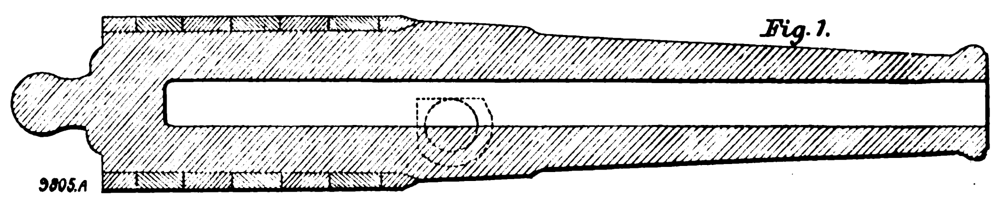
ENGINEERING.

MODERN FRENCH ARTILLERY.—No. I.

EVERY great war of modern times has brought with it experience, which in the succeeding period of peace, has been utilised to revolutionise existing practice in the construction of war material. The muzzle-loading smooth bores that battered down the Russian redoubts, the cast-iron 64-pounders which failed to make any impression on the walls of the Baltic forts, showed by their comparatively feeble performances the necessity for heavier and more destructive weapons.

Both in England and in France the defective performance of the artillery that was employed during the Crimean War, had stimulated inventors to produce better guns, and nearly a year before the treaty of peace was signed in Paris, on March 30, 1855, Mr. Armstrong had delivered to the English Government his first gun—a 3-pounder—in which were embodied the elements of a system that was to revolutionise the construction of ordnance all over the world. It is claimed that Armstrong was anticipated by a French captain of artillery, Treuille de Beaulieu, and that by quite a number of years; that in 1840 this inventor proposed the adoption of rifled guns, while in 1856 he advocated the substitution of steel instead of bronze in their manufacture. It is authentic that when the siege of Sebastopol was dragging slowly on, that the French Government had recourse to him to make for them guns of greater power and range than they then had at their disposal. In compliance with these instructions, Treuille de Beaulieu manufactured, first, two field guns which it is said gave very promising results, and afterwards sixty of heavier character that were intended for the siege of Cronstadt; the conclusion of the war, however, prevented these guns from being put in service. But the French had occasion for artillery after the Crimean War was concluded, and De Beaulieu was kept busy making field and mountain batteries for Algeria, Kabylie, and Cochin-China; in 1857 he commenced the delivery of these batteries. France, however, cannot claim the credit of this new departure in gun construction unchallenged, since an American inventor, Daniel Treadwell, advocated somewhat similar improvements in 1840; in any case this American claim has little real practical value, because it had no practical result. The Armstrong system of manufacture, on the other hand, was embodied in the first field gun delivered to the English Government in July, 1855, about the same time that the French War Office was applying to Captain de Beaulieu. It is worth noting that this first and insignificant field-piece was made with a steel barrel reinforced with one thickness of coils from the muzzle to the trunnion end, and with three outer coils over the chamber. The Armstrong type of gun, with certain modifications and improvements suggested by experience, was rapidly adopted by the English War Department, and about 1864 3000 guns, all of small calibres, had been delivered. The heaviest natures made before that date, that is to say, between 1858 and 1862, were 110-pounders, 300 of which, all breechloaders, were manufactured for the Navy in 1861; these guns fired 110-lb. shot with 14 lb. of powder, although they were originally designed only as 100-pounders. In 1864, after Mr. Armstrong had resigned his position as superintendent of the Royal Gun Factory, and had started the manufacture of ordnance on what was then a large scale at Elswick, guns weighing about 25 tons were being made there, 183 in. in total length, 145.25 in. in length of bore, 13.3 in. bore, and measuring 51.5 in. in diameter over the powder chamber. Those of course were very heavy guns for those days, and greatly surpassed the boldest efforts that had been attempted in French gun-making up to the same date. At that time the standard naval rifle gun of France, known as the "Canon de 30," was a cast-iron reinforced weapon 6.489 in. bore, weighing 8239 lb.; it was 128 in. in length, 108.295 in. in length of bore, and 23.62 in. in diameter over the chamber. A cannon of "30" from an American system upon which six guns had been made in Boston for the British Government in 1855; this system was no other than the screwed plug and breech with stripped thread; the only difference between the French and American device was that the latter was clumsy and unpractical, while in its modified shape it proved to be a very satisfactory device and embodied the principle of breechloading generally adopted to-day. A very brief review of what was done in the early days of heavy gun construction in this country and elsewhere may very properly preface what we shall have to say hereafter on French artillery, the modern history of which commences only after the Franco-German War.

Fig. 1.

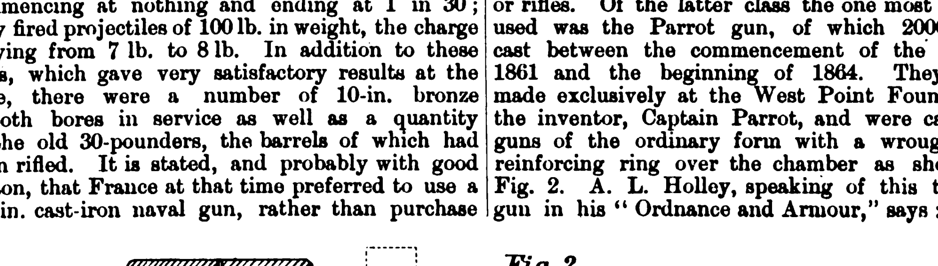


FRENCH CAST-IRON REINFORCED GUN; 1858.

was sent to Cochin-China and took part in an engagement at Tourane; this was the first rifled gun fired in war. Fig. 1 is a section showing the construction of this gun; it will be seen that the body is a solid casting reinforced by seven steel rings 4.4 in. thick and extending from the rear of the breech nearly as far as the trunnions. These guns were rifled with three grooves of increasing pitch, commencing at nothing and ending at 1 in 30; they fired projectiles of 100 lb. in weight, the charge varying from 7 lb. to 8 lb. In addition to these guns, which gave very satisfactory results at the time, there were a number of 10-in. bronze smooth bores in service as well as a quantity of the old 30-pounders, the barrels of which had been rifled. It is stated, and probably with good reason, that France at that time preferred to use a 6.5-in. cast-iron naval gun, rather than purchase

Whilst the experience of the Crimean War forced upon both the English and French Governments the necessity of abandoning cast-iron guns unless, as in the case of the French type, they were heavily reinforced with steel, the American War of Secession confirmed — at least for the time — United States artillerists in their belief in cast iron for guns of large calibre whether for smooth bores or rifles. Of the latter class the one most largely used was the Parrot gun, of which 2000 were cast between the commencement of the war in 1861 and the beginning of 1864. They were made exclusively at the West Point Foundry by the inventor, Captain Parrot, and were cast-iron guns of the ordinary form with a wrought-iron reinforcing ring over the chamber as shown in Fig. 2. A. L. Holley, speaking of this type of gun in his "Ordnance and Armour," says: "The

Fig. 2.



PARROT CAST-IRON REINFORCED GUN; 1861-1864.

steel from England to make heavier and more effective weapons; but even then the necessity for steel ordnance was appreciated, and great efforts were being made amongst French manufacturers to produce reliable steel; how well they have succeeded in this of late years, we shall see by-and-bye. Nevertheless it is worthy of note that about 1864, France was purchasing 300-pounder guns from this country. In addition to the cast-iron reinforced muzzle-loading guns, there were manufactured at the French arsenals, breechloaders, the breech-closing mechanism of which was adapted

100-pounder and the 8-in. and 10-in. guns are now cast hollow on Captain Rodman's principle, the advantages of which are well known. The bar of iron from which the rings are made is rectangular in shape when straight, but becomes wedge-shaped when bent into a coil, thus leaving a space for cinder to be squeezed out when the coil is upset. This feature is directly contrary and an evident improvement upon the Armstrong plan. The hoops are shrunk on without taper, the difference in diameters being $\frac{1}{16}$ in. in 1 ft. They are fastened to the cast iron only by the adhesion due to their tension, and have never been loosened during test or action. When a hoop is to be adjusted, it is heated and slipped over the breech, the gun being slightly depressed. A stream of cold water is then run into the bore, not for the purpose of cooling the hoop from the interior, but to prevent the expansion of the cast iron. The 8-in. rifled gun has thrown spherical smooth shell filled with earth to weigh 52.5 lb., with papier-maché sabots, at an initial velocity of 1809 ft. per second; charge 16 lb., the same charge that fires the elongated shot of 152 lb. at 1200 ft. With a charge of 25 lb. the gun fires a 68-lb. to 70-lb. cast-iron or steel spherical shot at above 1800 ft. per second, with about the same strain and no less safety. This gun may therefore be pronounced the most formidable service gun extant. Neither the English 68-pounder nor the French naval gun (6.5 in.), nor the United States cast-iron 8-in., 9-in., or 10-in. guns can endure such charges; the Armstrong 110-pounder (7 in.) cannot fire spherical shot, and the United States Navy 10-in. and the new English steel-lined 7-in. and 9-in. guns are not yet service guns. The British Government has spent (between 1859 and 1864) over 2,500,000*l*. on ordnance and plant, and although it has acquired a gun capable of higher charges for a few hundred rounds, and, what is more valuable, the experience which will enable it to fabricate the best steel cannon without further risk, it is still without a trustworthy naval gun or gun of position."

That this encomium on the Parrot guns was somewhat highly coloured is suggested by a statement found in an American book published by a Mr. Wiard in 1863, who stated that work on a number of 7½-in. cast-iron rifle guns at Westpoint was stopped because both in experiment and in service they were proved to be unreliable; nevertheless, the fact remains that the American cast-iron guns did admirable service—far better than the cast-iron guns either in the French or English Navy; this was chiefly due to the superior quality of the American cast irons, some of which withstood as high a tensile strength as 49,000 lb. per square inch, while the average of English gun irons did not exceed 20,000 lb. It is worth noting, however, that during the Crimean War some of the 32-pounders and 68-pounders fired from 2000 to 3000 rounds, and were in good condition at the end of this long service; in the London Exhibition of 1851 several cast-iron guns were shown varying in size from 6-pounders to 30-pounders; these had been cast at Liège, and had withstood from 2000 to 6000 rounds, remaining in a serviceable condition. The construction of cast-iron ordnance had in fact up to the year 1864 been developed as far as the imperfect nature of the material permitted; the American War gave a great stimulus to the art; guns, as formidable as it was possible to produce them, and also made very quickly and cheaply, were an absolute necessity, and since the Confederates, under the best circumstances, only owned or could produce, weapons inferior to those turned out of the Federal arsenals and private factories, it mattered little, except for the protraction of the war, if ranges were short, projectiles comparatively light, and powder charges low; the balance of advantages was still held with the northern troops, and that was all that was necessary. Nevertheless, the Parrot cast-iron rifle and the Rodman smooth bore, were formidable weapons; the former ranged in its natures from the 10-pounder weighing 890 lb. and costing 36*l*., to the 10-in. gun weighing 26,500 lb. and costing 900*l*. The length of the former was 70 in., and of the latter 144 in., the intervening calibres having approximately relative lengths; the powder charges varied from 1 lb. to 25 lb., and the weight of projectile from 10 lb. to 250 lb; the number of grooves in the 10-in. gun was 15, the depth $\frac{1}{10}$ in., and the rifling, which was on an increasing twist, had a maximum of one turn in 30 ft. These guns were able to withstand very hard usage as experience in service amply showed; thus a 100-pounder fired a thousand rounds with 10-lb. charges and 100-lb. projectiles; at the end of this service the piece remained in perfect condition except for a slight enlargement at the bore; a 300-pounder fired 600 rounds with maximum charges, before Charleston, and so forth. The Rodman smooth bores earned a famous reputation during the American War, and were indeed marvels of perfection, considering the material of which they were made; the principal calibres were 13 in., 15 in., and 20 in., they were cast hollow and varied in weight from 32,000 lb. to 115,200 lb., the latter (more than 57 American tons) being the weight of the 20-in. Columbiad. The service charge of this gun was 100 lb. and the weight of shot no less than 1000 lb., the length of bore was 210 in., and the maximum diameter over the chamber, 64 in. The 15-in. Columbiad, throwing a 440 lb. shot with a 50-lb. charge, was, however, the most favourite gun of this class. Both for the Army and Navy Department, the prescribed tests for the material of which these guns were made, was that they should have a tensile strength of not less than 30,000 lb. per square inch, while the condition of acceptance of a number of guns, was that one, selected from each batch, should withstand, for the smaller sizes, 1000 rounds, and for the larger calibres of 13-in. bore and upwards, 500 rounds. This reduced test was, however, accepted, for all natures, under existing circumstances, and it is stated that many of the 15-in. Rodman guns fired in actual service considerably more than the prescribed 1000 rounds that formed the test for the smaller calibres. One of the 15-in. navy guns made at this time was fired 900 times at test, with elevations varying from 0 deg. to 5 deg, and with charges increasing from 35 lb. to 70 lb., the weight of shot being in all cases 440 lb.; it was only after the 900th round that this weapon failed. It was with these smooth bore Rodmans that what was probably the last naval engagement to be fought with cast-iron ordnance in the English Channel, took place between the Kearsage and the famous Confederate steamer Alabama on June 19, 1864. Long ranges, such as are attained to-day, were not dreamed of during the American War, and at a time when fighting was at comparatively close quarters was a necessity, endurance of guns, weight of metal thrown, and comparatively rapid firing, were the useful conditions. Still, remarkable practice was made with the Rodman 15-in. gun throwing 328-lb. shots with 35-lb. charges. The range obtained under these conditions, with very considerable accuracy, exceeded 2000 yards, while with 50-lb. charges they reached a maximum of 5730 yards; these results were obtained with spherical shot. It is worthy of note that about the same time Armstrong was producing muzzle-loading smooth bore guns 9.22 in. bore to fire 100-lb. spherical shot; with these about the same range and accuracy were obtained as were given by the Rodman cast-iron guns.

Remembering the 110-ton guns with which our most powerful ironclads are now being armed, it is interesting to read in Holley's "Ordnance and Armour" that in 1864, "The standard cast-iron gun in England—in fact the standard naval gun—is the 95 cwt. 68-pounder of 8 in. diameter and 113.9 in. in length of bore, and 26.2 in. in diameter over the chamber; its cost is about 100*l*. It is stated that 100 new 68-pounders have been recently ordered on account of the failure of the Armstrong naval gun as a naval weapon. At the siege of Sebastopol the 68-pounders were on the whole very satisfactory in their range and endurance. Only two of them burst both at high elevations, and one after having fired over 2000 rounds. Some of those landed from the Terrible fired as many as 4000 rounds, usually with 16 lb. of powder, and very rapidly."

But although the standard naval gun of England of that date was of cast iron, and although the Armstrong guns of large calibre were wrongly reported to be failures, the works at Elswick were busy in turning out heavy ordnance; in fact, in November, 1863, a muzzle-loading gun weighing nearly 25 tons and throwing a 600-lb. shot with a 70-lb. powder charge, was completed; with an elevation of 23 deg., a range of 7200 yards and an initial velocity of 1250 ft. per second were obtained. It will thus be seen that during the eight years which had elapsed since Armstrong delivered his first 3-pounder to the British Government, the celebrated engineer and gunmaker at Elswick had made wonderful progress, still following closely the same lines of construction on which his original gun was made, that is to say, a series of concentric tubes formed by welding together in spiral coils long lengths of rectangular iron bars. At that time the specification given the makers of the iron from which the guns were produced, prescribed an ultimate tensile strength of about 26 tons per square inch, not over 27 tons nor under 25 tons, whilst permanent set was not to take place under a strain less than 13 tons per square inch, and the effects of compression were not to become permanent under a load of less than 14 or 15 tons per square inch. At that time the greater part of the iron used at Woolwich for making this type of gun was a mixture of 85 per cent. of Yorkshire, and of 15 per cent. of Swedish charcoal iron; it cost 20*l*. a ton. In 1862 the Royal Gun Factory at Woolwich could boast of a 12-ton hammer, while Elswick possessed one weighing 10 tons; shortly after Mr. Armstrong had quitted the position of superintendent of the Gun Factory in 1863, the coiled wrought-iron inner tube was replaced at Woolwich by a steel tube tempered in oil; it should not be forgotten, however, that the earliest successful gun—an 18-pounder made by Armstrong—had an inner tube of steel. As we have already stated, up to the year 1863, 3000 Armstrong guns had been made for the British Government at Woolwich and at Elswick, the total cost attending this production having amounted to a total of 2,539,547*l*. All the guns that had been made up to 7-in. bore were breechloaders, the larger calibres being muzzle-loaders. The cost of these guns was from 1s. to 1s. 5d. a pound.

The stimulus which had been given to inventors by the Crimean War, and the brilliant success that had attended Mr. Armstrong's efforts as a maker of guns, naturally produced a plentiful crop of inventions which, with very few exceptions, have passed out of sight long ago. The one brilliant exception is that of the Whitworth gun, of which in 1863 a considerable number of pieces up to 70-pounders had been fabricated. This manufacture has, since that date, gone on steadily progressing, with the best results, although unfortunately from various causes which it is not necessary to consider here, this country benefitted but little from the skill and energy which the late Sir Joseph Whitworth attacked the ordnance question, and later, what was even of still higher importance, the manufacture of high-class steel especially adapted for gun construction. Other nations have, however, been wise enough to take advantage of the opportunities afforded by Sir Joseph Whitworth, both for the purchase of guns and of steel for making them. Another able engineer, Mr. J. Longridge, who was very early in the field, and who still often protests against the weak points in our ordnance system, as early as 1860 advocated the adoption of coiled wire as a covering for gun tubes, and the experiments which he had even then made, gave marvellous results in the increase of strength obtained by this means of reinforcement; this system has been before the public at intervals ever since that date. Of other inventors, whose names have passed away, we may mention those of Mr. Lynall Thomas, of Captain T. A. Blakeley, who was very early in the field, in investigating and reducing to practice, the system of reinforcing guns with hoops placed under initial tension; the Mersey Steel and Iron Company, who, in 1856, made a forged gun in one piece except the trunnion ring, 13.014 in. bore, 15 ft. 10 in. long, and weighing more than 25 tons. The same firm showed in 1862 at the London Exhibition another large piece of ordnance, in which the inner tube, formed of staves welded together, was reinforced by an outer casing of plates bent around it and welded; the Mersey system of manufacture enjoyed a transient period of success, and several guns of modified designs were ordered by the British Government. Of solid forged steel guns, Krupp, of Essen, was the great representative and manufacturer, and had been so since the London Exhibition of 1851, where the first gun made by him on the system, afterwards to become famous throughout the world, was shown.

HELIOMETER AT THE CAPE OF GOOD HOPE OBSERVATORY.

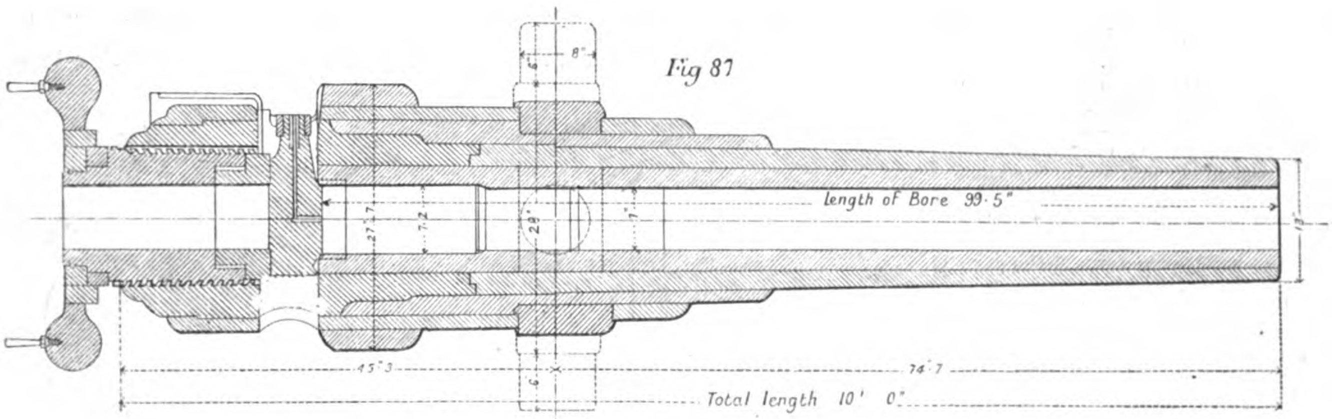
A COUPLE of years ago the Royal Observatory at the Cape of Good Hope received a most important addition to its equipment in the form of a heliometer constructed by Messrs. A. Repsold and Sons, of Hamburg. Of this instrument, which is probably the most perfect of its class yet constructed, we this week give a perspective view, Fig. 1, on page 12, while in Figs. 2 to 5, on pages 4 and 5, and Fig. 6, on page 3, we further illustrate its chief details.

In its general design the instrument under notice resembles that constructed in 1882 by the same makers for the Yale College Observatory at New Haven, Connecticut, but it is of greater optical power, its object-glass—which was made by Mr. Jakob Mertz, of Munich—being 7.5 in. in diameter, with a focal length of 102 in. Its details also include some modifications and additions desired by Dr. Gill, the Astronomer-Royal at the Cape, amongst which may be mentioned the provision of

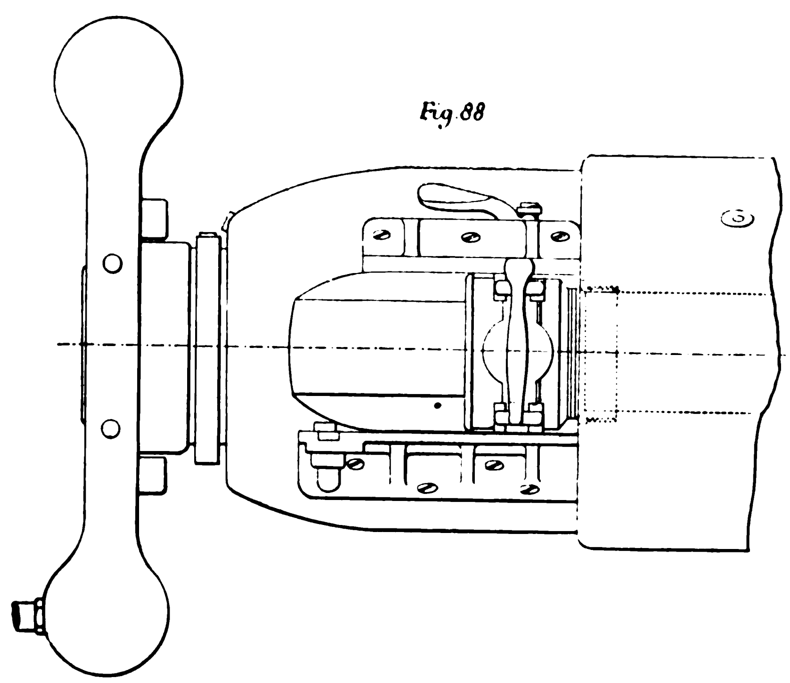
MODERN FRENCH ARTILLERY.
No. VII.

BREECHLOADING MECHANISM—*continued.*

The Woolwich System.—As we have already seen, the first important departure in the construction of ordnance in this country was also characterised by the adoption of breechloading mechanism, and this practice continued until a very large number of guns had been manufactured and delivered to the British Government. About 1864, however, when the tendency became more marked towards the construction of larger calibres and heavier guns, a strong feeling of antagonism against breechloading was evoked, with the result that all

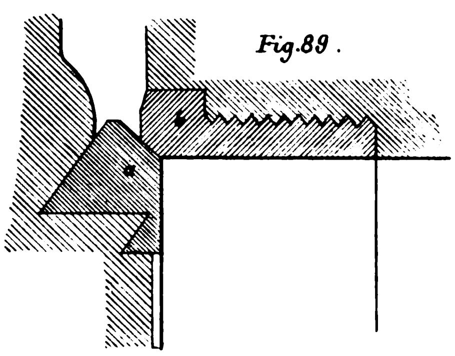


ARMSTRONG BREECHLOADING 7-IN. 82-CWT. GUN; 1862.



ARMSTRONG CONVERTED BREECHLOADING MECHANISM.

the larger classes of ordnance were afterwards made as muzzle-loaders; this state of things continued for about fifteen years, at which time England remained the only power which had not long before abandoned the system as obsolete and undesirable. In 1880 a return was made to breechloading for all classes of guns. There are many guns still in service which date back as far as 1860, and some of these are of the fairly large size of 7-in. bore, although their weight is only 82 cwt.; these were the nominal 100-pounders, but were afterwards known as 110-pounders on account of their projectile having been increased in dimensions; finally they were recognised in the service as the 7-in. 82-cwt. gun. These, together with 40-pounders of various weights, of 20-pounders ranging from 13 cwt. to 16 cwt., and of 6-pounders, 9-pounders, and 12-pounders, complete the list of calibres manufactured in the early days, and which are still in use. Fig. 87 is a section showing the arrangement of the Armstrong breech mechanism which was employed with very satisfactory results. The breech of the gun is extended for a considerable distance to the rear of the chamber, and a slot at right angles to the axis of the bore is cut through the gun immediately at the back of the powder chamber; beyond, the breech seating is screwed, and within it works a hollow breech-block, the inward or outward movement of which is facilitated by heavy weighted levers. Within the slot before mentioned a block slides to and fro, pierced as shown to receive the fuze, and fitted in the front face with a gas check. By running the breech-screw back the block is loosened and can be lifted out of the slot, leaving a clear passage through the opening in the breech-screw to the powder chamber for the introduction of the charge. The diameter of the opening in the breech-screw corresponds with that of the powder chamber, and the faces of both screw and powder chamber are bushed as indicated in the section. So recently as 1880 a number of these guns were converted into the side-closing system, which in a less satisfactory form had been introduced by Armstrong in the early days. Fig. 88 shows the method adopted, which was only applied to a



A GAS CHECK FOR ARMSTRONG BREECHLOADING SERVICE GUN.

number of 40-pounders. The alteration consisted in bringing the slot to the right side instead of leaving it at the top as in the old plan; this was done by carefully heating the trunnion ring and so slackening it, and then turning it for a quarter of a revolution to the left. The gun was then fitted with a solid breech-block; an upper and lower gun-metal bracket was fastened to the top and bottom edges of the slot, and between these the block slides backwards and forwards, its movement in and out of the gun being adjusted by means of a spring stop worked by a small lever above. The breech-block is fitted with a copper ring, and a special tin cup extractor is employed with this type of gun. Fig. 89 is a section of one form of gas check employed, in which the copper ring *a* in the face of the breech-block abuts against the bushing *b* in the chamber; this bushing for calibres up to 7 in. is made of copper, but for the 7-in. gun it is of iron.

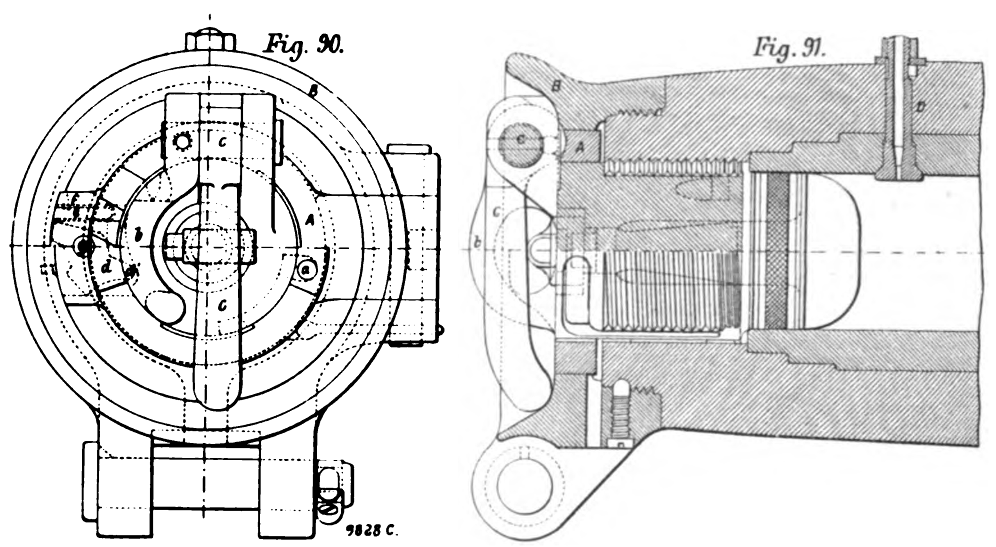
The annual report of the Director of Artillery and Stores for 1878 to 1879, urged that breechloading for heavy guns had become a necessity, owing chiefly to the increased length of bore, and it was in consequence of this report that the superintendent of the Royal Gun Factory was instructed to prepare designs for 20-ton and 40-ton breechloading guns. In 1879 a Special Committee of Ordnance was appointed, and one of its most important duties was to report upon the introduction of breechloading guns of heavy calibre into the service. This Committee was dissolved in 1881, by which time a considerable amount of useful work had been accomplished, and several guns of calibres ranging from 25-pounders to 12 in. had been constructed with breechloading mechanism and tested; all these were fitted with interrupted screw breech-blocks based on the French system. Experiments, which lasted for more than a year longer, confirmed the wisdom of the recommendations of the Committee on Ordnance, and in May, 1882, the definite adoption of breechloading was decided on as well as the entire abandonment of wrought iron in favour of steel; at the same time it was also decided that cast steel jackets and hoops should take the place of coils.

The breechloading mechanism in the English service comprises a solid steel breech-block cut with six or eight segments of screwed threads—the French system in short—while two methods of obturation are in use, the Elswick cup and the De Bange gas check. The cup system consists of a shallow steel cup bolted to the centre of the breech-block, which is made slightly convex, the back of the cup being flat. In the rear of the powder chamber a copper ring is inserted in such a position, that when the breech is closed by the block, the side of the cup is brought into close contact with the copper ring, and the pressure of the gas generated when the charge is fired, forces it outward and into the copper ring, and so prevents all escape of gas. Whilst this system is very effective as long as it remains in perfect order, the slightest imperfection which allows an escape of gas, soon cuts the cup to pieces, besides damaging the ring, and as the presence of any fragment of grit prevents perfectly close contact between the two parts of the abturator, it is a matter of the first importance that both cup and ring should be kept absolutely clean. After each round the cup should be turned upon its centre to present a fresh line of contact with the ring; neglect of this soon leads to scoring and to the temporary disablement of the gun. It is also necessary, on account of the expansion of the copper ring, to provide spare cups somewhat larger in diameter after the gun has been fired for some time; it is an easy matter to change the cups, but quite a difficult one to replace the rings. "From these remarks it will be seen that there are serious objections to the cup system, and consequently another method is recommended by the superintendent of the Royal Gun Factory, which is known as the De Bange obturation. This after full trial was adopted in 1882 for all natures of breechloading guns."*

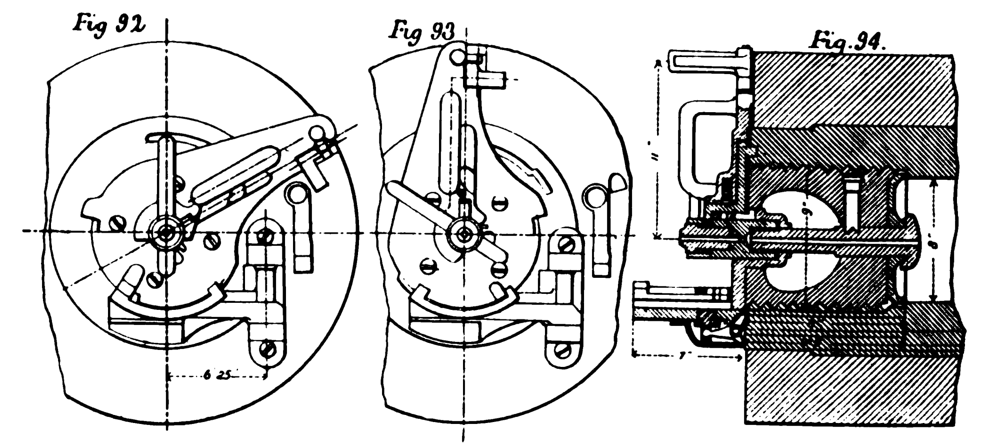
As we have already described in full detail the De Bange system, we may here confine ourselves to a notice of the gas check pad used in the British service, taken from the same source as the foregoing. This is made with a mixture of asbestos and grease worked into a ring and subjected to hydraulic pressure; it is inclosed between two annular discs of tin, the outer edges of which are strengthened by steel rings. "The action of the De Bange obturator is this: when the breech-block is pushed into the gun, the spindle and the pad mounted on its inner face enter the chamber with perfect ease; on turning the breech-screw the pad is brought into contact with its coned seat in the gun and pressed home by the travel or pitch of the screw. The bore is then perfectly closed by a species of buffer in contact all round the circumference; while the *tête mobile* forms a loose end to receive the force of the gas on discharge. On firing the gun the pressure acts on the steel mushroom head, and squeezes the pad against the breech-block, causing it to expand laterally; from symmetry of form and position this expansion must be radial to the axis and equal in every direction, and experience has proved that it is sufficient to prevent an escape of gas. After the pressure is removed, elasticity comes into play, and the obturator can be withdrawn from the cone by a straight pull, which can be given as soon as the screw is unlocked. The simplicity of this obturation is evident, and the system has been found perfectly effective in guns of every size; it involves little circumspection in use, and there is nothing in the gun which can ever require repair. As regards endurance, the pads are almost indestructible, except perhaps the wear of opening and closing the breech; spare pads are provided with every gun, and if necessary the old one can be easily changed by any one who has seen the operation performed. Some pads have been known to last thousands of rounds, but if the firing is rapid the wad may get softened by heat; in this case it should be changed and thrown into cold water for a time, and it will soon be restored to its condition again. Only field guns would be liable to such rapid fire, and the work of changing a pad in a small gun can be performed in a minute. Whatever the size of the piece, guns need never be thrown out of action for want of repair as in the case of cup obturation; but the pads should be carefully handled whenever removed from the gun, for by rough treatment the metal discs may get injured."

Figs. 90 and 91 show the modification of the French system applied by the Woolwich authorities to field guns; the illustrations represent the breech of a 12-pounder. The breech-block and seat are cut with six threaded segments, and the block passes through the ring A, which fits freely within a "hood" B screwed on to the outer jacket of the gun; on the right-hand side of this hood are two ears, between which are passed the hinge of the ring, the connections being completed by a hinge bolt. When the block is turned to be free in its seat it can be drawn through the ring, but cannot be disengaged from it, on account of the stop bolt *a*; the block is moved to and fro by the curved handle *b* after it has been unlocked by lifting the cam lever *c*, hinged to projections on the top of the block by the pin *c*; the operation of unlocking is effected by turning the cam lever and block through one-sixth of a revolution. The same turning movement depresses the tail *d'* of the latch *d* and turns it on its centre pin *g*, depressing the spring *e*, that presses against the projection *f* on the left-hand side of the ring. The latch *d* is thus freed from its recess in the hood, and after the block has been withdrawn as far as possible through the ring, the latter can be swung back clear of the bore; this latch can also be lifted, if necessary, by a loose pin passed through a small hole in the left-hand side of the hood. The obturator is of the De Bange pattern, with a mushroom head attached to a stem passing through a hole drilled in the block, and secured to it at the rear. The pad is of asbestos and grease subjected to hydraulic pressure, and between it and the face of the block are a number of thin metal discs for packing. When the block is turned to fix it in its seat, the slight forward travel forces the pad against the mushroom head (the chamber being slightly tapered at this point) and makes a joint, which is rendered gas-tight by the pressure of the head when the gun is fired. Forward of the breech mechanism is the vent bolt D passing through the body of the gun; it is of steel, the hole drilled through it being .15 in. at the lower end for a length of .415 in., and .22 in. for the remaining distance; it is secured in place by a nut with a spring washer; this vent bolt requires to be renewed after 100 or 150 rounds.

Figs. 92 to 94 are diagrams giving an idea of the arrangement of the breechloading mechanism for 6-in. guns; the details will be understood clearly by referring to our description of the French system; at one end of the first lever, and at the other to a block sliding in guides on the face of the breech; on this block is a pivot which engages in a slot formed in the lever of the breech-block. By operating the vibrating handle the breech lever can be turned in either direction moving the block with it. Fig. 97 is an end view of the breechclosing mechanism for a 9.2-in. gun, and is fitted on H.M.S. Impérieuse. The mechanism comprises the controlled carrier on which the block is withdrawn, or from which it is pushed home; the Stanhope lever just referred to, the safety arrangement for the percussion lock, and the safety electric firing apparatus. The controlled carrier is employed chiefly to obviate the danger of allowing so heavy a weight as the breech-block to swing freely on board ship in a sea-way. This carrier is supported on a bronze hanger bolted to the back of the gun and forming a complete ring, but extended below by two projections



BREECH MECHANISM FOR ENGLISH FIELD GUNS.



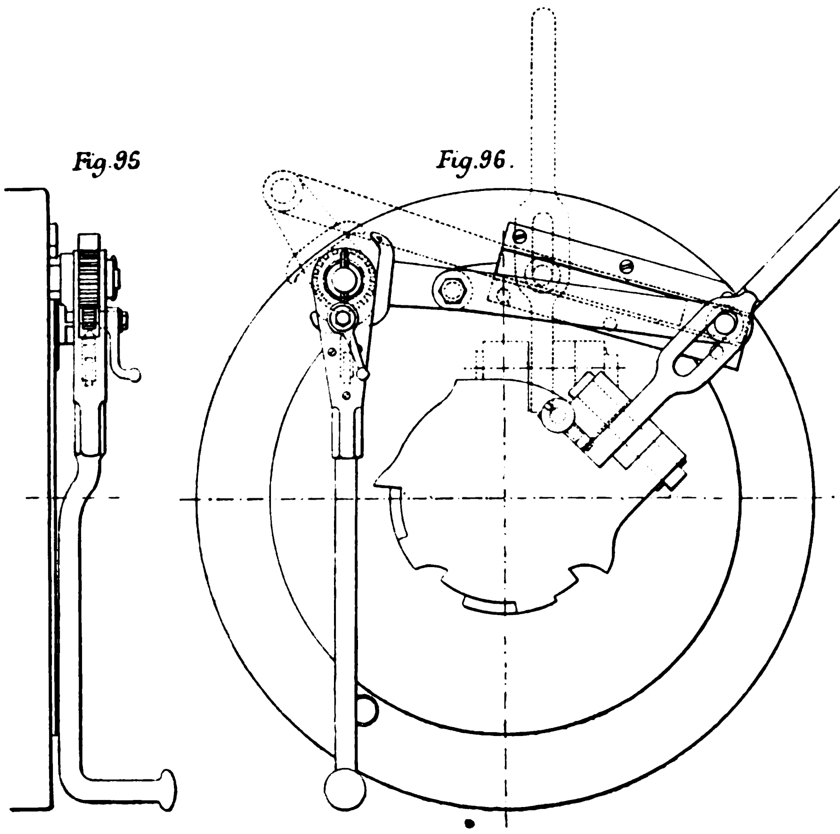
ENGLISH BREECH MECHANISM WITH CUP OBTURATION, FOR 6-IN. GUNS.

it may be pointed out that the spindle on which the obturator cap passes through the axis of the breech-block, is drilled as usual to receive the fuze, which is also fitted with an obturation arrangement to prevent the discharge of gas backwards; the lever forming an extension of the end of the breech-block is carried to a height of 11 in. and terminates in a handle by which the block is pulled over to the right when it is desired to unlock it. It is removed from its seat by pulling on the handle shown in Fig. 94, and received upon the swing bracket hinged to the back of the gun; longitudinal grooves cut in the lower part of the block take their bearings upon the guides of the bracket when the block is withdrawn. Of course for guns of small calibre all the operations can be performed by hand, but for larger sizes, either hydraulic or other power-gaining arrangements are necessary. One such arrangement is that illustrated in Figs. 95 and 96, and consists of a Stanhope lever worked by a vibrating handle which moves a toothed wheel by means of a double ratchet that can be thrown over to work in either direction. By this means a movement is given to one of the arms of the knuckle joint which is pivotted at the centre of the toothed wheel to the face of the breech. The other arm of the joint is connected to give a larger bearing to the breech-block resting upon it. A bronze plate attached to the end of the breech-block forms the head of the cam lever. On the hinged bolt, to which the carrier is hung, is mounted a toothed pinion which gears into a rack recessed into the side of the breech-block; the bolt is turned by means of a worm and wheel, the former being at the end of a horizontal shaft mounted in bearings and projecting forward at an angle towards the left for the convenience of the man who turns it by means of a handle. The wormwheel on the lower end of the hinge bolt turns idly upon it unless it is set fast by a clutch that is operated by means of a small hand-screw beneath. When this clutch is thrown out the carrier swings free. There is no latch used with this arrangement, but in its place is a spring stop underneath the carrier; this is simply a spring bolt which is usually drawn back and turned out of use, but when wanted, that is to say when the control device is out of gear, it is turned down, and when the carrier is swung back it drops into a recess, locking the carrier. The action of this mechanism is as follows: The breech-block having been turned to the withdrawing position and started by the pulling over the lever, the winch handle is turned, driving the wormwheel, and turning the pinion,

* "Official Treatise on the Manufacture of Guns," 1886.

which runs the block out by means of the rack recessed in its side; this continues until the block is clear of its seat, when, if the movement of the worm and wheel be continued, the carrier is swung round upon its hinge bolt clear of the opening in the gun. The reverse process is followed for closing the gun. The safety arrangement for percussion firing, prevents the gun from being prematurely discharged. Before the fuze can be inserted the lock must be withdrawn, and before it can be fired the lock has to be pushed up again so as to support the head of the fuze and bring the striker over the detonator; the end of the lock is slotted away on an incline, so that if the fuze is home it will pass over, and the insertion of the fuze, and its subsequent covering by the lock, can be partially effected by hand when the breech is opened; but the block cannot be pressed so far as slotted away; but when the block is turned into firing position the arm rides up an inclined plane, allowing the lock its full travel. On lowering the cam lever, a slide connected with it pushes the lock home into its firing position; this slide is actuated by the cam lever by means of a pin projecting from it engaging in a spiral groove cut in the face of the lever head. The lock engages in the slide by a spring bolt that drops into a hole in the slide; the latter is always in gear with the cam lever, so that whenever this is raised or lowered the slide is put in motion. But until the cam bed is pressed against the carrier by closing the breech, the lock does not engage in the slide, for a pin stops the hole of the slide when the breech is open, so that the lock bolt cannot drop into it. When the breech is open the lock can be moved to and fro to admit the fuze and to partially cover it, but it cannot be brought into

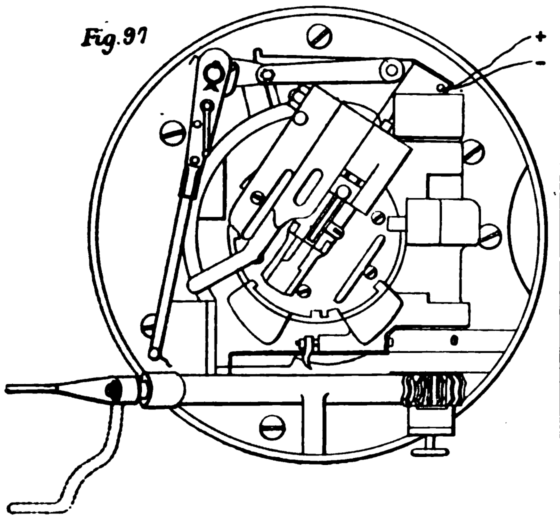
Fig. 95. Fig. 96.



BREECH-BLOCK STARTING MECHANISM; ENGLISH HEAVY GUNS.

to bring the striker into position; this can only be done by lowering the starting lever when the breech is closed, but not until then, for a pin projecting from the face of the lever bed engages a

Fig. 97



BREECH MECHANISM FOR 9.2-IN. GUN: H.M.S. "IMPERIEUSE."

slot in the under face of the lock and limits its play. This pin is kept pressed down by a spring that is capable of being withdrawn flush with its socket by a lever, one arm of which projects in the front face of the cam lever bed when the block is out. When the block is pushed home this arm is at first left undisturbed by the carrier ring being firing position; it must be pressed forward by hand partially to cover the tube, or the bolt will not engage in the slide of the cam lever, and if this is not done the striker will not operate even when the breech is closed.

The electric firing device is so arranged that connection is impossible until the breech is fully closed. The fuze wires are connected with a junction consisting of an ebonised lock, through which two tapering metal pins pass; these pins are about an inch apart, and project on both sides of the block. The projection on one side is to attach the fuze wires; those on the other side fit into recesses formed in a block on the gun placed upon the top of the carrier hanger; to this block are also secured the battery terminals. The holes for the battery terminals are in connection with the pins of the junction piece, but when the breech is open connection is interrupted by means of ivory plugs, which are carried on the end of a spring bolt, and by which they are forced into the terminal holes and locked fast by means of a spring. The holes are opened by a slide connected with the lock, the top of which is provided with a hook that projects above the bearings of the cam lever. When the breech-block is returned to its seat and locked, the hook upon the slide engages in another hook on the end of the spring bolt and pushes back the trigger. When the main lever is lowered the lock is pressed into the firing position, the spring bolt with its ivory plugs is forced out of the terminal holes and the battery connections can be completed, but if the fuze is not home the lock, as in the percussion firing arrangement, remains fixed and the gun cannot be fired.*

* "Official Treatise on the Manufacture of Guns."

THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

(FROM OUR NEW YORK CORRESPONDENT.)

THE first meeting of the year of this Society is one that attracts its members from all parts of the country, and is looked forward to as a special re-union. On the present occasion, many of the engineers who had been so magnificently entertained in England last summer, found themselves again assembled, and it is very certain that many kind words were spoken and many pleasant memories recalled of the visit of the engineers to England's hospitable shores.

The report of the secretary showed on January 1, 1889, the total membership of the Society was 1243. On January 1, 1890, the membership was as follows:

Honorary members, resident	5
" " non-resident	3
Corresponding members	3
Members, resident	180
" non-resident	830
Associates, resident	16
" non-resident	39
Juniors, resident	30
" non-resident	130
Total	1245
Fellows (five being members)	56
Subscribers to building fund 140, of whom 85 are entered in one or other of the above classes, and 16 deceased, leaving	39
Total connected with the Society January 1, 1890	1335

The additions during the past year to the several classes of the Society membership have been:

Members qualified	84
Associates qualified	11
Juniors qualified	32
Fellows qualified	1
Total additions	128

The decrease during the year was 36, as follows: Deaths, 21; resignations, 9; transferred, 6. The net addition during the year was 92.

The treasurer's annual report showed the receipts for the year to be 39,799.91 dols., including balance on hand on January 1, 1889, of 6515.02 dols. The expenditures for the year were 28,875.46 dols., the balance on hand on January 1, 1889, being 10,924.45 dols.

The Norman medal was then awarded to Mr. Theo. Cooper for his paper on "American Railroad Bridges," and the Rowland prize to Mr. Jas. D. Schuyler for his paper on "The Construction of the Sweetwater Dam." These awards seemed to give general satisfaction, and the announcement of the committees, as to their selections, was received with applause.

The Norman medal was founded in 1872 by the establishment of a fund of 1000 dols. by George H. Norman, member of the Society. It is a gold medal awarded by a Committee of Censors appointed by the Board of Direction for the paper deemed by them to be the best "contribution to engineering science, not merely relatively as compared with others presented during the same year, but as exhibiting the science, talent, or industry displayed in the consideration of the subject treated of and for the good which may be expected to result from the discussion and the inquiry."

The Rowland prize consists of 50 dols. in cash. This is awarded by a Committee for the paper they "deem most worthy of such recognition, the preference being given to papers describing in detail accomplished works of construction, their cost and manner of execution, and the errors in design and execution. This prize was established by Thomas F. Rowland, member of the Society, in 1882, and consisted also of 1000 dols. fund.

The papers must not have been in print before presentation, and the award in each instance is made annually. Should the Committee on the Norman medal not think any paper for that year of sufficient merit to receive the medal, the money is invested in books, and is given to the second best paper; the next year a medal is issued. Evidently the donor did not consider this failure could happen more than one year in succession, and in point of fact it has never happened since the medal was instituted, which shows that either the papers were excellent, or the Board of Censors were most appreciative.

As the constitution and by-laws of the Society

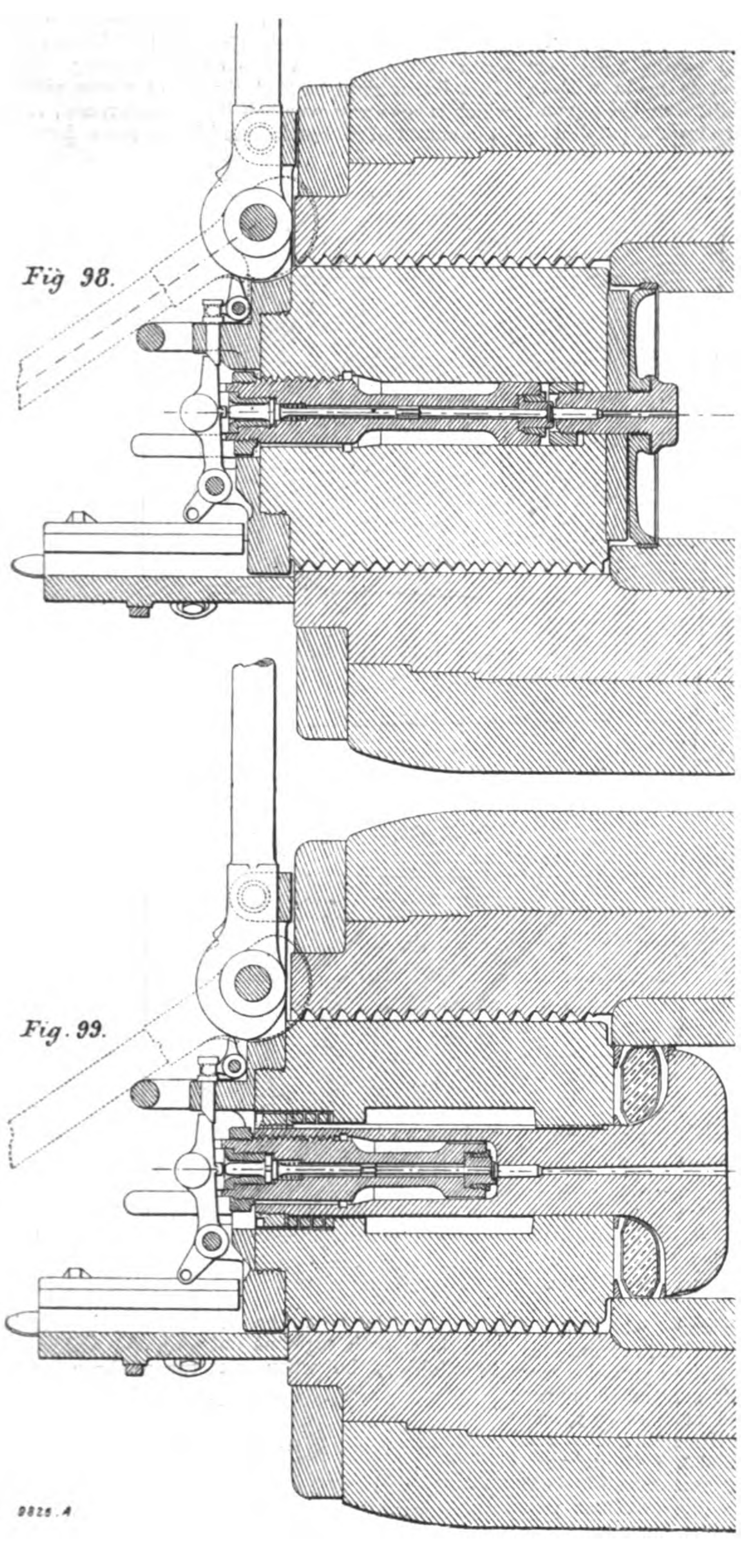
MODERN FRENCH ARTILLERY.
No. VIII.

BREECHLOADING MECHANISM—*continued.*

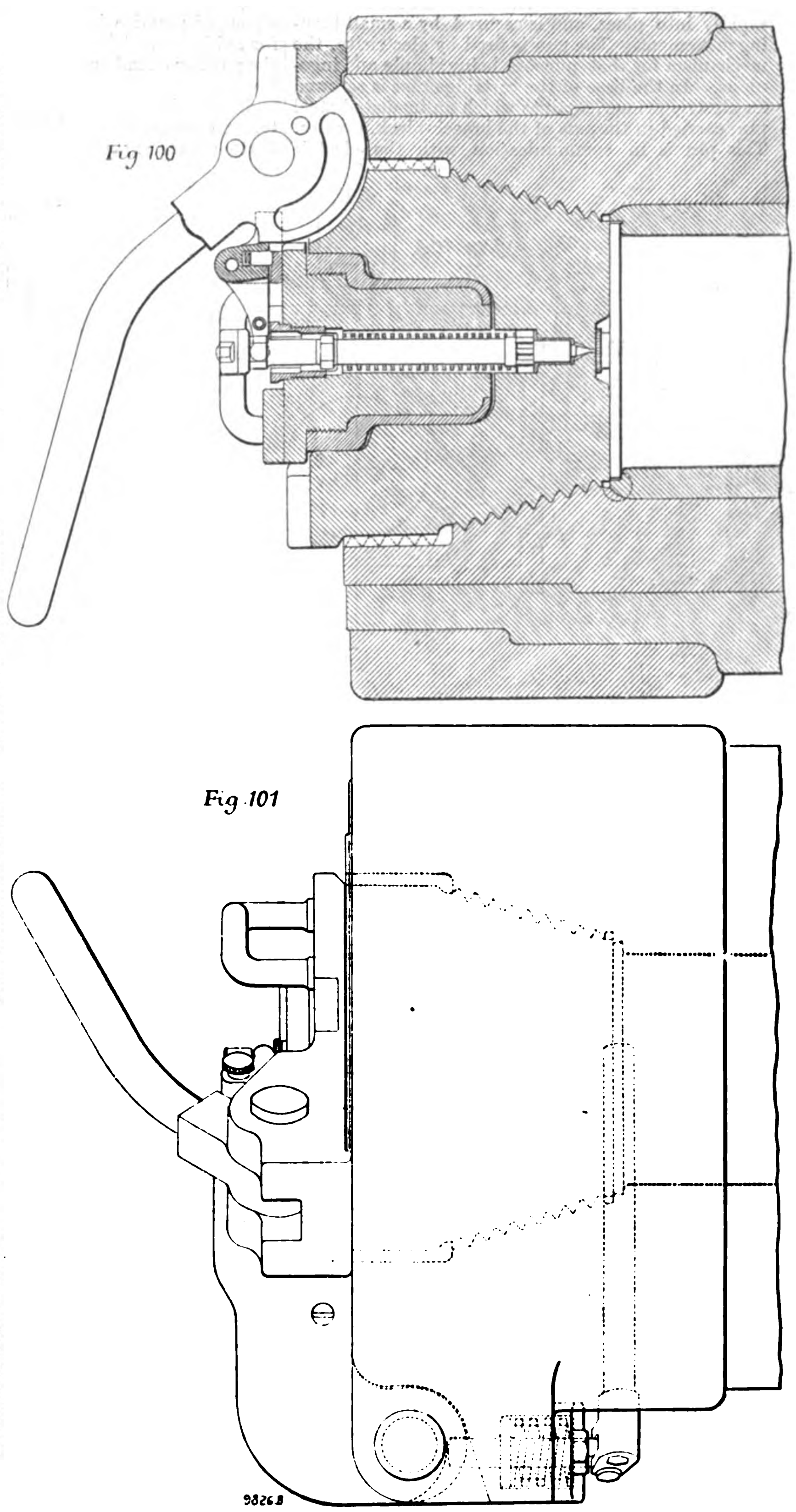
The Armstrong System.—We have referred in a previous article to the Armstrong system of obturation, known as the Elswick cup, and have given the official opinion respecting it. Fig. 98 shows the exact form of this cup, and besides is a section of the breech mechanism of a 6-in. Armstrong gun. The details of this mechanism call for no special notice either as regards the block, seating, locking or safety apparatus, which resemble the French standard system. With modifications in detail, Fig. 99 is a section of a similar gun, the block being fitted with a De Bange obturator. With regard to their two systems the Elswick firm say: "The breech opening gear and firing arrangements are the same in both cases, the difference in the drawings showing the two forms of obturator which are used. The cup is a flat-backed saucer of steel resting against the face of the breech-screw, which is slightly rounded. The cup also fits accurately into a ring of hard copper hammered into a groove in the gun, and the pressure of the gas in the chamber forcing the cup against the convex surface of the breech-screw effectually closes the space between the cup and the copper ring, and prevents the escape of powder gas. A great advantage of this form of obturator is that it is absolutely elastic and requires little or no force to enter it into position in the gun or to extract it. The cup, however, must be carefully handled, and like the Broadwell ring in a Krupp gun, will not stand knocking about to the unlimited extent which sometimes happens to them. Used, however, as it ought to be as a delicate piece of machinery, these cups frequently stand several hundred rounds without failure or even the necessity of putting in a new copper.

"The De Bange obturator has the principal advantage that it appears to stand all the rough treatment which gunners of both services are able to bestow up it. It is not, however, elastic like the cup, and particularly in the large sizes requires great power to extract the breech. In the 68-ton and 110-ton guns, for instance, hydraulic mechanism exerting a force of about 10 tons has to be employed to extract the breech screw."

Figs. 100 and 101 show the breech opening of the 6-in. Armstrong quick-firing gun. In this the question of obturators in the usual sense of the term is avoided, as the gun is used with a metallic cartridge case, which in itself does the obturation. There is also no doubt that it is an excellent form



THE ARMSTRONG SYSTEM OF BREECHCLOSING FOR HEAVY ORDNANCE WITH THE ELSWICK CUP, AND THE DE BANGE OBTURATOR.

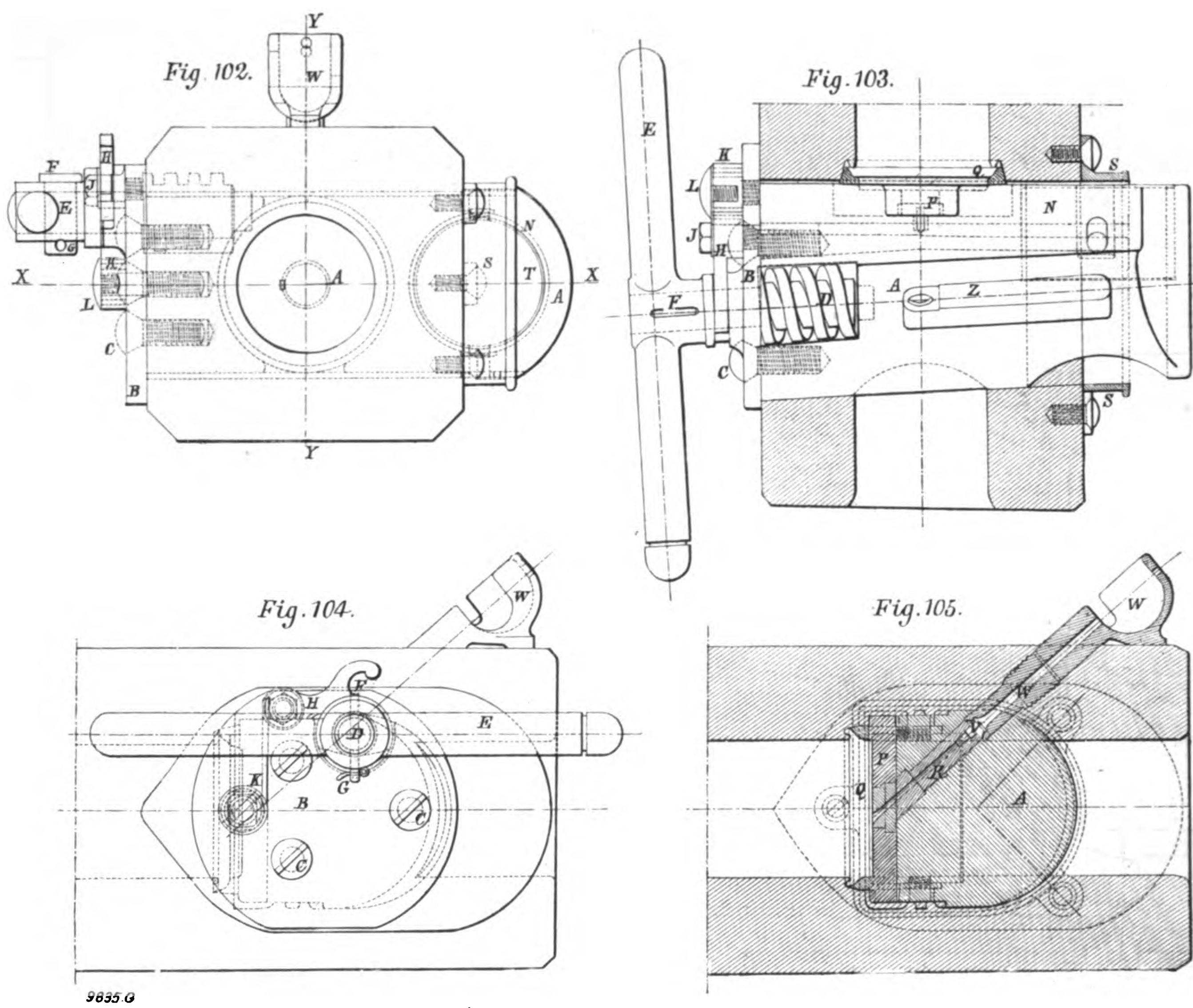


THE ARMSTRONG SYSTEM OF BREECHLOADING FOR QUICK-FIRING GUNS.

of obturator, the gas being stopped at the very mouth of the cartridge, and leaving no fouling in the chamber, and therefore no necessity for washing out between the rounds.

The breech is closed on the interrupted screw system, and to render the closing and opening more easy and rapid, the breech-block is formed in two steps, both of which have portions of an interrupted screw on their surfaces, the threads on one step standing longitudinally opposite to the blank spaces on the other. The breech-block swings rapidly into place, and is secured by a small turning movement. The gun is fired by electricity, the mechanism for that purpose being simple and ingenious. In the base of the cartridge case is screwed an electric primer, against which an insulated steel pin, carried in the axis of the breech-block, presses. This pin is in communication with the electric wires, which carry the current to fire the primer, only when the breech-block is closed, and secured by turning the lever downwards against the rear of the block. The circuit is closed and the charge fired by pulling the trigger of a pistol handle, arranged in a convenient position close to the sights. In case of the failure of the electrical firing gear each gun is also fitted with a percussion lock; the electric primer in the base of the cartridge is replaced by a percussion primer of the same form, and the steel pin, which in the former case supplied the electrical contact, now serves as a firing needle. The percussion firing gear also has a safety appliance to prevent the charge being fired till the breech is closed and locked. In this manner all danger of accidental discharge is avoided and complete security gained.

The Krupp System.—From the outset, Mr. Krupp, of Essen, adopted an entirely distinctive system of breech mechanism, which he followed consistently through the great and rapid development of gun manufacture, from its first application to field artillery, to his latest achievement in monster ordnance—the greatest that has been yet attempted in any country so far as weight is concerned. In its earliest and elementary stages the system was founded upon the crude ideas of Cavalli, and consisted of a simple wedge working to and fro in a suitably formed slot cut in the body of the gun at right angles to the bore, the wedge being held, more or less securely, in its place while the gun was fired. Of course such a mode as this soon passed out of practice. With gradual developments the mechanism assumed the form shown in Figs. 102 to 106, which may be taken as illustrating the most advanced practice in this system of breechloading for field guns. The body of the gun, to the rear of the powder chamber, is slotted out at right angles to the bore, the opening so formed having a flat face and a semicircular back, which is made with a taper, enlarging from right to left. On the top and bottom sides of the slot, ribs are formed parallel to the rear of the slot, so that the wedge when moved in and out may be always guided with the front face at right angles to the bore. Some partial screw threads are tapped in the left side of the upper wall, and the breech is secured in place by means of the locking screw entering these threads. The wedge A is of such a shape that it accurately fits the slot, when the block is in position and locked; it is of the form shown in Fig. 105, a circular passage, the diameter of the loading chamber being cut through it at the right-hand end; this opening T, when the breech is withdrawn into the loading position, coincides with the bore of the gun, and forms a passage for the projectile and cartridge. When closed the wedge assumes the position shown in Fig. 103, and that part of its front face closing the powder chamber, is recessed to receive a hard steel disc P, which, with the gas-check ring, forms the abutment to receive the shock of discharge. The upper face of the wedge is cut with an inclined slot Z (Fig. 103); through this the lower end of the upper section of the vent tube passes, and it forms a further guide for the wedge when it is drawn in or out. In prolongation of this tube a hole is drilled through the wedge, so that the centre coincides with the centre of the plate P recessed into the face of the wedge. When in firing position, the lower part of the vent tube fixed in the wedge coincides exactly with the upper part screwed in the breech, and at the point of junction a copper gas check is introduced to prevent any backward discharge of gas. To the left-hand side of the wedge is bolted the guard-plate B, fastened to the wedge by the three bolts C C; one of the principal uses for this plate is to provide a bearing for the locking screw D, and for the spring fastening that prevents the screw from shaking loose while the gun is being transported. The travel of the locking screw is limited by a stop on the bearing. The screw has a right-handed thread of coarse pitch, which is cut away over half its circumference; it is so mounted in its bearings and in the recess formed to receive it in the wedge, that when it is turned with the smooth segment outward, the wedge can be withdrawn, but when it is turned through half a revolution, the threaded part engages in the recesses cut in the body of the gun and holds the wedge securely; besides locking, however, its



KRUPP'S BREECH MECHANISM FOR FIELD GUNS.

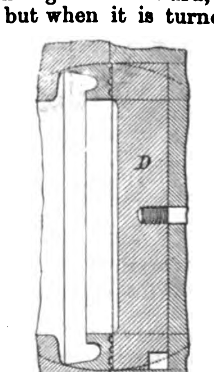
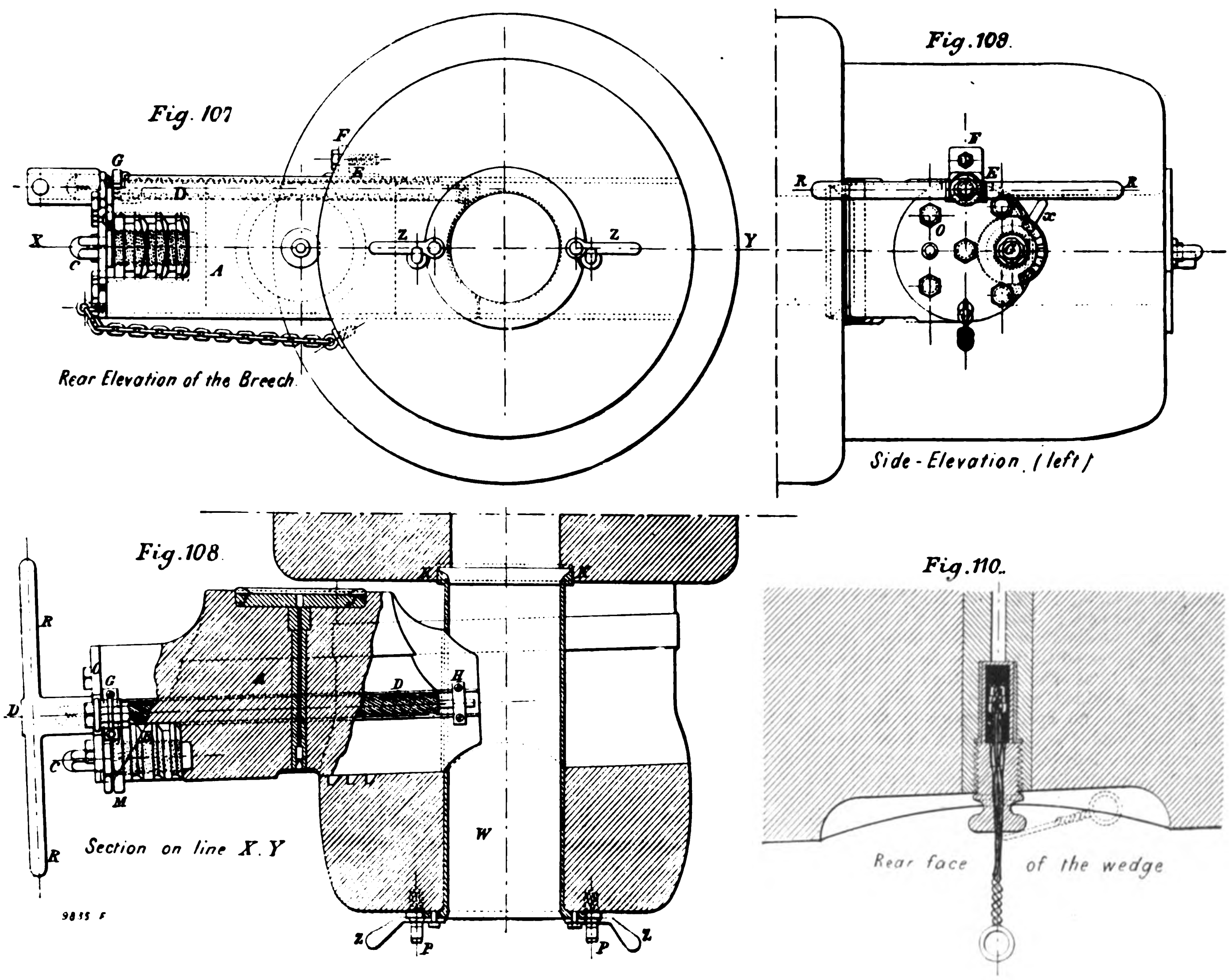
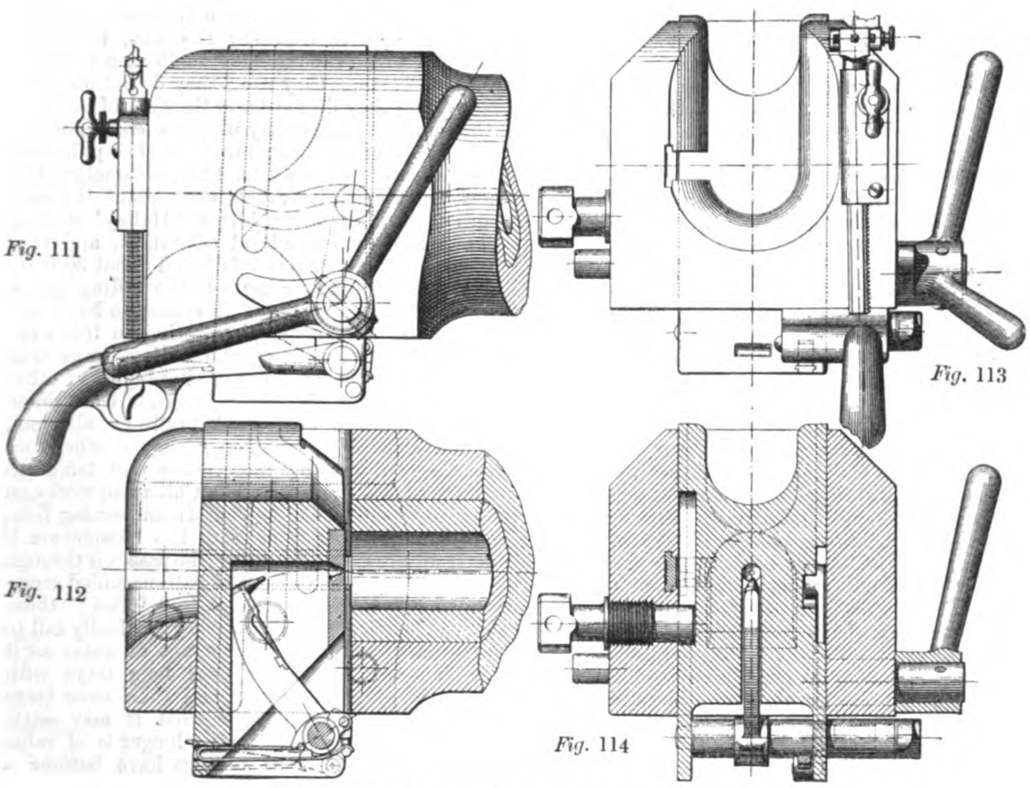


FIG. 106. THE BROADWELL RING.

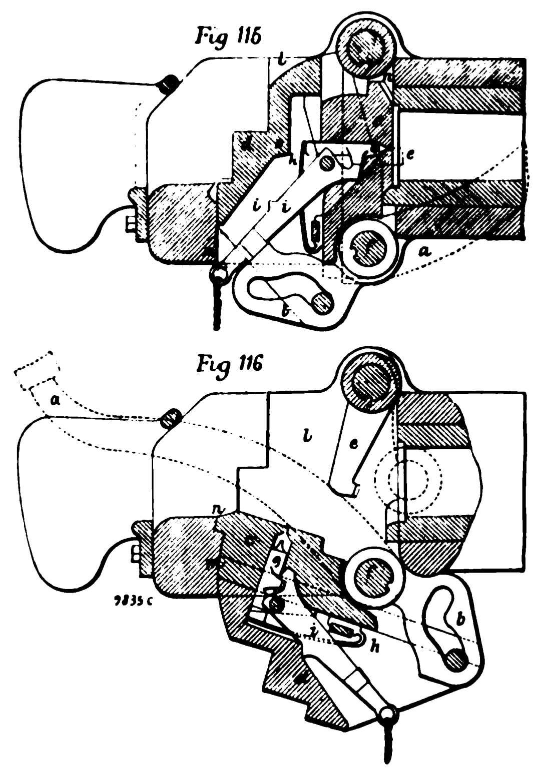
movement forces the face of the wedge up to the edge of the powder chamber. The screw is operated by the long lever E, which is fixed to the stud by a key and pin. It can be held in the locked position by means of a flat spring attached to the cover-plate and pressing on the stud of the locking screw projecting through the bearing; before the breech can be opened, the spring has to be lifted by the handle shown in Figs. 103, 104. In the opening at the right-hand end of the wedge through which the projectile and cartridge are introduced into the bore, slides a light brass tube from which studs project into grooves cut in the guides at the top and bottom of the slot; as the wedge is drawn out, these grooves force the tube forward, keeping it in contact with the back of the gas-check, and so prevent any dirt from entering the chamber; as the wedge is pushed home the tube recedes into the opening in the wedge. The gas-check is one of the details which helped to insure the success of the system: it is known as



KRUPP'S BREECH MECHANISM FOR HEAVY GUNS.



THE HOTCHKISS BREECHLOADING MECHANISM.



THE NORDENFELT BREECHLOADING MECHANISM.

the Broadwell ring, and is of the form shown in Fig. 106. The inner surface is cylindrical, the outer is spherical, the centre from which it is struck corresponding with that of the bore in the plane of the forward face of the slot; it is of course seated in a spherical recess in the chamber of the gun, and on its rear face are cut a number of concentric grooves to prevent the escape of powder gases. The vent screw W, which, as already explained, is screwed into the body of the gun, is provided at the top with a cup-shaped shield to protect the men serving the gun from any backward discharge of gas or primer fragments. The mechanism is completed by a brass cylinder S bolted to the right-hand side of the breech, and over which is fitted a leather hood that protects the mechanism from dirt. The mode of working this system will be gathered from the foregoing description of its parts.

The mechanism for guns of large calibre is very similar to the foregoing, and is illustrated by Figs. 107 to 110. As the wedge is too heavy to move in and out by hand, the necessary power is obtained by the quick-threaded screw D partly recessed into the upper surface of the wedge and engaging in a half-nut F secured to the breech. In this case the lever R that locks and unlocks the wedge can be mounted upon the square-ended stud of the screw, and the breech opened; a check chain prevents overrunning. When loading, a light brass cylinder W can be inserted from the back through to the rear of the powder chamber; the right-hand side of the wedge is not extended far enough to allow of a circular opening as with the field-gun arrangement, but the end is hollowed to a curve corresponding with the diameter of the chamber. The wedge which is recessed to receive a gas-check plate, is drilled through, as shown, for the friction primer (Fig. 110), provided with an obturating device, but which has no special features; the firing rod is finished inside the primer with a tapering stop, and when the lanyard is pulled the stop enters a countersink in the base of the primer case and checks any backward discharge of gas.

In future articles of this series we shall speak in considerable detail of the Hotchkiss system, which although essentially American, has found a great and successful field in France, and has in fact become nationalised there. In the Hotchkiss factory at St. Denis two types of guns are manufactured; the revolving cannon and the quick-firing gun. The latter is also largely made by the Elswick firm, and it forms the chief armament of its class in the French Navy. It is, in all its calibres, up to 10 centimetres, a breechloading gun on the sliding wedge system. Unlike Krupp, however, the movement of the block is vertical instead of being lateral. Figs. 111 to 114 illustrate the system quite clearly; from these views it will be seen that the breech of the gun is slotted, the face next the chamber being vertical and the rear face tapered. Within this slot slides a block, the top of which is recessed and the body made hollow for the firing device; the face of the sliding block carries a plate perforated for the passage of the striker. On one side of the sliding block a stud projects through the body of the gun, and on this is mounted a two-armed lever, outside the gun, and a lever with a stud at the end within the slot, the block being cut away to make room for it; the stud works in a curved path cut in the block, while the latter is limited in its up-and-down travel by means of a recess on the left-hand side, in which works the end of a screw as shown. By turning the handle of the operating lever in one direction the block is run down by the action of the stud in the cam path, until the recessed top coincides with the bore and a new cartridge can be inserted; the motion of the lever is then reversed and the block is raised, and held in position by the lever being pulled past the vertical and also by being held with a spring catch. The movement of lowering the block cocks the hammer, which is liberated by the firing trigger on the pistol handle. The extractor is operated by the end of its lever working in a curved slot that gives the requisite withdrawing motion.

Before terminating these descriptions of breech mechanisms, we may refer to that adopted by Nordenfelt for quick-firing guns, and which is represented in Figs. 115 and 116. The arrangement is remarkable for simplicity and the small number of parts, there being only ten in all. The principal pieces are the firing handle *a*, the action cam *b*, the breech-block *c*, the wedge *d*, the extractor *e*; of the remainder *f* is the pin in one with the firing handle, and to which the cam *b* is connected, *g* the firing pin, *h* the spring, and *i* the trigger; the last three being housed in the breech-block; *k* is the pin of the wedge fitting in the slot of the cam. The path of this slot is at first nearly straight, the remainder being curved to the radius of the firing handle. The wedge has a rising and falling movement in the slot *l* of the gun, and the upper face, as well as that of the wedge, is curved to fit on a correspondingly curved seat *m* at the rear of the gun; the top of the wedge is also curved, and on its front side is a projection *n*, that takes its bearing in a recess in the breech. The action of the mechanism is as follows: Assuming the gun to have been fired, the handle is thrown back through one-third of a revolution, drawing the wedge pin up the curved part of the slot in the cam *b*, into the straight path, and as the movement is continued, the wedge is forced down, the angle *o* in the hollow part of the wedge coming in contact with the projection *i* of the trigger and throwing it back; before this has happened, however, the firing pin is forced forward by the downward movement, and the main spring is compressed; the extractor cam lever has also actuated the extractor, forcing it back and started the cartridge case from the chamber. As soon as the wedge pin has reached the end of the slots in the cam, this continued movement of the firing handle sets up a downward motion of the wedge and block, which continues until the handle has reached its extreme travel, when the position of the various parts is as shown in Fig. 116, the last motion of the extractor lever being a sudden one that throws out the cartridge case.

A new cartridge may now be introduced into the gun, and the firing handle pulled forward; the rising wedge and block push the cartridge home, and the movement continuing, the trigger is pushed up until the hammer is started and the gun fired. The inclined face within the wedge prevents the firing pin from striking the cap of the cartridge until the wedge is quite home, and abuts firmly against the back of the slot; if the trigger is pulled prematurely the lugs on the firing pin strike against the inclined face of the wedge and the cap is not touched.

VICTORIAN GOLDFIELDS.

SANDHURST.

(BY OUR SPECIAL CORRESPONDENT.)

(*Continued from page* 162.)

THAT some of the Sandhurst people have learned to mine and crush quartz economically is beyond dispute; in fact, in a few cases, the mine records are astonishing, and point a most useful lesson to miners and millmen all over the world. The St. Mungo Mine at Eaglehawk being notably one of this class, some particulars concerning its work for the past half-year supply the lesson. The quartz in this mine is not in a defined lode, the western wall is the only one marked; the eastern wall is entirely broken up; from 600 ft. to 800 ft. the deposit is almost vertical, then it underlies west. The quartz is nearly pure white, intersected by bands of slate, and both show pyrites but little or no gold, the width of the deposit varies from 3 ft. to 35 ft.; a general fair average would be about 14 ft., and of this only about 6 ft. is put through the battery, the remainder being barren bands of rock. For 5½ years this mine has worked on quartz giving a yield of under 5 dwt. of gold to the ton; on this return some 28,000*l*. has been paid in dividends; the machinery has been kept in thorough repair, and the mine properly worked and developed. During the last six months the main shaft has been sunk and timbered 74 ft., 143 ft. of winzes made and timbered, and 210 ft. of drives, making a total of 427 ft. of ground sunk and driven. From all parts of the mine—including the lower levels, over 1200 ft. deep—10,190 tons of quartz have been raised and crushed, giving a return of 1851 oz. 17 dwt. of gold; 66 tons of pyrites were collected and gave a return of 144 oz. 9 dwt., or altogether a total of 1996 oz. 6 dwt., being an average of 3 dwt. 22 grains of gold per ton of ore mined and crushed. The following statement of receipts and expenditure show the dividend from this return:

Balance Sheet.

	£	s.	d.		£	s.	d.
To Capital 32,000 shares at 1*l*. each ..	32,000	0	0	By Uncalled capital	24,600	0	0
Profit and loss	10,499	9	4	Reserve shares	1,850	0	0
Bank	35	12	2	Mine and property ..	4,775	14	0
				Machinery and plant ..	11,309	7	6
	42,535	1	6		42,535	1	6

Receipts and Expenditure.

	£	s.	d.		£	s.	d.	£	s.	d.
To Balance last half-year	394	3	9	By Wages, mine account	4247	1	11			
Company's gold	7907	19	1	Wages, machine account ..	777	18	5			
				Materials ..	732	15	4			
				Firewood ..	578	0	0			
				Machinery wear and tear ..	96	8	0			
				Carting	17	6	6			
				Treating pyrites, cleaning plates	204	0	0			
								6653	10	2
Dr. Balance bank	35	12	2	Dividends ..				1200	0	0
				Mine and property, new lease ..				400	0	0
				Management, directors, and auditors ..	65	4	0			
				General charges, stationary, insurance, &c...	12	0	0			
				Lease rents, rates	7	0	10			
								84	4	10
	8337	15	0					8337	15	0

In this mine, as in almost all others on the field, it is necessary to do a lot of timbering and to fill up the worked-out portions as the mining progresses. With this in view nothing but cushing stuff is sent to the surface, the "mullock" or rock intersecting and inclosing the quartz vein is picked out below and left for filling, and in addition large quantities of "mullock" sent to the surface from workings some years back are returned underground together with tailings and the whole carefully packed into the cavities made by removing the quartz lode. In very many mines the soundness of the country rock is such as not to require filling to prevent the ground falling in, but it is invariably filled up all the same, for this reason: In working quartz in large cavities it would be necessary to employ staging to raise the miners up to the roof; when shots are fired in the quartz many large loose pieces do not fall down with the bulk of the quartz shifted, and would be most dangerous and apt to fall on the heads of the workmen as they were again fixing their staging to resume work, therefore, as in this class of mining almost all the ground is worked upwards, it is considered most advantageous and less hazardous to fill in the ground below as it is taken out, never leaving a greater space between the filling and the top of the roof than about 6 ft.; this timbering in loose ground before filling, and subsequent filling in of all cavities, is by no means the least expensive and troublesome part of the mining work.

I omitted to take particulars of the winding machinery on the St. Mungo Mine; but, the crushing plant is as follows: A 30-head stamper battery by Roberts and Sons, Sandhurst, stamps 9½ cwt. each, crushing the ore to pass through screens with 144 holes to the square inch—by the way, this is the manner in which the Sandhurst mill men know the size of the gratings they use; they do not use mesh screens, and they do not know the sizes of the holes in the punched plates they use by a corresponding size in mesh screens or by numbers. The pulp from this mill passes over about 12 ft. of amalgamated plates, from which it travels over about the same length of blanket strips, into a "Halley" shaking table, one for each five head of stamps, and then into a sump from whence it is lifted about 30 ft. in height into a shoot running it to the tailing heaps. Once on the tailing heaps it ceases to be of any value to the mineowners, excepting in this way: For the labour of keeping the tailing heaps trim and preventing their flowing or slipping on to other people's property, the right is given to Chinese labourers to take out of the tailings all gold, amalgam, floured mercury, or pyrites or other contents they can save by their crude and laborious methods of hand labour. The Chinaman works on the pyrites heap on the flowing stream coming from the shoot before the sand loses the momentum it gains from the stream of water; he passes it through long boxes with small pieces of battens nailed crosswise, known locally as "slips" or "ties;" these catch the heavier particles as they gradually fall to the bottom from out of the current of water as it loses its force, he runs it over long trays with canvas laid on the surface and then over trays covered with blankets, after that it may settle where it will on the heap and no longer is of value to any one; indeed the tailings have become a positive nuisance, and the tailing and sludge questions promise before long to become one of the hard nuts which has to be cracked by both miners, legislators, and others interested. Three Cornish boilers 28 ft. long by 6 ft. 6 in. with Galloway's tubes, supply the steam to an

In the finished pier there is a notable difference in the "skin" of the concrete above and below the tide level, the surface not being so hard in the upper part. Below the water level the concrete assumes an extremely hard surface, and its power to resist very severe attrition has been severely tried by the prolonged action of the large sharp lumps of slag rubble being thrown against it by the sea; this it has resisted remarkaby well. Above the water, on the other hand, after lengthened exposure to the air, the skin assumes a white colour and is much less satisfactory than similar work executed with Portland cement; only the skin is so affected however, an inch below there is no difference below and above water. In an exposed situation with frequent storms, the concrete has proved itself to possess a high power of resisting the destructive action of storm waves while still fresh. Frequently, as in all such works, the work has been assailed by severe storms within twenty-four hours after completion, and it has passed through all these (sometimes of several days' duration) without any injury whatever, even though —as in some cases—the temporary timber framing was carried away.

The results attendant upon the use of slag cement in these works have so far proved successful, and some of the concrete has now been two and a half years in place. Probably nothing less than ten years' actual experience can be accepted in settlement of so important a question as that of the actual action of sea-water upon a new and previously untried cement, but it will be seen that the results of the experience here and of the investigations which have been made are of a satisfactory kind so far as they have gone.

The engineer for the harbour works is Mr. William Kidd, Assoc. M. Inst. C.E., by whom they were designed, and they are being executed by the company's staff under his personal direction. Mr. P. J. Messent, M. Inst. C.E., Tynemouth, was consulted in finally determining the direction of the outer portions of the piers and the form of the entrance.

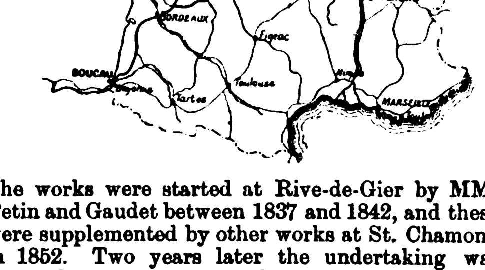
MODERN FRENCH ARTILLERY.

No. X.

THE ST. CHAMOND WORKS.

SOME time since (see ENGINEERING, vol. xlviii., page 297) we gave some detailed particulars of the works belonging to the Compagnie des Hauts Fourneaux, Forges et Aciéries de la Marine et des Chemins de Fer, known generally as the works of St. Chamond. We need only therefore repeat as briefly as possible a few facts connected with its history and importance. The group of great establishments amalgamated into a single company, whose principal offices are at St. Chamond, forms one of the principal centres of the iron and steel industries in the basin of the Loire. (See Fig. 117.)

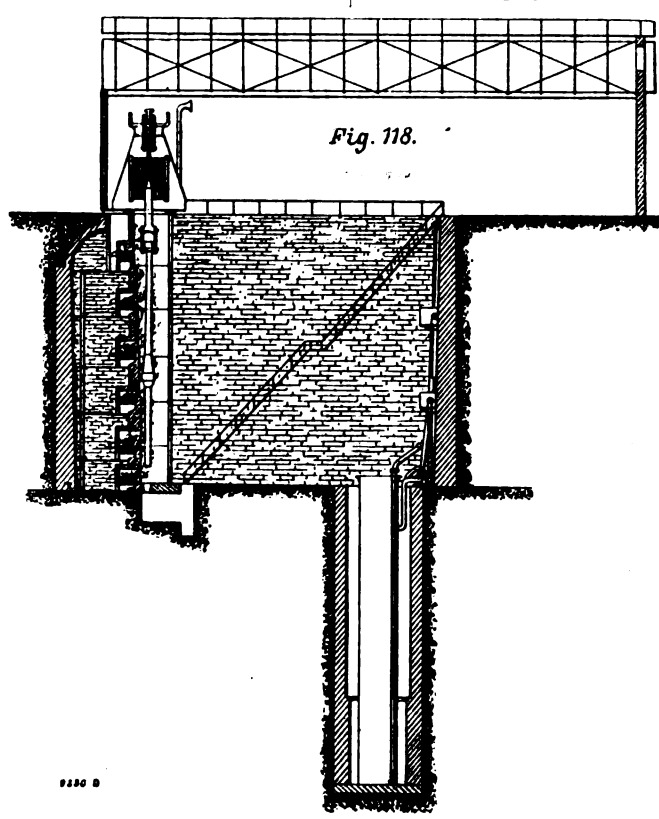
Fig. 117.



The works were started at Rive-de-Gier by MM. Petin and Gaudet between 1837 and 1842, and these were supplemented by other works at St. Chamond in 1852. Two years later the undertaking was changed into a company with a capital of 22,500,000 francs, when the steel and iron works of Assailly, the iron works of Lorette and Persan, and the charcoal iron blast furnaces of Clavières and of Toga were added. At various intervals since 1854, further extensions were made and modifications effected; the society was converted into a limited company with a capital of 13,000,000 francs afterwards raised to 20,000,000 francs; blast furnaces and iron works at Givors were established, coal mines were acquired at Unieux, forests purchased in Sardinia, and new works were started at Boucau, on the Adour, near Bayonne, to save the carriage of the enormous quantities of Spanish ores that the company were obliged to make use of every year. Naturally each of these various establishments, which in all employ 6000 men, has its speciality. Thus rails and metallic permanent way are made at Boucau, the Bilbao and Bidassao ores being wholly employed; the output of steel rails is about 70,000 tons a year. Other railway material is made at St. Chamond, Rive-de-Gier, and Assailly; carriage and engine tyres and steel frames being manufactured at St. Chamond, wheel bodies at Rive-de-Gier, and springs at Assailly. Steel ship-plates, beams, and angles are produced at St. Chamond and Boucau; at the former branch charcoal iron plates for ship works are also turned out in large quantities, while the manufacture of steel angles, T's, and special sections belongs to Boucau. Steel forgings for ship construction are made at St. Chamond and Rive-de-Gier, the former branch having a 100-ton, and the latter a 35-ton hammer. It was there that a number of 15-ton screw shafts, with three cranks, made in a single piece, were turned out at St. Chamond. War material—tubes, rings, jackets, armour plates, and to a smaller extent, finished guns—constitute a large part of the company's industry, St Chamond being one of the few works from which the French Government purchases steel parts, which are put together at the State arsenals. The ingots from which the various pieces are made, are produced at Givors and at Boucau, whence they are sent to St. Chamond for completion. We shall have occasion to consider later on, the manufacture of armour plates by this firm, but for the present we shall confine ourselves to the steel used for guns, and the objects produced. The pig irons from which the steel ingots are made for gun construction, are very carefully made and selected; those produced in the blast furnaces of Givors are from oxydulated magnetic Sardinian ore, mixed with selected ores from Spain and Algeria; the mines of Bilbao and Bidassao furnish the ores for the blast furnaces at Boucau. The pig iron employed contains on an average one ten-thousandth part of sulphur, and less than this proportion of phosphorus. All steel is made in the Siemens-Martin furnace; the plant is sufficiently extensive to produce and handle ingots of 100 tons, the subsequent appliances for the operations of forging, &c., being on the same scale, while a range of steam hammers from 10 to 100 tons are employed for dealing with gun tubes and jackets from 100 lb. to 50 tons of finished work, the rough ingots being of course at least double this weight. The work of annealing and tempering such large masses, involves the necessity of special plant, and as both these operations are carried out vertically, furnaces nearly 80 ft. in height, and tanks of the same depth, are required; there are three of these great installations at St. Chamond; the tanks being connected together, and requiring for one operation about 6000 cubic feet of oil. Fig. 118 gives some idea of the furnace and tempering pit, which are combined in the same building.

The general conditions under which the steel is manufactured to enable it to pass the very stringent specification of the French Government, are generally as follows, though it should be mentioned that the requirements of the War Department have, this year, been made somewhat more stringent. The mean cross-section of the ingot must be at least four times greater than that of the forged ingot before turning; the weight of the forged piece is never more than 50 per cent., and is often only 40 per cent. of the weight of the ingot employed. The ultimate tensile strength of the steel before tempering varies, according to circumstances, from 25.40 to 38.09 tons per square inch, with a minimum extension of 18 per cent.; after tempering, the tensile strength must amount to from 34.28 to 50.79 tons, with an elongation of from 12 to 14 per cent. These results must be obtained from test bars cut out of discs removed from each end of the steel block at right angles to its axis. Before these tests are made, a number of experiments are carried out with the steel, which, indeed, is tested at every stage, commencing with the selection of the ores, and continuing with analyses of the pig; tests—physical and chemical—of the crude ingots, and the final tests of the finished block. The reinforcing rings for large ordnance and field guns are made of cast or puddled steel, the latter being produced at Saint Chamond from charcoal pig made at the Corsican Iron Works of Toga, which belong to the company. Rings for naval ordnance are almost exclusively of cast steel; they are rolled in a manner analogous to railway tyres, and are tested with the same minute precaution as the gun tubes. Steel-framed carriages for all calibres are also made by the company, and the production of chrome-steel shells is a speciality, shared also by the Holtzer, St. Etienne, St. Marrel, Chatillon et Commentry, and the Firminy Works.

It was as long ago as 1848 that the St. Chamond Works first commenced the delivery of guns to the French Government; these were, of course, cast iron, and of small calibre, but since that date the production of ordnance and war material has been continued with constant development, and always



TEMPERING PIT AND ANNEALING FURNACE; ST. CHAMOND.

keeping to the front of the industry in France; we have mentioned in a previous article the famous 24-centimetre steel gun "Jeanne-Marie," made of steel supplied by this firm in 1864, and which did such good service at Mont Valerien during the siege of Paris. With improvement in manufacture came an increase in the power of production, until the works have arrived at their present proportions which are ample enough to turn out all classes of finished arms, from the repeating rifle of the Daudeteau type, to the large guns of 16.54 in. bore. The extent and completeness of the various installations enable the company to include and to follow all the successive stages of manufacture from the mine to the trial grounds, without having to apply to any other manufacturer for material or processes that enter into the production of the various elements of which modern artillery is composed. For this reason, no less than for the skill and care that are introduced into every branch of the manufacture, the St. Chamond Company enjoys a high and well-deserved reputation among the industrial works of France. The following list comprises the various classes of guns and parts of guns manufactured by the company:

Repeating rifles.
Quick-firing guns.
Mountain artillery.
Field guns.
Siege and garrison guns.
Coast defence and naval ordnance.

As the St. Chamond Works were among the earliest to supply the French Government with cast-iron guns, they also claim to have taken the lead in the manufacture of steel for modern artillery; in 1864, when the old cast-iron ordnance was systematically being strengthened, they furnished, from the Assailly branch, large quantities of tubes and hoops for the purpose. Even so early as 1865 they were producing steel parts for naval guns of 5.51 in., 6.29 in., 7.47 in., and even 9.45 in., and it was one of the last named guns which, during the siege of Paris, did excellent service at Mont Valerien. They were also one of the first French companies to make guns for foreign customers, as soon as the prohibitory law was removed, which had done so much to cripple home industry and to give every advantage to English and German makers.

We are indebted to our contemporary, the *Genie Civil*, for the following paragraphs on the history of the company since 1880. In that year it received from Mexico an order for sixteen batteries of field guns and eight batteries of mountain guns to be delivered with carriages, caissons, ammunitions, and accessories complete, and ready for action; these guns and carriages were of the De Bange system, as adopted by the French Government. This order arrived while the prohibitive law was still in force, and it was partly in order to prevent the order from falling into foreign hands, that the Government conceded the necessary privileges that have since had such important results. As a necessary consequence the company made every effort to extend its trade for war material abroad, with signal success. In 1885 the Anciens Etablissements Cail, with which to a certain extent it was associated, obtained from the Servian Government an order for fifty-four batteries of field guns of the reglementary De Bange French system. The St. Chamond Company shared this contract so far as the manufacture of the material was concerned, as well as the entire completion of one-third the order; the Cail Company finishing the other two-thirds with the material supplied from St. Chamond. The French Government also, despite its conservative system, of making all its guns at its own factories, while it is dependent for steel upon private makers, was compelled to lean upon St. Chamond, and when the pressure of military necessities was felt during the Tonquin compaign, it gave the company extensive orders, amongst which were sixty guns of 16 centimetres (6.29 in.) and a large number of carriages. As was to be expected, and as had been the case with the Cail Company, St. Chamond did not long confine itself to the execution of standard guns, whether of French or foreign types; in 1880, M. Darmancier, the engineer in charge of the ordnance department of St. Chamond, perfected a new type of carriage for reduced embrasures, and this, after having been tested at the fort of Giromagny by a Government commission, was adopted as a standard type, and an order for sixty such carriages was given to the company for placing in the forts and armoured casemates that were at that time being built by the French military engineers. A short time after, M. Darmancier invented a new form of hydraulic brake, and after some years of experiment, it was finally adopted by the company for all their siege guns of 6.10 in. and 4.72 in. bore; this arrangement, known as the St. Chamond brake, has been largely introduced in France, where no less than 1800 guns are mounted on carriages fitted with the brake, and a considerable number have been supplied to foreign powers. A further modification of this system, for bringing the gun back to firing position, found a useful application for barbette and minimum embrasure mountings. In other directions, such as the construction of rifled mortars, modified types of mountain guns, in which weights were reduced and recoil practically avoided, without reducing the efficiency of the gun, the able director of the St. Chamond gun factory has made some remarkable experiments for developing the construction of heavy ordnance, and the guns of large calibre to be manufactured by the firm will now be designed upon what is called the Darmancier system. By this system it is claimed that longitudinal and transverse strength is fully secured, while the mode of connecting the various parts is effective and practical. The interior tube, which is made of steel sufficiently hard to resist, as far as possible, the erosive action of the powder and the shearing strain of the projectiles, is surrounded by one or two rows of hoops in the ordinary way; it is then reinforced by a series of longitudinal steel staves laid around the gun from the breech to beyond the trunnions, or in some cases extending for the full length of the gun; these staves are locked into the hoops at each end, and form a complete envelope. Over this again are placed more hoops in one or two tiers according to the size of the gun.

