However, this is merely to show that attention in India has been called to this subject of practice, and I know that this continues to be the case. It should be known that we have in India ranges which are not possessed here in England. Across the water in France and Germany they have very considerable ranges contiguous to their stations for field artillery practice. As far as the practice of heavy artillery is concerned it is, I think, merely a matter of money—the cost is so great of finding the ammunition. Major Mackinlay has made some observations as regards velocity. Now though it is very desirable on account of accuracy to have a high velocity in all guns intended for direct fire with field artillery, there may be a limit on account of the excessive recoil caused by extreme velocity, the recoil being very difficult to govern. The carriage of the gun has to be increased very considerably in weight, and this causes a constant drag behind the teams. There are also difficulties as regards the fuse. However, as a fact, the velocity of our guns is superior to that of other Powers, and I have drawn up a comparison of the velocities of the horse artillery guns of Great Britain, France, Germany, and Russia.

Particulars of Horse Artillery Guns.

	Gun.	Muzzle-velocity.	R.V. at 2,000 yards.	R.V. at 3,000 yards.
		f.s.	f.s.	f.s.
British	12-pr., 3-inch	1,710	993	836
French	12-pr., 80 mm., or 3·15-inch	1,608	920	785
German.....	12-pr., 3·09-inch	1,525	913	786
Russian.....	12·125-pr., 3·125-inch	1,350	867	751

This is calculated on the assumption that the projectiles are of the following weight: British, 12·5 lbs.; French, 12 lbs.; German, 12·19 lbs.; and Russian, 15·125 lbs. I may observe, with reference to the lecturer's desire to exchange the 9-pr. M.L. for the 12-pr. B.L., that the 12-pr. is finding its way to India, and is the armament of our field and horse batteries at home. The velocities do not differ so much at 2,000 yards, but at 3,000 yards the superiority of the English gun is very marked. This muzzle velocity of 1,710 feet is as far as we think it advisable to go at present, for at the fighting range the velocity of the English gun is superior; to

increase the velocity we should have inconveniences alluded to without much corresponding advantage. As regards the fighting range, I must say it is an exceedingly difficult thing to determine what this range is. It depends very much on circumstances of ground and of position, the temper of your troops, and the temper of the enemy, but I set it at from 1,200 to 3,000 yards. The field artillery view of the question of velocity is as I have explained. Of course for armour-piercing and long-range firing at sea, from ships on coast batteries, higher velocities are required, and these we have. Referring to the lecturer's observations on tactics, one rôle of the artillery, and perhaps its chief one, is to take up positions favourable to its action, and there engage for some time¹ the enemy's formations of all arms, to occupy the enemy's artillery, and thus to give the infantry and cavalry freedom to manoeuvre or engage. Its duty is to assist the other arms by its fire, not by its movement, which should be restricted to the taking up of positions for some considerable length of time. The cavalry manoeuvre, but the horse artillery has to take up positions to support it; the infantry also manoeuvre and keep up engaging fire, but the artillery in support restricts its movement to a minimum, as when in motion it is non-effective. As regards the question of whether horse and field artillery should advance to shorter range, it must be apparent that the battery exhibits a very large target, and it must be a question for the commander of the troops, advised by the artillery commander, to decide as to how far the advance should be made. This is clear, that if at 1,200 yards a battery is doing good work, and by remaining it can still support the advance, it would lose time and effect by a forward move. It has been stated by a speaker just now that it would be completely swept off the ground if it were advancing over an open plain within effective infantry fire. It must therefore be a matter of consideration when the battery reaches a range within the effective fire of infantry whether it can best remain or advance. This question has to be decided on the spot. As to the question of instruction in range-finding, the field artillery should on all occasions of manoeuvre lay the guns at some defined object and give the estimated range. I do not think in making this remark I am offering any improper criticism. I think the field artillery commanders as a rule are always doing this. I am only pointing out that this is one of the methods of instruction which exist in the hands of Officers themselves. This estimate should afterwards be proved to be correct or otherwise, and the difference, if any, be noted. Such a system does I believe obtain in all batteries, and I merely mention it as an important means of getting good shooting in warfare. I have one other remark to make, and that is this, that although it would be very unwise not to take advantage of the means afforded by range-finders of ascertaining the range, it must be recognized that these instruments are not applicable to every position, and want of time, heavy fire, and numerous causes may intervene. The method of trial shots must in such cases be resorted to, and Major Mackinlay has given some trite remarks on the subject. We all know the method of ascertaining range by observation of sound travelling at the rate of 1,125 feet per second. An interesting application of this mode is to observe the smoke of the enemy's fire, and instead of using a watch to count mentally at a rate of, say, ten counts to every 1,000 yards. This mental counting is easily acquired by having a plummet suspended to vibrate at the proper rate,² and the method tried at manoeuvres has

¹ I think it sometimes is overlooked by commanders of the other arms that good shooting of the artillery is an operation of considerable difficulty in the field, requiring very nice appreciation of the distance and very nice adjustment of pointing and setting of fuze, also of judgment in regard to the projectile. All these matters require time and some continued staying in position. The movement from column to position may have to be rapid, but time is necessary to secure good and effective shooting. The way to shorten that time is to give a reality to field manoeuvre, and always aim at defined objects, giving the estimated range and trying that range afterwards; but we want more ranges in England, and as much practice ammunition as we can get, and moving and disappearing and reappearing targets.

² The instrument used to acquire the art of counting to correct time was a little frame of wood having suspended in it a plummet, which beats at a rate representing

resulted in wonderful accuracy of estimate of the distance of the enemy. I have made these remarks very hastily, being fully occupied, and I only wish to state here publicly my very great interest in the subject of the paper which Major Mackinlay has read to us, which is one which should not be lost sight of.

ADJUNCTION DISCUSSION.

May 2, 1887.

Major WATKIN, R.A.: Colonel Hughes in his remarks at our last meeting evidently fell into a very usual mistake in calling the depression *range-finder* which he saw at Sherness a *position-finder*. The two instruments are, however, totally and entirely different. The depression *range-finder* is only intended for taking ranges pure and simple. True, it is fitted with a horizontal graduated plate, but this is only for roughly directing the gun. It is evident that even supposing the reading on the plate is made to correspond with the reading on the gun-arc when the *range-finder* and gun are laid on any particular object, they will not be in agreement for an object in any other direction, unless the instrument happened to be immediately over the gun. The greater the interval separating them, the greater would be the discrepancy, or parallax, as it is technically termed; and, moreover, if widely apart the ranges as well as the bearings would differ. The *position-finder*, however, is specially designed to not only give the range and bearing of an object from the observing station, but to automatically correct the parallax, and instantly, without any calculation, give the true range and bearing for the guns concerned. This arrangement is absolutely necessary, for in some cases the observing station is many miles away from the gun receiving the information. The *position-finder* is also fitted with a peculiar electrical arrangement, which at the same moment transmits the range and training to the guns. The mere act of laying the telescope effects this; so that the moment the cross wires are on the object that moment the dials at the gun mark true range and training. As far, then, as the gunners are concerned they might be enveloped in smoke, or concealed behind a hill, perfectly invisible from the enemy; or they might fire on the darkest night and yet make perfect practice. Moreover, as explained in answering Captain Orde Browne, we can now, by what is called predicted firing, make excellent practice with the rawest material. Given a very small nucleus of trained men, I will guarantee to make splendid practice at the swiftest vessel, with men who only know sufficient drill to load their guns. These are accomplished facts. Eight years ago we made the shooting shown on that diagram (Fig. 6), and within the last year other practical trials have been made at targets towed in a zig-zag course in front of the battery and, as mentioned on Friday, hitting the target five times out of eleven rounds; the others being close to it. One word only as regards General Smyth's criticism on the diagram of practice (Fig. 6), which is one I had the honour of exhibiting in this Institution at my lecture on range-finding in 1881. Time would not permit me, nor would it, I think, be advisable here to discuss those criticisms, but this much I trust I may be permitted to say, that within the last few weeks that very diagram and those very remarks were the subject of official correspondence and enquiry at the War Office. I can only say that I am perfectly satisfied with the decision arrived

for every ten beats the flight of sound over 1,000 yards of the enemy's guns or rifles. Example: The flash seen, three tens and three overs counted the enemy's position is 3,300 yards distant. The system was introduced by Brigadier-General East, commanding the Sialket Brigade in 1883-84, where I saw it practised with considerable success. It was found very applicable even to infantry fire, and Sepoys were able to acquire the art of estimation of distance by this method. There is one inconvenience, and this is, it cannot be applied till the enemy opens fire. However, this he is sure to do sooner or later.

