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Friday, January 23, 1880.

LIEUTENANT-GENERAL Sir J. HENRY LEFROY, K.C.M.G., C.B.,
R.A., &c. &c., in the Chair.

LESSONS TO BE LEARNED FROM KRUPP'S MEPPEN EXPERIMENTS OF 1879.

By Captain C. ORDE BROWNE, late R.A.

THE purpose of this paper is to take a short review of the most characteristic features of the Krupp *matériel* experimented on at Meppen last summer, calling attention chiefly to the best results, and comparing them with corresponding ones obtained in this country, with a view to promote the discussion of those matters in which it may appear that we have most to learn.

The principal feature in the Meppen programme was the trial of Krupp's 40-centimetre (15·75 inch) breech-loading gun, weighing about 70 tons 17 cwt., known commonly as the 71-ton gun. (Fig. 1.) The trial was specially important for three reasons. 1st. It is the first breech-loader whose power approaches that of the 100 and 80-ton guns made in this country; 2nd. It is a steel gun; 3rd. Its proportions are based on results obtained during the last few years.

All these questions are interesting, and deserving of so much attention that it would be difficult here to deal fairly with all. For the purpose in hand, however, it is not necessary to discuss the question of the respective *metals* of the guns, because it can easily be shown that there was nothing in these experiments that bears upon this point beyond the negative fact that the steel guns in no respect exhibited any fault. We may safely say that our Woolwich guns would have done equally well, as far as the material is concerned, for the pressures in Krupp's guns were by no means excessive. The 71-ton gun, for example, was not subjected to as high a pressure as our own 80-ton gun has borne. A test which tries neither gun obviously furnishes us with no means of comparison, and hence the Meppen trials in no way furnish data for the discussion of the relative merits of wrought iron and steel guns, but bear entirely on the two other questions, namely,

The Institution is indebted to the Proprietors of "The Engineer" for some of the illustrations.—Ed.

that of breech-loading and proportions—the former as concerns ease in working, and the latter power and good shooting.

The 71-ton gun, Fig. 1, was mounted as for coast defence, on a traversing platform, and a carriage nearly of the English pattern in all respects. The brackets were made of wrought iron, the gun being elevated by multiple gear, N, acting on elevating arcs, O, fixed on the gun. Beneath the carriage were two hydraulic buffers. A modified form of Cunningham's chain gear, RR, was used for traversing the platform, which ran on trucks on three concentric racers, the pivot being about 6 feet in front of the carriage when run up. A lifting crane, J, was attached to the platform, fixed on a sort of axle, K, with a counter-lever with powerful spring, L, which required considerable force to compress it by bending down the crane, and which decreased the work of lifting the projectiles by the same amount, thus dividing the labour of lifting the projectiles into two operations.

15.75 IN. (40 CM.) CHILLED SHELL.

COMMON SHELL.

Weight of shell, empty.....	1,690.6 lb.	1,338 lb.
Weight of bursting charge	22 lb.	73 lb.
Weight of shell, filled.....	1,712.6 lb.	1,411 lb.

The gun was easily worked by a detachment of fifteen men. Ten rounds, with chilled projectiles, were first fired; the time occupied by the last five rounds was twenty-four minutes. The breech piece moved

Fig. 1.—16 IN. (71 TONS) GUN MOUNTED ON COAST-CARRIAGE.

H—Carriage, wrought iron.

I—Loading platform.

J—Crane, pivoting vertically on pillar hinged horizontally at K with counterspring on arm L beneath the carriage.

M—Chilled iron projectile.

N—Hand wheel for elevation with train elevating arc O.

P—Graduated disc, showing quadrant of (inner) edge of elevating arc.

Q Q Q Q—Handles for working traversing

KRUPP'S 15-75 IN. (40 CM.) 71-TON GUN.—WEIGHT OF GUN WITH WEDGE ABOUT 71 TONS.

FIG. 3.

32.1" = 26.5"
WOOLWICH (16 IN.) 80 TON GUN.

FIG. 4.

easily. A good deal of oil was used on it. The breech-loading certainly saved the men much labour, not only in the actual ramming home, but also in bringing up the projectiles, since it was not necessary for them to cross any of the racers or the Cunningham chain. The charge was made up in four cartridges, each containing 110 lbs. of prismatic powder. The least satisfactory part of the service of the gun was the difficulty experienced in the ignition of the charge and in remedying miss-fires. The vent was in the axis of the piece, and a disk of calico was torn off the bottom of the cartridge last entered, to expose the powder to the flash of the tube. The latter was of a bad pattern, short and weak. No stress is to be laid on this, as the remedy is obvious. A primer or a stronger tube would rectify this fault. A rather more serious difficulty was apparent when a miss-fire had occurred. The position of the vent was such that it was unusually dangerous to approach it while there remained any likelihood of the gun going off. A gunner may insert a tube in a vent in the top surface of a gun with comparative safety, but to thrust his hand into the cavity in the breech, and in such a position tamper with a doubtful tube and charge, would indeed be dangerous. On active service the risk, no doubt, would be run, and it is possible, if the man stood on the step of the carriage and reached round so that the gun in any unexpected recoil should carry him with it rather than run over him, that he might escape without injury. Nevertheless, while this modifies the objection, it remains sufficient to make it imperative to construct some implement to enable a tube to be removed and another entered with safety, even should a miss-fire be a much rarer occurrence than it was at Meppen last summer. The flash from the vent has been spoken of. This is an objection which belongs to all axial-vented guns. There was but little flash in Krupp's guns at Meppen, owing to an arrangement by which a loose platinum ball in the vent is driven up out of the way by the flash of the tube, but pressed back so as to close the vent by the rush of gas from the charge. An Italian Officer stated that this ball is not serviceable, but becomes worn and of little use after a time. Under any circumstances this difficulty is one connected with axial vents rather than with breech-loading.

A more important question is the shooting of the gun as regards power and accuracy. The chilled projectiles had 0.078 in windage, which is about the same as that in Woolwich projectiles, namely, 0.08 inch over a copper rim. The common shell subsequently fired, however, had the unpractical windage of about 0.01 inch over an iron body.

The diagrams Nos. 1 and 2 show a remarkable degree of accuracy, chiefly in the vertical direction, which argues well for the regularity of the charge, which surely must be attributed to the prismatic powder employed. It stands to reason that a charge composed of a fixed number of prisms of uniform size and density gives promise of greater uniformity being attainable than when pebbles are employed; and there seems no reason to doubt that whatever difficulties were at first experienced this has been achieved. Surely if two attempts are made to obtain regularity in powder—one by employing prisms each

uniform in size and shape, and if possible pressed uniformly, and another by means of pebbles of an accidental shape from uniformly pressed powder cakes—the former, though it may be difficult, offers promise of

DIAGRAM 1.

Group of Hits on Target made by 71-ton Gun at 2,734 yards Range.

