badly on account of the continual racing of the accumulator pumps. Subsequent examination showed the suction and delivery valve seats and faces much worn and cut.

There was no news of the Itata to be gained at Arica, and the Charleston cleared out again on the evening of June 3, after examination and repairs. A bolt in the universal joint of the main stop valve in the hydraulic room broke. Speed four to five knots. On June 4 the cruiser entered Iquique harbour, and there found the long-looked-for Itata. She was, however, in charge of the Baltimore and San Francisco, having arrived a few hours before, and surrendered to the American fleet. It must have been a sad disappointment to the Charleston, this tame ending to the search, after the worries and anxieties of nearly a month's leaky tubes and breaking down of blowers. The ship had the somewhat doubtful satisfaction of taking the Itata to San Diego, where she arrived on July 4—in time, we hope, to add something to the celebration of the great national festival.

In face of the open-hearted manner in which the experience gained during the quest of the Itata has been put at the disposal of naval engineers of all nationalities, comparisons may seem in questionable taste. If this should appear so at first glance to our own countrymen, we would remind them that the same manliness of character which has led to the publication of disasters will not shrink from criticism. It must be remembered, in the first place, that the United States engineers have not the accumulated practical experience in detail that we, on this side, have garnered during the years that our steam navy has been growing piece by piece. There is another thing, too, to remember—a matter to which we have already referred—that there is no Journal of Naval Engineers' Society to make our own shortcomings known. Nevertheless, we do not think those breakdowns, of which a record has been given, would have been likely to have occurred in an English warship. Whether their place would have been taken by others is a matter upon which our critics may fairly hold their own opinion. The troubles were all small, with the exception of the leakage of the boiler tubes. Of course we have our own difficulties with boiler tubes, but they are of a different sort. The tubes of the Charleston are of iron, and it was the tubes themselves which leaked, not the joint at the tube-plate. Mr. Hollis questions whether the material was defective. We should be inclined to think there was an absence of zinc in the boiler. The trouble occurred at moderate pressure for draught. Of course it is not steam pressure in itself which causes leaks in a boiler, but if a leak occur its seriousness is much intensified by additional pressure driving the water out at a quicker rate. In the British service care is taken to keep the zinc plates supplied in proper condition, and though boilers are, as far as possible, kept entirely free from scale, we do not hear of pitting such as occurred with the Charleston. We can indorse what Mr. Hollis says about the use of fans making stokers less diligent in keeping their fires in shape, and the extemporised water gauge was characteristic of native ingenuity and resource. In the Royal Navy a permanent gauge under the observation of the engine-room staff is a regulation fitting. The troubles with the fan engines, which form so large a part of the catalogue of mishaps, are attributed to their proper cause by Mr. Hollis. It is always better to place the motor in the engine-room, when possible, and in many English vessels, which depend largely on fan draught, it is so fitted, the fan only being in the stokehold. With regard to the bulkhead being too near the boiler, it is the practice in the Royal Navy to have a portable plate under such circumstances, and this provision may have been made in the case of the Charleston, although it may have been impracticable to remove it when on the run. In regard to the heating of the crank-pin brasses of the air pumps, which was a rather serious defect, the proper remedy was found by using white metal. In our own Navy we do not think that any other form of bearing would now be fitted for an engine of this magnitude. Wire rope we always consider an untrustworthy means of transmitting motion, and so it proved in the present case. Of course there are positions in which it is difficult to substitute other methods, and in such cases the wire rope should be kept well in view, and be often overhauled. Of course sheaves should be of sufficient diameter, and care taken to prevent corrosion. At best, however, it is apt to prove a treacherous material, and solid rods should be used whenever possible. Possibly the lesson of the Charleston in this matter may be of service in other navies besides that of the United States. The stripping of the thread on an eccentric rod of a fan engine points to a defect into which we think American engineers are prone to run; as they are apt to trust over-much to rods being screwed in. It sounds as if the rod were screwed into the strap. It is the practice in our own service to forge solid ends.

It is, of course, easy for us to be wise after the event in these small matters of detail. After all, the main engines ran perfectly throughout the voyage, and this is a matter to which the designers of the machinery, the contractors, and those in charge may all point with a pride that is fully justified. Indeed, the manner in which the United States Navy has been built up in so short a time is a matter upon which even so eminently a mechanical people as the Americans may worthily congratulate themselves.

ARMSTRONG QUICK-FIRING GUNS.

THE famous firm of Elswick can with unquestionable justice claim to have taken the lead in the construction and design of quick-firing guns of large calibre, and has maintained its position in this important branch of artillery.

