with plates, made on the Tresidder process, is mentioned; whilst other matters connected with armour are referred to. The diagrams showing perforation of armour are given. The second chapter in this section opens with an interesting comparison between the primary and secondary batteries of the new battle-ships in regard to weight of metal thrown in a given time. The author does good service by showing that the failures of guns are not all on our side, although our more outspoken and better-informed press brings any accident to British ordnance more prominently before the world than is the case with some foreign countries. A chapter on quick-firing guns follows, illustrations being given of the Canet 15-cm. quick-firing gun. This section of the work concludes with tables of British and Foreign naval ordnance in which details of construction and ballistics are given.

The fourth section of the book is in the nature of an appendix and contains reprints from official statements and papers; such as the annual explanatory statement of the First Lord of the Admiralty, the Report of the Committee upon that one-time enthusiastic, always much-snubbed, and now extinct body, the Royal Naval Artillery Volunteers. An abstract of the naval estimates is given, and a reprint of the Report of the Secretary of the United States Navy completes the work.

In bringing our notice to a conclusion it would be ungracious did we not return on our own behalf, and also, we feel sure, on behalf of our readers, a word of thanks to Lord Brassey for continuing this valuable publication. Where we have seen what we considered faults, we have not hesitated to point them out. That is always the duty of a review, however praiseworthy may be the motives of author, compiler, or publisher. We cannot, in the case of the Naval Annual, altogether banish from our mind that we are somewhat ungraciously looking a gift horse in the mouth, when we do otherwise than praise. We feel sure, however, that those reponsible for the publication would feel better pleased with a truthful estimate of their work rather than with a notice consisting wholly of a string of unmeaning adulation.

New Holidays in Essex. Edited by PERCY LINDLEY. London: 30, Feet-street, 61, Regent-street. [Price 6d.]
Walks in the Ardennes. Edited by PERCY LINDLEY. With Pen and Ink Sketches by J. F. WEEDON. Same Publisher.
Walks in Holland. By PERCY LINDLEY. Same Publisher.

Engineers are almost by necessity athletes, and no excuse need be made for commending in these columns books which guide pedestrians into such a district as south-east Essex, including the old-world villages of Burnham, Southminster, Bradwell, Maldon, Danbury, and the country between the Blackwater and Thames estuaries. The Great Eastern Railway has brought these various walking routes within a short railway ride of the metropolis, and with such an experienced and genial guide as Percy Lindley, one can almost experience the sensation of looking backwards over centuries. Writing, for instance, of Marney Towers, "one of the most fascinating and most remote spots in Essex," the author says standing there "one feels it has lost little of the seclusion of 400 years. The isolation and the solitude impress one. Time has stood still here. Not only the place, but the very atmosphere, is the same. The centuries have added nothing to the scene and taken nothing from it." Probably the people pray to be delivered from the railway engineer and the navvy. On the other hand one can walk within but a few miles into Booth's Salvation Army farm for metropolitan refugees. There are, in the book, many pretty illustrations and a map.

Again, for such as have time to go further afield, there are the other works on the Ardennes and Holland. Mr. Percy Lindley's works will not only give them all information necessary for full enjoyment of districts rich with varied scenery, but many practical hints which cannot fail to be of service. In each case, too, there are special chapters on boating, cycling, fishing, and shooting.

BOOKS RECEIVED.

Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution to July, 1890. Washington: Government Printing Office.
Colour Vision: An Essay Discussing Existing Theories, Explaining Views hitherto Incompletely Published, and Comprising Illustrated Descriptions of Important New Experiments. By EDMUND HUNT. With Three Plates. Glasgow: John Smith and Son. London: Simpkin, Marshall, and Co.
Florida, South Carolina, and Canadian Phosphates; giving a Complete Account of their Occurrence, Methods and Cost of Production, Quantities Raised, and Commercial Importance. By C. C. HOYER MILLAR. London: Eden Fisher and Co.
Report of the Rapid Transit Commission to the Massachusetts Legislature, April 5, 1892.
Ludgate Hill, Past and Present. With numerous Engravings. Second Edition. London: Hazell, Watson, and Viney, Limited.
A Dictionary of Electrical Words, Terms, and Phrases. By EDWIN J. HOUSTON, A.M. Second Edition, rewritten and greatly enlarged. New York: The W. J. Johnston Company, Limited.
Transactions of the Sanitary Institute. Vol. XII., 1891. London: Offices of the Institute.
Travels amongst the Great Andes of the Equator. By EDWARD WHYMPER. With Maps and Illustrations. Second Edition. London: John Murray.
Adressbuch und Waarenverzeichniss der Chemischen Industrie des Deutschen Reichs. Herausgegeben von OTTO WENZEL. 1892. III. *Jahrgang.* Berlin: Rudolf Mückenberger.
The Alternate Current Transformer in Theory and Practice. By J. A. FLEMING, M.A., D.Sc. (Lond.). Vol. II.
The Utilisation of Induced Currents. London: *The Electrician* Printing and Publishing Company, Limited. [Price 12s. 6d.]
Longmans' School Mensuration. By ALFRED J. PEARCE. London and New York: Longmans, Green, and Co. [Price 2s. 6d.]
Pumps and Pumping. By M. POWIS BALE, M.I.M.E. Second Edition, revised. London: Crosby Lockwood and Son.
Arakan: Past, Present, Future. A Résumé of two Campaigns for its Development. By JOHN OGILVY HAY, J.P. With Map. Edinburgh and London: William Blackwood and Sons.

MODERN UNITED STATES ARTILLERY.—No. XIV.

PNEUMATIC DYNAMITE SEA COAST GUNS; MODEL OF 1890. (Figs. 358 to 364.)

IN the defences of Boston, New York, and San Francisco, in addition to the high-powered modern rifles and mortars, are to be installed a number of pneumatic dynamite sea coast guns. These guns use compressed air as their motive power and throw a rocket-shaped projectile, containing as much as 500 lb. of dynamite or explosive gelatine.

The guns hitherto built by the Pneumatic Dynamite Gun Company have been pivoted at the breech, but the guns now being constructed for the United States have central trunnions, and, in appearance, are not unlike a powder gun mounted on a sea coast barbette carriage.

The 15-in. gun, shown in Figs. 358, 359, 360, and 361, has a heavy breech and a long slender chase, the latter being so light that it requires a support to give it longitudinal stiffness; this is accomplished, as will be seen, by a plate and angle-iron cantilever extending under the chase to near the muzzle of the gun.

The trunnions are slightly in the rear of the increase of diameter of the breech, and are supported on two trapezoidal cheek pieces. At the bottom these cheeks are connected by crossbeams and plates, and the whole is mounted on four roller casters, which support the carriage and also extend down inside the racer ring, and carry centring rolls, and the rear ones carry also recoil wedges. In Fig. 363 the bearing rolls are seen at 34, the racer ring at 29, the recoil wedges at 31, and the centring roll at 35. The operating cylinders of the recoil wedges are shown in Fig. 364 at 30. Before going into a detailed description of this rather complicated (when considered as a piece of artillery) gun it will be well to give a general description of its operation.

The gun, which is a breechloader, is made by bolting together three castings. The air is compressed, by means of an engine, in a reservoir of large capacity, and thence is conducted to the gun, through a central stand-pipe to the cheeks of the carriage, up through the cheeks to the trunnions—which are hollow—through them to the annular space around the breech of the gun, and from this annular chamber to the bore of the gun in rear of the projectile, by means of suitable valves. The construction of the barrel is shown in Figs. 359, 360, and 362.

In Fig. 360, 1 is the muzzle piece, and is made of bronze; 2 is the muzzle section of the barrel, 3 the middle section, and 4 the internal section. These sections are cast iron, and are made with flanges, by means of which they are bolted together; 5 is the truss boiler plate of wrought iron; 6 the barrel supports of cast iron; 7 the trunnion piece of cast iron; 8 the annulus of cast iron; 9 the firing valve casing of cast iron; 10 the firing valve bonnet of bronze; 11 the main firing valve of forged steel; 12 is the hydraulic packing leather, with pipes to differential piston; 13 is the sleeve or valve bushing, bronze; 14 is the breech piece of cast iron; 15 is the breech cover of bronze or steel; 16 is the cover hinge of steel; 17 is the valve seat of leather; 18 is the valve seat ring of steel. In Fig. 364 the breech is shown to an enlarged scale.

The seat for the auxiliary valve, with its supply and exhaust passages, is placed on the firing valve casing; it is shown in Fig. 364, as in a vertical plane through the axis of the bore, but it is actually in an oblique plane.

The carriage is shown in Figs. 362 and 363, and consists of the following parts: 19 is the elevating worm rack of bronze; 20 is the elevating worm of steel; 21 is the elevating worm bearing of cast iron; 22 is the elevating worm support of cast iron; 23 (shown also in Fig. 363) is the casing swing joint of cast iron; 24 is the interior part of the casing swing joint of cast iron; 25 is the packing ring of bronze; 26 is the hydraulic and air swing joint of bronze; 27 is the rear wheel bracket of cast iron; 28 is the front wheel bracket of cast iron; 29 is the racer ring of cast iron; 30 is the recoil wedge cylinder of bronze; 31 is a recoil wedge of cast iron; 32 is a training pinion of cast iron; 33 is the training rack of cast iron; 34 are the bearing rolls of cast iron; 35 are the centring rolls of cast iron; 36 is the side pipe of cast iron; 37 is the trunnion casing of cast iron; 38 is the trunnion packing carrier; 39 is the elevating motor; 40 is the traversing motor; 41 is the hand tramway shaft; 42 is the hand elevating shaft; 43 is a holding-down hook on the front of the carriage, to prevent lifting by recoil. The training and elevating of this piece are done by hydraulics or by hand; when done by hand, the hydraulic motors are easily detached and hand cranks attached. It has lately been decided that the elevating and training of all the guns will be done by electric motors. The passage of the air from the stand-pipe to the main valve annular chamber around the barrel necessitates two joints between movable parts, the trunnion joints between the trunnions and side pipes, and the centre swing joint between the side pipes and stand-pipe.

The centre swing joint, shown in Fig. 363, consists of an outer casing 23 attached to the gun-carriage side pipe 36 and a stationary post 24 which is bolted to the stand-pipe; to 24 is bolted a brass bush packing carrier 25, which has on its outside the hydraulic packings, which are filled with oil, under a pressure about 10 per cent. greater than the air pressure in the reservoir. Between the bush and 24 are small packings of soft rubber. The trunnion joints are so similar to the centre swing joint that a description of them is unnecessary. The firing, training, and elevating handles are all on the platform in reach of the gunner, and to reach the regulator he has merely to step on a ledge on the side of the carriage. The gun may be elevated to any degree from the horizontal to 35 deg.

The reservoir, which is quite large as compared with the volume of the bore, can be used for a number of fires before the pressure is too much reduced. In order to prevent too great a reduction of pressure at one fire, by allowing a rush of compressed air after a projectile has left the bore of the gun, it is necessary that the valve, which admits the air from the reservoir to the bore of the gun, should close automatically as soon as the projectile is out of the bore. The firing valve consists of a main valve and an auxiliary valve. The parts of the valves opening and closing the various ports are pistons which work automatically by an excess of pressure on one side moving them in an opposite direction; by this movement, ports are opened which exhaust the motive pressure into the atmosphere, leaving an excess of pressure on the other side, and the pistons move back to their original position. The first motion opens the ports connecting the reservoir and bore of the gun, and the second motion closes them. The main and auxiliary valves are shown in Fig. 364.

The Main Valve.—The main valve 1 is the outer casing of the valve; 2 is an annular passage to the firing reservoir; 3 is the valve bonnet and extends inward, the bore of it forming the rear part of the bore of the barrel, and the outer diameter forming the inner boundary of the annular space in which the annular main valve in contained. The outer boundary of this space is the bush 5. The valve 4 seats on a leather packing at 6 forming an air-tight joint between 2 and 7; 8 is an annular chamber behind 4, into which 4 moves at the opening stroke, which stroke is caused by the exhaustion of the air from said chamber by the auxiliary valve. The shoulder 9 is called the opening shoulder, because it is by an unbalanced pressure on this shoulder that the valve is caused to open when 8 is exhausted. For a like reason 10 is called the closing shoulder, because when the valve is open, on account of this shoulder, the pressure on 9 and the then exposed seat of the valve is equivalent to the pressure in the same area in chamber 8. When the pressure is resupplied through the auxiliary valve without the shoulder 10, the valve would be balanced, but by exposing 10 to atmospheric pressure only and relieving it of other pressure, the valve is caused to close by an excess of pressure on an equivalent area exposed to the reservoir pressure which has been restored to the chamber 8 as before mentioned. The passage 11 leads from the chamber 8 to the auxiliary valve, through which passage the compressed air passes out into the atmosphere when the auxiliary valve is open, and through which the compressed air re-enters into 8 when the auxiliary valve is again closed; 12 is a supply passage from 2, which is practically part of the reservoir; 13 is a hydraulic packing which prevents the pressure from passing from 8 into the atmosphere through the hole 14, which connects the shoulder space 10 with the atmosphere; for purposes above mentioned 15 is a similar packing, which acts only during the instant of exhaustion of the chamber 8 to prevent pressure from flowing in from the reservoir space 2; 16 is a leather buffer to receive the shoulder 17 of the valve 4 on the opening stroke; 18 is a rubber packing to prevent the passage of the air from the reservoir 2 to the barrel 19; it also prevents the same from 8 to 19; 20 is the buffer seat; 21 the buffer ring; 22 the seat ring; 23 the seat ring bolts; 24 the breech-piece; the breech cover is not shown.

The Auxiliary Valve.—The passage 11 connects the chamber 8 of the main valve with the auxiliary passages 26, 27, 28, 29, 30, and 31, and from a direct communication between the firing reservoir and chamber 8, so that when the valve 32 (usually called the "main auxiliary") is closed as in the position shown, chamber 8 is practically part of the reservoir; so, indeed, is every internal part of the auxiliary valve casings. It will be seen that valve 32 has four external diameters; the largest is at the left of the drawing, and they decrease toward the right, terminating in the part 33. When this valve opens it moves back until the largest face 34 strikes the buffer 35. The part 36 is then between the ports 27 and 29, and as a piston valve cuts off communication between them, at the same time 33 has come all the way out of the contracted opening into which it fits, and has left a free passage between chamber 8 and the atmosphere, through 11, 26, and 27, past the seat 37 and out through 38; 39 is the primary valve, and has its seat on 40. The interior of the casing 41 is so divided that it will be convenient to refer to the chambers as 42 at the right, 43, 44, and 45 at the left. When the valve is on its seat these are all in communication by passages 46 and 47 around the right-hand end of the piece, and through 48, 43, and 49 to 44, also by passages 50, 51, and 52, to chamber 53; 51 is an additional volume to 53, and performs no other office; 43 is also connected by 54 and the passage through the regulator 55 under the pipe 56 to the annulus 30, which constantly contains the reservoir pressure. It will thus be seen that all the pressure parts of all three of the valves are constantly filled with reservoir pressure. It is by exhausting the pressure from certain parts and maintaining it on others, that all of the valves are opened; by restoring the pressure again the valves are closed. This is, however, but partially true of the primary valve 39, inasmuch as that valve must be opened by hand through a part of its stroke. When opened in this way, so far that the chamber 42 is cut off from 48, the pressure can flow out through 47, 46, and 45, past 40 into the atmosphere, reducing the pressure in 42 nearly to that of the atmosphere; the full pressure being maintained in 43 forces 39 open until it strikes 57; 53 is now in communication with the atmosphere through 52, 51, 50, 44, and 45, past 40 and through 58, and is exhausted. The unbalanced pressure on the front or right side of 32 then forces it open and exhausts chamber 8 of the main valve through 11, 26, and 27, past 37, through 38, to the atmosphere, causing the main valve to open and admit the pressure into the gun barrel 19. The valves have now all been opened, but in order not to exhaust the pressure in the reservoir too much they must be closed automatically. To accomplish this a floating stem 59 has been placed between 39 and 32, so that by the opening of 32, 39 is closed to within $\frac{1}{16}$ in. or $\frac{1}{8}$ in. of its seat, far enough to shut off the passage past the seat 40; its momentum then seats it. Valve 32 will now remain open until sufficient pressure in 53 has flowed in through the pipe 56, and through the regulator and the bulb 55 to overcome the opening pressure on the opposite side, when 32 will close. The act of closing again puts 8 into communication with the firing reservoir, when it is refilled, and the main valve 4 is closed, and the act of firing is complete.

The regulator 55 consists of a body with a smooth and true hole, with an opening into one side for the controllable port, and a well-fitted piston having a longitudinal motion past the port. As shown in the drawing, the port is just closed; the appearance is that the piston is screwed down some distance past the port, but the triangular shape of the port causes that appearance.

The first movement of the valve 39, if operated by hand, would be made by the lever 60 and the trip toe 61. The normal position of the trip toe and the lever 60, which is called the firing lever, is that shown on the drawing. To fire the gun the firing rod 64 is moved to the left, advancing 61, which is pivoted on 60, and is held in its position by the spring 63 attached to the pin 65 in the firing lever; this spring holds the trip toe against the stop 62. As 64 moves to the left, the pin 65 moves to the right, and advances more rapidly than does the pivot of the trip toe, and by the time the toe has advanced far enough to allow the valve 39 to receive its motion from the air pressure, as explained, the pin 65 has advanced far enough to change its angularity with the arm of the trip toe; and as the valve flies away from the toe, the tension on the spring causes the toe to fly away from the stop 62, and leaves the way clear for the return of the stem of the valve. The firing lever may be returned to its normal position at any time, as the closing of the valve is independent of its position.

The Pneumatic Transmission.—This consists of two single-acting pistons, whose direction of action

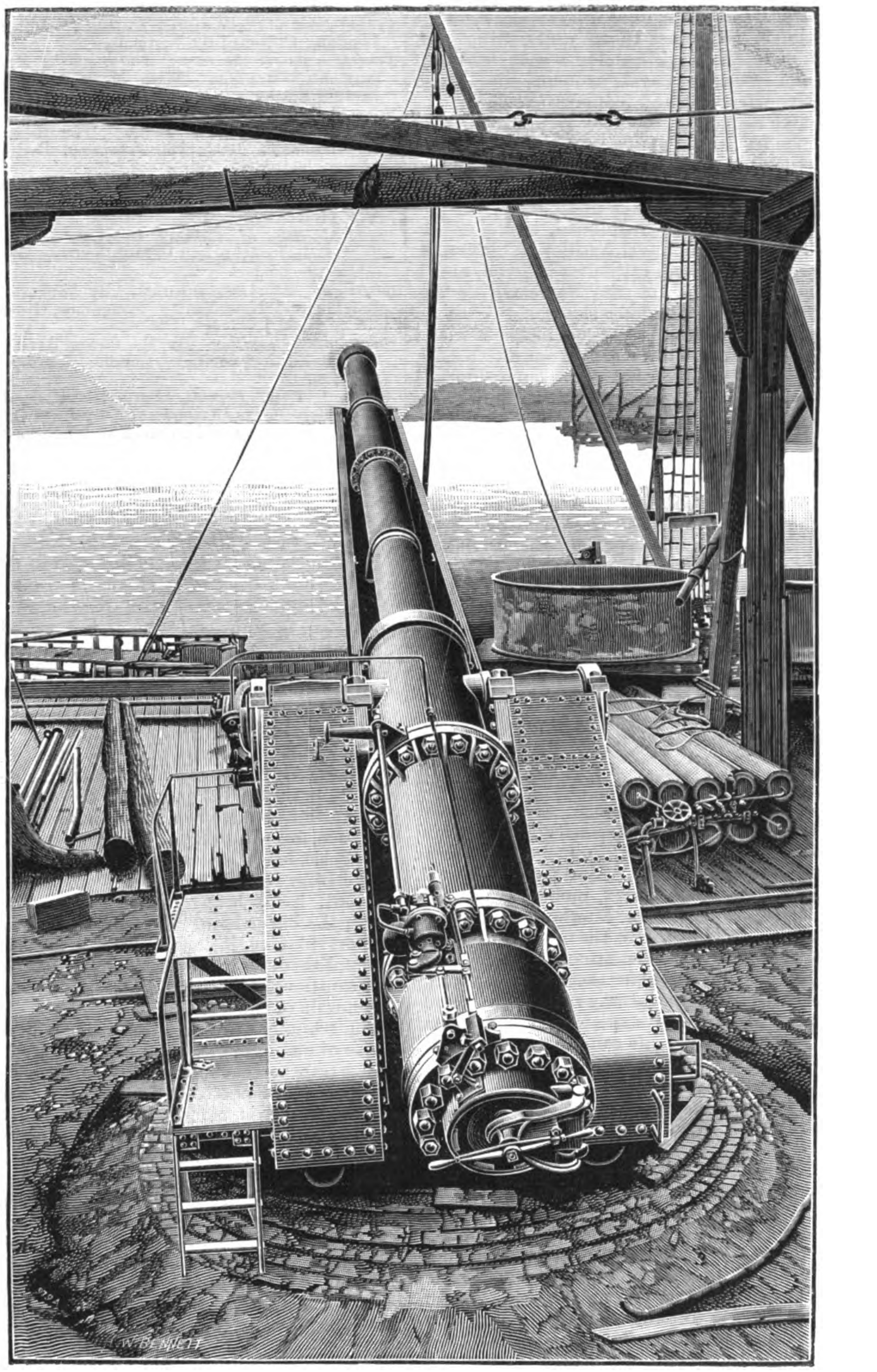


FIG. 358. 15-IN. PNEUMATIC DYNAMITE GUN.

15-INCH PNEUMATIC DYNAMITE GUN.

(For Description, see Page 3.)

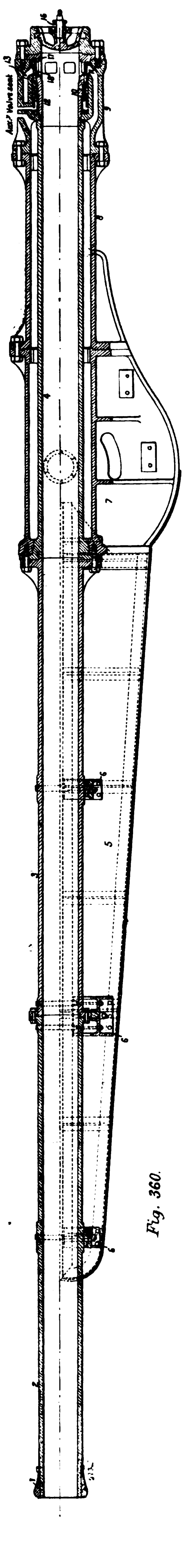
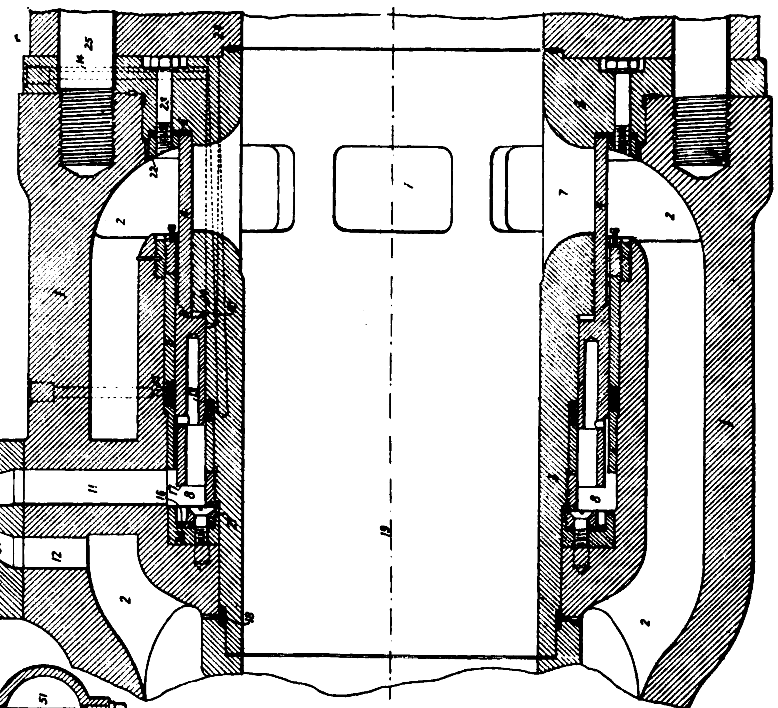


Fig. 360.



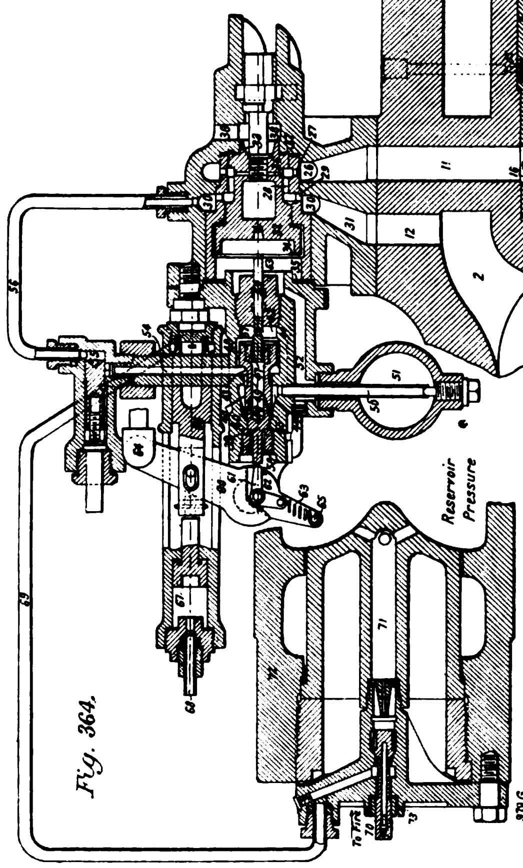


Fig. 364.

