The Progress of Ordnance Abroad Compared with that of Ordnance at Home

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THE PROGRESS OF ORDNANCE ABROAD COMPARED WITH THAT OF ORDNANCE AT HOME.

By Commander R. A. E. SCOTT, R. N.

I do not think I can commence this paper better than by quoting the words of the present distinguished Chief of the Admiralty, the Duke of Somerset,* respecting the value of this Institution, in which subjects that are not only professional, but such as are of deep interest to all Englishmen, can be discussed in the fair and open manner necessary to elicit truth. His Grace says:—

“I know in regard to the Navy a great many things are discovered, and are put aside for the want of a proper place to preserve them. Many years afterwards what are thought to be discoveries are made, and we often find, if we had looked back and consulted our papers, that the discoveries had been made a long time ago. That is continually occurring, and it shows of what great advantage an institution of this kind may be, in recording information of this character and communicating it throughout the Services.

“If you adopt as a matter of faith that So-and-so is quite right, and that whoever says to the contrary has a bad motive, and is a dishonest fellow, why, you may settle the question easily in your own mind, but you do not settle it to the interests of the country. What we have to do is to look at these questions calmly in all their bearings, and I am sure, if that were done, we should then arrive at a satisfactory result.”

Yet there may still be doubts in the minds of some as to the advisability of speaking the whole truth. Let such persons learn from the wise example of the Emperor across the water in at once exposing the real state of the finances of France, and thus making friends of his people by admitting them to his confidence.

It is only in great minds, and amongst a great people, that there is a readiness to acknowledge error; little minds and a little people try rather to shuffle out of false positions than to frankly admit a mistake; and there may be some who, like the bird that tucks its head under its wing, refuse to see. Such persons would desire to shut out the truth; but of what advantage is it to hide our true position from our own people? “To be forewarned is to be forearmed,” the proverb says, and any one who reads the French and other foreign works must know that continental nations narrowly watch our progress, and can estimate the full value of our changes far better than we do ourselves. We indeed have been too well satisfied; to properly consider and carefully weigh the effects of our alterations;

* Vide the Duke of Somerset's speech at the General Annual Meeting, on the 2nd March, 1861.

but, should war unfortunately take place, the present blind confidence in our armaments might be rudely dissipated, and untried weapons fail us at our utmost need.

Lately public attention has been much occupied with our naval armaments, and there is no subject of greater national importance; for on our maritime supremacy, our high position, nay, our very existence as a great people (humanly speaking), depends. There is therefore a necessity for thoroughly ventilating and settling the matter definitively. This will at once be evident, as well to the landsman present as to the seaman, when he is informed that, in a frigate of 51 guns, he may find, in consequence of our recent changes in ordnance, six different guns, and five different kinds of shot.

The naval artillerist is already too well aware of the disadvantages he will be placed under by such complications, and knows what must result from them when men's nerves are highly strung, comrades falling around, and smoke and splinters filling the decks; and, since there are in this Institution a large proportion of experienced officers both naval and military, I can confidently look for a patient hearing, and an unprejudiced decision upon the truth or error of my views.

In my former lectures, published in the nineteenth number of the Journal, I pointed out defects in the systems which at that moment were enjoying popularity in England, and I have since seen my statements fully confirmed. This evening I will endeavour to place before you what foreign nations are doing, and ask you to join me in contrasting their progress with our own, so as to see how far we have advanced relatively, if not absolutely.

Foreign Rifled Guns of Early Date.

It may cause surprise to hear how early rifled guns were used. In the Arsenal of St. Petersburg is a gun $2\frac{3}{4}$ inches in diameter, and 62 inches in length of bore, which was rifled in nine grooves in 1615. This gun is a breech-loader, and there are several wall-pieces and rifled muskets in the French and other museums, which were grooved about this date on plans that have been lately revived.

In 1661 the Prussians experimented at Berlin with a gun rifled in thirteen shallow grooves.

1694. Nuremberg had a gun forged and rifled, which was tested on several occasions.

1696. The elliptical bore was known, and had been tried in various parts of Germany.

1745. The date at which Robins was experimenting in England, the Swiss already possessed small rifled pieces.

1746. Munich had a rifled breech-loader made, and T. Senner was engaged in rifling various guns.

1816. Reichenbach rifled a bronze gun with seven grooves. This piece is still in possession of the family in Bavaria, and has been fired with pointed leaden balls.

1816 to 1819. M. Ponchara, a distinguished French artillery officer, was making various experiments with an old gun which he had rifled with thirteen grooves.

Fig. 1.

Montigny Breech Loader.

Fig. 2^a

Longitudinal Section.

Cavalli Breech Loader.

Fig. 3.

Plan View.

Fig. 4^a

Wahrendorf Breech Loader.
Longitudinal Section.

Fig. 4.

Fig. 5.

Austrian 24 Pf Howitzer

$\frac{3}{4}$ Elevation & $\frac{1}{2}$ Horizontal Section.

Fig. 6.

Timmerhans
Wad & Shot

Russian 56 Pf

Longitudinal Section.

Russian 120 Pf

Elevation

Spanish Projectile

Fig. 12. Fig. 13.

Prussian Field Piece.
Plan View partly in Section.

Cavalli Projectile

Russian Projectile

Transverse Section.

$\frac{1}{2}$ Elevation $\frac{1}{2}$ Section.

1833. Montigny of Brussels invented a breech-loading rifled piece, and the Belgian government had a gun made on his plan. The arrangement of the breech apparatus was simplified in 1835.

1836. The late Emperor of Russia, Nicholas, sent for the inventor, and ordered breech-loading guns of 18 and 24-pound calibres to be made and rifled on Montigny's plan. 1,800 rounds had been previously completed in his presence from a 12-pounder. When these guns were prepared 262 shots were fired in one day from the 18-pounder, and 100 shots continuously on successive days from both the 18 and 24-pounders, and neither was nor grease was used. But the commission presided over by General Samarakoff rejected the plan. (Plate I, fig. 1). After this, Montigny, the son of the former, went to England, but his applications for an extended trial were unsuccessful.

1845. Major Cavalli, a Sardinian officer, commenced his experiments on rifling, and these seem to have inspired Währendorf with a similar aim. Cavalli used a copper ring for closing the breech-joint, and he also tried a copper tube in the breech of his gun, which was rifled with two grooves for a plain iron shot. (See Plate I. figs. 2, 2a, and 3).

1846. The Swedish Baron Währendorf, before mentioned, affixed lead to the side of elongated projectiles mechanically, *thus*, and used a gun rifled with shallow flat grooves.

1847. Major Cavalli rifled an 8-inch gun, and attained good results, until the copper breech-ring was blown out. The breech of the gun subsequently gave way, just as happened in his later experiments in England.

1851. Währendorf's plan of coating the shot with lead was tried at Berlin with a 12-pounder rifled in six grooves, and a slow twist. The shells for this experiment were cast with two long and four short projections or studs, over which the lead coating was run. Währendorf also rifled guns with two grooves on a plan similar to that of Cavalli, but the lead coating, his own peculiar plan, was preferred by the Prussians. In Sweden, however, Währendorf's own country, the officers generally were opposed to the lead-coated or forced-ball system (so called from the projectile's outer surface of lead being larger than the bore, which necessitated loading at the breech), and a lieutenant in the Swedish navy named Engström affixed hard wood bearings or buttons to an iron projectile. This plan was tried against Währendorf's lead-coating system, but nothing transpired as to which had the advantage, until, in the Annals of the Swedish Academy of Sciences, which were published in 1859, the preference was accorded to the Engström system. Both plans were afterwards tested in France in 1857 by order of the Emperor Napoleon, but neither seems to have been considered as a great success. (In Plate I. figs. 4 and 4a, is shown the Währendorf gun.)

1856. General Timmerhans, of the Belgian Artillery, invented a wad which, by taking the rifle-grooves, gave rotation to elongated shot. His guns were rifled with two, four, and six grooves, with one turn in 18 feet, but the results were not sufficiently good to cause an adoption of the plan, which is shown in Plate I. fig. 5. Indeed every system that has been tried,

which does not give rotation to the ball from grooves in the bore, has failed in such manner as to show the impracticability of beneficially applying any other arrangement than that of rifling both gun and projectile.*

Not only plans of rifling, but also systems of breech-loading, have been continually brought forward, which have been sometimes identical with, and at others trifling modifications from, those of more ancient date; and it is also a fact that nearly every modern plan of grooving was used at least 250 years ago in muskets which seem to have been fired with round leaden balls. These necessarily gave little accuracy, and hence rifling did not supplant the smooth bore for muskets until an elongated ball was used, and it has not yet caused the smooth-bore great gun to be set aside. It should however be remembered that the mechanical fit was unknown in the early age of rifling, and it has been reserved to Mr. Whitworth to be the pioneer in the path of shaping the shot so accurately as to centre itself in a grooved gun. M. Cavalli certainly made very good practice with an iron shot, but this was from its tight fitting, which necessarily, like Wahrendorf's plan, required a breech-loader; but it was not until the precision of Mr. Whitworth's guns became known, that great accuracy from muzzle-loaders was regarded as even possible.

