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Publisher: Routledge
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Royal United Services Institution. Journal

Publication details, including instructions for authors and subscription information:
<http://www.tandfonline.com/loi/rusi19>

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W. Stirlino Lacon Esq., Chair
Published online: 11 Sep 2009.

To cite this article: W. Stirlino Lacon Esq., Chair (1862) Adjourned Discussion, Royal United Services Institution. Journal, 6:22, 165-183, DOI: [10.1080/03071846209415934](https://doi.org/10.1080/03071846209415934)

To link to this article: <http://dx.doi.org/10.1080/03071846209415934>

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ADJOURNED DISCUSSION.

Wednesday Evening, May 21.

W. STIRLING LACON, Esq., in the Chair.

Mr. MICHAEL SCOTT, C.E. : I shall be very glad to submit a few observations; but it will be with a good deal of diffidence in the presence of such an audience, inasmuch as I am not professionally connected with this subject. To me, Sir, it is a matter of purely scientific interest, and I shall make my observations as brief as possible, especially after the intimation which we have received from you.

In the first place, I would wish to say a few words upon the subject of breech-loading guns. We all admire the great ingenuity displayed by Sir William Armstrong in constructing his gun, but I think in the case of the large-bore naval gun, breech-loading is a mistake. I was puzzled for a long time to guess at the supposed advantages of breech-loading; but, as they were stated by Sir William Armstrong at the last meeting, we can have no longer any hesitation upon the point. The first advantage he stated was, that the men who were working the gun were not so much exposed. That is a point which must be left to naval officers to discuss; it is one which I cannot touch, and do not profess to have any knowledge upon; but I hope, as there are several distinguished naval officers present, we shall have some information upon it. The second advantage stated by Sir William Armstrong was, that a longer gun might be employed in narrow ships. Now it appears to me that the gun which will be required to deal with these iron-plated ships, will necessarily have a very great recoil. If the shot has a high velocity and is of considerable weight, the recoil of the gun must necessarily be great; and therefore the advantage that might have been claimed on this ground for the guns hitherto used in the naval service, may not be so apparent in the new guns that will require to be constructed to deal with the iron-plated ships. I will subsequently submit to the meeting a table which will show the amount of recoil that must necessarily follow the momentum that is communicated to the shot, if that shot is to have any effect upon the iron-plated vessels. The disadvantages of breech-loading, I think, are very apparent, when it is applied to large guns. In the first place, they are weak—I think necessarily and essentially weak. The answer to that may be—I think it was stated by a gentleman at one of the previous meetings—that the guns that have been constructed, are strong enough to bear the strain that they have been subjected to, and therefore there is an end of the question. But I think it is hardly the end of the question. A seven-inch gun made of wrought-iron has been found strong enough; but it follows, that if that gun of seven inches in diameter is strong enough as a breech-loader, a gun ten inches in diameter as a muzzle-loader would be as strong. If, therefore, it be an advantage to have the large guns, I certainly think that the muzzle-loader would have the advantage in the matter of strength. The case is very much this. In the case of the muzzle-loader, it may be considered, that the strain is applied in the middle of a tube, to burst it; in the case of a breech-loader it is applied at the end. It appears to me, therefore, to be very clear that the muzzle-loader having a closed end must have at least double the strength of the breech-loader having an open end. The fact of their being weak involves a small diameter; and, if breech-loaders are not weak, it is a very remarkable fact that we have not a gun of large diameter, a breech-loader. I do not know of anything above seven inches. If breech-loaders are equally strong, why not have them of larger diameter? In the case of the last gun that has been tested, so far as I know that gun, it was ten inches or ten inches and a half in diameter. It was not a breech-loader; it was a muzzle-loader. I am not aware that Sir William Armstrong has ever applied breech-loading to a gun above seven inches in diameter. If the guns are small in diameter, it follows that the capacity of the shell is small, and that the weight of the shot must be comparatively little. Further, the initial velocity is low. Now, if those guns made by Sir William Armstrong are of such vast strength, why not increase that initial velocity? Naval men tell us they want that velocity, and we know that the destructive power of the shot is as the square of the velocity; therefore velocity is a very important matter. But it appears from what Sir William Armstrong said on the last occasion, that the velocity from his gun is 1,210 as against the velocity of the ordinary 65-pounders, which is 1,580;

and, although Sir William Armstrong has a shot weighing 110lbs., he shows by his own figures that the relative effect of these shots from the 68-pounder is 17, and of his shot, on account of the lower velocity, although it has a much greater weight, only 16. Now this velocity is wanted, urgently wanted. If there is any hope of penetrating the plate, it must be by velocity; and the power of the shot increases directly, not as the weight, but as the square of the velocity. If it can be obtained, it is very desirable; but it has not apparently yet been obtained by any breech-loading gun. If the initial velocity is low, as I have just said, the force of the blow and the penetrating power of the shot must be small, and it would appear from the figures supplied by Sir William Armstrong on the last occasion, which are still on the board, that the penetrating power, the *vis viva*, the living energy of the shot, of the 110-pounder (I speak, of course, of close quarters, at the muzzle of the gun—I am not referring to long ranges at present) is only 16, as against the old 68-pounder spherical shot 17. In addition to this, there is in the Armstrong gun a great complication of parts, which are liable to injury. They are expensive; and if we compared the effect produced with the cost, the effect being less of the 68-pounder, I believe the immoderate expense would be very obvious. I do not know that it is desirable to say anything more upon this branch of the subject.

I shall confine myself to a very few remarks upon the shot and gun best adapted for dealing with plated ships. Spherical shot indents the plate; and the shot, if of cast-iron, breaks. Now, if it is desired that the shot should penetrate a plate, I say that the whole power absorbed in the indentation, in the bending of the plate, and the breaking of the shot, is lost. Flat-headed shot would neither indent nor draw the plate; and it has this advantage, that the impact being distributed over the whole of the surface, instead of being concentrated on a point, and at the same time—the impact taking place in the direction in which the shot is strongest—that is, vertically in relation to the surface, if it is intended to penetrate the plate, the flat-headed shot would unquestionably have the advantage. It might be objected that the flat-headed shot would meet with greater resistance from the air. Now this is a point of considerable interest; and it has been examined by a gentleman of the highest scientific qualifications, Mr. Froude.

Admiral HALSTED: I shall be happy to place at your disposal a reality, instead of the supposition you are giving us. Here is the actual measured plan of the effects of firing the 166-pounder shot on the Warrior target, on the 8th of April last.

Mr. M. SCOTT: I have not had an opportunity of consulting that.

Admiral HALSTED: Of course you have not; but I mean to say that what you are putting before us is a suppositional case, and you are perfectly welcome to use that diagram, for that is a reality.

Mr. M. SCOTT: I am very much indebted to you, Sir, but it would be difficult for me to examine it. It would be difficult for me to digest this diagram at the present moment. As I stated at first, my interest and connection with the subject is purely scientific. I am reasoning the matter from first principles. I know nothing about the experiments that have been made by the Government, and I do not profess to be able to say anything about them; I merely submit my views for what they are worth. Mr. Froude has shown that the resistance in the direction of motion to a plane moving obliquely is the same as the resistance to the plane at right angles with the line of motion, which is subtended by the oblique plane if the angle of obliquity is not less than about 60 deg. If so, we have then the condition of a pointed shot, as compared with a flat-ended shot. It would therefore appear that the resistance due to the pointed shot is the same as, and no less, up to the limit of 60 degrees, than the resistance of the flat-ended shot. That seems to be proved. I confess that I can see no error, nor has any one else that I know been able to see any error, in that conclusion. In the case of spherical shot, it may be argued in their favour, that, supposing they do not penetrate the plate, at all events the whole of the power of the shot is expended on the plate, whereas the flat-ended shot may go through and have a considerable power left, and, if it has no work to do inside the plate, that power will be lost; but in the case of shells, I apprehend, no influence will be produced, unless it does penetrate the plate. Therefore it would be desirable that they should be made flat. Now, I have been always told that, in the case of those partially plated ships, the ordinary spherical shell will not penetrate even the thin plate, and that, therefore, all they have got to fear is solid shot. But I can easily conceive that a flat-ended shell might be able to penetrate the thin plate, and might have very great destructive power when it had passed through that plate.