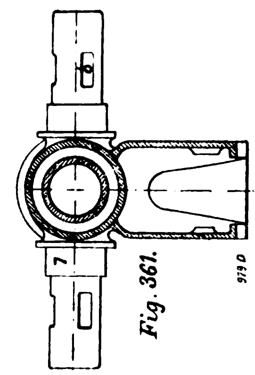


Fig. 361.

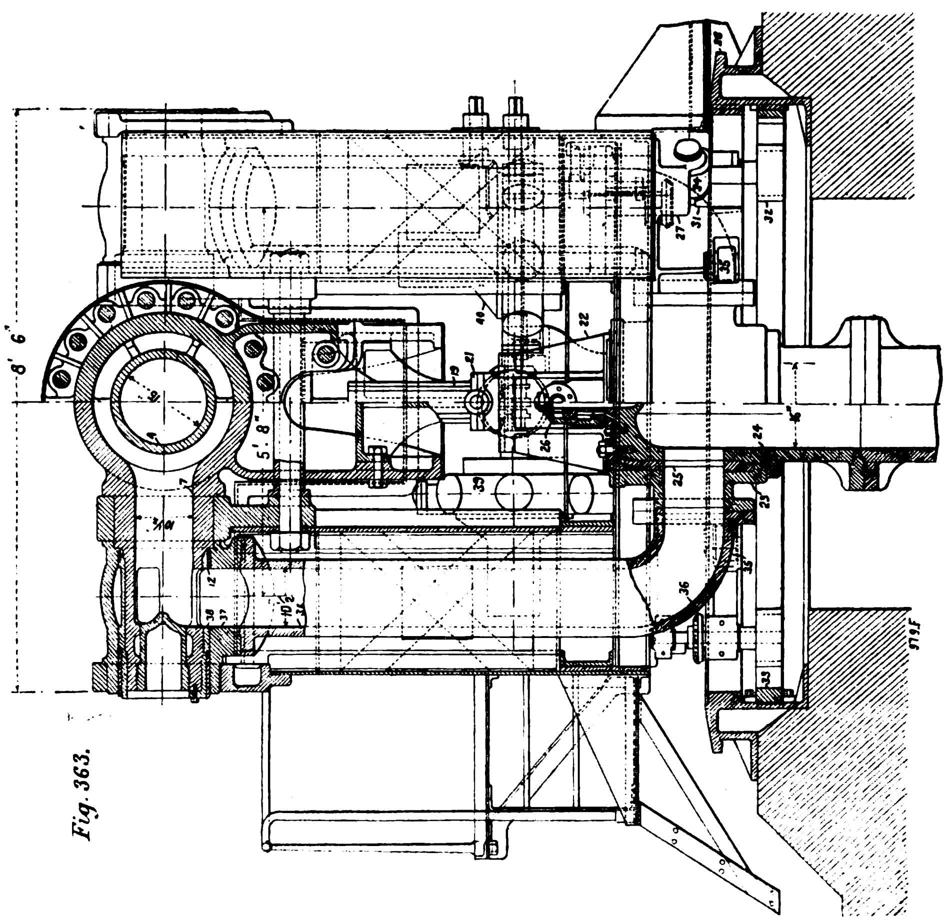


Fig. 363.

15-INCH PNEUMATIC DYNAMITE GUN.

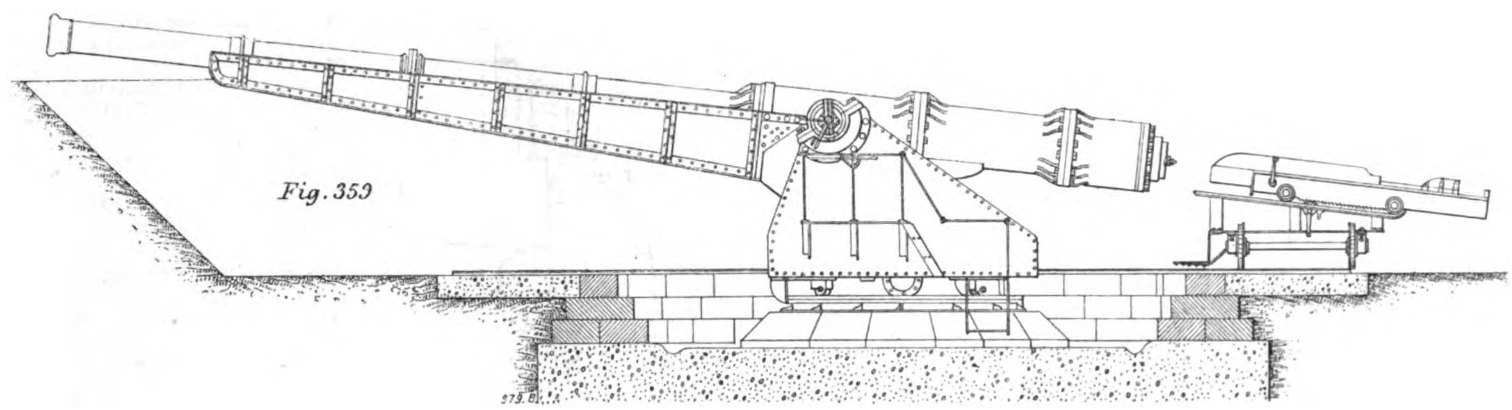


Fig. 359

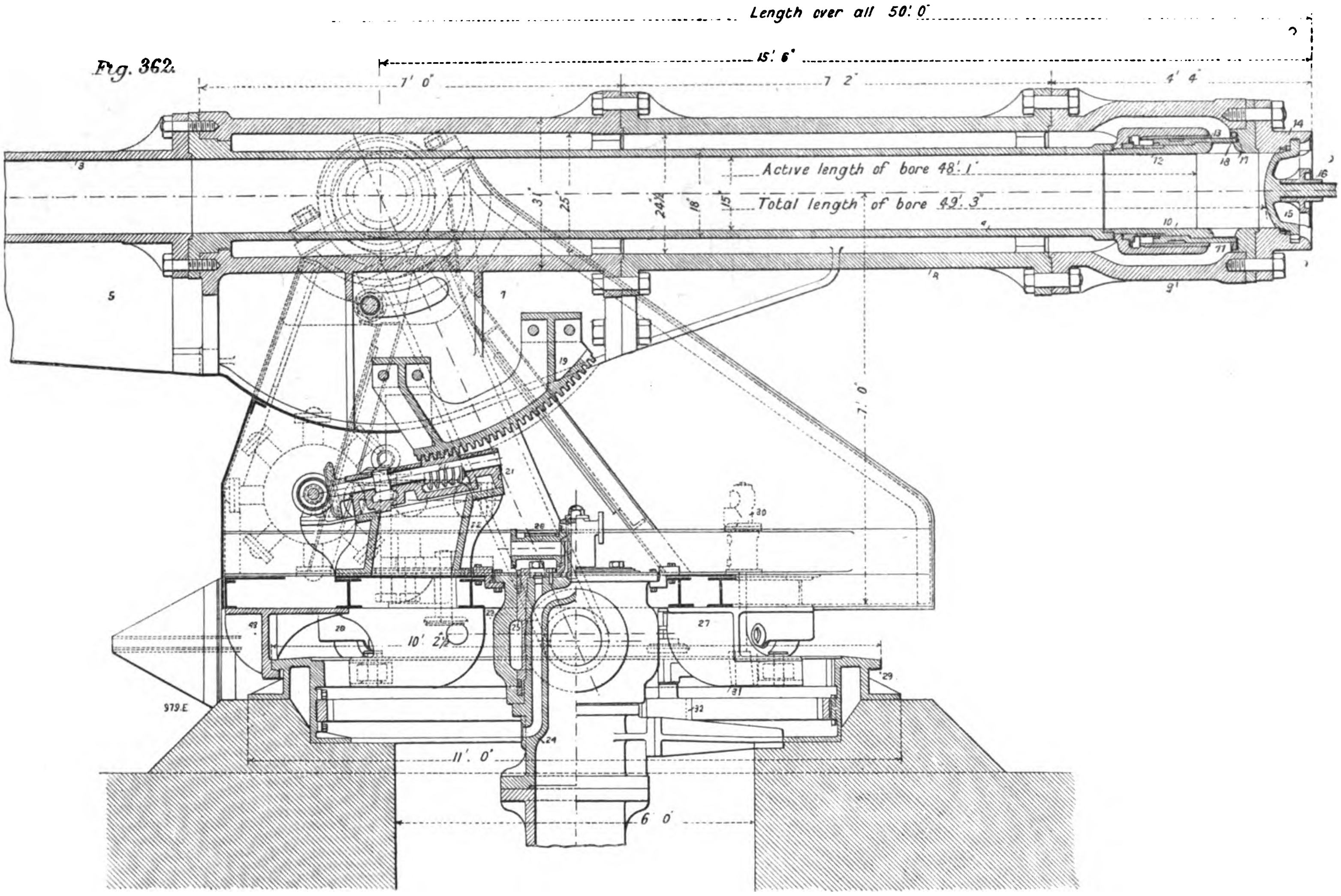


Fig. 362.

is opposed one to the other. They lie in one common axial line, and are shown at 66 and 67; 66 is the larger in diameter, and is under pressure only at the instant of firing; 67 is under constant pressure and of such a size that a similar pressure per square inch on 66 and on 67, will overcome the force on 67, and operate the valve 39 in addition. The duty of 67 is to return 66 to its normal position when the pressure is removed from it; 70 is a stop valve, and is arranged to supply 66 with pressure by forcing it in the direction indicated by the firing handle. It is placed in the left-hand trunnion of the gun 72, and a pipe 69 leads to the operating piston 66. When 70 is on its seat and no pressure is admitted to 66, the cylinder and supply pipe 69 are connected to the atmosphere by 73, so that any leakage through 70 will not put pressure on 67, and so fire the gun at an improper time; when 70 is opened its extended and enlarged stem closes the atmospheric holes 73. The supply for 70 comes through the centre of the trunnion plug from the reservoir pressure within the trunnion.

The reservoir is supplied with compressed air by a compound air compressor. The capacity of the compressor is 350 cubic feet of air per minute (reckoned as amount of air admitted to the intake cylinder). The maximum capability of the compressor is 3000 lb. per square inch. The ordinary working result, steam acting expansively at a mean pressure of 35 lb. per square inch throughout the stroke, is 2000 lb. per square inch, which is the contemplated storage pressure.

The ordinary supply for the storage reservoir, from each compressor, is 2.61 cubic feet of air per minute, or 156 ft. per hour at 2000 lb. per square inch, 312 at 1000 lb., and from both compressors (and with each plant of two guns) 624 cubic feet per hour. It is estimated that there is half a barrel of air lost at each shot, since it is found that there is no commensurate gain in velocity due to a loss of pressure at each shot, beyond that due to the employment of half a barrel length of air. The contract stipulates that the rate of firing must be at least once in three minutes for a projectile charged with 500 lb. of explosive gelatine, or an equivalent bulk of other high explosive, and twice that rate of speed for a projectile charged with 100 lb. of the explosive. In order to load the gun it must be brought to an angle of elevation of 7 deg.

The loading is done as follows. (Figs. 358 and 359.)

A carriage running on a track concentric with the rear ring has its upper surface inclined at an angle of 7 deg., and at such a height that when the gun is in the loading position the axis of the gun and the axis of the projectile on the carriage are in the same straight line. The carriage carries a projectile trolley consisting of a trough mounted on four wheels; and having its upper edges reinforced by angle-irons which extend some distance to the rear. These angles form guides for a crosshead having an extended rammer of sufficient length to push the projectile into its place in the gun. A light extension on the front part of the trough passes into the gun a sufficient distance to cover the valves and allow the projectile to be shoved into its place in the gun without any danger of injury to the valves. Suitable gearing on the carriage is connected by a wire rope to the crosshead on the trolley by passing the loop of the rope over the projectile and placing it in the grooves of the crosshead sheaves.

An inclined track leads from the bomb-proof to a given position outside the carriage track; a trolley with projectile is brought from the bomb-proof, and the carriage is so placed that it is a continuation of that on the incline; the trolley is then run upon the carriage, the rope placed in position in the crosshead sheaves, and the carriage pushed around until the projectile is in the prolongation of the bore of the gun; the breech gate having been previously opened and the gun placed at the loading angle, the carriage advances until it is stopped by a lug which strikes the gate. On turning the cranks the trolley is first advanced and the extension enters the bore until its motion is arrested by a stop; the projectile then advances into place. On reversing the cranks the trolley runs back, the carriage is pushed aside, and the breech is closed. The empty trolley is returned to the bomb-proof for another shell.

This gun is, by contract, required to satisfy the following tests: It must project a shell containing 500 lb. of the explosive to a range of 2000 yards, one containing 200 lb. to a range of 3550 yards, one containing 100 lb. to a range of 4500 yards, and one containing 50 lb. to a range of 5500 yards. Taking a rectangle of 360 ft. in length by 90 ft. in width as a horizontal target, the accuracy of fire must at least fulfil the following requirements: 87 per cent. of hits at 1000 yards, 74 per cent. at 2000 yards, 61 per cent. at 3000 yards, 47 per cent. at 4000 yards, and 35 per cent. at 5000 yards.

GLASGOW CENTRAL RAILWAY.

(*Continued from page* 679, *vol. liii.*)

WE give on page 8 profiles of the Stobcross and Kelvinside contracts (Figs. 29 to 31). They differ in several respects from the two other contracts, with which we dealt in our previous article. In the first place they are for a considerable length away from the public thoroughfares, and where streets or roads are burrowed under or crossed they are not so important nor accommodate such extensive traffic as Argyle-street. As a consequence operations can be more freely carried on, and except at one or two points the contractors have leave to raise the street in parts in order to lay a concrete arch to support the thoroughfare while excavating is proceeding. The subsoil again varies very much, although generally good. The worst subsoil so far met with on any of the contracts is in Stobcross depôt tunnel, and it was almost equally bad at the covered way entering the West End Park. Some idea may be afforded of the changeable character of the ground when we state that eleven variations in section to suit different strata and different modes of construction are in use. We reproduce the principal sections adopted. In streets where the railway is constructed in open cut the sections Figs. 32, 33, and 34 are used, while in the West End Park, Great Western-road, and through the Botanic Gardens, where the railway runs just over the rock, brick arching is sufficient to line the tunnels, and in one or two cases there is only part of an arch, which springs from the rock, as in Kelvingrove-street (Figs. 34 and 38). Concrete is largely used in works of primary importance, and it may be interesting here to note the composition and tests to which it was subjected. The cement was tested chemically, and any sample containing more than 1¼ per cent. of magnesia, or more than 62 per cent. of lime, was rejected. Bricks of concrete made from a mixture of one part of cement to three parts of standard sand had to stand a tensile strain of 180 lb. to the square inch when twenty-eight days old, during the last twenty-seven days of which it required to be submerged in water.

The Stobcross contract was let to Mr. James Young. His resident engineer is Mr. R. Adam, assisted by Mr. James Young, Jun., and Mr. D. McLellan. Beginning with Stobcross-street, it may be noted that the subsoil being mostly clay, it was deemed unnecessary to drive sheet-piling along the whole way, runners being substituted in some parts, driven to a depth of 30 ft. (Fig. 38). The very irregular building line of Stobcross-street rendered necessary the demolition and setting back of many of the buildings, in place of which handsome and substantial structures have been erected by the Improvement Trust. Other buildings near the railway have been successfully underpinned, the foundation in one case having been taken down a depth of 32 ft. The method adopted was practically the same as in Argyle-street, to which we have already referred. Along the greater part of the street the method of constructing the tunnel was by making first a safety arch of concrete to support the street while operations were in progress underground. It may be thus briefly described: One-half of the street was removed, the bottom of the excavation being made to conform to one-half of the arched covering of the tunnel. A layer of concrete 2 ft. 3 in. thick at the crown was laid over the earth usually about 6 ft. from the street level, and was bonded at the sides into rectangular holes or pockets 2 ft. by 2 ft. cut within the sheet piling at intervals of about 4 ft. Under the pockets there was bolted on to the sheet piling a half-timber waling 12 in. by 6 in. with ⅞ in. cleats at intervals of 12 in. to take up the thrust of the arch. The excavating and constructing of the half-arch was done in 12 ft. lengths and generally this distance when in stiff clay was done in about five 10-hour shifts with ten men to each shift, so that the barricade was never opposite any part of Stobcross-street for more than a week. When the street had been thus treated on one side, the roadway being re-made, operations were transferred to the other side, and the other half concrete safety arch put in. The fact that the ends were left very rough provided a sufficiently strong bond between the halves at the crown. The safety arch was 2 ft. 3 in. in thickness at the crown, increasing towards the haunches, where it was 6 ft. One-half is seen over the brickwork in the section on the top left corner of Fig. 33, but the whole construction is shown in Fig. 39, page 9. An artificial support having thus been provided the street was re-laid for ordinary traffic, and excavation was proceeded with under the arch. The concrete arch, however, was left for several weeks to set.

A top heading was first driven, and the section (Fig. 39) shows the method of proceeding. This top heading was advanced in 12-ft. lengths, the time taken being equal to 90 men-hours, and following up were workmen completing the excavation. The central portion of the face was sloped and stepped as shown. The sides were excavated with a plumb face and the part of the "dumpling" kept in position by sheeting and rakers. The extent of the step of the face in the centre and of the timber sheeting at the sides depended upon the nature of the ground. The concrete safety arch was supported by props as shown. This latter timbering was adopted merely as a precautionary measure as the safety arch was supported by the firm catch it had on the sheet piling owing to the pockets having been left in the piling. The side walls with the springers for invert were then built of brick in cement, and the arch thrown, all as shown by the dotted lines in Fig. 39. The props of course were removed as the brickwork advanced. The time occupied to take out a 12-ft. length, including the top heading, was 540 men-hours; without the top heading it was 450 men-hours, *i.e.*, 15 men working 30 hours.

At the western end of Stobcross-street the tunnel opens out gradually in width from 27 ft. to 37 ft. to accommodate the branching off of lines to the new depôt and for the Queen's Docks. It was determined in this case to adopt what is known as the German core system of tunnelling. It is only for about 40 yards long, but it may be interesting to describe it. To have adopted the ordinary method of timber centering would have involved the construction of many different centres for this short length owing to the radii of the arch changing. The side walls were first built of brick in trenches. The trench first sunk was 6 ft. wide, and had piles on one side and 3 in. sheeting on the other, with supporting struts, as shown on Fig. 40. The side wall was built on a foundation of concrete as shown, hard against the piles. This foundation subsequently formed the springer for the invert. The earth was then re-filled between the brickwork and the sheeting. In part of Stobcross-street where no sheet piling was put in, a slightly different method was adopted, as shown on Fig. 41. The spoil being removed from the trench between the sheeting, the lower part of which was driven after the upper part of the trench had been excavated, part of the invert was put in, and the brickwork in side walls and sewer built, after which the spoil was filled in between the walls and the sheeting. The half of the street was then raised, the "dumpling" being dressed with the assistance of light templates to the exact form of the soffit of the arch. The earth was then covered with sarking boards and the brick arching built on these. Up to this point of the whole works the thickness of the arch had not varied from six-ring work, but owing to the greater span of the arch the brickwork was increased in the ratio of two rings to each 10 ft., so that the brickwork at the end of the tunnel is of eight-ring work. When the one part of the work had been done and the street relaid, the other half of the work was undertaken. From the end of the tunnel here the street is carried on a girder bridge extending for a distance of a quarter of a mile. To it we shall refer in a subsequent article.

In this part of the work, for the girders and for the depôt adjoining the Queen's Dock, very extensive retaining walls have been constructed. These are built of masonry on concrete foundations. The minimum thickness is usually about 3 ft., and there is a batter of 1 in 8 in front, while they are stepped at the back. The thickness is usually about one-third the height of the wall, and this maximum extends from the base for at least one-third the height. We give three of the several sections prepared in Figs. 42, 43, and 44, page 9.

At the westermost end of Stobcross-street the railway goes in tunnel for a distance of about 200 yards under the existing depôt for the Queen's Dock. This tunnel is in very bad ground, with running sand, and has had to be driven with care. The driving was carried on from both ends till recently, when one of them, the east end, was stopped owing to the junction of the new Lanarkshire and Dumbartonshire Railway taking place at this point. A bottom heading 6 ft. by 6 ft. was driven from the timbered face shown on Figs. 45 and 46 to assist in draining the overlying wet sand; this heading, being restricted in dimensions, enabled better progress being made, and allowed trucks to run into the face to remove the spoil. It further admitted of the work of excavation to full dimensions being started at a point close to where the junction of the Lanarkshire and Dumbartonshire Railway takes place. The heading required to be heavily timbered as will be seen from the section showing timbering (Fig. 37).

After the heading had been carried foward 80 yards it was decided to timber up the end and proceed with the opening out of the tunnel in the ground through which the first heading had been driven.

At the western end of the tunnel the railway passes under the City and District Railway—the bridge will be described in a subsequent article—and again goes in tunnel. In this case the material is of rock with sand overlying it. The tunnel also goes under a terrace of dwelling-houses—St. Vincent-crescent—of four stories with basement, and with a view to underpinning these houses the contractors have driven towards the houses a drainage heading from a sump 40 ft. deep, close to the City and District Railway. In tunnelling under the buildings, the work in connection with which has been started, four shafts will be sunk, two for each side wall, but on opposite sides of the crescent, as shown on Fig. 48. The bottoms of the shaft will be connected by headings at right angles to and intersecting the main heading which runs from the City and District Railway to the north side of St. Vincent-crescent (Fig. 47). These headings are for the purpose of draining the overlying wet ground. Sections marked on Fig. 47, Nos. 1, 2 and 3, will be in tunnelling driving from the shaft referred to. The spoil being removed, they will be filled up solid with concrete, the concrete of No. 2 being afterwards cut away for the springing of the brick arch as shown. Nos. 4, 5, 6, and 7 will be trenched from the basement floor and filled up with concrete, but the key No. 7 will be put in with brickwork.

Generally fans, driven mechanically or by the air, are used for ventilating tunnels while being excavated, and on this line the mechanical method is adopted where required; but in the case of this St. Vincent-crescent tunnel a simple method has been adopted. A coal fire is placed at the bottom of the shaft through which the excavated material is raised to surface level by a crane, and this fire causes an upward draught from the mouth of the tunnel, while a downward casing of wood passing down the shaft and into the face conveys fresh air forced by atmospheric pressure into the working face, and keeps the air pure. The face on the occasion of our visit was 140 ft. from the shaft, and the simple arrangement was certainly effective.

The railway crosses under Dumbarton-road and along under Kelvingrove-street, where the contractors are at liberty to use the full width of the street, in successive short lengths. They dug a trench wide enough for the building of the whole tunnel, and as they found rock they turned the arch on the rock base as shown on Fig. 38. Further along the street, however, the rock gradually dipped, and it was deterin the British Navy. See ENGINEERING, vol. lii., pages 630 and 710.

Siemens' dynamo type HB $^{15}/_{19}$ coupled to an open vertical engine by Willans and Robinson, with an output of 200 ampères, 120 volts, at 320 revolutions per minute. Many similar sets are in use in the naval service. See ENGINEERING, vol. lii., pages 630 and 710.

Siemens' alternator type W 20, with directly coupled HD $\frac{10}{6\frac{1}{2}}$ exciter, has an output of 500 ampères, 80 volts, at 400 revolutions per minute. It is directly coupled to a Willans' GG engine, and was used for producing the current which, after transformation, was employed in the high tension experiments. It is fully illustrated and described in ENGINEERING, vol. lii., pages 630 and 710.

SIEMENS' APPARATUS FOR TESTING THE MAGNETIC QUALITIES OF IRON.

The principle of the instrument is the reverse of Weber's method of absolute measurement of current. As is well-known Weber employed for this purpose a bifilar electro-dynamometer and the earth's field. If D is the couple of the bifilar suspension, f the effective area of the coil, H the horizontal component of the earth's magnetism, a the angle of deflection, then the current

$$I = \frac{D}{fH} \tan a.$$

If the strength of the current is known, the strength of the field may be determined; or if the instrument has been calibrated for known magnetising currents, when no iron cores are in the solenoids, the effects of introducing iron cores of different permeabilities may be compared.

To carry out the principle practically, the coil of the actual apparatus is provided with a torsion spring in place of a bifilar suspension; though this latter is used in calibrating the instrument in

Fig. 84.

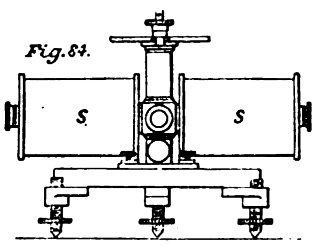
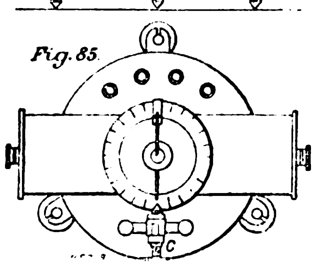
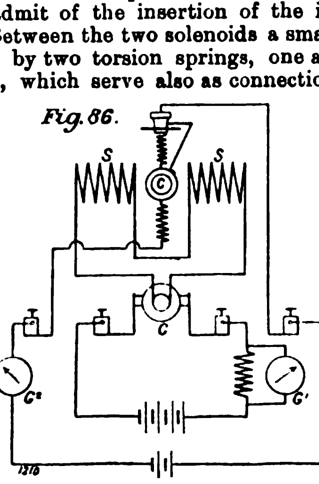


Fig. 85.



C G S units. Fig. 84 is an elevation, and Fig. 85 a plan of the instrument. It consists of two horizontal solenoids S S provided with longitudinal holes to admit of the insertion of the iron test-pieces. Between the two solenoids a small coil is suspended by two torsion springs, one above and one below, which serve also as connections to the

Fig. 86.



coil, the axis of suspension being perpendicular to the common axis of the solenoids. The connections of the field solenoids are so arranged that opposite poles are presented to the suspended coil. If a current traverses this latter, and the magnetic field is at the same time excited, the suspended coil will be rotated and can be brought back to zero by the torsion spring. The angle of torsion is directly proportional to the strength of the magnetic field in which the coil swings; that is, it is proportional to H if there is no iron, and to B (the induction) if there is iron. Hence one obtains the permeability of the iron in question.