DIAGRAM 3

ultimate success in the higher degree. As to the windage, stress can hardly be laid on the great reduction in the case of the common shell; the two kinds of projectiles made pretty nearly equally good practice.

Lastly, as to the proportions of the bore and chamber. The most striking feature is the length of the bore. Figs. 2, 3, and 4 show the relative lengths of the best heavy guns at present in existence, by which it appears that the bore of the 71-ton gun is only 20 inches shorter than that of the 100-ton gun, and 55 inches longer than that of the 80-ton gun. The chamber in length is 60·6 inches, that of the 100-ton gun being 59·7, and of the 80-ton gun 59·6. The calibre of

the 71-ton gun is 15·75 against 16 in the 80, and 17·72 in the 100-ton gun. Consequently, the bore of the 71-ton gun is 21·8 calibres long against 18 in the 80, and 20·5 in the 100-ton gun. The diameter of the chamber of the 71-ton gun is 17·32 inches, that of the 80 and 100-ton guns being 18·0 and 19·7 inches respectively, that is to say, it is 1·57 inches greater than that of bore as compared with 2·0 inches increase in the 80, and 1·98 inches in the 100-ton gun.

Speaking generally, then, the bore of Krupp's gun is relatively rather longer, and the chamber less enlarged than in the 100-ton gun, while in the 80-ton gun the bore is actually the shortest, and the enlargement of the chamber actually the greatest of the three.

On these proportions mainly depends the power of the guns. To be able to make a comparison between them, discrimination is necessary. It would not be right to take equal or proportionate *charges* as the basis of the comparison, because the principle on which a long gun is advocated is, that any greater result can thus be got from a gun with a given strain on it, but at the expense of some waste of powder.

It is clear, then, that looking to the endurance of the gun rather than the expenditure of powder, the basis of comparison should be *proportionate pressures*. It would scarcely be right to say *equal pressures*, because the thicker gun can fairly be expected to bear a greater strain than the thinner one. Now, the best results obtained from these three guns are as follows:—

The 80-ton gun at Woolwich with a proof-charge of 445 lbs., giving a pressure of 21·5 tons, discharged a projectile weighing 1,728 lbs. with a velocity of 1,657 feet per second—having 32,938 foot-tons stored-up work, or 658·37 foot-tons per inch circumference—equivalent to a penetration of a 32·34 inches plate of wrought iron. The 71-ton gun at Meppen is reported on one occasion, with a charge of 485·1 lbs., giving a pressure on the gun of 20·92 tons, to have discharged a projectile weighing 1,715 lbs. with a velocity of 1,703 feet per second—having therefore 34,489 foot-tons stored-up work, or 697·02 foot-tons per inch circumference—equivalent to the penetration of a plate 33·5 inches thick.

During the public trials in August, the 71-ton gun was not tested so severely, and it is therefore right to class the above in the same category as the Woolwich proof round above mentioned. In August the average weight of the chilled projectiles was 1,712·6 lbs. The firing charge was 452 lbs., the initial velocity was 1,648 feet, the stored-up work 32,241 foot-tons—the work per inch circumference 651·59 foot-tons, equivalent to a penetration of 32·12 inches. The pressure on the bore was 19·85 tons.

The highest result hitherto obtained with the 100-ton gun, of 17·72 inches calibre, has recently been furnished me by Captain Noble; it is as follows:—Charge, 573 lbs.; projectile, 2,000 lbs., about; velocity, 1,725·5 feet; stored-up work, about 41,300 foot-tons, or 742 foot-tons per inch circumference, equivalent to a penetration of nearly 35 inches of armour. The pressure on the bore was 18·0 tons.

It is quite clear, from the above, that the 71-ton gun is a much better weapon than the 80-ton gun, inasmuch as it beats it in every

respect. It fires a heavier projectile with a higher velocity, which has therefore more energy or stored-up work, and an inch and a-half more penetration, and all this is done with less pressure on the bore of the gun. The reason is that it is a better proportioned gun, its main advantage being its greater length. The 100-ton gun compares much more favourably with Krupp's gun, but, nevertheless, would do so better, if its length were greater. The main difference in the guns depends on the difference in the length; and the question naturally arises, how is it that our Government should be now completing and issuing 80-ton guns so inferior in power to Krupp's 71-ton gun, which achieved the results we speak of half a year ago? The answer is, that the guns are designed for the "Inflexible," and that, being muzzle-loaders, the vessel had to be made with portions of the deck corresponding to the length of the gun, to make provision for its loading. All this was determined five or six years ago. Since that time *our own investigations* have shown us the desirability of greatly increasing the length; but the gun being a muzzle-loader, it is impossible to do so. For the ship in question, a muzzle-loader is limited as to its length by inflexible conditions; and all that can be done is, by enlarging the chamber, to utilize to the fullest extent the disproportionate thickness of metal. Circumstances have, in this instance, then, combined so as to bring out the disadvantage of a muzzle-loader in a peculiar way; for we find ourselves, in the case of the "Inflexible," issuing new guns of obsolete proportions for a new ship, with an impatient public wanting to know why our new guns do not beat Krupp's, and that, in spite of the daily papers comparing our proof rounds with the service rounds of Krupp's guns. Apart from this trying instance, however, it is clear that every increase in length is in favour of the breech-loader, because the labour and inconvenience of muzzle-loading increase in an increasing ratio; and, in the case of turret guns, and probably in some guns in casemates and cupolas, muzzle-loading becomes eventually almost impossible.

To pass from this principal experiment to minor ones at Meppen.

Very remarkable results were obtained with smaller guns. An excellent 51-ton 14-inch gun was tried, the behaviour of which closely resembled that of the 71-ton gun, including the method of working, occasional miss-fires, and the like. An 11-inch (28-centimetre) howitzer, a 4.13-inch (10.5-centimetre) siege gun, and a 3.78-inch (9.6-centimetre), were fired, which did well, but need not be here noticed in detail.

A long 5.9-inch (15-centimetre) gun, on a special sea service carriage with oil buffer, gave good results; also an 8.27-inch (21-centimetre) howitzer, and a 5.9-inch (15-centimetre) mortar, were fired at dummy guns in a battery with good effect, notwithstanding that some of the fuzes failed to act.

Two remarkably characteristic guns, 3.4-inch (8.7-centimetre), were fired, fixed on pivots, one with little, and the other with absolutely no provision for recoil. With these is naturally connected another non-recoil arrangement of Krupp's, now well known, consisting of 6.1-inch (15-centimetre) gun, muzzle pivoting, the muzzle

being ball-shaped and working in a socket in an armour-plate. These three guns possess peculiarities deserving of attention.

