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The Present State of the Artillery Question

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Evening Meeting.

Monday, May 15th, 1865.

COLONEL PHILIP J. YORKE, F.R.S., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 1st and 15th of May, 1865.

LIFE.

Wason, E. S., Major, 33rd Regiment. 9l.

ANNUAL.

Laing, E., Ens. Middlesex Rifle Vols.
Lester, C. S., Surgeon, R.N. 1l.

Rogers, J. E. Varty, Lieut., 102nd Roy.
Mad. Fus. 1l.
Aynsley, C. M., Captain, R.N. 1l.

THE PRESENT STATE OF THE ARTILLERY QUESTION.

By Major C. H. OWEN, R.A., Professor of Artillery, Royal Military Academy, Woolwich.

THE subject that I have to bring before you this evening presents so many difficulties, that in attempting to lecture upon it I am afraid I shall be considered rather presumptuous. As, however, one of the great objects of this Institution is to discuss such subjects, I thought that, being a member, I should not refuse, when requested by the Council and several of my own brother Officers, to read a paper on the "Present State of the Artillery Question."

There are doubtless many of my brother Officers who could give you a better and more interesting lecture than the one you will hear to-night, but none would I think take more pains than I have done to look at the various questions in an impartial spirit.

I shall endeavour in the following observations to keep to facts and principles, and to avoid mere opinions or personal remarks; but shall necessarily be compelled to review briefly the constructions and pro-

posals of several inventors. Many confused notions which unfortunately still prevail, may I think be cleared away by dividing the subject into distinct branches, and treating each of these separately. I propose then to consider—

1. The materials for ordnance.
2. Methods of construction.
3. Systems of rifling.
4. Ordnance of different services.

Before proceeding, I will, however, remind you, as shortly as possible, of a few elementary principles relating to the strains exerted by the gas from the gunpowder upon the metal of a gun; for it is only by applying these, that opinions of any value can be formed respecting the relative merits of different materials and constructions.

When a charge of gunpowder is ignited in the bore of a gun the gas exerts equal pressure in every direction, and therefore, neglecting windage, the pressure on the bottom of the bore is equal to that on the base of the shot, and the pressures on the top and bottom as well as those on the sides of the bore balance each other. As the shot moves towards the muzzle, so will the space in which the gas is confined be increased, and the pressure be decreased. It is evident then that the thickness of metal may (as it always is) be safely reduced from breech to muzzle. A curve representing the pressure of the gas along the bore might be constructed on the assumption that the whole charge is converted into gas before the shot moves, but this is not the case in practice; in fact, as we know, the amount of gas generated, previously to motion being communicated to the projectile, varies according to circumstances in different guns.

The force exerted by the gas produces a double strain inside the bore—a *tangential strain*, tending to rend the metal lengthwise (through A, B, Fig. 1); and a *longitudinal strain*, which tends to fracture the gun across (through C, D,) or to drive out the breech.

FIG. 1.

The most important point to consider is the *initial strain*, or that to which the metal is subjected before the shot moves; for the gas then exerts its maximum pressure per square inch, and it is this first severe strain that usually causes the destruction of the gun. Now, in ordinary cases, the *initial* pressure exerted at the bottom of the bore by a *given charge* depends upon the amount of force necessary to set the shot in motion, for the greater this force, the longer is the time allowed for the ignition of the powder before the gas can expand.

In comparing then the strain in different guns, it is necessary to consider the resistance the projectile opposes in each case to the force of the gas, or in other words, the work the gas has to perform in putting the shot in motion. For instance, in a S. B. gun the spherical shot has merely to be rolled along the surface of the bore, and is

therefore probably set in motion when only a small portion of the powder is converted into gas. Should a cylindrical shot be fired from the same piece, there will be a considerable amount of friction between the shot and the bore, which must be overcome and cause delay. In a rifled gun additional work must be expended in giving a rotatory motion to the shot; besides which, the area of projectile presented to the force of the gas is much smaller for a given weight of shot in a rifled gun, than in a S. B. piece.* It is thus easy to account for the great proportional strain caused by a charge of powder in a rifled gun. Independently, however, of the increased strain, the grooving of the bore weakens the metal, especially if cast.

Before passing on to consider the materials for ordnance, I must also remind you, that if a gun consists of one solid mass of metal bored out, the exterior portions take but a small share of the strain. I need not dwell on this point, which has been so fully explained by Mr. Mallet, Captain Blakely, and others; and you are doubtless aware of the several proposals made and some of the methods adopted for equalizing the strains upon different portions of the metal of a piece of ordnance.

Materials for Ordnance.

The four materials generally used for ordnance are bronze, cast iron, wrought iron, and steel. In selecting a material for ordnance it must be remembered that it will not be subjected to a mere variable pressure, but that the force of the gas is percussive, resembling a blow rather than a pressure. It is therefore that the tenacity of a metal is not always a criterion of its suitability for guns. The properties especially required in a metal for cannon are elasticity, toughness (tenacity combined with flexibility), and hardness; ductility will allow a greater margin of safety beyond the elastic limit, but the strain should, if possible, be confined within this limit.† It is also important that a material capable of being manufactured with certainty be chosen, and that both the material and the method of construction be not too costly.

Bronze is sufficiently tough, and can, with skill and care, be cast so as to be uniform in quality, but it is costly and too soft for the bores of rifled guns; it does not corrode like iron, and therefore requires no painting.

Cast iron possesses the necessary hardness, but is very brittle, and, even with the greatest care in casting, is of uncertain tenacity. The Americans have of late greatly improved the quality of the cast iron ordnance by the selection of the most suitable ores, and by taking means to render uniform the contraction of the different portions of the metal in cooling; nevertheless, cast iron cannot be used for rifled guns, unless they are fired with very small charges.

* In all these cases it must be remembered that although the actual differences in time elapsing between the ignition of the powder and the moving of the shot under various circumstances may be very small indeed, the ratios of the times may be high.

† According to Barlow no thickness of metal can permanently resist an internal strain greater than the tensile strength of the material.

Many attempts have been made to strengthen cast iron guns by shrinking or driving wrought iron or steel rings or tubes over the breech; the jacket thus applied, being in a state of tension, should take a fair share of the strain; and as the cast iron will be compressed, it will be in a condition favourable to resistance to strain. Numerous experiments have, however, shown that cast iron guns strengthened on the outside will not stand the great strain caused by firing heavy elongated projectiles with even moderate charges; and this result has been confirmed by the many failures of the Parrott rifled guns in America. A better plan is to place the wrought iron or steel inside the cast iron, as proposed by Major Palliser, the stronger metal being then in the position where it is the most required.

Wrought iron is an excellent material in most respects for ordnance; it is exceedingly tough, and although not so hard as cast iron or steel, and therefore less able to resist injury from the action of powder and shot in the bore of a gun, it is not liable to snap like the far more tenacious material steel, and will withstand a greater moving or percussive force. Soft iron is preferable to the harder qualities, for, as Kirkaldy remarks, "although the softness of the material has the effect of lessening the amount of the breaking strain, it has the very opposite effect as regards the working strain. This holds good for two reasons: first, the softer the iron the less liable is it to snap; and second, fine or soft iron, being more uniform in quality, can be more depended upon in practice." It is difficult to obtain large masses of wrought iron without slight flaws, caused by the cinder and impurities not thoroughly got rid of in the working of the metal; but such flaws are generally of far less consequence than cracks of equal size in cast metals, and do not, like the latter, indicate the speedy destruction of the material; flaws across the fibre of the metal are necessarily dangerous. Wrought iron, in consequence of its toughness, possesses another great advantage over cast iron or steel; when fractured it does not, like those brittle metals, fly into a number of destructive pieces, but its failure is gradual, it may be easily noticed, and so injury to the gunners may be avoided.*

Cast steel being exceedingly hard and elastic, is well adapted for the bores of guns; but although its tensile strength is very great, it is liable to snap without warning when exposed to strain suddenly exerted. However, the steels now made for ordnance, both in England and on the continent, are much softer and tougher than ordinary cast steel of good quality. The steel used for the bores of our large guns is tempered in oil, by which means it is rendered both harder and tougher.

Great difficulty is still experienced in obtaining large masses of cast steel of uniform quality, but since the successful productions of Krupp and some of our own manufacturers, it is to be hoped that this objection will be before long overcome. There remain, however, two other rather formidable objections to the employment of steel alone, viz., the

* "Out of nearly 3,000 guns made on this principle no one gun has burst explosively."—Sir W. Armstrong's Evidence, Report on Ordnance, page 134.

great cost of the metal, and its tendency, when fractured, to fly into a number of destructive pieces, which render it less suitable than wrought iron for the exterior of a gun. By hooping steel with wrought iron, the endurance of the former is doubtless much increased, and its destruction is less dangerous.*

In the above remarks on wrought iron and steel, I have not attempted an inquiry into the best methods of producing these materials; I will only remark that by the adoption of the Bessemer process of conversion, the cost of wrought iron and steel would be much reduced, but that further experiments are required before the Bessemer metals could be safely employed in the manufacture of ordnance.

Methods of Construction.

Let us now consider the methods of construction. There is little doubt but that by casting a gun in one mass much time and expense in manufacture is saved, and that many difficulties experienced in making guns in different parts are avoided. At the same time it has not yet been proved that a material of sufficient strength, combined with uniformity in quality, can be obtained for casting into heavy ordnance, which will be subjected to the strains of large charges of powder. Cast-iron is too uncertain in character, bronze is too soft and costly, and soft steel, as I before pointed out, is very expensive, it is a dangerous material when fractured, and has not yet been sufficiently tried to prove its fitness for very large guns (of over 7-inch calibre).

