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### The Character of Gun Best Adapted for Naval Warfare, as Gathered from the Various Plans of Guns Proposed

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# The Journal

OF THE

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No. XXII.

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### Evening Meeting.

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Monday, May 19th, 1862.

His Grace the DUKE OF SOMERSET, First Lord of the Admiralty,  
in the Chair.

#### THE CHARACTER OF GUN BEST ADAPTED FOR NAVAL WARFARE, AS GATHERED FROM THE VARIOUS PLANS OF GUNS PROPOSED.

By Captain E. GARDINER FISHBOURNE, R.N. C.B.

MY LORD DUKE, AND GENTLEMEN,—

I will not take up the time of the evening with apologies for having undertaken to read this paper: let it suffice that, having been captivated by the beauty of the mechanism of the Armstrong gun, its great ranges, reported accuracy, and the undoubted genius of its constructor, I incidentally gave in this place a too unqualified assent to all that had been claimed for it. Finding that in some respects I had been misinformed on a point of such national importance, it became my duty to give equal publicity to my withdrawal of that assent.

To compare results obtained from an elaborately finished rifled gun, fitted with an accurate sight, a nicely adjusted missile, added to a carefully devised carriage, and elevating screw, with results obtained from an ordinary smooth-bore gun, without any of those advantages, firing an imperfect missile having a large amount of windage, yet, on that comparison, to found an estimate of the rifle *principle*, as contrasted with that of the smooth bore, was obviously incorrect—still more incorrect to give practice

at ranges, that were as favourable to the rifled gun, as they were unfavourable to the smooth bore. *No fair estimate of the principle* could have been arrived at, till equal genius had been expended in developing the merits of each *principle*.

The evils that arise from such a course, even in holiday practice, are great, but they are all intensified by the circumstances of warfare, owing to which, as Colonel Fox has justly observed, the inaccuracies of the man are as 20 to 1 of those which result from defects in his rifle; and if so in the field, how much more so afloat, where, in addition to the causes of inaccuracy enumerated by that officer, are superadded the motions of the ship. How *very* incorrect then must it be to consider a gun apart from the normal circumstances under which it will be used; yet, such has been done; a comparative estimate of the *principle* of the rifle, and of *that* of the smooth bore, has been made irrespective of that which, when the guns and objects are in motion and the distances unknown, must rule their useful qualities, viz. the form of trajectory and the straightness of ricochet.

For the inaccuracies arising from motion, whether it be that of pitching, rolling, or of transit across line of fire, or of rapid change of distances, or smallness of height of the object fired at, are best provided against by a flat trajectory and a ball that will ricochet straight—these will be more nearly attained in proportion as the time of flight, for the required distance, is reduced, and the ball more perfectly spherical, while the smashing effect will be increased in a higher ratio than even the square of the increased velocity.

Greater accuracy with the same guns, &c. at known distances, with heavier charges, arising from the greater velocity of projectile, is so well known and admitted, as not to need proof or explanation; but, great as are the other advantages of high charges, they are small as compared with those of a flat trajectory, where the distances are unknown.

A diagram will best illustrate this:—Plate I., fig. 13, represents two trajectories, one, that of a ball with such a velocity that it travels the distance in one second, and subject only to the fall of 16 feet; the other, of a ball that requires two seconds, therefore subject to a fall by gravity of 64 feet.

If no disturbing cause arises, a ship that is but 12 feet high, and there are few so low, will be struck at any point in the trajectory of the ball, with high velocity; whereas a ship 48 feet high or more, will be passed over by the ball having the lower velocity, and only within narrow limits of distance would a ship 30 feet high be struck by it in *its* trajectory.

High charges and high velocities are most valuable for accuracy under the circumstances of *actual* warfare; uniformly so when, as in naval warfare, the changes prevent the distances from being known, and where the varied motions of the gun-platform prevent any tentative process by which the distances might be even approximately estimated.

High velocities are rendered indispensable by the introduction of iron-clad ships. This is clearly shown in tables A and G, from which it appears that the old smooth-bore 68-pounder, with all its defects, is more effective than the carefully devised 110-pounder Armstrong, demonstrated by the greater penetration and greater indentation of the shot of the former.

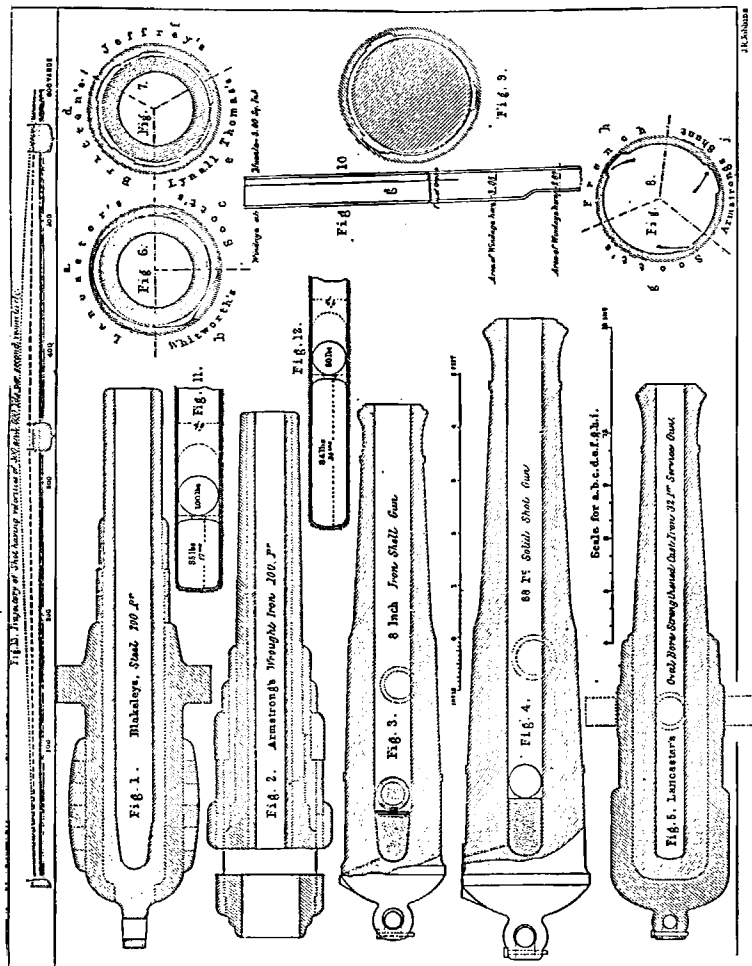


TABLE A.  
Obtained by measurement at Shoeburyness.

Nature of Gun.	Shot.	Powder.	Penetration.		Comparative Force of Blow, exclusive of Width.
			Depth.	Width.	
	lbs.	lbs.	inches.	inches.	
Old 68 ... ..	68	16	2½	7½	5·06
Armstrong .. ..	110	14	1½	—	2·25
Ditto... ..	200	10	¾	6½	0·56
Old 68 ... ..	Shell. 50	16	1½	11	2·25

} Cast Iron Shot.

FAIRBAIRN TARGET.

TABLE G.

Nature of Gun.	Distance.	Powder.	Thickness of Plates.	Penetration.	Remarks.
	yards	lbs.	inches.	inches.	
68-pounder ...	200	16	4½	2½	Obtained at Shoeburyness.
"	"	20	"	3	} From H.M.S. Excellent.
"	"	24	"	3·4	
"	400	16	4	3	} Wrought iron shot.
"	"	"	"	went through.	
"	600	16	10	1½	} Thornycroft's plates.
*Armstrong 80-p....	"	11	"	1	
*Ditto 40-p. ...	"	5	"	¾	

\* Compiled from official reports.

As it is generally admitted that the highest initial velocities can be obtained only with round shot, it is hardly necessary to offer proof: still the tables B, C, and F, set this forth in a clear light; these show not only that the initial velocities of round shot are greater, but that the time of flight for the most essential ranges is much less; by essential ranges, I mean those within which the iron clothing of ships may be materially damaged, up to 600 yards or more if the plating be thin, still further if the guns be increased in size.

TABLE B.  
OFFICIAL REPORT.—Velocities obtained by Capt. Andrew Noble, R.A., with Narvez's  
Ballistic Pendulum.