One piece, 3·4 inches in calibre, Fig. 5, was 14 feet $3\frac{1}{4}$ inches long. Its chamber was enlarged to an extraordinary extent, being 5·9 inches

FIG. 5.—Krupp's Long 3·4-in. (8·7 cm.) Trunnion-Pivoted Gun fixed, without recoil.

in diameter. The cartridge was a long bag, very loose on the powder, made so as to admit of being adjusted in the chamber by hand. The charge was 7·7 lbs. Two kinds of projectiles were fired—long ones, 12·5 inches in length, weighing 22 lbs., and shorter ones, 9·5 inches in length, weighing 15 lbs. The initial velocities of these projectiles were 1,829 and 2,098 feet respectively. The maximum pressure was 11·6 tons. During this extraordinary performance, the gun was held rigidly, being fixed on a strong vertical steel pivot, and so steady was it, that small coins placed on its barrel were not shaken off on firing, except near the muzzle. Eventually a Dutch Officer displayed sufficient confidence to sit astride on the gun while it was fired, with the projectile shooting between his legs at the rate of about 2,000 feet per second.

The second 3·4 gun somewhat resembled the above, but had provision for slight recoil, the pivot moving on its lower end as a centre, the gun forcing the upper end back against a piston or buffer.

The muzzle-pivoting 6·1 gun, Fig. 6, was worked easily, the armour absorbing the shock of recoil, and suffering in no way apparently beyond the structure appearing to spring a little in the earth. A man laid it while riding on a saddle placed on the chase of the piece; he employed sights directed through a small hole at a convenient height above the gun, and he fired the gun himself by pulling the lanyard while still sitting on the piece. This system has been tried by one Government experiment, but has not hitherto found favour. It certainly appears as if a heavy gun so fixed to a shield, and impressing its work on it every round, must soon destroy the structure, but apparently it would take a very long time for a medium gun to do so; and it is possible that a gun so completely protected, and able to fire with such great rapidity, might perform admirable service before it failed in this way, so that, under some conditions, such a gun might be very valuable.

The ball portion of the muzzle can be readily unscrewed, and so can the disc containing the socket into which it fits in the plate. This operation can be safely performed, a shutter being run up, which completely covers the opening from the enemy. It still appears possible, however, that a blow from a very heavy shot might distort and jam the screwed portion of the plate. Against ordinary siege guns such a gun working with all the speed due to non-recoil, and with such an extraordinary measure of security, might effect much.

Two trials against armour took place, one to show the comparative effects of firing against chilled and soft hammered iron structures. As both were manufactured by Herr Krupp, the trial cannot be regarded as a representative one of the system he opposes, and it would be a mistake to discuss it here.

The other was the firing of a 9·45-inch (24-centimetre) gun, with a charge of 165·3 lbs., and a steel projectile weighing 348·3 lbs., at a target consisting of a front 12-inch wrought iron plate, a wood layer of 2 inches, and a back wrought iron plate of 8 inches. The plates were rolled at Dillingen. The shot had a striking velocity of 1,876 feet, which would give 8,492 foot-tons energy or stored-up work, a

Fig. 6.-- Section of muzzle-pivoting gun in armoured salient fort. A, removable ball-piece, screwed on to muzzle of gun; B, socket disc screwed into shield; C, shutter; D, number laying gun from saddle-seat on chase.

penetrating figure of 288·5 foot-tons per inch circumference, and a penetration of 19·32 inches of iron. The projectile, however, of each of two rounds fired passed completely through the entire 20 inches of iron and grazed about 2,000 metres further up the range. The plates were indifferently rolled, and contained some phosphorus, it is said; but the penetration of the shot was, after making all allowance, extraordinary. They were scarcely deformed in appearance when recovered. The steel was excellent. They had ogival points, the heads being struck with a radius of two diameters.

To sum up, the features which chiefly concern us in these extraordinary trials are :—

1st. The success of the breech-loading system.

2nd. The great results obtained as to power and accuracy of fire.

3rd. The muzzle-pivoting and non-recoil systems.

Although these have been noticed in the short relation already given, one or two words may be useful to lead on to a discussion. First, it must not be supposed that equally good results have not been obtained as to power in this country when guns have been made in accordance with the conditions arrived at by our recent experiments, as may be seen from the following examples. *Two years ago* the new type Elswick 6-inch gun was fired with a charge of 33 lbs. and a projectile of 82 lbs., the initial velocity being 1,902 feet, and total energy 2,057 foot-tons; and in March last the same gun, with a charge of 37·5 lbs., discharged a projectile of 82 lbs. weight with a velocity of 2,031 feet, having 2,362 foot-tons total energy. With this may naturally be compared Krupp's 5·9-inch gun, fired at Meppen *last August*, with 33·1 lbs. charge, and with projectiles weighing 88·2 and 112·5 lbs., giving velocities of 1,835·3 and 1,668·7 feet, and total energy of 2,060 and 2,171 foot-tons respectively. On one occasion it is recorded in Krupp's printed tables as having fired a shot of 69 lbs. weight, with a charge of 37·5 lbs., with a velocity of 2,135·8 feet, having 2,183 foot-tons energy. In these comparisons the Elswick gun has slightly the advantage.

It can scarcely fail to be observed, however, that to rival the results of Krupp, Elswick achievements, not those of Government guns, are instanced. In some measure this may be accounted for by the fact that private manufacturers are untrammelled by routine, and a master of the question at once seizes the lessons taught by experiments, and works them out as he judges best. The Government does not appear to encourage the manufacturing departments to aim at taking the lead in experimental investigation.¹ There are, however, one or two serious lessons that we might learn from foreign trials. Take, for example, the three cases of breech-loading guns, breech-loading small-arm rifles, and prismatic powder. All these have been taken up,

¹ That is, while the Government encourages individual enterprise as in cases of open competition, it does *not* particularly encourage manufacturing departments to enter this field of work. The B.L. small arm competition instanced by Colonel Reilly is a case in point. The competitive shot trial in 1878 furnishes an exception.
—C. O. B.

tried, and discarded by us, while they were steadily worked out to a successful issue by Germany.

About 1853 the needle-gun was tried and rejected in England; Prussia, acting on her own judgment, patiently worked on at it, and in 1863 or 1864 the entire superiority of breech-loading arms became indisputably proved, and they were universally adopted. About 1866 we tried prismatic or pellet powder, and rejected it; and after adopting breech-loading guns about 1858, we gradually superseded them about 1866 by muzzle-loading ordnance, and now, after Germany has steadily worked out these questions to a successful issue, we are trying both one and the other again, and those who have weighed the results obtained by them, as compared with those of our own guns and powder, can hardly doubt that both will be eventually adopted. Whether it is that we do not sufficiently resist the pressure of a popular cry, or that we get led astray by the excellence of some individual result, the effect has been that we have not shown the same steadiness and thoroughness in our trials of *matériel* in the instances quoted as Germany.