Another method is to form the gun out of one solid forging, and this has been strongly advocated, but has also been utterly condemned by good authorities on the subject.† For guns of very small calibre, it has been adopted with some success, but when a piece weighing many tons is required, it is now pretty generally admitted that this plan will not give the required results. Experiments have shown that the strength of a forging, like that of a casting, is less as its size increases; but besides this, some parts of a heavy forging will in most cases be more soundly worked than others, and flaws, often running in the worst direction, and which cannot sometimes be detected until too late, will occur.

Another method is to build up or construct a gun out of a number of distinct pieces, and by this plan several important advantages are obtained. 1st. The parts may be of such a size that their soundness may be depended upon. 2nd. Different materials may be used, each being placed at a part of the gun where its peculiar properties are most required. 3rd. The materials may be applied in such a manner that their particles or fibres may run in a direction most favourable for resistance to the strains to which they will be respectively subjected. There is one most important condition that must not be neglected in building up a gun, viz., to provide against the separation of the different parts, for no matter what materials are used,

* That wrought iron hoops will prevent dangerous results when the inner steel tube gives way has been shown in many of the late trials of ordnance.

† Mallet, Armstrong, Anderson, American authorities, &c.

the gun will have little endurance if the different portions are liable to be shaken asunder by the shocks of successive discharges, or by the blows of an enemy's shot. It must also be obvious that a gun constructed out of a few large heavy pieces will be less liable to destruction, from the causes just stated, than one consisting of a large number of smaller and lighter parts.

We have obtained in this country considerable experience in the manufacture of built-up guns; not, as might have been foreseen, without many disappointments and much expenditure of both time and money. We are not perhaps indebted to any individual for our present system of building up; our experience has been gradually gained, but to Sir W. Armstrong cannot, I think, be denied the credit of being mainly instrumental in combining different principles and improving details, so as to produce an efficient method of manufacture for large ordnance. He has doubtless been ably assisted, both by his own partners and by his Assistants in the Royal Gun Factory, but no one can blame him for accepting this assistance or for turning to account the many advantages of his position. In saying this, I do not mean to justify his appointment as Superintendent of the Royal Gun Factories, which it is now generally admitted was a mistake.

The essential features of the Armstrong method of construction, are:—

1st. The disposal of the fibre of the metal round the bore (by coiling), so as to resist the tangential strain, the welds running in the direction of least strain as regards their separation.

2ndly. The employment of a breech piece, to support the bottom of the bore, with the fibre running lengthwise so as to resist longitudinal strain.

3rdly. The shrinking on the different portions, so that the exterior of the gun takes a due share of the strain.*

The separation of the different parts of the guns now made is guarded against, not only by the tension of one part over another, but by means of shoulders and corresponding recesses (Figs. 2 and 3).

FIG. 2.

FIG. 3.

These and other details of manufacture, as the decreased diameter of the cascable in the later M.L. guns, the best form for the bottom of the bore, &c., will, I dare say, be fully explained by Mr. Anderson, who I understand will give a Lecture here on the 26th of this month. Mr. Anderson is, I believe, an advocate of a steel barrel with a closed end, and he will doubtless give good reasons for his preference.

I will here remark on the vexed question of coiled iron for the inner tube of a gun. It is often asserted that a sound coiled iron tube cannot be made, and that it is folly to attempt to produce one. I must,

* As proposed by Captain Blakely (late R.A.).

however, beg to question this statement. Large numbers of coiled iron barrels have been made, and, notwithstanding slight flaws, have shown great endurance. If flaws must occur, they are, in a well-made tube, so small, and in such a direction, that they are practically of little importance, and do not usually enlarge to a dangerous extent before the gun is worn out.* The coiled iron barrels now made of a better iron than that previously used are almost free from flaws, and those that occur are very small.† The fact is, the barrels have been abused, not only for their own imperfections, but also for the failures of the vent pieces.

Several important modifications in manufacture, which will both decrease the cost and increase the endurance of the gun, have lately been proposed in the Royal Gun Factories, by Mr. Fraser, the Manager and Assistant-Inspector of Machinery. The chief modifications are a reduction in the number of coils; the use of a cheaper iron for the outer coils; the shrinking on of the outer coils and trunnion piece together; and an improved arrangement of shoulders and recesses to prevent separation of the parts. The cost of material is thus reduced, a less quantity of metal is required, much time is saved in the manufacture, and as the parts are large and few in number, and more disposed for mutual support, the endurance will, in all probability, be increased.

Mr. Whitworth is a strong advocate of steel for all parts of a built up gun.‡ His method of building up differs from that of Sir W. Armstrong:—"The tube of the gun is made taper, being in the $5\frac{1}{2}$ -inch bore gun 1 inch larger in diameter at the breech end than at the muzzle end; then a series of hoops are made, which are screwed together so as to form another tube, that is put on by hydraulic pressure,§ each layer is put on a little tighter than the succeeding one." Mr. Whitworth asserts that pressure is more certain than shrinking; the latter can, however, be done with sufficient accuracy. Captain Blakely also is, I believe, a strong advocate of steel for both inner tube and outer rings, although he has also employed both cast and wrought iron for portions of some of his guns.

The method of closing the bore of a built-up gun is an important question. The inner tubes of some of the large M.L. ordnance lately constructed in the Royal Gun Factories, as well as those of some of Blakely's guns have what are termed closed ends, that is, the tube is not bored through at the bottom; the solid end of the tube in the

* Sir W. Armstrong pointed out, before a Committee of the House of Commons, the difference between the flaws in the welds of a coiled barrel and in those of a forged solid tube. He said: "In the barrel which is forged solid, the lines of the weld run longitudinally with the bore; now we not only derive greater strength from the welds lying transversely to the bore (as in a coiled tube), but we also attain greater durability, because when they run in the direction of the bore, the scour of the gas eats into them, and causes fissures in the most dangerous direction, while in the other case the scour crosses the lines of the welds, and produces very little corroding effect."—Report on Ordnance, p. 131.

† A tube of coiled iron in a Palliser gun, after several hundred rounds, showed no sign of a flaw in a weld.

‡ The trunnion pieces of his experimental guns are of wrought iron.

§ Mr. Whitworth's Evidence. Report on Ordnance, page 126.

Different Methods of Closing Breech of M.L. Built-up Guns.

Breech of 9.2 inch Gun.

Breech of Armstrong 10.5 inch Gun.

Method of Closing Bore of 64 P.

- B. Inner Tube or Barrel
- C. Cascable
- P. Breech piece
- a. Copper Cup

Breech of 7 inch Gun proposed by Mr. Whitworth.

service guns is supported by a cascable screwed into the breech-piece, and in some of them also by a shoulder in the breech-piece. Sir W. Armstrong, Mr. Whitworth, and Major Palliser use open tubes, and close them by a plug of wrought iron or copper. The cascable in the Whitworth guns is not, like Armstrong's, cylindrical in form, but is shaped into two or more (screwed) cylinders, their respective diameters increasing from bore to breech (see Plate xxx). In closing the bore either of a M.L. or B.L. gun, one important principle should not be neglected, viz., that as the gas exerts an equal force in every direction, the thickness of metal should be as great, or nearly so, behind as over the charge. Inattention to this principle, or its sacrifice to other considerations, is a source of weakness in many B.L. guns. One advantage of an open end is, that the metal of the inner tube is relieved to some extent from longitudinal strain.

The relative cost of large ordnance made in different ways is approximately as follows :—

				£
Cast-iron guns	..	..	..	21 per ton.
Armstrong built-up ditto	..	..	..	100 ditto.*
Krupp's steel ditto	..	..	..	170 ditto.
Gun-metal ditto	..	..	:	187 ditto.

The latter guns (bronze) are valuable for re-casting. By the adoption of the modifications proposed by Mr. Fraser, the cost of built-up ordnance will, it is said, be much reduced, viz., to £10 a ton with a coiled inner tube, and to £55 a ton with a steel tube. Mr. Whitworth's guns, like all steel guns, must be very expensive; he told the Committee on Ordnance that his 5½-inch gun, weighing 4 tons, and made of homogeneous metal (soft steel) costs £700, which is about £175 per ton.†

The following will be, I think, considered sound conclusions on this part of the subject.

A cast iron gun strengthened by hoops on the outside will fail when rifled, but by placing wrought iron or steel tubes inside, better results may be expected.

A heavy rifled gun made in one mass either of cast steel or of forged iron cannot at present be trusted.

By properly disposing and adjusting together a few pieces of moderate size, a heavy rifled gun can be produced, possessing great strength and endurance, at a moderate cost.

The best material for the bore, as also the safest way of closing the inner tube, are still open questions.

Both coiled iron and steel will probably answer for the inner tube; for the exterior portions of a gun, however, there can be no question but that wrought iron is the best, as well as the cheapest, of the two.

Various opinions are held as to the relative advantages of breech and muzzle-loading ordnance, but the latter would appear to be the

* Lately about 87l.

† Report, page 108

best adapted to general service, as they are stronger for equal weights of metal, and simpler in construction. The advantages of loading cannon at the breech are—that a projectile of larger diameter than the bore can be used, and its axis will consequently be stable; that the gun can be loaded when run up, the gunners being therefore less exposed; that the gun can be worked in a smaller space (than a M. L. piece); the cleaning of the bore can be more readily effected, and any ignited substance left in the bore can be seen and removed; also, there is no danger of the shot not being *home*. This plan, however, is attended with the following disadvantages, viz., that the construction is more complicated than that of a muzzle-loading piece; that if the gun be of large calibre, the breech-loading apparatus, when sufficiently strong and heavy, will be unwieldy; and that with the same weight of metal, the breech-loading is a weaker and less enduring construction than the muzzle-loading.