Nature of Gun.	Powder.	Projectiles.			Velocity at 30 yards.	Initial Velocity.	Remarks.
		Nature.	Weight.	Diameter.			
	lbs. oz.		lbs.	Inches.			
32-pr. rifled shunt, 59 cwt. ...	5·8	Plain shell.	54	6·35	1215·7	1224·5	Solid zinc bearings. — E.G.F.
32-pr. 59 cwt., smooth	5·8	Cylinder.	54	6·35	1187·4	1201·0	
12-pr. A. 6 cwt.	1·6	Plain shell.	11·9	3·074	1103·4	1111·8	Experiments to ascertain the ef- fect of diminishing lead on base of 12-pr. Armstrong projectile.
12-pr. 6½ cwt. ...	1·4	Common shell.	8·12	4·55	1124·2	1163·4	
12-pr. A. 8½ cwt.	1·8	Seg. shell	11·9	3·024	1180·9	1190·2	
	1·8	—	11·9	3·074	1238·3	1248·2*	
	1·8	—	11·9	3·010	1200·0	1209·7†	
68-pr. 95 cwt. ...	16·0	Round shot.	66·4	7·91	1553·3	1579·0	
			51·8	7·91	1769·4	1809·9	
32-pr. 58 cwt. ...	10·0	Solid shot.	31·6	6·17	1653·0	1690·0	
12-pr. 18 cwt. ...	4·0	—	12·10½	4·52	1718·0	1769·8	

\* Shell fired under normal circumstances.

† Same shell, lead reduced to the same diameter as the gun, except 0·25 of an inch at the base.

TABLE C:

Description of Gun.	Point Blank Range.	Height of Platform.
	yards.	
68-pounder, 95 cwt. (smooth bore) .. .. .	310	8 feet.
*68-pounder, 112 cwt. (ditto)	400	8 feet.
100-pounder Rifled Armstrong	345	17 feet.
13-inch Horsfall 280-pounder (smooth bore) .. .. .	600	20 feet.

\* Service charge of this gun is 20 pounds of powder.

TABLE F.  
Royal Artillery Practice Cards.

	$\frac{1}{4}^{\circ}$	$\frac{1}{2}^{\circ}$	$1^{\circ}$	$2^{\circ}$	$5^{\circ}$
Brass 9-pounder, charge } 12lbs. 8oz. ... }	400	500	700	1000	—
Armstrong 12-pounder } charge, 11b. 8oz. ... }	150	300	560	993	—
Fired from own field carriages.					
Armstrong 12-pounder...	—	—	—	1130	2146
Whitworth 12-pounder...	—	—	—	1198	2368

Fired 17ft. above plane.

Armstrong and Whitworth competition with service charges, powder  $\frac{1}{4}$ th weight of projectile.

Whatever, therefore, may be determined on as to smooth-bore guns, round shot cannot be dispensed with, especially when the calibres are further increased, for elongated shot cannot be driven with equal velocity; their greater weight, and the friction on the lands, or wings, to give them rotatory motion, must always prevent their attaining very high velocities, nor can it with reason be said, that the charges with such shot can be increased to the amount used with the round shot, since the increased tension which that would entail would destroy any gun yet made, and likewise destroy many descriptions of rifle projectiles.

Table (B) of experiments is offered, in proof that there is no more friction in the shunt rifled gun than in the smooth bore, but that is simply impossible. The shunt rifled gun nips its missile as it passes out, for the purpose of obtaining greater accuracy, but if there is no greater friction there can be no nip and no directing power. It is but too palpable that there is a destructive amount of friction, and a retardation of the bullet near the muzzle of the bore, and from the shot being elongated, the powder is exploded under greater pressure, and a more elastic gas is generated, which, counterbalancing much of the force absorbed by the friction, may hide in part its existence from view. That the gas under such circumstances is more elastic, is proved "by the fact, of the back action increasing with the angle of elevation, and the initial velocity of round shot increasing with it *pari passu*."

The friction and consequent increase of tension prevents the powder charge from being increased in any of our present rifle guns, so as to obtain an effective initial velocity.

Had the powder been increased, the shunt shot would have stripped, or the gun itself would have yielded. But the fact is, the table does not supply data sufficient from which to form a correct estimate, and there is no parallelism between a cylinder with its large frictional surface, and a round shot, which rests upon a point and at once rolls in the bore.

And yet the experiment with the cylinder mentioned in Table B is



given as a proof that there is no friction in the rifled gun, overlooking two important elements wanting to constitute it a scientific experiment, viz., absence of equality of windage and of tension on the gun; the latter must always be the starting point, as that must determine the quantity of powder.

The argument that the smallness of the recoil of rifle guns, establishes that there is little friction, and therefore little tension on the gun, is a fallacy, for it is the intensity of the friction that prevents the gun from recoiling; so great is it, that it could not fail, with higher charges than those used for *them* now, in time to disintegrate such guns, by separating the chase from the breech, or more properly the inner cylinder from the outer; indeed, I believe this has already in many cases taken place.

The friction of some of the rifle projectiles has been estimated as absorbing nearly half the power of the powder burnt, all which goes directly to injure the gun.

The retardation of the shot, of which there can be no question, is an undeniable proof of the existence of the greater friction of rifle projectiles and of the increase of tension which it occasions to the guns.

The evil of retardation of the shot in ships' guns is so great, that it is a serious objection to any gun in which it occurs, as it becomes, from various causes common to ships, a very large element in inaccuracy—as, for instance, from the rolling motion, and the form of the decks, the effect of which would be similar to a jump from a violent recoil, or from the absence of a just preponderance, producing errors both in elevation and in direction, proportionate to the amount of the retardation.

Since I wrote the above, the following extract has been placed in my hands, in which are summed up the results of some experiments:—

“The 68-pounder was loaded and fired five times, *very good shots*, the distance being about 2,000 yards; while the 100-pounder Armstrong was loaded and fired three times, and, from some unaccountable reason, *very bad shots*, yet they were laid very well, so that in a seaway, or where at least the ship is rolling like the gun-boats do, 25° altogether, the 68-pounder pivot-gun beats the Armstrong 100-pounder completely. Such was the opinion of all who were there and saw the firing. I suppose on shore the Armstrong is best, but not at sea.” The extract bears the impress of truth, and that the writer was not prejudiced, for he deems the result as unaccountable, while I, under the circumstances, consider that none other could reasonably have been expected. This leads us to the conclusion that, with care in the improvement of smooth-bore guns and their missiles, we may obtain sufficient range and greater accuracy afloat than with rifled guns, while the former would possess what the latter is so wanting in, viz. smashing effect at short ranges.

I take this view, though it may be said to be retrograde. It is not so, however; rifling evades the difficulty by making others, which at short ranges are very much greater; in fact it destroys effectiveness against iron plates. Now I only propose that the causes of the errors in round shot shall be directly removed. These are: an undue amount of windage, imperfect sphericity, and absence of homogeneity. The following tables show how much may be effected by a reduction of the windage. Table D shows the effect of the reduction of windage:—

TABLE D.

Nature of Gun.	Length.	Weight of Powder.	Windage.	Elevation.		
				1°.	2°.	3°.
	ft. in.	lbs.	parts of inches.	yards.		
*32-pounder, 56 cwt. ..	9 6	10	·233	700	1130	1964
{ 32-pounder, 40 cwt. ..	8 0	6	·175	‡731	—	—
{ 32-pounder „	„	„	·175	715§	—	—
56-pounder, Monk, 97 cwt.	11 0	16	·175	†930	1340	2200
110-pounder Armstrong	—	12	Nil.	530	920	1970

\* From Aide Memoire to the Military Sciences.

† Handbook for Field Service

‡ Height above plane 15 feet.

§ „ „ „ 8 „

|| From Royal Naval Official Ranges.

Table C a (Appendix) shows the range at first grazes at point blank, it shows also the comparative initial velocities.

Table E, showing results obtained in America, appears to demonstrate that the windage of smooth-bore shot might be reduced still more, with satisfactory results as to accuracy, increase of initial velocity, and, therefore, of smashing effect, without, from a certain point, increase of tension on the gun; and, as the injury from lodgements arises from large windage, its reduction would increase the lives of guns.

This table establishes in a striking manner that the friction of, and tension on, these rifled guns must be very great, or the initial velocity of their shot would be very much greater; ·170, which is less windage than that of the smooth-bores in the naval service, gives a range of only 52 yards as compared with 288 with only ·025 windage.

TABLE E.

## AMERICAN EXPERIMENTS.

From Simpson's "Ordnance and Naval Gunnery," used as a text-book in the U.S. Navy.