The quick-firing guns made by the St. Chamond Company are on a system invented jointly by M. Daudeteau and M. Darmancier, which has the following characteristic features. The closing of the breech is effected by means of a block with interrupted threads, but of a light section; the De Bange obturator is generally employed, and the metallic cartridge case is replaced by a charge in a canvas bag. The breech is opened and closed by a simple mechanical device, for which considerable rapidity of action is claimed, and which will be described in detail later on. The calibres of this type made by the company are 1.46 in., 1.85 in., 2.24 in., 3.94 in., 4.72 in., and 6.10 in.; they are in two classes, light and heavy, the former giving an initial velocity of 1640 ft. per second, and the latter more than 2000 ft., the same kind of ammunition being used with both. The standard 1.85 in. gun is adapted for the metallic cartridge of the French marine; it is 45 calibres in length of bore, and fires a projectile of 3.38 lb. with a velocity of 2030 ft. per second. The breech-block is carried on a bracket, which can be lowered against the breech of the gun, and is operated by a hand ring, which is moved to and fro for opening and closing a safety bolt that prevents the hammer from striking the fuze till the gun is completely closed, and two extractors are employed for moving the cartridge; the sighting arrangements present no speciality. The gun may be mounted on any type of carriage; in its simplest form the latter consists of a cradle with trunnion brackets, the pivot resting in a socket which forms part of the fixed stand. By this arrangement the gun can be trained to any desired angle of the horizon. The cartridge holders are made to contain a number of rounds, and are fitted with springs, which lift each cartridge from the holder, so that it may be quickly removed. Three classes of ammunition are fired from this gun, all of which are of the same weight (3.38 lb.); the steel shell 3.5 calibres long; a large capacity shell of 4.5 calibres in length and containing a bursting charge of .77 lb. and shrapnel loaded with 35 balls of hardened lead. The standard mountain gun made by the St. Chamond Company has a calibre of 3.15 in.; its weight, including the breech mechanism, is 273 lb. It throws a projectile of 12.32 lb. with a velocity of 1000 ft. per second, representing a striking energy of 212 metric tons per ton weight of gun. The piece consists of two sections, which can be connected by means of an interrupted screw thread and nut, a metallic packing being introduced to secure absolute tightness, while safety wedges are also used to prevent either of the sections from slipping on the other when the gun is fired. The De Bange system of breech closing is adopted, the proportions corresponding to the standard in the French service. The carriage can be divided into four parts; the body, the frame carrying the trunnions, and the axle; the hydraulic brake and the two wheels. The body of the carriage is made of thin steel plate and the elevating gear is bolted to it; the frame, in bearings on the top of which the trunnions of the gun rest, is supported on the axle of the carriage, and is free to oscillate upon it. This oscillation after each discharge is controlled by the brake mechanism, which by a reaction device brings the gun back again to firing position. The system of brake is one patented by the company. The body of the carriage and the axle casing are connected by means of keys; the brake is fixed at one end to the lower part of the gun frame, and to the body of the carriage also, by keys. This arrangement of securing the various parts together is therefore very simple, and the whole operation of mounting or dismounting the piece can be completed in one minute by trained men. At ordinary angles of firing the amount of recoil is limited to a few centimetres; the width of wheel-base, and the efficiency of the brake, however, keep the piece always steady under fire. The heaviest weight of any single part of this artillery is 137 lb. (that of each gun section), so that for mule transport no difficulty is effected. The 3.15 in. mountain gun throws four classes of projectiles, all of the same weight—12.3 lb. Common cast-iron shell; shells with large bursting charge—2.62 lb.—and 4.5 calibres in length; shrapnel, filled with steel balls and case shot. We must reserve for a further article particulars of the war material made by the St. Chamond Company; it is to be regretted that the data available are somewhat meagre.

OIL-TESTING MACHINE.

THE oil-testing machine shown by the Eastern Railway Company of France at the late Paris Exhibition, is designed to determine the lubricating power of different oils employed for railway axle-boxes and the journals of shafts. The arrangements of the machine permit the trials to be made under various conditions, so as to reproduce as nearly as possible the conditions of actual practice, at least in regard to the nature and dimensions of the surfaces in contact, the method of applying the lubricant, the intensity of the pressure, and the speed of the rubbing surface. The machine is further provided with appliances for lowering the temperature of the rubbing surfaces and the oil, when desired, for the purpose of extending the scope of the researches which can be made by its aid.

The lubricating power of an oil being, at a given pressure and speed, inversely proportional to the tangential resistance developed at the circumference of the shaft to which it is applied, the machine is constructed to automatically register a quantity which is proportional to this resistance. This quantity, multiplied by a constant resulting from the particular construction of the machine, gives the total value of the frictional force, and by dividing this by the pressure exercised upon the surface of contact, there is obtained the coefficient of friction, that is, the characteristic of the oil under the conditions of the trial.

The machine consists of a shaft A (Fig. 1) of the same quality and make as the axles of the rolling stock of the railway. It is carried by two journals in two bearings B B', fixed on cast-iron frames C C' bolted to a foundation plate D. The shaft A has in its centre a journal F turned exactly to the same dimensions as the axle neck. Upon this bearing is placed a bearing G, held between axle-box bearings of corresponding dimensions. The shaft A is pierced axially with a hole 1 in. in diameter, for the passage of water, which can be sent through it at various speeds and quantities. The oil to be tested is placed underneath the journal F in the reservoir E, as in certain types of axle-boxes, and serves to supply a greasing pad. Fast and loose pulleys H H' and I I' serve to drive the shaft, the loose pulleys being ½ in. less in diameter than their fellows, in order to relax the belts when running idly. The motion is derived from a countershaft fitted with a speed cone pulley having six steps, and driven from a line shaft. When the latter is running 100 revolutions per minute the speed of the shaft A can be varied from 42.9 to 255.8 revolutions per minute with four intermediate stages. This would correspond, in the case of an axle 3.54 in. in diameter, with wheels of 35.78 in. in diameter, to a speed of 12.4 miles per

MODERN FRENCH ARTILLERY; ARMOURED TURRETS FOR COAST DEFENCE.

CONSTRUCTED BY THE ST. CHAMOND IRON AND STEEL COMPANY; LOIRE.

Fig 119

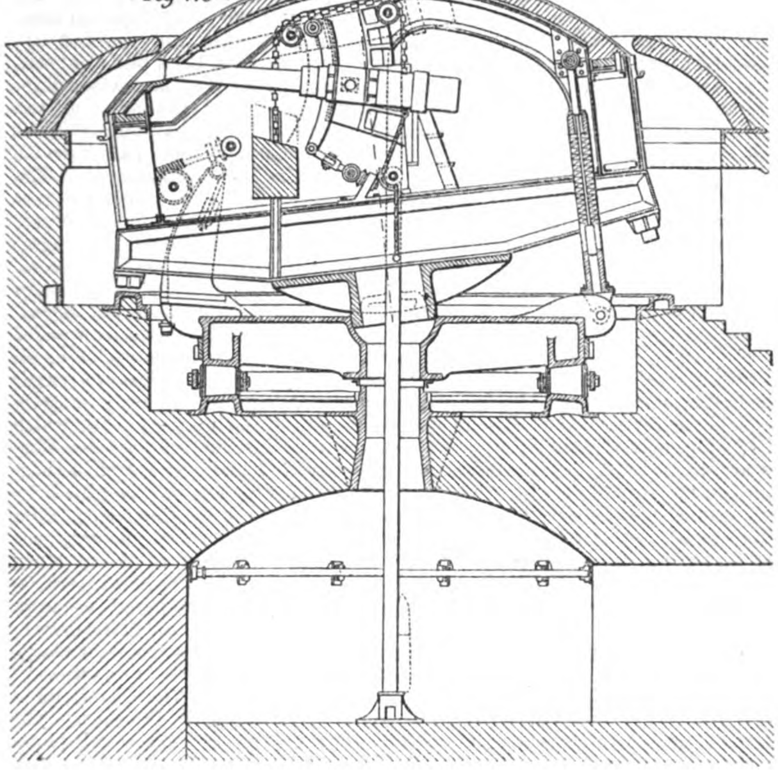


Fig 121

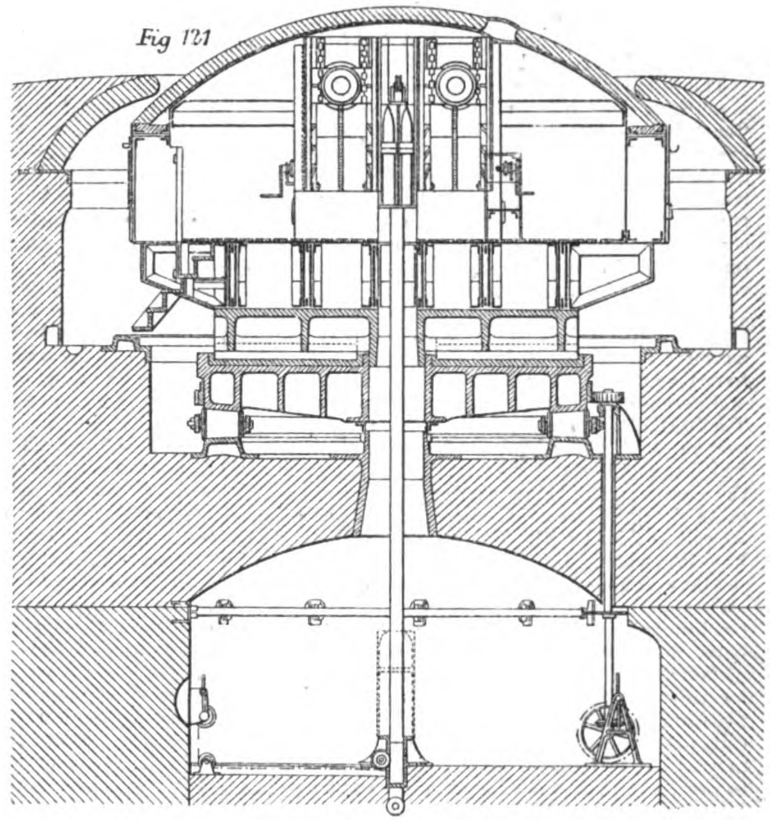


Fig 120

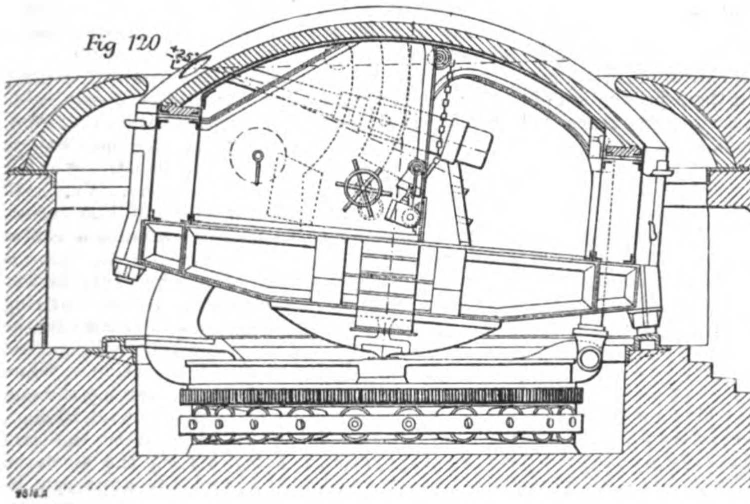


Fig 123

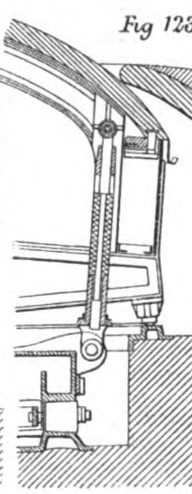
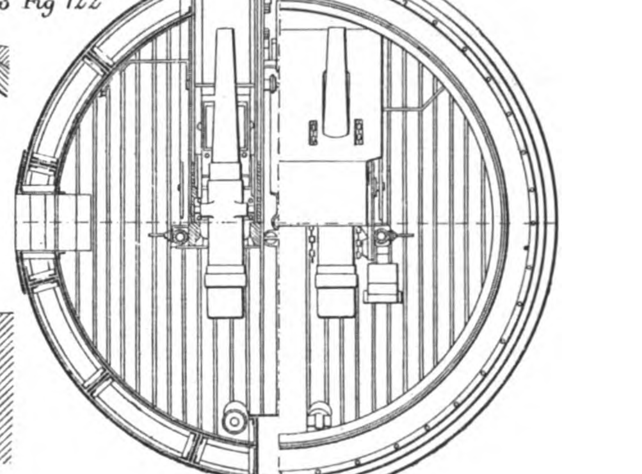


Fig 122



Besides constructing the railway to Autofagasta, which we learn has recently passed into the hands of an English company, the Mining Company has considerably improved the port of Autofagasta. A double storied pier advancing 300 ft. into the sea has been constructed to facilitate shipping and unloading, while hydraulic cranes and all modern appliances are in use. Extensive workshops have also been established at Autofagasta which are capable of undertaking any repairs required by marine engines or railway rolling stock.

The supply of water at Autofagasta is so bad, that the expense of obtaining the amount required for engines and locomotives is a most serious item in the expenditure of the railway. To remedy this serious drawback the company has commenced works with the view of bringing water from a distance of 195 miles. The supply of water which is to attain 88,000 cubic feet per twenty-four hours, is taken from the source of the St. Pedro at 11,500 ft. above the level of the sea.

The directors of the Huanchaca Company may well be complimented upon the results they have achieved, which could only be arrived at by a display of much energy, backed up by judicious and courageous expenditure.

MODERN FRENCH ARTILLERY.
No. XI.

THE ST. CHAMOND COMPANY—*continued.*

THE ordnance proposed by the St. Chamond Company for naval armament and for coast defence comprises two types—heavy and light—for each of the calibres from 15 centimetres (5.90 in.) to 42 centimetres (16.54 in.). The heavy type is a weapon of at least 36 calibres in length of bore, while the light type does not exceed 30 calibres. The principal points that characterise the designs of the guns prepared by this company, and which, it is claimed, possess special advantages, are as follows. 1. For the gun, the selection of a class of steel, possessing ample strength and at the same time high resisting power to the abrasive action of the powder. Unlike the Forges et Chantiers de la Méditerranée, who maintain that they occupy an especially favourable position in not being manufacturers of steel, so that they are always able to purchase in the best market, and to take advantage of every improvement in metallurgical practice, the St. Chamond Company assume that their position is peculiarly favourable because, ranking amongst the first steelmakers of the world, they are independent of other manufacturers, and can always be certain of the quality of material they use, because it is produced in their own works. 2. The system of longitudinal reinforcing is claimed as a special advantage in construction as preventing the inner tube from shifting when in service. 3. The special details of the breech-closing mechanism are—it is maintained by the company—peculiarly well adapted for its purpose, while the firing device is at once simple and absolutely safe. 4. For the system of carriages employed, it is urged that it is superior to any other type, because of its simplicity and compactness, the small use of wheels or rollers, the horizontal upper faces of the carriage, the absolute immobility of the underframe, and the perfect control of the recoil with the system of hydraulic brakes employed by the company. The carriages for large guns for naval purposes and coast defence are of two types—those with a central, and those with a forward pivot—the use of one or other of the types depending, amongst other reasons, on the height at which the trunnions of the gun are maintained; this level, which is kept as low as possible on board ship, rises to 7 ft. or 8 ft. for fortress guns. In addition to these standard types, the company has a special form of barbette mounting with a fixed platform, also adapted to coast defence.

The following are the leading classes of guns and mountings designed and made by the company: Coast defence gun, 275 millimetres (10.82 in.), and carriage with central pivot. This gun is of the usual St. Chamond pattern, and consists of a tube that extends for the whole length of the bore, one end being threaded to receive the breech-block. This tube is strengthened by a continuous row of hoops shrunk on from end to end; it is then covered with a second row of hoops for three-quarters of its length, and above them are placed the longitudinal segments that form the jacket. Over these again is shrunk an outer row of hoops, including the trunnion ring, to cover and unite the longitudinal reinforcement, and extending as far as the second row of hoops. The breechloading mechanism is on the De Bange system, with the addition of a safety apparatus, which prevents the fuze from being inserted and the charge from being fired until the breech is quite closed. The light gun of the same bore is 30 calibres in length; its weight, including the breech mechanism, is 22 tons, and it fires a projectile weighing 517 lb. with a velocity of 1900 ft., corresponding to an efficiency of 183 metrical tons per ton weight of gun. The mean pressure in the bore, measured at the breech, does not exceed 36,000 lb. per square inch. One type of carriage for this gun has a central pivot with a working platform at the rear; it is of steel, and is practically of the same construction as the heavy 155-millimetre (6.10 in.) gun of 36 calibres, to be referred to presently, with the exception of a standard 36 in. high beneath the underframe, so as to increase the height of the gun. On the working platform is placed the projectile crane, formed of a simple bent lever worked with a ratchet wheel operated by two men. This same carriage, with the platform removed, constitutes a central pivot mounting for board ship. In both types a shield made of hard steel is placed in front of the gun to protect the men serving it from the fire of machine guns.

The 200-millimetre (7.87 in.) light gun with Eclipse carriage is of similar construction to the 275-millimetre gun just described; it is 30 calibres in length, and weighs complete 8.4 tons; the projectile weighs 198 lb., and has an initial velocity of 1900 ft., corresponding to a striking force of 183 metrical tons per ton weight of gun. The carriage on which this gun was mounted at the Paris Exhibition was of the Eclipse pattern, pivotted forward, and comprised the following features: A pair of levers in which the gun is carried, oscillating on bearings in the frame, and connected with a brake at one-third of their height; the gun falls after firing, about 4 ft. 6 in.; an underframe carrying all the hydraulic brake mechanism, with a circular path in front, and two bearing wheels at the rear; a base provided with a roller ring and a pivot training for elevation. The range is from −7 deg. to +25 deg., and is effected with the ordinary gear; that for direction—the amplitude being 150 deg.—is given by operating a pinion that gears into a toothed quadrant bolted to the base. This type of carriage is now being constructed at the St. Chamond Works for a foreign Government.

The heavy 155-millimetre (6.10 in.) naval gun, 36 calibres long, was also shown at Paris, and is of the same construction as the foregoing; the inner tube, however, is only reinforced with one row of hoops before the longitudinal segments are put on, and these are then covered with a final row of rings, including the trunnion ring; the breech-closing mechanism is the De Bange, with the addition of a safety bolt and percussion device. The weight of the gun complete is rather less than 5 tons (4950 kilogrammes); one class of projectile weighs 88 lb., and the initial velocity with this is 2300 ft.; with a heavier class, weighing 121 lb., a speed of 1960 ft. is obtained, corresponding to an efficiency of 201 metrical tons per ton weight of gun. The mean pressure developed in the bore has always been found recorded, in service experiments, below 37,000 lb. per square inch, though it has been forced up to 45,500 lb. with special charges and without any injury to the gun. This gun was mounted at the Exhibition on a cast-steel frame, the various parts of which were left rough from the mould to show the excellence of finish that has been reached in the class of work by a few of the leading manufacturers in France.* The body of the frame contains a special form of trunnion bearings permitting of any required adjustment. The carriage is not fitted with rollers, but slides on the underframe, these slides being arranged so as to reduce as far as possible the strains upon the deck of the ship. The underframe consists of two vertical and parallel steel beams, strongly braced together, and with sufficient space left between them for the springs and the hydraulic main cylinders. On the outer sides of the frames are flanges, to which are bolted the small brake cylinders, the pistons of which are secured to the gun mounting. On the underside of the forward transverse beam is a circular plate bearing on the roller ring interposed between it and the bedplate; at the rear are two wheels running on a circular path, which with the bedplate is bolted to the deck of the ship, the latter forming the fixed point or abutment. Training the gun is effected by means of gearing, the angles varying from −10 to +30 deg., and the range for horizontal training subtends an angle of 150 deg. The hydraulic brake consists of two pairs of cylinders, one of a larger diameter than the other, and both being connected by pipes; the piston-rods of the smaller cylinders are, as stated above, connected to the carriage, while the larger cylinders transmit the energy of recoil to groups of Belleville springs placed between the sides of the frame. The carriage is erected so that an initial tension is always thrown on the pistons of the small cylinders sufficient to hold the carriage in a fixed position, no matter what may be the inclination of the ship's deck. The ammunition for the heavy type of 155-millimetre gun is of several classes; one projectile, weighing 121 lb., is fired with a velocity of 1970 ft., another, weighing 88 lb., has a rate of 2300 ft. The common 121-lb. shell is 3.5 calibres long; the high capacity shell, containing 22 lb. of bursting charge, is 5 calibres in length. The case shot weighs 121 lb.; the 88-lb. common shell is 2.8 calibres long, and the shrapnel, also of 88 lb., contains 620 balls.

Although the St. Chamond make a certain numbers of guns, the manufacture of ordnance takes only a secondary place in their production of war material, and of far greater importance is their manufacture of steel ingots, tubes, rings, and other elements of guns, supplied to the French Government and put together in the State arsenals; the manufacture of steel shells and that of steel armour plates. With these two last-named we shall deal on a future occasion, but in the present article we may refer in some detail to the system of armour-plated forts combined with heavy guns, which has been worked out with great completeness by the company, and is largely adopted by the French Government. We are indebted to *Le Genie Civil* for much information on this subject. In the work of reorganising and developing French coast defences, armour-protected forts have played a conspicuous part for many years, chiefly from the initiative taken by General Séré de Rivières, Secretary to the Superior Council of National Defence, and Director of Military Engineering to the War Department. In 1874 this distinguished officer established a Commission, at first under the presidency of General Cadart, and afterwards under that of General Segretain; Captain Mougin, since so widely known from his connection with the St. Chamond Company, was secretary at that time to General Rivières. The active life of the Commission lasted for four years, and during this time—having received *carte blanche* from the Government—a great deal of valuable work was done, and a long series of experiments were carried out, chiefly at Gâvre. In the four years, the Committee experimented with different models of armour plates and forts, weighing 700 tons, and costing 72,000*l*. In the course of 180 meetings at the trial ground, 3166 rounds, using 21 tons of powder, were fired at the different targets, a careful record of all results obtained being recorded; 104 tons of projectiles were fired during these experiments. During this long and important work, Captain Mougin was probably the most important figure, and the labours of the Commission had lasting results, in the form of several important military inventions which have passed largely into use in France since that date. The chief of these were the gun mountings since adopted by the St. Chamond Company; and the armour-plated casemate, with rolled iron shields and masked circular embrasures, such as have been put in execution in the forts along the Moselle and elsewhere. After the dissolution of the Commission, the appreciation of Captain Mougin's services was marked by his appointment as Chief of the Service of Ironclad Forts to the War Department. The St. Chamond Company, which took a deep interest in the experiments of the Commission at Gâvre, became closely associated with Captain Mougin, and adopted his system with considerable success. Referring to results recently obtained, a writer in the *Genie Civil* states that during the recent experiments in the camp of Chalons, the rolled iron plates of St. Chamond showed themselves superior to all the other types tested, as well against the shells loaded with melinite, as against the projectiles of chrome steel. In spite of the mystery with which these experiments were surrounded, the St. Chamond Company received official notification of these results, as well as of the success obtained by its plates, tried afterwards at the Bouchet powder factory. In this trial the plate was the only one able to resist the attack of melinite shell, which broke up all the other competing steel targets, whether forged or cast, and tempered in lead, oil, or water. More recently the Belgian Government, having divided among several makers a large order for casemates intended for the protection of Liège and Namur, repeated at Brasschaet, on a larger scale, the experiments of Bouchet. The results obtained with the St. Chamond plates were so striking that the various manufacturers were instructed to employ no others. At the present time the St. Chamond Company, in addition to fourteen of these turrets it has in hand, is furnishing the armour plates of rolled iron for nine others ordered of the Gruson Company.

In its latest development, Captain Mougin's oscillating turret appears likely to attract considerable attention in a short time, as the St. Chamond Company are now engaged in completing one of these structures, which is to be tested exhaustively at the polygon of the company at Longanaux. Figs. 119 to 123 illustrate the construction of this turret, which is so made as to oscillate around a centre connected to a platform on which the gun is mounted. In its normal position, Fig. 121, the two embrasures are concealed behind the armour ring around the dome. All the operations of training the gun both for elevation and direction, loading, &c., are executed with the gun in this position. When all is ready for firing, the four men serving the gun tilt the turret by means of gearing, about 10 deg., disclosing the embrasures; as soon as the gun is in firing position, but not before, the electrical firing circuit is complete, and the guns can be discharged. The guns are not mounted on carriages, but form a part of the turret itself, and the effort of recoil is utilised to throw up the turret about 1 deg., when it strikes against spring stops. At the same time, the men serving the gun instantly restore the structure to its Eclipse position.

In the engravings, Fig. 119 is a section of the cupola in its normal Eclipse position, and Fig. 121 is a section at right angles; Fig. 122 is a plan, and Fig. 120 is a view of the turret turned on its axis so as to free the embrasures and bring the guns into firing position. Fig. 123 is a section showing the spring that takes up the action of recoil. The whole structure being balanced, the work of operating it is comparatively slight; six men, including the officer, can easily fire two rounds in three minutes, including the various operations of moving the cupola. This system, it is expected, will displace that of the rising and falling turret of Colonel Bussière, an example of which has been executed by the Fives-Lille Company, and which was tested at Chalons, at the same time as an earlier type of revolving turret by Commander Mougin. The results obtained with the former were not considered satisfactory. Considerable steam power (12 or 15 horse-power) were required to drive the hydraulic machinery; the time used in raising

* We omitted in a previous article, when mentioning the names of those few firms in France who supply gun steel to the French Government, that of Jacob Holtzer and Co., of Unieux (Loire). The speciality of this eminent firm is the manufacture of chrome steel projectiles; from the works of this company, however, have been furnished steel to the Government for making more than 2000 guns of calibres ranging from 75-millimetre mountain guns to those of 16-centimetre.

and lowering the turret was considerable, and for relatively long periods the turret offered a conspicuous mark to hostile fire. The men required to serve this system were more numerous, and the speed of firing was slower. We have thought it useful to describe this system of Commander Mougin, because it appears likely to be adopted practically in France.

LITERATURE.

Service Chemistry; being a Short Manual of Chemistry and its Applications in the Naval and Military Services. By VIVIAN B. LEWES, F.I.C., F.C.S., Professor of Chemistry, Royal Naval College, Greenwich, Associate of the Institution of Naval Architects, &c. London: W. B. Whittingham and Co.

THIS book is not intended to qualify its readers as chemists, but, as its title indicates, has been written for a special purpose. In his preface the author tells us that the limited time at the disposal of the officers of both branches of the service, over and above that required for purely professional work, renders it impossible for them to undertake any such extended course of general study as would justify the subsequent employment of technicalities without full explanation; he has therefore, as far as the limits of the book would allow, gone fully into details of manufacture and other subjects generally considered beyond the scope of a chemical manual; as, for instance, the chapter on gunpowder, where the manufacturing, proving, and keeping of powders are treated as fully as the chemistry of its composition and explosion.

Inasmuch as the work treats not only of explosives but likewise of fuel, drinking waters, boiler incrustation, corrosion and fouling of ships, paints, ventilation, &c., it seems to us that its title might advantageously have had a more comprehensive character, because the work is one calculated to be quite as useful to young engineers, and indeed to members of some other professions, as to officers passing through the Royal Naval College. If, for example, we turn to the chapter on boiler incrustation, we find there information of a most useful and necessary kind for the young engineer. It is explained how, when a natural water is boiled, there is formed on the sides and bottom of the vessel the so-called fur in a kettle or the more serious boiler deposit; how this deposit delays the boiling of the water, gives rise to burning of the boiler-plates, and how, if it be thick, the plates may become red-hot. The author is, however, incorrect in saying that should the deposit crack and allow the water to reach the red-hot plates, the rapid evolution of steam often results in explosion. A little reflection will show that the plates cannot store up sufficient heat to cause explosion. Experiment likewise confirms this.

This chapter, whilst it deals largely with matters well known to experienced engineers, must prove very instructive to the student intending to follow our profession. *Inter alia*, it explains why, although sea water was almost universally employed in the older forms of marine boilers, it had to give place to distilled water upon the introduction of high-pressure tubular boilers, and how, notwithstanding this change, serious difficulties are still experienced from deposits, since the trouble has been only transferred from the boiler to the distilling apparatus, and so forth. The same chapter treats of incrustations from different kinds of water, causes of boiler incrustation, calcic carbonate, calcic sulphate, solubility, effect of concentration on sea water, effect of temperature and pressure on the saline constituents of sea water, formation of magnesic hydrate in marine boiler deposits, action of distilled water on boilers, waste of fuel entailed by boiler incrustation, prevention of incrustation, anti-incrustators, chemical and mechanical action of anti-incrustators, zinc in boilers, feed water heaters, and is altogether of a useful and practical kind, and rendered additionally valuable from the circumstance that the subject is one to which, as is well known, Professor Lewes has devoted special attention.

Another chapter likely to prove interesting and highly instructive to the engineering student is that on fuel. This chapter deals with fuels of different kinds, including wood, charcoal, peat, coal, liquid fuel, and gaseous fuels of different kinds, and gives comparisons of the calorific value of different kinds of fuels and their evaporative power. The author states that of late years the subject of liquid fuels has attracted great attention, and that with the discovery of the Russian oilfields methods of utilising this most important source of energy are daily becoming practicable; and that at the present time it is already in use for generating steam, both in locomotives and ships' boilers. After mentioning some of the advantages of liquid fuel it is stated that the present difficulty is cost, but that considering the enormous supplies now being obtained, a rapid reduction in price may be looked for. We may remark that to the question of cost is probably to be attributed the circumstance that liquid fuel did not come into extensive use in this country for locomotive and marine purposes some quarter of a century back, when its suitability was demonstrated at Woolwich Dockyard, at Messrs. Field's Candle Works, Lambeth, and elsewhere, under the patent of Messrs. Wise, Field, and Aydon.

Professor Lewes tells us that from experiments lately carried out by Mr. Holden, of the Great Eastern Railway, it appears that the most effective way of using liquid fuel is to inject it into the firebox, either of locomotive or marine boilers, above a thin layer of incandescent fuel, and that when used in this way, complete combustion and almost entire absence of smoke is attained. This is what was done about a quarter of a century back, as above referred to, but we believe a firebrick slab was found preferable to the thin layer of incandescent fuel.

Another chapter likely to be of general interest is that on drinking water. This chapter deals *inter alia* with natural impurities and their effect upon health; sewage contamination; sources of drinking water; purification of water; different processes of filtering and treating water.

Whilst opinions may differ as to whether the author would have done well to have assumed a general knowledge of chemistry in his readers, instead of incorporating in his text the fundamental principles and facts which are more fully treated in many other books, there can be no doubt that Professor Lewes has produced a most useful and reliable text-book with valuable chapters devoted to special subjects in which is given information seldom if ever to be found in the ordinary text-books of chemistry, and which cannot fail to be of great service to many students.

The index, which is a copious one evidently prepared with unusual care, is preceded by a series of upwards of 300 questions, having reference to the subject-matter of the body of the work.

THE FERRY STEAMER "TRANSFER."

ON page 287 of our forty-seventh volume we gave a short account of a new ferry steamer built to carry passengers between Windsor, in Ontario, and Detroit, Michigan, in spite of the thick ice which forms between the two places in winter. We now publish on our two-page plate, and on pages 350 and 351, detailed engravings both of the vessel and her engines.

The Transfer is designed to carry the cars of the Canada Southern Railway on to the Michigan Central line, and for that purpose is equipped with three lines of rails on the deck, these rails being capable of accommodating twenty-one of the longest eight-wheel freight cars, or fifteen passenger cars, each 56 ft. long. The boat (Fig. 1) is 280 ft. long over all and 17 ft. 3 in. deep; the breadth of the hull is 45 ft., and the breadth over the guards 74 ft. 6 in. When light with coal on board she will draw 9 ft. forward and 10 ft. aft; with twenty-one loaded cars her draught will be about 11 ft. forward and 12 ft. aft. The Detroit river, through which the Transfer plies, is subject to serious accumulations of ice. To enable the boat to break her way through them, she is formed with an exceedingly heavy bow having a vertical section like a sledge runner (Figs. 1 and 5), and strengthened by extra strong keelsons and additional bulkheads. Her powerful engines cause the bow to ride up the ice, breaking it down and separating it to leave a lane for the passage of the vessel. To aid the ice-breaking, the paddle wheels, 27 ft. 6 in. in diameter, have their wooden arms and floats encased in steel, the weight of each being 66 tons. The blows of the floats break up the pieces of ice parted by the bows. When the steamer made its first trip to Detroit on January 13, 1889, the run from the yards of the builders, the Cleveland Shipbuilding Company, Cleveland, was made in eleven hours and twelve minutes. For an hour and a half the speed was reduced, and for fifty miles the steamer broke her way through ice 4 in. to 6 in. thick. Her average speed in open water was twelve miles per hour, and this was only reduced to ten miles per hour through the ice.

The hull is covered with a steel deck and has a collision bulkhead forward, in addition to bulkheads between the store-room and engine-room, between the engine-room and boiler-room, between the boiler-room and the after engine-room, and at the end of the stern tube. Between the bulkheads belt frames occur on every sixth frame, except for 60 ft. in wake of the paddle wheels, where they occur on every other frame.

In addition to the paddle wheels there is a screw propeller 9 ft. 6 in. in diameter, also designed for breaking heavy ice. The screw shaft is 10 in. in diameter and 52 ft. long, and is inclined 2 ft. 4 in. in 49 ft.; the propeller projects 12 in. below the hull proper, being protected by a solid forged skag, which carries the bottom pintle of a solid forged rudder. To protect the rudder when backing in heavy ice, there is a heavy forging immediately over the rudder, and extending down to its top line. This forging is covered by the outside plating of the hull, and when backing into heavy ice the rudder is put amidships and a heavy bolt inserted through the forging into the rudder frame from the deck, thereby holding the rudder rigidly in a fore-and-aft direction. The after end of this forging extends down over the after corner of the rudder to prevent ice being in between the rudder and the horn.

The paddle engines (Figs. 2 to 4) do not drive direct on to the paddle shaft, but communicate their motion through spur gearing. This consists of a cast-steel pinion 5 ft. 4 in. in diameter, gearing into a spurwheel 16 ft. in diameter and 5⅝ in. pitch. The spurwheel is built with a cast-iron centre and arms in two pieces, and with a rim in twelve cast-steel segments. All the teeth are machine cut. Each paddle-wheel has its own independent engines and gear. These have each two cylinders 28 in. in diameter by 48 in. stroke. These engines have their air pumps driven independently by a beam engine (Figs. 6 and 7, page 350) with a steam cylinder 16 in. in diameter by 36 in. stroke; this drives two air pumps and four bilge pumps, while its centre column forms a jet condenser common to the two paddle engines.

The screw propeller is driven by a pair of horizontal engines (Figs. 8 and 9) having cylinders 28 in. in diameter by 36 in. stroke, with a separate air pump driven off the end of the shaft.

There are four boilers of the rectangular firebox pattern, 11 ft. 6 in. in diameter, and 16 ft. long, carrying a working pressure of 90 lb. The aggregate grate surface is 250 square feet, and the heating surface 9828 ft. Along the centre line of the hull between the boilers, are two steam drums connected to a steam separator. The funnels are at each side of the hull, and the bunkers amidships between the boilers, extending the full length of the boiler room.

Every room and compartment of the hull and paddle houses is supplied with coils of pipe for steam heating. On account of the great difficulty of getting water when working in ice, this vessel is provided with ten sea cocks, located in different parts of the ship. In engine-room is a Reynolds patent heater, 42 in. in diameter, 10 ft. high, also three pairs of duplex steam pumps for fire purposes, feeding boilers, washing decks, pumping bilges, &c.

The career of this ferry boat will be watched with a great deal of interest, and if successful will certainly lead to other boats of the same type being built. It must be a very fine sight to see her ploughing her way through ice 6 in. thick, as if unconscious of its presence, and leaving it behind her broken into fragments by the blows of her ponderous paddles.

INDUSTRIAL NOTES.

INDUSTRIAL questions, in one form or another, again overshadow all other topics, social and political. The Berlin Conference, as the outcome of the German Emperor's rescripts, has been constituted. The English Government is represented by four British plenipotentiaries and by four delegates. Why this class distinction should have been instituted is not very clear. The plenipotentiaries are: Sir John Gorst, Mr. C. S. Scott, C.B., Sir William Houldsworth, and Mr. David Dale. The four delegates are: Mr. Thomas Burt, M.P., Mr. F. Birtwistle, J.P., Mr. J. W. Whymper, and Mr. J. Burnett. The selection, on the whole, is a good one. Mr. Burt specifically represents the mining industry, Mr. Birtwistle the textile trades, and Mr. Burnett the engineering trades, above and beyond their general qualifications. British trade and commerce are not likely to suffer when represented by such men as those who are sent to Berlin. Whether any practical good can or cannot eventuate from the conference, in so far as British industry is concerned, it is satisfactory to know that its interests are safe in the hands of our chosen representatives. The report of the conference will be looked forward to with some interest, not only on account of what may come directly from its deliberations, but on account of its indirect results.

The action taken by the London Chamber of Commerce in the endeavour to promote a board, or boards of conciliation and arbitration, for dealing with labour disputes, is quietly and gradually, but steadily and surely making its way, not only in the metropolis, but also in the provinces. The outlines of its scheme are pretty nearly completed, and, in so far as a previous article, the inner tube is relatively thin, and is made of a very hard quality of steel to resist as far as possible the erosive action of the powder gases and the wear from the passage of projectiles. Over this tube are shrunk, one, two, or more rows of hoops, according to the size of the gun; around the surface, which is cylindrical, is laid longitudinally a series of steel staves, so as to form a continuous jacket; each of these staves is locked at both ends into the hoops in such a way as to add a considerable amount of longitudinal strength to the gun. The connections between this jacket and the hoops are so arranged that in firing, a strain is thrown on the joints, somewhat less than 13 tons to the inch.

We have also described the principal natures of ordnance constructed by the St. Chamond Company, and we may proceed to describe the chief of these guns and their carriages somewhat more in detail, using largely as our authority the *Revue d'Artillerie.* Taking first the 80-millimetre (3.15 in.) mountain gun, we find that it is designed to fulfil the same conditions necessary for easy transport as are aimed at by other makers of this class of ordnance. Fig. 124 is a section of one of these guns; from this view it will be seen that it is divided into two parts connected near the trunnions by a screw joint, the union being made gas-tight by means of a copper obturating ring. The thickness of the inner tube is not uniform throughout its length; besides the bore being enlarged for the powder chamber, the tube, a little in advance of the junction, is turned down so that its outside diameter is reduced; over the thinner portion of the tube is shrunk a long jacket with an enlarged and projecting socket at the back; this socket is cut with an interrupted thread, and on the jacket which reinforces the rear section of the gun, a similar screw thread is cut; the gun can thus be put together or disconnected by turning it through one-sixth of a revolution, and the joint is further completed by means of two keys that are forced into grooves cut in the two parts forming the joint, and are attached to the gun by small chains on the trunnion ring (Figs. 127, 128). A special form of wrench which is a part of the equipment of the gun is used to screw and unscrew the two sections; recesses are cut in the jacket near the breech to retain the wrench. The diameter of the powder chamber is 3.27 in., and its length 8.46 in.; the rifling is of the regulation French type for guns of this calibre. The carriage upon which the gun is mounted is illustrated by Figs. 125 to 128; it consists of the following parts which are easily separable. The trail C; the swinging trunnion arms D to which are connected the axle E and its covering F; the hydraulic brake G and two wheels which are of wood with a steel boss. The trail is box-shaped, made of thin steel; to the front end is rivetted a casting *d* which receives the tapered projection *e* on the casing that surrounds the axle; this is fastened to the trail of the gun by the key *f*. The swinging beam supporting the gun is formed of two cast-steel levers, the distance between which is somewhat greater than the width of the trail; these levers are connected together on the forward side by a steel plate and at the rear by the two bars *g* and *h*; they are mounted on the axle around which they are free to turn, the axle itself being held fast to the casting by means of a key shown in Fig. 125. The hydraulic brake is placed beneath the frame of the carriage; at one end it is suspended to this frame by the brackets *k*, but the other is articulated to the swinging levers by the pin *m*. The brake consists of two cylinders M and N, one placed above the other; it is the ram of the former that is attached to the levers D; the stroke of this ram is 5.27 in.; when recoil takes place the liquid is forced into

Fig. 125

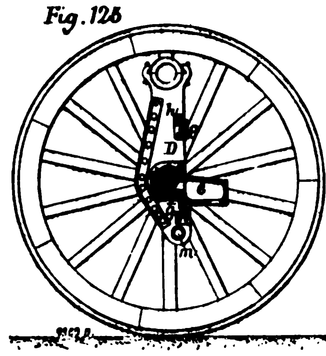


Fig. 124

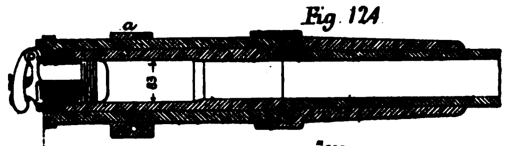
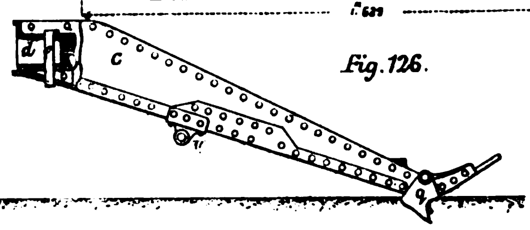
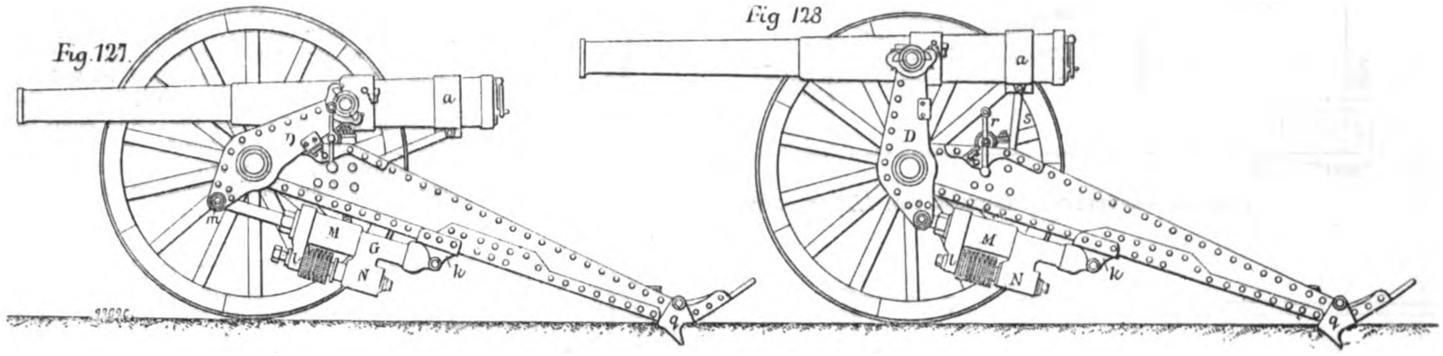
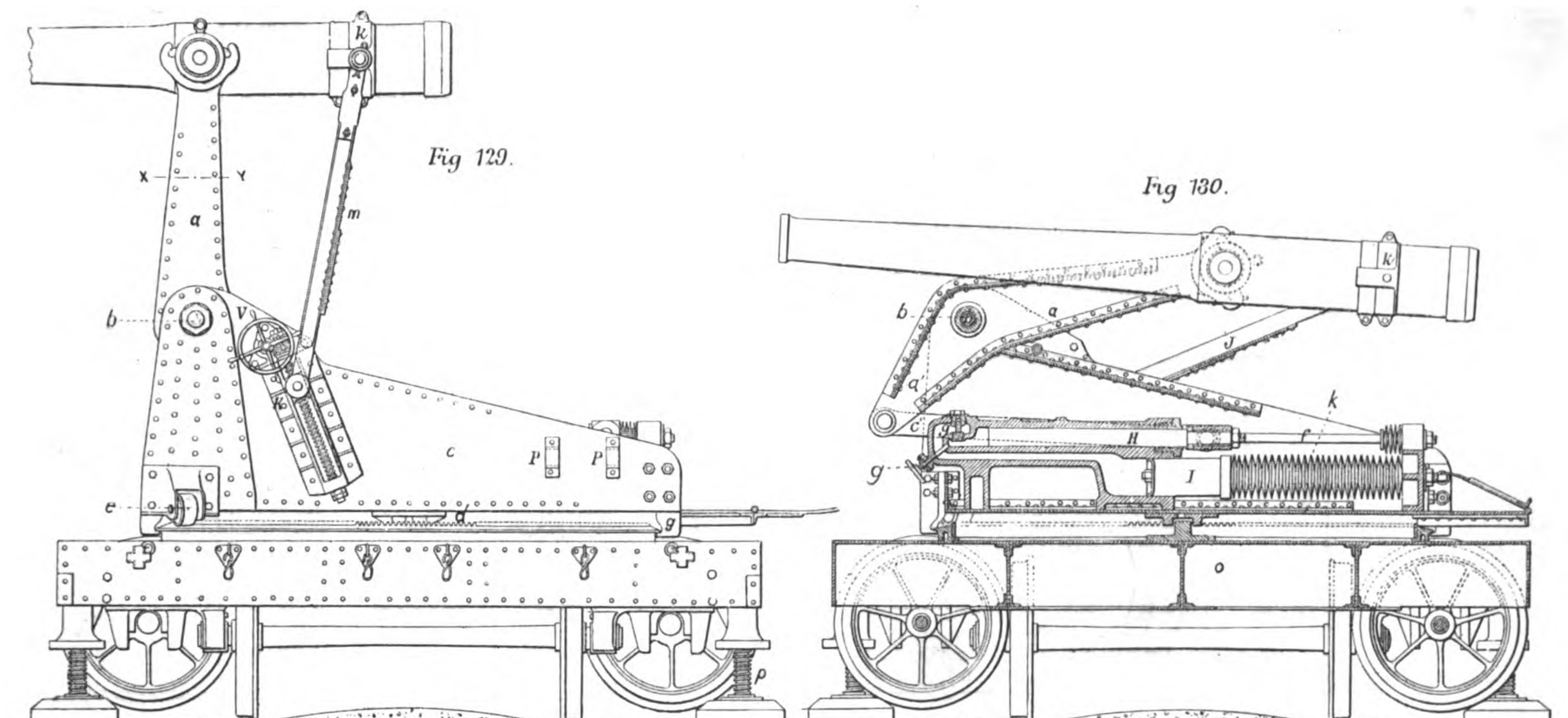


Fig. 126.





MOUNTAIN GUNS, 3.15 IN. BORE, MADE BY THE ST. CHAMOND COMPANY.

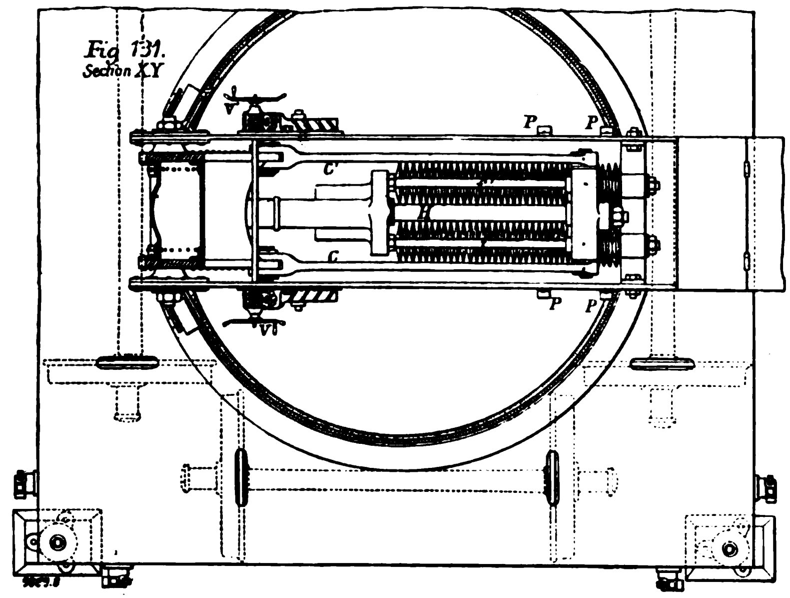


DISAPPEARING CARRIAGE AND TRAVELLING PLATFORM FOR 4.72 IN. GUN; ST. CHAMOND COMPANY.

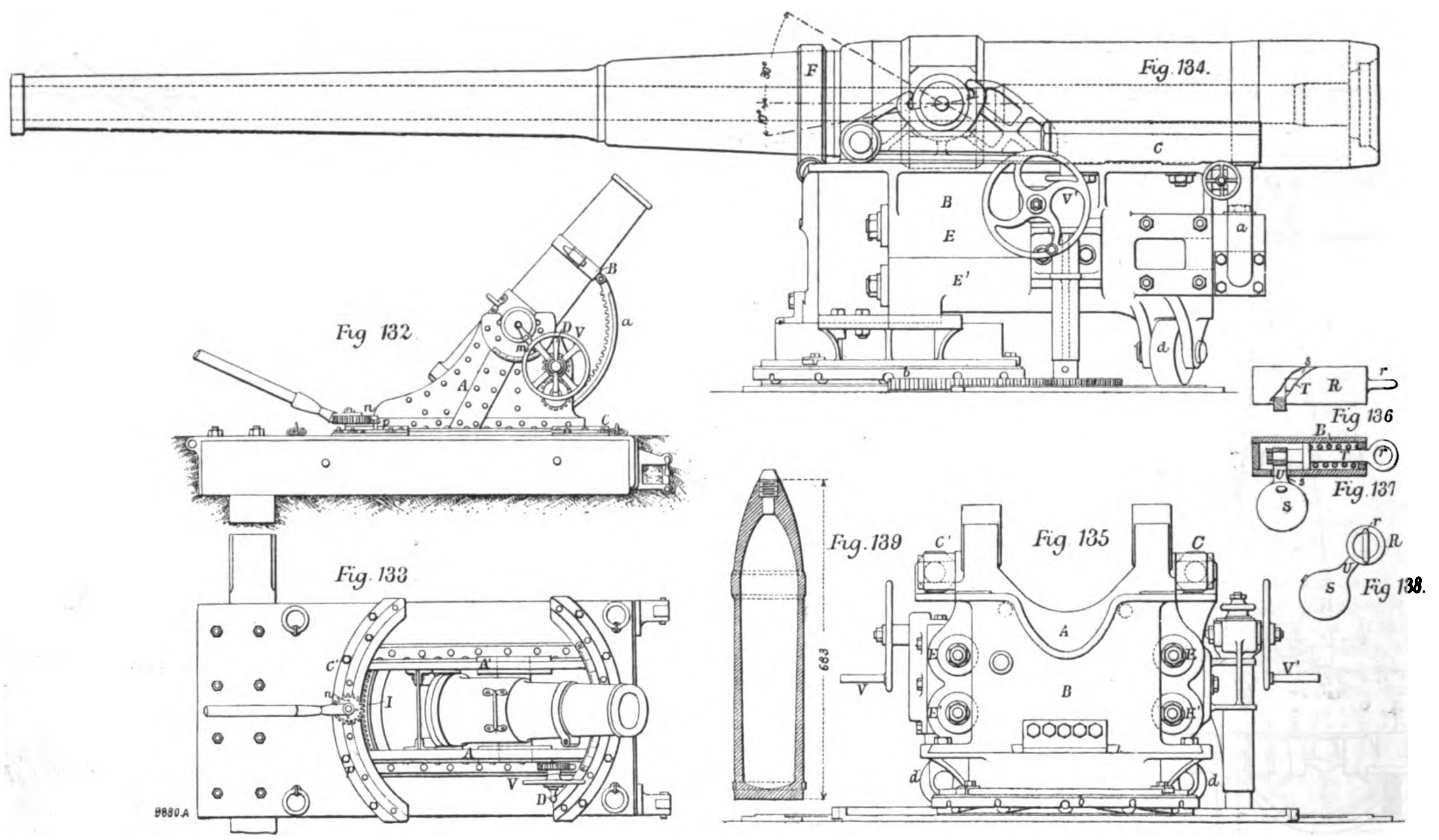
the second cylinder N, the ram of which has a larger diameter than that of M; the stroke of this piston is 1.18 in., and around its rod are placed Belleville springs which take their bearing against the projection l of the brake and serve to bring the gun back into firing position. When the gun is fired it falls back as shown in Fig. 127, the lower part of the swinging arm withdrawing the piston of the brake cylinder M and also forcing out that of N; above the centre, the arms come in contact with rubber buffers attached to the trail. As soon as the effort of recoil is finished, the compressed springs come into action and bring the gun back into firing position. The stability of the carriage is increased by the anchor q fastened to the lower end of the trail. The training device for elevation consists of two parallel screws turning in bearings fixed inside the frame of the trail; at the upper part of each of these screws is a pinion which gears into endless screws on a spindle actuated by the lever r. Upon the parallel screws carrying the pinions are two nuts, the guides of which are attached to the inside of the trail; these nuts are connected by a crossbar from the centre of which springs the elevating lever s, the upper end of which is jointed to the ring a passed around the gun. The usual graduations are provided for adjusting the elevation to any desired angle. The firing angles range from − 10 deg. to + 20 deg.; the total weight of the carriage is 440 lb.

Figs. 129 to 131 illustrate a special form of carriage for a 4.72 in. gun which is mounted on a travelling platform. As will be seen from the illustrations, the trunnions of the gun rest in the bearings formed in the top of two long arms a pivotted on a shaft b which is mounted on the carriage; these arms are rectangular in section, and are made of steel. The lower ends of the levers a^1 project below the horizontal shaft and are attached to the two connecting-rods C C, which, at the rear part of the carriage, are connected to the hydraulic brake. The carriage is framed with two steel beams of rectangular section c connected together by a plate above and below, the latter being stiffened by a central girder, which also forms the pivot d, on which the carriage turns. The frames are also connected in the front by a cross-girder, which, in addition, serves the purpose of supporting the two rollers e on which the carriage is traversed. Beneath this cross-beam are also placed two rods, on which are a number of Belleville springs that serve as recuperators to bring the gun back into firing position; at the upper part there are also two other rods f that act as guides to the traverse D of the brake in its longitudinal movement, and on which also are placed Belleville springs that serve as buffer stops in the event of the recoil being excessive. The two rollers above mentioned run on a circular way, and the crossbeams between the two longitudinal frames are attached by clips to this roller path to prevent the carriage from being overthrown when the gun is fired. The hydraulic brake is of the same type as has already been described for the above in connection with the mountain gun. It has two cylinders, in the first of which is a plunger H, and in the other (of larger diameter) is the ram I, which compresses the series of Belleville springs k that abut against the rear crossframe of the carriage; between the two cylinders is interposed a communicating pipe in which is a valve g^1. The maximum stroke of the ram in the large cylinder is 31.50 in. for the cylinder H, and for the cylinder I it is 9.45 in. The two brake cylinders, together with the connecting pipe, are cast in one piece of steel, and the brake is bolted to the bottom plate of the carriage. When the gun is fired it at once falls back into battery, turning upon the horizontal shaft b which is mounted on the carriage. The ram of the cylinder H is forced back by its rods, driving the liquid into the larger cylinder and raising the valve g^1; at the same time the Belleville springs are compressed. As soon as the recoil is completed, the valve falls back on its seat, communication is interrupted between the two brake cylinders, and the gun is held down in its lowest or protected position. The operation of reloading is now performed, and the gun can be brought up to firing height by opening a second valve, which allows the liquid to flow back into the upper cylinder, thus removing the resistance offered to the Belleville springs, which, in expanding, force the swinging arms carrying the gun up into the highest position.

The means adopted for training the gun for elevation are illustrated by Figs. 129 and 130; it will be seen that a collar is bolted round the gun near the breech, and that to this are attached two small trunnions. On each side of the main frame is bolted a casting shown at K, in the centre of which is mounted a screw running in bearings, and having



PLAN OF TRAVELLING CARRIAGE FOR 4.72 IN. GUN.

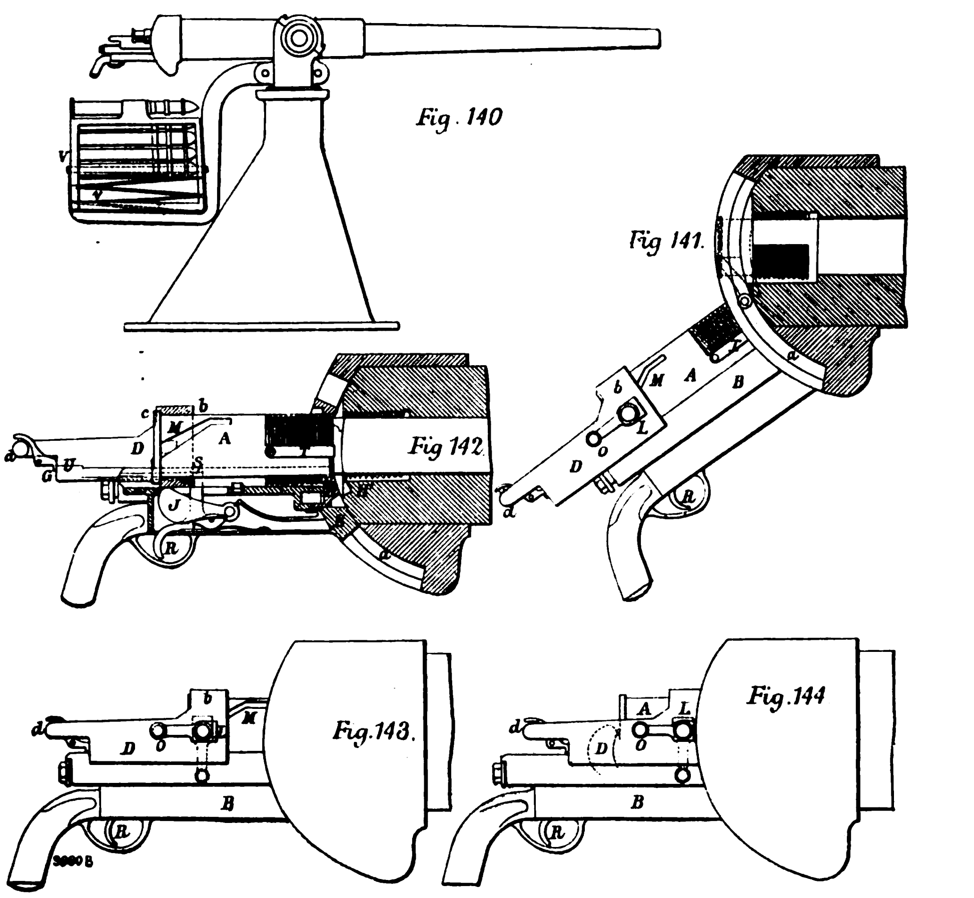


6.10-IN. MORTAR AND FIRING PLATFORM.

6.19-IN. GUN AND NAVAL CARRIAGE; ST. CHAMOND COMPANY.

at the upper end a wormwheel which gears into an endless screw, on the spindle of which is the handwheel V; this arrangement is similar on each side of the carriage. On the endless screw is a nut on which a stud is attached. A connecting-rod M joins the stud on the nut, and that on the collar around the gun, and by turning the handwheel in one direction or the other, the gun is raised or lowered to any desired angle. For pointing horizontally, long bars are inserted in the brackets P on the side of the frame, the fine adjustment being made with a pinion gearing into the circular rack upon the frame of the carriage.

The carriage on which the gun is mounted is placed on a travelling platform shown in the illustrations; on this underframe are mounted four pairs of wheels, one pair being at right angles to the other pair; on the centre of the platform is placed the pivot on which the gun-carriage works. Both of the two pairs of wheels are of normal gauge so as to travel on an ordinary railway; and one pair can be lowered when going over crossings or when it is desired to fire the gun. It will be seen that at each angle of the platform there is a powerful screw p; before the gun is fired all of these screws are lowered until the heavy wooden shoes mounted on them take a firm bearing on the ground and thus afford considerable stability to the structure. The gun is lowered by the recoil through a distance of about 40 in.; the angles of elevation range from -5 to $+30$ deg. for the 120-millimetre gun, and between $+5$ to $+45$ deg. for the 155 millimetre. The weight of the carriage is 3.5 tons, and that of the travelling platform 6.5 tons.



THE DAUDETEAU-DARMANCIER QUICK-FIRING GUN; ST. CHAMOND COMPANY.

The mortar illustrated by Figs. 132 and 133 is 6.10 in. bore of the light type; it is mounted on a carriage without any provisions for recoil; in fact both mortar and mounting are so constructed as to form a single piece. This gun is five calibres in length, and the total length of bore is 45 in. It consists of an inner steel tube reinforced with a steel jacket, and fitted with breech mechanism. The rifling consists of eighteen grooves of increasing pitch from 2.30 deg. to 12 deg. With a charge of 3.63 lb. it throws an 88 lb. projectile with an initial velocity of 656 ft. The mounting in which this gun is placed rests on a timber foundation strongly braced together; upon this platform are bolted two curved plates C that serve the double purpose of holding down the gun and acting as guides for the horizontal training. The carriage consists of two side plates of steel A braced together and bolted to the circular bedplate before mentioned. As will be seen on Fig. 132, at the end of the circular bedplate is placed a toothed quadrant I; into this gears a pinion n as shown, which can be turned by a lever and ratchet; the horizontal training is effected by this arrangement. For elevation the following detail is employed: A toothed arc a is attached at each end of the gun, collars B being placed around the latter near the breech and the muzzle for this purpose. Upon the side frame is mounted a handwheel V by which gearing can be operated, actuating a pinion that works with the curved rack just referred to; a graduated arc m is placed on the side of the carriage concentric with the trunnions, and on one of the latter is fixed a pointer which indicates the angle through which the gun is being trained. The platform which in the drawing is shown anchored to the ground, is arranged for the reception of axles and wheels for convenience of transport. The weight of the mortar illustrated is 854 lb.; that of the carriage, 792 lb.; and that of the bedplate 2000 lb. The total weight as mounted on wheels for transport is about 2 tons. The angles at which it is designed to be fired vary from $+10$ to $+60$ deg.

In Figs. 134 to 139 are shown the general outlines of a 6.19-in. gun and carriage made by the St. Chamond Company. The gun is constructed on the principles usually adopted at these works, and of which we have already given a general idea. In the piece illustrated only one row of hoops is shrunk over the inner tube; the longitudinal staves are then added and these are covered by a second row of hoops, in which the trunnion ring is included. The De Bange breech mechanism is applied to this gun, modified to the French regulation pattern; it is adapted for firing percussion fuzes. The safety device is not shown on the drawings, but may be generally explained as follows: A horizontal groove is cut at the back of the breech in which a bolt is free to slide and is constantly pressed towards the right by means of a spring; in the bolt is made a central rectangular slot, in which slides a box containing the striker; this box projects from the face of the bolt and a spring presses it constantly towards the right. When the breech-block has been turned through one-sixth of a revolution corresponding to its closed position, the right-hand end of the bolt strikes against an inclined plane which is formed in the ring that carries the breech-block, and the bolt is pushed towards the left; this movement uncovers the vent and the fuze can be introduced. If the main lever be now thrown down, a projection upon it acts upon the box containing the striker and forces it towards the left over the fuze. The hammer which is mounted on the lever is arranged as shown in Figs. 136 to 138. A small hollow cylinder R, Fig. 136, is mounted horizontally on the lever and occupies a position beneath the vent; in this cylinder is a pin T forced always to the left by a coiled spring and having a ring r at the other end to which the firing lanyard is attached; on this pin is mounted the tail of the hammer, the head s projecting through the cylinder and the tail passing through a spiral groove cut in the cylinder. In its normal position the spring always holds the hammer away from the breech and out of line with the vent; it is only when the lanyard is pulled that the hammer can be brought upon the fuze traversing the spiral groove in the cylinder. The gun illustrated is 36 calibres in length, its total length being 19 ft. 6 in., while the weight is nearly 5 tons. The powder chamber is 6.29 in. in diameter and 49.21 in. long; there are sixty-eight grooves varying in pitch from 1 deg. to 7 deg. The powder charge is about 47½ lb., and two classes of shell are fired with a velocity of 1970 ft. and of 2300 ft.; the former weighs 121 lb., and the latter 88 lb. Besides these, the ammunition supplied for this gun comprises shrapnel and case shot. A section of the large capacity shell is shown in Fig. 139.

The gun is carried in a cradle of cast steel, bearing on horizontal slides in the top of the underframe, the bearing surfaces on this latter are of bronze. The under carriage, which is of the form shown in Figs. 134, 135, is of cast steel in one piece, including the brake cylinders on each side. The system of hydraulic brake is similar to that already described; the cylinder C on each side of the carriage is the smaller one of the pair forming the brake, and its ram is connected with the cradle on which the gun rests; these cylinders are connected with the larger pair by the pipe a, and the batteries of Belleville spring that are used to store up the force of recoil and to bring the gun back to firing position, are placed in the cylindrical recesses E E cast in the body of the carriage. The rear of the carriage is supported by two rollers d running on a circular path bolted to the deck of the ship, and in front it is carried by a ring of live coned rollers that bear upon the baseplate. Training for elevation, which ranges from -10 to $+30$ deg., is effected by means of a toothed arc attached to a ring passing round the gun in front of the trunnions; this arc is traversed by means of suitable gearing operated by the handwheel V. Horizontal training is regulated by a pinion gearing into a curved rack on the bedplate, movement being given to this pinion by the handwheel V^1.

Finally, we may mention the 1.85 in. rapid-firing gun on the Daudeteau-Darmancier system already mentioned, which is being experimentally manufactured by the St. Chamond Company; a general view of this gun is given in Fig. 140, and the details of the mechanism are illustrated by the Figs. 141 to 144. In this gun the breech is closed with a block on which an interrupted thread is cut in three sectors, and the action required to open and close it is performed by a reciprocating movement given to the handle d. Upon the end of the breech is shrunk a steel block of the form shown in the figures, the back being curved to the arc of a circle; guides a are cut in the rear face of this block and in the end of the breech, and in these guides v slide the various parts composing the breech mechanism. These parts consist of a hollow bracket B, and the slide D at the end of which is the handle d, while the front is formed into a ring through which the end of the breech-block passes, and is held by the recess c shown in Fig. 142; in the breech-block are cut two spiral grooves M, and fitting into these grooves are projections that form part of the ring b. It is by means of these studs and grooves that the breech-block is caused to turn either for locking or unlocking, by moving the piece D to and fro. The form of the spiral groove is such that in drawing it towards the rear, the block is first set free and can then be withdrawn from the gun by the projection at the end taking its bearing in the recess of the ring b. While this is being done a projection H in the bracket B (Fig. 142) fits into a recess H^1 and holds it fast in the proper position; but as the breech-block is withdrawn, it compresses a spring which retains H, causing it to shift clear of the recess H^1, and the bracket falls into the position shown in Fig. 141, bringing the breech-block with it and leaving the chamber of the gun clear for reloading. The operation of closing the breech is the reverse of that we have just described; when in place, the various parts occupy the position shown in Fig. 144, where it will be seen that the eccentric block L is in contact with the end of the gun. The firing mechanism is set at half-cock by the falling of the breech and bracket, and the gun may be fired by pulling the trigger R, or automatically if the block L is thrown over into the position shown by the dotted lines, in which case the travel of the breech-block and its mountings is increased sufficiently to trip the lever G and cause it to release the detent. In order that this latter may be raised, it must come opposite a recess U (Fig. 142) formed underneath the carrier D, and the striker, which is placed in the centre of the breech-block, can only be released when the block is fully secured to its seat. The extractors consist simply of two flat springs with projecting hooks placed symmetrically on each side of the block; when the latter is in place the hooks pass over the rim of the cartridge case, which is afterwards withdrawn with the block. Fig. 140 illustrates one method of mounting this gun; it also shows a cartridge-holder which facilitates rapid firing; this holder consists simply of a light iron frame large enough to hold five rows of cartridges, ten in each row; beneath them is a spring v which forces them constantly up towards the top of the frame ready to the hand of the man serving the gun. The gun can be turned horizontally on its vertical pivot, and the training device for elevation consists of a toothed arc not shown in the engraving, but one end of which is attached to the gun near the breech; into this arc gears a pinion driven by a hand friction wheel. The weight of the gun is 500 lb., and the length of the bore is 45 calibres, the total length of the gun being 96½ in., including the breech mechanism; the powder chamber is 12.44 in. long and 2.23 in. in diameter; the rifling consists of twenty grooves cut with a pitch increasing from 30 deg. to 7 deg. The ordinary metallic cartridges of the French regulation pattern constitute the ammunition, and the powder charge is 1.7 lb.; the projectiles weigh about 3½ lb., and have an initial velocity of 2030 ft. Three kinds of projectiles are fired—steel shell, 3½ calibres in length, heavy bursting shell of 4½ calibres, and case shot containing thirty-five balls. The total weight of the complete cartridge is about 6.30 lb. However efficient this mechanism may be for quick-firing guns, it would seem that the work of handling the breech mechanism, except for very small calibres, would be extremely heavy.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—There was a slightly stronger tone in iron circles last Thursday, and a fairly large business was done in the iron warrant market. Prices, however, were slow to move, but the close showed a small advance on the day, that being the third day in succession to show a slight improvement. Scotch iron closed 2½d. per ton dearer, and Cleveland and hematite iron were, respectively, 5d. and 2½d. per ton higher in price, and the settlement prices at the close were—51s. 3d., 52s., and 64s. per ton respectively. The market was again firmer on Friday forenoon, and prices improved. At noon Scotch warrants were 5d. per ton higher than the closing quotation of the previous day, Cleveland being 3d., and hematite iron 5½d. higher in price. In the afternoon the improvement was maintained, the buying being heavy, and the best quotations of the day ruling. Scotch warrants closed at 51s. 9d. per ton, Cleveland at 52s. 3d., and hematite iron at 64s. 4½d. per ton. Makers' brands of iron were firmer, and a more hopeful view of the situation prevailed. On Gartsherrie Nos. 1 and 3 and on Eglinton Nos. 1 and 3 the price was in each case advanced 1s. per ton. The market was characterised by a fairly good tone on Monday morning, part of the buoyancy being due to the fact of the previous week's withdrawals of iron from the warrant stores being the largest on record. The shipments were also reported as being large, while the reports as to the home consumption seemed to show that there was no falling off to any noticeable extent. Business opened strong in Scotch iron, and the price was run up 4d. per ton, but near the close there was some heavy selling, and prices lost their early gain, the close being 51s. 6½d. per ton cash buyers, which showed a decline of 2d. per ton from last week's close. Cleveland iron was very buoyant, the demand was fair, and the rumour of a proposal to reduce the number of furnaces in blast, with the existing comparatively low stocks, had a firming effect. Although the closing price, 53s., per ton cash, was 4d. under the best quotation, still there was a gain of 9d. per ton on the day. The closing quotation for hematite iron was 64s. 6d. per ton cash, an advance of 1½d. on the day. At the forenoon meeting of the pig-iron warrant market yesterday selling rather preponderated, and prices generally gave way, the fluctuations ranging up to about 3d. per ton. Still the tone was steady, and at the afternoon meeting they firmed, so that the quotations recovered. Scotch iron closed 1d. under Monday's close, and hematite 1½d.; but Cleveland iron, after being 3d. down, recovered and closed as on the previous day, being 1s. 6½d. per ton dearer than Scotch iron. The market was depressed this forenoon. A fair amount of business in Scotch iron was done at lower prices, but Cleveland iron was without animation. Quietness was the rule as regards hematite iron. Down to 51s. 2½d. per ton cash was accepted for Scotch iron in the forenoon, but sellers were asking 51s. 4½d. cash at the close in the afternoon, when buyers were offering only 52s. 3d. per ton cash for Cleveland iron, and 64s. 1½d. for hematite iron. Last week's shipments of pig iron from all Scotch ports amounted to 9809 tons as compared with 8526 tons in the corresponding week of last year. They included 100 tons for the United States, 112 tons for South America, 210 tons for India, 548 tons for Australia, 130 tons for France, 230 tons for Italy, 865 tons for Germany, 490 tons for Holland, 600 tons for Belgium, 710 tons for Spain and Portugal, smaller quantities for other countries, and 5444 tons coastwise. The number of blast furnaces in actual operation in Scotland still remains at 89 against 82 at this time last year. The stock of pig iron in Messrs. Connal and Co.'s public warrant stores yesterday afternoon stood at 835,108 tons, as compared with 846,084 tons yesterday week, thus showing for the week a decrease amounting to 10,976 tons.

Foreign and Colonial Shipments of Machinery, &c., from the Clyde.—The foreign and colonial shipments of machinery, &c., from the Clyde, reported last week, included the following: Marine, sugar-crushing and other machinery, of the value of 9489*l.*, chiefly for Chili, Penang and Singapore, Melbourne, Shanghai, Japan, New York, and Trinidad; blooms, slabs, billets, rails, plates, bars, and other steel goods, for Japan, New York, Baltimore, China, Melbourne, Bombay, and Bilbao, valued at 12,200*l.*; pipes and other castings, sleepers, tiebars, cottars and keys, plates, sheets, bars, tubes, and miscellaneous iron manufactures, of the value of 49,400*l.*

The Coal Trade.—The extra demand for coals, induced by the English colliers' strike, has now passed, and the market has returned to its normal position. In the Lanarkshire and other districts (excluding Ayrshire) the miners are working well, and the supplies of coals are consequently large; but up to the present all that comes to hand is moving freely away. The top price of splint is down 3d., and that of ell coal about 6d. since this day week, but main coals maintain the former rate. The following are the prices at Glasgow Harbour to-day:

	F.o.b. per Ton				
	s.	d.		s.	d.
Splint	10	9	to	11	0
Main coal	10	0	,,	0	0
Steam	11	0	,,	11	6
Ell	10	9	,,	0	0

Ayrshire coal 9s. 9d. to 10s. f.o.b. at Ayrshire ports.

Best dross is in good demand, but lower qualities, being abundant, are rather easier in price. Household coals are now plentiful on account of the mild weather, but there is no change in wholesale prices so far. In Ayrshire the colliers are working unsatisfactorily, and for this reason the trade is quieter, and the prices are not quite so good as they were last week. Founders have now less difficulty in getting full supplies of coke.

Institution of Engineers and Shipbuilders in Scotland.—The usual monthly meeting of this Institution was held last night—Mr. Eben. Kemp, president, in the chair. Fourteen new members and graduates were elected, two of the former being life members. A very interesting discussion took place on Mr. A. S. Biggart's paper on "The Erection of the Superstructure of the Forth Bridge," the speakers including Mr. C. P. Hogg, Mr. Henry Dyer, Mr. Charles C. Lindsay, Mr. W. Renny Watson, and the president, all of whom heartily congratulated Mr. Biggart on the high character of the series of papers which he had communicated to the Institution in regard to the great work in whose construction he had been so intimately concerned. Mr. Biggart made an interesting reply, in the course of which he expressed the opinion that it was but right that such a body of engineers as were embraced in the membership of the Institution were entitled to get such detailed information as he had been able to communicate to them in his papers. A discussion then took place on Mr. Edward C. Peck's paper on "The Loss by Condensation and Re-evaporation in Marine Engine Cylinders." The speakers were: Mr. Dyer, Mr. James Weir, Mr. James Rowan, and the president. Other two new papers were afterwards read. One was on "The 'Rota' Engine," by Mr. J. MacEwan Ross, and the other was on "The Delivery of Water through Copper Wire Gauze Strainers," by Mr. John Barr, of the Glenfield Company, Kilmarnock.

Lecture on Public Lighting by Electricity.—Last Wednesday night a lecture on this subject was delivered to a meeting of the Philosophical Society of Glasgow in the grand banqueting hall of the new Municipal Buildings in George-square. The meeting was attended by a large representation of the Town Council and by many non-members of the Society who were present by invitation. Mr. Henry A. Mavor was the lecturer, and he had the benefit of the electric light on the premises, the primary current from his firm's central lighting station having a potential of about 2400 volts. The lecture was exceedingly interesting, and was extensively illustrated by striking experiments. At the close, Sir William Thomson, past-president of the Society, made some very approximate and valuable supplementary remarks, and on his motion a very cordial vote of thanks was awarded to Mr. Mavor for his highly instructive lecture.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Engineers' Wages.—The workmen engaged in the engineering trades of Sheffield are agitating for an increase of wages to the extent of 2s. per week. A full meeting has been held, when it was reported that two large firms had conceded the advance, and that others were considering the matter. The engineers contended that, not having had an advance for seventeen years, they are entitled to make the present demand. They determined to hand in notices terminating on April 12, and, whilst deprecating a strike, resolved to cease work if the necessity should arise.

The Application of Water-Gas to Steelmaking.—A number of gentlemen representing important steel works in various parts of the country have visited the Leeds Forge Company's works to judge for themselves of the capabilities of water-gas in melting pig iron and converting it into Siemens steel. The whole charge, consisting of nine tons, was completely converted into mild steel within the space of five hours four minutes, and when tapped it was to all appearance in a more fluid and better condition than that usually obtained under ordinary producer gas. At the same time, the material is described as being much better under the new method.

Advance of Wages in the Iron and Steel Trade.—The accountants' return submitted to a meeting of the standing committee of the Midland Iron and Steel Wages Board in Birmingham on Monday, Mr. B. Hengley presiding, showed that the average selling price of iron during January and February was 7*l.* 18s. 4d. per ton. This ascertainment entitles puddlers in this district under the sliding scale to 9d. per ton, and tonnage men to 7½ per cent. advance, commencing on Monday next. Selling prices have advanced 13s. since the December return, and puddlers' wages are raised to 9s. 3d.

A New Feature in the Coke Trade.—In consequence of the recent strike in South Yorkshire, fourteen furnaces have been damped down at Frodingham, leaving only four working. Little or no iron has been sent away from the district during the month of March. This is a serious matter for the South Yorkshire coke trade, as owing to the number of furnaces standing idle, a large quantity of coke will be thrown on the market. There are now about 2000 men thrown out of employment in the district of Frodingham.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Market.—Yesterday the attendance on 'Change was not large and the amount of business transacted was small. Prices were not quite so strong as on the previous day. This was to some extent accounted for by the fact that owing to the advanced quotations holders of warrants commenced to sell pretty freely. In spite of the slight fall in prices yesterday, however, the tone was pretty cheerful, but buyers were somewhat chary about entering into contracts for delivery ahead, and in fact very little if any forward business was done. It must be noted that shipments of iron and steel are beginning to improve, and that inquiries, especially from Continental firms are more numerous than they have been for some time past. The first thing yesterday morning No. 3 g.m.b. Cleveland pig iron for prompt f.o.b. delivery was sold at 53s. per ton, but information from Glasgow showed prices in the Scotch centre rather easy, and this caused buyers here to hold off. At a later hour some purchasers were not willing to give more than 52s. 6d. for No. 3, but there were others ready to do business at 52s. 9d. Towards the close of the market affairs again improved, and transactions were recorded at 53s. Makers would not do business at the foregoing figures, but it is believed that if pig iron advances another shilling or two there will be producers ready to sell. They have not booked orders for several months, and many of them must by this time have got well through their contracts. The price of grey forge iron is 53s. Middlesbrough No. 3 warrants opened yesterday at 52s. 9d., but closed steady at 53s. cash buyers. To-day affairs were quiet and not much business was done. In the morning it was reported that No. 3 had changed hands at yesterday's closing figure, but as the day wore on prices fell, and No. 3 g.m.b. Cleveland pig, for prompt f.o.b. delivery, was at the close of the market nominally 52s. 6d., but buyers would not give that figure. Middlesbrough warrants closed at 52s. 3d. cash buyers. Makers of hematite pigs here ask 72s. 6d. per ton for mixed numbers, but hematite warrants are very considerably cheaper than makers' iron.

Manufactured Iron and Steel.—The manufactured iron industry continues quiet, but some makers report a rather better inquiry. Few, if any, new contracts, however, are being entered into and prices do not improve. There are producers who state that prospects are improving, but others express doubts of quotations advancing much. Common bars are 7*l.*; ship-plates, 6*l.* 15s. to 7*l.*; and angles, 6*l.* 15*l.*, all less the customary discount for cash. In the steel trade there is very little new to report. Producers, however, continue fairly active, but inquiries are few and new orders are very difficult to obtain. Heavy sections of rails are 6*l.* and ship-plates 7*l.* 15s., both at works.

Weardale Ironstone.—The inability of the Weardale Iron Company to blend satisfactorily the Weardale ironstone so as to make steel, has necessitated the building of a special furnace at Tudhoe, which is about to be lit up

MODERN FRENCH ARTILLERY.

CONSTRUCTED BY THE ANCIENS ETABLISSEMENTS CAIL.

(*For Description, see Page* 449.)

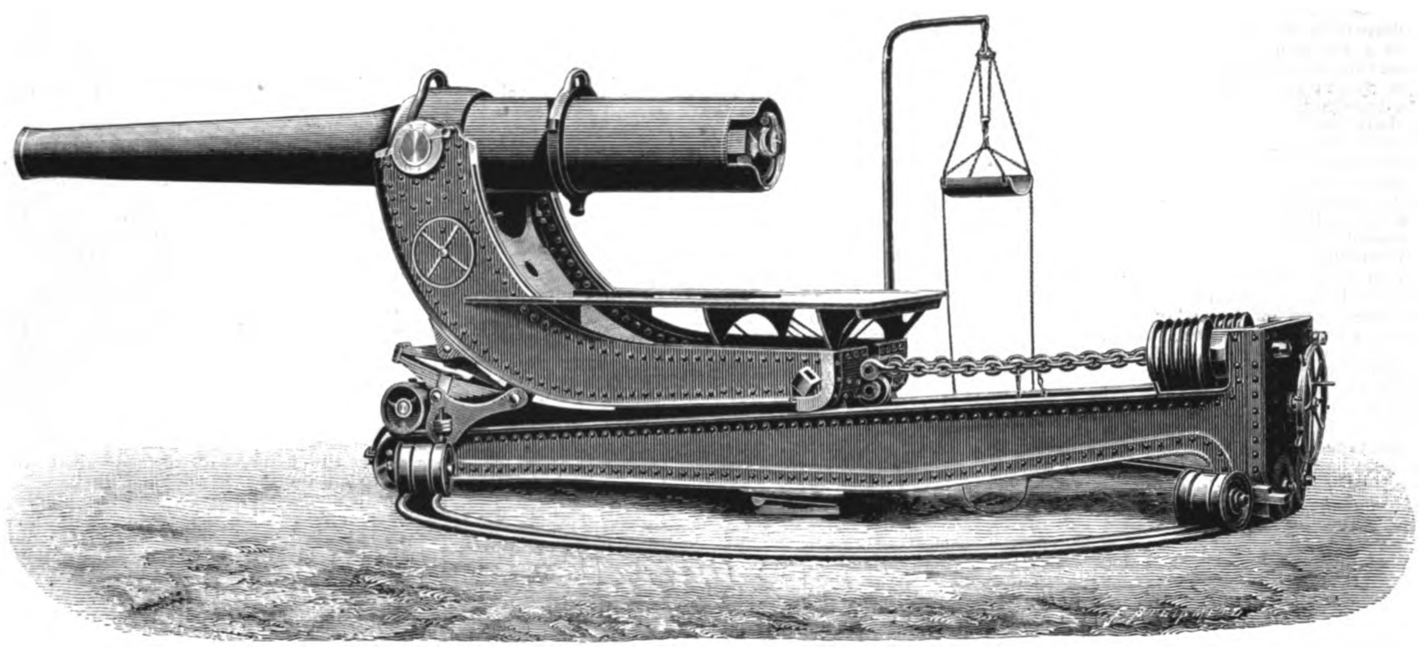


FIG. 146. DE BANGE COAST DEFENCE GUN (9.45 IN. CALIBRE) MOUNTED ON CARRIAGE.

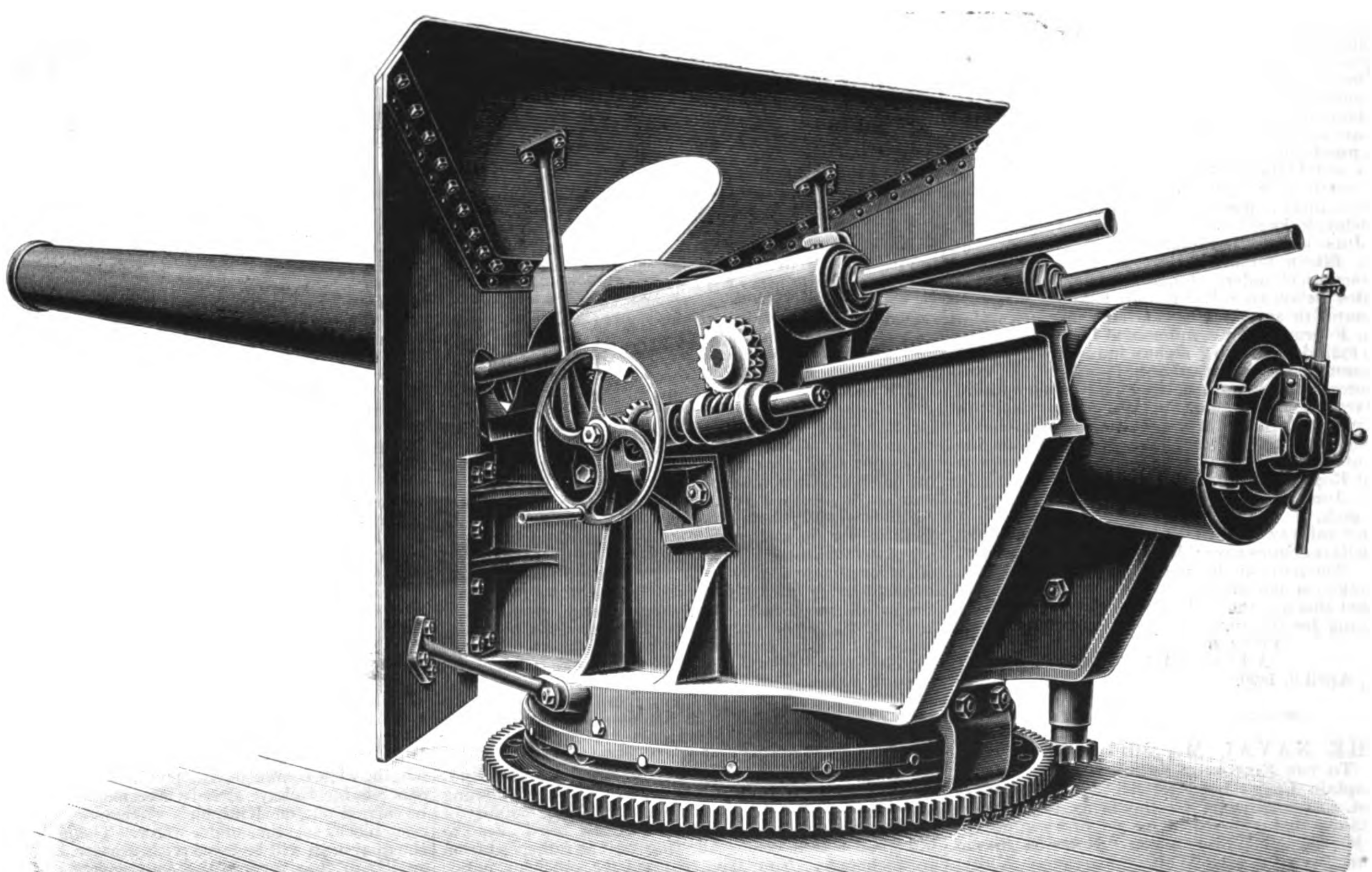


FIG. 147. DE BANGE 6.10 IN. GUN MOUNTED ON NAVAL CARRIAGE, SHOWING SHIELD AND BRAKE GEAR.

several more soda cellulose manufactories were constructed shortly afterwards. The cost of production was disproportionately high to begin with, but was gradually lowered. The sulphite method, which was a Swedish invention, then became more generally used, and has no doubt a future. During the year 1889, nine new sulphite manufactories were erected in Sweden.

CONDITION OF THE SHIPBUILDING TRADE.

SINCE we last wrote on the prospects of the shipbuilding trade there has been no improvement, although we are not inclined to the belief that there has been any retrogression. Statistics, compiled from semi-official sources, show that whereas on January 1 last the number of vessels building on the Clyde, the leading shipbuilding port in the country, was 166, and the aggregate gross tonnage of these 300,000 tons, the vessels now in course of construction have been reduced in number to 118, while the tonnage is now 245,000, or about the same as it was about a year ago, and a decrease in tonnage on the two months of 18.5 per cent. And it may be safely assumed that the same ratio of decrease holds good in the case of the other ports. Taking 15 per cent. as a fair average, we find that the reduction of work in the whole kingdom will be about 175,000 tons. The production has been slightly more than this, as a few—but only a few—contracts have been booked during the two months. Notwithstanding this apparent dulness, the contract prices of vessels do not show any appreciable decline; nor can there be any for some time. Builders generally have a large amount of work on hand, and although the men are working more regularly than at the close of the year, or even in January, it is not being executed as rapidly as contract time demands in the majority of cases. Added to the influence of this activity is that of the stiff prices of steel and other constructive materials, which have not fallen far from the top, and a very important consideration in all departments is the enhanced market value of labour. It is true that one or two builders, who do not share the general experience of having plenty of work on hand to keep their establishments actively employed, are disposed to take rather less than was going a few months ago. A case in point may be given. A shipowner had all but fixed with, say, A. B. for a steamer two months ago. He subsequently desired heavier machinery, and A. B. wished an addition on the stipulated price, which the shipowner did not care to give. New specifications were issued, including heavier machinery, and a firm has secured the contract at a price 10 per cent. below the amended offer of A.B. This is an exceptional case, illustrating the desire of builders to fill empty berths when they have them, and is not an indication of a general depreciation in contract prices. The production of the past two months will not fall far short of 200,000 tons for the kingdom, and may be regarded as very good, especially in view of the shortness of February. In Scotland the production has been 49 vessels of 71,920 tons for the two months, of which total the Clyde contributes 39 vessels of 57,220 tons, the largest total on record for the same two months, being 2000 tons above the total of 1882, the previous "big" year. February was an unusually heavy month, the output in Scotland being 28 vessels of 48,388 tons, of which 25 were steamers, having engines of over 45,000 indicated horse-power. Of the total six of 14,125 tons were for Scotch owners, three of 6050 tons for English, three of 5490 tons for France, two of 4250 tons for China, four of 3400 tons for Norway, one of 3010 tons for Germany, two of 2230 tons for South America, and one of 400 tons for Australasia. Last year's proportion of one-third foreign to two-thirds British is therefore maintained thus far. The return by the Registrar-General of Shipping for January, which has just been issued, being rather later than usual, shows that there has not been the same large increase to the tonnage afloat as was the case in one or two of the months at the close of the past year. This is due largely to the violent weather, the casualty list including over 100 vessels of 40,000 tons. The additions to the registry are mostly steel screw steamers. The vessels registered number 109 and the tonnage is 83,447 tons gross, 60 being steamers aggregating 72,624 tons, with engines of 8726 nominal horse-power. The withdrawals total 169 vessels of 64,766 tons, including 49 steamers of 33,283 tons, and 5153 nominal horse-power of engines. The net gain is therefore 18,681 tons, and 3573 nominal horse-power, but there is a decrease of 60 vessels, which clearly indicates the increasing popularity of large vessels. Six vessels of 838 tons were bought from foreigners and 36 vessels of 15,168 tons were sold to foreigners. The aggregate additions in December were 115 vessels of 88,370 tons, but deducting the withdrawals the net addition was only 23,961 tons. The net increase in January means 230,000 tons in the year.

MODERN FRENCH ARTILLERY.
No. XIV.
THE GUN FACTORY OF THE CAIL COMPANY—*continued.*

WE have endeavoured in a previous article to set forth the opinions held by French artillerists on the De Bange system of constructing ordnance, and the amount of credit that should be given to that inventor according to the same authorities; we now propose to describe, with as much detail as possible, the special features of his system in its most recent developments. The exhibit of artillery that was made at the Paris Exhibition last year, afforded a good illustration of what the Anciens Etablissements Cail were doing in this direction; the large number of guns they displayed in their pavilion gave, of course, no indication of the amount of work they had then in hand of this description; nor is it essential to our present purpose, which is simply to describe the different types of ordnance made by them. Some information on the subject, however, was supplied by the company in the handbook referring to their exhibit; from this we learn that it was in 1877, after a long series of experiments, that had lasted through four years, that the French War Office accepted the De Bange system and introduced it into the field artillery service. The first calibres that were supplied and passed into the army, were delivered in the year just mentioned, and were of 3.15 in. and 3.54 in. bore. Some years after this date a number of large types were made by Cail for the Government; mountain and siege guns, some for naval and coast defence, ordnance, and rifled mortars. Naturally certain improvements and modifications were gradually introduced into the system, and within four or five years the company was in a position to fill orders from abroad as well as those they received from the Government at home. Since the year 1882 the following is the list of guns furnished by them, and of the purchasing countries:

1. Mexico.—8 batteries of field guns and 8 batteries of mountain guns.
2. Servia.—45 batteries of field guns and 7 of mountain guns. It should be mentioned with regard to Nos. 1 and 2, that these orders were filled jointly by the Cail and the St. Chamond Companies, as has been stated in a previous article.
3. Sweden.—2 batteries of field guns.
4. Costa-Rica.—1 battery of field guns and 2 of mountain guns.
5. Denmark.—1 gun of 149 mm. (5.86 in.), and carriage fitted with hydraulic brake.
6. Brazil.—1 naval gun of 179 mm. (7.04 in.), mounted on a carriage fitted with hydraulic brake, and one rifled mortar of 3.15 in.

Making a total of 441 guns and 489 carriages.

The following is a list of material supplied by the company to the French Government, the Cail Company securing the contract on account of their favourable prices. There are more than twelve firms in France which are asked for tenders, and the order is always given to the firm who quotes the lowest price.

A. For the Navy:
75 guns of 65 mm. (2.56 in).
25 guns of 140 mm. (5.51 in.)
31 carriages for quick-firing 65 mm. guns (2.56 in.)
55 ditto for guns of 140 mm. (5.51 in.)
27 carriages for guns of 160 mm. (6.29 in.)
19 carriages for guns of 190 mm. (7.47 in.)
9 carriages for guns of 240 mm. (9.45 in.)
7 carriages for guns of 270 mm. (10.63 in.)
175 torpedo tubes completely fitted.

B. For the War Department:
130 carriages for guns of 155 mm. (6.10 in.)
1 non-recoil carriage for a mortar of 155 mm. (6.10 in.)
1 non-recoil carriage for mortar of 220 mm. (8.66 in.)

Besides a large quantity of ammunition.

Prior to the year 1882 the Cail Company had manufactured for the State a large number of carriages both for the marine and the army. For the former they had made
50 carriages for guns 100 mm. (3.94 in.)
165 carriages for guns of 140 mm. (5.51 in.)
69 carriages for guns of 190 mm. (7.47 in.)
And for the War Department:
103 carriages for small casemate guns.
413 carriages for similar guns of larger calibre.
300 carriages for guns of 90 mm. (3.54 in.)
90 carriages for guns of 95 mm. (3.74 in.)
175 carriages for guns of 155 mm. (6.10 in.)

From the foregoing list it would appear that the largest gun attempted by the Cail Company, at all events on the De Bange system, was the ill-fated piece of ordnance of 340 mm. (13.39 in.), which figured at the Antwerp Exhibition and came to an untimely end when it was tested subsequently. As a matter of history it should be placed on record that the Anciens Etablissements Cail were among the most active co-operators with the French Government during the siege of Paris in 1870. It was not only war material which they laboured continuously to supply, for their shops were full of machinery required to supply, as well as might be, the wants of a hard-pressed population during that trying time. It was they who in an incredibly short space of time constructed the mills in which grain was ground into flour by the Government and distributed amongst the inhabitants of Paris. During the siege, with a delay of less than four months, they furnished to the Government of national defence 67 mitrailleuses, 110 breechloading Reffye bronze guns, 1 apparatus projecting petroleum, and a large quantity of miscellaneous material, and especially for ammunition.

The ordnance shown by the Cail Company at the Paris Exhibition comprised guns of all calibres, from mountain batteries 80 mm. bore to a cannon of 320 mm. (12.60 in.), complete upon its mountings, and intended either for coast defence or for naval purposes; in addition to this was a special type of rapid-firing gun. All these, excepting the last-named, were on the De Bange system, and showed the latest modifications that had been introduced. Before proceeding to describe them in detail, we will pass rapidly in review the different types, adding a few words upon the special characteristics of each.