On the other hand, a muzzle-loading gun has a simpler and stronger construction, but the gun detachment are more exposed than with a breech-loading gun, and if loaded carelessly, the shot may not be rammed *home*, in which case the metal of the gun may be fractured by the suddenly condensed gas.

Systems of Rifling.

I will now say a few words on the different systems of rifling. In what does a *system of rifling* consist? Essentially in the method of giving the rotatory motion to the projectile. This definition will not satisfy some inventors, who wish to claim a particular *twist* as a part of their *system of rifling*. It would, however, be quite as reasonable to claim a particular charge. The rotatory motion, as you all know, is given to prevent the projectile from turning over in flight; and the velocity of rotation required depends upon the form, length, and weight of the projectile, no matter what the system of rifling may be; in

fact, the number of revolutions made by a shot = $\frac{\text{I. V.}}{\text{length of twist}}$, and therefore, with the same charge, the same twist must be obviously necessary.*

A twist, like a charge, may suit a particular rifled gun, but this is quite another thing. A *gaining twist* is advantageous, for, by employing it, the initial strain upon the gun is reduced, the rotatory motion not being given when the shot is set in motion, but gradually acquired as it moves down the bore. It is better to give rather more twist than is required under ordinary circumstances at the expense of a little extra strain; for should the twist be merely sufficient to impart the necessary rotatory motion with the service charge, the velocity of rotation will probably be too low with a reduced charge to keep the projectile steady in flight.†

* The I. V. is very little affected by the system of rifling.

† This was practically shown by the inaccurate practice of the 600-pounder, when fired with a small charge.

The diameter of the bore has also been often mixed up with the system of rifling, with which it can have nothing whatever to do. As the diameter is decreased, so will an elongated projectile oppose a less surface (in proportion to its weight) to the resistance of the air, or of that of the substance fired at; but, on the other hand, it will expose a less area to the force of the gas, and will therefore have a lower initial velocity; it will have less capacity as a shell; its cartridge must be elongated, thereby throwing the strain forward, the amount of powder that can be usefully employed will be less, and if the length of the bore be not increased, the expansion of the gas will be more limited. This question has been discussed in this room, and should be now thoroughly understood. In the table below the loss of initial velocity by decrease in the size of the bore is clearly shown:—

Ordnance.	Charge.	Projectile.		Initial velocity.
		Weight.	Diameter.	
	lbs.	lbs.	inch.	
Britten's (32-pr. rifled)....	5	50·36	6·2½	1209
Armstrong's 40-pr.....	..	41·25	4·75	1197
„ 3 grooved shunt	9	68·40	6·4	1283
Whitworth's 70-pr.....	..	68·56	{ 5·5 5 }	1132
Armstrong's 70-pr.....	10	74·60	6·4	1271
Whitworth's 70-pr.....	..	68·56	{ 5·5 5 }	1199

Mr. Whitworth and his admirers have constantly asserted that his small-bore gives a flatter trajectory than the larger bores chosen by Armstrong, Britten, and others. This is, however, not the case under all circumstances, and arose partly from the fact of the Whitworth guns first tried, being fired with charges of $\frac{1}{8}$ of the weight of the projectile, whereas the greater number of other rifled guns used charges of only $\frac{1}{16}$ or $\frac{1}{20}$. Mr. Whitworth is quite right to use as large a charge as he can, but this must be taken into account in drawing comparisons. In practice from two rifled guns of different calibres, but firing projectiles of the same weight with equal charges, the large bore will give a lower trajectory for a short range than the small bore, but at long ranges the small bore will give the lower trajectory. For the larger bore will give the higher I. V., and therefore up to a certain range the lower trajectory; but as the projectile with the smaller diameter is less retarded, its trajectory will gradually become lower, as compared with the other, until beyond a certain range the smaller bore will give the lower trajectory. Small bores have found little favour on the continent, and it is for the authorities to demand either a large or a small bore, as circumstances may require.

The following conditions are requisite in any rifled gun to ensure accuracy of fire:—a rotatory motion must be given to the projectile

round an axis parallel to, or coincident with, that of the bore; the axis of the shot must be stable on leaving the bore; and the velocity of rotation imparted to the projectile must be sufficient to counteract the pressure of the air tending to turn the shot over or render it unsteady in flight.

Great numbers of rifled guns with projectiles to correspond have been proposed, but most of the *systems* of rifling that have been adopted by any service, or tried on the practice-ground, may be divided into the following classes:—

(1) Muzzle or breech-loading guns having projectiles of iron fitting the peculiar form of the bore mechanically.

(2) Muzzle-loading guns, with projectiles having soft metal studs, or ribs to fit the grooves.

(3) Muzzle-loading guns, with projectiles having a soft metal envelope, coating, or cup, which is expanded by the gas in the bore.

(4) Breech-loading guns, with projectiles having a soft metal coating larger in diameter than the bore, but which is compressed by the gas to the form of the bore.

I shall only give types of each class, for there will be no occasion to explain the different systems, which have been so fully described by Captains Scott and Fishbourne.

The Whitworth and Lancaster systems may be taken as examples of the 1st Class.* The great advantage shared by both is, that the projectile is made of only one metal; but as this must be iron, a steel bore is indispensable. Unless both bore and projectile are turned with great accuracy, and cleared from rust or dirt, the projectile may jam in loading—a very serious objection, for in the heat of action the gun might be fired when the shot was not home, and thus be burst. Mr. Whitworth has very ingeniously modified the hexagonal form, so as to facilitate the loading, and if enough windage be allowed, difficulty in loading will not probably be experienced; as, however, the windage is increased, the fire will be less accurate, and the bore will suffer more wear. The hexagonal form is unfavourable as regards capacity of shell, and as the projectile is made of hard metal, the *gaining twist* cannot be employed either in a Lancaster or Whitworth gun. In the Lancaster there is a much greater tendency to jam than in the Whitworth system.

The French, shunt, and Scott's systems belong to the 2nd Class. In all, the shot is centred so as to ensure stability of axis, there is no difficulty of loading, and, as the driving sides of the studs or ribs can be made of soft metal, the wear of the grooves is much reduced, so that either iron or steel may be used for the bore. By placing on the shot smaller studs in front than behind, a *gaining twist* may be employed.

Bashley Britten's system is a fair example of the 3rd Class; it possesses several important advantages, viz., easy loading, accuracy of fire, and but little wear of the grooves; but the projectiles will not bear large charges, the expanding envelope giving way. Parrott's and Blakely's systems are nearly similar in principle.

* Lancaster now has a few copper steadying studs to facilitate loading.

The Armstrong and Prussian B. L. systems belong to the 4th Class. With these the bore can be readily cleaned, the loading can be easily performed, in the smaller natures of guns at least, and the soft coating does not injure the bore. The chief disadvantage is the great initial strain due to the necessity of the compression of the lead coating.

The system of rifling is not, after all, of such very great importance; good results, as regards accuracy of fire, may, doubtless, be obtained with most of them, if both guns and projectiles are manufactured with equal skill and care.

Ordnance of different Services.

I will now endeavour to compare British with foreign ordnance, and I think I shall be able to show that our condition is not quite so hopeless as has been represented, but rather the reverse. I shall not allude to the S. B. cast-iron or bronze ordnance, with the capabilities of which we are all well acquainted. I will take the different natures of guns in the following order:—

Field guns (including position pieces).
Siege and garrison guns.
Naval and coast battery guns.

It is now pretty generally acknowledged that rifled ordnance should be used in preference to S. B. guns for land service. The English, Americans, French, Prussians, and other leading powers, are supplied with rifled guns both for field and siege service; a proportion of S. B. pieces may be retained, but chiefly with a view to economy. In the late American campaigns considerable numbers of S. B. guns were employed by both sides, but this may be easily accounted for; the country is so densely wooded that case-shot ranges are frequently the only ones practicable, and, no doubt, both sides were obliged to use any guns that they could procure.

You are all aware that the advantages gained by substituting rifled for S. B. guns, are

Increased accuracy of fire.
Destructive effects at greater ranges.
Capacity of shell.

The two latter being due to the elongated forms of the projectiles fired from rifled guns.

By placing the weights of projectiles, the proportional charges, and the bursting charges of the shells, of different field guns in a table, the relative values of the latter as weapons may be compared.

RIFLED FIELD GUNS.

Nature of Gun.	Weight of Gun.	Charge.	Projectiles.			
			Shrapnel or Segment.	Common Shell.		
				Weight.	Burster.	
	Cwt.	lbs.	lbs. oz.	lbs. oz.	lbs. oz.	
British. $\left\{ \begin{array}{l} 20\text{-pr.} \\ 12\text{-pr.} \\ 9\text{-pr.} \end{array} \right.$	16	$\frac{1}{8}$	19 10	20 8	1 0	The weights in the column of shrapnel for American guns are those of solid shot.
	8	"	10 8			
	6	"	8 5			
French. $\left\{ \begin{array}{l} \text{Cannon de 12} \\ \text{do. 4} \end{array} \right.$	12	$\frac{1}{10}$		25 4	1 1	
	6 $\frac{1}{2}$	"	11 7	8 12	0 7	
American. $\left\{ \begin{array}{l} 20\text{-pr.} \\ 10\text{-pr.} \\ 3\text{-in.} \end{array} \right.$	15 $\frac{1}{2}$	$\frac{1}{16}$	19 8	18 12		
	8	"	10 8	9 12		
	7 $\frac{1}{2}$	"	10 0	10 0		

The Prussian 12-pr. steel rifled gun weighs rather more than 7 cwt., the charge is $\frac{1}{10}$, and the projectiles weigh about 13 lbs.

For ready comparison I have given the weights of guns in cwts., and the weights of the charges in terms of the weights of their respective projectiles. I have purposely omitted mountain artillery, as, in a short lecture, my remarks must be confined to the most important questions.