Kind of Powder.	Range in Yards.	Pressure on Plug.	Pressure per square inch in lbs.	Diameter of Ball.	Windage.
		lbs.		inches.	parts of in.
Dupont, 30 ...	288	301	1·179	5·63	·025
	92	331	1·297	5·535	·120
	52	207	811	5·485	·170

Tables C and C *a* (Appendix) show ranges and particulars of Horsfall's 280-pounder; this Table shows the point-blank range as compared with those of the Service 68-pounders and Armstrong 110-pounder. The 68 appears to a disadvantage; its range was taken at a height of only 8 ft., the other two, Sir William Armstrong's at 17 ft, and Horsfall's at 20 feet. This would make a considerable difference in their range against that of the 68-pounder. The time of flight of Horsfall's smooth-bore is about half that of the other, and shows abundantly, to what perfection smooth-bore guns may be brought. The windage in the 68-pounder is  $\cdot 198$ , that in Horsfall's is only  $\cdot 08$ , the effect of which may be gathered from the American results.

In the field it is admitted that the difficulty of judging distances, and other disturbing circumstances, are such, as to confine the ranges of projectiles for military purposes to 2,000 yards; afloat, the disturbing causes, *which are constant*, are greater, from which the various movements in rifle sights become causes of error, therefore the most useful ranges cannot be greater than those obtained by Mr. Horsfall's gun at little above point blank, and with powder only one-sixth the weight of shot, while the elevation of rifle guns is considerable for the same distances. Then, as the angles of descent are great, the chances of striking an object are scarcely worth the powder used. The smashing effect of this gun would be three times that of the 150-pounder.

The former conclusion Sir H. Douglas arrived at *some time* since, for he says,—“The main principle which should govern our choice of naval guns is, to prefer those which with equal calibre possess the greatest point-blank range.” This was the correct view to have taken before the introduction of iron-coated ships; since that, we have no choice, as no other guns will be completely effective against iron plates, if against other ships either.

Imperfect sphericity, another cause of error in round-shot, may be removed in working scrap-iron into wrought-iron shot, made requisite by the introduction of iron-plated ships; a nearer approach to homogeneity will at the same time be made, while the expense of such, will still be far below the cost of any of the elongated shot.

Since this paper was written I have seen a pamphlet on this subject, in which the value of smooth-bore guns and improved shot are set forth. It is by Mr. M. Scott, C.E., and shows the turn which the public mind is taking.

To the extent that we have adopted rifle guns, to the exclusion of smooth-bores, for the navy, we have given up the substantial advantages of low trajectories, straight ricochet, smashing force, simplicity, and economy, for the very occasional advantages of long range. Therefore, for efficiency, no less than for economy, we must revert to the smooth-bore in principle, and invest talent and money to develop its merits.

But rifle guns and elongated shells, especially of small and medium calibre, have decided advantages, because of the greater quantity of powder these shells are capable of containing, and long range is also sometimes very important for the support of troops and for breaching purposes; we should therefore endeavour, if possible, to combine the advantages of the round-shot with those of the elongated, in one description of gun; but even for the simplicity which this would bring with it, no sacrifice of initial

velocity is admissible. So that, unless a mode of rifling can be found, that will not involve undue windage, we must have both descriptions of gun, in numbers proportionate to the relative importance of each: little windage, then, must be the ruling qualification in the selection. Such is that proposed by Captain Scott, R.N., such is that used by the French in their rifled gun that admits of the use of round balls. It should be a muzzle-loader, simple of construction, strong, and as little liable to get out of order as possible; for neither ships nor fleets can take factories to seawith them.

This would exclude all multigrooves, or those with a sharp-edged rifling, which would be destroyed by the passage of round shot over the lands.

Breech-loaders would also be excluded, for they would be too weak in the breech to stand the high charges necessary, and they are dangerous; their greater weakness will be seen by a glance at Plate I. fig. 2, which represents the Armstrong breech-loader, in contrast with Plate I. fig. 1, which represents a 200-pounder gun of Captain Blakely. Thus, in fig. 2, the entering the cartridge, &c. from behind, entails a bad form of chamber; the squareness of the end of which, in Sir William Armstrong's gun, is a proved cause of weakness, as is evident from a comparison of that shown in fig. 3, which is a form known to add to the endurance of the gun. The holes for breech-screw and breech-piece further greatly impair its strength; indeed it seems impossible, with so many parts subject to the action of highly elastic gases, that a gun thus constructed, could be otherwise than weak, and extremely liable to injury.

The coils are shrunk on hot; the metal, of course, contracts in every direction, consequently the joints open; it were impossible they should be close; the *overlapping* pieces at the joints indicate the knowledge of this defect. All these are points of weakness, and the whole of the great vibration which takes place every time the gun is fired must be thrown in turn on these separate parts, and not distributed, owing to the continuity being broken, which must lead early to the disintegration of the gun.

The maximum initial velocity being of necessity the primary consideration, when the smallest increments of time involve the whole question of hitting or not, and always diminish the chance of doing so, lead-coated shot cannot be safely used, nor those either where lead is expanded or compressed into grooves, for the charges required to give high velocities, would certainly force these missiles through the gun without their taking the rifling, causing them to strip; and to use hardened lead on the compression principle with high charges, would inevitably prove fatal to the piece; the liability of leaden missiles to become out of shape by falls would, when it occurred, as is too probable on board ship, increase much the difficulty of loading from the muzzle, and also the danger of bursting the gun.

High charges also would crush up compound shell, and damage the bore near the chamber even more than is the case now, which is so much so in the expanding rifle projectiles, that the grooving at the seat of the projectile is after a time obliterated. The uncertainty and danger of these is such that it becomes a question whether, even for special though unfrequent service, they should be used on board ship.

It has been set forth as a merit that such guns are economical because of the small quantity of powder required for them, covering up the fact, that the sum saved in powder is more than doubled in the cost of the shot.

**APPROXIMATE PRICES OF ARMSTRONG AND SMOOTH-BORE SHOT.**

	Description of Gun.	Charge.	Cost of		Total.
			Shot.	Powder.	
			lbs.	s. d.	s. d.
Armstrong . . . . .	110	14	17 0	9 4	26 4
Smooth Bore . . . . .	68	16	3 0	10 8	13 8
Armstrong . . . . .	40	5	8 0	3 4	11 4
Smooth Bore . . . . .	32	10	1 5	6 8	8 1

It cannot be economy to sacrifice efficiency, and such guns are valueless against iron plates.

The Whitworth gun, though giving satisfactory results with long ranges, under circumstances seldom or never occurring on board ship, is still open to many serious objections.

The angles of its missile in the process of rotation, press against the inner surface of the gun, and cut into it, tending to rip it up.

Lastly, it is unsuitable for round shot, as the angles, as may be observed from Fig. 6 *b*, would necessarily entail a great loss of power by the escape of gas; the shot also would be proportionately small for the same reason.

The Lancaster oval, Fig. 6 *a*, would be very dangerous with large charges, and it also is unsuitable for round shot; the loss of power by the escape of gas would be very great, but a more serious objection is, that the use of round shot and high charges would destroy the gun very shortly.

Without enumerating all the rifle guns, it appears to me that the claim to superiority lies with the three-grooved guns, the others being thrown out, by the large portion of the bore that is cut away by many grooves, or by wide grooves, entailing weakness and undue windage.

Figures 6 and 7 represent sections of different rifle guns drawn to scale; a round ball is placed in the bore, and show the amount of windage that the use of such, would entail in each kind respectively, very large in Lancaster's and Whitworth's, and least in that of Captain Scott. Captain Blakely has abandoned his, and has adopted that of Captain Scott in the guns he has made for foreign governments. Plate II. fig. 18, shews the effect even more distinctly. Suppose the rectangle *a* to represent the whole of the inner circle of the cylinder of the gun, then the smaller rectangles *b*, *c*, *d*, *e*, *f*, *g*, *h*, represent the quantities of this circle required to be left untouched in rifling, according to the respective plans named.

The total amount of windage occasioned by the different systems of rifling, when the present round shot are fired, is given in table H.

Fig. 18.  
Comparative Surfaces of  
Original Bore untouched by Rifling.



Fig. 15.