The method of connecting up the instrument is shown in the diagram, Fig. 86. A commutator C is provided for reversing the direction of the current in the field solenoids, which is not more than 5 ampères, and can be conveniently measured by a shunted torsion galvanometer G^1, as shown. For the suspended coil c a current of not more than 0.2 ampère is required, and this can be measured by an unshunted torsion galvanometer G^2.

REGULATOR FOR STAGE LIGHTING.

A very interesting portion of Messrs. Siemens' exhibit at the Crystal Palace Exhibition was a model theatre in which the lighting effects were produced by electricity. This model was exhibited at the Frankfort Exhibition, and is illustrative of Messrs. Siemens' system of stage lighting, which is already in use on the Continent.

Mr. F. G. Bailey, in the first instance, and latterly Mr. Le Rossignol, of Messrs. Siemens Brothers, gave daily entertainments in the Pompeian House, where the model theatre was placed. These were eminently successful and showed how easily the operator could, with the apparatus in hand, produce the most beautiful lighting effects.

Fig. 87 is a perspective view of the regulator, which comprises a series of triple switches for footlights, floats, wings, &c., there being one switch for each colour of lamp, viz., white, blue, and red; also a series of regulating resistances, placed in the lower portion of the regulator by means of which the degree of illumination can be varied at will, quickly or slowly, and independently or together, by a single regulating handle with which any set of lights can be connected by spring catches. Thus the regulation of the whole of the lamps on the stage is under the complete control of one operator.

(*To be continued.*)

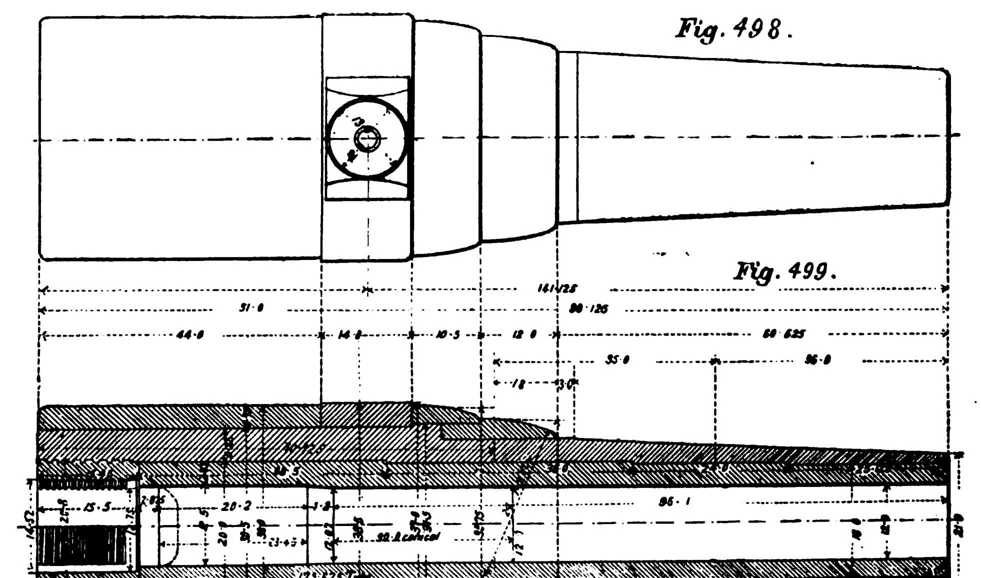
MODERN UNITED STATES ARTILLERY.—No. XXIV.

THE 3.6-IN. BREECHLOADING FIELD MORTAR.

(FIGS. 494 TO 497, PAGE 314.)

AT present in the United States there have been adopted three mortars. One is 3.6 in. in calibre and the other two are 12 in. in calibre.

Fig. 498.



12-IN. BREECHLOADING MORTAR.

The 3.6-in. mortar is a short rifled breechloading piece, which is intended for use in the field to deliver a vertical fire against the *personnel* of an enemy whose troops are protected from the direct fire of the field guns by entrenchments or by the inequalities of the ground. It replaces the Coehorn smooth-bore mortar which was formerly used, and is a much more accurate and powerful piece, besides having a much greater range.

The improvement of the new mortar over the one formerly used will be seen from the following Table:

TABLE XL.—*Old and New American Mortars.*

Mortars	Calibre.	Weight of Piece.	Total Length.	Maximum Powder Charge.	Projectile.	Range.
	in.	lb.	in.	lb.	lb.	yards
Coehorn, smooth bore ..	5.82	164	16.32	0.5	17.75	1200
3.6-in. rifled, steel ..	3.60	244	24.80	1.0	20.00	3500

With the full charge and an angle of elevation of 45 deg. the range of the new mortar is about 2 miles, which will compare favourably with similar mortars in other services.

It is constructed to fire the same projectiles that are used in the 3.6-in. steel field gun, and consequently does not require a specially manufactured projectile. In the field this is an advantage, since it reduces the variety of projectiles that must be carried. The total length of bore is 5.25 calibres, or 18.9 in., and that of the rifling is 14.4 in.

The rifling is uniform, being one turn in 30 calibres, the twist being a right-hand one. There are twenty-four grooves, whose width is 0.3 in. and whose depth is 0.05 in.; the width of the lands is 0.17124 in.

The projectiles that are used in this mortar are both steel and shrapnel. For long ranges the full charge of 1 lb. of powder will be used, while for shorter ranges, in order to preserve the advantage of high-angle fire, reduced charges will be used, the minimum being 3 oz.

The body of the mortar is made of a single piece of forged steel with the trunnions forged solid with the piece; after forging the whole piece is oil-tempered and annealed. The mortar is estimated to stand a pressure of 22,000 lb., though in practice it will be limited to 18,000 lb.

To facilitate the handling, handles are screwed into the trunnions.

The rear sight, which is a V-shaped slotted piece of steel, is screwed to the piece $1\frac{1}{2}$ in. from the breech of the piece, while the front sight, which is a knife-blade, is attached 0.6 in. from the muzzle. A distance of 22.5 in. between the sights is thus obtained.

The breech mechanism is similar to that of the field guns, the vent, however, being axial instead of radial. The lever in the field gun is replaced by a bolt, which is turned by hand. This bolt is connected with a vent cover, which keeps the vent closed until the breech is locked.

Two lever handles attached to the block assist in its rotation and withdrawal.

The first carriage used consisted of reinforced steel check-plates, riveted and bolted to wooden sole-pieces, which were slotted with sheet metal and rested on a platform. The carriage, which is 39.5 in. in length, places the trunnions at a height of 14 in. above the ground. It is so constructed as to allow the mortar to be fired at all angles of elevation between 0 deg. and 60 deg. Its weight is 260 lb.

A second carriage for this mortar, similar to the first, has the frame transoms and soles cast in one piece of steel. It is somewhat shorter than the first carriage, being 36 in. in length.

The type mortar was tested by firing 714 rounds, 518 of which being with full charges. At the completion of the test the piece and carriage were subjected to a rigid examination and were found to be practically uninjured; fifty consecutive shots were fired from the mortar in 56 minutes and 25 seconds, including a delay of 3 minutes and 10 seconds to repair the platform.

TABLE XLI.—*Ballistic Particulars of the 3.6-In. Steel Field Mortar.*

Calibre	3.6 in.
Weight	250 lb.
Total length	24.6 in.
Length of bore...	52.5 calibres.
Twist in number of calibres	30
Number of grooves	24
Width ,, ,, ...	0.3 in.
Depth ,, ,, ...	0.05 ,,
Width of lands	0.17124 in.
Powder chamber { Length	3.9 in.
Powder chamber { Diameter...	3.8 ,,
Weight of powder charge	1 lb.
,, projectile	20 ,,
Ratio of weight { of charge to weight of projectile ...	1 lb. to 20 lb.
Ratio of weight { of projectile to weight of piece	1 lb. to 12.5 lb.
Initial velocity	650 ft.
Muzzle energy { Total	58.57 ft.-tons.
Muzzle energy { Per ton of gun	524.7 ,,
Muzzle energy { Per pound of powder ...	58.6 ,,

Charge. oz.	Elevation. degrees.	Mean Range. yards.
3	15	321.3
5	15	533.9
8	15	887.5
11	15	1216 5
16	15	1993.1
16	25	2709 3
16	30	3000.3
16	35	3082.5
16	40	4164.1
16	45	3281.4
		Greatest Range.
16	45	3413 yards.

12-IN. BREECHLOADING SEA-COAST MORTARS. (FIGS. 498 TO 502.)

There are two types of mortars adopted for the defence of the the United States coast. Both of the mortars are 12 in. in calibre; one is built up entirely of steel, while the other consists of a cast-iron body, and has shrunk on this body steel hoops.

THE 12-IN. BREECHLOADING MORTAR (STEEL).

This piece is 141.125 in. in length, and weighs 13 tons. It is composed of one tube, one jacket, two C hoops, one D hoop, three A hoops, one base ring, one copper packing ring, breech mechanism.

The tube is enveloped by the jacket and the two C hoops which cover it entirely to the muzzle.

The tube is inserted in the jacket from the rear in a manner similar to the 8-in. breechloading rifles. A shoulder on the jacket abuts against a corresponding shoulder on the tube. The C hoops are assembled from the front and cover the tube for a distance of 71 in. Each hoop is stepped on its interior and have plain abutting joints. By means of the three steps on the tube it is reduced in thickness from 3.75 in. over the powder chamber to 3 in. at the muzzle.

In rear of the tube is a copper packing ring. The base ring is screwed into the jacket, and is forced under heavy pressure tightly against the packing ring. The base ring is held in place and prevented from unscrewing by means of three coupling pins, which are halved into the jacket and base ring. On its interior surface the base ring carries the slotted screw thread to receive the breech-block.

The D hoop is assembled from the front. It abuts against a shoulder on the jacket and covers the joint between the jacket and C_1 hoop.

The A hoops are assembled from the rear. The A hoop covers the joint between the D hoop and jacket. The other hoops envelop the jacket, A_2 being the trunnion hoop.

At the rear end of the tube is the gas-check seat, its length being 2.875 in. The powder chamber is 12.5 in. in diameter and 20.2 in. in length, measured from the front of the obturator when the breech-block is closed. The chamber and rifling are connected by a conical slope 4.2 in. long, whose front part forms the seat for the band of the projectile. The rifling is made conical for a distance of 30 in., the diameter in rear being 12.07 in., and in front 12 in.

12-IN. BREECHLOADING MORTAR, CAST-IRON BODY, STEEL HOOPED. (FIGS. 500 TO 502).

The body of this mortar was cast on the Rodman principle, viz., the bore was cooled first by means of running water being forced in it while the exterior was kept liquid by having fires built around it.

Upon the breech of this cast-iron body is shrunk a row of 7 A hoops, and outside of the A hoops, are shrunk a row of 6 B hoops.

The slotted screw for the breech mechanism is cut in the body of the mortar.

One of the cast-iron mortars has been lined with a steel tube, and the erosion by the powder gases thereby much lessened.

Breech Mechanism.—The two mortars are fitted with the same breech mechanism, which is entirely different from that of the other guns. The general shape of the block, exterior and interior, the obturator, pad, friction washers, and locking-nuts are very similar to those of the guns previously described.

The difference between this block and those previously described lies in the rotating device. This consists of a face-plate or banjo, which is attached to the rear face of the breech-block by means of five screw-bolts and a transverse dovetailed slot. This plate in its general shape is a circular disc of steel, with an arm extending in the direction of the radius for the purpose of carrying the mechanism for rotating the block. This arm gives to the plate the general shape of a banjo from whence it derives its name. The central portion of the banjo is bored out to the same diameter as the cavity in the breech-block, which contains the obturating spindle and nuts, and is given the same taper so as to form a continuous opening with that of the block.

The end of the radial arm of the banjo is mortised, and contains two journals. The lower journal in the mortise carries a pinion, and on its rear end the rotating crank, which is held in position by a looking-bolt.

The upper journal in the mortise carries a large pinion which gears into the lower one. This upper journal projects in front of the arm and carries a small gear, whose teeth, when the block is closed, engage in the teeth of a rack bolted to the outer rear face of the breech.

The rotation of the crank through this gearing transmits the motion to the rack and causes the arm, and necessarily the block also, to revolve. The vent-closer works in a slot in the arm, and necessarily revolves with the block. In addition to this motion it can move in the direction of the radius. On the upper end of the vent-closer is a stud which projects into a groove in the base-ring. This groove is concentric with the axis of the block, except at its right-hand end, where it is eccentric, and of a greater radius than the rest of the groove. Just as the block is locked the stud on the vent-closer enters this portion of the groove, causing the vent-closer to move out radially and uncover the vent. The translating device is the same as that of the other guns. The rifling of the two mortars is a semi-cubic parabola, one turn in 40 calibres at the origin, one turn in 20 calibres at 17.10 in. from muzzle, uniform to muzzle.

TABLE XLII.—*Ballistic Data of the 12-in. Sea-Coast B 4 Mortars.*

		12-In. Steel.	12-In. Cast-Iron, Steel Hooped.
Calibre	in.	12	12
Weight	tons	13	14.25
Total length	ft.	11.7	10.75
Length of bore ...	calibres	10	9
Twist in number of calibres ... ... { breech		40	9
Twist in number of calibres ... ... { muzzle		20	9
Number of grooves		72	68
Width of ,, ...	in.	373	379
Depth of ,, ...	,,	.07	.07
Width of lands	,,	.15	.175
Powder chamber { length	,,	20	15.57
Powder chamber { diameter	,,	12.5	12.4
Density of loading		1.05	1.13
Weight of powder ...	lb.	100	80
,, projectile ...	,,	800	630
Ratio of weight { of charge to projectile		1 to 8	1 to 7.8
Ratio of weight { of projectile to piece...		1 to 56.4	1 ,, 50.6
Initial velocity	ft.	1150	1152
Muzzle energy ft.-tons { total		7334.2	5795.6
Muzzle energy ft.-tons { per ton of gun... ...		564.1	406.7
Muzzle energy ft.-tons { ,, pound of powder...		73.34	72.4

We append (see Fig. 503) a perspective view of a 12-in. Armstrong mortar and carriage to give a general idea of the points of similarity and difference between the American and English weapons of this class.

THE BRITISH ASSOCIATION.

(*Continued from page* 291.)

ELECTRICAL DISCHARGES.

PROFESSOR E. WIEDEMANN, of Erlangen, gave a wonderfully condensed account of experiments on discharge phenomena in vacuum tubes, which he has been studying together with Dr. Ebert. The general arrangement was the following: Plates were placed opposite the conductors of an influence machine without any india-rubber parts; wires up to 40 metres long led from those plates to condenser plates, near or between which tubes filled with rarefied gases were held. An adjustable bridge across these wires was found useful in rendering oscillations, of low pitch as a rule, but up to a million a second, more regular. Very many forms of tubes have been used, some coated inside with silver or platinum, hollow cylinders with gauze ends, glass bulbs, &c. If a larger and a smaller tube are approached, the larger acts like a match for the smaller, causing the red positive and blue negative glow to appear; if a smaller ring tube is inside a larger ring, dark spaces form in the outer ring near the pole ends, these spaces increase and reach the inner tube, which then lights up. In a cylinder with gauze ends the blue replaced the red; on higher exhaustion the whole tube glowed white, and became dark finally; the negative effect is frequently more lasting. Professor Wiedemann did not claim any vacua higher than half a millimetre. His view is that the dark spaces and the protection offered by outer tubes, &c., are due, not to those parts being non-conductive, but to absorption of the oscillations. The discussion dealt with this and Professor Schuster's paper referred to in our last issue. Mr. Crookes had noticed that long vacuum tubes filled with oxygen would not brighten up on approach to Tesla coils, if previously kept in the dark, until gently rubbed. The reason was given by Professor von Helmholtz, who stood up for Volta and Faraday, and perhaps disappointed the section for a moment by explaining in a homely, old-fashioned way, frictional electricity and the Volta couple as contact effects, instead of soaring into transcendental heights. The invisible gas film which adheres to the surface of glass tubes, too thin to display Newton's colours, plays a very important part, inasmuch as it prevents true contact. A little mercury in a partially exhausted tube becomes electrified by the slightest motion, as we know from Torricelli's vacuum, and now from Mr. Crookes'. When the tube is at rest, the electrification disperses, glass not being a perfect insulator. The effect of these invisible air films Professor von Helmholtz noticed in an unpleasant manner when determining the resistance of mercury resistance-units. They raise the resistance. Closer contact and a smaller resistance is realised by filling after exhaustion; and from resistance measurements he derived that such films have a thickness of $\frac{1}{100}$ of a wave length. If a drop of petroleum is introduced into the tube, which in itself would, of course, increase the resistance, the lowest resistance values are obtained, the oil removing the air film. Lord Kelvin quoted another example of the force of such small electrifications. Mr. Bottomley could make a little pendulum swing for sixteen hours inside an exhausted bulb; but if the lead ball once touched the glass the motion stopped.

STABILITY OF PERIODIC MOTION.

The mathematics of this contribution to the kinetic theory of gases have kept Lord Kelvin, P.R.S., busy for over a year. If a particle is free to roll in a perfectly smooth trough, it can be projected in a straight line along the bottom of the trough. If dropped from one edge it will oscillate up and down the sides, this motion not interfering with any longitudinal motion imparted to it. If, however, the trough is not perfectly even instability will arise. Examples would be furnished by a ball of iron projected over a line of horizontally arranged magnets, not exactly in the line of the magnets; or a ray of light passing zig-zag through a row of lenses. Under certain conditions periodic motion can be stable, as Lord Kelvin illustrated. The support of a rigid pendulum capable of swinging in a vertical plane was, by means of a crank, moved up and down at an increasing rate; for certain values of the vertical motion the pendulum was stable, at intermediate values it jerked dangerously. A simpler illustration occurred to Lord Kelvin when Professor Osborne Reynolds handled a pointer; he annexed it and balanced it by moving it up and down. Professor Reynolds has made experiments of a similar character. A shaft rotating at various speeds and loads became stable for certain values of speed and load, whilst at lower or higher speeds tremors shook the bearings; if the shaft was properly protected by a guard ring, stability was again obtained at a certain higher speed. Professor von Helmholtz referred to meteorology. When hotter and colder strata of air are moving above one another, the motion may cause condensation in the stratum saturated with moisture. This might account for the formation of the mackerel sky. We could also calculate the point at which the waves of water, originally at rest beneath the moving atmosphere, and rising higher and higher, would finally become unstable and break.

The Specific Conductivity of Thin Films.

Professors Reinold and Rücker have continued their beautiful experiments on soap films, from which several years ago they derived an estimate of the size of molecules. In pure soap-water films the specific electrical conductivity increases the thinner the films become, the lowest resistance value obtained in the case of a film of 22 micro-millimetres being only one-seventh of that of an ordinary film. The authors are inclined to ascribe this effect to the breaking down of molecular continuity produced by the extreme tenuity of the films, which in this state appear black. The thinness of the film hardly affects the specific conductivity if the soap-water contains glycerine and a little metallic salt, nitrate of potash.

The Theory of the Perfect Influence Machine.

Mr. J. Gray, of Glasgow University, has constructed and tested influence machines according to Maxwell's ideal machine, in which equiquantic and equipotential lines must form the cycle of Carnot's heat engine. Sparking at the contacts which the carrier makes at the charging and discharging points, would always cause losses apart from avoidable leakage. To eliminate these, Maxwell caused the carrier to make contact with the charging and discharging springs when the carrier is of the same potential as the spring; and he effected this by prolonging the contact springs of the discharging conductors to meet the carrier. For the charging conductor this was deemed insufficient, and he devised special "regenerators." These Mr. Gray finds, however, less efficient than the prolonged springs. The paper is essentially a theoretical study, like his other paper on "Slow Oscillations from Condensers of Great Capacity."

Mr. Magnus MacLean, M.A., of Glasgow University, contributed two papers, "Sources of Heat Generated in the Galvanic Battery," and jointly with Mr. A. Galt, "Some Experiments with a Ruhmkorff Coil." The latter is based upon the following considerations: The "make" and the "break" in a primary circuit induce equal quantities of electricity in the complete secondary circuit. If there is a gap, however, the break impulse is stronger than the make impulse in the opposite direction. The authors are measuring the different quantities of electricity set in motion by means of a copper electrolytic cell in circuit with a vacuum tube, and the secondary coil of a small Ruhmkorff.

Electric Conductivity in the Magnetic Field.

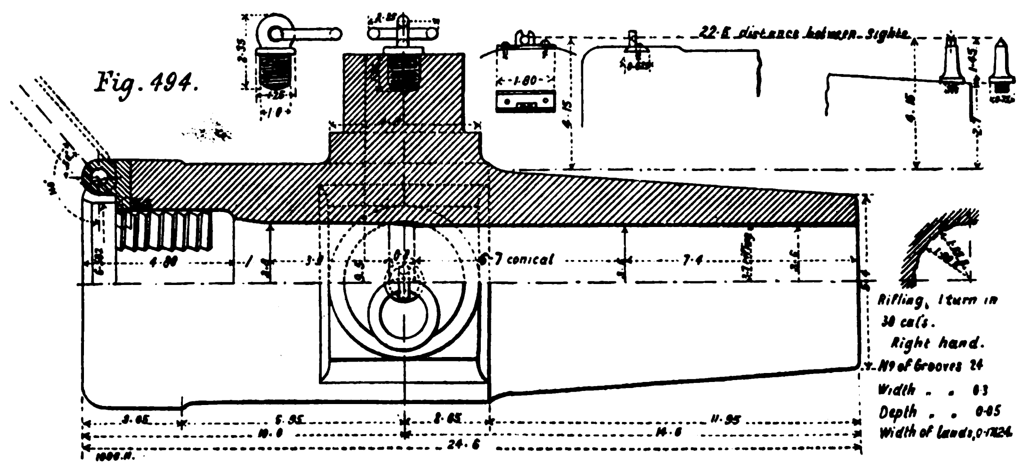
Dr. Peddie has continued the researches of Goldhammer and Righi on the conductivity of copper and bismuth in the magnetic field, using stronger fields. As regards bismuth the author confirms Righi; the resistance increases, first slowly, then more rapidly, and again more slowly with increasing magnetisation, so that there is a very distinct resemblance between the resistance and the magnetisation curve. The resistance of copper he found the same in all fields, and he does not confirm Goldhammer as to the connection between these effects and the Hall effect.

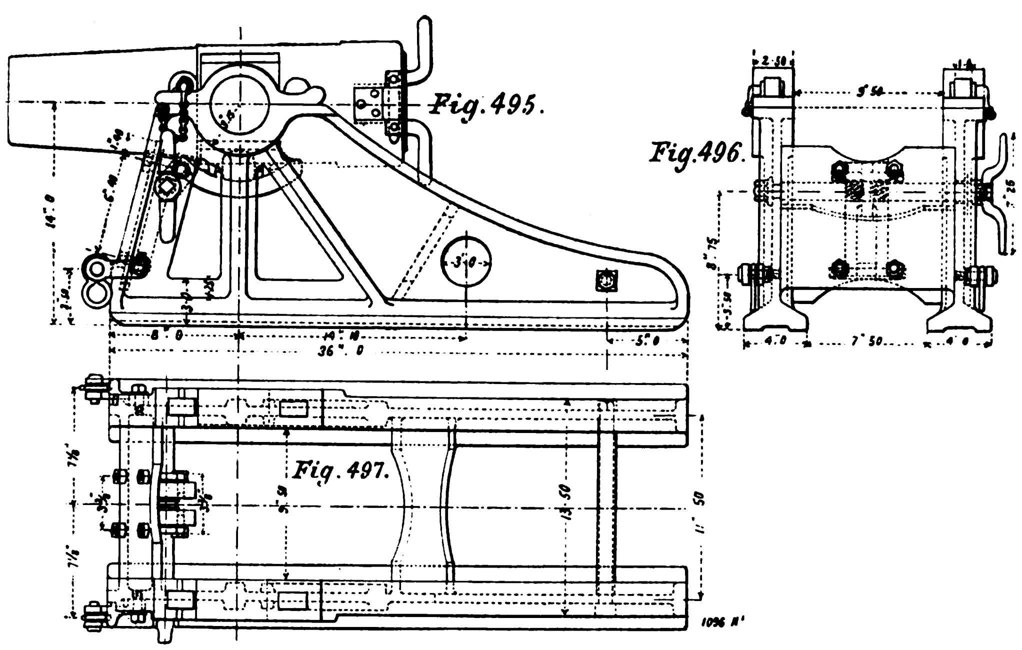
The Interference Method for Spectroscopic Analysis.