The table shows that the projectiles of the different guns differ little in power, the French having a slight advantage; the British, however, are fired with the highest velocities.

	Velocity in feet.
British. $\left\{ \begin{array}{l} 20\text{-pr. common shells} \dots\dots \\ 12\text{-pr. segment} \dots\dots\dots \\ 9\text{-pr. do.} \dots\dots\dots \end{array} \right.$	1114 per second.
	1218 do.
	1036 do.
French. $\left\{ \begin{array}{l} \text{Cannon de 12 common shells} \\ \text{do. 4 do.} \end{array} \right.$	1006
	1066

The French employ three kinds of projectile, and all experience shows that one projectile will not answer three distinct purposes. Common shells are often required under circumstances where segment shells would be useless; and a case-shot which depends for its action upon the preparation of a fuze is very objectionable; simple case-shot and common shells will probably be introduced into the field-service batteries. In actual warfare our Officers have generally kept a number of segment shells with their fuzes prepared for case firing.

As regards precision of fire, I have little hesitation in saying that the practice of our B. L. Armstrong guns is quite as accurate as can be required for any service, and I believe more so than that of most of the foreign guns. I will give you an instance. In the Aide-Mémoire de Campagne, of 1861, the mean errors, both in range and direction of projectiles fired from the canon de 12, are so eccentric that nothing can be made of them: at 1,300 metres the error in range is only about one-sixth of what it is at 400 metres, and at 2,050 metres the error in direction is less than it is at 700 metres. The canon de 4 appears to be a more accurate gun; the mean errors in range at 1,000 and 1,800 metres are 22 and 27 metres respectively; those in direction and at the same ranges, 1.2 and 2.5 metres. With our B. L. rifled guns the mean errors in range at 1,000 and 2,000 yards are 19 and 21 yards respectively, and in direction .8 and 2.1 yards respectively.

The Prussians, like ourselves, employ B. L. guns for field service, the French, Americans, and others, M. L. guns. In the Armstrong B. L. (screw) system, strength has been to some extent sacrificed to easy loading, but notwithstanding the abuse poured down upon both the method of closing the bore and the whole construction of our B. L. field guns, they are perfectly safe and can be readily served; the vent-piece* lasts but a short time compared to the rest of the gun, but should one fail it can be easily replaced by another, and the present form prevents dangerous results.

The Prussian field guns are of Krupp's steel; the French and some other nations have converted their S. B. bronze guns into rifled pieces, thus utilising their old *matériel*, but not obtaining ordnance that will wear like wrought iron or steel guns. The American 3-inch gun is a solid forging, and as it is so small, the metal is probably sound.

Let us now compare the siege and garrison guns.

* In consequence of its support by the breech-screw being only partial, and the vent being bored through it.

REVISED SINGE OR GARRISON ORDNANCE.

Nature of Gun.	Weight of Gun.	Charge.	Projectiles.					Chargo will probably be reduced
			Shot.	Shrapnel or Segment.	Common Shell.			
					Weight.	Burster.		
{ B. L. 7-in. (heavy) do. (light) .. A. L. 64-pr. .. B. L. do. (wedge) .. B. L. 40-pr. .. }	Cwt.	lbs.	lbs. ozs.	lbs. ozs.	lbs. ozs.	lbs. ozs.		
	81	$\frac{1}{3}$	90 0	98 0	98 0	8 0		
	73	$\frac{1}{10}$	90 0	98 0	98 0	8 0		
	65	$\frac{1}{8}$	64 0	62 10	60 0	4 8		
	61½	"	64 0	61 14	60 0	4 4		
	{ 35 32½ }	"	41 3	39 0	38 5	2 8		
{ 100-pr. .. 30-pr. .. }	86½	$\frac{1}{7}$ to $\frac{1}{10}$	{ 70 0 100 0 }	..	100 0	..	Burster about 8 lbs.	
	37½	$\frac{1}{10}$	30 0	..	25 0	..	Burster rather over 1 lb.	
French..	56	$\frac{1}{8}$ to $\frac{1}{12}$	{ 60 0 100 0 }	..	..	..		
Spanish	62	$\frac{1}{8}$	61 0	..	..	..		
Prussian	53½	$\frac{1}{10}$	..	..	57 0	2 0		

As our guns are of wrought iron, but those of the Americans, French, and Spaniards are merely hooped cast iron guns,* there can be but little question as to which would prove the safer and more enduring pieces. The Prussian gun in the table is simply a cast-iron gun, but they have also some steel pieces. The formidable effects produced by the shells of the 40-pounder and 7-inch guns (owing to their large bursting charges) have been amply shown in our own experiments. The 7-inch guns were intended as naval pieces, and their fire would be most formidable against wooden ships, for which purpose they were constructed; they are mere shell guns, and undoubtedly the worst Sir W. Armstrong made; but it must be remembered that they were introduced without proper experiments, when there was a great pressure for rifled guns, and when it was erroneously considered that guns should be made as light as possible. The B. L. screw system cannot be applied with advantage to guns of such a size, unless the charges are very small; with large charges, if the vent-piece is sufficiently thick, it is too heavy to handle conveniently. But the 64-pounder and the 40-pounder are excellent guns.

We now come to the ordnance required for ships of war and coast batteries, which must be constructed to bear very large charges of powder and heavy projectiles, so that their fire may prove destructive to iron-plated vessels; an object some people seem to imagine the only legitimate one left to artillery of the present day.

It will be sufficient for our purpose to compare the heavy British ordnance with those of the Americans, for other nations have done little or nothing in the manufacture of guns throwing projectiles over 100 lbs. in weight. We sometimes hear mysterious rumours of monster guns supplied to foreign governments, but as they are also said to have been made in this country, we need not be alarmed. In fact, as we publish the results of our experiments, we cannot be surprised if other nations wait, perhaps wisely, until a certain amount of success has been obtained in the manufacture of large guns, and while thus saving their money, they will be enabled to start at once with good materials and tried constructions. Of this, however, we may be certain, that whatever power possesses the best guns at the commencement of a war will have a great advantage over others not so well provided; although such pieces cannot for long be confined to any one particular service.

In the table I have only given the American S.B. ordnance. The United States have also two large rifled guns.†

Gun.	Projectile.	Charge.
8 inch	175 lbs.	16 lbs.
10-inch	250 „	25 „

But as they are hooped cast-iron ordnance, they failed, as might have been expected; and after six had burst in the Federal fleet, while bombarding Fort Fisher, and 44 men were killed, they were condemned in the strongest terms as unsafe by the Admiral.

* American, hooped with wrought iron; French and Spanish with steel.

† They have also a few Blakely and other rifled guns, but the Parrott rifled guns are alone recognised in their latest official tables.

BRITISH M.L. BUILT-UP ORDNANCE.

Gun.			Projectile.		
Nature.	Weight.	Charge.	Weight.	Burster.	
	Tons.	lbs.		lbs.	
Rifled.	13-3" (600-pr.)	23	70	{ Steel shot .. 603 " shell .. 585 Cast iron do .. 554	24 42½
	10-5" 300-pr.	12	35	{ Steel shot .. 301 " shell .. 297	15
	9-2"	12	44	{ Steel shot .. 221 " shell .. 206 Cast iron do. .. 202	11 15½
	7" L.S.	7	25	{ Steel shot .. 100 Cast iron do. .. 100	
	7" N.S.	6½	25	{ Cast iron shell .. 93 Do.	7½
	6½-pr.	3¼	8	{ Cast iron shot .. 63½ " shell .. 60	4½
S. B.	150-pr.	12	{ 40 35 20	{ Steel shot .. 168 Cast iron do. .. 150 " shell .. 104	6½
	100-pr.	6	{ 25 20 12	{ Steel shot .. Cast iron do. .. 94 " shell .. 66	

S. B. CAST IRON AMERICAN ORDNANCE.

Gun.	Weight of Gun.	Charge.		Weight of Shot.	Weight of Shell.	Bursting charge of Shell.
		Service.	Minimum.			
	Tons.	lbs.	lbs.	lbs.	lbs.	lbs.
20-in. L.S.	51.42	100	..	1,000		
do. N.S.	44.64	100	..	1,000		
15-in. L.S.	21.91	50	..	440	330	17
do. N.S.	18.75	35	60	400		
13-in. L.S.	14.61	30	..	300	224	7
do. N.S.	16.07	40	..	280	224	
11-in. N.S.	7.14	15	20	170	130	
10-in. L.S.	6.72	{ 15 shell 18 shot }	..	127½	100	3
do. N.S.	5.35	12½	16	125	100	
do. N.S.	7.36	40	..	125	100	
(or 125-pr)						

All cast hollow, except the 10-in. of 5.35 tons.

All shell guns except 10-in. 125-pr.

20-in. gun only, at present, experimental.

Solid shot are only to be fired from the 15-in. N.S. gun at iron clad vessels, and then with 50 lbs.; 20 rounds may, however, be fired with 60 lbs.

The S.B. guns are formidable weapons, although they are merely cast-iron shell guns. The 20-inch gun is at present only an experimental piece; and I think we may safely conclude that for some time to come there will be very few of them, and the few that may be made will be very cautiously used. The bursting of the 15 or 18-inch gun would probably completely paralyze a ship's crew, and destroy all confidence in these pieces. Our guns being made of wrought-iron will not, on failure, break up like cast-iron or steel ordnance; and from their accuracy of fire, the capacity of their shells, and the power these latter have of maintaining a comparatively high velocity (in consequence of their elongated form), the British are in all probability greatly superior as weapons to the American guns.

One of the most important questions at the present time is this, are monster guns required? Opinions are divided; but let us turn to facts, and see what has been done. I have endeavoured, in the following table, to arrange some of the leading facts in order, so as to give an idea (necessarily a rough one) of the projectiles and charges necessary to actually penetrate certain structures at different ranges. I have not chosen the targets in preference to any others, but simply believing that they represent the average resistance offered by sea-going vessels, and also for convenience of comparison.