at. But after all, as Major White remarked, this is ancient history, for the practice there depicted was made in 1879, by an instrument the original proposal for which was submitted in 1867. In these days of progress, even eight years is a long time. I certainly have not been satisfied to stand still, and I have produced, and trials have been made of, several improved instruments. The present Service position-finder is totally and entirely different from the one employed in 1879, and at least ten times as efficient. Colonel Richardson remarked that he thought weather would totally vitiate the results obtained with the position-finder. I can only say that on one of the days of trial it was quite a question whether H.M.S. "Harpy" would face the elements, and observing her through the position-finder telescope, I thanked my stars I was not a sailor. A naval Officer in his remarks deprecated the towing of targets, even with a long tow-line, as dangerous. This certainly would be the case if special precautions were not taken; but in every case that I am aware of every care has been taken, and an Officer told off to each gun, so that no accident should occur; and without a towed target I do not see how they are to have actual experiments at position-finding with moving objects. With regard to field range-finding, there has been a great deal of ancient history introduced. Captain James, for instance, referred to some of his experience in the Zulu War, which would be quite in the early infancy of the range-finder; but even then opinions differed, for Colonel Colley is reported to have very much approved of the instrument, at that very time, for surveying. Here, again, there have been many improvements, but so impressed have I been with the want of system, of proper training (or rather no training), of proper appreciation of the advantage to be obtained by the use of a range-finder, that I have purposely kept back for nearly five years a new and much more efficient range-finder until the system, now happily established, had taken effect. This new range-finder will, I think, meet most of the objections that have been urged against the present Service instrument. There is one remark of Captain James with which I utterly disagree. He says that even if we had a perfect range-finder it would be useless, owing to the variation in the strength of the powder necessitating different elevations for the same range in different climates. It is only within the last very few years that the subject has attracted particular attention, and the very great differences that arise in the velocity, due to comparatively slight variations in the hygroscopic state of the powder, appreciated; and I believe many of the adverse opinions on my range-finder are due to this very cause. But surely an Officer in command of a battery ought to know what state his ammunition is in before going into action. How easy to ascertain this by a trial shot! Suppose the range-finder to give the distance of an object as 2,000 yards, but he finds it is necessary to put the tangent scale at 2,200 yards, let him accept the facts, whether it is due to the range-finder or the ammunition, and make the necessary allowance when in action. With regard to howitzer fire, I think it was Captain James who mentioned to you the great damage that howitzer fire at long ranges would effect, and we shall not be behindhand, I hope, in utilizing this nature of fire. The accuracy with a 9-inch gun mounted as a howitzer was perfectly marvellous, and I have designed a special position-finder for working with it. With regard to telescopic sights, I do not wish to make any remarks adverse to Major Scott's system if it really does improve the shooting, but opinions are, I think, certainly divided as to the efficiency of telescopic sights, but all are agreed, I believe, as to the absolute necessity of a good telescope, unconnected with the sights. I should myself prefer a good double telescope, which can be used without any support, and which has been brought now to great perfection. The lecturer remarked on the probability of error in the Scott sight, due to the short bearing. A simple calculation will, I think, show that this source of error is by no means exaggerated. Taking the distance between the V's, $4\frac{1}{4}$ inches, and imagine a burr, or piece of dirt, of the thickness of only $\frac{1}{32}$ th of an inch on one of the bearings, the resulting error would be fifteen minutes of angle. In the 13-pounder M.L. gun a similar error could not be made without displacing the scale $\frac{1}{32}$ ths of an inch, and we must also remember that a man with a good eyesight can appreciate with the naked eye an angle of one minute. I also think that a non-erecting eyepiece, as issued with the Scott's sight, is not a practical arrangement for ordinary mortals. This may not so much matter in laying at a target, but I ask anyone who

has looked at a landscape, or stack of chimneys, with a non-erecting eye-piece to say if it would be an easy matter to lay on any particular point. It is also very puzzling to lay with a reversed image. What ordinarily requires "trail right" to correct the laying really requires "trail left," and so on for the other movements. I suppose an erecting eye-piece could be issued, but it would make the instrument very much longer. Again, in the sight the angle of the elevation has to be set by means of a vernier, and I know, from long experience as a Gunnery Instructor, in the old days of the Armstrong gun, how difficult it was to teach men a vernier. I am not an advocate for telescopic sighting myself. If, however, the telescope is to be used in connection with the sight, I think that the principle I advocated some years ago, and I much regret that press of work and other untoward circumstances prevented my getting my sight ready for the trials that took place some time ago, is the right one. I have just brought it here to ventilate the subject. The principle is this, that the sight shall be used only as an adjunct, to assist the eye by magnifying the image. When looking over the sights of a gun the eye focusses first on the foresight, and then on the distant object. Why should we not have a telescope to do the same thing? My design is this. Here is an ordinary erecting telescope, fixed on the top of the ordinary tangent scale. You clamp this to the required elevation, and move the telescope until the cross wires are laid on the foresight of the gun, thereby correcting the telescope each time by the fixed gun sights. All you have now to do is to re-focus on the distant object, and lay your gun in the ordinary way, until the cross-wires are on the object. The telescope has a large object glass, and a proper directing eye-piece, so that no confusion may arise in laying. There is nothing here to get out of order, as the sight is re-set every time by the gun sights at long radius. This, I venture to think, is the true principle to work upon. A gun may often be laid on an obscure object by the aid of an opera glass, the observer going well back in line with the sights.

Major HAX, R.A.: In support of various things which were stated last time as to matériel and the armaments of our field artillery at the present moment, I wanted just to quote the numbers as they stand.¹ Out of 107 horse and field batteries (depôts included), there are only 20 at the present moment armed with modern accurate guns. In the First Army Corps, out of 19 batteries, there are only 11 armed with new guns, though all the 12-prs. are here; while in the Second Army Corps, of 14 batteries, only 4 are armed with 12-prs. There are 5 batteries of 13-prs. at the present moment unplaced in Army Corps which might be transferred to the First. Now to say a word about range-finding. It seems to me that a better telescope than that supplied in the Watkin range-finder is needed for the definition of the exact point of the object from both ends of the base. As there are still 15 batteries of 16-pr. guns in the Service, it would be well to draw attention to the tangent scale of this piece as perhaps one of the worst sights ever put on a rifled gun by any Government. Besides coarseness and other defects, the degrees are on the back of the scale. They are entirely hidden by the metal of the gun, and cannot be used. At the top there is the nut, which is graduated in minutes, and in using the scale the Commanding Officer of a battery has to give such a direction as this: "2,650 yards, three minutes;" and if that is not confusing to a gunner I do not know what is. I think this might be very easily changed by carrying the marking of the degree graduations slightly round the blank side of the scale. There is an unused or blank side on the 16-pr. scale, and the degrees might be carried just the least little bit round, and doing that the scale could be easily read and therefore used on the left side of the gun. I have offered to do

¹ There are by R.A. list of April, 1897—

71	9-pr. batteries
15	16-pr. "
14	13-pr. "
6	12-pr. "
1	7-pr. battery

it in my own battery at my own expense, but am not allowed, and I am therefore entirely unable to use my degree scale. Another difficulty caused by using a yard scale is that three distances appear to exist for every range: first, the distance given by the range-finder; secondly, the distance given by the actual use of common shell; and, thirdly, the distance required to take the shrapnel shell. That again is very confusing to the gunner, who cannot understand why there are three distances in yards for the same range. Of course if the yards disappear, and we use degrees, the confusion would cease.¹ Orthoptics seem to be most useful for a non-orthoptic sighted gun. There are two on the table. I get them from Steward, the optician's, in the Strand, for 3s. each, including the little case in which they are, and by offering them as prizes in each of the subdivisions for good laying, I get a number into the battery. Density of atmosphere and refraction will have to be seriously studied in order to get accurate shooting with a 12-pr. and 13-pr. These two things have not been necessary hitherto for a gunner to take into consideration with a less accurate gun. Lateral errors, owing to the particular targets which we usually fire at in the field, are generally comparatively unimportant, but errors in elevation are vital; therefore I venture to suggest that we should use continually the horizontal² line in the instructional bi-colour target. I mean turning the target so that the line shall be horizontal, and by constantly using it thus we should get a number of men in each subdivision to lay steadily, constantly, and everlastingly with a "full sight." It would be worth anything to know that certain men in every subdivision will accurately lay with a "full sight" each time you give it them to do. I would suggest the offering of prizes to encourage the laying of guns in each subdivision. I wanted to say one word about aiming tubes, viz., that the use of aiming tubes in batteries might improve the laying immensely in this way, that we should make it an afternoon pastime. In all good infantry regiments I believe there are now "shooting clubs," to which the men subscribe, buying ammunition, and using in their leisure time the ammunition for shooting. Similarly we might use some of our carbine ammunition, and we might probably buy a great quantity more. I know my own battery would be glad enough to spend a half holiday sometimes, in fact very frequently, in the use of the aiming tube. With reference to correction of fire I want to say a word or two. The lecturer did mention it; but I would press the suggestion that the zone which he described as existing between the first and second "trial shots" should be proportioned always to the range. At 1,000 yards, you would probably find 200 yards between your first and second shells sufficient; you can easily place your target between these limits; but if you go to between 3,000 and 4,000 yards' range, I think you will need a difference of 800 yards, even in some cases, or 400 yards on each side of the estimated distance. To make 600 or 800 yards between the first and second shots is not a bit too much to ensure a clear result (you may very easily have too little distance, but it is not easy to have too much). Supposing the two points of bursts to be distinctly visible under the glass to the eye of the Commanding Officer, then he will be able to place his target, remembering the effect of perspective, as was suggested by the lecturer. In reference to shrapnel fire, I am quite sure that much study and practice is needed to get a really intelligent combination of elevation and length of fuze, so as to obtain the best results. I have several times met Officers coming back from practice who have said that a gun-pit was placed in such a position that it could not be hit, and on asking what was meant, I have understood that when the time fuze was fitted, say, at 12, the shell burst 200 yards short, and that when at the next discharge it was fitted at 13, the shell burst just over the gun-pit, and therefore the gun-pit could not be hit. They forgot probably that elevation has an immense deal to do with it, as well as fuze, and that these two can be worked singly, in combination, or one against the other. I think some mechani-

¹ In using a yard scale one is prone to forget the accidental existence on the nut of minutes of elevation. One isn't thinking probably of minutes. This would not occur in using a degree scale.

² The clinometer (Watkin's) affords a ready and accurate means of comparing the laying of successive shots at the horizontal line.

cal arrangement is greatly needed to enable a correct estimate to be formed by a range party of the position of bursts of shrapnel; and being an Officer who has seen a great deal of range work at practice camps, I know from experience how extremely difficult it is, especially when your target is on a slope, and the gun is perhaps higher or lower than the target, to form any judgment of the exact height above plane, so as to tell the firing party the position of the burst of the shell.