Breech-loaders—Wahrendorf and Cavalli.

The first breech-loading gun upon record was used by the English (and on this account I mention it) in 1428 at the siege of Orleans, but whether made in England or not is uncertain. France very early made breech-loaders, and her museums, as well as those of Strasbourg and Bavaria, contain breech-loaders of very early date, and in England there is also a large collection of foreign guns.†

Passing over, however, the breech-loaders of former years, it may be remarked that, in later days, not even the experiments of the elder Montigny, successful as they were, nor the later improvements of his son, succeeded in bringing breech-loading into general use; but, in 1842, Wahrendorf brought forward a plan which for simplicity and strength is still unrivalled. It consists of a round bolt passing through and across the breech, and supporting a valve from which a handle extends to the rear of the gun. When the gun is to be loaded, the bolt is withdrawn, and the valve pulled out by its stem or handle; and, when this operation is completed, the valve is pushed in, and the bolt shot across behind it; and they are then set tightly together by the turn of a screw upon the handle, which projects out of the rear of the gun. (Plate I. fig. 4). The effect of the discharge is to push the valve more tightly against the bolt, and the greater the force of the explosion the more is the valve itself extended. Even should an escape of gas occur, which is unlikely, no great damage can

* In preparing this account of foreign ordnance, the author has met with considerable difficulties, for so little is generally known that even the descriptions of otherwise credible eye-witnesses cannot be fully relied on, from their not understanding the points in which systems of rifling differ.—R. A. E. S.

† In the Museum on Woolwich Common is a French gun dated 1619, with a moveable vent-piece almost identical with that of the present service rifled guns.—R. A. E. S.

be done; but, in all the experiments, the valve, from being on the principle of the steam-piston, seems to have perfectly closed the breech. The gun of 1842 was designed for firing round shot which were covered with lead so as to close the windage. The plan was tried at Shoeburyness, and on board the "Excellent," but the results came far short of the inventor's expectations. Indeed, cutting off the windage entirely, from which such great results were formerly expected, is now found to be a disadvantage. Wahrendorf subsequently introduced an oblong instead of a rounded bolt for the breech apparatus of his rifled guns, and one of these is now under trial by the Ordnance Select Committee—the Service plan of closing the breech by a screw-stopper, and the later plan of effecting the same object by a pair of wedges, having proved equally unsatisfactory.

Caavalli's plan of breech-loading is very similar to that of Wahrendorf, but the apparatus is less simple. There were several of his rifled guns at the siege of Gaëta, but so many accidents happened with them in the trenches, that, on the bursting of a pivot-gun, which reduced the gun-boat to a wreck, the Sardinians, or rather the Italians, following the example of the French and Americans, abandoned the breech-loading, and are now only making muzzle-loading guns. Thus, while, after more than four centuries of trial, other nations are giving up the moveable breech because it does not unite perfect closing of the breech with the solidity essential for heavy guns, we are still going from plan to plan in the hope of effecting what will, even if successful in closing the breech, be scarcely safe with the heavy charges necessary to give the high velocity of projectile which is requisite for smashing armour plates.

But I must here go back a step to mention one, Treuille de Beaulieu, whose researches, following his previous experience of warfare, have so much influenced the rifling of the guns of European nations, and to whom France owes her present system. Long had he to struggle against opposition, and to bear the contemptuous treatment of his proposals by committees.

In the case of the elder Montigny, we have already seen that, although the Emperor Nicholas invited him to St. Petersburg, and the results were most satisfactory, the committee of the Russian Artillery, after putting all kinds of obstacles in his way, obliged the unfortunate inventor to discontinue his labours in their country; and but for this jealousy, so unfortunate for the Russians, they might have met us at Sebastopol with rifled guns.

French Rifled Muzzle-Loaders.

You will perhaps be surprised to hear that, so early as 1842, M. Treuille de Beaulieu addressed a complete paper on the subject of rifling guns to the French Artillery Committee, who, it is said, had not even the politeness to acknowledge its receipt.

In 1850 this artillery officer again urged his proposal, and this time the Committee, with a little more courtesy, did acknowledge the receipt of his letter, but this was the extent of attention they gave the subject.

Now we have seen first one committee rejecting a system for rifling, which deprived the Russians of a weapon that might have gone far to counteract their disasters in the Crimea, at Silistria, and at Bomarsund;

and we have seen a second throwing aside a plan, which deprived France, during its contest with the Russians, of a weapon that gave such remarkable assistance in their subsequent combats with Austria.

Colonel Treuille de Beaulieu's paper would probably have remained to this day in the pigeon-holes of the French Committee office, had not the Emperor, persuaded that smooth-bore guns were not equal to the requirements of modern warfare, stirred up the question of rifled arms, and led to the production of the artillery colonel's paper, somewhat about the time that Lieutenant Engström's plan was under trial in France. I may here venture to remark, that a despotic prime minister, who, despite committees, and in defiance of precedents, will take upon himself the responsibility of ordering the trial of a system which gives reasonable hope of success, and on a sufficient scale to test its merits, only endears himself the more to the people as a thorough patriot; and, as such, all must esteem Lord Palmerston, and admire his decision for an immediate trial of a battery of Mr. Whitworth's guns. Excuse this little digression, and I will return to Colonel Treuille de Beaulieu, and what he has done for the French artillery.

The French Emperor, after satisfying himself of the superiority of the Colonel's plan over that of Engström's wooden bearings and Wahrendorf's lead, at once rifled some brass pieces, and sent them for immediate service in Algeria. Here their success was apparent, but the guns were considered too heavy, and, on receiving this report, the Emperor rifled his light brass pieces, and thus, at a very trifling expense, France was placed in possession of the artillery which was soon to do such good service in the field. These pieces consumed their usual powder and their ordinary shot as well as fired the elongated projectile, an arrangement that enabled the French to cut up the astounded reserves of Austria when at a distance, and to overthrow their squadrons at close quarters by the unfailing case-shot. The repulse of the Austrian cavalry is worth recording—they had formed in the plain, and were seen from the heights bearing down upon the thinned and wearied columns of the French infantry, when the order "load with case" was given to the artillery, and, as the cavalry dashed onwards, burning to achieve a victory, they were met and rolled over by a shower of canister-balls that sent back many a charger riderless, leaving gaps in their ranks which hopelessly disordered the survivors, and prevented them from again returning to the charge.

The rifling of the French bronze field-pieces that did this execution consisted of six rounded grooves, and the projectiles had twelve zinc studs* or buttons placed in pairs (see Plate I. fig. 6), one stud being arranged so as to push the bearings of the shot tight against those sides of the groove on which it would press in coming out, to prevent an injurious play on the shot's starting. The weight of the gun is about 6 cwt., and

* The French sloped off the bearing side of the buttons to the angle at which they were found to have been rubbed down by the rifle grooves on discharge, and they attributed much importance to the use of zinc; but have latterly discovered that accuracy of adjustment of bearing is alone required. The rubbing down aslant merely showed that the projectiles were not preserved concentric in their passage out of the gun. One of the projectiles fired at Solferino is in the Museum of the Institution, together with various rifle-shot used in England.—R. A. E. S.

that of its rifle projectile 9lbs., and it was this lightness which enabled Tartar ponies to draw the French field-pieces through the marshes of China, in which our own guns of $8\frac{1}{2}$ cwt., and mounted upon heavy carriages, stuck; a defect which is about to be remedied by introducing an Armstrong gun and shot of the same weight as the French.

Besides these field-pieces, the French, after careful trials of the two-grooved elliptical rifling for larger ordnance, gave it up for three central grooves in December, 1860, and, as the plan was simple and inexpensive, they at once carried it out with their heavy guns, and were again ready for the contest. The ordnance thus treated were cast-iron 30 and 50-pounders, which were rifled so as, in addition to their usual smooth-bore ammunition, to throw shells of 60 and 89lbs., containing $5\frac{1}{2}$ and about 8lbs. of powder respectively. These guns were strengthened by hoops put on the breech. (*Vide* Captain Blakely's Lecture, vol. iv. p. 401 of the Journal of the Institution.)

The projectiles, instead of having twelve studs wholly of white metal, were fitted with three large studs, one half of which were of zinc, and the other half cast on the shell. (See vol. v. page 434, plate ii. of the Journal). The rifling of the gun commences from straight, and increases gradually in quickness of turn from breech to muzzle, the object aimed at, being to allow the projectile to move easily at the first impact of the charge, so as to lessen the strain upon the breech. This is, in my opinion, a mistake, for the studs strike the sides of the rifling very hard, which, besides wearing down the edges of the grooves, breaks off portions of the studs, occasioning an erratic flight to be taken by the ball. These studs are also liable to injury from carriage, and flattening by a fall. In both cases there might be a difficulty in loading, and they are not safe for firing over ships or advanced works.