This paper, by Professor Michelson, of Chicago

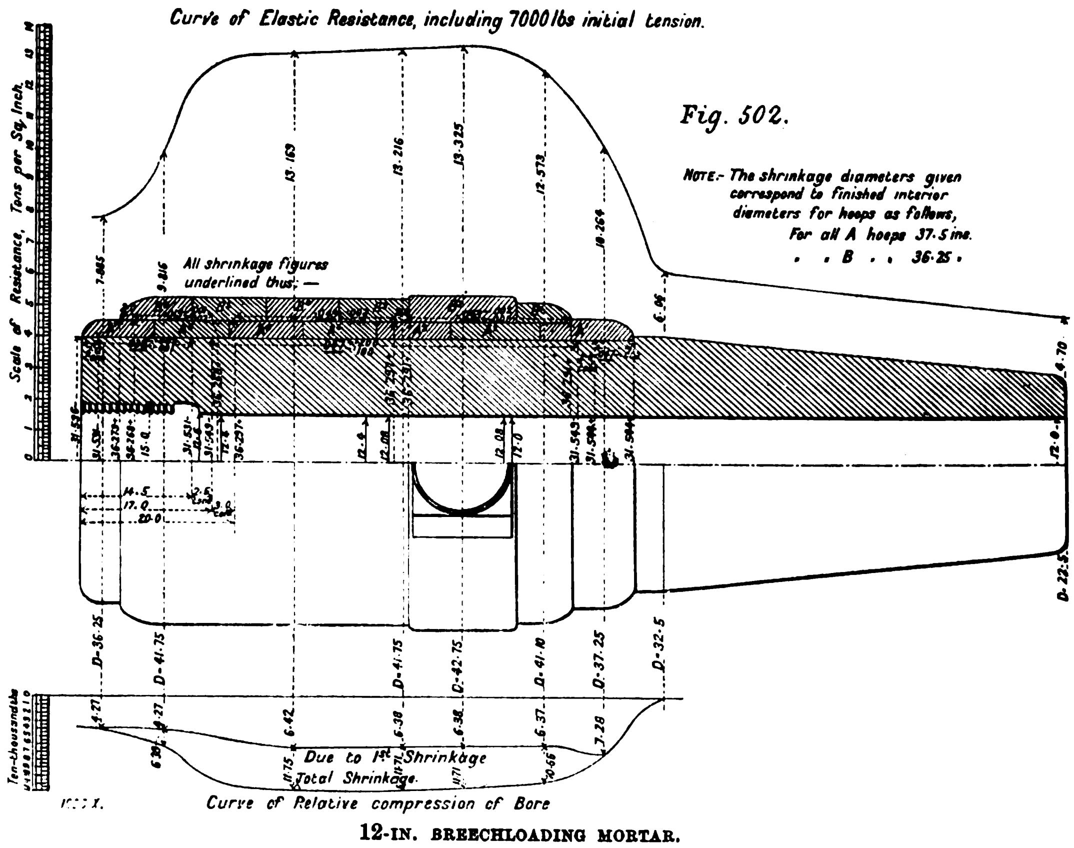
MODERN UNITED STATES ARTILLERY.

(For Description, see Page 312.)





3.6-in. Breechloading Mortar and Mounting.



12-in. Breechloading Mortar.

MODERN UNITED STATES ARTILLERY: BREECHLOADING MORTARS.

(*For Description, see Page 312.*)

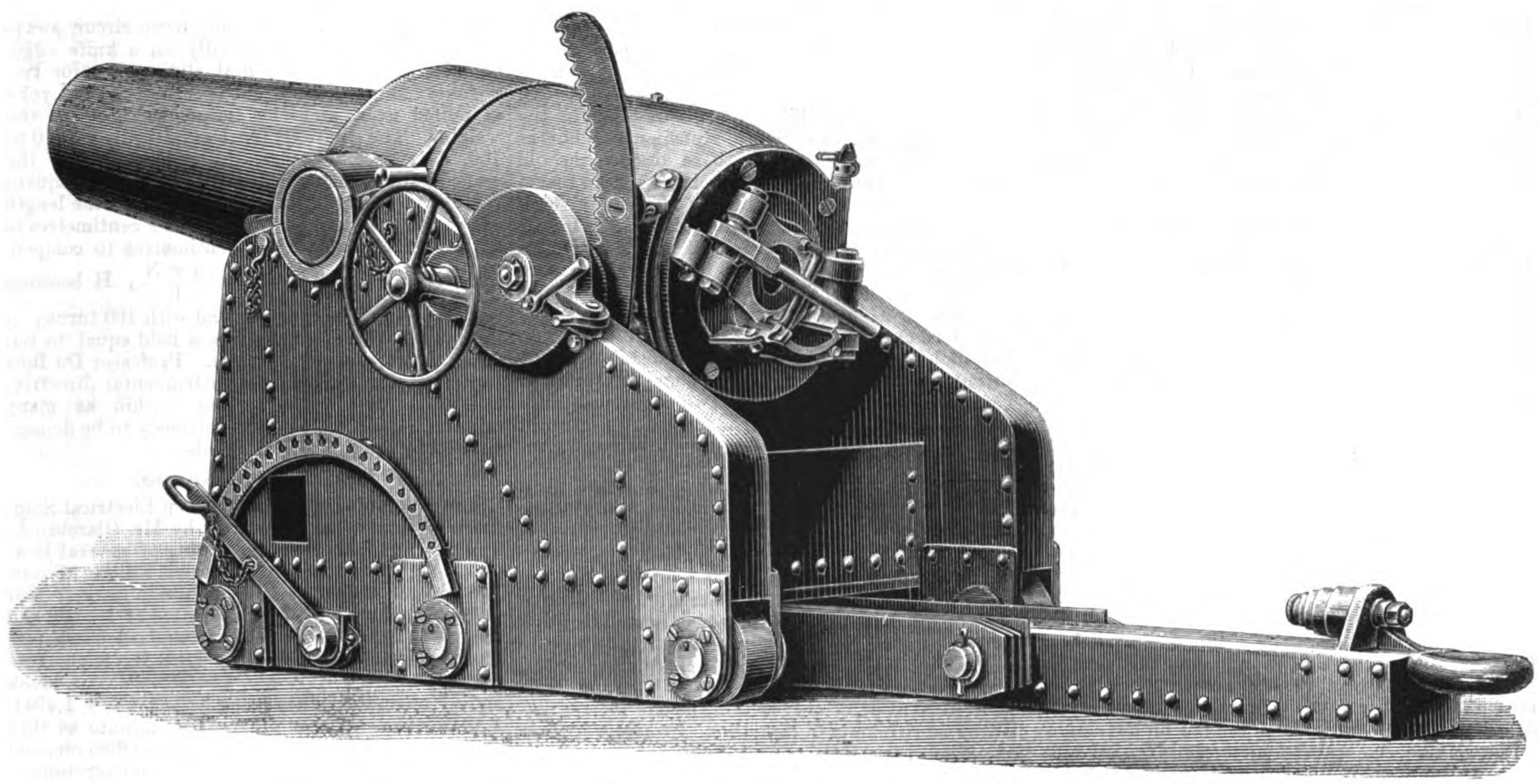
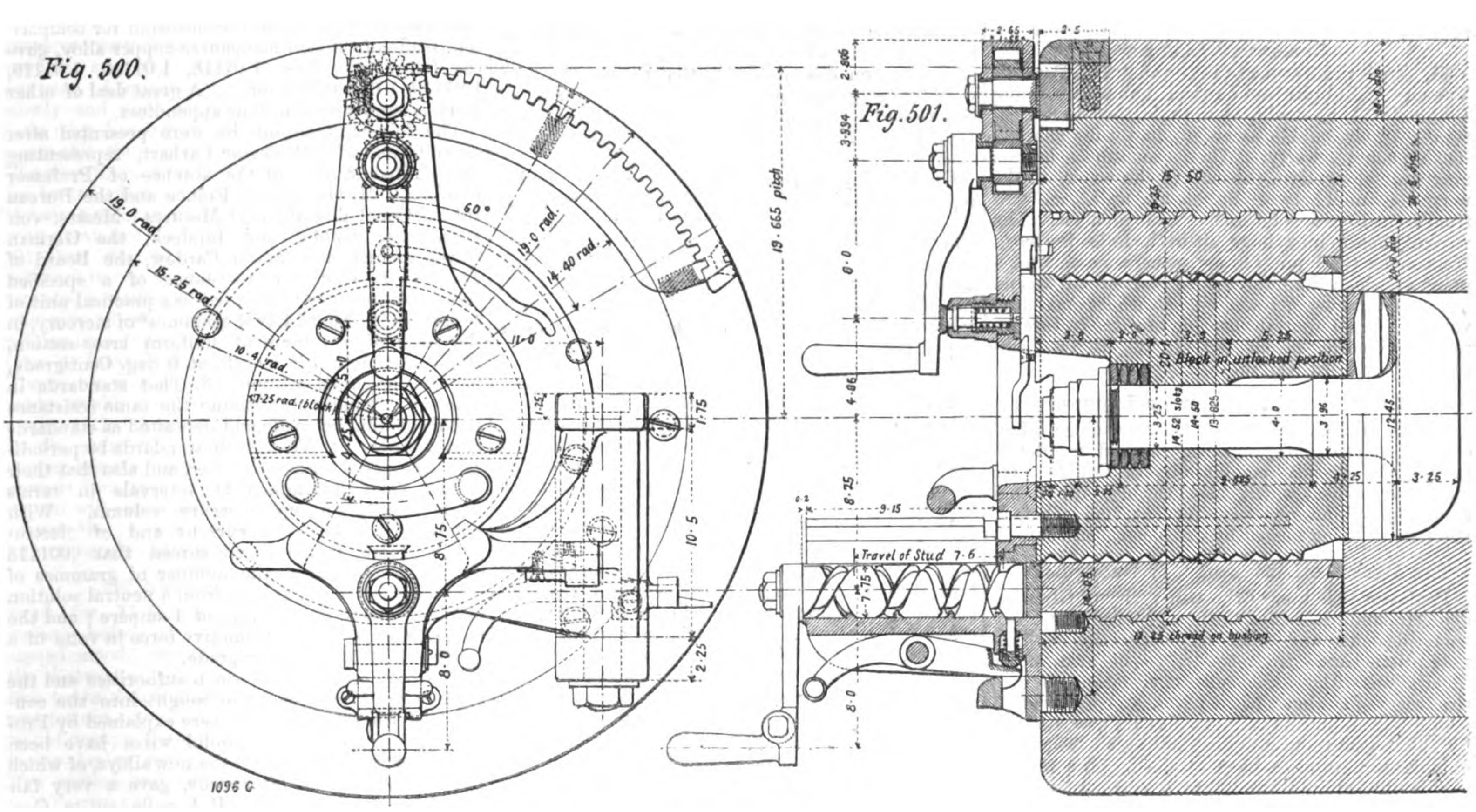


FIG. 503. 12-IN. BREECHLOADING MORTAR AND MOUNT; SIR WM. ARMSTRONG AND CO., NEWCASTLE-ON-TYNE.



BREECH MECHANISM FOR 12-IN. AMERICAN MORTAR.

University, was characterised by Professor Schuster as the most important contribution brought before the meeting. By means of the ordinary methods for producing dispersion, we can separate lines whose distance apart does not exceed one-fiftieth of the distance between the two sodium lines. Beyond that we could only go with enormous and impracticable gratings. Professor Michelson superposes the light vibrations from two or more sources in different phases, having traversed different paths, and traces the intensity curve of the resultant light, the "visibility curve" for different phases and various sources of light. The mathematical analysis of these curves discloses the nature of the source of light. The visibility curves are traced experimentally, a polariscope with a quartz lens, consisting of a plano-convex and a plano-concave lens, cut respectively parallel and vertical to the axis, serving for intensity comparisons by the eye. The interference fringes are produced by means of a refractometer with two parallel thick glass plates and mirrors for reflecting the light back, and are examined by means of a telescope. The substance under examination is in a vacuum tube fitted for heating, compressing, and electrical discharges. The apparatus, the "wave compiler," was shown and explained. In the case of the two sodium lines, we have two sources of light of different refrangibility producing periodic variations in the fringes. If then such fringes appear, we have to deal with a double source of light; and similarly Professor Michelson proves a light to be triple and quadruple. His observations confirm what has long been suspected, that perhaps all our simple lines are in reality double, triple, or more complex still. The components are often extremely close to one

MODERN UNITED STATES ARTILLERY: THE WATERVLIET ARSENAL.

(*For Description, see Page 377.*)

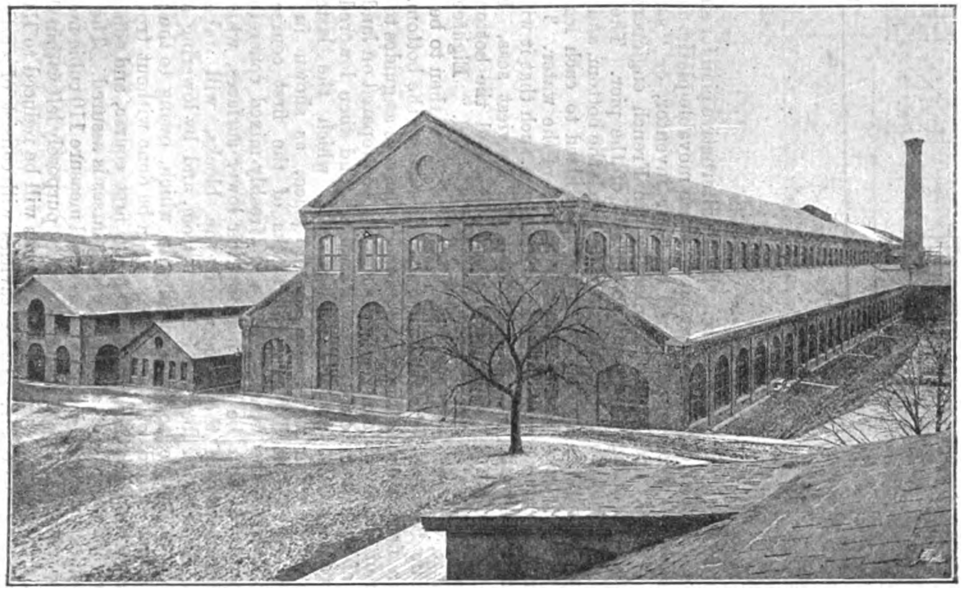


Fig. 504. The gun-shops, Watervliet Arsenal.

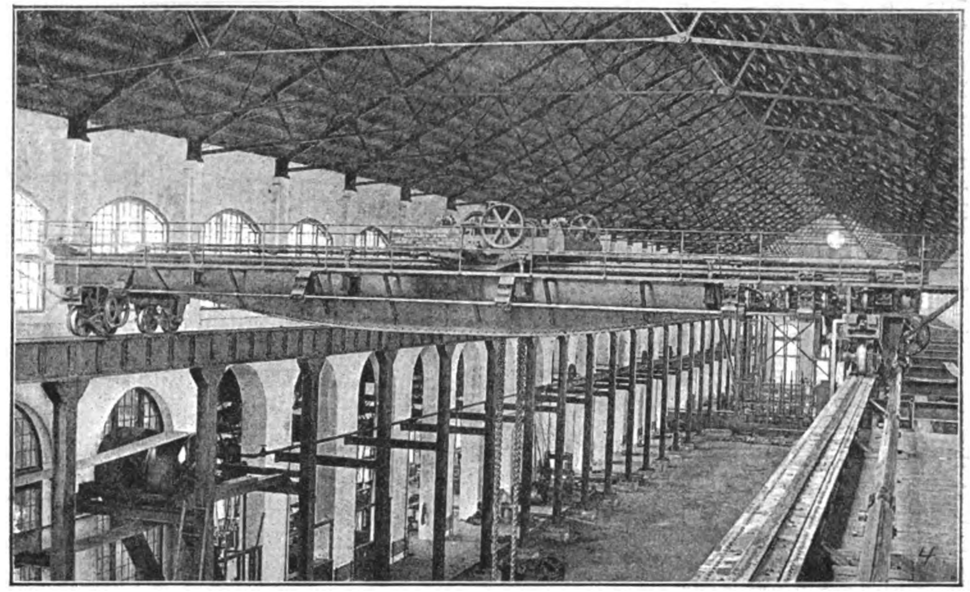


Fig. 506. Travelling crane in new gun-shop.

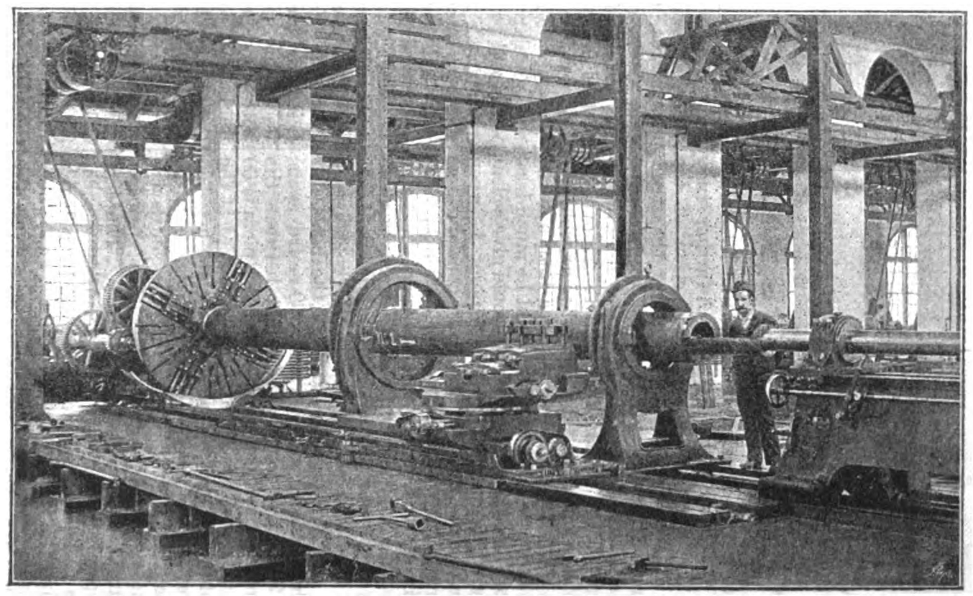


Fig. 505. 12-in. gun tube in lathe.

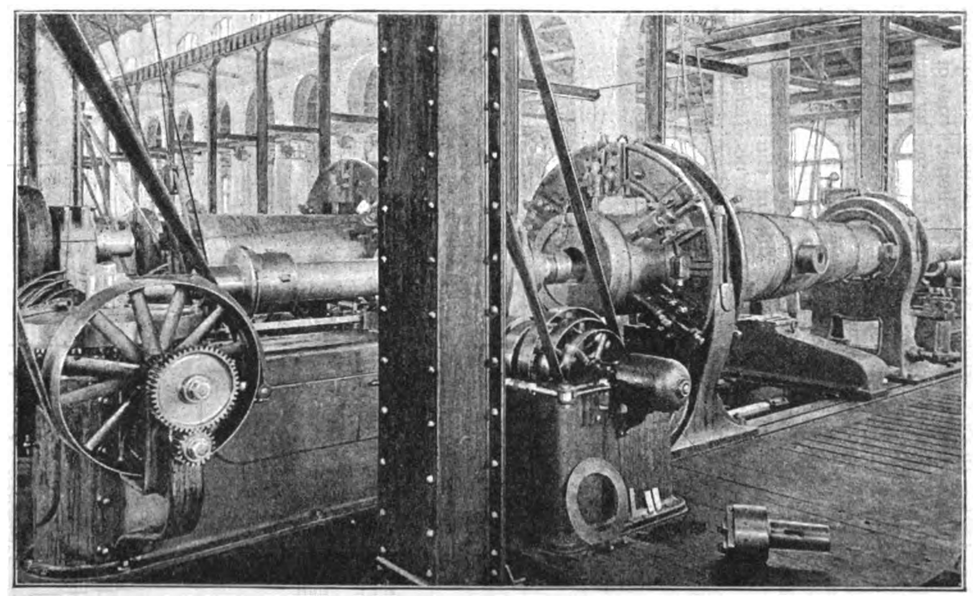


Fig. 507. Threading and slotting machines.

MODERN UNITED STATES ARTILLERY: THE WATERVLIET ARSENAL.

(*For Description, see Page 377.*)

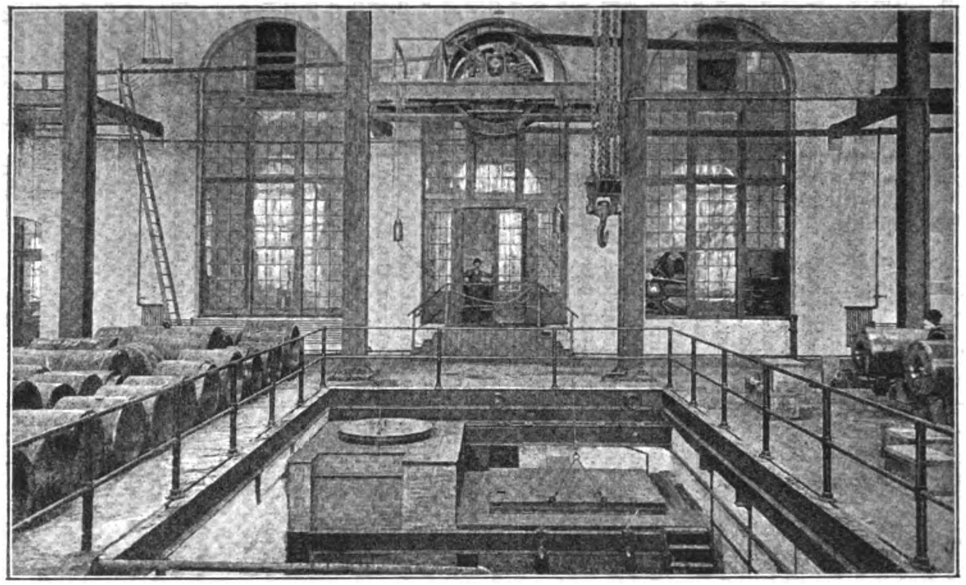


FIG. 508. SHRINKAGE PIT AND FURNACE.

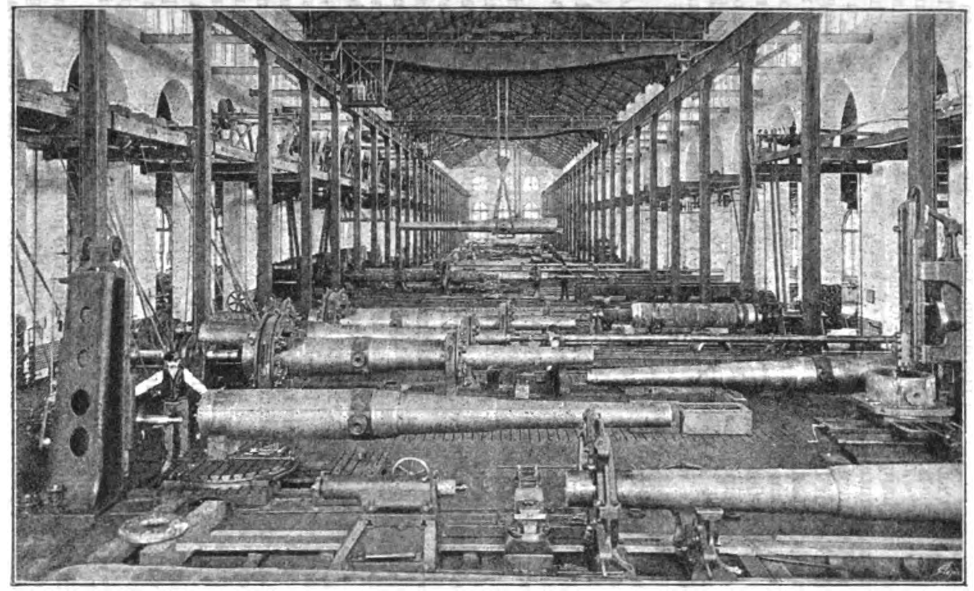


FIG. 510. INTERIOR OF NEW GUN-SHOP.

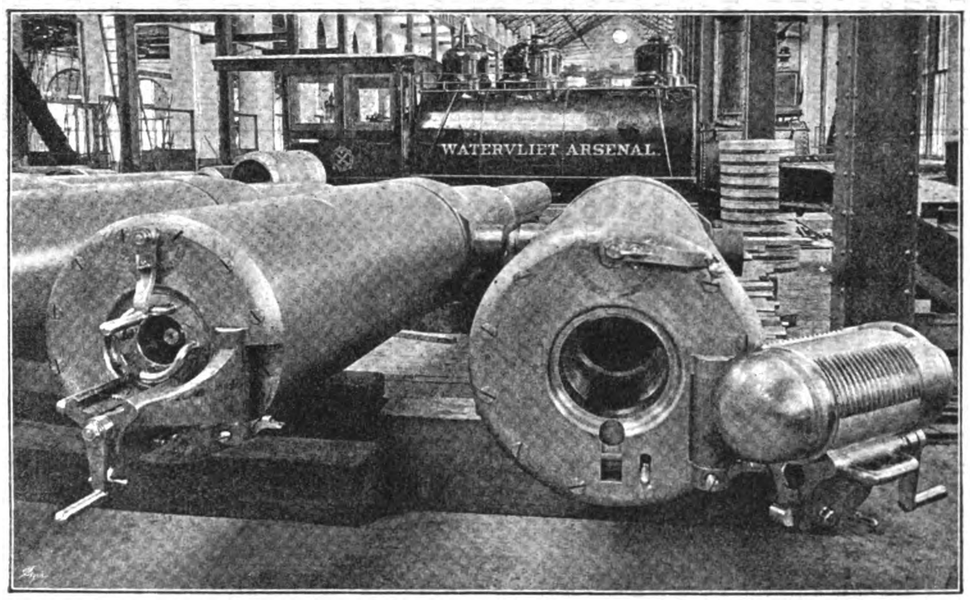


FIG. 509. 8-IN. GUNS READY FOR SHIPMENT.