Colonel STRIBLING, R.A.: With reference to a remark made the other day on the subject of firing at towing targets, it may interest the meeting to know that last year and the year before we carried out the practice with a considerable number of guns in the Southern District at a towing target. The first time I saw the gun fired I must say it seemed to bear out what the naval Officer who spoke the other day said. The shot seemed to me to go uncommonly close to the vessel, and I could not understand it at the time. It was explained to me in this way afterwards, that for fear of losing one target they had taken the precaution of sending out with the steamer a second target, and that target was towed a very short distance behind the steamboat. Instead of laying the gun at the proper target, which was 400 yards away, the gun not having been properly overlooked or something of that kind, it was clear that No. 1 had laid it on the target close under the hull of the steamer. Fortunately the steamer was not hit. I think, with ordinary precautions, there is no danger whatsoever in firing at towed targets. I watched the practice most closely last year. We fired a great number of rounds from the Needles and other batteries on the west end of the Isle of Wight, but I never saw a shot go anywhere where the slightest danger would arise from it. 400 yards is an immense distance, as you will understand, when you are confined to firing at only 2,000 yards' range. It gives an enormous margin, and, I think, it is perfectly safe. Major Mackinlay very properly drew attention on this subject of accuracy of fire to the distinction between guns firing from rests and guns firing from the hand. I think he also drew a distinction between the different kinds of artillery fire—field artillery fire, coast defence artillery fire, and siege artillery fire. In all these cases we fire from a steady platform. In the case of field artillery fire there is the element of unevenness of the wheels which requires correction, but in the coast defence fire not only have we a steady platform, but we also have a level platform. The difficulty in that particular sort of fire is that we must be prepared to shoot at a moving object. In case of siege artillery practice the object is stationary. The platform is level and stationary also. Fire is deliberate, and ought to be the best of the lot. I will only say a word or two upon the second of these three, namely, coast defence practice. Of late years we have made a stride, I think in the right direction, in obtaining for field artillery a land range. We have also, I think, made a stride in the right direction in obtaining for siege artillery a special place of practice at Lydd. I think it only remains now for a suitable place to be found as a school of practice, or whatever it may be called, for coast defence artillery—a place where we may carry out experiments, year by year, with that particular sort of firing, and a place to which we may send as many of our garrison batteries as possible for carrying out their annual practice. At present I am one of those who feel that battery practice ammunition is almost wasted. I do not think it is the way to give our gunners, for coast defence practice, to bring them up to fire with what may be called obsolete guns and ammunition. The name of an Officer much interested in this subject was mentioned by the lecturer—Colonel Lyons—who unfortunately has not been able to attend here to-day; and with your permission I should like to read an extract from a letter that I hold in my hand from him upon this subject. He says: "I hope you will insist very strongly on the necessity for a school for the instruction of Officers and non-commissioned officers in coast defence practice, and for our own instruction and experiment too—as the best of us are only still groping in the dark in this most difficult and complicated subject. One thing is certain, that No. 1's must be men of some education and much intelligence, as well as simply good pointers, for we have already discovered here that an immense deal has to be left to their individual action, and that any interference with them when actually in action against a ship moving rapidly necessarily results in failure. The Officers' functions appear to be limited, once the firing has commenced, to directing at which vessel to fire, and to giving the probable speed. Such being the case you can

readily understand how complete and extensive must be the preliminary training and instruction, and how constant the practice required to form reliable No. 1's. The necessity for more ammunition you cannot too much impress upon the minds of your hearers. Nothing can be done to teach others until we know more ourselves, and that practice under Service conditions from a place like this, with every possible facility for carrying it on, alone can teach us. We have a strong tideway, a narrow channel, numerous batteries armed with a suitable gun, and, lastly, we shall soon have a position-finding system in working order. Where else can all these advantages be obtained at one place?" I agree fully with Colonel Lyons in what he has there said as to the great advantages that we may hope to gain by having such a school of gunnery for coast defence. I think it is most important that we should have such a place, and that the money that is now expended upon the annual battery practice ammunition should, if possible, be devoted to something of this kind. I would just say about coast defence practice that it seems to me to divide itself under two heads, that of drill and that of the command of work. I think under the head of drill we have that which is within the power and command of the detachment. I think there is that outside the detachment which requires to be specially attended to in coast defence work. The service of ammunition, the laying of the piece—a most important thing—all comes within the charge of the detachment; besides that there is the question of range-finding, there is the deflection-finding, and there is the communication which requires to be established for thorough efficiency between the Commanding Officer at the observing station and the gun gallery. In the gun gallery where detachments are placed in casemates we know that it is impossible for them to estimate the range or the deflection; or to judge of the results of the practice. They are absolutely helpless, I think, in regard to all these things, and they need help from outside. I have no doubt it was a knowledge of that which started Major Watkin in the labours which have resulted in what we have heard of the position- and depression-finder, and in which we wish him every success; but still we have not yet got that laid down in particular places, it is still under its trial, and I do not think we ought to be quite satisfied with giving up all our gunnery and putting it into that most beautiful machine. The stations may be cut off; we may be severed from them; and I should not like to feel stuck down in a fort with a number of men without the means of doing something. Supposing the wires were cut or the station was cut off, I should like to have some arrangements made to meet those difficulties. Where you get into a very flat country such as we have down about Spithead, the difficulty of taking ranges is very great, and none of the systems yet introduced are thoroughly successful. The Watkin depression-finder is not yet served out to these forts. They are not high enough for ordinary range-finders, and therefore we have absolutely nothing. At present we have no efficient means of obtaining the range. I think we ought not to rest there, and I do not see why we should not use what they have in ships. I do not see why we should not have in every fort a compass, not a magnetic one but a compass graduated to the north, of a certain size, with a graduated arc. I do not see why we should not be able to communicate from one fort to the other so as to give the varying position of any particular vessel, and with a chart by us why we should not be able to lay down upon that chart roughly, but fairly accurately, the position of any such vessel. Any way it is better that we should have something of that kind that is not a machine, and that would be applicable in any fort, and in those perhaps more particularly where Major Watkin's depression position-finder may never be applied. The other thing I think of importance is some means of taking the angular distance of a vessel when passing in front of the fort in some given time. That element of distance of a vessel passing in front of a fort in a given time must be taken notice of in firing at a moving target. None of the rules that have been supplied I think are applicable to it. I do not think it is possible that we should work out any of these rules for ourselves, and I do not think it is fair to expect that our men should be able to do so. We want three dials in our gallery in communication with the Commanding Officer's station above, one indicating the direction that the ship bears from the fort, another giving the range, and a third giving the deflection for a given number of seconds. I think with those things stuck up in the gallery before No. 1, it would be possible to make the detach-

ment independent, as Colonel Lyons has suggested; and No. 1 would have nothing to do but to look at the board to get the range and the necessary deflection. Given the elevation and the deflection, it will remain for them only to lay the sights on the object.

Colonel HUGHES: I wish, Sir, to explain something that I said on Friday, and, if time permits, to add to it slightly. I mentioned the other day that when the Volunteers were practising with the reduced charge, I understood the reduction was due to a desire to save expense. I have had it explained to me since that the main cause was that the guns which we were practising with were found to be unable to maintain the strain of the former charge, and that the charge has been reduced for safety. I am very glad to make any correction of any error into which I might fall, but one has always an idea, if you have no better explanation, that probably the saving of expense has been the object.

The CHAIRMAN: You quite understand it was not especially for the Volunteers.

Colonel HUGHES: I understood none but Volunteers used those guns; they are the 64-prs.

The CHAIRMAN: It was the Service cartridge. If you had to fight anybody to-morrow the same cartridges would have been used. That was the point I wanted the public to understand.

Colonel HUGHES: I am anxious that anything stated should be stated as accurately as possible, and if there are any errors into which I, as a Volunteer, may fall, you must put it down not to a want of will, but to a want of knowledge. In consequence of the higher position which the Volunteer force seems to be gradually arriving at, seeing that it is more relied upon than in the past to aid in the defence of the country, it becomes really a very anxious thing for Volunteers to see that they have the proper training and practice, and proper guns to practise with. Twenty-five years ago when I joined, we were firing with an 18-pr. with the old round shot. It used to wobble about in the gun, and would sometimes go to the right or to the left 50 or 100 yards. We practised to a very large extent with those guns, 24-prs. and 32-prs., in Plumstead Marshes, until the wreck of the Berber Railway has strewn the ground, and we did not practise last year. But with that exception we have gone down to those marshes for twenty-five years, and have fired some hundreds of rounds every year of these obsolete round shot out of these obsolete smooth-bore guns. It seems to me that training with guns of that nature will not fit our Volunteers to defend the coast, and that they will not be able to go from that practice and immediately take charge of a 10-inch gun with all its complicated machinery, which requires a great deal more training to work. It would appear to me to be about the same thing to put one of those 10-inch guns into the hands of Volunteers who have only been accustomed to fire the old obsolete 24- and 32-prs. and round shot, as if you were to put into the hands of our infantry the old Brown Bess, and then expect them when the time came to take up some weapon that they had never fired with at all, and to tell them they were now to use it for the first time, and expect that the practice that they had had with those obsolete weapons would make them perfect when they came to use modern firearms, say at Wimbledon, or in actual warfare. I feel certain that the time has come when we ought to practise with the guns we are expected to use when the emergency arises. Another point is this, namely, that Officers of Volunteers have the opportunity of going through a school of instruction which embraces a certain course at Shoeburyness. That course is no doubt short, but is still useful, but having gone through it for two months, which is the most they can go with the Government allowance, they are supposed from the Government point of view to be perfect, and always have the letters "P.S." after their names in the Army List. Now we have Officers who passed through that school ten years ago, but if they ever wanted again in the course of their lives to go through another course, they would have to do it at their own expense. I submit with great respect that the change of armament and matériel with regard to our artillery is so rapid, and the weapons are so constantly improving, that it ought not to be supposed that a Volunteer Officer who has been through that school ten years back is at the present time in the proper sense of the word a passed school Officer. He ought to be allowed, in my opinion, to go, say, every five years for a month, or if