The mountain guns were all of the same calibre —80 mm.—and corresponded in their dimensions to the regulation French weapon; the general arrangements of mounting, &c., were also the same. The leading particulars of this gun are as follows:

Diameter of bore between lands ...	80 mm. (3.15 in.)
Diameter measured to the bottom of grooves	81 mm. (3.19 in.)
Total length of gun ...	1 m. 200 mm. (47.24 in.)
Length in calibres	15
Number of grooves	24
Total weight of gun...	231 lb.
Weight of projectile	13.2 lb.
Weight of powder charge	.88 lb.
Initial velocity	820 ft.

The carriage differs chiefly from the regulation French type in the arrangement of the springs for checking the recoil; both gun and carriage can be taken into parts for the convenience of transport, the whole being mounted on three mules. The ammunition boxes are loaded in pairs on mules, and each box contains seven rounds. The following are some further particulars of this weapon:

Height from ground to centres of trunnions	29.73 in.
Angle of recoil	33 deg.
Diameter of wheels	35.67 in.
Width between wheels	26.77 in.
Weight of carriage without wheels ...	242 lb.
Total weight of gun and carriage complete	583 lb.
Greatest elevation above horizon ...	30 deg.
Angle of maximum depression ...	12 deg.

Of field guns two types were shown; one of very light construction intended especially for mountainous districts, the other corresponding to the regulation field gun of the French army. The following are particulars of the former matériel:

Diameter of bore between lands ...	3.15 in.
Diameter to the bottom of grooves ...	3.19 in.
Total length of gun	59.06 in.
Total length in calibres	18.7 in.
Number of grooves	24
Total weight of gun	363 lb.

MODERN FRENCH ARTILLERY.

CONSTRUCTED BY THE ANCIENS ETABLISSEMENTS CAIL.

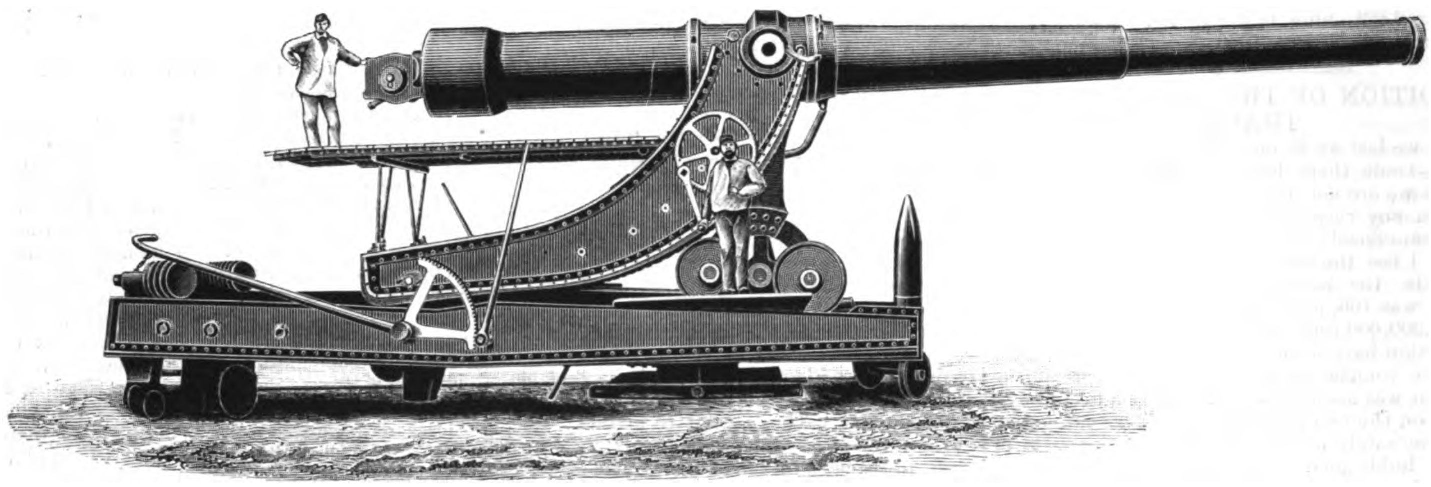


FIG. 148. 34-CENT. (13.39 IN.) GUN AND CARRIAGE IN FIRING POSITION.

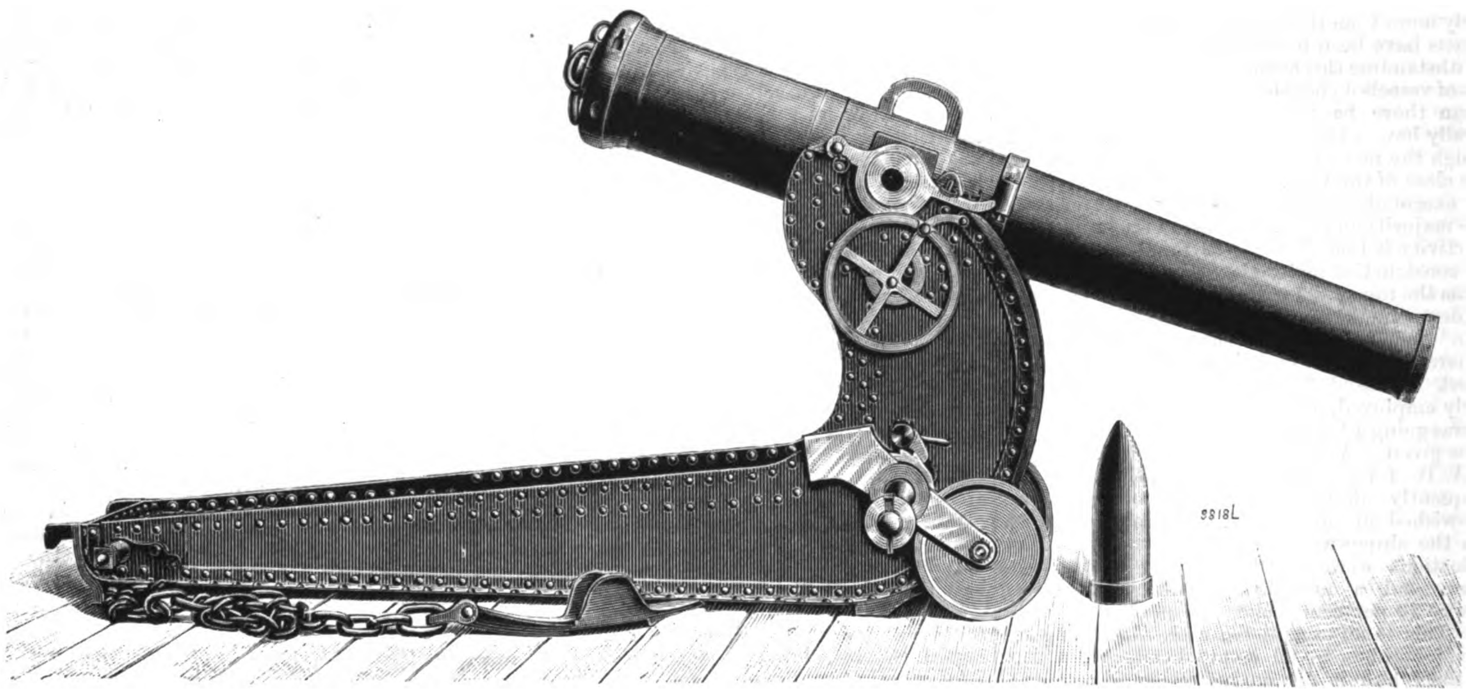


FIG. 149. MORTAR 6.10 IN. CALIBRE, AND TRANSPORT CARRIAGE IN FIRING POSITION.

Weight of projectile	13.2 lb.
Weight of powder charge	1.1 lb.
Initial velocity	951 ft.

The carriage is built of steel plates, as well as the limber; the ammunition wagon contains 18 projectiles in six cases, and 20 cartridges in five leather cases.

The following are some additional particulars:

Height from ground to centre of trunnions	33.86 in.
Angle of recoil	30 deg.
Diameter of wheels	45.27 in.
Distance apart of wheels	43.21 in.
Weight of carriage	528 lb.
Total weight of gun and carriage ...	902 lb.
Maximum angle of elevation	25 deg.
Maximum angle of depression... ...	10 deg.
Weight of limber loaded	770 lb.
Weight of ammunition train	792 lb.

The heavy type of field gun corresponds almost exactly with the regulation French weapon and has the following dimensions:

Diameter of bore between lands ...	3.15 in.
Diameter between bottom of grooves...	3.19 in.
Total length of gun	89.76 in.
Total length in calibres	25.5
Number of grooves	24
Total weight of gun	925 lb.
Weight of projectile	13.2 lb.
Weight of powder charge	3.3 lb.
Initial velocity	1574 ft.

The carriage is in all respects similar to that of the French regulation pattern, all but a few quite insignificant details. The limber is entirely of steel excepting the pole and the wheels. It carries 30 projectiles in six boxes, and 30 powder charges in six leather cases; the various tools and spare pieces are contained in two drawers. The ammunition wagon, which is also of steel, has a capacity double that of the limber; it is also so arranged as to carry a spare wheel and pole, as well as various tools.

Height from ground to centre of trunnions	41.73 in.
Angle of recoil	30 deg.
Diameter of wheels	53.36 in.
Distance between wheels	56.10 in.
Weight of carriage	1117 lb.
Total weight of gun and carriage ...	2101 lb.
Maximum angle of elevation	25 deg.
Maximum angle of depression	6 deg.
Weight of limber loaded	1551 lb.
Weight of ammunition train loaded ...	2178 lb.

The following are particulars of the ammunition employed with these guns:

A. Shrapnel.—

Number of balls	23
Weight of shell empty	12.38 lb.
Weight of exploding charge	.34 lb.
Weight of fuze	.48 lb.
Total	13.20 lb.

B. Case Shot.—The case shot consists of a steel plate shell and of a number of hard lead balls separated by cast-iron discs made so as to break up on striking. In the head of this projectile is placed a double-effect fuze, timed for thirteen seconds, which corresponds to a range of 4000 metres.

Number of lead balls	105
Number of cast-iron segments ...	36
Weight of projectile	10.9 lb.

C. Mitraille Case Shot.—This class of projectile consists of a zinc shell filled with balls of hardened lead, the spaces between them being filled with melted sulphur.

Number of balls	85
Weight of projectile	12.21 lb.

The siege guns exhibited consisted of one of 120 mm. (4.72 in.) and another of 155 mm. (6.10 in.). The former was of the regulation French pattern; as regards its dimensions it was as follows:

Diameter of bore between lands ...	4.72 in.
Diameter of bore to bottom of grooves	4.79 in.
Total length of gun	10 ft. 8 in.
Total length in calibres	27
Number of grooves	36
Total weight of gun	4950 lb.
Weight of projectile	39.68 lb.
Weight of powder charge	11 lb.
Initial velocity	1672 ft.
Height from ground to centre of trunnions	70.87 in.
Angle of recoil	33 deg.
Diameter of wheels	61 in.
Width between wheels	59 in.
Weight of carriage	2092 lb.
Weight of hydraulic brake	660 lb.
Total weight	4202 lb.
Maximum angle of elevation ...	30 deg.
Maximum angle of depression ...	15 deg.

The carriage on which this gun is mounted is of the French standard pattern and is built of steel, but the gun can also be placed on any fixed mounting if it is desired to use it in a fort. The projectiles fired from this gun are common shell and shrapnel; the former is of cast iron with a percussion fuze in the head.

	lb.
Weight of empty shell	37.4
Weight of bursting charge	1.8
Weight of fuze	.48
Total weight	39.68

The shrapnel consists of a steel plate envelope filled with hard lead balls separated by cast-iron stars. The bursting charge is placed in the head, and to the point is fitted a combination fuze timed to thirteen seconds, corresponding to a range of 5000 yards.

Number of lead balls	252
Number of iron stars	120
Weight of shrapnel	38.37 lb.
Weight of bursting charge	.62 lb.
Weight of fuze	1.28 lb.
Total weight	40.27 lb.

The howitzer of 6.10 in. bore was of the pattern known in the French artillery service as the short 155 mm. Its dimensions are:

Diameter of bore between lands ...	6.10 in.
Diameter of bore at bottom of grooves	6.17 in.
Total length of gun	94.48 in.
Length in calibres	15.5
Number of grooves	48
Total weight of gun	2310 lb.
Weight of projectile	88 lb.
Weight of powder charge	6.6 lb.
Initial velocity	984 ft.
Height from ground to centre of trunnions	44.5 in.
Weight of carriage	2475 lb.

The mounting of this gun is intended for fixed position, provision being made for placing it on wheels to facilitate transport.

Of ordnance for coast defence and naval service, three types may be mentioned; those of 155 mm. 270 mm. and 320 mm. (6.10, in. 10.63 in., and 12.60 in.). The 155 mm. coast gun is 35 calibres in length, and is intended to give very high initial velocities. As the gun is fired by the man who stands directly behind the breech an obturating fuze is necessary. The device employed is on the De Bange system—a friction fuze which can only be fired when the breech is quite locked, protection being secured by means of a safety bolt. The following are the particulars of this gun:

Diameter of bore between lands ...	6.10 in.
Diameter of bottom of grooves... ...	6.17 in.
Total length of gun	17 ft. 7 in.
Length in calibres	35
Number of grooves	45
Total weight of gun	10,450 lb.
Weight of projectile	110 lb.
Weight of powder charge	55 lb.
Initial velocity	2132 ft.
Height of trunnions above floor ...	43.31 in.
Maximum recoil	25.59 in.
Maximum angle of elevation	25 deg.
Maximum angle of depression	10 deg.
Total weight of mounting	6 tons.
Weight of shield	1470 lb.

The carriage is of cast steel, with a central pivot and hydraulic brake. A device is introduced within the frame for taking the strain off the carriage and deck of the ship when the latter is in a seaway by means of Belleville springs, which are compressed by the weight of the gun if rolling occurs. A shield made of chrome steel is attached to the forward part of the carriage, to protect the men serving the gun. The common shell fired from this gun is of cast iron, with a percussion fuze in the head. The weights are as follows:

	lb.
Weight of empty shell	73.1
Weight of bursting charge...	3.25
Weight of fuze	.484
Total weight	76.834

The projectile used for firing test charges is a cast-iron cylinder weighing 110 lb.

The mortar of 270 mm. (10.63 in.) corresponds in dimensions with the standard French mortar for coast defence. The following are some of its principal particulars:

Diameter of bore between lands ...	10.63 in.
Diameter of bore at bottom of grooves	10.76 in.
Total length of gun	11 ft. 1.8 in.
Total length in calibres...	12.5
Number of grooves	80
Total weight of gun	6 tons
Weight of projectile	374 lb.
Weight of powder charge	33 lb.
Initial velocity	984 ft,
Height from ground to centre of trunnions	65.72 in.
Length of carriage	99.43 in.
Weight of carriage	6 tons.

The mounting for this mortar is, of course, intended to be fixed; it can, however, be mounted on wheels for convenience of transport.

The gun of 320 mm. (12.60 in.) was the largest piece of ordnance shown by the Cail Company at the Exhibition. We shall have more to say of its construction on a future occasion; in the mean time we may give some of its leading particulars. It was mounted on a coast-defence carriage, but is adapted also for naval service. This gun was built upon the latest modification of the De Bange system, in which the biconic arrangement of tubes is reduced to very limited proportions. The following are the leading dimensions of the gun:

Diameter of bore between lands ...	12.60 in.
Diameter to bottom of grooves ...	12.72 in.
Total length of gun	40 ft. 10 in.
Total length in calibres	39
Number of grooves	120
Total weight of gun	47 tons.
Weight of projectile	880 lb.
Weight of powder charge	440 lb.
Initial velocity	2132 ft.
Maximum range	12.5 miles.
Height from ground to centre of trunnions	11 ft. 5.7 in.
Maximum recoil	79.74 in.
Maximum angle of elevation	30 deg.
Maximum angle of depression... ...	12 deg.
Weight of mounting complete... ...	54 tons.

The Cail Company, not possessing any firing ground of their own, asked, and obtained the permission of the French War Department, to have this gun tested at the State Polygon at Calais, before it was sent to the Exhibition. The tests were made on May 7, 8, and 9, 1889, by a Government Commission, and from these experiments it was found that the energy imparted to the projectile on leaving the gun was 8622 metric tons. This energy was sufficient to have penetrated an armour iron plate at the muzzle of the gun 35.43 in. in thickness, or 29.53 in. thick at a range of 1500 yards. At the muzzle of the gun the shot would have penetrated a steel plate 23.62 in. thick, and one 19.69 in. thick at a range of 1500 yards. The carriage on which this gun was mounted will be described hereafter.

We shall defer until the next article a notice of the Engstrom quick-firing gun, the manufacture of which is a speciality of the Cail Company, and which completed the collection of war material exhibited by them at Paris. Figs. 146 to 149, on pages 446 and 450, are general views of the representative types of artillery made by the Cail Company. Fig. 146 illustrates a coast defence gun of 240 mm. (9.45 in.), mounted on its carriage and in firing position. Fig. 147 is the gun of 155 mm. (6.10 in.) on a naval carriage, showing the position of shields and hydraulic brakes. Fig. 148 is a general view of the great 340 mm. (13.39 in.) gun and carriage, the former being in firing position; and Fig. 149 is a 155 mm. (6.10 in.) rifled mortar, mounted on its carriage, which is available for transport.

NOTES.

A FREE HARBOUR AT COPENHAGEN.

A LARGE free harbour at Copenhagen, of which there has been so much talk, will probably soon become a reality, judging from a statement the other day by the Danish Minister of War. The Government proposes to construct the harbour at the northern boundary of the town, where a very considerable amount of preparatory work has already been done, resulting in an extensive sea front and an important available area of land. The free harbour will consist of two distinct sections, the commercial and warehousing portion, which will commence almost immediately to the north of the famous Langelinie promenade—one of the finest in the north of Europe—and extends towards the north. Still further north there will be the section for industrial undertakings, &c. Between the two and with access to both, will be a steam-ferry harbour for the projected steam-ferry communication with Malmö, Sweden, which will be carried on simultaneously with the Elsinore-Helsingborg steam ferry, the starting of which is however closer at hand. The new harbours will be connected with the custom-house premises and the railway stations by railway lines. The harbour proper will occupy about one-third, and the "free" land about two-thirds of the whole area. Also at Malmö, in Sweden, just opposite Copenhagen, there is some project about a free harbour, but whether this plan will ever be realised remains to be seen. It is natural enough that Malmö should be wishful to make a counter-move, so as not to feel the effect of the large Copenhagen free harbour too much.

SAND PUMPING, DREDGING, AND THE MERSEY BAR.

The Mersey Docks Board have taken the first practical step towards the cutting of a channel through the bar which makes access to the port of Liverpool almost impossible in the case of large vessels, except near flood tide. The Board have intrusted Messrs. Simons and Co., the well-known dredging machinery manufacturers on the Clyde, to design and construct a powerful centrifugal pumping apparatus to be fitted to one of the steam hopper barges built by this firm some time ago. The work of dredging at the bar is to be carried out under the direction of Mr. George Fosbery Lyster, M. Inst. C.E., engineer to the Mersey Docks Board, and it is to be hoped the much desired result will be attained. It is too late in the day to point out the serious inconvenience caused by the bar to inward-bound steamers, especially the great Atlantic packets, the gain in time by fast steaming being often more than counterbalanced by the long delay, in some cases many hours, waiting for sufficient water at the bar. It is intended to begin with a set of pumps to raise 500 tons per hour and to work in depths ranging from 10 ft. to 35 ft., but doubtless when the advantage is established more extensive plant will be employed to facilitate the work and make the proposed channel wider and deeper. The dredging material will be discharged into the hopper of the barge, which has capacity for 500 tons. The pumping apparatus will be similar to that fitted on board the Beaver, built by Messrs. Simons, and now at work at Natal. In our issue of August 16 last, we illustrated and described this vessel, which has two 18-in. centrifugal pumps, with suction pipes. The two pumps work independently and are driven from the propelling machinery by shafting. The tubes are each 67 ft. 6 in. long, and can dredge sand at a depth of 40 ft. from the water level. Great care was taken in designing the pump discs. They work to 150 revolutions per minute and absorb 180 indicated horse-power. At this speed they can raise fully 1000 tons per hour. The engineer of the Natal Board, in reporting on the work of the Beaver, states that the vessel is doing good service. In one week she lifted 10,500 tons, and discharged over the bar 10,000 tons, and towed outside seven barges about 100 tons each. The time of dredging was 24 hours 30 minutes. Time slipping moorings, depositing the spoil, and picking up moorings again, 37 hours 15 minutes, or a total of 61 hours 45 minutes, and the first load lifted was in 45 minutes, or equal to 666 tons per hour, with one pump working all the time. The engineer adds: "We could certainly do more work if we could get back to the moorings without being delayed, but the crowded state of the harbour renders it difficult to get back, and a lot of time is lost thereby." The best single day's work done by the Beaver was five loads, or 2500 tons raised and discharged about four miles off. The usual ten-hour day's work is raising five loads and discharging four loads, or *vice versâ*. The result of the work at Natal of the Beaver and a bucket-ladder dredger Otter, also built by Messrs. Simon, has been that whereas several years ago the ships trading to Natal were of about 400 tons, steamers of 1700 tons and drawing 16 ft. of water can now safely go up to the wharves. The Otter is making a channel 300 ft. wide, and has in a short time increased the depth from 16 ft. to 18 ft. over the whole area, and the desired depth (22 ft.) will doubtless be obtained shortly. These facts must be encouraging to the people of Liverpool, as they augur well for the success of their project to remove the barrier which, if taken away, would raise their port to rank among the finest in the world.

THE EFFECT OF A PIG-IRON CARGO ON SHIPS' COMPASSES.

The important question of the effect of a cargo of pig iron on the compasses of a steamer came up at a Board of Trade inquiry just held at Glasgow, into the circumstances attending the loss of the steamer Dunrobin. The point is not exactly new, but the fact that the theory was supported by Mr. William Bottomley, who has been for thirteen years associated with Sir William Thomson in the manufac-

MODERN FRENCH ARTILLERY.
No. XV.

The Gun Factory of the Cail Company—*continued.*

We may now proceed to describe in detail the most recent development of the De Bange system as carried out by the Anciens Etablissements Cail, and exhibited by that company at the Paris Exhibition last year. The most important piece of ordnance that has been manufactured on this system was the 340-mm. gun (13.39 in.) shown at the Antwerp Exhibition. A 320-mm. (12.60 in.) gun, together with one of 155-mm. (6.10 in.), is completely illustrated by Figs. 150 to 162 on page 468. These illustrations and much of the following information are taken from the *Revue d'Artillerie*. The general dimensions of both these guns were given in our last article. The construction of the 155-mm. gun is shown in the section, Fig. 154, page 468, where it will be seen to consist of an inner tube covered with two rows of hoops, the first one extending the whole length of the tube; the outer row reaches somewhat in advance of the trunnion ring. The biconic system of reinforcement already described, and illustrated to an exaggerated scale (see Fig. 145, page 403 *ante*), is modified in such a way that the objections raised against the system and confirmed by experiment, have practically disappeared, and the construction approximates very closely to the standard French practice. Near the breech the outer surface of the tube is swelled so as to present the appearance of a double cone with the bases abutting; a corresponding form is also given to both rows of rings at this point. Beyond and at a short distance in front of the trunnion rings, a similar biconic enlargement is made, the increase in the diameter, however, only amounting to 5 mm. From this point to near the muzzle a slight and uniform taper is given to the tube, but at the end, for a distance of about 10 in., the tube is coned in the opposite direction, so that at the extreme end the diameter is larger than it is at a foot nearer the trunnions. Of the rings in the inner row, one only is biconic, the others are cylindrical as far as the next enlargement, and are tapered beyond; only one ring of the second row is biconic, and the front ring of this row, beyond the trunnions, is held in its place by a recess made in the adjacent inner ring. The chamber is 50.39 in. long, or more than 8 calibres; its diameter is 6.41 in., or .31 in. greater than that of the bore. The length of the rifling is 25 calibres. The breech-closing mechanism, which is of the De Bange latest pattern, is illustrated by Figs. 157 to 159. The firing tube is screwed into the breech-block. It is illustrated separately by Figs. 155 and 156, where it will be seen that the outer end is inclosed by a gas-check device, consisting of a cap sliding over the tube that forms an extension of the fuze; this cap is enlarged to form a flat handle P, and the end of the projecting firing pin terminates with a cylindrical head O. The breech-block, which is, on its general lines, of the De Bange pattern, is provided with a safety apparatus shown in Figs. 157, 158, and 159. The bolt A is split (Fig. 157), and is carried by the swinging bracket, on which it is free to slide, and it is operated by means of the handle N. Between the jaws of the split bolt A is placed the lever B, turning around the axis C, which is fixed to A. The upper end of this lever B is forked at B[1], this fork being in the axis of the gun when the block is closed; a flat spring tends always to press the end D of the lever forward. On the inner side of the bolt a groove is cut terminating in the recesses E and F, connected to the groove by inclined planes. A finger G enters this groove carried on the outside of the cylinder I (Fig. 158), and held up by the coiled spring. At the other end of the cylinder is a second finger H, sliding in a groove, and preventing the cylinder I from turning. When the bolt is moved up or down by the handle N, the finger G remains set in the groove R, and the travel of the bolt is limited by the recesses at the top and bottom of the groove; the finger pressing against the side of the recess being sufficient to prevent any further accidental movement of the bolt. When the breech-block is closed and the fuze introduced, if the bolt is pushed from right to left, the end of the firing pin enters the fork in the top of the lever B, whilst the enlarged end P is held fast between the two branches of the bolt. The gun is fired by pulling on a lanyard passed through the hole D of the lever B; by pulling on the cord, the head R of the firing pin is pulled forward by the movement of the lever and the charge is exploded. The bolt enters a recess M made in an extension of the breech-block, and in order that it may be slid up and down to effect the manipulations necessary for firing, the breech-block must be completely closed. It is this latter device that constitutes the safety apparatus.

The form of naval carriage on which this gun is mounted is shown by Figs. 160 to 162. It is of cast steel and has a circular baseplate, which is bolted to the deck of the ship. Upon this plate is a live ring with a series of conical rollers. The form of the carriage will be seen from the illustrations as well as the position of the hydraulic brake. The axis of the brake cylinders is on the same plane as that of the trunnions, which are mounted on the slides, to which are also attached part of the elevating gear. The forward part of the frame serves as an abutment to the brake, the piston-rods being bolted to it. For vertical training a toothed sector is bolted to the side of the gun, a toothed wheel inside the frame (see Fig. 160) being geared into it. Motion is given to this pinion by means of a handwheel and bevel gearing turning an endless screw (Figs. 160 and 161). In order to permit the angle of the gun to be adjusted up to the moment of firing and to avoid straining the teeth of the pinion by the recoil, the motion of the handwheel is transmitted to the endless screw by means of a toothed cluch *a*, Fig. 160, so that at the moment of recoil the clutch is disengaged, but comes automatically into gear as soon as the gun is brought back into firing position. A slight longitudinal play is also given to the endless screw by compressing the Belleville springs that are placed against it at the moment that recoil takes place (Fig. 161). The gun is trained horizontally by a pinion mounted on a vertical shaft, and gearing into the circular rack on the baseplate. A special arrangement, not shown in the illustrations, is introduced to check the inconvenience arising from the rolling of the vessel containing the gun. Within the mounting, and attached at one end to the base and at the other to the carriage, are a series of bars, on which are placed a number of Belleville springs in such a way that the weight of the carriage is partly thrown upon the springs, which are compressed; these springs also aid in lessening the shock of recoil. This gun is provided with a steel shield mounted upon the forward part of the frame. The 320-mm. (12.60 in.) gun (Figs. 150 and 151) is a heavy piece of ordnance weighing 47 tons. It consists of an inner tube reinforced by four tiers of rings, the first extending for its whole length; the second is carried as far as the middle of the chase; the third a little beyond the trunnions; and the fourth stops a little in advance of the powder chamber. Like the gun we have just referred to, the De Bange system of construction is introduced in a reduced fashion, so that the type resembles the French standard model more closely than the original De Bange pattern. The tube is swelled near the breech and muzzle, and the rings over these parts have corresponding forms. Over the whole length where the first row of hoops is covered by the second row, the outer faces of the former are biconic, the inner faces of the second row being of course turned to correspond; the fourth row is all cylindrical. The total length of the gun is 39 calibres; that of the rifled portion being 29 calibres. The diameter of the powder chamber is 12.99 in. and its length is over 8 calibres. The mechanism of the breech is similar to that described for the smaller gun, and the safety appliance is identical; the breech is operated by hand. At the Exhibition the gun was mounted on a central

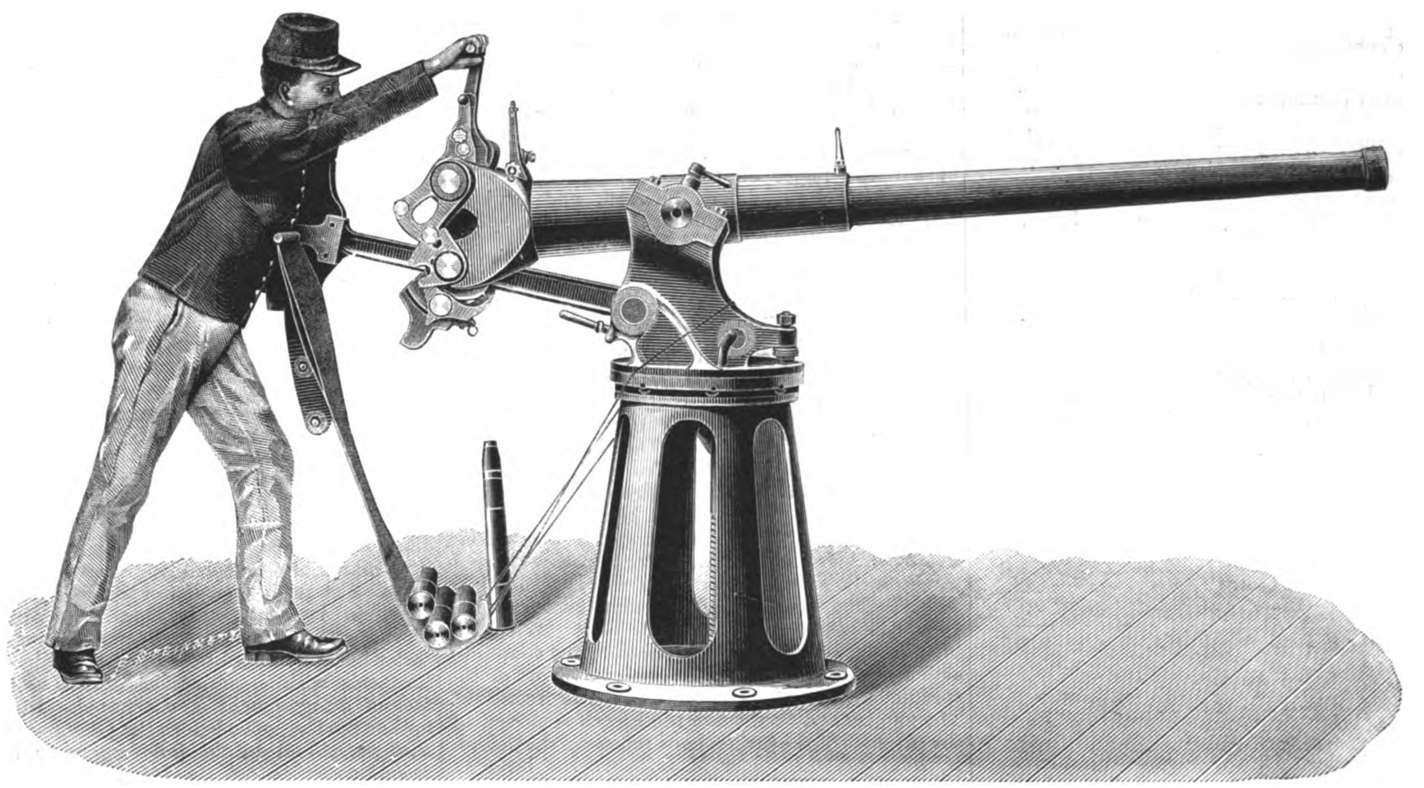


Fig. 179. The Engström quick-firing gun.

pivotting carriage that was built for the 340 mm. gun shown at Antwerp and which afterwards failed when tested; the weight of the mounting is 54 tons. It should be mentioned that a number of rounds were fired from the 320-mm. gun, and which established the following ballistical properties. With a charge of 418 lb. of brown prismatic powder, an initial velocity of 2132 ft. per second was obtained, with a pressure of about 42,700 lb. per square inch; the residual velocity of the projectile at about 1600 yards was measured and found to be 1928 ft. The mean range with an elevation of 10 deg. was about 10,000 yards.

Fig. 179, page 465, is a general view of a quick-firing gun made by the Cail Company upon a system devised by Captain Engström, a Swedish artillery officer. Before describing the construction of this gun, which is illustrated fully by Figs. 165 to 178, page 469, we may give a few particulars of it. Two types are made, one heavy and the other light, the following being the particulars:

	Heavy Type.	Light Type.
Diameter between lands...	2.24 in.	2.24 in.
,, to bottom of grooves	2.264 ,,	2.264 ,,
Total length of gun ...	89.56 ,,	59.86 ,,
Length of gun in calibres.	40	26
Number of grooves ...	24	24
Total weight	660 lb.	440 lb.
Weight of projectiles ...	6 ,,	6 ,,
,, charge, 1.9lb...	1.98 ,,	1.32 ,,
Initial velocity	1827 ft.	1528 ft.
Speed of firing per minute	30 to 35	30 to 40
Height from ground to centre of trunnions ...	...	44.28 in.
Maximum recoil	5.90 in.	3.15 ,,
,, angle of elevation	13 deg.	10 deg.
Maximum angle of depression	20 ,,	20 ,,
Weight of carriage ...	1210 lb.	1265 lb.

The projectiles for the light type of this gun are common shell and shrapnel; for the heavy type, common and armour-piercing shell. The cartridge is formed either of brass tube or of linen and paper with a brass base. Particulars of the projectiles are as follows:

Common Shell.

	lb.	lb.
Weight of brass cartridge case ...	2.53	2.09
,, paper cartridge case ..	1.98	1.76
,, empty shell	...	5.654
,, bursting charge ...	...	.22
,, fuze	...	.176
Total weight ...	...	9.900

Shrapnel.

Number of balls	104	
Weight of shell	...	5.8
,, bursting charge ...	...	.176
Armour-piercing shell	...	
Weight of empty shell	...	5 30
,, bursting charge.. ...	...	.11
,, fuze	...	.11
Total weight... ...	...	11.496

The mechanism of the heavy and light types of the Engström quick-firing gun differs only in a few unimportant particulars, so that the illustrations Figs. 165 to 178, and the following description, serve equally for both. The breech of the gun is made with four projections, placed in pairs, parallel to each other, and above and below the axis of the bore (Fig. 165). Holes are made in these projections to receive the end of the spindles O and O^1, Fig. 167, which carry the principal pieces of the breech mechanism. These are, first, the block A (Fig. 168), which turns around the axis O, and is extended backwards by the lever B, at the end of which is the handle C; and second, the block D, that turns around the axis O^1, and the motion of which is controlled by the block D. This controlled motion is produced by the sector E (Fig. 168,) on which are two pins, *e* and *e*^{1}, which act as ratchets, while on the spindle O^1 is another sector F, in which are two corresponding recesses *f* and *f*^{1}. When the lever B is thrown upwards, the sector E is depressed, the pins gearing into the recesses of the sector F cause the block D to open outwards, exposing the end of the bore. Fig. 168 represents the various parts when in the loading position. To close the breech, the lever B is pulled downwards, when the reverse movement is produced. Before the pin *e* clears the recess *f*, the bearing face *a* of the block A (Fig. 172) presses against the corresponding face *d* of the breech-block D, and when the lever is home, it is held in position by the former. On the spindle O there is also a finger *m*, which in the movement of opening the breech pushes the block D to the rear, as soon as the bearing face *a* of the block A clears the face *d* of the block D, that is to say while the pin *e* of the sector E is still in gear.

The gun can be fired by hand with a trigger, or automatically as soon as the breech is closed. The firing device is mounted on the block D, and moves with it. The different parts comprise a slide G, a striker H, which can be replaced at will (see details Figs. 167 to 178), a main spring I, and a detent K, on which are the fingers *i* and *i*^{1}. This latter is free to turn an axis at right angles to the right side of the block. When the gun has been fired, and the lever B is lifted, the recess *n* in the block A (Figs. 166 and 172) engages with the finger *g* of the slide G, and presses it back. There is an enlargement at the end of the striker H (Fig. 178) that bears in a recess in the slide G; and when this latter is forced back, the striker moves with it, compressing the spring I, until the arm H^1 of the striker enters a recess in the lower part of the detent; the gun is then at half-cock. The various parts of this mechanism are shown in Figs. 177, 178, &c. These different movements take place during the early part of the motion of the blocks A and D. When it is completed, the firing device continues to move with the blocks. On closing the breech the recess *n* in the block A again engages the finger on the slide, and presses the latter forward, and when the breech is completely closed a pressure of the finger on the detent K releases the striker, which is driven forward, and explodes the cartridge. For automatic firing a special arrangement is introduced, shown in Figs. 168, 169, and 170. On the right side of the block A are two pins L and L^1; on the former is placed loosely a button, on which is formed the projection M. This projection can take two positions shown in the engraving; when it is in that corresponding to the dotted line, Fig. 169, it is out of use; when it is as shown by the full line, it liberates the striker by pressing against the finger *i* of the detent, when the breech is closed. On the axis L^1 is a lever R free to move to and fro; at its upper end is a finger *r*, which can enter a recess *r*^{1} in the face of the block A. The lever R is recessed on the inner face, and contains a flat spring (see section Fig. 170). The spindle L, where it passes through the lever R, is eccentric, while within it is made with two flat faces (Fig. 169) against either side of which the spring can be made to bear. When the projection M is in its lowest position, the combined action of the spring and the eccentric part of the spindle L, lifts the finger *r* out the recess *r*^{1}. The gun is then fired when the breech is closed, by the pressure of the projection *i* releasing the detent. If, however, the finger M is above the lever R, which is its ordinary position for hand-firing, the point of M enters a recess in the breech-block, and the gun cannot be opened; the lever B may then be used in connection with the butt for training the piece. Before opening the breech after firing, it is always necessary to release the block A from the finger *r* by pressing on the end of the lever R. A safety device is introduced consisting of a projection *i*^{1} in the detent K, which presses against one of the lower flanges at the end of the gun, and holds the detent, until the breech is closed, when the finger falls into a recess *i*^{11} and is set free.

The cartridge cases are removed by two independent extractors N and N^1 (Fig. 166), placed in front of the breech-block and free to move vertically to a limited extent. When the breech is closed they enter two recesses formed at the back of the gun, and are held there by means of the springs I^1 I^1, which are extensions of the main spring I. When the breech is thrown open, the extractors first slide upwards for a short distance and loosen the cartridge case in the bore, then falling back with the block they carry the case with them.

The mounting of the light type of this gun is shown in Fig. 163. It is a rigid stand, carried by a series of Belleville springs arranged around the base, and which are sufficient to absorb the force of recoil. The heavier pattern has a carriage furnished with a hydraulic brake. During recoil the carriage turns backwards around a horizontal centre fixed on the underframe, the motion being controlled by the brake cylinder, which is set vertically. The underframe is mounted on a baseplate and ring of live rollers. Both guns are trained with a stock. Fig. 179 gives a clear idea of the appearance of this gun and its carriage.

THE INSTITUTION OF NAVAL ARCHITECTS.

IN our two last issues we have dealt (see pages 405 and 433 *ante*) with the chief part of the papers read and discussed during the recent meeting of the Institution of Naval Architects. We have now to deal with the concluding proceedings.

LIFE BOATS.

The final sitting of the meeting was held on the evening of Friday, the 28th, when the first paper read was on "Experiments with Lifeboat Models," by Mr. J. Corbett, of Manchester. This interesting paper we shall print shortly with the diagrams by which it was illustrated, so we may at once proceed to the discussion. This, although of an animated and prolonged nature, was not perhaps of great practical or scientific interest.

Briefly stated, the author's proposals are to substitute for the comparatively narrow and deep self-righting boats now used by the Royal National Lifeboat Institution, a more shallow and beamy non-self-righting boat. This vessel would be far less likely to turn over than the existing boats, having greater natural stability, but if she did turn bottom up she might remain in that position. We cannot now enter fully into the points raised by the author, but these will be seen when we publish his paper. The Royal National Lifeboat Institution, as represented by its officials at the discussion, prefers its own design. Who is right and who is wrong will be likely to remain for a very long time at least an open question, as any trials to settle the question are not likely to be made, as the difficulties in the way of carrying them out on a practical scale are undoubtedly great.

THE SCREW PROPELLER.

The last paper read at the meeting was that of Mr. James Howden on "Various Theories of the Screw Propeller." This was a very long paper, occupying nearly thirty pages of the Transactions, and had to be very much abridged in the reading.

The author commenced by referring to the two papers read at last year's meeting of the Institution by Mr. R. E. Froude and Professor Greenhill respectively, both of which treated of the theory of the screw propeller. In these papers the theories of Rankine and Cotterill were referred to, and the author also made mention of the researches of Dr. Froude. It may be said generally that Mr. Howden has no agreement with these eminent authorities, a fact which he makes no attempt to gloss over, as he speaks with no ambiguous phrase, so far as the fact of disagreement is concerned. In 1877 the author read a paper before the Glasgow meeting of that year, and in the following year he read a second paper before the Institution of Engineers and Shipbuilders of Scotland, in which he shows the error, as he believed, of Rankine's theory. In 1889 he read a second paper before the latter Institution. The arguments brought forward in the present paper were those the author had already advanced in the memoirs to which reference has been made. He quotes various authors on the subject to show how widely Rankine's theory has been accepted. As we published Mr. Howden's paper of 1877 in full,* our task of giving a fairly intelligible abstract of his present contribution will be much simplified. Mr. Howden says:

"As the correctness of Professor Rankine's and every other theory will be more easily tested if it can be first clearly demonstrated what are the actual motions of the water produced by the action of the screw under any given dimensions, pitch, slip, and velocity, the author undertakes this demonstration. That such a demonstration is possible may be inferred from the following considerations.

"A screw is an instrument whose dimensions, shape, and relative position of every part to each other can be definitely ascertained; also its exact linear progress per revolution when working; consequently an exact geometrical delineation of its movement in the water and the relative position to the water of every part can be made. This delineation, when properly analysed, will therefore reveal the only action on the water that is possible by each and every part of the propeller during each revolution under any given conditions of working. This investigation is made simpler by first examining the action of the propeller under the conditions of its being a screw of uniform pitch, and that it

* See ENGINEERING, vol. xxiv., page 313.

THE MANCHESTER SHIP CANAL.

That great engineering work, which is to convert the inland city of Manchester into a port accessible to ocean-going vessels, has already occupied a considerable share of our columns. So far back as the year 1883 we published a series of articles in which were given the probable characteristics of the then proposed scheme. This was before the Parliamentary business, which cost such a vast sum to carry through, had been disposed of. Since then we have kept our readers fairly informed of the progress of the undertaking and the work actually done* under the direction of Mr. Leader Williams, the chief engineer. We have also from time to time illustrated and described various parts of the plant and machinery used on the work.

For the facilities which have been afforded us for gathering the information we have laid before our readers, we have to thank Mr. Leader Williams, and also the members of his staff, who have taken so much trouble at very busy times in giving us information. We also have to thank the engineers of the contractors' staff for their ready courtesy in supplying us with details of the work.

We now propose giving a description—founded on information obtained during a visit of some duration which we recently paid to the work—of the most interesting parts of the work carried out since our last articles appeared, but before entering into details we will say a few words of general explanation, as many of the features have been altered since we last wrote.

Tracing the course of the work upon the plans, we find the canal, from its lower end at Eastham up to Runcorn, skirting along the shore of the estuary of the Mersey ; sometimes, where points intervene, cutting through the solid land, and again, when inlets or bays are met, being formed partly by walls built up, and partly by excavation. In the latter case a certain part of the estuary has been encroached upon so that the incoming tidal water has had less space to fill, and, therefore, it is claimed, the scour on the ebb over the bar of the Mersey will be less efficient. This, of course, is the old objection which proved fatal to the proposal to bring the canal down the middle of the estuary, and it has, we believe, led to further trouble. How far the very small space occupied by the new works of the canal can effect the vast flow of water of the Mersey we will not pause to inquire; and, indeed, the matter has been sufficiently argued before duly authorised tribunals ; but we must confess that on first blush the objections raised appear exaggerated.

However this may be, openings have been made in the walls of the canal so that there is a communication between the canal and the estuary in order that the tide may flow in and out. In this way the canal will be semi-tidal up to the Latchford Locks, 21 miles from Eastham, for all tides having a rise of over 14 ft. above the level of Old Dock Sill, Liverpool, will flow into the canal through the openings mentioned. The highest spring tides have, we believe, a height of about 22 ft. over Old Dock Sill, and thus there will be a maximum average rise of tide in the lower part of the canal, of 8 ft. Tides under 14 ft. would have no effect. It may be further noted that the present plan is to bring the canal almost altogether inland, for the part that will run into the estuary forms but a small part of the whole. In this way the piece between Eastham and Latchford will add greatly to the tidal space and will more than compensate for the narrow strips cut off the shallow margin of the estuary; very different from the large deep water area taken by Liverpool to work docks.

It may be added that the ordinary breadth of the canal at the bottom is 120 ft. and the standard depth is 26 ft. The slopes of the canal, where excavated in soft material, are pitched with rock from the cutting. Where the natural rock is met it is excavated to a batter of 1 in 6.

The canal is 35 miles long, and the total rise from Eastham to Manchester is 71 ft. 6 in. The rise at the various locks is as follows :

	ft.	in.
Eastham	tidal	
Latchford	16	6
Irlam...	16	0
Barton	15	0
Manchester...	13	0
Total	60	6

The canal will be approached from the estuary by the Eastham channel. This has a considerable depth at low water, but will want some dredging to allow large steamers to approach. It is, however, one of the principal channels, and is, moreover, of a permanent nature, not fluctuating like so many other channels in the estuary. Messrs. Simons, of Renfrew, are constructing a hopper dredger to carry 850 tons at 9 knots. The cost of this vessel is about 25,000*l*. Outside the locks the canal approach will have a slope pitched with stone from the cutting.

Upon passing through the Eastham Locks we find the canal is considerably broadened to allow room for ships to lay by whilst waiting. Between Eastham and Runcorn the canal skirts the estuary ; and the various small streams which flow into the estuary, and which the canal would block off, have to be carried by means of syphons under the canal. These syphons are composed of iron. All the water for supplying the canal is taken from above Runcorn, but there are no storage arrangements, as the waters of the Mersey, Irwell, and other rivers will all flow down the canal to Latchford. About three miles from Eastham the canal crosses Ellesmere Port Bay. This is the terminus of the Shropshire Union Canal. As the Ship Canal will close off from the estuary the mouth of the other canal, all craft will have to pass down the Ship Canal to Eastham. The great difficulty will be that the traffic between the Shropshire Union Canal and the estuary must not be closed during construction, and this has afforded a difficult problem for the engineers to solve.

From Eastham to Ellesmere the scenery is of a picturesque nature, consisting of cliffs well clothed with trees ; but the canal works are not doing much to perpetuate these rural charms, either here or elsewhere along the route. At a distance of ten miles from Eastham the canal crosses the principal feeder of the estuary, viz., the River Weaver, and the embankment forming the wall of the canal has to be carried across the mouth of the Weaver, and the traffic has to be kept open. This forms a second engineering feat of some difficulty and importance. The bed of the river is clay and river sand. At Ellesmere Point there is also clay and river sand, but with rock under. In order not to encroach more than necessary on the space of the estuary, extensive piling and sheeting is being carried on. At the time of our visit these operations were in full swing and appeared to attract a good deal of attention on the part of the authorities. A water jet was being used to aid the driving powers of the monkey, and this seemed to cause a certain amount of trouble in its direction, for occasionally it devoted its energies to most undesirable ends.

In the estuary of the Weaver the Ship Canal Company have constructed a lock to connect the Weaver with the Weston Canal, and higher up the canal there will also be a lock through the outer embankment at Weston Point, which is the dock termination of the Weston Canal. This lock will give the Weaver Navigation access to the estuary; or vessels may go down the Ship Canal to Ellesmere Point and Eastham. It will be seen, therefore, that vessels bound for the Weaver can either come through the locks at Eastham and up the Ship Canal, or can come up the Mersey to Weston Point and through the locks in the embankment. In the latter case on getting through the locks they will be able to go right into the already existing Weston Docks, as there is the same water level there as in the canal, therefore gates will be unnecessary. These docks communicate with the Weston Canal.

From what has been said some idea of the initial difficulties Mr. Leader Williams has to overcome will be gathered. It may be said that great advantages will follow for the Weaver Navigation, in consequence of the Ship Canal works. Thus if the water in the estuary has ebbed out when a vessel arrives at the mouth of the Weaver, she will be able to get down the Ship Canal to Eastham ; or she might, by taking the same course, escape the last of a foul tide. It must be remembered also that with regard to draught of water the Weaver craft will be benefitted also, for the difficulty in getting heavier draught vessels up to Northwich, and other places on the Weaver, was not because there was not water enough in the Weaver itself, but that water was lacking in the estuary ; that is to say, there was better water in the little Cheshire stream than in the big and important estuary of the Mersey. This point has been well brought out by Mr. Lionel B. Wells, of Manchester, who was, for many years, resident engineer to the Weaver Navigation, succeeding Mr. Leader Williams in that post, and under whose guidance many of the works of that important piece of inland navigation were constructed.

The Canal Company, by their Act, are bound to pass all the water from the Weaver direct into the estuary without passing it down the canal. For this purpose tidal openings 600 ft. long are to be constructed in the canal embankment. There are also 300 ft. of sluice-way capable of lifting 15 ft. The sluices to be used in case of heavy floods to which the Weaver is subject,* and to pass off tidal water. These sluices are ten in number, each 30 ft. wide, constructed under Mr. Stoney's patent, similar to those working so successfully at Belleek and other places in Ireland.

From the Weaver up to Runcorn is a distance of about three miles, and here three main canals have their termination in the docks there constructed. The canals are the Weston Canal, in connection with the Weaver Navigation, the Bridgewater Canal, now the property of the Ship Canal Company, and the Runcorn and Latchford, or Old Quay Canal, which is also owned by the Ship Canal Company. The last named is now blocked up for a distance of about eight miles from its termination, owing to the fact that the Ship Canal occupies its site. When the Ship Canal is opened the remaining portions of it will serve as feeders for the trade of the smaller canal, and will be joined by a lock outside Warrington. The outer bank of the Ship Canal will inclose all these three smaller canals and their dock terminations. They will have their exits into the estuary by locks in the embankment, or the traffic may be taken down the Ship Canal to Eastham if necessary.

The canal next passes under the Runcorn Bridge, so well-known as a feature in the journey to Liverpool. This bridge will have a clear headway of 75 ft. above ordinary high-water level, and this determines the height to be allowed under bridges throughout the canal.

After passing Runcorn the canal strikes inland, crossing and recrossing the windings of the Mersey and Irwell, and sometimes occupying the river bed altogether. All the way up to Warburton, which is about 11 miles from Runcorn or 25 miles from Eastham, the River Mersey is kept open and flows down to the estuary. At present it is being diverted into a new channel at three places, where it now crosses the line the canal will take. At Warburton the water level of the river and of the canal will be the same, and it is here the canal and the river may be said to join. There are locks in the Mersey at Warrington, and to this point the river is tidal.

From Warburton the canal will take the place of the old natural river, the original winding course being filled in by spoil.

(*To be continued.*)

* See Engineering, vol. xxxiv., pages 590, 628; vol. xxxv., pages 73, 114, 227, 241, 263, 388, 590; vol. xxxvi., page 591; vol. xxxvii., pages 60, 93, 199, 363; vol. xxxviii., pages 131, 191; vol. xlii., pages 63, 622; vol. xliii., page 115; vol. xliv., pages 177, 241, 300, 374; vol. xlv., pages 569, 596, 647; vol. xlvi., pages 65, 238, 273, 325, 610, 626.

MODERN FRENCH ARTILLERY.

No. XVI.

Gun Factory of the Forges et Chantiers de la Méditerranée.

There are but few large private gun factories in France in which heavy ordnance is manufactured on an extensive scale, and the principal is the establishment belonging to the Compagnie des Forges et Chantiers de la Méditerranée, started at Havre less than ten years ago. Its transactions are already on an important scale, especially with foreign Governments, and its productions have acquired a reputation sufficiently high to justify the opinion that it will, before long, become a serious competitor of private makers in this country and elsewhere ; for this reason any information connected with these works possesses a particular interest, especially taken in connection with the magnificent display made by the company in the palace of the Minister of War at the Paris Exhibition last year, and which attracted more attention than any other exhibit of the kind. In future articles we propose to describe the works of this company, and in considerable detail to consider the different classes of ordnance manufactured

* A description of the Weaver Navigation will be found on pages 244 and 564 of our thirty-eighth volume.

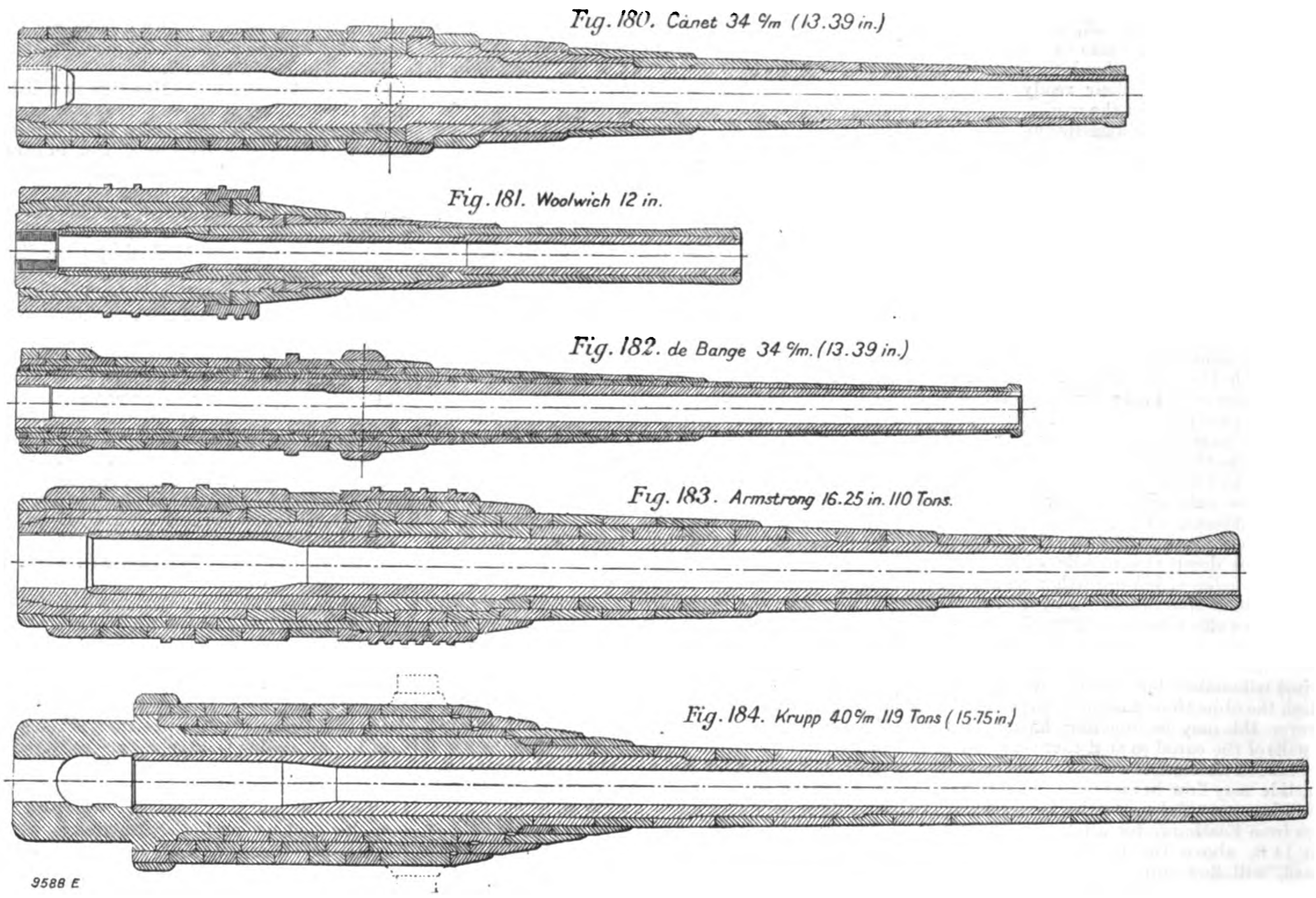
by it. For the present we shall confine ourselves to a consideration of the general features in the design of the heavy guns made by the company, because their practice constitutes an important chapter in the history of modern French artillery.

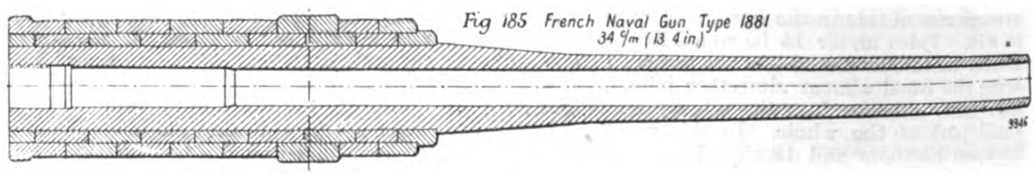
It is claimed for these guns, which are all manufactured on the Canet system, that they offer ample guarantee for excellence of material, perfection of workmanship, and efficiency in service. Every detail connected with them—and many of them present a considerable originality in design—has been worked out by M. Canet, the director of the establishment, who, after having received a special and admirable training in this country, has shown that he has learned how to profit from the valuable experience he obtained here. A fundamental principle controlling his designs is that of giving great longitudinal as well as transverse strength to his guns, in order that they may be able to resist without injury, not only the extremely high working pressures due to the service charges, but also to abnormal strains which from time to time, and from various causes, are developed in the bores of heavy guns. All the various parts of which these guns are formed are, as far as possible, symmetrical in shape and varying gradually and uniformly in thickness, in order that they may be well adapted to withstand the various trying operations of forging, tempering, and annealing. The general characteristics of the design are as follows: The inner tube that extends from end to end of the gun is relatively of considerable thickness; this is strengthened by two long sleeves or jackets shrunk upon the tube and gripping each other at the joint; they are connected together at this point by the trunnion ring, which butts against a shoulder of the rear jacket, and is screwed on the front one. These jackets are shrunk upon the inner tube as tightly as is consistent with the nature of the material used, the object being to produce a gun body as nearly as possible as strong as if it were made one piece. Over the jacket are then shrunk one or several tiers of broad steel rings, varying in number and thickness with the calibre of the gun. All the various parts are cylindrical, in order to secure perfection of workmanship and uniformity in shrinkage. The jacket extends for the whole length of the tube, to which it consequently gives a largely increased longitudinal resistance, this precaution being especially necessary to resist the great strains to which, in the future, guns will be exposed, by the use of the new slow-burning, smokeless powders, which will probably come into general use.

It should be mentioned, however, on this point that in France, at least, considerable uncertainty exists on the subject of smokeless powders, and it is evident that prolonged experience only can determine whether the new explosives will remain undeteriorated for any considerable period.

Figs. 180 to 185 give a good general idea of the typical forms of construction upon the Canet, Woolwich, De Bange, Armstrong, Krupp, and French Navy systems. In this diagram the great comparative length and simplicity of construction of the Canet 12-in. gun will be seen at a glance.

Another feature in the Canet guns is the system of breechclosing. This we have already referred to, and shall consider in detail later on; but in the mean time we may say that the block is made with a modification of the interrupted thread, is provided with a special arrangement of obturator of the De Bange type, and has various devices for firing, as well as safety appliances, most of which present considerable originality. In many of the patterns the method of working the breech-block is reduced to the simple operation of turning a hand lever always in the same direction, a system the prototype of which exists in this country, and which certainly presents striking advantages over the rather complicated gear which is employed in the standard naval artillery of France. It is claimed for the Canet guns that they impart specially high initial velocities to the projectiles fired from them, and that this advantage is not gained at the cost of excessive strain upon the gun, but that it is due to the particular form of rifling adopted; to the method of utilising the expansion of the powder gases; and to the special characteristics of the respective guns. In advancing the claims of his system, M. Canet points out that it has been urged against comparatively light projectiles that they lose their initial velocity very rapidly, and he admits that this allegation is well founded when it has reference to shell, which are too light for the calibres from which they are fired. But between the shorter Canet projectiles and the heavier ones made by Krupp, the difference is scarcely appreciable at the range of 2000 metres; that is to say, for the distance which it is assumed will be about the average range for future naval engagements, and the striking power is practically the same for both classes of projectiles. But the shorter shell has this advantage over the longer and heavier one, that it is more effective in its destructive action against armour plates; it penetrates with more certainty and is less exposed to the danger of breaking up under the shock of impact. One of the principal advantages obtained by giving projectiles a very high velocity is that it secures for them a correspondingly flat trajectory, and consequently increases the chances of their being more effective by extending the dangerous zone to a considerable degree. It is urged that with the Canet guns firing at 1000 metres' range, the dangerous zone is 33 per cent. greater than it is with a Krupp gun of the same calibre and the same length of bore. For example, if with a Krupp gun it is possible to strike the object aimed at, in spite of an error of 300 metres in judging the distance, with a Canet gun the target





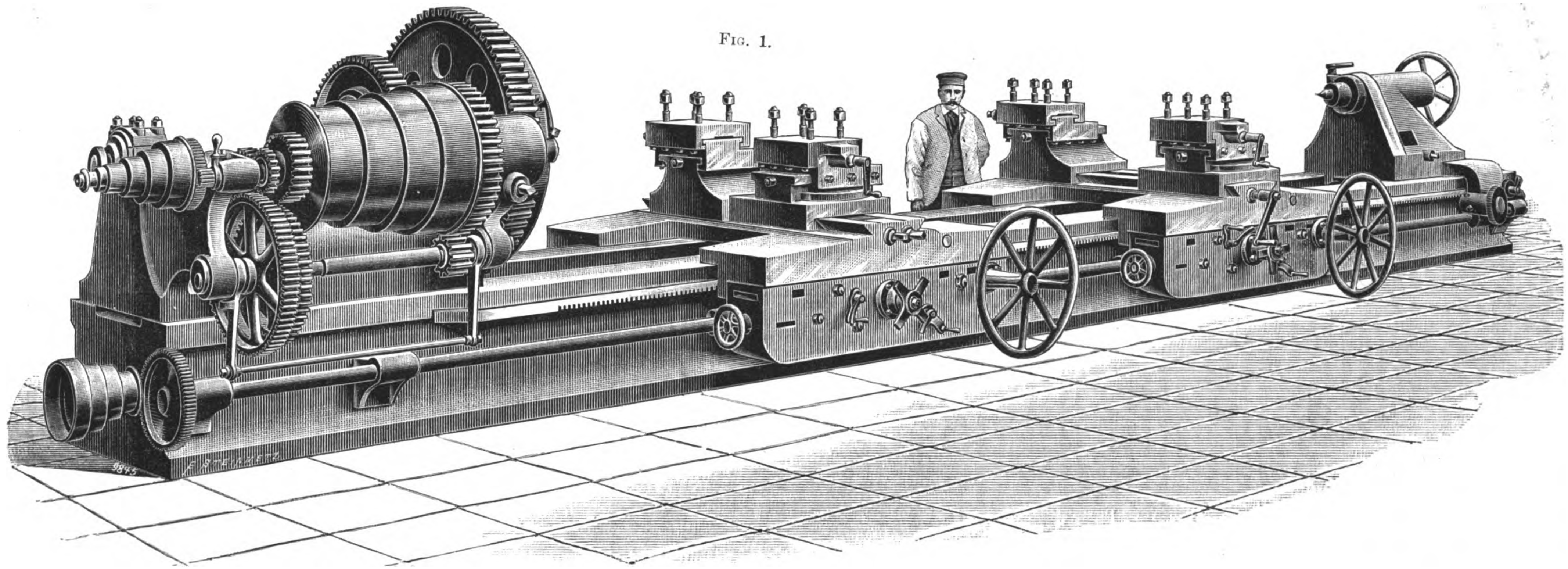
DIAGRAMS SHOWING CONSTRUCTION OF VARIOUS STANDARD TYPES OF GUNS.

HEAVY CRANKSHAFT LATHE.

CONSTRUCTED BY MESSRS. G. RICHARDS AND CO., LIMITED, ENGINEERS, BROADHEATH, MANCHESTER.

(*For Description, see Page* 501.)

FIG. 1.



would be hit even if this same error was increased to 400 metres. The striking angle being smaller with a flatter trajectory, the projectiles reach the target more nearly at a normal, and it results from this that any reduction of the striking energy is compensated for, while the penetration is at least as great as that obtained with a heavier projectile striking with greater energy but at a more acute angle. In 1886, the guns of 6.29 in. and of 4.72 in. of the 1885 type, which were mounted on board the Haytien despatch boat, the Toussaint Louverture, and which were only 30 calibres in length, gave an initial velocity of 2030 ft. and 2000 ft. with projectiles weighing 119 lb. and 46 lb. respectively. In 1887, the 5.90 in. and 9.45 in. guns, 36 calibres in length, built on the 1885 Canet model, to the order of the Creusôt Works, for firing against its armour plates, gave, with projectiles weighing 88 lb. and 366 lb., velocities of 2160 ft. and 2240 ft. respectively; while in the most recent trials with quick-firing guns, an initial velocity of no less than 2750 ft. per second has been obtained. Since that date, in consequence of experiments carried out with the new slow-burning powders, some modifications have been made in the design. These changes refer chiefly to the form of the powder chamber, and to the density, weight, and nature of the charge, and it is claimed as absolutely certain that the Canet guns of the latest type will give from 1960 ft. to 2620 ft. initial velocity, according to the length of the bore. That this claim has been fully substantiated is shown by the figures given above. It may be mentioned that the nine guns of 10.63 in. bore, and fifteen others of 5.90 in., model 1887, that the Société des Forges et Chantiers are now making at Havre, and which will form the armament of some Greek ironclads being built by the same company, must give the guaranteed velocity of 2250 ft. and 2260 ft. under pain of forfeiture. In the same way a number of 12.60 in. (32 cent.), of 38 calibres, and of the 1888 pattern, in course of construction for the Japanese coastguard ships Matsushima, Itsukushima, and Hashidate, will give an initial velocity of 2290 ft., upon which the guns are to be accepted, or rejected if they fall short of that velocity. The proportions of these guns are based upon the results obtained from a great number of experiments made in France and elsewhere, on the expansion of powder charges, and it is confidently maintained that a velocity of 2430 ft. can always be relied on with guns of 42 calibres in length. An interesting comparison is made by the engineer of the gun factory at Havre between the 9.45-in. gun, supplied in 1887 to Creusôt, and the 13.39-in. De Bange gun with biconical reinforcing rings constructed by the Cail Company, and already referred to. The 9.45-in. gun was fired with a normal powder charge of 198.4 lb.; the De Bange gun, 13.39 in., had a normal powder charge of 485 lb. The ratio between the weight of the charge and the capacity of the bore was 6.5 for the Canet gun and 5.5 for the De Bange gun. The first then, all other things being equal, fired a charge 18 per cent. superior to that of the De Bange gun, and consequently if it had been constructed on the same principle it certainly could not have withstood the excessive strains set up within the bore.

Table VI. (see next page), which is translated from the *Aide-Mémoire de l'Officier de Marine*, 1890, by M. Ed. Durassier, is an official publication of the general particulars of the Canet guns for all calibres, and will be followed hereafter by more detailed tables of the same character. All their various natures are referred to as the 1879 model; they are all built of steel, and adapted either for naval or for coast defence, and the weights of their respective charges are for brown prismatic powder.

We have already referred to the excellence of the gun steel made in France at a very limited number of factories; it is of interest to know that in the Havre factory the steel made by various manufacturers is employed, so that advantage can always be taken of any progress or development made by the different works; it should also be mentioned that considerable quantities of Whitworth compressed steel are employed; it is evident that the competition thus set up is always certain to result in every maker doing his utmost to supply the highest quality of metal that is possible. The steel thus furnished is forged, tempered, and annealed at the works, and it is subjected to a severe series of tests to ascertain its resistance both to tractive and compressive strains, while particular care is taken to test its limit of elasticity, the conditions in this respect being more severe than are required by the French marine. All these trials, which are made upon test-pieces cut from each end of the different ingots, are carried on with as much publicity as possible, and are always under the control of the different agents employed by various governments for whom orders are in execution at the works. This system has the undoubtedly good effect of maintaining the quality of steel furnished at a very high standard, and of enabling the inspectors to satisfy themselves about every piece of metal that is put into each gun.

No less important and difficult than the design and construction of heavy guns called for to-day are the means of providing such guns with suitable platforms and carriages on which they can be mounted, trained, and fired. The strains thrown upon the carriages by the reaction after firing are so considerable, that it is necessary to have them very powerful; it is also absolutely essential on board ship that the amount of recoil should be reduced to the narrowest limits, and

Table VI.—*General Particulars of Guns of Various Calibres made on the Canet System by the Société des Forges et Chantiers de la Méditerranée at Havre.*

(*From the Aide-Mémoire de l'Officier de Marine*, 1890.)

Nature of Gun.	Length in Calibres.	Bore.	Length of Bore in Calibres.	Weight of Gun.	Weight of Charge.	Weight of Projectile.	Initial Velocity. Feet per Second.	Thickness of Iron Armour Plate that can be pierced at Muzzle of Gun.
cent.		in.		tons	lb.	lb.		in.
37	30	14.57	28	71.1	594	1364	2000	38.54
37	36	14.57	34	84.8	726	1364	2330	44.88
37	43	14.57	41	114	858	1364	2427	50.78
37	50	14.57	48	128	968	1364	2624	56.70
34	30	13.39	28	55.2	440	1056	2000	34.06
34	36	13.39	34	65.8	572	1056	2330	39.76
34	43	13.39	41	88.5	660	1056	2427	44.88
34	50	13.39	48	99.6	748	1056	2624	50.39
32	30	12.60	28	46	378.4	880	2000	31.46
32	36	12.60	34	54.4	466.4	880	2330	36.73
32	43	12.60	41	73.8	550	880	2427	41.42
32	50	12.60	48	82	624.8	880	2624	45.82
30	30	12.01	28	32.8	330	770	2000	29.61
30	36	12.01	34	47.1	409.2	770	2330	34.57
30	43	12.01	41	63 9	484	770	2427	38.97
30	50	12.01	48	71.8	550	770	2624	43.46
27	30	10.63	28	27.6	226	528	2000	24.60
27	36	10.63	34	32.7	279.4	528	2330	28.74
27	43	10.63	41	44.3	330	528	2427	32.44
27	50	10.63	48	49.9	374	528	2624	36.26
24	30	9.45	28	19.4	160.6	374	2000	20.95
24	36	9.45	34	23	198	374	2330	24.45
24	43	9.45	41	31.1	231	374	2427	27.28
24	50	9.45	48	35	266.2	374	2624	30.43
22	30	8.66	28	15	123.2	286	2000	18.43
22	36	8.66	34	17.8	151.8	286	2330	21.50
22	43	8.66	41	24	176	286	2427	24.25
22	50	8.66	48	27	202.4	286	2624	27.12
19	30	7.47	28	9.63	79.2	185	2000	15.0
19	36	7.47	34	11.48	99	185	2330	17.48
19	43	7.47	41	15.45	114.4	185	2427	19.69
19	50	7.47	48	17.37	132	185	2624	22.09
16	30	6.29	28	5.75	48.4	110	2000	11.69
16	36	6.29	34	6.85	59 4	110	2330	13.66
16	43	6.29	41	9.2	68.2	110	2427	15.39
16	50	6.29	48	10.38	79.2	110	2624	17.21
15	30	5.90	28	4.75	39.6	92.4	2000	10.82
15	36	5.90	34	5.7	48.4	92.4	2330	14.13
15	43	5.90	41	7.6	57.2	92.4	2427	14.29
15	50	5.90	48	8.55	66.0	92.4	2624	15.55
				lb.				
14	30	5.51	28	8,558	33	74.8	2000	9.76
14	36	5.51	34	9,790	39.6	74.8	2330	11.41
14	43	5.51	41	12,540	46.2	74.8	2427	12.91
14	50	5.51	48	14,850	52.8	74.8	2624	14.41
12	30	4.72	28	5,390	19.8	46.2	2000	7.75
12	36	4.72	34	6,160	24.2	46.2	2330	9.05
12	43	4.72	41	7,920	28.6	46.2	2427	10.19
12	50	4.72	48	9,350	33.0	46.2	2624	11.37
10	30	3.94	28	3,124	11.88	27.5	2000	6.17
10	36	3.94	34	3,564	14.52	27.5	2330	7.20
10	43	3.94	41	4,576	17.16	27.5	2427	8.11
10	50	3.94	48	5,412	19.8	27.5	2624	9.09
9	30	3.54	28	2,266	8.58	19.8	2000	5.15
9	36	3.54	34	2,596	10.56	19.8	2330	6.02
9	43	3.54	41	3,344	12.32	19.8	2427	6.80
9	50	3.54	48	3,960	14.08	19.8	2624	7.59
mm.								
84	Short	3.31	21.4	880	3.52	16.3		
	Long	3.31	27.4	1,144	4.62	16.3		
	Light	3.31	19.7	451	1.76	10.12		
75	Short	2.95	23.4	638	2.64	11.5		
	Long	2.95	29.4	858	3.52	11.5		
	Heavy	2.95	33.4	1,034	4.4	13.64		

that it should be thoroughly controlled by simple, compact, and easily managed appliances. Probably no manufacturers have done so much to develop the design and construction of mountings for heavy guns as the great Elswick firm, especially since they combined with themselves the practice and experience of Mr. Vavasseur. It will be seen in future articles that, no less in mountings than in the construction of ordnance, M. Canet has shown a boldness and originality of design, which, while possessing many things in common with the Armstrong-Vavasseur practice, has such important and distinct points of departure, as to make a detailed comparison of the highest interest.

A valuable criticism on the Krupp system of heavy gun carriages made by a French writer may be referred to here. He points out that the efficiency and rapidity in serving a gun depends to a large extent on the arrangement of the frame and the various appliances attached to the carriage. Rapidity of fire is in effect one of the essential conditions of modern artillery, one of the principal purposes of which is to do the greatest possible amount of damage in the shortest time, before an enemy can carry out the same tactics. It is objected that the naval carriages made by Krupp are large and heavy, while the manipulation is difficult. At the same time the carriage properly so called is very high, and from its peculiarities of design, excessive strain is thrown upon the parts after each discharge; the brakes are placed very low down and the valves are closed by springs, that do not always work regularly. Almost precisely similar objections are urged against the De Bange system of carriage, which is so designed that many of the most important parts have tensile and bending strains thrown upon them, instead of being exposed wholly to compression. It is claimed that these defects are avoided in the new types of carriage made at the Forges et Chantiers Works at Havre, and which, as we have said before, have many points in common with the Vavasseur system with important modifications. Thus the turning valve in the latter is replaced by an arrangement in the brake cylinder (to be described hereafter), which always exerts a constant resistance, resulting in an important advantage—it is claimed—on account of its relieving the carriage of considerable strain. Returning the gun to firing position can be effected with a varying speed, which is entirely under control, the movement being regulated by an hydraulic apparatus and pump, which has the advantage of always keeping the brake cylinders filled, when required, and which can be done with two or three strokes of the piston. The arrangement is also such that the gun is held absolutely secure upon its carriage in heavy weather. The training gear for elevating large naval guns is not worked by a handwheel mounted on a shaft, which is exposed to various risks, but by means of a simple device connected with a hydraulic cylinder, and by which the operations can be very easily performed without handwheels. The introduction of a live roller ring beneath the firing platform is made to obtain a better distribution of pressure upon the baseplate and to facilitate the horizontal training of the gun; each of the rollers can be taken out for cleaning or renewal with very little trouble. The distance between the axis of the trunnions and that of the brake cylinders is reduced as much as possible in order to lessen the strains caused by recoil, while, the carriage being a low one, the stability is considerable. Ammunition is brought to guns mounted in turrets by means of a central tube, which is movable with the carriage: this arrangement possesses the advantage of enabling the men serving the gun to load at any time and in every position, and even when the gun is being trained.

In concluding this preliminary reference to the type of guns and carriages constructed by the Forges et Chantiers de la Méditerranée, it might be mentioned that these works are the only ones in France possessing a Polygon in which the trials of guns and carriages can be conducted at all angles of elevation. This Polygon, which is established as a trial ground for the society and for the French marine, at Hoc, near Havre, possesses a very fine collection of testing apparatus of all kinds, as well as cranes and travelling bridges for handling weights up to 90 tons; it is connected to the gun factory, as well as to Havre, by lines of railway, and it is here that important and interesting trials are being constantly carried out.

THE ELECTRIC LIGHTING OF THE EDINBURGH EXHIBITION.

When it is remembered that the Edinburgh Exhibition was originally suggested by electricians, to mark progress in the development of the science, and that, notwithstanding its subsequently extended scope, electricity still forms the distinctive feature, it will very naturally be assumed that the arrangements for lighting will be complete and exemplary. It is almost unnecessary to say that the application of electricity to the purposes of illumination will be exhibited in its many distinctive phases. Many of the stalls will be separately lighted, and probably every type of motor will be requisitioned to provide the power for dynamos. It is yet too early to deal with such separate installations or with the arrangements for lighting railway stations and outbuildings with anything like completeness and accuracy. They are not yet in evidence, or completely fixed upon, and looking to the jealousies which exist in such a case it is at least prudent not to refer to any particular separate illumination at the present time.

We therefore desire to deal with the general installation for lighting up the courts and grounds which have had preliminary trials, leaving the lesser installations to be dealt with later. The complete arrangements, it may be said, have been carried out by the Electrical and Lighting Committee, and have been personally superintended by the convener of that committee, Mr. A. R. Bennett, electrical manager of the National Telephone Company in Edinburgh, who was one of the originators of the Exhibition and has taken a deep interest in the undertaking from its inception, having done good practical service in carrying it to its present state.

The engines used to provide the necessary motive power for the dynamos have been supplied, with one or two exceptions, by Messrs. Robey and Co., Lincoln. Messrs. Alley and McLellan have supplied one of their well-known Westinghouse engines, and several gas engines and other motors are to be used. The lighting of the Concert Hall and reception rooms has been carried out by Messrs. King, Brown, and Co., of the Rosebank Electric Works, Edinburgh, while the Brush Electrical Engineering Company, Limited, have fitted up the necessary plant for lighting the main buildings, Machinery Hall, locomotive annexe, eastern annexe, Art Galleries, and the general illumination of the grounds. The Brush Company seem now almost to have a monopoly of this kind of lighting for exhibitions, their plant being excellently well adapted for it, since it enables many lamps to be arranged in series on one circuit, and is free from complications and delicate appliances requiring constant adjustment.

The principal engine by Messrs. Robey is a 80 horse-power, nominal, compound horizontal fixed engine, fitted with Richardson and Rowland's patent automatic expansion gear. The cylinders, which are both steam-jacketted, are respectively 18½ in. and 30 in. in diameter, with a stroke of 40 in. Each cylinder has trip valve gear and the cut-off on the high-pressure cylinder is capable of being varied from *nil* to three-fourths of the stroke, whilst the cut-off on the low-pressure cylinder is variable by hand when the engine is running. The engines work up to 65 revolutions, and the power is transmitted from a flywheel 15 ft. in diameter by 1¾ in. ropes. The working steam pressure is 100 lb. to the square inch, and the engines indicate 400 horse-power maximum. Both high and low-pressure cylinders have independent steam inlet and exhaust valves. The former consist of double-beat Cornish equilibrium valves fitted to each end of the cylinder so as to get a short steam passage, which enables the initial pressure at all times to be nearly as great as that in the boiler. Those on the high-pressure cylinder are under the direct control of the governor. The exhaust valves consist of a special arrangement of Corliss slide valve, which gives a quick wide opening to the exhaust with a very small travel. They are placed on the underside of the cylinders, to facilitate the efficient draining of the interior, and to enable the piston to work with the least possible amount of clearance. They are worked by eccentrics upon the horizontal shaft driving the admission valve gear. The bearings are made in three adjustable parts of Babbit's metal, with lubricators for continuous running. There is a receiver, through which the steam passes from high-pressure to low-pressure, and this receiver is superheated by a current of high-pressure steam from the boiler circulating through a coil of piping placed inside of it. The receiver is lagged with wood and sheet iron. The Messrs. Robey, it may be added, are sole makers of engines fitted with this gear, and they are made both single and coupled, high-pressure and condensing. It is claimed for the latter type that it does not use more than 15 lb. of steam per horse-power per hour. This engine drives six Brush arc dynamos, each with thirty-five lights.

The next engine in point of size is of a somewhat different type, having a short stroke, with a higher speed. It is a 65 horse-power nominal horizontal fixed engine. The cylinders are 15 in. and 26 in. in diameter, steam jacketted. The stroke is 28 in. The high-pressure cylinder has Richardson and Rowland's patent automatic trip expansion gear, with Corliss slide exhaust; the low-pressure cylinder an ordinary rectangular slide having a variable travel. The revolutions made are 86 per minute. The flywheel is 12 ft. in diameter, and the rope by which power is transmitted 1¾ in. thick. The working pressure is 100 lb., and the maximum indicated horse-power 320. The engine bedplate is of exceedingly massive construction. The crankshaft is made of forged steel, with throws cut out of the solid and accurately balanced and carried on three extra long bearings cast upon the engine bed. The bearings are lined with Babbit's metal, each made adjustable in three directions. The flywheel overhangs by the side of the engine bed, between it and an outbearing carrying the end of the crank-

LITERATURE.

Aid Book to Engineering Enterprise. By EWING MATHESON. Second Edition. London and New York: E. and F. N. Spon. (820 pages).

THIS valuable and well-known book has now reached a second edition, both parts being combined in one volume instead of being in two as before. Some alterations have also been made in the text; a chapter on mining enterprise has been added, the chapter on the manufacture and uses of steel has been rewritten and extended, and reference has been made to some modern applications of electricity. The volume is one which ought to be in the hands of every one contemplating the inauguration of engineering enterprises abroad, as it clearly lays down the conditions upon which success depends, and the kind of information which must be obtained before plans can be properly drawn. Attention is also drawn to the various modes of forming contracts, and to the conditions necessary to the purchase of engineering materials.

The Railways of Scotland; their Present Position, with a Glance at their Past and a Forecast of their Future. By W. M. ACWORTH, Author of the "Railways of England." London: John Murray, 1890.

Mr. Acworth's work needs no introduction to the general public. His "Railways of England" proved such delightful reading that any other book from his pen is sure of a good reception; and all the risk it can run arises from the high expectations that it must fulfil. We may say at once that this volume is quite equal to its predecessor, without being in the least degree a copy of it. The circumstances of the Scotch railways are so different from those in the southern part of the island, that they present perfectly new features of interest. The most striking of these is the fierce competition which exists between them, the very thought of which would drive an English manager mad. For instance, two great lines carry passengers from Glasgow to Greenock, some 25 miles distant, at return fares of 2s. 6d. first class, and 1s. 6d. third class. One would imagine that such traffic would not be worth caring for, but it evidently is, seeing what efforts are made to obtain it. The Caledonian was the only line for a quarter of a century; then the Glasgow and South-Western, at enormous expense, formed a new line which delivered passengers on the pier, instead of in the middle of the town, and gained nearly the entire traffic. In 1865, the Caledonian obtained an Act to carry their line forward to Gourock, three miles further, and after several enforced postponements they have lately completed this scheme, and have regained the bulk of the traffic lost more than twenty years ago. There is now a report that the Glasgow and South-Western Company contemplate carrying their line past Gourock to the Cloch, in order to regain their old position.

Of course it is not the local traffic to Greenock that excites the contest, but the excursion and holiday traffic to the coast, to Dunoon, Rothesay, and the many pleasure resorts of the west. The facilities for reaching these places are perfectly wonderful. In the half-hour after four in the afternoon eleven fast trains, with thirteen boats in connection, start from Glasgow, and there are corresponding trains back each morning during the tourist season. The fares by all these trains are very low—less than half those which prevail on trains starting from London, and yet the railways pay fair dividends.

Another peculiarity of the Scotch companies is that they have most extensive running powers over each other's lines. The Caledonian and the Glasgow and South-Western both use the same road for their Greenock trains as far as Paisley. Carlisle Station is the joint property of the Caledonian and the North-Western, but the North-Eastern, the Midland, and the Maryport and Carlisle, on the English side, and the North British and South Western on the Scotch side, have running powers into it, and over a good many miles of the road outside it. The North British is under statutory obligation to compete with itself by bringing the Caledonian trains from Larbert and the north into its own Waverley Station at Edinburgh. Again at Larbert the east and west coast traffic meets (the Forth Bridge will, however, alter this), as well as the Glasgow traffic for the north, and is taken on to Perth by the Caledonian. When the Scottish Central amalgamated with the Caledonian in 1865, and with the Scottish North-Eastern in 1866, the North-Western and the Midland were given powers to run to Aberdeen and also into the Caledonian termini at Edinburgh and Glasgow.

The Forth Bridge threatens to intensify the competition north of Edinburgh by shortening the distances on the east coast. There has been great uncertainty as to these precise distances, and we therefore transcribe the following list, which Mr. Acworth admits may contain some trifling inaccuracies, in spite of the trouble he has taken to obtain it:

From London to Perth:
By west coast is now 450 miles; will be 450 miles.
By Midland route is now 475½ miles; will be 455 miles.
By east coast is now 462 miles; will be 441¼ miles.
i.e., the east coast was 12 miles worse, and will be 8¾ miles better than the west coast.

From London to Aberdeen:
By west coast is now 540 miles; will be 540 miles.
By Midland route is now 565½ miles; will be 536¾ miles.
By east coast is now 552 miles; will be 523 miles.
i.e., the east coast was 12 miles worse, and will be 17 miles better than the west coast.

The struggle will thus be carried on right to Aberdeen, since the west coast companies have definitely promised to do everything that the east coast may do, and it will thus enable the Great North of Scotland to compete on better terms with the Highland.

The work is by no means confined to instances of the way in which the Scotch companies contrive to earn dividends out of apparently unremunerative traffic. It commences with an account of the old wagon-ways constructed in the eighteenth century, and traces the progress of locomotion to the building of the Caledonian line. The second chapter deals with the outlook for the future, particularly with regard to the changes introduced by the opening of the Forth Bridge. The third gives an account of the race to the coast, and describes some special features of Glasgow and Edinburgh traffic. The Great North of Scotland and the Highland Railways form the subject of the fifth chapter; while the last is devoted to minor features. The volume is thoroughly readable from end to end, and the information it conveys will render a long journey northward far less wearisome than it usually is. The passenger who understands the peculiar circumstances of the line over which he is travelling, and the difficulties the directors have to meet, will find a thousand things to interest him on the way, and will not give way to a feeling of irritation at every little inconvenience he may encounter.

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MODERN FRENCH ARTILLERY.
No. XVIII.

THE GUN FACTORY OF THE FORGES ET CHANTIERS DE LA MEDITERRANEE—*continued.*

THE Société des Forges et Chantiers de la Méditerranée is, as we have said, the most important of the private naval establishments in France. The company possesses extensive shipbuilding works at La Seyne, close to Toulon; engine works at Marseilles; and at Havre, another shipyard and engine works, while during the last few years an ordnance factory on a very extensive scale has been created there. No doubt this last addition to the company's works would have been brought into existence many years earlier, had it not been for the restrictive legislation which put a stop to all enterprise in France so far as the manufacture of war material was concerned, and until the company were set at liberty to produce ordnance themselves, they were placed in the unsatisfactory position of seeing ships that they had built for foreign customers, armed with guns that had been purchased in England or elsewhere. As soon as the law permitted, the company set to work to alter this state of things, and they proceeded with the work in a manner that would have done credit to the most enterprising American spirit; they were, it is true, exceptionally fortunate in having as the chief of their ordnance works, an engineer—M. Canet—who had been brought up in what was certainly one of the best possible schools, that of the Vavasseur

Ordnance Company, since amalgamated with Sir William Armstrong and Co. The influence of this excellent training is evident in the work now produced at Havre and which we propose to describe in considerable detail, illustrating, as it does, not only the most advanced practice of ordnance manufacture in France, but also a practice which is able to hold its own with that of works of far older date and greater celebrity; in fact the most remarkable feature of this, the latest development of the Forges et Chantiers, is that it has sprung up almost suddenly into fame and must be reckoned as one of the great gun factories of the world. The Havre ordnance works are indeed worthy of the great company to which it belongs, a company that employs about 8000 workmen, and has since it was first established, supplied shipping to home and foreign customers to the value of 560,000,000 francs.

The Société des Forges et Chantiers de la Méditerranée was one of the most active assistants of the French Government during the Franco-German War, towards the close of which, when the State factories had utterly broken down, it manufactured large quantities of guns and other war material. During this trying period no less than 300 pieces of artillery of various calibres, as well as 1200 carriages, were made at Marseilles, and before the close of the war a well-organised ordnance department had been developed there. When peace was restored, all use for this department came to an end, for the State wanted no more guns just then, and sales to foreigners were impossible. Quite a number of years elapsed before the much needed change was made, years during which many people, besides M. Thiers, occupied themselves in bringing it about. The strong incentives of patriotism and profit were indeed great enough to maintain a constant pressure on the Government, and amongst those who kept the subject always to the front were M. Dupuy de Lome, vice-president, and M. Douët-Pastre, general manager of the Forges et Chantiers Company. When the Society again began the manufacture of ordnance, it was under totally different conditions, and with a far wider scope; it was not at Marseilles that the new works were started, as it was considered for every reason preferable to have a large branch establishment at the opposite extremity of France, and to keep the new works entirely distinct from the parent company. And it was not by any means as a factory for the service of the State, because while full privileges were granted as regarded foreign trade, the Government arsenals proposed to retain in their own hands the manufacture of all ordnance required for the army and marine. The Forges et Chantiers Company, therefore, commenced their new factory with the bold determination of entering into competition with the gunmakers of England and Germany—with Elswick and Essen especially. At the same time should any necessity unfortunately arise in the future, they would be in a position to render aid to the country, very different to that they had given in 1870. The works were started under the best possible conditions, all the experience painfully gained during the war was available; the rapid progress made by a few manufacturers was at the same time an incentive to competition and afforded valuable sources of information; the possible field for business with foreign customers was almost unlimited, while the certainty of being able to aid the country in the event of necessity, gave additional zest to the enterprise. M. Canet, who was from the commencement appointed as chief engineer of the gun factory, was thoroughly fitted for the responsible position for which, as we have seen, his previous experience had prepared him, and he started with a somewhat bold but very practical scheme for the organisation of the works. This was nothing less than a complete programme for the manufacture of so large a series of ordnance, that it should comprise every possible variety that could be required by any nation, and for every purpose, according to our present lights on the subject; at the same time, while introducing into his plan a large number of original, and often very bold details, he held fast to all that experience had taught should be followed in the design and manufacture of heavy guns. One part of his plan was so to arrange the factory that it should be adapted to the production of a large series of different natures and calibres. This series comprised seven types of mountain and boat guns of 75 and 84 millimetres (2.95-in. and 3.31-in.); for quick-firing guns, three types of each, and from 6.5 to 15 cent. (2.56-in. to 5.90-in. bore). The other types provided for were as follows: Mortars of from 7.5 to 34 cent. bore (2.95-in. to 13.39-in.); howitzers from 7.5 to 34 cent. (2.95-in. to 13.39-in.); short and long siege guns from 7.5 to 34 cent. (2.95-in. to 13.39 in.); siege guns from 90 to 270 millimetres (3.54-in. to 10.63-in.); and naval and coast defence cannon from 9 to 37 cent. (3.54-in. to 14.57-in.). Each of the calibres for naval service and coast defence was further subdivided into five types of 25, 30, 36, 43, 50 calibres in length. By this system there exist no less than twelve different classes divided into a number of types.

Each different class of gun has its own form of breech mechanism, the leading principles being alike in all, but the details varying with the purpose of the piece; there are in all six distinct patterns for field and moutain guns, for boat, quick firing, coast defence, siege, and the heaviest nature of ordnance. In the same way for the various carriages, a special type is made for each class of gun, so that a complete system has been elaborated for all the variations in gun construction that are required, at all events for some years to come.

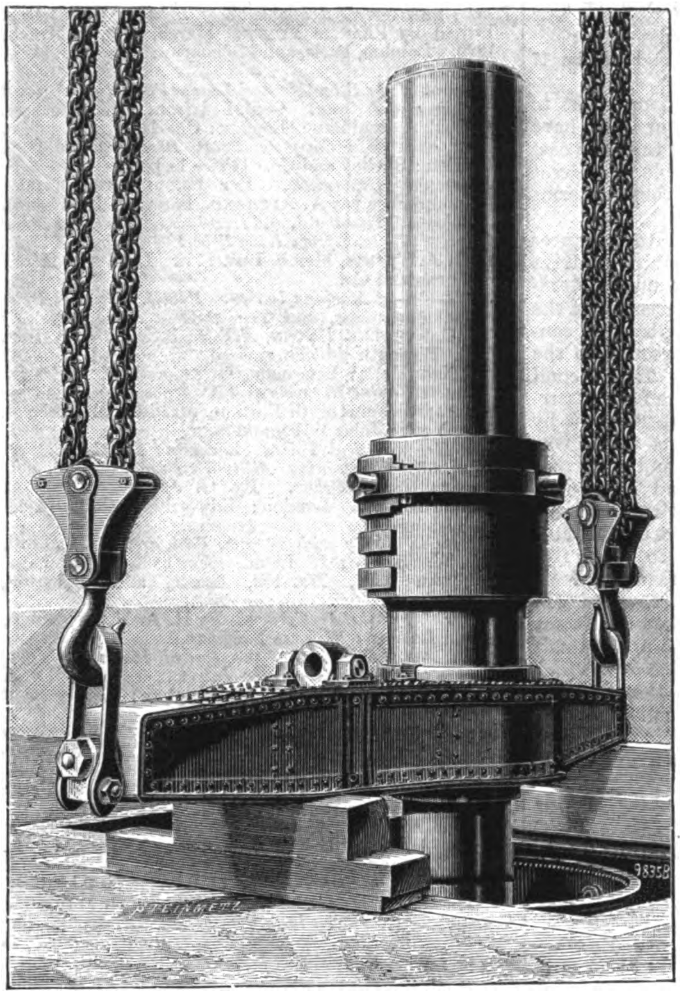


FIG. 188. SHRINKING ON THE RINGS OF A 33-CENTIMETRE GUN.

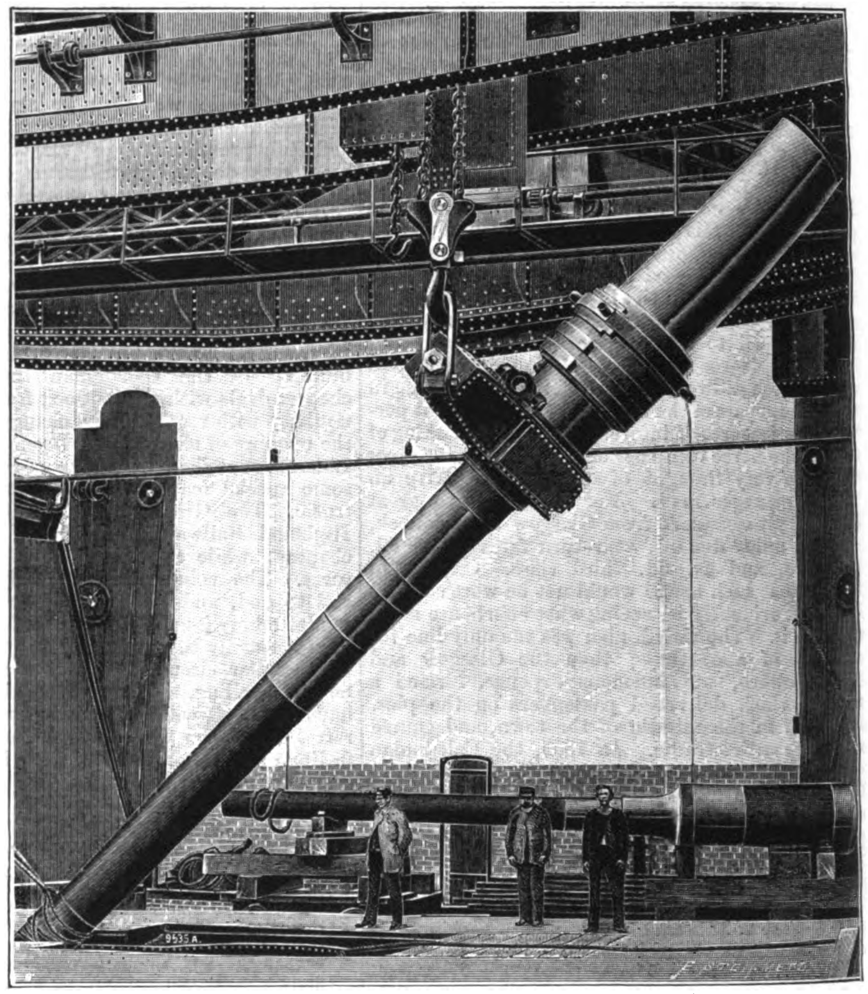


FIG. 189. LIFTING 33-CENTIMETRE GUN AFTER RINGS HAVE BEEN SHRUNK ON.

