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Naval Ordnance

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Friday, April 19th, 1861.

MAJOR-GENERAL THE HON. JAMES LINDSAY, M.P. in the Chair.

Friday, May 17th, 1861.

CAPTAIN E. G. FISHBOURNE, R.N. C.B. in the Chair.

NAVAL ORDNANCE.

By COMMANDER ROBERT A. E. SCOTT, R.N.

THE importance of the subject on which I have the honour of addressing you, has been very much enhanced by the fearful conflict which seems on the eve of commencing in America; and who can say how long peace may be preserved in Europe, or what effect this sad struggle may ultimately have upon our own finances?

To my mind at least, this unnatural war looming in the distance, and the agitated state of Europe, have rendered it of the utmost consequence that the large sums now being expended upon our coast defences, ships, and guns, should be laid out so judiciously as to preclude a hasty re-construction in case of war, and a state of transition that might even imperil our maritime supremacy.

Let us therefore first examine what naval warfare *has* been, and how far these conditions have been changed, and then whether such changes have been met in the present and proposed armaments; so as to have a clear view of our preparedness to meet every contingency.

Our greatest naval commander, whose victories were really "conquests," not satisfied with giving as his final instructions "that no captain could do very wrong who placed his ship alongside an enemy," was accustomed to fasten at the top of his highest mast the signal, "Engage the enemy more closely." "And at Trafalgar, leading the weather column in the 'Victory,' and brushing the 'Bucentaure's' stern, Lord Nelson poured in a broadside that killed or wounded 400 men and dismounted twenty guns; and whilst his crew were listening with characteristic avidity to the deafening crash made by their shot in the hull of the French flag-ship, they were nearly suffocated with the clouds of black smoke that entered the 'Victory's' port-holes, and their heroic commander and his officers on deck were covered with the dust that issued from the crumbled wood-work of their enemy's stern."

Have the circumstances really changed since then? No. And, although we have longer ranges, we have and are fast getting better protected vessels, so that the change is merely one of degree and not of kind, and will not influence the distance at which naval actions will be fought. Sir Howard Douglas, in his last gunnery pamphlet, says, "that it is derogatory to the character of the British seaman to say that he would prefer *the iron sides of a slow vessel* to the velocity of the craft that would at once bring him alongside an enemy." Indeed, nearly all those actions which have been attempted to be fought at a distance are those we have most reason to be ashamed of, and when we give up our confident rush, our unhesitating assurance of victory, and prefer to remain at long balls, cowering under the lee of shoals or behind bulwarks, it will be a dark day for Britain.

Decisive battles have been, and will ever be, fought at close quarters, in confusion and smoke, amidst the dying and the dead, as when the American frigate "Chesapeake" succumbed to the English "Shannon" with guns dismounted, carriages destroyed, 179 of her crew killed and wounded, and her decks streaming with blood.

Need I say that there must be simplicity of gun and simplicity of projectile under such circumstances, and that length of range is but a secondary consideration. On this point I may quote an extract from a speech made at the Civil Engineers' Institute by Sir W. Armstrong, who seems to have mastered the works of foreign artillerists, as well as the opinions of our own, and whose early training eminently qualified him for sifting the valuable from the useless. He says, "The public was always captivated by the attainment of long ranges, but great delusion prevailed on that subject." And again, "That however perfect the weapons might be made, the fate of a battle would never be very materially influenced by very distant firing. The real struggle would always lie within a distance of 2,000 yards, and the first consideration should be to make the weapons as destructive as possible within that limit."

Having thus indicated the necessity for simplicity of gun and projectile, it is hardly necessary to point out, that non-liability to injury from blows or rough usage is also essential for close fighting; and as there would be little time for extra polishing and oiling, and guns would have to be kept uncovered in war, it is likewise requisite that no parts of the gun should be liable to be affected by the weather.

In order to arrive at the essentials for a naval gun, it is necessary to glance at the improvements which have been made, and to compare the destructive effects of rifle projectiles with those of the round ball at the distances at which decisive naval actions have been, and will still be, fought.

Bearing in mind then that length of range is but a secondary consideration, and that distant firing against plated ships would be wholly thrown away, and were it not so, that British pluck and dash could not *then* be brought into play, we have now to inquire which weapon has hitherto proved the best for close quarters. The answer is, the smooth-bore gun; numerous careful experiments having shown that the solid 68lb. round ball fired from the old 68-pounder has a far greater smashing effect than the elongated shot from the new service rifled 100-pounder.

This superior result is due to the higher velocity of the round ball, and, $\text{velocity}^2 \times \text{weight} = \text{force of the blow}$ (approximately), it is easily seen, why the 68lb. round ball has, besides making a larger hole, a more smashing and shaking effect on iron, stone, or wood, than a shot of much smaller diameter coated with soft metal. Besides this greater effect, the round ball is more easily loaded, and hence is better adapted to the exciting and critical moments of "close quarters."

The "Times" correspondent with the field force in China, in his spirited report published in that paper, stated that the new rifled field piece proved inferior to the smooth bore for close quarters; he said, "That the range seemed too close (for the Armstrongs,) so three of Desborough's 24-pounders were ordered to the front, and in five minutes the Chinese fire was effectually silenced." And in another place he wrote, "At short ranges under 300 yards, however, the old round 9-pounder, and the 24-pounder howitzers, seem to be more efficient than the conical shell. Desborough's guns, beautifully served, were the most successful against the Creek Battery." These were smooth bores.*

The round ball, from rolling over in the bore on the first pressure of the elastic fluid, occasions comparatively little strain or jar on the gun, while the rifle shot, on the contrary, has to be fairly shoved out along the spiral groove, which detains it. This detention, till the shot un-threads itself, causes the elastic fluid generated by the combustion of the powder to be much compressed, and to react from the shot against the bottom and sides of the bore with great violence, a strain which is very much increased when the windage (the safety-valve of weak guns) is closed, and a leaded projectile of larger diameter than the bore has to be first started, and then driven through rifle grooves almost instantaneously.