you will every ten years for two months, and to have the Government allowance on each such occasion. It is not fair to suppose that passing an examination with a different nature of gun will cause him to be a competent Officer ten or fifteen years afterwards, when the armament is entirely altered. There is another point with regard to firing at moving objects. That is a great difficulty. Firing at a target is easy enough, but as to firing at moving objects we have not sufficient practice to begin with. I have thought for years of a plan which might help a little and be useful, but it has never been tried that I know of, and of course it is almost impossible for a private individual to try experiments of this kind. However foolish it may appear, I will be bold enough to mention it for your criticism, and for the consideration of those who are better qualified to examine into these things than I am; it is this, that at the top of a fort, say like Garrison Point Fort, or any of those forts in the Solent, a camera obscura should be erected, and on the table of that camera obscura concentric rings should be marked, so as to give every 100 or 200 yards right up to the horizontal line. Of course the lines would be so close when they got nearer to the horizon that they would be almost useless, but for a very considerable distance, 3,000 or 4,000 yards, it would be quite possible, I imagine, merely by concentric rings on the table, to show the distance which an object seen to be moving over the plain was away from that camera obscura table. A still further advantage would be derived if numbered lines were drawn outwards like the points of a compass longitudinally, to show the exact direction in which that ship was, so that it might be possible to see by looking at the table of the camera that a vessel was approaching such a number of degrees north, or whatever it was, to identify it, and so many hundred yards away from that fort. That would be constantly correcting itself by the figure of the ship being seen to be passing over the table of the camera. One objection has been urged to it; it is said it could only be used by daylight, but I am not so sure of that, because if a ship were attacking that fort the flash of the gun in the ship could be seen on the camera probably even at night, and you would put your finger at once on the place on the camera table where you had seen the reflection of the flash, and by bringing your own lamp you would be able to read the number of yards and the direction in which that ship lay. It is an idea; I do not know whether I have made myself understood; I am not aware that it is in operation; I believe it has been mentioned with regard to the laying of torpedoes, but I have not heard the idea of concentric rings or lines. I have never tried it, and it may be absurd. With regard to Major Watkin's depression range-finder, the one I was talking about was as near as possible immediately over the gun, and therefore the training shown on the plate at the foot of the instrument in that case should have been the same as the training for the gun itself below. I feel that it would be a great advantage if Volunteer Officers were allowed, and it were an understood thing that they were allowed, to obtain such books as are issued by the Artillery Institute at Woolwich. I have seen some of the books, but I believe I have had to obtain them *sub rosa*. They were certainly not available in the ordinary course at the time I studied them. Some years ago there were some very valuable papers written on the armaments of our forts at Gibraltar and other places. I had to borrow those books; I could not purchase them. I believe they were forbidden to be circulated at that time except to members of the Institute themselves. That may be a very proper regulation. You may not wish that they should get into the hands of strangers, but I think Volunteer Officers, especially those in command of artillery corps, are in such a position of trust that they should be allowed to receive, especially on payment, any of those publications in order to improve their position and efficiency. I think the time has come when the defence of the country, especially the artillery defence of the country, is put upon us as an absolute duty; we are not an auxiliary in the ordinary sense, but absolutely grafted into the ordinary defensive force, in the first line, so to speak; and it will be very important for the authorities to consider not only the question of our instruction, but also that all our detachments shall have some practice at any rate with the guns that we may have to use. Efficiency, I know, can only be obtained over a great number of years. I speak as a Volunteer Officer of twenty-five years' standing, and I must have superintended the practice of at least 7,000 rounds of gun ammunition during that time. Therefore I speak

with some amount of confidence that at the present moment, notwithstanding all that practice, our guns have been so obsolete that I fear without a great deal further training we should not be in a position to man those other and larger guns which we are supposed to be capable of doing. With regard to the sights on the 61-prs., if that gun is permanently to be fired with a reduced charge of 6 lbs., I think it is a pity that the sights are not altered.

The CHAIRMAN: I think I can tell you about that. There will be a further supply from stores for the next year, when you will get another kind of powder, R.L.G.⁴, with a charge of perhaps 10 lbs. or 11 lbs., and with that prospect it would be premature to alter the sights. I do not know who told you about the reduced charge, but I do not think it could have been a first-class authority. The reason of its introduction was not explained to you.

Colonel HUGHES: No. I believe it is in consequence of the weakness of the gun, but whatever powder may be introduced, if the weakness of the gun is a fact, we shall still have to use this printed table instead of the yards on the tangent scale, and the actual tangent scale used does not agree as to yards distance with this printed scale, so that one has to hold this paper in one hand and not speak about hundreds of yards at all, because that would be inaccurate, but we have to say "4 degrees 56 minutes," or whatever it may be; and I feel if the gun is going to be permanently fired with a reduced charge, the sights themselves ought to be altered accordingly, and the yards distance properly marked thereon.

Lieutenant E. T. YONGE, R.A.: I think it has been agreed by all that the present annual practice is insufficient to meet the requirements of the present day, when accuracy of shooting, i.e., hitting, is of so much importance. I have calculated very roughly that the cost of annual practice for 101 batteries of garrison artillery is 9,000*l*. This seems very little to devote to such a serious matter, viz., the preparation of men to defend the country from an invader. Failing the increase of money for ammunition for more annual practice, could not some other system be introduced instead of annual practice for training our gunners? With regard to the training of field artillery, it is excellent, I think, as it stands if it were only increased and batteries had more of it; but the training of the garrison gunner is very different in all respects to that of the field gunner. The field gunner is always more or less in the open and liable to be killed, and hence all the detachments should be good shots to replace any of the No. 1's who are killed; whereas the garrison gunner should, if he is not, be entirely under cover and to a great extent safe from the fire of an enemy. Such being the case, it is not absolutely necessary in a garrison battery to have every man a shot, and yet it is absolutely necessary to have the most accurate shooting in a sea front, especially at passing ships. Ships with speeds of 17 knots passing a fort want a lot of hitting. Of course a ship would probably have obstacles to contend with and not have such a high speed. I think it is generally admitted that obstacles and guns must go together to effect a perfect defence. To get a few good shots per battery, a course of thorough training might be resorted to. If a battery sent ten or more men per annum to certain shooting depôts to go through a course of drill at laying, and then practice with firing, and then obtaining a certificate in the same way as for signalling, &c., there would be a certain number of men capable of taking charge of a heavy gun entirely, feeling a certain amount of confidence which is half the battle in himself and in his shooting. By having these stations, a system of moving targets could be carried out in perfect safety. Towing with a steam launch is not a safe method by any means, as has been stated, as, besides the danger of wrong deflection, in turning a launch, it has to pass the line of the target, and hence an accident might easily ensue. I was placed in the same position myself once out at Hong Kong. I think in the garrison artillery good shots among the non-commissioned officers and men are absolutely necessary, as the Officers of the battery would be entirely occupied in superintending the service of the guns in their charge, and they would hardly be spared to take over the duties of a No. 1 of a gun. No time in shooting can be wasted nowadays, as only a very few rounds can be got off at a passing object from one gun—three or four rounds, I think, is what we got off at Hong Kong two years ago—and to attain good results we want good shooting. For a commander of a fort to have any confidence in his position, he wants to have

trained men under him to fire the guns with perfect accuracy. I hope some change will soon be seen in the present system either in increase of ammunition for the annual practice, or a school of training formed. I should like to add that with the amount a garrison gunner has to learn in the present day, he has not much time to spare for training in laying, and I believe there is no drill so difficult and tedious. I believe the Morris tube will relieve this monotony to a great extent, and the sooner we have it throughout the Service the better.

Colonel A. MONCHIEFF, C.B. : I do not think there is any subject connected with coast artillery more important than that alluded to by Colonel Stirling, namely, the means of firing at moving, or indeed stationary objects. By means of observations made from positions outside, or away from the battery itself, which in action would frequently be smothered with its own smoke, such information can easily be conveyed to each battery. No doubt the new position-finder, where it can be used, will supply that information and the means of firing guns accurately in proportion to the length of base, or, in other words, the height of the point of observation, without the gunners themselves seeing the object aimed at; but, as was remarked, there are cases where there is no height for the new position-finder, which needs a vertical base, and in these cases it is equally necessary that batteries should be provided with external means for finding the position of ships, for indicating their movement in any direction, and for laying the guns accurately. I would suggest to our Chairman to look up the plan for doing so submitted by me to the Director of Artillery on the 31st of August, 1870, and the drawings relating thereto, which I think, if brought up to date by the use of the electrical instrument now employed, would answer that purpose perfectly well. The basis of my plan was having two external points of observation, which secured the advantage of extreme accuracy from having a long base-line, and conveying the angles simultaneously from both points at fixed short intervals of time to each battery, and afterwards suggestions for making the operation automatic. This would enable the Officer commanding each battery, or some one detailed for the purpose, not only to have the exact range of the moving vessel at each observation, but to know the direction in which it was going, and by means of a graduated ruler to lay the gun accurately on the ship in advance. In the case of a moving vessel, the best result would probably be got by laying the gun in front of the vessel, and when the vessel touched the line of fire, it could be discharged either from the battery itself, or in consort with other guns from the point of observation. It would be the duty of the detachment to lay the gun with the proper allowances for error or deflection caused by wind and time of flight or otherwise. Making these allowances, plotting the telegraphed observations, &c., would be an important part of the drill required for the efficiency of each gun. The importance of being able to work guns accurately and quickly by information conveyed from without cannot be exaggerated. There are other considerations bearing on accuracy of fire which I believe were touched on at the last meeting, and which depend on the way the gun is mounted, quite independent of the gun itself, which I should have referred to, but I see opposite a gentleman who can do justice to this point. Instead, therefore, of making any further remarks myself, I would suggest that Mr. Anderson should address us upon that subject.

