Science in Heavy Gun Construction.

In our article last week we asserted that heavy guns lined with thick steel tubes, which latter have to support the whole of the longitudinal strain as well as the first shock of the transverse strain, are constructed in defiance of the teaching of science, and that they violate first principles.

The list of known explosions of steel lined guns without giving warning comprise the 100-ton gun at Spezzia, one 38-ton gun on board the *Thunderer*, two 38-ton guns in France, one 9½-inch 18-ton gun on board the *Renown*, one 9½-inch 18-ton gun at Constantinople, two 9-inch 12-ton guns at Shoeburyness, one 9-inch 12-ton gun at Woolwich, one 8-inch 9-ton gun at Shoeburyness, one 8-inch 10-ton gun off Cadiz on board the Russian frigate *Alexandra Newski*, one 7-inch 6½-ton gun on board one of H.M. ships at sea; two 7-inch experimental guns at Shoeburyness (68-pounders lined with steel), and two steel-lined field guns in India. Against this ugly list Sir William Palliser can point to the extraordinary fact that no gun lined with a coiled wrought-iron tube of any pattern, that has been introduced either into our service or adopted by other nations, has ever yet burst, whether at practice or at proof. We therefore feel justified in maintaining that he has proved his case. It should be remembered that six of the heaviest explosions took place very nearly within the last twelve months, so that the mildest possible powder, half the size of brick-bats, had then been made and issued, to spare the lives of these heavy guns, and money had been lavished to build them of the most costly materials, but neither the one nor the other has saved them from the inevitable consequences of a neglect of the rules of science. The sad view of the matter is, that, six heavy guns—two English, two German and two French—having burst in about twelve months, when, and where, it may be asked, is the next explosion to come off? From a scientific point of view, we cannot see how there can be a sudden cessation of such accidents, and this makes the situation all the more alarming.

It is a positive relief to turn from these disasters and their originators—on the one hand manufacturers devoid of science, and on the other Government officials who know nothing of either manufacturing or science—to a scientific method of building up guns which knows no failure. As we have already mentioned in a former article, Sir William Palliser in constructing his guns throws the whole of the longitudinal strain upon the casing, or *outside*, of the guns, and absorbs the transverse strain by placing loose coiled wrought-iron barrels in the *inside* of the guns. About 2,000 of his guns, up to the 80-pounder, are in continual work at home and in the colonies, and none of them have ever burst in proof or in practice. The United States officers have carried out experiments lasting five years, and have definitely adopted the system we have described.

LONGITUDINAL STRAINS IN GUNS.

The bursting of the 100-ton gun on board the *Duilio* is a remarkable instance of the necessity of throwing the longitudinal strain upon the outside part, or casing of a gun. In other words, it illustrates forcibly that this strain should be transferred from the limited area of the inner tube to the larger area of the casing. For, if there be 100 square inches bearing that strain at the inside of the tube, and if the diameter of the casing be twice that of the gun, then there would be 400 square inches, or four times the number of square inches supporting that strain when transferred to the casing. Thus if the longitudinal strain were to cause a total pressure of 4,000 tons, the pressure on the tube would amount to 40 tons per square inch; while, if transferred to the casing, it would only amount to 10 tons per square inch. The law enunciated by Sir William Palliser—namely that Barlow's law of transverse strains in a gun holds good for longitudinal strains too—is a question of first principle. The Ordnance Select Committee expressed their opinion 12 years ago that they were inclined to believe that Sir William Palliser was right. The subject is of sufficient importance to demand the special attention of the committee now sitting at Woolwich, and it is most desirable that they should have an opportunity of determining this important point.

Had Sir W. Palliser's law been understood, the *Duilio* gun would not have burst. Ignorance of that law has foisted four huge and dangerous monsters, namely four 100-ton guns, upon the country, at a cost, inclusive of carriages, mounting, and construction of ramparts, of probably £150,000. An inquiry ought to be at once instituted as to whether these guns are or are not safe in their present state, and whether boring up the steel tube and lining it on Sir W. Palliser's plan might not render them serviceable.

There can be no doubt but that the general belief existed that Sir W. Palliser's 7-inch gun would burst when it was fired doubly loaded. Surely the extraordinary strength shown by that gun, and the complete disappointment of all expectations as to the result of the experiment, ought to make our military authorities pause before they continue to lavish money upon attempts to bolster up steel-lined guns. They should remember that Sir W. Palliser was bitterly opposed for years with regard to the conversion of cast-iron guns, and that all the arguments now used against the extension of his system to large guns were employed against the conversion of cast-iron guns. The same authorities who opposed his most useful and economical converted ordnance, looked upon his now famous chilled shot as mere folly when he proposed them. "How," it was argued, "could such a wretched thing as cast-iron shot equal a steel projectile."

It took some eight years before his armour bolts were understood and adopted in the Navy, and in our iron-clad forts. When the Admiralty adopted his bolts, the lords sent Sir William a letter of thanks, for he gave the Navy the use of his invention free from all claims; he has, in fact, never received anything for what otherwise might have been a valuable property. It is plain that Sir William has been for many years the uncovenanted servant of the War Office and Admiralty; but unfortunately for the interests of the public service, departmental jealousy—from which, however, the Admiralty are perfectly free—has been enabled to take advantage of the changes of administration, and the advent to office of new men, *ignari loci* has been the means of throwing absolute power into the hands of those who are inventors, manufacturers, and judges in one. The motto of the Ordnance Branch of the War Office has, for too many years, *tria juncta in uno*.