Having thus laid before you the first essentials of a naval gun, viz. simplicity and non-liability to injury, and having shown that the round ball, besides being more destructive for close quarters, is more easily loaded, and is discharged with incomparable less strain on the gun than the elongated shot, it remains to add, that as the navy are trained to fire low, and therefore a large proportion of shot strike the water before hitting, it is very important that naval projectiles should ricochet straight. This the round ball does, and, besides always striking fairly, it has a flatter trajectory up to 2000 yards, and a much flatter one up to 1000, than the fine groove rifle projectiles.

It is generally supposed that the 68 lb. round ball, having, as I have already mentioned, rolled over in the bore, maintains a slight rotation for 600 yards, up to which distance it is very accurate, but after this there is a sensible and increasingly rapid falling off, both in speed and accuracy. As a shell, the round ball, from its small capacity, is very inferior either for shrapnel, powder, or the fearful molten iron. It is true that the round ball can be made red hot, but this is attended with danger to the gun, and is not easily carried out on board ship; its effects also are trifling compared with those of the stream of molten liquid which the larger elongated shell would pour out. This shower of fire would enter every aperture, and drive the men from their guns, after the shell had first delivered its blow on the vessel's side. Thus we see, that in some cases,

* See note at page 431.—ED.

such as a first broadside and for the purposes of distant bombardment and for accurate fire, to cover boats attacking an enemy, or troops landing in the face of one, the elongated shell is very superior to the round; but for a hand-to-hand engagement and close battering, greater results can be obtained from the solid round ball, and with far less strain on the piece.

Let us then sum up the points for a naval gun, and examine closely how far these have been met in former guns, and whether any of the plans at present proposed have succeeded in meeting these requirements. This will enable us to judge whether a combination of such qualities can be obtained from any one gun, and if not, what points should be sacrificed so as to secure the essentials of simplicity and smashing effect, with as many other good points as can be united in the same weapon.

A naval gun then should,

- 1st. Be simple in its construction,
- 2nd. Be not liable to injury from blows or weather,
- 3rd. Fire a shot of large diameter (from 8 to 10 inches or more,)
- 4th. Be able to use the smashing round ball at close quarters;
- 5th. Give a flat trajectory,
- 6th. Have projectiles which deflect little, and ricochet straight and evenly,
- 7th. Fire elongated molten iron shells,
- 8th. Fire elongated powder shells, near or across ships, &c. with safety,
- 9th. Fire shrapnel or built-up shells over boats with safety,
- 10th. Fire canister.

This last is essential for gun-boats to sweep the banks of rivers; a shell cannot replace it for close quarters. A large diameter is included in the above list, for without great size the round ball would have little smashing power, nor could a high velocity be obtained from elongated shot, unless they offered a large area in proportion to length for the powder to act upon, in propelling them. The captivation of the public with long ranges has led to lengthening the projectile at the cost of its efficiency, and has occasioned one great advantage of rifling to be overlooked; viz. the power it confers of shortening the gun without much loss of effect, owing to the detention of the shot and the consequent earlier combustion of the charge. The use of loaded (forced) projectiles, and breech loaders, has even caused a step to be taken in the wrong direction, first by rendering the adoption of a slow-burning powder to lessen the strain on the gun, and then a lengthening of the barrel in order to give the powder time to burn, a necessity.

The first of the qualities enumerated as essential for a naval gun is met in the existing smooth-bore guns, but they are deficient in the last points, and are also inaccurate at long ranges. Inaccuracy, however, at long ranges is not of vital importance, for errors in pointing, in naval warfare, are three to one greater than those which result from the inaccuracy of the guns. Up to breaching distance, however, accuracy is of considerable moment, and especially for shore operations. The deficiencies in the smooth bore, have been long observed, and in 1845 and 1846 they were attempted to be supplied by M. Wahrendorf and Colonel Cavalli. Both these gentlemen adopted breech-loaders and tight-fitting shot; the

...er using principally a leaded projectile and several shallow grooves, and the latter, an iron shot with two grooves.

The former plan was adopted by Prussia, the latter by Sardinia; and although the lead-coated shot were at first most in favour, both they and breech-loading have now been discarded by nearly all the continental nations.

The French commenced making trials of two shallow elliptical grooves, out of which they fired some projectiles with a long and some with a short bearing. These were entirely of iron, the rifle twist being in the former case equal throughout the bore, but in the latter increasing towards the muzzle. Although, when tried in England, the plan gave greater accuracy than that of the early oval, saw-grooved, or two grooved breech-loader, the French do not seem to have been satisfied with their own system, and in December, 1860, changed their plan to the present three grooves, with which they have rifled their heavy ordnance.

This groove is similar on its bearing side to that adopted by myself more than a year before, only it has an additional piece taken out on the opposite side for facility of loading. See Plate II. figs. 17, 18, and A.

The rifling, like my own, is intended to fire round shot, but the French have retained the increasing spiral, and are consequently forced to have a short bearing, a button, which is of zinc on the side which takes the groove in coming out of the bore; the other half of the button is of iron, and cast with the projectile. In the field gun the buttons are wholly of zinc and more numerous, and they are somewhat differently arranged.

The Prussians, however, having early pushed forward the rifling of their old guns and made a large number of new breech-loaders of Krupp's steel, as well as new breech-loaders of cast-iron, have adhered to lead-covered shot, and this, as Fourcault alleges, "because they are unwilling to incur the expense of change to a non-leaded projectile."

It is right that I notice the fact that, in 1780 or 1790, Manton rifled a brass service gun with a number of shallow rectangular grooves, and fired a projectile, having a wooden sabot affixed to its rear for the purpose of taking the rifling, and there were previously a few other experiments, as well as some subsequently, which produced little result. Manton's rifled gun is still lying in the Arsenal.

But it is now time to examine how far these and other systems of rifling meet the requirements of Naval Warfare, and in doing so it is necessary to distinguish between the grooving itself, and the gun which receives it. For instance, any wrought iron coil gun used by Sir W. Armstrong might have its rifling changed from the many groove to three grooves; and this particular coil structure of gun is that used by Blakely and others.