With the desire to elicit opinions on the points of greatest practical importance, I shall conclude by expressing the conviction that the Meppen trials show that we are placed at a great disadvantage under some conditions by our muzzle-loading system. Until recently, the Italians and ourselves were the main supporters of muzzle-loading guns. These guns were characterized also by being made of wrought iron, which complicates the comparison I now wish to make. Still, the fact remained that England and Italy had *muzzle-loading guns*, of 100 and 80 tons weight, and of a power that no breech-loading ordnance could rival.

The Meppen trials have exhibited a gun which entirely surpasses the last-mentioned piece, and, for its weight, compares well with the former.

Instead of dealing with a theoretical gun existing only on paper, then, we have one in thoroughly good working order, loading and firing by hand, with a rapidity, and shooting with a power and accuracy, far beyond the achievements of the 80-ton gun up to the present time.

This result is not due to a want of knowledge on our part, but to the impossibility of applying our knowledge to the case of the 80-ton gun. With muzzle-loading guns on our present system, we have greater labour in loading, and we have to commit ourselves to the length of our gun three or four years before we bring it into the service.

To argue that breech-loaders should be at once adopted would be to commit the fault I have complained of above, but surely we have sufficient reason to give them a trial, on a large scale. If breech-loaders have the advantages of ease and rapidity in working, of the possibility of changing their length without revolutionizing the surrounding structure of the ship, and of affording greater cover, especially when non-recoil carriages of any kind are employed, they surely deserve a full trial, even at the cost of having both breech and muzzle-loading guns in our service.

Mr. STUART RENDEL: I am perhaps the last individual in the room who ought to presume to rise the first, because I come to it quite unprepared to take any part in this discussion, and have only one remark to make, and it is not at all of a controversial character. It seems to me that in the very interesting lecture to which we have listened, there has been something too much almost of that modesty which belongs to the British Officer. I think the lecturer has hardly given England that position she has earned in artillery science of late. While he assumes to compare English artillery generally with German, he occasionally slips into a perhaps natural forgetfulness of the progress made in one part of England as combined with that made in another. If we are to compare German artillery, whether of Service or of private origin, with our own, let us compare it with English artillery as it emanates from the entire country. I am not here to say that there should be any conflict between the provinces and performances of Elswick and Woolwich, but I say, let them stand together as against any foreign competitor. Naturally, I have listened to all that has been said with a strong sense of what has been done at Elswick as well as with a lively recollection of what has been done at Woolwich, and thus it happens that I note what I think requires your notice also: that this great advance which we are now considering originates wholly with the changed conditions with which artillerists have to deal, which change again originates wholly from investigations into the action of fired gunpowder, which this country initiated and conducted, and for which this country can claim in an especial degree the credit. If a proof be wanted, it is this, that this country was the first to take advantage of the change. It did so in the case of the 100-ton gun. You have heard what the 100-ton gun has accomplished. I have nothing to add to that statement, but I will point out that these things were done by us now long ago. It may be that they were accomplished by Elswick, rather than by Woolwich, because of those difficulties besetting Government manufactories, which the lecturer so clearly indicated. However, let us not forget that they were accomplished by England, and that long ago. Then again it has been, I think, somewhat in the mind of Captain Orde Browne, and it may be in the minds of some here, that we have failed to do as much as we might have done, because we have clung obstinately to muzzle-loading. But it should be remembered to our credit, that the 100-ton gun, which has not yet been surpassed, is a muzzle-loader, and it has been acknowledged by the lecturer, that it compares very favourably with the great Krupp breech-loader constructed long after it. Moreover, the 100-ton gun is actually a service weapon on board ship. Four such guns are now afloat in the Mediterranean. That is an artillery triumph of which I think England may fairly be proud. At the same time, further progress no doubt may render breech-loading more essential. Yet even so, it is known, and should be remembered to-day, that breech-loaders of very considerable power were introduced into this country some years back. I refer to such guns as the 40-ton breech-loader produced at Elswick nearly five years ago. To sum up, what I wish to point out is, that when we talk of artillery, we should confront it not with the artillery from one source alone in this country, but with the artillery which the country can produce generally, and while I say that, I say it without the least assumption that one source in England is better than another. Germany has this remarkable advantage, that while its factory has the invaluable support of very large Government orders, it is also a private factory, and can make large quantities of artillery for other countries, thus adding wide experience to powerful resources. Germany has the advantage of range and resources combined in one factory, they therefore mutually strengthen one another. We distribute them between two, by which much is lost. We have in Woolwich the very great experience which a Government factory can attain through vast and regular order, and in Elswick the greater elasticity, the greater readiness of resource, the greater stimulus, and the less embarrassment by considerations of departmental exigency, which belongs to the private manufactory. But at any rate, let us take together the achievements of both factories when we are contrasting English artillery with German artillery.

Captain BRIDGE, R.N.: I have no observations of my own to offer, but Admiral Hamilton, who has been compelled to leave the room on official business, has asked me to say that, if he had been able to remain until the end of the lecture, he would

have taken this, the first opportunity which has occurred in the presence of an assemblage amongst which are numbers of his brother Officers, to publicly express his thanks to Herr Krupp for the kindness and civility with which he and the naval Officers who accompanied him were received during the trials at Meppen and their visit to his factory at Essen last year.