I will not detain you longer, Sir, upon that point, and I fear that perhaps I have

detained you too long; but I wish to say a few words upon the subject of the size of gun that can be obtained for naval purposes, and to deal with iron-plated ships. Now, to penetrate a $4\frac{1}{2}$ -inch plate, for instance, requires necessarily great force of shot. That force is made up of weight and velocity; and the limit of the force of the shot is the strength of the gun, which of course is determined by the strength of the material. Assume, for the purposes of argument, that the material is wrought iron, and that this material is three times stronger than cast iron; and assume that the strain of the cast iron is equal to that of the iron in the 68-pounder; then, I think, it can be determined theoretically what would be the bore of the guns for different weights and velocities of shot; and I have constructed a table for the purpose of illustrating this. The accompanying table shows the weight of shot which may be fired from wrought-iron smooth-bored guns, of various sizes and with various velocities, without straining the metal more than the metal of guns in the service is already strained. The type of the service gun I have taken is a 68-pounder.

Bore of Gun. inches.	Weight of Shot for velocity of			Weight of Spherc. lbs.	Weight of Elonga- ted Shot. lbs.	Velocity of Elonga- ted Shot. feet.	Force of Blow of Elongated Shot.	Momentum of Re- coil from Elongated Shot (Col. 6).	Weight of Gun, to give same Re- coil.
	feet. 2000	feet. 1750	feet. 1100						
8	Ordinary 68-pounder.			70	..	1600	1.0	1.0	5.0
7	118	154	390	47	93	2253	2.64	1.87	9.35
8	135	176	446	70	140	1964	3.02	2.46	12.30
9	152	198	502	100	202	1734	3.40	3.13	15.65
10	168	220	555	131	273	1565	3.75	3.82	19.10
11	185	242	611	174	366	1422	4.13	4.65	23.25
1	2	3	4	5	6	7	8	9	10

Column 1 gives the bore of the gun in inches; column 2 gives the weight of the shot which may be fired with a velocity of 2,000 feet per second; column 3 gives the weight of the shot which may be fired at the velocity of 1,750 feet per second; and column 4 gives the weight of the shot which may be fired at the velocity of 1,100 feet per second. The next column gives the weight of a sphere of the diameter stated in the first column; the next is the weight of an elongated shot of two diameters length, but not solid, hollow behind; the next gives the velocity of that elongated shot; and the next gives the force of the blow, that of the 68-pounder ball, taken at 70 pounds in round numbers, moving at 1,600 feet per second, being taken as one. The principle upon which this table is calculated is very simple; but it involves a great number of figures. I have stated publicly on previous occasions, and I do not know that it has ever been disputed, at all events I place in the hands of the Secretary of the Institution the details of it. I do not know that it can be disputed, because there does not seem to be any dispute whatever with respect to the theory, namely, that the power of the shot is the *vis viva* of the shot, the living energy, the weight multiplied by the square of the velocity. If that be so, then the only other element is the diameter of the gun. The

force of the blow, you will observe in column 8—and it is somewhat important—varies very considerably. The argument is this—assuming wrought iron, in the first place, and assuming that wrought-iron is three times as strong as cast-iron, that without straining the metal of the gun more than the metal of an ordinary 68-pounder is strained by firing a 70 lb. shot at 1,600 feet per second, this is the effect. These numbers represent the force of the blow, or the effect produced by the shot from these varieties of gun.

A MEMBER: May I ask, what charge?

MR. M. SCOTT: It is quite irrespective of charge. The question has nothing to do with the quantity of powder. It is a relative question—not an absolute. I do not profess to give the absolute effect; I do not know that it is possible; at all events, as far as I am concerned, I do not profess to deal with it at all. If you fire a 68 lb. ball at the velocity of 1,600 feet per second, that is represented in this table by the figure as 1; and, if you fire any of those other weights at those other velocities stated in the table, the *vis viva*, the force, the destructive energy of the shot, will be as represented in this column, without reference to what the powder may be. It may require one pound or a thousand pounds of gunpowder; it does not affect the relative question. It affects the absolute question, no doubt; but the relative question is not affected, and the table is merely a relative table, to show what the effect of various diameters of guns and various weights of shot would be. From this table it appears—and it is a somewhat curious result—that for a given bore of gun, whatever be the weight and velocity of the shot, provided these vary in such relations as to keep the strain on the gun the same, the destructive power of the shot always remains the same. I think that is a point of some importance, and I am not aware that it has ever been stated before. I think important results will flow from it. For example, one conclusion would be this—that a light shell, provided the material of the shell was strong enough to bear the impact, would penetrate at very close quarters, because all these calculations have reference to the velocity at the muzzle of the gun—would penetrate equally with a heavy shot.

A MEMBER: If it did not break up.

MR. M. SCOTT: Assuming that the material of the shell bore the impact as I say, provided it did not break up, the light shell, having the higher velocity, would penetrate quite as readily as the heavy shot with a low velocity; and it would appear from that table, that this is a fixed quantity, an unalterable quantity, provided the strain of the gun remain the same. In reference to any given diameter, you have the figures, which show that, no matter how you vary the weight and the velocity, the effect at the muzzle of the gun must be the same. Without detaining you, however, any further upon this point, I would just say a few words upon the recoil of guns. That is a point, surely, that is practical, and surely it is interesting. The ninth column of the table represents the recoil for the elongated shot in column 6, and the velocity is in column 7. The column marked 10 gives the weight of gun to give the same extent of recoil as an ordinary 68-pounder; provided the resistance, the compressors, and other artificial means, be increased in proportion to the weight of the gun. I think it is a practical question for the naval officers present to determine, whether they can deal with guns of 12, 15, 19, and 23 tons. If they cannot, it necessarily and inevitably follows that they must expect a greatly increased recoil—increased in velocity, and increased in distance. As for example: suppose you take the 9-inch gun, the weight of which, to give the same recoil as the 68-pounder, would be 15½ tons. If that be found inconvenient, possibly it might be diminished; and, suppose that the weight be diminished to one-half, the distance of recoil will be increased four times. If you diminish the weight of that gun to one-half—suppose you make it between 7 and 8 tons—the velocity of the recoil will be doubled, and the distance of that recoil will be four-fold. If, therefore, the recoil of an ordinary 68-pounder is 8 feet, the distance to which that gun would recoil would be 32 feet. That, I say, appears to me to be a matter of considerable practical importance, and one that would be very well worth the consideration of the naval officers present.

Gentlemen, I will not detain you longer; I will merely say this—that, although these statements do not appear, perhaps, at first sight, to be what you may call practical statements, that is, that they are not the result of absolute experiments with individual guns, there is not the slightest doubt about the principle. It is not to be disputed, and, therefore, it must have a very considerable bearing on the practice.

Commander ROBERT SCOTT, R.N.: In following those who gave you such very well-digested speeches on the merits of their own plans last night, I am placed at great disadvantage, for it was not my intention to have compared my own propositions with those