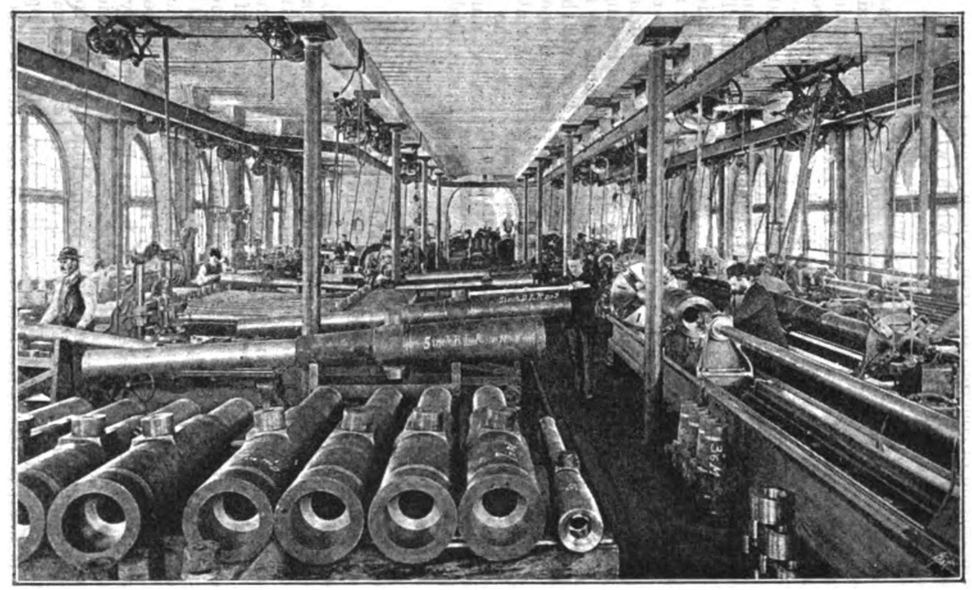


FIG. 511. INTERIOR OF OLD GUN-SHOP.

one beneath it. By subsequently filling the wells thus formed with concrete the thorough binding of the work is assured. There will thus be formed a veritable caisson of concrete and iron, which, when completed, will be filled with stone, which will afterwards be grouted up into a solid mass. The upper part of the pier will be capped with a solid layer of concrete faced with granite, as shown in Fig. 3.

It is also proposed to use the saddles for erecting the spans. Owing to the construction adopted, the building-out system cannot be employed, and hence these massive saddles will be used to take the place of ordinary false work, as indicated in Figs. 1 and 2.

As regards the commercial prospects of the bridge, the promoters claim that it would be possible with suitable terminal arrangements to despatch one train every quarter of an hour from each end, or 192 trains in the 24 hours, which would give an annual traffic of 1,400,000 passengers and of 21,120,000 tons of freight. They do not, however, anticipate anything like so dense a traffic. Indeed, the total annual movement of goods and passengers between England and the Continent in both directions is at present only 700,000 passengers and 43,000,000 tons of goods. As regards the former item, they consider that the bridge would greatly stimulate passenger traffic, and that a total of 1,000,000 passengers of all classes could be relied upon, and would very likely be exceeded. If the fares were not fixed too high, this estimate is probably not extravagant, and in the tunnel inquiry before the House of Commons Mr. Oakley estimated that the passenger traffic between England and France would be doubled in five years and tripled in fifteen. The average fare for the million passengers is put down at 14.50 francs, or about 11s. 7d., which would correspond to about 5.9d. per mile. This is a high fare, but probably, not sufficiently so to check the development of the traffic at all seriously.

As regards the merchandise only, a proportion of the present tonnage could be relied upon to cross the bridge. The promoters claim, however, that it is not the commerce between France and England alone that will contribute to the bridge, but that a certain amount of the traffic in high-priced goods between England and the whole of the Continent will also pass the bridge. The total traffic between all the countries of Europe and England is about 40 to 45 millions of tons, taking one year with another. Of this total two-thirds represent a value of 430 million francs, whilst the remaining one-third represents a value of 7653 million francs, and it is this latter portion only that can be relied upon to contribute to the revenue of the bridge. The point upon which opinions will differ, however, is as to what proportion of this should be taken in making estimate. It is certain that the whole of even the most valuable goods will not cross the bridge, since for many countries the sea route is so much more direct, that the bridge route would be out of the question. The promoters reckon on 5,000,000 tons from all sources, of which 4,000,000 tons will be goods having an average value of upwards of 38*l*. a ton, the remainder being lower-priced goods coming from, or going to, the immediate neighbourhood of the bridge. This traffic is nearly equal to that of the Great Northern and the Lancashire and Yorkshire Railways, which serve manufacturing and mining districts, and is about ten times that of the London, Chatham, and Dover Railway Company. This total of 5,000,000 is made up as follows:

	Tons.
Grande vitesse, comprising goods worth more than 5000 francs per ton... ...	= 600,000
Petite vitesse, 1st class, of an average value of 1230 francs per ton	= 700,000
Petite vitesse, 2nd class, of an average value of 400 francs per ton	=1,400,000
Petite vitesse, 3rd class, of an average value of 236 francs per ton	= 700,000
Petite vitesse, 4th class, of an average value of 103 francs per ton	=1,600,000

On these data for goods and passengers the promoters make the following estimate of the revenue of the bridge.

	Quantity.	Rate. f. c.	Amount. francs
Passengers	1,000,000	14 50	14,500,000
Goods, grande vitesse	600,000	39 50	23,700,000
,, petite ,, 1st class	700,000	18 00	12,600,000
Goods, petite vitesse, 2nd class	1,400,000	15 00	21,000,000
Goods, petite vitesse, 3rd class	700,000	12 00	8,400,000
Goods, petite vitesse, 4th class	1,600,000	10 00	16,000,000
			96,200,000
Total ...			=3,848,000*l*.

At the same time, very considerable exchanges of gold and silver take place between this country and the Continent, and from these and subventions from railroad companies who would benefit by the construction of the bridge, it is estimated that another 80,000*l*. could be obtained, making the total estimated revenue equal to 3,928,000*l*. per annum. The estimated cost of constructing the bridge being 32,740,000*l*., the interest, at 5 per cent. per annum, would take 1,637,000*l*., which, with cost of maintenance, working expenses, &c., would, it is estimated, be brought up to 2,000,000*l*., thus leaving a surplus of nearly as much again for increasing the dividends paid or for reducing tariffs. It would thus appear that the enterprise would pay even if the revenue of the company was only one-half of that estimated by the promoters. We have given the basis of this estimate above, and our readers must judge for themselves to what extent this is likely to be in excess of the actual receipts.

LITERATURE.

Die Elektrische Schweissung und Löthung. By Etienne de Fodor. Vienna: A. Hartleben.

Mr. Etienne de Fodor, Director of the Central Electric Station at Athens, is the author of several volumes of Hartleben's Electro-Technical Library, amongst them those on estimates for electric lighting plants, the incandescence light, electric motors, and electric meters. Some of these have already been noticed in our columns. The volume before us is probably the first treatise on a branch of applied science which, though hardly ten years old, already displays remarkable vigour. Mr. de Fodor offers an able summary of what has become known about electric welding and soldering. He describes well, his language is free from cheap generalisations, and his criticism seems fair and to the point. Some features, however, suggest pressure of time. The arrangement is not faultless; occasionally the important feature of an innovation is added in a foot-note, which look like an editorial afterthought. This circumstance may also explain the "we" in which the author speaks. Suggestions of his own are quoted in the third person. Mr. Fodor distinguishes welding proper, union by fusion and soldering; further, as sub-groups, other processes in which the electric current does not act directly, forging by means of the arc, within heated conductors, or, lastly, by rapidly alternating the magnetic polarity within the iron to be operated upon. Before proceeding to a general discussion Mr. Fodor then abstracts variations of the ordinary welding process proposed by Mr. Coffin. Mr. Coffin is, as yet, in this field at any rate, chiefly known as a fertile patentee. The patents in question would belong to the various divisions of Mr. Fodor—this may be an excuse for their being mentioned in this place.

The general advantages offered by the electric welding processes are then pointed out in moderate language. The cost should at present not be too closely inquired into. A special welding plant must manifestly be expensive. Under these circumstances the practice ascribed to the Thomson Welding Companies should have been explained more fully. They require, we are told, a deposit on apparatus supplied, and make a charge based upon the number of welds effected as registered by the apparatus itself, and the economy realised upon former practice.

Theory proper is disposed of in two pages. The relations between temperature and resistance of metals are explained by the aid of the researches of Dr. J. Hopkinson, and particularly of M. Le Chatelier. The editor forgot, however, to mark the names of the respective metals under the resistance curves of Dr. Hopkinson, and quotes specific resistances in units of the British Association. The chapter on experiments and tests relies upon Sir Frederick Bramwell, Mr. Fish, Professors A. B. W. Kennedy and S. P. Thompson, and Mr. Kirkaldy. Why another chapter on changes in structure consequent upon welding is not added here we do not know. These experiments and the chapters on current distribution, dynamos and tranformers, and welding apparatus concern almost exclusively the Thomson process, and we find hardly any other names but those of Mr. Elihu Thomson and of his able fellow-worker, Mr. Hermann Lemp, one of Mr. Edison's assistants of the early days of Menlo Park. Towards the end of this chapter only we meet the name of Mr. Coffin, whose conductor heads are to answer for any section of bars, and who claims to have welded almost everything; for instance, iron to copper. Mr. Coffin also figures foremost among those who wish to avoid oxidation by operating in a partial vacuum, or in a compressed gas chamber, or even under water. The combined and indirect welding processes aim at raising the resistance of the weld, in order not to be compelled to work with very large currents; currents of 100,000 ampères have been spoken of. Here Mr. Dewey is introduced, who welds in the magnetic field or employs a special magnetising coil with laminated core for rapidly alternating currents. Dr. Coffin has similar plans; he also interposes a bad conductor, afterwards to be withdrawn. This idea seems first to have occurred to Mr. H. Bassler, who coated the ends with graphite. Mr. Coffin further uses the arc playing upon the weld and electrically in series with the weld. Coffin, Powler, and Dewey recommend, also, heating from the outside, even by gas, a rather retrograde step. Elihu Thomson emphasises that the heating should proceed from the inside.

The next division on fusion confines itself to union by fusion; electric furnaces and crucibles must be left to other books. The fusion process, practically the Benardos process, would at first sight appear to be superior to the welding process. It can manage pieces of any size and shape and does not require costly apparatus nor enormous currents. For its roughest form any arc light circuit might suffice. But the regulation of the arc is a very difficult matter. Hence the necessity of special accumulators which do not mind a rough discharge, and of special switches. Benardos originally made the metal plate the negative pole, and thus hoped to prevent all oxidation and burning, the carbon pencil being the positive pole. Unfortunately the negative pole does not become hot enough; at least not in air (the opposite seems to apply in a vacuum), so that this supposed advantage had to be abandoned. It is to be regretted that the accounts about the Benardos process are so contradictory. The system has perhaps not had a fair, sufficient trial. In cases of emergency and on boardship, for instance, the process might do excellent service. Mr. Fodor publishes a table of reports from four Russian works—the Kolomna Iron Works, and the Wladikawkaf, Waronesch, and Orel-Vitebok railroads. The metals dealt with were iron, steel and copper, while the parts were plates, valves, Westinghouse brake gear, axles, &c. Irregularities in the welds, and affection of the eyes of the men, at first seem to be frequent; the four verdicts are—unsatisfactory, satisfactory, on the whole satisfactory, very satisfactory. The last verdict comes from the Roslavel Works of the Orel-Vitebok Railway. The utilisation of the magnetic blowpipe, lengthening and deflecting the arc by magnets, is claimed by Benardos, Coffin, and Zerener. The principle involved was perfectly understood by Davy, and the researches of Quet, Jamin, Werdermann, and others might be consulted in case of patent litigation. The electric soldering has been studied by Benardos, Carpenter, Coffin, and Mener; also by Fodor, who uses a wheel of German silver and an intermittent current. The next chapter—electric forging—mentions the forge of Dewey, pulverised carbon, the anvil of Thomson and of Burton, of the Boston Electric Forging Company, and others. In the small arms and rifle factories at St. Etienne steel springs are tempered by means of the current, one man making 2400 springs a day.

The chapter on "Various Applications" requiring special apparatus, shows that the electrical metal-working has a great future. Wires and cables are soldered, the Western Union Telegraph Company preferring such wires; chains, wheels, hoops, supplied; long tubes, tubular coils made of short ends; plates are riveted, or only perforated, and the fused metal dropped into the hole (Benardos and Lloyd and Howard); tin boxes soldered; sheet metal stamped, dies made, tools mended and joined together, band saws welded, &c. Mr. Ries designs a special plant for welding rails up to lengths of 1000 ft., for whatever purpose that may be; Lieutenant Wood, of the United States navy, makes projectiles out of two or three pieces; others supply cartridges; the wires for Crogier guns are welded; iron vessels and casks for petroleum, acids, ether, &c., are manufactured by the Benardos process at Schwelm; the Roger's Typograph Company in Cleveland weld brass and steel bars, 800 a day; and so on. As regards the direct welding of sheet copper to copper tubes little has only been done. To encourage such work, Mr. Fodor adds a chapter on the adaptability of metals for welding operations. They all seem to be suited, gold, silver, platinum, and especially also nickel fluxes are required for metals and alloys, whose oxides would not melt at welding temperature. An appendix gives a translation of the experiments of M. Bullard on the welding of wires and wire ropes, including locked ropes. This part is not illustrated. There are altogether 138 diagrams for the 236 duodecimo pages.

BOOKS RECEIVED.

The Locomotive Engine and its Development. By CLEMENT E. STRETTON. With numerous Illustrations. London: Crosby Lockwood and Son.

Transactions of the Seventh International Congress of Hygiene and Demography. Section VII.—Engineering in Relation to Hygiene. Edited by C. E. SHELLY, M.A., M.D. London: Eyre and Spottiswoode. [Price 2s. 6d.]

The Compass. A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen, and Students. Vol. I., 1891-92. Edited by WILLIAM COX. New York: Keuffel and Esser Company.

The Gas and Water Companies' Directory, 1892. Edited by CHARLES W. HASTINGS. London: Hazell, Watson, and Viney, Limited.

The Engineering Telegraph Code. By A. H. BLACKBURN, M.I. Mech. E., and JAMES STEVENS, M.I. Mech. E. London: 9, Fenchurch Avenue, E.C. [Price 40s.]

The Comparative Merits of Various Systems of Car Lighting. By A. M. WELLINGTON, W. B. D. PENNIMAN, and CHARLES WHITING BAKER. With 77 Illustrations and Complete Index. New York: Engineering News Publishing Company.

Advanced Building Construction, a Manual for Students. By the author of "Notes on Building Construction." London and New York: Longmans, Green, and Co. [Price 4s. 6d.]

The Construction of Pump Details. By PHILIP R. BJORLING. With 278 Illustrations. London: E. and F. N. Spon. New York: Spon and Chamberlain.

A Treatise Relative to the Testing of Water Wheels and Machinery. By JAMES EMERSON. Fourth Edition. Willimansett, Mass., U.S.A.: Published by the Author. [Price 1 dol.]

MODERN UNITED STATES ARTILLERY.—No. XXV.

THE NATIONAL GUN FACTORY.

(FIGS. 504 TO 511.)

THE National Army Gun Factory, of the United States, is situated at Watervliet Arsenal, West Troy, New York. The grounds contain 109 acres of land, and on the east have a frontage of 1600 ft. on the Hudson River, 800 ft. of which is a stone wharf. The Hudson at the arsenal is 700 ft. wide and of sufficient depth to allow any of the river boats to come alongside of the wharf. To the west the grounds extend 1700 ft.; to the Erie Canal, about 600 ft. from the river, and to within 200 ft. of the Delaware and Hudson Railroad, gradually narrowing so that the western portion of the grounds is triangular in shape. The grounds are inclosed by a solid stone wall 8 ft. high, except along that portion of the east line that fronts on the Watervliet turnpike, where there is a high iron picket fence, thus affording a fine view of the arsenal grounds. The Erie Canal runs through the grounds from north to south and is spanned by three bridges, one being a new iron railroad bridge.

The transportation facilities by both rail and water are unsurpassed. By means of the Hudson River the ocean is readily reached; the Erie and Champlain canals afford water transportation north and west, and the several railroads near at hand provide transportation to any part of the United States. A track has been laid in the grounds, connecting on the west with the Delaware and Hudson Railroad, and on the east, running from the gun-shop across the canal to the dock on the river, where a 60-ton crane readily transfers the guns from the cars to the vessels.

Previous to the establishment of the gun factory at Watervliet, all of the shops were on the east side of the Erie Canal, the water of which furnished the motive power required. They are well adapted for the manufacture of caissons and limbers, other equipments, implements, ordnance stores, and leather work, the construction of which is carried on extensively at present. The officers' quarters, soldiers' barracks, hospital, and storehouses are located on the west of the canal.

In February, 1884 a board of officers was appointed by the President to inquire into the question of establishing a Government gun factory. The board recommended the establishment of two gun factories and selected Watervliet as the site for the army gun factory, and Washington, D.C., as the site for the navy gun factory. It was some time before an appropriation could be obtained from Congress, but in 1887 the manufacture of breechloading steel field guns was begun. A lumber shed on the ground, west of the canal, was transformed into a gun-shop, and with limited facilities the work was begun. After it was decided to establish a large gun factory, an appropriation for 350,000 dols. was made for the building, and 750,000 dols. for machinery and equipments for the manufacture of large guns.

Operations commenced on the north wing in order to get it in working order. This wing is 400 ft. in length and 128 ft. in width. The central section is 165 ft. long, and the south wing, which is at present nearly completed, is 400 ft. long and 158 ft. wide, so that the total length of the factory is 965 ft. The north wing and central section were completed, and the manufacture of guns was commenced in them during November, 1890, although none of the large lathes had been delivered at that time. At present there are, in the north wing, six large lathes each 98 ft. long, together with a large number of smaller lathes, boring mills, drills, slotting and milling machines, and all the tools necessary for the finishing of large calibre seacoast rifles.

In the view of the gun factories the new gun factory is seen on the right and the old shop on the left, the small building between being for offices and wash-rooms. (See Fig. 504, page 374.)

The view (Fig. 511) of the interior of the old gunshops shows a number of partially finished 7-in. breechloading howitzers in the foreground; beyond are a number of 5-in. siege guns, while on the right, near the lathe, are several 3.6-in. field mortars.

In the central section are the furnaces, where the hoops are heated in order to give them the necessary expansion for the assembling of them. The shrinkage pit (Fig. 508) is situated in front of the furnaces, and is 20 ft. by 40 ft., and 54 ft. deep. There are two overhead travelling 30-ton cranes, which run the whole length of the building, giving facilities for the transportation of weights up to 60 tons, and it is intended to put in an 80-ton crane (Fig. 506). The power is furnished by a steam plant located in the central section, and consisting of a battery of three tubular boilers 6 ft. by 16 ft. each, and a 250 horse-power double-cylinder engine, with all the connections and fixtures belonging to the most approved modern designs. The building is lighted by 300 electric lights. The engine and boiler capacity is to be still further enlarged.

In May of 1891, the work of erecting the south wing of the gun factory was begun, and it is now closed in and the roof on, and the carpenters are ready to lay the floors. In this wing will be established the plant for the manufacture of 16-in. guns. Some of the machinery for this wing has already arrived. It is expected that the manufacture of a 16-in. gun will be begun this year. The 80-ton crane will travel the length of the south wing, and as far as the shrinkage pit. The various illustrations on pages 374 and 375 give a good idea of the arrangement of the shops.

MANUFACTURE OF AN 8-IN. BREECHLOADING STEEL RIFLE.

The process of manufacture of an 8-in. breechloading steel rifle at the Watervliet Gun Factory is as follows: The gun steel forgings from which the gun is made, are purchased from private manufacturers. The principal sources of supply are the Bethlehem Steel Company, the Midvale Steel Company, and the Cambria Iron Company, all located in Pennsylvania. The steel is made by the open-hearth process, and after casting it is forged, rough bored, and turned to within 0.25 in. of its finished diameter and length, and then oil-tempered and annealed.

As the oil-tempering tends to warp the long pieces, such as tube or long hoop forgings, great care and skill is required in order to turn serviceable pieces from them.

The forgings, as received at the factory, are bored to nearly their finished dimensions in the interior and turned on the exterior to dimensions slightly greater than their finished size, the object being to leave just enough metal to finish and no more, since an excess of metal would interfere with the oil-tempering upon which many of the valuable properties of the steel depend.

The processes may be divided into: 1. Operations before shrinkage. 2. Operations after shrinkage.

OPERATIONS BEFORE SHRINKAGE.

The Tube.—The first step is to inspect the tube carefully, measure its interior and exterior diameters at a sufficient number of points to see that there is enough metal to finish to the prescribed dimensions. The tube is next tested for warping, since it may be so bent in the oil-tempering that, although the prescribed dimensions are all correct, the boring tool will not be able to pass through the tube without "running out."

The instrument to test for warping is simply a lever of equal arms pivoted at a fixed point. The tube is mounted in a lathe and centred at the breech and muzzle so that it will run true at those points. One end of the lever carrying a small point is introduced into the bore and kept pressed against it as the tube revolves. The other end of the lever, resting against a scale, is the indicator. If the tube, at the point tested, is eccentric, the indicator will move up and down as the tube revolves, and the eccentricity is thus measured. The tube is tested at regular intervals, and the plotted results will show whether the tube is serviceable or not. In case the eccentricity is not too great it can be corrected by shifting the ends of the tube, and making the boring tool start eccentrically, and gradually diminishing its eccentricity with the length of travel of the tool.

Boring.—After being centred, the breech end is faced and all measurements laid off from this end, a certain allowance being made in length for finishing. The tube cannot be bored before shrinkage to the exact diameter of 8 in., as the shrinking on of the jacket and hoops is likely to warp it slightly. Illustrations of the boring tool, furnaces, and shrinkage pits will be given in a subsequent article on the Washington navy gun-shops.

The powder chamber is then bored to 9.30 in. with the roughing tool, then reamed to 9.40 in., and the conical slope connecting the powder chamber with the main bore is then rough-bored with a taper boring tool.

After the preliminary boring is finished, centres are inserted in the bore at the breech and muzzle, and the tube is turned to the shrinkage dimensions. It is then measured internally and externally, and is ready for the shrinkage of the jacket. The jacket and hoops are then bored and turned in a similar manner to the tube.

Assembling of the Tube and Jacket.—In all modern gun construction, the assembling of the various hoops is made possible, by the expansion of the exterior parts by heat. In the use of this agent several points must be considered. First, the heating must be uniform. Irregular heating will cause irregular expansion, and the hoops or jacket will be elliptical in cross-section, and also very probably they will be bent or warped longitudinally, and consequently will not slip over the corresponding shrinkage surface. Besides, in case the assemblage was accomplished, the unequal heating will cause unequal contraction and the tube would be bent. Second, except where gas is used, the surfaces should not come in contact with the flame, as they would be covered with smoke and cinders.

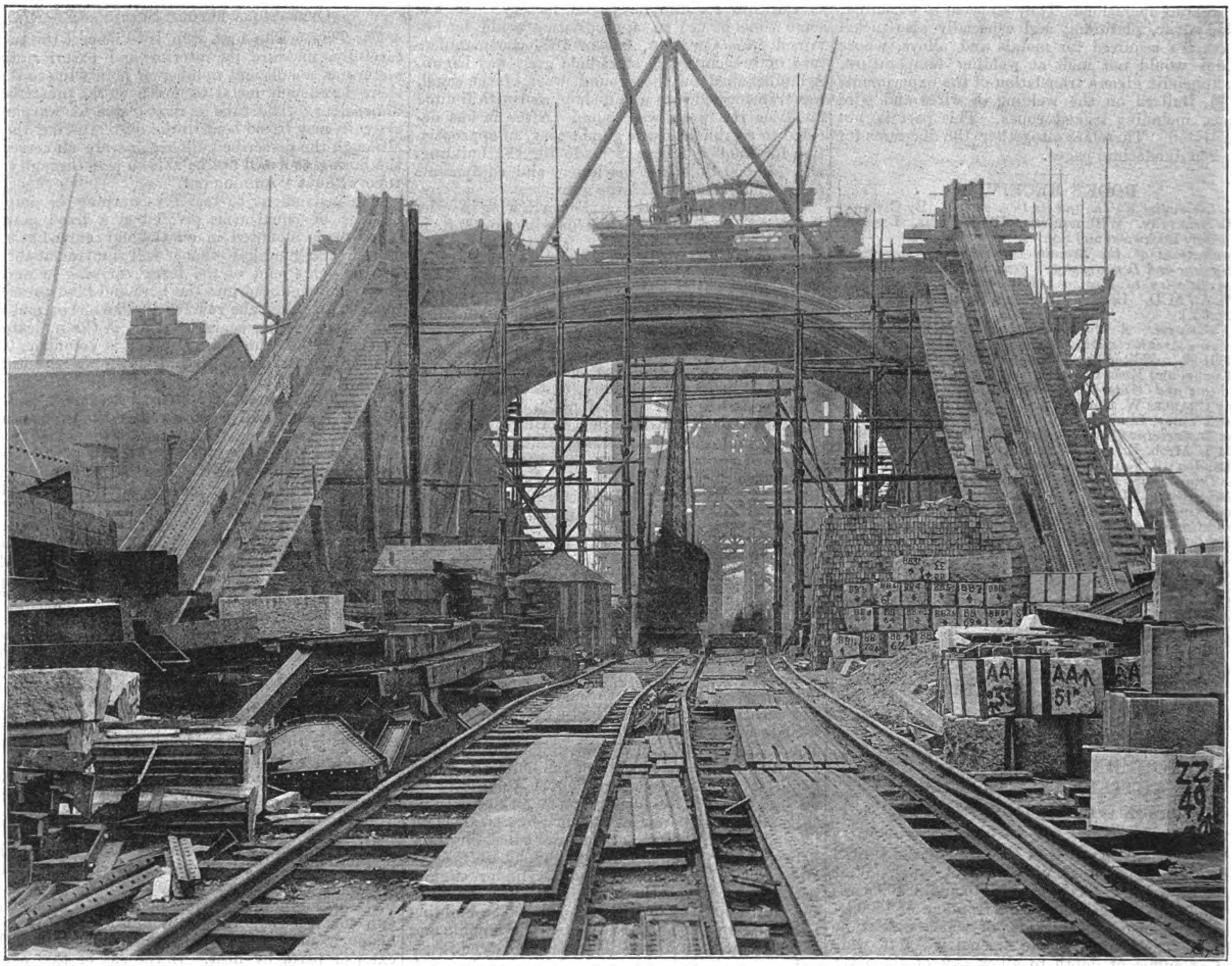
In the 8-in. rifle the tube is inserted in the jacket from the rear end; in the other guns it is inserted from the front. The general plan adopted is to place the tube in a vertical position, muzzle end up, in the shrinkage pit, to lower the jacket over it, and then pull the tube up through the jacket until the shoulders are in contact.