In the cast-iron service 32-pounder, which was rifled on the French plan, and tried at Shoeburyness, the zinc was put upon the wrong side of the button, so that in loading the zinc pressed against the grooves, and, on coming out, the iron came in contact with them. The consequence was, that, in 40 rounds, the iron had knocked away the edges of the bearings of the grooves, and rendered the gun unserviceable; but, despite these disadvantages, the practice so impressed one of the competitors, that he said, "Well! that is a good plan!" and, as his own gun was in trial, we may take what he said as of some value.

In addition to these naval guns, the French have some light brass mortars, which are likely to prove useful for dropping shells upon the deck and into the engine-room of a foe.

Austrian Rifling.

The Austrians, taught the value of rifled pieces at Solferino and Magenta, must be admitted to be not bad judges of the worth of the French plan. Their first trials of rifling commenced about 1857, and were continued through 1858 and 1859 without any decision being arrived at; but, on the 4th April, 1860, after some previous experiments, breech and muzzle loading rifles, and lead-coating and French studs, were tried against each other. On this occasion the Emperor was present, and a

unanimous decision was given in favour of Treuille de Beaulieu's plan, because—

1st. It could be quickly and cheaply carried out.

2ndly. It united facility of fire with sufficient accuracy.

3rdly. It combined in one piece the advantage of the gun and howitzer.

4thly. It allowed of the employment of all the existing material.

But mark, Austria is not satisfied that she possesses the best gun, and, since February, 1861, has been making trials of three systems of rifling. She is also making experiments with a new metal for ordnance, and has lately obtained excellent results from gun-cotton, which has been fired from short and thick-chambered pieces of bronze. (See Plate I. fig. 7.)

Austria, like France, Spain, and other countries, has made trials of finely-grooved breech-loaders on a plan similar or analogous to that adopted in this country, and did intend in 1859 to cast breech-loaders at Marcazell, but decided in 1860 that any advantages in accuracy from centering the projectile on so many points was more than counter-balanced by the greater delicacy and expense of lead-coated shot, and the want of solidity resulting from a breech-loading plan.

Russian Rifling.

The Russians are now endeavouring to make up for lost time, and to rifle the heavy ordnance, mounted on their various fortresses, on a plan similar to that of the French. They have already purchased portable rifling machines from Messrs. Vavasseur and Co. of London, with the intention of grooving the guns without moving them off their carriages; and they also mean to use the rifling machines in a similar manner on board some of their ships; but their larger guns*—120-pounders of 10½ inches bore, firing a hollow shot of 120lbs. (the solid would be about 160 lbs.) and the 56-pounders, which are like the American columbiads—they now intend to rifle. (These guns are shown in Plate I. figs. 8 and 9.)

The Russians had rifled several of their smaller fortress guns (30-pounders and 24-pounders) with six grooves, and their field-pieces have been mostly rifled in a similar manner, but, instead of placing the studs in pairs, and having twelve of them, they use only six placed alternately. Their rifling has an equal twist, and the grooves are slightly narrowed at the bottom. In the field-piece they are sloped off on one side to allow the projectile, the bearings of which are also sloped off, to wedge itself tightly; but these slight modifications, which have been also tried in France, possess no advantage over the fittings adopted for the French service. (See Plate I. figs. 10 and 11).

Swedish and Dutch Rifling.

In Sweden, Baron Wahrendorf's own country, Lieutenant Engström's

* These guns are, it is believed, to be strengthened at the breech by hooping, and may then be rifled in three grooves to fire a projectile with long iron bearings instead of studs, as the Russian trials with this plan have been satisfactory. An officer was lately in England gathering information respecting the English experiments with iron shot.—
R. A. E. S.

system was preferred; but the French plan is considered still better, and is the one now used.

The Dutch have also preferred the French system of rifling and have applied it to bronze guns. The reasons for this almost general adoption are given in very similar terms to those made use of in France, viz. that M. Treuille de Beaulieu's system was—

The simplest;

The quickest and easiest to carry out;

The cheapest, and involved no complications.

Spanish Rifling and Strengthening for Cast-iron Guns.

The Spaniards rifled their field-guns on the French plan, and used them against the Moors at the siege of Tetuan, and—as an author, M. Mangeot, whose researches I have largely availed myself of, states—“taught the Moors by improved weapons the advantages of civilization.”

Their heavy guns have, like the French, been lately rifled with three grooves, the only difference being that the twist of the rifling is uniform, and that the projectiles have studs in pairs instead of one large stud only for bearings. (See Plate I. figs. 12 and 13.) Spain has also followed the example of France in hooping her heavy ordnance, having previously ascertained that the unhooped cast-iron guns rapidly deteriorated, and ultimately burst at less than 200 rounds, but that the hooped guns, when properly fitted, which was arrived at by careful experiment, always stood more than 1000 successive discharges.

The final decision of the Spanish Committee is thus given: “The path we must follow is clearly indicated,—cast-iron cylinders hooped, a most simple manufacture, which, once established, only requires great care in securing the proper diameter to the bore of the hoops. The difference between the diameters of the hoops and of the cast-iron part must be determined by experiment aided by calculation.”

Sardinian Rifling.

The Italians made several trials of Cavalli's system of rifling in two grooves at Turin, and ultimately decided that the ribs on his shot were unfit for field-pieces. These ribs projected too far for the size and weight of the shot, and consequently stopped the rotation, and materially lessened the range. The tightness of fit was found also to be a serious objection to using the plan for muzzle-loading.

At the siege of Gâeta many of the guns used were grooved on the French system, and some threw zinc-ribbed shot similar to those used in the Armstrong shunt: but the guns for these last, and a crowd of various small calibres of guns, were gradually suppressed, Cavalli's and Wahren-dorf's systems abandoned, and breech-loading entirely given up. The “*Revista Militare*” of Turin, dated 1859, contains, according to Fourcault, a full account of the failure of the breech-loaders, and states that the accidents which happened had been fully anticipated, the plan being unfit for heavy guns; and thus the Italians, having first adopted the French plan for field-pieces, now took it in its entirety for heavy guns also.

Prussian Rifling for Cast-iron and Steel Guns, and Belgian Rifling and Bessemer Metal.

But are any nations using the lead-coated shot? Yes; the Prussians, who first adopted breech-loading and a compression plan.

They have had a large number of steel field-pieces made by Krupp of Essen; these weigh 800lbs. and throw projectiles of 13lbs.; but their heavier guns are cast from charcoal iron of a very superior quality; but mark, with these rifled guns the Prussians have retained several smooth-bores, so as not to lose the advantages of the straight ricochetting and rolling of the round ball. Their field-gun is given at Plate I. fig 14.

The Belgians also, impressed by the accounts of the immeasurable superiority of the English rifled piece, and influenced by Prussia, seem to have very lately decided upon lead-coating, but have wisely adopted a slight modification of Wahrendorf's plan of closing the breech; this differs from the Armstrong in that, while a little extra pressure forces the breech-stopper (vent-piece) of the latter away from the end of the bore, causing a dangerous escape of gas, the valve face of the Wahrendorf stopper is only more fully expanded and the stopper more tightly pushed against the bolt which supports it in the bore of the gun. [Shown by a model on the table].

The Belgians are also testing Bessemer's steel for rifled guns, and have, as far as their trials have gone, found it to be a very superior metal; and, as it can be produced at comparatively small cost, they will probably largely employ it.

In England, Bessemer's own country, his metal has not yet been tried by Government, but it was used in one of Mr. Whitworth's guns.

Portuguese, Swiss, and Egyptian Rifling.

Not to fatigue you by further details of the guns of European countries, I may mention that, besides the nations spoken of as having preferred the French system on account of its simplicity, its allowing of the use of the old ammunition, and combining the advantages of the smooth-bore and rifle,—the Portuguese, the Swiss, aye, even the Egyptians, have, after careful trials, condemned breech-loaders and delicate projectiles as unfit for the rough usage of war, and have followed the safer plan of rifling their present guns and using elongated shot as well as all their present ammunition.—(Fourcault, "Le Canon Prussien," edition of 1861).

American Large Iron Guns, cast hollow.

But it is time to go across the water to the Americans and to examine what they have done. You must all have heard of the Dahlgren and Columbiad guns. The former is in shape very like a soda-water bottle, being much rounded over the breech; the latter is rather a straighter gun; but of the large weapons, which alone seem to be in favour in the States, their 15-inch-bore guns are the most in favour. (*Vide* Plate II. fig. 1.) The gun represented was cast hollow at the Pittsburg foundry, under the direction and after the method of Captain F. J. Rodman; it weighs 49,100lbs., and is 165 inches long in the bore; the thickness of metal

S K E T C H E S .

Fig. 1.

American 15 Inch Gun.
Weight 40,000 lbs.

Section, Parrot or Blakeley Gun.

Fig. 2.

Fig. 5.
Horizontal Section of 19 Inch Sea Service Mortar.