The works which are specially devoted by the Forges et Chantiers Company to the manufacture of guns, are in Havre, and close beside the older machine shops of the company and with which they are connected, a very useful arrangement, as the two establishments work together, a great deal of the machine work for the carriages being done in the latter factory; this department is under the charge of M. Cazavan. All the work connected with the construction of turrets and the whole of the hydraulic machinery is executed at the Seyne works, near Toulon, under the direction of M. Laganne. The central offices of the company are in Paris in the Rue Vignon, and it is there that all designs for guns, carriages, &c., are prepared by M. Canet. Finally, we may mention that the artillery works are under the management of Major Roger, a French artillery officer. One of the most important adjuncts to the company's gun factory is the Polygon or firing ground, which is located at Hoc near the mouth of the Seine; it is situated not far from the works, with which it is connected by lines of railway, and is very completely appointed for the conduct of every kind of trial with ordnance of all calibres. From what we have said it will be readily understood that not only the Forges et Chantiers Company, but the whole country, is proud of these ordnance works, of recent origin, it is true, but nevertheless so complete that they succeed in obtaining and executing satisfactorily orders for foreign powers, which, until recently, could not have been placed in France at all.

We may now commence a description of the factory, taken partly from a notice published a short time since by our contemporary, *Le Genie Civil*. The artillery works occupy a large rectangular space of ground bounded on the north by the railway running from Paris to Havre, on the south by the Rue d'Harfleur, to the west by the old machine shops of the company, and to the east by waste ground belonging to the company, and reserved by them for future extensions. The principal entrance to the factory is by the Rue d'Harfleur, where the offices are situated, and by which materials of a light description are brought by road ; at the opposite end the railway is utilised for the transport of heavy freight. Sidings from the main line, and a complete system of lines laid down over the works, allow of an easy distribution of material, while another series of lines extending to the quays and basins of Havre give full facilities for shipping and unshipping the heaviest objects taken into or brought out of the works. The Polygon is situated about four miles from the factory. The works include a large number of buildings, which occupy a total surface of about 100,000 square feet ; the general arrangement adopted is that of a number of separate structures adjoining each other. These extend from north to south for a total length of 420 ft., and communicate with one another ; from east to west the buildings are divided into twenty bays of about 20 ft. each ; in the centre is a large shop of 55 ft. 9 in. span and a height of 30 ft. to the springing of the roof principals. The two spans adjoining this central bay, and communicating with it, are each of them 30 ft. in width and 20 ft. high to the springing of the roof. On each side of the outer bays are a number of buildings devoted to miscellaneous purposes ; on the west side is an annexe containing the offices, and there is here a special workshop, to which reference will presently be made, 39 ft. span and of the same height. The main buildings are wholly of iron, and the roof principals are placed 19 ft. 8 in. apart, being carried on double columns that serve at the same time to support the travelling cranes ; the two-page illustration (Fig. 186) published this week gives a good idea of the interior of the principal shop. Considerable trouble was experienced in obtaining good foundations for these buildings, and for the heavy tools they contain. The ground at this place consists of sand and marl for a depth of 30 ft. or 35 ft., and it was necessary that the columns, as well as many of the heavier machines, should be carried on a pile foundation. Motive power for this workshop is furnished by two compound engines of the marine type, which can be driven separately or coupled together, according to requirements ; each of them is of 80 horse-power nominal, but they can develop 120 horse-power ; the ordinary working speed is 90 revolutions per minute, and they are furnished with steam by three Galloway boilers, two of which are sufficient for the engines, a third being kept in reserve. This motive power was supplied from the company's works at La Havre. Both engines and boilers are placed on one of the buildings forming the western annexe to the principal shops ; the main shaft of the engine is placed parallel to the axis of the buildings, so that by means of two large driving pulleys on the engine shaft power can be transmitted direct to the five lines of shafting within the works. One of these pulleys gives motion to the shafting in the central nave, the other by means of underground countershafting drives the machinery in the four other bays.

A very complete means of handling heavy masses of material is essential in these works ; the central nave, where the largest machine tools are placed, is provided with two travelling cranes, one able to lift 60 tons and the other 30 tons, but they are so arranged that they can be worked in combination, and in this way can handle masses weighing 90 tons. The western bay is furnished with a travelling crane of 30 tons, besides hand winches, and the eastern bay has a 10-ton traveller ; in addition the northern end of the western bay, in which steel rings and jackets are stored, has a 7-ton hand winch. All the travelling cranes are driven by endless belts, and are controlled by friction gearing. The engraving (Fig. 187) on page 566 shows the interior of the carriage shop. The pit constructed for shrinking on the steel jackets and reinforcing rings is 26 ft. 3 in. deep and about 8 ft. in diameter ; it is situated at the north end of the central nave. This pit is fitted with all the appliances required for heating the rings by gas, as well as for handling the heavy masses of steel that have to be raised, lowered, and shifted. Figs. 188, 189, and 190 illustrate the method of handling heavy guns in the shops during and after the process of shrinking on the rings. There are several smaller pits, in which field and other light guns are put together.

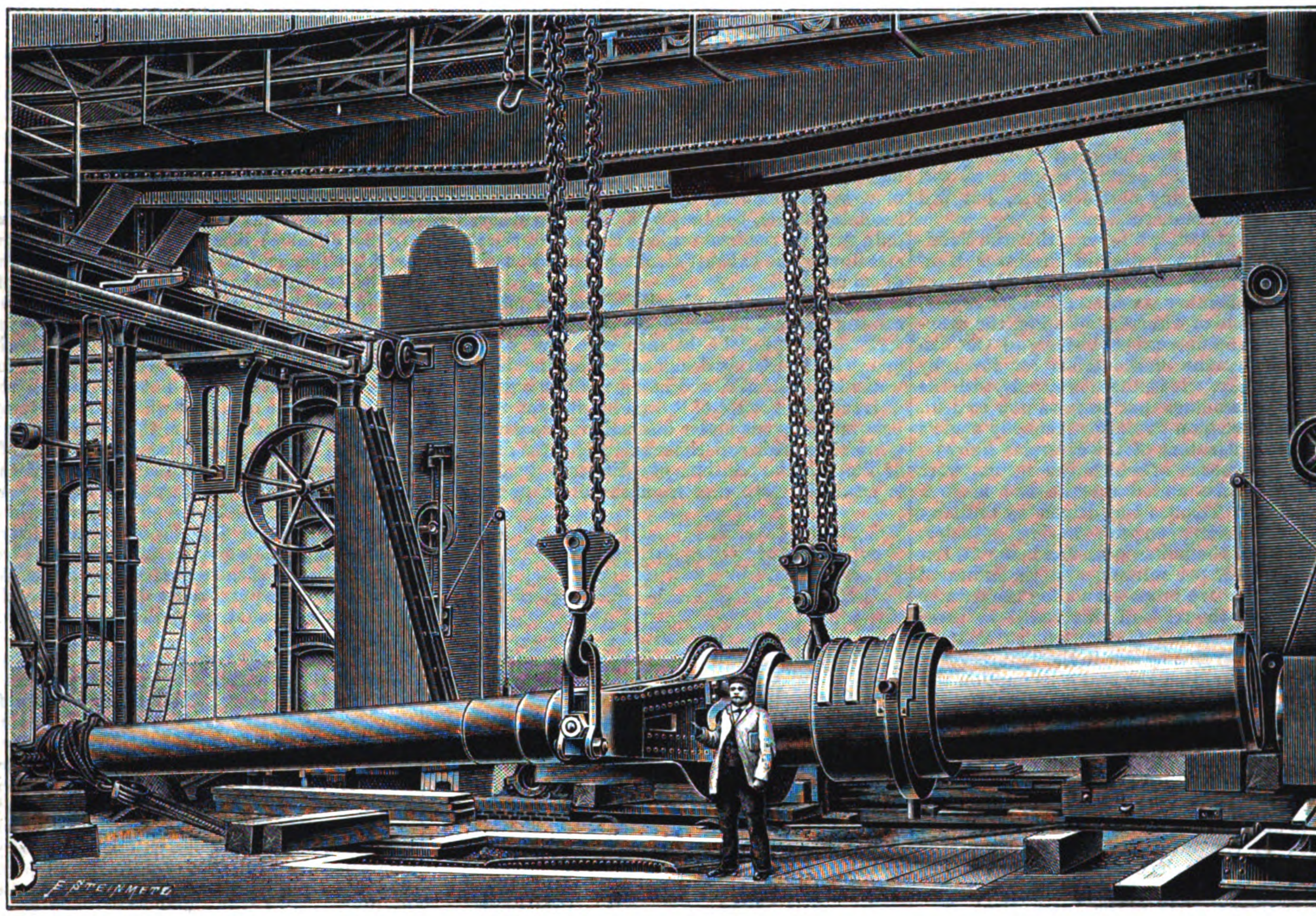


FIG. 190. TRAVELLING CRANE IN GUN SHOPS SHIFTING A 33-CENTIMETRE GUN.

THE INSTITUTION OF MECHANICAL ENGINEERS.

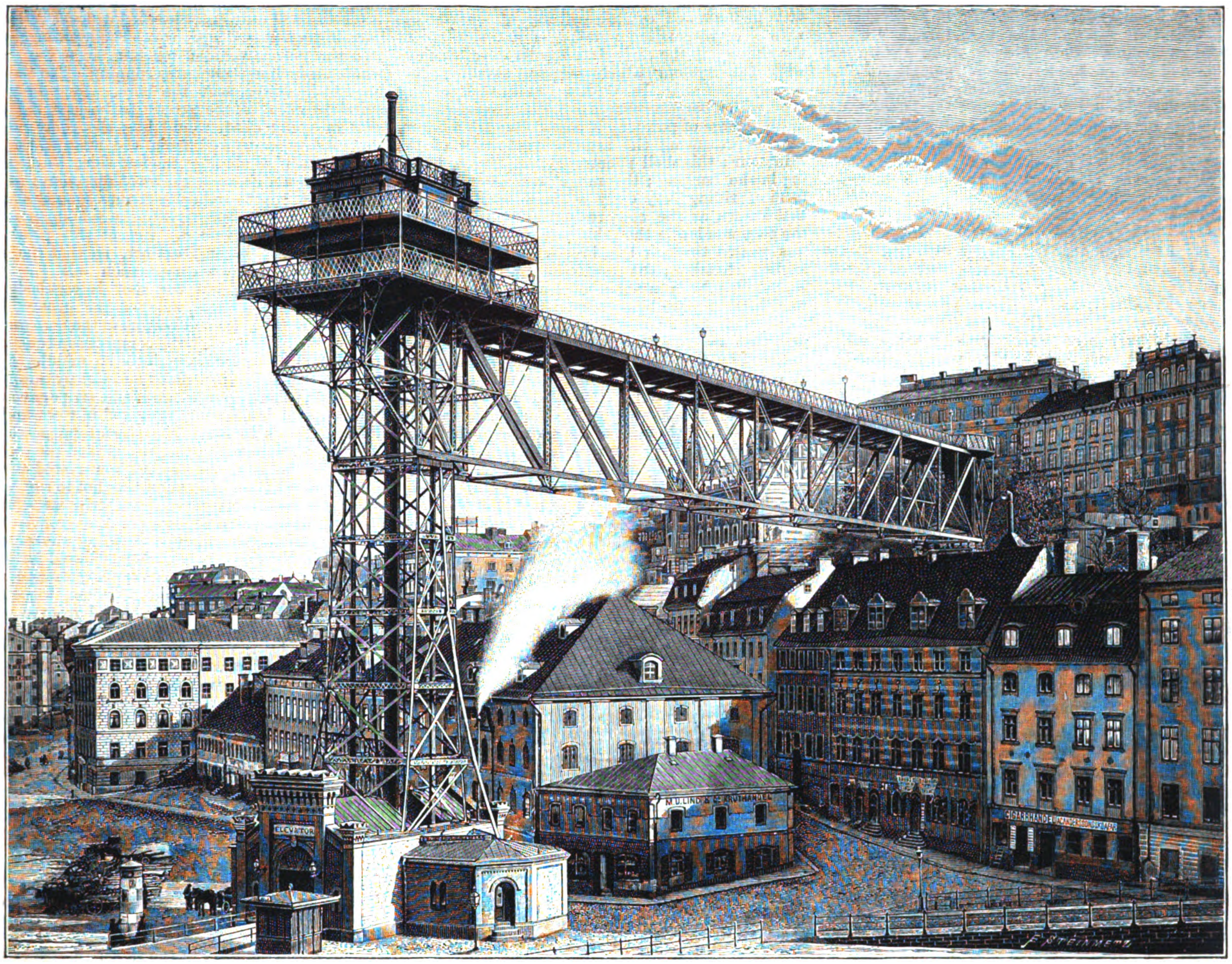
ON Thursday and Friday of last week the spring general meeting of the Institution of Mechanical Engineers was held in the theatre of the Institution of Civil Engineers by invitation of the Council of the latter body. There was a very short programme, for it comprised only the address of the President, Mr. Joseph Tomlinson, and a single paper ; but the importance of the meeting must not be estimated by the number of communications brought forward, for the paper read dealt with results of such value as to thoroughly warrant the time devoted to its discussion. Mr. Tomlinson's address we print in full on page 575 of the present issue ; it will be found on perusal to be exceedingly interesting and of considerable historical value. In illustration of his address Mr. Tomlinson had also got together a very extensive collection of photographs, &c., of early and recent locomotives, and this collection, which was exhibited during the meeting, was examined with much interest.

MARINE ENGINE TRIALS.

The single paper above referred to was contributed by Professor Kennedy, and constituted the second report of the Research Committee on Marine Engine Trials. As our readers will remember, the

PASSENGER ELEVATOR AT STOCKHOLM.

(*For Description, see Page* 32.)



MODERN FRENCH ARTILLERY.

No. II.

WHILST in England, France, and the United States, the respective processes of making guns by built-up wrought-iron coils, by cast iron reinforced with steel rings, and by cast iron alone, were followed, Mr. Frederic Krupp, of Essen, had commenced the manufacture of ordnance upon an altogether different principle which, in later years, was to be amalgamated with the English, and subsequently with the French system, and form the type upon which the most powerful ordnance of the present day is constructed. As early as 1851, Krupp had made guns forged out of solid steel ingots, and the first example of this kind of gun construction was seen in this country at the great Exhibition of that year. Following this direction, Krupp gradually increased the means of production at his disposal, not only as regards quantity but weight also, and at the London Exhibition of 1862 he surprised the world by forged ingots of crucible steel, as well as by finished guns, far larger that had ever been turned out before in a single piece; the 21-ton steel ingot which he displayed would look but small beside the 100-ton ingot that was exhibited last year at the Paris Exhibition by the St. Chamond Company, but it was, for its time, quite as marvellous a production. In January, 1861, the capacity of the Essen works was considerable, judging from the fact that they were able to produce daily two steel ingots suitable for 8-in. guns, or larger numbers of smaller bores; they also possessed a steam hammer of 40 tons, which in those days was of tremendous proportions. Besides a number of small-calibre guns which Krupp was then manufacturing in large quantities for foreign countries—Belgium, Austria, Russia, &c.—he showed at the Exhibition of 1862 a 7-in., an 8.12-in., and a 9-in. gun; the latter was then by far the largest gun ever forged solid, and was intended to fire 250-lb. projectiles; it weight was 18,000 lb., and its price about 2000*l.*; it was either intended as a breech-loader or as a muzzle-loader if the breech end were closed by a solid plug. This gun was one of a large number which Krupp was then making for the Russian Government, an order which included 5.9-in. guns, besides a quantity of 8-in. and 6-in. bores; in addition to these he was also constructing for the same Government some 11-in. breech-loading guns, while others of 15-in. bore were under consideration. Although, as was to have been expected, a certain percentage of this class of ordnance failed under moderate tests, its general powers of resistance were unusually great. In 1862 the British acquired three Krupp breechloading guns, a 20-pounder, a 40-pounder, and one of 110 lb., the latter being of 7-in. bore. These guns were tested at Woolwich towards the close of 1862 and the beginning of 1863, with very favourable results, while on another occasion a 12-pounder was filled to the muzzle with powder, shot, and broken shell, and could not be burst. Several years before, in 1857, two guns of similar calibre, but not rifled, were also put to extreme test in Paris; these were each fired 3000 times without injury, and afterwards one of them was used as a target and thus broken. The other was fired twenty times (after the 3000 rounds above referred to) with 6.6 lb. of powder and two shot; ten times with 6.6 lb. and three shot, and six times with 13.2 lb. and six shots; after these extended trials the gun was found to be uninjured, and it was determined not to test it further. An experimental gun of the same type had previously endured 2000 rounds with heavy charges, when with a second series of tests it burst with the fourth round.

About 1863 the Bessemer process was attracting much attention and great things were expected from it for producing gun material. It was not probable that at a time when improvements in ordnance formed the burning question of the day, Mr. Bessemer would not put the capability of his steel through a practical test for this purpose; accordingly quite early in the course of his practice—too early for the success of his experiment—he constructed a Bessemer steel gun, of which the principal dimensions were as follows: Length of bore, 7 ft.; diameter of bore, 4.75 in.; maximum outside diameter, 9.5 in.; thickness of walls, 2.37 in.; weight, 1070 lb. This gun was altogether too light, nevertheless it resisted severe tests before it failed. Five series of three rounds each were fired with an increasing number of spherical shot, from two in the first series to seven in the fifth; after these, two rounds were fired with eight shot, the powder charge being 2.2 lb. throughout; the gun burst violently during this last series owing to the wedging of the shot. It should be mentioned that although Mr. Bessemer's name is but slightly associated with the early history of modern ordnance, his influence and investigations—to say nothing of the revolution which he had made in the steel industry—assisted greatly in the rapid progress of gun construction, and it was Mr. Bessemer who was one of the first to propose to the Third Napoleon, the use of steel for heavy guns in France. In fact at one time it appeared that he was going to rank amongst the prominent gunmakers of the world, for in the London Exhibition of 1862 he showed a 24-pounder steel gun which was the ninety-second that had been made by Messrs. Henry Bessemer and Co.; the prices charged at that time for gun steel varied from 4.5d. to 6.5d. a pound. Both Messrs. John Brown and Co., and Messrs. Naylor, Vickers, and Co., of Sheffield, manufactured comparatively large quantities of steel ingots for making guns; the latter works in 1864 were able to produce 10-ton steel forgings. A 20-pounder Armstrong gun made with a steel tube supplied by Vickers and Co., fired 100 rounds with a service charge of 2.5 lb. and with cylindrical projectiles, increased every tenth round from 20 lb. to 200 lb.; the length of the last series of these shots was only 15 in. shorter than the bore.

We have seen that the French lay claim to the first proposal of rifling guns, on behalf of Captain Treuille de Beaulieu; and that in 1840, Professor Treadwell, an American, was advocating a similar device; both these inventors, however, appear to have been anticipated by some years, and it would seem that the idea is due to a Belgian, Montigny, who, after vainly endeavouring to persuade his own countrymen to experiment with his idea, found better fortune in Russia, where trials were conducted with 12-pounders rifled under Montigny's directions; the results, however, were unfavourable, and the scheme was abandoned not to be revived. Cavalli, a Sardinian, in 1845, and Wahrendorf, a Swede, in the following year, both proposed methods of rifling; the device of the latter is worth recording, since it consisted in coating the projectiles with lead, which, in a modified form, was largely adopted at a later day. Beaulieu's method of rifling, which was in practical use during the several Algerian campaigns, and afterwards, in 1859, on a much larger scale in the Franco-Austrian war, was afterwards adopted by the British Government. The system consisted in the use of twelve metal studs, arranged in two rings around the projectile so as to project in the surrounding grooves formed in the bore of the gun; on being fired these studs took their bearings within the grooves so as to give the desired location to the projectile. This method answering so well with smaller calibres, the French began to apply a modification of the system to heavier ordnance. First they commenced with two shallow elliptical grooves opposite each other, a uniform twist being given in some cases, and a gaining twist in others. It was soon found that this method was entirely imperfect, and that the shot would not centre themselves on the two bearings thus provided; this led to the adoption of three grooves within the bore and the definite employment of the gaining twist, while the projectiles were cast with circular projections covered with white metal to take their bearing in the grooves. In this way a number of cast-iron 30 and 50-pounders, strengthened with rings as already described, were manufactured. The old 30-pounder, reinforced with steel and rifled, constituted in 1861 the French standard naval gun; it weighed 8240 lb. and was of 6.5 in. bore; its charge varied from 8 lb. to 26 lb., and it threw 99-lb. projectiles; it was rifled with three grooves of the form shown in Fig. 3. Both the Austrian and Russian governments, who naturally followed with the deepest interest the experiments

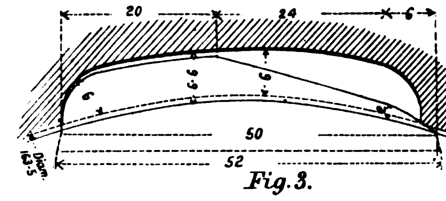


Fig. 3.

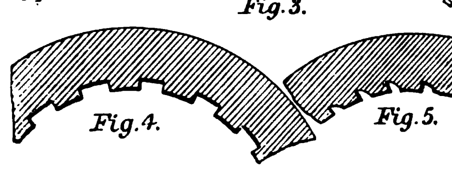
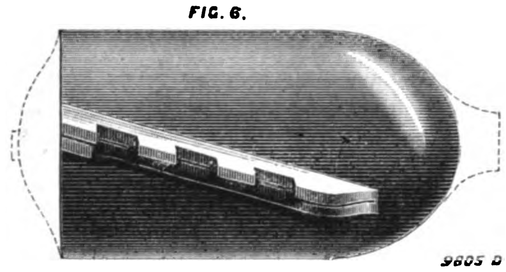


Fig. 4. Fig. 5.

that were proceeding in France, very quickly adopted the French system of rifling and studded projectiles with certain modifications suggested by their special requirements; the same remark applied in fact to so many European countries that the method may be said to have become universal. In England for many calibres it was substantially adopted, and the time had not yet come for Krupp to take the lead in manufacturing ordnance for many of the great powers of Europe. The Whitworth system, which was patented as early as 1855, was wholly different; the bore of the gun was, broadly speaking, hexagonal, and a projectile which was first turned cylindrical, was afterwards cut with a corresponding number of flat sides to fit the rifling; in the early days results were obtained with this system which surpass anything previously obtained. In 1862, a 130-lb shell of this type, with a bursting charge of 3.5 lb., was fired with a 27-lb. charge of powder; it passed through a 5.5-in. plate representing the armour protection of the Minotaur; this shell penetrated the target, bursting in the backing; the range was 800 yards. A form of rifling very early adopted by Krupp was that known as the compression system, in which the shot was larger than the bore of the gun, and was passed through the breech into an enlarged loading chamber; the projectile in this case was surrounded by a number of leaden rings, which were kept in place by corresponding grooves in the shot. This was an improvement on Wahrendorf's plan that was proposed in 1846, and was quickly followed by Armstrong and the Royal Gun Factory at Woolwich. The Prussian rifling consisted of a large number of very shallow and narrow grooves which were intended to give the leaden rings a large bearing. The early form of the grooves in the Prussian system of rifling was practically rectangular, as shown in Fig. 4; the Armstrong modification is also shown in Fig. 5. As this system involved making the chamber in the gun larger than that of the bore, it was obviously unsuited for muzzle-loaders, and to overcome this difficulty, Mr. Armstrong invented his system of shunt rifling, which was so arranged that the shot could easily be forced home from the muzzle and then turned round, so that when it was fired it would take its bearing on a shallower part of the grooves, and so receive the necessary rotation. This method is illustrated in Figs. 6 to 9, taken from Holley's "Ordnance and Armour," and may be described in detail, as it was an invention of some considerable importance at the time. "The projectile is fitted with three bars of zinc abutting against and projecting above iron ribs cast on the shot. The tops of the zinc bars are sometimes notched, as shown, to facilitate compression. The outsides of the zinc bars bear against the lands of the gun and rotate the projectile. The development of one of the grooves is shown in Fig. 9, a section of the muzzle with the shot going in by Fig. 7, and the same section with the shot coming out by Fig. 8. The grooves at the muzzle are slightly wider than they are lower down, and are stepped at two levels, the lower level corresponding with the entire rib, and the higher level being narrower, so that the projectile will only enter by the low level or deeper part or portion of the groove. The high level runs into the muzzle parallel for 8 in. in a 7-in. gun, where an incline commences running off to the low level 14 in. lower down the bore. Supposing the spiral direction of the groove to be such that the shot in going down would hug the right side of the groove as viewed from the muzzle, then in coming out it would hug the left side, because the rotation would be in a contrary direction; as the shot goes down the right side it runs against a curve or switch, which deflects it to the side upon which the high level is situated. But at this point the high level has become extinct, so that the shot runs easily without compression all the way down. In coming out the shot is regularly revolved by the straight side of the groove, but slides along the sides and bottom of the bore until it reaches the incline, when the compression commencing gradually squeezes it up into the middle of the bore, so that it leaves centred and tightly nipped." After a very short time the use of zinc strips gave way to a series of brass studs arranged in rows and of different forms to serve the special purposes required; one row round the base guided the shot as it entered the gun, the second row rested on the bottom of the grooves to allow the shot to run home easily, while in the larger calibres, strips were introduced to bear against the sides of the grooves and insure rotation. This method of rifling was speedily adopted in Russia in a somewhat modified form. A curious system of rifling was very largely and successfully adopted in the United States, known as the expansion system; the lands and grooves were almost of equal width and varied from $\frac{3}{8}$ in. to $\frac{3}{4}$ in. and about $\frac{1}{20}$ in. deep for smaller calibres, the dimensions for larger guns being about twice as great; the rifling, excepting in the Parrot guns, was always of a uniform twist. The projectiles were of cast iron and were made with a number of longitudinal slits, converging from the outside of the shot into a central opening; these slits were filled with soft metal, and when the gun was fired the pressure of the powder gases within the central opening forced the soft metal outwards and made it take its bearings in the grooves. The late Mr. Hotchkiss, whose name has become famous in connection with his system of revolving cannon and rapid-firing guns, adopted a somewhat different system; in his projectile the base was cast of a reduced diameter and a cast-iron cap was fitted to it, leaving a circular space between the top of the cap and the body of the shot; this space was filled with lead, and when the charge was fired the powder pressure forced the cast-iron cap further upon the socket made in the projectile, at the same time squeezing out the lead and forcing it to enter the grooves; from the commencement of the American War up to the end of 1863, Mr. Hotchkiss had delivered more than a million and a half of these projectiles to the United States Government, and was at that time still turning them out at the rate of 3000 a day. It may be mentioned that ranges up to 6000 yards were commonly made with field guns fired with these projectiles, and that very accurate practice was obtained at that distance.

FIG. 6.



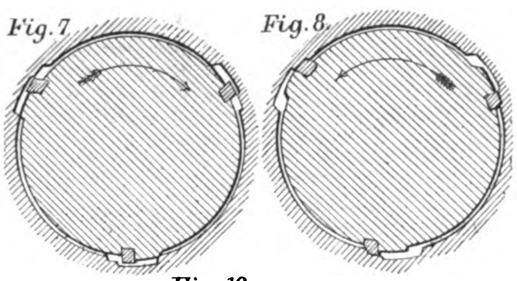


Fig. 7. Fig. 8.

Fig. 10.

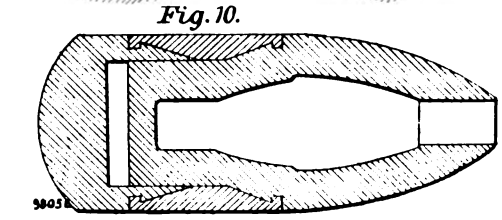


FIG. 9.

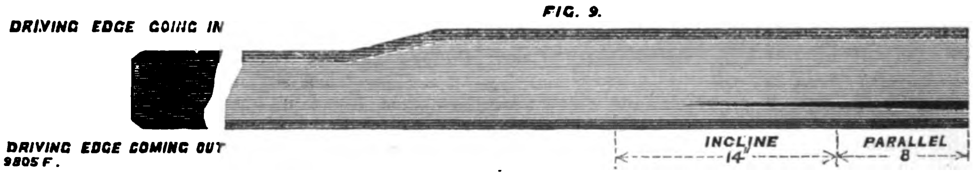


Fig. 9 is a section of the Hotchkiss projectile, which was very closely followed by Mr. Lynall Thomas in this country; it was with a projectile of this character that the greatest range recorded up to that date (1864) was obtained — 10,070 yards, or nearly six miles; the projectile was a 175 lb. shot fired with a 27-lb. powder charge at an elevation of 35 deg. from a 7-in. steel gun weighing 7 tons and rifled with seven grooves, made by the Mersey Iron Company. The Blakeley Ordnance Company, which, during the American War, did a very large business in ordnance and projectiles, made great quantities of shot and shell to be used in their own and in Confederate guns, attached a copper cup by means of a screw to the base of the shot, which was expanded by the pressure of the powder gases; the forward part of the shot was supported by a number of soft metal studs. The first idea of this kind appears to come from America, where large quantities of shot and shell were used both by the Federal and Confederate armies having brass cups cast into their base. In the Parrot rifles a thick brass ring was placed at the base of the projectile, which served the same purpose as the lead ring in the Hotchkiss system. It is needless to say that invention was as busy in designing projectiles as in scheming guns, but with the exception of the Whitworth flat-fronted steel shell, all the numerous forms and methods proposed are about as obsolete as the guns of the same period; the chilled cast-iron shot of Sir William Palliser, which for so many years were, and still are, the standard pattern adopted by the British Government, were not then invented, though in 1864 he had already made experiments in casting spherical shot with a chilled surface.

It is rather interesting to recall the fact that while for small calibres Mr. Armstrong had shown conclusively the advantages of breechloading, it was not considered possible in England to adapt it with success to large guns; the general opinion on the subject is embodied in a report of a Select Committee of Ordnance in 1863, which states, "That the preponderance of opinion seems to be against any breechloading system for the larger guns." A want of reliable material appears to have been recognised as the principal obstacle to successful breechloading, both Armstrong and Krupp had made 7-in. guns, throwing 110-lb. shot and loaded from the breech, but the powder charges were low and the weapons inefficient. All the great authorities at that time were advocates of muzzle-loading, and the conclusions to which they came, influenced gun construction, in this country, for many years. Mr. Armstrong, Sir Joseph Whitworth, Captain Coles, were all unanimous in advocating muzzle-loading for heavy guns, chiefly on account of the structural weakness involved by the modes of construction of breechloading systems then in use.

HELIOMETER AT THE CAPE OF GOOD HOPE OBSERVATORY.

(*Concluded from page 6.*)

WE have now to speak of some further details connected with the sleeve 16 shown by Figs. 2 and 3 on page 4 *ante*. In addition to the friction wheels 35 already mentioned, the flange of this sleeve next the objective carries two indices, 65, for the position circle, while two other indices, 66, for the declination circle are carried by the central portion of the sleeve as shown in Fig. 3. Both the circles just mentioned are read from the eye end of the telescope by the microscopes 37, 37, which are carried by mountings 67, a prism 68, occupying half the field, being provided for reading the declination circle, while the line of sight through the other half

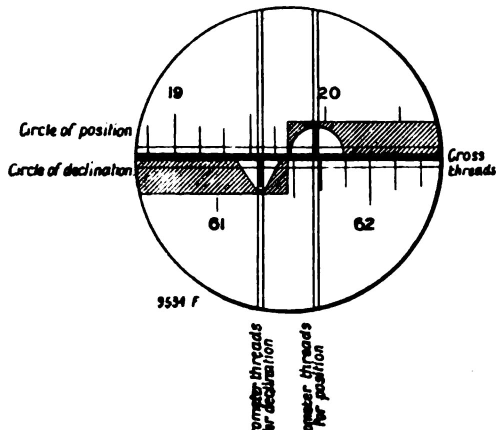


FIG. 7.

of the field passes direct to the position circle. By this arrangement the provision of separate microscopes for each circle is rendered unnecessary. The micrometers with which the microscopes 37 are fitted resemble that provided for reading the divisions of the object-glass slides. They are, however, provided with duplicate screws and sets of wires, one set for each half of the field of view. The image of the divisions of the two circles, with the two sets of micrometer wires as seen in each microscope, is shown in Fig. 7 annexed. From this view it will be seen that a diaphragm has been inserted in each half of the field, one diaphragm having a semicircular and the other a triangular notch in it so as to clearly distinguish the scales of the two circles. The necessary illumination of the field is given by an incandescence lamp contained in a casing having two bull's-eye lenses 70, throwing the light on diagonal reflectors 69 provided at the ends of the cross-tubes of the two microscopes.

The arrangements for rotating the telescope tube, and thus adjusting the line of division of the objective to any desired angle, are also shown by Figs. 2 and 3, page 4, and by Fig. 6, page 3. Four different movements may be imparted. The quickest movement is effected as follows: At the eye end of the telescope (see Fig. 6, page 3 *ante*) is a hand ring 73, which runs between friction wheels, and is provided with teeth on its inner periphery. These teeth transmit motion to a pinion on a spindle carrying at its other end another pinion, which through an intermediate wheel gives motion to the inner occular tube, the end flange of the latter carrying a geared ring 72 (see Figs. 2 and 3). The transmission spindle just mentioned carries at its end a head 74 (see Fig. 6), which if turned directly affords the second speed. The fourth, or slowest speed, is given by means of a tangent screw 75, Fig. 2, which is carried by a ball bearing on the flange of the telescope sleeve, while its nut is double-jointed to a ring 76, which encircles the flange of the inner occular tube. This ring is provided with a clamping screw 77, which through the intervention of bevel gear and rods is operated from the eye end by means of the handwheel 78, Fig. 6. In the same way the tangent screw 75 is also operated from the eye end by the handwheel 79. Finally, the handwheel 80 is connected by gearing to the rod carrying the handwheel 79, and it can thus be used to give the latter a more rapid motion than if used direct; this constitutes the third speed of movement.

It will thus be seen that near the star-shaped head of the outer eye-piece tube, which is not capable of rotation, we have the hand ring 73 and the four handwheels 74, 78, 79, 80 giving position movements to the object-glass mounting; also the bearings for the four keys 18, 19, 20, and 21 by which the declination clamp and slow motion, and the right ascension clamp and slow motion are respectively operated; and also the supports for the microscopes 37 by which the declination and hour circles can be read. Close to the microscopes will be likewise seen two small slates 81, for recording observations, and near them are also two knobs, 82, for moving the telescope by hand.

The finder 83 (see Fig. 1, page 12, and Fig. 6, page 3 *ante*), is of 3.15 in. aperture and 1 ft. 7 in. focal length; it has a field 4 deg. in diameter, and is provided with a micrometer in which a right and left-hand screw shifts two wires simultaneously from the centre to the borders of the field. This arrangement enables the observer to take in the large field of the finder an approximate measure of two objects to be afterwards dealt with in the telescope. The object-glass of the finder was made by Dr. Schroeder.

The various parts of the eye-piece end with which we have just been dealing are fixed, as we have said, to the outer casing tube, which does not revolve with the telescope. Adjoining these, but moving with the telescope, are the ordinary micrometer 84 (see Figs. 1 and 6), the registering micrometer 85 at the end of the microscope for taking readings of the divisions of the object-glass slides; and the three keys 30, 31, and 32 respectively operating the object-glass slides, the screen-wheel, and the radial screen shutters. The key 31 carries a finger moving over a graduated scale, and it also moves a small wheel shaped like the screen-wheel and moving with the latter.

The registering micrometer 85 is mounted on a slipping piece, so that its fixed wires can be adjusted in the same way as those of the micrometer 61 (for examining the divisions of the object-glass slides) already described. This micrometer 85 is so arranged that instead of taking the readings from the drumhead of the micrometer screw and an adjacent arc showing the total number of revolutions, an impression is made upon a travelling paper slip. The impression is produced by the action of a quick-threaded screw.

The illumination of the ordinary non-registering micrometer is so arranged that the light of an incandescent lamp enters from behind. The drum of the micrometer screw has its figures reversed, and the readings are taken by means of a small mirror in which the illuminated graduations are reflected. The arrangement is such that a far-sighted observer scarcely has to move his head to read the micrometer; when required, however, a small magnifying lens can easily be added.

The electrical leads for the illumination of the instrument and for bringing the head at the eye-piece end into communication with a chronograph, comprise four wires which emerge from the upper part of the column, as shown in Fig. 1, page 12. Two of these wires split into two pairs, of which one pair convey the lighting current to the two microscopes for reading the hour circle. The remaining four wires pass down to the counterpoise 11, the current entering there through four contact rings to leads which pass through the polar axis. At the large opening in the declination sleeve the current is again transferred by suitable contact arrangements to leads passing through the declination axis whence two wires pass to the chronograph contact apparatus at the eye end. The remaining two wires again split, one pair of wires passing to a switch near the end of the outer occular tube, while the other pair pass to the two large contact rings 39 behind the position circle, thus conveying the current to the revolving part of the telescope. Three incandescence lamps have to be illuminated by these last-named leads. Of these lamps, one, 64 A (Fig. 4, page 5), has already been dealt with; the second (at the eye end) illuminates the drum of the micrometer 84 at the eye end, the divisions of the occular draw-tube and the disc and hand denoting the positions of the screens and shutters at the object-glass end; the third (also at the eye end) sends its light on to the small mirror 64 (Fig. 4), which, by reflection, illuminates the field. The light of this last-named lamp can be reduced at pleasure by the introduction of resistances; the two others can be turned on or extinguished independently by means of a switch on the inner occular tube. Another switch on the outer occular tube conveys the current either to lamp 69 on the cradle 16 of the central tube (see Fig. 3, page 4), and simultaneously to two lamps for the microscopes for declination and position readings (lighting also the small slates 81); or alternatively to a light for the micrometer of the finder. This last current, of course, has to be conveyed through contact rings as the micrometer has a movement of rotation.

The clockwork by which the telescope is given its diurnal motion in right ascension stands at the foot of the central column, as shown in the general view, Fig. 1, on page 12 *ante*. From the clockwork the motion is transmitted by the shaft 87, and the arrangement of bevel gear already mentioned to the worm 4 which drives the hour wheel. A noticeable feature in the clock-driving arrangements is the form of governor used. This is an elastic pendulum 89 consisting of a long steel rod rigidly fixed at its lower end, and carrying at its upper end a heavy weight. At the top of this weight is a small knob which is caught by a fork projecting from the last vertical driving shaft of the clockwork. The weight is prevented from occupying an exactly axial position, and thus when driven round by the clock it describes a circle, the radius of which is dependent upon the speed of rotation and the resistance to flexure of the steel rod by which the weight is supported. The increase in the radius of this circle due to the action of centrifugal force consequent on a slight increase of angular speed thus produces a much greater increase in the actual velocity of the weight, and thus enables the inertia of the latter to equalise considerable variations in the relation of the driving power to the resistance. The capability of this governor for absorbing surplus power depends upon the molecular friction set up by the bending of the steel rod. This governor is identical in principle with that long used on the Hughes printing telegraph instruments, but we believe that it was independently invented by Messrs. Repsold, whose application of it to the driving clockwork of telescopes is certainly original. Its performance is, we understand, most satisfactory.

The observing seat used with the heliometer we are describing is clearly shown by the general view, Fig. 1 on page 12 *ante*, and it is of the same pattern as that supplied by Messrs. Repsold to the 30-in. refractor at the Pulkowa Observatory. The timber frame 91, slightly raised above the floor line, runs on four wheels, the axes of which, if produced,

THE GUN FACTORY OF THE FORGES ET CHANTIERS DE LA MÉDITERRANÉE, HAVRE.

(For Description, see Page 553.)

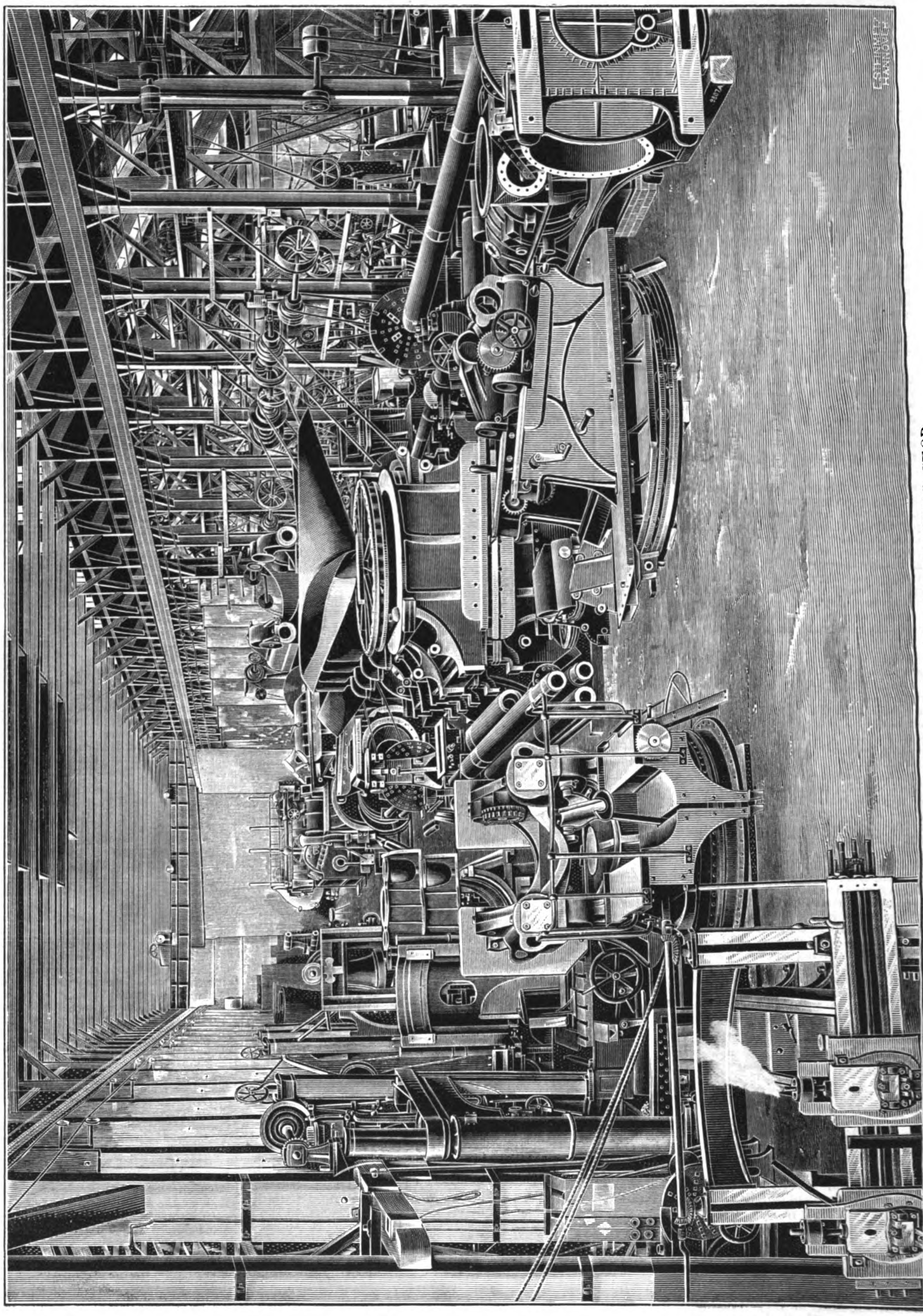


FIG. 187. INTERIOR OF CARRIAGE ERECTING SHOP.

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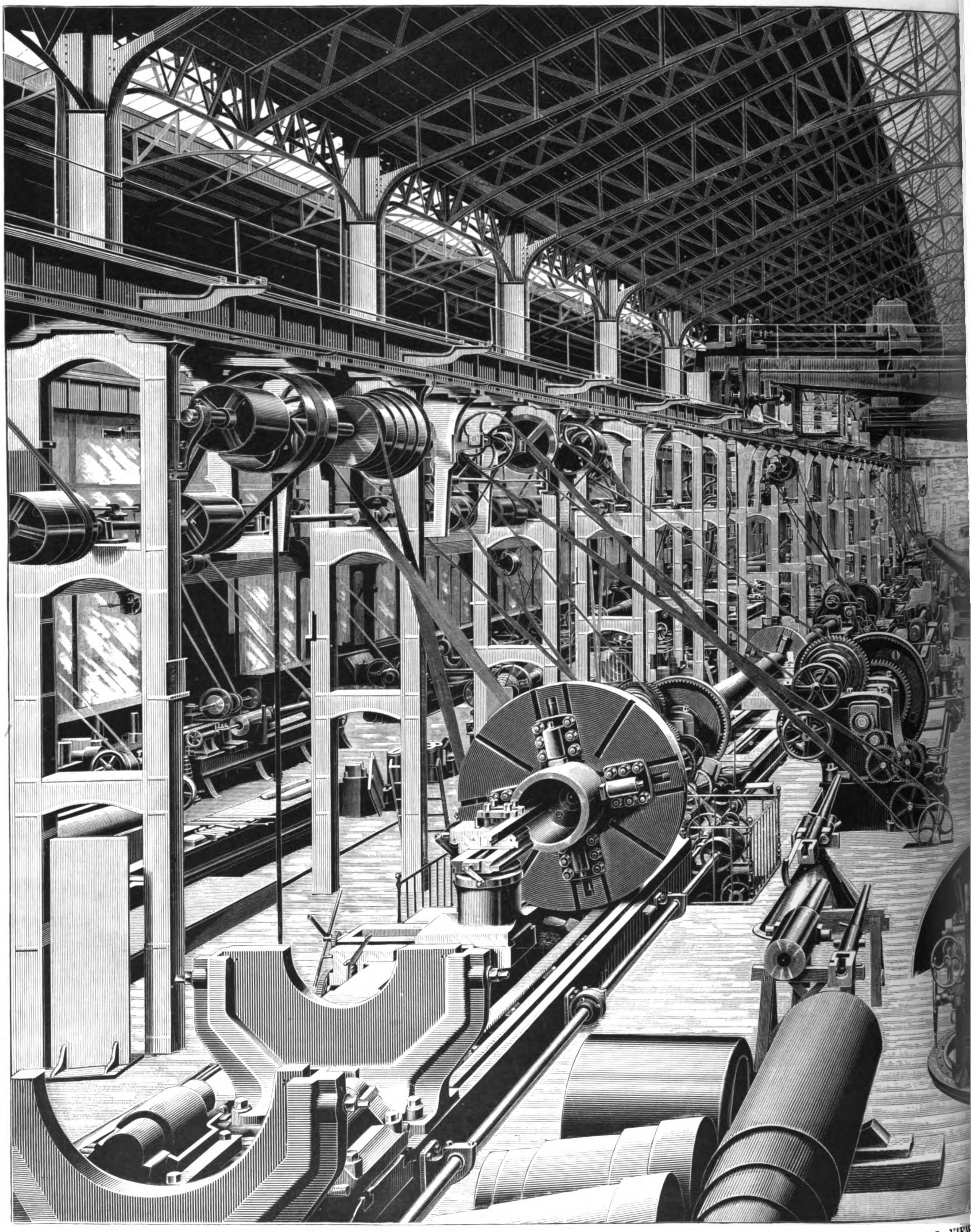

FIG. 186. GENERAL VIEW

...NTIERS DE LA MÉDITERRANÉE AT HAVRE.

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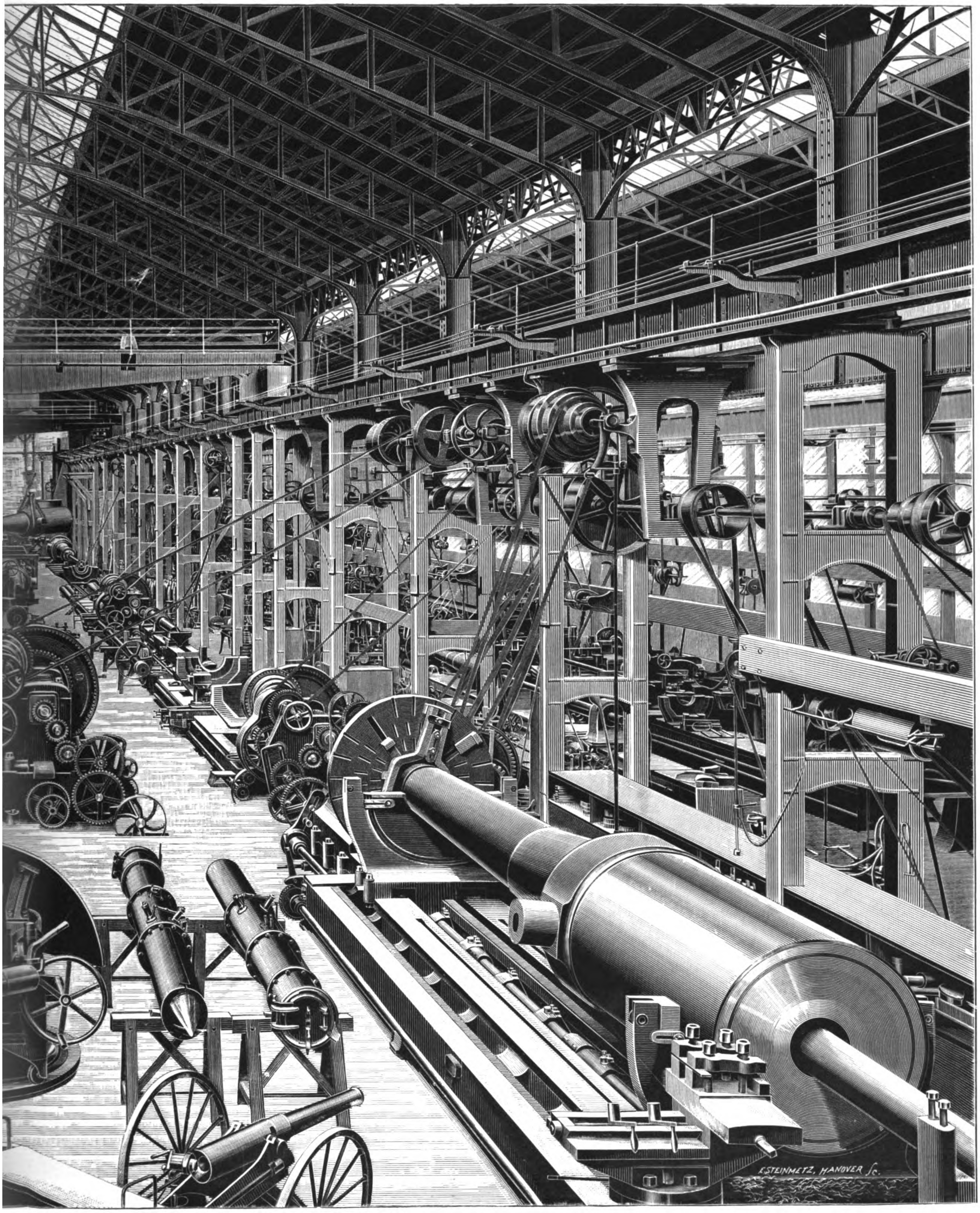

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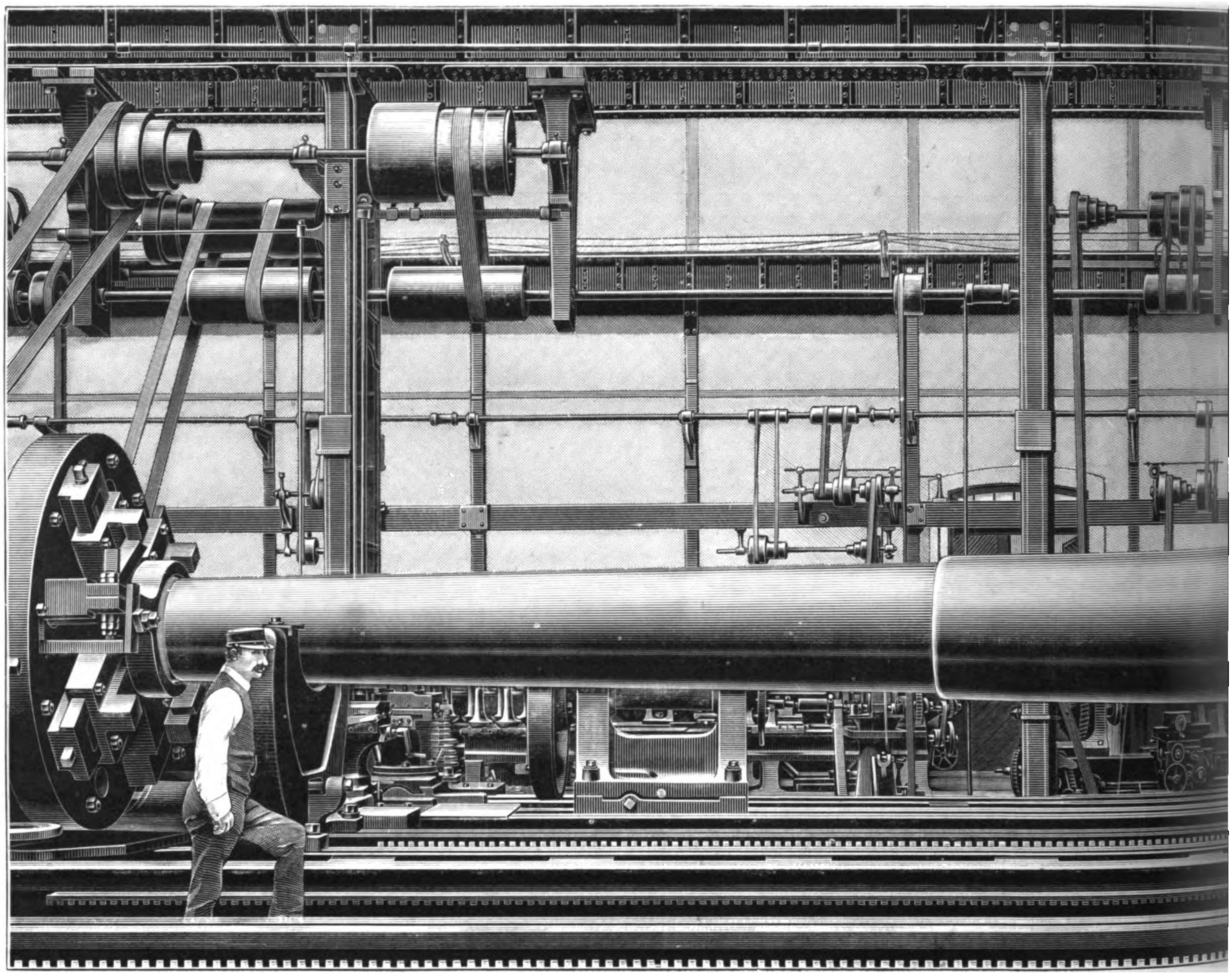


Fig. 191. One hundred-ton gu

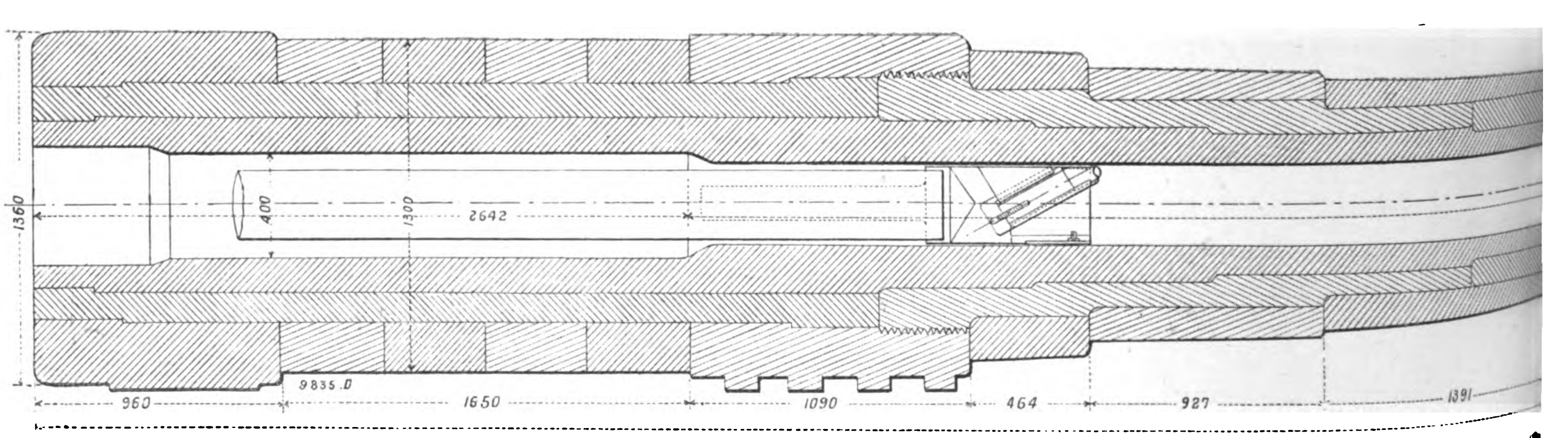
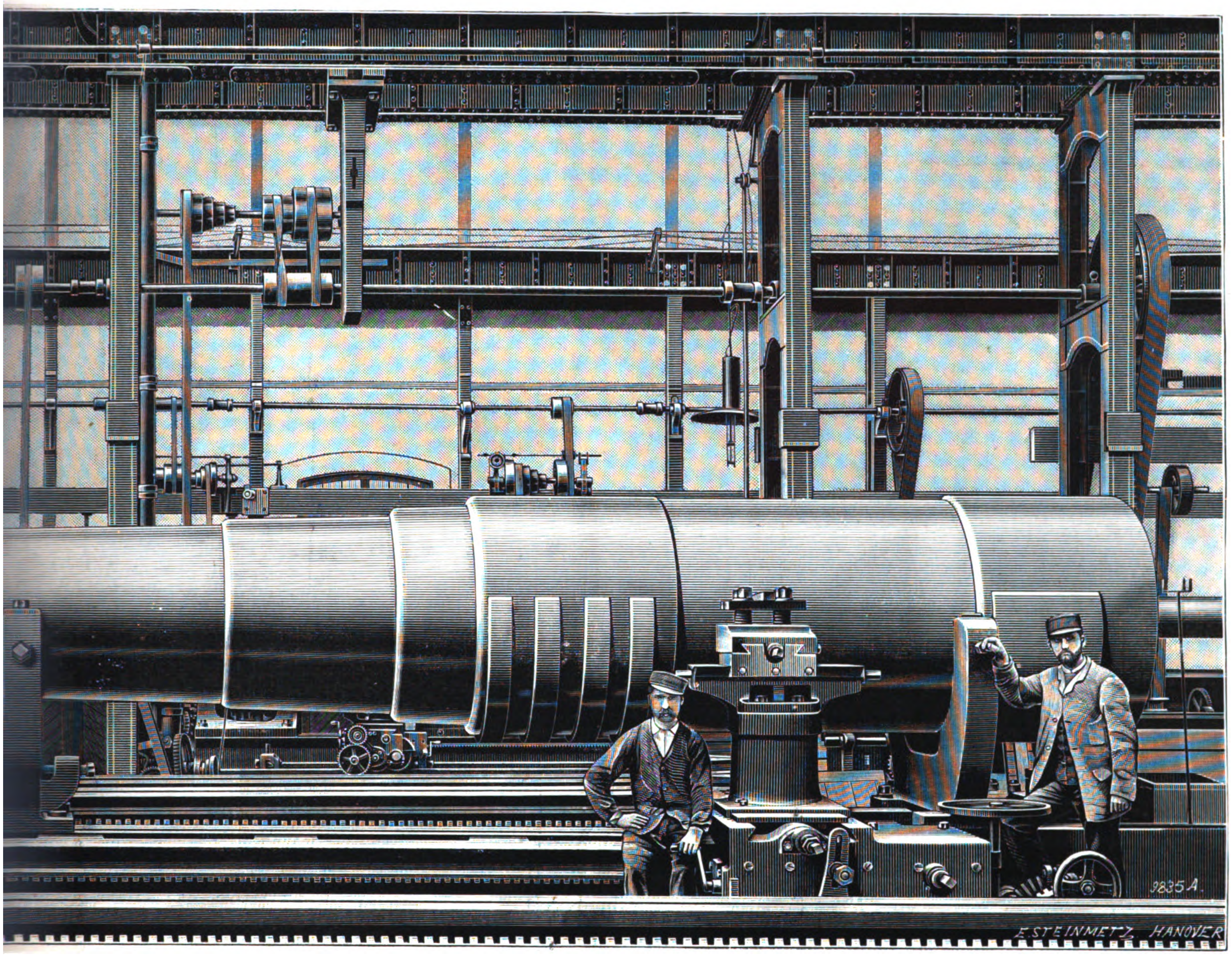


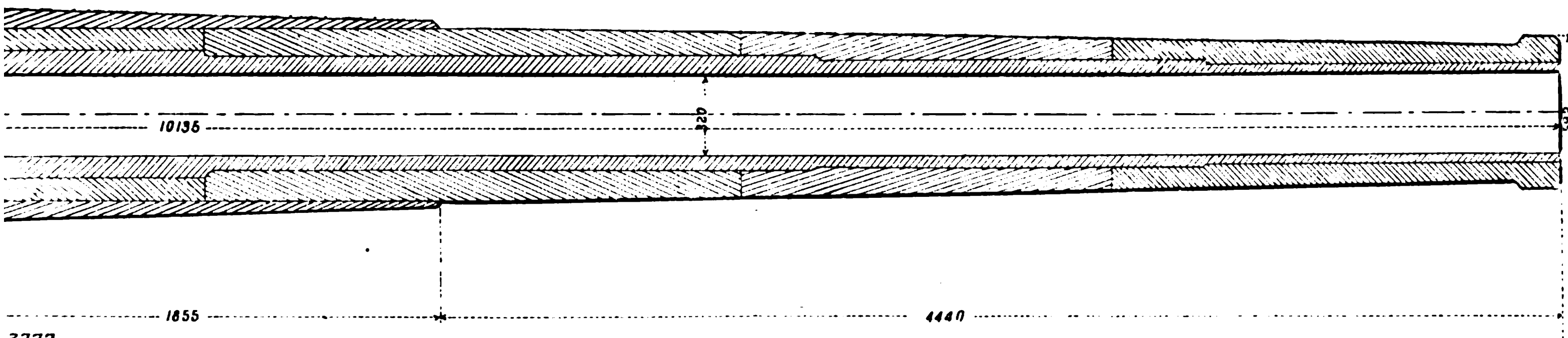
Fig. 192. Section of 32-centimetre

NTIERS DE LA MEDITERRANÉE AT HAVRE.

Page 586.)



, AND 32-CENTIMETRE 66-TON GUN.



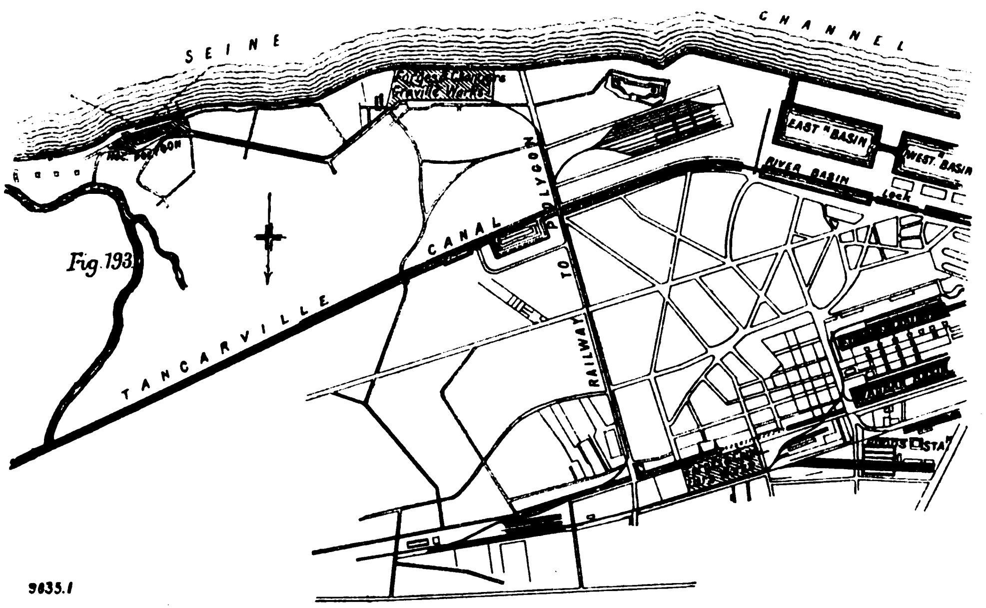
FOR THE JAPANESE GOVERNMENT.

MODERN FRENCH ARTILLERY.
No. XX.

THE FIRING GROUNDS OF THE FORGES ET CHANTIERS COMPANY AT HAVRE.

THE Forges et Chantiers de la Mediterranée is the only private company manufacturing ordnance in France that possesses a complete and well-equipped firing ground. The importance, or rather the absolute necessity of such an addition to a gun factory, may be readily imagined. With the ever-increasing demands for more powerful weapons, and the rapid strides being made with the new explosives, the art of heavy gunmaking becomes less than ever dependent upon theory, and more dependent upon practice. And apart from the fact that principles of design can now be often confirmed or refuted only by experiment, there are numerous details of the highest importance, the value of which can only be ascertained on the firing ground. The efficiency of fuzes; the best method of making up and exploding charges; the testing of each detail of breech mechanism, and of different forms of obturators; the examination of the behaviour of hydraulic brakes, and the carriages to which they are attached; all these and many more, form subjects for continuous and anxious trial during the long and tedious work of perfecting a new design, or modifying standard types to withstand more severe conditions. It often happens that the most carefully conceived plan breaks down utterly under test, not from any fundamental defect in the design, but for want of proper proportions that can be only decided by the ordeal of fire, which determines that this geared wheel must have a certain amount of play, that that one must have none, that such a pin must be a tight fit, and such another must be slack, and so on through a series of slight changes which would not have been thought desirable by the most careful engineer, and which no prevision could have suggested. Results otherwise unattainable are thus rendered possible by a system of trial and error, in which the most minute features of every experiment are carefully recorded by a trained staff, and practice has to be modified according to the direction which the results obtained, indicate. Of course this experience is very costly to acquire; gunnery experiments at the present time can only be effectively pursued by very wealthy manufacturers or by governments. Some of the smokeless powders now employed in France cost no less than 15 francs the kilogramme, so that a 6-in. quick-firing gun will readily consume more than 50*l*. worth of explosives alone during a minute's firing, and the charge for the larger calibres often exceeds 100*l*. for powder. To this has to be added the cost of projectiles, fuzes, &c., to say nothing of damage, deterioration, and the heavy wear and tear inseparable from the terrific shocks resulting from firing heavy charges. A trained and costly staff is also an absolute necessity, otherwise the lessons taught in this expensive manner may be thrown away. Yet all this must be regarded as a part of the establishment charges of an ordnance manufacturing company, to be added to the price of production, and paid for gradually by the purchasers of these costly weapons. To the successful gunmaker a well-equipped polygon possesses the same importance as a good laboratory to the successful scientist.

The plan, Fig. 193, gives an idea of the location of the firing grounds of the Forges et Chantiers, and its position relative to the rest of the company's works. They occupy a large area on the north bank of the estuary of the Seine, here of very considerable width, not far from the shipyard, and connected to the ordnance and general works of the company by a line of railway laid partly on the high road, crossing the Tancarville canal that terminates a little to the westward in its own system of docks and basins that connect it with the port of Havre. Two other lines of railway belong to the company, one joining the main system of the Western Railway Company to the east, and the other running down to the great docks on the west. Everything required for testing at the Polygon has therefore to be taken on trucks from the ordnance works to a junction, and there switched on to the service line that terminates in the firing ground. As the weights to be carried often exceed 60 tons, special trucks are required for the purpose of transporting them. The Polygon occupies a long strip of coast land considerably above the level of the sea, the edge of it looking down on the broad foreshore of the estuary, which is always uncovered except during periods of exceptionally high tides. Sometimes it happens—once in a century it is said—that a combination of tide and wind submerges the land along the coast to a depth of several feet. Such a tide occurred about four months since, when the whole of the firing ground and its equipment was submerged for 4 ft. or 5 ft., causing disaster to the powder stores, measuring instruments, and everything else that could sustain damage. The special advantage of the site selected, and known as the Pointe du Hoc, is that it possesses the four classes of range necessary for ordnance experiments, all four being available from the same row of firing platforms. Immediately opposite the middle of these platforms, and at a sufficient distance from them, is a double covered way protected by ample earthworks, and filled with sand for a length of 50 or 60 yards; this covered way serves to receive projectiles fired into it across the screens connected with the chronographs. From the same platforms, guns can be trained to fire across the estuary when target practice is required, while by directing them to the south-west, long-range firing out to sea is available. Fig 201 (see page 616), gives a very good general idea of the firing grounds. On the right hand are shown the covered ways and protecting earthworks, and immediately opposite them towards the left, are the firing platforms. The railway from the works runs parallel to the northern limit of the Polygon, and terminates beside a long traversing pit at right angles to the railway and parallel to the line of platforms. In this traversing pit, which is long enough to extend beyond the last platform, rails are laid to receive the numerous wheels of a heavy traverser, to the platform of which, rails are bolted; the level of the traverser corresponds to that of the ground. At this level and on both sides of each platform, other rails are laid, in such a way as to form an extension of the lines on the traverser; at the end nearest the railway an additional pair of rails is laid. These arrangements are necessary for moving heavy weights from the railway to any one of the firing platforms. For this purpose a travelling crane capable of handling 80-ton loads is provided; it is illustrated in Fig. 194 (page 612), where it will be seen to consist of a strongly framed derrick mounted on four wheels and carrying on the top a platform and winch. When a truck loaded with a gun has been brought down from the factory (see Fig. 202, page 616) it is run under the crane and raised; the truck is then removed and the loaded crane is placed on the traverser and hauled along to any of the platforms that may be desired. It is then shifted off the traverser over the platform, and the gun is lowered on to the carriage previously prepared for it. An extension of the rails laid in the traverser pit is made to the edge of the coast where an isolated firing platform is fixed; this is used for testing guns at various angles, the elevation of the shore above the sea being sufficient to give the necessary amount of depression. Fig. 202 gives a very good idea of the range of firing platforms, with the protecting bank behind, a locomotive and gun truck on the left-hand side, the traverser and travelling crane, and the traversing pit in front of the row of firing platforms.



PLAN OF THE WORKS AND FIRING GROUNDS OF THE FORGES ET CHANTIERS DE LA MEDITERRANEE AT HAVRE.

These platforms call for some description; they are very simple and efficient, and are admirably arranged for their purpose. On a rigid foundation of concrete and piles, is secured a large circular bedplate of cast iron, in the face of which are a number of slots converging to the centre. All the bedplates—one for each platform—are identical in form and dimensions; they are of course made very strong and heavy to withstand the strains to which they are subjected. The carriages, whether they serve as supports to guns under tests, or are themselves being tested, are secured to the bedplates by bolts that can be moved in the slots, passing through holes in the bedplates of the carriages and secured above by nuts. To complete the system the holes in all types of carriages, which serve ultimately to receive the holding-down bolts on boardship or in forts, are drilled in such positions that when a carriage is placed on a platform the bolt holes coincide with the slots; there is, therefore, no difficulty in making the connection rapidly and securely.

Every precaution is taken to prevent accident to those engaged on the firing ground; immediately at the back of the range of platforms is a long and high embankment, access to the top of which is gained by a stairway at one end, where an observing station is established provided with instruments for noting results obtained with long-range firing (see Fig. 201). At each end of this earthwork is formed a proof chamber entirely screened from the firing platform. A simple and ingenious device has been adopted for observing the general effects of the rounds fired when the guns are directed against the sand-filled covered way; a large mirror mounted on trestles, so as to be portable, is placed opposite the entrance of either proof chamber, and by giving it the necessary angular adjustment, all that takes place at any of the platforms can be minutely observed. Fig. 195, page 613, shows this arrangement clearly. On the caution signal being given that a round will be fired, every one on the ground retires, either to the chamber or behind the embankment, and it is only after a second signal that the lanyard is pulled, or the electrical connection completed by the firing number, whose place also is behind the embankment. By a strict observance of these precautions and by military discipline everywhere, the tests that are constantly being carried on at Hoc have been unattended by any accident. In a light shed at the back of the embankment is a powder store containing only a limited supply of explosives for the day's requirements, the main store being in a suitable magazine. It is in this shed that cartridges are made up of such weights and proportions as are called for by the special experiments being made; the smokeless or semi-smokeless powders now chiefly used, are practically free from danger of premature explosion, unless, indeed, they were incited thereto by the unintentional discharge of the black powder, of which a certain quantity is at hand for making primers for the cartridges.

In another part of the Polygon is a large quadrangle inclosed by heavy earthworks, from the inner slope of which project banks of similar sections cutting up a part of the space into a series of recesses, but leaving a large central space clear. In each of these recesses is a light wooden and iron shed, and a tramway runs around the quadrangle connecting all the sheds together and terminating in a magazine. This is the place where cartridges of various calibres are made up for store; the

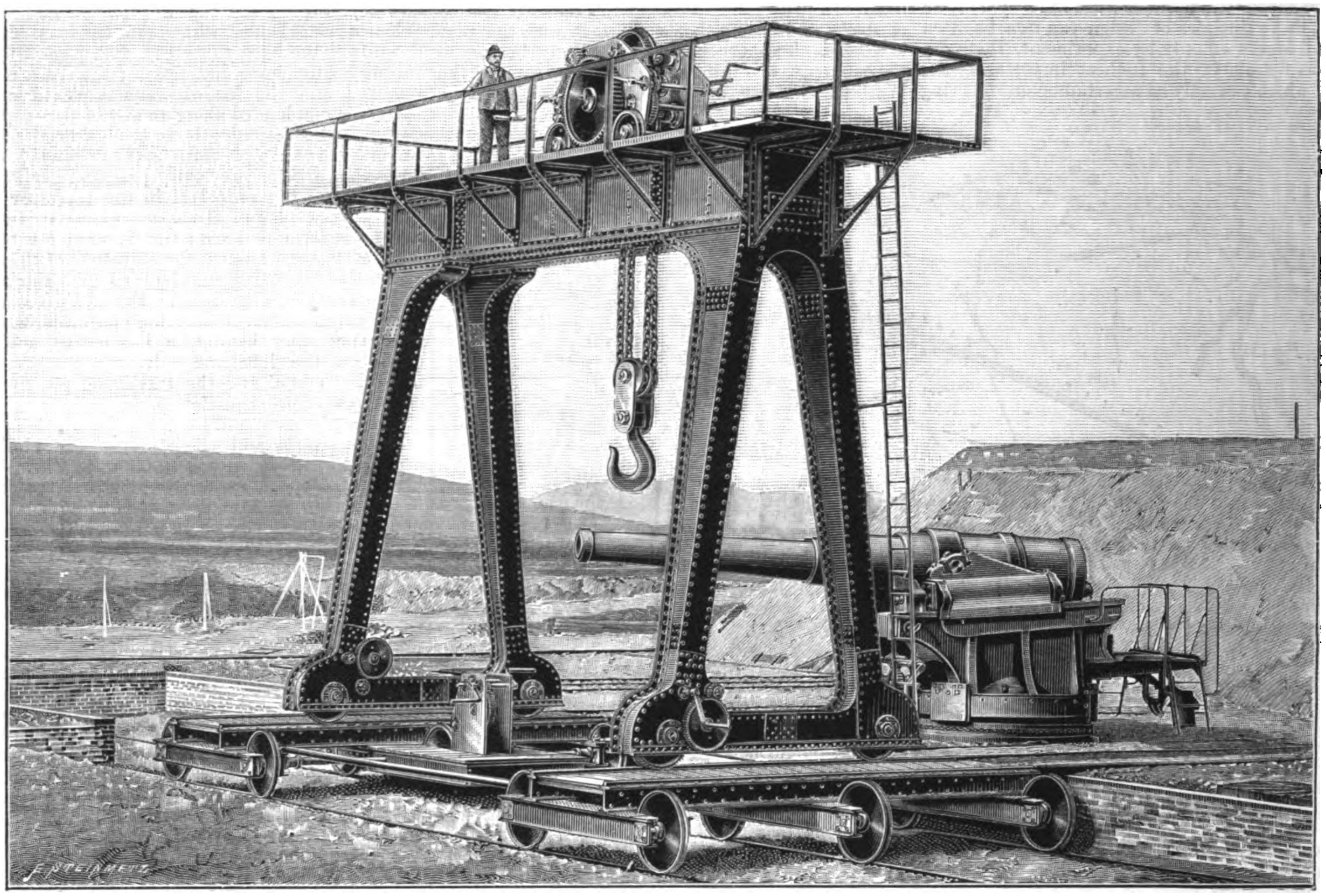


FIG. 194. EIGHTY-TON TRAVELLING CRANE AND TRAVERSER AT FIRING PLATFORMS; THE HOC POLYGON.

arrangement will be understood by reference to Fig. 196. The work, which is more or less dangerous, is thus carried on by a man isolated in each recess, and if an explosion did occur the lightness of the

TABLE X.—DETAILS OF FIRING TESTS WITH A CANET 15-CENT. NAVAL GUN, 36 CALIBRES.

Number of Round.	Projectiles.					Cartridges.					Recoil.		Chronograph Speeds.				Crusher Gauges.								Muzzle Velocities.	
	Number.	Weights.		Distance from Base of Projectile to Breech of Gun.		Powder.	Weight of Charge.		Length.				No. 82.		No. 85.		Heights.				Pressures.					
																	Bottom.		Top.		Bottom.		Top.			
		lb.	kilos.	in.	m.	B.N.	lb.	kilos.	in.	mm	in.	mm	ft.	m.	ft.	m.	in.	mm.	in.	mm.	lb. per sq. in.	kilos. per sq. cent.	lb. per sq. in.	kilos. per sq. cent.	ft.	m.
1	48	94.51	42.960	50.00	1.270	5—1890	22	10	22.84	580	19.65	499	1947	593.1	..	..	.448	11.4	.448	11.4	17,836	1254	17,836	1254	1998	609
2	70	93.83	42.650	49.80	1.265	5—1890	24.2	11	23.62	600	20.08	510	2089	637	2093	637.9	.428	10.9	.428	10.9	22,172	1559	22,172	1550	2149	655
3	34	93.80	42.640	49.80	1.265	5—1890	26.4	12	28.35	720	20.40	518	2211	674.6	2205	671.7	..	..	..	..	27,976	1967	29,043	2042	2270	692
4	7	94.73	43.060	50.00	1.270	5—1890	28.6	13	32.29	820	20.56	522	2356	718.2	2004	710.7	..	..	..	..	32,955	2317	34,149	2401	2411	735
5	42	94.49	42.950	49.88	1.267	5—1890	30.8	14	33.47	850	20.87	530	2487	758	2474	754.2	..	..	..	..	37,434	2632	36,808	2588	2549	777
6	58	94.78	43.085	50.11	1.273	5—1890	28.6	13	33.08	840	20.79	528	2352	717.7	2004	710.7	..	..	..	..	33,552	2359	34,149	2401	2408	734
7	74	93.94	42.700	49.84	1.266	5—1890	30.8	14	33.86	860	20.95	532	2461	749.9	2444	744.7	..	..	..	..	40,122	2821	37,804	2658	2519	768
8	60	94.71	43.050	49.88	1.267	5—1890	30.8	14	33.86	860	20.95	532	2467	752	2461	749.9	..	..	..	..	36,325	2554	37,434	2632	2532	772
9	88	93.94	42.700	49.96	1.269	5—1890	26.4	12	28.35	720	21.34	542	2206	672.5	2205	672.1	..	..	..	..	31,688	2228	..	..	2270	692
10	37	93.80	42.620	50.00	1.270	5—1890	33.1	15	33.86	860	21.50	546	2576	785.1	2572	783.9	..	..	..	..	47,375	3331	43,848	3083	2648	807
11	61	94.48	42.920	50.07	1.272	5—1890	33.1	15	33.86	860	21.54	547	2587	788.6	2589	789.2	..	..	..	..	41,414	2912	45,754	3217	2661	811

Fuzes: Obturating fuze, naval model. Obturation: Good. Breech manipulation: Quite easy. Angle of fire: 0 deg.

shed and the heavy banks on each side of it would, it is hoped, direct the explosion upwards without affecting the adjoining sheds; this theory has not up to the present been confirmed or refuted by experiment. As the cartridges are completed they are filled into light iron cases of different types, according to varying calibres. Figs. 197 to 200, page 614, illustrate their construction; from these views it will be seen that they are made of sheet copper, rectangular in section with rounded corners, and finished at the top and bottom with flanged joints. In the top of each case is a circular opening stiffened with a brass ring over which a second ring is screwed; the top of the inner ring forms a seat for the brass cover to this opening which is hinged as shown and secured by a bayonet joint that is operated by turning a lever attached to the centre of the cover to and fro. Figs. 197 and 198 are respectively a section and plan of a case to hold four half cartridges for a 27-cent. gun, and Figs. 199 and 200 are corresponding views for one containing six cartridges for a 15-cent. gun. Handles for moving these cases are attached to the sides as shown in the diagrams.

Beyond the various protective earthworks are situated rooms for the ballistic observers (see the left-hand side of Fig. 201); the instruments comprise Le Boulengé chronographs and the Peigné telemeters, to which we shall refer in a subsequent article. These instruments are of course sufficiently removed from the firing platforms to be uninfluenced by any shock or vibration. Besides these rooms is the dwelling-house for the men employed at the Polygon; various signalling towers and ranging stations complete this very important installation.

The relations of the Forges et Chantiers Company with the French Government are such that a company of artillery privates with their officers remain constantly at the Polygon under the control of the company, the same men remaining for a term of years before being exchanged. All the manipulations connected with the testing of guns and carriages are carried out precisely under the same conditions as at a State factory, and all observations and records are taken by the officers in charge, and by the inspectors employed by the purchasers of matériel, prior to acceptance. All reports are framed upon a series of type schedules, and are filled up so that corresponding tests can be immediately compared. Thus, excepting for their own private information, the directors of the gun factory take no part in preparing any of the reports which are in every case of an official character; by this arrangement they are entirely cleared from any suggestion that might be made of regarding results in too favourable a light, and can accept with more confidence the records obtained than if they were made by their own employés.

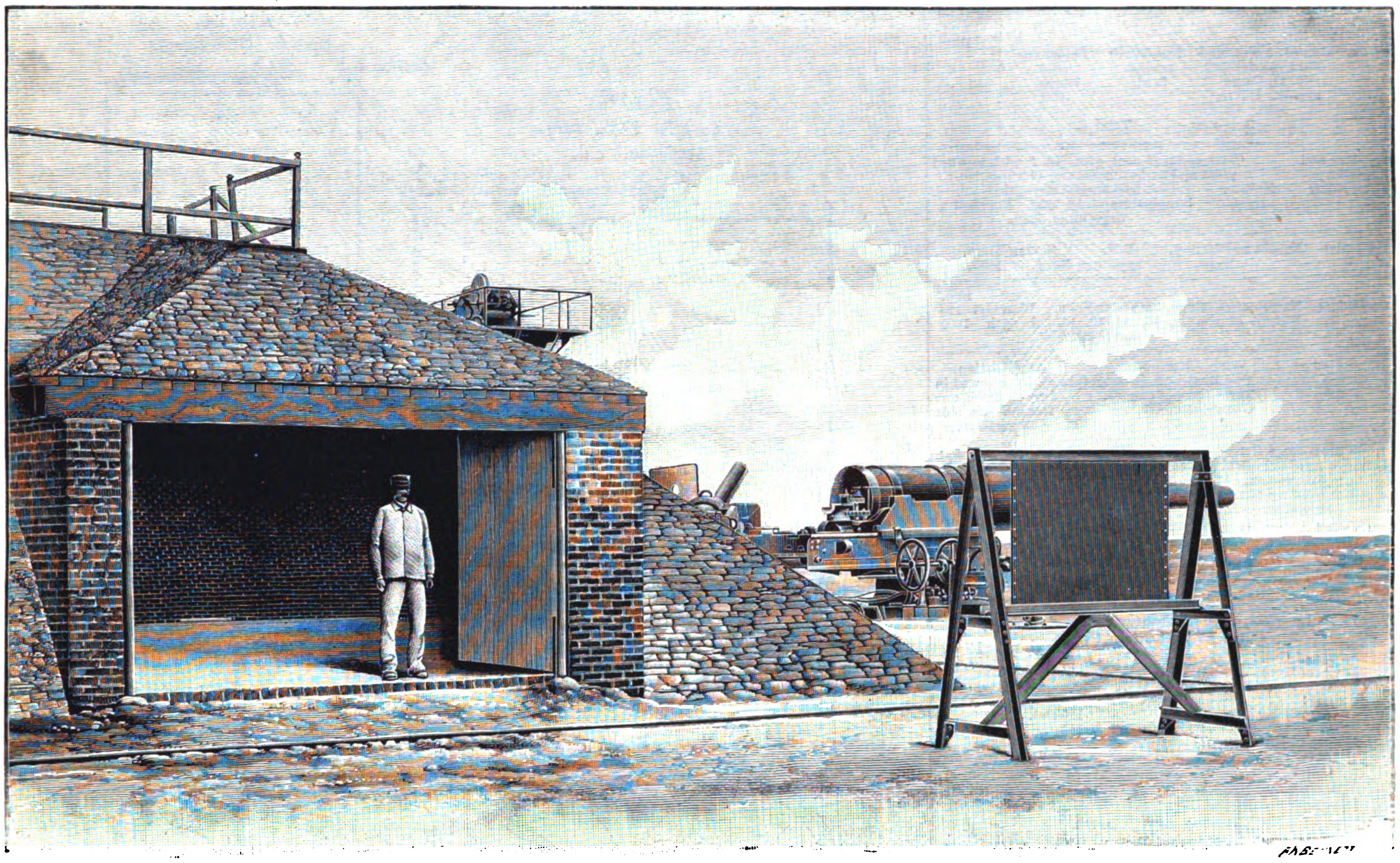


FIG. 195. ARRANGEMENT OF MIRROR AT THE HOC POLYGON FOR VIEWING FIRING TESTS FROM PROOF CHAMBER.

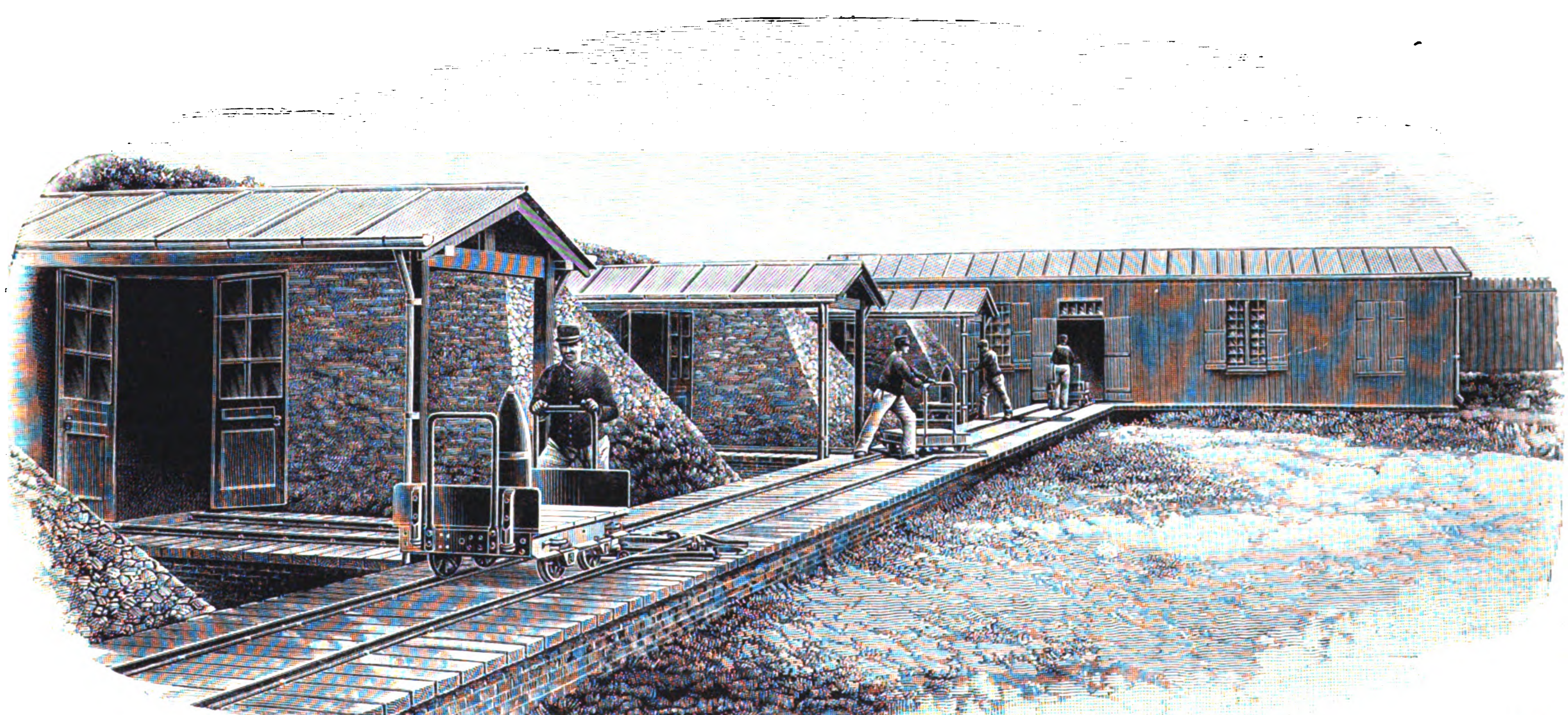


FIG. 196. PROTECTED INCLOSURE FOR CHARGING CARTRIDGES AT THE HOC POLYGON.

We reproduce in the accompanying Tables some of the schedules employed by the company; Nos. IX. and X. refer to some very interesting tests recently made with a 15-cent. naval gun on a forward pivotting carriage that will form part of the armament of the new Greek ironclad recently completed at Havre. The explosive used was one of the new semi-smokeless powders, the base of which consists of dissolved gun-cotton mixed with nitrates to check the velocity of combustion, so that it forms one of the so-called slow-burning powders, though, as a matter of fact, the combustion is almost instantaneous. As delivered for making up into cartridges, this explosive is cut into strips about 8 in. long and ¼ in. thick; these strips are bound loosely into fagots which fit easily into the powder chamber, and are packed one on top of another in a canvas bag, the length of which, of course, varies with the weight of charge. In the open air this explosive burns, but without much intensity, and it cannot be fired without a comparatively heavy priming charge of gunpowder; an ordinary percussion fuze is then sufficient to produce ignition. The small quantity of smoke produced with this explosive possesses but little density, and lasts but for a very short time, falling to the ground, and quickly clearing away. Of its energy the annexed Tables give a sufficient proof; we think

TABLE IX.—*Forges et Chantiers de la Mediterranée.*

Direction de l'Atelier de l'Artillerie.	Government,

Firing experiments made on May 7, 1890, at the Polygon of Hoc. Order No. 438.

Summary of Report.

Object of experiments.	Reception firing tests of 15-cent. Canet gun No. 11 and of forward pivotting carriage No. 8.

Summary of Results.

				Gun.	Carriage.
Gun.	Gun of 15 cent. and 36 cal., model 1887, No. 11, Canet system, Havre, 1889.	Number of rounds fired.	Before the trial	0	0
			During trial.	8	8
			Total	8	8

Carriage and platform.		Carriage for 15-cent. gun, No. 8 with forward pivot and hydraulic brakes, Platform No. 5.
Projectiles.	Nature.	Cast iron special strength.
	Date.	Supplied March 18, 1889. Finished September, 1889.

Powder.	Nature and factory.	B.N.	Sevran Livry.
	Type.	Specimen No. 5.	1890.

Cartridges.	Nature of envelope, asbestos linen.		mm.
	Weight of charge, 10, 11, 12, 13, and 14 kilos.	Diameter	178
		Length	1200

	Nature.	Application.
Ballistic apparatus employed.	Two Boulengé chronographs. Three crusher gauges. One velocimeter.	Two screwed in breech-block, one free on left side of carriage.

Chronographs.	Chronograph No. 82.	Chronograph No. 55.
Distance from muzzle of gun to first screen.	50.18 m.	51.18 m.
Distance from muzzle of gun to second screen.	100.18 m.	101.18 m.

Barometer 760. Thermometer 15 deg. Hygrometer 0.
Wind: Direction north. Force light.
Persons present at trials.
Present MM.

TABLE XI.—*Comparative Results with Armstrong and Canet Breechloading Guns.*

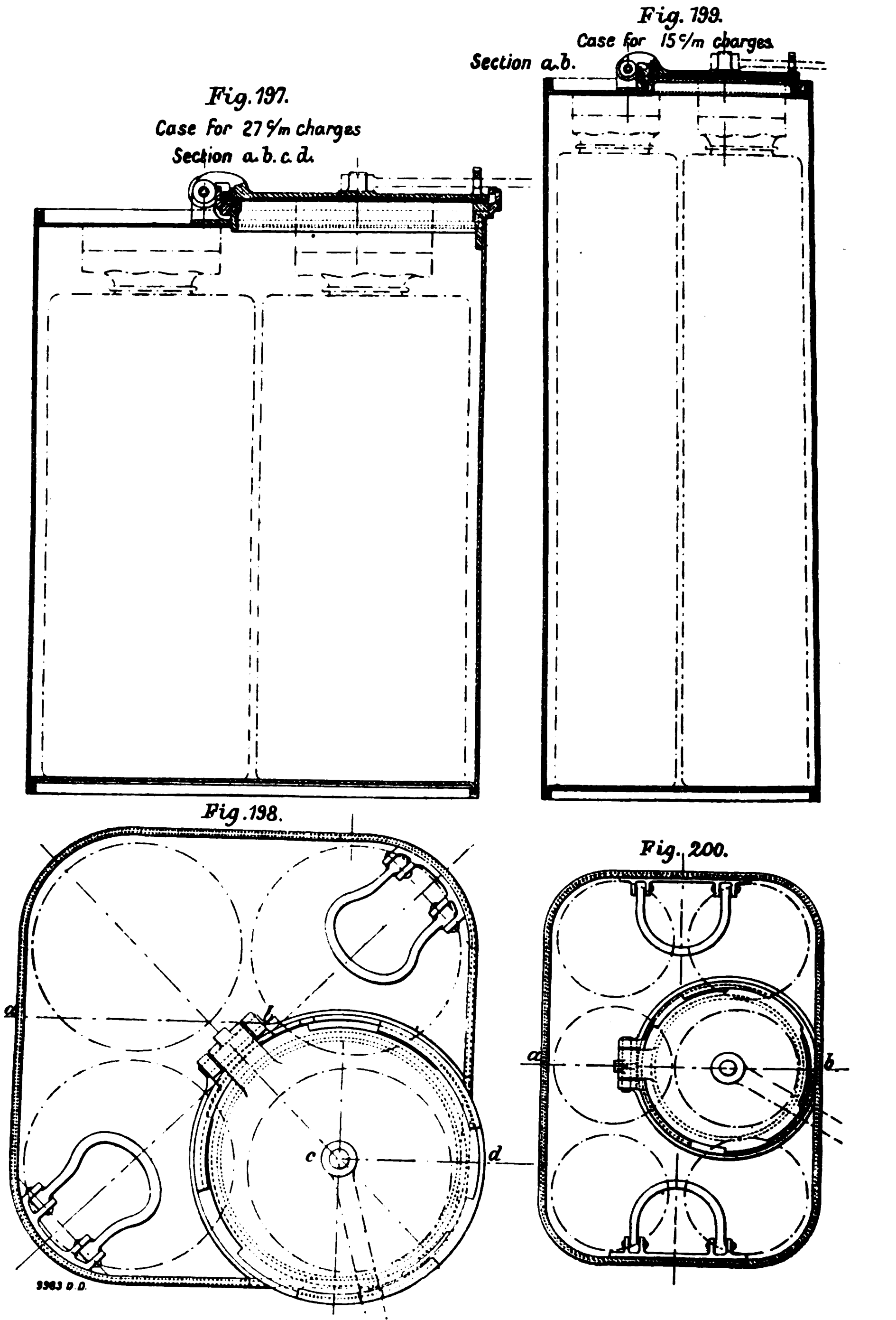
Nature of Gun:
Armstrong .. .. 6 in. quick-firing
Canet .. .. 5.90 ,, naval
Weight:
Armstrong .. .. 110 cwt.
Canet .. .. 114 ,,
Length of bore:
Armstrong .. .. 40 calibres
Canet .. .. 34 ,,

Number of Rounds.	Class of Gun.	Nature of Charge.	Weight of Charge.	Weight of Projectile.	Initial Velocity.
			lb.	lb.	ft.
1	Armstrong ..	Brown prismatic	55	100	2110
1	Canet ..	Semi-smokeless	**22**	**94.51**	**1996**
2	Armstrong ..	Brown prismatic	60	100	2256
2	Canet ..	Semi-smokeless	**24.2**	**93.83**	**2149**
3	Armstrong ..	Smokeless prismatic	35	100	2230
3	Canet ..	Semi-smokeless	**26.4**	**93.90**	**2270**
4	Armstrong ..	Smokeless prismatic	37.5	100	2320
4	Canet ..	Semi-smokeless	**28.6**	**94.73**	**2411**
5	Armstrong ..	Smokeless prismatic	38	100	2336
5	Canet ..	Semi-smokeless	**30.8**	**94.49**	**2549**
6	Armstrong ..	Smokeless prismatic	39	100	2383
6	Canet ..	Semi-smokeless	**28.6**	**94.78**	**2466**
7	Armstrong ..	Smokeless prismatic	40	100	2422
7	Canet ..	Semi-smokeless	**30.8**	**93.94**	**2519**
8	Armstrong ..	Smokeless prismatic	40.5	100	2454
8	Canet ..	Semi-smokeless	**30.8**	**94.71**	**2532**

TABLE XII.—*Comparative Results Obtained with Smokeless Powder in 6 in. and 5.9 in. Guns.*

—	1. Armstrong.	2. Canet.	3. Canet quick-firing.
Bore .. .. in.	6	5.9	5.9
Weight of gun .. .. .. cwt.	110	114	100
Length of bore .. .. .. cal.	40	34	40
Weight of projectiles .. .. lb.	100	94.798	88.892
,, charge .. .. .. ,,	38	30.86	33.069
Nature of powder	smokeless	smokeless	smokeless
Initial velocity .. .. .. ft.	2340	2533	2749
Total energy .. .. .. foot-tons	3797	4215	4655
Foot-tons energy per ton of gun	626.8	751.3	951.6
,, ,, pound of powder ..	97.28	136.6	140.8
Strain on gun .. tons per sq. in.	16.5	16.5	18.4

we are correct in saying that no such results have ever before been obtained with a gun of the same calibre and length of bore (36 cal.). For the sake of comparison we give in Tables XI. and XII. the records of one round from an Armstrong quick-firing 6-in. gun of 40 calibres made a few months since, with smokeless powder, and in a third column are given the corresponding figures from a quick-firing Canet gun of 15 cent. (40 cal.) made in March last with French semi-smokeless powder. It will be noticed in Table XII. that while the foot-tons of energy developed in the Elswick gun were 3797, the energy of the Canet gun was 4215 foot-tons, while the corresponding figures for the 15-cent. quick-firing gun are even more remarkable. During its latest trials, made a few days ago, this gun surpassed all its previous records. With a charge of stronger explosive, a velocity of no less than *2887 ft. per second* was obtained, developing a total energy of 5136 foot-tons, equivalent to *1027.2 tons* per ton weight of gun. And this without any undue fatigue of the steel. It will also be noticed, in columns 1 and 2, that the measured strain in the 15-cent. naval guns was alike in each case, but it is evident that in the Canet 15-cent. this strain must have been sustained farther along the chase. Quite apart from any question of relative merit in the guns themselves, these Tables are of the highest possible interest as indicating a rapid development in the manufacture of explosives, and suggest the necessity of consequent modifications in the design of ordnance to meet the greater uniformity in the strains set up along the gun. It is for this reason that the approaching trial of the first 66-ton Japanese gun will be of especial importance to artillerists.