Important alterations or modifications have from time to time been introduced, so that the quick-firing guns of to-day differ materially in detail from those that were first produced in 1886. The modifications referred to have taken place in nearly every detail that goes to make up the complete gun and mounting; for instance, comparing the quick-firing gun originally designed with those now under manufacture, we find that the calibre of the guns has advanced from 4.7 in. to 6 in., or it may indeed be said (as will afterwards be explained) to 12 in. The protecting shields, originally of 1¼ in., have now in some cases reached 6 in. in thickness, the shape of the shield being also modified to give better protection; and the breech mechanism has been improved so as to give a higher rate of fire.

It may be explained that a gun is technically known as quick-firing when a metallic cartridge-case, carrying the percussion cap or electric primer, is used with it. The powder charge and projectile may or may not be made up in one cartridge, but the loading is known as "simultaneous" if they are, and as "separate" if they are not. There has been considerable difference of opinion as to the merits of these two systems. With "simultaneous" loading no doubt a slightly higher rate of firing can be obtained on show occasions, that is, when the cartridge being brought up beforehand, it is simply a matter of hurrying the ammunition through the gun regardless of expense or of all the conditions that necessarily obtain on service. The cartridge-cases may also be more favourably treated with simultaneous loading, for no gas can escape them until after sufficient pressure has been established to set them out against the chamber of the gun. This latter advantage is, however, a very small one, as will be readily understood when it is explained that with separate loading 6-in. cartridge-cases (made at Elswick) are frequently fired from 15 to 16 times each, and even 20 rounds have been obtained from one case.

No practical artillerist would sacrifice any advantage to be gained under service conditions for the sake of being able to make a show under conditions which do not even approach those existing on service; and if, therefore, rapidity of fire is considered, it is evident that the advantage under service conditions lies decidedly with separate loading. On board Her Majesty's ships a large number (about forty) of projectiles are stowed in racks close to each gun. This is a sufficient supply to provide for most actions, especially as intervals would certainly occur when a slacking of fire would give an opportunity of renewing the supply from the shell-rooms, if the action lasted for an abnormally long time. The argument that it is dangerous to keep loaded shell in racks on deck cannot be advanced with reference to quick-firing guns, for it is evident that if the quick-firing properties are to be developed, not only must a certain number of shell be brought up round the gun in readiness for loading, but some loaded cartridge-cases must also be placed there. The danger has to be accepted, therefore, whichever system of loading is adopted.

With the projectiles placed in racks near the gun, it is necessary only to hoist the lighter portion of the charge from the magazine; a sufficient supply can therefore be maintained to meet the requirements of the guns, an absolute impossibility with simultaneous loading; as the guns are loaded so quickly, even with separate loading, that the firer never has to wait, greater speed cannot be necessary; lastly, if simultaneous loading is used, both the cartridges and fuzed projectiles must be placed in the same magazine, a condition which must involve some danger.

It is understood that although the French Navy commenced by adopting simultaneous loading, they have now changed to separate loading.

Cartridge-cases are used with Elswick guns up to the 6-in. 100-pounder, but above this size obturation is provided for by other means, such as the De Bange pad, or short cartridge-cases, with which very successful experiments have recently been completed. Therefore the guns above 6-in., although designed for very rapid loading and firing, cannot strictly be termed quick-firers.

Although a 6-in. quick-firing gun was submitted for trial very shortly after the successful conclusion of the 4.7-in. gun trials, it was not accepted for the British services, because it was thought with black powder so much smoke was developed at each discharge that quick firing at a target could never be carried out. The adoption of these more powerful guns was therefore most unwisely postponed until the introduction of the smokeless powder cordite removed the objection. But that the objection was really groundless has now been amply proved, for with black powder (E.X.E.) fifteen rounds were fired in 3 minutes on board H.M.S. Royal Arthur at a target the distance of which at the commencement of the practice was 1600 yards, and at the conclusion 2200, the ship steaming about 8 knots, and nine hits were recorded. Practice almost as good has also been reported from the Royal Sovereign and other ships.