Major L. K. SCOTT, R.E. : I wish to say a few words about sights for ordnance. During my service I have been a Musketry Instructor for something like five years, and have gone in for the improvement of the shooting of the Army for the last fourteen years, so that, among other things, I have made a study of sighting. My idea is that no system of training, however perfect, can be of any use unless you have got good sights. By a good sight I mean (1) a sight which is theoretically sound in principle, or, in other words, which will give you a command over the axis of the gun, whether it rests on a level platform or not, without having to make and apply corrections for every change in the inclination of the sights due to a change in platform; (2) a sight which will accept your corrections in a constant manner, and which, after each recoil of the gun, will continue to give, without any alteration in elevation or deflection, corresponding constant results in the shooting. But if the sights are *not* sound in principle (such as is the case with the Service sights) you lose command over the axis of the piece as soon as the gun wheels are

not on a level platform, and the shooting must be very uncertain, although you may have had any amount of previous training in laying or in the making of calculations for correcting errors due to the inclination of the sights. With a view to remedying this defect in the service sights, I have proposed a system of sighting which will dispense with the inaccuracies of shooting due to the inclination of the wheels of field-guns. With a view to do that it is necessary to have a sight which can be placed upright whenever the wheels are inclined. We know perfectly well the first rule in musketry practice is to put the sight upright. In the case of a gun taken out on the side of a hill, the wheels are no longer level, and therefore the sight (which in the arsenal is fixed so as to be vertical in a gun with wheels on a level platform) is inclined, and the result is, of course, the shot goes to the right and low if it is inclined to the right, or to the left and low if it is inclined to the left, unless certain calculations are made to correct the error. Calculations, I believe, under fire are impossible. I think most men who have had the opportunity of seeing service will agree to this. It is for this reason that I have invented sights which dispense with the necessity of making these calculations. These sights are called revolving sights because they have a revolving movement which allows of their being placed at will into an upright position when the gun wheels do not rest on the level, just in the same manner as the rifled sights are placed vertically by turning the rifle round in the shoulder, and then you will shoot correctly. From the fact of being able to place the sight into a vertical position, a very simple mechanical system of training men in laying a gun, viz., in making corrections, has been developed. Thus, suppose from a gun sighted in this manner you fire a shot with your sight level, and you observe the point of impact of this shot when looking over the sights of a gun alongside similarly sighted and similarly adjusted and laid on the same target, and it happens to go to the right, all you have to do is to move the deflection leaf to the left till the notch of the back sight and the top of the fore sight and point of impact are in line, and by so doing you measure the amount of deflection, and if you then, with the corrected line of sight, relay, by moving the trail, the gun on the target, your next shot will go in the correct line. Of course that mechanical correction must be very much more accurate than any calculation you may make from the result of guesswork. For the Service sights, the ordinary mode of calculating the amount of deflection for an error to the right is to guess how much it has gone to the right and to reduce the amount in yards to minutes of deflection. Again, if the sight be inclined, another correction has to be made which is to multiply the difference of the level of the wheels in inches by the angle of elevation, and to divide by hundredths of the range in yards, and then to remember to give the resulting deflection to the proper side, otherwise the shooting will be worse than before. Anybody who can do these calculations under fire must indeed be an exceedingly calm man. The mechanical method of correcting errors in shooting derived from the employment of these revolving sights for guns converts the gun into a simple machine whose functions are under perfect mechanical control, and thus any man of very ordinary intelligence can with a minimum amount of training produce a maximum effect of fire. Where the country is undulating guns would generally be on a commanding position—if the shot be fired at an enemy's gun, also on a high position, and the shot go to the right and below—it is just as easy to correct the error in the elevation by the mechanical method applied vertically to the slider as it is to correct the error in direction by the mechanical method applied horizontally to the deflection leaf. There is a telescopic sight exactly on the same principle as the revolving sight, which is necessary to enable you to aim to the full range of the gun. You can of course make much more accurate observations with it than with the naked eye over the ordinary sights. Supposing you are using the telescopic sight and the shot fired has gone to the right and low, all you have to do to correct for direction is to move the horizontal pointer inside the telescope to the left, and to correct for range to depress the telescope on to the point of impact of the shot. The man who is using a telescopic sight similarly laid and adjusted on the gun alongside of you is enabled to observe exactly where it has gone, and he corrects the errors in range and direction in about five seconds. The observer gives the correction found to the No. 1 of the first gun, and relays his gun on the target. The No. 1 of the first gun does the same, and this time watches the

effect of the shot from No. 2 gun, and, if necessary, makes any needed correction, which usually is not required. All the guns of the battery are then sighted alike, and perfectly accurate shooting is the result. At Hay some two years ago there was an Officer firing with one of these telescopic sights at a field-gun in the open. I think he had to find the range. He guessed it to be about 2,300 yards. He fired a first shot with one gun, giving the proper deflection, as he thought, to the sight for wind; he observed by means of another telescopic sight on the next gun alongside the fall of the shot. He found it went somewhere to the right, too low or too high. He corrected it in the way I tell you, and in the next shot he smashed the gun up. Now a gun is a very small object at 2,300 yards—it is only 5 feet broad between the wheels—and wants a very good shot to hit it, and his doing so shows that the principle is correct. The fact of having any system of sighting which corrects mechanically all errors in shooting must be a great boon, because it enables a system of training to be developed which is easily learned by every man. Very few men can make these calculations, but if you substitute mechanical corrections for mathematical calculations of course a far greater number of men in the artillery will be able to shoot well; and as shooting is the *raison d'être* of artillery, this is a very important point. With regard to the telescopic sight, I did not come here with the intention of cracking up the advantages of my own telescopic sights, but, as Major Watkin has made some disparaging remarks regarding my telescopic sight, and had nothing to say against the one which he calls his own, I must reply.¹ In the first place, he referred to the distance between the V's, and said that if a burr or small grain of dirt got in between the trunnions of the sight and the V's you would get errors in shooting. I have not been working at this business for fourteen years not to know that fact. At the same time, you have your fingers, and you can give the thing a rub round, and can put your fingers through the V's and take the dust off. But even if the sight has a burr on it, it would not make any odds, because, supposing your first shot goes to the right or the left, at the very next shot you correct it; and therefore you go on shooting with your burr just as well as you did before without it. I am surprised to hear Major Watkin propounding such a weak argument against my sights. If the Service tangent sight got burred or bent you would not be able to place it into its socket, and no shooting at all would be possible. Then there is another point he also made a remark about; this sight being an inverting one—he said, what a great many people say who have never looked through a telescope sight, viz., that the inversion of the image is a trouble. I do not deny that it is a trouble, but the inconvenience vanishes by three days' use. I was requested by the French Government, some eight or nine years ago (who at first made the same objection to the inversion of the image), to supply them with an erecting image glass. I did so, and when I went to France afterwards and asked them whether they had used it, they said, "No; if a man has to learn to look through a telescope sight it is just as easy for him to learn to see a thing upside down as it is to see it erect." If you have an erecting eye-piece in the telescope it reduces the field. Of course in the field-battery telescope you must have the thing as small as possible, and when you have to make the thing small you want to eliminate everything that will make it large. With that object I keep the telescope as small as possible, and with the inverting eye-piece I get double the field which I would get with an erecting eye-piece. In the field, when you are looking through the telescope, you will understand that you ought to be able to see a good way all round the target, otherwise the finding of the object would cause delay. The erecting eye-piece reduces the field very much. When you are looking through the eye-piece, which inverts the image, you see the deflection scale exactly as you see it in your own sight. When you want to give right deflection you move the pointer along the scale to the right, and when you want to give left deflection you move it to the left. With an erecting eye-piece it is just the reverse. If then you have to teach a man to give deflection to the right, when you ought to give it to the left,

¹ And at the same time would remind you of the quotation—

"Hic Niger est, hunc tu Romane caveto,"

he is a rival inventor.

and *vice versa*, you would increase the complication. He said also that when you are looking through the telescope which is inverting you cannot see whether you are pointing to the top of the chimney or to the right of it. This difficulty experienced by Major Watkin is quite new to me. I was not aware that an inverting telescope possessed the property of making the head of a man change places with those of his feet. And then he referred to the movements of the trail being reversed. Supposing when you are looking through an inverting telescope you see that the pointer is to the left of the target, you do not think of the trail at all, but you see that the pointer has to be moved to the right; and so in order to get that pointer to the right you say, "Trail right." It is perfectly simple. If you see the pointer to the right of the object you want to move it to the left, and you say: "Trail left." Instead of creating a complication by having an inverting eye-piece, you really get a great advantage, and that advantage was reported upon by the French Committee who tried it in 1876. With regard to training of the batteries, it is not my business to talk on that subject; but from the point of view of an outsider who has been accustomed for many years to the training of men, I hope I am not intruding in making a few remarks. It appears to me, from having trained some 2,500 men in musketry, that the training of artillery in the use of their sights might be improved; for instance, on field days, no laying of the gun should take place without going through a rehearsal of what you would go through on actual service. The range should be found in the first place properly; the sight should be carefully laid on the object with proper elevation and deflection for wind, or anything else, and the aim should be tested by an Officer. Also, if possible, the range should be found first of all, and the sights should be adjusted under cover. For instance, supposing you are on the top of a hill, with the ground sloping to the rear, the range-takers should go out to find the range, and should come back to give it to the No. 1's who would then give the correct elevation and deflection to the sights, and then the battery should gallop up and commence firing at once. That can only be done with sights that can be put upright on the revolving principle; for, supposing that you set the Service sights (which have no revolving movement) to the correct elevation and correct deflection for wind, &c., in rear of the position, and that you galloped up to the position, the wheels would be perhaps exactly on the other tack, and the corrections you have made down below for wheels and wind would be very incorrect for the new position. The fact of being able to set a sight correctly for position is a very great advantage on the side of the gun sighted with a revolving sight. All your field-guns with revolving sights are, as it were, always upon a level platform, and there is no calculation to be made for wheels.