FIGS. 197 TO 200. DETAILS OF BOXES FOR STORING LOADED CARTRIDGES.

TABLE XIII.—*Method of Tabulating Tests of Carriages.*

Forges et Chantiers de la Mediterranée.

Direction de l'Atelier d'Artillerie.	Government, France, War Department.

Order No. 439.
Firing Trials of May 7, 1890, at the Hoc Polygon.
General Report of Trials.
Object of Trials.—Recèption tests of central pivotting coast defence carriage for 240 mm. gun.
General Particulars.

Nature of gun.	Canon of 240 mm. bore No. 8, De Bange system Creusôt steel.	Number of rounds fired.	Before the trial	0
			After ,,	5
			Total ..	5

Carriage and platform.	Cast-iron carriage, Vavasseur-Canet system model 1886. Platform No. 4.
Projectiles.	Cast-iron cylindrical, from Rennes.
Powder.	A 26/34 and P B 2.
Cartridges.	Nature of envelope, asbestos cloth. Weight of charge, 46.2 lb., 92.4 lb., 116.6 lb.

Barometer 760. Thermometer 15 deg. Hygrometer 0.
Wind: Direction north. Force light.

TABLE XIV.—*Particulars of Rounds Fired for Testing 240-Millimetre Gun Carriage.*

Number of Round.	Weight of Projectile.	Nature of Powder.	Weight of Charge.	Recoil.	—	Elevation.
	lb.		lb.	in.		deg.
1	374	A 26/34	46.2	40.16	Projectile fired into sand	angle 0
2	374	A 26/34	92.4	44.28	,, ,,	,, 0
3	374	P B 2	116.6	45.07	,, ,,	,, 0
4	374	A 26/34	92.4	43.50	,, ,, sea	,, 20
5	374	P B 2	116.6	44.28	,, ,, ,,	,, 20

Friction fuze; model, 1874. Obturation; good. Plastic obturator. Breech manipulation; easy.

At the Hoc firing grounds three crusher gauges are employed at each round; two screwed into the mushroom head of the obturator, one near the bottom, and one near the top of the bore, while the third is left loose in the chamber. In addition to these gauges the gun is connected with a Sébert velocimeter to record the characteristics of recoil, and incidentally the velocity of the projectile; the latter value is, however, obtained direct with Le Boulengé chronographs.

Tables XIII. and XIV. show the form adopted by the Forges et Chantiers Company for recording the tests of gun carriages. The mounting to which these Tables specially refer, was one of a large number of cast-iron coast defence carriages for 24-cent. guns made for the French Government. The regulation trial consists of firing three rounds with varying charges into the sand-filled covered way, and two rounds out to sea at a maximum elevation. The guns for trials of this nature are supplied by the War Department, just as for testing naval carriages, such as those for the Marceau, they are furnished by the Marine.

THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 585.)

IN our last issue we brought our notice of the recent meeting of this Institution up to the end of the first day, and we now proceed to deal with the rest of the proceedings.

ALUMINIUM IN STEEL.

The first paper taken on Thursday, the 8th inst., was that of Mr. W. J. Keep, of Detroit, Michigan, the title being "Aluminium in Carburetted Iron." This paper we shall shortly print in full, and we may therefore at once turn to the discussion.

Mr. James Riley was the first speaker. He pointed out that nothing had excited more interest of late than the use of aluminium in the manufacture of steel. He had been pressed to use it, and its virtues had been much extolled, but he had not formed so high an opinion of its merits as many of his friends appeared to do; at any rate, he thought the advantages gained were too dearly purchased at a cost of from 1*l.* to 2*l.* per ton on the steel produced. Aluminium was, however, becoming cheaper, and if the cost were sufficiently reduced, its use would be a matter for consideration. He would say that the purpose for which he had used aluminium was to endeavour to lower the melting point of the steel, so that in making complicated castings there should not be the same risk of cracks during cooling, a result which naturally depended upon the temperature to which the metal had to be brought to produce fluidity. Aluminium certainly did have this effect to a remarkable degree. An alloy was made of 20 per cent. of aluminium of second quality, and 80 per cent. of steel, and which gave 18.3 per cent. of aluminium on analysis. The specific gravity was 6.23, although the mean specific gravity of the two substances would be 6.89. This alloy was very fluid when in the crucible, but it set with extreme rapidity, so much so that only half the contents of the pot could be poured out. This of course was an extreme case, but in some of the steels containing large percentages of aluminium the same effect was observed. With 2¾ to 4 per cent. of aluminium, it was noticeable. An addition of 8 per cent. of aluminium made the alloy so short and crystalline that it was useless for work. As to the effects on the casting, he did not find them very great. The tensile strength was slightly increased; not very much, in fact they often found the superiority of one cast of ordinary steel over another as great as that of a sample of aluminium steel over ordinary steel. It might be two or three tons to the square inch. The elastic limit was considerably raised, and there was an addition to ductility. With one per cent. of aluminium these results would all be found. These advantages were, however, more apparent in the testing room than in actual use. The increase of fluidity was, after all, the great advantage given by the use of aluminium. One of the great sources of cost of steel castings was the amount of scrap that was necessary owing to the large heads that had to be given. If, owing to better running of the steel, the moulds were filled with sound metal, heads and gates could be reduced perhaps 75 per cent.; or even if they could be brought down 50 per cent. it might pay to spend a certain amount on aluminium. So far as his own experience went, however, and he had made hundreds of tests, he had ceased to use aluminium more than a year before, because he did not find any economy in its application; in fact the advantages gained in the manner indicated were not sufficient to equal the cost of the aluminium at that time. Lately, however, the merits of aluminium had again been brought forward, and he had been much pressed to use it. He was told of important results obtained by people, although he never met the people themselves. However, the advantages claimed were so great that he had been induced to have another set of experiments made upon a number of tests including a wide range of percentages of aluminium. At the present time, however, his mind was pretty well made up that there would be no commercial advantage in the use of aluminium in steel except perhaps for making thin castings.

Mr. Spencer, of Newburn, said that he could indorse most of what had fallen from Mr. Riley; in fact he (Mr. Riley) had said very much what the speaker would have said himself, with regard to the use of aluminium in steelmaking. He would only add that in the use of this alloy much depended upon the application, and he found that it would not do for all grades of carbon. With higher percentages of the latter aluminium was less advisable to use, for with higher grades the results would not come up to the anticipations many people formed. In castings there was considerable advantage from causes which Mr. Riley had pointed out, and no doubt it would be useful in the production of intricate castings.

Mr. J. Riley said he had intended to speak upon an important point. It was that in big charges of metal, from 10 to 15 tons, the effect of the aluminium might be dissipated before the end of the charge was reached when making castings. The experiments hitherto made, upon which opinions had been formed, were chiefly upon small quantities of metal in crucibles, and the results in such cases were often very different to those which would be obtained when trying the same thing on a larger scale. In this respect it differed from silico-spiegel, the effect of which will last to the end. The use of aluminium in the effect it had on the production of other alloys was also of great interest. For instance, if copper and iron were melted together, and the resultant mass were examined under a microscope, it would be found that the copper was simply distributed throughout the mass, and the two were not really alloyed; but if aluminium were introduced the alloy was found to be perfect. In the case of nickel steel this property of aluminium had been found of value, the introduction of the latter at the end of the charge having the effect of producing a very perfect alloy.

Sir Lowthian Bell wished to indorse Mr. Riley's last remark. One of the chief uses for aluminium was for the manufacture of aluminium bronze. In making that alloy the temperature of the melted copper was increased when the aluminium was introduced, thus showing that chemical union was taking place between the two.

Mr. A. Allen was of opinion that often there were traces of aluminium in iron and steel without the fact being recognised. The chemists engaged in works naturally cut their work as short as possible, and professional chemists were given instructions what to test for when a sample of iron or steel was sent to them. The result was that tests were only made for the commoner or more important elements, and aluminium might often be present without there being any knowledge of its presence. Faraday said he had found aluminium in steel, but Dr. Percy had thrown cold water on this and intimated that it was an analytical error and had said at any rate it could not have been English steel. Many persons had been misled by this authoritative expression of opinion. The speaker thought that the number of samples of pig iron which had been analysed and which had been proved not to contain aluminium was exceedingly small. It was not easy to estimate aluminium but there was one good published method. He had known a case in which one chemist declared there was 2 per cent. of aluminium in a sample of steel whilst another analyst had said there was none at all. It was not certain that aluminium remained although the metal had been through treatment intended to introduce it, and he would point out, with regard to what Mr. James Riley had said, that though aluminium might be put into the pot it was by no means certain it would be found in the steel. It would be interesting if Mr. Riley would have analyses made of the various samples of steel he had made so as to find if it really remained. With regard to aluminium bronze it would be of interest to the meeting to hear that at Newcastle they were using copper to recover aluminium from the slag, and this was found quite successful.

Dr. E. Riley said that he could hardly agree with what had been previously stated with regard to aluminium in pig iron. He had had samples of iron and copper sent to him for analysis specially with regard to aluminium, and he had failed to find it. This had caused some people to express a good deal of surprise and annoyance, as the metal had been treated to contain aluminium. A young chemist had found 2 per cent. of the alloy in one of these samples in which Dr. Riley had failed to identify it; but on inquiry the speaker discovered that the reputed aluminium was no doubt really silicon which had been taken from the vessels used in making the tests. It was difficult to say positively when aluminium was present if only in small quantities, and he was quite satisfied that aluminium might often be put into iron to produce certain results, but when the iron came to be tested, the aluminium would be found to have disappeared. He would like to ask Mr. James Riley whether aluminium had an effect in taking the oxygen out of iron. In that case it would account for the fact.

Mr. Stead, of Middlesbrough, said that for some time past he had given a good deal of attention to the subject of the effect of aluminium in steel and a means of analysis to discover its presence in that metal. It was the latter point that would more particularly occupy his attention. He had never failed to find a trace when it had been added to steel, although some of it might have disappeared. He agreed with Dr. Riley that it might be removed from steel by oxidisation, for he had made experiments to that effect. In this way aluminium would be removed from steel subject to an oxidising influence. If carbonic oxide were blown through a charge of steel it would remove all the aluminium present except indications in the form of alumina, caused by the action of the oxygen on the aluminium. The speaker next described a method of testing for aluminium which he had set forth in a paper read before the Society of Chemical Industry; and he pointed out how in this method the errors likely to arise in testing by the crude plans often followed might be escaped. Mr. Stead urged that when steel manufacturers sent samples to analysts they should say for just what elements they wished tests to be made. A complete analysis of steel would occupy about a fortnight, for it was really a very complicated piece of work to undertake. He had on one occasion been blamed for returning an analysis of a steel in which he had not shown aluminium. He had, however, had no instructions with regard to this alloy, and he had followed the usual course, testing only for the more ordinary constituents. It was a curious thing that when steel and aluminium were mixed that an increase in volume took place. For this he could offer no explanation, but he gave instances, showing that the fact existed.

Mr. Hadfield referred to the debt of gratitude the members owed to Mr. Keep for putting the results of his researches before the Institute. For a long time past it had been stated that aluminium lowered the melting point of iron. This the speaker did not consider to offer a sufficient explanation of the fact that the fluidity of iron and steel was increased by aluminium. He would attribute the latter phenomenon to one or two causes; firstly, by the expansion of the aluminium itself; or, secondly, that when aluminium was oxidised to alumina it produced a very fusible slag. The latter, the speaker thought, the more probable cause. Mr. Galbraith in his paper on "Certain Chemical Phenomena in the Manufacture of Steel" gave what the speaker considered the real explanation of the part played by aluminium, although he was not referring to the latter. He said that "a metal charged with oxide of iron, no matter what amount of heat you put into it, will run cold owing to the infusibility of the oxide." In melting iron and steel there was, as a rule, some oxide present, and it would therefore seem probable that aluminium acted beneficially by reducing this infusible slag and cleansing the molten bath. The point of fusion was not reduced, as Mr. Hadfield could prove, owing to the assistance of M. Osmond. He sent the latter a carbonless iron alloy containing 5 per cent. of aluminium. This alloy had been heated to 1475 deg. Cent., as tested by the Le Chatelier long, to be used for heel, centre, and mitre-posts. These would be about 12 in. by 16 in. in section, or say 62 cubic feet, which would be about $1\frac{7}{8}$ tons when dressed. There are other timbers perhaps heavier than this, but not so long. The difficulty of getting together long massive logs of greenheart such as we have described is very great.

The mitre-posts are also bolted together with diagonal bolts. The beams are tenoned into heel and panel-posts, the latter obviating very long beams, and, indeed, it would be impossible to get sufficiently large timber for these very big gates, excepting by the method described. The heel-posts are 13 in. radius. The heel-post, caps, and plates are of steel; the pivot plates are of steel and the pivots are of steel also. There is a horizontal strap 7 in. by $\frac{3}{8}$ in. on each side at the top. There are steel collars to the panel-posts top and bottom.

(To be continued.)

MODERN FRENCH ARTILLERY.

No. XXI.

THE FIRING GROUNDS OF THE FORGES ET CHANTIERS COMPANY AT HAVRE—*concluded.*

IN describing the arrangements of the Hoc Polygon we referred to the various instruments employed of which, of new and very ingenious types, designed by Colonel Peigné, are installed on the firing grounds. Finally, for testing the behaviour of gun-carriages under fire, the various phenomena attending their recoil, bringing back the gun to firing position, &c., and incidentally, for the measurement of the velocity of the projectile by that of the recoil of the gun, the velocimeter of Général Sébert is always employed. To give a detailed description of these various installations would require more space than we have at our disposal, but we propose to convey in as few words as possible some idea of the principles on which they are based, and the mode in which the instruments are employed.

The construction and the mode of working of the Boulengé chronograph are almost too well known to require special reference; a short general notice of it will therefore suffice in this place. The frame of the instrument consists of a long brass column, Figs. 204 and 205, attached to a triangular foot which is provided with adjusting screws *b b* for levelling the base, so that the standard can be set absolutely vertical. On each side of the standard are sliding brackets that can be fixed in any desired position by set screws; in operating the instrument one bracket is always set higher than the other. The brackets carry, each an the resistance they offer to gravity; two independent circuits are therefore employed with a proportional numbers of cells. Suitable arrangements are made for cutting off the current from both magnets either simultaneously or at an interval, with the result that the bars drop either together or one after the other. The function of the shorter bar F is simply to start mechanism by which a record can be cut on the surface of the longer bar C. The distance of the mark thus made on the latter, measured from a datum point also engraved on it, indicates the time occupied by the bar in falling through that distance. To avoid calculation, tables of equivalents are supplied to the observer, by which the whole range of distances, in inches and thousandths of an inch, are reduced to the corresponding velocities of a projectile in feet per second. The distances marked on the bar C are measured by a graduated scale on which the datum points are marked. The bar on which these records are made is sheathed with a thin tube of zinc D which receives them, and which may be renewed as often as desirable. The mechanism by which the marks are engraved is of a very simple character. Immediately below the shorter bar F is a tube L to receive it as it falls, and beneath this tube, but clear of it, is a small disc connected by means

FIG. 204.

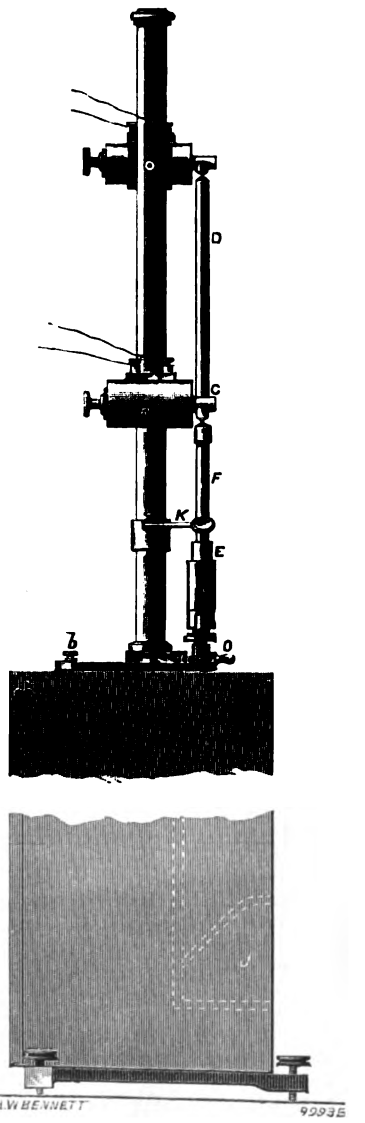


FIG. 205.

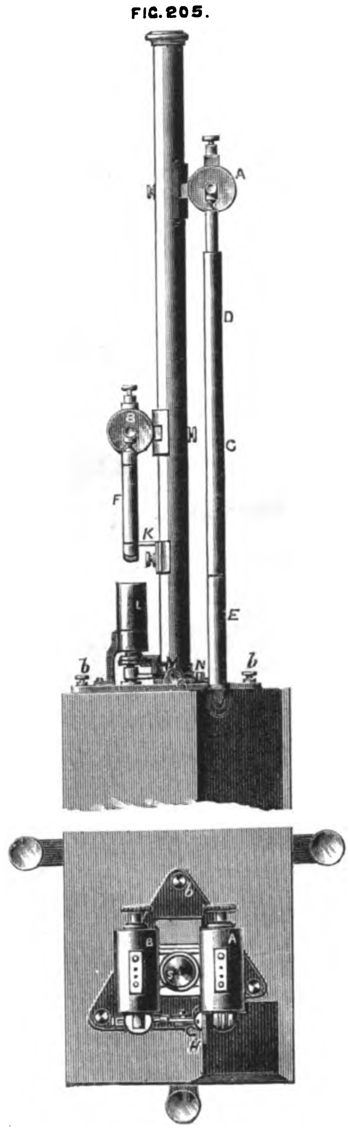


FIG. 206

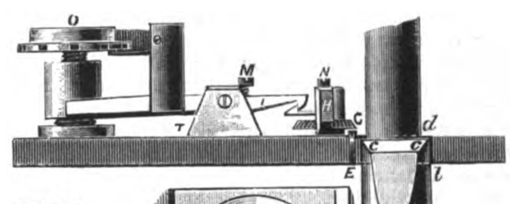


FIG. 207

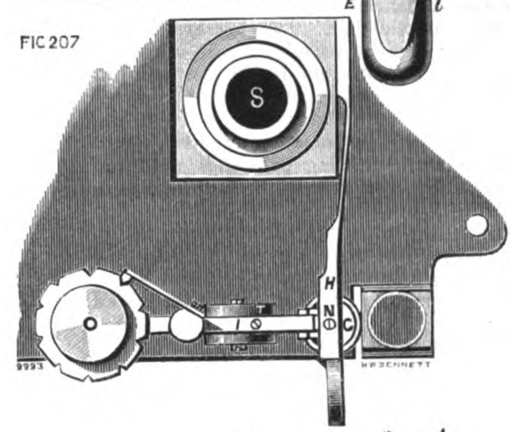


FIG. 208.

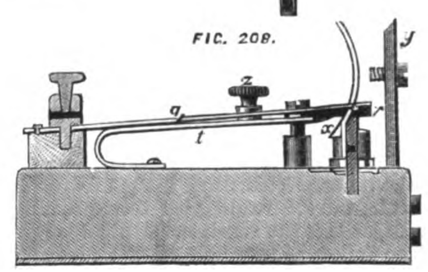
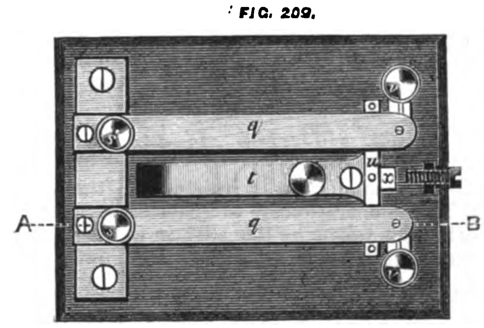


FIG. 209.



DIAGRAMS SHOWING CONSTRUCTION OF THE LE BOULENGÉ CHRONOGRAPH.

for measuring the results obtained, and the phenomena developed, when testing guns and carriages. For the former, the principal data required refer to velocities of projectiles from which striking energies, power of penetration, energy of shot per ton of gun, per pound of explosive, &c., are deduced. To obtain this information two Le Boulengé chronographs with screens are employed. The results of long-range firing, range, accuracy in direction and elevation, together with the various deviations, and so forth, are obtained by means of telemeters, several electro-magnet A B, with electrical connections to suitable batteries, the current from which is so adjusted by means of resistances, as just to support an iron bar. The proper working of this part of the instrument is checked by adding small sliding brass weights to the bars, the necessary strength of current being such as to support the bars, while it is insufficient to carry the weights in addition. The bars thus held by the two magnets are of different lengths and weights, the strength of the currents being proportioned to of a central stem to a lever pivotted to a bracket on the frame of the instrument. The detail of this part of the chronograph is given in Figs. 206 and 207. In these figures, the disc is shown at O, and the lever beneath it at I. The end of this lever opposite the disc is provided with a catch that holds a detent which arrests the action of a spring that drives a small revolving disc G with a cutting edge. When the bar falls on the table its weight strikes up the catch and liberates the spring, causing the knife to revolve. The longer bar when released falls through guides until it is arrested by the table.

In the circuit by which the longer bar is sustained is included a number of fine copper wires, passed across a large wooden frame, which is placed in front of the gun, and at a safe distance from it. Similar wires on a second frame at some distance from the first are connected with the circuit belonging to the battery of the shorter bar; these frames constitute the screens through which the projectile has to pass. The wires from both batteries are coupled to a circuit breaker, so arranged that the current can be cut off from each circuit simultaneously. This instrument (Figs. 206 and 207) consists of a small insulated base, on which is secured a bent plate spring t, carrying at its free end a cross strip of insulating material u. On each side of this spring are two steel plates $q\,q^1$, in connection at one end with two of the binding screws; the two other binding screws have metal pins $r\,r$ connected to them, which are immediately beneath the steel plate just alluded to. By depressing the central spring the plates are depressed, and the two circuits are completed, and they can be held in this position by a latch x, which retains the end of the spring. By releasing this latch, however, the spring flies up, taking with it the steel plates, and breaking both circuits simultaneously. This device is rendered necessary for accurate readings of the chronograph. If both the bars be released simultaneously by operating the circuit breaker, the distance through which the longer bar will fall before the shorter one has struck the disc and put the marking knife in operation, is a definite amount, occupying a fixed period, and this having been accurately determined, must be allowed for in measuring the distances afterwards recorded on the zinc casing of the bar. The height of fall of the shorter bar can be regulated within certain limits by adjusting the disc on which it drops, but the distance is usually a fixed one for all experiments. Upon the graduated rule with which the distances marked on the bar are measured, a zero line and a line corresponding with that produced by the circuit breaker, when the instrument is adjusted normally, are engraved, and it is necessary, before commencing a series of experiments, to ascertain whether the marking produced by the chronograph, when both bars are released simultaneously, corresponds with that on the graduated rule.

When the gun is fired, the projectile, which is generally flat-headed, to insure fracture of one of the copper wires on the screens, passes through the first and afterwards through the second screen. When the wires in the first series are broken, the circuit of the longer bar is interrupted, and the bar falls. When the second screen is passed the other circuit is broken, the shorter bar falls, starting the knife, which makes a mark on the longer bar, the position of which depends on the length of time the projectile has taken in passing from one screen to the other. This mark is read off on the graduated scale, and the reading is referred to a table of velocities, so that the result can be obtained at a glance. The following example of the mode of calculating velocities by this instrument is taken from the Official Treatise on the Manufacture of Ordnance: "Let the height $h = 8.573$ in., through which the chronometer (the longer bar) has fallen, measured from the origin or zero. Then, since $h = \frac{1}{2} g^2$,

$$t = \sqrt{\frac{2\,h}{12 \times g}} = \sqrt{\frac{8.573}{6 \times g}} = .2107 \text{ of a second.}$$

Deduct .15 of a second for the instrument (the time allowed for the operation of the shorter bar), and .0607 is the time taken by the shot in passing over the space between the two screens. It follows then from the ratio $\frac{\text{space}}{\text{time}}$, which is the common expression for rate of motion, that the velocity $= \frac{120}{.0607} = 1977$ foot-seconds." It should be mentioned that 120 ft. is the standard distance in English official trials between the two screens. Fig. 203 shows the general arrangement of a chronograph installation.

In order to utilise to the fullest extent the costly experiments of firing at long ranges, instruments of the greatest available accuracy are necessary, and of these the telemeter is the most important; its function is to determine the length of range obtained with precision, and to enable comparisons to be made between the different rounds fired. At the Polygon of Hoc in all trials of this nature, the guns under test are fired out to sea, the column of water (Fig. 211) created by the falling projectile being high enough, and of sufficiently long duration, as a rule, to enable the observer to bring it within the range of a field glass before its subsidence. The chief condition involved is the reading of ranges up to

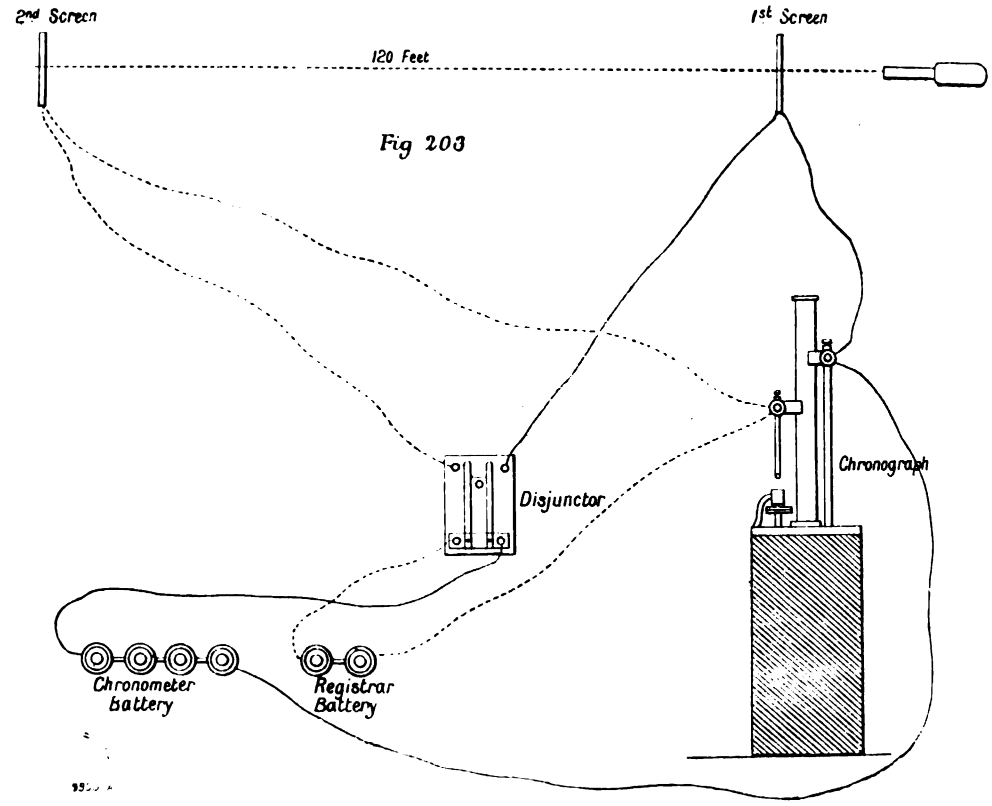
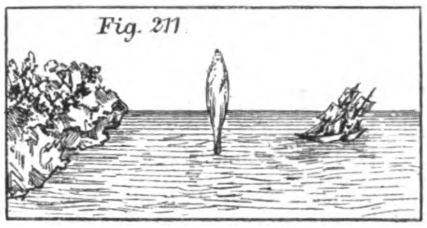


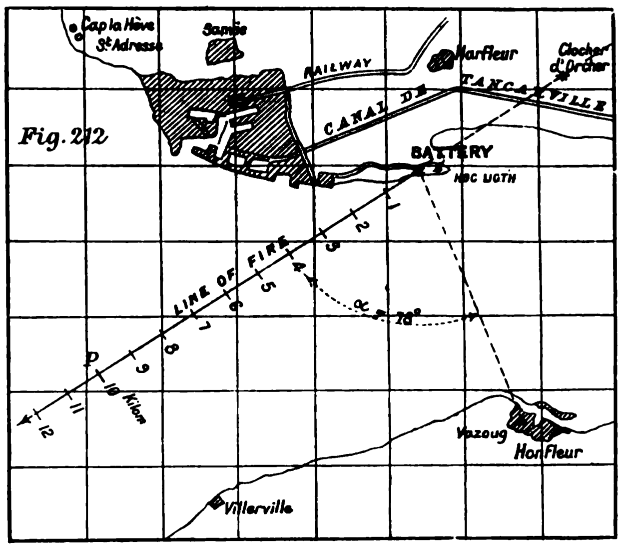
DIAGRAM SHOWING CHRONOGRAPH CONNECTIONS.

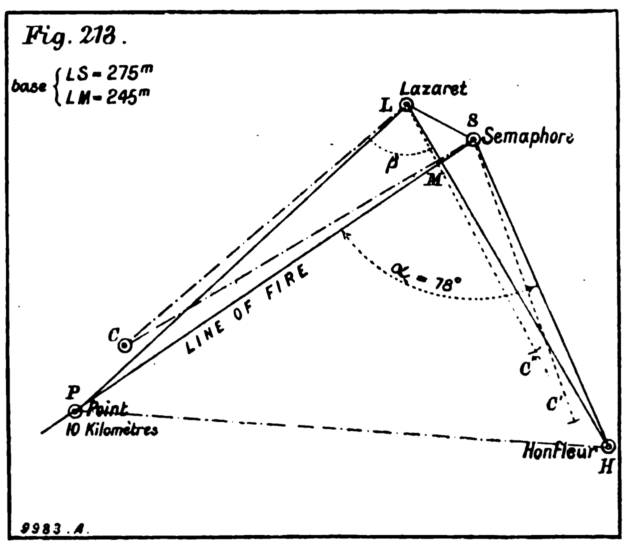
FIG. 210. THE DE PEIGNE TELEMETER.

10,000 metres with a maximum error of 50 metres, and the telemeter that has been designed, and is in constant use for this purpose, differs sufficiently from instruments of the same class generally employed, to call for a somewhat detailed description. The line of fire at the Hoc Polygon (see Fig. 212) is directed towards the south-west, and ranges at the rear with the belfry of Orcher. Two buildings adjacent to the firing platform, an old lazaret L and a semaphore S (Fig. 213), about 275 metres apart, constitute an oblique base in relation to the line of fire, and its extension L M furnishes a useful base of about 245 metres. If P is an imaginary point 10,000 metres distant, the triangle to be solved is P L S, which becomes C L S for any point C at which the projectile falls. The two observing stations L and S must therefore be supplied with theodolites, by means of which the value of C S can be deduced. Now in order to differentiate the point P from a point, 50 metres, more or less, from it, it is necessary that the horizontal circle of each theodolite should give accurate readings up to one fiftieth of a millimetre, on a limb of .40 metre radius. The impossibility of taking such minute readings with accuracy, even supposing that the vernier could be correctly graduated, led the inventor of the instrument in use at Hoc to construct theodolites without a limb or vernier, but which, nevertheless, afford means of obtaining readings of very great precision. The designer of this ingenious telemeter is a well-known artillery officer, Colonel Peigné. The problem appears a somewhat paradoxical one, but its solution is extremely simple and logical.

A marine telescope (Fig. 214) is mounted on a tripod with locking screws, and with a non-graduated circle, but with an adjusting screw V; it carries in front of the objective a small mirror M (see Figs. 214 and 215) mounted on an axis that is controlled by the rod T by means of the micrometric screw A, the head of which is accurately graduated. Direct or lateral rays can be thrown upon the mirror at will by turning the shield O, Fig. 215. The micrometer consists of a plate divided into 240 equal part (see Fig. 216) in such a way that readings up to one twelve-hundredth part of its diameter can be taken; thus in Fig. 216 it will be seen that the column of water thrown up by the falling projectile stands opposite the division 1072. It should be mentioned that the scale of the divisions shown on the diagram is the actual size as seen through the microscope of the instrument. Both the observing stations are provided with instruments of the kind just indicated, and they are regulated in such a manner that when their direct optical axis is turned to coincide with that in which the point P falls 10,000 metres distant along the line of fire, this same axis passes, by reflection, through the Chateau of Honfleur, the azimuth of which makes, with the line of fire, an angle of about 78 deg. Fig 213 indicates the manner in which the mirrors are regulated; an auxiliary base has been measured, and with a circle divided into spaces of five seconds, the triangle L S H has been solved. The angle equalling P S H is assumed to be 78 deg., and from this the triangle L S P is deduced terminating at the point P at a distance of 10,000 metres. From this triangle L S P has been obtained with absolute correctness, the value of the angle P L H equal to S which serves as the base for regulating the telescope L. For adjusting the mirrors in the observing station, two permanent points were fixed by theodolite, on the coast between St. Addresse and Harfleur; these gave the angle β from the station L. Two other points were also fixed giving the angle α from the station S. In taking an observation the telescopes are mounted on their tripods in the stations L and S, and they are sighted direct upon the right-hand points on the coast St. Addresse-Harfleur; the mirror M is then adjusted by means of the screw A until the points on the left-hand side are seen, by reflection, on the same division of the micrometer; the graduation on the head of the screw Y is then noted. This being done each observer looks for the column of







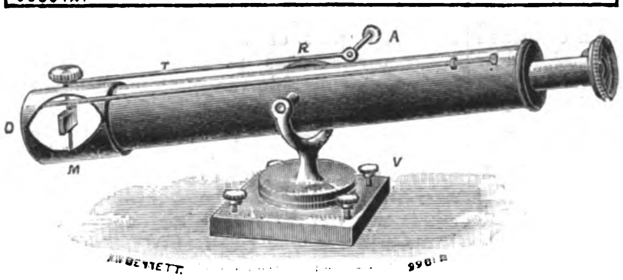


Fig. 214.

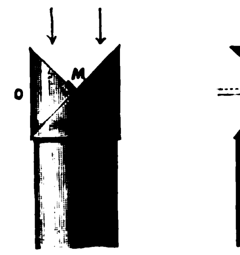
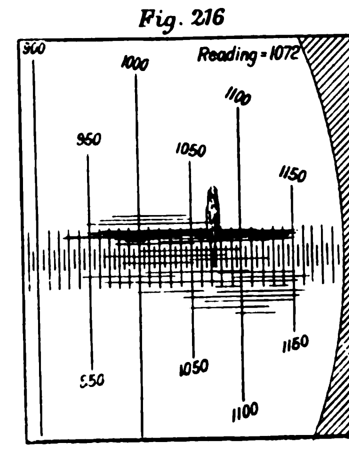
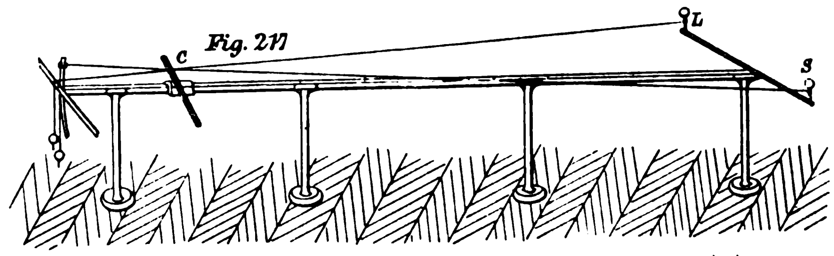
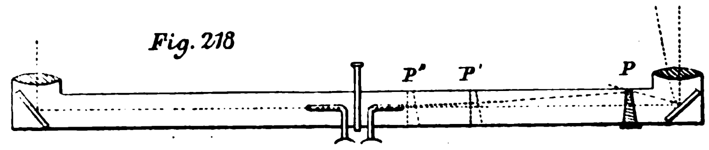


Fig. 215.







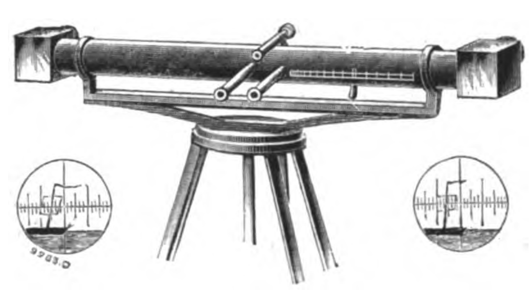
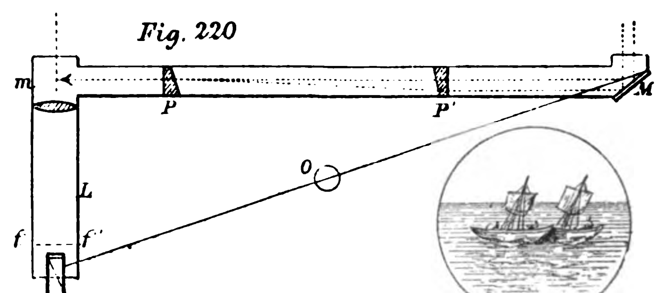


Fig. 219.

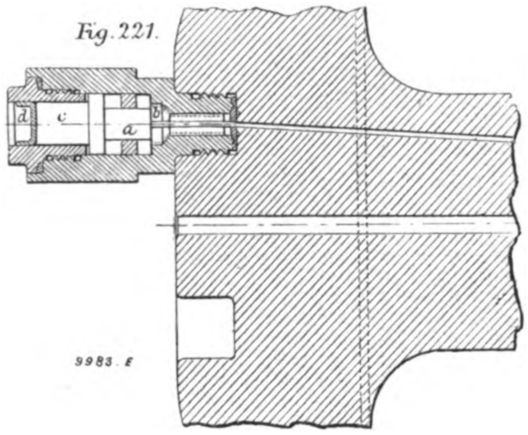


THE DE PEIGNE TELEMETERS.

water through the telescope, and stops the circle of the tripod, by means of the screw V as soon as he has obtained the desired result and has taken the reading—1072 for example. The point of fall being C it is necessary to measure the angle C L P and C S P from which the triangle C L S can be solved. If, without shifting the telescopes, an observation by reflection is made, it will be noted that the Chateau of Honfleur is no longer in the optical axis, but that the division—1072 for example —takes the direction S C′ or L C″. The angles C L P, C″ L H are in fact equal, and so are the angles C S P and C′ S H. This being done by turning the micrometric screw A of the mirror, the Chateau H is brought over the division 1072, given by the column of water. The reading then taken on the graduated head of the screw gives the angle C L P or C S P with very great accuracy because the rod T (see Fig. 214) is of considerable length; a spring R presses constantly against the end of the micrometric screw A to prevent loss of movement, and the head of the screw is sufficiently subdivided to give the necessary accuracy of reading. The angles C L P and C S P being known, the variations in range and direction can be obtained graphically. In a proof shelter close to the firing platform is mounted upon cast-iron standards a long graduated bar, Fig. 217. This bar represents the line of fire to a convenient scale; at one of its ends is marked the oblique base L S with its two observing stations; at the other end are two arcs of circles struck from L and S as centres and graduated to correspond with the divisions on the micrometric screw of the telescopes. Each of the actual stations is connected with the shelter in which this model is placed, by telephones. The person operating the graduated bar, fixes on each of the two arcs, at the divisions indicated by the signals given through the telephones, two wires attached at one end to the points L and S. Their intersection gives the triangle C L S, which it was desired to solve, and a slide, to which is attached a transverse scale, is pushed along the graduated bar, as far as the point C; the range and the amount of deviation can then be at once read off by the observer. It has been proved by repeated trial that the maximum error in this method does not exceed 40 metres in a range of 10,000 metres. The observer has ample time to solve the triangle and to enter the result before the gun can be loaded for the next round. It will be seen from the foregoing description that Colonel Peigné has succeeded in solving a difficult problem in an extremely efficient and simple manner, and without the use of instruments that require very fine readings and are liable to error in their adjustment.

The same inventor has designed for the Polygon of the Forges et Chantiers Company two instantaneous telemeters by which a moving target can be followed, and will indicate if any vessel that may be passing is in dangerous proximity to the line of fire. The first of these instruments is mounted on a tripod; it has a base 1.75 metres long, and by means of reflecting prisms the observer can use it like an ordinary telescope. The two objectives are placed at each end of the base, and the rays are reflected by a mirror set at an angle of 45 deg.; Figs. 218 and 219 indicate the general arrangement. The apparatus is adjusted on a stand as illustrated. The manner in which it is used is very simple; each eye-piece is provided with a finely-divided micrometer screw (see Fig. 219). The instrument is moved until the vessel to be observed is brought into the field on the left-hand side, then, by means of a small lever, the observer moves a deviating prism along to the points P, P¹ or P², until the vessel in the field appears to be seen in the right-hand objective. This movement at the same time shifts an indicator along the graduated bar carried on the straight part of the tube of the instrument, and its position when the observation has been completed indicates the distance of the vessel; the error in the readings made with this telemeter does not exceed 100 metres in 4 kilometres. Fig. 210 is an engraving of the complete instrument. The second instrument (see Fig. 220) is mounted on a foundation of masonry; it has only one eye-piece, and readings can be taken with a maximum error of 100 metres in 6 kilometres. It consists of a tube *m*, 2 metres in length fitted with a mirror at each end and a telescope on the side at L, fixed normal to the tube. The whole instrument turns upon a carefully adjusted horizontal ring, the tube being mounted on an axis O. The telescope being directed on the object under observation, it receives in its focal plane *f f*¹ the direct image of the object; then by reflection from the mirrors M and *m* it also receives in the same focal plane the same image from the other extremity of the base. There are thus two adjacent images in the field which can be made to coincide by sliding within the tube, the prism P¹ having the same angle as the prism P, but reversed. The position of P¹ which makes the two images overlap, gives the desired distance. This apparatus is extremely simple and very easy of manipulation; its readings, as already stated, are accompanied with a percentage of error that is almost negligible. As regards its telemetric installations, the Polygon at Hoc leaves nothing to be desired, and the instruments in use possess considerable interest on account of their originality of design.

The apparatus known as the crusher gauge—originally suggested, we believe, in the United States—but first practically applied in England, affords a means now universally employed for ascertaining approximately the pressures set up in the bore of a gun on the explosion of the charge. In its most developed form it is as shown in Figs. 221 and 222. The piston *c*, Fig. 221, is of steel,



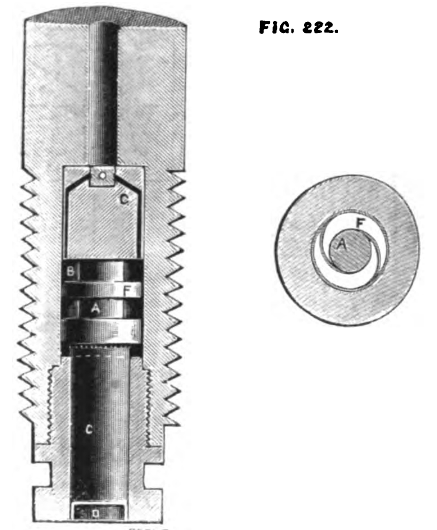
FRENCH CRUSHER GAUGE.

and the bore, which is of carefully determined section, is subjected to the action of the powder gases, and is pressed against the small cylinder of copper *a*, which abuts against the plane surface of an anvil *b*. The copper cylinder is centred by a rubber ring, but it is left quite free to expand laterally; a brass obturator mounted on the piston prevents the powder gases from penetrating into the interior of the crusher apparatus. As this obturator is not always quite certain in its action, it is a common practice to provide an exhaust passage to carry off any gases that may pass the obturator and enter the cylinder; the presence of this gas would tend to make the results given by the instrument incorrect. By means of a series of preliminary trials, the reduction in the height of the copper cylinder, is determined by subjecting standard specimens to known pressures. It is of course assumed that the powder gases would produce effects similar to that of mechanical force, and the effect of the latter being known, the value of the former can be ascertained by comparison. The copper cylinders employed by the Forges et Chantiers de la Mediterranée are 8 mm. in diameter and 13 mm. in height. The selection of the metal of which they are made and the production of the cylinder is a very delicate operation, as the correctness of the results obtained, depend of course upon the resistance to crushing being known and uniform. In order to imitate as closely as possible the action of the powder gases, the specimens subjected to mechanical pressure are acted upon as rapidly as is possible, consistent with the avoidance of shock. The crusher gauges are screwed with the greatest care and accuracy, into the mushroom head of the breech mechanism, at equal distances from the centre, above and below, in a vertical plane; they thus project into the powder chamber. In quick-firing guns, however, the gauge is screwed into the base of the metallic cartridges, and commonly a crusher is left free in the chamber. Before firing, the exact height of the copper cylinder is carefully checked, and after firing the cylinder is removed and its reduced height is very accurately gauged with micrometric callipers. This height corresponds to a certain pressure, and from a series of tables prepared by experiment the exact reading can be made at once without any calculation.

By way of comparison we publish in Fig. 222 a section of the standard crusher gauge employed in England, the illustration referring to the type used for measuring pressures in the bore. In this figure A is the copper cylinder, B the chamber, C the piston, *d* the obturator, F a watch-spring that takes the place of the centring rubber ring; G are exhaust passages, and H is the nozzle screwed into the front of the gauge. The standard size used has a piston one-sixth of a square inch in section, and the copper cylinder is half an inch long, and one-twelfth of an inch in cross-section. It should be mentioned that the practice of fixing these gauges to the breech mechanism has been given up in this country.

The Sébert velocimeter is an instrument of great ingenuity and value; it is used at Havre for recording the behaviour of gun-carriages under test, and incidentally for ascertaining the velocities of projectiles, and the amount of powder pressures. A brief description of its arrangement for measuring recoil will be sufficient for the present purpose.

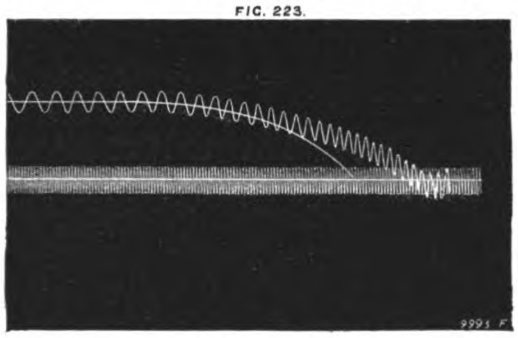
FIG. 222.



ENGLISH CRUSHER GAUGE.

The instrument is attached to a wooden base which is secured to a fixed point adjacent to the carriage; its function is to describe a record on a strip of thin steel that has been previously blackened with a thin film of carbon. As a matter of fact two records are made, one referring to the action of the carriage during recoil, the other to its movement when coming back to firing position. Upon the wooden base are fixed two guides in which the steel ribbon is free to slide, and these guides are so arranged that when the recoil is completed, they are shifted to one side so as to offer a fresh surface for the return record. One end of the ribbon is attached to the slide of the carriage so that when recoil takes place it is drawn out; a similar but reverse action takes place when the slide comes back and draws the ribbon back with it. The recording part of the apparatus consists of a small carriage so mounted in fixed supports that a considerable range of angular and lateral motion can be imparted to it, and it can be held in any desired position by set screws. On this carriage is placed a tuning-fork giving 1000 vibrations per second, and it is provided with electrical connections in such a way that the rate of vibrations can be maintained uniform for two or three minutes. A small steel point is attached to one branch of the fork and vibrates with it. A second point is held stationary on a pin in advance of the first and exactly in line with it. Under these conditions if the ribbon be drawn under the styles, a single line would be inscribed; if the tuning-fork be vibrated, and the ribbon is not moved, the vibration would be recorded by a short transverse line, the width of which would mark the amplitude of vibration. But if the ribbon be drawn under the styles, the fixed one would inscribe a straight line, whilst the vibrating one would make a series of loops to the right and left of the centre line. The form and size of the waves thus drawn indicate the velocity of the movement of the ribbon and any variation in its character. The value of the record thus produced is limited only by the possibilities of accurate reading, and as the lines inscribed are very fine, by means of a microscope and crossed hairs, a great degree of minute subdivision is practicable, and a curve can be laid down showing the movements of the carriage in functions of the time. As the return movement to battery is much less rapid, while the vibrations of the tuning-fork are maintained at their normal speed, the character of the diagram produced is quite different to that of recoil; the transverse markings cease to be open loops and come very close together; their characteristics can, however, be read with a microscope. In Fig. 223 we reproduce one end of the diagram described on the steel ribbon, which shows distinctly the nature of the recoil, and return to battery, motions. As the lamp-black film is very delicate these records are immediately protected by a coat of varnish, after which they can be examined with safety. It is obvious that the length of the diagram corresponds with the amount of recoil. Fig. 223, which repre-

FIG. 223.



VELOCIMETER DIAGRAM.

sents one end of the diagram, illustrates the shifting over of the ribbon from the recoil to the return to battery position. What we have said will give some idea of the nature and mode of using this instrument, which cannot be fully described without the aid of drawings; these we may publish at some future time, together with the ingenious projectile velocimeter of Général Sébert, which is placed in the projectile and leaves its record completed, although the instrument itself is destroyed by the shock of the shot when it buries itself in the sand bank.

THE GREAT WESTERN RAILWAY STEAMERS.

THE Great Western Railway Company finding it desirable to improve their cross-Channel service between Weymouth and the Channel Islands, in connection with the Paddington and Weymouth express, entrusted to Messrs. Laird Brothers, of Birkenhead, the design and construction of the required fleet of three steamers. The builders strongly recommended the adoption of twin screws, and the results attained by these steamers fully justify their anticipations.

The boats were named Lynx, Antelope, and Gazelle, and are precisely alike, but for some reason, difficult to trace, the Gazelle has made a faster record than either of the others.

Their dimensions are 235 ft. long between perpendiculars and 228.7 ft. long on the load water line. The greatest beam is 27.6 ft., depth moulded is 14 ft., and the load draught is 11 ft. aft and 9 ft. forward. At this draught they displace 790 tons. There are bilge keels 10 in. deep, and between these and the centre bar keel two other short bilge keels are fitted. In the deadwood aft an aperture is formed similar to that in single-screw vessels to allow the twin screws to revolve in areas which extend beyond the midship longitudinal vertical plane.

The general arrangements are indicated in the views on our two-page plate; the interior fittings are all that can be required for elegance and comfort. There is a very complete electric light installation, consisting of a Willans engine coupled direct to a Latimer-Clark compound wound dynamo.

These vessels are built with seven water-tight bulkheads, thus dividing the ship into eight complete compartments, and with any two of these in communication with the sea, the vessel would still float. It is seldom that the principle of subdivision is carried out so far in small boats, and intending passengers may regard these boats as practically unsinkable, a point of no slight importance in these days of high speed. Abaft the collision bulkhead is worked a water-tight flat extending to the next bulkhead, thus forming a ballast tank, which is used for trimming the ship according to the requirements of the trade. A ballast tank is built in the after part of the forehold for similar use. The after peak can be used as a ballast tank if necessary; thus, no matter what cargo may be carried, it is always a simple matter to keep the ship at any desired draught.

We hope to illustrate the engines in an early issue, and therefore shall defer the description of them for the present. They are of the triple-compound type, with cylinders 16½ in., 26 in., and 41 in. in diameter respectively, with a stroke of 30 in.

Before the vessels were placed on their station last summer the usual official trials were made on the Mersey with the following results:

	"Lynx."	"Antelope."	"Gazelle."
Number of revolutions per minute	121.22	122.05	120.00
Indicated horse-power	1702	1667	1650
Mean speed ...	16.50	16.79	17.04

The contract trial speed guaranteed by the builders was 16 knots. It is an interesting fact that on the preliminary trials propellers of cast iron were used of exactly similar dimensions, but by substituting propellers of manganese bronze a gain of over half a knot in speed was attained.

The work of the first season has proved that these vessels more than equal the most sanguine expectations.

	Knots.
The average taken of twenty-four runs of Lynx is	16.6
The average taken of twenty-four runs of Antelope is	16.4
The average taken of nineteen runs of Gazelle is	17.4

During all weathers.

The Gazelle may have been more fortunate in tides or weather, and has maintained the lead she had on the trials. The average speed on the station has proved in excess of the maximum trial trip speed guaranteed by the builders. The boilers have been regularly worked under a pressure of from ⅞ in. to 1 in. water.

During the winter each boat has been round to Birkenhead to be fitted with an additional rubber in order to better suit the pier arrangements, and occasion was then taken thoroughly to examine the boilers, which were found to be in perfectly satisfactory condition and not punished from the effects of being constantly under air pressure.

These vessels are the fastest screw Channel steamers on the British coast.

ELECTRIC LIGHTING AT KESWICK.

AT the concluding ordinary meeting of the session of the Institution of Civil Engineers, held on Tuesday, May 20, Sir John Coode, K.C.M.G., President, in the chair, the paper read was on "The Keswick Water Power Electric Light Station," by Messrs. W. P. James Fawcus and Edward W. Cowan, Assoc. MM. Inst. C.E.

This was believed to be the first attempt to utilise available water power in this country for the purposes of a public supply of electric light. Early in last year the directors of the Keswick Electric Light Company instructed the authors to prepare plans, and to procure tenders, for the erection of a central supply station in or near Keswick. As the area proposed to be lighted was large and sparsely populated, it was seen that the only feasible system to adopt was an overhead high-tension one. The alternating current transformer system was finally selected, and a site on the River Greta, about ⅝ mile from Keswick, was chosen for the erection of the station, the river being here available at 20 ft. head. The saving effected in using this water power was considerable. The rent paid for the water was 10s. per horse-power per annum. Taking the number of horse-power hours required per annum as 100,000 for the present output of the station from a 50 horse-power turbine, the cost per horse-power came out as 0.06d. On the other hand, taking the price of steam coal at 15s. per ton, and the quantity burnt per horse-power per hour as 6 lb., the cost per horse-power hour came to 0.48d., or eight times the cost of the water power. In addition to this, the attendance required for a turbine was, of course, less than that necessary for a steam engine and boiler; the first cost, maintenance, and depreciation, were also considerably less, and the chances of a breakdown much less likely. As there was a possibility of partial failure of the water supply during extreme drought in summer, it was decided to provide steam in addition to water power. The turbine was of American design, and was called the Victor. It was of a "mixed flow" type, the wheel being 20 in. in diameter. Its speed was 273 revolutions per minute; this was at least 70 per cent. greater than the speed of an "inward," an "outward," or a "parallel flow" turbine would have been, working under a similar head. Its design was exceedingly compact, and the regulation, which was effected by opening and closing a cylindrical sluice working between the guide passages and the wheel, was all that could be desired. As the turbine was 16 ft. above the level of the tail race, a draught tube was necessary to give full effect to the head of 20 ft. This draught tube was of wrought iron, 14 ft. long and 3 ft. in diameter. The maximum velocity of water flowing through it was a little over 4 ft. per second. The engine was a Westinghouse of simple type, having two single-acting cylinders, 10 in. in diameter by 9 in. stroke; it gave with 80 lb. of steam, at 250 revolutions per minute, 50.11 brake horse-power. The floor space taken up by the engine was 7 ft. by 4 ft. The boiler was a 20 nominal horse-power Hyde duplex, 4 ft. 6 in. in diameter, and 11 ft. 6 in. in height. Its working pressure was 120 lb. to the square inch. The alternator, which was designed by Mr. Gisbert Kapp, and manufactured by Messrs. Johnson and Phillips, the contractors for the electrical plant, was a 30 kilowatt separately excited machine, giving an output of 15 ampères at 2000 volts. Its speed was 750 revolutions per minute, and the frequency 75. The armature had a cast-iron supporting ring, 28 in. in diameter and 2½ in. wide, provided with six arms. The armature core was of charcoal iron strip, 2½ in. wide, wound with paper insulation to a depth of 8 in. There were nineteen coils, each containing 100 turns of 0.072 in. wire, covered to 0.092 in. in two layers. The resistance of the armature, after working some hours, was found to be 7 ohms. The magnetic field consisted of twelve magnets on each side of the armature. The cores and pole-pieces were of wrought iron, the yoke rings of cast iron. The former were cylindrical, 3⅜ in. in diameter. The latter were 4 in. by 7¼ in. Each core was wound with six layers of fifty-eight turns per layer, with 0.102 in. wire covered to 0.117 in. The total resistance of the field after working some hours was 11.2 ohms. At full load the energy of the field was 3 per cent. of the output of the machine. The framework was of substantial construction, and the machine when running was remarkably free from vibration. Its open design admitted of the free passage of air to the armature, which would carry 20 ampères without overheating. The magnets could be racked aside for access to the armature. The exciting dynamo was a 1-kilowatt machine of the Gramme type, giving 10 ampères at 100 volts. Regulation was effected by varying by hand the resistance in the field-magnet circuit. Two circuits left the station, both of which were double-pole fused, and provided with double-pole switches and lightning arresters. There were some special features in the method of carrying out the overhead mains. If wire of high insulation had been used the expenditure would have been considerable, and it did not appear that any great advantage, other than increased durability of the mains, would have resulted. It was, therefore, determined to use a lower insulation for the mains, and to rely upon the points of support for insulation, also to use special arrangements for cutting off all surface leakage where the wires entered the consumer's premises. The authors were not aware that attention had been paid to this point before, yet it would seem that in wet weather, upon a long line of overhead mains, even with the best insulation, the surface leakage, when high-tension currents were employed, would be considerable; and if devices were not adopted for cutting this off where the wires entered buildings, leakage to earth must result, which might be a source of danger as well as of loss. The mains at Keswick were being insulated from earth, and from each other, by oil throughout the system. The house leading-in wires were insulated with vulcanised india-rubber of the highest quality, and were threaded through a shackle oil insulator, the wire being cemented in with Chatterton's compound. Such an arrangement should effectually cut off surface leakage from the mains. The leading-in wires entered the roof through a stoneware pipe, provided with a covering piece to keep out rain and cover a reservoir of oil in the mouth of the pipe. The sizes of the mains were fixed for a current density of 500 ampères to the square inch. The fall of potential, between the generating station and the town, was only slightly above 1 per cent. at full load. Steel suspension strand was used for supporting the mains for all circuits, consisting of three strands, each strand being 14 B.W.G., and galvanised. One short run of underground mains was being tried, the Brooks fluid system being used. This system had much to recommend it; it was simple, cheap, and durable, and did not take long to lay down. The transformers were Kapp's patent, and they transformed the high-tension current of 2000 volts to 100 volts. A double-pole, quick-make and quick-break switch, with double-pole fuze and lightning arrester, was used in the high-tension circuit with each transformer. Both the transformers and the switches were inclosed in cast-iron water-tight cases. A series of experiments had been made to test the efficiency of the machinery, with the result that the total efficiency of the generating plant at the station came out at about 40 per cent. at ¼ full load, and over 70 per cent. at full load. In connection with the arrangement of this central station scheme, the authors had occasion to make a comparison between the illuminating power of the glow lamp and gas; the results showed that the relative values usually given were misleading, as they almost invariably dealt with a standard London Argand, a burner seldom used for ordinary lighting. This burner was generally taken as giving from 15 to 16 candle-power for 5 cubic feet of gas consumed per hour; whereas out of a large number of ordinary burners taken haphazard, and tested where they were in use, in Chester, Manchester, and Keswick, at various times, it was found that the light given by 5 cubic feet of gas per hour was more frequently equal to 8 candles or less. This would show that in practice one 16 candle-power glow lamp gave approximately the same degree of light as two ordinary burners, each consuming 5 cubic feet of gas per hour. This conclusion seemed to be borne out by the result obtained by Dr. Hopkinson, who, experimenting on some ordinary burners, found the average candle-power to be 1.76 per cubic foot of gas. As regarded glow lamps, Sir David Salomons found that 100-volt 16 candle-power Edison-Swan lamps averaged 17 candle-power at 100 volts. The light had been received with great favour at Keswick, and already the demand was equal to the supply of the present plant. Supply was commenced at the beginning of the year, and the station had run without hitch up to the present time—a man and a boy being found sufficient for tending the machinery.

MODERN FRENCH ARTILLERY.
No. XXII.

THE FORGES ET CHANTIERS GUN FACTORY—MOUNTAIN AND FIELD GUNS.

IN the following articles we propose to describe the various types of field and mountain artillery manufactured by the Forges et Chantiers de la Mediterranée upon the Canet system; the standard sizes of field guns are of 75 millimetres and 84 millimetres (2.95 in. and 3.31 in.); the standard types are each of two classes, short and long. These models only differ from each other in their dimensions and weights, which vary according to the special class of service for which they are intended. They are designed with the object of combining thorough efficiency and destructive effect with as little weight as is possible. The efficiency of field artillery has during the last few years been largely increased by modifications in its form, and by the use of new and special powders; at the present time it is remarkable for its high power, accuracy of aim, and long ranges, qualities which are due to the comparatively great length of bore, to the form of the chamber, to the nature of the powder, and to the character of the projectiles. The great strength of the material employed in these small-bore guns, allows the use of very high charges, and consequently of the attainment of correspondingly high initial velocities. It is almost unnecessary to say that both as regards the quality of steel employed, and the care in its subsequent manipulation, as much trouble is taken in the selection of material and in its manufacture, as is done with guns of high calibre; the steel used in all field guns is forged, tempered, and afterwards annealed, and on account of the relatively small weights employed, and the uniformity of form adopted, the tempering and other operations are carried out under the best possible conditions to obtain a maximum degree of resistance for the gun. The jacket which reinforces the rear part of the tube possesses an equal strength both longitudinally and transversely, and it is claimed for the Canet system that no such high degree of longitudinal strength is obtained either in the French Government gun factories, nor at the Krupp Works. Rapidity of firing and simplicity of handling are secured by the adoption of a system of breech-closing adopted from the French standard type but modified in many important details. Considerable changes have also been made in the plastic obturator of De Bange in order to avoid hardness in working, and modifications have been introduced in the method of firing the gun, while safety appliances have been added consisting mainly of an automatic vent protection; thanks to this simple addition it is impossible for premature discharge to take place, or for the gun to be fired until the breech is entirely closed. The necessity for such a safety apparatus, which it is stated does not exist either in the French standard type, nor in the Krupp field guns, has been fully realised in consequence of various accidents that have happened from the accidental premature firing of the cartridge, on many occasions. The form of the breech screw has been modified in such a way as to simplify the various parts, to render the maintenance more easy, and to check their being injured by mud or sand, which by this arrangement is prevented from entering the mechanism, and especially from getting between the breech-block and the carrying ring.

The body of the carriage is made of two steel side-plates strongly braced transversely by steel cross-framing; the wheels are of steel with bronze centres, and a method of oiling is introduced which is continuous and automatic. While the frame is extremely light it has an ample margin of strength, and the material throughout is arranged to take its part of the strain in the most advantageous way; by this means the dimensions are reduced to a minimum throughout the whole of the carriage. The amount of recoil is very small and is taken up by the Lemoine cord brake, which is the standard form adopted in France; this brake is absolutely automatic, and releases itself as soon as the gun is brought back into firing position.

For field guns the range for vertical training has an amplitude of from − 6 deg. to + 20 deg., and can be regulated with great accuracy and speed. While preserving ample stability in the carriage, the width of wheel base has been reduced; such field artillery can therefore be drawn through narrower paths than those which are required for the passage of standard French or German field guns.

The Canet mountain and field artillery is adapted for firing five classes of projectiles; the common cast-iron shell, the high capacity steel shell, shrapnel, mitraille, and case shot. The weight of each class is the same for the same calibre, 10.12 lb. for the 75-millimetre mountain gun, and 11.4 lb. for field artillery. On another page are given sections and particulars of the various types for mountain guns. (See Figs. 238 to 242.)

The common shell, filled with very violent powder, is fitted with a percussion fuze; the other types of projectiles are fired with combination time and percussion fuzes. Each field gun is provided with a limber in which is stored a part of the ammunition, the remainder being placed in the tumbrils. The cartridges are stored in boxes made of wood with steel mountings. Special wagons are provided with each battery for containing tools, spare parts, &c.; this material is very light and strong; the width between the wheels is the same as that for the gun carriages, so that they can pass through very narrow roads and turn freely. Table XV. contains the results of firing trials with 75-millimetre mountain guns carried out between 1887 and 1889; the data are sufficiently detailed to show clearly the efficiency of the arm, and indicate the average duty obtained.

The mountain guns made on the Canet system are, like all others of the same class, especially

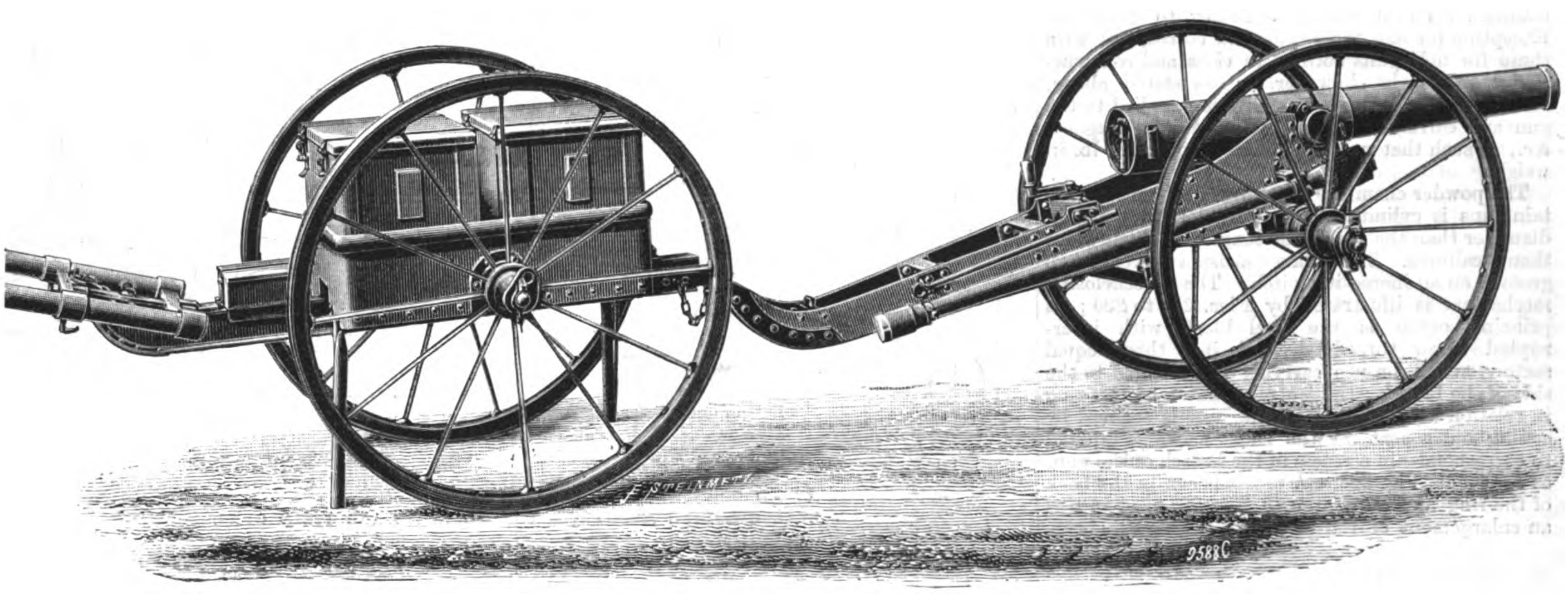


FIG. 237. 75-MILLIMETRE MOUNTAIN GUN AND BOAT GUN CAISSON.

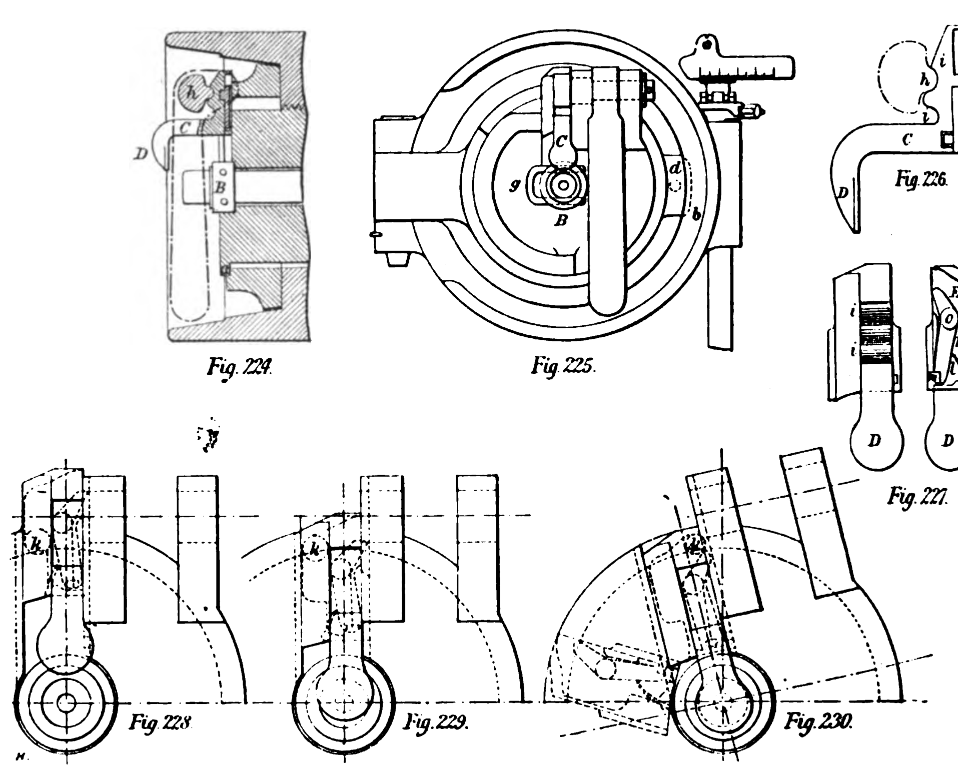
TABLE XV.—FIRING TESTS OF CANET MOUNTAIN GUNS 75 MM. (2.95 IN.) MADE AT THE HOC POLYGON AND AT SEVRAN-LIVRY, BETWEEN FEBRUARY, 1887, AND JANUARY, 1890.

Dates of Trials.	Weight of Projectile.		Nature of Powder.	Weight of Charge.		Initial Velocity.		Pressure.	
	lb.	kilos.		lb.	kilos.	ft.	metres	lb. per sq. in.	kilos. per sq. cent.
December, 1888	**10.12**	4.600	C2 5th lot	**.882**	0.400	**951**	290	**12,131**	853
May, 1887	**10.12**	4.600	C2 4th lot	**.992**	0.450	**925**	282	**8,818**	620
,, ...	**10.12**	4.600	C2 3rd lot	**.992**	0.450	**1060**	323	**14,122**	993
,, ...	**10.12**	4.600	C2 4th lot	**1.058**	0.480	**1020**	311	**11,121**	782
,, ...	**10.12**	4.600	C2 3rd lot	**1.058**	0.480	**1096**	334	**14,038**	987
December, 1888	**10.12**	4.600	C2 5th lot	**1.102**	0.500	**1083**	330	**14,094**	991
April, 1888	**10.12**	4.600	C2 3rd lot	**1.102**	0.500	**1079**	329	**14,086**	990
February, 1887	**11.44**	5.200	C2 special	**.882**	0.400	**922**	281	**11,121**	782
May, 1887	**11.44**	5.200	C2 4th lot	**.992**	0.450	**951**	290	**10,094**	709
February, 1887	**11.44**	5.200	C2 special	**.992**	0.450	**974**	297	**12,131**	853
,, ...	**11.44**	5.200	Do.	**1.058**	0.480	**1010**	308	**14,578**	1025
May, 1887	**11.44**	5.200	C2 4th lot	**1.058**	0.480	**978**	298	**12,131**	853
April, 1888	**11.44**	5.200	C2 3rd lot	**1.102**	0.500	**1076**	328	**14,094**	991
December, 1888	**11.44**	5.200	C2 5th lot	**1.102**	0.500	**1089**	332	**18,731**	1317
,, ...	**13.64**	6.200	C2 5th lot	**.992**	0.450	**896**	273	**14,122**	993
April, 1888	**13.64**	6.200	C2 3rd lot	**1.058**	0.480	**935**	285	**16,910**	1189
,, ...	**13.64**	6.200	C2 3rd lot	**1.102**	0.500	**948**	289	**16,910**	1189
May, 1887	**15.62**	7.200	C2 4th lot	**.992**	0.450	**830**	253	**11,121**	782
December, 1889	**10.12**	4.600	B N smokeless 1st lot	**.441**	0.200	**938**	286	**7,706**	542
,, ...	**10.15**	4.615	Do.	**.529**	0.240	**1092**	333	**14,193**	998
,, ...	**10.23**	4.650	Do.	**.551**	0.250	**1138**	347	**15,417**	1084
,, ...	**10.12**	4.600	B N 2nd lot	**.529**	0.240	**971**	296	**9,869**	694
,, ...	**10.12**	4.600	Do.	**.617**	0.280	**1145**	349	**15,986**	1124
,, ...	**10.12**	4.600	Do.	**.595**	0.270	**1063**	324	**13,326**	937
,, ...	**10.12**	4.600	Do.	**.595**	0.270	**1092**	333	**13,027**	916
,, ...	**10.12**	4.600	Do.	**.661**	0.300	**1207**	368	**19,257**	1354

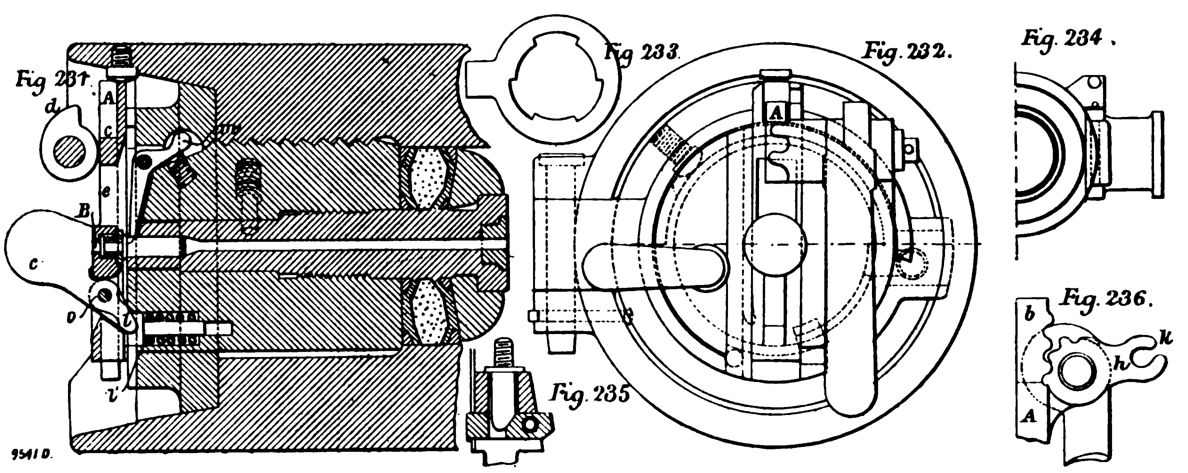
intended for service in hilly countries, where their transport, except on the backs of animals, is difficult or impossible. The standard type for these guns has a bore of 2.95 in. and the weight is 218 lb.; the comparatively large calibre enables a destructive fire with relatively heavy projectiles to be maintained while the weights are kept down as low as possible. Considerable power and accuracy at long range are claimed for this class of gun, these qualities being due to the form of the powder chamber, the nature of the powder, and the character of the projectile. The gun is made of a single block of steel, forged, oil-tempered, and annealed in the usual way; the breech-block, the trunnion ring, and a ring over the breech, are the only separate parts to the construction. The method of breechclosing is very similar to that employed for the field guns just described, the same system of gas and fuze checks being also used, as well as the various safety appliances. The carriage consists of two steel frames connected by cross-bracing, and the mode of checking the recoil is similar to that adopted in the field guns; the gun can be very easily dismounted from the carriage, and the latter can be divided so as to reduce the weight of transport. The gun can be trained for elevation from − 20 deg. to + 20 deg. Excepting for size the projectiles correspond with those for field guns both as to class and construction; the weight, however, is, as stated above, 10.14 lb. The system of subdivision applied to the gun and carriage, the limber ammunition wagons, &c., is such that no single piece exceeds 220 lb. in weight.

The powder chamber* both for field and mountain guns is cylindrical and considerably larger in diameter than the bore; the length is a little more than 5 calibres. The rifling consists of twenty-two grooves on an increasing pitch. The breechclosing mechanism is illustrated by Figs. 224 to 230; its principal organ is the steel block with interrupted screw threads divided into three equal sectors, and a bronze carrying ring hinged to the side of the breech; the central position of this ring in relation to the bore of the gun is secured by coning out a seat for the ring—which is tapered to correspond—in a recess in the breech of the gun, as shown in Fig. 224. A recess is cut in the back of the ring as shown at *a* in Fig. 224, and in this an enlargement of the breech-block takes its bearing; this arrangement appears an extremely useful one, as it helps to exclude dust or dirt from working its way into the breech. In the inward and outward movement through the ring, the breech-block is guided by the projecting edges of the lower threaded segments; the principal working lever is hung vertically to the block as shown in Fig. 225. The block is secured either to the ring or to the gun by means of the bolt *d* see (Fig. 196), and which is placed in a recess on the right-hand side of the ring; when the breech is closed the projection is locked in a recess made in the side of the breech-block, while the outer projection *b* extends outside the ring and enters a recess cut in the jacket. When the breech is opened and the block is drawn to the rear, the bolt does not move and the latch remains in its place, but at the end of the movement, the effect of the block striking the ring is to force the bolt towards the left and shift the latch in such a way that it becomes locked to the ring and so holds the breech-block securely. In closing the breech a stud which is screwed into the back of the gun, enters an opening made in the latch and forces the inner projection out of its seat and at the same time causes the outer latch to enter a recess cut in the gun and so making the latter fast with the ring. Figs. 224 and 225 illustrate in detail the breechclosing mechanism of these guns, while Figs. 231 to 237 show the form employed for a gun of somewhat different character but which may be conveniently referred to in this article. This is the standard type of boat gun of 75 millimetres, made on the Canet system at Havre.

In this arrangement the stem of the obturator is screwed into the block and the mushroom head is loose upon it. The firing mechanism and safety device are as follows. A bolt A slides in a vertical groove cut in the back of the block; at the upper end of this bolt is a short rack *b*, Fig. 235, on the left side of which is a recess *c* that receives the finger *d* of a cam on the main lever axis. Below the recess *c* is a rectangular opening *e* and below this again is fixed the striker B, which is held back by a spiral spring; the head of the striker projects from the face of the bolt, and beneath it is a recess in the bolt through which passes the finger *l* of the hammer C; this hammer turns upon the centre *o*, and the finger *l* is exposed constantly to the pressure from a spiral spring lodged in a recess cut in the lower part of the breech-block at l^1. A flat spring with a projection at the bottom is attached to the bolt and holds it fast by entering a corresponding recess cut in the face of the block. On the axis of the main lever is a cam *h*, Fig. 235, with teeth on one side gearing into the rack on the bolt, and with a forked projection *k* on the other side. To the breech-block is attached an extractor, the head of which, *m*, projects somewhat into a recess cut in the carrier ring; the bent lever of this extractor, which is mounted on an axis as shown, is constantly pushed outwards by a small spiral spring recessed in the block. When the main lever is thrown upwards to open the breech, the finger *d* of the cam presses against the bolt and forces it down, carrying with it the hammer, the finger *l* of which, compressing the spiral spring, turns the head of the hammer away from the bolt, but when this movement has continued until the axis of the hammer is lower than the centre of the spring, the effect of the latter is to hold the hammer at half-cock. In this position the projection attached to the flat spring fastened to the bolt enters the recess in the block and keeps all the parts fixed; the operation of unfastening the breech-block can then be continued. With the turning of the block, however, the extracting lever strikes against a stop on the inside of the ring and starts the cartridge case. In closing the breech the various operations are reversed; the gun is fired by means of a lanyard passed over the hook *k* of the cam *h*; by pulling on this cord, the bolt is lifted through the teeth on the cam, gearing into those on the rack of the bolt; when the movement has been continued until the axis of the hammer is above the centre of the spring, the top of the bolt strikes against a stop *p* fixed to the gun, and



BREECHLOADING MECHANISM FOR MOUNTAIN AND FIELD GUNS.



BREECHLOADING MECHANISM FOR 75-MILLIMETRE BOAT GUN.

* See *La Revue d'Artillerie*, October, 1889.

just as this takes place the hammer has been driven against the fuze and the gun is fired.

It has been found unadvisable to fit guns for this purpose with friction fuzes, because when they are used on boat service, the man firing the gun must often stand behind it, and in this position he would be exposed to the danger of a rush of gas, or possibly the projection of a part of the fuze. For this reason the Canet boat guns are always fitted with percussion locks. The equipment of this weapon always comprises water-tight iron caissons that serve for the transport of ammunition, and on occasion for baggage and ambulance purposes.

Fig. 237, page 667, illustrates a mountain gun, with the caisson made for the boat gun. Both types of weapon are identical, except for the firing mechanism, as already explained, and they each weigh 220 lb. The mountain gun and carriage are arranged to be taken apart for mule transport, and there is no caisson. The boat guns, which are also intended to be used on shore by landing parties, can be drawn by hand, or by mules if available. The caisson for this gun contains two ammunition boxes of ten rounds each. The various parts are, however, so designed that they can, in case of necessity, be easily separated and loaded upon animals when the conditions of transport require it.

The obturator of the block shown in Fig. 224 is of a modified De Bange pattern with tin discs and brass split rings. A collar B is placed at the rear end of the movable stem and is fastened to it by a staple *g*; the stem is drilled to receive the fuze and is bushed in front with a copper bushing. The safety apparatus is illustrated by Figs. 226 to 230, and is of a very ingenious character; it consists of the bolt C shown separately in Figs. 226 and 227; this bolt projects at right angles to the breech of the gun and terminates in an enlarged end D, which, excepting when the breech is fully closed, covers the vent. The rising and falling movement required to operate this safety device is controlled by the combined action of the starting lever, and the turning of the breech-block in its seat. It will be seen that on the spindle upon which the lever is secured, is fastened the cam *h*, the tooth formed on which gears into the two teeth *i i* cut upon the upper part of the sliding bolt C; the front face of this bolt has a slot cut on it in which enters the finger *k* attached to the upper part of the ring; one part of this slot is straight and is cut parallel to the axis of the bolt, the other part is curved. In a recess at the top of the bolt is fixed the small double-ended lever E shown in Fig. 227; this turns upon the axis *o* and a flat spring *l* presses constantly upon the lower arm of the lever at the bottom of which is a small cross-piece *m* that enters a recess cut to receive it in the breech-block. The various positions occupied by the safety bolt are shown in Figs. 228, 229, and 230; of these, Fig. 228 shows the breech closed and ready for firing; Fig. 229 illustrates the position of the bolt when the main lever is thrown up prior to starting the breech-block, and Fig. 230 the position of the various parts when the block is free and almost ready to be withdrawn. The action of this apparatus will now be clear; the first result of throwing up the main lever is to lower the shield on the bolt D over the vent by means of the cam *h* gearing into the teeth *i i*; it is evident that as soon as this movement takes place, firing is impossible until subsequent operations raise the shield clear of the vent. As the breech-block is turned, the finger *k* on the ring, after passing the straight part of the slot in the bolt C, enters upon the curved portion and pressing against the upper end of the lever E causes the bolt to fall into the position shown in Fig. 230; the projection *m* then enters the recess made for it, and locks the bolt. At this moment the cam *h* on the lever axis is free of the teeth *i* on the upper part of the bolt and the vent is thus absolutely protected. The reverse operations take place when the breech is closed and when the block is securely fixed in its seat, the safety shield is lifted clear of the vent and the gun can be fired (Fig. 228).

Figs. 238 to 242 illustrate the different kinds of projectiles for the 75-millimetre mountain gun; the weights are given in Table XVI.

TABLE XVI.—PARTICULARS OF PROJECTILES FOR 2.95-IN. MOUNTAIN GUN.

NOTE.—The various weights given in the following Table are those to which the nearest approximation is made, but the actual weights are subject to slight variations. The fuze employed for the different kinds of shell is a combination time and percussion fuze; except for common shell, in which a percussion fuze is employed.

Fig. 238.

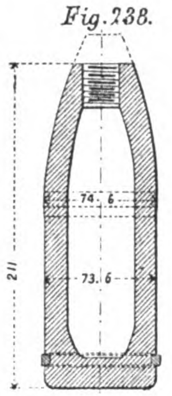


Fig. 238.—Common Shell.

		lb.	kilos.
Weight of cast iron	..	**8.987**	4.085
,, band	..	**.154**	0.070
,, fuze..	..	**.484**	0.220
,, bursting charge	.. ..	**.495**	0.225
Total weight	..	**10.120**	4.600

Fig. 239.

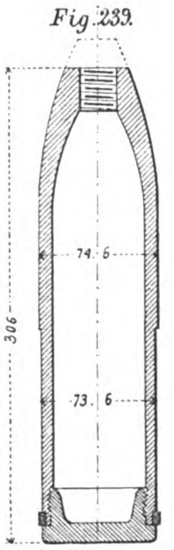


Fig. 239.—High Capacity Shell.

		lb.	kilos.
Weight of steel..	..	**8.118**	3.690
,, band	..	**.154**	0.070
,, fuze..	..	**.484**	0.220
,, bursting charge	.. ..	**1.364**	0.620
Total weight	..	**10.120**	4.600

Fig. 240.

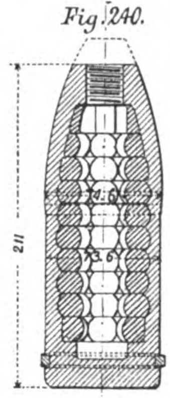


Fig. 240.—Shrapnel.

		lb.	kilos.
Weight of cast iron	..	**5.764**	2.620
,, balls..	..	**3.454**	1.570
,, band	..	**.154**	0.070
,, fuze..	..	**.484**	0.220
,, bursting charge	.. ..	**.264**	.120
Total weight	..	**10.120**	4.600

Fig. 241.

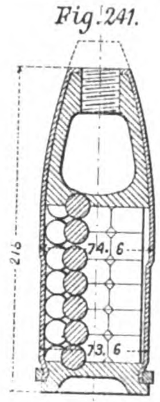


Fig. 241.—Mitraille.

		lb.	kilos.
Weight of cast iron	..	**5.764**	2.620
,, balls..	..	**3.454**	1.570
,, band	..	**.154**	0.070
,, fuze..	..	**.484**	0.220
,, bursting charge	.. ..	**.264**	0.120
Total weight	..	**10.120**	4.600

Fig. 242.

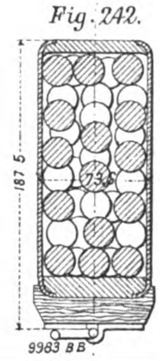


Fig. 242.—Case Shot.

		lb.	kilos.
Weight of balls..	..	**6.809**	3.095
,, case..	..	**2.387**	1.085
,, resin	..	**.924**	.420
Total weight	..	**10.120**	4.600

DREDGING IN THE MERSEY DOCK ESTATE.

(*Concluded from page* 639.)

Third Period, 1885 to the Present Time.—The increase of the dock area at Liverpool and Birkenhead by the opening of certain new docks from time to time, and the large increase due to the completion of the New North Dock system, rendered it necessary in 1884 that additional dredging appliances should be obtained. A small Priestman dipper dredger, mounted on one of the ladder dredgers, had been in use for some time, and from the satisfactory manner in which it worked, it was determined to adopt that kind of appliance on a very much larger scale. After mature consideration it was decided that a large steam hopper barge should be fitted with four Priestman's grab buckets. The vessel was to be 185 ft. long and 33 ft. beam, with a hopper capacity of 800 cubic yards, the engine to be compound and the speed 10 knots, the "grabs" to be of the A size, and to be capable of raising about 36 cubic feet per lift. The contract was let to Messrs. Simons, and was completed by them in a highly satisfactory manner in 1885, the cranes and grab buckets having been made by Messrs. Priestman, of Hull. In Fig. 6 on page 678 we give a perspective view of this vessel, while a longitudinal section, plan, and cross-section are shown by Figs. 7, 8, and 9 on pages 670 and 671.

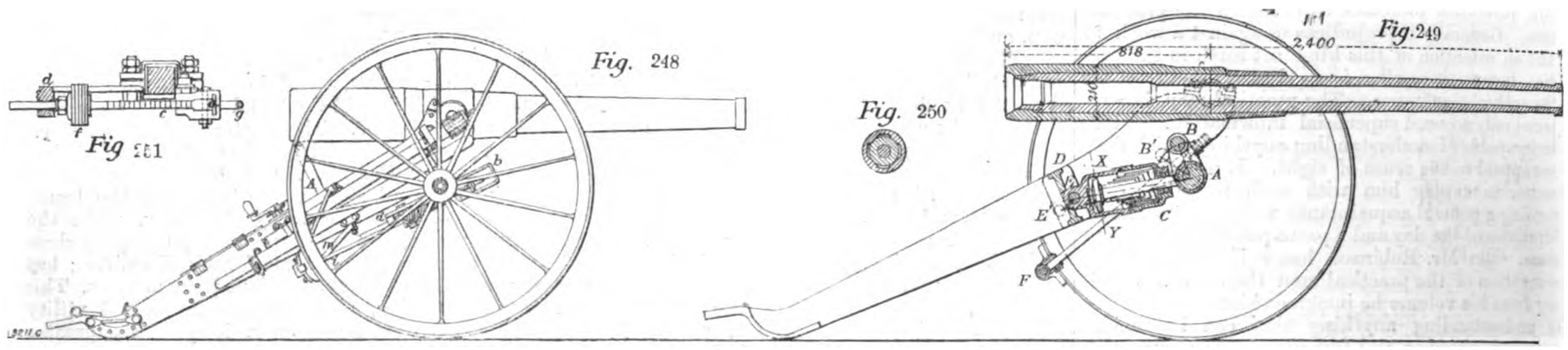
The advantages of this system of working soon became apparent. The vessel named "No. 9," being self-contained, could proceed direct to dock on returning from the tipping ground, while she occupied less room in dock than a dredger and steam hopper, a matter of great importance in docks crowded with shipping. She carried nominally as much as two of the largest hoppers, but in reality a good deal more, as the mud being raised in a larger volume than with the small buckets of the ladders, is more solid, and as a consequence there is less slush and water. Great as were the advantages in connection with this mode of working, there was one drawback, and that was the wear and tear to the grab buckets, although the workmanship of these buckets was excellent, and the materials of good quality. Mr. Morgan, the superintendent of dredging, looked into the matter, and after consideration a bucket of a new type was made and tried. This gave such excellent results that it is now being employed by the Mersey Dock Board for all the dipper dredgers in use by them.

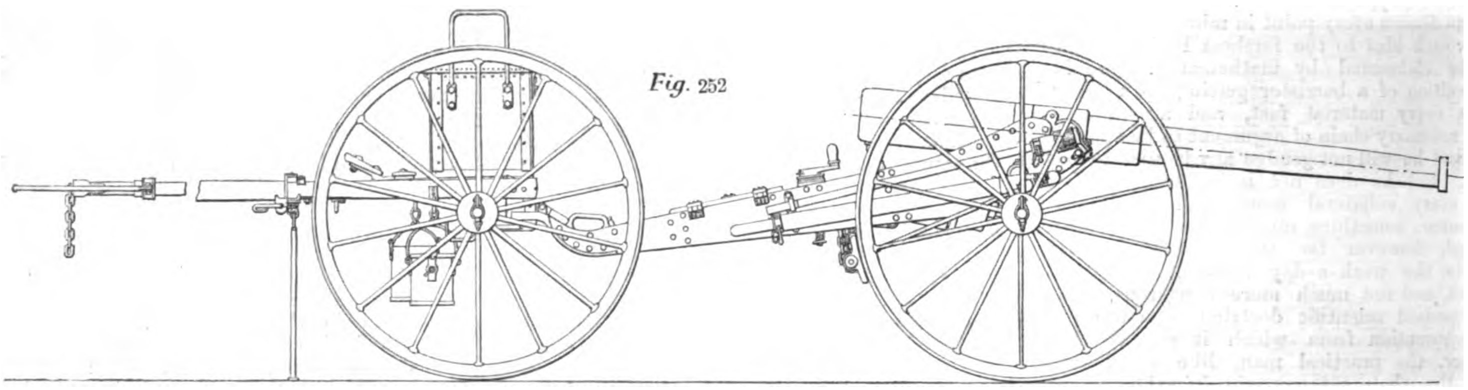
The general construction of the bucket, which Mr. Morgan has patented, is shown by Figs. 10 to 13 on page 672, which scarely need description. It is worked by two chains passing over the jib-head of the crane. The lifting chain is shackled to a large cam-shaped ring or eccentric fixed on a sleeve, which turns loosely on a shaft passing along the apex of the bucket from one end to the other; to the same sleeve are fixed two smaller eccentrics, one on each side of the centre, and to these are attached chains of fixed length made fast to an upper crosshead, from which connecting-rods pass to the top edges of the sides of the bucket. The opening chain is attached to the crosshead referred to. When the bucket is open the lifting chain lies wound round the large eccentric. The closing is effected by hauling on the lifting chain, thereby winding in the chains on the small eccentrics, and so pulling down the crosshead, the connecting-rods from which force the sides of the bucket together. The bucket opens when the opening chain is held, and the lifting chain let go. The central shaft then lowers away from the crosshead and the sides of the bucket expand, until the short chains between the latter and the small eccentrics are fully unwound; at the same time a certain length of the slack of the lifting chain becomes wound on the large eccentric. The eccentrics on the shaft are so arranged as to give a large power towards closing the bucket at the commencement of closing, it being then desirable

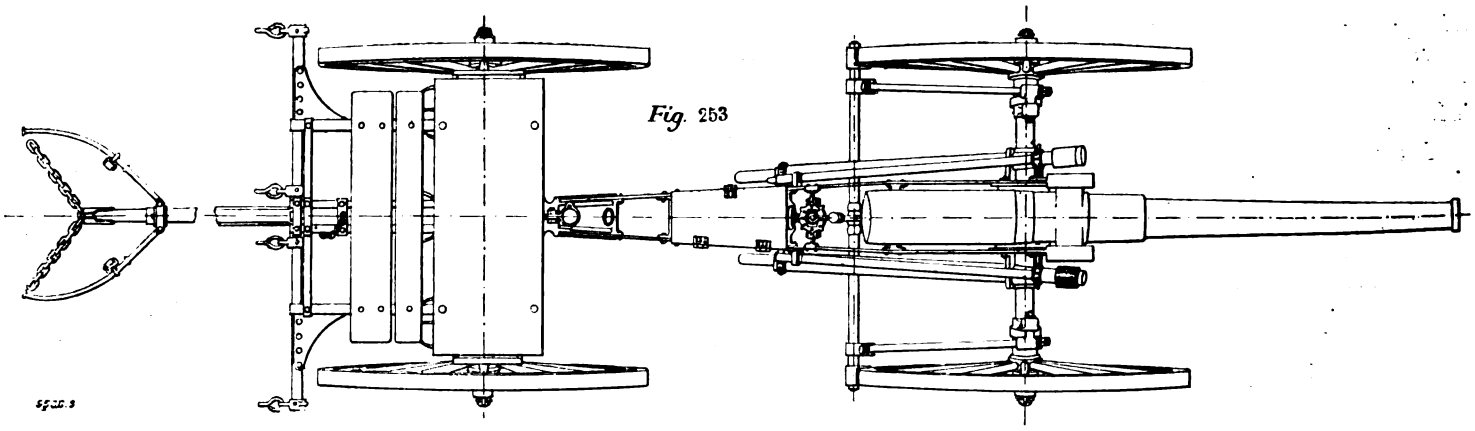
FIELD GUNS AND MOUNTINGS ON THE CANET SYSTEM.

THE FORGES ET CHANTIERS DE LA MEDITERRANÉE, HAVRE.