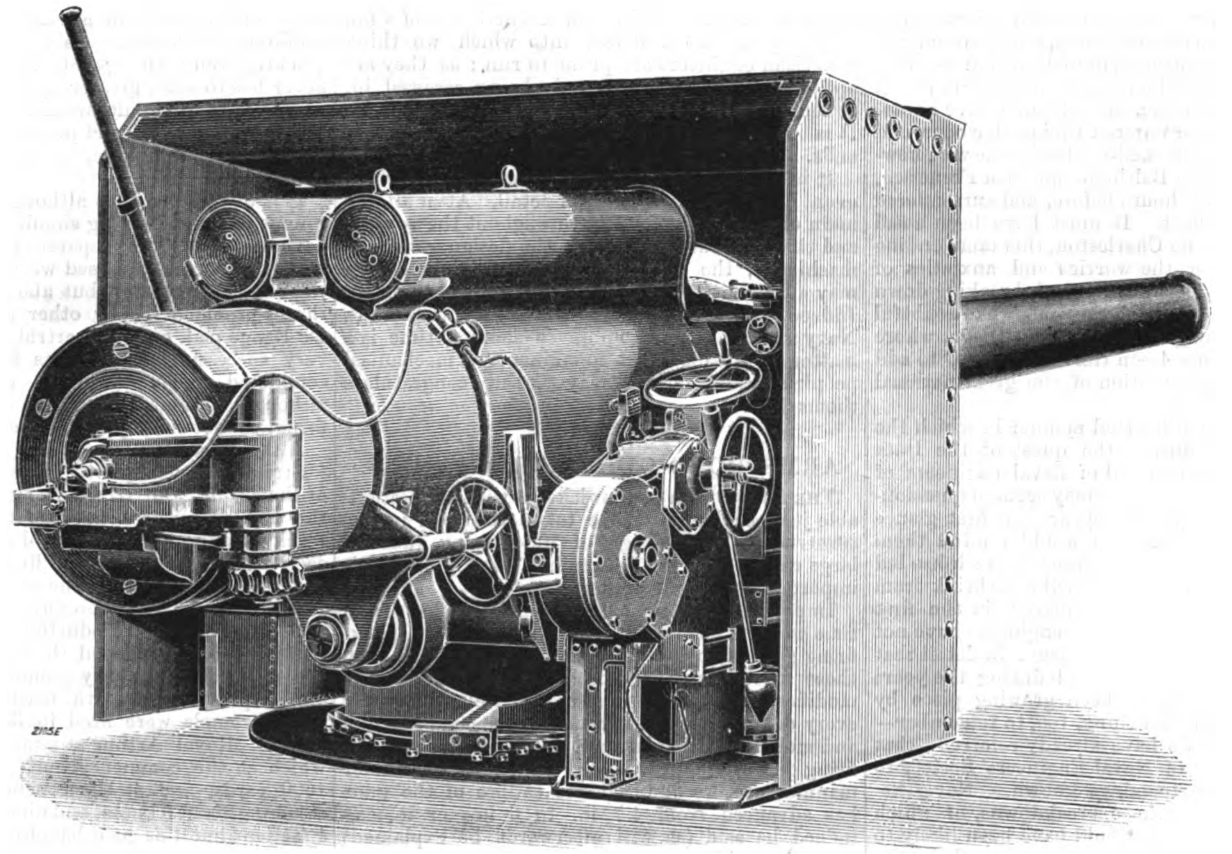
It is hardly possible that such excellent results can be beaten, even when cordite is used, and as with the old 6-in. gun and mounting, practice at the rate of one round in 50 seconds was considered good, the importance of the mistake made in deferring the introduction of 6-in. quick-firing guns can be appreciated. The result has been that a large number of the old pattern guns and mountings have been supplied, and have now either to be put aside as useless, or remain where they are to block the way for the new gun.

Comparing the above speeds of firing, it will be seen that the quick-firing gun can fire four times as many shots in a given time as the old gun. If the energies of the shot from the two guns be considered equal (as a matter of fact, the quick-firing gun has the advantage here also), the quick-firing gun is four times as powerful as the old gun, or, in other words, a ship armed with ten quick-firing guns would be a match for a rival armed with forty old guns. In 1890, however, cordite was recognised as practical, and the development in size and power of the quick-firing guns immediately advanced.