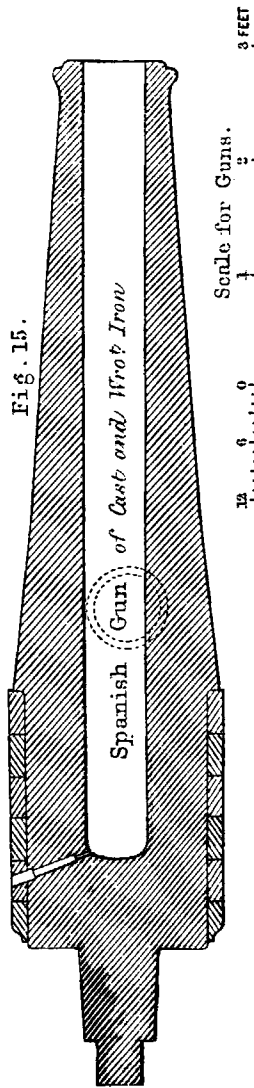


Fig. 14.  
French

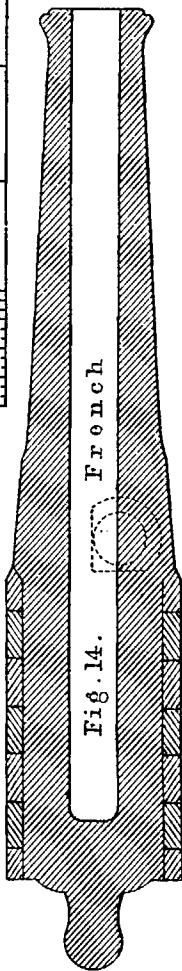


Fig. 17.

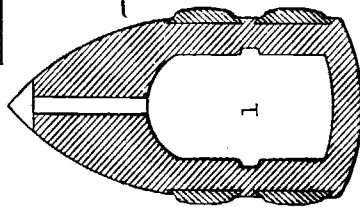


Fig. 16.  
j

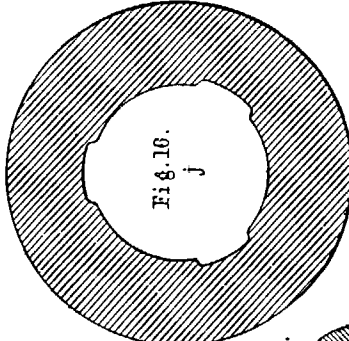


Fig. 19.



Fig. 20.

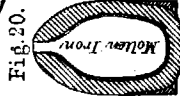


Fig. 21.



Fig. 22.



TABLE H.

Diameter of bore ... ..	6·375
Diameter of round shot ..	6·177
Windage ... ..	·198

	Area of Bore.	Area of Round Shot.	Area of Windage.
Original bore ... ..	31·92	29·97	1·95
Scott's ... ..	32·24	„	2·27
Britten's ... ..	32·55	„	2·58
Armstrong's shunt ... ..	32·97	„	3·00
Jeffrey's ... ..	33·07	„	3·10
Lynall Thomas's ... ..	33·34	„	3·37
Whitworth's ... ..	34·62	„	4·65
Lancaster's ... ..	34·73	„	4·76

The above results have been obtained by measurements from the guns.

There are three guns with three grooves—the Shunt, by Sir William Armstrong; \* the French gun; and that of Captain Scott, of the Navy. (Plate I. fig. 8.)

In the shunt gun the grooves are double, with sharp edges (Plate I. fig. 9); the rotatory motion of the shot is produced by zinc ribs, which run in the grooves—slack going in, to facilitate loading, tight coming out. For greater accuracy, the rifling diminishes in diameter towards the muzzle, to nip the ribs (fig. 10); this necessarily increases the tension on the gun, to which it must prematurely yield; also, there cannot fail to be uncertainty from unequal yielding of the zinc, and a great danger that, with high charges, the ribs would strip off. The missiles would be delicate for the rough usage of ship service, and the feeling that shot might strip would have a very bad moral effect. The bearing side of the groove of the French gun (see fig. 8 *h*) is not unlike that of Captain Scott's (fig. 8 *g*); the preference is due, however, to the latter, as the direction of the friction is less injurious to the gun.

Again, the rotatory motion of the French missile is produced by studs of soft metal, which are liable to injury, and would certainly fail under the pressure of high charges, and when bent, are liable to burst the gun.

\* *Sir William Armstrong*.—You have no correct section of the shunt principle there?

*Captain Fishbourne*.—Mr. Vavasseur kindly measured all the guns, and drew them for me. He will establish the correctness of his measurements.

*Sir William Armstrong*.—He cannot: there are no measurements given.

*Captain Fishbourne*.—The measurements are given in table H.

*Sir William Armstrong*.—Then in the diagrams you are showing, there is a far larger space in the grooves than actually exists.

The rotation of Captain Scott's shot is obtained by ribs cast on the shot; they are simple, strong, little liable to injury, and cannot fail; better to steady and direct the shot, and give greater accuracy than studs. The edges of these ribs are softened off by a coating of zinc, giving them any advantage that may belong to soft metal, without the disadvantage.

*g* fig. 8, represents the shoulder of Captain Scott's; the friction, which is in the direction of the circle, bears against it, whereas, owing to the nipping of the shunt, the pressure is directly outwards, tending to burst the gun, *i* fig. 8. If there is no friction, there is no directing power.

No doubt round shot might be fired from these three guns, as also that of Mr. B. Britten, and, indeed, others; but the loss from windage through the many or deep grooves would prevent round shot attaining a sufficiently high velocity. The many grooves and the wide grooves, impair the strength of the gun, while the narrow lands would soon be eaten through by the friction (*d, e, f*, fig. 7).

Nor can the evil be remedied, for with increase of powder the grooves must be deepened, or the soft metal will strip or ride over the lands without taking the rifling. By the system proposed by Captain Scott of having strong iron wings, as it were lubricated by a soft metal, great initial velocity for a rifle may be obtained; the mode of rifling being least injurious to the strength of the gun. His missile being also the strongest, simplest, cheapest, and least liable to injury, possesses the strongest claim to be adopted as the naval pattern for a rifle gun.

I might have gone into many details interesting and important in their degree, but *unimportant* till the question of principle was decided. To that I have endeavoured to confine myself, and I feel sure the discussion were better thus confined. I have satisfied myself, and can only wish I may have satisfied my audience, that with round shot (perhaps it may be with smooth-bore guns) alone shall we be able easily, safely, and economically to obtain that velocity of flight over short ranges, that shall be effective against iron-plated ships; and that the long-range guns are of more limited value for military purposes generally than has of late been supposed; and, as they are of still less value for naval purposes, it will be matter of grave surprise that so much has been spent in producing guns so deficient in the prime qualifications for good naval guns—viz., 1st. Great initial velocity—no great part of which must be sacrificed to the rifling. 2ndly. Simplicity of construction in gun and in all its appointments. 3rdly. Muzzle-loading, for safety with high charges. 4thly. Mode of rifling to be strong, simple, and least injurious to the gun, or easily injured by round shot, or by any other cause, such as leading, constantly in operation. 5thly. Missiles to be simple, strong, and least liable to injury.

It is due to Captain Scott to say that thirteen months since he strongly insisted in this place on the value of rifled guns that would admit of the use of round shot, and that every experiment in that direction establishes more and more the correctness of the views he then stated. The *Times* in a recent number gives 3 and  $3\frac{1}{2}$  inches as the penetration of a 68-pounder with 20 and 24 lbs. of powder, the probability is that the windage of that guns was .198—far too great; that of Horsfall's gun is only .080; .060 would be sufficient; a reduction to half .198 would produce nearly, if not quite double the effect reported. The cast-iron guns in their present



condition would hardly stand the high tension, but hooping them would be a rapid, effective, and economical way of using up our present stores, and of obtaining an early supply of guns; the propriety of ordering more cast-iron guns is doubtful.

A question here arises as to the construction of the guns: we have seen what danger and weakness arose from violating the law of homogeneity in the breech-loaders; this may not be repeated without grave responsibility, and as we must have high charges at all costs, with increased tension, it seems the undue application of the coil system as in use, will have to be modified, if not abandoned, for forging in whole, or to a greater extent; the forged guns would stand the blow of a shot vastly better than a coil gun. And therefore it is an important consideration as to whether it is worth paying 650*l.*, the price of a 110-pounder, for what at 300*l.* or 350*l.* would suit our purpose equally well on most points, and better on this important one.

As a practical illustration of how the two systems of coils and forging might be combined with advantage I may suggest the following, the result of conversation with practical men:—

The internal tube reaching to the muzzle should be forged in one piece, closed at the breech, of iron approaching to the character of steel, and wrought on a mandrel, hollow; breech-piece, including the trunnions, should then be brought over; lastly, over the chamber there should be a coil, to give more tensile strength to resist the effect of explosion.

The question is one of great national importance, both in an effective, an economic, and commercial point of view, so great as to justify us in calling on those gentlemen who have displayed so much talent in working out their respective plans, to look at the question less from a personal and more from a national point of view, and agree to differ as to the respective merits of their respective plans, and, while differing, agree to join in producing the gun best suited to serve their country's interests.