Line of

Fracture

Fig. 3.

Armstrongs Cast Iron Hooped Naval Gun.

a. a. Space covered by Wrought Iron Hoops.

Fig. 7.
Longitudinal Section of Gun.

a. a. a. Space occupied by Spiral Jacketing.

Fig. 8.
68 PF Cast Iron Gun.

a. a. Diameter of original Bore.
b. b. Diameter of bored Bore.
c. c. Wrought Iron Tube, occupying space bored out

Fig. 4.

Side Elevation of Cast Iron Gun, showing mode of strengthening by
Wrought Iron Hoops tried in England 1861.

Fig. 6.

Form for New Cast Iron Guns.

through the sides of the gun at the junction of the bore with the chamber is $16\frac{1}{2}$ inches, and the thickness of the metal at the muzzle 5 inches.

This gun had fired 350 rounds before the middle of last year with shells weighing from 305 to 335lbs., and an average charge of 35lbs. of large-grained powder; it was worked with facility, requiring from 1' 10" to 1' 52" to complete loading, running out, training, and firing.

At 6° elevation, the shot struck the ground at 2017, 1937, 1902, 1892, and 1873 yards; the lateral deviations being 1, 3, $\frac{3}{2}$, 5 yards to right, and 5 yards to the left. The time of flight was from $6\frac{1}{2}$ to 7 seconds. The initial velocity was found by experiment to be 1328 ft. per second with 40lbs. of large-grained powder, and 1282 ft. per second with 50lbs. of perforated cake.

At 28° 35' elevation, the range of this gun with shell of 334lbs. was found to be 5,200 yards with 50lbs. perforated cake, and 5,400 with 40lbs. of large-grain powder; the time of flight being about 27 seconds.

The large-grain powder used, differed from common powder only in the size of the grains, which are $\frac{1}{10}$ inch cube, and in the degree of pressure to which it is subjected in manufacture.

The perforated-cake powder, invented by Rodman, is prepared in solid compressed cakes (subjected to a pressure in the making equal to what they will be subjected to in the gun), and perforated with holes to permit access to the flame; it is intended to reduce the excessive strain to which very large guns are subjected with fine-grained powders, which are inflamed almost instantaneously, and before the heavy projectile is started from its seat. This was ascertained by the "pressure gauge" attached to the gun, or introduced into its chamber; and the comparative initial pressures of "perforated cake," "large-grained," and common cannon powder, were thus found to have about the ratios of $\frac{1}{4}$, $\frac{1}{3}$, and unity. This, writes Major J. Barnard, of the U. S. Engineers, is a result of very great importance in its bearing upon the practicability of using cast-iron guns of extraordinary calibres.

Speaking of rifled guns, Major Barnard says range and accuracy are of little value unless the projectile possesses the necessary destructive qualities. And again, "to damage a vessel seriously it is not the hole-punching property which we need; it is the smashing effect, the staving in of planking and timber; or, if a hole alone is made, that it shall be so large as to defy plugging."

The Americans are abolishing 24 and 32-pounder guns, and substituting Columbiads and Dahlgrens, rightly considering that such small-bore guns will be of little use in a future conflict. The early guns had a large chamber of less diameter than the bore itself, but this was found very objectionable in practice, as the shortening or reducing of the charge left an air-space which endangered the safety of the gun. During the last war with England the Americans used a very thin metal instead of flannel to cover the powder, in order to prevent the necessity of sponging at close quarters; and they have lately succeeded in making their powder water-proof. Another of their plans is to cover their old round shot with pulp to reduce the windage, which is, even in the 15-inch gun, only $\frac{1}{16}$ of an inch; we, however, foolishly continue to give a windage which was necessary some

50 years since, when balls could not be cast truly spherical; but which with the exactness of the present castings, under the very able superintendence of the head of the Laboratory Department, could be now advantageously reduced by one half.

American Strengthened Rifled Guns.

The Americans have rifled their field-pieces, and have been rifling some of their heavy ordnance; the "Parrott" gun is merely a cast-iron piece rifled and then strengthened by hoops on the Blakely plan. (See Plate II. fig. 2.) The *Times*' Correspondent writes thus: "The Parrott gun, made by the eminent founder at West Point, is a simple workman-like-looking piece of artillery, with a thick iron band shrunk over the breech, and its range is nearly as great as that of the Armstrong, and its cost very much less;" and again, "Captain Dahlgren informed me he was surprised to find we were content with iron in our guns of such inferior fibre;" and also, "in the qualities of iron the Americans say our standard is much lower than theirs."

This opinion seems to be borne out by the unequal expansion of the cast-iron guns which were lately attempted to be strengthened by tubing (see page 18), when the bending, on heating, occasioned the destruction of two guns before one could be successfully tubed; and in the English work on "The Useful Metals" it is stated, at page 213, that "The quality of our pig-iron has deteriorated within the last half-century. In an English gun imported into America in 1845, the cast-iron was of a density of 7.04, and tensile strength of 18,145lbs. to the square inch; while other English guns, imported about thirty years previously, contained metal of a density of 7.202, and tensile strength corresponding to 28,067lbs. to the square inch."

The Americans have invented many breech-loaders, and amongst others a plan which they supplied to this country, at a cost, of, I believe, 10,000*l.* including the six guns and patent. These six guns are still lying near where they were landed in the Arsenal, quite unfit for use; they are rifled with several shallow grooves similar to those used by Prussia, and were intended to fire lead-coated shot.

The Americans, however, carefully eschew the use of breech-loaders, though they seem to have been at first favourable to compound projectiles. The Southern Confederacy has purchased very many of its heavy guns from England, which, with few exceptions, fire lead-coated shell. At the cannonading against Fort Pickens, these leaded projectiles struck on their base, which was heavier than the front, and did not explode; the range obtained was, however, sufficient to show the value of rifled weapons, for the smooth-bores mounted in Fort Pickens were unable to reply to the distant bombardment.

The value of rifled guns was equally shown in the chase of a small Confederate steamer by the North American frigate "Minnesota;" for the former pitched several rifle shells upon the latter's deck, causing very serious damage, and some loss of life, while keeping quite out of reach of the latter's smooth-bore guns.

It only remains to add, that the Americans have rifled their field-pieces,

and are reducing their guns to as few calibres as possible, following in this the example of the French, who are, it is said, bringing the mass of their ordnance to 4 calibres, viz., 1 for the field, 1 for the siege, and 2 for naval purposes, viz. 30 and 50-pounders; and this wise plan is also being followed by Austria and Sardinia.

Having thus examined what continental nations and our cousins across the Atlantic are doing, it will be well to compare our own progress with what they have effected at so small an amount of effort and expense: in fact, foreign countries have, for the most part, given to their old guns by rifling a very great increase of range, and obtained greater effect by the use of elongated shells, still retaining the use of their former ammunition.

English Rifles; Solid Round Shot and Shell Guns.

England, however, unrivalled in resources and in manufacture, has adopted a new gun, and with it a principle of rifling, which cannot be applied to her old artillery; she is therefore, like Prussia, obliged to retain smooth bores, and thus to have two guns to perform the work of one; and, while most other countries are reducing the various kinds of ordnance to four or six sizes of bore altogether, we have already seven or eight small calibres and about 20 varieties of Armstrongs, in addition to as many or more different diameters and descriptions of smooth-bore guns. Awakened, as we were, from our complacency respecting the old ordnance, we have very much over-estimated the effects which would be produced by rifled ordnance, and hence have neglected the improvement of our cast-iron guns; and, as the Armstrong system could only be applied to specially constructed weapons, the smooth-bores were at first virtually put aside, being regarded by those who had little experience of warfare with something approaching the contempt entertained for "Brown Bess." This did not, however, lead to stopping the supply of cast-iron ordnance, and we have continued to receive shot and also *shell* guns, which answered well whilst the round ball and the round shell were alone fired, though, even then, the larger guns were barely strong enough (from being cast of bad form and solid instead of hollow); but now that round balls are only valuable within 600 yards against plated ships, and shells of little or no use against them, their form, size, and mode of manufacture, are evidently unequal to the requirements of modern warfare.

English Plans for Strengthening Cast-iron Guns; Casting upon a Core; and Remarks upon English and French Rifling.

In manufacturing the new artillery, difficulties soon arose, and it likewise became evident, that the force required to squeeze a leaded ball through a barrel of smaller size than itself threw a strain upon the weapon, which increased in a very rapid ratio as the size of the bore increased. The shunt method of rifling had been tried with a cast-iron service 32-pounder in 1859, and this gun bursting at the 50th round, indicated that an increase of strength was necessary, and therefore "hooping," which had been proved a success when applied by Captain Blakely in 1856, was again resorted to.

Instead, however, of hooping the existing ordnance on a plan which had proved successful, a new pattern weapon, which was thick in front of

the trunnions, and very thin at the breech, was supplied. (See Plate II. fig. 3.) But as the hooping, *a a*, did not unite the cast-iron to the wrought-iron bands, the weapons had so little longitudinal strength, and were so weak at *b b*, where the thickness of cast-iron was suddenly reduced 2 or 3 inches, that the guns proved unsafe.