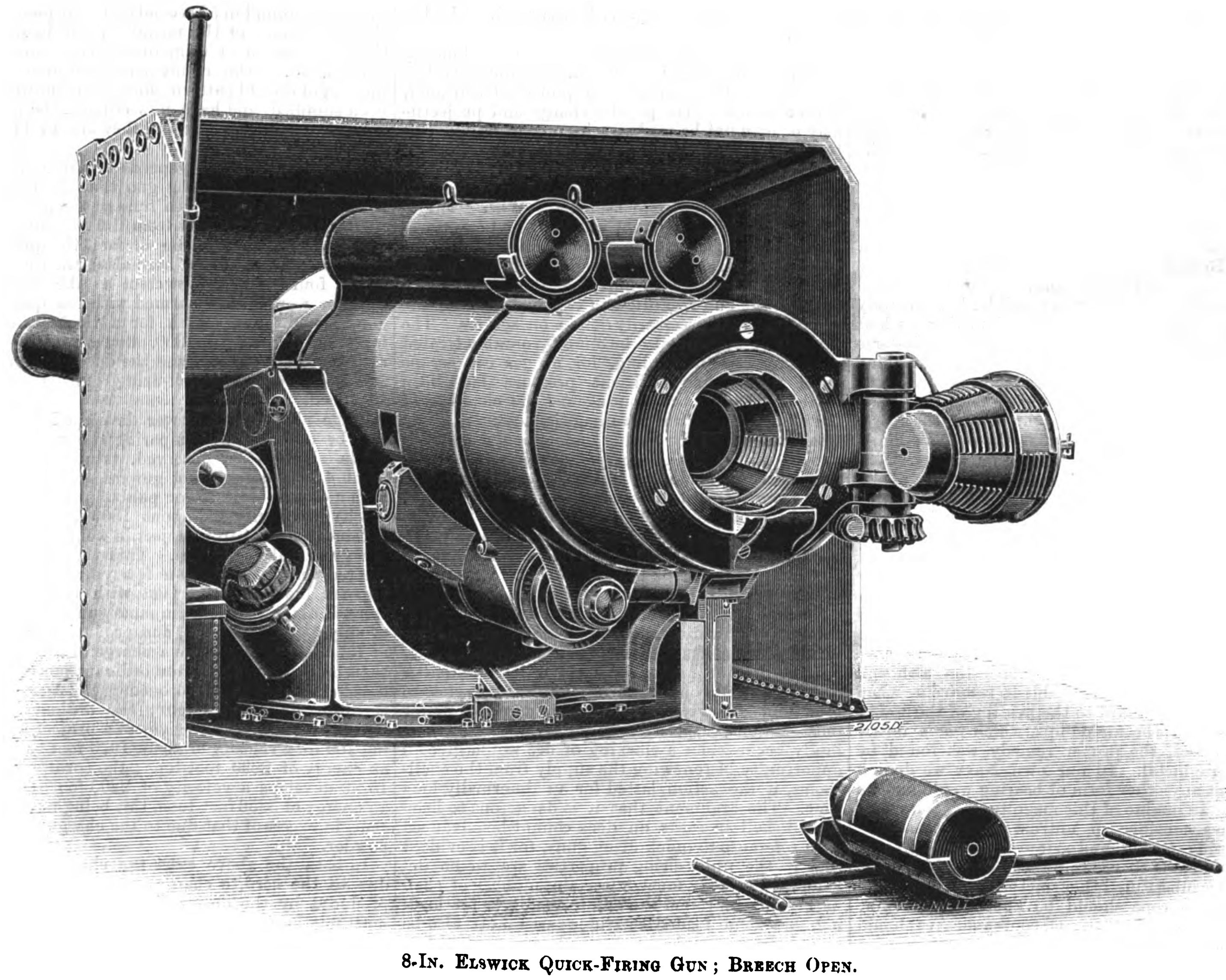
Some idea of the power developed by cordite will be obtained by comparing the results of the Table. It will be observed, taking the Government 4.7-in. quick-firing gun as an example, that with a charge of 12 lb. of pebble powder (ordinary black) a velocity of about 1800 foot-seconds is obtained, giving to a projectile weighing 45 lb. an energy of 1010 foot-tons. This velocity was considered very satisfactory a few years ago, but now appears low in comparison with the 2100 foot-seconds obtained from the same gun with a charge of only 5½ lb. of cordite, and producing an energy of 1375 foot-tons. Here a charge of cordite of less than half the weight of the ordinary powder charge develops 36 per cent. more energy. Again, taking the 6-in. quick-firing gun, the ordinary powder charge is 34 lb., which gives to a projectile weighing 100 lb. a velocity of about 1970 foot-seconds, or an energy of 2690 foot-tons; the cordite charge of 15 lb. develops a velocity of 2200 foot-seconds, or an energy of 3356 foot-tons, this being nearly 35 per cent. in excess of that due to the charge of ordinary powder.

In both the above cases the chamber pressures due to the cordite charges are lower than those produced by the ordinary powder charge, and it must not be forgotten that the mounting receives comparatively less strain; for the energy of recoil with the light charge of cordite would be less per

THE ELSWICK 8-IN. QUICK-FIRING GUN.