Mr. ANDERSON, C.E.: I have considerable diffidence in speaking on the very suggestive paper we have heard, because it deals so much with the practical working of artillery. I have never laid a gun on a distant object in my life, and therefore I have very little practical knowledge of actual shooting; but I have given a good deal of attention to the theory of the discharge of artillery with reference to the construction of gun carriages, and I cannot resist the opportunity which has presented itself of asking for information respecting the effect of the steadiness of the gun carriage on the shooting. With the old short guns, firing with full charges, I suppose it is pretty well agreed that the shot had left the gun before sensible recoil of the gun and carriage had commenced, and that, therefore, any motion of the gun at an angle to the line of fire did not materially affect the accuracy of the aim. But with long guns, I think it has been proved by direct experiment, at Woolwich and elsewhere, that the shot has not actually left the muzzle when the recoil begins to take place, and it is on this point that I should like to have the opinion of the author of the paper, and of other practical gunners present, whether, under those circumstances, the motion of the gun at an angle to the line of fire, or the kick of the carriage, does not materially affect the accuracy of the aim. The transverse motion has been avoided in some gun mountings, as, for example, in a very notable manner, in the system adopted by Sir William Armstrong in mounting the heavy guns of the "Colossus" type, in which the elevation and depression is given by lowering or raising the rear ends of the slides; consequently the line of recoil is always in the line of fire, and any inaccuracy due to transverse motion is eliminated; I do not suppose that the method of mounting was adopted for the

purpose of attaining the object named, but it was a contingent advantage of it, and Mr. Nordenfeli has done the same thing in his recent mountings. He has practically done away with the trunnions of the gun, and has mounted the whole apparatus by which the recoil is controlled, so that it pivots in the vertical plane on an axis which is coincident with and at right angles to the axis of the gun, so that, in that case also, the recoil takes place in the line of fire, and it seems to me that with long guns it must be an important element in favour of accuracy. I had the privilege of seeing, last year, at St. Petersburg, the mounting for an 11-inch rifled mortar constructed by a Colonel Raskaroff, of the Russian Marine Artillery, in which he makes the mortar recoil at an angle of thirty-five degrees; that being an average inclination for high angle fire; and the accuracy which characterized the shooting of that mortar has been attributed to some extent to the steadiness of the carriage, and likewise to the fact that the gun recoiled very nearly in the line of fire. In some mountings the gun rises very quickly at the moment of recoil, and it seems to me that the consequence must be, if the shot has not left the barrel before the recoil begins, the shot must be thrown up and the muzzle of the gun must be depressed. Accordingly in such mountings we find friction gear attached to the elevating arrangements, to prevent them being broken by the tendency to rotate the guns, as this tendency must always exist if the guns do not balance at all times on their trunnions. The author has not touched upon this point, but probably he has considered it and will be able to say from his experience whether there is much importance in it. In the case of the Moncrieff mounting for larger guns, I have adopted the plan of making the base of the carriage longer than the gun itself, with a view to preventing any jump, and arranging the elevating gear so that at the longer ranges, at any rate, the gun shall recoil as nearly as possible in the line of fire. It remains yet to be seen what sort of shooting these guns will make.

Mr. E. H. CARBUTT: I was glad to find that the first speaker referred to the large number of batteries which are still without the latest pattern of gun. I may say, considering that a Chancellor of the Exchequer has gone out of office on the question of War Office expenditure, it is the more necessary that those gentlemen who know our deficiencies should speak out, and let the public know that if they intend this little island of ours to be properly defended, we, who have the smallest army in the world, and have the largest possessions to defend, must be supplied with the latest and best guns that can be designed. In the House of Commons I did my best to persuade the Government to spend money upon making more guns of the latest and best type. I was much impressed a year or two ago, when going to the military sports at the Agricultural Hall, to see what we were told was the best battery in the world, to find it was supplied with an old-fashioned muzzle-loading gun. I think it was a pity when an exhibition was made of the "best battery in the world" that we should not have had a breech-loading gun to show what we were doing. I have always held the opinion that we in England do not spend enough money in experiments, and that it would, be very much better if we did spend more money, for we should not then go on making guns and gun carriages which turn out not so good as they might have been if we had continued making experiments. It is also very essential that our men should be trained. We have very few men compared with foreign armies, and, therefore, it is quite right that they should be the best trained. I am sure the country would not begrudge the money. It is recommended that all these men who are to work the guns should be well educated. No doubt that would be of essential value. I think the fact of all the men in the German Army being well educated has much helped them. All the men who have to become efficient in gun practice and firing should be as highly intelligent as we can possibly make them. It is all very well to highly train the Officer, but he cannot always be with his men. Therefore it is quite right that you should endeavour to get well-trained and intelligent men. I should like to ask a few questions in reference to the diagram showing the result of firing with a 9.2 inch breech-loading gun at 1,000 yards' range. The result shows very good work; could the author state if that figure was obtained when the gun was new, or if he has any idea what number of rounds the gun fired before it made that good practice? We were told by Colonel Maitland, in a very excellent paper, at the

Civil Engineers, the other day, that in some cases the rifling is all worn away, or eroded after the gun has fired 176 charges, and I think the largest number of rounds he has got out of a gun is about 200 charges before it required relining. One would like to know at what stage this particular practice was made. May I ask the author if he has had any experience with different forms of rifling, as to the practice he can get? I have an impression that the increasing twist which we adopt is not the right system. I believe you never can get the speed forward to coincide with speed in the twist. The War Office has partly given up the increasing twist, as now you have the increasing twist only half the length of the gun, and uniform twist the other half. I do not think that would tend to accuracy of fire, because you have to alter an increasing twist to a uniform twist. Has the author had any experience on that subject, or with any other system of rifling? Perhaps he may have had some experience with the Whitworth polygonal system. My opinion is that we shall at some future time adopt a mechanically shaped shot, so that when the gun is worn or eroded you can still go on firing and have the benefit of the rifling. I also believe that in the mechanically shaped shot if any windage occurs through wear or erosion the windage will help to rotate the shot, and, therefore, will make up, to a certain extent, for the loss of rifling. I feel rather dissident in giving my opinion upon this point, because I came rather to gain information than to impart it.

Captain WALTER JAMES, late R.E.: With your permission I should like to say a few words supplementing the few remarks I made the other day. There was a point to which I meant to have alluded, and on which the lecturer has touched, namely, a matter which I may say, *en passant*, has had a good deal of attention paid to it on the Continent—the question of high-angle shrapnel fire for land service. The Prussian artillery possess a 15-centimetre short-rifled mortar, which, according to men who have had practical experience in its shooting, will render overhead cover necessary in siege batteries up to a range of 2,500 metres. I am speaking on a subject on which I have very particular information. The information in question was given me by an Officer who had charge of the siege train at Mainz: he is a personal friend of mine, and he told me that from his own experience he would say that the 15-centimetre rifled mortar would render it impossible for gunners to serve guns on any battery up to a range of 2,500 yards. I believe there is no such weapon in existence in England. It is always a little difficult of course for anybody like myself to know what is going on in England. It is always easy enough for me to find out what is going on abroad, but, as far as I am aware, judging from those excellent works, the departmental proceedings of the Director of Artillery and the Ordnance Select Committee, there is no such weapon in existence. I believe myself those weapons will have a very large influence on future warfare. I know the Germans propose to use them combined with long-range infantry fire for the reduction of small *forts d'arrêt* erected at various parts of the French frontier. If big mortars will have a great effect on the sea-going ships, so this small mortar will have a large effect on land operations. The shell it fires weighs about 80 lbs., and contains a very large number of bullets, the effect from which would be of an exceedingly murderous character. Sir Michael Biddulph gave a list of velocities of field guns the other day, and said the muzzle velocity of the Russian gun was 1,350 feet.¹ He was giving there the short Russian artillery gun, with which they only arm some of their horse artillery batteries. It is not quite fair to quote that as an ordinary Russian small gun, that is to say, it is not the equivalent of our new 12-pounder, and must be looked upon more as a sort of intermediate step between our 7-pounder and the 12-pounder. That Russian gun formed the armament of the Russian field batteries certainly eight years ago. The point I brought out with regard to these guns, the point which Major Hay has touched, is, that although the Germans re-armed their field batteries in 1873-74, although the French re-armed their batteries a few years afterwards, for some reason chiefly known, I believe, to the Chancellor of the Exchequer and the British tax-payer, the field artillery of England at the present moment is armed with weapons which must be looked upon

¹ See my article "Modern Field Artillery," in vol. xxiv of the Journal, p. 737.

as distinctly unfavourable as compared with those in use in all the great European armies. I always think on these occasions, although our audience is an excellent one, it is chiefly professional. It is hardly the army itself that wants to be educated, but it is the British Chancellor of the Exchequer, the Member of Parliament, the taxpayer that wants to be educated. If we could transfer the scene of our lectures to another sphere, I am perfectly certain the effect which they have amongst us would be supplemented by a very much greater effect exactly in the quarters in which it is wanted to take place. Major Watkin quoted Sir George Colley as an authority on range-finding. I should be the last person to detract in the least from the fame of a very excellent and gallant Officer, but I cannot help thinking that Sir George Colley's opinion on the Watkin range-finder were probably theoretical. I very much doubt whether he had had the practice with it that I have had. I very much doubt whether he was aware of the fact that occurred at the battle of Laing's Nek, and which was told me by the Officer who took the range himself. The range obtained with the Watkin was enormously out, doubtless because it was not in adjustment. This bears out what I have said, viz., that the Watkin does not stand knocking about, it gets out of gear, and then the range you get is often an absurd one. I do not decry range-finders, though I do not think the Watkin is a very good one. Major Watkin also referred to me as saying that powder and other things had to be taken into consideration. Of that I was perfectly well aware. He went on to say that supposing he got with the range-finder 2,200 yards, and found afterwards that it was only 2,000, that was of course the sort of thing that he expected would turn up. That statement contains exactly the point on which I am at issue with Major Watkin. He says the range-finder is so accurate, I say his range-finder is not always so. We must have the trial and error shot after all, and it is very little use supplementing these by an instrument which cannot be relied on always to be in adjustment.