The next plan tried was that of casting gun-metal upon these iron weapons; but the molten brass, after burning the iron it was thus cast upon, proved to be so yielding, that the iron breech burst and opened about an inch without any (apparently) great strain being thrown upon the brass. Captain Blakely was then permitted to try to utilise these new iron castings, and his method has hitherto stood the proof, in the only gun altered by him. Subsequently, a plan of binding the breech to the rest of the gun was tested, the piece being cased in wrought iron, and bound together by longitudinal bands attached to its trunnions; but the results were very disproportionate to the expense. The mistake of trying to hold on the breech longitudinally has arisen from the gun's breaking against the thick breech on bursting; but it is in reality first fractured at the seat of the shot, and then flies open, breaking off the pieces on each side. A cast-iron gun goes gradually, of which indications are generally given by minute cracks, which gradually enlarge, but can only be seen round the vent hole. Another plan of strengthening was that attempted by inserting a tube of steel or wrought-iron inside the larger cast-iron ordnance which were proportionately bored out; but the difficulty of getting the proper amount of tightness, the weakening of the gun where the tube abutted against the bottom of the bore, and the fact that if put in without damaging the piece the tube might crack and the gun burst without warning, will always render such a method as unsafe in practice as it is difficult and expensive in its application (see Plate II. fig. 8). The last plan of strengthening tried is that shown in Plate II. fig. 4, but, as the thickness of the wrought iron was at the breech end, no advantage resulted from its employment; and thus, strengthening cast-iron guns has been pronounced a "fallacy," and, as it appears, is definitely condemned. The Armstrong gun itself is, however, a proof to the contrary, and affords an example of the union of two different irons, (the grain of the one crossing the grain of the other,) yet resulting in giving that strength which was found unattainable prior to the use of the forged breech, to which the coil tubes are welded: another example was afforded by Captain Blakely's strengthened gun, which was fired at Shoeburyness in 1856, and threw 2,389 shot, whilst 479 shot only were fired from a brass piece before it was disabled, and 351 and 137 respectively from two unstrengthened cast-iron guns before they burst; the powder charges being very great in all four cases.

It has been stated that the French ordnance is not stronger than before it was hooped; it is possible that this might appear true under a similar test to that used in England, which consists in increasing the weight of the proof-cylinder by the weight of one of the gun's shot every 10 rounds (by which means the strain is made to act in a different manner and direction to that thrown upon the gun when firing the proper service charge); but it is not true as respects the ordinary endurance, which is rendered much more uniform and continuous by hooping.

I may remark, that all guns properly cast are sufficiently strong to resist a few rounds of very heavy charges, but by using them the particles of iron would be disturbed, and then would not re-arrange or re-settle themselves unless a long period of rest were given.* With smaller charges, cast-iron guns slowly deteriorate with constant use, but they become very rapidly weakened if fired continuously, so much so, that, were a gun to be fired rapidly for 300 or 400 rounds and then proved with a heavy charge, it would almost inevitably burst. The object therefore to be aimed at is, to prevent the disturbance of the particles, and the consequent deterioration of the piece; and this is what the hooping *does* effect, when the gun is fired with the charges which the hoops are calculated to withstand; should a greater strain, however, be thrown on the gun, the hoops first become strained, then break, and the cast-iron, relieved of its supports, goes also.

These hoops, if well manufactured, will give very great support to the gun from the strain upon them being "tensile;" this will account for the success of the Spanish experiments in strengthening, in which the hooped guns withstood 1,200 rounds uninjured, while similar unhooped pieces burst in less than 200 rounds.

The guns tried in Spain were all 32-pounders, which were rifled on the plan previously described, and fired with about 7lbs. of powder and projectiles weighing 60lbs. Unlike a smooth bore, in which the ball rolls over and starts at once, rifling, besides weakening the gun in proportion to the depth of the grooves, greatly increases the strain by detaining the shot; and it is the lengthened period the breech has to withstand the great pressure, resulting from the reduced windage, the detention of the shot, and the combustion of a larger portion of the powder charge before the shot starts, which is so destructive to the endurance of rifled cast-iron ordnance.

It is undoubtedly true, that a more fibrous structure than is to be met with in the present cast-iron, is required for powerful rifled guns; but we have so greatly neglected to make the best use of cast-iron, that both our guns and our mortars have been cast of a form which is not only weak, but also tends to their destruction.

* Many experiments have shown the destructive effects on cast-iron ordnance from continuous firing, as also the increased strength resulting from long rest; and, by allowing two or three months or more to intervene between the series of discharges, a very much greater number of rounds may be safely obtained than in the case of almost daily practice with the same gun: the endurance is also much affected by firing at high elevations, at which the weight as well as friction of the shot has to be overcome, and little or no relief is afforded by recoil. At page 218 of the work on "The Useful Metals," published in 1857, it is stated that "pieces cast some years before testing stood several times the quantity of firing of other pieces cast but a few months previously." The tensile properties of the metal did not explain the difference; and the form, dimensions, weight, method of casting and cooling, and the manner of proving, were the same in all the pieces tried. Casting hollow, or, as it is termed, upon a core, instead of solid, very materially increases the strength and the endurance of guns, and is, therefore, always used by the Americans for heavy ordnance. In England we have likewise had similar results, for while there is, it is said, no record of any 13-inch mortar bored out from the solid, standing 700 rounds, there are at the present moment two mortars in the Royal Arsenal which were cast hollow, and have respectively withstood 2,000 discharges.—R. A. E. S.

Mortars.

The effect produced by this faulty form was seen in the bombardment of Sveaborg, when nearly the whole of the mortars employed either burst, or were rendered unserviceable; the best, that of the "Growler," cast in 1813, standing 355 rounds only.

By a reference to the drawing, it will be seen that the trunnions prevent the expansion of the iron at the places where they unite with the piece; hence, as the iron warms, it expands at the bottom, and the mortar being supported upon its trunnions, a severe shock is thrown upon that part which is in the line of least metal, and has been further weakened by expansion; the result is, a gradual disturbance of particles and rapid deterioration, until at length the mortar opens and generally splits in two pieces, much as if chopped down by some instrument. (See Plate II. fig. 5.) An inspection, however, of the remains of the mortars will afford convincing proof that some cause was at work to produce such very similar results, and will show how little our mortars are to be relied on for continuous bombardment. The mortars might, however, be strongly hooped at the breech, and then they could be rifled so as to throw incendiary shells of very great capacity.

Doubtless the placing of the trunnions at the re-inforce would greatly increase endurance and give other advantages, but the solution of this important question is now to be looked for in short and comparatively light rifled guns of large calibre, to fire elongated shells of very great powder or molten iron capacity, either horizontally or at mortar elevations.*

Destructive Effects of Air Space in Guns.

Having thus endeavoured to show the faulty shape of our present guns and mortars, and that no plan affording reasonable ground to hope for success has yet been applied for strengthening them, other than that proposed by Capt. Blakely, which proved successful, I may now mention, in proof of the little attention paid to the improvement of our heavy naval guns, that, although the bore has been constantly observed to have been expanded near the seat of the shot—in reality between the powder and shot—the cause was not known until the "proof" of the Sardinian ordnance. It was then found out, owing to the damage done to so many of the guns; and, as a very thick wad was used, attention was directed to this point; the result was, that the damage was found to have taken place just where the wad lay, and it thus became evident that the compression of the loose wad left a considerable air space, and caused the damage. In the service cast-iron guns, the metal of which is turned down at the seat of the shot, where strength is most required, and are disproportionably

* Howitzers mounted upon rotating mortar beds of modified construction, and supported by elastic rings to absorb recoil, would be especially useful for firing into port-holes, or for sweeping the decks of ships, and the banks and shores of rivers; they might also be advantageously used for dropping molten iron shells upon the unprotected parts of vessels, or into dockyards, &c. At great elevations the rifled howitzer would carry its elongated projectile beyond the present mortar range with less than half the mortar charge of powder.—R. A. E. S.

thick at the breech, the use of a soft wad, or making the rear of the projectile of tapering form, which leaves an air space, greatly diminishes the endurance of such ordnance when "rifled;" hence, in testing the relative strain of different systems of rifling with these guns, it is necessary to use projectiles of similarly shaped base. It had been long known that a wad placed between two shot in a smooth bore caused them to break up, and that red-hot shot which were fired with thick wetted junk wads endangered the piece, but no application was made of this knowledge; there can be little doubt, however, that the "proof" has much damaged our cast-iron guns, and that the system on which both the Armstrong and smooth-bores are tested, and on which all our tests for endurance are conducted, needs considerable alteration. There is a story told of two gun-makers respecting this point. One of them had been sending down his guns to have them proved, and a great number had burst. He asked the other how he managed, that his guns answered so well. He replied, "That is my secret"; but, being pressed to explain the cause, at length said, "I do not prove my guns at all."