(*For Description, see opposite Page.*)







similar poles together. Each system is securely fixed to a circular brass frame, which fits on to the cylindrical case of the instrument in such a way that the systems are capable of being turned round, together or separately. The instrument has a tangent scale, which is adjusted in its position before the instrument is sent out, so that the needle indicates equal differences of readings for equal differences of current. There is also shown an ampère gauge, of which there are different types made, ranging from .5 to 500 ampères. These, with other instruments on the stand, will be viewed with great interest.

On a stand in the north court of the main building Professor James Blyth, of the Glasgow and West of Scotland Technical College, also exhibits several ingenious appliances for electric measurements. These include among others a current weigher, which gives the results in absolute measurement. In his current and voltmeters he reaches his result by determining the strain of a spring produced by the attraction of a current in a solenoid acting on a thin soft iron armature. An interesting instrument is his volt and current thermometer, in which a current is used to produce a change of temperature in a long thread of mercury in a glass tube, and from the expansion of which the measurements are determined. All his exhibits, it may be said, indicate the type of work that the student of electricity in the Glasgow Technical College may be expected to face, and demonstrate the good fortune of the directors in having the services of a man capable of devising such instruments.

Messrs. Clark, Latimer, Muirhead, and Co., London, are well represented by ammeters, voltmeters, galvanometers, proportional coils, resistance boxes, and the standard cells. They have also on the roof of the Machinery Hall a search light projector of 20,000 candle-power, which is worked from one of their Westminster dynamos.

One of the largest and most complete demonstrations of what electricity can do for lighting, for locomotion, and for general mechanical driving purposes, is that of the Electric Construction Corporation, Limited. Above their stand is erected a boarding, fully 2 ft. deep, carrying about 800 16 candle-power incandescent lights, forming the letters composing the name of the company, and the effect of the illumination is striking. The electricity for these lamps is supplied by an Elwell-Parker alternating current dynamo, driven by a Willans engine, as used by the Metropolitan Electric Supply Company. In this machine the armature is stationary, contains a laminated iron core of large section, and permits of good facilities for perfect insulation. The rotating portion of the machine consists of a number of soft wrought-iron poles, bolted upon a cast-iron centre fixed on the shaft. The armature is covered with wood so as to protect the attendant. The dynamo runs at about 400 revolutions, with an output of 100 kilowatts. There are also two Elwell-Parker continuous dynamos driven by horizontal high-pressure engines. Part of the electricity generated by these is for driving sewing machines on Messrs. Singer's stand, and other motor purposes, and part for storage. The system of storage and distribution exemplified on the stand is that adopted by the Chelsea Electricity Supply Company, described in a paper read by Major-General Webber before the Mechanical Science Section of the British Association at Newcastle, and noticed in our report of the meetings.* Among the other exhibits of the application of electricity here, we may notice the electric tramcar, as in use in Birmingham.

The India-Rubber, Gutta-Percha, and Telegraph Works Company, Limited, of the well-known Silvertown Works, although represented only by one exhibit, must take a prominent position, as the machine has many merits. The chief characteristic is the compactness, the engine and dynamo being bolted on one bedplate of cast iron, occupying together about 10 ft. The driving engine is the "Globe" compound direct-acting type, made by Messrs. Musgrave and Sons, Bolton. The cylinders are 8½ in. and 15 in. in diameter, and the stroke 8 in. There is a single balanced valve between the cylinders. The whole engine is inclosed in sheet-iron casing, and the well in which the crank works is partly filled with lubricating oil. The engine works under a pressure of 100 lb., and up to 375 revolutions per minute, the piston speed being 500 ft. The dynamo develops 350 ampères, the electromotive force being 105 volts. The field magnets, which weigh 3 tons 8 cwt., are of Low-moor iron, and the armature weighs 21 cwt.

An adjoining exhibit offers a contrast to such dynamos as that just described. It bears the date February 22, 1844, and is one of the earliest magneto-electric machines constructed on the principle of Faraday's discovery. The maker was

* See ENGINEERING, vol. xliii., page 357.

THE CANET BREECH MECHANISM FOR A 75-MILLIMETRE BOAT GUN.

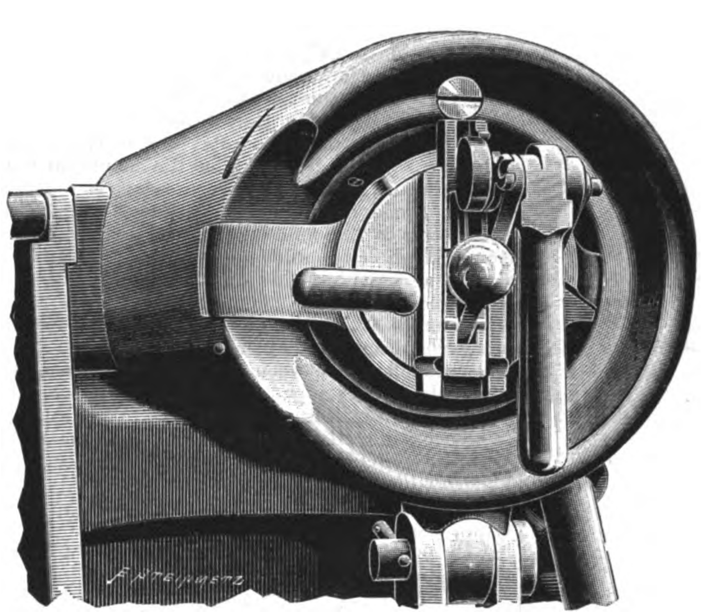


FIG. 254.

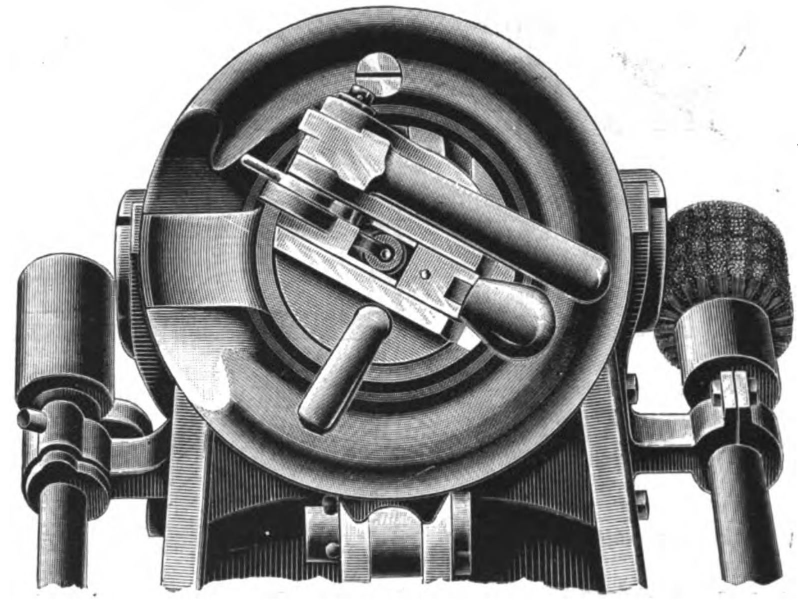


FIG. 255.

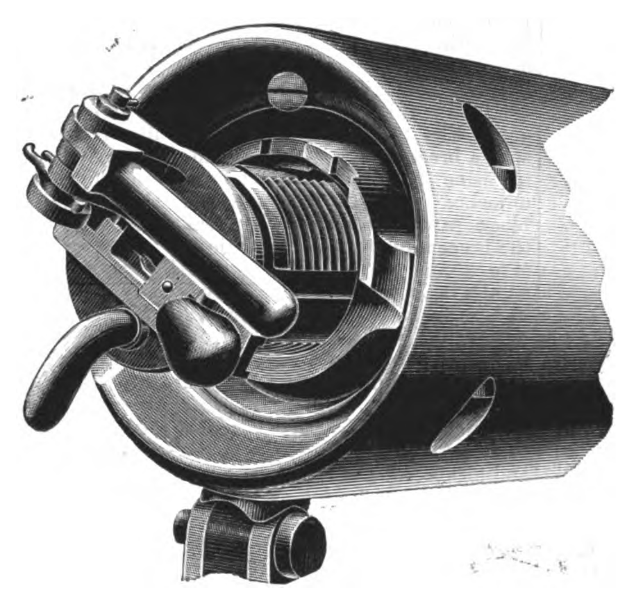


FIG. 256.

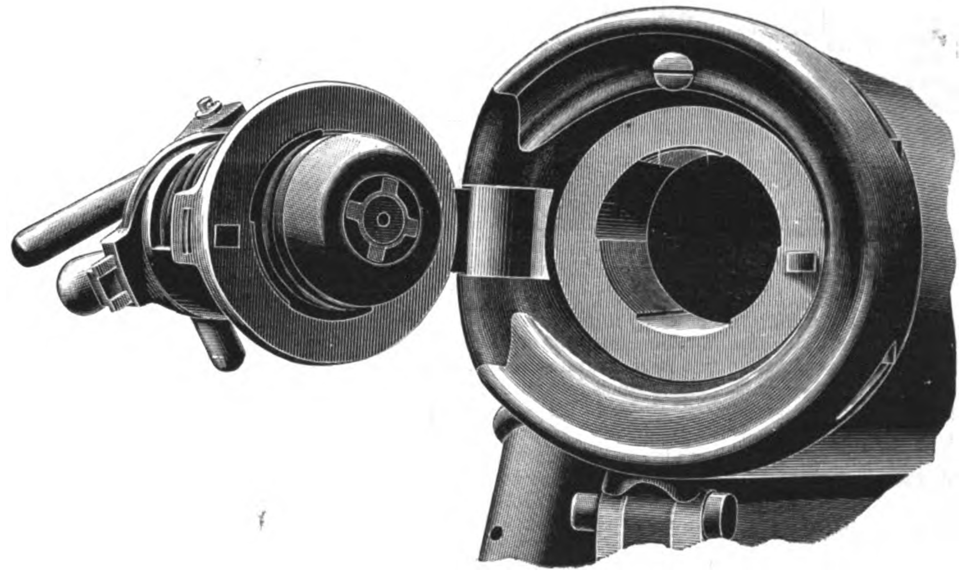


FIG. 257.

Mr. J. S. Woolrich. Bobbins wound with copper wire are fixed on the rim of a wheel and caused to pass by the rotation of the wheel through the jaws of four sets of permanent steel magnets placed symmetrically. The wires from the separate bobbins run to the nave of the wheel, where the currents are collected in the usual way. The presence of this primitive yet wonderfully perfect instrument links up the magnificent mechanical results of electrical engineering with Faraday's far-reaching discovery of the seemingly insignificant fact that if a wire loop be moved to cut the lines of force in a magnetic field a current will flow in that loop.

The firm of Ernest Scott and Co., Newcastle-on-Tyne, have a good exhibit of electric lighting plant for ordinary and ship use. The machines are of the alternating type giving a very high voltage and are associated with transformers, of which some examples are shown. One machine, driven by a Robey vertical engine, 8¼ in. cylinder by 8 in. stroke, develops 10 ampères at 1000 volts, the armature making 1200 revolutions. A type of plant for ship installations is shown. It consists of a 6½ in. by 6 in. vertical high-speed engine, coupled direct to a dynamo with a Gramme ring armature, making 325 revolutions per minute, giving 65 volts, 70 ampères, sufficient to maintain 100 incandescent lights. One or two of their machines are used for lighting stands.

The conversion of the energy of electricity into mechanical work is illustrated at the stand of Messrs. Immisch and Co., well known in connection with the construction of electric motors for propelling the Thames electric launches. They exhibit motors similar to those in these launches. On their stands is also shown a tramcar motor working to 1000 revolutions and developing 10 brake horse-power. It is of a type used by the North Metropolitan Tramway Company at Barking. These motors occupy little space and are of great service for many purposes. Such as in mining operations, whether for haulage, or for driving drills, or coal-cutting machines. The relative work done to the weight of the motor is about one-horse power per hundredweight. A motor may be seen driving an Ingersoll percussion rock drill, the current being supplied from one of Messrs. King, Brown, and Co.'s dynamos.

Excellent exhibits in dynamos and plant generally are shown by Messrs. Prentice, Napier, and Co., Suffolk; Norman and Sons, Limited, Glasgow; Woodside Electric Company, Glasgow; Hartnell Wilson, Leeds; King, Brown, and Co., Edinburgh; Kennedy Rankin and Co., Kilmarnock; the Brush Company, and others. Sir William Vavassour shows primary batteries chiefly for electric lighting, and the Lord Justice Clerk of the Court of Session, better known as Mr. J. H. A. Macdonald, is also an exhibitor. There are three electric welding machines, from Mr. Richard Miller, Glasgow.

However much the ordinary visitor may be impressed with the importance of electricity for practical uses by the magnificent demonstration of the methods of producing, distributing, and using this power, yet the enormous strides which have been and are being made will be more vividly enforced by the brilliant array on several stands of artistic fittings which manufacturers find it to their advantage to provide for the progressive wants of the times.

MODERN FRENCH ARTILLERY.
No. XXIII.

THE FORGES ET CHANTIERS GUN FACTORY—MOUNTAIN AND FIELD GUNS—*continued.*

THE carriages for both mountain and field artillery are similar in design, the principal differences being those involved in constructing the former in separate parts that are light enough for mule transport and can be easily and rapidly put together. The general appearance of the various mountings is illustrated by the views Figs. 248 to 253 (page 694). The lightest form of carriage is shown in Figs. 248 and 251; it is made of two side plates of steel connected at the upper and lower ends by steel castings, the lower junction-piece being provided with the necessary attachments for coupling to the limber and training the gun; the side frames are in addition strongly braced together by cross-ties. The frame is mounted on steel wheels with bronze centres; the wheels are 37 in. in diameter for the mountain guns, and 47 in. for the field artillery; the distance between the wheels varies from about 27 in. to 42 in.; the total weight of the complete carriage is 308 lb. for the mountain, and 858 lb. for the field guns. The illustrations show the mode of training these guns for elevation; the arrangement consists simply of a lever A, one end of which is pinned to projections on the breech of the gun, while the other end is connected to a nut mounted on a

Table XVII.—Particulars of Weights of Various Types of Projectiles for Canet Field Guns.

Fig. 243.—Common Shell.

	lb.	kilos.
Weight of cast iron ..	10.340	4.700
,, band.. ..	.154	0.070
,, fuze	.484	0.220
,, bursting charge	.462	0.210
Total weight ..	11.440	5.200

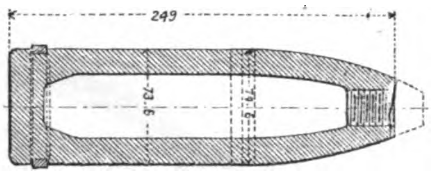


Fig. 244.—High Capacity Shell.

	lb.	kilos.
Weight of steel	9.218	4.190
,, band.. ..	.154	0.070
,, fuze	.484	0.220
,, bursting charge	1.584	0.720
Total weight ..	11.440	5.200

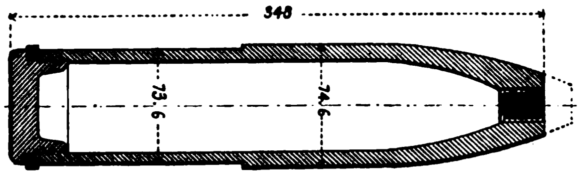


Fig. 245.—Shrapnel.

	lb.	kilos.
Weight of cast iron ..	6.567	2.985
,, balls . ..	3.905	1.775
,, band ..	.154	0.070
,, fuze	.484	0.220
,, bursting charge	.330	0.150
Total weight ..	11.440	5.200

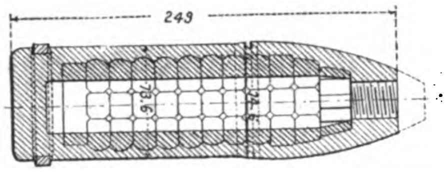


Fig. 246.—Mitraille.

	lb.	kilos.
Weight of cast iron ..	7.557	3.435
,, balls.. ..	2.970	1.350
,, band ..	.154	.070
,, fuze	.484	.220
,, bursting charge	.275	.125
Total weight ..	11.440	5.200

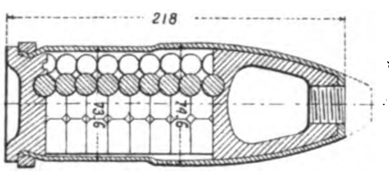
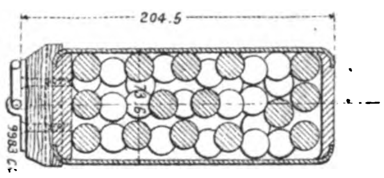


Fig. 247.—Case Shot.

	lb.	kilos.
Weight of balls.. ..	7.700	3.500
,, box	2.750	1.250
,, resin ..	.990	0.450
Total weight ..	11.440	5.200



screw that can be traversed by means of a crank handle as shown; the angular range for mountain guns is from — 20 deg. to + 20 deg, and — 6 deg. to + 20 deg. for field guns. These guns are trained horizontally by shifting the trailing end of the carriage, rings being provided for that purpose as shown. A type of brake largely employed is that illustrated in Figs. 248 and 251, and already referred to as on the Lemoine system. It consists of the following principal parts: (1) A flat plate spring *a* held in front of the axle by two stirrups *b*; (2) a rack *c*, Fig. 251, supported at one end by the spring just referred to, and at the other by a bracket *d* attached to the stirrups; this rack passes through a guide bolted beneath the axle and formed with teeth that can gear into the rack; for a part of its length it is also cut with a screw thread on which is placed the nut *f* by which the range of the brake action can be regulated. At each end the flat spring is held by cords which are passed around the inner boss of the wheel centres, and beyond are attached to the extremities of the rods *i* which are jointed to the bars *m*, that pass from the frame to the wheels, where they carry the brake-blocks. The operation of this brake is very simple; the force of recoil tends to drive the gun and carriage backwards; in doing this, however, the cords wound around the boss of the wheels are affected and set up a pull on the brake levers by the action of the two levers *i i*, the elasticity of the system being secured by the action of the plate spring to which the cords are attached; the degree of recoil can be adjusted by the position of the nut *f* on the rack bar. This simple form of brake is not applicable to the heavier types of field guns, and accordingly a different pattern is used for the heavier models; this pattern is clearly illustrated in Figs. 249 and 250. The side frames of the carriage are not attached direct to the axle but are articulated with it and are further connected by means of an hydraulic brake; this arrangement is carried out as follows. On the axle are placed two sleeves A, on each of which are two projections; underneath each plate forming the side frame are two brackets between which pass the projections on the sleeve and to which they are secured by the bolt B; by this means the frame can turn round the axle. The brake arrangement is shown in the figures; the cylinder is extended at the rear in such a way as to form a trunnion through which a pin E passes, attaching it to the crossbar D, connecting the two side frames together; the piston-rod of the brake is connected to a sleeve mounted on the centre of the axle. Fig. 249 is a section through the cylinder, and from this it will be seen that while the piston is circular, in the walls of the cylinder four passages are cut, the areas of which are variable; the cylinder is made in two lengths, the forward half being screwed into the rear half and provided in front with a gland through which the piston-rod passes; within this part of the cylinder is placed a coiled spring, the smaller end of which presses against the piston; beneath the latter are placed two disc springs to take up the shock of the gun when it comes back into firing position—the position shown in Fig. 249. The action of this arrangement is very simple; as soon as the gun is fired the recoil throws it backwards, pivotting around the axle A; the extreme position of the bolt B and the cylinder trunnion E are shown in dotted lines at B' E' in the section; this movement causes the piston to be displaced in the cylinder, compressing the coiled spring and forcing the liquid past the piston through the passages in the wall of the cylinder. The recoil being completed, the spring which has been compressed by its action now expands and brings the gun back slowly into firing position. In addition to this arrangement the brake-blocks on the wheels are thrown into action; these blocks are mounted on a crossbar F, Fig. 252, that passes from one wheel to another, and is held in place by two levers *b b* that are mounted eccentrically upon the axle, the movement of which forces the brakes upon the wheels; of course these blocks can be removed from the wheels at any moment. The device for training in elevation, although resembling that already described for the lighter type of gun, differs in its details. Instead of a rod being attached to the breech of the gun and to the elevating screw, a cylinder is employed containing two coiled springs separated from each other by a piston, the rod of which is secured to the elevating screw. By this means an elastic connection is obtained between the training screw and the gun, and the shock caused by firing is absorbed by the springs. With this type of carriage the wheels are 52½ in. in diameter, and the width between them is about 37 in. The weight of the complete carriage is 1078 lb., and the limiting angles of fire range from − 6 deg. to + 20 deg.

Figs. 243 to 247 are sections of the various types of projectiles made for the 75-millimetre field gun. It will be seen that while the general characteristics are the same, they differ slightly in form and dimensions, and the total weight is greater, 5.2 kilos. (11.44 lb.) As in the mountain gun ammunition, the diameter of the shot is reduced over a considerable part of its length from 74.6 millimetres to 73.6 millimetres; the position of the copper band is the same in all cases. Except for the case shot the head is open to receive the fuze. It will be noticed in Figs. 241 and 246 that the mitraille case consists of a cast-iron head and base, the former being cored out to hold the bursting charge. The balls are placed between the head and base, the whole being enveloped in a steel envelope, the thickness of which has to be very carefully adjusted, to secure the shell opening properly at the moment of rupture, and at the same time to prevent it from bursting during flight.

All the foregoing are the latest and most approved types, the patterns being dated April, 1890. Table XVII. gives particulars of the weights of these projectiles.

Table XVIII. (see next page) contains particulars of firing tests made with the Canet field guns of 75-millimetre bore at the Polygon at Havre and at Sevran-Livry, between January, 1887, and January, 1890. The tests with smokeless powder afford an interesting comparison with those fired with ordinary charges.

In our last article (see page 668 *ante*) we referred to the special breechloading mechanism for boat guns; Figs. 254 to 257 (page 695) are illustrations of such a breech, and show the gun closed and ready for firing (Fig. 254), the block turned round into the unlocked position for withdrawal (Fig. 255), the block partly drawn from its seat (Fig. 256), and the breech open for the reception of a new charge (Fig. 257). The movements of closing are of course similar but reversed. As we have already explained, the breech of these guns is provided for firing percussion fuzes, friction fuzes being unadvisable on account of the generally enforced proximity of the man to the gun when firing. The hook to which the lanyard is attached that trips the hammer is seen in Fig. 256, in which position, as well as in all others, except Fig. 254, where the breech is closed and locked, no pull would affect the hammer, which is held fast by a spring engaging in a recess in the block as already explained, while the block is being turned into the position shown in Fig. 255; during this movement the hammer is cocked, and continues so, being held by the safety spring.

ON THE LAWS OF STEAMSHIP PROPULSION.

By Robert Mansel, Whiteinch, Glasgow.

In 1857, writing some controversial letters in an engineering journal named the *Artisan*, I entered upon an exposition and defence of the quantities known as "Admiralty coefficients." About that time these had been subjected to a virulent criticism, for most part founded upon misconception of their nature and scope. I have always insisted, in their inception they were founded upon correct principles; but there were "ignored and misrepresented elements," and in guarded language led up to a further step; they had been rendered misleading and meaningless by the introduction of a specious but false hypothesis as to the law of the resistance. Thus the doctrine, in the same machine doing work at different speeds, or equally, the cases of similar, but different machines, doing like work, the ratio of the work done to the amount of power taken to do it being necessarily the measure of the comparative efficiency of the various machines employed; there was nothing in this other than a mechanical truism, which, however, has to be taken in connection with the following mechanical principle, in the usually presented aspect of the subject, seemingly quite a paradox, and therefore, although of paramount importance, put aside and utterly neglected.

Two hundred years ago Sir Isaac Newton, in a scholium to the "Third Law of Motion," made the statement: In every machine it would be found, the quantities, the gross work done, and the gross

TABLE XVIII.—FIRING TESTS MADE WITH CANET FIELD GUNS 75 MM. (2.99 IN.) AT HOC AND SEVRAN-LIVRY, BETWEEN JANUARY, 1887, AND JANUARY, 1890.—*(See preceding page.)*

(A. Long Type)

Dates of Trials.	Weight of Projectile.		Nature of Powder.	Weight of Charge.		Initial Velocity.		Pressures.	
	lb.	kilos.		lb.	kilos.	ft.	metres	lb. per sq. in.	kilos. per sq. cent.
November, 1888	10.12	4 600	C2 5th lot	3.30	1.500	1801	549	26,141	1838
,, ,, ...	10.12	4.600	C2 3rd lot	3.30	1.500	1905	550	21,335	1500
January, 1888	10.12	4.600	Do.	3.30	1.500	1834	559	23,824	1675
April, 1888	10.12	4.600	Do.	3.52	1.600	1922	586	23,013	1618
,, ...	10.12	4.600	Do.	3.52	1.600	1926	587	25,757	1811
,, ...	10.12	4.600	C2 4th lot	3.74	1.700	1988	606	31,333	2203
,, ...	10.12	4.600	C2 3rd lot	3.74	1.700	1995	608	33,253	2338
,, ...	10.12	4.600	C2 5th lot	3.96	1.800	2063	629	32,954	2317
January, 1887	11.44	5.200	C2 special	3.08	1.400	1755	535	28,332	1992
May, 1887	11.44	5.200	C2 1st lot	3.08	1.400	1830	558	28,616	2012
April, 1889	11.44	5.200	C2 5th lot	3.30	1.500	1722	525	29,043	2042
January, 1888	11.44	5.200	C2 3rd lot	3.30	1.500	1899	579	21,761	1530
May, 1887	11.44	5.200	C2 1st lot	3.52	1.600	1906	581	31,233	2196
February, 1887	11.44	5.200	C2 special	3.74	1.700	1916	584	33,850	2380
January, 1887	11.44	5.200	Do.	3.74	1.700	1942	592	34,968	2460
April, 1888	11.44	5.200	C2 3rd lot	3.85	1.750	1912	583	29,868	2100
,, ...	11.44	5.200	Do.	3.96	1.800	1959	597	32,642	2295
February, 1887	11.44	5.200	C2 special	3.96	1.800	1995	608	37,292	2622*
January, 1888	13.64	6.200	C2 3rd lot	3.30	1.500	1771	540	25,373	1784
April, 1888	13.64	6.200	Do.	3.52	1.600	1700	518	31,362	2205
,, ...	13.64	6.200	Do.	3.52	1.600	1719	524	33,552	2359
January, 1888	13.64	6.200	Do.	3.74	1.700	1755	535	32,329	2273
April, 1888	13.64	6.200	Do.	3.74	1.700	1794	547	32,428	2280
January, 1888	13.64	6.200	Do.	3.85	1.750	1843	562	32,713	2300
December, 1888	13.64	6.200	Do.	3.96	1.800	1847	563	38,004	2672*
April, 1888	13.64	6.200	Do.	3.96	1.800	1866	569	33,850	2380
December 2, 1889 .. .	11.44	5.200	BN 144 smokeless	.793	0.360	1233	376	7,708	542
,, ,, ...	10.12	4.600	Do.	1.32	0.600	1673	510	18,376	1292
,, ,, ...	10.12	4.600	Do.	1.65	0.750	1912	583	29,242	2056
,, ,, ...	10.12	4.600	Do.	1.65	0.750	1919	585	30,267	2128
,, ,, ...	11.44	5.200	Do.	1.65	0.750	1827	557	31,048	2183
December 27, 1889	10.12	4.600	BN 154 smokeless	1.65	0.750	1886	575	23 581	1658
,, ,, ...	10.12	4.600	Do.	1.98	0.900	2162	659	33,737	2372
,, ,, ...	10.12	4.600	Do.	1.98	0.900	2142	653	34,831	2449
,, ,, ...	10.12	4.600	Do.	1.98	0.900	2155	657	35,429	2491
,, ,, ...	10.12	4.600	Do.	1.98	0.900	2057	627	35,913	2525
(B. Short Type).									
March, 1887	10.12	4.600	C2 1st lot	1.764	0.800	1372	418	13,710	964
,, ...	10.12	4.600	C2 4th lot	2.2	1.000	1476	450	16,910	1189
April, 1888	10.12	4.600	C2 3rd lot	2.2	1.000	1515	462	25,174	1770
,, ...	10.12	4.600	Do.	2.425	1.100	1597	487	24,605	1730
.. .. ..	10.12	4.600	Do.	2.646	1.200	1722	525	30,708	2159
,, ...	11.44	5.200	Do.	2.2	1.000	1427	435	22,600	1589
,, ...	11.44	5.200	Do.	2.425	1.100	1561	476	25,757	1811
, ...	11.44	5.200	Do.	2.646	1.200	1630	497	31,603	2222
,, ...	13.64	6.200	Do.	2.2	1.000	1355	413	25,373	1784
,, ...	13.64	6.200	Do.	2.625	1.100	1430	436	29,043	2042
,, ...	13.64	6.200	Do.	2.646	1.200	1519	463	32,954	2317

* Firing tests for ultimate resistance of gun.

power doing it, would be always equal to each other. To fix ideas, suppose we take the displacement form of the Admiralty coefficient:

$$C=\frac{D^{\frac{2}{3}}V^3}{E}.$$

The physical interpretation of this was, or ought to have been, the numerator is the definite expression for the gross work done when a vessel of displacement D is propelled at the rate of V knots by the expended gross indicated horse-power E. Now any one possessing even a slight knowledge of the subject is aware, this formula, applied to the actual trial data of any steam vessel, gives values for C with violent, capricious, and inexplicable variations. Newton's proposition, therefore, seemed supremely ridiculous, and never showed in the running at all; while the saltatory antics of the coefficient C have been carefully registered as a *pabulum* from which naval architects were to derive inspiration as to "comparative efficiency." At least, judging from the explanations given with the "Trial Data of Steam Vessels of the Royal Navy" and other oral statements, this seems to have been the theory at the British Admiralty. It, of course, remained open for any one to challenge the numerator as to whether it was a true measure of the work done, and a vast amount of misdirected acumen has been employed in order to obtain some supposed better expression for its elements. Many investigators got involved in a haze over the question, whether immerged mid area, surface, or displacement ought to be taken for the first factor, and even a man of clear insight, the late Dr. Rankine, failed to perceive this was a trivial matter, scarcely touching the real difficulty, and so he concluded the immerged frictional surface, multiplied by a function of the water-line angles; or, as he termed it, the "augmented surface," was the one thing needful. Another class of investigators, while asserting the resistance to vary as the square of the velocity V^2, in the same breath challenged the V^3 factor in the representation of the power. This was simply ignorance of mechanical principles, supplemented by confused notions as to mathematical ones. Since, to assert a V^2 resistance, could be overcome at a V speed, by other than a power varying as V^3, is quite as absurd as for an arithmetician to deduce that two and one taken together give something different from three. It is a mathematical necessity. If the power be not proportional to the cube, the resistance must be varying in some other ratio than the square. Dr. Rankine's investigation, the earlier one of Professor Reéch, and its recent application by the late Dr. Froude, as well as the published values of the Admiralty coefficients, each and all directly imply and assert the truth of the hypothesis, that the resistance varies as the square, and, consequently, that the power varies as the cube of the speed, and *ipso facto* are necessarily erroneous; the key to the enigma being the simple fact, in the usual circumstances of steamship propulsion, the resistance does not vary in the ratio of the square of the speed, and hence the power does not vary as the cube. To find the law of the resistance, and thence the true relation between the power and speed, it is, probably, simplest to build up from the following proposition: The differential coefficient, with respect to the speed of the logarithm of the resistance, is equal to a small coefficient, constant for adjacent ranges of speed, through which the circumstances of trial are unchanged. In symbols this is expressed thus:

$$\frac{d \log R}{d V}=a.$$

Where R denotes the resistance, and a this small constant coefficient; again,

$$d \log R=a.\,d V,$$

which, by the simplest application of the integral calculus, gives,

$$\log R=a V+\log b.$$

The constant introduced by the integration being taken of the form $\log b$.

$$\therefore\ R=b \log^{-1} a V=b\,10^{aV} \quad . \quad . \quad (I.)$$

is the true form of the resistance, and by adding log V to each member of the preceding equation we also have,

$$\log R+\log V=\log b+\log V+aV,$$

or, again,

$$\log R V=\log b V+a V.$$

Now R V is that definite existence which Newton defined as *actio agentis*, "action of the agent," which, eighty years later, John Smeaton named mechanic power, and which is understood, when, now-a-days, we write or speak of energy, measuring it in James Watt's conventional horse-power units. So that, denoting this by E, we have,

$$\log E=\log b V+a V,$$

which implies the following forms:

$$E=b V \log^{-1} a V=b V\,10^{aV} \quad . \quad (II.)$$

and the incorrect Admiralty formula,

$$E=\frac{D^{\frac{2}{3}}V^3}{C}$$

can be changed into the very approximate correct form,

$$E=\frac{D^{\frac{2}{3}}}{C^1}V\,10^{aV} \quad . \quad . \quad . \quad (a)$$

susceptible of another important modification, as follows:

$$E=D^{\frac{2}{3}}\,V\,10^{a\,(V-X)} \quad . \quad . \quad (b)$$

in which the divisor of the second member is replaced by a special speed X, diminishing the exponential speed factor. It will easily be noticed, this X is a speed, such that X = V will give,

$$E=D^{\frac{2}{3}}X,$$

and by taking the difference of equations (b) and (II.) we have:

$$0=\log D^{\frac{2}{3}}-\log b-Xa.$$

Whence, the explicit value of X is seen to be,

$$X=\frac{1}{a}(\log D^{\frac{2}{3}}-\log b). \quad . \quad . \quad (c)$$

These equations involve the relation of power and speed, so long as the quantity a remains constant, but a very limited experience, especially with fine vessels, driven over a great range of speeds, will show us, in the same vessel, we may have two or even three values for a, with sympathetic changes on b, X, and other constants in various easily deduced allied formulas (which I have pointed out, as involved in the foregoing formulas). In other terms, we have these quantities constant through a certain range of speed, beyond which they change to other values, and remain constant through another range; finally changing to a third set of values at the highest speeds attained in practice. General explanations, however, unless accompanied by actual examples, are difficult to follow out; these may be readily obtained from any carefully conducted, honestly reported, data of steamship trials. The "Admiralty Tables of Trial Data" are a common and most valuable treasury of such facts. The importance of the subject may warrant some space and attention being given to the application. I noticed recently a report of the trials of H.M.S.S. Widgeon, a comparatively small vessel, 165 ft. by 31 ft. and 805 tons displacement.

THE CANET SYSTEM OF FIELD ARTILLERY.

(*For Description, see next Page.*)

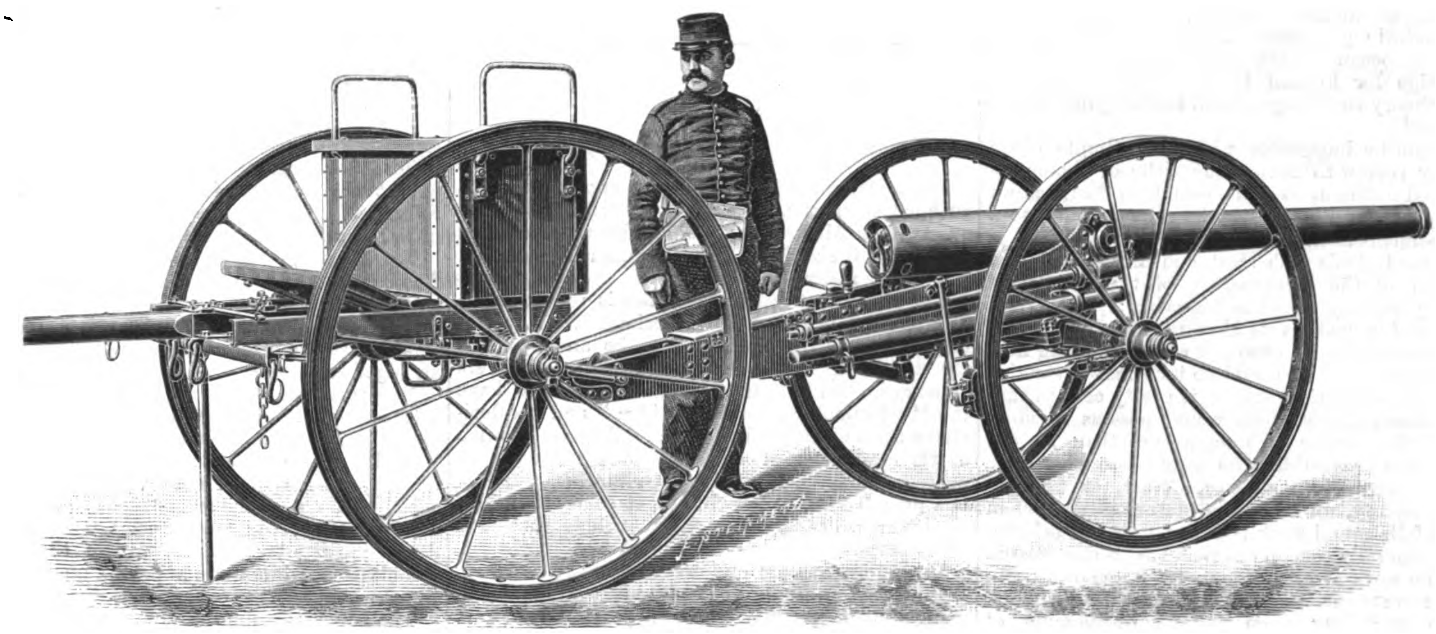


FIG. 258. CANET FIELD GUN AND LIMBER.

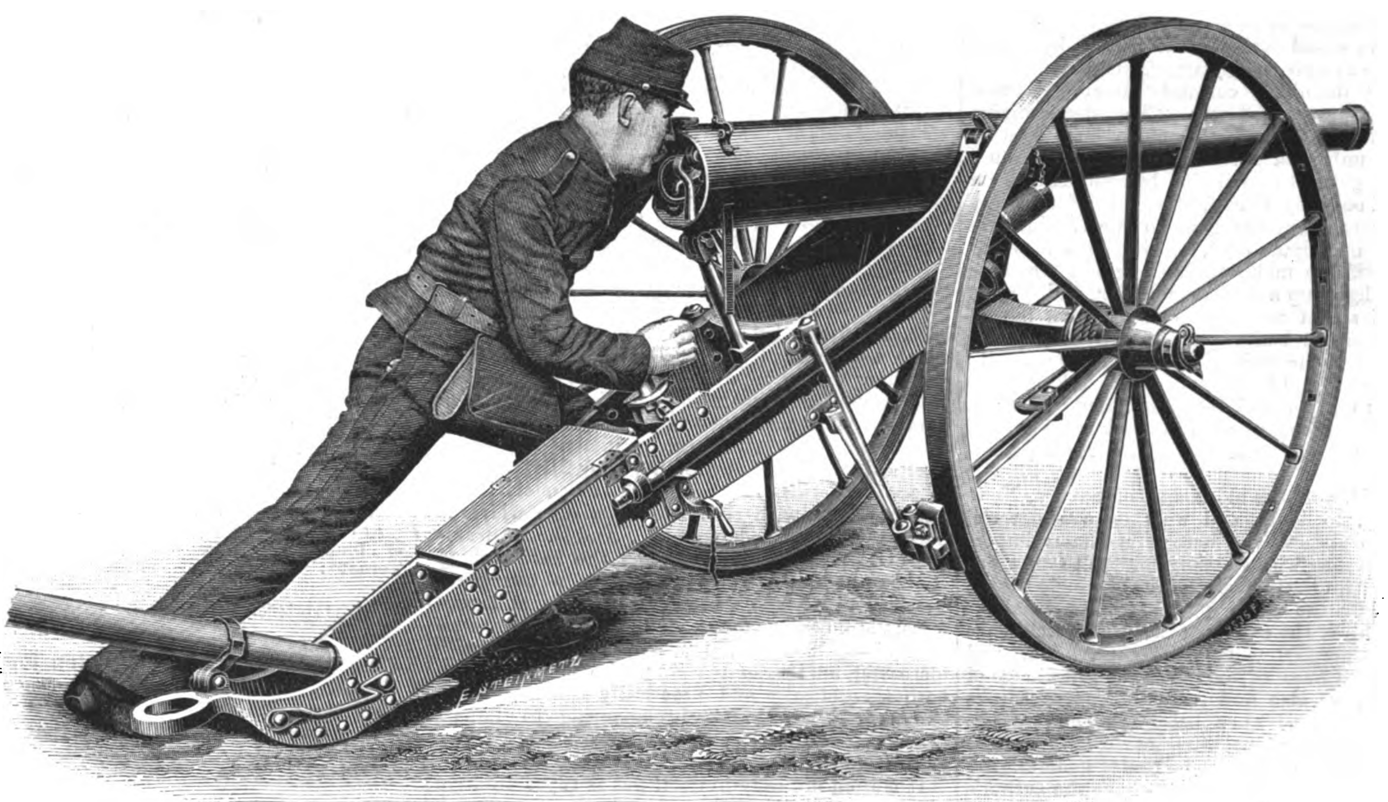


FIG. 259. CANET FIELD GUN SHOWING METHOD OF TRAINING.

LITERATURE.

Steam and other Prime Movers. A Text-Book both Theoretical and Practical. By HENRY EVERS, LL.D. London: Walter Scott.

WE are informed in the author's preface to this work that the title should have been "Steam and a *few* other Prime Movers." That this correction was required will be evident when on examination it is found that no prime mover at all other than a steam engine is in any way considered; the only approach to such consideration being the mention of gas engines as one type of engine, and this fact by itself hardly gives much practical or theoretical assistance to the willing student; this being —again according to the preface—the aim of the author.

It is fortunate that the aim was thus described, because otherwise it would have been extremely difficult to understand why the author had ever written the work under consideration; there still remains the difficulty, why he thought that the contents of his book would be of any value in accomplishing the result aimed at. But it is at any rate some satisfaction to know that there was an aim, and what it was.

So far we have not advanced beyond the preface, but the book is so full of singular "facts," that there is hardly a page about which one or two columns might not be written. The very title-page itself is suggestive. For it at once suggests the inquiry whether the author exactly knows what a prime mover is. There was some time ago an author of some repute, of whom Dr. Evers may have heard, named Rankine, who also wrote a treatise on prime movers. Now that book is not compared to the present, except that when such very similar titles are chosen, the comparison naturally suggests itself. The point, however, for consideration is that Rankine—and his book, although not of course comparable with Dr. Evers', was yet a very fair one —used the title "The Steam Engine and other Prime Movers," not "Steam," &c., and he defined as a prime mover a machine by which the powers of nature are utilised. It is probable that this difference of ideas on what constitutes a prime mover accounts for the defect first mentioned, Dr. Evers probably considering steam by itself to be one kind of prime mover, a marine engine or land engine as a different kind, and a rotary engine as another kind again, and so on.

Perhaps now it will be well to take some notice of the contents of the book itself; and it will probably be expected from the preceding remarks that such notice will not be extremely favourable. This impression is perfectly correct, in fact, we may say that, taken as a whole it would be difficult to imagine a worse book on the subject it is supposed to treat. There are undoubtedly some items of useful information, but they will be found in nearly all cases to be between quotation marks, and will be better studied in their original places than in the pages of this book. Where, however, the author's own ideas are set forth, it is difficult to say which is the more useless, the theoretical or the practical; perhaps on the whole the former is the worst, because every one picks up his practical knowledge for himself by his own observation, but in theory the effects of bad teaching may never be effaced.

It would be impossible within the limits of an ordinary review to notice one tithe of the errors contained in the book, this would, in fact, take a book as large if not larger than the original, so a few specimens must suffice.

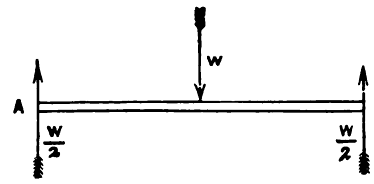
Chapter I. deals with Heat and Steam, and as a specimen of the lucid nature of the definitions generally we may take the following: "The temperature of a body is its thermal state considered with reference to its power of communicating heat to other bodies." It would be incorrect to say this is a wrong definition, but it is pretty certain that after hearing it, a student would possess no more idea of the nature of temperature than he did before, in all probability he would lose what little idea he originally possessed. Next, in defining kinetic energy, we meet the statement that when a stone falls actual work is done; it is, we believe, pretty generally considered that this is one case in which no work at all is done; for there is no resistance overcome, and work has just been defined on the preceding page as the overcoming of resistance. After the preceding we are informed that "Heat is a sensible condition of matter," and we presume it follows that the hotter the matter the more sensible it becomes; if this be correct some writers would derive great benefit by taking up an abode as near the equator as possible.

The next definition certainly deserves a new paragraph, being as follows: "The steam engine is the manifestation of the united impulses of countless numbers of invisible particles of steam." We are not going to spoil this by commenting on it; we will only say that if, after reading this, any maker of steam engines goes to the trouble and expense of employing men, and buying and working up metals to make up his engines, when he need only light up a fire in a boiler, and let the particles of steam manifest them for him, he deserves to become bankrupt. In the rest of the chapter we find the unit of heat wrongly defined; the increase of total heat explained as taking place according to a formula for the latent heat; a non-condensing engine with a back pressure of 6 lb.; and various other equally interesting statements.

Chapter II. goes the old round of Savery, Newcomen, &c., to Watt, and we then consider the action of the slide valve; here it is almost impossible to go wrong with so many sources to draw on, but we meet an ingeniously arranged single-ported valve in which the steam port as drawn is about twice the size of the exhaust; and the sketches are here, as generally, very poorly executed, and plainly show a want of any practical knowledge of the engine; we also find that the author thinks that if the exhaust open before the end of the stroke, this indicates negative inside lap; if it be so, negative inside lap must be pretty general.

In Chapter III., on Boilers, we have the author's opinion that steel of from 33 to 40 tons tensile stress is best adapted for boilers; this hardly agrees with the opinion of the Admiralty, who are pretty extensive users of boiler steel, since they actually reject any steel above 30 tons; perhaps after reading Dr. Evers' book they will alter this unwise course of procedure. Rivetting also supplies us with some peculiarities; a rough practical rule that diameter of rivet should equal thickness of plate being illustrated just below by a case of a $\frac{7}{8}$-in. rivet in $\frac{1}{2}$-in. plate, and a proof on the next page that 2-in. rivets make a better joint in $\frac{1}{2}$-in. plate than 1-in. rivets do; comment here would be superfluous. Among the preceding we find also the astounding statement that the strength of double rivetting is 98 per cent. of that of the plate.

The book contains fifteen chapters, and we have only now arrived at Chapter III., although only a selection of the erroneous and absurd statements with which the book is crammed has been given. It is plainly impossible to proceed in this manner all through, but we cannot help noticing one or two more gross errors. To illustrate the strength of plate a diagram which we here reproduce is inserted, and below is given the equation.



$$W \times \frac{l}{2} = \text{depth or thickness} \times \text{tension.}$$

By a reference in the book it appears that the author has written, or is about to write, a treatise on Applied Mechanics; judging by the specimen here given it should be decidedly amusing reading, if not very instructive.

The next point calling for notice is a most extraordinary use of the word "calorimeter." A calorimeter is generally understood to be an apparatus for measuring quantities of heat, but Dr. Evers appears to think it means an area; for we have the "calorimeter over the bridge," and "calorimeter through the tubes," &c., all given relative to the grate area of a boiler. Had the term appeared once only, it would be natural to suppose it a printer's error, but finding it repeated no less than four times, we can only conclude that it is really put down as representing an area.

One more extract and we shall have finished. "If an engine be running at 30 miles an hour, and using a given quantity of steam per mile, and we double the speed, *the resistance being constant*, the power is double, and hence twice as much water is evaporated *per mile*;" the italics are ours; and we think that any one will agree that the author of such a statement as the preceding would be much better employed in getting some sound knowledge of mechanics for himself, than in writing books to instruct others.

It may appear that it was hardly worth while devoting so much space to the examination of a book of this class. For an explanation of the reason for so doing we will return to the place whence we started, viz., the title-page. On that page we find the author described as the author of "Navigation and Nautical Astronomy," "Steam," "Trigonometry," "Mensuration," &c.

Here then is the explanation of the utter worthlessness of the book, and of many other books which have misled and still mislead hundreds of the younger and in some cases older members of the engineering profession. Written by men having a superficial knowledge of everything, and the almost invariable accompaniment of sound practical knowledge of nothing, they fill the minds of students with, in some cases, erroneous ideas, and in others with that half-knowledge which is perhaps even more dangerous. And the injurious effect does not stop here; for the hardworking student finding himself landed in a quagmire, becomes disgusted, classes all teachers and professors alike as humbugs, and becomes thus often a stumbling-block in the path of the now happily increasing number of teachers, who understanding both theoretically and practically the science of engineering, are earnestly labouring to impart sound professional knowledge to the rising generation of engineers.

It is then not only in itself but as representative of a class, that we condemn this book as one which can hardly, under any circumstances, be of use, but which is on the contrary almost certain to do great harm to any student who attempts to obtain from it help in the study of the steam engine.

Year-Book of the Scientific and Learned Societies of Great Britain and Ireland. London: Charles Griffin and Co., Exeter-street, Strand. 1890.

Lockwood's Builder's and Contractor's Price Book. London: Crosby Lockwood and Co., 7, Stationers' Hall Court, Ludgate-hill. 1890. [Price 4s.]

The "Shipping World" Year-Book. London: *Shipping World* Office, Gresham Press-buildings, Little Bridge-street. 1890.

The Colonial Year Book for 1890. London: Sampson Low, Marston, Searle, and Rivington, Limited.

The Stock Exchange Year-Book for 1890. By THOMAS SKINNER. London: Cassell and Co., Limited. [Price 15s.]

The Mining Manual for 1889-90. By WALTER R. SKINNER. London: 4, Birchin-lane, E.C. [Price 10s. 6d. net.]

The Mercantile Year-Book. Edited by WALTER LINDLEY JONES. London: Lindley Jones and Co., 46, Watling-street, E.C.

In the "Year-Book of the Scientific and Learned Societies" is given a short review of the history and organisation of the societies, of the conditions of membership, and a list of the papers read by the members at the meetings last year, with such notes as are possible regarding the sources from which the papers may be had for perusal. It will thus be seen that the book is a valuable one for reference, and as it is compiled mostly from official sources it may be taken as accurate.

Lockwood's Price-Book has undergone complete revision, and the recent improved methods of construction have been taken into account in the compilation, electric lighting, ventilation, and sanitary appliances generally being fully dealt with. Where the markets do not fluctuate to any great extent this annual should form a good book of reference. The notes as to the sources of supply of many metals and minerals are worth studying.

To all engaged in shipping, the Shipping Year-Book is indispensable. It contains all that one should know about ports and harbours, dues and tariffs, foreign weights and measures, recent additions to shipping legislation, and the information is arranged in a convenient form for handy reference.

Regarding all British colonies a great amount of interesting detail is given in "The Colonial Year-Book." The different colonies are arranged alphabetically and of each information regarding the history, topography, mineral products, government, social life, &c., is given. Maps of all the colonies are included. An introductory article by Professor J. R. Seeley treats generally of the history of colonisation, while in an appendix questions affecting the whole of the colonies are discussed.

The enormous number of new limited liability companies registered last year has made a very perceptible change on the bulk of the annual dealing with public companies. In the work entitled "The Stock Exchange Year-Book," there is given a record of all public companies, indicating their origin, the management, and the financial results. The work is too well known to the investing and speculating public to require further notice.

A publication of a kindred nature is "The Mining Manual," in which details are published of all mining companies, and in addition a directory of mining directors. A separate section is devoted to South African companies. Some idea of the scope of the book may be inferred from the fact that it deals with 1527 mining companies, the nominal capital totalling 157.6 millions, and the paid-up capital 116 millions sterling.

"The Mercantile Year-Book" contains a directory of exporters in the principal cities of the kingdom, and of the merchants and importers abroad with their representatives and buying agents, along with the tariff and import duties in the colonies.

BOOKS RECEIVED.

Handbuch für den Eisenschiffbau. Von OTTO SCHLICK. Mit Atlas. Leipzig: Arthur Felix.

Report of the Royal Commission on the Mineral Resources of Ontario, and Measures for their Development. Toronto: Warwick and Sons.

MODERN FRENCH ARTILLERY.
No. XXIV.
THE FORGES ET CHANTIERS GUN FACTORY—MOUNTAIN AND FIELD GUNS—*concluded.*

THE three illustrations, Figs. 258 to 260, show the form and construction of the limbers used for

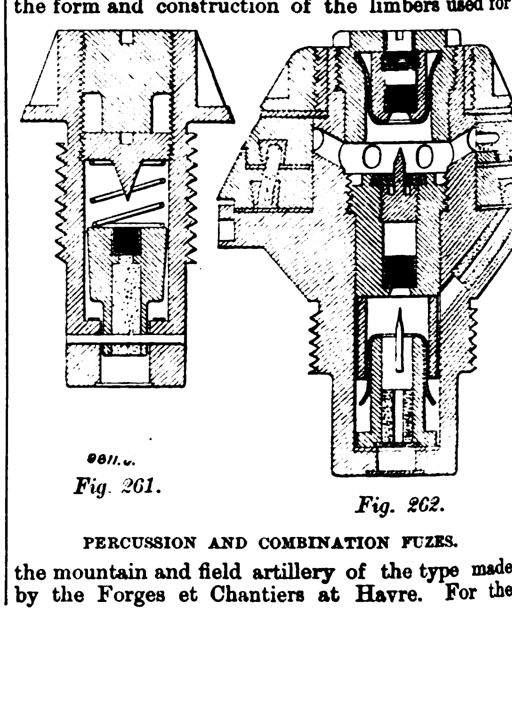


Fig. 261. *Fig. 262.*

PERCUSSION AND COMBINATION FUZES.

the mountain and field artillery of the type made by the Forges et Chantiers at Havre. For the former the wheels are of the same pattern as for the gun carriage, and the ammunition boxes carried on the frame each contain ten rounds, there being two of such boxes. Figs. 258 and 259 (see page 721) show the manner in which the trail of the gun carriage is attached to the limber. That for the field guns shown in Fig. 258 carries three ammunition boxes, of which one contains twenty-four rounds, and the other two twelve rounds each; in a separate box there are carried spare parts, tools, &c.

The ammunition for the various types of 75-millimetre guns has been already described; in the head of the common shell is screwed a percussion fuze shown in Fig. 261, in which the cap containing the fulminate and firing charge is held in

TABLE XX.—*Composition of a Completely Installed Field Battery of 75-mm. Gun.*

Number of guns	6 long type	6 short type
Steel carriages on steel wheels	6 ,,	6 ,,
Tumbrils and ammunition cases..	6 ,,	6 ,,
Cartridge boxes	9 caissons (3 boxes of 24 rounds)	9 caissons (1 box of 36 rounds) (1 box of 24 rounds)
Portable forge	1 long type	1 short type
Battery wagon .. .	1 ,,	1 ,,
Forage ,, .. .	1 ,,	1 ,,
Mitraille boxes	68 ,,	50 ,,
Common shell loaded (percussion fuze)	374 ,,	329 ,,
Shrapnel (compound fuze)	374 ,,	329 ,,
Cartridges	816 ,,	708 ,,
Friction fuzes	1360 ,,	1360 ,,
Total number of horses ..	108	78

mountain and field gun equipments in use in the British service, to afford some means of comparison with those of the Canet system we have just described. There are five natures of carriages for mountain guns in the service, the weights of which are shown in Table XXIII.

The early patterns of these carriages were of wood; these were succeeded by composite carriages of steel and wood. The present service types are of iron, and the carriage consists of two brackets, two transoms, a trail-piece, axle-tree, and wheels. The brackets are of plate iron cut away as far as possible for lightness and stiffened with angle iron along the upper side. The frames are connected and strengthened by the two transoms; they are parallel as far as the second transom, after which

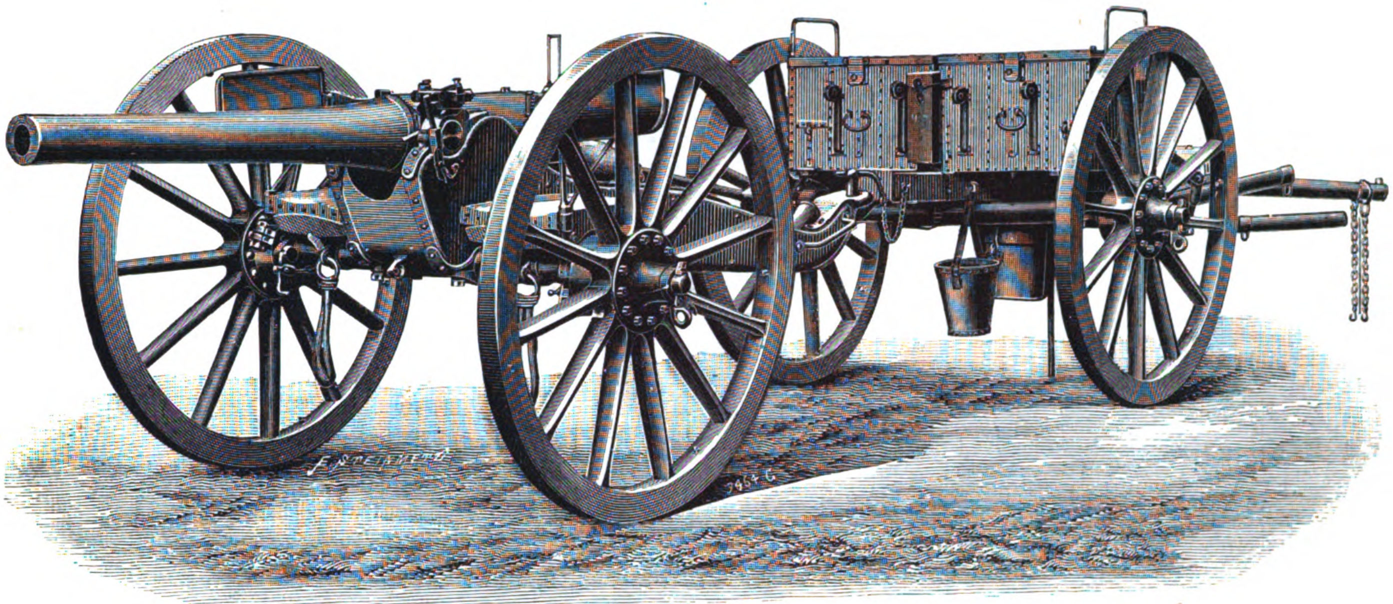


FIG. 276. 12-POUNDER ELSWICK FIELD GUN AND LIMBER.

FIG. 264.

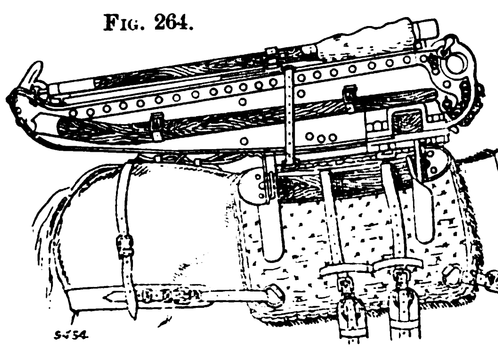


FIG. 265.

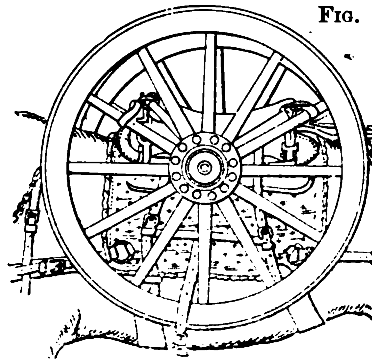


FIG. 266.

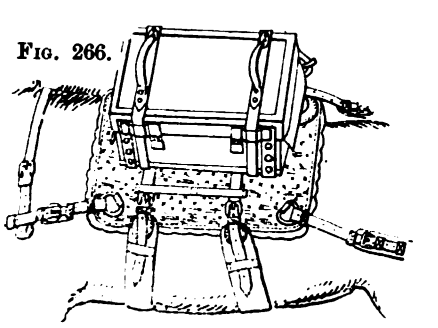
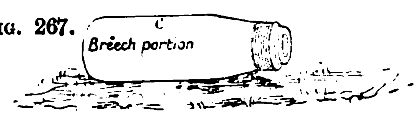


FIG. 267.



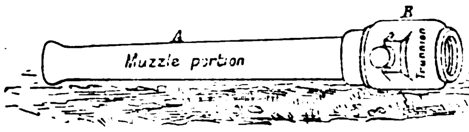


FIG. 268.

FIG. 269.

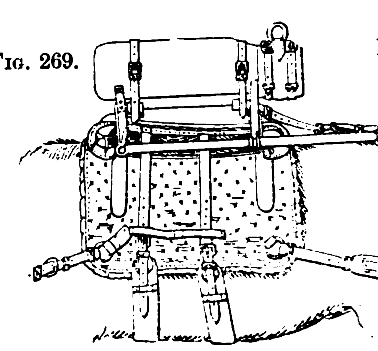
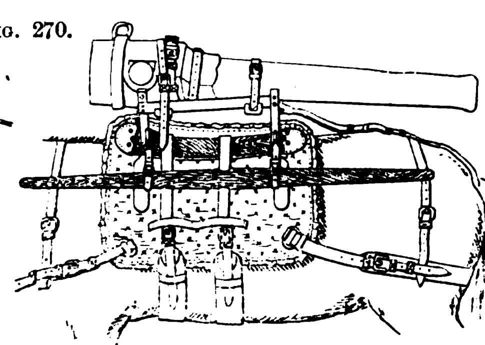


FIG. 270.



ELSWICK MOUNTAIN GUN AND CARRIAGE PACKED FOR TRANSPORT.

place by a soft metal pin passing through the body of the fuze; it is also kept from the striking point by a light spiral spring; when the shell strikes, the pin is sheared and the charge is thrown against the striking point. The shrapnel and case shot are fitted with a combined time and percussion fuze illustrated by Fig. 262, and the principle of which will be described on another occasion.

In Table XIX., page 726, are given particulars of the 75-millimetre and 84-millimetre mountain and field guns made at Havre on the Canet system by the Forges et Chantiers Company; Tables XX. and XXI. show the compositions of standard mountain and field batteries.

TABLE XXI.—*Composition of a Complete Mountain Battery.*

Steel guns of 75 mm. and 16 calibres	6
Carriages and steel wheels	6
Ammunition boxes (7 rounds)	100
Portable forge	1
Tools and accessories	14 boxes
Shrapnel boxes..	100
Common shells loaded percussion fuzes	300
Shrapnel loaded compound fuzes	300
Cartridges	700
Fuzes	1000
Number of mules required	76

Table XXII., page 726, contains particulars of the ballistic characteristics of the mountain and field artillery.

It may be interesting to give a few details of the

TABLE XXIII.—*Weights of Carriages for Mountain Guns' British Service.*

Nature.	Weight.	
	Without Wheels.	With Wheels.
	lb.	lb.
R.M.L., 7 pounder, 200 lb.	206	350
,, 150 lb.	180	306
R.M.L., 2.5 in. { Mark I.	292	484
R.M.L., 2.5 in. { ,, II.	324	539
Limber, R.M.L., 7 pounder, 200 lb. ..	..	382

they converge and are united in the trail-piece. To the front of the frames are attached the brackets recessed on the under side and having angle irons rivetted round the recess to make bearings for the axle-tree. The latter is forged solid and has pins on each side 7 in. long to receive the wheels which are 2 ft. 3 in. apart. The axle-tree is secured to the brackets by clips. Fig. 263 shows a general view of this carriage, and also the means for training it in elevation. This consists of a frame hung to a pin over the brackets and having attached to it a bearing for a screw; the top of the frame serves as a guide for a wedge on which the breech of the gun rests, and by turning the screw in either direction the gun can be raised or lowered. The height from the ground to the centre of axles is 2 ft. 3½ in. The carriage can be carried by one man and the wheels by another. The Elswick mountain gun and carriage, which is largely used in the service, differs in many respects from the foregoing. Figs. 264 to 270 (page 723) illustrate it packed for transport. The gun shown is a 7-pounder and is made so as to be easily separated into two parts and as easily reunited for service (Figs. 267 and 268). Two mules are required to carry the gun, which is packed on the saddle shown in Figs. 269 and 270. Three mules are required for the carriage and a fourth carries the ammunition boxes. The elevating gear of the Elswick field gun, Fig. 271, consists of a toothed quadrant pinned to the gun and brought into gear with a pinion mounted in the frame, and which is driven by a worm. The brake consists simply of a rope by which the wheels are lashed to the trail.

Figs. 272 to 274 (page 725) illustrate one of the service types of carriage for a 12-pounder breechloading field gun (see "Official Treatise on Military Carriages"). The trail is trough-shaped in section and built of steel side plates .192 in. thick, stiffened by angles rivetted to their upper edge. At the bottom they are connected by a steel plate, and the trail is further strengthened by an eye forging at its lower end and by two transoms. The trunnion bracket

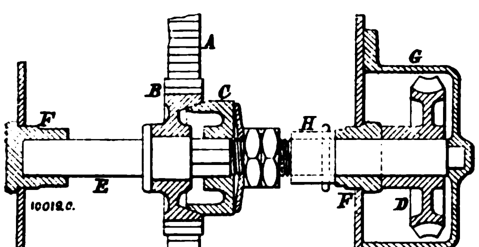


FIG. 275. ELEVATING GEAR FOR 12-POUNDER FIELD GUN.

of the form shown is rivetted to bracket plates at the front of the trail and the trunnions are carried in this bracket and held by capping pieces. The upper side of the trail is partly covered by steel plates so as to form a box. The axle-tree is square and made of steel, and is connected with the bracket plates of the trail by steel stays, the rear ends of which are secured to the trail as shown. The elevating gear of this gun is shown in Fig. 275. It consists of the arc A made of steel and with twenty teeth. The elevating pinion B gears into this arc; it is 3.9 in. in diameter and has fourteen teeth, within it is the friction cone C made of gun-metal and set up in place by a spring and two nuts. The wormwheel D is 3.87 in. in diameter and has twenty-two teeth. This is inclosed in a case G, and the wormwheel and pinion are mounted on a spindle 1 in. in diameter and running in the bearings E and F. The top of the arc A is pinned to the breech of the gun and can be moved up and down against a guide bolted to one of the transoms; the pinion gearing into it is loose on its spindle, but can be made fast by setting up the friction cone; when this is done, if the wormwheel be turned by means of a worm not shown in the drawing, the gun can be raised or lowered through any desired angle; the range of this gear is 16 deg. of elevation and 8 deg. of depression. The brake gear is shown in Figs. 273 and 274 (page 725). A band of steel is placed round the inner flange of each wheel, and the ends of each band are connected by a bolt and nut, so as to put on any tension that may be desired. Ratchet teeth are formed on the band, and when the gun is in action these are in gear with a steel pawl hung to a pin fitted in the front end of the tensile stay; on the same pin is a gun-metal bracket in which is a slid-

FIELD AND MOUNTAIN GUNS.

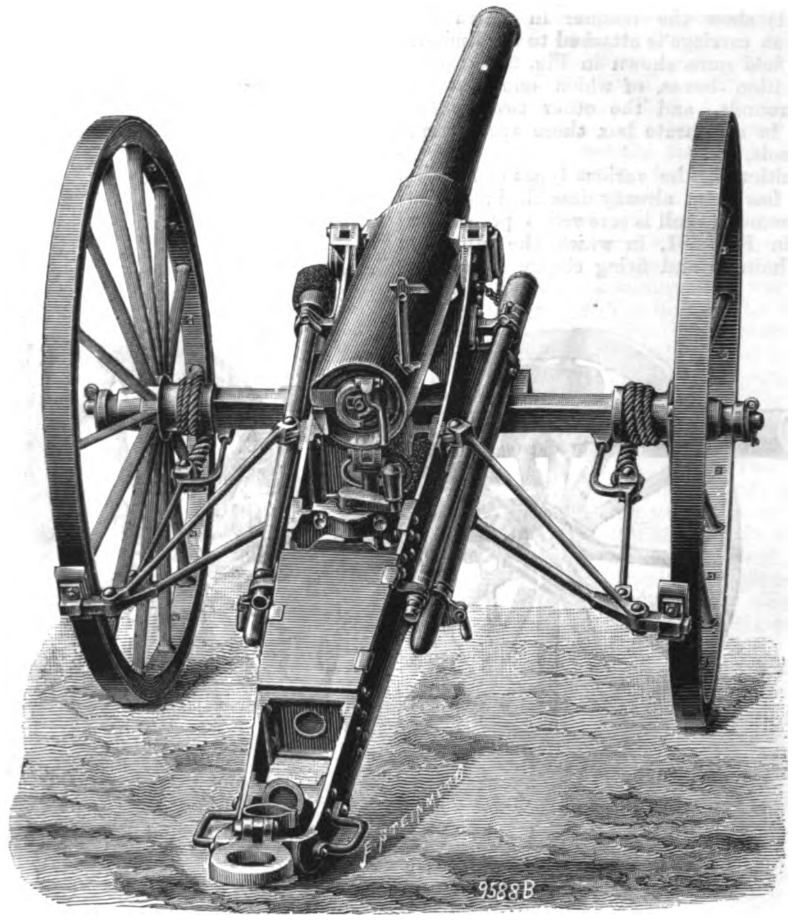


FIG. 260. CANET FIELD GUN SHOWING TRAINING GEAR AND BRAKE.

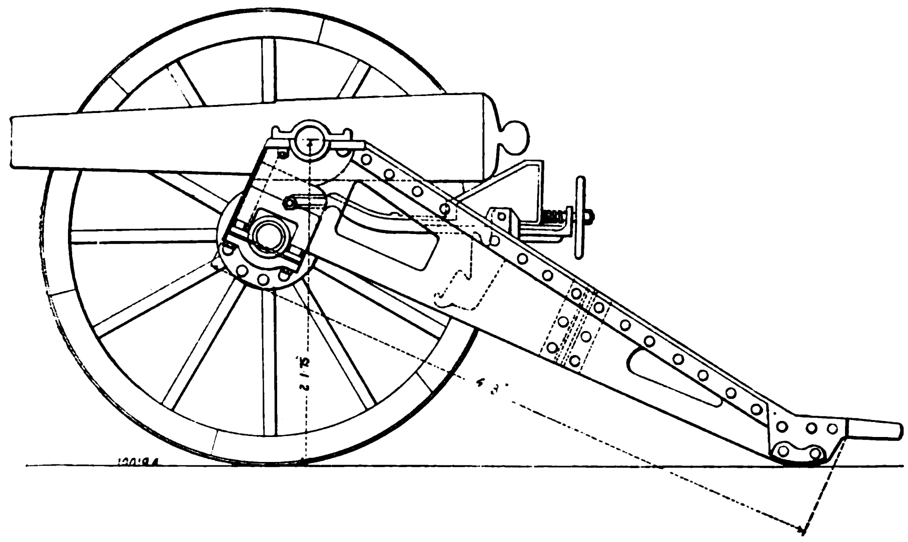


FIG. 263. 7-POUNDER MOUNTAIN GUN AND CARRIAGE, BRITISH SERVICE PATTERN.

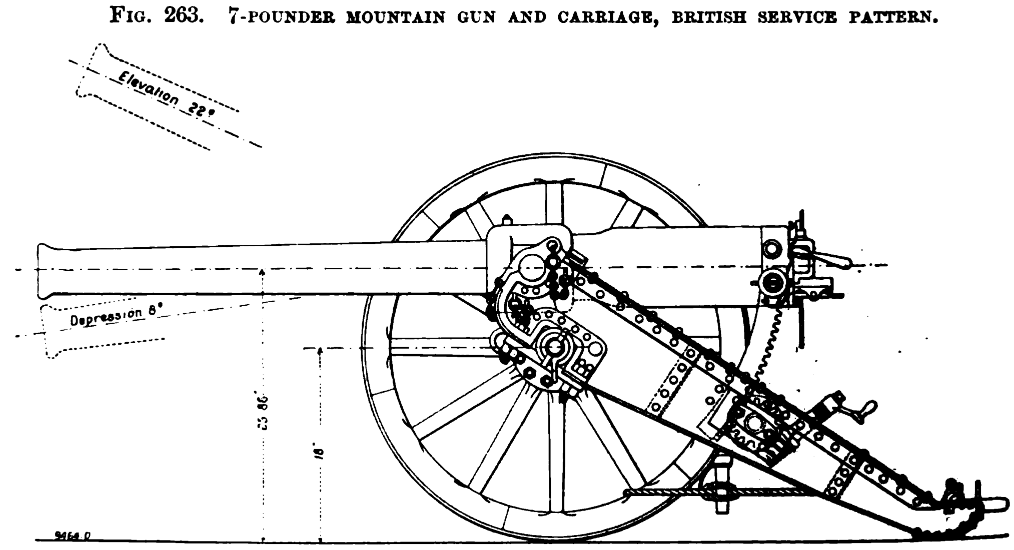


FIG. 271. 12-POUNDER ELSWICK FIELD GUN AND CARRIAGE.

FIELD AND MOUNTAIN GUNS.

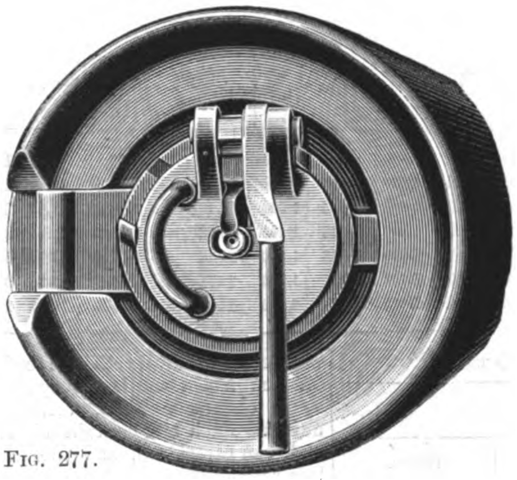


Fig. 277.

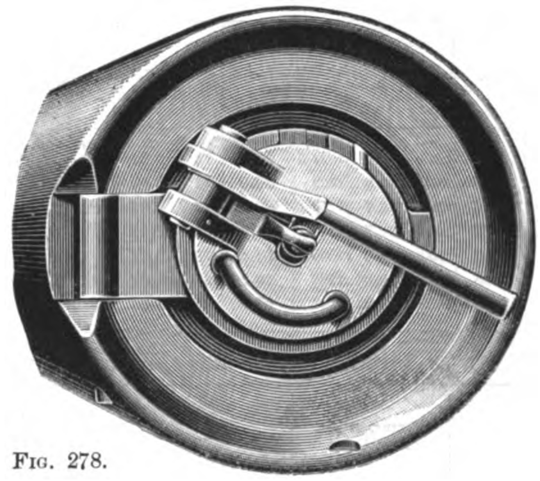


Fig. 278.

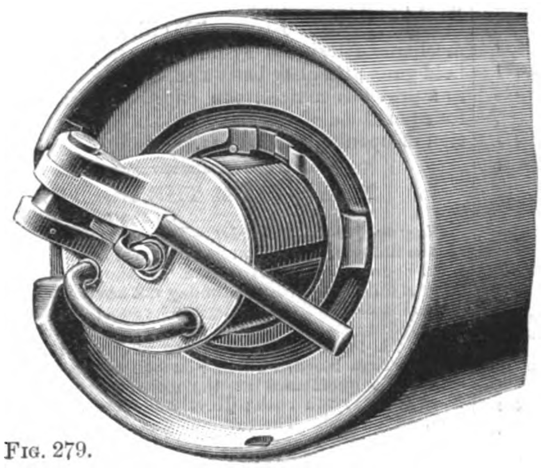


Fig. 279.

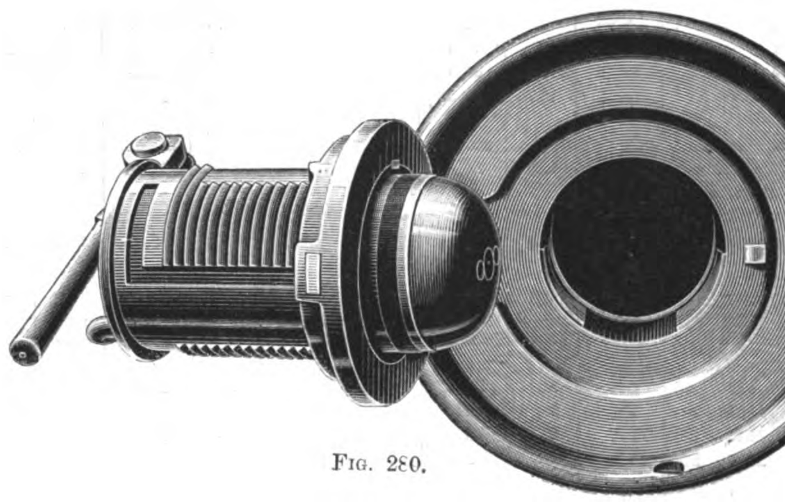


Fig. 280.

BREECHLOADING MECHANISM FOR CANET FIELD AND MOUNTAIN GUNS.

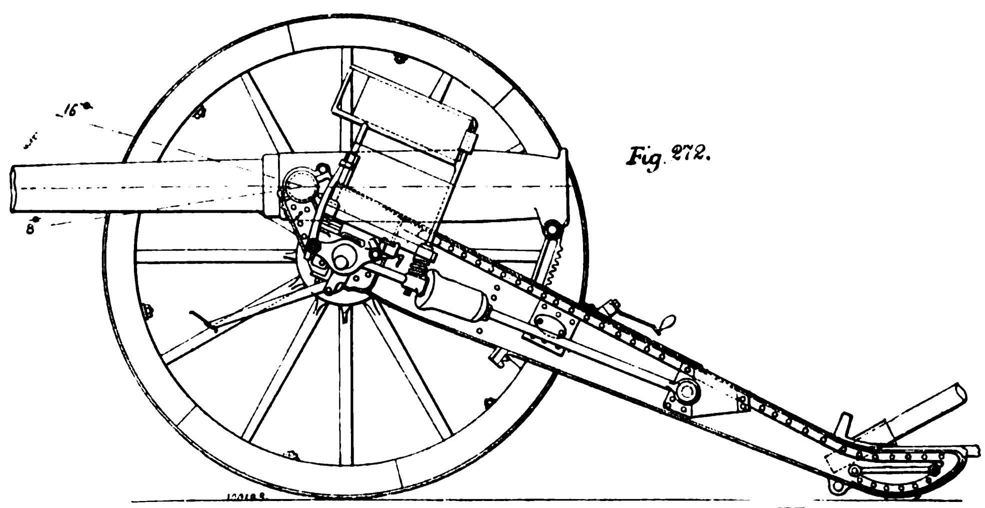


Fig. 272.

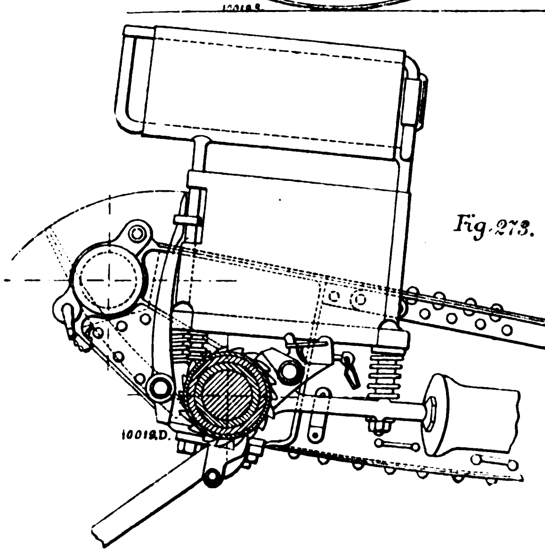


Fig. 273.

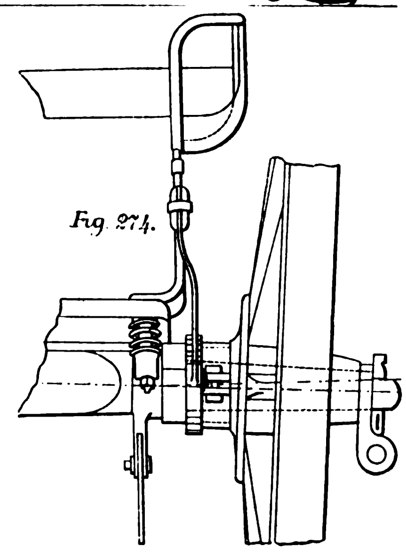


Fig. 274.

12-POUNDER FIELD GUN AND CARRIAGE, BRITISH SERVICE.

ing stud of gun-metal, which when the carriage is in action, is pressed by a spring against the pawl which is thus held in gear with the teeth on the brake band. The arrangement is such that the wheel cannot turn during recoil, but is free to revolve in running up. The pawl can be released at will by drawing on a cord attached to the sliding stud in the bracket. To enable the brake to be used in travelling without releasing the pawl, a lever is hung near the driver's seat, by depressing which the lower end of the lever can be made to engage in the teeth of the brake band and then skid the wheel.

Fig. 276 (page 723) illustrates a 12-pounder breech-loading field gun and carriage of a pattern designed at Elswick, and adopted as the arm for the Royal Horse and field batteries. The gun is wholly of steel, and consists of a barrel hooped at the breech end, the material being distributed so as to give the maximum strength for the least weight. The breech mechanism is exactly the same in principle as in the larger Elswick guns, but somewhat simplified. The gun is vented radially from the top, and in the middle of the chamber, by a removable steel vent, so that when it is rendered unserviceable another can be inserted immediately and without the aid of a skilled artificer. With the copper vents fitted to the older patterns of field guns, the insertion of a new vent was an operation requiring very great care and considerable skill, often taking two or three days to complete, besides which a number of the necessary tools were special and were kept at certain stations only. The carriage is in general appearance similar to the ordinary type of field carriages, but it has many distinct characteristics. It is formed of two steel cheeks flanged inwards for strength, connected by five diaphragms of steel. This rests on a forged steel axle-tree, being kept in position by bearings, and further connected by two round tempered steel stays fitted at the centre with a strong steel spring to give elasticity to the carriage. An automatic brake to check recoil is fitted to each side, and acts

TABLE XIX.—GENERAL PARTICULARS OF CANET MOUNTAIN AND FIELD GUNS; FORGES ET CHANTIERS DE LA MEDITERRANÉE.

Nature of Gun.	Calibre.		Total Length.		Length of Bore.		Diameter of Chamber.		Length of Rifling.		Number of Grooves.	Final Angle.	Weight of Gun.		Weight of Projectile.		Weight of Charge.		Initial Velocity.		Total Energy.		Thickness of Iron Plate Perforated at Muzzle.		Maximum Range.	
	mm	in.	mm	in.	mm.	in.	mm.	in.	mm	in.			lb.	kls.	lb.	kilos.	lb.	kilos.	ft.	m.	ft.-tons	m. tns	in.	cm.	yards	m.
Mountain and boat gun	75	2.95	1200	47.2	1024.5	40.33	78	3.07	880	34.65	22	Uniform Rifling 6 deg.	218.25	99	10.14	4.600	.882	0.400	984	300	69.15	21.42	1.299	3.3	4375	4000
Light field gun ..	75	2.95	1800	70.8	1600	62.9	78	3.07	1330	52.3	22		451.94	205	10.14	4.600	1.94	0.880	1361	415	146 6	45.42	2.284	5.8	6463	5910
Short „ „ ..	75	2.95	1950	76.7	1750	68.8	78	3.07	1470	57.8	22		573.20	260	10.14	4.600	2.205	1.000	1542	470	166.9	51.69	2.520	6.4	7303	6680
Long „ „ ..	75	2.95	2400	94.5	2200	86.6	78	3.07	1805	71.07	22		791.45	359	11.46	5.200	3.086	1.400	1706	520	231.3	71.65	3.189	8.1	7497	6855
Short „ „ ..	75	2.95	2700	106.3	2500	98.4	78	3.07	2100	82.6	22		1036.2	470	13.67	6.200	3.968	1.800	1788	545	303 4	93.99	3.858	9.8	9744	8910
„ „ „ ..	84	2.95	2016	79.38	1792	70.56	87	3.07	1500	59.0	26		881.84	400	16.31	7.400	3.53	1.600	1575	480	275.2	85.25	3.308	8.4	7907	7230
Long „ „ ..	84	2.95	2520	99.2	2296	90.40	87	3.07	1900	74.7	26		1146.39	520	16.31	7.400	4.63	2.100	1804	550	361.4	111.92	4.015	10.2	10433	9540

TABLE XXII.—PARTICULARS OF MOUNTAIN AND FIELD CANET GUNS, 75 MM. (2.95 IN.).

—	Mountain and Boat Guns.		Field Guns. Light.		Short.		Long.		Heavy.	
	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
Calibre	2.95	75	2.95	75	2.95	75	2 95	75	2 95	75
Total length of gun	47.2	1200	70.8	1800	76.7	1950	94.5	2400	106.3	2700
„ „ bore	40.33	1024.5	62.9	1600	68.8	1750	86 6	2200	98.4	2500
Length of bore in calibres .	13.66	13.66	21.33	21.33	23.33	23.33	29 33	2933	33.33	33.33
	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos
Weight of the piece	218.25	99	451.94	205	573.20	260	791.45	359	1036.2	470
„ shell	10.14	4.60	10.14	4.60	10.14	4.60	11 46	5.20	13.67	6.20
Ratio of weight of gun to weight of shell	21.5	21.5	44.56	44.56	56.5	56.5	69.0	69.0	75.8	75.8
Weight of powder charge .	.882	0.40	1.94	0.88	2.205	1.000	3.086	1.40	3.968	1.80
	ft.	metres	ft.	metres	ft.	metres	ft.	metres	ft.	metres
Muzzle velocity	984	300	1361	415	1542	470	1706	520	1788	545
	foot-tons	m. tons	ft.-tons	m. tns.	foot-tons	m. tons	foot-tons	m. tns.	foot-tons	m. tons
„ energy	69.15	21.42	146.6	45.42	1669	51.69	231.3	71.65	303.4	93.99
Remanent velocities at .. .. (yds. / metres)	ft.	metres	ft.	metres	ft.	metres	ft.	metres	ft.	metres
547 yds. / 500 metres	909	277	1165	355	1299	396	1460	445	1571	479
1094 / 1000	840	256	1043	318	1125	343	1260	384	1378	420
1641 / 1500	777	237	955	291	1017	310	1115	340	1224	373
2188 / 2000	722	220	882	269	935	285	1020	311	1109	338
Range at different angles .. .. (deg.)	yards	metres	yards	metres	yards.	metres	yards	metres	yards	metres
5	1640	1500	2357	2155	2789	2550	3139	2870	3735	3415
10	2734	2500	4046	3700	4626	4230	5006	4580	6250	5715
15	3664	3350	5386	4925	6146	5620	6403	5855	0174	7475
20	4375	4000	6463	5910	7306	6680	7497	6855	9744	8910
	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.
Weight of carriage, minus wheels	227.1	103	529.1	240	617.3	280	762.8	346	948.0	430
„ wheels	97.0	44	220.4	100	264.5	120	306.6	140	352.7	160
Total weight of gun and carriage	542.3	246	1201.5	545	1455.0	660	1862.9	845	233.69	1060
	ft.	metres	ft.	metres	ft.	metres	ft.	metres	ft.	metres
Width of carriage	2.231	0.680	3.61	1.10	3.87	1.18	4.09	1.220	4.265	1.30
		deg.		deg.		deg.		deg.		deg.
Extreme angles of fire	..	−20+20	..	−6+20	..	−6+20	..	−6+20	..	− 6 + 20
Number of shots carried in limber	..	20	..	24	..	24	..	24	..	24
	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.
Weight of limber complete ..	498.2	226	837.7	380	981.0	445	1111.1	504	1322.7	600
„ gun and limber ..	1040.5	472	2039.2	925	2426.0	1105	2973.9	1349	3659.6	1660
Weight per horse	..	..	509.3	231	606.47	276	493.8	224	606.5	276
Number of shot in full caisson ..	..	..	..	60	..	60	..	72	..	72
			tons	kilos.	tons	kilos.	tons	kilos.	tons	kilos.
Weight of filled caisson	..	..	1.004	1,020	1.017	1033	1.271	1291	1.476	1,500
Weight of batteries and accessories	..	..	17.625	17,905	18.892	19.191	22.756	231.18	26.826	27,250
	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.	lb.	kilos.
Weight per horse	..	..	529.1	240	586.4	266	474.0	215	555.5	252
Total muzzle energy of battery ..	414.8	128.52	879.8	272.52	1001.0	310.14	1387.3	429.9	1820.0	563.94
	foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons	foot-tons	m. tons
Striking energy per ton weight of gun..	696.1	216.3	714.8	221.5	641.6	198.8	643.8	199.5	645.5	200
Striking energy per ton of gun and carriage	280.8	87	268.8	83.3	252.7	78.3	273.7	84.8	285.9	88.6

on the nave of each wheel. The seats by the side of the gun are mounted on springs, so that in travelling over rough ground the men are not subject to the jarring as in the old pattern. The elevating gear consists of a steel arc attached to an eye on the under side of the breech of the gun, having teeth cut on the rear edge geared into a pinion on the same shaft with a wormwheel. The pinion is of steel, and, somewhat as in the service gun before described, it has a friction cone in one piece with it, which fits into a coned recess in the bronze wormwheel. It is forced into this place by means of a dished steel spring pressing on the reverse side of the pinion to that on which the cone is. The requisite amount of pressure is obtained by means of a nut screwed on to the steel shaft which carries the pinion and wormwheel, and which is held in its position by a steel pin. The friction between the surfaces of the cone on the pinion and the wormwheel causes them to rotate together, but to slip slightly when the gun is fired. The gear is carried by a bronze bracket fixed to one of the connecting diaphragms. The limber is similar in construction to the carriage, but is fitted with a centre pole instead of shafts as in the ordinary limbers. The limber boxes are of steel, and are partitioned for projectiles and cartridges, the former of which stand on india-rubber washers in wood trays, while the heads fit into recesses cut in wood blocks fitted to the lids. The near box is provided with a small compartment with hinged door at the rear, and contains a Scott's telescope sight with which the gun is fitted, in addition to the ordinary sights. The off box has a similar compartment, but contains spare obturator wads, vent bolts, and keys for fixing. Each box contains eighteen projectiles and eighteen cartridges, and the carriage itself carries two rounds of case shot and two cartridges to be used in an emergency.

Figs. 277 to 280 (page 725) illustrate the breech mechanism designed by M. Canet for mountain and field guns; this has been already described in detail in a previous article, the engravings show clearly four positions of the breech-block during the operation of opening the breech.

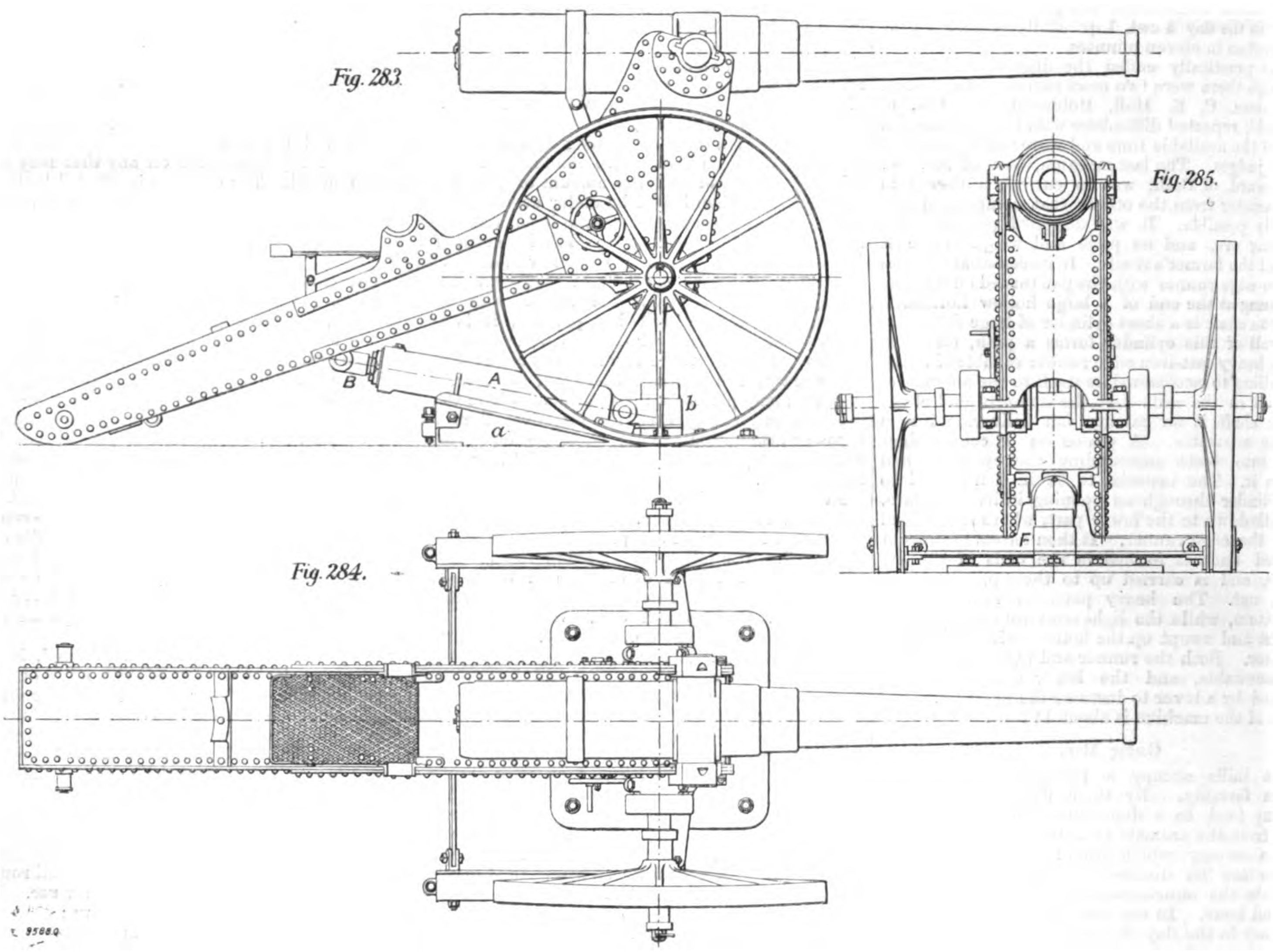
NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—There was a continuance of the flatness in the iron market on Thursday, the upward spurt which was caused by the Board of Trade returns on the preceding Monday not having been backed up. Renewed selling during the forenoon resulted in the price falling back to 44s. per ton cash for Scotch warrants, to 40s. 7d. for Cleveland, and to 50s. 0½d. for hematite iron. Prices receded further in the afternoon, and the settlement quotations at the close were—Scotch iron, 43s. 10½d. per ton cash; Cleveland, 40s. 7½d.; hematite iron, 49s. 10½d. The market was a trifle firmer on Friday, and the prices of warrant iron had a slight rebound after Thursday's depression. At noon Scotch warrants were 3d. per ton higher than at the close on the preceding day, and there were advances of 3d. and 2d. per ton respectively on Cleveland and hematite iron. In the afternoon the improvement was maintained, warrants being a turn dearer in price. The more timid "bears" assisted to stiffen prices in their efforts to reduce their accounts within more manageable limits. The closing settlement prices were—Scotch iron, 44s. 3d. per ton; Cleveland, 40s. 10½d.; hematite iron, 50s. 1½d. per ton. A better tone was evident in the market on Monday, partly on account of reports of large shipments last week. The dealings were chiefly in Scotch warrants, the price of which advanced 2½d. per ton in the course of the day. Cleveland iron gained 7d. in price, and hematite iron 5d. per ton. At the close the settlement prices were—Scotch warrants, 44s. 6d. per ton; Cleveland, 41s. 6d.; hematite iron, 50s. 7½d. per ton. Quietness was the rule of the warrant market yesterday, quotations being fairly steady, and not varying in the forenoon above 1d. per ton in the case of Scotch iron, while in the afternoon a better demand set in and prices rose and closed 1½d. per ton over Monday's final quotations. Cleveland iron was weaker at the start, an increase having been made to stocks which was not looked for; but the quotations stiffened, and closed 2d. per ton up. Hematite iron was depressed and declined in price 4d. per ton in the forenoon, but recovered 3d. in the afternoon. The closing settlement prices were—Scotch iron, 44s. 7½d. per ton; Cleveland, 41s. 7½d.; hematite, iron, 50s. 6d. There was a sharp upward movement in the prices of warrants this forenoon. On Scotch warrants the improvement was 5d. per ton, on Cleveland 8d., and on hematite iron 4d. above the closing prices yesterday. A further improvement took place in the afternoon in the price of Scotch and hematite iron, while there was a decided drop in the price of Cleveland warrants, sellers asking 41s. 11d. per ton cash, as compared with 42s. 4½d. at the close of the forenoon market. A correspondent of one of the local papers, writing on the question of the price of iron, says he is puzzled, along with many others, no doubt, at the action of investors in the iron warrant market at the present time, if current reports are correct. There are reports, he says, that warrants are being lifted off the market for investment purposes, even in face of extreme dulness in freights, resulting in the laying up of numerous steamers and an almost complete stoppage of shipbuilding orders. He questions the truth of the statements that warrants at present prices are being taken up, as he believes that before there is any upward movement prices must drop to about their old level; and even then, he says, unless trade takes a decided turn for the better they will hang for a considerable time. The number of blast furnaces in actual operation is now 83, as compared with 82 at the same time last year. Last week's shipments of pig iron from all Scotch ports amounted to 8679 tons, against 5353 in the corresponding week of last year. They included 340 tons for the United States, 1120 tons for Canada, 425 tons for Australia, 185 tons for France, 552

12-CENTIMETRE SIEGE GUN AND CARRIAGE; CANET SYSTEM.

(For Description, see Page 751.)



The discs are of chilled iron, the running disc being on a horizontal spindle. Mr. Robert Graham's mill (Carlisle) is fitted with Cumberland stones 2 ft. 6 in. in diameter, the spindle being horizontal.