of others, except in a very general manner, having already given publicity to them here, as elsewhere; and I am strengthened in this view by the able discussion of them by Captain Fishbourne, and I remember, also, the old proverb, "Let another praise thee, and not thine own self." I should, however, be admitting the correctness of what has been here asserted, did I not oppose facts to those assertions; and, therefore, with your permission, I will examine a little more closely into what Mr. Lancaster stated last night; as, if correct, the rifle question is certainly settled in favour of the oval; the exterior of the lead, he said, gave off in fumes, and the grooves, at any rate—pointing to mine—the grooves, he said, crush up, and, as grooves crush up and lead evaporates, the only remaining plan is the oval. I trust, however, to convince you that Mr. Lancaster is quite as much beyond the mark in what he mentioned last night—I am sorry to mention names, but, the comparison having been made, I am of necessity forced into it. I cannot help it, and I hope you will see that; because, if my groove crushes up, what is the use of my gun? It is evidently a useless thing, and all that has been advanced is mere moonshine. However, as I have said, Mr. Lancaster is quite as much beyond the mark as he was when he wrote to the *Times*, and mentioned that his own gun had fired 284 rounds, which I know that he afterwards admitted not to be correct. Again, Mr. Lancaster said in this very letter, that Mr. Jeffrey's shot and my own were forced home by a heavy metal rammer, the same which had to be applied after double sponging, in order to force home each of his shells which had been carefully turned to one exact windage. In my own letter in reply to that, which also appeared in the *Times*, I said, that, if the heavy metal rammer had to be used in practice-ground under such circumstances, it certainly would condemn any such gun for naval purposes *in toto*, but it was not used with my gun. And I will ask this, and there are several naval officers here, who, as well as myself, have seen the oval gun fired, for I was at Shoeburyness in 1854, and was sent purposely there. I need not read my own notes on the subject; I shall be very happy to let any of those officers see them, and my report to the then Controller. We have seen the gun, and we know exactly what it has done; and, had the oval been a good gun, should we have thrown it aside altogether? or would they in the Crimea, when it was of such consequence to fire a shell, with a large bursting charge, have entirely given up the oval, and continued to fire the round ball, which, of course, had a short and unequal range from the gun? I leave it to yourselves to judge whether such would be the case. However, it would be beside the mark did I give all my objections to the competitive trial, prior to which my gun had fired so many more rounds than Mr. Lancaster's and others, excepting Mr. Bashley Britten's (I am not going to touch on Mr. Britten's gun), and completed them within a much less time. My gun had been bored, rifled, and fired up to 300 rounds, as fast as the shell could be recovered, and the days afforded to me to carry out the experiment at Shoeburyness, would allow. It certainly never entered into my head, on the score of injury to the rifling, to object to the competitive trial, although my gun had previously fired 300 rounds, for at their conclusion the assistant superintendent, with myself, examined the gun most carefully, and we could not see a line in the gun worn down, and he said to me, "The bore appears quite perfect." But are there any other indications? Yes, when the shot were fired rough at first, and not smoothed off as I fired them there, and a soft metal put outside, the same soft metal that Sir William Armstrong afterwards used in solid strips (or even perhaps before, but I think it was afterwards) I put on liquid zinc, forming a beautiful coating, placing a soft metal in front of a hard bearing, which could not possibly give way. But, before that was done, the paint of my shell was really merely smoothed down after firing. It seemed so extraordinary a fact, that when it was mentioned to Captain Blakely, and also to Mr. Lynall Thomas, both these gentlemen inquired into, and examined the case for themselves; and so did the Admiralty. But is that all? Certainly not; fifty shells completed 300 rounds. There were some few new shells introduced, with which I tried an experiment, which is not worth while going into here, but about forty-six of these shells were recovered off the range and re-fired. That is how the 300 rounds were made up. The Report states that not one of these shells was cracked, and the assistant superintendent said to me, "I consider the shells are still serviceable." One of these shells is now in the Exhibition. If the bearings of the shells had been scored, or if there had been rubbing or crushing, it would certainly have shown itself upon them; but as nothing of the kind took place, and as I made some objections to the Committee's trial, I should certainly have objected *in toto* if I could have detected the least irregularity upon the line of my rifling; but such was not the case. As far as human eye could judge, and I examined the gun several times with those at Shoeburyness, it seemed perfect.

But, as the gun has been compared with his by Mr. Lancaster, that is not the only point

in which it should be compared. The shells were all easily loaded, as I have now said ; but what took place as to the other shell of the oval with which my gun has been compared ? The first shell that was fired in this competitive trial went out of the gun broken up. A per-centage of those that were picked up, seen by Mr. Haddan as well as myself—who can say whether it is the case or not—I have not spoken to him on the subject, but he happened to pass as I was examining the heap to look for my own shot—a considerable per-centage of these shells were cracked also. The reason of that cracking is obvious. Suppose you take a flatter groove—my groove (Plate I. fig. 8 g)—the shell of course has a bearing upon that groove, and comes out in consequence easier. But cut away that groove, and bring it round and make it into an oval, there is then no bearing, and, unless the shot is exceedingly tight, you can see there must be considerable play. Now, the gun turns the shot, and the shot has to come out grinding against the bore, and I ask any one who understands what friction is, whether there is most friction with the plain or flat bearing, or with the oval bearing, and a shot that wedges itself round against the side of the bore ?

Not only so, but I think it is apparent to everybody, that, under most cases, such a wedging open would be much more liable to burst a gun than grooves such as I propose. The strength of cast-iron guns is very unequal; were the cast-iron equal we should have fewer cases of bursting; but I think most of us know of many cases of bursting that have occurred. When I was at Shoeburyness a gun burst and it broke the legs of three sergeants; it was a gun of the oval bore.* We know that three Lancasters burst in the Crimea, and therefore, speaking of bursting, we are pretty much—as Mr. Haddan expressed it—"in the same box, the whole of us."

Experiments have been put forward, and they may be again put forward, as indicating the relative value of different systems of rifling, and therefore it is really important to examine into what has been tried. There happened to have been competing together the shunt of Sir William Armstrong and my own gun with grooves, Mr. Haddan's also with grooves, (though shallower and swept out more), and, on the other hand, Mr. Bashley Britten's, and Mr. Jeffrey's, and the oval bore. Now this list completes the whole that were competing, and, as it takes in the whole, it is necessary to dwell a little more on this subject. I think that the endurance of one gun, does not prove much; the opinion of the President of the Select Committee certainly was in the same direction, for, when he brought forward the plan of strengthening, mentioned last night by Mr. Haddan, he at once tried it upon four guns—two sixty-eights and two thirty-twos. Could it have been settled by one gun, I imagine he would not have taken four guns for such a purpose. I think we must all admit, that we have been somewhat mistaken as to the strength of cast-iron. When $5\frac{1}{2}$ pounds of powder have been fired with the lead-coated shot, the guns have gone; with 5 pounds they have stood. When over 6 pounds has been fired with the iron shot, those guns have also gone; therefore, if we are to use the unstrengthened cast-iron guns, we shall have to use a very low charge. When Mr. Whitworth's gun burst, which was a 68-pounder rifled on his plan, they asserted that the shot stuck in the bore; it was referred to Mr. Anderson, who at once said that what surprised him was, not that the gun burst, but that it stood at all.

Much has been said as respects lead-coated shot. Speaking of Sir William Armstrong's grooved gun, it is clear it is not suited to high velocities; and I think that it is shown by Sir William Armstrong himself, for he has only used the shunt with high charges of powder. The shunt has been fired with 20 pounds, but the other guns certainly will not stand large charges of powder—they cannot be fired with large charges of powder. It has been said in this Institution that a large charge of powder was used in the 110-pounder gun. Yes, but the lead in the rear is then cut away. I have examined many of the 110lb. shells, looked at those very narrowly that have been picked up after firing, and I have observed this, that while with the longer bearing of the shell the slip upon it is very slight, with the shorter bearing of the shot of the same weight, the slip upon it is considerable. But you will ask me "How have you ascertained the slip?" I think I could show you how. The width of the groove and the width of the lands we will assume as being nearly the same. Now, the lead on the shot that has come out of the gun, if it does not slip, ought to be fully the width of the land; but instead of that, it is not. In the solid shot it is not more than half the width, and in some cases I think, it is less than half the width, almost up to a point; and any of you who will examine the shot fired, will see exactly the

* We are requested by Captain Scott to state he confounded this gun with another of Mr. Lancaster's, which burst on a different occasion, viz. on Jan. 31, 1856.—Ed.

same thing and how that is indicated, and, if you examine those fired at the butt, it is true they show the rifling, but how much that rifling has slipped round, it would be difficult to say.

However, there was another assertion made here, and I think what I have said of the shunt indicates, although Sir William Armstrong does not quite agree with it, that the detaining of the projectile is damaging; he has said it is an advantage. If detaining the projectile be an advantage, I imagine that he would not have made his last breech-loading gun a shunt. It was tried against the Thornicroft plates down at Shoeburyness. On that occasion the wedges stuck fast; afterwards in trial, on being brought back, the wedges broke, and the gun itself was returned to Elswick. It has come back, and has been housed in the arsenal store ever since.

Breech-loaders have been spoken of, and I believe Sir William has gone to the limit of size in breech-loading. In fact, he allows, as we know perfectly well, you cannot lift out the vent-pieces. One of the strongest men at Shoeburyness said to me "It is the easiest thing possible, just try, I like to convince you." I said "I am very happy to do it," and we commenced lifting out the breech-piece. But after we had lifted it out two or three times he had enough and did not wish to lift it out any more; and I can tell you we had a great deal of difficulty in dropping it down exactly in its place. And therefore, with breech-loading, the fact is, over seven inches it cannot be worked at all; you may take any breech-loader you like, I have not seen any of that size that can be worked.