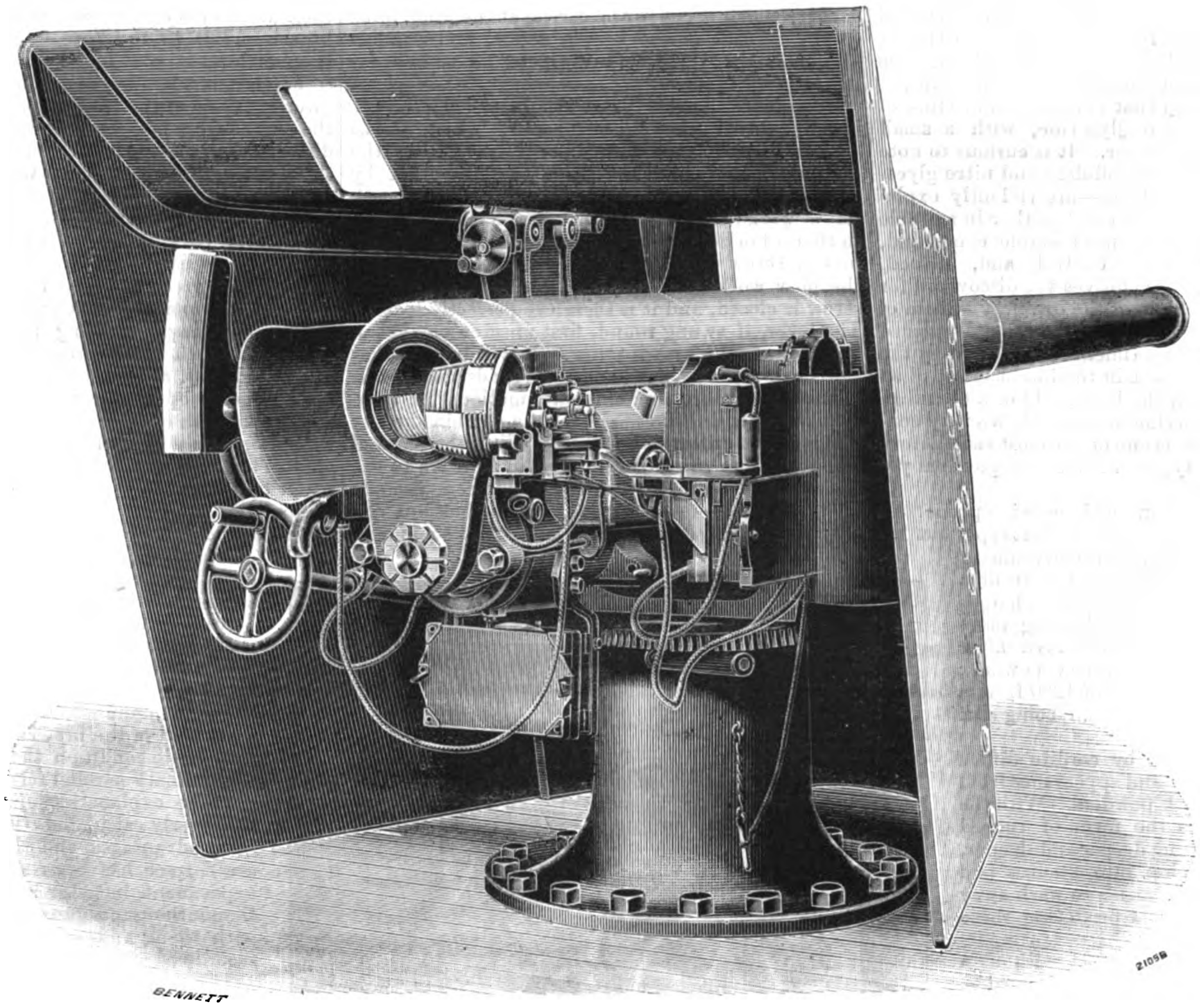


8-IN. ELSWICK QUICK-FIRING GUN; BREECH CLOSED.