Messrs. E. F. Turner, of Ipswich, bring their experience as milling engineers to bear on the subject of farmers' mills, and consequently their apparatus does not conform to any of the usual types. It is illustrated on page 745. Instead of following the old idea of grinding between a fixed and revolving surface, a plan which had its rise before the dawn of history, they supply a cheap roller mill consisting of two finely serrated revolving rolls, running at differential speeds of about 7 to 2. Before reaching these, the grain passes through a pair of nearly plain rolls in which it is cracked or bruised. If this is all it requires it can be diverted into the delivery spout at once. Both sets of rolls can be accurately adjusted for distance, and both are provided with springs to allow them to move back to pass hard objects. The capacity of the mill is 60 bushels of maize, ground into flour, per hour. Both sets of rolls are driven from the same pulley through spur gearing.

Mr. W. H. Coward, of Bath, entered a grist mill on the same principle as his disintegrator, which is described on page 747.

ENGINES.

Apart from the engines submitted for trial, there is really nothing whatever amongst the motors exhibited at Plymouth which calls for detailed notice. All the leading makers of agricultural engines, such as Messrs. Clayton and Shuttleworth, Messrs. Marshall, Sons, and Co., Messrs. Ransomes, Sims, and Jefferies, Messrs. Ruston, Proctor, and Co., Messrs. Robey and Co., Messrs. R. Hornsby and Sons, Messrs. Garrett and Sons, &c., are represented, but at none of their stands did we see a single novelty in steam engine construction. Messrs. John Fowler and Co. and Messrs. Aveling and Porter occupy their usual positions facing the entrance gates, but neither of them show any novelty in the way of steam ploughing engines or traction engines. In fact, the only unusual object at Messrs. Fowler's stand is unusual not for its novelty but for a contrary reason, it being a steam ploughing engine of the double-drum type, a class of engine which has not been represented at a Royal Agricultural Show for many years past. Messrs. Charles Burrell and Sons, Limited, show a couple of traction engines of which one is a compound, having the two cylinders placed one above the other (the two piston-rods being attached to a single crosshead), a type which they introduced last year. This engine, which has cylinders respectively 6½ in. and 10¾ in. in diameter with 12 in. stroke, is spring mounted on the system which we illustrated on page 740 of our last issue, and it is noticeable for its very moderate width, its measurement over all being only 7 ft. 2 in., although its wheels have 18-in. tyres.

It is gratifying to notice that although at present our leading agricultural engineers are too busy to trouble themselves with the introduction of new types, they are certainly not neglecting the perfection of their modes of manufacture, and every year brings evidence of improvements in machine work and in the design and construction of those minor details which have so large an influence on the production of really good engines at a moderate cost.

Among the gas engines we noticed that the "Forward" engine of Messrs. T. B. Barker and Co., of Birmingham, has been greatly modified. It follows the regular Otto cycle, and is very neatly designed. The ignition is effected by a hot tube, the three valves—gas, air, and exhaust—are all worked from one lay shaft. A pendulum governor is used in combination with a hit-and-miss arrangement. In one of the engines the governor is put back every stroke by a projection on the exhaust valve arm, and in this way all chance of its sticking and giving too much gas is avoided. The engine presents a very neat appearance. Messrs. Crossley Brothers, Limited, Manchester, show a new design of a 2 horse-power engine, in which all the valves are on one side, allowing the engine to be placed close to a wall.

IMPLEMENTS.

For the use of small farmers Messrs. Davey, Sleep, Harris, and Co., of the Excelsior Plough Works, Plymouth, show a combined charlock cleaner and horserake. The cleaner consists of the usual serrated knife with a rotating brush above it. The knife cuts off and drags out the weeds, while the brush clears them off the blade and prevents it choking. The whole is mounted on a horserake, and can be easily removed when not required. On the same stand is a horserake which has no spring in the locking motion; in place of this the levers are so arranged that when the rake is at work they stand in the same straight line, and offer a firm abutment to the pressure tending to lift the rake. A novel kind of cart is also exhibited. It has a leg or support at the forward end just behind the shafts; this support ends in a slipper foot, and is mounted on a screw coupled by a chain to a handwheel. When the cart is about to descend a hill the screw is turned until the foot rests on the road; this acts as a brake, and also takes the weight off the horse's back.

A very promising improvement in harvesters and reapers is shown by Mr. J. N. Davies, of Gweleath, Cury, Cornwall. It consists of a rotating conical

MODERN FRENCH ARTILLERY; SIEGE AND GARRISON GUNS.

CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERRANÉE.

(*For Description, see Page* 751.)

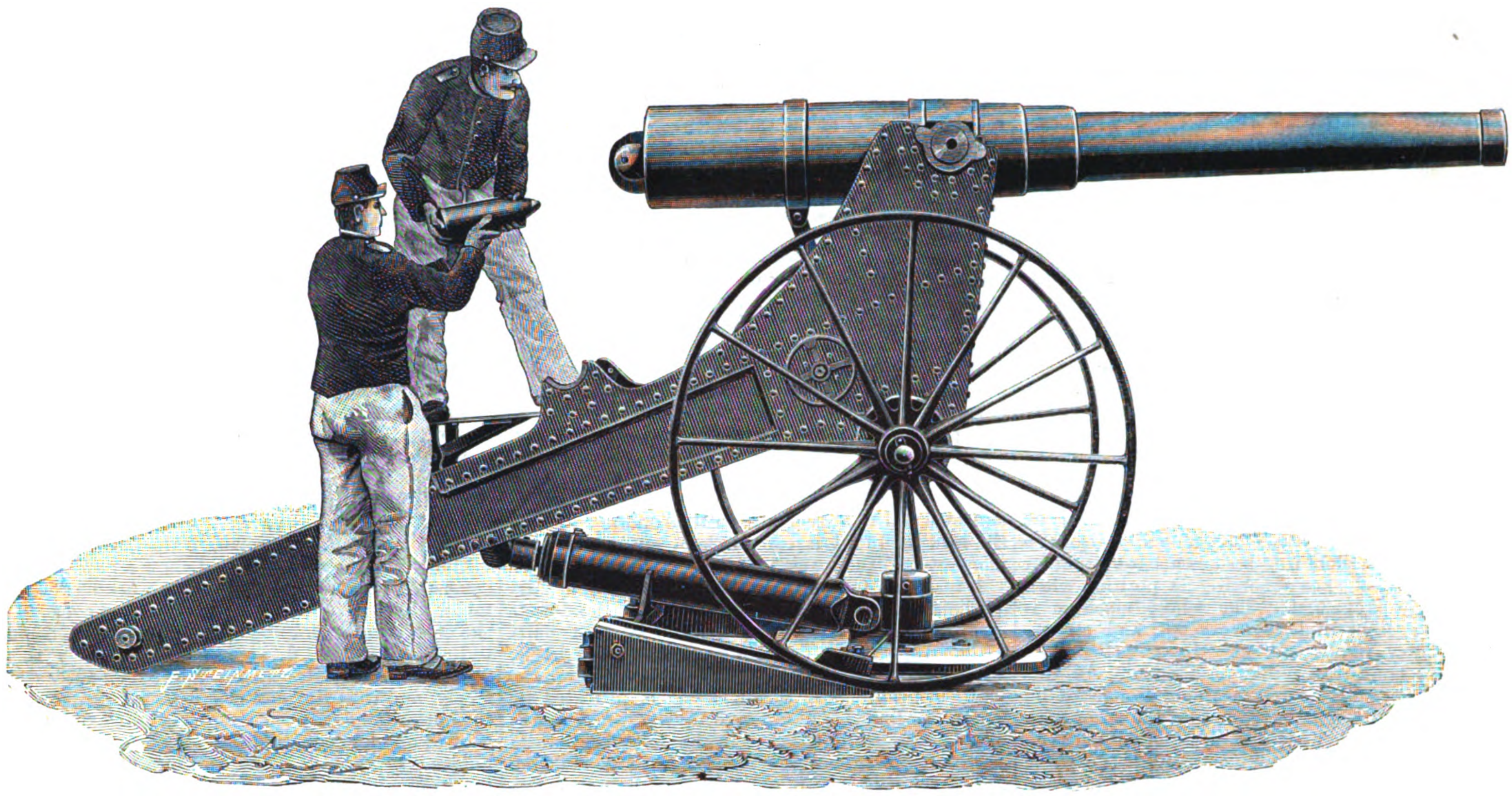


FIG. 287. 12-CENTIMETRE SIEGE GUN AND CARRIAGE.

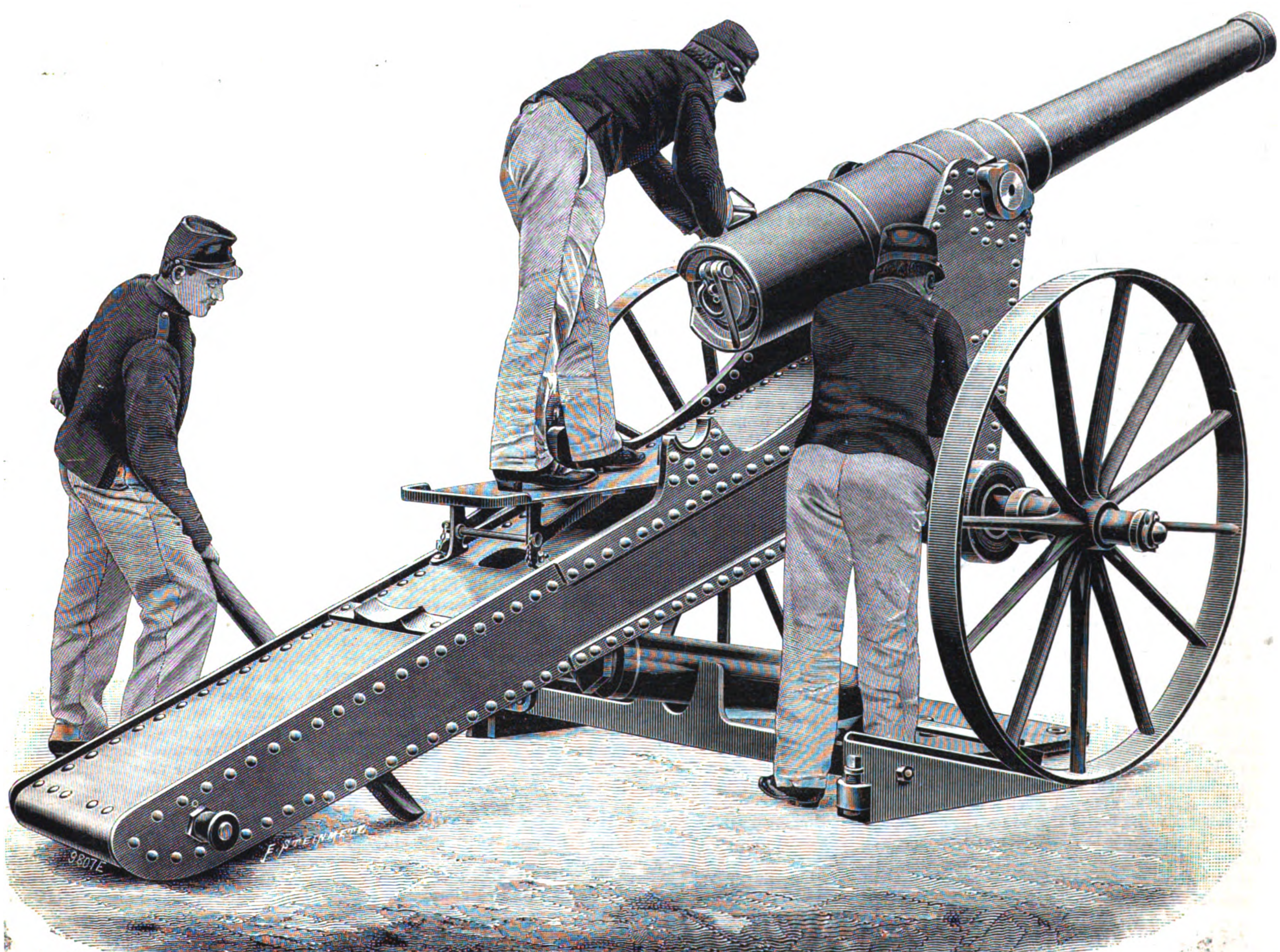


FIG. 288. 15-CENTIMETRE SIEGE GUN ON TRAVELLING CARRIAGE AND HYDRAULIC BRAKE.

roller, corrugated lengthwise, and mounted on the off side of the machine. Its use is to disentangle laid or twisted crops. Ordinarily a part of the crop which is cut is entangled with the standing corn and accumulates on the side of the machine in a way which is inconvenient and dangerous. But with this appliance the cut stalks are drawn out of the rest of the crop and are passed on to the platform while the remainder then slides off, ready to be cut on the next journey.

Amongst the implements at the stand of Messrs. R. Hornsby and Co., Limited, is a new pattern of light reaper, named by the makers "Hornsby No. 20." One of the chief features in this reaper is that the slow motion required for the rakes is obtained direct from a chain-wheel on the main axle instead of being derived from the high-speed motion required for the knives, as is the usual arrangement. The arrangements for controlling the gathering motion of the rakes and other adjustments are also exceedingly well worked out. Close by, also, Messrs. Hornsby show one of their new "Hornsby-Hoosier" drills, this being a very light drill of the American Hoosier type. The details of this drill are very ingeniously designed. No change-wheels are employed to vary the speed of the spindle carrying the feed rolls, but the amount of feed is regulated by varying the length of the rolls utilised. The coulters can be used either in line or zig-zagged, and their points are made so that they tend to draw down into the ground and so do not require to be weighted. Each coulter also is so made that it can yield if it strikes a large stone or other obstacle, at once resuming its position when the obstacle is passed. The whole machine is exceedingly light and yet very stiff and strong. Another new implement at Messrs. Hornsby's stand is a combined pulper and slicer. In this machine the spindle carries a single disc fitted on one side with slicing cutters, and on the other with teeth for pulping. This disc is situated between two hoppers, and the spindle carrying it is capable of being moved endwise through a space of some 3 in. so as to give a free space on either side of the disc. When moved into one position the slicing side of the disc is brought near one of the hoppers, and clearance for the cut roots to fall away is left on the other side, while when shifted into its other other extreme position the pulping side of the disc is brought against the hopper which is used for pulping, and a free space for the pulped material to get away is provided on the other side. Two "strawsonisers" are also shown at Messrs. Hornsby's stand. The makers have completely metamorphised the construction of this apparatus since it made its appearance at Windsor last year, and have reduced it to a very simple and practical form. As our readers are aware, this apparatus distributes solid materials in the form of powder or fine grains, or liquid manure, &c., by the action of air jets. The supply of air for working the jets is given by a small Sturtevant fan driven by gearing from the axle of the machine, and the details of the arrangement for adjusting the amount of materials delivered, &c., are exceedingly well worked out.

To load hay from a field into a wagon, Messrs. Lankester and Co., of 110, Southwark-street, London, show the Keystone hay loader, which is of American origin. It runs on a pair of wheels and can be attached to the rear of a wagon which then runs down the windrow and automatically transfers the hay or loose grain to the wagon. The apparatus consists of a cylinder carrying forks, like a tedder, and driven from the axle. These forks are mounted on rods which have levers at the end running over a cam path. By the action of the cam the forks clear their load as they come to the top of the circle in which they revolve, and drop it on to a long travelling apron of light construction, which carries the hay upwards, and finally drops it into the wagon.

A number of distributors for various purposes are shown by Mr. G. Greenfield, Eakring, Newark. One of these is fixed to the back of a cart and driven by a chain from a wheel fixed to the nave of the travelling wheel. The others are self-contained. Messrs. W. H. Nicholson and Sons, Limited, of Newark, show a new form of horserake with a very simple locking motion, consisting of a catch which locks the lever for a second when it is dropped, and then rebounds and leaves it free for the next operation. The details of this rake are exceedingly well worked out.

Messrs. Adams and Co., of Northampton, show a steerage drill worked by a handwheel behind. By means of shafts and bevel wheels this wheel is connected to the fore carriage. It is also coupled to a long drum which lifts all the coulters at the end of a row.

MISCELLANEOUS.

To provide a cheap platform weighing machine for farmers, the Western Counties Agricultural Co-operative Association, Plymouth, have taken the agency for the Osgood United States standard scales. The platform and pit are built of timber, and the main beams are of the same material. To allow for the variation of the timber the knife-edges bear upon discs which rest on other discs with convex surfaces, and these again repose upon rubber cushions, so that the parts may always easily adjust themselves to one another. It is claimed that perfect accuracy can be obtained with these weighing machines, while their cost is exceedingly moderate. Of weighing machines of the ordinary type Messrs. W. and T. Avery, of Birmingham, have a large collection. They show one combined with a cart, and another with a wagon, so arranged that the exact load can be measured without disturbing the goods. By means of a lever the weight is transferred from the axle to the machine, there being no load on the knife-edges at other times. They also show a weighing machine combined with a jib crane. The pulley at the end of the jib is mounted on a lever which is connected at its other end by a rod to a steelyard on the framing. When the load is lifted it can be held suspended for a moment and then weighed.

A machine for washing hops is shown by Mr. William Lambert, Staplehurst, Kent. It consists of a tank mounted on wheels and fitted with shafts for horses. The pumps are geared to the wheels, and five nozzles are provided at each side for the jets. An automatic arrangement is provided by which the liquor is discharged up the poles, and is immediately shut off between the hills, the pumps continuing working all the time. The machine can be changed in two or three minutes to act as a fire engine.

Messrs. Eddy and Sons, Kennford Iron Works, near Exeter, show a very convenient earth scoop for contractors' use. The scoop is drawn along by the horse until it is full; the man who is guiding it at the handles then tilts it forward on its cutting edge and puts his foot on a lever. This draws out two catches and allows two square rods to fall, each carrying a wheel at the lower end. The scoop is then run away on its wheels to the place where it is to be tipped. The man then raises the handles till the cutting edge catches the ground, when the scoop turns completely over, discharging its load.

The trials of the disintegrators showed very clearly the necessity for the magnetic separator of Mr. Harrison Carter. This consists of an inclined shaking shoot down which the material, such as bones, slides to a rotating drum. This drum contains a large number of electro-magnets energised by a current from a small dynamo. The poles project above the surface of the drum, and catch any pieces of iron that may pass over them. By means of a commutator the current is cut off from the magnets when they are at the under side of the drum, and they drop their load into a hopper separate from the bones, which fall forward into a heap. If this machine had been used in the trials it would have averted an accident which occurred.

The principle of the self-acting flushing tank is applied by Mr. J. Best, of 23, Old Town-street, Plymouth, to the hydraulic ram, in situations where the stream is so small, or at times becomes so small, that it will not close the valve and set the ram in action. At any convenient height above the ram there is fixed a tank, and the stream is delivered into it. It here accumulates until the tank is nearly full, when it lifts a float; this float is connected to a hollow tipping lever partly filled with mercury. As soon as this lever is raised past the centre the mercury rushes to the other end, lifting the lever and opening a valve, which allows the contents of the tank to rush down a pipe to the hydraulic ram, and work it until the supply is exhausted. The valve is then closed, and the water commences to accumulate afresh. The same exhibitor has some handy little water wheels and pumps for supplying water to country houses.

Dolberg's narrow gauge railway for farm purposes is shown by Mr. W. A. Stone, of Prague, Austria. In connection with it is a portable log crane, for getting timber on to the trucks. This consists of two bars, which, when put together, form a kind of arch. They are joined by a pin at the top, and there are several holes in each to allow of adjustment. The lifting chains are worked by levers and pawls. At each stroke of the lever the chain is drawn forward over a pulley the length of a link, and is then held by a second pawl. The foot of the bar is of sufficient length to prevent it sinking into the ground, and will adjust itself to any inclination.

DAIRY.

As usual, Messrs. T. Bradford and Co., of High Holborn, London, have a large supply of dairy machinery. In addition to their many well-known churns they show a new design called the "post diaphragm." It consists of a vessel, nearly hexagonal in vertical cross-section, rotating on a horizontal spindle. Dividing it into two parts longitudinally is a grating of wooden bars set at various angles. The cream is deflected, as the churn is rotated, at each angle of the hexagon, and then is driven through the "post diaphragm," the result being a great agitation and rapid production of the butter. For people who like to indulge in the luxury of freshly-made butter for breakfast the "morning" churn is provided. It is intended for the production of small quantities of butter, and consists of a barrel-shaped glass vessel, graduated in pints. It is fixed in a frame by which it can be turned end over end. The churn is specially suitable for a lady who takes an interest in her dairy, and likes occasionally to churn for herself. To separate the butter from the butter-milk, Messrs. Bradford show a new worker, consisting of a corrugated roller working over a table. The novelty of the arrangement consists in the corrugations running spirally, instead of longitudinally, and the table being rounded. By these alterations the butter-milk is able to run away more freely, and thus the end is gained without working the butter too much. Two sizes of this machine are shown, one for hand and one for power. When the butter is cleansed it is made up into half-pounds by means of a dairy table fitted with a die. The top of the die is closed by a lid worked by hand, and the bottom is forced up by a foot lever, thus rendering the butter very solid. The arrangement is very similar to a brick press.

A very convenient weighing machine for milk-sellers is shown by Messrs. Freeth and Pocock, of Wandsworth-road, Vauxhall, London. There is a loose platform on the machine, and this is connected to a tipping hoist by which the railway churn can be raised and its contents discharged into the refrigerator. The machine is one of Avery's self-registering type. The can is placed on it and the weight stamped on the ticket; the milk is then emptied and the can returned for the tare to be taken and impressed on the ticket. There is thus no chance of mistakes occurring, while the operation is very expeditious.

Visitors to the Royal Show always find an attraction in the capital display of the Dairy Supply Company, Limited, of Museum-street, London. This year there is shown a delaiteuse of very large size. This is merely a centrifugal machine for removing the milk from newly churned butter. It consists of a perforated cage standing on a vertical spindle running at 550 revolutions per minute. The butter is inclosed in a bag and placed in this machine, until all the butter-milk is expelled. After this is done it needs very little working to mass the grains together, and consequently they are not rendered greasy. The quality of butter is rapidly deteriorated by friction. In the working dairy the same firm show De Laval's instantaneous butter-maker. The object aimed at in this apparatus is to conduct the two operations of separating the cream from the milk and of churning the cream each at the appropriate temperature. The former is done at 75 deg. to 80 deg. Fahr., and the latter at 50 deg. to 55 deg. The fresh milk runs over a heater into a Laval separator of the usual type; the skim milk flows away, while the cream trickles over a small refrigerator, supplied with cold water, into a tiny churn fixed to the frame of the apparatus, and driven at 3000 revolutions per minute. This is a small horizontal cylinder in which revolves a beater or whisk, and in its passage through it the cream becomes converted into butter and butter-milk, or, as the Scandinavians aptly call it, "churn milk."

In the interval since the Windsor Show, the direct butter extractor shown by the Aylesbury Dairy Company, of Bayswater, London, has been very considerably modified, and it is now offered as a practicable machine for dividing new milk into skim milk and butter at one operation. It consists of a separator revolving at 6000 revolutions per minute in the usual way. The skim milk accumulates at the periphery and the cream masses itself in a vertical annular layer inside it. In the centre of the vessel is an inner open-topped compartment, slightly conical, the mouth being the smallest part. The cream gradually accumulates in this inner vessel, in which is a light paddle-wheel or cage. This wheel runs loose on its spindle and by an eccentric arrangement can be pressed into the wall of cream around the inside of the compartment, when it revolves at the same peripheral speed. The following is a summary of the explanation of its action given by the exhibitors. Cream consists of butter globules mixed with a small quantity of skim milk. If the last traces of milk be removed the globules will coalesce and form perfectly pure butter. The bars of the wheel keep parting the cream, and thus enable the skim milk that was in the cream to escape therefrom, leaving only pure butter globules, which coalesce somewhat together, and escape from the drum by a spout provided for them.

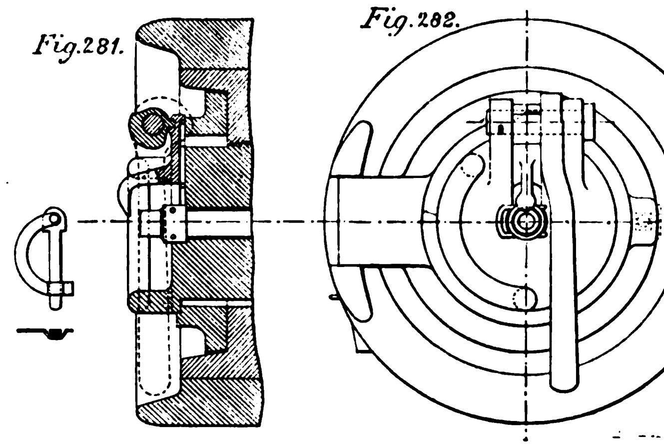
The same firm show two new small hand separators this year. They are of simpler construction than their larger machines, the sharp spouts which were used for skimming out the liquids being abandoned, and the outflow taking place through appropriately placed passages. They also show a whirling apparatus capable of being fixed in a separator and designed to receive 140 test tubes for testing the quality of milk. This size is, of course, only suited for very large dealers who obtain milk from many sources, and wish to guard themselves against receiving fluid which has already undergone a partial extraction.

MODERN FRENCH ARTILLERY.
No. XXV.
FORGES ET CHANTIERS DE LA MEDITERRANEE—SIEGE AND GARRISON GUNS.

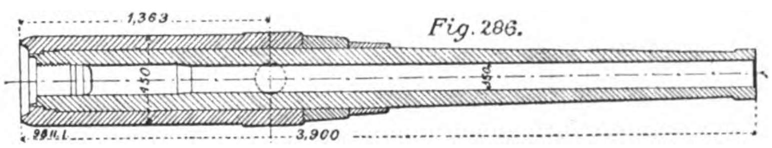
THE siege and garrison guns made on the Canet system at the works of the Forges et Chantiers de la Mediterranée, are classified into a series of the following eight calibres:

9 centimetres	=	3.54 in.
10 „	=	3.94 „
12 „	=	4.72 „
15 „	=	5.90 „
19 „	=	7.47 „
22 „	=	8.66 „
24 „	=	9.45 „
27 „	=	10.63 „

Each of the foregoing calibres is divided into two types, short and long; the former is intended to give an initial velocity of at least 1312 ft., and the latter a velocity of 1700 ft. per second to the projectiles. The complete series thus comprises sixteen types of guns, the larger ones of very considerable power and range, and among them may be selected weapons adapted for almost any class of land service. Thus these guns vary in efficiency from the short nature of 3.54 in. which can penetrate at the muzzle a wrought-iron plate of 2.5 in., and has a range of 7400 metres, up to the long 10.63-in. gun that can pierce 17 in. of wrought iron at the muzzle, and has a range of more than seven miles. A large number of experiments have been carried out with the Canet guns of these types, and they have been found to give initial velocities much higher than those of the French regulation pattern; indeed, as will be seen from the particulars contained in Table XXIV., M. Canet has attained with them velocities of nearly 2000 ft. per second, while the material employed has not suffered from the heaviest strain to which they have been subjected—25,600 lb. per square inch.



BREECHLOADING MECHANISM; SIEGE GUNS.



15-CENTIMETRE SIEGE GUN.

These guns are mounted either on wheeled carriages or on disappearing mountings, or for the heavier natures, on the various patterns of garrison carriages. The eclipse or disappearing mountings have many advantages to recommend them; they are easily worked and offer a great degree of security to the men engaged in working, either behind a parapet or in a well. The special arrangement of brake adopted by M. Canet for this class of mounting, to which special reference will be made later, possess, it is claimed, great compactness, while the brake cylinders being placed horizontally, the strains set up can be more easily controlled, and there is an absence of the shock which accompanies the arrangement, in which the brake piston is attached to the balanced frame of the mounting. No central well is required for the reception of the brake cylinder, and the dimensions of the base-plate are reduced, so that the pit in which the gun is placed can be made of smaller dimensions. It is also claimed that the gun is free to fall back through a larger angle than is possible with an oscillating brake cylinder, the rod of which is attached to the balanced frame.

The Canet 12-centimetre (4.72 in.) siege gun, which is a very convenient calibre, throws a projectile weighing 39.7 lb. with an initial velocity of 1700 ft., and is a very formidable type of artillery. It is provided with a simple form of breech mechanism (Figs. 281 and 282) with the ordinary plastic obturator and a safety apparatus, consisting of a bolt on which is mounted a shield covering the vent. This opening remains protected during the whole time that the breech is being opened or closed, and it is only at the moment when the breech-block lever is thrown down and the block is fully closed that the shield rises and the fuze can be inserted. The arrangement is in fact similar to that for field and mountain artillery, already described and illustrated in Figs. 277 to 280 on page 725 *ante*. The end of the breech is so made that there are no hollows in which sand or dirt can accumulate, and which would serve to interfere with the working of the breech mechanism. This gun is mounted on a wheeled carriage, the frame consisting of two steel plates solidly braced together (see Figs. 283 to 285); between the axle and the connecting pieces mounted on the frame, a heavy rubber sheathing is placed, intended to reduce the shock of recoil. The frame is also provided with shoe brakes, *a*, Fig. 283, to limit the recoil, and in such cases where it is desired to reduce it to a minimum a hydraulic brake is introduced. In front the carriage rests upon a bedplate

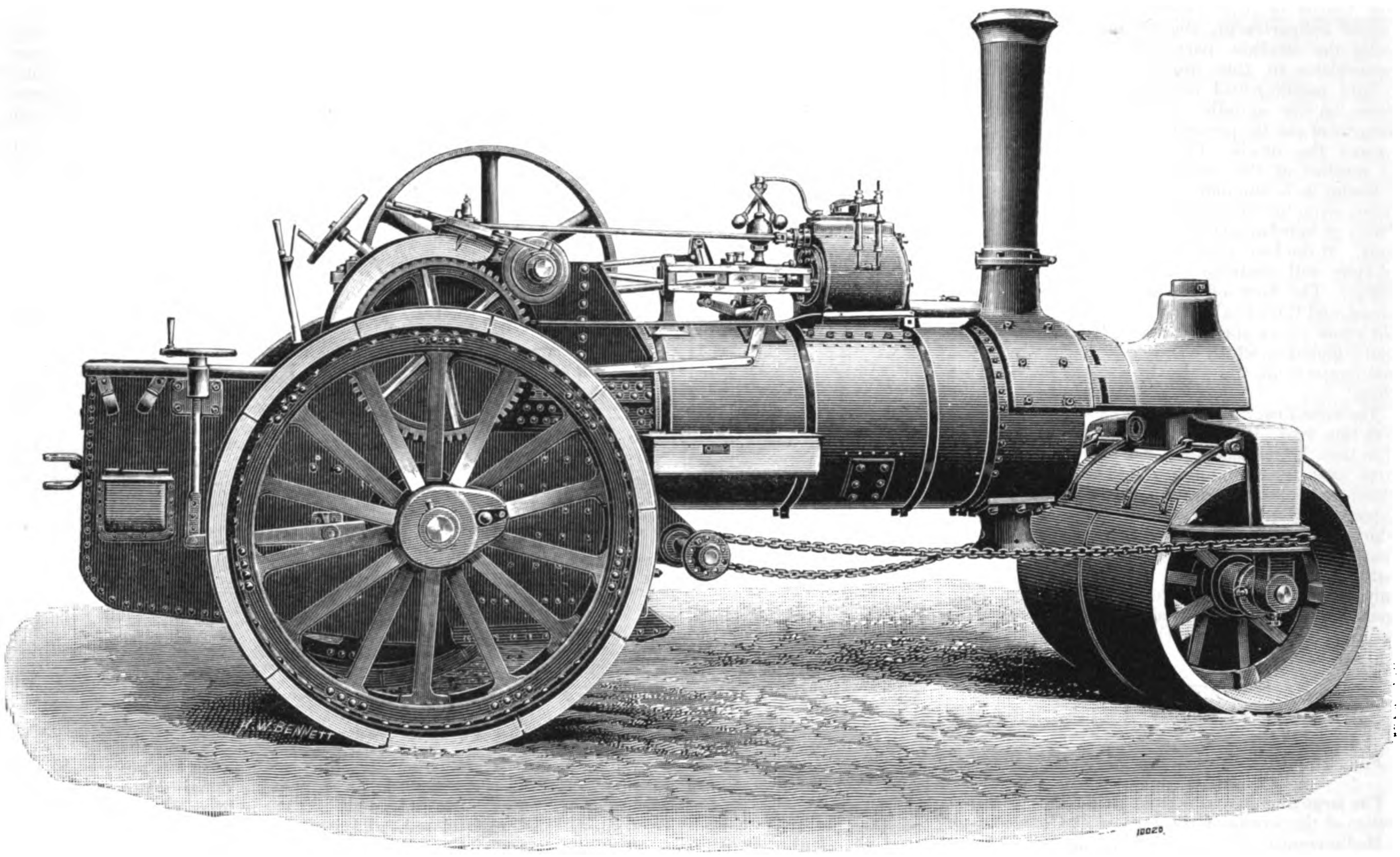
TABLE XXV.—PRINCIPAL PARTICULARS OF FIELD AND GARRISON GUNS (CANET SYSTEM); FORGES ET CHANTIERS DE LA MEDITERRANÉE.

Type of Gun.	Calibre.		Total Length.		Length of Bore.		Diameter of Chamber.		Length of Rifled Portion.		Number of Grooves.	Angle of Rifling.	Weight of Gun.		Weight of Shell.		Weight of Charge.		Muzzle Velocity.		Muzzle Energy.		Perforation in Wrought Iron.		Maximum Range.	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm			lb.	kilos.	lb.	kilos.	lb.	kilos.	ft.	m.	ft.-tons	m. tons	in.	cm.	yards	m.
Field and garrison gun, short type	3.52	90	63.7	1620	54.57	1386	3.70	94	39.4	1000	28	Uniform rifling at 6 deg.	793.7	360	16.75	7.6	2.64	1.2	1312	400	200.1	61.99	2.52	6.4	8,087	7,395
Ditto, long type ..	3.54	90	92.1	2340	82.92	2106	3.70	94	68.4	1740	28		1322.8	600	16.75	7.6	4.41	2.0	1706	520	333.2	104.76	3.66	9.3	9,963	9,110
Ditto, short „ ..	3.94	100	70.8	1800	60.63	1540	4.09	104	43.6	1110	30		1080.2	490	23.15	10.5	3.53	1.6	1312	400	276.4	85.62	2.87	7.3	8,476	7,750
Ditto, long „ ..	3.94	100	102.8	2600	92.14	2340	4.09	104	75.9	1930	30		1807.8	820	23.15	10.5	5.95	2.7	1706	520	467.3	144.74	4.28	10.9	10,563	9,660
Ditto, short „ ..	4.72	120	85.0	2160	73.47	1866	4.87	124	52.3	1330	36		1873.9	850	39.68	18.0	5.95	2.7	1312	400	473.85	146.79	3.78	9.6	8,767	8,015
Ditto, long „ ..	4.72	120	122.8	3120	111.27	2826	4.87	124	92.34	2345	36		3086.4	1,400	39.68	18.0	10.36	4.7	1706	520	801.0	248.12	5.51	14.0	11,056	10,110
Ditto, short „ ..	5.90	150	106.3	2700	92.61	2352	6.10	155	65.3	1660	46		3637.6	1,650	77.16	35.0	11.68	5.3	1312	400	921.5	285.42	5.15	13.1	9,044	8,270
Ditto, long „ ..	5.90	150	153.5	3900	139.85	3552	6.10	155	113.7	2890	46		6062.7	2,750	77.16	35.0	19.84	9.0	1706	520	1557.6	482.46	7.55	19.2	11,536	10,550
Ditto, short „ ..	7.47	190	134.6	3420	115.20	2926	7.67	195	83.0	2110	58		7385.4	3,350	154.3	70	23.15	10.5	1312	400	1843.2	570.96	7.20	18.3	9,329	8,580
Ditto, long „ ..	7.47	190	194.5	4940	175.0	4446	7.67	195	144.5	3670	58		12,125	5,500	154.3	70	39.68	18.0	1706	520	3115.1	964.94	10.47	26.6	12,040	11,010
Ditto, short „ ..	8.66	220	155.9	3960	133.4	3388	8.89	226	96.0	2440	66		11,464	5,200	242.5	110	36.38	16.5	1312	400	2896.7	897.23	8.93	22.7	9,842	9,000
Ditto, long „ ..	8.66	220	225.2	5720	202.7	5148	8.89	226	167.3	4250	66		18,739	8,500	242.5	110	63.93	29.0	1706	520	4895.0	1516.3	13.03	33.1	12,839	11,740
Ditto, short „ ..	9.45	240	170.1	4320	145.5	3696	9.72	247	105.1	2670	72		14,925	8,760	308.6	140	46.30	21.0	1312	400	3686.4	1141.9	10.0	25.4	10,029	9,170
Ditto, long „ ..	9.45	240	206.3	6240	221.1	5616	9.72	247	182.3	4630	72		24,912	11,300	308.6	140	79.37	36.0	1706	520	6230.0	1929.8	14.57	37.0	13,155	12,030
Ditto, short „ ..	10.63	270	191.4	4860	163.7	4158	10.94	278	118.1	3000	82		21,164	9,620	440.9	200	66.14	30.0	1312	400	5266.5	1631.3	11.85	30.1	10,382	9,495
Ditto, long „ ..	10.63	270	191.4	7020	248.8	6318	10.94	278	205.2	5210	82		35,581	16,140	440.9	200	114.64	52.0	1706	520	8921.6	2763.3	17.64	43.8	13,948	12,755

COMBINED TRACTION ENGINE AND ROAD ROLLER.

CONSTRUCTED BY MESSRS. WALLIS AND STEEVENS, ENGINEERS, BASINGSTOKE.

(*For Description, see Page* 754.)



b, Fig. 283, to the forward part of which is connected a brake cylinder whose piston-rod is coupled with the end of the frame; after firing, the carriage mounts two inclined steel guides and afterwards falls back again into firing position by gravity. The discharge orifice of the brake is variable and maintains a very regular action during the recoil. This is the arrangement proposed by M. Canet some years since as the French standard type for the 6.10-in. French siege guns. Training the gun for elevation is effected by means of a differential gear to be described presently, and which is used largely in the Canet carriages. Training for direction is effected by means of levers, the carriage being free to revolve on inclined planes around a pivot provided for the purpose; a platform is provided at the rear of the carriage for the man training the gun. This weapon is of a light and simple type, while the form of mounting adopted gives it great stability. The rapidity of fire is much increased by the fact of the gun coming back automatically into firing position, thus saving all the more or less serious manipulations necessary when mountings for this purpose are not provided. This great ease in handling is one of the special advantages of the arrangement illustrated, and which cannot fail to be appreciated by every one who has had to train a siege gun mounted on the older types of carriage.

The construction of these guns is illustrated in Fig. 286, where it will be seen to comprise one long tube extending from end to end, the breech being enlarged for the powder chamber and the breech seating; over this is shrunk a jacket extending to the trunnion ring, and in front are two thinner taper rings. The arrangement for training for elevation is shown in Fig. 283; it consists of a straight rack A attached to a ring that passes round the gun and gears into a pinion that is turned through the handwheel C, which is fast on the same shaft; two guide rollers of gun-metal press against the back of the rack and keep it in position. The handwheel does not act direct on the pinion, but through the medium of a differential gearing, which is arranged in the following manner: Upon the spindle of the handwheel is fixed an excentric that turns inside a disc, and is separated from it by means of small friction wheels arranged around its periphery. Around the outer side of the disc are cut nineteen teeth; this disc is placed within a second disc, but eccentrically to it; on the periphery of this disc are cut twenty teeth, and upon its spindle the pinion gearing into the rack is attached. The outer disc, which is held in its place by studs, does not turn, but has simply sufficient movement to give one-twentieth of a revolution to the inner disc for each complete revolution of the handwheel.

The hydraulic brake which is attached to this gun is illustrated in the various figures; it consists of the cylinder A^1, in which moves a piston B. The rod of this piston is hollow, and within it passes a rod secured to the bottom of the cylinder; this rod is made of a variable cross section. The head of the piston is made with four inclined openings, which are in communication with a central opening made in the opposite side of the piston. Between the two faces is interposed an annular valve formed with four lateral openings and with four inclined grooves; this valve is held down on its seat by a coiled spring. Inclined grooves made in the head of the fixed rod of variable section effect communication between the inner space of the piston and the body of the pump. When recoil takes place the valve is lifted and allows the liquid to flow freely through the openings in the head of the piston. The variations in the area of the central opening are assured by the variations in the section of the fixed rod, which are so calculated as to produce a constant pressure through the cylinder throughout the recoil. As soon as the recoil is terminated, the valve in the piston closes, and the fluid can only pass through the other side by the narrow openings in the piston and the grooves; this gradual flow brings the gun back into firing position as slowly as may be desired, the rate of return being regulated by altering the size of the openings. The air inclosed in the cylinder expands, and is compressed according to the position of the fixed rod of varying section, and in this way an air cushion is provided to absorb shocks. The illustrations show that the cylinder is attached to a pivot in the bedplate placed between the wheels, while the piston rod is secured to the under side of the carriage. To insure the return of the gun to firing position, two shoe wedges *a*, Fig. 283, are placed at the rear in contact with the wheels; they are connected by two crosspieces to which they are jointed, the forward one F is mounted on the pivot of a platform *b*, around which it can turn; in the other one G is a recess in which the brake cylinder can rest. By this arrangement the wedges are made independent of the movement of the carriage when the gun is elevated, and they are always parallel to its axis. We annex particulars of the projectiles for the 12-centimetre gun; those used with the 15-centimetre

TABLE XXIV.—*Experiments with* 12 *cm.* (4.75 *in.*) *Siege and Garrison Guns, Canet System, Model* 1889, *made in January and March*, 1890.

Weight of Shell.		Kind of Powder.	Weight of Charge.		Muzzle Velocity.		Pressure.	
lb.	kilos.		lb.	kilos.	ft.	m.	tons per sq. in.	kilos. per sq. cm
41.88	19.	C2 brown	**6.614**	3.	**1296**	395	**4.73**	745
41.88	19.	,,	**7.716**	3.500	**1418**	432	**7.56**	1190
41.23	18.700	,,	**8.818**	4.	**1542**	470	**10.09**	1590
39.68	18.	,,	**10.14**	4.600	**1679**	511	**13.84**	2180
40.78	18.500	C2 black	**8.818**	4.	**1411**	430	**13.97**	2200
40.34	18.300	C2 brown	**8.818**	4.	**1529**	466	**10.63**	1675
40.34	18.300	,,	**10.14**	4.600	**1670**	509	**13.59**	2140
40.56	18.400	BN. sample 155, 1889	**3.307**	1.500	**1037**	316	**1.492**	235
40.34	18.300	,,	**4.409**	2.	**1309**	399	**3.016**	475
40.34	18.300	,,	**5.512**	2.500	**1598**	487	**6.35**	1000
40.34	18.300	,,	**5.512**	2.500	**1581**	482	**6.159**	970
40.34	18.300	,,	**6.063**	2.750	**1699**	518	**7.43**	1170
40.34	18.300	,,	**6.063**	2.750	**1706**	520	**7.43**	1170
40.56	18.400	,,	**6.614**	3.	**1828**	557	**9.59**	1510
40.34	18.300	,,	**6.614**	3.	**1818**	554	**10.35**	1630
40.56	18.400	,,	**7.165**	3.250	**1945**	593	**11.24**	1770
40.34	18.300	,,	**7.185**	3.250	**1913**	583	**10.35**	1630
40.12	18.200	,,	**7.165**	3.250	**1942**	592	**11.75**	1850

bore weigh 77 lb., and, with a maximum powder charge of 19.8 lb., have an initia lvelocity exceeding 1700 ft. The length of the shell varies from 2 to 2.8

TRIPLE-EXPANSION ENGINES OF THE S.S. "MARIPOSA."

CONSTRUCTED BY MESSRS. BLACKWOOD AND GORDON, ENGINEERS, PORT-GLASGOW.

Fig. 3.

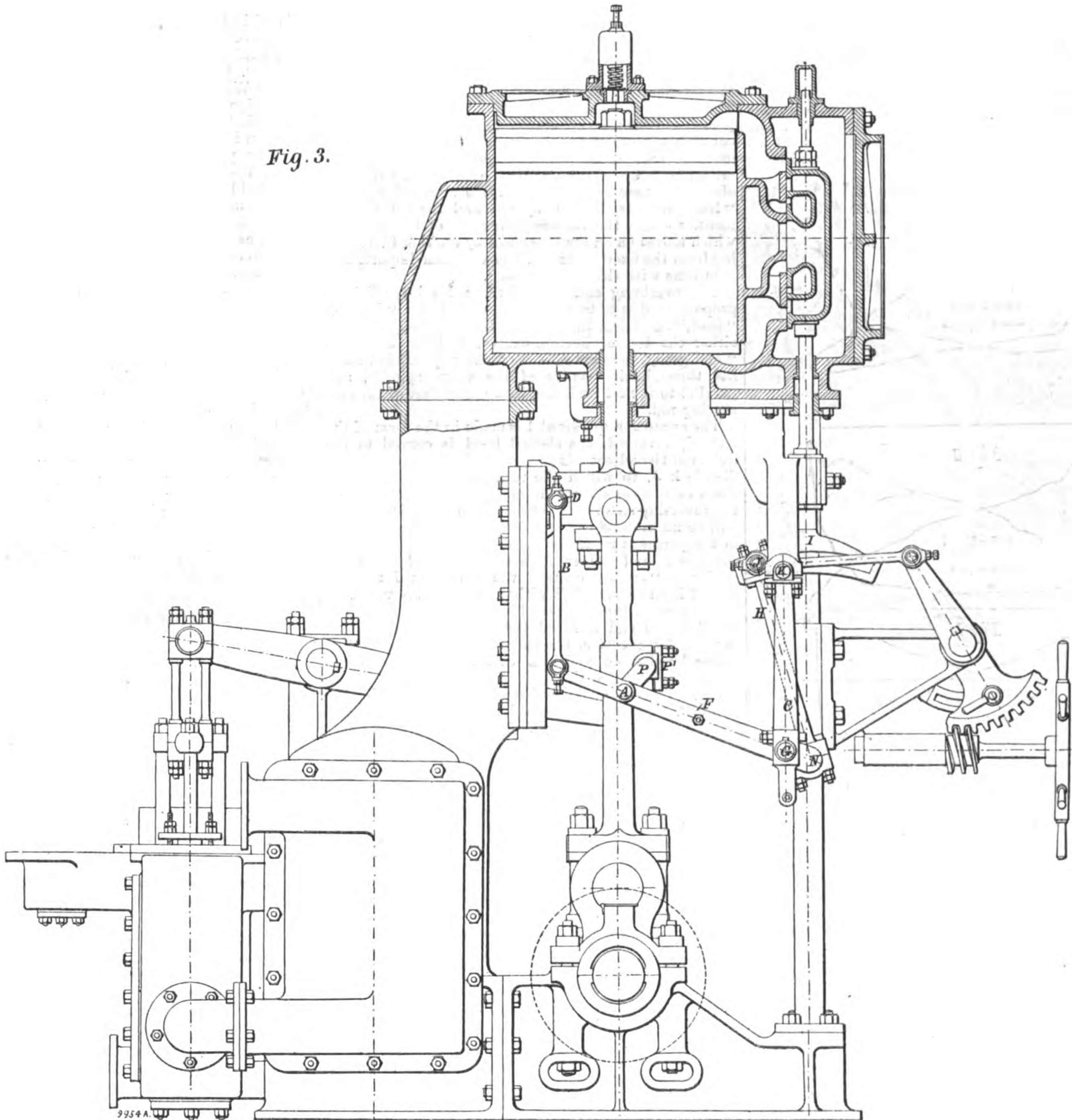
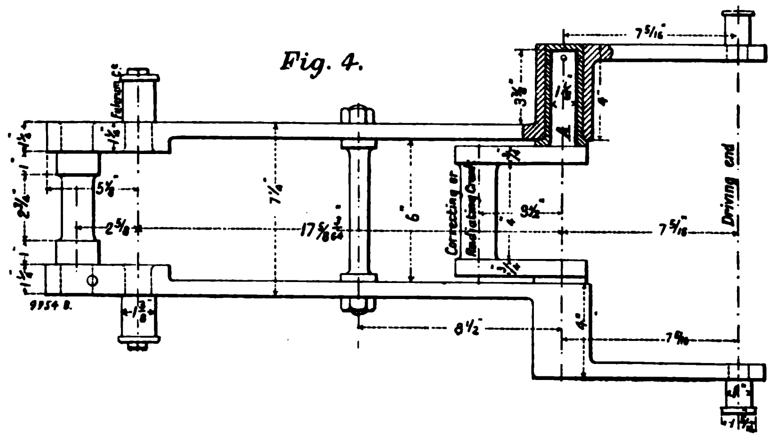


Fig. 4.



calibres. The ballistical data of the various types of siege and garrison guns made by the Forges et Chantiers at Havre, will be given in our next article. Fig. 287 (page 749) conveys a good idea of a 12-centimetre siege gun mounted for firing, and Fig. 288 is a similar view of the 15-centimetre gun. The trunnion bearings on the frames for supporting the gun during transport are shown in these views. Table XXIV. is the record of a series of experiments made with a 12-centimetre Canet siege gun at Havre during the present year; Table XXV. contains general particulars of all the different types of Canet siege and garrison guns.

ENGINES OF THE S.S. "MARIPOSA."

WE give this week a two-page engraving with other views on the present page, of the triple-expansion engines of the screw steamers Mariposa and Langosta, these engines, together with the vessels to which they belong, having been constructed by Messrs. Blackwood and Gordon, of Port-Glasgow, to the order of Messrs. J. and A. Allan, of Glasgow, and under the superintendence of their engineer, Mr. David Johnston, of Glasgow.

The vessels are of the following dimensions; viz.: Length, 153 ft.; breadth, 28 ft.; depth, 9 ft. 6 in. They are constructed to Class 100 A1 at Lloyd's (coasting) and are capable of carrying 150 tons cargo on 8 ft. draught of water. The hatches are specially large and each steamer is fitted with two 2½ tons steam cranes manufactured by Messrs. Napier Brothers, of Glasgow. Altogether everything is arranged for the rapid handling of cargo, as Messrs. Allan intend using these steamers as feeders for their large vessels on the River Plate, which latter vessels, owing to their depth of draught, cannot come alongside the wharf.

It was essential to the purpose for which these small

MODERN FRENCH ARTILLERY.
No. III.

FOR nearly four centuries the manufacture of ordnance in France was carried on exclusively in the arsenals of the Government, all private enterprise in this direction having been checked, while the purchase of war material from foreign countries was prohibited; and although after the conclusion of the Crimean War the French Government was conscious of its inability to keep a front place with other nations who were then making rapid progress in the art of heavy gun manufacture, it did not avail itself of the opportunities afforded by the Elswick firm, and by Krupp, of Essen, to supply itself with ordnance from abroad, which it could not manufacture at home. During the Franco-German War the rule was relaxed so far that field batteries were purchased from several foreign makers, while, as we have seen, at an earlier date, guns for trial had been obtained from Krupp. When the war of 1870 broke out, the metals then employed for making guns —cast-iron and bronze—were prepared wholly in the Government establishments; the metallurgical works of Douai and of Bourges supplied the material for the land artillery, while those of Ruelle, Nevers, and St. Gervais, worked for the marine. After the conclusion of the war, French manufacturers were unable to produce steel suitable for heavy guns, and when, about 1873, the Government made naval ordnance of the so-called 1870 type, the French Admiralty purchased all the inner tubes from Messrs. Firth and Son, of Sheffield. But not only was private enterprise fettered by a total prohibition, from supplying the needs of the country so far as war material was concerned; it was further hampered and indeed stifled, by regulations that prohibited any French industrial from furnishing ordnance to foreign governments—a very superfluous prohibition considering that France at that time was far behind either England or Germany in the fabrication of guns. The result of this short-sighted policy made itself disastrously evident during the Franco-German War, and taught France a lesson by which she has very fully profited, as the magnificent display of light and heavy artillery in the pavilion of the Minister of War, on the Esplanade des Invalides, proved last year. Before the close of the Franco-German War, when it had become only too evident that the Government system had hopelessly broken down, engineers and manufacturers had done their best to supply the deficiencies of the State arsenals by manufacturing war material as rapidly as possible, but the time and opportunity had passed, and all their efforts were practically fruitless. After the conclusion of the war, the Government—in spite of experience — only partially relinquished its old practice, though it went so far as to employ French metallurgical works for the supply of raw material, while it continued to keep the fabrication in its own hands.

In 1872, M. Thiers conceived the idea of establishing in France a great central factory which should be to that country, what the works at Essen were to Germany; such establishments already existed at Creusôt, as a steelmaking industry, and at St. Chamond, and special efforts were made to encourage these gigantic factories and to make of them powerful auxiliaries to the State arsenals. It was not, however, for several years that a sufficient inducement was given to private firms to devote time and money in establishing works for the manufacture of ordnance, or even for the special manufacture of gun steel tempered in oil and annealed, or for armour-piercing projectiles; but in August, 1885, a law was passed by which the production of war material for foreign countries was sanctioned, and at last French industry was set free not only to prepare to render invaluable services to the country in the event of another war, but also to compete with England and Germany in the sale of guns to those powers that have the money to buy, and the necessity to possess, but which at the same time have not the power to produce for themselves. We shall hope to show in following articles to what extent French manufacturers have profited by the privileges thus tardily afforded them; it will be seen that in less than five years since the prohibition has been removed, the country has made a marvellous progress, that it has been able to put into extensive practice the advanced views which even in the early days of heavy artillery gave France a leading position so far as theory was concerned, and which were afterwards followed and improved upon by foreign makers. In the manufacture of the highest class of material employed, she is excelled by no country in the world, and she is already a powerful competitor with England and with Germany in foreign markets, while -- until the necessary familiarity with certain French processes has been acquired by English manufacturers — we have been compelled to purchase large quantities of armour-piercing projectiles from Holtzer, Firminy, and other makers of special steel in the district of the Loire.

Cast iron still enters largely into the manufacture of French ordnance for coast defence, and types that were originated before or about 1870 have not yet passed out of service, though the patterns have, of course, become obsolete. Experience and theory have combined to recommend the continued use of such cheaply made guns for special purposes, and they do not differ very widely in their design from the earliest pattern of reinforced guns experimented with after the conclusion of the Crimean War, and which we have referred to in a previous article.

Modern French artillery may be said to date back to 1868, when cast-iron guns of 19, 24, and 27 centimetres (7.47 in., 9.45 in., and 10.63 in.) were made; the type of this gun is shown in Fig. 11, where it will be seen that it consists of a cast-iron body reinforced behind the trunnions by two rows of narrow steel bands, the outer row being much thinner than the inner one; it was further strengthened by a steel lining forced into the body of the gun and secured by screws; this lining tube was introduced from the muzzle in a manner presently to be described. This form of gun was known as the "1864 type converted into type 1868," the former pattern being wholly of cast iron. A few years previously the first serious efforts at strengthening this kind of ordnance had been made by adding rows of steel rings around the cast body (see Fig. 1, page 1 *ante*); these were muzzle-loaders. The pieces of this type made at a somewhat later date,* are breechloaders, and the length of the bore is 17 calibres. To about the same date belongs the cast-iron mortar shown in Fig. 12; this is also of cast iron strengthened on the outside, only with one row of steel rings; there is no lining tube, but the bore is rifled and the length is equal to 10 calibres. This mortar, though now ancient, is practically the same as the 1883 type, largely mounted for coast defence, and the mode of construction is still followed in the State factories. The types of heavy guns made in 1870 were of 14, 19, 24, 27, and 32 centimetres bore (5.51 in., 7.47 in., 9.45 in., 10.60 in., and 12.60 in.); the bodies of all these calibres were of cast iron with a steel lining tube and outer steel rings. In the largest calibre the tube was made in two lengths screwed together, and for all the sizes excepting the 5.51 in., there were two rows of reinforcing rings; in all cases the lining tube was screwed in from the breech. In a modified type produced a few years afterwards, the proportions of all the various calibres were the same as those just given, but in order to employ a heavier charge of slower powder, the chamber was enlarged. The 10-centimetre steel guns manufactured in 1874, were known as the 1870 model; these in fact closely resembled the earlier type in their design, but the cast-iron body was replaced by steel, which, it is needless to say, was not of such quality as can now be made. A few years later, calibres and weights were increased, and the first 27, 34, and 42 centimetre guns were produced, on what was called the 1875 model, and subsequently others of greater length and of 37-centimetre bore upon the so-called 1875-79 types. In and after 1878 this enlargement of the powder chamber was definitely adopted, and in the same year a new calibre, 6.29 in., was made. The use of slower burning powders and heavier charges was naturally followed by an increase in the length of the gun; the 17 calibres of bore was extended to 25 calibres, and a number of such heavy pieces of artillery, of reinforced cast iron were made after 1870; at present only two such guns are in service; they are 12.60 in. bore, 25 calibres in length, and form a part of the defence of Toulon. Before 1879, the length had been again increased to 27 calibres, and artillery ranging from 13.39 in. (34 centimetres) to 16.54 in. (42 centimetres) were made of these proportions; a considerable difficulty, however, was found in the course of manufacture, the lining tube when forced in from the muzzle could not be tightly secured; attempts were therefore made to introduce it from the breech, but this was found impossible, and ultimately the practice was adopted of setting in the tube from the muzzle and securing it in place by special devices; the breech-screw was made in this tube. Both the 34-centimetre and the 42-centimetre—the latter were made with steel bodies—were reinforced with three steel jackets besides the lining tubes. The lengths of these larger guns varied from 21 to 22 calibres; they weighed 75 tons and threw ordinary cast-iron shells of 1430 lb. with an initial velocity of 1730 ft.; the weight of the steel shells was 1760 lb., and they held a bursting charge of about 22 lb. The 42-centimetre guns above referred to were built upon the designs of the French Artillery Department, and at the State factory of Ruelle, the steel having been supplied and the elements finished, at St. Chamond. They were among the first of the large calibres manufactured in France, when the change was made from cast iron to steel as a material for ordnance; that they were practically manufactured at private establishments instead of at one of the French arsenals, was of course due to the fact that these latter factories did not possess the appliances for producing and finishing large masses of steel, while M. Thiers was about that time making partially successful efforts to break down the system that had been established for so many years, and by which France was wholly dependent upon its own imperfect practice for its ordnance.

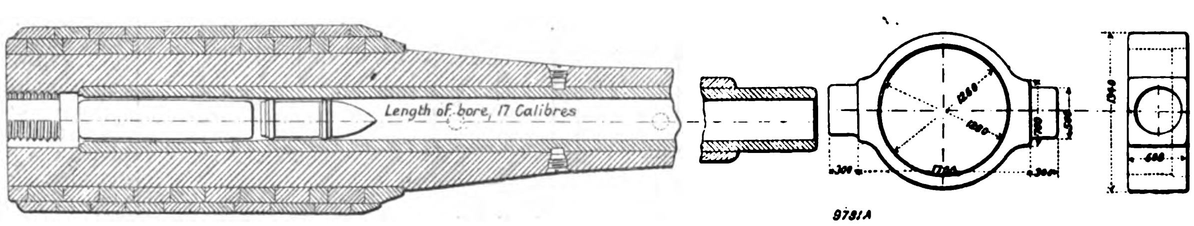


FIG. 11. CAST-IRON REINFORCED FRENCH GUN; TYPE 1864 CONVERTED TO 1868 MODEL.

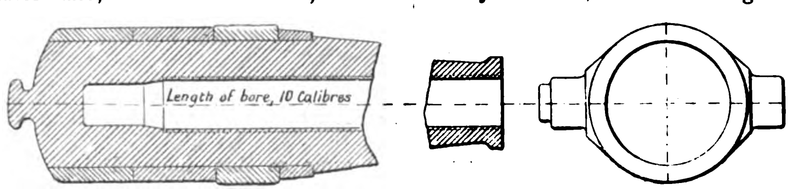


FIG. 12. FRENCH COAST DEFENCE MORTAR; 10 CALIBRES.

At that time all the heavy guns in France, both for coast defence and for naval purposes, were produced at the Ruelle foundry. This factory was established in 1750, when the site was found to be peculiarly favourable for the purpose on account of the plentiful supply of high-class iron ore and charcoal that existed in the neighbourhood; in 1776 this factory became Government property, and enlargements and improvements have been ever since going on to adapt it in some measure

* Some of the information and illustrations here given are reproduced from *Le Nouveau Matériel Naval*, by MM. Ledieu et Cadiat.

to the rapidly growing requirements of ordnance manufacture. The foundry at Nevers was established as late as 1830, and in 1875 was of sufficient extent to turn out about 300 guns a year, varying in calibre from 5.5 in. to 10.6 in. It was at Ruelle that the first experiments were tried in France for rifling cast-iron ordnance, according to the plans of Treuille de Beaulieu, and special plant was laid down for the purpose; as we have already said, the immediate occasion for such ordnance passed away, and so far as large calibres were concerned, the experiments went no further at the time. It is interesting to note, however, that it was at Ruelle, about the close of the Crimean War, that a cast-iron 8.6 in. gun was bored out to 11.8 in. and rifled with two grooves. The rapid improvements that were being made in the manufacture of heavy guns in England and Germany were rapidly leaving France behind, and the earliest efforts made to strengthen the French cast-iron guns with steel hoops having proved unsuccessful, considerable 120*l*., of the same materials of which it was proposed to use for the larger weapon; this gun was carefully finished, bored, and rifled, and was then tested to destruction, the number of rounds fired from it, before it failed, giving an indication of the value of the metal. Careful experiments with the powder were also previously made by bursting with it a gun the strength of which was accurately known; by this means the strength of the metal to be employed could be very closely estimated. When this test had been passed successfully the metal was mixed with twice the quantity of other brands that had also been tested, and samples taken from this mixture were subjected to tests formulated by the French War Office. We do not know exactly what were the limits of strength insisted on, but at the present time the best cast iron made at Ruelle must show an elastic limit varying from 9.5 tons to 11.4 tons per square inch, and a breaking strain not inferior to 14.5 tons. This limit is approximately downward; the casting was open from end to end, and the breech tube was afterwards introduced from the rear. On each side of the casting pit, two small shafts A and B were made, and from them channels were formed leading to the mould. A 3-ft. head above the breech was allowed for, and in casting, the channel *a b* was first opened, allowing the metal to flow into the mould until it rose almost to the level of the second channel *c d*; pouring was then discontinued from the

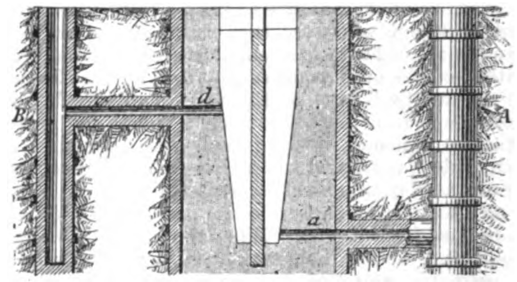


FIG. 16. MODE OF CASTING GUN BODIES AT RUELLE.

channel *a b*, and the metal was introduced from the pit B until the mould was filled and the casting completed. Charcoal was then piled over the pit and left for forty-eight hours, when the casting was removed and the operations of turning and boring carried out. The gun was subsequently placed in a brick annealing furnace, and heated to a temperature of 540 deg.; the steel tube was screwed in and the whole allowed to cool; afterwards the outer rings were shrunk on, the first of these being the trunnion ring. The operation of rifling completed the gun, and it may be mentioned that for guns having a bore of an even number of centimetres, the number of grooves composing the rifling was equal to about double that of the centimetres of bore, while the number of grooves was one in excess of the centimetres of bore, if the latter were odd. Tables I. and II. on the next page give some of the general particulars of the French heavy guns in service in 1873, as well as comparisons with French and English ordnance of the same date.

Figs. 17 to 22 show the different kinds of projectiles used, and Fig. 23 illustrates a type of gun adopted in 1870 and manufactured as late as 1881; these are of 32 centimetre bore; in the earlier model the lining tube was in two lengths of steel screwed in at the breech, but the form and dimensions illustrated are those of the 1881 type.

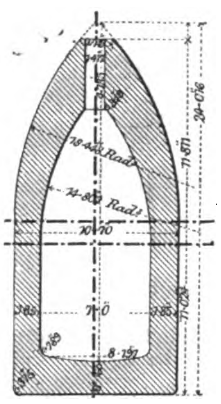


FIG. 17.

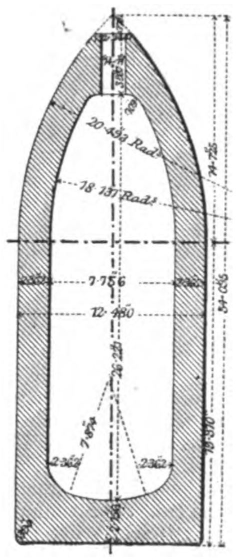


FIG. 18.

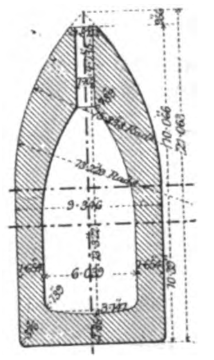


FIG. 19.

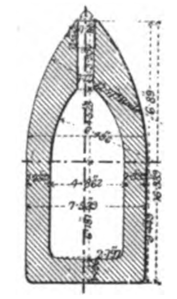


FIG. 20.

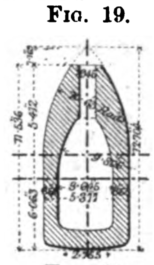


FIG. 21.

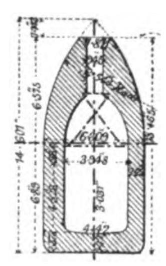


FIG. 22.

PROJECTILES FOR FRENCH ORDNANCE; 1873.

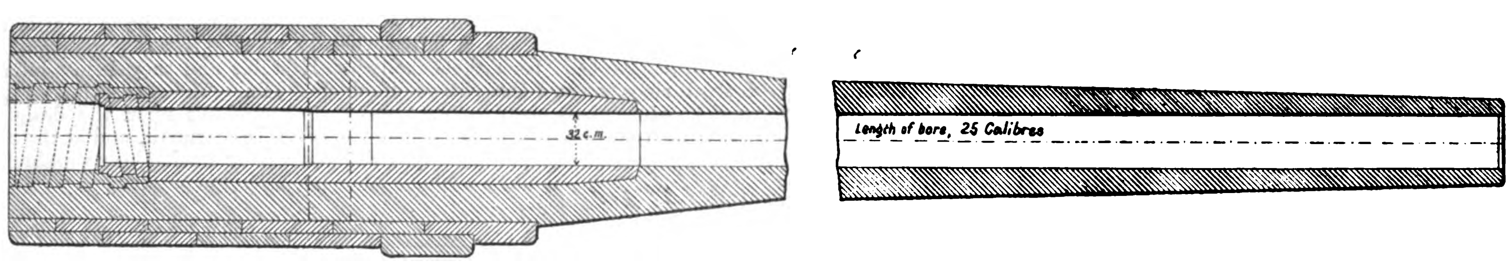


FIG. 23. TYPE OF 32-CENTIMETRE FRENCH GUN; MODEL 1870-81.

modifications were made and different types produced, the principal of which we have already described, and which gave very favourable results so far as the smaller calibres were concerned; the 6.3-in. guns especially showed considerable powers of resistance, rising as high as 1000 rounds with 100 lb. projectiles and 19.8 lb. of powder. Such was the condition of heavy artillery in France at the time when the war broke out with Germany, and the Government factories were taxed to their fullest extent for the production of bronze field guns.

After the conclusion of the war the attention of French engineers and artillerists was very naturally devoted, as we have seen, to the question of improving heavy guns, cast iron still being the chief material employed, but reinforced in different and improved methods; the principal of these types we have just referred to. In a report on French gun manufacture, made by Lieut.-Colonel Reilly, C.B., in 1873, some interesting particulars are given of the methods then in vogue for making such guns, which were practically the same as those followed in Sweden, and we may refer here to this report, though it will partly take us back over the ground we have just traversed; we believe, however, that the practice to be described is practically that followed at the present time. The first step was to make a carefully finished model gun at a cost of about the same as that imposed by the Washington Ordnance Bureau as early as 1863, which specified that the iron employed should have a tenacity of not less than 30,000 lb. per square inch, and it is probable that with all the care that was exercised in the selection and testing of the metals employed, that the results obtained could not have been much inferior. Rifling cast-iron guns that were not reinforced, was very quickly abandoned in France as being worse than useless; experiments proved that smooth bores which could resist long and continuous firing became, after rifling, practically useless. It was this experience that led to the adoption of a steel lining tube, which was at the same time well adapted to receive the rifling and to protect the cast iron from the immediate shock of the explosion. It was also found that the cast-iron guns when they exploded, always failed at the rear of the trunnions, and this suggested the adoption of the steel reinforcing rings outside the cast-iron body, from the breech to a point forward of the trunnions. Thus strengthened, the standard type of French guns adopted after the Franco-German War, and still in use for coast defence, was that shown in the illustrations, Figs. 13 to 15 (see page 54). The mode of casting the gun bodies at Ruelle is shown in Fig. 16. The mould was inclosed in an iron casing and placed vertically in the casting pit with the muzzle

As we have already stated, cast iron is very largely used for heavy ordnance in France at the present time; this class is, however, only reserved for coast defence guns, steel being used exclusively for naval purposes and partly for land service. Economy of production and the facility and rapidity with which such guns can be made, are sufficiently good reasons for keeping them in service, especially considering the comparatively high duties to which they can be subjected. The working pressure which is recognised as being safe for cast-iron guns of large calibre, steel lined and reinforced with outer steel tubes, is 34,135 lb. per square inch, which does not fall far short of the working pressures for the steel guns of similar calibre made between 1875 and 1881, and which vary from 39,820 lb. to 41,250 lb. French artillerists appear to look upon this very moderate increase in efficiency as dearly purchased at the five or six-fold cost of steel guns and the slowness with which they can be produced. The great objection to the use of cast-iron guns of large calibre is reported to consist chiefly in the narrow margin of safety which they offer; such guns may be fired a very large number of rounds up to the pressures we have just mentioned, but if, owing to any irregularities in the powder, the pressure be suddenly increased, the risk of the gun burst-

TABLE I.—*Particulars of French Cast-Iron Reinforced Guns*, 1873.

Nature of Gun.	Calibres.	Total Weight.	Length of Bore.	Charge.	Weight of Projectile.
centimetre	in.	cwt.	in.	lb.	
14	5.456	52.26	89.88	8.82	41.11
16	6.484	98.42	118.27	16.5	99.3
		tons			
19	7.638	7.9	135.39	33.1	165.4
24	9.499	13.8	162.55	61.7	317.6
27	10 803	21.7	163.70	88.2	476.4
32	12.6	34.5	204.1	136.69	760.5

TABLE II.—*Comparative Efficiency of French, English, and German Guns*, 1873.

Nature of Gun.		Weight of Projectiles.	Powder Charges.	Muzzle Velocity.	Total Energy in Foot-Tons.	Energy per Pound of Powder in Foot-Tons.
	in.	lb.	lb.	ft.		
French ..	6.484	99.3	16.5	1312	1185	71.8
English ..	7	115	30	1561	1943	64.8
German ..	6.796	123	25.35	1559	2073	81.7
French ..	7.638	165.4	33.1	1486	2533	76.5
English ..	8	180	35	1413	2492	71.2
German ..	8.236	217.2	37.48	1385	2889	77.1
French ..	9.499	317.6	61.7	1427	4484	72.7
English ..	9	250	50	1420	3496	69.9
German ..	9.499	306.4	52.91	1312	3657	69.1
French ..	10.803	476	88.2	1378	6273	71.1
English ..	11	535	85	1315	6415	75.5
German ..	10.236	414.5	70.55	1385	5514	78.2
French ..	12.6	760.5	136.69	1312	9077	66.4
English ..	12	700	110	1300	8205	74.6

ing violently is very great. Apart from the bad moral effect which this source of danger produces on the men, there is, of course, a considerable amount of actual risk in handling such guns even with the greatest care; obviously the cure for this danger is to use as moderate powder charges as possible. The cost of producing cast-iron ordnance at the present time in the Ruelle factory is about 21*l*. per ton, and such guns without either lining tubes or jackets can resist a strain of 9500 lb. per square inch on the surface of the bore; with one row of jackets this resistance is raised to 19,300 lb. per square inch, while with two rows of jackets it is again increased to 28,680 lb., and with a steel lining tube to 45,930 lb. In other words, the reinforcing of the cast-iron body increases its strength four-fold. As for the cost of production the following Tables give some interesting information; Table III. shows the cost of production of the

TABLE III.—*Cost Price of French Ordnance.*

Nature of Gun.	Weight, including Breech Mechanism.	Total Cost.	Price per Pound.
	lb.	£	d.
27 centimetre, 10.63 in., model 1864-66	45,100	684	3.64
27 centimetre, 10.63 in., model 1870..	51,084	1188	5.58
27 centimetre, 10.63 in., model 1870-71	56,100	1360	5.82
27 centimetre, 10.63 in., model 1875 No. 1	62,260	4308	16.6
27 centimetre, 1063 in., model 1881	63,030	3200	12.18

10.63-in. gun which alone has been constructed in all the different types from 1864. By means of the figures contained in this Table it is possible to estimate the cost of other calibres and patterns by multiplying the total weight of the gun by the price per pound in each particular type; the cost of various other natures are given in Table IV.

TABLE IV.—*Cost Price of French Guns of Various Calibres.*

Calibres.	1864-66.	1870.	1870-81.	1875. (Steel).	1881 (Steel).	
	£	£	£	£		£
14 cent. 5.51 in.	63.30	137.48	..	..	.. .. ..	364.68
16 cent. 6.29 in.	166.80	258.84	..	..	Heavy	564.44
					Light	444.72
19 cent. 7.47 in.	266.88	406.88				
24 cent. 9.45 in.	483.76	800.52	..	..	.. ..	2005.44
27 cent. 10.63 in.	684	1188	1360	4308 No. 1.	.. ..	3200
34 cent. 13.39 in.	..	2475.40*	..	7504.24†	Inner tube in two lengths	5368
					Inner tube in one length 21 cal.	5333
					Inner tube in one length 18.5 ,,	5880.40

* This was an experimental gun.
† Steel lined and reinforced with steel tubes.

The present method of making cast-iron guns in France does not, as we have said, appear to differ largely from that we have already described as being followed in 1873. The material employed is, first fusion charcoal iron of the highest quality; to this is added a certain amount of other cast iron, the proportions being regulated more by habit than by any actual rule; the metal is melted in a reverberatory furnace, and the casting is made in an upright pit, a core being used to save the work of subsequent boring and to harden the surface of the metal. The cannon is cast breech upwards, and the liquid iron is syphoned into the mould so as to produce a more solid casting. After cooling, the gun is placed in the lathe and is accurately turned and bored and otherwise made ready to receive the lining tube. After this has been done, the gun is placed vertically with the breech upwards, and it is then heated equally along the whole length of the bore in an annular furnace; the arrangement is shown by Fig. 24, which also indicates the introduction

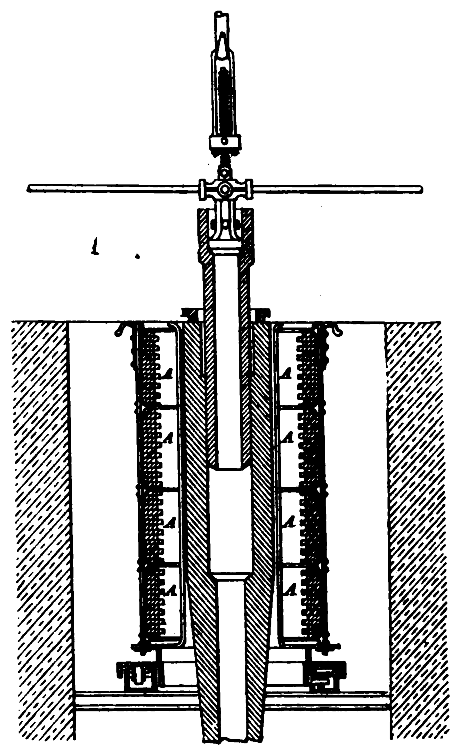


FIG. 24. METHOD OF LINING CAST-IRON GUNS.

of the lining tube. It should be mentioned that the two processes are not carried on simultaneously, the work of tubing being only commenced after the furnace has been removed. The portion A of the latter is filled with coke, and when this is well burnt it is applied around the gun, the amount of expansion being carefully watched, and as soon as a proper degree has been reached, the furnace is at once removed and the tube is introduced; this latter, carried on a cast-iron mandrel as shown in the drawing, is brought over the gun, and then by means of the levers the workmen rotate the tube, at the same time that they press it downwards, until they are stopped by the completion of the process, and the bedding of the tube against its bearings at the breech.

VICTORIAN GOLDFIELDS.

SANDHURST.

(BY OUR SPECIAL CORRESPONDENT.)

(*Continued from page* 18.)

To give some idea of how quartz mining originated, and how it was regarded by diggers of that day, necessitates going back to a time a year or so before the rich alluvial diggings were beginning to give out. About the year 1854, a digger named E. M. Emmett brought to Commissioner Panton some white quartz which he had broken from an outcrop on what is now Hustler's line of reef. It was in appearance as though the pure white quartz had been dropped into bright yellow butter and picked out again, the gold was so thick in the stone. Emmett's mates would not join him in working this. "Why should they?" they said; "here was much better stuff in the soil, and it only required digging and washing; gold could not be washed out of stone and 8 square feet of that rock was not worth having." Subsequently, when sinking became deeper or when necessitated by other causes, the Commissioners increased the diggers' alluvial claims until two men could take up ground to the extent of 20 ft. square. In those days there was no law for quartz mining in Australia; nothing was known or thought about it. Emmett discovered this golden stone through making his camp fire on an outcrop of a reef; the fire first split the stone and then he noticed the gold, though, when once found, there was plenty of the same kind of stuff to be seen all around. Doubtless he and his mates drifted off in the exodus from Bendigo to search for other and similar fields, at any rate nothing was thought of the discovery. The Government officials used to amuse themselves on Sundays by going over to the hill and chopping off specimens full of gold to give to visitors when they came to Bendigo. The first man who took up a piece of ground on a quartz lode was an African black, a regular "Uncle Tom." He occupied about 40 ft. by 20 ft. on this same outcrop, and made his living by breaking off specimens to sell to visitors. No one disturbed him in his occupation of the ground, although he held many times more than the law allowed, because no one considered it worth bothering about. Then two boys, generally thought to be runaway apprentices from a merchant ship, occupied a piece of ground on Specimen Hill—now the spot where the deepest gold mine in the world (Landsell's 180) is being worked. At this place the gold was in a ferruginous quartz. The boys fixed up a "dolly" and pounded the quartz in an old stump, and washed the finely broken stone. People regarded their work as a harmless display of puerility and did not trouble themselves further. Eventually a German named Balerstead bought out the boys for 60*l*. Before he left that ground a few years afterwards he is said to have taken gold to the value of over half a million sterling out of workings not much over 400 ft. deep. Hustler, the man after whom the line of reef is named, bought out the African, and so quartz mining began to grow slowly. These men did not actually buy rights, there were no rights to buy, but the Commissioners of those days were the law; they recognised undisturbed or unprotested occupation of ground, and ruled by equity more than by written codes. Hustler erected a mill consisting of three stamps, each about 4 ft. high; they dropped on a heavy iron grating made of something like firebars. The motive power was supplied by a man who turned a handle. The quartz was burned before being put through the mill. Some men then began to get out quartz from the outcrop of lodes and crush with dollies, or get it crushed by appliances such as Hustler's, who, by the way, charged 5*l*. per ton for crushing quartz. Then began attempts to mine quartz more systematically. Open cuttings were made on the outcrops of lodes, or underlies were worked down and the stuff hauled to the surface in hide buckets raised by a hand windlass. It was only in 1857 that anything approaching the modern crushing battery was introduced on the field, and even then the price of 5*l*. per ton was maintained for crushing. At the same time as these early efforts in quartz mining were being tried by some, another class of men began to displace the old digger; these were the "puddlers." They were more settled and steady in their habits, and were contented to see three or four years' work ahead with about an average earning of from 12*l*. to 15*l*. per week. They took all the stuff that the digger had turned over and put it into puddling machines and ground it into fine mud; a stream of water carried off the mud, and the heavier portions were cradled and panned off until the gold was saved. In this way all the soil which once covered the hillsides and gullies of Bendigo, was washed down the watercourses and spread over the plains for twenty miles below. It was in 1858-9 that the first sludge nuisance began, and it is still a question likely to cause grave trouble in the future.

As may be imagined, during those stirring years between 1851 and 1857, the enormous population suddenly coming together into the area of a few square miles, having no organised system, and without due regard for sanitation, brought as a consequence serious responsibilities to the Government officials responsible for the maintenance of order. Enormous numbers of animals were slaughtered to supply food. At first this was done wherever a butcher chose to set up his business, and the blood and offal were allowed to dry up, be carried down

FRENCH CAST-IRON REINFORCED ARTILLERY.

(*For Description, see Page* 51.)

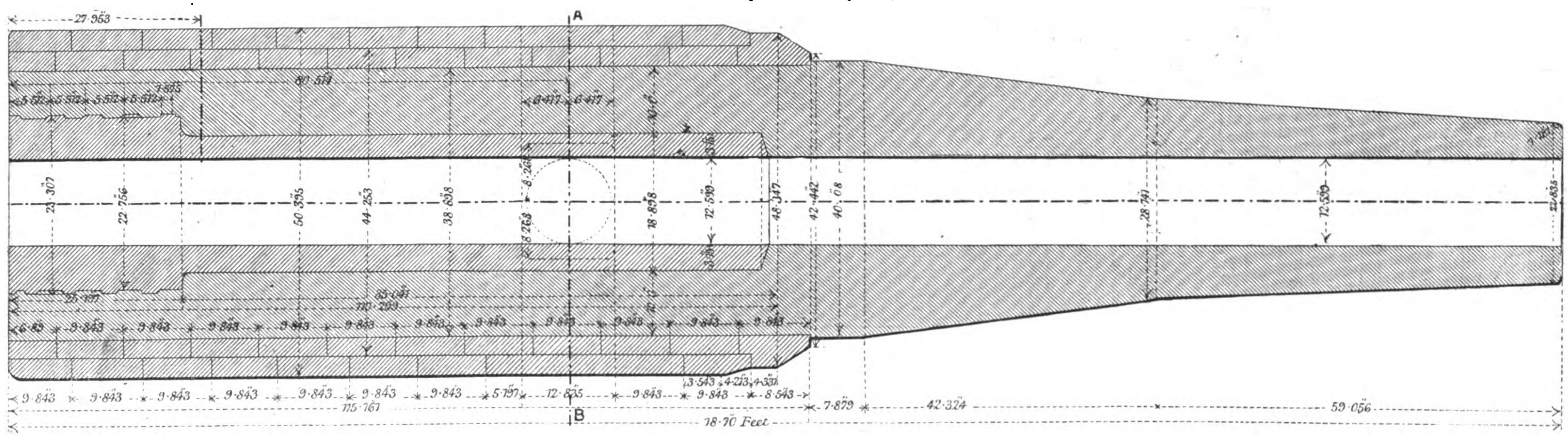


FIG. 13. 32-CENTIMETRE BREECHLOADING GUN WITH CAST-IRON BODY, STEEL RINGS, AND PARTIAL STEEL LINING TUBE.

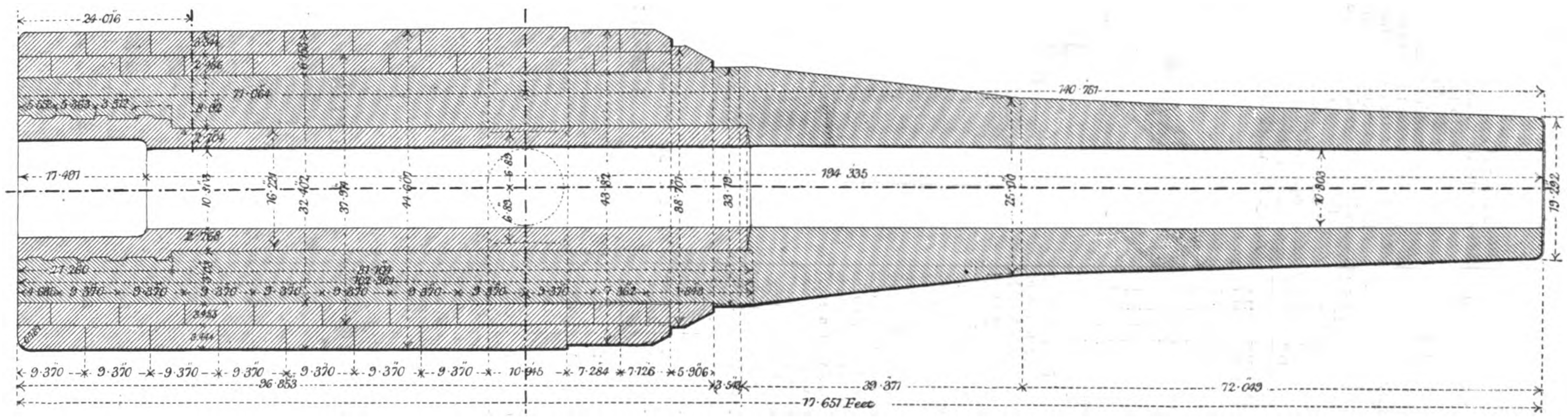


FIG. 14. 27-CENTIMETRE BREECHLOADING GUN WITH CAST-IRON BODY, STEEL RINGS, AND PARTIAL LINING TUBE.

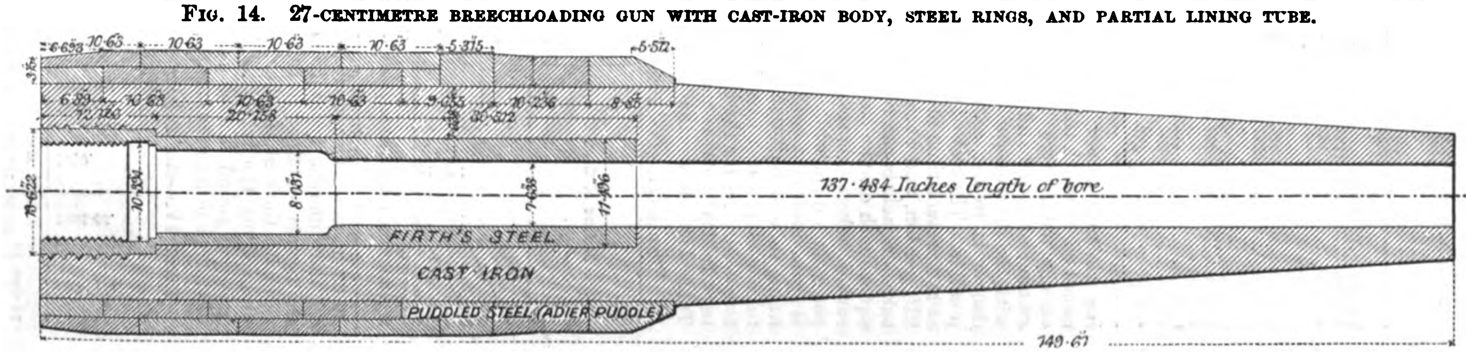
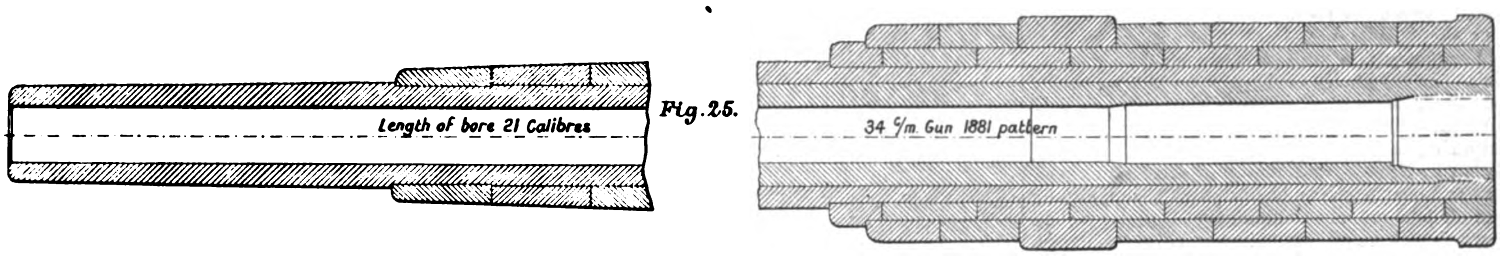


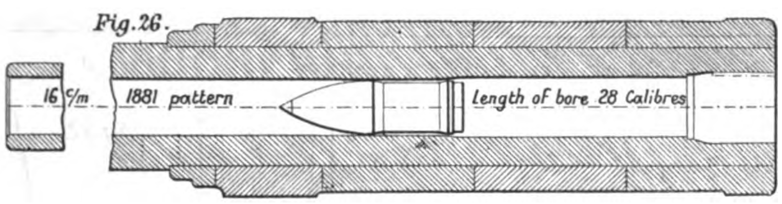
FIG. 15. 19-CENTIMETRE CAST-IRON GUN WITH STEEL RINGS AND PARTIAL LINING TUBE.

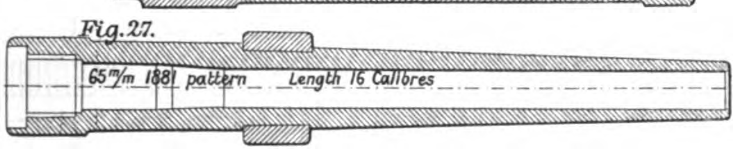
MODERN FRENCH ARTILLERY.
No. IV.
STEEL ORDNANCE.

IN the *Aide-Memoire de l'Officier de Marine* for 1889, by Ed. Durassier, the various existing types of French naval ordnance which are manufactured at Ruelle* are described briefly as follows: The cannon of the 1870 type are made with a body of cast iron lined with a steel tube and reinforced outside with one or two rows of steel hoops. The guns of the 1875 model consist of a steel body with a lining tube and one or two rows of hoops, all being made of steel. The guns of this type are divided into two classes, short and long. Modifications of the types of 1870 and of 1875 differ only from the standard models in having enlarged powder chambers. Lastly, the 1881 type and its subsequent modifications are made wholly in steel with one or two strengthening jackets. All of these guns are breechloaders; the larger calibres down to 14 centimetres (5.51 in.) have an arrangement by which the breech mechanism is supported by a bracket, while for the smaller sizes the breech-block is carried in a ring hinged to the body of the gun.



34-CENTIMETRE GUN MADE OF FIRTH STEEL.





16-CENTIMETRE AND 65-MILLIMETRE STEEL GUN, FRENCH STANDARD TYPE.

The first steel guns tried experimentally in France were undoubtedly those which had been purchased from Krupp of Essen, and also from Armstrong. In 1856, 12-pounder smooth bore muzzle-loading guns made of steel were subjected to a long series of experiments. In 1857 two such guns, 4.88 in. bore, were tried in Paris, when it was impossible to burst or injure them by firing. In a report dated July 12, 1857, it is stated that one of these guns "was fired 1400 times with a service charge of 4.4 lb., 600 times with a charge of 3.3 lb., and 1000 times with a charge of 3 lb.; in all 3000 charges which it resisted perfectly." In a previous trial a gun of the same class had endured 1400 rounds with 4.4 lb. of powder, and 1600 rounds with reduced charges, but in a second series of trials it burst at the fourth round with 6.6 lb. of powder. Another gun after 3000 of such rounds, was fired 20 times with 6.6 lb. and two balls, ten times with 6.6 lb. and three balls, and six times with 13.2 lb. and six balls. The gun remained uninjured at the end of these extreme tests (see Holley's "Ordnance and Armour"). About 1862 this country was manufacturing built-up steel 300-pounders for France, but two years later the steel works of Assailly, now forming a part of the celebrated St. Chamond establishment, commenced the manufacture for the first time in France of steel tubes and jackets for heavy ordnance. It was stated in a recent number of the *Temps* "that thanks to the active collaboration and continued help of General Frebault and Colonel Maillard, the Assailly Company has been able since 1865 to manufacture tubes and bodies for guns in steel for calibres of 14, 16, 19, and 24 centimetres (5.51 in., 6.29 in., 7.47 in., and 9.45 in.), especially for naval purposes. The 'Marie-Jeanne,' a steel gun 24-centimetre bore, which, during the siege of Paris, did such good service at Mont Valerien, was the first gun of large calibre manufactured in France with French steel, and this was made by the St. Chamond Company; these works can therefore claim to have taken the initiative in this branch of military industry." The weight and importance of steel ordnance made in France rapidly increased, and several other firms followed the initiative taken by St. Chamond, but it was not until between 1875 and 1879 that the Creusôt Works undertook the production of steel guns of very large size, following, in fact, in the footsteps of the works at Elswick, whence had been sent in the same period, the first of the famous 100-ton guns for the Italian Government; this development made France independent of Messrs. Firth and Sons, from whom it had been purchasing large quantities of gun steel. The only heavy ordnance in France to compare with these—or, indeed, with the heaviest natures then made at Woolwich—were eight 16.54-in. and five 13.39-in. guns (1875-1879), constructed at the State factories from material supplied by private makers. These, and six others of 14.57-in. bore, of which the elements for three were made at Creusôt, and for three at St. Chamond, were the first of the largest steel guns produced in France, and with more or less important modifications, chiefly as regards reduced size, they have served ever since as standard types. The 37-centimetre (14.57 in.) guns weighed 72 tons, and were designed to throw 1180 lb. projectiles with an initial velocity of 1960 ft.; of the eight 42-centimetre guns mentioned above (16.54 in.), two were 21 calibres in length, the remaining six being 22 calibres; the steel bodies were reinforced by three steel jackets, and they weighed 75 tons. The shorter natures were intended to throw a projectile weighing 1430 lb. with a velocity of 1730 ft.—a common shell containing a bursting charge of 80 lb.—or a steel shell 1716 lb. with a bursting charge of 23 lb.*

It is scarcely to be supposed that, if France lagged behind this country in the matter of heavy ordnance, it was because she was not thoroughly alive to all that was going on in England, Germany, or Italy, or that she could not, had she considered it expedient, have taken a front rank instead of following closely behind; but the practical solution of problems in heavy ordnance is a very costly one, which doubtless France—adopting the American policy—preferred to see practically studied by some other power, and although it was a matter of early necessity to answer the big guns of England and Italy with others as powerful, and possibly of greater endurance, yet the experience with these large bores and heavy weights does not seem to have been very satisfactory, and France, not caring to venture further on the same lines, preferred to pursue a somewhat retrograde policy. During this period she was making a large number of experiments with different types of guns at Gâvre, and was gradually accumulating experience before committing the country to a vast and doubtfully useful expense. "The 1881 type of artillery is characterised by the suppression of the tube, the fixing of which in place was a very delicate and difficult operation for heavy calibres; the body of the gun was made of tempered steel. Guns of 65 millimetres (2.56 in.) had no jackets excepting the broad ring carrying the trunnions. Those of 90 millimetres (3.54 in.), 10 centimetres (3.94 in.), 14 centimetres (5.51 in.), and the light 16 centimetres (6.29 in.), had one thickness of jacket. The 16 centimetres heavy type, the 24 centimetres (9.45 in.), the 27 centimetres (10.63 in.), and the 34 centimetres (13.39 in.), had two reinforcing jackets. In proportion to the increase of the bore, the thickness of the jackets relatively to the body of the gun was increased. The practice was followed, as far as possible, not to have greater thickness of steel than was employed in the type of 1875, though it was found that this practice could not be closely followed for very large calibres. The great risk which is incurred in the use of steel forgings or blocks of very large dimensions arises from the uncertainty about imperfections in the interior of the metal. The progress that has been made in the manufacture of steel permits us to hope that the bodies of heavy guns will have sufficient elasticity to exert on the adjoining thicknesses of metal, a sufficient compression under the force exerted by the use of jackets of relatively heavy dimensions. Long experience and careful experiments appear to have made French artillerists stop at the 34-centimetre gun as the maximum calibre; in its latest form this weapon has a weight of 53 tons, and is intended to give to a projectile weighing 924 lb. an initial velocity of 1970 ft.; such a projectile fired at short range will pierce a forged iron armour plate 29.14 in. thick and a wooden backing of 32 in."* Fig. 25 shows the type of 34-centimetre gun of the type immediately preceding that to which the foregoing paragraph refers; this particular piece has several peculiarities; the body was manufactured of steel supplied by Messrs. Firth and Sons, of Sheffield. It is made in two parts, an inner tube extending the whole length of the piece, that is to say, for 28.5 calibres for the long type, and 21 calibres for the short type, and a long steel jacket; around this are shrunk two steel jackets made up of broad rings. As already stated, in the actual guns now manufactured the inner tube is often dispensed with, and the body is made of one piece of solid steel; Figs. 26 and 27 indicate this type of construction; they represent, however, two smaller calibres, the former, the 16-centimetre (6.29 in.) gun, and the latter the 65-millimetre (2.56 in.) As will be seen, this smaller gun is not reinforced excepting by the trunnion ring, the thickness of the body being increased behind it towards the breech. The earlier type of steel gun, that is the 42-centimetre bore made between 1875 and 1879, and already referred to, is indicated in Figs. 28 and 29 (see next page), but the precise arrangement of lining tube and jackets is not shown and the gun may be considered as obsolete.

The following is a general description, gathered from the source we have already quoted, of the process now followed in the manufacture of French steel ordnance. The steel is cast in ingot moulds having the form of a truncated cone, sufficient length being allowed at top and bottom to cut off the ends where the metal is less likely to be perfectly sound; this casting is the first process in the manufacture of the body of the gun, and the lower part of the ingot corresponds

* Some French guns, especially 10 cm., 16 cm. (steel), and 27 cm. to 32 cm. (cast iron and steel), for coast defence, were made at Havre by the Forges et Chantiers de la Mediterranée.