The Duke of SOMERSET: Gentlemen, I am sure you will all agree with me that at any rate this is a most important question to be considered, and that we ought to be greatly obliged to the gentleman who has opened this discussion for us. Now that it has been opened, I hope the discussion will be carried on by those who have considered the subject fairly and calmly. For myself I would say this, that I have read a great deal and heard a great deal about guns of all kinds. Of what I have heard there is a great deal I do not believe, and very little that I do believe. What we want is to get some progress. I have not yet heard distinctly whether you intend entirely to give up the cast-iron gun, or whether you take entirely to the wrought-iron gun. Whether you object to the rifled or the spherical ball bore is another question; but I should like to hear from those who have considered the subject some little progress. I believe we shall get that progress best by just calmly talking over the matter.

Vice-Adm. the Honourable Sir FREDERICK GREY, K.C.B.: As Sir William Armstrong is here, perhaps he would have the kindness to explain to us some of the points connected with his gun that have been objected to, and that would, perhaps, open the discussion in the most satisfactory way.

Sir WILLIAM ARMSTRONG: The paper which has just been read, embraces such a large number of facts which I feel myself called upon to answer, that I really do not feel able, on the spur of the moment, to go into a complete refutation. There can be no doubt but that this question will have to be adjourned; and it would certainly be more satisfactory to myself, and probably in its results more satisfactory to the meeting, if you would allow me to take a little time to consider the subject. I should be prepared the first thing to-morrow night to give a general statement, not only in refu-

tation of what has been advanced, but also as conveying my own views as to what is proper to be done in regard to naval armaments under the present aspect of the question.

Major-General ANSTRUTHER, C.B. said, the recorded range at ten degrees of elevation of Sir William Armstrong's gun, speaking from memory, was 3,598 yards, and the longest range ever known to be got by a round shot was 3,130 yards. With one-eighth of the shot's weight, Sir William Armstrong's gun got more initial velocity, because it got more range, at the same elevation than the round shot ever attained. (No, no.) He was prepared to maintain it against all comers.

Colonel WILFORD, R.A.; I will explain in a few words why the initial velocity of round shot is greater than that of the Armstrong shot. In the first place it has been determined by the galvanic apparatus at Shoeburyness that the 68-pounder, as a matter of fact, has greater initial velocity than the Armstrong. Now for the reason why. Suppose we take two projectiles of equal diameter, one spherical, the other elongated; the transverse section, or that perpendicular to the trajectory, will be equal in each case; therefore the column of air to be displaced will be equal in each case; and hence the resistance will be the same. But, the elongated projectile overcoming the same resistance of air, has much greater weight behind it to overcome that resistance. Hence it is, that, although a spherical projectile of equal diameter may have a much higher initial velocity at the muzzle than the elongated, yet, suffering a much greater retardation, its velocity is much more rapidly diminished; therefore, in the latter part of its flight it passes more slowly over the ground; hence it does not go the same distance at the same elevation as the elongated, which, although starting at less velocity, preserves it more uniformly throughout its flight.

General ANSTRUTHER was much obliged for the answer. It was the first time he had been able to get an answer. But as the initial velocity was not the subject of discussion, he should not go into it now, except to say that he differed *in toto* from all that Colonel Wilford had stated. To return to the point under discussion, Ought not all these experiments in guns to be tried in brass, because, if condemned, they could be re-melted? Why was it that everybody used the most expensive metal, and hammered out 900 guns, only to find that there was a better gun which could be made? The objection against brass guns was, that they drooped at the muzzle. Now, the drooping at the muzzle was owing to the very injudicious plan of placing the trunnions. Were the trunnions placed close up to the muzzle astragal, there could be no drooping.

General Anstruther here produced the model of a modification of the Prussian breech-loader, which he described, and declared to be the simplest and speediest loading gun in the world.

Colonel WILFORD: I should like to explain why brass cannot be used. In artillery you cannot safely proceed from small things to great, as you can in many other things. A thing that answers perfectly on a small scale in a model, fails on the large scale. Now, I proceed to show in a very few words why an experiment with a small brass gun would be worth nothing as applied to a large gun. Many years ago iron mortars were introduced into the service, and why? Because, when large brass mortars were used, holes were burnt in the chamber owing to the immense heat generated by a large charge of powder acting on the material of the gun metal. The results of the experiments can be seen in Sir William Armstrong's department at Woolwich as conducted by General Sir Thomas Blomfield, formerly Inspector of Artillery. Therefore, if you are to make these experiments on a large scale in brass guns, the heat generated would be so great that the form of the gun would very soon be changed, and your experiment would be comparatively valueless.

Lieutenant-Colonel CLAY, 8th Lancashire Artillery Volunteers: Although I am myself unprepared to speak upon a subject of so much importance, still, having had some slight experience in the manufacture of guns of large calibre, I may perhaps be permitted to make a few remarks, which will be short and to the purpose. I think, in the first place, it will be very desirable that each gentleman who addresses the meeting should endeavour, as far as possible, to avoid treading upon his neighbours' toes, and confine himself to bringing before the meeting any merit which he considers may apply to his own invention or to the particular article in which he is more immediately interested. In the year 1856, during the Russian war, when accounts appeared in the public papers that it was desirable large ordnance should be made, a gun was attempted to be manufactured somewhere in Lancashire by an eminent engineer, that gun failed, and it was stated in the public prints that the reason of the failure was, that, on account of the long continued heat of the mass of metal, the iron was carbonised to such a

degree, that, even if the gun had been made, it would have been weaker than cast iron. We felt that our reputation as iron-masters, making the largest description of forging, was somewhat at stake, and we resolved at once to offer to make and present to Her Majesty's Government a gun as large as, or larger than, the one attempted to be made. The reason of that was, that when so eminent an engineer had attempted to manufacture a gun, and failed, we thought, our name not then being so well known to the public as it is now, that Government would not have been justified in making another grant of public money for us to make a similar attempt; therefore, the only means by which we could get the Government to try the gun, was by offering it to them in such a way, free of cost, that it could not be refused. The gun was made, and was proved on the shore at Liverpool by Major Vandeleur, Instructor of Artillery, who was sent down expressly for that purpose. It was proved with 45 pounds of powder, and with shell loaded with lead, weighing 310 and 318 pounds. This was then thought such an enormous charge for artillery, that the then Select Committee sent charges to Liverpool weighing from 10 to 24 pounds, with instructions that we were to begin with the smaller charges, and, if the gun did not burst, we might proceed to the larger ones. In the absence of the Artillery Instructor, Sir Duncan Macdougall, in command of the Lancashire Artillery, then at Liverpool, placed a gun detachment at our disposal. We began with 10-pound charges, and went on to the 20 and 30-pound charges. When the Artillery Instructor arrived, we had reached the 30 pound charge. He expressed his surprise, and told us it was useless to go on any longer with smaller charges. An experiment was also made, perhaps the first ever made, at the request of the Instructor of Artillery, against a battery-plate of 4½ inches thick. A target was hastily constructed on the shore, steadied with nine balks of timber about 14 inches square, and firmly imbedded in a bank of sand, which solidified the whole structure. That battery-plate was probably masked in a manner that has never been equalled since. This was in the year 1856. Table Ca (Appendix) shows the comparative ranges of the 68-pounder 95 cwt. service gun, and the 100-pounder rifled Armstrong gun, and the 13-inch Horsfall gun, at point-blank range. Each division of this table represents 10 yards. While the 68-pounder ranged 310 yards and the Armstrong ranged 345 yards, the 13-inch gun ranged 600 yards. The data with respect to the 68-pounder and the 100-pounder are taken from the "Handbook for Field Service," published this year. The data of the 13-inch gun is from the report supplied by Colonel Mitchell to the War Office, a copy of which the War Office has favoured us with. It has been remarked, and the remark is a very just one, that the circumstances are not entirely parallel in these three cases—that the 68-pounder gun was fired from a height of 8 feet above the plane, that the Armstrong gun was fired from a height of 17 feet above the plane, and that the 13-inch gun was fired from a height of 20 feet above the plane. This ought certainly to be taken into consideration; but, if we make a deduction from the range of these, to correspond with the height of the plane of the Armstrong gun, we shall have to knock off 90 yards in the range, which will give us a range of 510 instead of 600 for the 13-inch gun as against the 345 yards of the Armstrong gun. I have not made the comparison with the 68-pounder smooth-bore service gun, because after all the 13-inch monster gun is only an exaggerated 68-pounder. The ranges were not merely confined to point-blank range, but up to 10 degrees of elevation, the same guns being taken in the comparison. Up to 10 degrees of elevation we start with a slight advantage over the two other guns; at 12 degrees the Armstrong gun takes the lead, and, as everybody knows who has at all studied these matters, increasingly so, at still higher degrees of elevation. A remark was made just now that no smooth-bore gun ever got a range beyond 3,600 yards; that is simply ridiculous, because this monster gun has had a range of 5,009 yards.