Leaving therefore the full details of the structure and metal of guns for some future occasion, I wish to bring before you the present plans of rifling, which may be all classed under four distinct systems. These are—

- 1st. The Compression.
- 2nd. The Expansion.
- 3rd. The Centring against the Bore.
- 4th. The Concentric.

1st. *The Compression*.—This plan was early adopted and perfected by the Prussians, who obtained very great accuracy and range, using a

charge of only one-tenth the weight of the projectile, and, as it is the first successful application of a lead-coating plan, I will particularly describe it.

The Rifling consists of numerous shallow rectangular grooves similar to those used by Manton. These are sixteen or eighteen in number in the field piece, and proportionately more in larger guns.

The Projectile is encircled by four rounded lead bands or hoops (See Plate I. figs. 1 and 2) which have their outer surface of larger diameter than the bore. The gun is therefore necessarily loaded at the breech, the aperture being closed by a solid wedge pushed across the bore, and the leakage of gas prevented by a valve and a papier-mâché cup, which by the explosion of the powder are pressed tightly against the wedge, effectually stopping all escape of gas.

The vent is bored through the gun itself. After discharge the wedge is drawn back and the cup pushed through the gun with the sponge, which leaves the bore open from end to end.

The simplicity of this plan recommends it as the best method of breech loading that has yet appeared, and the lead on the projectile having plenty of space to yield does not strip; from the same cause the friction in the bore and strain upon the gun are comparatively small.

To facilitate loading, the breech chamber is of larger size than the remainder of the bore; into this, the projectile and powder are quickly and easily placed, and as no leading occurs, the rapidity of fire is considerable. The wedge, however, according to the French, is liable to get set fast by rust or grit.

Of these guns very little was known until recently, and then it was found that the Prussian field pieces gave a range and accuracy equal to those of the more finely grooved English weapon, and with a less charge, viz., with one-tenth instead of one-eighth the projectile's weight. The 24-pounder of cast iron threw a shell of 56 lbs., which contained a large bursting charge, with similar precision.

The next compression rifling is that called the fine-groove, or Armstrong plan. The grooves are thirty-eight in number in the field piece, and seventy-six in the gun of seven inches bore, called a 100-pounder.

These grooves had a figure nearly rectangular when first adopted for the service, but are now sloped out on one side (see fig. 3); the original rifling was that shown by Fig. a.

The depth of the grooves is not equal throughout the bore, the lands being sloped out towards the centre to lessen the friction; the bore and depth of the grooves are the same just in front of the breech chamber and at the muzzle.

The projectile is coated with lead hardened by an admixture of tin. In the earlier shot there was an opening or score near the centre for the lead to strip into, the surfaces of the lead being otherwise nearly straight, but lately the metal has been reduced in front and the score made nearer the heel, which is now the largest part of the shot. (See fig. 4.)

By this alteration the friction has been greatly reduced, for only the rear of the shot now goes down to the bottom of the rifle grooves; and, while the strain on the gun has been lessened, the range and accuracy have been increased.

This change, and the rounding out of the sides of the grooves which are

COMPARISON SYSTEM.
(SKETCHES)

Prussian

1
Section of
Segment of
Gun.

Manton 1790.
also used by Inyal Thomas.

2
Lead covered by Lead covering
Iron Shell with external Grooves
Ribbed Lead covered Shot

3
Segmental Transverse Sections of Rifling.
Original Groove (Saw)
Adapted Groove.
Present Groove.

Armstrong

4
Lead covering
Half Elevation of Shell with
Grooves filled by Lead covering
Half Elevation of Shell and
Lead covering

5
Transverse Section
of Gun

SHUNT PLAN

6

6
Elevation of Shot
The dotted lines show Shell
a.a. Zinc rib shown raised
b.b. Grooves to facilitate compression
c.c. Cast pyrexicon to support zinc rib

EXPANSION SYSTEM.
Transverse Section of Guns.

British

7
Transverse
Section
of Shot
10

Section of Segment.

8
Saw Groove
Used by
Blakeley with
Loaded Shot and by
Colt Withnut with
Iron Shot

Jeffrey
Section of Shell.

9
Lead dovetailed at
rear of Shell.
7

a. a. Lead affixed to floor of
Shell by zinc b. b. Wood Plug
Screwed on

opposite to those that drive or give rotation to the shot, has greatly decreased the fouling and tendency to strip.

Instead of the wedge plan of breech loading adopted by Prussia, the fine-groove gun has a stopper, held in its place by a breech screw, and through this the charge is introduced, the stopper being lifted out of the gun for that purpose.

The vent opening is made in this stopper, called a vent-piece, which in the larger ordnance necessitates double priming, that is, a small charge called a primer is placed in the lower part of the aperture which communicates immediately with the bore, before the stopper is lifted back into the loaded gun. The screw is then hoisted tight, and the usual friction priming tube introduced into the hole in the top of the vent-piece.

Let us now compare this finely grooved piece with the requirements for a naval gun :

The first was, it should be "simple in construction."

The finely grooved weapon consists of many parts, and its rifling is very delicate, while the deflecting sight increases the time and difficulty of pointing.

The coils of which the gun is made, though exceedingly strong to resist direct internal pressure, often show flaws after firing, and the gun is easily injured by blows ; the coils are also liable to separate.

These flaws and this separation are partly occasioned by the want of a muzzle swell, which occasions a strong reaction, injuriously acting upon the piece after each discharge.

This was shown by the 100-pounder which was returned from Shoeburyness badly cracked in the inner tube of the breech, and in another gun also sent back on account of a smaller flaw in a similar part.

It was also equally apparent in the 12-pounder which failed and became wholly disabled in the ordinary practice at Shoeburyness.

2nd. It should "not be liable to injury from blows or weather."

The damage sustained by blows on the outside was shown in the experiment of firing with a 9-pounder smooth bore brass field piece at a rifled 12-pounder coil gun, and also at a 9-pounder brass gun. The charges were very much reduced, so as to resemble the effect of distant firing. In this trial, the 12-pounder was broken to pieces in three rounds, each blow being alone sufficient to disable it, while the 9-pounder, after receiving the same number of shots on one side, sustained a similar discharge against the other, and remained still serviceable for discharging grape, case, or 6-lb. round balls. In fact, but for one blow on the thinnest part of the chace, the gun could have continued to fire its usual ammunition, and, while the broken breech loader would have perhaps not been worth removal from the field of battle, the brass gun could have been made as serviceable as ever in a couple of hours.