* *Nouveau Matériel Naval*, par MM. Ledieu et Cadiat.

* *Nouveau Matériel Naval*, par MM. Ledieu et Cadiat.

with the breech. After a first reheating the ingot is placed beneath the steam hammer and gradually roughed out into shape; this operation, however, is only completed after several reheatings; in the case of the 34-centimetre gun there are at least ten or twelve. After the forging has been completed, the block is placed in an annealing furnace raised to a clear cherry heat and then allowed to cool very gradually; the first rough turning is then completed, which brings the block down approximately to it its final dimensions; it is necessary, however, to allow a margin, because the operation of tempering, however carefully it may be performed, is liable to distort the shape of the block, and it is especially required to take out the slight curve which is almost always produced in the heating furnace before tempering. The next process is boring the block; for this purpose a crown drill is employed which cuts away the metal in an annular form, leaving a steel cylinder in the middle of the bore; after this, the turned and bored block is again annealed and oil-tempered; the tempering furnace is vertical, and has to be of large dimensions to receive the bodies of the heavy calibres; it is afterwards plunged into a vertical bath of oil. The tempering is carried out at two operations; in the first of these the steel is raised to a clear cherry heat or about 1000 deg. Cent.; in the second it is only brought to a dull red, corresponding to 600 deg. Immediately on being brought out of the furnace the tube is plunged into the oil bath, and remains there until it is quite cold. The practice of tempering in molten lead has of late found strong advocates in France, and many interesting experiments have been carried out in this direction, chiefly by the Chatillon et Commentry Company; to these we shall take an opportunity of referring on another occasion. Test-pieces are removed from the tube before and after tempering; these are discs cut perpendicularly to the axis of the bore, both at the muzzle and breech; out of them are cut the bars which are subjected to a series of carefully arranged tests for tensile strength, resistance to shock, bending, and elasticity. The Société de St. Chamond showed at the Paris Exhibition a large number of these test-pieces which had been subjected to the trials prescribed by the French Department of Marine; these trials are as follows: The falling weight tests are made on bars 1.18 in. square by 11.81 in. long, or .79 in. square and 7.87 in. long, the falling weight of the block being 39.6 lb., and the maximum height of drop 108.27 in. The following Table gives particulars of the regulation tests:

TABLE V.—*Government Test for Gun Steel under a Falling Weight.*

—	Tubes and Hoops.		Breech.	
	1.18 in.	.79 in.	1.18 in.	.79 in.
Weight of tup	39.6 lb.	39.6 lb.	39.6 lb.	39.6 lb.
Height of fall	108.27 in.	43.31 in.	108.27 in.	43.31 in.
Distance between knife-edges	6.29 ,,	4.72 ,,	6.29 ,,	4.72 ,,
Minimum number of blows	15	20	15	20

If the test-pieces have shown resistances equal to the prescribed amount, the tube itself is subjected to a powder test before any of the jackets are placed around it. Care is taken that the strain thrown upon the tube by the explosion of the charge, is somewhat less than that corresponding to the elastic limit of the metal. The mode of carrying out this test is indicated in Fig. 30; the charge of powder is placed as shown between projectiles, which are encircled with copper rings so as to fit the bore closely; one of these projectiles is bored through to allow the passage of the firing circuit. The tube is subjected to three such rounds, one near the breech, one in the centre, and one at the muzzle. This powder test is objected to by many artillerists as unnecessary, costly, and very troublesome; it is, we believe, likely to be abandoned. As shown in the engravings, the jackets are composed of a number of broad steel rings, which are made in a manner similar to the mode followed in producing railway tyres; they are rolled roughly into shape on a mandrel and afterwards forged. The rings are carefully tempered in oil precisely in the same manner as the body of the gun, and they are subjected to tests for tension, compression, and bending in a similar way to the larger body of steel; the powder test is of course omitted, but in its place every finished ring is tested upon a coned mandrel, which is driven into the ring at one blow. Before this last test takes place, the rings are finished as nearly as possible to their ultimate size, but they are distended by the mandrel in a proportion of 2.5 millimetres per metre of diameter; after they are withdrawn from the mandrel, they are carefully measured, and if the permanent extension exceeds 1 millimetre per metre, the rings are rejected. All the various fittings of the guns, including the breech-blocks, are made of cast steel, carefully forged, oil-tempered and annealed; sample pieces are taken from the steel of which the various parts are made and subjected to test.

Although a considerable number of heavy guns in France are made without any lining tubes, some of the types and calibres are provided with them; the process of inserting them is very similar to that described in a previous article for lining cast-iron guns, only in this case the steel tube is introduced at the muzzle, the body being suspended vertically, breech downwards. The greatest care has to be exercised to heat the whole mass regularly throughout its length, since if this is not attended to the expansion would be uneven, and the operation would result in failure; the heat applied must also be kept carefully within certain limits that have been ascertained by experiments, and which, if exceeded, would tend to set up molecular disturbances in the metal which would affect its strength; the temperature which has proved to be the safest, and at the same time sufficient for expanding the metal, does not exceed 400 deg. Cent. The gun is placed in a pit in communication with the furnace, from which air, heated to the temperature above named, is delivered direct into the bore of the gun, and is also allowed to circulate around the exterior of the body. The lining tube, which is suspended over the bore, is run down rapidly as soon as the latter is sufficiently expanded, and when it is definitely in place the body is cooled by a stream of water distributed equally over the outer surface, commencing at the breech and going upwards; this method of proceeding is necessary, because as the metal near the muzzle is thinner it cools more rapidly, and by cooling the mass with a stream of water from the breech upwards, the process is rendered uniform and the contraction upon the lining tube is made equal throughout. The amount of contraction given to the reinforcing rings, as well as to the body of the gun from the lining tube, is equal to 1.7 millimetres per metre in diameter; the expansion obtained by heating the metal to 400 deg. is equal to 3 millimetres per metre. In some cases it is found more convenient to make the gun body in two pieces, and the old method of joining the blocks together prior to inserting the lining tube, has been abandoned since 1886 in favour of the following process. The block which forms the breech portion of the gun is finished, the forward end being formed as shown in that part of Fig. 31 marked A; into this the tube is driven, the forward end projecting, and when the whole has cooled down, the second block which forms the forward part of the gun is shrunk over the projecting part of the lining tube. The adjoining ends of the blocks A and B are forced one over the other as shown in the diagram, the depth of the locking shoulder at M being 1 millimetre; the lengths of the parts brought into close contact are drawn to

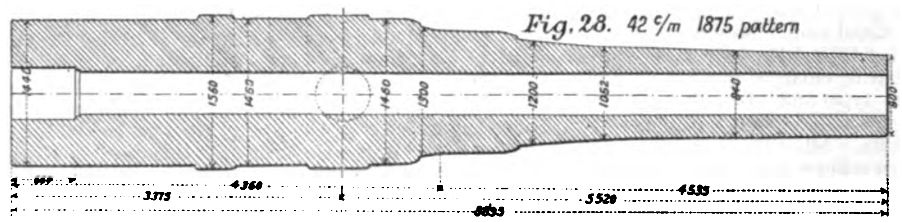
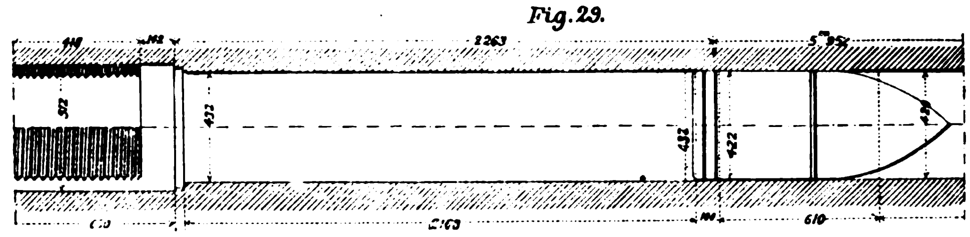


Fig. 29.



42-CENTIMETRE STEEL GUN; OBSOLETE TYPE, 1875-79.

Fig 30

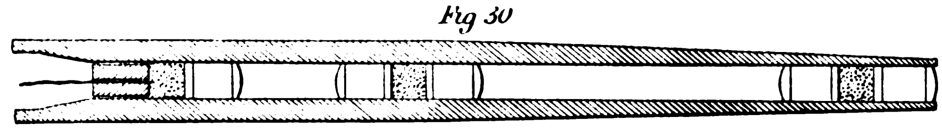
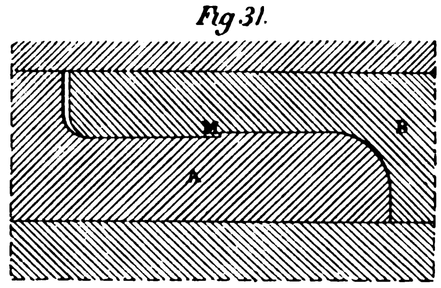


DIAGRAM OF POWDER TEST.

Fig 31.



LOCKING JOINT FOR LONG JACKETS.

Fig 32.

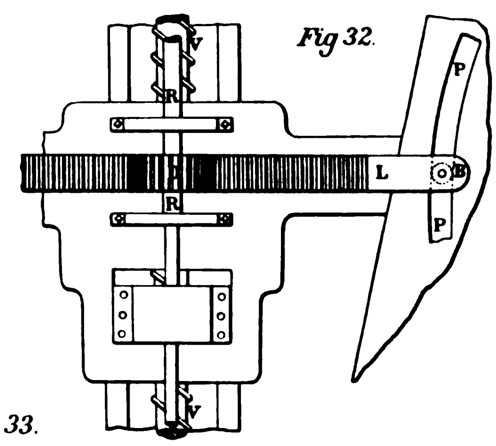
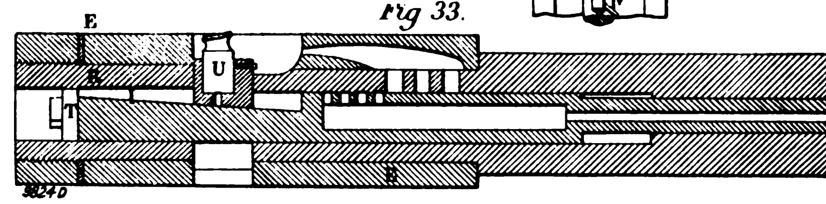


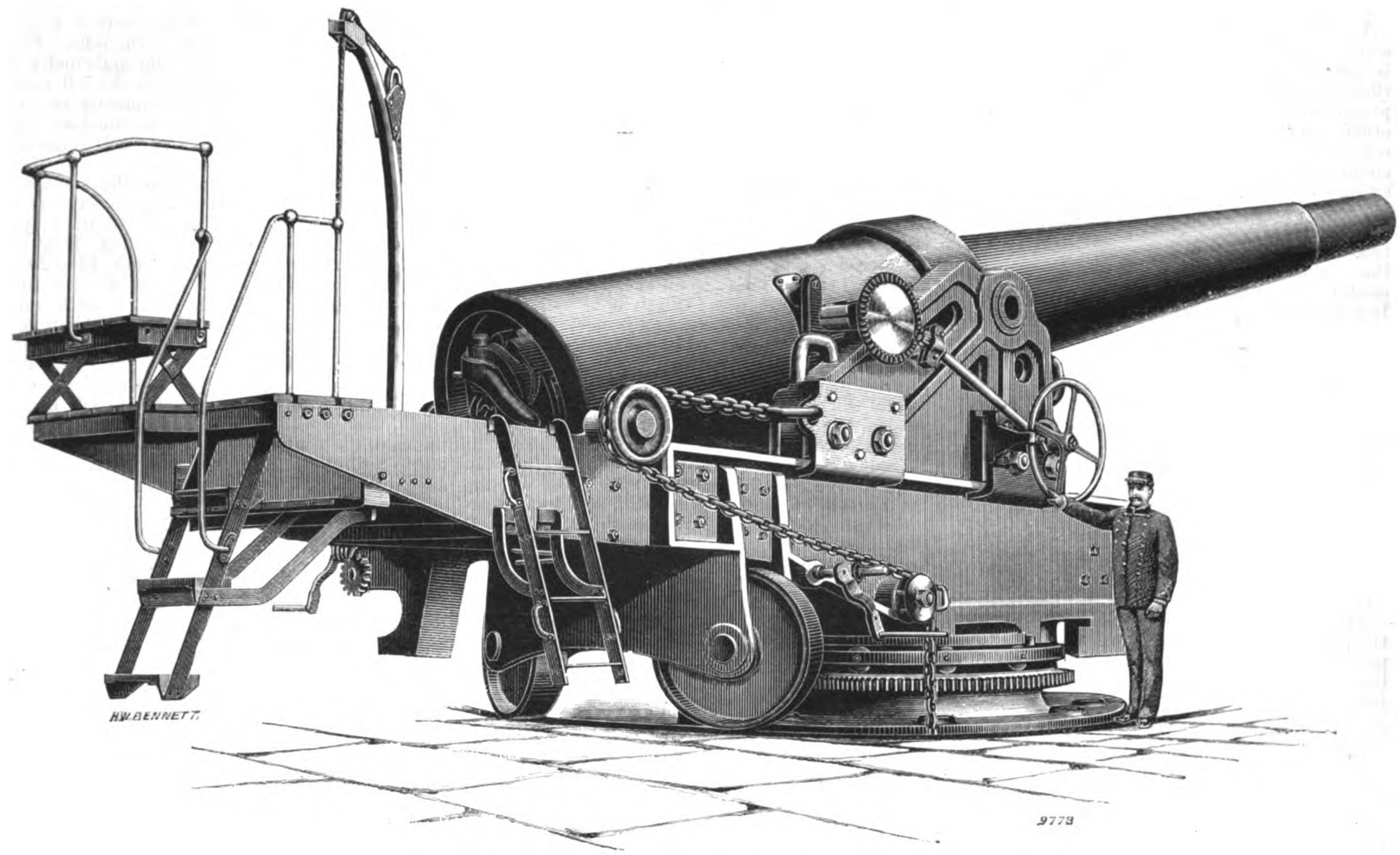
Fig 33.



FIGS. 32 AND 33. RIFLING MACHINE.

32-CENTIMETRE STEEL GUN AND CARRIAGE.

CONSTRUCTED BY MESSRS. SCHNEIDER AND CO., CREUSÔT.



scale on the section. This process, however, is entirely unusual, as either of the large works of St. Chamond, Firminy, or Creusôt are capable of turning out solid blocks surpassing the specifications of the French gun factory, and large enough to form the body of the heaviest calibres made. The adjustment of the reinforcing rings, in one, two, or three tiers, is the next stage in manufacture; a slight projection is formed around the breech of the gun to serve as a shoulder, against which the first ring may be driven; the body of the gun is placed in a horizontal position, and the rings having been expanded by raising them to the necessary temperature, they are forced on one after the other until the first series is completed, when the metal is cooled by a plentiful application of cold water, and the surfaces are trued up perfectly for the application of the next row of the reinforcing rings. After these operations have been completed the gun is ready to be placed in the rifling machine, the general principle of which will be presently indicated. Fig. 38 above shows a finished 32-centimetre breechloading gun and carriage made by MM. Schneider and Co., of Creusôt.

As we have already stated in a previous article, the earliest experiments with rifled guns in France were carried out with only two grooves opposite each other; this was about 1855. Experience soon showed that this number was altogether insufficient to give the necessary rotation to the projectile, and the number was gradually increased, until, in 1870, as many grooves were cut in the bore as the latter was centimetres in diameter, or one in excess if the number of centimetres was unequal; the width of the lands was 10 centimetres. Subsequently the number was again increased, until in 1875 it was one and a half times the number of centimetres of bore, and again it was increased to twice for all calibres, the width of the lands being reduced to 4 millimetres. The system of rifling adopted for French naval guns differs from that in use for land defences, and which is known as the Parabolic system. In this the development of a groove represents the arc of a parabola tangent to the generating line at the breech, and making with this line a constantly increasing angle; this curve is extended for a considerable part of the length of the bore, and is then terminated by a uniform twist; by this system it is claimed that the advantages of uniform and of increasing twists are combined, the angle formed by the last portion of the rifling being sufficient to insure a sufficient rotation to the projectile whilst the gun is subjected to less strain as the shot is gradually started from rest along the parabolic portion. In naval guns, however, the parabolic curves of the grooves are followed throughout.

Figs. 32 and 33 are diagrams, and the following is a description of the rifling machine generally employed in France. An endless screw V, Fig. 32, which is mounted parallel to the axis of the gun as it is centred in the rifling lathe, gives motion to a carriage that supports the rifling bar R; at the end of this bar is the cutting head shown in section, Fig. 33, and which contains the rifling tool used; if no movement of revolution is given to the bar R, it would cut—through the motion due to the screw V—a straight line. It is therefore necessary to give it a turning movement to an extent that can be carefully regulated, and this is effected by means of a pinion D which is mounted upon it, and which gears into the rack L, to which a movement can be given at right angles to that of the cutting bars. At one end of the rack is a pin B, which passes through a curved slot in a fixed former P, and the combined movement of the rack and of the driving screw V forces the cutting bar to turn to the curve desired, and which is varied at will by the form of the slot P. As it is necessary that the rifling tool shall only project from the head when it is making its cut, it is mounted in a slot in the head as shown in Fig. 33; the bar R is made hollow, and through it passes the rod T, the end of which terminates in an inclined head I. This rod is free to slide to and fro in the bar R, and upon its position depends the projection of the cutter U or of its withdrawal within the head E. As will be seen from the section, the rod T is also hollow, and it, as well as the head E, is provided with a number of ports through which an abundant supply of oil or soap and water can be fed to the cutting tool. Fig. 34 shows the standard form of rifling adopted, and by way of comparison earlier forms of French rifling are given. Fig. 35 shows the type of about 1861. The bore was rifled with three such grooves cut with an increasing twist, and into which entered three studs on the projectile faced with zinc. Fig. 37 is a sketch showing the relative position of these three grooves, and Fig. 36 is a similar section indicating the earliest form of French rifling.

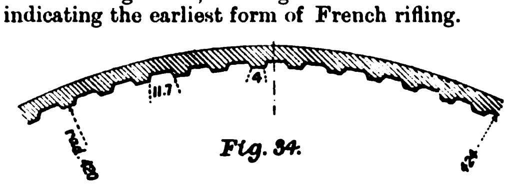


Fig. 34.

STANDARD FRENCH RIFLING.

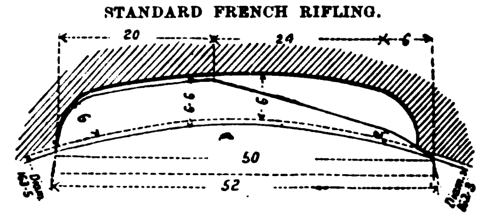
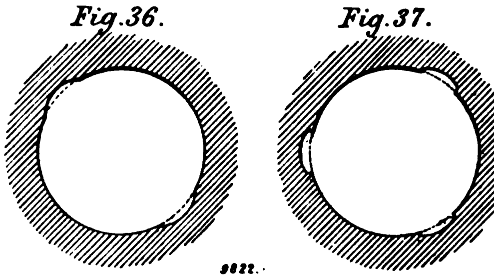


FIG. 35. FRENCH RIFLING, 1861.

Fig. 36. Fig. 37.



FIRST AND SECOND FORMS OF FRENCH RIFLING.

Hitherto we have not referred to the breech-loading mechanism which forms an all-important feature of modern ordnance; but in subsequent articles we shall describe in detail the standard systems as used for French guns, and compare them with the methods adopted by some other countries.

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MODERN FRENCH ARTILLERY.
No. V.
BREECHLOADING MECHANISM.

WE now come to a consideration of the methods employed in French practice for opening and closing the breeches of guns of all calibres, and this part of the subject will be most usefully considered by reviewing the different standard systems employed by other countries which, with one notable exception, have all followed, with more or less modifications, the method first worked out in a practical shape by France. This is the interrupted screw system, in which the breech-block or plug used to close the rear end of the bore, is cut with an interrupted or stripped thread, so that its surface presents an equal number—six or eight—of smooth segments, and as many threaded ones. The seating in the bore of the gun to receive this plug, being cut in a corresponding manner, it follows that the block can be thrust into the seat, the threaded parts of the former being opposite the smooth segments of the latter, and when home a partial revolution of the block fixes it in position, and, with the various devices which are employed, makes a secure and gas-tight closing to the breech. To go back to the commencement, in the year 1842 Captain Treuille de Beaulieu submitted a report to the Minister of War, on rifled guns, in which a screwed breech-block is suggested. Certainly a part of the original credit for this must be given to the United States, where, in 1853, a joint patent was taken out by J. P. Schenkl and A. S. Saroni, for an interrupted breech-block. Two years after, the English Government purchased six guns from a manufacturer at Boston in which the breech was closed upon the same principle, but they were absolutely useless owing to the crude and imperfect manner in which the work was carried out. Figs. 39 and 40 illustrate the arrangement; a thread was cut in the enlarged end of the bore *b*, and a corresponding screw on the breech-plug *a*; three longitudinal grooves were then planed out of the screw cut in the bore, and similar grooves were cut across the threads of the breech-screw. A collar was attached to the latter on which were mounted two small pinions *d* working in a rack upon the face of a bracket on each side of the gun, and by which the breech-block was run in and out and supported. This crude plan was very speedily replaced by the independent work of the earlier French artillerists into a practical form which contained the elements of the system now so generally employed. One other invention in the early days of breechloading guns may be mentioned here, as it contained the germs of a successful system, which, in combination with the stripped thread, has of late years been successfully introduced for guns of relatively large calibre. This is Captain Blakeley's taper screw shown in Fig. 41, and which was patented in 1860. By this plan after the block A had been turned two or three times, it was free of the gun, and could be withdrawn along the slides provided outside for its support.

FIG 39

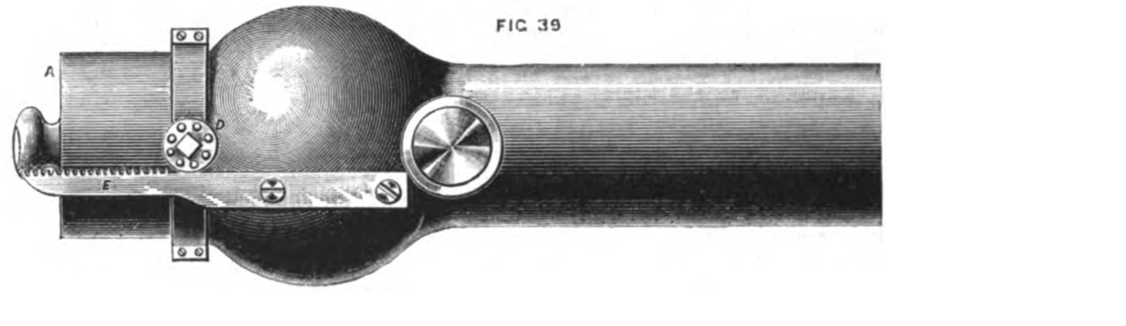
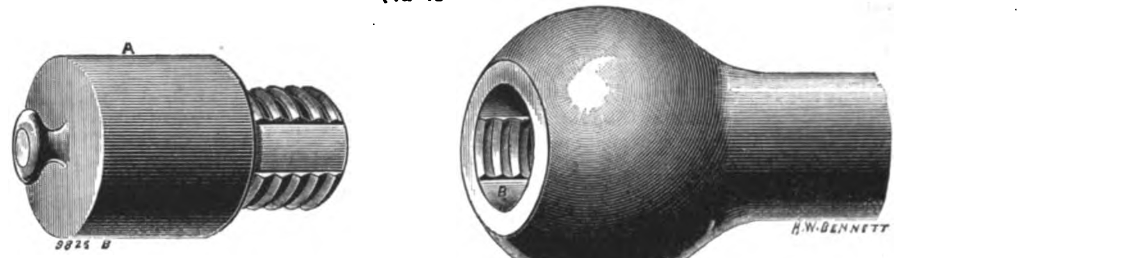
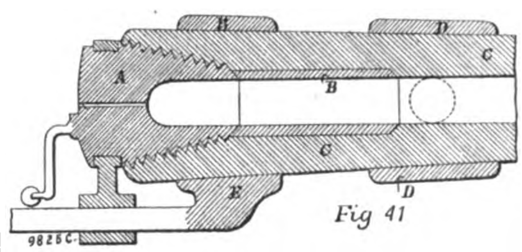



FIG 40


AMERICAN INTERRUPTED BREECH SCREW; 1853.



BLAKELEY'S TAPER SCREW BREECH; 1860.

The wedge system employed by Krupp finds no application in France, excepting in the special case of the Hotchkiss rapid-firing guns, in which, however, the wedge is moved vertically, not horizontally as in Krupp system, and opinion in England has—rightly or wrongly—indorsed and imitated French practice. "Wedge guns have found favour abroad, and there are several varieties of the wedge system; but the objections to this class are weighty; it requires great length in the breech, which is the heaviest part of the gun, and the wedge itself too heavy in very large guns for proper facility in working the piece; while exposure of men at the side to the chance of escape of the gas is a serious objection to any wedge system. The plan adopted by Krupp appears to be an effectual method of closing the breech, and certainly lends itself to strength of construction, but on comparison with the interrupted screw system the latter was found on the whole to offer superior advantages. The interrupted screw system had been adopted in many countries abroad, and had passed through satisfactory trial. Guns closed on this plan are lighter and more easily worked than those on any wedge system. With the Krupp wedge the obturation is sometimes very defective. This method also possesses the advantages of being suitable for all the known systems of obturation, especially the De Bange, which has proved so very successful."*

1. *Standard French System.*—By gradual development the screwed breeches of Beaulieu and Verchère de Reffye have grown into their present form; and with the improvements of De Bange find a universal application in France. The De Bange system is of course only one of the several modifications in detail of the interrupted screw, and of which the more modern forms adopted by the Forges et Chantiers de la Méditerranée, are also modifications.

Figs. 42 to 46, on the next page, illustrate with tolerable accuracy the system of breechloading followed in France in the Government gun factories, and designed by the officers of artillery of marine. The principal parts of the mechanism consist of the breech-block, which is made of steel, and on which is cut a screw thread, which is removed over three equal segments of 60 deg.; the recess in the bore in which this block engages, is provided with three corresponding segments of screw threads and blanks. It is evident from this arrangement that one-sixth of a turn, which is always given from right to left, suffices to disengage the threaded portions of the block and seat, and to bring those on the former, opposite the smooth portions of the latter; when in this position the block can be either withdrawn from, or introduced into the bore. In guns of moderate calibre this operation can be performed by hand, but in the larger natures, some mechanical appliance is necessary, such as hydraulic power, toothed gearing, or belt transmission. Secured to the end of the body of the gun, to the right of, and below the axis of the bore, are two brackets or supports for a vertical spindle which serves as a hinge, and two winches secure a console or bracket which can be swung to and fro upon this hinge. Two handles fixed to the rear of the breech-block as shown at P serve to withdraw the block from the bore, and deposit it upon the console, after the block has been liberated by one-sixth of a turn of the lever M; the form of the console S is curved to provide a fair seating for the breech-block, and has two raised guides formed upon it. After the latter has been withdrawn clear of the gun and is resting upon the console, the latter can be thrown back upon its hinge pin B, so as to clear the bore of the gun and allow the projectile and charge to be placed in the powder chamber. For smaller guns these operations lie well within the power of the men during the work, but for the heavier calibres mechanical assistance, as above stated, has to be provided. Thus in the heavy 32 and 34 centimetre cannon, the breech-blocks of which weigh from 1500 lb. to 2000 lb., while the system of swinging brackets is preserved, various devices are added to facilitate the manipulation and to insure safety. These devices in the calibres just mentioned comprise an

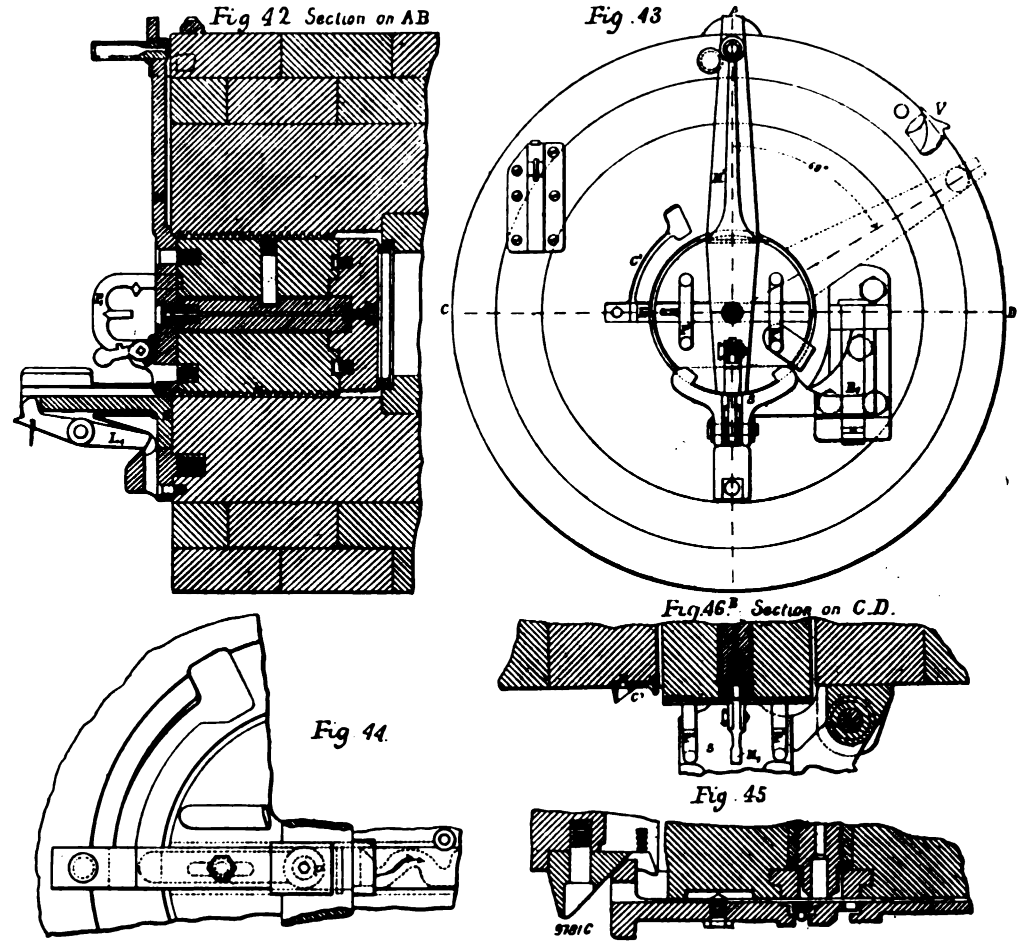
* Official Treatise on the Manufacture of Guns and Text-Book of Service Ordnance.

endless screw for turning the loaded console backwards or forwards; a system of multiplying gear for entering the block or withdrawing it from the gun, and a rack and pinion for turning the block so as to open or close the gun. In the largest calibres, however, these appliances are insufficient, and the various movements are obtained by means of an endless chain and a hydraulic winch; moreover, the temporary support of the breech-block is not attached to the gun but to the platform of the turret on which it is mounted. It is evident that in swinging the console fastened to the breech to and fro with its heavy load, considerable care must be exercised lest the block should fall from its somewhat limited support, and to prevent this the movement of the console is rigidly determined by a spring latch L which forms an efficient lock, either as soon as the block is swung into the position for receiving this block, that is when it is in contact with the breech of the gun, beneath the block seating, or when it is turned back out of the way.

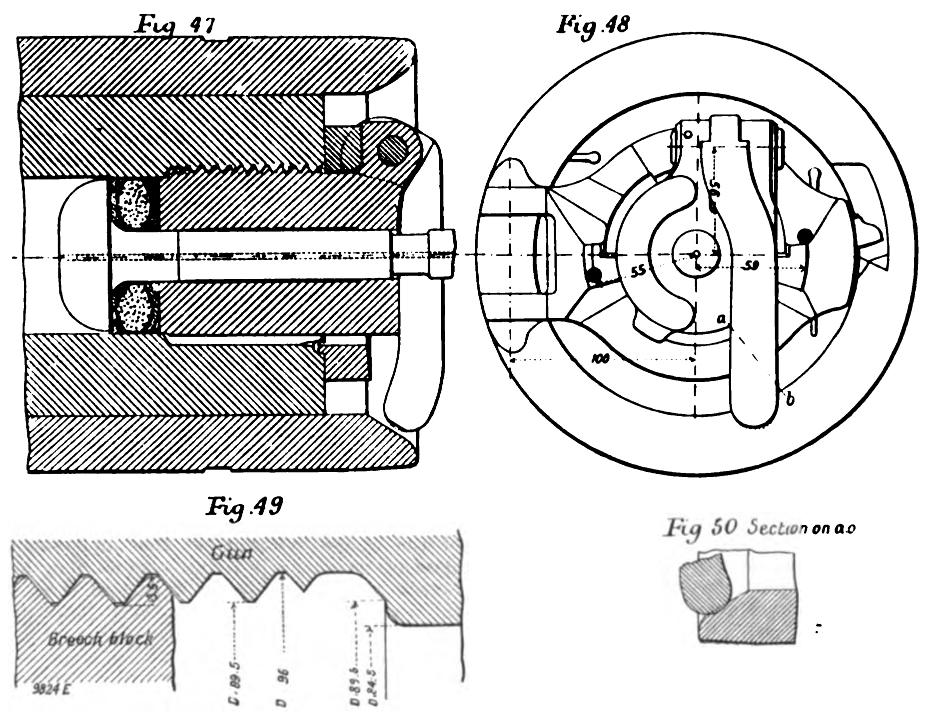
Various safety devices are added to the breech-block mechanism to prevent the starting of the block from its seat when it is once in position, and to render premature firing, either from accident or carelessness, impossible. Fig. 43 shows a device adopted to secure the former object; it consists of a spring latch V set in a recess cut in the breech of the gun, and so arranged that while the starting lever M can pass freely over it in going from the vertical or unlocked position, to the position marked in dotted lines and which represents the breech-block secured, it prevents the lever from passing towards the left and so opening the gun. Another safety device consists in the bolt E which slides to and fro in a recess marked on Fig. 43. This bolt serves several purposes; it covers the fuze and prevents the gases from escaping outwards; it is provided on the underside with longitudinal grooves which, in the event of a premature explosion of the fuze, conduct the gases laterally towards the side of the gun; and it prevents premature firing because the detonator remains covered so long as the breech-block is not exactly in its proper place. The movement which it is necessary to give to this bolt in order that it may cover and uncover the detonator, is controlled by a groove formed radially with the bore in the back of the gun c^1, Figs. 43 and 44; at the upper end of this groove is an enlargement into which the end of the bolt falls when the breech-block is locked. When the breech is completely closed, the point of the bolt falls into the enlarged part of the groove, and it can be lifted by hand far enough to permit the gunner to expose the nipple on which the cap is placed; when the bolt is released the end within the groove falls upon the lower face of the enlargement, exposing the cap to the action of the hammer, and the gun can then be fired. If the starting lever is turned towards the left, the end of the bolt travels up the inclined plane, joining the enlargement with the goove, and the displacement thus produced is sufficient to cover the vent with the bolt so that it is possible to fire. Figs. 44 and 45 are enlarged views of the bolt mechanism and its groove. In some cases the hammer which fires the charge, is mounted upon the bolt and is actuated by a spring; this involves the introduction of additional safety appliances, so that the firing block becomes quite a complicated piece of mechanism.

In order to make a gas-tight joint between the end of the breech-block and the gun, some efficient system of obturation is necessary. That shown in Fig. 42 is practically similar to the Broadwell ring, which will be described hereafter in connection with the Krupp system of breech closing; this ring, which rests against the face of the breech-block and takes its bearing in an arris cut round the edge of the bore, is expanded under the action of the explosion and forms a very efficient gas check.

De Bange Breech-Closing Mechanism, 1877.—Figs. 47 to 50 show the earliest type of the De Bange system as applied to an 80-millimetre (3.15 in.) field gun. At the date of this design (1877) no attempt had been made to adapt the plan to large calibres, and for small weights the bracket arrangement for supporting the block when withdrawn, was unnecessary; its place was taken then, as well as in the present types, by a ring hinged to the back of the gun, and through which the block is free to slide. The diameter of the powder chamber in the gun illustrated is 3.33 in., the breech-block seat being enlarged to 3.78 in. as a maximum diameter, and to 3.52 in. at the threaded portion. The pitch of the screw is 7 millimetres, and the threads are cut with a flat of .5 millimetre. The jacket surrounding the inner tube of the gun projects beyond its rear face, and is finished with a chamfer, while the rear face of the inner tube is recessed for a portion of the circumference of the breech seating to receive a corresponding projection on the hinged ring. This latter is attached by lugs on one side, to a hanger formed on the jacket of the gun; the inner diameter of the ring is such as to allow the breech-block to slide freely to and fro when it is turned to the unlocking position. The front end of the block is somewhat reduced in diameter to fit the powder chamber, and on the rear is a curved handle by which the breech can be moved to and fro, and lugs at the top of the block for attaching the lever. The block is bored through its axis to receive the spindle of the mushroom-headed obturator, the form of which, as well as of the gas check pad, are shown in the section Fig. 47. The spindle is drilled through for the fuze, and the opening in the mushroom head is bushed with copper. The end view, Fig. 48, shows the breech in its locked position, and it will be seen from this figure that the lower end of the lever fits into a recess cut for it in the jacket of the gun (Fig. 50), while on the right-hand side is also a recess formed to take a latch fastened on the ring. The action of the mechanism is sufficiently obvious; on the lever being raised, it can be used to turn the block through one-sixth of a revolution, when it will pass through the ring, by pulling on the handle at the back of the breech-block. On releasing the latch of the ring the whole mechanism can be thrown back clear of

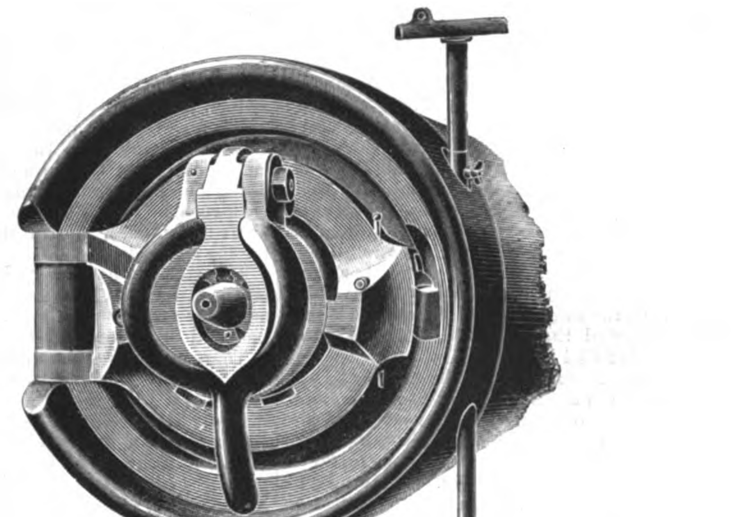


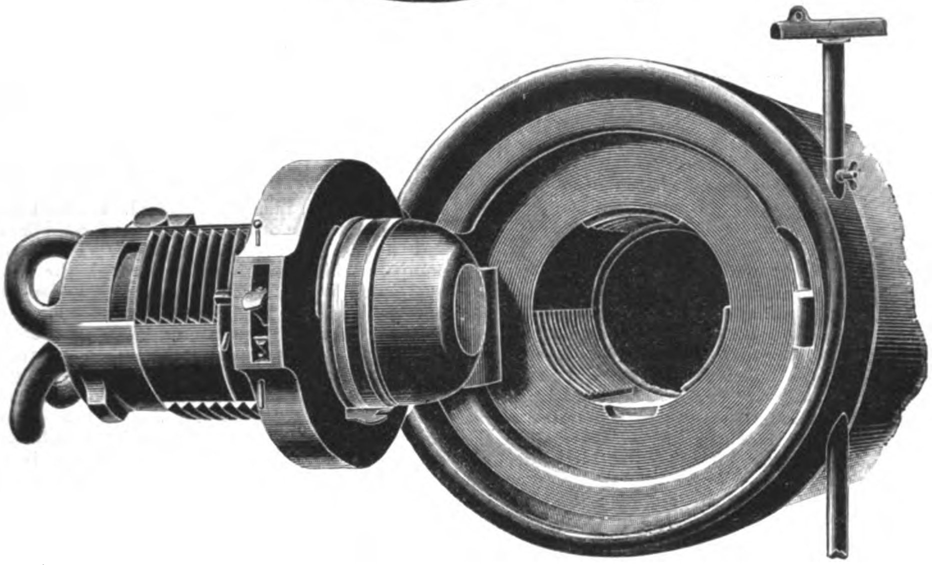
FRENCH STANDARD BREECH MECHANISM.



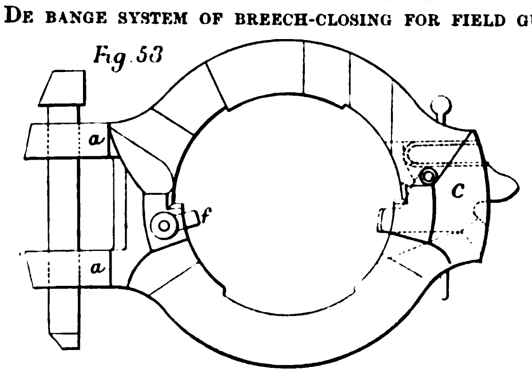
THE DE BANGE SYSTEM OF BREECH CLOSING; 1877.

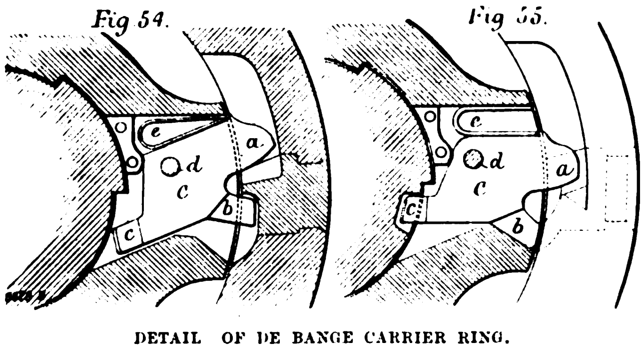
THE DE BANGE SYSTEM OF BREECH-CLOSING.



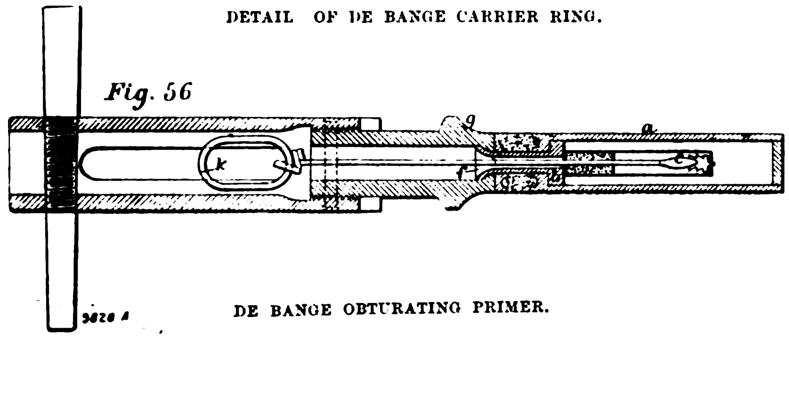


FIGS. 51 AND 52. DE BANGE SYSTEM OF BREECH-CLOSING FOR FIELD GUNS; 1889.





DETAIL OF DE BANGE CARRIER RING.



DE BANGE OBTURATING PRIMER.

the bore, and after the gun is loaded, a reverse operation closes the breech. Figs. 51 and 52 are perspective views of the latest form of the De Bange mechanism as made by the Cail Company. These views explain very clearly the forms and relative positions of the different parts; they also show that the modifications from the earliest type are quite insignificant, a sufficient proof of the importance of the De Bange invention and the perfection of the details when it was first produced. The only point to which attention may be directed is the manner in which the ring is hinged to the gun. A recess is cut out of the jacket on the left-hand side, and a hole is drilled through to receive the hinge pin, a distance-piece being introduced between the ears on the ring to make the joint solid. The form of the latch on the ring is also shown, as well as the locking recess for the end of the lever.

Figs. 53 to 55 are diagrams showing the arrangement of carrier rings and the latch which forms an important detail in securing the breech mechanism of small calibres; the latter is attached to the ring and has projections which catch into corresponding recesses in the outside jacket of the gun. It consists of the following parts: the latch bolt C mounted on a pin *d*; the outer projection *a*, the lower projection *b*, the heel *c*, and the spring *e*. It will be seen from the diagram that this latch is carried in an enlargement of the ring immediately opposite the hinges *a*, *a*, and that the heel *c* projects within the opening of the ring. When the man operating the gun throws up the main lever and turns it to the left, releasing the screwed portions of the breech-block from the corresponding sectors of the seat, he at the same time depresses the heel *c* of the latch by forcing it against an inclined path in the breech-block; this operation turns the bolt upon the pin *d*, compresses the spring *e*, and raises the upper point *a* of the bolt, at the same time lifting the projection *b* into a catch in the jacket of the gun. By this operation the carrier ring is free from the screw and for the moment is secured to the breech of the gun. Now if the lever be pressed down, the cam upon it acting on the carrier ring forces the breech-block, out loosening the gas check, which has been expanded hard against the wall of the powder chamber by the previous explosion. The breech-block can then be drawn out of its seat through the ring by which it is supported until it strikes against the stop *f*; during this backward travel the heel of the latch *c* slides along the face of the breech-block until it falls into a recess cut in the latter, releasing the spring *e*, throwing down the lower projection *b*, and thus releasing the ring from the breech of the gun, and at the same time attaching it to the breech-block. For closing the breech the operations thus described are reversed.

The De Bange obturating primer is illustrated by Fig. 56. It consists of the case *a* which passes through the centre of the breech-block; of a spindle *d* with an enlarged head *c*, which fires the charge; of a gland *b* within the tube *a*, and within which moves the wire *d*. The gland *b* is secured to a tube *g*, between the head of which and the base of the tube *a*, surrounding the gland *b*, is some plastic packing; the head *g* is screwed to the tube *h* which projects from the rear of the breech-block; this tube *h* has a long slot *s* formed in one side and within it, the termination of the wire *d* looped into a ring *k*, is free to slide. A bell-crank hung to the recess in the rear of the breech-block passes through the slot *s* and engages in the ring *k*; the other end of the bell-crank serves as a connection for the lanyard. On pulling the wire *d* the fuze is fired, the pressure of the powder gases forcing out the plastic packing, and the enlarged head *c* sealing the opening in the gland *b*.

SHIPBUILDING AND ALLIED INDUSTRIES.

THE indications at the close of the year promised continued activity in the shipbuilding trade, but the first month of the new year closing to-day will be noted for the almost entire absence of new contracts. In Scotland only four vessels, which, combined, do not make up 2000 tons, have been booked by shipbuilders, and as great a dearth of orders is experienced in the north-east coast, and very few inquiries are in the market. But, after all, the shipbuilders do not complain; on the other hand, they welcome this "lull." At the annual meeting of the Tyne Shipowners' Assotion the other day, the Earl of Ravensworth spoke the sentiments of shipbuilder as well as shipowner, when he expressed the hope that the enormous output would receive a check. There are various reasons for the

the early part of this century, who built and operated one on the Hudson River from Hoboken to New York City.

Professor Denton made a comparison between the performance of the Orange, a side-wheeler with low-pressure beam engines, and the Bergen, a double-end propeller with triple-expansion engines. The original plan had been to have this paper read on the Bergen, and thus combine a practical illustration with the presentation, but the Bergen resented this method, and finding every other resource to fail, decided to arrange her boilers so they could not be used, and womanlike, she broke her stays, and that settled it.

This paper, which was extremely interesting, we shall shortly publish *in extenso*.

THE SINGER SEWING MACHINE WORKS.

The next day the party took the Laura M. Starrin again, and started for Elizabethport to see the Singer Sewing Machine Works. When it was arranged to take the Bergen, Dr. Henry Morton, the genial president of Stevens Institute, had, with his usual hospitality, tendered the Society a lunch on board, and the change of boat brought no change of heart to our good friend, so the Society had the pleasure of enjoying a most excellent feast, and thinking of Dr. Morton in the pleasantest manner possible. On arriving at the dock of the Singer Sewing Machine Works, the party were met by the officers of the company and conducted through a fine park to the works, which were carefully inspected, and the various labour-saving devices thoroughly appreciated. In a manufactory where so many pieces are constructed and put together, even a slight saving in each aggregates to a large amount. A general description of the works is as follows: They are located on Newark Bay, and the main factory building has a frontage of 230 ft. on First-street, with a width of 60 ft. The Trumbull-street annexe to this building is 800 ft. long and 50 ft. wide, the whole being four stories in height. Below this building, on Trumbull-street, are the cabinet and box factories, each 200 ft. long and three stories high. On the north side of the grounds, adjoining the Central Railroad property, are the forging and foundry building, together making one continuous building 1430 ft. in length. The foundry alone has an area of $2\frac{1}{2}$ acres in one open floor, and the total floor area of the works is 18 acres. On the opposite side of First-street is the Singer Park (private), which extends to Second-street on the west, and occupies the space between Trumbull-street and the Central Railroad of New Jersey, covering about 3 acres. The first Singer machine was made in Boston in 1851, and the firm of I. M. Singer and Co , the late Mr. Edward Clark being the "Co.," was formed during that year, the business being carrried on in New York City. After various changes of location, necessitated by an increasing business, the company came to Elizabethport, where they have both railroad and water facilities, being distant from New York City about 12 miles by rail and about 14 by water. The company have their own steamer, and consider they save considerably by its use; they also load their machines in cars at their sheds, and thus avoid cartage, and reduce breakage due to handling to a minimum.

The plot occupied by the works contains 32 acres, and has a dock frontage of 800 ft. There are over four miles of railroad track within the yard, on which two switching locomotives, owned by the company, are kept constantly employed. The works consume annually about 15,000 tons of coal, which is received direct from the mines, *viâ* Central Railroad of New Jersey, without rehandling. Gas for lighting and manufacturing purposes is made on the premises, and the company have their own fire department, thoroughly organised and equipped, including a system of electric fire alarm signals. They also have a complete telephone exchange connecting all departments with the main office and with each other.

On these premises the Singer Company have also extensive boiler works, entirely separate from the buildings already enumerated, in which they manufacture for the Babcock and Wilcox Company, of New Jersey, their patent water-tube boilers, of which over 40,000 horse-power were constructed during the year 1888. The steam power used in the works is supplied by twenty-two of these Babcock and Wilcox boilers.

The works give employment to an average of 3300 individuals, and have a capacity of 1500 sewing machines per day. They, of course, consume a very large amount of raw material, the daily melt of pig iron alone varying from 75 to 80 tons.

About 40,000 dols. in wages is weekly distributed among the employés, the most of whom live in Elizabeth.

The present works were first occupied in the fall of 1873. Since that time various additions have been made, the last one being finished in the spring of 1888.

The Singer Company have thoroughly systematised the manufacture of sewing machines, introducing and successfully using automatic machinery in every department, and with their large corps of well-trained employés, the work in their immense factory goes on with the precision and regularity of clockwork. In the factory everything is scrupulously neat, and every provision is made for the safety, health, and comfort of those who spend their time within its walls, even the various rooms are heated by overhead pipes, and the ventilation problem has been carefully studied and solved with judgment. The emery wheels are protected, and the general air of the employés was that of industrious and skilful workmen, who were satisfied with their position and appreciated the care their wants had received at the hands of their employers.

The visitor to the works will find that while a close and exhaustive study has been made of the strictly useful and practical, the beautiful has not been forgotten. Through the yard are scattered trees which overshadow well-kept lawns, thickly dotted with flowers, and, indeed, the grounds, on which a force of men is kept continually employed, have more the appearance of a park than a factory yard.

The officers of the company are: F. G. Bourne, president; William F. Proctor, vice-president; C. A. Miller, secretary; E. H. Bennett, treasurer.

Some of the machinery proved to be of the greatest interest, especially that used in making the needles. The tasteful designs painted on the machines, such as bouquets of flowers and other decorations, are put on very much like the decaliomaine process, and this work is done by girls. The name of the company is put on in a similar way. The old method was to have these painted by hand. Some of the cabinets containing the machines attracted attention from the richness of the wood, and on inquiry we found they were made of cotton-wood. They had a high polish and a beautiful grain. The question as to who used all these machines came constantly to the lips of the party, only to learn the company had a large series of works at Glasgow, Scotland, although they do not turn out as much as the Elizabethport ones.

After spending a delightful day and being very much impressed with the wisdom, skill, and forethought of the officers, the party re-embarked. The return to New York was charming, and the statue of Liberty seemed never to have looked so attractive. The principal topic was the coming World's Fair in New York City, and a wish that the foreign attendance might be large. On this point, it might as well be understood, that New York City will hold a World's Fair in 1892. It will not affect the question at all where Congress may designate the location. We shall have our Fair, it will leave any other so far in the shade that visitors will not care to even see it.

The next day concluded the session; it was marked by a pleasant reunion on the City of Paris at a lunch of many old friends. The Inman Company had kindly sent the invitation to the Society, and many of the Inman officials took this occasion to meet the engineers they had taken such good care of during the summer. All agreed that this was the line to sail on, one of the impromptu speakers saying that he did not care to sail on any other, not even that line who boasted they never had lost a passenger, and he added, "except by starvation." Of course, Captain Fred. Watkins did the honours of his beautiful ship with his usual grace, and when his health was proposed it was remarked, that he always had the World's Fair on board, and the American woman came in for her share of the praise.

The New York Committee really felt their labours were not in vain, and if the expressions of their guests were sincere, the guests felt they had profited by the visit.

GERMAN STEAM NAVIGATION.—A German line of steamships has commenced running between New York and Venezuela.

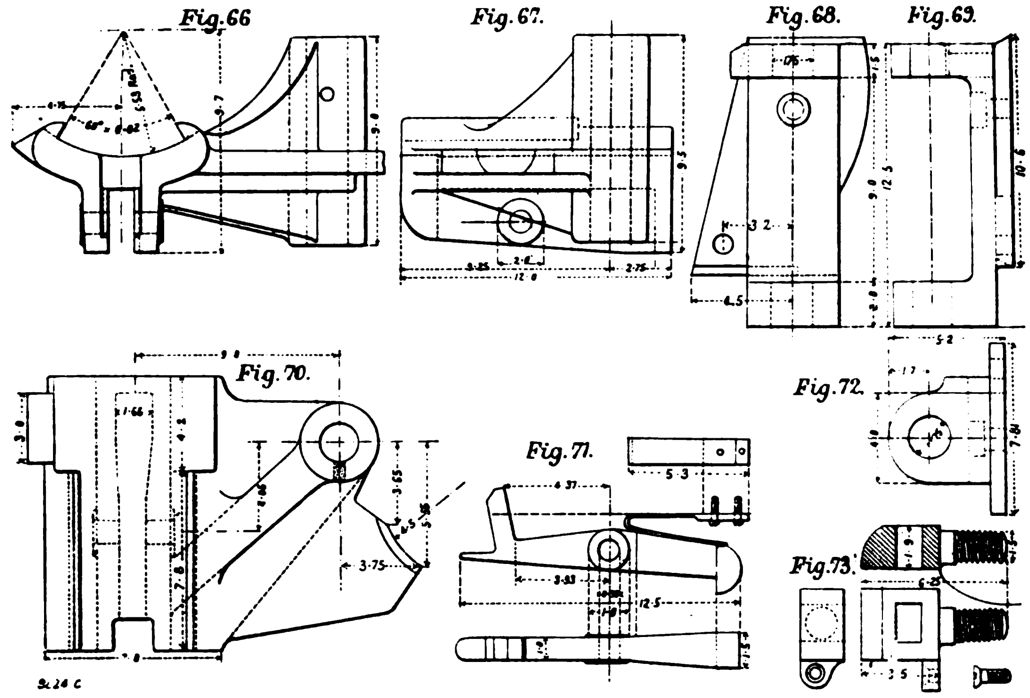
MODERN FRENCH ARTILLERY.
No. VI.

BREECHLOADING MECHANISM—*continued.*

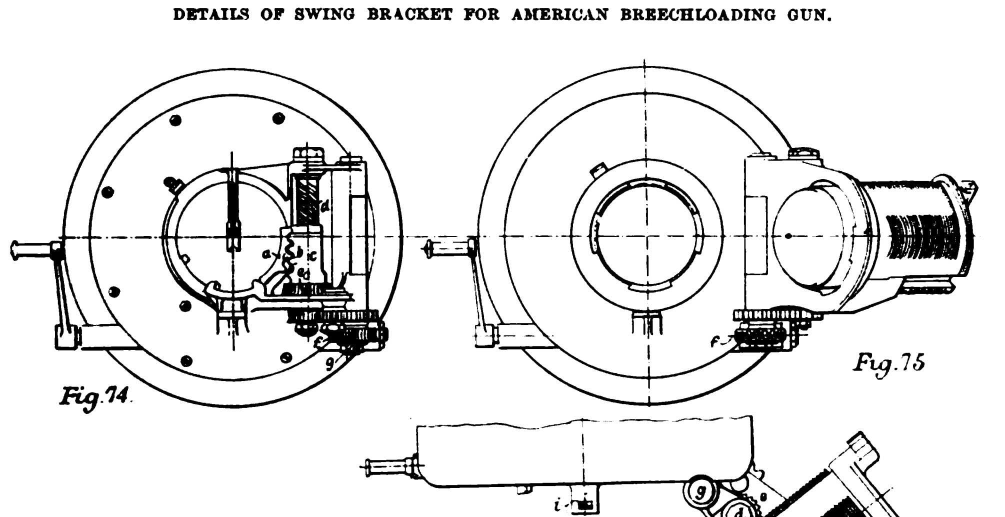
United States Modifications of the French System.—Figs. 57 to 73, pp. 135, 136, illustrate very completely the details of the French system of breechloading mechanism, as adapted to an 8-in. steel rifle of the class made for the United States Government at the West Point Foundry, New York. The four principal parts of the mechanism are: (*a*) the breech-block; (*b*) the spindle, the inner end of which carries the mushroom-headed obturator bolt; (*c*) the lever; and (*d*) the swinging bracket. The breech-block, which of course is of tempered steel, has smooth surfaces, over three sectors of the circumference, the other three sectors being threaded; the 1 st thread at the back of the block is left complete to arrest the block at the proper point of insertion when the threads are in a position to engage, one-sixth of a turn completing the locking; this operation of turning carries the block forward .125 in. and forces the obturator pad into place. The diameter of the chamber of this gun is 9.5 in., which corresponds to the diameter of the end of the breech-block in advance of the threads. The maximum diameter of the breech-block seat is 11.06 in., that measured to the bottom of the threads is 11.04 in., and to the top of the threads is 10.50 in. The total depth of the block seat is 12.5 in., of which 11 in. are occupied by the threads (see Fig. 61). The form of thread is shown in Fig. 62; it is commenced about .8 in. from the rear end of the block, the pitch being .75 in. Two of the sectors have the threads interrupted by a recess nearly 1.5 in. wide, and of the form shown in Figs. 62 and 63; this is to receive the corresponding projections on the bracket to hold the block when the breech is open. The rear of the block is formed with a tapered recess (Figs. 56 and 65), 3.65 in. deep, 6 in. in diameter at the back, and 5 in. at the front part of the recess; further the block is bored through with a central hole, 2.46 in. in diameter, to admit the spindle carrying the obturator head. Curved handles (Figs. 63 and 64) are formed symmetrically on each side of the block, and these, with the lugs to which the lever is attached, are cut from the solid piece of which the breech-block is formed. The spindle is clearly shown in Fig. 58. The mushroom head is 2.9 in. thick, and its normal position is somewhat less than 3 in. in front of the block, which allows space for the gas check; the diameter of the head is 9.4 in., allowing a clearance of .1 in. in the powder chamber. The spindle, where it joins the head, is 2.995 in. in diameter, and passes into the hole in the block, which for a length of 5 in. is 3 in. in diameter. The enlarged size of the spindle is only 2.75 in. long, beyond which it is reduced to 2.46 in., as far as the threaded end at the rear, which is of two diameters, as shown. Two adjustable nuts and a copper washer are placed on this part of the spindle within the recess in the block. The position of these nuts is regulated by the thickness of the gas check pad, and they have reverse threads to lock the spindle. Beyond these nuts the spindle is extended for 3.65 in , and with a reduced diameter of 2 in. The spindle is drilled on its axis from end to end, to form the vent; the diameter is .2 in., except in front, where the mushroom head is bushed with copper and the diameter is reduced to .10 in. The lever is pivotted and supported between the handles of the block by a bolt that passes through the lugs provided (see Fig. 58), and around which the lever revolves. This lever has three functions: When the handle is upright it serves to revolve the block, either for locking or unlocking; when the block is turned to the locked position, and the lever is thrown down, the eccentric at its hinged end enters a recess cut in the body of the gun and locks the block; and when it is desired to draw out the block after it is unlocked, a downward pull on the end of the lever forces the eccentric against the breech of the gun, and starts the block. When the gun is closed and locked, the position occupied by the lever is that shown in Fig. 58, the lower part of the handle being caught by a spring attached to the bracket. The form of the lever is shown in Fig. 57, the recess cut to receive the eccentric when the gun is locked in Fig. 59.

The swing bracket is that part of the breech mechanism which serves to support the block when it is withdrawn from the gun, and on which it can be thrown back out of the way for loading. The bracket is attached to a hanger of the form shown in Figs. 68 and 69, which is bolted to the breech of the gun; the top and bottom of this hanger has projections through which passes a hinge bolt and secures the bracket to the hanger; the latter is shown in position in Fig. 57. The bracket is a strong casting, the end where it is secured to the hanger being 9 in. deep, and drilled for the hinge bolt to pass through. The bearing table is 12 in. long, and is curved accurately to the form of the breech-block; at the outer sides are two projecting guides of a clutch form. The level of the table coincides exactly with that of the bottom of the breech-block; the positions of the guides correspond with those of two grooves cut longitudinally in the block. Flanges beneath the table serve to strengthen the bracket and to carry the latch, which is an important detail in the mechanism. When the bracket is turned so that the inner face of the table is in contact with the breech of the gun, and the breech-block is unlocked and started, it can be pulled out by hand upon the bracket, the guides controlling the movement and holding the block steady. The latch, which is shown in position in Figs. 57 and 58, and separately by Fig. 71, serves the double purpose of holding the bracket fixed, while it is in position to receive the breech-block, and afterwards of keeping the latter in its place when the bracket is swung back. The latch is hung on a pin about the middle of its length, this pin passing through the flanges underneath the table; a bent spring underneath the table presses on the top of the latch and tends to hold it down. When the bracket is swung round to receive the breech-block, the inner end of the latch, which is formed with a catch, rises over a curved stop screwed into the breech of the gun, and when the bracket is in its final position the latch falls into a recess in the stop, and keeps the bracket fixed. When, however, the breech-block is fully withdrawn, the outer end of the block strikes a finger projecting from the other end of the latch, lifts it from the recess in the stop, and as soon as the bracket is turned, the bent spring throws up the latch, engaging the finger with the end of the block, and holding the latter part. When the bracket is again swung round for closing the gun, the reverse action takes place.

The operation of the breech mechanism is as follows: The block being locked as shown in the position, Fig. 57, and it being desired to reload, the lever is pulled upwards through an angle of 180 deg., and when in this position it is turned round through one-sixth of a revolution, when the pin on which it is mounted strikes against the stop provided for the purpose; the lever is then pressed downwards to start the breech-block, and it is then lowered until its end rests against the rear of the bracket, which has been brought against the breech of the gun, and is held by the latch as above described. The block is withdrawn from its seat by pulling the handles, the relative positions of the various parts being such that the grooves in the block take on to the guides on the bracket. A sharp pull is required to fully withdraw the block, and when the latter arrives at the end of its travel, it strikes the latch, becomes locked, and at the same time releases the bracket, which can be swung back clear of the bore. After the charge has been inserted in the chamber, the bracket is turned back, and on coming into position is locked by the latch, which at the same time releases the breech-block. The lever is then raised, and the block is slid forward into its seat until the first thread strikes its bearing; the lever is then turned through one-sixth of a revolution, and the block is locked, the operation advancing it through .125 in.; the lever is then pulled down till the lower end is caught in the spring. It should be mentioned that in this arrangement a gas check fuze is employed, and that the obturator pad is made of the usual mixture of asbestos and suet.

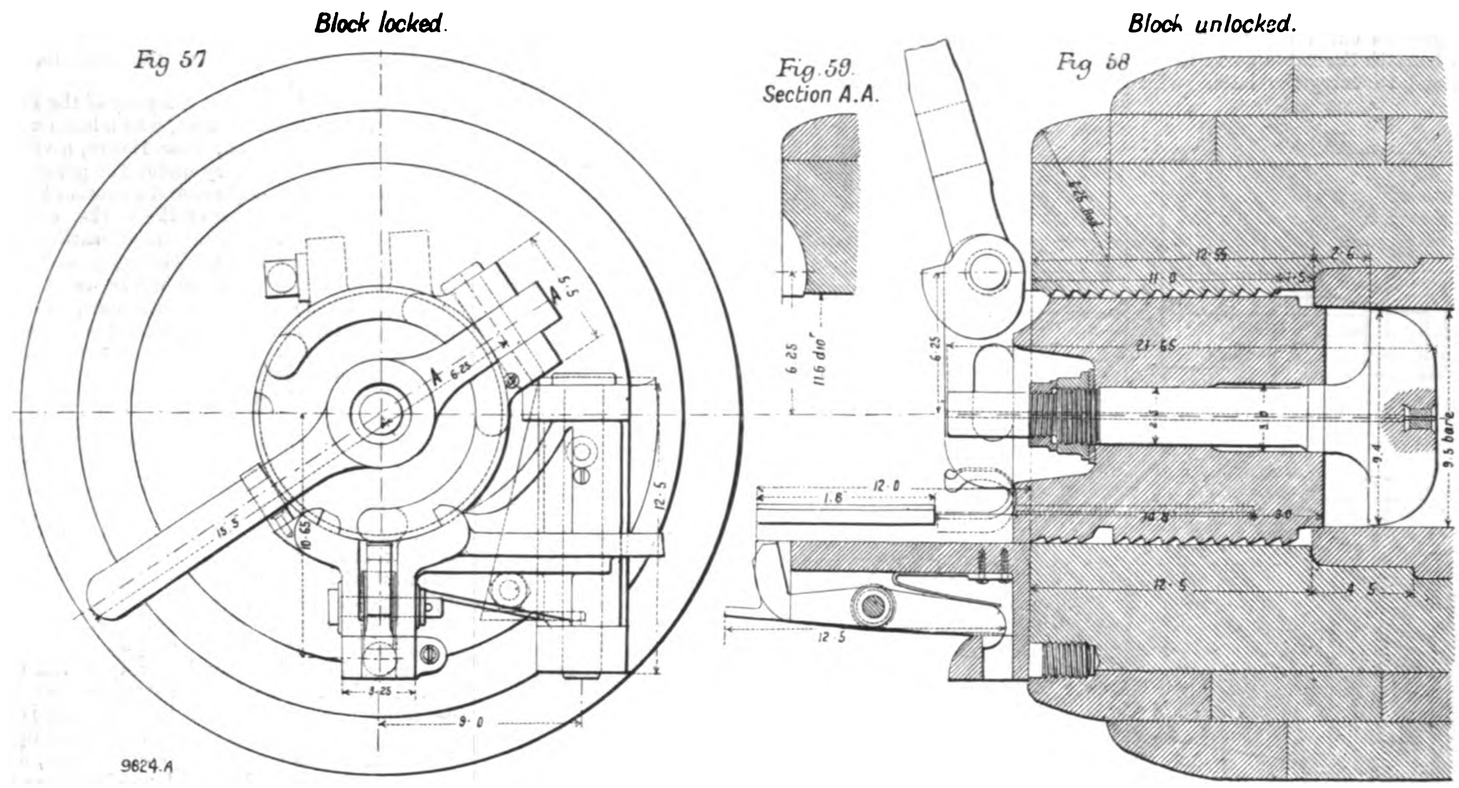


DETAILS OF SWING BRACKET FOR AMERICAN BREECHLOADING GUN.

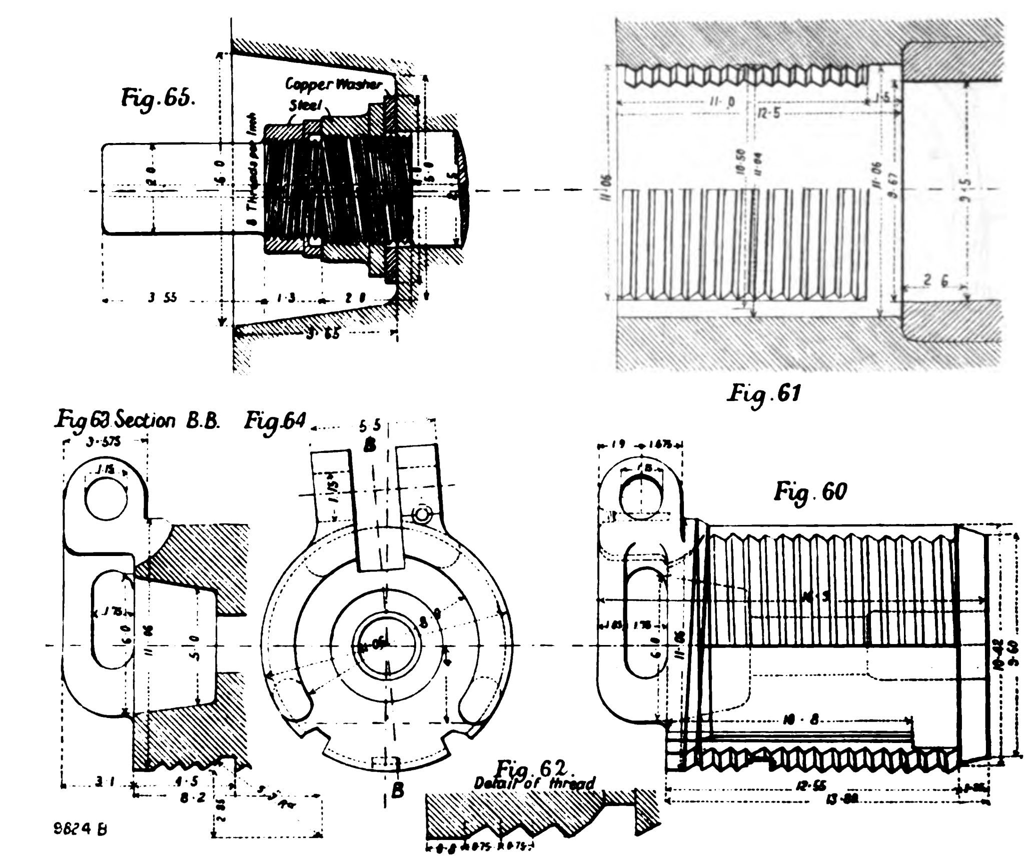


CANET SYSTEM OF BREECHLOADING WITH RACK AND QUADRANT.

The Canet System.—The company of the Forges et Chantiers de la Mediterranée, which has, during the last few years developed, near Havre, a very large and important gun factory under the general direction of M. Canet, has perfected a system known by the name of the director of the works, and which comprises many important modifications of the standard French system. The guns of large and small calibre made at these works are known by the general title of Canet ordnance, and as we shall see later on, they possess many details of novelty and interest. Confining ourselves for the present to a general description of the breech mechanism, we find that the Canet guns both for naval purposes and for coast defence, are fitted with breechloading devices on the stripped screw system, but into which many improvements have been brought. Obturation is always effected by means of a modified De Bange plastic wad of a special form, which is designed to avoid any hardness or inconvenience in working, and which in varying sizes is used for guns up to the largest calibres and highest powers. In certain cases the stem of the head holding the wad in place is fixed, and the head instead of being mushroom shaped is in the form of a ring, but with this latter type the stem is movable with the head; by this arrangement, while the same pressure on the breech-block is maintained, an increased pressure is thrown upon the obturator, and as a necessary consequence, a better obturation is secured with low charges — a very obvious advantage. The mushroom is attached to a movable stem, which passes through the axis of the breech-block. This stem, which is drilled through for the fuze, is formed at the rear end with an enlarged opening, the front being bushed; the spindle changes its position according to the extent to which the obturating pad is flattened. Firing the gun is effected by means of a bolt composed of two parts, one of which slides in a groove in the ordinary manner; this circular groove is cut on the rear face of the breech and the tail of the bolt engages in it. The other part of the bolt, following the axis of the gun, is connected to the first by a slide. This second part of the bolt can be made fast with the movable stem by a piece, in which, however, it is free to slide easily when it follows the movement of the bolt. From this arrangement it follows that that portion of the bolt mounted on the movable stem is free to follow all the movements of the latter, while it remains at the same time in connection with the first part of the bolt on which are mounted the percussion and safety devices. The firing mechanism consists of a hammer which is movable around an axis, and carries at its tail end a small roller which is controlled by a spring. The detent is formed by a special forging, on which are placed four fingers; these are mounted parallel to the axis of the breech. The first finger carries the ring of the firing cord, the second takes a bearing when the hammer is lifted, and under the action of a spring, in a lateral recess cut in the side of the wing of the hammer, prevents the latter from falling upon the fuze. The third finger opposes this by stopping against a projection on one side of the hammer, and so prevents this latter from coming in contact with the percussion fuze, if from any cause it becomes released without having been pulled by the firing cord. It is only when this cord is drawn that the projection is removed and allows the hammer to strike the fuze. The fourth finger, which engages in the groove of the breech-block, prevents all movement of the axis of the detent so long as the bolt is not in its proper position and the striker is not exactly in range with the fuze. It is only in such a position, when the fourth finger is opposite an enlargement made for this purpose in the slide of the bolt, that the detent can act and the hammer fall. During the rotation of the breech-screw the tail of the bolt remains engaged in the groove formed in the body of the gun, and the bolt is thus kept absolutely fixed. It is only when the breech is completely closed that the enlargements made at the upper and lower ends of the groove allow the bolt to be raised for putting the fuze in place and to be afterwards lowered to make ready for firing. This system of breech-block is thus provided with a triple safety apparatus, because the gun cannot be fired: 1. So long as the breech is not closed. 2. So long as the striker is not exactly over the fuze. 3. Firing is impossible except by pulling on the firing cord. All parts of the mechanism are moreover very simple, easily cleaned and maintained, while the working of the system presents very little inconvenience. The working lever pulls over, and is formed with a cam which, when the breech is closed, holds the block firmly locked. When the threaded sectors of the block are turned so as to be clear of the threads in the bore, by pulling over the lever the same cam which takes a bearing against the body of the gun assists in slackening the obturator in the usual manner. We shall illustrate this mechanism later on.



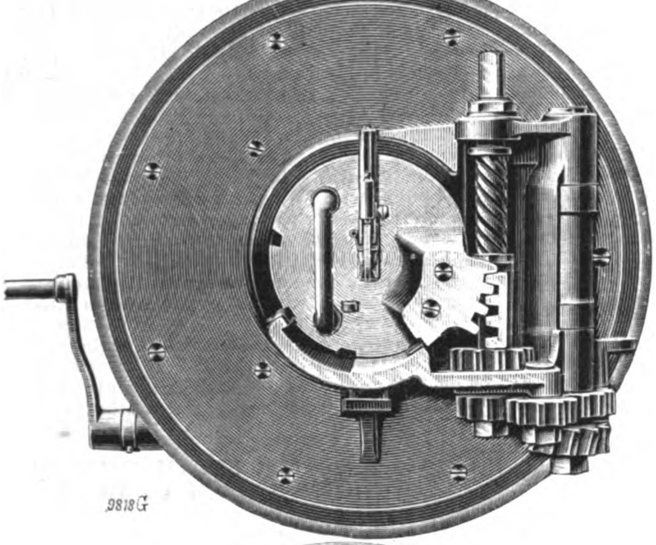
BREECHLOADING MECHANISM; THE FRENCH SYSTEM MODIFIED BY THE UNITED STATES

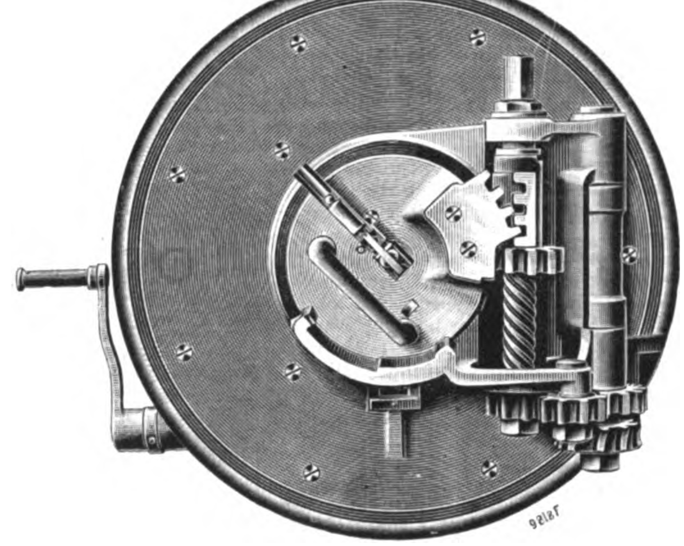


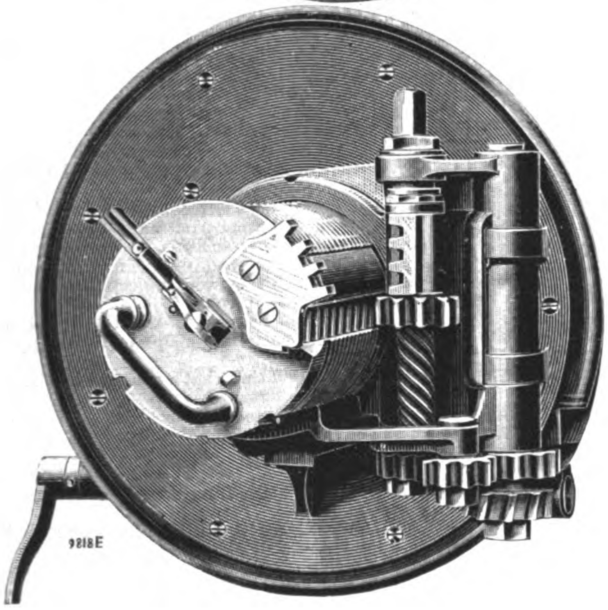
For the manipulation of the breech mechanism in heavy calibres, special appliances belong to the system above described, which allow the man serving the gun to carry out all the various operations by means of a single lever which is turned only in one direction. The rear face of the breech-block has fitted to it a toothed sector *a* (Figs. 74 to 80) gearing into a rack *b* carried upon a movable nut *c* mounted on a vertical screw *d* which is attached to the console. When the screw *d* is turned, the nut *c* rises, and the rack acting upon the toothed sector *a* turns the breech-block. When this movement has been carried sufficiently far to release the threads of the block from those in the bore, the nut is stopped against the upper bearing of the screw, which then actuates the pinion *e* which is cut with helicoidal teeth, and attached to the nut *c*; this pinion gears into a rack cut in the side of the breech-block and withdraws it from its seat in the bore. Whilst this screw is being turned the tail of the bolt that carries a small roller rises up a curved path fixed upon the back of the gun. As the bolt rises, the tail of the hammer comes against a stop that forces the dog to lift and produces an automatic safety arrangement. When the screw has arrived at the end of its travel, the pinion *e* butts against the extremity of the threaded portion and becomes fixed. A bolt *i* upon the console of the gun is thrown out and the whole system swings around the axis *g* attached to the gun; the arrangement of this console bolt is very simple and no springs are employed. The pivot *g* has mounted upon its lower end a pinion *f* which is turned by means of an endless screw upon a shaft worked by a crank. The various operations can be performed either by hand, by means of hydraulic apparatus, or by belt transmission. The breech-block is fitted with a triple safety apparatus, which makes it impossible to fire the gun: 1. Until the screwed part of the breech is not completely home in the bore. 2. So long as the bolt is not immediately over the fuze. 3. Unless the firing is performed by drawing on the lanyard. The great advantage of this system is that it can be manipulated in every position of the gun by only one man, and by turning a crank always in the same direction. The operations are moreover easy and rapid on account of the convenient arrangement of the different parts, and especially on account of absence of complicated mechanism. The system has been adopted by several countries — Japan, Greece, Chili, &c.—both for naval and coast defence guns. Figs. 77 to 80 are perspective views that show the breech mechanism in various positions.

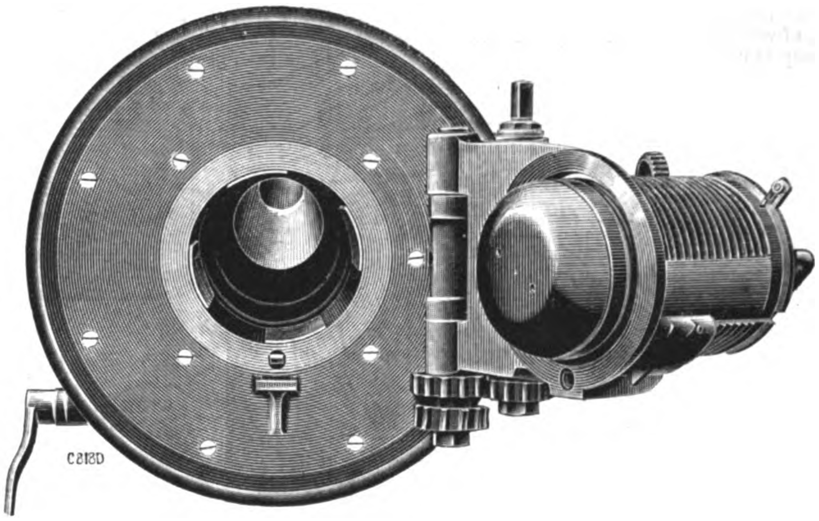
Canet's Quick-firing Guns.—Figs. 81 to 85. The speed at which these guns can be fired is due to two reasons; to the simplification in the operations of opening and closing the breech, and the use of metal cartridge-cases, which contain the charge, and are attached to the projectile, so that both are inserted in the chamber at one operation. These of course are features common to every system of quick-firing gun; but they are, as we shall see, carried out in the plan we are about to describe, in a manner presenting many original details. The breech-block

THE CANET SYSTEM OF BREECH-CLOSING MECHANISM.

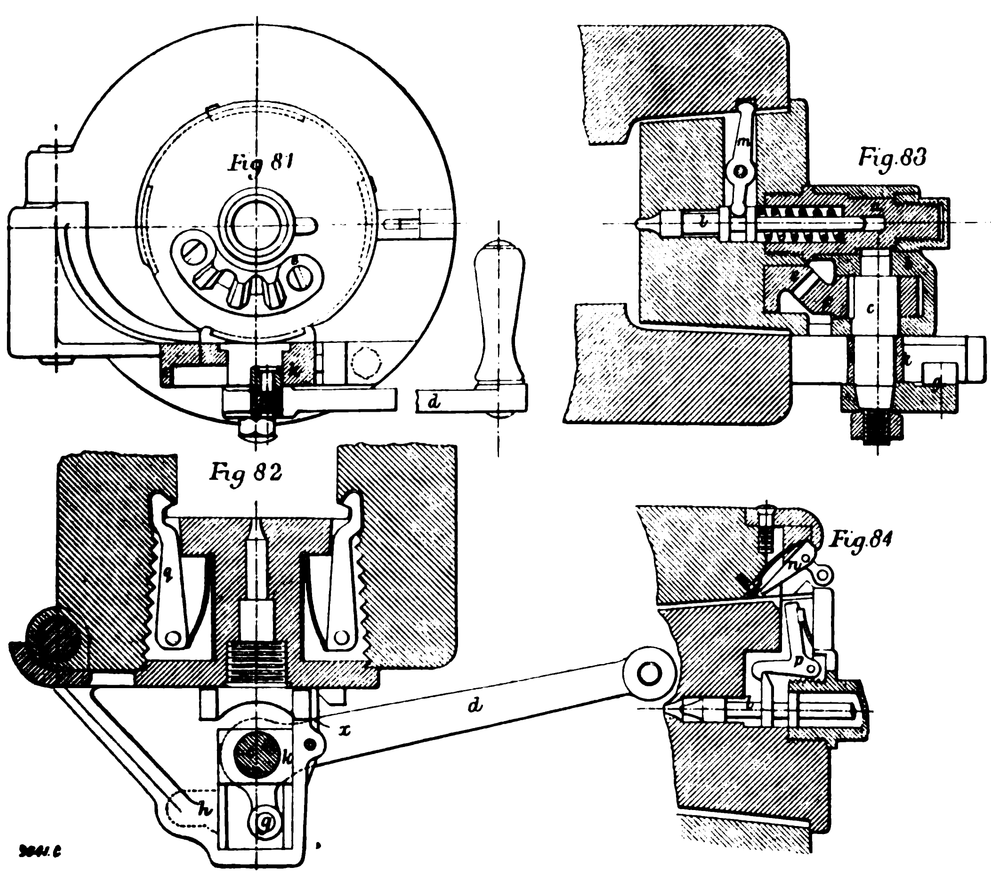






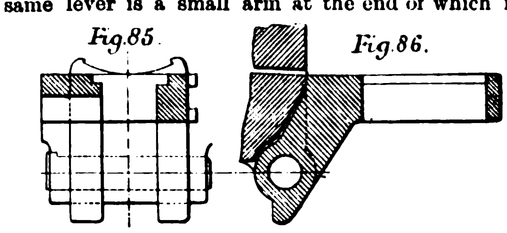


FIGS. 77, 78, 79, AND 80. CANET SYSTEM OF BREECHLOADING WITH RACK AND QUADRANT.



THE CANET SYSTEM OF BREECH MECHANISM FOR QUICK-FIRING GUNS.

Fig. 83 is of the ordinary interrupted screw type, and the mechanism operating it has to perform three distinct movements ; unlocking the block from its seat ; withdrawing it to the rear ; and turning it back clear of the breech upon the hinged console which supports it. These operations are effected by turning a horizontal lever *d* which works from right to left. This lever is mounted on a pivotted bearing *c* carried on a sliding block *k*, which moves in a groove cut in the lower part of the console and in the same plane as the axis of the gun. As soon as this lever is turned, a pinion *f* mounted upon it, gears into a bevelled tooth segment *e* forming part of the block of the gun, and causes the block to turn through one-sixth of a revolution, that is to say until it is free in its seat ; upon the same lever is a small arm at the end of which is



mounted a roller *g*, and at the moment that the block is released this roller enters a lateral recess *h* in the console. By continuing the movement of the lever *d*, this roller abuts against the end of the recess and serves as an adjustable fulcrum for the whole system ; the sliding block *k*, on which the lever is mounted, is then displaced and travels in the groove made in the console (see Fig. 85) ; this movement, of course, causes the breech-block to be withdrawn from its seat in the gun—the actuating mechanism being fast with the breech—and as the console is in a position to receive the block, it takes its bearing upon this latter; when it is out of the gun the sliding block is at the end of its travel and becomes fixed; by continuing the movement of the lever, force is exerted upon the console, which is caused to turn around on its axis or hinge pin which is placed at the side of the breech. The extracting device acts automatically; it consists simply of two claws held by springs recessed one on each side of the breech-block with the ends projecting in such a manner that when the block is returned to its place and forced home, the ends of the extractor bars close over the rim of the cartridge, the empty case of which is withdrawn with the block the next time the breech is opened. It is evident that by reversing the operations thus described, the block is returned to its seat and the breech is closed ready for firing. It should be mentioned that the console is fitted with a safety latch which secures the bracket both when it is thrown back or brought round to the closing position, and that this latch works automatically without the use of springs. We shall later on illustrate this mechanism and some of its modifications, as well as the firing device shown in Figs. 83 and 84.

COMPOUND PASSENGER LOCOMOTIVE.

WE publish this week a two-page engraving of a compound passenger locomotive of the "Mogul" type which was exhibited at Paris last year by the builders, the Société Suisse pour la Construction de Locomotives et de Machines, of Winterthur. The engine is one of a series constructed for the Jura-Berne-Lucerne Railway, of which line Mr. R. Weyermann is the locomotive superintendent.

Fig. 5.

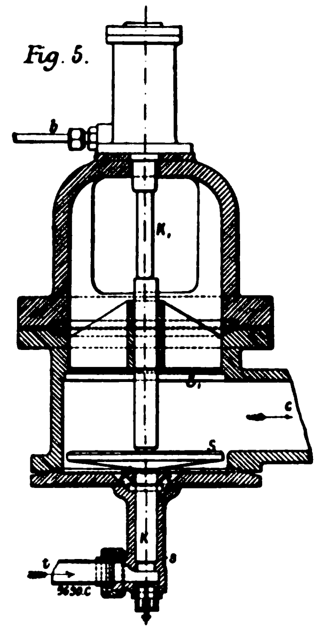
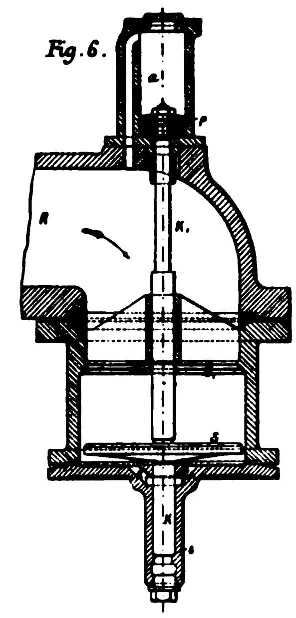


Fig. 6.



As will be seen from our illustrations, the engine is of the outside cylinder type with inside frames and valve gear, the latter being of the Stephenson pattern. The cylinders are respectively 17.7 in. and 25.2 in. in diameter with 25.6 in. stroke, and have the valve chests placed on the top as shown in Fig. 4. The valves are worked through rocking shafts, as in American practice, and the valve spindles are flattened at one part of their length so as to enable them to spring through a distance equal to the versed sine of the arc described by the upper end of the rocking lever arm to which they are connected.

As will be seen from the dimensions above given, the capacities of the high and low-pressure cylinders are in the ratio of 1 to 2 very nearly, and in order to secure as nearly as possible an equal distribution of work between the two cylinders under varied conditions of working, the Von Borries system was adopted of proportioning the two reversing arms so as to give different grades of expansion for the two sides of the engine when "notching up." Thus, in the engine under notice, the corresponding cut-offs in the two cylinders with various positions of the reversing lever are as follows:

Percentages of Cut-Off.

High-pressure ...	13	20	31	41	51	60	76
Low „ ...	20	29	42	51	59	66	80

By this means a very equal distribution of the work is effected.

To facilitate starting, the engine is fitted with a Von Borries automatic starting valve, the construction of which is shown by the detail views, Figs. 5 and 6, annexed. This apparatus is placed at the junction of the intermediate receiver or connecting pipe, with the large cylinder, the steam leaving this intermediate receiver at R and passing off to the low-pressure cylinder at C. If the engine stops with the high-pressure piston on a dead point, so that the engine cannot start in the ordinary way and no steam can be exhausted to the low-pressure cylinder, the live steam passes from the high-pressure valve chest through the pipe *t* and acts upon the lower end of the spindle K, the pressure thus exerted raising the valve S and closing it on its seat S_1. When the spindle K is thus lifted it uncovers the small openings *e e*, and live steam can then pass to the low-pressure cylinder, thus starting the engine. As soon as the engine gets to work the exhaust from the high-pressure cylinder of course raises the pressure in the intermediate receiver, and this pressure acting on the valve S, overpowers the pressure of the live steam on the lower end of the spindle K and forces the valve off its seat, thus allowing the exhaust steam from the high-pressure cylinder to pass to the low-pressure, the engine then continuing to work compound. To insure the valve S being forced right down into the position in which it is shown in Figs. 5 and 6, there is provided a small piston *p* working in a cylinder *a*, the upper end of which is in free communication with the receiver. The area of this piston is such that the pressure of the receiver steam on it is sufficient to overpower the pressure of the live steam on the lower end of the spindle K.

The boiler, which is worked at a pressure of 156 lb. per square inch, has a shell made of Krupp's "flusseisen," which has a tensile strength of from 21½ to 25½ tons per square inch, with an elongation of 18 to 20 per cent. before fracture. The longitudinal joints are double-rivetted butt joints with inside and outside butt strips. The inside firebox is of copper, and the tubes are of steel with copper ends next the firebox. The chief proportions of the boilers are as follows:

		Square Feet.
Heating surface:	Firebox...	80.7
	Tubes	1223.8
	Total	1304.5
Firegrate area		16.1

The boiler is furnished with a large dome in which is placed the regulator. The steam pipe, it will be noticed, passes through the top of the barrel close to the dome, and is then led externally to the valve chest of the high-pressure cylinder, while the exhaust from the high-pressure cylinder traverses an arched pipe in the smokebox on its way to the low-pressure cylinder. It will be noticed that the joints of the steam pipe are coned joints, each secured by a single central bolt.

The engine is, as we have already stated, of the "Mogul" type, and the six-coupled wheels are 4 ft. 11.8 in. in diameter, while the diameter of the single pair of carrying wheels at the leading end is 3 ft. 0.6 in. The rigid wheel base is 12 ft. 1.7 in., while the total wheel base is 20 ft., the position of the leading axle being controlled by radius links.

The springs of the coupled wheels are arranged beneath the axle-boxes, those of the middle and hind wheels being connected by compensating levers, while other compensating levers connect the front ends of the springs of the front pair of coupled wheels with the hind ends of the springs belonging to the leading axle. Moreover, the two leading springs are connected by transverse compensating beams which transmit their load to the centre of the cross-frame connecting the two leading axle-boxes.

The construction of the framing is clearly shown by our engravings, and calls for no special description. A strong transverse stay of box section secures the necessary rigidity at the point of attachment of the cylinders. The engine is fitted with the Westinghouse brake, which acts on the two hind pairs of coupled wheels, and the fittings generally are neat and substantial. The engine weighs 39½ tons empty, and 43¼ tons in full working order. It is accompanied by a four-wheeled tender which carries 1565 gallons of water and 4.2 tons of coal, the weight of this tender being 10 tons empty and 21 tons full.

We may mention in conclusion that the Mogul type of locomotive was introduced into Switzerland by the Société Suisse in 1875, since which date it has been adopted for heavy passenger service on many Swiss railways. We give on page 140 a perspective view of another engine built in 1886 by the Société Suisse. This engine is of the same general type as that we have been describing, but is without a dome and is fitted with outside valve gear of the Walschaert pattern, instead of inside gear, as is the case with the engine shown by our two-page illustration. The Westinghouse compressed air reservoirs also are placed on the side footplate instead of under the foot-plate at the trailing end.

THE MANCHESTER STEAM USERS' ASSOCIATION: ITS SYSTEM OF INSPECTION AND GUARANTEE.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been called to a letter by Mr. Michael Longridge, headed "The Charlesworth Boiler Explosion," which appeared in your issue of the 17th ult., the latter part of which it is thought might lead to misapprehension as to the course the Manchester Steam Users' Association took with regard to a range of six boilers placed under its inspection in the year 1873, the furnace tubes of one of which collapsed on September 4, 1874. Absence in London, and the press of other work, prevented my replying before.

From Mr. Longridge's letter it might be inferred that the Association had approved and "guaranteed" the boilers, whereas the Association had given warning of the danger incurred in working them at so high a pressure as that to which they were subjected, more especial y with regard to the furnace tubes, and declined to "guarantee" the boilers until these tubes were strengthened with encircling hoops or other appropriate means.

This is not the first time that a question has been raised in your columns with regard to the "guarantee" of these boilers by the Manchester Steam Users' Association. In your issue of June 2, 1882, a letter appeared from Mr. Charles Longridge, which was replied to by me in yours of June 30 and July 14, 1882, and I do not know that I can do better than quote from the first of those letters on this occasion.

"The facts of the case are briefly as follows: The boilers, which consisted of a range of six of the Lancashire type, were insured by the Boiler Insurance and Steam Power Company, as stated by Mr. R. B. Longridge at the inquest consequent on the explosion, from October 27, 1866, to October 27, 1872, at a pressure of 65 lb. on the square inch, though this pressure was exceeded in working. They were transferred to the Steam Users' Association on the 7th of March, 1873, when arrangements were at once made for having the boilers laid off one or two at a time, according to the convenience of the owners, so that they might receive a series of 'entire' examinations. In this way two of the boilers were examined 'entirely' on Saturday, March 15, 1873, two others on the following Saturday, March 22, and two more on Saturday, March 29, thus completing the whole series. In reporting on these examinations it was at once pointed out that the furnace tube which subsequently collapsed, as well as the tubes of three of the other boilers, *were too weak for the pressure at which they worked, and that the Association could not 'guarantee' them* or take any responsibility with regard to their safety until they were strengthened with encircling hoops. This was repeated to the owners of the boilers *again and again*. The owners received these representations most courteously, but unfortunately they were advised by their boilermakers, who were an eminent firm, that the boilers were perfectly safe, and were persuaded not to apply the hoops recommended. In consequence of the Association's urgency, however, they ordered a new engine to reduce the pressure, and ultimately resolved on taking out the entire range of boilers and putting in new ones. This resolution was carried out, and they have now a fine range of boilers, with flue tubes strengthened at each of the ring seams of rivets with flanged seams, and working safely at 75 lb. on the square inch. At this pressure they have now been 'guaranteed' for about eight years, and it is fully expected that the Association will be able to renew that 'guarantee' from year to year for at least twenty-five years from the day on which the boilers were laid down, and in all probability for several years longer.

"It was while this new range of boilers was being put in that the weak furnace tube previously condemned in the Association's reports collapsed . . . This boiler would have been taken out in another week or so . . ."

"This is a very brief statement of the case. I would gladly send you copies of all our reports and correspondence with regard to these boilers, but this would take up several columns of your space. Enough, however, I trust has been said to show that the Manchester Steam Users' Association did *not approve these boilers, but, on the contrary, refused to guarantee them*, and gave warn-