It is confessed that a naval broadside-gun must fire a heavy charge, and I certainly think this element of weakness the breech-loading, should be eliminated from the gun. To pass on, however, Sir William has told us an effective broadside-gun must have a large bore, in order to have a high velocity, and this of necessity entails firing a round ball, and therefore that the new naval gun is to be a smooth-bore. If not presumptuous in one who has all his life studied the subject—because I do not come before you without having studied the subject; in 1854 I was sent to Shoeburyness in order to keep the Controller-General of the Coast Guard informed of what was going on in gunnery there, and to report to him whatever was likely to be beneficial to the navy. Mine are the ideas of a whole lifetime, and I may say I have passed years in devising and carrying out what I believe to be a very simple and easy mode of uniting the advantages of the smooth-bore and rifle in one gun. I would especially say it is very desirable to unite them, and for this reason—that we really do not know, what form the attack or defence in future warfare may assume—a point I hope very soon to hear discussed in this Institution, and I am quite sure some very valuable facts would be brought forward in relation to ship-building and other points. I hope Captain Coles, whom I see present, and whom I believe has spoken of giving us a paper, will do so on an early occasion. It is a subject of really national importance, and we shall all be delighted to hear him; on that ground there is no difference of opinion; I am sorry to say on the rifle question a very strong amount of feeling certainly does exist. The new gun that Sir William Armstrong is now manufacturing, is 106 inches long in the bore, it is 9.22 inches in diameter, it is to weigh 112 cwt.; that is the exact dimension of the gun, but I think I need not give my opinion farther respecting it. However, from such a gun, if rifled, shot whether flat or round-headed (for this must depend on the form and outside of future vessels) with a shell rear would prove very effective by bursting between the plates and backing. There are many mistaken ideas about shells. I think there are one or two experiments that Captain, or rather Admiral, Halsted has watched very narrowly. When the shell was thickened in front, it was found that it passed through a plate of three inches and did not break up—I am now speaking from memory. Captain Inglis of the Engineers gave a lecture on penetration of shot, and I would recommend all who are interested in the question to get it. There are many experiments recorded that I tried in vain to get elsewhere, and many of them are of very great value. However, with respect to that, and as illustrating in some measure what Mr. Michael Scott, whom I never had the pleasure of seeing before to-night, has stated, I believe that the same penetration which is here given, an inch and a half, was attained by the shell fired from the 68-pounder. It went with a very high velocity, and if we can give that, without over-weighting our projectile, so much the better. I do not see the necessity of what Sir William Armstrong has here said about doubling the weight of the projectile, because, in doubling the weight, of course you increase very considerably the strain upon the gun. I think you may cast your projectile considerably lighter, with a cutting flat front, and shell in the rear, which would

cut through or at least penetrate far enough to discharge its small mine, and do considerable damage inside the armour plate ; I believe it will be found to be a very destructive kind of shell, and a shell we shall possibly have to use in future warfare.

A MEMBER: Are you alluding to the smooth-bore ?

Commander SCOTT: I am speaking of a rifle gun ; but I speak of combining the two, and I say we must have a gun of this description at once ; it is no use going on as we have been. We have had one era of artillery, and we have gone on and made an immense number of guns, I believe opposed to the opinion of every naval officer who has considered the subject at all. I know it was stated at meetings nearly two years ago that we were really retrograding in going to small-bore rifled guns, and I think it is now very desirable not to take a turn in the other way, and hold on to smooth-bores entirely, but combine the two, for we do not know what future warfare may really necessitate. One of the most important things that has been very much overlooked is that of molten iron. The molten iron will fill up the shell and make it almost solid, so that you will at first have the full blow of the molten iron, and, unlike powder, the molten iron, if you can pitch it against anything, will stream over it ; it may stream into the port. This will be found, I believe, a very fearfully destructive weapon. The Armstrong gun will not throw it, that is, practically it will not do it. The small round shell contains too small a quantity to be effective. What we want is a large quantity ; but even the less quantity sufficed to set a vessel on fire ; and when it was tried, although they had the engines and everything ready, as is well known to Admiral Halsted, they could not put the fire out.

With regard to the recoil, I believe there are very simple means of reducing it. India-rubber behind the trunnions, I think, will do it ; that is, it will save the gun, by lessening the strain. Sir William Armstrong mentioned the bore of the gun being soft, and wrought-iron is very soft, and that it might be necessary to use a sabot. There was a kind of one used when we actually did fire round-ball out of my rifled gun ; not that it was necessary. In that particular gun we used a small wad made by Mr. Belfield, which answers all the purposes, and can be made for about 3d., but I trust we shall have a bore sufficiently hard, whether of steel or some other metal, so that we shall not require anything of the kind, and I look upon every addition as of course complicating the gun.

To return to our present cast-iron guns. Colonel Lefroy has stated, they have been long known to be improved by a reduction of windage, but they won't stand it (these are his words). Has it ever been tried, because I can find no experiment of the kind, to make a reduction of charge equivalent to the reduced windage, because then you will have accuracy, and you also save powder. I am not aware of any experiment, either, to test the increased accuracy arising from a more exact boring of the gun. Some may not be aware, that none of our guns are truly bored, and the few that are, are the exception ; the rule is they are bored roughly, and I believe it is a considerable element of error, and one that does not appear to have attracted much attention. But as the 68-pounder now stands, it is accurate, and some excellent shooting has been made with it, and, if I mistake not—in fact, I know it is the case—at 300 yards at Shoeburyness it beat the rifle guns on one occasion, though pointed by Sir William Armstrong himself. I believe where the charge is increased, the accuracy would be much more sustained ; instead of stopping at 16 lbs. of powder, we could go up to 24 with our 68-pounders. Now we cannot do it with the guns in their present state, and, as the Duke of Somerset justly said, it is very desirable to do what we can with our present stores. Now Captain Blakely has proposed a plan for simply hooping. Mr. Lancaster proposes to encase the gun ; and Mr. Haddan says the guns are not strengthened by either method. First, with respect to Captain Blakely's method of strengthening. Here is a trial of strengthening, by order of the Select Committee in 1835, which Captain Blakely has put into my hand, in which I find that the Blakely gun stood an immense amount more firing than any other.

A MEMBER: What size gun was it ?

Commander SCOTT: I gave the size in a former lecture here.* Perhaps you will kindly look at it ; my memory does not serve me. I think I ought to pause here one instant, as Captain Blakely has taken my rifling, but with my permission. I asked the

* See Lecture on Progress of Ordnance at Home, &c., p. 18, vol. VI., Journal of the Institution.—ED.

Admiralty if they had any objection to his doing it; when Captain Blakely spoke to me about the matter, and kindly offered me something, I said, "The only thing I have to say about it is, that you will please to consult me about the rifling, that I may see that it is well done." I cannot say that he has always consulted me on the subject; I believe it is, that he thinks it would put me to trouble and expense, but I should always be very glad to see him on the subject. I may mention, however, that Captain Blakely examined that gun of mine that was burst, and wrote to say that he found the rifling not at all injured. I have to stop here one instant, and I am sorry I omitted it, to speak of the endurance exhibited by the different competitive guns. Now, among the guns fired in the competition at Shoeburyness, excepting my own and Mr. Bashley Britten's, there was no gun that had fired near 300 rounds, and our guns had fired them at elevations. The guns that completed the sixty-five competitive rounds were taken from Shoeburyness, where they had been fired at elevations, mounted on their carriages, placed in the cell at Woolwich, and suspended horizontally on a swing. The consequence was, on the first impact of the charge, the gun recoiled; and my own opinion is that Mr. Lancaster's gun, if it has fired 1,000 rounds, will probably go on and fire 2,000 more; for every one knows what a different thing it is to fire a gun horizontally, and suspended where it will at once recoil, and these differences were my reasons for objecting to my gun being put into the trial. When my gun did burst, the coated shot were somewhat in favour, and iron-shot, if possible, were to be set aside. Various hypotheses were set up about the bursting; but, when the pieces of my gun were brought together, it was found there was a very bad flaw in the bore, and, when I managed to get hold of my ten shot and examined them (only ten rounds were fired in this competitive trial before my gun burst), I found the shot were scratched along their bearings, showing that the gun had been gradually opening. There was nothing but what is straightforward about the matter; there had been various theories put forward, and I have no doubt, those who advocate lead coating, as is generally the case, wish to believe what they wish to be true.

But I have wandered away, and I must apologise to you for it, from Captain Blakely's strengthening. After seeing Captain Blakely's hooping, it struck me that putting it on straight in one piece, would be better. I have not seen it; but I also know at the same time that any man would put it on in one piece, if it were not for the expense; it is more expensive to put it on in that way. Mr. Parrott, in America, I find since I gave my last lecture, says his plan differs from that of Captain Blakely, in that he puts it on in one piece, whole; and it is precisely that mode by which he gets the increased strength, and I have no hesitation myself in expressing my firm belief, that such a mode of strengthening, if the jacket is carefully put on by hydraulic pressure at a certain force, is the best, and I will give you a reason for it. In the Armstrong gun at the end, there is a large piece; it is a forged breech-piece, and I believe it is the only part of the gun which I have never seen broken. Hoops are welded immediately against this forged piece, the grain of the iron running in a different direction, and over this another coil is put. They are two different sorts of iron. If over the wrought iron the coil gives strength, why should not the coil over the cast-iron give strength, provided you regulate the tension properly? I allow in the proof in the cell, the hooping may not appear to strengthen the gun in any great degree, and for this reason, the proof in the cell consists in gradually increasing the weight of the cylinders, the first cylinder being heavier than any shot you would fire out of it.