Proposed Form for New, and Plan for Strengthening Present, Cast-iron Ordnance.

But it is time to point out the shape that is likely to give good new cast-iron guns, and also the plan that promises to utilise our present stock, and to convert it into rifled ordnance at a moderate cost; but, even if not afterwards rifled, it would be certainly advantageous to strengthen the guns of 8-inch bore; for, in the case of the 68-pounder, a powder charge of 20lbs. or more, and a tighter fitting shot of about 72lbs., could then be projected with a much higher velocity than that obtained by the 68-pounder ball at present used. The *rifle* charge for cast-iron guns should be about half the *round-shot* charge, which would produce about an equal strain up to an elevation of 5°.

With respect to new guns, the form shown at Plate II. fig. 6, is proposed, the piece being chambered to lessen the re-action against the bottom of the bore. This shape will give thickness and rigidity where the strain comes, and prevent the disarrangement of the particles by the great force exerted, tending to pull open the bore at the seat of the shot. The guns will also expand equally on warming, and thus two elements of weakness—unequal strength and unequal expansion—will be got rid of; and, if the length be slightly reduced, new guns of 8 and 10-inch bore could be cast to fire solid balls instead of the present ineffective round shell—which can alone be fired from all the 10-inch and the 8-inch, (except the 95 cwt. guns supplied to the "Warrior" and similar vessels)—without any increase of weight, or any extra cost.

The strengthening of the present ordnance would be best accomplished by a single wide coil or jacket (see Plate II. fig. 7), forced on cold by carefully measured hydraulic pressure, which could be effected at very small expense. The new and the strengthened guns could then be rifled, and fire the elongated projectile in addition to the usual smooth-bore ammunition. This strengthening might be applied to all guns from 18-

pounders upwards, inclusive, by which means rifled weapons would be at once attained at moderate cost; these might, when unserviceable, be replaced by guns of a better material, such as strong hollow forgings, coil-jacketed from breech to trunnions, with a wide hoop over the jacket at the seat of the shot; this arrangement would leave the tough forged muzzle—the exposed portion of the gun—to withstand the blows of hostile shot; or else they might be replaced by hooped castings of Bessemer's steel, a metal which will be probably employed ere long for making shot. Of 18-pounders we have a large number, and it is probable that these, if rifled and strengthened as indicated, would be quite equal to the 40-pounder Armstrongs (the largest guns, next to the 100-pounders, which have hitherto proved sufficiently satisfactory to be manufactured in large numbers) for ship use. The bore of the 18-pounder is considerably larger than that of the 40-pounder, which would be advantageous; and the expense of its rifle projectiles would be only perhaps a third of those which have been supplied for the Armstrongs, and the cost of its round ball perhaps not more than one-fifth that of the solid 40-pounder Armstrong shot.

Armstrong Guns.—Whitworth and Armstrong Competition.

Having thus endeavoured to show the small reliance that can be placed on our mortars, how the present guns can be utilized, and new strong guns cast, it remains to speak of the Armstrongs, which are being introduced into the service so fast as to bid fair to supplant the cast-iron pieces. These guns are made up of coils which are not adapted to withstand blows from hostile shot, and they are grooved too finely to stand exposure and rough usage, or to fire any other ammunition than the lead-coated projectiles specially designed for them. The calibres vary from a bore which is a little larger than a 2-pounder to one larger than a 42-pounder, or, as usually denominated, from 6 to 100-pounders. Of these, the 12-pounder field-piece is to be replaced by a 9-pounder for the horse artillery, which will give two weights of shot, viz. 9 and 12lbs. for the same field-work. In the Chinese campaign the 12-pounder was found too heavy for the marshy ground, nor was its destructive effect commensurate with its accuracy of fire. Sir Robert Napier's dispatch, given in the Times of November 5th, 1860, speaks of the Tartars advancing on more than one occasion despite our fire, and it is said that Desborough's troop alone prevented the sabring of the gunners who were working a couple of the Armstrongs. On board ship, the guns have hitherto proved to be dangerous, requiring a caution which is impossible in any case save in target practice, or very distant firing; and the guns have been also found to be inaccurate if at all corroded by rust, or if mounted upon a quickly moving platform. Contrary to what is generally believed, the competition between the Armstrong and Whitworth 12-pounder strikingly exhibited the inferiority of lead coating, for the projectiles deviated from the line of aim considerably more than those of simple iron, and at 10° ranged very unequally and much less; and, as on board ship a gun is never upright for two consecutive seconds, the Armstrong allowances for deflection could not be correctly calculated. The report of firing is annexed (see Tables, pages 28, 29). In practice

also difficulties occur, for the shot cannot be re-fired, and, if the charge be reduced, the accuracy is lessened and air space has to be carefully provided against.

At close quarters, at which decisive actions will ever be fought, the Armstrongs are very inferior in smashing effect, and the many niceties of adjustment necessary to ensure safety will, when men's nerves are highly strained, be certain to result in appalling accidents; for the mere want of tightness is certain to cause a leakage of gas, and to convert portions of the breech apparatus into destructive missiles, at the same time that a suffocating vapour from grease, lead, &c., would fill the deck.

That this is not a highly-coloured picture, is evident from the narrow escapes of the crews in the "Trusty," "Illustrious," "Edgar," and "Marlborough," in which last vessel the cabins and furniture were reduced to a wreck, the gun's crew thrown down, and the captain of the gun scarred on the face; and for this accident there was no apparent cause, but only a suspicion that some grit had stopped the vent-piece from going down properly.

As pivot-guns this ordnance is still more unsuitable, from the numerous delicate parts of the weapon liable in this exposed position to be hit by the grape or case of an enemy; and, if the wedge plan of breech-loading be adopted, the spreading out of two wings or wedges, one on each side of the breech in loading, will increase the chance of the guns being disabled, and the crew hurt by the fragments.

Breech-loaders for Pivot Guns.

It is a mistake to suppose breech-loaders to be well adapted for pivot-guns; the contrary is the case, for, such guns being intended to be fired at great elevations, should be as solid as possible in the breech; the strain upon the rear being very greatly augmented as the elevation is increased. Not only so; but the gun, which has perhaps just got the range, must be brought horizontal before loading, by which a considerable time, and probably accuracy, is lost between the rounds; and, as the muzzle of a deck gun can be easily got at for loading, there seems no reason for opening and weakening the breech, and complicating what can be otherwise better done from the muzzle.

The expense of the Armstrong guns and projectiles is very great, and the fact of their delicacy, and the inability of the guns to fire any but their own carefully prepared shot, might prove a serious disadvantage in war. At Sebastopol, for instance, where we picked up and refired the Russian shot, had our guns been Armstrongs, and the Russians been armed with rifled pieces grooved in accordance with their present plan, they could have easily dovetailed a little lead into the rear of the Armstrongs and refired them; whereas the fine grooves of our guns would have been ruined by re-using their own refired projectiles, and could not have returned a single Russian shot.

Broadside Naval Guns.

Turn we now to ships where the space is confined, and different sizes of shot and different charges have to be provided. What a dilemma poor Jack would be in with two different kinds of ordnance on the lower deck

and three on the upper. Why, in the hurry of action, he would be putting the square shot into the round holes, and the round shot into the square holes. I ask any man who has been on a ship's deck in action to say what does or does not take place. When men are stirred up by the excitement of action they are not able to attend to niceties. I can even speak of the "hurry" which is displayed in the practice on a field-day in the "Excellent," where I have been more than once the sponger or loader of the officers' gun. And what must be the case in a close hand-to-hand fight!

One of the great advantages of rifling, viz. that of enabling a molten-iron shell of very large capacity to be fired in safety, will also be lost. This advantage has been lately overlooked, as the Armstrongs appear unsuited for the purpose; and it cannot, therefore, cause much surprise that, because the loose-fitting round shells of small capacity have produced so little effect from smooth bores, the dangerous hot shot are again talked of as an arm for future use. I trust, however, that they will be given up.

The comparison so often made between round balls and rifled shot, is seldom if ever made as respects their comparative cost and their value at close quarters, but only as respects their effect at distances too great to be correctly measured, or to produce any decisive result in actual warfare. The question, as regards naval ordnance, is not, however, between the round ball and the elongated shell, for the round ball is the most effective, and is far more easily handled and loaded at close quarters, and the rifle shell is the best for bombardment; but between a mode of rifling that *will* admit of the use of the round ball at close quarters, and one that *will not* admit of its use. By adopting the former plan, good broadside guns throughout would be obtained for the decisive struggle,* and this is the first and the main point to secure, and the cost of ammunition would be kept at its old rate; by the latter plan, the broadside power would be lessened, a mixture of different sorts of weapons rendered necessary, and the simplicity essential in naval warfare entirely lost. I need not dwell upon the expense of the ammunition for such finely-grooved guns, nor the doubts about its keeping serviceable in the warm and moist atmosphere of a tropical climate; but I wish to remark, that the guns themselves are so delicate, that the powder cartridges of the 40 and 25-pounders are made up round pasteboard cylinders; and that the fouling, which occasions extra strain on the gun and stripping of the projectile, can only be prevented by the use of a wad composed of various perishable ingredients.