The separation of coils has frequently happened "in proof" with both 40 and 100-pounders, and also took place with one 120-pounder shunt, and may be expected to happen on service, from the concussion and friction resulting from the jar before the loaded shot starts, and the strain of driving it through a hole of smaller diameter than itself.

The number of pieces the gun is composed of greatly increases the chances of mishap. For instance, in China the vent-piece flew out

when the gun was most required to check the Tartars, and after a night's rain the breech-screws of one battery were set fast. At Shoeburyness also the vent-piece flew out of the 80-pounder while being fired by the Select Committee; and lately a 12-pounder vent-piece did the same in trying penetration into wood.

The grooving easily gets injured. This was shown by Mr. Baring, who stated in the House what had happened to a 100-pounder "which had been sent to Portsmouth, but not to be fired, as it had been somewhat injured by a shell bursting at its mouth;" and other instances of injury from the shot breaking through the lead-coating whilst under proof have also occurred.

The deflecting sight is required, from the lateral deviation of the fine-groove projectile from the straight line; but so delicate and perplexing a sight would not answer where the distances are constantly changing. This lateral deviation is caused by the excess of weight of lead and iron in the rear of the projectile; and this excess, which is required by the peculiarities of the system, will not allow its axis to remain tangential to the trajectory, and thus causes the shot to describe a lateral curve, deviating more and more from the straight line as the velocity of flight and rotation lessens.

3rd. It should "fire a shot of large diameter, from 8 to 10 inches."

The 100-pound projectile has less than 7 inches diameter of iron, and the 40 and 25-pounders about 4·7 and 8·6 inches respectively, which is a trifle more than the diameters of the 12 and 6-pound round balls. The 40 and 25-pounders are, therefore, of little use for broadside firing, and of no great use for bombardment, their shells containing only 2½ pounds and 1 pound of powder.

4th. "Be able to fire the smashing round ball at close quarters."

This cannot be done without damaging the grooves.

5th. "Give a flat trajectory."

The great friction in the bore, and the lengthening of the projectile, in order to gain powder capacity and great range, considerably reduce the velocity, and consequently the flatness of trajectory. From these causes, the range of the 100-pounder at 1 degree of elevation is little over 500 yards—a distance which is attained by the 68 and 32-pound smooth-bore guns with about half a degree of elevation.

6th. "Have projectiles which deflect little and ricochet straight and evenly."

The weight of the projectile being in the rear causes it to turn over if the point be arrested; so that the shot would probably strike sideways, instead of delivering a straight and full blow on ricochetting. The weight in the rear also keeps the point of the shot raised, instead of following the trajectory; this diminishes the penetration. Future warfare may prove that such projectiles, from being so readily and often so unevenly deflected, must be very cautiously used in supporting a friendly vessel.

In breaching the tower at Eastbourne at 1,032 yards, it was observed that, while some of the rifle projectiles penetrated from 7 to 8 feet into the brickwork, others did not pass through more than from 1½ to 2 feet. This difference was probably owing to some of the shot striking less fairly than the others. A familiar illustration of a somewhat similar effect is afforded

the difference between hitting a straight and a bent nail; for, while the former easily penetrates hard wood, the latter will make but comparatively small impression.

7th. "Fire elongated molten iron shells."

This may be done in target practice, using a very small charge, but can scarcely be effected in naval warfare; for the heat soon expands the shell, and then a vast increase of strain in forcing it through the bore ensues, which greatly augments the danger of the shells crushing up in the gun and destroying the grooving.

A short time since two 100-pounders were placed at 700 yards from the section of a wooden vessel at Shoeburyness, and the charge was reduced from 12 to 6 pounds of powder; despite the lessening of the charge, which prevented precision of fire, the vent-pieces of both guns were broken, before much damage was done to the wooden side.

8th. "Fire elongated powder shells near or across ships, &c."

This cannot be ensured, as the enormous pressure renders the shell liable to crush up.

At the Eastbourne experiment several shells burst at the muzzle, and the grooves of the 100-pounder howitzer were filled with lead, the projectile necessarily going wide of its mark. I saw a more striking instance of the effect of stripping at Shoeburyness. The gun was pointed and fired by an experienced naval gunnery captain, and the projectile went so far to the left, and so short withal, as to go close over a marine artillery officer and party, who were laying out a target on another range. At Woolwich also, during the trial of initial velocities with the ballistic pendulum, the screens were much cut up by the stripping, and had to be changed. In the Chinese campaign,* pieces of the lead coating of the projectiles fell on the skirmishers of the 44th.

Lord Herbert, in moving a vote of thanks to the forces, remarks:—

"It is said by Sir R. Napier that he never saw forts better defended. His words are worth quoting:

"The enemy made a noble and vigorous resistance; no entry had yet been made, the breach had not been completed; the gate was

* With reference to the Author's statement as to what occurred in China, we think it fair to our readers and Sir William Armstrong to subjoin the following letter from Major Hay, R.A., late Assistant Adjutant-General, Royal Artillery Expeditionary Force in China, to Sir W. Armstrong, which has been published since the delivery of the Lectures.—ED.

"2, Coates-crescent, Edinburgh, 25th March, 1861.

"Dear Sir William,—It was not my intention to have taken any notice of the article which appeared in the *Mechanics' Magazine* of the 1st of March, headed 'The Armstrong Gun,' it being so utterly at variance with the substance of my actual reports.

"But my attention having been called to an article in the *Morning Post* (22d March), copied from the *Mechanics' Magazine* of the previous week, commenting on the speech made by Mr. Baring when laying the Army Estimates before the House, in which the writer in the boldest way challenges the production of my report to substantiate, I imagine, his former statement, I am induced to write to you, in order that you may, should you deem it necessary, contradict in any way the statements contained in those articles.