Colonel REILLY, C.B., R.A. : Reference was made by Captain Orde Browne to the Cunningham gear having been rejected because of the inconvenience of the chains. Now, in the first place, the Cunningham gear was not rejected for that reason ; and, in the next place, I do not see how it affects muzzle-loading or breech-loading, because the shot in many of our batteries goes along to the muzzle by a traveller overhead. Therefore, as far as that goes, it has nothing whatever to do with muzzle-loading. Of course, the whole question with regard to breech-loading and muzzle-loading is the mode of loading the gun, because the results produced, whether the shot comes out of a breech-loading or a muzzle-loading gun, are precisely the same. If you want a certain result, you get it just as well out of a muzzle-loader as a breech-loader. There was a time when people thought it was different, but I am perfectly certain Mr. Rendel will undertake to produce a muzzle-loader that will produce every single result that a breech-loader will produce. I am not advocating either system. I want the best gun to be got for the service. Of course, one would have thought that on board ship was the place for breech-loaders, but the Navy have always had a very strong prejudice against them, and at last the Admiralty has listened to what the Officers of the Navy considered best, as they have to fight the guns. I am rather astounded at Captain Orde Browne, who served so long in the Arsenal, telling us that the Government of this country have been backward in carrying on experiments. It is to me the most astonishing thing I ever heard, because, if you look at the records of the War Office, and of the Committee of which our gallant and distinguished chairman was the head for a long time, I think you will hardly consider that the Government sat still. The extraordinary thing is the number of inventors they have allowed to come forward, and spend the public money. When the Committee was deciding what rifle they would adopt for the Army, I do not know how many were sent in, but at least twenty-seven were allowed to compete. Of course, the natural result was twenty-six out of the twenty-seven hated the Government, for there was only one that could be adopted, and there were hardly any of them such insignificant people but that they could not get some member of Parliament to ventilate their ideas. My friend, Sir William Palliser, does not let the Government sit still, I am sure. He is always ready to point out anything that is wrong, and the very experiment going on at Woolwich now, shows that every suggestion that everybody can bring forward has been tried, but the "Thunderer" gun has not burst yet. Then we go from guns to small arms. Reference has been made to what we have done with small arms, because we refused to adopt one of the very worst breech-loading rifles I ever saw in any service, namely, the German needle-gun. It was the first introduced, and, of course, it did great execution ; but the reason it did great execution was much more in the hands of the gallant men who held the rifle than in the rifle itself. But, however, what I come to is this. When we took it into our heads to go in for breech-loading rifles we adopted the Snider, which was very good indeed, and a great many people think it is good enough still. We at last adopted the Martini-Henry, and when the French were looking out for improvements, they had a committee which sat at Vincennes, and, however unfortunate they may have been in the field, there can be no doubt of this, that their Officers are most scientific men. The French ordnance and line Officers, who were entrusted with this commission, were most laborious in their trials. Their investigations extended over a year and a half, and they have come to the unanimous conclusion that the best military weapon that had been submitted to them was the Martini-Henry rifle in the service of the British Army. So that, you see, we are not so behindhand as might be thought ; we do work along, which I think of immense importance, because we may rush away too quickly in changing our field guns. You know the Prussians had an immense success, and their artillery did great work, but you must remember the great masses of artillery that they collected together, and brought to bear upon the French. They showed a great development of the science and knowledge of moving guns together in the field, and formed immense masses of guns, which had great effect.

At Gravelotte and Mars la Tour they had as many as 150 guns in line at a time, and of course they produced a great effect; but this does not at all prove that that result was obtained because they had breech-loaders. If the Woolwich guns at present in use had been there, I am certain the result would have been as good, and I myself, think better. I can say this, that the Prussian guns did not at all come up to what Prussian Artillery Officers expected of them during the war of 1870. I had the opportunity of going to Berlin, and while there General Walker was kind enough to take me to the different Officers. They showed us all the returns made as to the various guns, and if we ever had an action in which our guns suffered as the Prussian guns did, there would be such a row in this country as would drive all the artillery out of the place. At Orleans, where there was not a very large army, there were 22 guns that became disabled from their own fire. The greatest proof, however, that what I am saying is correct is this, that at the end of 1870 the Prussians discarded the whole of their field artillery, and adopted a new gun. We must not, therefore, worship success too quickly, but must be careful in what we are doing. When I look at that breech arrangement, I ask you, having a gun producing the same result, whether you would not rather do without it in the field, for if it tumbled into deep mud, such as there was in the front of Orleans, into the dongas in Zululand, or into the mud in the Crimea, the result would be very much the same as that which happened to the German guns in front of Orleans.

MR. LONGSDON: With reference to the remarks of the last speaker as to the Prussians having discarded their gun, I may state that the guns which were said to be defective were those constructed upon the "Wahrendorf" system, and that since the Franco-German War, the German Government has re-modelled the whole of their artillery with guns constructed entirely upon the "Krupp" system, and similar to the field gun, a model of which is on the table.

COMMANDER W. DAWSON, R.N.: The lecturer has placed before us in the most impartial way the very thought which has been in the minds of naval men for a great number of years, namely, that we have in the British gun, taken weight for weight, a gun that gives much the weakest blow as compared with all foreign guns. I was much amused a few months ago to read a laudatory article on artillery in the *Times*, which compared the performance of the British 80-ton muzzle-loader with the 71-ton breech-loader belonging to the Germans. In that article it was stated that, having made certain alterations in the powder chamber, the powder and the rifling of the British gun, the blows struck by these guns were equal. The principal item in making comparisons between guns, is the weight. But that German 71-ton gun had a breech-loading apparatus, which apparatus must add four or five tons to the weight as compared with the muzzle-loader. For purposes of fair comparison of hitting power, you must take that gun as being 66 tons weight as compared with our 80-ton muzzle-loader. Supposing the same hitting power to be developed in these two guns of unequal weight, you have this result, that the British gun is of $\frac{1}{2}$ less value than the German gun. If I correctly understood Mr. Rendel, he tells us that the 100-ton gun, which is 30 tons heavier, only does as much work as the 66-ton German gun. (MR. RENDEL: Oh no, not at all. I simply ventured to endorse the valuable remarks of the lecturer.) In any comparison between guns, I take it that the primary item is weight for weight. Colonel Reilly has told us that there is a prejudice on the part of the Navy against breech-loading apparatus; and to this prejudice is due the fact that we have the weakest hitting gun in the world. (COLONEL REILLY: I never said anything of the sort.) I understood you to say that there was a naval prejudice against breech-loading guns, and the lecturer says, that it is due to our want of breech-loading apparatus that we have such short weapons, and that this shortness gives us the weakest hitting gun in the world. So far from there being a prejudice on the part of naval Officers against breech-loaders, I believe that the intelligence of the Navy has all been the other way. I will take an Officer who is a fair representative of the intelligence of the Navy, and who has held the highest appointments in connection with the ordnance of the Navy—I mean Admiral Sir Cooper Key—as being an authority who may be looked upon as the spokesman of the intelligence of the Navy in any matter of this kind. I think it is not more than ten or twelve years ago since, as Director of Naval Ordnance, he placed on record in an official document "on the