I believe the hoops prevent the iron from disintegrating. You know the particles are merely laid together; they are in close proximity, but there is no interlacing of fibre; and the continued concussion opens them, and, if opened, any gun will go—continuous fire, is proved always to destroy the guns. I believe hoops, however, will prevent disintegration, and, if you prevent that, I have no doubt in my own mind you could make our present 68-pounder, hooped in such a way, a strong durable gun, capable of firing 24 pounds of powder.

Mr. Lancaster proposes to encase the gun, and he says that a cast-iron interior would be less liable to injury than one of wrought iron. If Mr. Lancaster proposes to apply the plan to our present guns, I believe the expense will be an insuperable objection to it, for if you cut away the trunnions—I do not enter into the question of putting the casing on, it will be rather difficult, but it is a difficulty that may be got over. I think the expense will be exceedingly great; quite half that of a good wrought-iron gun. If he intends to hoop new castings, it may be asked, would not a less brittle metal be better?

I certainly should prefer myself good wrought-iron to cast-iron, and would venture to suggest as an experiment that might be easily tried, to take one of the Armstrong guns, that have been used in proving vent-pieces, of which there are four—the coils are opens so that they are of no further use—and let it be fired at. There is the muzzle also of a good forged gun, that of Mr. Lynam Thomas, which might be fired at, and also that of a 68-pounder. Then you would come at once to the respective endurances of the three, in being fired at. But with regard to Mr. Lancaster's gun that he speaks of here, there was an endurance mentioned of 81 rounds. I am satisfied that I was not mistaken in stating that that gun was considerably heavier than the 68-pounder; and therefore it is not surprising that if the gun be very much heavier it should stand a very much larger number of rounds.

I am sorry I have taken up so much of your time, and I will conclude with only one observation about the Armstrong gun. A gentleman thought that he would investigate the matter for himself; the Captain of a man-of-war was a friend of his, he went on board, and at his request the captain sent for the gunner and the gunner's mate. There was an Armstrong gun on board, and they showed him everything about it. He took the gunner aside, and said "Tell me what is your candid opinion about it;" and says Jack "Well, Sir, my opinion is that it is a verry dangerous gun."

Admiral TAYLER, C.B.: As the time is very short, I shall only make a few observations. In fact, the very able discussion we have now had from Commander Scott, renders it totally unnecessary for me to expatiate more fully on anything that has been said, because I fully agree in everything he has stated.

I will, therefore, briefly describe to you a gun of my invention, and also a conical ball,* and I believe I was the first person who brought forward conical balls. In the year 1842 I proposed conical balls, and Admiral Sir Philip Durham wrote to Marshal Soult mentioning it to him, and, the Government having given me the permission to publish my work on Gunnery, he put the question to me, and asked me if I would show him the model. As I had permission to publish it, and of course it would be known to every one, I gave him one of the models; he was the Minister of War, and he declared that he had never seen or heard of any conical ball before; at the siege of Toulon the French invented an oblong ball, but he admitted it was tried and failed. About six months after this Colonel De Vigny took out a patent for a conical ball, because he found the conical ball was calculated for a rifle that he had invented some years previous; and it was evident the conical ball was not known in France, or the patent could not have been allowed. I forwarded this conical ball and shot to different members of the Government; they were sent down, I believe, to the "Excellent," to be tried. It was intended to be tried by an English musket, which they were made for; but I received a letter, stating that they would not try musket balls, I must send down 32-pounders. Now, I had no foundry, and, as a half-pay officer, was not at all disposed to set up one; and, therefore, they gave me the go-by, and there was an end of it. But a very short time after this, when our fleets were fitting out for the Baltic and Sebastopol, and I also sent them a plan to take Cronstadt, and how to fire concentrated broadsides; and I stated that I had tried these balls many years before, and on the coast of Spain. In 1812 I invented the sights combining the elevation and lines of sight in one focus. It was brought out seven years afterwards by an artillery officer, and is now called a military invention. This had wings, which were intended to prevent the shot wabbling in the gun, because a conical ball without wings; when it leaves the muzzle of the gun, would wabble. Mr. Lancaster took off the wings, and tried the conical ball before the Queen and Admiral Berkeley, at Spithead; and, in consequence of the wings being taken off, it diverged from the axle of the gun, and injured the lighthouse. Finding that was the case, they capized the ball, and fired it so that when it left the gun it performed a somersault like Grimaldi.

This is a gun (*showing a model*) that I invented; it has two grooves only, and the conical ball has four. These two have zinc attached to them to fill up the grooves, the other merely fills up the bore of the gun. When the ball is sent home, it is turned out of the groove into a slot, and, on being discharged, offers the same resistance as an expansion ball. This is supposing you wish to have it rifled, because it is not decided yet whether you are to have it rifled or not. I load it from the breech, so that the men are not exposed to rifle firing through the ports; because, even in these iron vessels, they

* A model of Admiral Tayler's gun and conical shot may be seen in the Museum of the Institution.—Ed.

must have their ports open occasionally. There is a small cone, and there is a slot inside; and, as you bring home the cartridge, this cone fits into the slot, and of course there is no escape of gas inside, and the men are not so exposed in loading the gun.

This is my fuse, which will answer every purpose. If a vessel is within a yard or at three miles, you have only to turn round the inner case, tighten the screw, and it will explode by time at 1, 2, 3 miles, and by concussion during its flight. There was a shell with a military fuse invented after this, and the Government took it up and adopted it. It was probably very good on shore, where you are firing with a fixed gun; but it is not at all adapted for the naval service, because you had to bore out the hole according to the distance, and then you handed it to the captain of the gun, and, by the time he has loaded, two steamers advancing towards each other or separating, would make a difference of a quarter of a mile, and, if you loaded one broadside, and the vessel came up to the stern of you and held off on the opposite side, it would remain in the gun and be no manner of use afterwards, and you could not draw it, therefore you must throw your shot away.

Admiral HALSTED: How many years is it since you proposed that fuse?

Admiral TATLER: It was in 1840 I proposed conical balls, and the fuse I invented in 1854, I think.

Mr. RICHARDS, of 2, Caroline Street, Bedford Square, then read a paper in which he recapitulated some of the desiderata of a naval gun, and an extract from the specification of a patent which professes to supply them.

Captain FISHBOURNE: Mr. Chairman, ladies, and gentlemen,—I am afraid I shall have to claim your indulgence, for the subject is important. Perhaps I may reverse somewhat the order as to the names of the persons to whom I allude. As Mr. Haddan did not offer any remarks on my paper, but merely referred to a very important subject—that is, the material of which guns should be made—I need not say anything in reference to his mode of rifling. The subject he brought forward is a very important one—I mean, the subject of metals; and the carrying out of his experiments may certainly lead to very satisfactory and economic results. It has been objected to Mr. Haddan, that he has been asked to make a large gun of the metal he referred to, and he has been unequal to do it. The answer, I dare say, many of you read in the *Times* of to-day (I have had no conversation with Mr. Haddan myself), that is, the impossibility of a private individual undertaking the works necessary for constructing guns of that description. Mr. Clay, in describing Mr. Horsfall's monster gun, told you of his difficulties in constructing it, and the greater facilities he has now, for constructing a gun of that kind; and I must say I do entirely sympathise with those various inventors who have had difficulties thrown in their way. There is boundless expense entered into, to try experiments that give no prospect, I think, of success; and experiments that do offer much prospect of success have not been carried out. Mr. Bashley Britten said little or nothing, either, as to the points that I raised with respect to his rifling. He brought forward an interesting subject, drawing a contrast between his guns and Sir William Armstrong's, in which he carried me with him entirely; and I sympathise with him, that he has not had the opportunities of trying it more effectually than he has had. Mr. Lancaster objected that the diagram did not exactly represent the degree of ovality that he now approves. Well, I was dealing with Lancasters as they are, not with Lancasters as they might be. All I can say is, I have no interest in the matter. I have no desire to set forward any one. I wanted to see the best gun; and it was partly because I was independent, and had no crochets and no hobby to ride, that I was solicited to undertake this paper. If Mr. Lancaster will produce the best gun, the best rifled, and the best in all particulars, we shall hail it with joy. We want a best one, for we have not got it as yet. I thoroughly concur in what Mr. Lancaster said, when he was dwelling upon the question of cast-iron and wrought-iron guns, built-up guns of that description as shown in Plate I. fig. 2, that they are not fitted to undergo the rough work of ship guns. We all know that there are circumstances under which a ship, to save herself, is obliged to throw her guns overboard, and recover them again. I ask, in what condition those guns would be, if they were thrown overboard on rocky ground? Again, it often happens that they have to land the guns to fortify a point. It does not always happen that they have the facilities for hoisting them into the boats, and there is a great deal of rough work in dragging them over the cliffs. I want to know how it is to be done by that gun. Apart from the way in which Sir William Armstrong treated the subject, saying, "Well, it had stood," I may ask, what was my argument throughout my whole paper? It