TARGET PENETRATED BY STEEL ELONGATED PROJECTILES.

Range.	Weight of Gun.	Projectile.		Charge.	Target.
		Nature.	Diameter.		
yds.	cwt.	lbs.	in.	lbs.	
200	8	12 shot	3	1½	2½" iron plate.
"	"	12 shell	"	"	" and 12" wood backing.
"	81	110 shot	7	12	5½" iron plate.
"	13½	10½ "	"	25	Warrior.
600	148	130 "	6½	25	"
800	tons	130 "	"	27	"
1500*	12	221 "	9½	44	Small plate.‡
" †	"	301 "	10½	45	"
2000	22	610 shell	13	70	Warrior.

It appears then, from what has been already accomplished, that there is at present no occasion to employ monster ordnance for the destruction of ordinary plated vessels. The guns we are now making, which will throw projectiles of 200 or 300 lbs. weight, with charges of 45 lbs., are, if properly used, which no doubt they will be, quite sufficient for the purpose. Further than this, however, it is probable that few iron plated sea-going vessels (now afloat) could withstand the fire

* Ascertained for this range by using a 30 lb. charge at 200 yards.

† do. do. 35 lb. do.

‡ 5½ inches of iron and 27" of wood; the wood and iron not disposed in such an advantageous manner for resistance as in the "Warrior" target.

of our rifled 7" guns of 130 cwt., fired with 25lbs. charges, at 800 or even 1,000 yards range; . ~~for~~ we must remember that, in actual warfare, vessels are constantly subjected to a continuous fire, and not merely to a few blows delivered at certain intervals of time; and, that a structure may thus be kept in a constant state of vibration by the repeated impacts of shot, and will offer less resistance than when time is allowed, between the rounds, for the metal of the armour to resume its former condition of repose. We should also remember that the few plates upon which experiments are usually made are in all probability of sounder construction, than those produced in quantities for the plating of several vessels; also, that when a ship has been for some time at sea, and may in addition have been in action, the armour (bolt plates and fastenings) will have been subjected to many shocks and strains, and will, therefore, have been considerably weakened.

I may here remark that Mr. Whitworth deserves great credit for showing that 'more might be accomplished against iron plates, by employing rifled guns of moderate weight and hard projectiles, than by firing at them with a rude monster like the Horsfall gun, with the much-vaunted round ball; also for proving that iron plates could be pierced by shells, at that time considered next to an impossibility. It is now probable that we shall not be compelled to use steel for our projectiles; the *chilled* iron shot proposed by Major Palliser giving promise of success.

For the destruction of floating batteries, monster guns would certainly be required, but may not be procurable, as such batteries could be made practically invulnerable. For naval actions S. B. guns may be necessary; but it is easy to choose a system of rifling which admits of both spherical and elongated projectiles being fired from the same gun. I will, however, venture to say that rifled guns that will bear a charge of $\frac{1}{2}$ † will answer every purpose.

I might have been expected to allude to the late Armstrong and Whitworth experiments, but I have purposely avoided doing so, for I never could see that any object would be gained by them, except the probable satisfaction (or rather increased dissatisfaction) of two rival manufacturing firms and their respective adherents. Whatever the report may be, I cannot believe it will satisfy the Officers of Her Majesty's service.

As far as my branch of the Service is concerned (for I will not presume to say what course should be taken with naval armaments), the Government has ample means of obtaining the best information and advice on a purely artillery question (the respective merits of two guns) from a regularly constituted Committee, a School of Gunnery, and a Director-General of Ordnance, besides many Artillery Officers of

* The result of a recent experiment shows "that a structure such as the 'Warrior' can be penetrated at 200 yards range with elongated shot and shot cast in chill, when the form of the head of the latter is elliptical, fired from a 7" rifled gun with $\frac{1}{2}$ charges;" and the report adds, "but it is probable that had the 7" steel shot been elliptical headed, instead of hemispherical headed, penetration would also be effected at the longer range" (1200 yards).

† $\frac{1}{2}$ has lately been fired with success.

high rank and great experience, and who hold responsible positions in or near London. Then why ignore these, and appoint a mixed committee, many of the members of which can know nothing whatever concerning the requirements of the service. As for the Artillery and Naval Officers on it, a better selection could not probably have been made; and I would not say a word against any of the other members, who are all able men, and have no doubt done their best to obtain true results. But the decision upon a mere artillery question should not be left to a mixed committee.

Purely scientific experiments* are often better left to committees composed of Officers and well known men of science, but these should not be mixed up in any way with trials of guns, carriages, or other *matériel*.

John Bull must learn patience, and not expect to re-model his artillery in a year or two; and he should also turn a deaf ear to the loud and positive declamations of amateurs, and trust all questions of armament to those who are educated for and spend their lives in the service. Those who propose valuable inventions, and still more those who spend time, thought, and money in carrying them out, deserve our gratitude, and should be amply rewarded by Government, but they should not therefore be constituted judges of other inventions, or, unless Officers of experience, be taken as authorities on military or naval questions.

The CHAIRMAN: I am sure the meeting will support me in returning our best thanks to Major Owen for his very excellent summary of a difficult and complicated subject. I dare say there are many gentlemen present who take an interest in the subject, and now is the time for them to make any remarks.

Captain FISHER, R.N., C.B.: I am sure that Major Owen deserves credit for the measure of impartiality which he has given to the subject. But as a naval man, and representing those who have contended for the smooth bore, I am not satisfied with the curt way in which he has dismissed its merits. And while I would admit that Major Owen is correct in saying that you can get accuracy with any description of rifling, if you will only invest the same amount of mechanical skill in rifling the gun in each case, yet there are other questions which make a very material difference as to what description of rifling is best. As respects naval matters, and the gun which has obtained the latest favour, as we gather from the papers, it appears to me that there is a very decided objection to it for naval purposes. I mean what is called the French gun with large studs. Why it should be adopted without almost any experiments, I am at a loss to conceive; inasmuch as the failures, with the enormous expenditure that has been fruitlessly incurred, have taken place, because of the insufficient experiments that have been made. Now, we are going to jump into the adoption of another system without any sufficient experiments whatever. It must be very patent to anybody who considers the matter, that in firing a shot with studs at an iron plate, although it may be equally accurate with another shot of a different description, those studs must be sheared off before the shot can penetrate through into the ship—this is a very serious objection. There is another objection to it, which is a very serious one. Take, for instance, one of its shells, the holes for the studs penetrate half way through the metal, consequently reducing the strength of it very materially. Now, a most important advantage is that of having the power of penetrating iron plates with shell. But if the shells are weakened to that degree, to get equal strength with a shell that

* To ascertain the laws of resistance of the air, or those of different materials to the impact of projectiles, &c., or the suitability of any substance (as gun-cotton) to military purposes.

is not cut away, you are obliged to reduce the size of the shell, and with that the powder capacity. Here is a section of a shell of this kind. The strength of the side of the shell is only equal to its weakest part; whereas if you have no studs, but have a rib of the description of that on Captain Scott's shells, the side of the shell, instead of being weakened, is strengthened, and there is really no obstruction to the entrance of the shell into the iron plate, inasmuch as this rib is but a knife edge; and so far tends to cut in rather than to offer any retardation. Then, with respect to the general question of the smooth bore, or rifle gun, the whole question of tension is utterly ignored. And yet that is the very difficulty that we have always had to contend with—to get guns strong enough to bear large charges, as Major Owen justly says; for a naval gun must be a gun that will stand large charges; and just in proportion as you have a gun that will stand large charges, in that proportion, you do not want monster guns. Take, for instance, some of those experiments that Major Owen has been referring to; the 168 lb. shot fired out of a 10½-inch gun, as compared with the 300 lb. shot fired out of the same gun. The effect was much about the same. The difference of charge of powder was only 5 lb.; one was fired with 45 lb. of powder, the other with 50 lb., yet if you multiply 45 by 300, and 50 by 168, you get the relative strain brought on the gun under different conditions, irrespective of the strain, the result of the retardation from the rifling. Major Owen says that is not much. But I cannot understand the argument, that the retention of the shot occasions development of power, unless there is a development of strain also. We know very well that there is a result arising out of it, hence these guns do not stand. Here is a section of the Woolwich gun, with the arrangement of large grooves that are necessary for these large studs. This is one of the shot. You see the studs; you see how much the bore of the gun is cut out. Take the Scott groove and compare it with this. The depth of the groove in this is nearly double that of Scott's, and the width of it is considerably more than double. You can see how much of the gun is taken out, and how much the inner cylinder of the gun is injured by it. Then, again, I must take exception to the view which Major Owen has put forward as to the advantage to be gained by its gaining twist. I believe it is a great mistake. I have no hesitation in saying, that when you come to use large charges, which are—I will not say indispensable, but which are economical for naval purposes, (for in proportion as you have these large charges you can have smaller guns, and a greater number of them, and more effective guns into the bargain), I say, if you use the large charges that may be used with a description of rifling, and such a description of shell as those of Captain Scott's gun will admit of, then, as a necessary consequence of that gaining twist, the Woolwich gun will not stand; the effect will be something like a cart moving along a road at a considerable velocity, on coming to a stone suddenly, it jumps up. You allow a shot to acquire an enormous velocity, then you shunt it. It is like shunting a railway train going at full speed—that which no one is mad enough to do—as the trains always slacken their speed. That is just what takes place here, from the suddenness of the curve; the shot starts straight, but when it has got an enormous velocity, its course is changed by this curve. The necessary consequence is, that only some of the studs have a bearing; they do not all bear along fairly; this produces an oscillation, and it is not until the shot has proceeded a considerable distance that it loses the oscillation which is acquired by the sudden jump given to it by the alteration of the curve. I would take this opportunity of saying that I contend that in no one of the experiments—(I will challenge any one to produce a single experiment that has been duly fair to the spherical shot as compared with the rifled)—has there been a fair comparison; and I contend, with such a large amount of money as has been expended on such experiments, that at this day we should not be left without a fair, distinct, and satisfactory experiment—I mean such an experiment as would satisfy, or which at least could not be taken to pieces by those who are contending for the use and value of the smooth bore; more particularly as so large an economy is involved in the question. I say that the tension which has been the great difficulty that we have had to contend with, has been altogether overlooked—the tension occasioned by the round ball is exceedingly small, and the charges have never been increased proportionately. The answer is that smooth bores cannot burn so much powder. But has the powder been adapted