A casting is placed in the pit and supported on heavy timbers in such a position that when the jacket is lowered into place over the tube, the muzzle end of the latter projects a short distance above the jacket. This casting is so shaped that the cylindrical portion fits the base of the tube, and the face of the latter rests on the turned surface around the cylindrical part. Above this casting is placed a second casting, also supported on timbers, and based so that the tube will pass through it. On this casting rests the jackets when lowered. A recess is turned on the muzzle of the tube, and a wrought-iron collar with two trunnions arranged so that it can be quickly clamped on the

THE TOWER BRIDGE.

MR. J. WOLFE BARRY, ENGINEER, LONDON.

(*For Notice, see Page* 380.)



tube, and the latter hoisted through the jacket. The jacket is hoisted in a similar manner.

The tube is lowered into the pit breech first, passing through the upper casting and resting on the lower one; it is made vertical and braced. When the jacket has been sufficiently expanded in the furnace, it is run out on the car, lifted by the crane, brought over the tube and lowered until it rests on the casting. The crane is then quickly attached to the tube, which is drawn up through the jacket until the shoulders come in contact, and the crane suspends both tube and jacket, thus insuring a close contact at the shoulders. It is desired to have the jacket grip the tube just below the shoulder first, and then gradually extend the contact circle to the breech. To do this a water-tight collar is employed. It consists of a wrought-iron hoop hinged at one end of a diameter, and at the other end having a hinged clamp by means of which it can be quickly clamped at any point on the jacket. This collar has a thick lining of wood, and inside of this is an asbestos lining which comes in contact with the heated surface. By means of this collar the streams of water are prevented from running down the sides of the jacket, which would cause unequal cooling and contraction. The collar is first clamped just below the shoulders and the water turned on; the water issues through holes on the inner circumference of the water ring, and thus gives a uniform supply all around the exterior of the jacket at this point. The water ring is made by bending a piece of 1-in. water pipe into a circle of sufficient diameter to move freely along the hoop to be cooled. When the metal had cooled sufficiently, the collar is moved down a few inches, and the operation is repeated. In this manner the jacket is finally shrunk on the tube.

After cooling, the jacket and tube are removed from the pit, and after being measured for compression are placed in position for the assembling of the C hoops.

Assembling the Hoops.—The hoops are sometimes assembled with the gun vertical and sometimes with the gun in the lathe, the operations being the same as those described for the jacket, with the exception of the clamping device. This latter consists of a cast-iron collar in halves, which can be fixed at any part of the gun by means of bolts running through the flanges. Three holes are bored in the collar 120 deg. apart, parallel to the axis of the gun, and through these holes run three heavy rods, threaded over nearly their whole length, and having their outer extremities bent in the form of an L. The collar is clamped on a hoop already assembled and the L-rods hooked over the heated hoop to be assembled; nuts on the threaded ends of the rods are screwed up, and thus the hoop held tightly in place and the water turned on.

Stages of Assemblage.—The tube is first turned for the jacket and C1 hoop. These are then assembled, and the gun is then returned to the lathe, and the shrinkage surface turned for the C2 and C3 hoops, and these hoops are then put on. The gun is then returned to the lathe and the shrinkage surfaces turned for hoops C4, C5, C6, C7, and C8, and for hoops D1, D2, D3, and these hoops assembled. The last shrinkage surface is then turned for the A hoops, and these hoops are assembled, giving the completed gun, already described.

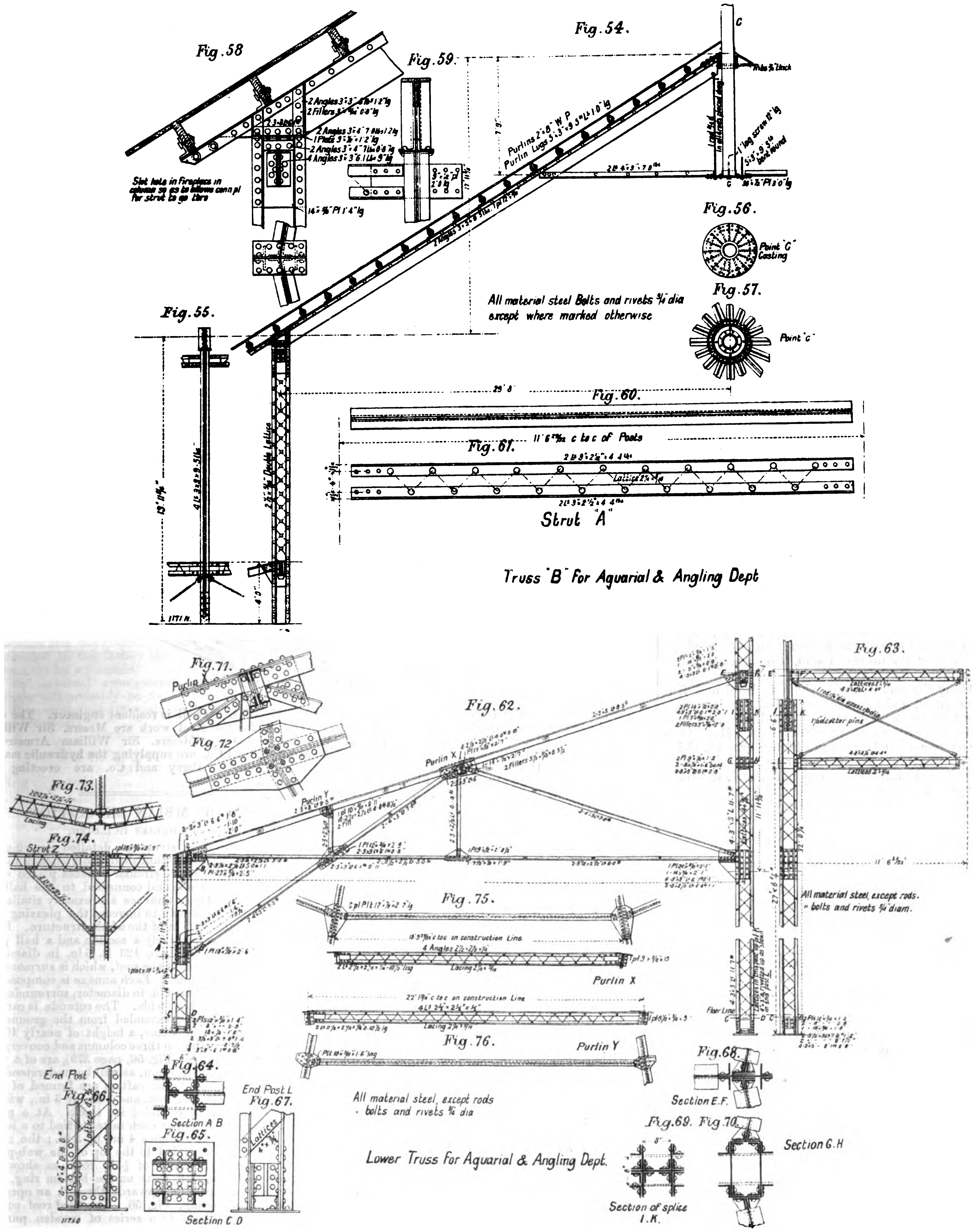
These operations complete the "Operations before Assembling," and before the gun is finished it has to be subjected to the "Operations after Assembling." In order to show the accuracy of the formulæ for shrinkage from which the dimensions of the various parts of this gun were computed, it is interesting to glance at the Tables on page 380.

Operations after Assembling.—After assembling, the gun is mounted in the lathe and bored to 7.94 in. by a first cut and to 8 in. for the finish. The powder chamber is bored to its finished size at one cut and the slope connecting it with the bore is finished. The thread for the sleeve is then cut on the jacket and also the thread on the sleeve. The copper packing ring is cut out of a thick sheet of copper in one piece, inserted in its place, and the sleeve screwed home by lever power. The slotted sectors on the sleeve are then planed out and the gun is reversed in the lathe and rifled.

After rifling, the breech mechanism is fitted to the gun, and the exterior is finish turned; it is then

THE WORLD'S COLUMBIAN EXPOSITION; DETAILS OF FISHERIES BUILDINGS.

(For Description, see Page 380.)



finally measured and shipped to the proving ground at Sandy Hook, New Jersey.

The existing proving ground, owned by the Government at Sandy Hook, New Jersey, is situated at the entrance to the lower bay of New York Harbour; the main channel passes within less than a mile of its northern extremity. It can be reached from New York city, twenty miles distant, by rail-road, or by boat, in from one to two hours. The Government dock is on the inner shore, a few hundred yards from the point of the Hook; this is used exclusively for Government purposes. The

TABLE XLIII.—*Prescribed and Actual Shrinkages in Assembling Guns.—First Shrinkage.*

Section of Gun.	Prescribed Shrinkage.	Actual Shrinkage Average.	Allowed Variation.	Actual Variation.
	in.	in.	in.	in.
I.				
II.	0.018	0.01699+	—.003	—.00101
III.	0.018	0.01679+	—.003	—.00121
IV.	0.018	0.01790+	—.003	—.00010
V.	0.017	0.01733+	—.003	+.00033
VI.	0.017	0.01673	—.003	—.00027
VII.	0.017	0.01669+	—.003	—.00031
VIII.	0.017	0.01705	—.003	+.00005
IX	0.015	0.01513	±.0015	+.00013
X.	0.013	0.01330	±.0015	+.00030
XI.	0.012	0.01205+	±.0015	+.00005
XII.	0.011	0.01094	±.0015	—.00006
XIII.	0.011	0.01107	±.0015	+.00007
Second and Third Shrinkages.				
I.	0.025	0.02544+	±.0015	+.00044
II.	0.033	0.03312+	±.0015	+.00012
III.	0.033	0.03320+	±.0015	+.00020
IV.	0.027	0.02754	±.0015	+.00054
V.	0.036	0.03565	±.0015	—.00035
VI.	0.021	0.02092+	±.0015	—.00008
VII.	0.021	0.02095	±.0015	—.00005
VIII.	0.018	0.01800	±.0015	

Section of Gun.	Calculated Compression.	Actual Compression.	Difference.
	in.	in.	in.
I.	0.0084	0.0104	+0.0020
II.	0.0133	0.0135	+0.0002
III.	0.0106	0.0117	+0.0011
IV.	0.0105	0.0116	+0.0011
V.	0.0107	0.0120	+0.0013
VI.	0.0105	0.0112	+0.0007
VII.	0.0085	0.0086	+0.0001
VIII.	0.0073	0.0077	+0.0004
IX.	0.0046	0.0051	+0.0005
X.	0.0041	0.0046	+0.0005
XI.	0.0038	0.0044	+0.0006
XII.	0.0035	0.0040	+0.0005
XIII.	0.0036	0.0042	+0.0006

railroad company has been permitted to erect a dock on the inner shore about one and a half miles from the first dock for the accommodation of their steamers, and to this their steamers run from points on the Jersey coast. Transportation from the gun factory at Watervliet Arsenal by water is about 175 miles by the Hudson River and New York Bay. Vessels loaded at the arsenal can deliver direct at the proving grounds. The reservation consists of the entire peninsula of Sandy Hook, approximately five miles long and varying in width from about 100 yards at its southern part to about a mile near its northern end, the average width being about half a mile.

Along the outer shore, which is level and free from trees, exist ranges overland for low-angle firing up to about 4500 yards, and for mortar or vertical fire up to about 6500 yards. Back from the shore are sand dunes and higher ground, rising not above 25 ft. To the west of the line of fire, and about 1½ miles from the north end, is a small marsh. The railroad runs along the western shore from the neck at Navesink Highlands to the company's dock; it is located there by permission of the Government without having any rights ceded to it.

At present there are on the proving grounds a machine and carpenter shop for repairs, two storehouses, an office and instrument house, where are located the various instruments for measuring the velocities of projectiles, quarters for officers, enlisted men, and employés, and some other buildings belonging to the Government under charge of the engineer department. The present experimental battery is situated near the northern end of the track; the guns are mounted in part on permanent platforms and arrangements exist for various classes of fire.

Long-range firing is had over water, and is measured by use of plane tables, one of which is situated at the battery and another at the Navesink Highland Light, giving a base of over 5 miles; though not quite as accurate or satisfactory as if the firing was over land, it is sufficiently so for all practical purposes. The water range is in the immediate vicinity of the battery, so that experiments with shell and shrapnel and with direct and ricochet fire can be carried on; the action of water fuzes, of high explosives in water, and torpedoes, can be advantageously experimented with; also firing at fixed or moving targets.

THE TOWER BRIDGE.

IN our two-page plate and on page 378 we give three illustrations of the Tower Bridge. These illustrations have been prepared from photographs recently taken, and illustrate the work in progress. We shall describe this important structure in greater detail at an early date. Our illustration on page 378 is taken from the Middlesex side, and shows the approach from that shore. Our left-hand engraving on the two-page plate is taken from the Surrey tower, and shows that on the Middlesex side. A part of the Tower of London and the Tower Walk is shown on the left of the picture. The remaining illustration is taken from the approach on the Surrey side, and gives a more general view.

The Tower Bridge has been designed by Mr. J. Wolfe Barry, and is being built for the Corporation under the direction of the Bridge House Estates Committee, of which body Mr. A. Pursell is the chairman, and Mr. A. M. Nortier the secretary. The roadway is a lifting bridge on the bascule principle; that is to say, the two leaves rise in a vertical direction and are counterpoised on their inner ends. The opening between the piers is 200 ft. In the left-hand view of our two-page plate the Middlesex half is shown in the course of construction, the part already completed being in the position that will be assumed when the bridge is open to allow for the passage of shipping. The leaves of the bascule, or roadway bridge, are to be actuated by hydraulic machinery placed in suitable chambers in the piers. The centre of the pivot is 13 ft. 3 in. inside the face of the pier. The total length of each lifting part from the centre of the pivot to the end is 113 ft. 3 in. The short end is 49 ft. 3 in. and the balancing is by kentledge. The steel skeleton of the bridge towers will be encased in masonry so as to harmonise, as far as possible, with the neighbouring Tower of London. For foot passengers the two towers will be connected at the top by two fixed spans; the length of each fixed span is 237 ft., and consists of two cantilevers and a centre girder. The height of the columns of the towers is 119 ft. 3 in. There are three landings to each tower, the floors being of steel. The approaches to the piers are on the suspension principle, each chain being in two segments of unequal length. These are not shown in our engravings. There will be two hydraulic passenger lifts in each tower, in addition to staircases. Mr. E. W. Cruttwell is resident engineer. The contractors for the steel work are Messrs. Sir William Arrol and Co.; Messrs. Sir William Armstrong, Mitchell, and Co. are supplying the hydraulic machinery. Messrs. Perry and Co. are erecting the masonry.

THE WORLD'S COLUMBIAN EXPOSITION OF 1893.

Fig. 52.

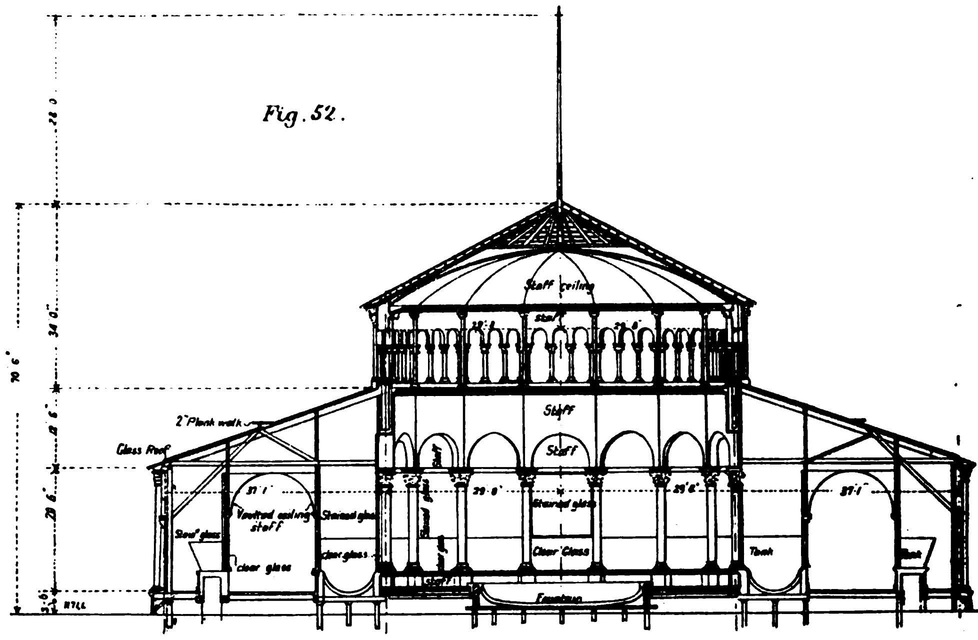
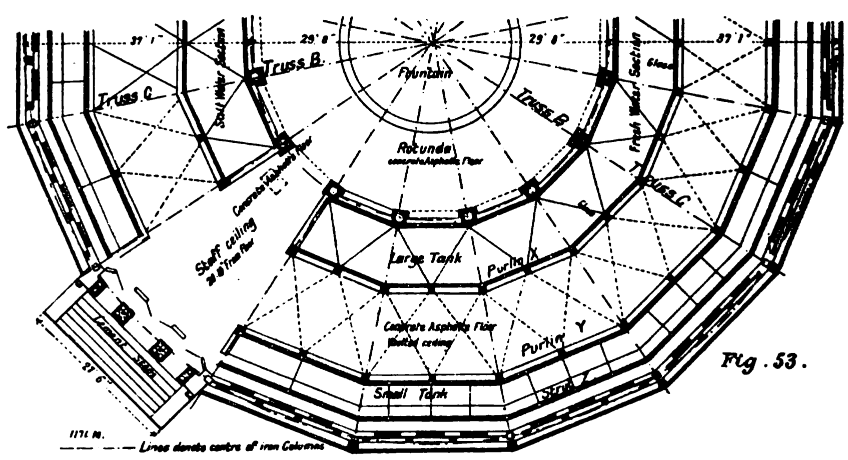


Fig. 53.



ANNEXE TO THE FISHERIES BUILDING.

THE COLUMBIAN EXPOSITION.

THE FISHERIES BUILDING.

BESIDES the main structure, detailed drawings of which we have already published, the Fisheries Building is completed by two circular annexes placed symmetrically on each side and connected to the hall by covered ways. These annexes are exactly similar in design, and help greatly to increase the pleasing and bold architectural effect of the whole structure. Figs. 52 and 53 are respectively a section and a half plan of the annexes. They are 123 ft. 6 in. in diameter, and 70 ft. to the apex of the roof, which is surmounted by a flagstaff 28 ft. high. Each annexe is composed of a central rotunda 59 ft. 4 in. in diameter, surrounded by a lower roof 37 ft. 1 in. wide. The rotunda is carried upon sixteen columns, extended from the ground to the springing of the dome, a height of nearly 40 ft. The principals resting on three columns and converging to a central casting (see Fig. 56, page 379), are of a very simple form of construction, as will be understood by reference to Fig. 54. The rafters are formed of two steel angles 9.5 lb. per foot, and 3 in. by 5 in., with a web-plate 12 in. deep and ⅜ in. thick. At a point 7 ft. 9 in. from the apex each rafter is tied to a lower ring, Fig. 57, by two angles 4 in. by 3 in.; the ring, Fig. 57, being suspended to the top of the web-plate of the rafter by a series of ⅞-in. rods, as shown in Fig. 54. The flagstaff rests on the bottom ring, and is secured to it, passing upwards through an opening formed in the casting, Fig. 56. The tiled roof covering is secured direct to a series of wooden purlins 2 in. by 8 in., fastened to the rafters by angle brackets; a detail of this arrangement is shown in Fig. 58. The same figure illustrates the connection of the rafter to the head of the stanchion, which is built up of two pairs of angles connected by light lattice bars. A

TABLE XLVI.—WEIGHTS, DIMENSIONS, CHARGES, &c., OF THE SERVICE AND EXPERIMENTAL BREECHLOADING ARMY UNITED STATES GUNS.

Nature of Gun.	Calibre.	Weight.	Total Length.	Length of Bore.	Twist in Number of Calibres.	Number of Grooves.	Width of Grooves.	Depth of Grooves.	Width of Lands.	Powder Chamber. Length.	Powder Chamber. Diameter.	Powder Chamber. Density of Loading.	Powder Charge. Weight.	Powder Charge. Nature of Powder.	Projectile. Length.	Projectile. Weight.	Ratio of Weight. Of Charge to Weight of Projectile.	Ratio of Weight. Of Projectile to Weight of Piece.	Initial Velocity.	Muzzle Energy, Foot-Tons. Total.	Muzzle Energy, Foot-Tons. Per Ton of Gun.	Muzzle Energy, Foot-Tons. Per Pound of Powder.
MOUNTAIN ARTILLERY.	in.	lb.	ft.	cals.			in.	in.	in.	in.	in.		lb		cal.	lb.			ft.			
3-in. steel, Hotchkiss	3	218	3.7	13.6	..	24	..	..	..	3.48	..	0 85	85	..	..	12	1 to 14.1	1 to 18	870	62.9	646.3	74
FIELD ARTILLERY.																						
3.2-in. steel	3.2	829	7.5	26	30	24	.30	.05	.119	10	3.8	..	3.75	I K	..	13 5	1 ,, 3.6	1 ,, 61.4	1700	270.4	730.8	72.1
3.6-in. steel	3.6	1230	7.5	22.7	..	..	..	..	..	..	..	..	4.63	..	..	20	1 ,, 4.3	1 ,, 61.5	1554	334.8	609.7	72.3
3.6 in. steel field mortar	3.6	250	2	5.25	30	24	.3	.05	.171	3.9	3.8	..	1	..	..	20	1 ,, 20	1 ,, 12.5	650	58.57	524.7	58 6
SIEGE ARTILLERY.																						
Guns.																						
5-in. steel	5	3660	12.1	23.5	35	32	.35	05	.141	19.70	5.70	..	12.5	..	..	43	1 ,, 3.4	1 ,, 85.1	1829	997.1	611.7	79.6
Howitzers & Mortars.																						
7-in. steel howitzer .	7	3710	8	12.4	35	40	.399	.06	.16	10.64	7.20	..	9.75	..	..	105	1 ,, 10.7	1 ,, 35.3	1085	856.8	519.2	87.8
SEACOAST ARTILLERY.																						
Guns.		tons																				
8-in. steel	8	14.25	23.2	32	Breech 50, Muzzle 25	48	.373	.06	.15	44.25	9.5	..	130	Brown prismatic	..	800	1 ,, 2.3	1 ,, 106.4	1935	7,786.5	546.4	59.9
10-in. steel	10	30	30.6	34	Breech 50, Muzzle 25	60	.373	.06	.15	53.25	11.8	..	256	,,	..	575	1 ,, 2.2	1 ,, 116.8	1940	15,001	500	58.5
12 in. steel	12	52	36.6	34	Breech 50, Muzzle 25	72	.373	.06	.15	62.5	14.2	..	440	,,	..	1000	1 ,, 2.2	1 ,, 116 5	1940	26,089	501.7	59.5
Mortars.																						
12-in. cast-iron, hooped with steel	12	14.25	10.75	9	35	68	.379	.07	.175	15.57	12.4	1.13	80	,,	..	630	1 ,, 7.8	1 ,, 50 6	1152	5,795.6	406.7	72.4
12-in. steel	12	13	11.7	10	20	72	.373	.07	.15	20	12 5	1.05	100	,,	5	800	1 ,, 8	1 ,, 36.4	1150	7,334.2	564.1	73.34

no ruins in America. Here we first rode in the ingenious travelling walk and saw the Women's Building, which was sufficiently constructed to give a clear idea of its appearance. It is to be a handsome and artistic structure; the noble and graceful figures sustaining the roof are particularly noticeable. The enormous skeleton of the Building of Mechanical and Liberal Arts next claimed our attention. The facts about this structure are simply overwhelming. It is the largest building in the world—everything, by the way, in Chicago is the "largest in the world;" they can't help it, it so happens—being five times the size of the Coliseum at Rome, and having an area of over 30 acres. The Administration Building will be a very handsome structure; the colossal statues which are to ornament it were examined with great interest. All are strong and beautiful, but the group "Patriotism" is especially fine. The sight of rows and rows of enormous heads, wings, and limbs on the floor was novel and interesting, and vaguely suggestive of a nightmare. Do not let the reader think our tour of the Exposition grounds was made in carriages; so extensive are they, that we were obliged to go by railroad, and even then had but little time at each point. The mechanical features were the ones which were most attractive to this party, and as the chief engineer and some of his assistants were members of the Society and were present, we had rare opportunities for seeing what is to be, as well as to comment on what was.

Re-entering our carriages we next drove toward the heart of the city down Drexel Boulevard and Madison Avenue, admiring the many broad roads stretching in all directions and the lines of handsome residences. After visiting the machine works of Fraser and Chalmers we returned to the train, where we learned that washouts had blocked all exit, and that we must remain overnight. By the courtesy of Mr. Wm. Chalmers, who first sent beautiful bouquets to our train for the ladies and then invited the entire party to attend the theatre, we all passed a delightful evening, and next morning walked about the city until eleven, when we started westward, proceeding slowly through the flooded country. In many places the tracks had been only temporarily sustained. The great tracts of level pasture land looked like a shining lake; in one place we could see ten miles of water, with here and there a small house appearing submerged to the second story. As the afternoon drew on the scene was a beautiful one; the gold and crimson of the sunset clouds dyed the waste of waters, and the delicate new foliage of the trees was pale yellow against the deep blue sky. In some places the train crawled slowly over a track that waved in curves frequently reversed, while the track being shored up on temporary cribwork, trestling, and the like, caused the car to tip from side to side, which kept up a certain amount of interest in our progress. A curved line is undoubtedly a line of beauty, but a vertical curve on a railroad track does not conduce to æsthetical thoughts. The water in many cases covered the rails entirely, and photographs were taken at frequent intervals, for we had a full complement of the Kodak fiend, in fact, they were so largely in the majority that, perhaps, they should be considered as in the normal condition, while we, who were not, might be called the anti-camera lunatics. A glance at the map will show the locality as being between Chicago and Rock Island. The mapmaker has again kindly taken out all curvatures, and the reader will notice that the Rock Island route is positively a bee-line from Chicago to Omaha. If he don't find it so in practice that is no fault of the mapmaker, who certainly has done his best in the case.