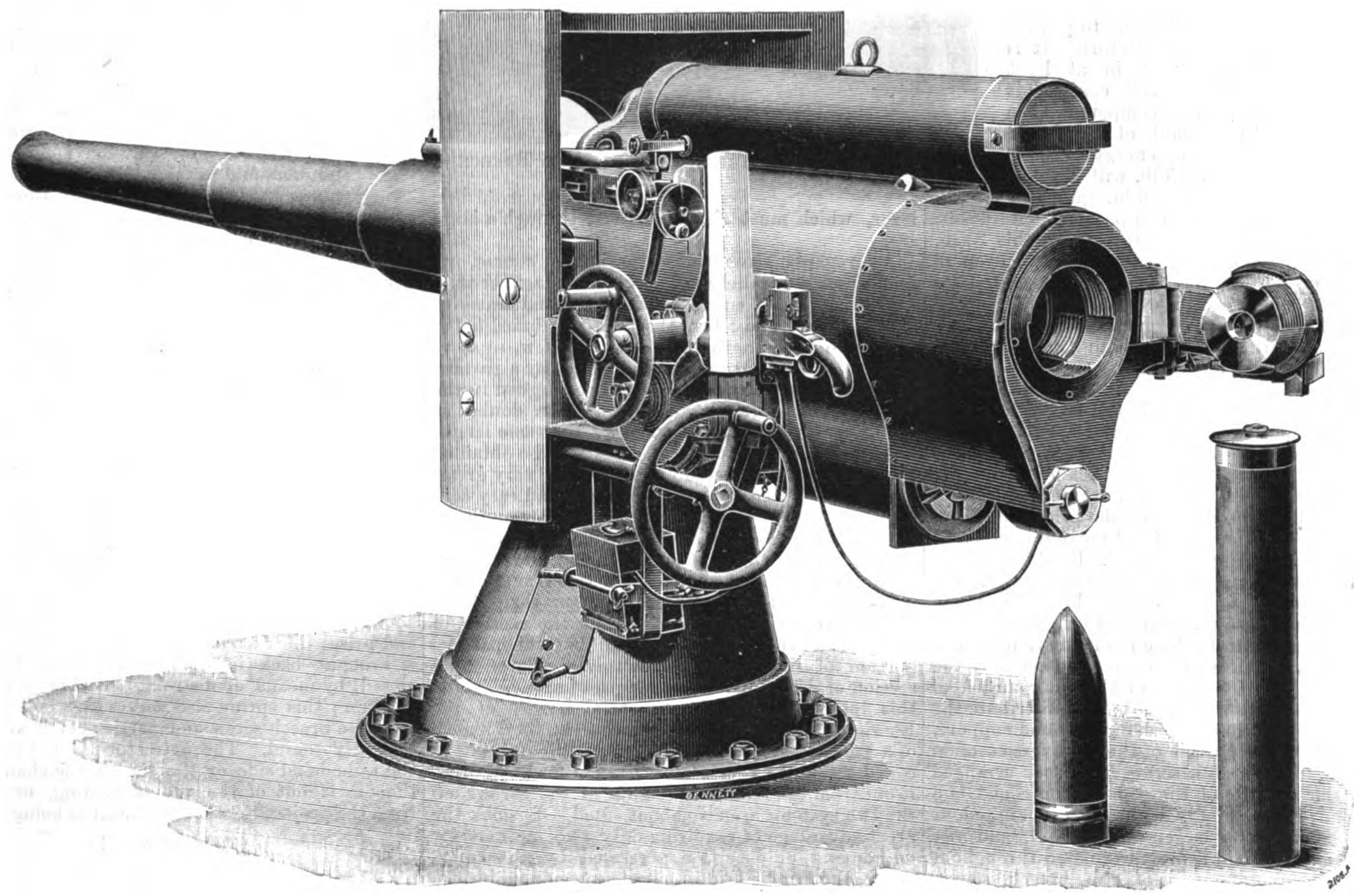


8-IN. ELSWICK QUICK-FIRING GUN; BREECH OPEN.

THE ELSWICK 4-IN. AND 4.7-IN. QUICK-FIRING GUNS.



THE 4-IN. ELSWICK QUICK-FIRING GUN.



THE 4.7-IN. ELSWICK QUICK-FIRING GUN.

foot-ton of energy of shot than it would be with the heavier charge of black powder.

Cordite is so called because of its appearance. It is manufactured in lengths, having a circular section, the diameter of which varies from that of a very thin string for rifle calibre arms, to that of a thick cord for the larger sizes of artillery. Its manufacture does not concern us at present; it will suffice to mention that cordite is a mixture of nitro-cellulose and nitro-glycerine, with a small admixture of mineral matter. It is curious to note that although both nitro-cellulose and nitro-glycerine—the latter especially so—are violently explosive alone, yet when combined together in suitable proportions they form a most stable compound, which is perfectly under control, and, indeed, forms one of the best explosives yet discovered for use in both quick-firing and the ordinary system of breechloading guns. This has been amply proved by a vast number of experiments carried out by the English Government, both in the intense heat of an Indian summer and in the bitter cold of a Canadian winter. All the experiments have shown very conclusively that cordite is one of the most satisfactory of all the different types of smokeless powders yet introduced.