to the conditions of the smooth bore as it has been adapted to the conditions of the rifled bore? Has the amount of powder it would burn been tried? No. When the rifled-bore guns were bursting, what was done? A slow-burning powder was invented, but has a fast-burning powder been tried for the conditions of the smooth-bore round ball? No, it has not. The same powder has been used, when the conditions are altogether different, and require altogether different powders. While we are living in a scientific age, many of the experiments have been of the most unscientific character. This ought not so to be. As a Naval Officer, I cannot agree altogether with Major Owen, in saying that we are not to go outside the Services for advances on these subjects. Both in my own Service and in the Army, our advances have been altogether from the outside. You may remember the controversy that there was between Sir Charles Douglas and Mr. Clark, respecting Naval Tactics. A great deal of good is to be got from the outside. I think the tendency of Naval and Military men, and, indeed, of all professional men, is to get into grooves; but in this case we have got into the wrong groove, and seem determined to stick there, instead of trying to get out of it.

Commander SCOTT, R.N.: I would make one or two remarks in reference to the subject. With respect to the Horsfall gun, Major Owen omitted to say that the shot struck the ground 800 yards short before it struck the target on ricochet, and that although it did strike the ground it went nearly through the target. Then, again, the Horsfall shot was not of steel. If it had been of steel, who could doubt that it would have gone through; but although the shot was of cast iron, had it not ploughed up the ground first, it would have gone through the target. The Whitworth cast iron shot produced no effect on the target. The reason that naval men do contend for the round ball firing is just on account of what Major Owen has said—that you may not get the rifled shot home if you are in a hurry. I think when you are yard-arm to yard-arm with an enemy you would like to fire away as fast as possible. We know that unless your ship can keep up a continuous fire you are likely to be overpowered. You may have a very valuable rifled gun indeed. It may be capable of hitting the smallest object at three and a half miles; still, what you would really want to do where you are yard-arm to yard-arm is to fire away and keep down your enemy's fire; therefore, naval men think it very undesirable to give up the round ball. We do not wish to throw away the advantages of the rifle, especially as we can superadd to the advantages of the rifle the round ball firing. Captain Fishbourne has pointed out the difference between the groove of my seven-inch competitive gun and the French groove. The French groove is rather more than twice as deep as mine, and taking things as they are at the present time, the initial velocity of the round ball fired from my gun is 2,162 feet per second, which is, I believe, the highest velocity ever obtained in round-ball firing. I would remark, with reference to the late competition of seven-inch guns, that there has been no quick firing at Shoeburyness with them. One can only conclude, therefore, that these guns cannot stand their charge of 25 lbs. of powder in quick firing. I do not believe they will stand this charge with elongated shot; and if they will not stand 25 lb. of powder in quick firing when yard-arm to yard-arm, we have certainly been very much mistaken as to the effect which these guns were expected to produce. We know, however, the guns will stand the highest charges you can put into them with the round ball. Another thing we want a rifled gun for, is shell firing. In the competition firing at Shoeburyness there has been no shell firing. Whatever may be the case against plates, we shall, against wooden ships, want to fire shells with fuses in them. If you do not put in fuses we know that against the wooden ship's side there will be no explosion. Well, this kind of firing has not taken place at all. I more particularly mention it because in the gaining twist of the French gun the shell lies in the bottom of the bore. It goes along the bottom of the bore until it meets a part of the groove which lies sufficiently across the bore to throw the shell upwards. When it meets that part and is thrown upwards, there is a jar against the upper side of the gun. The effect of that jar may be seen in one of the guns rifled on that plan which was cut open at the arsenal at Woolwich. I have no doubt myself that we should, when using shells in firing from such guns, have constant premature explosions. Major Owen has spoken of the chilled iron being

valuable. I believe myself, as the chill is on the outside of the iron, that it merely makes the iron very hard there, but it does not penetrate into the inner part of the iron. The shot or shell in this state is very brittle, and not in a proper condition, especially for a shell at all. At sea it is of immense importance to be able to produce the greatest possible effect. When we can get the better projectile we shall certainly not use the worse; therefore, any Commander having steel projectiles which he can fill with powder, and which will go through into a ship and burst there, would never think of using chilled projectiles, which would break up at the moment of impact, for he would then lose entirely the destructive effect of shells penetrating and bursting between decks, which will be so fatal in actions on board ship. I would remark with respect to another point that the seven-inch breech-loading gun with the powder charge and weight of projectiles given in Major Owen's table does not really represent the state of artillery at the present time, for the size of the shot and shell is being reduced, and the latter will not have capacity for an 8 lb. bursting charge; and, therefore, the seven-inch gun is by no means the formidable gun that is there represented. With respect to the Parrott guns, they answered very well when fired slowly, but they broke down in bombardment directly they commenced firing rapidly. Now, as we have not fired any of our large guns rapidly, we do not know what the effect will be upon them. I think it important to know what these guns will do in rapid firing, and what the French gun with the gaining twist will do. It should be tried in rapid firing against the other competitive gun, which has a longer bearing. There is a long continuous bearing in one case, and only a line of bearing in the other, until the projectile gets near the muzzle. Until then there is but one stud touching, and it merely bears on its edge; and as the projectile is continually advancing along an increasing curve, the stud is continually bearing upon different lines of its surface, therefore the wearing action from bearing upon so small a surface must be very much greater than if you had a long continuous surface. Another point of importance is that if you have that straight line of rifling at the breech of the French gun, how are you to keep your shot home in the rolling motion of a ship? The shot will certainly slip away from the charge. Where the rifle twist is across the bore of the gun at the breech, the shot will roll against the bearing side, and then back to the loading side of the groove, and will not start; but where the groove is straight with the axis of the gun, the shot in bad weather is liable to roll right out, unless there is a wad in front. We do not fully know what the effect of a wad will be, but we know it will add considerably to the strain upon the gun. I would say also, with respect to the Parrott guns, Major Owen has been comparing the Parrott guns made during the war with our guns brought up to the present time. That is, I think, a wrong sort of comparison. You should compare them instead with what we intended to use at the time the Parrott guns were made. At that time there were a number of guns cast for our own navy. They were cast in a peculiar way. Most of those present will remember them, and they were intended to be strengthened with cast iron hoops outside. There were a great number of these castings ordered, but 300 of them only supplied, and 100 of them hooped, before it was found that they burst after a few rounds. These were the guns we intended to have rifled and placed in our ships in 1862, so that what occurred in the American service would, had our ships been thus armed, have occurred in our own, and these are the guns with which, I think, the Parrott guns ought to be compared.

The CHAIRMAN: The title of Major Owen's paper is the present state of the ordnance question.

Major OWEN: I did not go back at all.

Captain SCOTT: I am not objecting to facts in Major Owen's statements; but the comparison was made with the American guns produced about that time, and the manufacture of which there was a necessity to go on with.

The CHAIRMAN: It is the actual gun we are dealing with.

Captain SCOTT: The cast-iron Parrott is the actual gun of America, because there has been no opportunity for experiments, so I take our rifled cast iron guns, which were the guns making at the time when the Parrott guns were commenced.

Major OWEN: I have not touched on the history of the subject at all. I take the guns as they are now in the service.

Captain SCOTT: But you compared them with the American guns. Therefore, I think it is fair, on the other hand, to show the position of the American ordnance at that time.