That evening we reached Rock Island, where the Government has one of its finest arsenals, and crossed the Missisippi under the soft light of the full moon. The river was greatly swollen by the recent rains, and looked almost like the ocean, but the tracks were so high that the floods caused no delay nor even anxiety.

(To be continued.)

MODERN UNITED STATES ARTILLERY.—No. XXVI.

THE NAVAL GUN FACTORY.

(FIGS. 512 TO 522.)

THE Gun Foundry Board, which was convened by the United States Congress in 1883, after having made a thorough examination of the methods of gun-making as practised by the leading nations of the world, recommended the establishment of two national gun factories, one for the army, as stated in a previous article, at West Troy, New York, the Watervliet Arsenal, and the other for the navy at the Washington Navy Yard, Washington, D.C. In October of 1886 the Washington Navy Yard was set aside for the manufacture of ordnance and the establishment of a gun factory for the navy. The funds for this work were supplied by Congress, which in August, 1886, appropriated a sum for the beginning of the factory.

Several plans were proposed and carefully discussed for the arrangement of the buildings of the factory. It was finally decided to utilise the building which had previously been used for a forge and anchor shop, and transform it into a 6-in. and 8-in. gun factory, and directly adjoining the north end of this building it was determined to erect a large building for the finishing of guns of the largest calibres.

The floor of the forge and anchor shop was to be lowered, the roof raised, and a 40-ton travelling crane introduced, which would run the whole length of the building. In the large building was to be placed the shrinking pit, and a 110-ton travelling crane was to be introduced.

A large shop to the west and adjoining was to be utilised as a carriage and projectile shop, and was to be equipped with a 25-ton travelling crane. The other buildings on the west side of the yard were to be utilised for a foundry, a finishing shop for small parts, carpenter shops, pattern shops, &c. In the different shops were to be placed all the necessary machinery of the most improved modern type.

The present annual capacity of the shop is as follows:

Three and a half	12-in.	guns.
Eight	10	,,
Ten...	8	,,
Thirty	6	,,

or a proportionate number of other calibres.

The plans once determined upon, the work of construction was begun and rapidly pushed forward. In 1888 the walls of the large gun-shop were finished, the iron framing for the roof was completed and its erection commenced. The 8-in. gun-shop was cleared out, the floor levelled, the crane supports all completed, and the shop made ready for the concreting of the floor. In the gun-carriage shop the piers for the support of the 25-ton travelling crane were partially completed. All of the machinery, engines, boilers, &c., were contracted for and partially completed. In excavating the shrinking pit, great difficulty was experienced by the existence of quick sand at the point where the pit was to be placed, but all difficulties of construction were finally overcome. In 1890 the gun factory proper was completed, all of the machinery was in place in the south gun-shop and the shop in full operation. The 110-ton crane was erected, tested, and found satisfactory. Some of the large lathes have been delivered, and the others will be completed and in place by April, 1893. The designs for these lathes are considered superior to any at present in existence abroad.

The Baltimore and Potomac Railroad has sidings run into every shop, so that forgings can be placed on the cars at the foundry of the Bethlehem Iron Company, where they are obtained, and without further handling can be delivered directly to the gun factory.

The process of manufacture of the guns is very similar to that employed by the Army Gun Factory at Watervliet, New York.

The increase in the machinery and in experience has greatly lessened the cost of manufacture, as will be seen from the following Table. On this point the following Tables are of interest:

TABLE NO XLIV.—*Cost and Time Required in Constructing Navy Guns at the Washington Factory.*

Calibre.	Average Cost of Manufacture. Washington Gun Factory. 1888.	Average Cost of Manufacture. Washington Gun Factory. 1890.	Average Cost of Manufacture. By Contract with Private Firms.	Average Time of Manufacture in Ten-Hour Days. Washington Gun Factory. 1888.	Average Time of Manufacture in Ten-Hour Days. Washington Gun Factory. 1891.
in.	dols.	dols.	dols.	days	days
6	2649	1298	3400	115	6[illegible]
8	5163	2772	3500	225	105
10	6334	3500	..	240	150

MODERN UNITED STATES ARTILLERY: NAVAL GUN FACTORY, WASHINGTON.

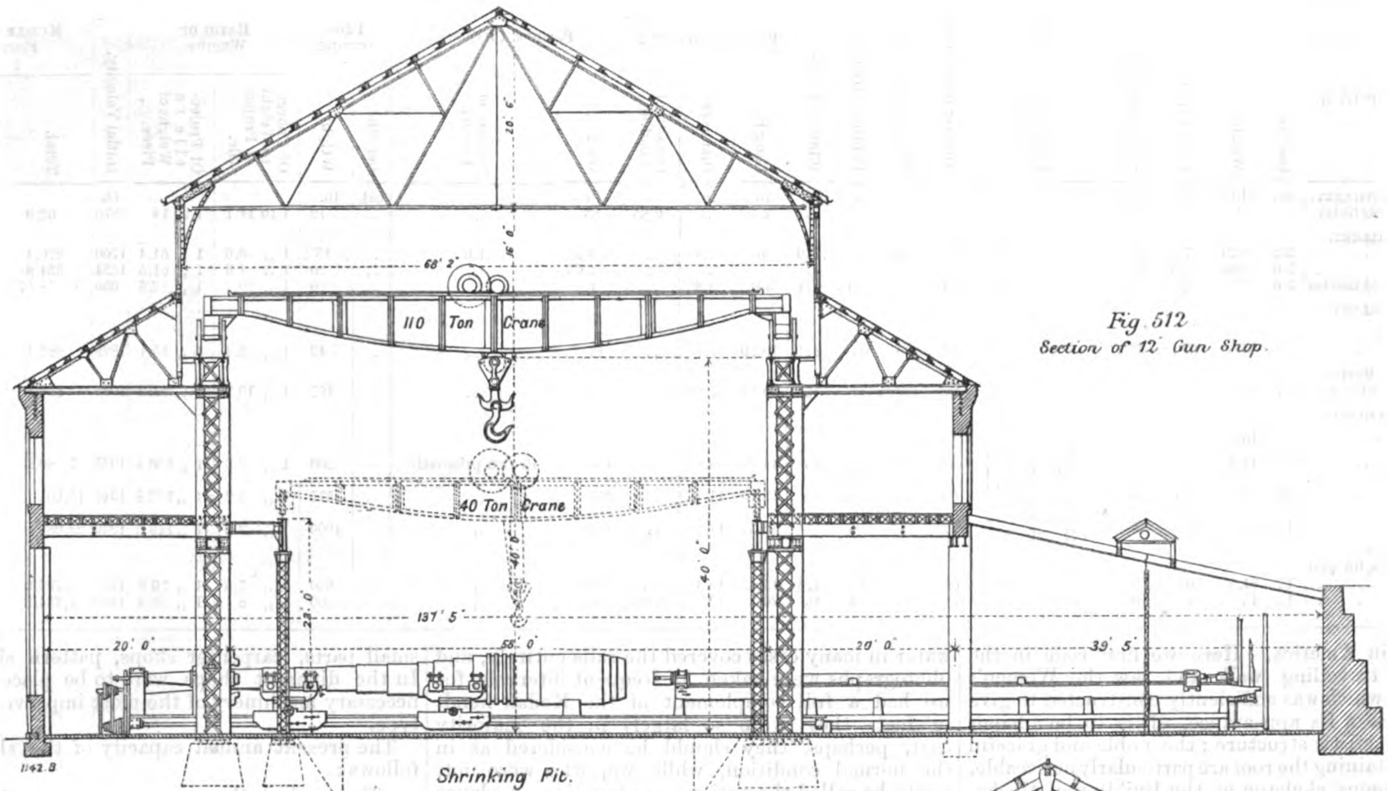


Fig. 512. Section of 12" Gun Shop.

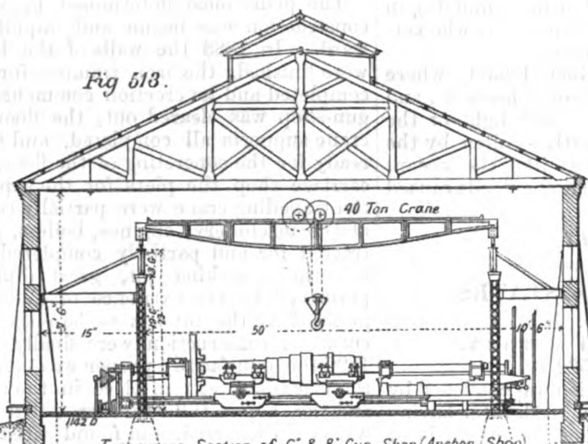


Fig. 513. Transverse Section of 6" & 8" Gun Shop (Anchor Shop)

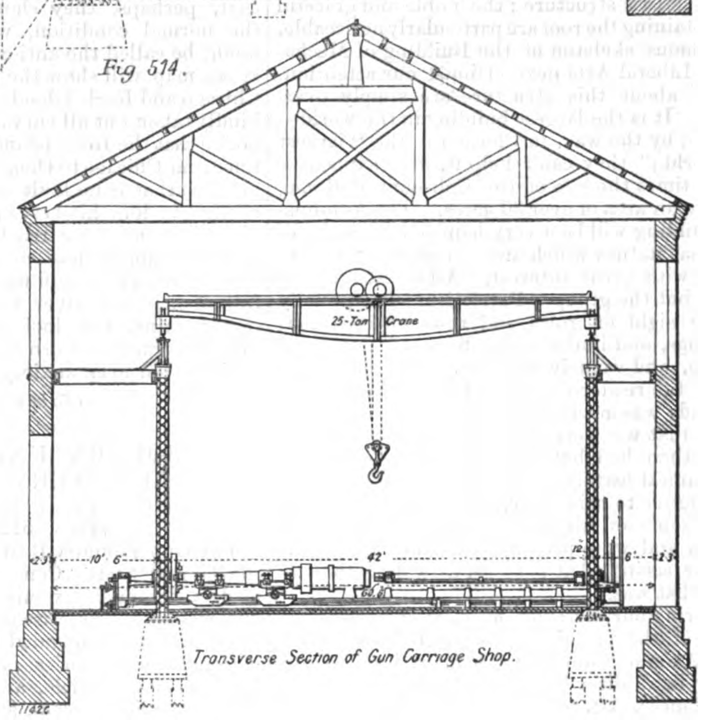


Fig. 514. Transverse Section of Gun Carriage Shop.

TABLE XLV.—*Materials, Cost, and Labour in 6-In. Gun Carriages.*

—	Labour.	Material.	Total Cost.
Average of	dols.	dols.	dols.
First 10	4,423.10	2,133.21	6,556.31
Second 10	3,027.41	1,283.32	4,310.73
Third 10	2,250.74	1,191.35	3,442.09
Fourth 10	1,963.85	1,344.67	3,312.72
Fifth 10	1,708.00	1,116.00	2,824.00

Several interesting new designs have recently been turned out by the Naval Gun Factory. A breech mechanism for 10-in. and 12-in. guns has been designed, in which the continuous revolution of a crank revolves and unlocks the block, withdraws it, and swings it clear of the breech. The reverse motion of the crank closes and locks the breech. A new breech mechanism for rapid-firing guns, known as the Dashiell breech mechanism, has been constructed. It works by the simple motion of a lever, the moving of which, as in the Canet system, in one direction opens the breech, and in the opposite closes it. This gun is mounted on a very compact and handy carriage. A field carriage for rapid-firing guns, with landing parties, has also been constructed.

Figs. 512 and 515 are a section and a plan of the 12-in. gun-shop; Fig. 513 is a section of the 6-in.

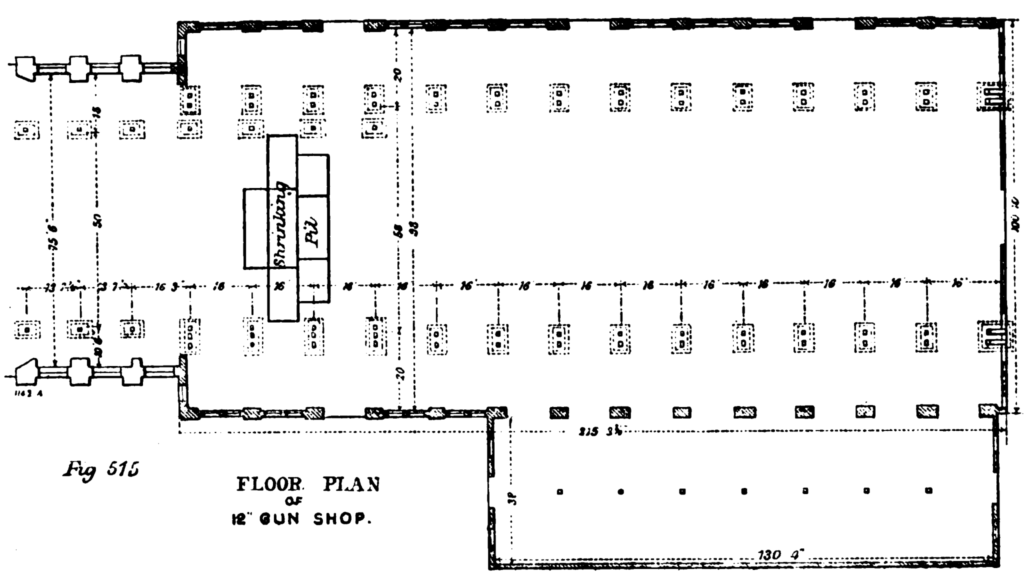
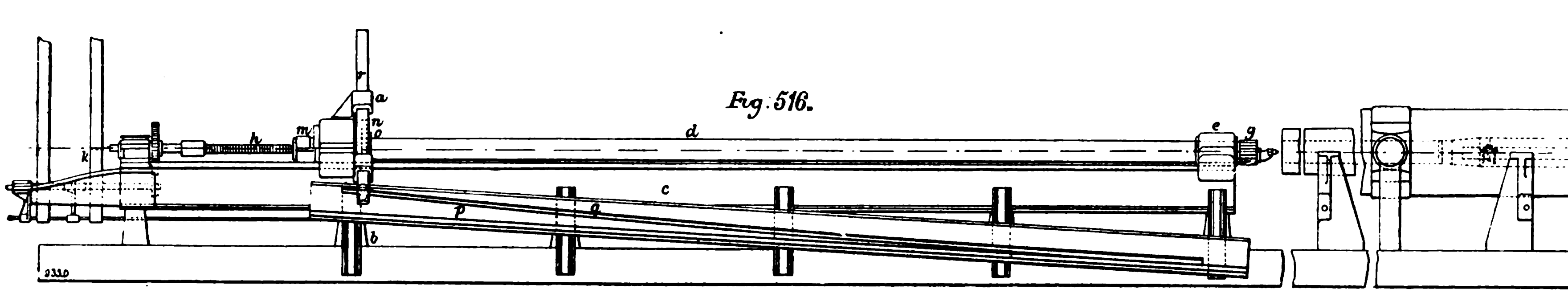
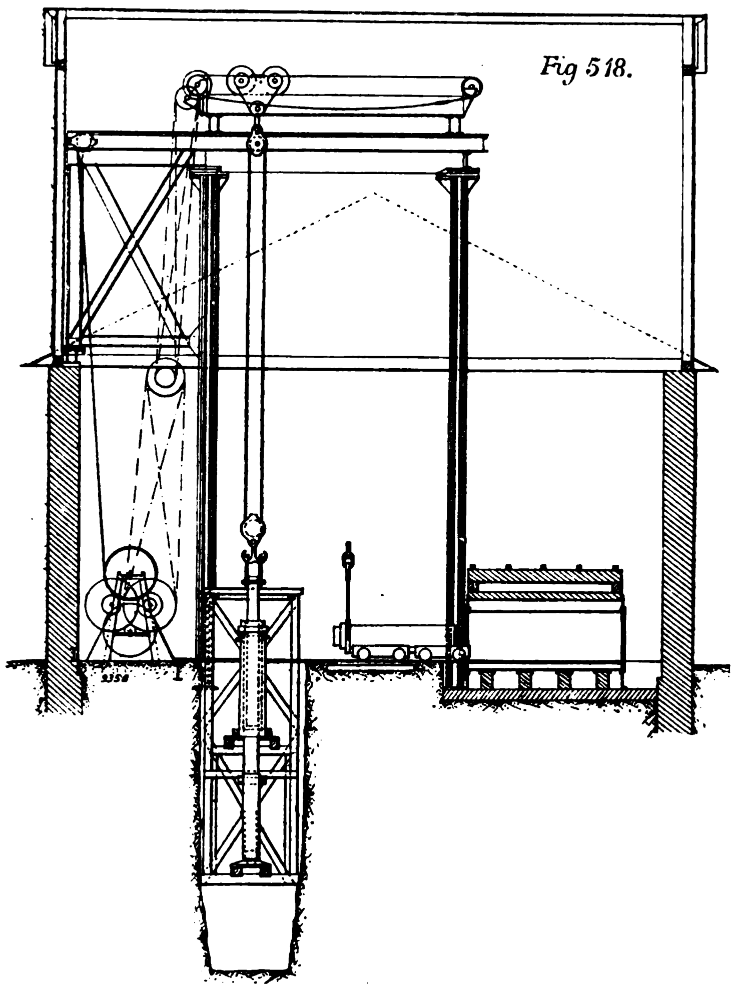


Fig. 515. FLOOR PLAN OF 12" GUN SHOP.

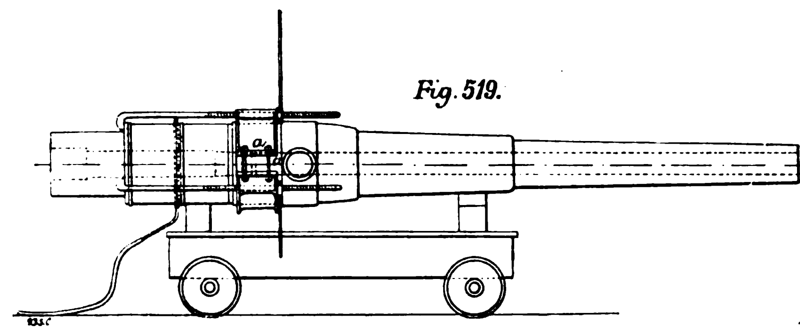
MODERN UNITED STATES ARTILLERY: THE WATERVLIET AND WASHINGTON GUN-SHOPS.

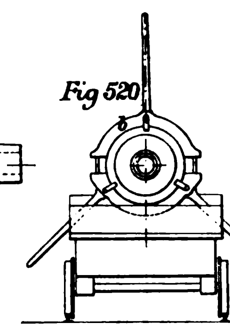


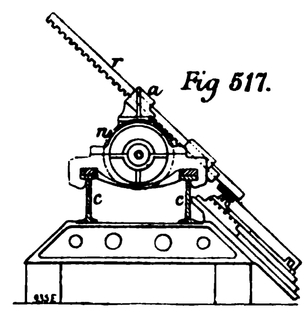
RIFLING MACHINE.



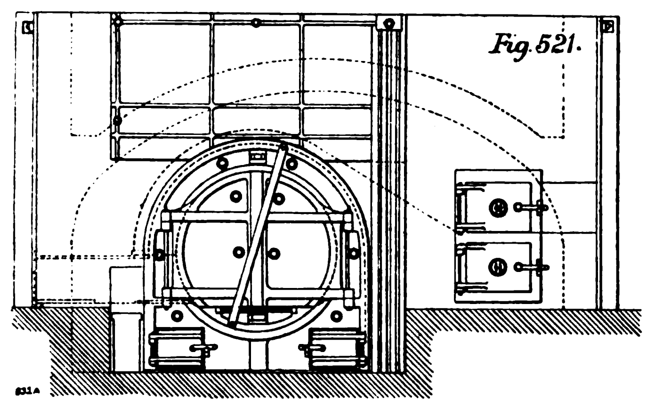
SHRINKING PIT.

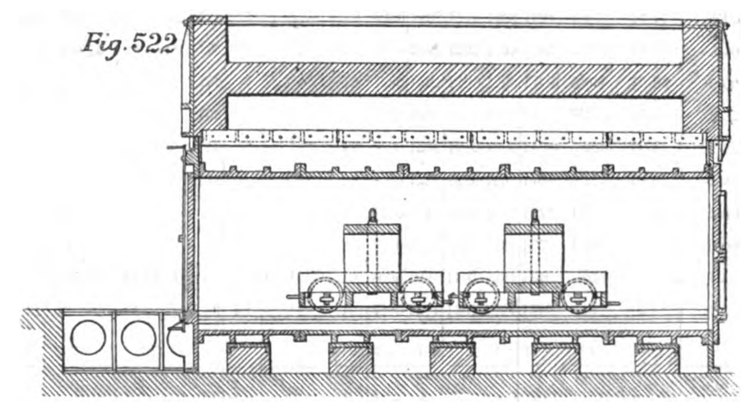






CLAMPING DEVICE FOR PUTTING ON RINGS.





HEATING FURNACE.

and 8-in. gun-shop; and Fig. 514 is a section of the carriage-shop. On the present page we publish several illustrations of some of the plant employed, and which was referred to in our last article upon the Watervliet factory.

The boring tool for the first cut of the 12-in. tube in the gun lathe is a semi-cylinder of cast iron, about 3 calibres long, and of the same diameter as the bore which it is to make. On its forward end it carries a steel cutter, and at its rear end it is keyed to a long boring bar, which is concentric with the bore, and accurately aligned, so that throughout its travel it will continue in the axis of the bore. An accurate hole is first bored for a short distance by means of a small tool, and the boring tool is then pushed forward into this hole. The tube is rotated, and the boring bar and tool pushed forward by means of a powerful screw, which is driven by the same mechanism that drives the lathe, so that any change in speed of the lathe

TABLE XLVII.—WEIGHTS, DIMENSIONS, &c, OF UNITED STATES NAVAL BREECHLOADING GUNS.