General ANSTRUTHER: At ten degrees.

Lieutenant-Colonel CLAY: Not at ten degrees?

General ANSTRUTHER: That is the statement.

Lieutenant-Colonel CLAY: At ten degrees the range is 3,540.

General ANSTRUTHER: Which is 50 yards less still than the Armstrong, and it is not a smooth bore.

Lieutenant-Colonel CLAY: I can only give the data as I take it from the "Handbook of Field Service," and from Colonel Mitchell's "Report," and I consider, with the explanation about the difference in the height of the plane, we must take them as authentic. With regard to the charges of powder, the charge with the 68-pounder service gun is 16 pounds; with the Armstrong 100-pounder the charge is 12 pounds; and with the Horsfall gun the charge has been 50 pounds. Ninety rounds had been fired out of

that gun with 50 pounds of powder each. The proportion of the charge of powder to the weight of shot, was, in this case, one-sixth. Before manufacturing the gun, reference was made to the late eminent Sir Howard Douglas; I made a journey to France purposely to consult with Sir Howard Douglas. Before we commenced the manufacture of that monster gun in 1856, Sir Howard Douglas's remark, which I have never forgotten, was to the effect, "Give me a gun that will range at point-blank and I do not care anything for any long-range gun, or for any particular benefits that may result from it." He admired and wished to have the most powerful point-blank gun. I may perhaps mention incidentally, with regard to that gun, that I suppose no gun has ever had more powder and shot blown out of it. The recorded experiments, taking the quantity of powder for charges from 10 pounds up to 80 pounds, show that there have been upwards of 7,000 pounds of powder and 60,000 pounds of shot blown out of that gun, and, if a slight defect has shown itself, I should like to be informed where the other gun is, that has blown out anything like the same amount of powder without showing any defect. I am happy to say that at last, after many years' endeavours, we are about to get some measure of justice to that gun. Lord Ripon at the War Office to-day promised that it should be immediately tried, and in its present condition. In visiting it a few days ago at some gun experiments at Portsmouth, I was sorry to find it nearly buried in the shingle, and so rusted was it, that I hardly knew my own child. I find that the officers who proved it, and even the very gunners, who are there still, informed me, although they had no knowledge of who I was, that they have the most unbounded confidence in the gun and I fearlessly challenge the whole country, when I say that that gun as a battery gun is unequalled, and has had more effect than any other gun that has ever yet been made.

While upon this subject, I may, perhaps, say a few words about the forging of guns and building them up. At several meetings such as this held in London, I have almost alone stood up for the plan of making guns in one piece of wrought iron, and I am glad to find at last, that the opinions of many gentlemen who have studied this question are somewhat modified, and coming round to that view of the subject. Whether solid-made guns or built-up guns are the stronger, I care not to inquire into; all I care about is, that the guns I advocate, solid-made wrought-iron guns, are amply sufficient for every useful purpose, and at the same time I believe they can be made at a very much less cost than any built-up guns, with the exception perhaps of guns the principal portion of which is cast-iron, and strengthened by wrought-iron or steel hoops. That is a question which I wish not to enter into, but I would merely guard myself by saying that I do not mean to say that solid wrought-iron guns can be made cheaper than those guns. The question will probably be entered into by the various gentlemen whom I see round me, in dealing with the merits or demerits of cast-iron for ordnance purposes. With regard to the size of the gun, it seems now to be an important question as to what size a gun can be made safely or economically, with the view of being placed in our forts, or, if possible, be carried by our ships. In 1856, the monster gun, weighing 21 tons 17 cwt. was pooh-poohed as a gun too large for any useful purpose whatever, yet I may take this opportunity of observing, that the proportions of which I intended to make that gun were considerably increased by the authorities at Woolwich. Now, there seems to be an opinion that, at any rate in fortifications, guns, if they are effective, can be used of any size that it is possible to make them. I do not know whether I am out of order. I am not much accustomed to be examined by Committees, but upon my examination by the Defence Committee, a few days ago, I had some questions asked me there. Perhaps my Lord Duke would inform me whether I am permitted to make known to the meeting what was said upon that occasion.

The Duke of Somerset: I do not think there will be any danger in your stating it to the assembly.

Lieut.-Col. CLAY: I was not aware whether it might be considered private and confidential. I was asked whether I could undertake to manufacture a gun which would penetrate the sides of the *Warrior* at 1,000 yards. I stated that I should have no hesitation, with our present machinery, to undertake to manufacture a gun that would, in my firm belief, fracture the side of a ship constructed as the *Warrior*, covered with four-and-a-half-inch plates, at 1,000 yards. I was then asked the question whether I would undertake to do it at 2,000 yards. The question became a very different one, and involved so much difficulty that I declined to give any answer upon that subject; but it was there stated, that, if guns could be constructed, it would be desirable to construct them of such a size as to enable them to make a serious impression upon vessels

such as the *Warrior* at 1,000 yards. I believe there would be no difficulty whatever in making them, although the monster gun weighs 21 tons. I have no hesitation in saying, that, with our improved machinery, guns very much larger could be made with equal facility. I should like to say a few words about the method of making guns, as exemplified in the Prince Alfred gun. That gun was forged hollow. In the monster gun, at the end of the breech, as is generally the case when contraction sets in with either cast or wrought iron work of unequal dimensions, a small drawing or shrinkage took place in the bore of the gun. That is in consequence of the gun shrinking unequally; the cooling of the gun from the outside formed a solid arch, and the interior, in consequence of its weakness, gave way. We were not then in possession of so much experience as we have now, about the strength of the breeches of a gun, or that guns could be made upon this principle where a considerable proportion of the breech might be cut away with safety. Therefore, the bore was somewhat shortened, and a piece which we call the plug-piece was placed in the breech at the bottom, leaving most ample strength behind. It was simply to prevent the *débris* from the combustion of the gunpowder getting into the crack and causing the ignition of the next charge when there came to be rapid firing. That was got rid of by the plug. I am informed by the officers and men who conducted the last experiment, when the gun was proved with 80 pounds of powder, impressions being taken before and after two explosions, that no perceptible difference took place in that so-called flaw, and I was informed that the flaw was in the plug, a separate piece that was put in. And, as to the efficiency of the gun as a battery gun, I am informed that there is such confidence among the officers and men who have tried it, that they have no hesitation whatever in carrying on further experiments with it.

A gentleman asked if this Horsfall Gun was cast solid.

Lieut.-Colonel CLAY: It was forged solid and bored.

Colonel LEFROY, R.A., F.R.S.: At this late hour of the evening, I will not detain the meeting more than a few minutes. I have heard from my friend Captain Fishbourne several statements which I think extremely erroneous, and several arguments which appear to me extremely fallacious. In the first place, I wish to set at rest one doubt that has been expressed, in extremely strong language, by Captain Fishbourne, as to the possibility of giving a high initial velocity to a rifle-shot. I am in a position to state that an initial velocity of 1746 feet per second has been given to a rifled shot, with a charge of one-fourth the weight, with an Armstrong gun. On the same principle, we may reasonably conclude that an equally high initial velocity may be given to any other Armstrong gun with one-fourth the charge, the velocities with the service charge being nearly the same. I am far from saying that those guns will continue to stand being fired, an indefinite number of times with that charge. At all events, they can be fired a short time, because it is the habitual proof-charge of the Armstrong gun, and many of them have stood a great many proof rounds. Therefore there can be no doubt about that; there is no doubt they will stand to a considerable extent. I can also set at rest another question, namely, that it is impossible for lead-coated shot, forced through the bore with that velocity, to take the rifling. I reply, in point of fact, they do take the rifling, as can be seen any day at Woolwich, where they are fired with that one-fourth. Again, it is said that the less friction there is in the gun the greater the velocity. Now, we have guns of different lengths, and we find that when we shorten the gun we lose velocity very materially; that is to say, whatever it lost in friction, is more than made up by the time which is given to the powder to exert its entire force. It is a well-known principle in rifling, and I am surprised to hear it questioned at this time of day. Again, a comparison has been drawn between the point-blank ranges of a great variety of shot, fired at different heights above the plane. These point-blank ranges mean the distance from the muzzle to the point where the shot first strikes the sands below. Such a comparison is surely fallacious. The only true scientific comparison of point-blank range is the distance from the muzzle of the gun to the second intersection of the trajectory with the line of the sight. And, when we come to consider what are the real angles at which these shot are fired, it is sufficient to account for the difference of point-blank range. For example:—a shot fired horizontally by spirit levels from a platform seventeen feet high will range say 400 yards, but this shot is really attributable to an angle of three-quarters of a degree. But, when we come to discuss these things with scientific precision, we must be careful to eliminate all the sources of variation, and to reduce them to their proper value. Again, a comparison has been drawn between the 68-pounder shot with