Brigadier-General LEFROY, R.A., F.R.S.: I have heard a great many things from time to time in this theatre which have astonished me, but I can safely say I never heard here anything which has so astonished me as the statement that has just fallen from Commander Scott that his gun and the other guns with which it has been compared have not been tried with shells. Commander Scott was, I think, present; if not, he must be very well cognisant of the fact that every one of these guns has been tried with shells—some shells loaded with sand, and some shells loaded with gunpowder. He is also probably aware that out of the shells that were tried, the whole of the shells on one system of rifling, which I need not name, split from the excessive strain thrown upon them; and the whole of the shells on other systems, among which I am glad to say his is one, did not split, and are serviceable, and some of them were fired a second time; therefore, that has been a most unaccountable mistake on the part of Commander Scott. The next thing was with regard to round shot. I think any gentleman would be left under the impression that no round shot had been fired from those guns. Very far from that, the guns being nearly of 42-pr. calibre, round shot of a special gauge were made for them, weighing 43 lbs. 6 ozs., and have been fired with two charges, 20 lb. and 12 lb. The 20 lb. charge is nearly half the weight of the shot. It gave enormous velocity. I think it gave a velocity of 2,100 feet. Such a velocity is extremely unprofitable, inasmuch as it is lost. It is absorbed by the resistance of the air in a very short space of time indeed. Then I turn to that drawing before you, in which Commander Scott has drawn an unfavourable comparison with respect to the French groove. I do not deny that Commander Scott advocates a groove which is less deep, and cuts much less into the gun; but I say a diagram of that kind is apt to give an erroneous impression, because you see the depth of the groove, but you do not see the thickness of the cylinder into which that groove is cut. However, I am not standing here to defend the French groove; on the contrary, I think the French groove is made unnecessarily deep. I now turn to the more agreeable point of referring to what we must all have learned with pleasure from the lecture of Major Owen—the substantial progress that has been made in the last four or five years in the making of the guns in our service. I apprehend that the Officers present here are not the advocates of this system or of that system; but their sincere and earnest desire is that the British Army and the British Navy should be in possession of the best, the most effective, the most simple, and least complicated and least costly gun that the mechanical skill of the country can supply. To produce that gun is the great object of those who are concerned in these questions, an object which is pursued under extraordinary difficulty, from the energy and self-assertion with which antagonistic principles and opinions are enforced in this place and in other places. But what we have learned from Major Owen, and what I can corroborate from my own testimony, is that, first, as regards the making of coil guns, to so great a degree of perfection has the coiling been brought by the better selection of iron, by a more skilful treatment of it, by that experience which is acquired in the lapse of time, that I saw a gun cut open the other day, and the closest examination could not detect the slightest joining or welding, or any other imperfection; and in some of the examinations which we have made lately, it has been necessary to apply strong acids, in order to ascertain the fact whether the gun had been coiled or not. That is surely a point on which we may all congratulate ourselves. Another point on which Major Owen touched, was that of a very skilful suggestion of Mr. Anderson, to hook the coils together, to prevent lateral displacement. There can be no question that when Sir William Armstrong first began to make his coil-guns, he trusted too much to the strength of the simple weld. We know the force of a weld is only one-half of the force of the metal in another direction, and the separate coils were butted against one another, without making them unite. We have now for a considerable time hooked the coils together, and they are consequently stronger. The next great point on which we may congratulate ourselves, and in which we are a-head of every power in Europe and America, is in the simplification lately introduced by Mr. Fraser, who by an

ingenious extension of the same principle, and by the selection of iron of different quality, has improved and cheapened the process of manufacture. Iron is the most protean substance in the world. Most of us will admit that five years ago we knew nothing about it; and we have all had to learn its qualities by costly, laborious, tentative processes, in which the great difficulty was first to ascertain the results, and then to draw correct conclusions from them. The result has been that guns are now produced, as Major Owen told us, at a cost of one-third, or at all events less than one-half of what they were produced for originally, and they are no doubt much better guns. So much, then, for the structure of the gun. Next, as to the question of round shot, whether we should primarily contemplate that state of things which naval men, full of the glories of their service in past times, are prone to talk about, as yard-arm to yard-arm engagements, but which I, as a landsman, firmly believe to be a myth. There is no doubt nobody questions that, within a short distance, say 50 yards or 100 hundred yards, the frightful velocity of—2,100 feet if you like—which can be got up with a round shot of steel, gives it an overwhelming penetrating power which nothing can resist. But that velocity is resisted by a spring, by the atmosphere itself which is a spring, and it is absorbed with extraordinary rapidity. For example, to take the ten and-a-half inch smooth bore in the service, if you fire that gun with round shot, with a charge of 45 lb. or 50 lb. of powder, that shot loses at about 480 yards, if my memory is correct, the penetrative power which the same gun rifled and firing elongated shot, with a charge reduced in the same proportion, or if not absolutely in the same proportion, reduced from 45 lb. to 35 lb., carries about 300 yards further. I think there is strong reason why we should prefer that our guns should be rifled, and should fire elongated shot, because they carry their velocity with them; rather than that you should put in those destructive charges which have this mechanical effect—they develop heat and flame, which disintegrate the mechanical structure of the gun. No matter whether the resistance in front of it is less or more, the mechanical structure of the gun is disintegrated by the heat of these great charges. It is not the strength of these guns that is in doubt, it is their endurance. We have never yet had an instance of failure of guns connected with the insufficient strength of the coiling. We have had the breech-pieces blow out in two cases; but the coils of these guns, the parts which surround the chamber have always resisted, and I believe they always will resist. But what we do find is that the powder searches out and eats into the imperfect welds of the iron, the silicates, and other foreign matters, and produces a state of things which, though it is not dangerous—for that is quite proved—is undoubtedly alarming, and may very reasonably justify the uneasiness which Officers, only accustomed to the smooth-bore guns, and the different material of former days, feel when they find these fissures and cracks presenting themselves. One can only hope that experience and progress will teach Officers that there is less danger to be apprehended from these things than they suppose. My desire has been in these few remarks to lead those Officers present, whose only wish is to receive information as to the real position of the Artillery question, to feel that it is not in that state of either neglect or—were I not humbly concerned myself I would add—of incompetence, which it has been so much the object of certain gentlemen to represent; that we are making guns far exceeding in power those possessed by any power in Europe or America; that those guns are put to proofs far exceeding anything that any other country ventures to put its guns to. The American Parrott 300-pounder gun, for example, is used with only 25 lbs. charge; the American 15-inch gun, which is the counterpart in weight of the Armstrong 600-pounder gun, is used with 35 lb. of powder; whereas we use 90 lb. of powder with round shot, and 70 lbs. with elongated shot. The same comparison holds good in many other instances. Other Powers use small charges; for the most part their charge is one-tenth or one-twelfth, ours is one-fourth or one-fifth. A few years ago we did not know how to make large guns; we are now learning to do it. For Heaven's sake do have a little patience, and a little faith in those who may be called upon by competent authorities to advise, to report, and to inquire into these matters. If you have good reason to think that they are incompetent, affected by personal partialities in any way, unfit for their duties, performing them in a manner which is not satisfactory, remove them, and put men whom you can trust into their

places. But do not abolish their offices, or run away with the notion that its duties can be performed by irresponsible and often interested advisers. Their office is an indispensable one, as indispensable as that of the Lord Chancellor himself.

Commander SCOTT: Will you allow me to ask one question, whether it is not the fact that the whole of the shells that were fired in my presence were filled with sand, and therefore were no more shells than that shot on the table?

General LEFROY: That is a new definition of a shell, but I believe Captain Scott is strictly correct, that the shells fired in his presence were filled with sand. Now, I will ask him, whether he is not aware that the same shells having been recovered, were fired afterwards filled with gunpowder?*

Captain SCOTT: Will you allow me to reply? Five shells only of my 50 shells which were recovered off the range were washed out, and fired against five French shells which were new, and five of Sir William Armstrong's shells also new. That is all the competitive shell firing there has been; and that was not in my presence. So I believe I am strictly correct in saying that there has been no shell firing at Shoeburyness, nor has there been quick firing. The 7-inch competitive guns I am speaking of.

Rear-Admiral Sir FREDERICK W. E. NICOLSON, Bart., C.B.: I do not rise to prolong the discussion on the subject which has been brought before us; but as a member of the Council of this Institution, I wish to express my great gratification, and I am sure you all cordially join in it, that at last we have heard from a member of the Ordnance Select Committee, a most competent authority, facts which will be recorded in the *Journal* of our Institution, and which will be read with interest by everybody who has the slightest acquaintance with these matters. It is so rarely that any person in an official position rises here to take part in our discussions, that I for one am highly delighted to find that my friend General Lefroy has on this occasion broken through that official reserve which I think is, generally speaking, too rigidly maintained, and has given us the advantage of his great knowledge, by the clear, and I may say, eloquent statement which he has made.

Major-General BOILEAU, R.E., F.R.S.: I would wish to ask one question of Major Owen, who has been so kind as to give us a most interesting paper on the construction of guns, whether the question of the external forms of the gun in reference to its longitudinal section has been made the subject of investigation and experiment. Everybody must observe in the models lying on the table, that in the form of the American Parrott gun, and of the others which have more or less similarity, there is a very marked difference; that after the gas has passed the reinforcement or breech of the Parrott gun, there is comparatively a very small amount of strength throughout the whole of the rest of the gun. The chase, I think it is called. But in these guns there appears to have been more attention paid to the relative power of the gas, as it extends along the bore. The Blakeley gun, as it appears to me, approaches more nearly than others to the form which the exterior of the gun ought to possess, to be in the same condition of resistance in respect of the tension and force of the gas at the different portions of the bore along which it passes. Of course I do not mean to say that there is or can be an exact relation between the tension of the gas and the resistance of the gun; but it has occurred to me to ask, especially as I remark so great a distinction between the external form of the Parrott gun and Blakeley gun, whether the subject of the exterior shape of the gun, with respect to longitudinal section, has formed the subject of investigation with the Select Committee, and if so, whether any specific conclusions have been arrived at? My own experience, which is confined chiefly to small bore shooting (and I may be permitted to say that the principle applies to large guns), has satisfied me that rifled barrels

* Remarks subsequently communicated by Brigadier-General Lefroy.—Officers unacquainted with Shoeburyness may require to be informed that there are stringent orders applying to the firing of shells filled with powder, whether fused or not; local circumstances require precautions to be taken which are not necessary with shells filled with sand, and which would be very inconvenient if enforced on every occasion of practice. It is consequently customary to fill the shells with sand.—J. H. L.

shoot better in which the barrel is nearly as thick at the muzzle as at the breech. I have one rifle which has nearly the same thickness at the muzzle as at the breech, and it shoots so remarkably well, that I call it "Bull's-eye Jack." The other rifles, which are not so thick at the muzzle, appear to go off with a twang, which must give the shot an inaccurate direction. Those of the Armstrong guns which I have seen at Woolwich appear to me to have that one defect, that the part before the trunnions was exceedingly slender, as compared with the other part, and was liable in delivering its shot to give a vibratory motion, which would alter its direction to a certain extent.