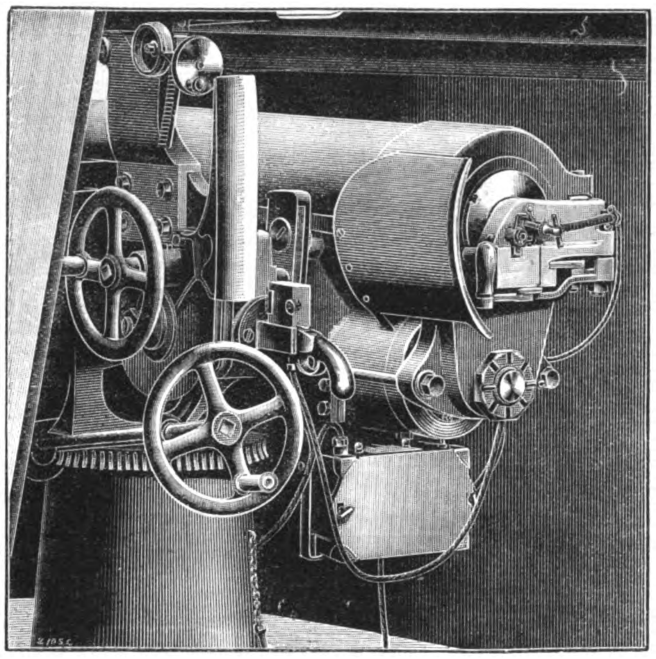
Much has been written on the erosive properties of cordite and powders of a similar type, but we may mention that the English Government have fired upwards of 600 rounds from a 6-in. quick-firing gun with service charges of cordite, without the gun showing more erosion than that usually observed after firing 400 rounds with ordinary powder; they have also fired upwards of 1200 from a 4.7-in. quick-firing gun, the gun being still serviceable.

The erosion produced by cordite differs very much in character and appearance from that produced by black powders. With the latter, erosion takes the form of rugged furrows, which, growing deeper and deeper, may eventually develop into fissures and cracks, whereas cordite seems to wash away the entire surface without producing these marked furrows.

We cannot leave this subject without a reference to the French smokeless powder, and we must certainly give our neighbours the credit of having been the first to introduce a smokeless powder into their service. The main ingredients of their powder are well known, but they still claim to possess secrets concerning its manufacture. It is satisfactory to believe that in at least one very important respect cordite is superior to this mysterious compound. We refer to the weight and bulk of the charge necessary to obtain a given energy of shot, for a cordite charge of 15 lb. will develop about the same energy in a 6-in. gun as a charge of 25 lb. of the French powder. Moreover, the cartridge-case necessary to contain this 25 lb. is larger than the English cartridge-case, even in a greater proportion than is to be accounted for by the difference of weight of the charge.

We will now give a description of the Elswick modern quick-firing guns, explaining as we proceed the reasons for the modifications that have taken place in the original design. As the guns are all made on the same principle, it will be best to select the largest, the 6-in., as the typical one for description, and to commence with the breech arrangements which are a speciality of the Elswick guns, and are perhaps the most important feature of quick-firing guns. The breech screw is on the principle of the interrupted screw, but the front portion is tapered, the rear portion being cylindrical. By this arrangement two advantages are secured—firstly, the action of opening and closing the breech is much simplified, as the withdrawal and bringing away of the breech screw can be done in one motion instead of two; and, secondly, the cone shape enables the screw not only to take hold of the inner surface of the breech hoop and jacket, but to distribute the engagement, and therefore the strain and support, over a much larger portion of the transverse section of the gun. The breech screw is further arranged so that the threads of the smaller or coned end correspond longitudinally with the interrupted or plain spaces of the larger or rear end, and *vice versâ*; thus the strain is also distributed throughout the entire circumference of the breech screw, instead of, as formerly, half the circumference being lost by the interrupted spaces. The coned breech screw passes on to the central projection of the carrier from the front, and is prevented from coming off by a bolt. This bolt screws into the breech screw, and has a plain end fitting into a groove, which is cut in the carrier at the same pitch as the threads of the breech screw, and which is long enough to allow the bolt to be turned for screwing up the breech.

To operate the gear there is a hand lever on the lower side of the breech screw, which works always in a horizontal plane; it pivots on the carrier, and is attached to a sliding block by means of a connecting-rod. A pin in the breech screw works in a vertical slot in the sliding block, so that a horizontal motion of the latter causes the breech screw to turn. The centres about which the gear works, are on their dead points when the screw is closed, and it is therefore perfectly locked. The lever, if swung round, first unscrews and then brings away the breech screw. It will be seen that the coned screw is particularly well adapted to this system, for there are only two motions for it to pass through, and these are readily combined so as to give the operator but one. With the parallel screw matters are different, for, in addition to the two motions required with the cone screw, there is a long motion of withdrawal. Three motions can only be combined in a single one, by a compound lever, which must also be moved through a large arc.