was not as to what it had stood. I said it had not at all had the test it ought to have, or to which it must necessarily be put, if it is to give the high initial velocity we must have at all cost. There are two or three remarks made by Colonel Lefroy, which I did not answer at the time, and which I think it necessary and important to answer. For instance, Colonel Lefroy cited as proof, that Sir William Armstrong's gun was a suitable gun for naval service, that various Continental nations had adopted it; but he did not add that no naval power has adopted it. Russia, France and America have studiously avoided it. Then again, in respect to the manner in which Colonel Lefroy commented upon my paper—and I must also join with him, Sir William Armstrong—it was, I think, not fair. Thus, for instance, I am made to say on each occasion by them what I did not say, and they have answered what they have undertaken to say for me, rather than what I did say. Upon the subject of strength, Colonel Lefroy says, that as for my exception to the strength of the gun, why, it has proved itself sufficiently strong. Now, I did not say it was not strong. I did say it was strong; but what I did say was, that it was not strong enough to bear the high charges that it will have to bear, if it is to give us the initial velocity that is wanted. Those are two different things; and I particularly use in my paper this expression, that it would burst prematurely if it were subjected to these high charges. Why, Colonel Lefroy says so himself. "Oh," he says, "it will bear these charges, because we have tried it; but," he says, "you cannot continue it, because it will burst." Why, the proof of the pudding is in the eating, and he has given us an illustration of it. Then, with respect to stripping. He says that I stated, that if you attempted to give it the high initial velocity, it would strip, or that it would be dangerous to the gun—that it would not take the rifling, in fact. Now, Colonel Lefroy answers, that the guns have all been subjected to proof charges, and that their missiles have taken the rifling. What do we mean by rifling? and what do we mean by a rifle? We mean by a rifle that which performs the functions of a rifle, that is, it gives rotatory motion, and continues that rotatory motion, in order to get accuracy of fire. Now, I say, you may have any kind of rifling you please, or any kind of marks upon the missile; if it does not perform the functions of a rifle—that is to say, give and continue that rotatory motion, so as to establish precision—it is not a rifle practically. Such is the fact with respect to this. Table K represents a series of trials; mind, not high velocities, but such as is due to a very small increment of powder; for instance, from 1.75 lbs. to 1.50 lbs.; and the series is continued alternately, so that there can be no doubt of the accuracy; because, of course, with thirty rounds the piece gets hotter, and, if they did not alternate, it would not be fair. Now, what is the fact? We find that, just in proportion, every time as the higher charge is used, so it becomes less accurate. (See table.) The correctness of this may be gathered by an examination of the columns of Table K. headed "Charge" and "Mean Observed Deflection," contrasting column 9 with 15, which contains the results with an iron shot. So that there is a regular law established, that just in proportion as you increase the initial velocity, and increase the quantity of powder, so the rifling slips. It is evident here. [Pointing to a French shot and one of Mr. B. Britten's on the table.] Here is where the slip takes place. Anybody who looks at this, will see the slip here. On each side of these buttons there is the evidence of the slip. There is a series of these tables to prove what I say; and if it were not as I state, Sir William Armstrong is perfectly sensible of the value of initial velocity, and would have obtained initial velocity if he could have obtained it. He would have put more powder, if either the missile or the gun admitted it.

Then, as to the velocity. I do not say that they could not attain high velocity; I said, relatively as high as smooth-bore guns. Colonel Lefroy cited, in a very triumphant tone, "that they had got 1,746 feet from a rifle shot," whereas from an old round-shot 9-pounder they only got 1,613. Now, I might adopt the tactics of that fine old fellow Sir Richard Keats, when he got in between two enemies off Algeiras—he just backed astern, and let the two enemies fire into each other, for he had other work to undertake. If I turn to the *Times*, I find that Sir William Armstrong admits the whole question, that a smooth-bore has a greater initial velocity; and you remember last night he stated it again. So that what are we to say? Here is Colonel Lefroy, defending Sir William Armstrong, saying that his missile gets the higher velocity, and Sir William Armstrong, on the other hand, admits the whole question, and says that it is not so. Well, I think I need not say anything more about Colonel Lefroy.

Sir William Armstrong commenced his remarks by saying that I had no experiments, and he brought as his experiments just the record of an experiment. I would ask, what are all these but records of experiments? (Pointing to the various tables against the wall.)

TABLE K.
I.—REPORT OF Ordnance Select Committee on Practice with ARMSTRONG and WHITWORTH GUNS, alluded to by the President, page 122.

3759 { 1871 B. ARMSTRONG'S B. L. 12-PR. GUN, *versus*
1943 C. WHITWORTH'S B. L. 12-PR. GUN.

With reference to *Minute* 3625. Report of Practice submitted.

OBJECT.—To ascertain range and deflection of Whitworth's B. L. 12-pr. Gun, in comparison with Armstrong's 12-pr. Gun.

DATE.	No. of Rounds.	Charge.	Elevation.	ARMSTRONG'S 12-PR. B. L. No. 6.						WHITWORTH'S 12-PR. B. L. No. 1.					
				RANGE.			Mean Time of Flight.	Mean Observed Deflect.	Mean Time of Flight.	RANGE.			Mean Observed Deflect.	Mean Time of Flight.	
				lbs.	deg.	lbs.				deg.	lbs.	deg.			lbs.
1861	5	1-50	2	yds. 1108	yds. 1150	yds. 1130	yds. 12	yds. 4	seconds. 3-4	yds. 1169	yds. 1223	yds. 1198	yds. 19	yds. 11	seconds. 3-5
"	"	1-75	"	1226	1307	1256	26	5	3-6	1266	1344	1289	28	12	3-4
"	"	1-50	5	2128	2165	2146	11	9	6-8	2072	2186	2367	119	11	6-9
"	"	1-75	"	2331	2399	2358	15	11	7-3	2335	2644	2471	97	12	7-0
"	"	1-50	10	3512	3597	3568	24	12	9-8	4137	4318	4222	68	8	10-2
"	"	1-75	"	3866	3961	3908	41	17	12-9	4348	4449	4399	25	6	13-1