Commander ARTHUR, R.N.: There is one point which Major Owen stated on his own authority; therefore, I do not hesitate to differ from him. It is in reference to the effect which constant firing will have on the plates. I deny totally that any plates that will bear the fire of three shots near one spot will not bear the same test on the whole surface. It is the bolts that give way. To take it for granted that the plates will give way before the bolts do under these circumstances would be leading ourselves astray, and drawing our conclusions from an error. The bolts are the points to which we should draw our attention. There is also another point. I think we are rather liable to error as regards initial velocity. I think, if the point is clearly considered, you will find that the initial velocity will bear direct relation between the charge of powder and shot, if the friction of rifled shot is taken into consideration. Of course, there are some cases in which a gun firing a rifled shot is also used for smooth-bore shot. In that case there will be a large proportion of powder wasted by want of length of barrel, and by escape in the grooves; in fact, the powder cannot be burned. This is a thing, of course, that will have to be determined in the guns which are used. Where you try to construct one gun for two purposes you will always find that you will fail partly in one of them. (I merely make these remarks, wishing that there may not be any error.)

Captain SELWYN, R.N.: Will the meeting allow me to say one or two words with regard to points that have not been touched upon by the lecturer? First, with regard to the use of steel for guns. I think I understood the lecturer to acknowledge, as has been acknowledged in this theatre over and over again, that to steel we look for the best effects. I should like to ask to what extent experiments have been carried in this country with the view to realize the predictions on metal which promises us the best results? Has not very much more labour been expended in trying to perfect that which is acknowledged to be an inferior metal, instead of trying some experiments on a large scale on the stronger metal? We have arrived at the use of steel for the interior of our guns. The question is, cannot we carry the use of that metal further? And on what does the advantage which we have gained depend? I take it that the condition to be desired in the interior of a gun is extreme hardness. The Americans have obtained that in a very large measure by chilling the casting, by pumping water through the gun while it is cooling in the core. We have used steel tubes. In both cases success has been gained to a certain extent in producing a good gun. We have got the hard interior surface; but we have not considered as yet how far we might by coincident slow cooling of the outside, artificial slow cooling, produce that peculiar arrangement of tension of the metal, which might give us better results than we have yet had. I think experiments might be usefully tried in that direction. The thickness of guns at the breech, to which the lecturer also adverted, seems to me to be also very ill understood. In this gun which you see before you, you have an arrangement which certainly gives points of weakness and points of strength, but by no means are those points arranged with reference to the tension inside the gun. The American guns are made very much with that view. They follow the curves which one would naturally expect outside, to follow the curves of tension inside. I confess I could not follow the lecturer into his view of the subject when he said the diameter of the bore and the twist of the rifling did not influence the tension on the gun. First of all, we must consider that the increased diameter of the bore infers a much greater increase in the weight of shot, and that that shot is always reposing on the lower side of the bore until it goes out of the gun. In every system it so reposes on the bottom of the bore, except in the central or wedge system of Captain Scott, which brings the shot up into the

centre of the bore. It is perfectly clear that if we increase the twist up to a given point it tends to burst the gun, so that there is a point evidently at which the twist does very materially influence the tension on the gun. Now, where is the point at which it does not influence at all? It is very remarkable too that although we are told most eloquently by General Lefroy that we have done better than other powers, we are told by the lecturer that the French gun gives about the worst practice that he ever saw, so bad that he could not make head or tail of it.

Major OWEN: I did not say anything of the kind. Perhaps I spoke very indistinctly. I have no doubt you understood me to say that. I did not say it was the worst practice I ever saw. I said that, judging from their published results, the practice from one particular gun, the *canon de 12*, is exceedingly bad.* I am sure, if you look at the tables, you will find that what I state is the case.

Captain SELWYN: I think it is only a question of degree. However, it is certainly not the commendable gun one would imagine from the effect produced, yet, it is now brought forward as the system which is to supersede all those of which we have previously heard. It is the gun of the day. It is a gun which has none of the advantages of being able to fire round shot without injury to the grooves; none of the advantages of the centrical system at all, or only in a small measure obtained lately by giving a peculiar form to the studs, which has had the result of doing to a certain extent what Captain Scott does perfectly, and has so far materially improved the firing of the French gun. The studs are turned to a peculiar surface, and they do act to a certain extent as wedges, and centre the shot to a certain extent.

Major PALLISER: That I deny; they do not centre it in the least.

Captain SELWYN: General Lefroy also said that the rifled gun had fired a 35 lb. charge, and that the guns we are now using carry frightful charges of powder. I think we shall all recollect that in the Dardanelles we have seen guns that have fired much larger charges than those we are talking of now—stone shot, it is true, and very large charges. I think Baron de Tott fired a 200 lb. shot out of one of these guns, and was not much frightened at it. I distrust and dislike apology for little holes made in the gun. First, we are told that hoops were invented; then that the coils were perfect; then that they required hooks. The coils do not appear to me to be hooked together. The different portions of the gun are hooked together, but the welds of the coils are not a bit more hooked together than they were before. I must also take great exception to what General Lefroy said with regard to the myths of the naval profession generally. He may depend upon it when a gentleman, with the experience and means of Admiral Sartorius, gets up and merely expresses the general opinion of naval men in saying that no action was ever or will be, decided at long range, an Artillery Officer must not qualify these as myths. We do know what we are about at sea. I do not think we shall ever undervalue the high velocity which we seek for in advocating the use of the round ball. We know what we want, and we would only ask our artillery friends to concede to us the belief that we are not attacking their guns, but we are simply asking for as good a weapon as we think we can get, and, I think I may say more, which we shall get, with the united talents of Armstrong, Anderson, and Fraser; and I hope by and bye Captain Scott will be considered, and that his gun will have a thoroughly fair trial, which it never has had yet, and not a trial by some one in their own way for their own purposes.

Major PALLISER: I felt called upon to take exception to your remark about that shot being centred. You said it was a matter between me and Captain Scott. I have seen repeatedly in the papers that the good shooting of that gun was due to the shot being centred on Captain Scott's principle. I have seen it stated in the *Army and Navy Gazette*, the *Engineer*, and in other papers. I did not think it worth while to contradict or take any notice of these statements; but when I hear Captain Selwyn deliberately state here that it is the centring principle that has made that gun shoot so well, I think I am justified in expressing my dissent from it. I have examined a great number of the shot which have been fired, and have found inva-

* The grooves, the twist, and the studs in this system are different to those in the so erroneously termed French or Palliser system of rifling.—C. H. O.

riably, a "step" on the driving edge of one row of studs in each shot. As you have already stated, the shot lies in the bottom of the bore by the action of gravity, and when the gun is fired, the pressure of the fired gunpowder, passing over the upper part of the shot, holds it firmly down. The theory of rounded grooves, and of correspondingly rounded studs, whereby the driving pressure of the grooves lifts the shot into centre, will not bear examination. What is actually the case is this: the studs shear at the first starting, and the upper stud over-rides its groove, and thus a portion of it, which I have termed a "step," projects between the bore of the gun and the body of the shot, and thereby prevents the shot from rising towards the centre. You will find there is a step or projection .08 of an inch high on the studs on one side of that shot, and that the studs on the other side are shorn quite level with the body of the shot; therefore, as these shot never did rise into centre, I do not think it can be said "that the good shooting of that gun is due to the centring system." There is another point I wish to notice. I think somebody remarked that round shot and elongated shot have not been tried under similar circumstances. Now, would round steel shot, weighing 105 lbs., fired with 25 lbs. of powder out of a 9-inch smooth-bore gun, be considered a fair comparison with an elongated steel, or chilled shot, weighing about 100 lbs., fired with 25 lbs. of powder from a 7-inch rifled gun?

Captain FISHBOURNE: Certainly not; the tension on the gun would not be equal in each case.

Major PALLISER: The same weight of shot and the same weight of powder?

Captain FISHBOURNE: That is not the question. The question is to get the greatest results from a given gun. You take your gun and get the greatest results from it; I will take my gun and get the greatest results from that, the strength of the gun being the limitation.

Major PALLISER: You do not think the same weight of powder and the same weight of shot a fair criterion?

Captain FISHBOURNE: Certainly not.

Major PALLISER: Then I have nothing further to add.

The CHAIRMAN: If no other gentleman has any remark to make, perhaps Major Owen would wish to reply.

Major OWEN: Captain Fishbourne misunderstood me as to the gaining twist. I did not say that by employing the gaining twist the whole gun was relieved from strain. I said it was relieved from a certain amount of initial strain (the strain at starting), which is usually the strain that causes the damage.

Captain FISHBOURNE: I did not mean to represent you as saying that.

Major OWEN: As to what Captain Scott said about the Horsfall gun. I am quite aware that the shot used by Mr. Whitworth was steel, and that the shot out of the Horsfall gun was cast-iron. I do not give that example to show particularly the effect of an elongated shot, but to show that Mr. Whitworth, by skilfully employing the elongated form, and also a better material, produced those effects. Captain Selwyn remarked that the bores were chilled to obtain hardness. I never understood it in that way. I believe the bores of guns in America are chilled in order to render uniform the contraction throughout the mass, so that the different portions of the metal should be in a state of equilibrium. I do not believe it is the case at all, that the Americans chill their bores for hardness, cast-iron being sufficiently hard without chilling, but to render uniform the contraction. Captain Selwyn also, I think, rather misunderstood what I said about the twist, and about the diameter of the bore. I did not say that they had no effect on the strain: I said they were no part of the system of rifling. On the contrary, I said the twist increased the strain, and I pointed out that by employing the gaining twist, the strain was decreased. If the twist did not affect it at all, why did the gaining twist decrease the strain? There is another point. I think General Boileau alluded to some experiments with reference to the exterior of the gun. I am not aware of any experiments, except what the Americans made several years ago, by firing bullets at different portions of the gun—the Dahlgren experiments. Some Officers may know of other experiments. I am not aware of any.