its present initial velocity and what the initial velocity would be, were the windage reduced. Every officer knows we cannot reduce the windage of our guns; we should burst them if we did. Sir Howard Douglas drew attention to the subject in 1818, and no great reduction has been made since. If we do reduce it, we must reduce the charge of the guns. To account for the great difference of range between the late smooth-bore wrought-iron gun, it is sufficient to know, that, whereas the area of the bore through which the gas is able to escape in the 68-pounder gun is one-twentieth of the whole quantity, in the 150-pounder it is represented by  $\cdot 015$ . So absolutely necessary is it to bring into comparison all these elements of dissimilarity in the results of guns, before you can draw any satisfactory conclusion. I will not take upon me to defend Sir William Armstrong's guns, or to argue from very erroneous drawings that they must be weak when in fact they are strong; that Sir William Armstrong will do tomorrow. Those guns have given proof of strength which no other guns have given. Perhaps no other guns have been tried in the same way: but the fact has been more than once mentioned that the 100-pounder gun has fired a continuous series of 100 rounds with the service charge, and cylinders increasing from 100lbs. to 1,000lbs., without exhibiting any weakness. On the other hand, forged guns, not on the coil principle, one of them made by Horsfall himself, and I allude particularly to Mr. Lynam Thomas's gun, have after long-continuous firing shown flaws of so treacherous a character, that that gun burst with a weaker charge than the charges with which it had previously been fired with impunity for a considerable space of time, and justifies one in feeling a doubt as to the possibility of forging those great masses; or at all events we may question the evidence of the strength of these great masses thus forged.

Lieut.-Colonel CLAY: That gun was made of steel, a new material; it was the first attempt at a gun of that kind, forged solid, according to plans with which we had nothing to do. I mention here publicly, it was burst by the jamming of the shot in the bore. The shot was such as must inevitably burst the gun.

Colonel LEFROY: I was at Shoeburyness on that occasion, and I do not think it burst from that at all. With regard to the exact method of rifling which should be adopted in a muzzle-loader, I should wish to state that the attention of Europe is divided between two systems of rifling. The French, the Spaniards, the Dutch, the Russians, have all adopted the system of muzzle-loading guns. On the other hand, the Austrians, the Prussians, the Belgians, and the Germanic States generally, have all adopted the breech-loading system, to which every objection that can be urged against Armstrong's gun is applicable in a three-fold degree, showing again that the game is not entirely with those who are playing for the muzzle-loaders.

Captain BLAKELY: At this late hour of the evening I will say a very few words only. In the first place, I will remark, that I was very much astonished to hear a person of Colonel Lefroy's deep scientific attainments state, that, if the friction in the Armstrong gun is very great, therefore it would follow, as a matter of necessity, that the shorter the gun, the greater the velocity, because, if that were the case, if we had no length at all, the velocity ought to be extremely high indeed. The fact is, seeing that friction is very great, and retards the ball, adding length to the barrel does not give so much additional velocity, as would be attained if the friction were not so great. With respect to the materials of which guns should be made, a mere expression of opinion whether wrought iron is good, or brass is good, is valuable; we ought to look entirely to facts. Now, as to the Armstrong or coil system. I have got a book in my hand dated 1845, giving an account of this coil system; it was tried, and abandoned on account of its total failure. The experiment was made by Mr. Treadwell, the President of the American Academy, a man of very high standing in his country. He made guns on that plan, not only in America, but also in France; he made them of a very considerable size. They had not in America at that time the large machinery which we have in Liverpool now, and they only made those guns the size of 32-pounders; they made them nearly as the guns are now made at Woolwich, of little coiled spirals of wrought iron welded end to end. I will read Mr. Treadwell's own words:—"A number of rings or short hollow cylinders are first formed by means of various moulds, dies, and setts connected with the powerful press before alluded to. The rings are upon their inner sides, and to about one-third of their thickness, of steel; the outer portion being of iron, wound about the inner steel ring, and the whole welded together. They are joined together, end to end, successively, by welding, thus forming a frustum of a hollow cone, the hollow being cylindrical. In giving form to the cone, in the press, its size is determined by a mould of great thickness and strength, which incloses the heated portion of the

cone, while a solid mandrel occupies the hollow cylinder, the fence being applied to setts upon its ends. The pores of the metal are therefore closed, and the metal condensed to a degree not to be obtained by the hammer. By turning and boring, this frustum of a cone is formed into the cannon, the breech being closed by a screw plug, and the trunnions fixed upon a band, which is likewise screwed upon the outside of the gun. The trunnion-band and trunnions are formed, like the cannon, by machinery moved by the hydrostatic press." That is a very accurate description of the process now carried on at Woolwich.

Sir WILLIAM ARMSTRONG : A very small resemblance, indeed.

Captain BLAKELY : At Woolwich, a screw is used to weld the short cylinders together, end to end, instead of a hydrostatic press, and the Woolwich guns are not lined with steel. Now, Mr. Treadwell's guns thus formed with steel lining stood very well, but Mr. Treadwell, thinking he could dispense with the steel altogether, formed some cannon of wrought iron, on the coiled principle, welded from end to end, and these utterly failed. I will read his words :—"During the trials of these guns at Fort Monroe, I was engaged in making the thirty-two pounders contracted for with the department of the Navy. These were finished in November 1844 ; and, although their weight was less than 1,900 pounds, the calibres being seventy inches long, one of them bore a succession of charges, commencing with eight pounds of powder and one of shot, and ending with twelve pounds of powder, five shot, and three wads. I ought to state, however, that in making some other guns of like size and kind, being unable to procure steel of proper quality for lining their bores, and misled by the extreme hardness of the small guns, I ventured to make them of iron throughout. The consequence has been, that, in two instances, guns similar to these made for the Navy in other respects, on being fired with very high charges, as sixteen pounds of powder, were enlarged by the ball making a lodgment of about  $\frac{1}{100}$ ths of an inch deep, and show a slight starting of the metal upon the external surface corresponding with the point of lodgment. The use of steel, however, is certain to obviate all imperfections of this kind hereafter." This, my Lord Duke, is evidently a faithful account of an experiment fairly conducted, and I think it should not be thrown aside as perfectly worthless.

Mr. SAMUDA : Yes, it ought ; it has nothing to do with what we are making in the present day.

Captain BLAKELY : It shows if you are going to use a cast-iron bullet that the wrought iron will not stand it. Some time afterwards Mr. Treadwell in 1856 proposed another system of construction based upon an experiment which he formerly made, and upon other data. I wish to call your attention to the principle of the proposed construction :—"To obviate the great cause of weakness arising from the conditions before recited, and to obtain, as far as may be, the strength of wrought-iron instead of that of cast-iron for cannon, I propose the following mode of construction. I propose to form a body for the gun, containing the calibre and breech as now formed of cast-iron, but with walls of only about half the thickness of the diameter of the bore. Upon this body I place rings or hoops of wrought-iron, in one, two, or more layers. Every hoop is formed with a screw or thread upon its inside, to fit to a corresponding screw or thread formed upon the body of the gun first, and afterwards upon each layer that is embraced by another layer. These hoops are made a little, say  $\frac{1}{1000}$ th part of their diameters, less upon their insides than the parts that they enclose. They are then expanded by heat, and, being turned on to their places, suffered to cool, when they shrink and compress, first the body of the gun, and afterwards each successive layer, all that it encloses. This compression must be made such that, when the gun is subjected to the greatest force, the body of the gun and the several layers of rings will be distended to the fracturing at the same time, and thus all take a portion of the strain up to its bearing capacity." It thus appears that Mr. Treadwell, finding coiled-iron guns would not do, lined them with steel, and succeeded in making excellent 6½-inch guns ; but that for larger sizes he afterwards recommended the plan I have now read.

A gentleman inquired whether any were made and tried on that system.