"requirements in a naval gun," that the Navy would be very glad to get a good and simple breech-loader, and he gave his reasons for that preference. "But," he said in effect, "what we do not want, is a gun that will fire off at both ends. Give us a decent breech-loader, simple in its parts, not liable to get out of order, and that can be trusted, and we would prefer it. We have no objection against breech-loaders in themselves."¹ I take it that the main element of hard hitting by heavy shot of given weight is simply velocity; and that velocity is to be obtained by a better combustion of gunpowder. We have not yet attained to a perfect knowledge of the right way of consuming gunpowder. I am not prepared to say what is the right way; but years ago, in this Institution, and elsewhere, I called attention to the improved combustion which might be obtained by air-spacings, combining several kinds of powder in the same cartridge, and so on. We have been improving our mode of combustion of powder lately, by enlarging the chambers, which is one way of air-spacing; but I do not believe we have yet obtained anything like perfection. We must go on and improve; there is no finality in these matters. It is in that way that the length of the gun tells—in improving the combustion. But there is another matter which has a great deal to do with the velocity of the shot, namely, getting the shot out smoothly and evenly, so that the axis of the shot coincides with the axis of the gun. You will say I am going on an old hobby, but when we adopted the system of French stud rifling in 1865, it was said by the Ordnance Select Committee that that system of rifling gave decidedly the lowest velocities. There can be no dispute now as to why the studded projectiles "gave" "decidedly the lowest velocities," for immediately in front of the seat of the shot in the 7-inch experimental gun, there were a number of cracks and burrs, which showed what the shot was doing in the bore; and how the driving power evolved from the combustion of the powder was used up by the shot, in hammering the bore, and striving to destroy the gun instead of gliding out of the gun with an even motion, and therefore with an increased velocity. The *Times* article, to which I refer, stated that one of the great improvements that had been made in the British 80-ton gun was, that there had been adopted, instead of the "decidedly lowest velocity" stud rifling, what might be called the Bashley Britten expanding base system, by putting on what is otherwise called a gas-check, so as to rotate the shot by that means. The abolition of the stud rifling had a great deal to do with the increased velocity, as well as the enlargement of the powder chamber, which gave better air-spacing; but all that will be of little avail unless the proportions of the gun are improved. There is no question that the longer the gun, other things being equal, the greater will be the velocity; and in this we were only going back to old times, for the ancient guns shown in the Tower are much longer than the present service guns. The Navy has great reason to be thankful that an artillery Officer has at last come forward in this Institution to say what naval Officers have been saying for years, that weight for weight, our ships are provided with the weakest hitting guns in the world. The time has come when a remedy must be applied, and when British guns shall be able to hit a blow quite equal to a German gun of similar weight. I hope that if I have offended anybody in past times in my efforts to call attention to the "decidedly lowest velocities" of studded projectiles, and the weak blows of British guns, they have long ago forgotten and forgiven it. I never said anything against the French rifling of British guns with a view to hurt any man's feelings, but I did so with a view to remedy those weak points to which Captain Orde Browne has now so ably and so impartially called attention. I hope that his plain statements may be more successful than mine were, and that they will result in our getting naval guns which, weight for weight, will do as much work as any foreign gun.

Colonel REILLY: I ought not to have said "the prejudice of the Navy;" I should have said, "the officially recorded opinion of the Director of Naval Ordnance, ten years ago."

The printed official document to which I refer was written by the Director of Naval Ordnance, about the year 1863, but I find that I have mislaid it, so that I am unable to quote the exact words. Another part of the document was quoted by me in "Naval Guns," vol. xvi, R. U. S. I. Journal, p. 353, of 1872.—W. D.

Mr. SCOTT RUSSELL: I should be very ungrateful, Sir, not to thank Captain Orde Browne for what seems to me one of the most valuable of the many papers on artillery, naval and land, which I have had the pleasure to hear in this house. On almost every point which his paper has touched I think he has done good service to the Navy in this country, in which especially, as you know, I am most deeply interested. On the point of muzzle-pivoting, on which he has expressed some valuable convictions and some very wise doubts, I will simply say that that is a question to which I have given the most careful attention, and on which I have made many practical experiments for the last twenty years, for my own instruction. I believe in "muzzle-pivoting." I entirely believe in this wonderfully bold step taken by Krupp; and on each of the points on which doubts have been raised, I feel satisfied that, with prudent foresight, this muzzle-pivoting will be most successfully introduced along with breech-loading into our armoured ships. The manner of its introduction is a serious question, and I quite agree that, if the whole of the arrangements in a ship are not made at her first construction on the distinct understanding that her guns are to be so mounted, and if the whole structure of the ship and the arrangement of the iron plating is not devised for that special purpose, it will be an utter failure. On the other hand, the whole of those arrangements can be so made that large guns can be most successfully used in our men-of-war, and the many advantages of that system, I think, most of you will clearly see. You get rid of complicated carriages, you do not require much room, and altogether you can make a far more efficient man-of-war upon that system than upon any other. I took the trouble, as soon as I heard of the successful experiment, to study carefully how it could be marked out, and I think, when we have the courage to try, first of all, a gunboat, and, secondly, a moderately-sized ship, with these non-recoil muzzle-pivoting breech-loading guns of Krupp's, we shall find that they may be made a great success; but I say, unless great skill is applied to the contrivance of the ship herself, what Captain Orde Browne has said will take place, and a good deal of damage will be done both to the plating and to the ship which carries the plates. In regard to breech-loading, I have merely to say it was my duty, in earlier days, to design the guns for and arm a great many vessels of war, and after my experience I entirely go in favour of breech-loading guns for naval purposes. I am extremely grateful, therefore, to Captain Orde Brown for having the courage to advocate that object in the manly manner that he has here done. I beg to say distinctly that breech-loading has been discouraged, and, if you like, I will say disgraced, in our own service, entirely by our having introduced as breech-loading guns, in the naval service, one of the worst designed, worst constructed, and most dangerous systems of guns that ever was seen on board a ship; and that I say from ample experience, because I have stood beside them while they were being fired, and you all know what has happened in such cases. Those of you who have been to Woolwich have seen, as I have seen, a large field covered with the *débris* of beautiful breech-loading guns, thrown aside as old scrap iron, and I believe sold as such. With regard to slow-burning powder, I think too much attention cannot be paid to that; it is most important. I would also say, do attend carefully to the proper building up of the cartridge; do attend, now that you are adopting breech-loading, to the central fire of that cartridge, to the proper spacing in the inside of the cartridge, and to have the cartridge built up of proper portions, all fitting into each other as they ought to do; and then you will find that, if you cleverly contrive your cartridge, you will get perfectly uniform pressure upon the shot from the first moment to the last in the barrel, and then you will get the greatest possible velocity and the largest possible projectile for the least possible pressure on the inside of the gun, and, therefore, the longer duration of your gun. On all these points, I think this lecture has given us most valuable recommendations and hints. In regard to the proportions of the gun, I venture somewhat to differ from the author of the paper. I think he is rather in favour of a longer gun. Now, I quite agree with a long gun in certain circumstances, and especially if you can have a breech-loader; then a longer gun is convenient in a ship; but, in regard to that point, I would submit to his attention this—comparative proportion. If he will kindly consider how small an increase to the inside of the bore of a gun will give him for a shot of given weight the same initial velocity that he would get by a very considerable addition to the length of a gun, I think he will rather go in