"The Armstrong guns in China rendered the most valuable service, being always in the most efficient and serviceable condition, although put to very severe tests. They were never withdrawn from action and their places supplied by others; on the contrary, the Armstrong guns were invariably the first to be ordered up when artillery was required. At Tongchow, on the 14th of August, and again on the 21st, at the capture of the Upper

known to be built up; the attempts of the French to escalate at their angle were unsuccessful. At this juncture, with the permission of the Commander-in-Chief, I brought up two 24-pounder howitzers, and two 9-pounder guns of Govan's, to within eighty yards of the rampart, which, firing over the heads of the men on the 'Berm,' cut away the parapet at the point where the defence was most obstinate."

9th. "Fire shrapnel or built-up shells over boats with safety."

Similar dangers occur here to those already pointed out, and, if the lead coating be firmly attached to the projectile, it does not break up well, but I will refer to what happened in China, where the stripping already noticed, joined perhaps to the superior battering effect of round ball, as shown in the first experiment at Dover, seems to have been the cause for smooth bore guns alone being brought up at the most critical part of the whole campaign.

10th. "Fire canister."

This cannot be done, and shell cannot replace it; every shell too, intended to burst and scatter its contents and its own pieces before striking any object, requires two fuses, as the lead, by closing the windage, prevents the usual lighting of the time-fuse by the explosion, and therefore renders an additional percussion arrangement necessary, doubling the chances of a miss-fire, or a premature explosion, if the composition be disturbed.

The next compression plan of rifling is that of the shunt, which, instead of numerous fine grooves, consists of three double grooves with sharp edges and corners, and the projectile, instead of being coated with lead, hardened by zinc, has three zinc strips driven into it. These form the bearings of the shot, and they are let in by means of three undercut grooves along its surface, the grooves being of greater width in front than at the rear, to allow the strips to be driven home. See figs. 5 and 6.

The peculiarity of this mode of rifling is the additional groove, which, as now developed, is exactly as if three grooves, like those of the service rifled musket, were laid upon three plain grooves. To understand this, it is necessary to know that the musket grooves are deeper at the breech than at the muzzle, and, as a necessary consequence, the portions of lead which on discharge were expanded out to the bottoms of the grooves, the portions, in fact, that took the rifling, become more and more compressed as the ball travels onward to the muzzle where the grooves are shallowest.

North Taku Fort, the Armstrong batteries were firing over the heads of our infantry in advance, and the guns never ceased firing in consequence of any casualty to our men—quite the reverse; those guns continued firing while the infantry advanced to storm the enemy's works. It would have been most surprising if slight alterations had not suggested themselves in both guns and ammunition, considering that they were being tried for the first time, and that they were most jealously watched by all.

"In fact, from the instructions I received before leaving England, it was my duty to point out the slightest defect. This I did, and I was glad to observe, in a recent visit to the Royal Arsenal, Woolwich, that those defects had all been remedied in a manner which experiments had proved to be most successful; and I now feel confident that the British Artillery have the first gun, with the most perfect ammunition, in the world.

"I am, yours very faithfully,

"R. J. HAY, Brevet Major Royal Artillery,
"Late Assistant Adjutant-General, Royal Artillery Expeditionary
Force, China.

"Sir W. G. ARMSTRONG, C.B., &c."

This shallowing of the grooves is perfectly even throughout the musket barrel from breech to muzzle, but the bore itself is of uniform diameter.

The bore of the shunt is likewise uniform, and the incline regular. In the earlier guns of 1859 and 1860, the incline commenced behind the trunnions, and was only placed upon one groove, then on two grooves, and now the incline is upon all three grooves, only commencing at one and a half or two feet from the muzzle. It is also less steep, and the groove itself is shallower than at first.

The name "shunt" tends to mislead—the fact is, that, as the projections of the shot could not be loaded through the compression groove, sufficient width is allowed in the deeper groove beside it for the projectile to pass easily by the compression incline; at the end of which, the groove is narrowed to prevent the escape of powder, and not allow the projectile to have too much play on starting.

It is here necessary to ask you to bear in mind that, just as a male screw is pushed into a female screw pressing upon one side, and is withdrawn resting against the opposite side, so the muzzle loading rifled projectile goes in with its projections bearing against one side of the spiral grooving, and comes out on discharge pressing against the other, which, by obstructing its passage causes it to turn round or rotate.

Hence then the projectile when rammed home lies against the loading side of the groove, and on receiving the pressure of the elastic fluid is forced against the opposite side of the groove.

In the shunt gun the projectile, after striking the flat surface of the groove against which it has to slide, and unthread itself, goes generally along the bottom of the bore until it reaches the three inclines, when the compression commencing gradually, as already shown, squeezes the ball up into the middle of the bore, so that it leaves, centered and tightly nipped.

On the equality of this nipping, or rather on the equality of the yielding of the zinc strips, accuracy wholly depends, but as a fall, or even a knock, would alter their position, and the squeeze throws a great strain on the gun, the plan is hardly a suitable one for naval warfare.

Indeed the plan was abandoned after the bursting of many strengthened cast-iron guns, and a plain flat groove was tried; but as no accuracy could be obtained from this it was given up, and the shunt again returned to.

The double groove of the shunt cannot be easily sponged, owing to its sharp corners and edges, and were these edges to be rounded, or to become worn, the zinc strips would slip over the rifling.

The tight nip at the muzzle, though less dangerous than when the compression commenced further back on one groove only, which necessarily made the shot glance off to the opposite side of the bore, is still very destructive to the gun, as shewn in the opening of the heavy wrought iron shunt gun in proof, and the wear of the compressing grooves.

The modification of the shunt system, consisting in reversing the grooves and projections by making the former in the shot and placing the latter upon the bore, was equally unsuccessful, one of the ribs of a wrought iron gun giving way after about 100 rounds.

In comparing the shunt with the standard, it seems, like its many-grooved predecessor, to come short on the first 4 points, and not to have

hitherto been a success on the 5th and 6th. With regard to the 7th, viz. to "fire elongated molten iron shells;" this can hardly be done; for the expansion of shot caused by the molten iron filling, would increase the strain on the gun, and likewise increase the severity of the nip upon the bearings of the expanded shot.