The past successes of Sir W. Palliser entitle his proposals to consideration; he maintains that if the stump of the gun which burst on board the *Thunderer* were lined on his plan with a coiled wrought-iron barrel, it *would not burst* if fired with a double charge similar to the second *Thunderer's* gun into pieces. He founds his opinion upon experiments as shown in our illustration, and maintains that though the barrel might bulge round the seat of the front charge, no further harm would ensue. He points to the fact that the first *Thunderer* gun is not bulged round the supposed seat of the front charge, as being one of the several proofs that that gun was not double-loaded when it burst. What we regard as especially objectionable is that while an experiment which would be of such infinite benefit to the service has been rejected on the score of expense, money should have been forthcoming by tens of thousands of pounds for purchasing 100-ton guns, which now must be dangerous because they have been constructed in ignorance of first principles. Since we have undertaken the task of endeavoring to elucidate these principles, we have shown two illustrations, which we trust will enable our readers at a glance to appreciate the difference between the application of science in gun construction on the one hand, and the lack of it on the other.—*United Service Gazette.*

LECTURE ON THE PRINCIPLES WHICH SHOULD GUIDE THE CONSTRUCTION OF HEAVY ORDNANCE, AND ON THE MATERIALS FOR THE SAME.*

The construction of heavy ordnance is a subject which at the present time possesses especial interest in this country, because of the recent accident on board the "Thunderer."

I propose to direct your attention to the following divisions of the subject :—

1st. The nature of the force with which we have to deal.
2nd. The material which has to control and direct that force.
3rd. The proper disposition of that material.
4th. The arrangement for giving the projectile the necessary rotation.
5th. The effect of chambering.
6th. The proper arrangement of the material in the construction of breech-loaders.

1st. *The force with which we have to deal.*—This is the force of fired gunpowder. Many other explosive compounds have been proposed, but I believe it is now universally admitted that gunpowder is that which is best suited for artillery purposes.

Here, however, we are met with the fact that there are many varieties of gunpowder. These, however, as regards our own service, may be confined to R. L. G. and pebble powders, the latter being that which is now solely used in heavy guns.

The advantages claimed for pebble powders are that whilst they give as great or a greater muzzle velocity they cause less strain upon the gun than the R.L.G.

That they cause a less strain is quite true, and is due to the fact that they burn slowly and continue burning whilst the projectile is moving towards the muzzle.

It may, however, be shown that with *a given weight* of powder the mean pressure is less with a slow than a quick burning powder.

Taking the pressures in the 10-inch gun fired with 75lbs. of pebble powder and a 300 lb. shot, of which a diagram is given in Messrs. Noble and Abel's paper on fired gunpowder (Phil. Trans. 1875), we find that with a maximum pressure of 18 tons per square inch, the terminal pressure at the muzzle was 3 tons, and the mean pressure about 6¼ tons per square inch.

Now when the shot reached the muzzle the chase was filled with gas at a pressure of 3 tons per square inch. If now that gas were passed back by a piston until it occupied the original volume occupied by the charge, and if there were no transmission of heat, which, as I will presently show, would be the case, the pressure would rise to 33·63 tons per square inch. But the work done in compression would be exactly equal to that given out in expansion, so that if the charge had been converted into gas *instaneously*, the chamber would have been filled with gas at 33·63 tons, and that gas in expanding to 3 tons would have given a mean measure of 9½ tons per square inch against 6¼ tons per square inch given by the pebble powder.

Roughly speaking, if the powder had been instantaneously converted into gas, the velocity of the shot would have been increased by twenty per cent., but this would have been obtained by an increase of pressure in the gun, from 18 to 33·63 tons, or about 86 per cent.

It is therefore evident that with the same weight of charge there is a loss of velocity with slow burning powder.

This appears to be borne out by the experiments recorded by the Committee on Explosives (Second Report, page 9), where the velocity obtained in a 12-inch gun with 85 lbs. pebble powder was 1,287 feet per inch, and with 67 lbs. of R. L. G., 1,157 feet per inch.

If the charge of R. L. G. had been 85 lbs., the velocity would have been 1,304 feet per inch, or about three per cent. greater than with the pebble powder, and a similar result would be obtained from the experiments recorded at page 10 of the Preliminary Report made with a 10-inch gun and charges of 60 lbs. of R.L.G., and 70 lbs. of pebble powder.

The difference of velocitys between these powders is, however, so small that there can be no doubt of the wisdom of using the slow burning powder in large guns as at present constructed.

This being so, we may assume that we have for our motive power an elastic fluid attaining a pressure of 20 to 24 tons per square inch in guns of 12 inch diameter, and probably 30 tons in larger guns. What regards us, however, at present, is that we must provide for much higher pressures in large guns, even though we do adopt slow-burning powder.

The material of which the gun is to be made.—For heavy artillery we may leave bronze out of the question, and confine ourselves to cast iron, wrought iron and steel.

Much confusion of idea arises from the want of a really scientific nomenclature on this subject. By many writers, iron and steel are treated almost as though they were distinct metals, whilst the fact is that iron, whether cast or wrought, and steel, are in all their varieties only alloys of the metal iron with other substances.

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*Lecture delivered at the United Service Institution by James A. Longridge, M.I.C.E.