favour of a slightly increased diameter of bore than of a considerably greater length of gun. Allow me merely to say to him that I think a quarter of an inch upon the bore would give him as much more power as two or three feet of additional length to the gun. It is quite a matter of calculation, with regard to any particular case, whether you give the preference to the one or the other. In regard to the shape of the shot, I would merely say there is no doubt that the penetration of the shot itself depends considerably upon that sharp formation of the part of the shot to which he alluded, although I agree with him as to the indications which are given by these cracks and stars of fracture, and what not, of the armour plate; I believe that a plate which yields in folds, like what he calls the weaker plate, not cracks and stars, is the stronger of the two, and with all my experience I find that the tougher and more plastic the quality of the metal of the plate is, the more efficient is its resistance to the entrance of the shot; but on the contrary, if the outer skin of the plate can be made conveniently of hard steel, while the part of the plate behind it is made of a tougher material, then the plate will have the double benefit, first, of the high resistance to penetration which the steel gives when it cracks in the form of these stars, and, secondly, that the retarding force of the pliant metal behind will also be turned to good account. I think, therefore, neither the one quality nor the other is a mark of betterness, but that the combination of the two together in one plate is the thing we should always seek for. As to what was said in regard to the introduction of the needle-gun into this country, I am very glad that that was quoted, because I can confirm everything that was said by the author of the paper. He said the needle gun was successfully introduced in a certain year, and almost immediately declined. It so happens that I know all about that. I had to get the needle-gun introduced into this country. I brought the secret to our Government, and I got the needle-gun made for them. I had nothing to do with gunnery; I did it entirely for the service of my country, and for the advantage of the Government of that particular day, and I had a distinguished friend, very high in the Government, who entreated me to go over and get that gun for them. I did so, and I had made in this country a dozen guns, which I presented to the Government. They had them tried; they were found perfect, and what do you think the report was? That the guns were excellent, that they made beautiful practice, that they could fire with astonishing precision and extreme rapidity, but that Her Majesty's Government ought not to have such guns, because they would enable all the soldiers to throw away the whole of their ammunition in three or four minutes, and leave themselves helpless for the future. I leave you to judge how wise, how prudent, and useful a decision that was for a Government to arrive at in England. In regard to breech-loading, in like manner, I would say that the breech-loading of the French was successfully introduced into this country very early, and that, also, was declined by the officials of the Government. I think that the one fact that the arrangements of Krupp enable you to fire such a gun as we have heard of in four minutes is practically to say that one gun of that sort in one of our ships would be as good, and would fire as many shots in a given time, as four of our own construction. After that, let us consider the chances in battle, of a ship armed with that gun and a ship armed with our guns of the same weight. I would call attention to another circumstance. Very admirable criticisms on this paper have been given by an eminent official, and he has told you the great effects which have been produced by certain military guns of certain descriptions. Allow me to say this, that there is a radical difference in the question of muzzle-loading and breech-loading, between small military field guns and large guns used in the armoured ships of modern times, that there is not only no analogy, but an utter opposition, between the conditions of the two. Take a small gun out in the field and take a great gun behind an armour-plate. Is there any analogy whatever between those two conditions of things? There is none; and you will find, in practice, that it is almost as easy for you in the field to get at the muzzle as at the rear of your small gun; and you find, also, that in the field you are just as little protected from shot when you are in the rear as at the muzzle of your small gun; and, therefore, the whole question has nothing whatever to do with small field guns. The question is for great guns, not for ships alone, but for land fortresses as well as for sea-going armoured ships; therefore, I must again return my best thanks simply as an

Englishman who cares about his country, who cares to see the artillery of his country better conducted than it has been, who cares to see the Navy of his country well worthy of the sailors of his country. It is on that ground that I feel very grateful to this Officer for the courage and pluck, the energy and judgment, with which he has written this paper.

Major-General S. E. GORDON, R.A., C.B.: Commander Dawson has spoken rather in a disparaging tone of the Woolwich system of rifling. I was comparing lately the practice made with this magnificent gun of Herr Krupp's (the 40 cm. gun) at 2,800 yards, with the practice of our despised 38-ton gun at 3,400 yards; the mean error in deflection of the latter was '6 of a yard, and of the former '78 of a yard. They are both excellent guns, and you cannot say that one gun shoots better than the other; therefore the system of rifling of the Woolwich gun is as good as that of Herr Krupp. With regard to the mean error in range, it is decidedly in favour of the Krupp gun, but that arises from the excellent powder which was used. It evidently shows great uniformity in the charges of powder and that the gun was most carefully laid for elevation. We do not use prismatic powder at present, and I am sorry that it or some other slow-burning powder, has not been introduced. I believe steps are being taken in that direction; but it is a very serious matter for a country like ours, with numerous ships, Colonies, &c., to make a sudden change of this sort, necessitating the introduction of new sights for the guns, new magazine accommodation, &c. Captain Orde Browne spoke of the Cunningham gear, and I believe the objection to its being adopted in our Service was that in training the gun to the right the chain becomes slack on the left; then if you wanted to train it a little over to the left you had to work in the slack chain before you commenced to move the gun to the left. The lecture is entitled "Lessons to be learned from Krupp's 'Meppen Experiments Last Year,'" and certainly we saw they had magnificent breech-loading guns, loaded in the most simple and easy manner, showing that such guns can be worked very easily by hand, and I trust shortly we may have guns of the same kind. A lesson which I learnt is, that it is necessary for anyone accepting a similar invitation to that given to witness experiments at Meppen, to have at any rate one of the qualifications said to be necessary to make a good General, viz., "*un bon estomac*;" if he has not that, I advise him not to go to Meppen, looking at the hospitable, indeed magnificent, manner in which all the Officers assembled were treated—hospitality which I would wish gratefully to acknowledge in the presence of Herr Krupp's agent in London, Mr. Longsdon.

Captain CUSTANCE, R.N.: There was a remark in the paper to the effect that the 80-ton gun was meant for the "Inflexible;" I beg to ask the lecturer whether it is correct that an 80-ton gun will be mounted at Dover, and if so, whether that gun would be of the same length as the 80-ton gun which is intended for the "Inflexible?"

Colonel CLINTON: I wish to add the expression of my admiration of the lecture which has been given to us this day. I rise also to say a very serious omission has been made by a great authority, Mr. Scott Russell, in speaking of the question of breech-loading and muzzle-loading; he has quite left out the question of ramming down the shot, which is a very serious matter in loading a great gun. You must consider the enormous difference that that operation makes, and besides that the gun has to be run in to be loaded. In loading the breech-loader, on the contrary, the men are not exposed, and in every respect it has an immense advantage over the muzzle-loader.