This tighter nip would increase the projectile's tendency to crack, for the heavy liquid metal renders all shells filled with it very liable to break before they become thoroughly heated.

Comparative safety might be obtained by reducing the charge, but this would, in most cases, sacrifice much of the accuracy and destructive effect of the shell.

8th. "Fire elongated powder shells near or across ships with safety."

This cannot be insured, for portions of the zinc strips are liable to break off, and the slightest loosening in carriage, &c., would, on firing, cause the strips to be jerked out of the projectile when nipped at the muzzle.

9th. "Fire shrapnell or built-up shell over boats with safety." The same objections apply here.

10th. "Fire canister."

This could be done, but at the risk of destroying the sharp edges of the grooving.

System of Expansion.

From the compression, we have now to turn to the expansion system.

This plan was adopted by Mr. Lynall Thomas both in service cast-iron, and in a large forged gun made for him by the Mersey Company.

The weight of his gun, which was left rough, was about six tons, the diameter of the bore 7 inches, and from it the longest ranges, and the greatest known velocity of rifle projectiles, have been obtained.

The gun has been fired with 25lbs. and 27lbs. of powder, and with projectiles weighing 175lbs., and these were thrown about 10,070 yards.

The rifling is similar to that used by Mr. B. Britten, but the grooves are more numerous, and the expansion, which seems more perfect, is effected in a different manner, by driving out a hard metal.

The twist of the rifling was sharper than that used by others who had adopted the expansion system, and the ranges were very equal.

The 2nd expansion plan is that of Mr. Jeffrey, who has ably applied the principle of the Minié bullet to ordnance projectiles. (See figs. 7 and 8.)

The rifling consists of several shallow elliptical grooves, the number being proportioned to the calibre of the gun.

In the 32-pounder last rifled, there are seven grooves, which leave rather more one-third of the bore as "land," the rest being cut away by the rifling.

The 32-pounder projectile weighs about 44lbs. when empty; of this the lead weighs 14lbs., and the powder capacity is about 2½lbs.

The lead is affixed to the rear of the projectile by dovetails, into which it is cast, and a hollow resembling that of the Minié bullet is left at the bottom, for the purpose of causing the lead to expand out into the rifle grooves.

A wad or covering, consisting of flannel coated with soft soap, is

(SKETCHES)
LANCASTER'S OVAL CENTERING AGAINST BORE SYSTEM.

Early French

c. c. Loam lining for Mollen Iron.

a. a. Circular Wad

Hadden has lately used a flat bottomed Shell.

Whitworth's (Hexagon)

CONCENTRIC SYSTEM.

Sections

n. n. Add Pieces taken out for large Calibers.

Solid headed Shell for 1st Brousside, &c.

French, Decr, 1860

Balanced Shell.
b. b. shows Rib on Shell.
c. c. c. Loam lining.

Elevation of Shot

wrapped round the rear of the projectile, and this facilitates the loading, decreases the windage, and lubricates the bore of the gun.

The 3d expansion plan is that of Mr. Britten.

The rifling consists of shallow rectangular grooves, removing half the surface of the bore.

In the 32-pounder there are seven grooves (see figs. 9 and 10).

The 32-pounder projectile weighs about 48lbs. empty; the lead, which weighs about 14lbs., being affixed chemically to the plain surface of the casting by means of zinc; a wooden plug is screwed on to the bottom of the projectile, which, being driven against the lead on discharge, causes it to expand into the grooves. Captain Blakely has used this shot with a triangular groove.

The difficulty experienced in the expansion plans is that of keeping the axis of the projectile coincident with the long axis of the piece. At low elevations, the friction along the bore tends to raise the rear of the shot, and facilitate the equal expansion of the lead; but, if the lead at the rear expands equally, it is clear that the iron forepart of the shot, having nothing to raise it, must continue to rub along the bottom of the bore. At high elevations, however, the shell keeps more fairly along the bottom of the bore, the lead on its upper surface expanding the most. An illustration of this is found in the greater accuracy obtained at high as compared with that obtained at low elevation with the same gun.

The accuracy also is found to be lessened by a slow twist, and hence it is essential that the bearings of the projectile be sufficiently firm "not to slip," a result difficult of attainment with a heavy shot and a metal sufficiently soft to expand out into the rifling.

The expansion of the lead at the rear of the projectile increases as the combustion of the powder becomes more perfect from the bore's warming; and hence, when the gun is weakened by being heated, an increased strain is thrown upon it, by the sharper driving out of the lead into the rifling and more instantaneous closing of the windage.

The lead, however, has the advantage from its greater weight of maintaining rotation better than iron only; but this advantage is more than counterbalanced by the loss of powder capacity, and the slow initial velocity of the projectile.

System of Centring against the Bore.

1st. Mr. Lancaster's plan :

The gun is rifled as an oval, by which only a trace of the original bore is left at the lesser diameter, called the minor axis of the piece. The greater diameter, or major axis, being, in the last 32-pounder, about six-tenths of an inch larger than the minor, so that, considered as a two-groove rifle, the grooves are three-tenths of an inch deep at their centres. (See Plate II., Figs. 11 and 12.)

The earlier projectiles, namely, those sent to the Crimea, were made of wrought iron, with no rifle twist upon them, but more recently the shot have been bent to the shape of the bore; some of these had a wrought iron casing put over the cast-iron projectile, and this projecting 4 inches to the rear carried a lubricant which the wooden wedges at the bottom sent out, while expanding the casing so as to fill the bore.

The casing was perhaps intended also to lessen the play of the shell on turning over from the loading to the bearing side on coming out, but it has been now given up.

All the plans however of centring against the bore are more or less trying to the shells, according as the windage and consequently the play, in turning from the loading to the firing bearing, is greater or less.

The weight of the last projectile employed, is about 44 lbs. and its powder capacity about $4\frac{1}{2}$ lbs. It is thick in the rear and thin in the front, tapering to a point.

The next plan of centring against the bore is that of Mr. Haddan.