* The 68lb. round ball will perform more work than the Armstrong shot at probably less than a third the strain upon the gun; and a properly rifled wrought-iron piece would send its flat-headed shot with a shell base to burst inside the $4\frac{1}{2}$ -inch plates. Such a gun would also fire the round ball, and, when requisite, could use the heavy charges necessary to give a very high velocity in perfect safety. A very high velocity seems to produce an effect far beyond what the formula velocity² x weight gives; and if the generally received rule—that the resistance of armour plates is as the squares of their thickness—be correct, then at 200 yards the actual work done by the 68-pounders is double that of the Armstrong 110-pounders, when both shot are of cast-iron, and fired with 16lbs. and 14lbs. of powder respectively. This result is to be attributed to there not being sufficient time for the particles of iron round the part struck to properly aid in supporting it; and hence, if a much higher velocity can be obtained, and which I think will be the case, we may yet find that strengthened or wrought-iron 68-pounders will send their round balls—but certainly short flat-fronted elongated projectiles—through any target hitherto constructed.—R. A. E. S.

S K E T C H E S .
Segmental Sections of Comm.'s Scott's Centric Rifling.

Fig. 1. For powerful Ordnance.

Fig. 2. Position of Shot when leaving Gun.

Fig. 3. Showing application of Centric Rifle bearings
by Projections on the surface of Bore.

These difficulties are the result of the fine grooves and the compression system, which, as is well known, is fast destroying the larger Armstrong guns; and although the new 70-pounder is to have a wider groove of altered shape, and a muzzle swell, little advantage will be gained.

Rifling with Plain or with Central Grooves.

Were, however, the leaded projectiles and fine grooves to be given up, and any plain groove and a simple iron projectile adopted, these difficulties would be obviated, and a much higher velocity obtained without straining the piece. It is true, that the result might not appear so favourable in target practice, but this could also be met by taking the plan of grooving, which I have already advocated before this Institution, (see Journal, vol. v. p. 437,) and which from its form is very easily sponged, and centres the projectile without jar, while its peculiar curve yields all the accuracy attainable by any known system (Plate III. fig. 1.) Hitherto the plan has not been carried out with great exactness, having been only applied to a cast-iron service 32-pounder gun, to which the projectiles were not fitted with precision; yet, with these disadvantages, and the gun weakened as it was by the rifling (for which it had never been intended), that plan gave an accuracy which was stated to be "good," and a range which at 2° was considerably greater than that of the Armstrong 100-pounder. It has also stood 310 rounds at various elevations, although a bad flaw existed in the bore.* The chief peculiarity of the system consists in shoulders for the projectile to glide easily out upon; and as it rests upon three bearings each from 5 to 12 inches long on the long axis of the shot (for shot from 5 to 12 inches in diameter), with a surface-breadth nearly equal to the depth of the rifle grooves (see Plate III. fig. 2), the amount of wear is truly inappreciable. Like the system of De Beaulieu, I confidently expect it will ultimately come to the front; and my only fear is that some inventor, with a longer purse than I have, perceiving the value of my concentric system, may, by some slight modification, gain the ear of those who control these matters and rob me of my labours. It would be easy, for instance, to turn my grooving inside out, and obtain results similar in kind, but in less perfection. You will see that such a figure as this (Plate III. fig. 3) will effect the purpose; but, though Sir W. Armstrong was recently in doubt whether the rib or the groove belonged properly to the bore, I have myself a strong opinion that a rib in such a situation would render even *this* recent composite wad inefficacious, and reduce the gun to the standard of a mere target weapon.

Of such plans we have had enough—they must fail in warfare; for although it is well to be enabled by exact fitting to fire with great accuracy, it is still more important for a weapon not to be rendered useless when this great nicety cannot be observed; or when, as at Sebastopol, on the top of a hill, any kind of shot are most thankfully received. We should, therefore, as suggested in my lecture previously alluded to, while aiming at making really powerful guns, with from 8 to 10 inches or greater

* The muzzle of this gun will be shown in Class 11 in the International Exhibition, together with one of its (seven times) re-fired shells.—R. A. E. S.

diameter of bore—guns which will project their shot with a very high velocity, and consequently flat trajectory, within fighting distances—bear in mind, that heavy charges strain the gun in projecting the rifle shot with a velocity which is readily attained by the round ball; and therefore that the power given by rifling should be added to that of the smooth bore, instead of the latter's being sacrificed to it.

English and French Rifled Guns: their different Nomenclature.

In the facility of using round shot, or adapting almost any sort of shell to its use, consists the value of the French system, and it is also extremely simple and inexpensive; and, even supposing that their guns could not with perfect safety fire more than one or two hundred rounds with elongated projectiles, the French would still have effected a great change at a trifling cost, for they have rifled their 30 and 50-pounders, so as to preserve the round ball and all the old ammunition, and have enabled these guns to discharge, in addition, projectiles, of which that fired from the 50-pounder has a larger diameter than, and probably contains as large a charge as, the Armstrong 100lb. shell.

While, therefore, we have been expending large sums, aiming at obtaining guns which shall be good rifles only, omitting the more important quality of smashing power at close quarters, the French first secured the easily managed round ball, and then added to its effect the advantages of the rifle projectile, in one gun; they have also suppressed varieties of calibres, and in the "Gloire" have carried out this simplification by arming her with 38 rifled 50-pounders; and, unlike our nomenclature, which places the Armstrong 40 above the French 30-pounder, which fires a 60lb. shell, containing more than double the powder charge, they still call their guns by the old names of 30 and 50-pounders: a difference that in the event of hostilities would at least detract from the merit that might otherwise be obtained, were an Englishman armed with the 40-pounder Armstrong to capture an enemy with guns of such very superior power as the French 30-pounders. In fact, with the exception of the 100-pounder, there is no finely-grooved weapon that could produce much effect against even a wooden ship, for the small hole which the shot would make, if they did penetrate, would be a very trifling matter; and the powder charge of the shells of the 40 and 25-pounders is too small to produce any great damage. And thus having endeavoured to indicate the progress of ordnance at home, and to show the value of our rifled guns, I have only to add, that the country owes a debt of gratitude, and something more substantial, to those gentlemen, who, although the service has no claim upon them, have given up years of their time, and incurred much anxiety and expense, in working out a problem so difficult and of such great national importance.

CAPTAIN BLAKELY.—It is rather late to commence a discussion, and I can add but little to the information which Captain Scott has been so kind as to give us on the subject. I would not like the meeting to suppose from what has been said that the French are satisfied with their guns standing only 200 or 300 rounds. On the contrary, they did not cease

their trials until they had fired some of their 32-pounders which had been strengthened, a thousand times, with the full charge of powder and three shot. They then fired one, 3,000 rounds with a single charge of powder and a single shot. So that they are pretty well off. The Spaniards have strengthened their gun—the old 32-pounder. They have tried several different ways of strengthening them. They did not know that there was any law; they did not know the proper difference of diameter to give between the hoops and the cast-iron gun. They had to find this out. They have been very liberal in publishing to the world the exact details of all these experiments, and they had a very good gun to commence with.

They began by making the hoops a little too tight, and the same in every other particular, and they found the gun did not stand so well. They then tried a little larger hoop, until they found out what the exact law was; and the last gun, now used in the Spanish Navy, has been fired 1,367 times with 8lb. of powder and a 62lb. shell. So I think they are furnished with a weapon which at all events is not liable to burst and injure their gunners.

LIEUTENANT WINDUS, H.M.I.N., asked whether some trials were not about to take place with the Belgian gun, that had been mentioned, with elongated shot, instead of spherical.

CAPTAIN SCOTT.—Yes; the Belgians have had guns made of Bessemer steel, a metal which they are inclined to adopt. They tested one gun, and it stood an extraordinary number of rounds. There is a clear report upon the subject in Fairbairn's last work on Iron. The lead shot was taken by ourselves, as well as by other nations, at an early date, because we did not then perfectly understand rifling, and did not know how the iron shot could be shaped so as to truly centre in the bore. The plan of now making a shot cut its passage through the grooves is a great waste of power, especially when you can so easily shape the projectile to the rifling. Fitting is a mechanical operation, in which the English excel. I point this out, because I think we are going in a wrong direction in continuing to manufacture lead-coated shot. They will decay from damp, and those in store are decaying and the lead exfoliating. Many of you are aware that Lord Clyde sent home some bullets which could not be got down into the rifles at all. The lead had exfoliated, and the bullets were too large, and at Delhi several of our men were shot down while trying to force the bullets down the bore of their rifles.

The CHAIRMAN proposed the usual vote of thanks to Captain Scott for his valuable paper.