Captain ORDE BROWNE in reply said: In regard to what Mr. Rendel has said on my having stated that the country was generally behind in knowledge, I would call attention to one or two places in the paper where I have said the opposite: for example, "It must not be supposed that equally good results have not been obtained 'in this country.'" I have carefully stated that equally good results have been obtained where we have made use of the knowledge we have ourselves found out. And, again, "Since that time our own investigations have shown the desirability of 'greatly increasing the length.'" Therefore I hope I have not in any way implied that *artillery knowledge* in the abstract has been behindhand in this country, but in certain particulars we have not *carried it into practice*. What Mr. Rendel says, of course, is very fair as to the Elswick 100-ton gun having been designed some years ago,

and therefore it stands to a certain extent in the same position as the 80-ton gun, that it is made on the knowledge attained some years ago. The greater increase of length in that Elswick gun compared with its predecessors would in itself be a proof of what I have stated, that it has been our own investigations that have shown the guns require to be made longer. Again, with regard to our being behindhand in construction generally, I mentioned—but I dare say it may not have attracted attention—that it is very remarkable how in most respects the carriages of Krupp's guns are almost the same that you see in the Carriage Department in the Royal Arsenal; therefore we cannot be said to be behindhand in carriages. But what I have endeavoured to show is that Krupp has had the opportunity of bringing these investigations into practice in some ways that has not been done in this country. With regard to what Colonel Reilly told us, I confess I have expressed myself rather strongly now and then with the object of getting what I hope will be valuable opinions, and I have carefully noted down information we have received in the course of the discussion. Colonel Reilly, referring to the Cunningham gear, explained that we had a spouting by which the shot came up to the muzzle, and the matter was therefore easily to be dealt with, whether the chain rose or whether it did not. But unless you could have spouting to convey the men across who have to ram home, it seems to me that the objection still holds good. Of course there is not that objection with the breech-loader, because the whole of the loading is done behind the chain, and the traversing also is done behind the chain. I do not know that the men ever have to go to the muzzle at all in action. With regard to the progress in the especial matter of breech-loaders, I cannot consider that England now has the lead. The Italians and ourselves are the only ones, as far as I know, that have latterly adhered to muzzle-loaders; and the Italians have recently ordered a very large breech-loader of 100 tons. We have, I believe, a small breech-loading non-recoil gun in the bottom of the ditch at Dover: but except that, I really do not know any breech-loader that is at present being tried in the Service. Therefore I cannot see at this moment how it can be maintained that we are taking the lead in breech-loading.

Mr. RENDEL: We have in this country a 40-ton breech-loader on the principle of the 100-ton breech-loader now being made, and that has been made something like three years. I beg to repeat I hope that there will be a discrimination between "we" as meaning Woolwich and "we" as meaning England.

Captain ORDE BROWNE: At this moment I am speaking of "we" as meaning Woolwich. I know that 40-ton breech-loader. I have seen it long ago. I was speaking of the Government experiments at this moment. I am glad you corrected me. Mr. Scott Russell made some remarks about the size of the bore and the length, which would require to be gone into in detail. It is a difficult matter, but it seems to me that there is a fair opportunity of carrying it out at this moment, because we have the 80-ton gun with spare strength, so that the chamber can be enlarged, and we have also the 71-ton gun, with greater length. One ought to be able out of those two guns to get something like a comparison. It would be difficult to discuss now the probable difference of effect between a slight increase in the bore and a slight increase in length. With regard to the plate target, I am afraid I did not make myself clear. I did not mean to commend a target for starring, but merely to point out that a projectile has in some sort of way to get through the target. To do so, it must make a hole. Even in the softest wrought iron the way in which it is made is by tearing the wrought iron into a cross opposite where it strikes; then it has to open the hole. If the wrought iron is of a laminated character, it bends back in preference to tearing any more, and the shot gets through; but if the wrought iron is good and well rolled, then the shot has to tear the corners away, which exactly corresponds with the formula in the Artillery Department, which makes the work to be done depend not on the square, but on the first power of the radius or diameter of the projectile. I have been very glad to hear Mr. Scott Russell express approbation of the paper in many respects, but I do not think that there is anything else in his remarks I have to notice.

The CHAIRMAN: The discussion has taken the direction to-day as it is perhaps too apt to do here, rather more of an attack and defence of the Government than seems to me to be strictly the subject before us. We have all learnt a great deal in twenty years, and I can corroborate the statement made by my friend General Gordon,

because I was myself President of the Ordnance Committee at the time that in 1868 we did recommend to the Government a very extensive series of experiments with breech-loaders, but it was our duty to point out that it would certainly cost not less than 10,000*l*. You may suppose no Chancellor of the Exchequer was prepared to admit that estimate, and the consequence was the experiments were not made. Here particularly is the great advantage which attaches to Herr Krupp; and I am particularly pleased to express the great admiration I entertain for the energy, the scientific skill and ability, the extreme liberality, with which that really great mechanician has pursued these experiments in gunnery, the freedom with which he has thrown open his results to the world, and the liberality especially of late years with which he has admitted Officers from every country in Europe to witness his most cherished experiments; a liberality which I trust he is not singular in, for we have also pursued the same policy for a long time. I am happy to have the opportunity of expressing my great admiration for him.

With regard to the particular questions Captain Browne has brought before us, all I can say is, as I have been I believe held up to obloquy in this Institution very often as an advocate of breech-loading, I am not likely now to take any opposite line. We have undoubtedly learned much as to the best method of breech-loading; we have borrowed from the Prussians and the French, and we are borrowing all round. The fact is, to compare the experience of an 80-ton with a 70 or 60-ton gun is futile; there is no comparison between them at all. We are advancing inch by inch, and I affirm most confidently that the last ten years England has been second to none in the race of artillery. Our results in their scientific value, and the degree in which they have been quoted and translated into all languages, will bear comparison with those of any other country. Nor do I blush for the Duke of Somerset, although he made a great mistake when he accepted the Armstrong breech-loader in 1860, for he undoubtedly accepted a very bad form of breech-loading. It was a very admirable gun, and being dazzled by its marvellous results he lost sight of the imperfections attaching to the mode of closing the breech. With regard to our position at the present day there is a field battery of breech-loading guns being prepared at Woolwich. Neither in respect to the experiments which we have been pursuing in regard to the development of the power of gunpowder, the moderation of its impulsive action, obtaining the greatest possible result by increasing the chamber of the gun, the just proportion of the length of the gun to the best effect produced, nor in any other practical matter you can name, is the British Government in any degree behind Herr Krupp or anybody else. I have always been an advocate for breech-loading, and certainly it is not possible to have an application more obviously advantageous than the application of breech-loading to ships' guns. I tremble a little bit at Mr. Scott Russell's proposal to pivot these guns, but he being a shipbuilder knows how to do it, and I should be glad to see the experiment tried.

With regard to the little details of comparison of foot-tons here and there, really those are questions which it is impossible to attach any importance to. The latest experimenter has the advantage of the previous experiments before him, and like buckets in the well, one is always up and another down. We as Englishmen are proud of the Government under which we live, to which we owe the unrivalled blessing which we enjoy of that freedom of discussion which permits us here to be freely discussing and imputing blame to the Government. We must accept with that, some disadvantages, and one of those disadvantages is that in respect to the administration, the executive power, the expenditure of money, there is an extraordinary jealousy of independent action on the part of naval and military officials, and that it is that has caused a great retardation and delay and difficulty in carrying out experiments which all those concerned have known to be very desirable. Public opinion makes sure progress, but it makes slow progress. Ultimately these things come about, and in the long run we are the stronger, the better, and the safer for the prudence of our course. I am sure we may record our most cordial thanks to Captain Orde Browne for his valuable paper.