The rifling consists of 3 large and shallow elliptical grooves about one sixth of an inch deep, which take away nearly two-thirds of the surface of the bore. (See Figs. 13 and 14.)

The projectile has three wings on its fore part, which are put on straight with the axis of the shot.

The rear tapers and has a shoulder for a ring wad a, a.

The inventor described its shape as being like that of a skittle pin, but he has lately modified this figure.

The 32-pounder projectile weighs about 52 pounds, and its powder capacity is about $3\frac{1}{2}$ lbs.

The last plan of "centring against the bore" is that of Mr. Whitworth.

The rifling is called "hexagonal," but there are twelve sides, six wide and six narrow; one portion of the six wide sides is sloped off, which facilitates loading, &c.

The projectile, after being turned to an exact round in the centre, is planed over the portions which correspond to the six flat sides of the grooves.

This planing on six sides of the projectile (which is entirely of iron) leaves it with sharp edges for bearings on which to centre itself in the gun. The projectile is long, tapering at each end, the rear being flat and the front rounded, while the rifle twist is very sharp. (See Figs. 15 and 16.) Of the plans of centring against the bore, the hexagonal gives the least play to the projectile, but, as there is no shoulder to receive the shot on its turning from the loading to the bearing side of the groove, the projectile wedges itself round against the bore, which the sharp edges have a tendency to cut. The effect of this may be seen in the breech loading 80-pounder that cracked at Portsmouth, and was sent back to Woolwich; but with guns of smaller calibre, which are fired with low charges of powder and light shot, the wear is comparatively small. For further information on the subject of giving rotation to the shot, I may refer you to Captain Blakely's paper on "Rifled Ordnance," published in vol. iv. of the Journal of the Institution, page 397.

The Concentric System.

The 4th system, "Concentric," is that which I laid before the Minister of War in 1859, and which was carried out before the close of the year in a 32-pounder service gun and rifle projectiles.

The rifling is called "central" from the peculiar mode of centring

a simple iron projectile, which, instead of inclining towards the bottom of the bore in its passage out, is centred on its rounded bearings without jar by the first pressure of the elastic fluid. (See Figs. 19 and 20.)

This is effected by the peculiar curves of the shoulders of the three grooves, which incline towards the centre of the bore, and thus form three rails for the projectile to glide out upon without being compressed or strained.

The projectiles, however much they may vary in diameter from unequal casting, so long as they are not too large to go into the gun, or too small for their bearings to reach the edge of the shoulders, are retained concentric with the bore by the shape of the curves; an advantage that cannot, I believe, be obtained by any other arrangement of grooves. In fact, unless a similarly curved shoulder be adopted, the least variation of size in an iron projectile, must reduce what was perhaps intended for three long bearings, to three mere points. This will be apparent by considering that the outer part of any rifle groove is longer than the inner, and hence, if a curved projectile be planed to a twist, which would correspond to that of a whole turn in twenty feet, its surface curve will be slower than intended, if the projectile be of less diameter than the proper gauge, and sharper than intended, if the projectile be larger.

In neither case would the shot bear against a long line of the (spiral) rifling, and hence would lie across the bore, and be liable to crack, from the twisting action to which it would then be subjected. Practically, it is extremely difficult, if not impossible, to plane or turn an iron projectile so as to fit on a long bearing *against the bore*, for, in proportion to the increase of charge used, the shot will wedge itself further round from the wider or more deeply grooved part of the bore to the narrower or shallower part; in other words, the major axis of the shot, has, in proportion to the increase of powder charge, a greater force driving it more tightly into the minor axis of the piece.

The central grooves are three in number, and not over $\frac{1}{3}$ th of an inch deep ($\frac{1}{4}$ th is sufficient), and about a fourth of the surface of the bore is swept out by the rifling. The shell weighs 38lbs. empty, and contains 4lbs. 13oz. of powder. In the case of firing heavy projectiles from a gun of large calibre, it would be necessary to take out a small piece, so as to form a shallow shoulder for the shot to turn against in loading. (See Fig. A.) Leaving you to compare the methods of rifling of Messrs. B. Britten and Jeffrey, firing compound projectiles, and those of Messrs. Lancaster and Haddan, firing iron shot, as their plans are said to be "competing" with mine, I may perhaps venture, as a gunnery officer, to assert that many of the points which are desirable for a naval weapon are obtained by the concentric system, and these are what I beg you to join me in examining. The first four points laid down in the standard given at page 426 are evidently possessed by this system.

The 5th, "Give a flat trajectory" is also obtained; the mean range of the rifle shell fired at 2 degrees elevation from the common cast-iron service 32-pounder being 1,130 yards, whilst the range of the shell fired from the wrought-iron 100-pounder is only from 910 to 920 yards.

The elevation however is in the first case given by quadrant, in the second by tangent sight.

It is now known that lead-coated shot make a smoother hole than those of iron only, and it is certain that the projections on the latter would increase the splintering effect. Taking a circle over the projections of the 32-pound rifle shell, it is very little smaller in diameter than the iron portion of the 100-pound projectile.

6th point. "Have projectiles that deflect little, and ricochet straight and evenly."

The projectiles are balanced, and are thinner and lighter at the ends, which are rounded when intended for long range or ricochet.

The principal weight being thus in the centre of the shell, and its rounded ends of equal weight, it appears to go point foremost throughout the trajectory, and not appreciably to deflect. The shell also ricochets with tolerable evenness, though always slightly to the right.

The round ball, however, can be used from the gun for this purpose, and especially for hitting the hulls of low gunboats at a long distance on a smooth sea.

7th. "Fire elongated molten iron shells."

For this the system is well adapted; and, as the projectile centres evenly upon its rounded bearings without any dangerous jar, a full powder-charge can be safely used, and long ranges for burning distant arsenals, &c., be obtained.

8th. "Fire elongated powder-shells near or across ships with safety."

Three hundred rounds have been fired from the rifled 32-pounder cast-iron service gun, and about 46 of the 50 elongated shells with which this number of rounds was obtained were re-fired 6 times each (some 7 times), and *were still serviceable*.