ARMSTRONG BREECH-LOADING 12 PR.

REPORT OF EXPERIMENTAL PRACTICE.

SHOEBURYNESS, 2nd April, 1861.

Height of axis of Gun above plane, $3\frac{1}{2}$ feet.

Nature, ARMSTRONG'S B. L. 12 pr. Gun, No. 6.

Barometer, 29.7.

Wind, South—3.

Weight 8 cwt. qrs. lbs.

Length 7 $\frac{1}{2}$ feet.

Diameter of bore . . . 3 inches.

Spiral, if rifled, 1 turn in 38 calibres.

Grooves, Number 33. Width, 0.15 inches. Depth, 0.05 inches.

Nature and object of the experiment—To ascertain the Range, &c., of Armstrong's Breech-loading 12 Pr. Iron Gun, in comparison with Whitworth's Breech-loading 12 Pr.

Programme received 23rd March. Stores received, 2nd April, 1861. Minute No. 3625.

No. of Rounds.	Charge.	Elevation.	Recoil.	Projectile.			Times and Mean Time of Flight	Range, 1st graze.	Mean Range, 1st graze.	Deflection.			REMARKS.	
				Nature.	Weight and Mean Weight.	Windage in inches.				Correction allowed for.	Left.	Right.		
	lbs.	deg.	Feet.	Armstrong's Strong Shot.	lbs. mean.		sends.	yds.	yds.		yds.	yds.		
1	1.75	2	8.0		12	Nil.	3.5	1239	—	—	Nil.	4 $\frac{1}{2}$	—	3rd April.
2	—	—	7.10		—	—	3.7	1271	—	—	—	6 $\frac{1}{2}$	—	
3	—	—	8.0		—	—	3.6	1238	—	—	—	6	—	
4	—	—	8.0		—	—	3.7	1307	—	—	—	4	—	
5	—	—	8.0		—	—	3.6	1226	1256	—	—	4 $\frac{1}{2}$	—	
6	1.5	—	7.0		—	—	3.4	1108	—	—	—	5 $\frac{1}{2}$	—	
7	—	—	7.0		—	—	3.4	1133	—	—	—	5	—	
8	—	—	7.0		—	—	3.6	1150	—	—	—	4 $\frac{1}{2}$	—	
9	—	—	7.0		—	—	3.4	1121	—	—	—	3	—	
10	—	—	7.0		—	—	3.3	1137	1130	—	—	3 $\frac{1}{2}$	—	
11	1.5	5	6.9		—	—	6.8	2134	—	—	—	11	—	2nd April.
12	—	—	6.8		—	—	6.9	2163	—	—	—	9	—	
13	—	—	6.6		—	—	6.6	2157	—	—	—	8 $\frac{1}{2}$	—	
14	—	—	6.6		—	—	6.8	2146	—	—	—	10 $\frac{1}{2}$	—	
15	—	—	6.6		—	—	6.8	2128	2146	—	—	7	—	
16	1.75	—	7.9		—	—	7.2	2357	—	—	—	13	—	Wind increased to 4.
17	—	—	8.0		—	—	7.3	2331	—	—	—	11 $\frac{1}{2}$	—	
18	—	—	7.10		—	—	7.2	2356	—	—	—	11	—	
19	—	—	8.0		—	—	7.4	2351	—	—	—	11 $\frac{1}{2}$	—	
20	—	—	8.0		—	—	7.3	2399	2360	—	—	11	—	
21	1.5	10	4.6		12	—	12.2	3512	—	—	—	12	—	Wind changed and increased. Squally.
22	—	—	4.8		—	—	12.4	3576	—	—	—	11	—	
23	—	—	4.6		—	—	—	3593	—	—	—	17	—	
24	—	—	4.6		—	—	12.4	3597	—	—	—	12	—	
25	—	—	4.5		—	—	12.2	3563	3568	—	—	11	—	
26	1.75	—	5.0		—	—	12.8	3943	—	—	—	8	—	
27	—	—	5.0		—	—	12.8	3893	—	—	—	23	—	
28	—	—	5.0		—	—	13.0	3961	—	—	—	14	—	
29	—	—	5.1		—	—	13.0	3866	—	—	—	19	—	
30	—	—	5.1	—	—	13.0	3873	3908	—	—	21	—		

Elevation throughout by Quadrant.

The Gun was mounted on a Travelling Carriage, and placed on one of Lieutenant-Colonel Clerk's Platforms, on the level.

Wads, choked in the Cartridge, were used throughout the Practice.

(Signed)

A. J. TAYLOR, Colonel R.A.,

The Secretary,
Ordnance Select Committee.

Commandant and Superintendent.

WHITWORTH BREECH-LOADING 12 PR.

No. 1. REPORT OF EXPERIMENTAL PRACTICE.

SHOEBURNESS, 2nd April, 1861.

Height of axis of Gun above plane, $3\frac{1}{2}$ feet.

Ordnance . . . Nature, WHITWORTH'S E. L. 12 Pr. Gun, No. 1.
 . . . Weight cwt. qrs. lbs.
 . . . Length $8\frac{1}{2}$ feet.
 . . . Diameter of Bore, Major axis 3 in., Minor 2.75 in.
 . . . Spiral, if rifled, 1 turn in 55 inches.
 . . . Grooves, Number . . . Width, . . . Depth,

Barometer, 29.7
 Wind, South—3.

Nature and object of the Experiment—To ascertain the range, &c., of Whitworth's Breech-loading 12 Pr. Iron gun, in comparison with Armstrong's Breech-loading 12 Pr.

Programme received 23rd March. Stores received 2nd April. Minute No. 3625.

No. of Rounds.	Charge.	Elevation.	Recoil.	Projectile.			Times and Mean Time of Flight	Range, 1st graze.	Mean Range, 1st graze.	Deflection.		REMARKS.
				Nature.	Weight and Mean Weight.	Windage in inches.				Correction allowed for.		
	lbs.	deg.	Feet.		lbs. mean.		secs.	yds.	yds.			
1	1.75	2	7.0	Solid Shot—Hexagonal shaped.	12.004	—	3.5	1266	—	Nil.	—	3rd April.
2	—	—	7.3		—	—	3.6	1344	—	—	—	
3	—	—	7.6		—	—	3.4	1250	—	—	—	
4	—	—	7.3		—	—	3.4	1280	—	—	—	
5	—	—	7.6		—	—	3.4	1306	1290	—	—	
6	1.5	—	6.6		—	—	3.6	1223	—	—	—	
7	—	—	6.6		—	—	3.6	1211	—	—	—	
8	—	—	6.6		—	—	3.4	1183	—	—	—	
9	—	—	6.6		—	—	3.5	1209	—	0	0	
10	—	—	6.6		—	—	3.4	1159	1193	—	1½	
11	1.5	5	6.0		—	—	7.2	2442	—	1½	—	2nd April.
12	—	—	6.0		—	—	6.2	2072	—	—	2	
13	—	—	6.0		—	—	6.8	2389	—	—	—	
14	—	—	5.10		—	—	7.2	2449	—	—	2½	
15	—	—	6.0		—	—	7.2	2486	2368	1	—	
16	1.75	—	7.0		—	—	7.0	2475	—	2½	—	Wind increased to 4.
17	—	—	7.0		—	—	7.2	2644	—	—	1	
18	—	—	6.9		—	—	6.9	2335	—	—	2	
19	—	—	7.0		—	—	7.0	2370	—	—	1½	
20	—	—	7.0		—	—	7.2	2533	2471	—	2½	
21	1.75	10	6.9		—	—	13.2	4409	—	4	—	Wind changed and increased. Squally.
22	—	—	6.8		—	—	13.0	4348	—	10	—	
23	—	—	6.8		—	—	12.8	4387	—	7½	—	
24	—	—	6.9		—	—	13.0	4405	—	8½	—	
25	—	—	6.9		—	—	13.4	4449	4400	4	—	
26	1.5	—	5.0		—	—	12.6	4137	—	4	—	
27	—	—	5.6		—	—	12.9	4299	—	3	—	
28	—	—	5.0		—	—	1.0	4139	—	2½	—	
29	—	—	5.0		—	—	12.8	4318	—	3½	—	
30	—	—	5.0		—	—	12.8	4220	4223	2	—	

Elevation throughout by Quadrant.

The Gun was mounted on a Travelling Carriage, and placed on one of Lieutenant-Colonel Clerk's Platforms, on the level.

The Powder and Wad were contained in the usual Tin Cases.

The rounds marked * were fired with Tin Cases that had been used previously, there being no more in store, and they were simply well cleaned, and answered quite as well as when new.

The Wad weighs about 2 oz. 4 drs., and the empty Tin Case about 8 oz. 8 drs.

(Signed) A. J. TAYLOR, Colonel R.A.,
 Commandant and Superintendent.

The Secretary,
 Ordnance Select Committee.

Official Reports, as extracted from the excerpt Minutes of Proceedings of the Institution of Civil Engineers.—Ed.