ELSWICK 4-IN. QUICK-FIRING GUN, SHOWING BREECH CLOSED.

As regards strength, there is, of course, no doubt that a parallel screw would be stronger than a coned screw of equal length, and equal diameter at the small end; but there is no difficulty in adding to the length of the coned screw, so as to obtain the same strength as is given by a parallel screw of a given length. It might be argued in the same way that a full screw is more than double as strong as an interrupted screw of the same length and diameter, but the advantages to be obtained by the use of the interrupted screw are very great, and it is adopted with the necessary and easy condition of proportionately increasing its strength.

But there is a considerable portion of the Elswick breech screw which is parallel, and the fact of coning the front portion causes the rear parallel portion to be of much larger diameter than if the screw were entirely parallel. Thus the section of each turn of thread is greater, so that the parallel portion of the Elswick screw gives a large total section of thread in a short length of axis. Taking this into consideration, the total length of the Elswick screw is about the same as the total length of a parallel screw of equal strength, and as the coned screw can very readily be lightened by boring it out from the rear, the weights of the screws on the two systems are also about equal. Besides the great advantage of requiring only two motions for withdrawal or insertion possessed by the coned screw, there is a decided advantage gained by the distribution of the strain over a larger area of the breech hoop into which the screw gears. This was very clearly shown by experiment. Longitudinal sections of breech screws geared into tubes were constructed; the sections of the tubes having previously been marked with lines at right angles to their axes, heavy stresses were applied to pull the breech screws to the rear. Under the action of these stresses it was found that with the parallel screw the lines became distorted, showing that the interior layers of the tube had to bear the strain, the outer layers not being similarly strained. This distortion was not marked in the same way when the model of the coned screw was similarly experimented on.

Another experiment to test the resistances of coned and parallel screws by the application of hydraulic pressure, showed that the calculations were quite correct, and that the two screws yielded at the same point. This experiment was carried out by applying increasing pressures for certain periods. When these pressures became high, it was found that, although the coned screw was perfectly free to open each time the pressure was relieved, such was not the case with the parallel screw, which became very stiff as the final pressure was approached. It is very difficult to account for this result by theory, but practice showed that it exists beyond all doubt.

The Elswick coned screw embodies another feature of very great importance, which is, however, independent of the actual coning. We allude to the arrangement, due to Mr. Vavasseur, by which the interrupted sections on the coned portion correspond to the uninterrupted sections on the parallel portion. The stress is thus distributed throughout the whole circumference of the screw and of the breech hoop, a much more favourable condition than is obtained with the ordinary parallel screw.

These explanations ought to show that, if properly calculated, the coned screw has great advantages, and that the calculations are correct has been shown, not only by experiment, but also by the fact that more than a thousand guns have now been fitted with them, and no failure has as yet been recorded.

The extractor is an important item in the mechanism of guns using cartridge-cases. It must be simple, strong, and effective; but with large guns it must have a limited action in comparison with such guns as 3 and 6 pounders, for with the latter the extractor can advantageously be constructed to entirely eject the old cartridge-case, and no harm will be done by its falling freely to the ground. With the larger guns, however, this cannot be allowed, both for the convenience of the gunners and for the sake of the cartridge-cases themselves, as one of these heavy cases would certainly crush a man's toes if it fell upon them, and it would be badly distorted if it fell freely and struck hard ground or the deck.

For these reasons the extraction is arranged in the large quick-firing guns, to take place in two motions. The cartridges are infallibly started by a very powerful extractor, which only has sufficient motion to insure their being free for the remainder of the extraction, the conical shape of the cartridge and chamber rendering a small motion sufficient for this purpose. The cartridges are then completely withdrawn and laid on the ground by means of a hand extractor, which readily fits over and firmly holds the primer.

The mechanical extractor is worked by the carrier in opening the breech screw. It consists of a rod passing through one side of the gun and fitting into the groove for the rim of the cartridge-case, in such a manner that, when it is turned about its own axis, the fitted part acts as a lever and prises the cartridge to the rear. The extractor is brought back into its place, as the breech is closed, by means of a strong helical spring outside the gun; this spring also serves as a buffer to prevent the breech screw and carrier being swung too violently round. The extractor is fitted either on the right-hand side or the top of the chamber, so that it is out of the way of loading, or damage from the projectile, when the latter is being entered.

(*To be continued.*)

COMPRESSED GAS.—Compressed gas is being introduced as a motive power for river boats on the Seine.