As the shell stood this knocking about without a single one getting cracked, it may be fairly inferred that they can be fired over and across friends without the slightest danger.

It is worthy of notice that the rifle grooves showed no trace of wear after 300 rounds, and the great strength of the projectiles is greatly due to the projections or flanges which form their bearings.

9th. "Fire shrapnell or built-up shells over boats with safety." This also can be done.

10th. "Fire canister."

The rifling will discharge these and all the present service ammunition without the slightest danger of being injured, for the outer edge of the shoulder is rounded off, and no possible amount of wear could damage the centring of the elongated projectile.

The value of the grooving for firing round shot has been sufficiently proved at Shoeburyness, where great accuracy was obtained; and, were the bores of new guns left a trifle smaller, they could be rifled on the central principle, and without lessening the facility of loading them the round balls would be projected with much greater precision, and also with greater range, than that at present obtained from the smooth-bore gun.

I have now to point out that the simple elongated iron shot is superior to the compound for storeage and carriage, that it does not cost half so much at first, and, while the iron shot can be re-fired for practice, neither the leaded nor the zinc-ribbed shot can.

In a sea-way, a wad would be required to keep the charge from

oving; it is doubtful whether this could be safely used with the shunt, and still more questionable in the case of expanding projectiles, which, by losing the windage, cut off the gas, that, with an iron-shot, would pass by and drive the wad out before it.

The expanding lead shells also are, from the weight of lead affixed to their rear, obliged to have a considerable thickness of iron in front to counter-balance that weight, and a corresponding reduction of thickness at the centre; this makes the shell weak and of less value for breaching.

All leaded shot carry a great weight of lead, merely for the purpose of taking the rifle grooves, and this soft mass is very liable to get out of shape, and to stick in the bore on loading; and, while the lead-coated projectiles are less than the diameter of the bore of the gun, the iron shot have the advantage of the additional width of the projections which extend into the grooves.

As respects the finely-grooved breech-loader, it is clear that the strain of starting the projectile, wedging it through a narrow hole, and again nipping it at the muzzle, must be very great, and that every successive shock must tend to weaken the whole fabric of the gun, as well as to disintegrate the metal of the vent-piece.

It is likewise apparent that the friction caused by forcing the projectile to cut its way out of the gun is so much propelling power lost, and this power is really expended in destroying the gun, which absorbs it.

How, then, it may be asked, can this loss of power be avoided? The answer is, by using an iron shot, and if, as some suppose, hard cast-iron bearings will not answer, there is no difficulty in softening or coating them.

The advantage of breech-loaders is very doubtful, for both the vent-piece and screw, and also the wedge, are liable to get set fast, and the flat surfaces presented by both these stoppers occasion a damaging shock to the breech, more especially at high elevations. This effect is avoided, or ought to be, in the muzzle-loading rifle by chambering the bottom of the bore. Breech-loaders are certainly unfit for exposed situations, and have as yet not given satisfactory results between decks, while the additional metal required in the rear adds considerably to the weight of the gun.

Whatever may be decided respecting breech-loading "per se," it is not to be denied that the leaded compression system, which cannot be used without breech-loading, is the most trying of all systems to the breech apparatus, and it therefore becomes a question whether it is not advisable to give up the plan, for the sake of securing the safety, or at least the longer life, of the gun.

That the fine-grooving itself is not advantageous with large guns has been already in part shown, but the reduction in the projectile's velocity from friction, would be a great drawback to the value of any rifled weapon, and it led to the partial adoption of the shunt-grooving for the navy.

The want of flatness in the trajectory of the 100-pounder shot affords a sufficient proof of this reduction of velocity, but with guns of larger bore the loss would be still more serious.

The fact is, that a soft metal yields too much to give sufficient rotation to a heavy shot, or to prevent its gravitating towards the lower surface of

the bore, and, if the metal coating be made harder, the strain of squeezing it through the bore would be too great for the gun.

The author of the finely-grooved ordnance stated at the C. E. Meeting "That the projectile should rule the gun," and hence, having adopted the built-up segmental shell (patented by Holland in 1854), he had devised "the form of gun most suitable for throwing it." This seems to have been a mistake, for improvements in projectiles are quite as likely to take place as improvements in the cannon which fire them; and by this rule an improved projectile might necessitate a change of gun.

But this built-up projectile is in my opinion inferior, and gives less sure results than those which could be obtained from an elongated shrapnel shell (with a powder charge in the rear), which on bursting would be certain to scatter destruction *in front* as well as at the sides.

It is hardly necessary to mention that there is no practical difficulty in holding any iron shot by studs sufficient to detain it in its place, and prevent the possibility of its sliding too far, in loading from the breech; and such studs could be affixed to the shot, so as to be easily knocked off, in loading from the muzzle.

As to the precision attainable by iron projectiles, this in all plans mainly depends upon the accuracy of fitting, and, were it to be properly carried out, extraordinary perfection would be attained, without at all injuring any of the qualities required by a naval gun.

The adoption of iron shot would likewise admit of the use of what promises to be a formidable means of offence, viz. a flat-headed shot with a powder shell having a percussion fuze in its rear. (See Plate II. fig. B.) Such a shell, if fired from a powerful gun, would penetrate the armour plate and then discharge its mine in the side of an opponent.

But ordnance, as before stated, should be of from eight to ten inches calibre, or more, and, were the present lengths of guns reduced, greater facility of loading would be attained, and thus really powerful rifles of ten inches bore could be constructed, so as not to weigh more than our present sixty-eight pounder cast-iron guns.

Such rifle guns would fire a round ball of 136 lbs. weight (at close quarters), and also an elongated shell of about the same weight, containing nearly 20 lbs. of powder. Such guns would be simple also, and the effect of their projectiles would resemble those of the concentrated broadsides, that future warfare with plated ships will necessitate; and I cannot close these Lectures better than by quoting the words of the preface to the Emperor Napoleon's admirable treatise on the past and present of artillery, where he says:

"Whatever is complicated fails in producing good results in warfare; the promoters of systems forget always that the object of progress ought to be, to obtain the greatest possible effect with the least possible effort and expense."