Mr. T. NORDENFELT: As to the question of the short shot being deviated by the recoil, that is quite true as far as we have found out. We discovered that with the usual velocity in high velocity guns anything above 30 calibres began to have effect upon the firing, and therefore the recoil carriage has been made in such a manner, that when the gun recoils it lowers itself about a quarter of an inch, but is absolutely parallel to its previous position. That was the old carriage, but in the last one we made it recoils absolutely in its old line of fire. We had a very interesting result with that carriage last week at Spezia. The 6-pounder gun with 2,200 feet velocity was fired at three ranges, 1,200, 800, and 600 yards. There was no wind, the smoke hung about so that we could not see except each time we changed the aim to another target. We fired at these varying ranges, changing targets every three rounds, twenty-four shots in 2½ minutes, and the hits were fifty per cent., the vertical deviation being less than one metre on 6-feet targets. This shows the satisfactory construction of the carriage, as only the first shot of every three was aimed, the other two being fired without adjusting the aim. Now, allowing that we got every possible advantage in the matter of good training, sights, deviation, and all other points mentioned, I think the main point which the author has evidently taken as an axiom, is the high velocity and the proper shape of the projectile. Now, where we have to deal with shrapnel, as it is not a question of a large bursting charge, and, consequently, not a question of making the gun of a larger calibre, for the purpose only of giving more capacity to the shell, naturally you make the projectile as long as you can, and give it the highest possible velocity. For shrapnel fire this is important, but when it comes to navies or the defence of fortifications, firing at objects at sea, the question becomes still more important. Of course in fortifications for the defence of our ports, you have not the rolling platform of the ship, but you have the movement of the enemy's vessel and its speed, and for anything like such firing the very highest velocity is surely a necessity. You can always arrange recoil carriages in such a way as to take up the effect of any velocity. Just to mention one instance: in firing with 2,200 feet velocity at 2,000 yards, if we miscalculate the range of a ship 25 feet out of water, and we aim at the water line, we still hit it, miscalculating the range at 2,000 yards, 200 yards. If on the other hand I reduce my velocity to 1,900 feet, or to the ordinary velocity of the English 6-pounder, 1,856 feet, if I miscalculate the distance

of the ship at the same range by 100 yards I must miss it. For the difference between 1,900 and 2,200 you have double the chance of hitting; there is no getting over this fact. You actually double the probability or chance of hitting by increasing the velocity of the same projectile from 1,900 to 2,200 feet. Therefore I would urge, when any question of construction comes up, for positions where you cannot have time always to judge the rapidly varying distances, the exceeding importance of having the very highest velocity that can be had with safety to the gun, and which can be easily dealt with by means of the recoil carriage.

The CHAIRMAN: Before the lecturer replies, I think I may be in the unusual position of being able to give Captain James some information. How a gentleman of his known energy can say that he has greater difficulty in getting information from England than from abroad, is a thing I cannot understand. I understood him to say he was interested in the question of vertical fire from shrapnel, and thought it had not been resorted to or tried in England.

Captain JAMES: Pardon me. With the greatest deference to what you say, I did not say it had not been; I merely asked for information whether it had.

The CHAIRMAN: You were not sure whether it had or not. I have seen it tried myself, or I have seen the results of it. It was tried at the siege works at Lydd. The piece, I think, was an 8-inch howitzer, and the shrapnel was designed to throw the bullets forward as much as possible. Though the velocity was low the accuracy of the piece was very good for a high-angle fire, the burst occurred at about that position, and was such as to cause the most destructive effect upon the gun detachment round a dummy gun in a sunken emplacement against which the piece was directed. The experiment was made, and the result satisfactory.

Captain JAMES: The point I was asking was with regard to a small piece like the 15-centimetre rifled mortar.

The CHAIRMAN: The 15-centimetre is a 6-inch. You rather minimized it by describing it as a smaller piece.

Captain JAMES: It is less than a field gun.

The CHAIRMAN: It is a 6-inch rifled mortar or howitzer; this was an 8-inch.

Captain JAMES: What will the 8-inch weigh?

The CHAIRMAN: The principle is the same. The experiment was tried. I am not sure that it has not been tried also in the 6-inch.

Captain TODD, 3rd Middlesex Artillery Volunteers: I rise to back what Colonel Hughes has said about the schools. I and my two sons had two months in them, also most of my brother Officers. We represent a regiment of 960 men, all efficient. We served two months at Woolwich and Shoeburyness, going to the Guards at Wellington Barracks for six weeks. We have been told about the intelligent men that we ought to have for the artillery; well, we have them; we produce them, and we pay in money, time, and labour towards training them ourselves. The men are out of pocket also. It is not the Government that pays for the entire training, &c.; the Government Grant only covers part of the expense. It costs me at the very lowest estimate 50*l.* a year out of my own pocket for prizes and different things to assist in making my men efficient. I wish to say it is not a Treasury question; it is a question of whether the authorities will speak out unmistakably, plainly telling Members of Parliament and the general public who do not take part in the patriotic work that we are engaged in, giving them to understand that it will be a bad day for England if she depends upon two Army Corps, even though they may be of 60,000 men. Numerous brother Officers of volunteer artillery have told me that they perfectly agree in deploring the cutting down of those fine Royal Horse Artillery batteries that we have heard of to-day. It is no fault of the Royal Horse Artillery that they are armed with bad guns; whose fault is it? The fault should be found out and rectified, that Horse Artillery should be increased, only armed with better weapons, and I contend that if the authorities spoke out in a plain and honest manner to the public and to Parliament they would vote any amount required, even millions if necessary, for our defence. We had 11 millions voted once, although one million of that was lost or mislaid. To what are we relegated after all this work at the schools? We are sent to Plumstead, simply to satisfy the Government requirements that we have fired off so many rounds, and

this out of guns that are worse than useless. The whole thing is a farce. The men make a laughing stock of it. I have heard men say they could kick a football with more precision than they can send these spherical shots towards the butts. I mention this that you may know how strongly we feel upon the subject. We adopted the Morris tube the moment it came out. We gave our men an hour's practice once a week; we found the tubes and the ammunition, and the men spent an hour in what they considered recreation, although it was very hard work. We made them excellent shots, and then they went to Plumstead with their carbines.

Their practical work was certainly supplemented by theoretical work, but the practical work was much more good to them than any theory that we can give them. For 300 men in my particular division we have one 40-pr. and two 32-pr. smooth-bore worn-out obsolete guns. We simply train the recruits with the 32-prs., and then we take them on to the 40-pr., after that the greater part of our work is done with that one 40-pr., because we do not like to give the men the old weapon the 32-pr. to work on.

Lieutenant YOUNG, R.A.: I wish to answer Captain James' remarks with regard to Major Watkin's range-finders. I was at Hong Kong towing a target, and if it had not been for the possession of the Watkin depression range-finder, I feel quite certain that I should have been in great peril. The practice was really wonderful; the shooting was beautiful; the range kept varying a good deal, and yet the shots were as near the targets as they possibly could be.

Captain JAMES: I said nothing about the depression range-finder. I was referring to the field range-finder.

Lieutenant YOUNG: With regard to the field range-finder, I want to ask Captain James whether he thinks that what is more or less a very correct instrument is to be put against carrying extra rounds in the limber, for in these days, when we want to get along as quickly as possible, the less we carry the better. I have used the field range-finder; it is a very good instrument, and very accurate. I think it is simply through rough handling, that it might get out of order.

The CHAIRMAN: It is not usual for us on these occasions to ask each other questions, because you might go on to a very late hour. I have received from Colonel C. B. Brackenbury a paper which he asks me to have read, but it is against the rule to have papers read in the absence of members, I have therefore referred it to the Secretary, who will lay it before the Council. Possibly it may find its way into the Proceedings in the form of a note.¹ I will now ask Major Mackinlay if he has any observations to make upon the criticisms which have been offered.

Major MACKINLAY, R.A.: I will endeavour to be brief in my reply, as so many of the questions which have been raised have been replied to by other speakers; for instance, Captain Orde Browne was answered by Colonel Stirling, Major Watkin, and Mr. Nordenfelt. Colonel Scott very strongly brought out the necessity for more practice ammunition; his great experience in the command of practice camps adds weight to his words. With regard to the criticism of the diagram (Fig. 6) I can only say that I received it as a general illustration of the accuracy produced by the range- and position-finding arrangement. No doubt there is some force in the remarks of General Smyth—an Officer of great experience, and whose opinion is entitled to the highest respect—but after what Majors White and Watkin have said it seems unnecessary for me to make any further allusion to the matter. Only one naval Officer took part in the discussion, but Lieutenant Tupper gave very valuable information. I hope his proposal for a shell to leave smoke on the water to assist in range-finding by trial shots will prove a practical success. Major Douglas Jones was the first of several speakers to touch on the important question of the ranges at which horse and field artillery should engage in action; this opens out the wide subject of field artillery tactics, which I would suggest might form the subject of a future paper at this Institution. Major White's proposal that prizes should be given for range-finding seems likely to be useful, and I trust may be carried out. Colonel Richardson's words on mechanical laying are doubtless worthy of much attention; I cannot but think, however, that his remarks about the difficulty of

¹ The paper was considered inadmissible.—Ed.