Captain BLAKELY : It is now used in America under the name of the Parrott Gun. The Parrott gun is a little thicker in the cast iron, which would perhaps weaken it rather more ; but of all the Parrott guns which have been used in the present war in America only one has burst. The French tried precisely the same plan. Here is the figure of a French gun (Plate II. fig. 14) ; it is the same as the old 32-pounder gun ; it has seven steel hoops upon it of about 2 inches in thickness, very carefully adjusted on the inside, and the consequence is, that guns of that description have frequently

been fired 2,000 times without destruction; and they are able to pierce the plates at 1,000 yards without any difficulty.

A gentleman asked what was the size of the plates.

Captain BLAKELY:  $\frac{1}{4}$ -inch plates. With 25 lbs. of powder they throw a 92-pound shot through  $\frac{1}{4}$ -inch plates, with 1-deg. elevation only, 1,000 yards. I have not seen them do it; but my authority is such that I cannot possibly doubt it. If any doubt is thrown upon the fact, I have here the official report of the Spanish gun (Plate II. fig. 15); they have tried the same gun; it is of very much less strength, as you perceive from the figure, than the French gun (fig. 16 is a section of the bore, and fig. 17 k, l are sections of the shell). The hooping extends a very short distance indeed, and yet with that Spanish gun they were able to fire 1,366 rounds with an average charge of 7 lbs. of powder and a 61 lb. projectile before the gun burst. The Ordnance Select Committee of Spain say in their report: "Although the 1,366 rounds fired with the above charge of powder and an elongated shot of 61 pounds are sufficient proof of the satisfactory resistance of the gun, the following observations will render still more apparent its excellence, and consequently that of the hooping system. During the first days of proof, 100 rounds were fired with intervals of only from one to one minute and a half. This made the gun so hot that it could not be touched with the hand. The following days 50 rounds were fired in the morning and 50 in the evening, with the same rapidity." With such rapid firing, I do not think any brass gun would have stood 100 rounds. But, supposing my argument to be entirely fallacious with respect to the necessity of hardness in the gun, still we must use cast iron, for the simple reason that we cannot get anything else.

General ANSTRUTHER: You can get cast brass.

Captain BLAKELY: I do not think brass has ever yet been cast the size I was about to say we must use, and that some of the American guns are being made now; they are making them of 17, 20, and 25 tons weight.

General ANSTRUTHER: Half that size of brass will do.

Captain BLAKELY: Therefore we have no choice, if it comes to huge guns. The late events in the mouth of the Mississippi river prove that it is not only necessary to have guns which will injure a ship, but guns that will stop a ship. We want a gun, from which one or two shots will stop a ship, and we want to place those guns in such a position that we are perfectly certain to hit the ships. I should prefer about 100 or 150 yards to 1,000, because the more one sees of artillery practice the more one would like to have the enemy pretty close. Should steel prove to be the best material, we shall find ourselves more limited, and more obliged to build the guns up because we are limited as to the amount of steel which we can get. We have no choice in the matter. We are obliged, by the necessities of the case, either to use cast iron, or to build up the guns in pieces, because we can only get pieces of a certain size.

Captain FISHBOURNE: Perhaps it is right I should answer one or two remarks which were made by my friend Colonel Lefroy. I can quite understand his being a little riled at my poaching upon his preserve, and his not adopting the recommendation which your Grace gave, that we should calmly talk over this subject. I am quite sure if he had calmly considered it he would not have said what he did. He has charged me with want of scientific accuracy in my comparison of point-blank ranges and different elevations. There is no doubt there is a great irregularity in the returns which come from his office, and they require a Philadelphia lawyer to discover what's what. I think I have distinctly stated to this audience what's what in these tables. I have explained distinctly where they come from, and I have explained what is the weight they are entitled to. There is no mistake with respect to the 68-pounder, and no mistake about those experiments at Portsmouth; they were all fired from a common platform. There is no difference in height of level there, and they are the results of the comparative penetration of those shots. I understand Colonel Lefroy to say, the guns will not stand if there is a reduction of windage. Now the windage of those guns is .192, and they have stood that. It is a most difficult thing to give a relevant fact; it may be a fact in Colonel Lefroy's mind, but we want relevant facts; it is quite true if you put an undue tension upon an old 68-pounder, it will not stand; if you reduce its windage unduly it will burst; but the question is, Can you make a gun such as he is arguing for being made, built up if you please, or of wrought iron, that will stand it? I say, if Sir William Armstrong's gun will bear the enormous tension which he tells us it does, make them on the same principle, but let them be smooth bores, and let them have small windage; he says the guns will burst if they have small windage.



This which I have described as being  $\cdot 233$  in the 32-pounder (see Table D.) has been reduced by Monk to  $\cdot 175$ , but we have got guns with less windage than that. Colonel Lefroy knows perfectly well that in the arsenal there are many guns which have the windage as low as  $\cdot 120$ , and I believe even as low as  $\cdot 1$ , very nearly one-half of that which I have described as the windage of the 68-pounder. But what is the fact with respect to the Armstrong gun, I mean the multigrooved gun? If there is no windage at all, either it has less tension, and does not bear the enormous strain he tells us it does, or else we can reduce the windage of our guns very materially. I do not profess to a great deal of scientific accuracy, but I do believe that I have taken pains, and that I am accurate as respects these statements.

On the motion of General Lindsay, seconded by General Boileau, the discussion was adjourned to the following evening.

## ADJOURNED DISCUSSION.

Tuesday Evening, May 20th, 1862.

Colonel P. J. YORKE, F.R.S., in the Chair.

Sir W. ARMSTRONG, C.B.: Mr. Chairman and Gentlemen,—The chief argument adduced last evening by Captain Fishbourne, in support of his position that rifled guns were inferior to smooth-bores, was the alleged incapacity of the rifle to produce high initial velocities. This he attributed to the friction sustained by the cylindrical projectile in passing through the bore; but he adduced no experiment in support of that view. I, on the contrary, taking an opposite view, am enabled to refer to experiments which were made only last week, in which the rifled 12-pounder gun was loaded with a charge of one-fourth instead of one-eighth the weight of its projectile, the same in fact as the usual charge of the smooth-bore 68-pounder, and the result was that the initial velocity rose to 1,740 feet per second, being something more than the initial velocity of the round-shot gun; I can also appeal to experiments which have been made with lead-coated projectiles, having the lead considerably reduced in diameter, so as to facilitate the passage of the shot through the bore, and it was found that, instead of the reduced friction increasing the initial velocity, the result was rather the contrary.

Now, this is not at all difficult to understand, because you will easily see that by holding back the projectile until the powder is thoroughly converted into gas, that you will get a higher pressure upon the projectile, and impress a greater quantity of work upon it. But at the same time, those two facts of the greater initial velocity attained with the increased charge, and of the effect of diminishing the friction, put an end to the argument which was advanced last night by Captain Fishbourne, to the effect that the friction of the shot through the bore, was the cause of the loss of the velocity. Now, the fact is, the low velocity of a rifle projectile is due to a very simple and very intelligible cause. It is simply this, that the weight of the projectile is unusually large in relation to the charge. It is fired with one-eighth, instead of being fired with one-fourth, and of course it is perfectly natural that the velocity should be lost; in fact, the rifle projectile is generally equal in weight to about two spheres, and it is precisely equivalent to loading a smooth-bore gun with two shot instead of one. If Captain Fishbourne will try the experiment, he will find, if he double-shots his gun, notwithstanding the absence of that friction which he ascribes to the rifle-shot, the initial velocity of the two spherical shot will not be one atom greater than the initial velocity of the elongated shot of the rifle projectile. But although in the rifle projectile we get a smaller velocity, we, on the other hand, gain by the additional weight. The measure of the damaging effect of a shot is well known to be expressed by the square of the velocity multiplied by the weight; so that the energy or power of inflicting mischief in the case of a 68-pounder, which has an initial velocity of about 1,580 feet a second, would be expressed by 1,580 squared, multiplied by 68, the weight of the projectile. On the other hand, the energy or mechanical force of the rifled 110-pounder, would be expressed by 1,210, which, with the charge of 14lbs., is about its initial velocity; 1,210 squared, multiplied by the weight of the projectile, 110lbs. Those numbers work out rather large; but the result would be a proportion of about 17 to 16 in favour of the 68-pounder gun. That is at the muzzle of the gun; and this small difference, you observe, is not even proportioned to the difference in the charge; it has been clearly ascertained that, where the charge is increased, the effect is increased quite in the same proportion. Now I am