Is not Table K an experiment with the Armstrong and Whitworth? These are taken from Colonel Lefroy's own book. Every one of these are experiments, and they might have been multiplied to any number. And yet he says, I have no experiments; and, lo and behold you, he brings one. Then, with respect to the shunt gun, Sir William Armstrong objected to the diagrams, I had not given a fair measure of it, and so on. They were all measured by Mr. Vavasour. He is a constructor of guns; he is perfectly conversant with them; and, so far from doing Sir William Armstrong any injustice, that given is the most favourable specimen of the large shunt family (see Plate I. fig. 9). If I were to have taken some of the earlier patterns, the windage would have been much larger; and, instead of Sir William Armstrong occupying the place he does in Table II, his name would have been considerably lower. When you consider that Sir William Armstrong was asked to speak on this occasion, and he asked for longer time; for there was such a multiplicity of figures that he really must get up figures, in order to be able to refute mine! If I was speaking upon my horn-book, I would not have to ask for time; and one would have thought that there was nothing here that he was not thoroughly conversant with. Sir William Armstrong affects to make light of the ricochet. Major Owen, R.A., in his lecture delivered here, does not do so, though he is favourable to rifled guns. Here is an extract from some information given before the House of Representatives in America: "Captain Dahlgren lays great stress on the certainty of large round projectiles *en ricochet*, which is most useful on water, and his 11-inch shells, weighing 135lbs., are certainly very formidable against wooden ships." I recollect an anecdote with respect to the value of ricochet. One of the steamers employed on the coast of Spain could not get in—I do not know precisely why, but she could not fire direct, because of an intervening point of land, upon the town; but she fired upon a cliff that was facing the town, and threw her shot very effectually into it. Now, I should like to know how Sir William Armstrong's shot would ricochet into that? They would not at all. Yet he attaches no value to the circumstance of ricochet! Then he seemed to throw a great deal of doubt upon this American experiment. Now, here is this work—Simpson on Gunnery—from which Table E is taken; anybody can read it; it is very interesting, and I think it bears evidence of the truth. The proof of it is, evident from his own gun. He wants to say this experiment is of no value, in order to disparage my statements with respect to the value of reducing the windage. But what is the fact, both with respect to Mr. Bashley Britten's gun and with respect to his? Why, because they reduce the windage, or because they reduce it so as to destroy the windage altogether, they produce great results with small charges. Why, that is just what takes place here. Either Sir William Armstrong does not produce results that he says he does, with small charges—there is not that extreme tension upon his gun, by explosion in his gun, that he states there is—or else this table is true. Then, if it is true, it is monstrous to draw a comparison between old guns with very large windage, and his guns that have no windage at all. He went into a long argument last night, to prove that it was a question of weight, not of friction. Now, here are some experiments that prove the very reverse. If it was the weight that was the cause of the higher initial velocity, then, instead of getting 1,609 feet initial velocity with the 51-lb. 8-inch shell, and 1,579 with the 66-lb. shot, these figures would be reversed (see table B). He says that the effect of the weight retaining the shot in the gun so much longer increases the elasticity of the powder to such a degree that it overcomes and gets a greater result. Why is it not shown so here? Here is the greater weight, and here is the less initial velocity. The fact is, that there *is* friction, by which, and by giving rotatory motion, power is absorbed, as any one who believes in mechanical laws must admit.

Sir William Armstrong undertakes to say that I said that the trajectory in this diagram, (Plate I. fig. 13), was that of his shot—of his ball. I did not say so. Here is my paper, in which what I did say is written. I simply supposed the case of a shot that would travel a distance of 600 yards in one second; and I supposed the case of another shot with less initial velocity, or half the initial velocity, that would require two seconds to travel the same distance. Then I drew *that* as an illustration of what would be the result. I, of course, gave Table C a, Appendix, also; but there I gave the actual quantities, and pointed to the actual quantities. The lines (see Table) represent the point-blank ranges of these respective guns, as given by the authorities. I am not in the least responsible for them. The table was prepared by Mr. Clay, and it must be taken for what it is worth. The principle is just the same. If, on the contrary, instead of taking only one second and two seconds, where the difference between fall by gravity is the difference between 16 and 64, I had taken the difference

between two and three seconds, there the difference would have been greater, because it would have been the difference between 64 and 144 feet. Now, Sir William Armstrong repeats a statement, and I must say it is deserving of comment, and of strong comment. We can understand a person at a meeting, getting up and speaking hastily, and extemporally, using an expression that is not quite to the point, or giving a fact that is not relevant; but when Sir William Armstrong asks for time, and when a fact such as it was—for it was a fact of its kind, but not a relevant fact—was given by Colonel Lefroy with respect to the rifle as compared with the round shot, and Sir William Armstrong hears that, and then twenty-four hours afterwards repeats that, I say it is deserving of comment. Now, what are the facts concerning that? The meeting was led to suppose that this was an accurate rifle projectile, such as is used in ordinary service. It was not such. Here is the paragraph which appears in the paper, "It has been the fashion of late, on the part of those who have studied gunnery, to assert that the initial velocity imparted to a shot from a rifled cannon is less than that which would be derived from a smooth-bore gun. Sir William Armstrong joined issue on this point, and, in order to settle the matter, he, on the day alluded to, loaded a 12-pounder, on his principle, with a shell weighing 8 lbs. with a 2 lb. charge of powder, and the initial velocity obtained was 1,740 feet. A 9-pounder smooth-bore was then loaded with a shot of 9 lbs. and 2½ lbs. of powder, and the initial velocity amounted only to 1,613 feet."* The first position is this. I stated that elongated rifle balls could not be projected with the same initial velocity as round balls, and I stated the reason. The greater weight, and the wings, or rifling, would prevent the one from being projected with the same velocity as the other. Now, here is not an ordinary rifle projectile. His ordinary rifle projectile for this piece is 11lb. 12oz. He reduces that down to 8 pounds. How does he do it? He must cut it in various ways. He must cut it shorter; and I have no doubt he reduced the lead. He reduced a great deal of the friction; and in fact he reduced it as far as possible to the conditions of a round ball; and then he fires it against a round ball, out of an old 9-pounder, with all its windage, while he reduced all the friction of his own.

Mr. G. RENDEL: No, no.

Captain FISHBOURNE: Well, comparatively.

Mr. G. RENDEL: The shot was not reduced in any way.

Captain FISHBOURNE: Are you prepared to say that?

Mr. G. RENDEL: Certainly.

Captain FISHBOURNE: Perhaps you will explain afterwards how it was?

Mr. G. RENDEL: I have nothing to explain, except that the shot was not reduced.

Captain FISHBOURNE: Then what was it, may I ask?

Mr. G. RENDEL: You say the shot was turned down.

Captain FISHBOURNE: Perhaps you will explain. I am not anxious to mislead in any way. Perhaps you will kindly explain what was done.

Mr. G. RENDEL: I merely say that the shot was not reduced.

Captain FISHBOURNE: I say it was reduced from 11lbs. 12oz. to 8lbs. Will you describe how it was reduced?

Mr. G. RENDEL: I will, if you will allow me. You stated that the lead was reduced at the back, to take away all the friction. Such was not the case.

Captain FISHBOURNE: That was my impression.

Commander SCOTT: It was a specially prepared projectile, not the ordinary one. Perhaps you will state what it was. Let us have the fact.

Mr. G. RENDEL: I merely wished to correct one important statement that was likely to mislead the meeting.

Captain FISHBOURNE: Will you state the whole facts? Because that is really the point to be arrived at. I do not want to mislead the meeting.

Commander SCOTT: Describe the projectile.

Mr. G. RENDEL: I am not in a position to describe the whole facts, but I hear things stated that are not correct. I understand you to say that the lead is turned down at the base of the shot, with the view of reducing the shot to the condition of a shot fired from a smooth-bore gun. I believe that such is not the case, and, as it is an important feature in the experiment, I think it right to say so.

Captain FISHBOURNE: You reduced the weight.

Mr. G. RENDEL: I know nothing of the weight. I know there is a 9-pounder shot fired from a light 12-pounder gun. There is such a shot as a 9-pounder, and I believe

* See Army and Navy Gazette, May 17, 1862.

that must have been the one used in the experiment, not a special shot constructed for the purpose. You would lead the meeting to suppose that a special shot was made for this experiment, and that I call in question.

Admiral HALSTED: When you use the term "turned down," do you use it in the sense of reducing the diameter, paring down?

Mr. G. RENDEL: I am answering Captain Fishbourne.

Captain FISHBOURNE: I understand it was a 12-pounder gun, and not a 9-pounder, that you spoke of.

Mr. G. RENDEL: It is the same calibre; and the size of the gun is stated.

Captain FISHBOURNE: Gentlemen, I am not in a position to tell you. What I say is this, that the meeting was led to believe that this was an ordinary service projectile; that an elongated rifle shot was projected, and produced the velocity of 1,740 feet. Neither did Colonel Lefroy nor Sir William Armstrong say anything about the reduction of the weight at all. Now, what I complain of is this, that in a public meeting of this sort, men in the public service, upon a public question, with one of Her Majesty's ministers in the chair, should undertake to get up and state half the facts.

Commander SCOTT: As the meeting has been interrupted on this occasion, I may claim from the Chairman permission to say this, that the 9-pounder is served out as a 9-pounder, and never mentioned as a 12-pounder. The 12-pounder gun is issued as a 12-pounder. I never heard a 9-pounder called a 12-pounder in my life, and I do not know that it has ever been.

Mr. G. RENDEL: The 9-pounder is simply a 12-pounder shortened.

Commander SCOTT: It is a different gun which has been supplied, in consequence of the other gun being too heavy for the horse artillery. I know it quite as well as you do. It is a 9-pounder.