making garrison artillerymen into good shots may lead to some misunderstanding; probably he has a high standard of excellence, and he might call a man badly trained of whom others would speak well. Only this morning I was at the Royal Military Repository, Woolwich, and there had evidence in the records on the instructional target of the accuracy of his men in laying. As the instructional target has been several times mentioned, I should like to draw attention to a small improvement which Quartermaster-Sergeant Earnshaw, R.A., Royal Military Academy, proposed some ten days ago. If the large target is held vertically the small lead triangle, on the centre of which the aim is taken, will sway about like a pendulum, and thus time is lost in adjusting it; it is therefore usual to tilt the face of the large target backwards a little; but there the triangle sticks, and only moves by jerks. The improvement suggested is the addition of two small wheels or rollers at the bottom of the triangle to enable it to move regularly. This is practically shown by the actual target before you, over which two leaden triangles are moved—one is the ordinary Service arrangement, and the other has wheels attached to it; the latter is observed to move more regularly than the others (see Plate 6). The surface of the large target should be planed smooth. If it should be found desirable that the man laying the gun should adjust the triangle himself, in order that he may not suffer from the unskilfulness of another person, I am assured by Mr. Jacob, of the firm of Messrs. Siemens Brothers, that this could readily be effected by means of an apparatus of pianoforte wire and a drum at the short distance of 100 yards, at which the instructional target is generally used. General Sir Michael Biddulph's remarks on the superiority of our new field-guns over those of other European nations are a cause of congratulation, and they furnish a strong reason for the general adoption of these pieces on a large scale, as advocated by Major Owen Hay and Mr. Carbutt. Colonel Stirling's very valuable remarks told of progress in the garrison artillery, and gave a record of what has lately been accomplished by the armament of perhaps the most important of our coast defences. I cannot say that Major Scott has convinced me that the short distance apart of the V's for his overbalance telescope sight is a matter of no practical importance; but with reference to the inverting eye-piece I should like to mention that having had no practical experience in its use as a gun-sight, a few days ago I asked Major Marshall, R.H.A., whose battery is supplied with them, if his men were puzzled by the inversion of the image in the field of view, he replied, "Not at all." He then took me to his gun park, a gun was brought out—which I laid myself by means of Scott's telescopic sight with inverting eye-piece—and one of the gunners of his battery traversed for me and appeared to understand the working of the sight, which seemed to me also easy to manipulate; an ordinary erecting eye-piece is, however, also supplied. Captain James remarked that Prince Kraft's letters on artillery have only appeared in German and in French; but I am glad to be able to say that Major Walford, R.A., has translated these valuable writings into English, and the letters have now begun to appear in the monthly issues of the Proceedings of the Royal Artillery Institution, and are attracting considerable attention. Mr. Anderson asks for information, but he himself and Mr. Nordenfelt have given us valuable facts about recoil in the line of fire which are, I think, new to most of us; though knowing for many years that the mounting has considerable influence on accuracy of fire, I only lately heard in general terms from him and from one of the Officers of the Royal Carriage Department that recoil in the line of fire is desirable with the present long guns. In reply to Mr. Carbutt, I cannot see any disadvantage in the employment of both the uniform and the increasing twist in the same gun, as one runs insensibly into the other—the uniform twist when developed on to a flat surface being a straight line which is tangential to the curve which is the development of the increasing twist; neither can I think a mechanically-fitting projectile, such as that of Whitworth or Lancaster, superior to one which is forced into grooves which are employed not only in England but also on the Continent. Windage should, I believe, be avoided to prevent the erosive action of the powder gas on the surface of the bore as much as possible. I will endeavour to find out how many rounds¹ the

¹ Major Bainbridge, R.A., has since informed me that 25 rounds had previously been fired.

9-2-inch gun had fired before the ten rounds referred to in Fig. 2. I wish in conclusion to express my thanks to many Officers of the Royal Artillery and Royal Navy and to other gentlemen who have assisted me in the preparation of this paper.

The CHAIRMAN: We certainly have had a very interesting lecture, and one which has elicited a great many observations and a great deal of discussion which I think will be of considerable interest, and I hope of practical value. Major Mackinlay felt unable to criticize Colonel Stirling's observations, but it struck me that his suggestion as to dials communicating from the Commanding Officer to the gun floor is a useful and valuable one. Of course we are all familiar with the means of communicating orders on board ship from the Commanding Officer to the engine-room, and so forth, but it has not been carried out to any great extent on land, and there is a difficulty in knowing what you have to communicate, because you cannot talk to your subordinate at length. You want to be able to give him definite orders. Of course it is easy with an engine to say, "Go ahead," "Stop," and so forth, but the idea of communicating elevations and deflections was new to me, and I think that that might be worked out. Colonel Hughes observed that he could not get the Artillery Institution Proceedings, as I understand, but I know that they go to foreign societies, therefore they are not regarded in any way as secret or confidential. I think the difficulty is more financial than anything else, and I trust if he finds a practical difficulty in obtaining them now that that may be overcome hereafter. Certainly for myself I should like to see the institutions of the Royal Artillery Regiment used to foster and encourage volunteers as much as they can in every possible way. We have had so much said as to the need of pressure being thrown upon the Administration with regard to the provision of 12-pr. field-guns, that a few words might not be out of place to describe the existing situation. I believe if at any time within the next few months an Army Corps were to leave this country it would be armed with 12-prs. entirely. I believe that if a little later next year two Army Corps were ordered abroad, they would go armed with 12-prs. entirely. That is more satisfactory than you might have imagined from the observations made in this discussion. We have certainly been a long time in getting out these 12-prs., but possibly we may have avoided some stumbling-blocks in doing so. Supposing, for instance, we had made our minds up to equip our field artillery a few years ago, we should hardly again be in a position to equip ourselves with the 12-pr. breech-loading gun that we think so highly of. In short, I think the method by which John Bull proceeds in managing his affairs shows that he is not altogether a fool. His conclusions are the outcome of a great many years' practice and experience, and I suppose he takes advantage of his insular position. It seems to me he is never in a hurry. If we had in 1873, when the Germans brought out their new field-gun, immediately rushed into the field we should have had, perhaps, after a few years the 13-pr. muzzle-loader. We should have equipped ourselves with that, and then if we had gone on a little we should have equipped ourselves with the 13-pr. breech-loader, so that we should now have been saddled with two sets of equipment, and, finally, should have wished to have equipped ourselves with a third; so that, on the whole, I think that we are not in any such a very unsatisfactory position as regards those guns. Seven batteries have already been issued. There can be no doubt that we have made a very great step in advance. Good guns I do believe do make good shooting, and I think we shall take advantage of that fact, and shall progress in accuracy also. A friend of mine, speaking to me yesterday afternoon, said: "You are going to the discussion to-morrow; is accuracy regarded as the principal thing in the artillery?" I rather thought turnout and smart movement were the principal things." I must confess that in answering him I had to hedge a little. I said accuracy certainly is the principal thing, but it has not always been so regarded. I do think, however, the time may soon arrive when we shall be able to say this, that accuracy in fire is the most important accomplishment of the artillery Officer and non-commissioned officer. We have had a good description from Major Scott of his own sight, from which I think great things may be hoped. It has been a long time coming, but is now pretty well admitted into the Service, and though I have not seen shooting with it myself, I believe we shall derive great advantage from it, and also from Major Watkin's position-finder; in fact, we are at an epoch: now as to *means*, with the

introduction of the telescope sight and the position-finder. This is the first year in which the telescope sight, I think, will have been tried at practice camps on an extensive scale, and certainly it is the first year in which the position-finder of Major Watkin will have been used by Service batteries, not for experiment but for practice on the coast. A position-finding installation has been made at Plymouth where about half a dozen guns are in connection with the instrument, and authority has been obtained for using a certain amount of ammunition, and the Officers and non-commissioned officers will at once be thoroughly taught in the use of that instrument. I hope another year we shall be able to hear a fresh account of the result which has been so obtained. Inasmuch as Major Watkin's position-finder cannot be readily supplied all over the world wherever batteries are stationed, I think the moment has arrived when more than ever schools are necessary—that is to say, schools where men can be trained. Officers and men if they are to learn the use and practical application of the Watkin's position-finder must go to some place where it is in operation, and therefore the establishment of schools of shooting is a matter of greater importance than ever it has been before. The subject of schools has been alluded to by several gentlemen, and I am delighted to find how much it seems to be welcomed. It is the Officers and non-commissioned officers who chiefly require to be taught, and upon whom the expenditure of time and trouble in teaching them will be most repaid. When you think of the difference in cost of ammunition between supplying a whole battery of soldiers with so many rounds to fire or supplying a limited number of Officers and non-commissioned officers, I think it is clear that by the adoption of that system we shall be able to make our money go further, and the public will get a more adequate return for their money than under the old system of causing every man to fire so many rounds. No doubt the stride made recently in artillery is enormous. We have arrived not only at an epoch in means of shooting, but at a great epoch in the guns themselves. The point is how to utilize this increased power. As regards the field batteries, and the remarks made as to the individual skill of gunners in laying—though I do not quite follow Colonel Richardson—I do think there is a good deal to be said in that direction, because with the rifleman, he and his weapon are one, and he has to do almost everything—to make his own allowance for wind, and so forth, and to understand his own weapon; whereas in the case of the artillery it is different. As the Volunteers are likely to have field artillery, I should like to impress upon them that the essence of their work is to establish a thorough system of co-operation and mechanical regularity in laying so as to attain the proper direction of fire. Fire discipline for the artillery means something different from fire discipline in the infantry and other arms; it means such a mutual understanding between the Officer and those he commands, that all mistakes and misunderstandings are eliminated, that the work of laying may go on, the order once given what the elevation is to be, with most accurate mechanical regularity, round after round; that each man should understand exactly his own duty, and should do it. What they have to keep in mind is to consider the battery as a machine in the hands of the Commander, to organize direction and observation of fire, correction of sights, mechanical accuracy in laying, and the utmost regularity throughout. Hit, hit, hit, is the maxim for the artilleryman. I will conclude by expressing thanks on your behalf to Major Mackinlay for the lecture he has given us.