Captain FISHBOURNE: What I contend is, that under any circumstances it is a one-sided experiment, and I want to know why one-sided experiments are to be made; and I want to know why, after one-sided experiments are made, they are given publicity to in the public press, when experiments that are of immense value and immense importance, that make altogether in the opposite direction, are kept covered up. Sir William Armstrong affected to throw discredit and doubt upon Table E. I had a great many more facts of this description. I did not want to crowd them upon the meeting. The first part of Table G was in the *Times* newspaper; others were taken from measurement at Shoeburyness and the official reports, and Sir William Armstrong affects to say that these are not accurate. The principle on which the numbers given in Table A, and headed comparative force of blow, are calculated is the admitted principle, that the resistances of iron plates are as the squares of their thicknesses. These figures are only inverting the operation, and taking the indentation, and squaring that, as giving a measure of the force of the blow which made those indentations.

There is another fact that I do think Colonel Lefroy and Sir William Armstrong, more especially Sir William Armstrong, when he was talking upon this very important question, should have told us at the same time, and that was a fact which he kept quietly from us; and certainly, by what he said, he led us to believe that there was no such fact in existence. It is this: that from a smooth-bore gun, with a 150 lb. shot, 2,000 feet velocity was obtained. Now, I dare say most of the persons present do not know that such an experiment has been made at all, and I do say it is one-sided for Colonel Lefroy and Sir William Armstrong to speak about the wonderful velocity of 1,740 feet got from his gun, and to speak of it as the greatest velocity. I do not actually use his words, but certainly that was the impression left behind, that it was greater velocity than was obtained from the smooth bore, when we have the smooth bore giving 2,000 feet instead of 1,740. It is quite true, there was a large quantity of powder, but it was a smooth bore. That is the question at issue. His rifle guns will not bear the amount of powder that was fired out of these smooth-bore guns; and the whole question turns upon this.

Admiral HALSTED: Allow me to make one remark. The charges from which these initial velocities were got, were all fired by galvanic battery; and in the case of the 80 lb. and 90 lb. charges, they were fired from two different places. The length of the cartridge amounted to about two feet, and two wires were put in, with about the space of eight inches between them. The cartridge was therefore divided into three parts. That is how that initial velocity was obtained. Otherwise it was utterly impossible for a gun of that description to have burned 60, 70, 80, or 90 pounds of powder during the period of the passage of the shot from the breech to the muzzle. Therefore, all these velocities are perfectly abnormal.

Captain FISHBOURNE: I think, Admiral, you are a little beyond the book; because Sir Howard Douglas gives an initial velocity of 2,200 feet.

Admiral HALSTED: I merely stated how it was obtained.

Captain FISHBOURNE: But you went beyond, and said that was a velocity that was purely abnormal.

Admiral HALSTED: I meant that mode of firing the cartridge was perfectly abnormal. It is usually fired from the touch-hole.

Captain FISHBOURNE: I beg your pardon. It just comes to this—that, notwithstanding the objections which Sir William Armstrong undertook to refute, I am not aware that the audience will say that he has refuted a single fact or a single statement that I have brought forward; I do not know that he has undertaken to do so directly; he has cast, as I said before, a doubt upon Table E; but there it is. Here is the work: * the man will speak for himself. Any person who reads this book will be, I am sure, satisfied as to the character of it; and it is really a representation of facts, and it is just as much an experiment, and I say a far more accurate experiment, than that, in which 1,740 feet initial velocity was obtained; and I think you will observe that Sir William Armstrong acknowledged that in the end we must have smooth bores for ship's broadside guns. I am quite satisfied of it myself. I am quite satisfied that it is not with lead-coated projectiles, or lead in any shape on projectiles, that you can at all get the initial velocity that will suit for ship guns, for breaching purposes, at short distances; and therefore if you cannot from strong missiles of this description [pointing to an iron shot with iron bearings] get the initial velocity you want, you have no alternative but to have smooth-bore guns; and I think it is quite evident that this is the conclusion Sir William Armstrong has come to himself; but I do say, and I do feel—and I think any persons who consider about it, will agree with me—that, seeing the number of crotchets Sir William Armstrong has had upon the subject, it is hardly fair to leave our service any longer at the mercy of his further crotchets. I do feel most strongly that the question ought to be an open one, and that experiments by other people ought to be admitted, that there should be an independent body to determine what the experiments should be, and to see them carried out. Why, what is the fact? Here we have these old service guns, that have done us good service, condemned by wholesale, just upon the mere fiat, that "this will not do," or "that will not do;" in the same style in which he condemns this, "Oh! this is impossible, it cannot be; I give you no reason for it." As if we were all children that we must accept his dicta, just because he chooses to say it. Why, really it is quite sad. A criminal, if he only goes to the judge *in forma pauperis*, has a counsel appointed to defend him, but here these poor smooth-bore guns, with all their disadvantages, have the judges and jury and counsel and spectators all against them. No wonder they are condemned and thrown out of court. I do say the country would never get better worth for a fee, than if it were to appoint a person or suitable persons to watch these experiments and see that they are proper experiments and properly tried. Would any one believe that Sir William Armstrong, who demonstrates to you, and writes to the *Times* newspaper on, the importance of initial velocity, should systematically neglect it? There is not one experiment that is made, except those lately, in which the grand object has been to get greater initial velocity. Every experiment has been "how not to do it."

I am sorry I have troubled you so long on the matter. I have hardly made it as clear as I should like to have done, because it is a large subject and it is not my subject. There are many others who would have undertaken the subject much better, and done much better by it; but it might have been said that they had a crotchet, or a hobby to ride. I have none.

The CHAIRMAN: Having now brought this discussion on the best naval guns to a conclusion, I may mention that the Council have before them the subject of the best metal for a naval gun, on which they hope to elicit equally valuable information as they have done on the present occasion. As soon as it is arranged, they will advertise when the discussion is to take place.

A vote of thanks was passed to Captain FISHBOURNE, for his paper, and the proceedings terminated.

* Ordnance and Naval Gunnery. By Lieutenant Simpson, U.S. Navy.

Since the above discussion took place a 9-pounder Armstrong segment shell and a 12-pounder Armstrong proof shot have been deposited at the Royal United Service Institution, by Colonel Lefroy, R.A., with the undermentioned description, to illustrate his remarks:—

"1.—9-pounder Armstrong segment shell (weighing without fuse or bursting charge 8½lbs.) This specimen has been reduced to 8lbs. by removing 4oz. of the inside metal, and is one of those prepared for a determination of the initial velocity of an Armstrong shot fired with a charge of one-fourth its weight, May, 1862.

"For charge 2lbs., the mean velocity was:—

1,662 feet per second with A₁ powder.

1,746 feet ditto with 2₁ A powder.*

2.—12-pounder Armstrong proof shot, fired with a charge of one-fourth its weight. Exhibited to show that shot fired with this charge take the rifling.—ED.

* 2 A₁ powder has a much larger grain than A₁.

We are requested by Captain Fishbourne to add the following explanatory note:—

"Understanding that Colonel Lefroy has sent an Armstrong 12-pounder shot, and a 9-pounder segment shell, reduced to 8 lbs. to be deposited in the Institution to prove the correctness of his statements, I beg to add that I did not question his facts, but their relevancy to my statements.

"I did not say that under exceptional circumstances, and with velocity greater than usual, the Armstrong shot would not take the rifling; my statement was, that if elongated lead-coated shot were driven up to the maximum velocities obtainable with spherical shot, the former would slip, or burst the guns if the coating were hardened, and I especially alluded to heavy naval guns, which are fired with high charges for breaching iron plates.

"The experiment with the 8 lb. shell was irrelevant, as I did not say that a high velocity could not be given to an elongated shot under any circumstances; but that to an elongated shot could not be given a velocity equal to that given to a spherical shot under the conditions stated in my paper, in which I dwelt on the necessity for heavy guns and high charges for ship purposes.

"The following would have been relevant to my paper, and would have been a useful and a scientific experiment:

"A spherical shot with the smallest practical windage fired from a gun of equal diameter, and precisely similar to the 110-pounder (but with a smooth bore), and with a charge that would bring equal tension upon it with that which the 110-pounder multi-groove is subjected to, when fired with the highest charge it will *safely* bear."—ED.

TABLE Ca.—RANGES IN YARDS.

Ranges of 68-pound and 100-pound taken from the Handbook for Field Service, 1862.
The range of the Horsfall 13-inch Gun taken from the official Report to the War Office dated 5th February, 1857.
Height of axis of bore above the plane, the 68-pounder gun not stated.
100-pounder Armstrong 17ft.
13-inch Horsfall 20ft.