Nature of Gun.	Calibre.	Weight.	Weight.	Total Length.	Distance Across Rimbases.	Greatest Diameter of Gun Body.	Total Length of Bore.	Length of Rifled Bore.	Twist of Rifling.	Grooves. Number.	Grooves. Width.	Grooves. Depth.	Chamber. Length.	Chamber. Diameter.	Chamber. Capacity.	Total Capacity of Bore.	Travel of Projectile.	Weight of Charge Service Velocity.	Weight of Projectile.	Total Weight of Fixed Ammunition.	Ratio of Projectile Weight to Weight of Gun.	Chamber Pressure.	Muzzle Velocity (Service).	Remaining Velocity at 1000 Yards.	Remaining Velocity at 1500 Yards.	Remaining Velocity at 2000 Yards.	Remaining Velocity at 2500 Yards.	Muzzle Energy.	Thickness of Steel which Shell will Perforate at Muzzle.	Thickness of Steel which Shell will Perforate at 1500 Yards.
	in.	lb.	tons	ft.	in.	in.	in.	in.	in.		in.	in.	in.	in.	c. in.	c. in.	in.	lb.	lb.	lb.		tons	ft.-sec.	ft.-sec.	ft.-sec.	ft.-sec.	ft.-sec.	foot-tons	in.	in.
4-in. breechloading rifle, Mark I.	4	3,380	1.5	13.7	..	13.0	157.29	130.29	Zero to 1 in 25	30	.279	.025	24.74	4.30	367	2,037	132.55	12 to 14	33	58	$\frac{1}{102}$	15	2000	1651	1501	1364	1246	915	7.15	4.77
4 in. rapid-firing gun	4	3,400	1.5	13.7	..	13.0	157.50	128.12	Zero to 1 in 25	30	.279	.025	25.38	4.44 / 4.09	329	1,994	132.12	12 to 14	33	..	$\frac{1}{103}$	15	2000	1651	1501	1364	1246	915	7.18	4.77
5-in. breechloading rifle, Mark I.	5	6,190	2.8	13.5	21.0	18.0	150.27	120.75	1 in 180 to 1 in 30	20	.485 / .435	.05	27.07	6.5	899	3,326	123.20	26 to 29	60	..	$\frac{1}{103}$	15	2000	1697	1563	1439	1323	1,660	8.67	6.09
5-in. rapid-firing gun	5	7,000	3.1	17.4	..	16.5	191.50	164.40	Zero to 1 in 25	30	.349	.025	32.00	5.55 / 5.10	655	3,965	168.00	28 to 30	50	95	$\frac{1}{140}$	15	2250	1847	1678	1516	1374	1,754	9.00	5.90
6-in. breechloading rifle, Mark I.	6	10,775	4.8	15.8	25.0	21.5	176.0	136.65	1 in 180 to 1 in 30	24	.485 / .435	.05	36.85	7.0	1,409	5,360	139.15	50	100	..	$\frac{1}{108}$	15	2000	1735	1616	1505	1402	2,773	10.27	7.57
Ditto Mark II.	6	10,900	4.9	16.1	25.5	21.5	180.08	144.85	1 in 180 to 1 in 30	24	.485 / .435	.05	32.73	7.5	1,410	5,595	147.35	45 to 48	100	..	$\frac{1}{109}$	15	2000	1735	1616	1505	1402	2,773	10.27	7.57
Ditto Mark III., of 30 cals.	6	10,800	4.8	16.3	24.0	20.5	183.75	147.26	Zero to 1 in 25	24	.485 / .415	.05	33.99	7.0	1,299	5,552	149.76	44 to 47	100	..	$\frac{1}{108}$	15	2000	1735	1616	1505	1402	2,773	10.27	7.57
Ditto Mark III., of 35 cals.	6	11,554	5.2	18.8	24.0	20.5	213.75	177.26	Zero to 1 in 25	24	.485 / .415	.05	33.99	7.0	1,299	6,404	179.76	44 to 47	100	..	$\frac{1}{116}$	15	2080	1807	1680	1565	1458	2,990	10.83	8.00
Ditto Mark III., of 40 cals.	6	13,370	6.0	21.3	24.0	21.0	243.75	207.26	Zero to 1 in 25	24	.485 / .415	.05	33.99	7.0	1,299	7,256	209.76	44 to 47	100	..	$\frac{1}{134}$	15	2150	1865	1737	1618	1507	3,204	11.38	8.39
8-in. breechloading rifle, Mark I.*	8	27,600 / 28,800	12.3 / 12.9	21.5	33.8	39.0	239.91	195.16	1 in 180 to 1 in 30	32	.485 / .435	.05	42.05	10.5	3,569	13,541	197.86	105 to 115	250	..	$\frac{1}{110}$ / $\frac{1}{115}$	15	2000	1808	1719	1634	1554	6,932	14.51	11.69
Ditto Mark II.	8	29,100	13.0	21.5	33.8	39.0	239.91	195.16	1 in 180 to 1 in 30	32	.485 / .435	.05	42.05	10.5	3,569	13,541	197.86	105 to 115	250	..	$\frac{1}{116}$	15	2000	1808	1719	1634	1554	6,932	14.51	11.69
Ditto Mark III., of 35 cals.	8	29,400	13.1	25.4	33.8	28.75	290.52	242.77	Zero to 1 in 25	32	.485 / .415	.05	45.05	9.5	3,176	15,548	245.47	105 to 115	250	..	$\frac{1}{118}$	15	2080	1880	1787	1700	1615	7,498	15.61	12.36
Ditto Mark III., of 40 cals.	8	34,000	15.2	28.7	33.1	28.75	330.52	282.77	Zero to 1 in 25	32	.485 / .415	.05	45.05	9.5	3,176	17,564	285.47	105 to 115	250	..	$\frac{1}{136}$	15	2150	1943	1848	1757	1670	8,011	16.10	12.97
10-in. breechloading rifle, Mark I., of 30 cals.	10	57,500	25.7	27.4	..	40.0	306.26	247.26	1 in 180 to 1 in 35	40	.485 / .435	.05	57.17	12.5	6,880	26,639	250.43	225 to 240	500	..	$\frac{1}{115}$	15	2000	1848	1777	1708	1642	13,864	18.75	15.34
Ditto Mark I., of 35 cals.†	10	60,660 / 63,100	27.1 / 28.2	30.5	..	40.0	343.76	283.76	Zero to 1 in 25	40	.485 / .415	.05	57.17	12.5	6,880	29,480	286.93	225 to 240	500	..	$\frac{1}{121}$ / $\frac{1}{126}$	15	2080	1922	1848	1777	1707	14,996	19.83	16.75
Ditto Mark II., of 30 cals.	10	56,400	25.1	27.4	..	39.0	307.26	247.26	Zero to 1 in 26.8	40	.485 / .415	.05	57.17	12.5	6,831	26,530	250.43	225 to 240	500	..	$\frac{1}{113}$	15	2000	1848	1777	1708	1642	13,864	18.75	15.84
Ditto Mark II., of 35 cals.	10	61,900	27.6	31.2	..	39.0	354.91	294.91	Zero to 1 in 25	40	.485 / .415	.05	57.17	12.5	6,831	30,350	298.08	225 to 240	500	..	$\frac{1}{124}$	15	2100	1940	1865	1793	1724	15,285	20.10	16.97
12-in. breechloading rifle, Mark I.	12	101,300	45.2	36.8	..	45.0	419.20	343.12	Zero to 1 in 25	48	.485 / .415	.05	74.14	14.5	12,043	51,355	346.06	425	850	..	$\frac{1}{119}$	15	2100	1964	1900	1837	1777	25,986	24.16	20.94
13-in. Ditto Mark I.	13	135,500	60.5	40.0	..	49.0	454.46	370.46	Zero to 1 in 25	52	.485 / .415	.05	80.88	15.5	15,059	64,857	373.58	550	1100	..	$\frac{1}{123}$	15	2000	1977	1918	1860	1805	33,627	26.66	23.42

* 8-in. breechloading rifles Nos. 1 and 3 are not hooped to the muzzle, while Nos. 2 and 4 are. † 10-in. breechloading rifle No. 3 differs in exterior from 10-in. breechloading rifle No. 4, and is somewhat lighter in consequence.

will be accompanied by a corresponding change in the feed of the tool. The pressure on the cutting tool tends to keep the semi-cylindrical head tightly pressed against the bore, and consequently it always travels along a perfect cylinder. The first cut bores the tube to a diameter of 7.80 in.; it is then reamed out to 7.875 in.

The tool for this reaming has a flat cast-iron head, with two cutters at opposite extremities of the diameter; the tool is made into a cylindrical form by bolting to each side of the flat cast-iron head a semi-cylindrical packing of hard wood, generally cherry or lignum vitæ, and so turned that they will fit the bore very tightly. The cutters are thus guided and kept steady, and, being plentifully supplied with oil, the bore is polished.

The rifling machine, as shown in Figs. 516 and 517, consists of the bolsters, bed, rifling bar, rifling head, feed screw-driving and return pulleys, front bearing, rear bearing, sliding or middle bearing, rotating gear, index plate, rack or copying bar, supporters for the table, table, curved bar, fastenings.

The bolsters b rest on the shears of the lathe and support the bed. The bed c carries the rifling bar, its bearings and the driving and return pulleys. The rifling bar d rests on a fixed support e in front, and a sliding support f in rear, and also has an intermediate support which is not shown. The rifling head g is keyed to the front end of the bar, and carries the rifling tool. The rifling bar is hollow and in its interior has a long feed screw h, by means of which the motion of translation is given. This screw is driven by means of the driving pulley k, and works in a bronze bushing m which is attached to the rear sliding support, so that the bar and bearing move together longitudinally; at the same time, the bar is free to rotate in its bearings.

The twist is given by the following arrangement shown in the section, Fig. 517. A gear n is placed at the rear bearing, and in front of it the index plate o. The plate is connected with the bar, so that one cannot rotate without the other. The gear runs loose upon a sleeve in the rear bearing, so that it rotates independently of the bar. The index plate contains a number of teeth or notches depending upon the number of grooves in the gun and the number cut at a time by the cutter. A pawl or eccentric is placed upon the gear, and by bringing this into action it drops into one of the notches of the index plate, and connects the gear and bar so that one cannot rotate without the other. The curve of the rifling is obtained by laying out the flexible steel bar p in the shape of the developed rifling curve. This bar is supported on a cast-iron table q with grooves in it for convenience in fastening the flexible bar in any desired position. A rack r, with rollers on the outer end which bear against the curved bar, is arranged so that its teeth act on the gear attached to the rifling bar. As the bar is shoved through the gun, the rack, since its rollers follow the curve of the flexible bar, causes the rifling bar to rotate and describe in the gun the rifling curve which, if developed, would give a curve of the same form as that of the flexible bar. When one groove is finished the index plate and gear are disconnected, the bar rotates one notch, the gear and plate again connected, and a second groove is cut. This operation is continued until all of the grooves are cut.

The heating furnace, Figs. 521 and 522, consists of a cast-iron cylinder whose length and diameter are such that it will receive a 12-in. jacket. This cylinder is supported, with its axis horizontal, on strong cast-iron supports at proper intervals. It is closed at its rear end by a cast-iron plate or head, and at the end toward the shrinkage pit, with two cast-iron doors which, when open, leave the whole diameter of the furnace clear. The upper half of this cylinder is covered externally by a second half-cylinder of cast iron covered on its upper side by firebrick. Considerable space is left between the cylinder and its covering half-cylinder for the passage of the flame and heated air. The cylinder and half-cylinder are set in firebrick, an arch being thrown over the half-cylinder, leaving a fireplace between it and the firebrick lining of the half-cylinder. The furnace for firing is built on the right side of the cylinder and extends the whole length. On the bottom of the cylinder are bolted two rails on which runs the car that carries the mass to be heated. By a special arrangement of flues and valves the flame and heated air first strike the firebrick lining of the semi-cylinder, pass between it and the upper arch, thence around the bottom of the inner cylinder, and up around the top, passing, this time, between it and the half-cylinder, and then down around the bottom of the inner cylinder and out the stack. By this circulation the intense heat on the metal is avoided and the heat well utilised. This furnace works well, and a temperature of 970 deg. has been attained. The car can be readily pushed in or out and the crane tackle attached to the heated hoop or jacket to be raised. The assembling pit is directly in front of the furnace. Fig. 518 shows a section of the shrinking pit, and Figs. 519 and 520 illustrate the clamping device employed in drawing on the rings over tube.

Table XLVI., page 405, summarises particulars of weights, dimensions, charges, &c., of the service and experimental breechloading army guns of the United

States, and Table XLVII., page 408, gives similar particulars of naval guns.

The Naval Proving Ground.

The tests of naval guns, armour, &c., have hitherto been carried on at Annapolis, Md., where the proving ground was located. The range was a very poor one, since the training of guns was much interfered with in winter by oyster boats, and in summer by fishing and pleasure parties. It was therefore decided to change the site of the proving ground, and in February, 1890, a tract of 659 acres of ground was purchased in Charles County, Md., on the Potomac River, about 26 miles below Washington, and here has been located what is known as the Indian Head Naval Proving Ground.

The site was a marshy valley covered with undergrowth. The marsh has been drained; a wharf and sea wall of piles, several feet higher than the greatest freshet record, inclosing the water front, has been built; a railroad for the travelling crane and flat cars has been constructed connecting the wharf and slip with the velocity and range and armour batteries; a firing butt has been finished and is in satisfactory operation; and the necessary apparatus for measuring velocities are in working order. Gun platforms for all calibres from the smaller rapid fire to the 12-in. gun have been erected and are ready for use; three bomb proofs have been completed; the chronographs and targets are in position; necessary roads have been finished; and a chronograph-house, magazine, store-house, stable, and other necessary buildings have been completed. Three officers' quarters have been completed, and a building will be erected for the accommodation of occasional visitors and boards of officers.

Three target butts have been put up for use in testing the new American armour-plates, and a curved structure has been erected for the tests of barbette armour. Preparations are almost completed for the tests of armour-piercing projectiles.

A scow is being built for the transportation of material from the gun factory to the proving ground. The proving ground will have telegraphic communication with Washington, and a steam launch has also been purchased for the use of the station. One of the valuable features of the ground is a railway crane, by means of which it is possible to send guns, as large as 8 in. in calibre, from the Washington Gun Factory to the proving ground, prove, and return them to the factory the same day. The instruments have been transferred from the proving ground at Annapolis to Indian Head, and the first gun, a 6-in. breechloading rifle, was tested at the latter place on January 24, 1890. Since then all reception tests of naval powder and armour, and the proof and tests of all naval guns and mounts, have been conducted at this new naval proving ground.

THE IRON AND STEEL INSTITUTE.

In our last issue we gave an account of the proceedings of the first day, Tuesday, August 20, of the recent Liverpool meeting of the Iron and Steel Institute. We now proceed with our report of the following day's proceedings.

Alloys of Iron and Chromium.

The first paper on the list was a contribution by Mr. R. A. Hadfield, entitled "Alloys of Iron and Chromium." To this was added a report made by Mr. F. Osmond on the chromium steels of the author. This was a very long paper, almost a treatise; but to complain on that score would be as if a man were to grumble at the weight of his purse. Moreover, the author had got through his heavy task in fair time, so that it was possible to distribute to those members more specially interested in the subject advance copies of the paper. That is a practice which should be universally observed, but the majority of people are so slovenly in their work—"too busy," they prefer to call it—that it is often difficult enough to get a manuscript in time to print for the meeting. Perhaps some day we shall become sufficiently enlightened to conduct meetings such as these in a sensible manner, and speakers will have a chance of preparing their remarks beforehand; so that not only the most glib-tongued, but also those who understand the subject, may get an equal hearing. We commenced the publication of Mr. Hadfield's contribution in our last issue and continue it in our present number. Our readers will recognise the characteristically thorough manner in which the author has executed his task, and the mass of valuable information contained in the paper. The work may well take its place beside the monograph on manganese steel, which the author contributed to the proceedings of the Institution of Civil Engineers. Before commencing the reading of his paper, Mr. Hadfield made special reference to the report of M. Osmond, (for which we must refer our readers to the Proceedings of the Institute), which, he pointed out, was the result of much careful work of a high character, and he trusted the meeting would express its appreciation of M. Osmond's labour.

The discussion on this paper was opened by Professor Roberts-Austen, who referred to the great importance of the paper and the interest that was taken in it on account of the work that had previously been done by the author. The results obtained confirmed the views of Osmond and the speaker in regard to the existence of iron in two forms; and if these views were correct, they explained many of the anomalies which arose in the manufacture of iron. It was held that as carbonised iron cooled there were two changes. One was at 850 deg. Cent., and was due to molecular change in the iron itself; the other was at about 650 deg., and was a change in the relation between the iron and the carbon. The carbon, in fact, appeared to secure the hard properties of iron, which existed at a high temperature, at a low temperature, that is if the alloy were subjected to the process of hardening by dipping in water, mercury, &c. In examining the curves as to cooling which accompanied the report, it would be seen that when the initial temperature was high—over 1300 deg. Cent.—the curve was fair throughout; but if the initial temperature was lower—from 900 deg. to 1000 deg. Cent.—the bump in the curve showed distinct recalescence, or an evolution of heat at the point at which the carbon change referred to should take place. This seemed to confirm the conclusions already put forward, for it might be that, at the higher temperature of 1320 deg. Cent., the iron was in the β condition, and that the slow cooling of the alloy, which contained chromium, did not allow the change to be made in the softer variety of iron. M. Osmond had referred to this in his report, but the speaker had arrived at the same conclusion as the result of independent working on other lines. In these alloys the carbon removed the chromium from the sphere of its ordinary action, and that the result was much the same as would ensue were carbon alone present, supposing the initial temperature of cooling low. They must not forget, however, that all varieties of carbon steel showed recalescence, the chromium steel showed none when the initial temperature of cooling was high. Professor Roberts-Austen wished, however, to guard himself from making absolute statements. At present, he said, we are only on the threshold of this inquiry, and our explanations must necessarily be tentative and incomplete. The President said that no one could help admiring the ingenuity of Professor Roberts-Austen's explanations, but to him they were not quite satisfactory. At the same time, he could suggest no better solution of the problem.

Mr. Vickers, of Sheffield, said that experiments he had made confirmed the conclusions which the author had set forth in his paper. In dealing with this subject the difficulty had been to get chromium without carbon, and it was not always possible to tell whether observed effects were due to carbon or chromium. It would be a great thing if pure chromium could be obtained. The moment carbon was removed chromium seemed to be lost also. In the use of chromium in the open-hearth furnace the oxidisability of the chromium was so great that it was exceedingly difficult to get any quantity of chromium mixed unless they had a large quantity of carbon. The experiments the speaker had made with the open-hearth furnace had not been satisfactory in that way. The speaker did not agree with all that was said about the use of steel in a hardened and unhardened state, and he always contended that steel was tougher and harder when hardened; at any rate, for gun-making. His firm had always made steam hammer piston-rods of hardened steel, and with good results. He had also found that the hammer-hardened state to which reference had been made, was the softest. In a chromium steel of something over 1 per cent. the hammer-hardened steel had had a strength of 50 tons, as compared with 93 tons for the same steel when hardened at 1500 deg., or 75 tons at 900 deg. When the 1500 deg. sample was annealed again at the same temperature the strength returned to approximately what it was before.

Mr. Galbraith referred to the effect of quenching on the specific gravity of steel. If the operation were performed at high temperature the specific gravity fell considerably.

Dr. Anderson said that chromium steel had given a little trouble at the Royal Arsenal, and as there was a difficulty in mixing the chromium, even in small quantities, would there not be greater difficulty in big work? Would the small quantity of chromium diffuse itself fairly in the mass? At Woolwich they had had a large gun hoop, the walls of which were 6 in. thick. It had been oil-hardened, and some hours after a report was heard which was not accounted for at the time. Some months after there was a second report when the hoop was put in the lathe. It was afterwards found, on breaking the hoop, that there was an internal crack 4 ft. long and 4 in. wide. The analysis of this hoop showed that chromium was in the steel, although he did not know how it had got there, but supposed it had been by accident. The speaker referred to the effect of steel cooling under compression and the consequent disappearance of recalescence, and to the use of wire in making guns, it having been found practically impossible to burst weapons made on this principle, but they were going to try the extent of its tenacity. The advantage of wire was that they felt safer, but with large masses of metal it was impossible to say what the internal state might be. A gun might be strained almost to the verge of rupture so that it would ultimately fail with a small charge, and for this reason it was desirable to use metal in small quantities. It was possible to improve steel to all appearance by treatment, but internal damage might be set up which annealing would not remove. For this reason wire was better than large masses.

Mr. F. W. Webb said that at Crewe they had found good results from chrome steel, so that they were now using it for all carriage springs. They also found great advantage in its application to tyres. For tools they found it excellent, the cutters made from this alloy lasting twice as long as ordinary. They had cutters in the lathe turning axles for two days continuously, and without lubrication. Mr. Webb said that he was getting particulars on this question together, and he hoped to make them public at some future time.

Mr. Saniter asked if chromium had a desulphurising effect similar to that of manganese.

Sir Frederick Abel referred to a part of M. Osmond's report in which it was stated that the latter had gathered from his experiments that chromium may exist in steel in three states at least, either separately or simultaneously. First, in the state of dissolved chromium. Secondly, in the state of a compound of chromium, iron, and carbon, in the form of isolated globules. Thirdly, in the same condition in the form of a solidified solution. In view of the difficulty of getting a satisfactory mixture, the speaker suggested that the second form would be of the nature of ferro-chromium distributed in a fine condition through the mass.

In replying to the discussion Mr. Hadfield said that he thought that there would be as uniform a mixture obtained with chromium as with carbon. Mr. Vickers preferred a softer steel which was oil-hardened, but the speaker did not see that any advantage was gained over the use of a naturally harder steel, and the process of oil-hardening must produce strains, and he agreed with Mr. Kreutzpointer as to the desirability of having a material free from strains. With regard to what he had said about hammer-hardening and Mr. Vickers' remarks, he would remind the meeting that he had only referred to chrome steel. As to the question raised by Dr. Anderson he did not see any difficulty in getting a uniform alloy of chrome steel. At the Paris Exhibition Holzer had shown an 18-in. square ingot, and he did not think there was any difficulty in getting it uniform; in fact, the thing was being done on the Continent, and if we did not exert ourselves in this country in the same manner, our trade would certainly suffer. He was glad to hear what Mr. Webb had said in this connection. In reply to Mr. Saniter he would say that chromium does not act as a desulphurising agent. He was sorry he could not throw more light on the question referred to by the President, His impression was that the chromium acts in some way in causing a more intimate connection between the carbon and the iron. He agreed with the Preauthor says: "Although the first two editions of this book, in its former shape, found a very favourable reception, the author yet deemed it necessary to make some changes when this third edition was called for, if only to record the progress made in the field of telephony without exceeding the compass of the volume." The author has not strictly adhered to this latter point, inasmuch as the new edition has been enlarged by a dozen diagrams and a score of pages; and he has done very little to keep his promise as regards recent progress. The statistical remarks—there are no statistics—refer to the year 1887. We notice one quotation of a more recent date—*Le Pantelé-phone de Locht-Labye*. Paris: 1890—and we do not think we have overlooked many others, references being scanty, and, indeed, not required in books of this type. The illustration of Edison's phonograph looks very ancient. Neither Mr. Edison nor Mr. Berliner would probably be satisfied with the note that the phonograph has been improved by Edison in many respects, and modified by Berliner under the name of "gramophone." The title indicates that the matter has been treated with special regard to practical application. It would be difficult to substantiate that claim. The popular descriptions of the numerous transmitters and receivers are clear and good, although the list is defective; and so are, on the whole, the chapters on telephone lines and central stations. The latter, however, will hardly benefit the practical man who would also expect more guidance to distinguish between antiquated types and efficient apparatus actually in use.

Dangerous Structures, a Handbook for Practical Men. By A. H. Blagrove. (84 pp.). London: B. T. Batsford, 1892.

This unpretentious little work, reprinted from articles published in the *Building World* in 1890, is a handy little manual intended for practical men, "to suggest (as stated in preface) ready means for getting over difficulties which frequently occur in practice," and it will probably suffice for that purpose. It deals chiefly with remedying defects found to exist in structures, and gives a fair idea of rough-and-ready means of dealing with these. It consists of ten short chapters—on foundations, walls and piers, roofs, arches, lofty structures, stone lintels, timber beams, ties, struts, and shoring; the mere enumeration of these gives a sufficient idea of the scope of the work. The chapter on defects in lofty structures may be specially noticed as interesting; it contains an account of the methods (successfully tried) of bringing back certain chimney shafts to the vertical, and notably the Townsend chimney at Glasgow, 454 ft. high, after it had deviated 7¾ ft. off the vertical.

BOOKS RECEIVED.

The Journal of the Iron and Steel Institute, 1892. London and New York: E. and F. N. Spon.

The County Councillors' Directory, Containing a List of the Aldermen and Councillors, with Addresses, for all Counties and County Boroughs under the Act of 1888. London: *Contract Journal* Company. [Price 2s. 6d.]

Lightning Conductors and Lightning Guards. By Oliver J. Lodge, D.Sc., F.R.S. London: Whittaker and Co., and George Bell and Sons.

The Present Position of Roller Flour Milling. By Henry Simon, M. Inst. C.E. Manchester: 20, Mount-street.

Mechanics for Engineering Students. Illustrated with 140 Examples Worked out. By A. N. Somerscales. Hull: R. C. Annandale. [Price 1s. 6d.]

Pumps and Pumping Machinery. Part I. By Frederick Colyer, M. Inst. C.E., M. Inst. M.E. Second Edition, revised, enlarged, and new matter added. London: E. and F. N. Spon. New York: Spon and Chamberlain.

A Text-Book of Coal Mining. For the Use of Colliery Managers and others. By Herbert W. Hughes. With very numerous Illustrations. London: Charles Griffin and Co. [Price 18s.]

MODERN UNITED STATES ARTILLERY.—No. XXVII.

The Gatling Gun. (Figs. 523 to 536.)

The United States has no body of its artillery armed with a machine gun. A large number are, however, kept on hand for use in case of emergency, and to all the artillery stations, and also to a large number of stations where troops of other branches of the service are posted, machine guns have been issued and are there kept in reserve and the troops instructed in their use.

The machine gun adopted by the United States service is the Gatling gun. Its use is not confined to the army, for it is probably used more extensively in the navy. The gun appeared in 1865, and since that time no change of importance has been made in the principles on which it is constructed, though great improvements have been made in the feed.

The gun consists, practically, of ten breech-loading magazine bolt guns; each independent of the others, and each loading, firing, and ejecting the empty shell once with every revolution of the cluster. As shown in Figs. 523, 524, and 527, the ten barrels are grouped around the central spindle, to which they are attached by two barrel plates.

The handle may, as shown in Fig. 523, be attached to a crankshaft at the side, Fig. 527 at A, and the barrels revolved by turning this handle. In this position one turn of the handle gives one-tenth of a turn to the barrels and one barrel is fired.

The rate of fire may be increased by removing the piece B, Fig. 527, and attaching the handle to the central shaft itself. In this position one turn of the handle will give one turn of the barrels, and all of the barrels will be fired.

Each barrel has its own bolt, and each bolt contains an axial firing-pin, around which is coiled a spiral main-spring, Fig. 525; the firing-pin terminates in a knob A, which is for the purpose of cocking; C is the extractor, and B a lug on the bolt, by means of which the bolt is given a reciprocating motion in the direction of the axis of the barrels.

The barrels project in front through a face-plate which revolves with them. The sights are two in number, and are situated on either side of the piece. Fig. 528 gives the breech-view, the breech being closed by a breech-plate which screws on to the casing. In this breech-plate is cut an axial hole through which the central shaft passes and terminates in a knob, and also a second hole at A, which is closed by a screw-plug. This plug can be easily removed, and through the hole can then be withdrawn any one of the locks by merely revolving the barrels until the bolt which is to be removed comes opposite the hole. As the action of any bolt is entirely independent of the others, the removal of any bolt will not interfere with the working of the gun, but will merely decrease the rapidity of fire. The barrels are entirely inclosed in a brass casing, Fig. 527, except at the point where the feed is inserted, by means of which cartridges are dropped in succession in front of the bolts. The mechanism of the gun is thus protected as far as possible from dirt and dust, which might injure or clog the parts. On the interior of the casing at the breech is cut a cam groove, in which engages the lug B of the bolts. By means of this groove the reciprocating motion is given to the bolts; Fig. 525 shows the development of this cam groove. Bolt I is just under the feed at the top element of the gun casing, and the cartridge has just been dropped from the feed in front of it. The lug on the under side of the bolt is engaged in the cam groove, and as the barrels are revolved, the bolt is constrained to advance towards the barrel, gradually shoving the cartridge home, as shewn in the various positions, II., III., IV., and V. At IV. the knob on the head of the firing-pin, before mentioned, engages in the cocking rib, and it is thus prevented from advancing any further. The bolt, however, continues to advance, and the main-spring is thus compressed. When the bolt reaches the position V., the knob on the firing-pin arrives at the end of the cocking rib, and the firing-pin flies forward, discharging the cartridge.

From V. to VIII., the plane of the cam groove is at right angles to the axis of the barrels, and there is no motion of the barrels in a longitudinal direction. This slight pause in their longitudinal motion is necessary in case a primer hangs fire. From VIII. to X., the cartridge is withdrawn and ejected. From X. to I., the plane of the cam groove is again at right angles to the axis of the barrels, and there is no longitudinal motion to the bolts. During this time the cartridge is dropped in front of the bolt. At B, Fig. 528, is seen a knob; on this knob is an arrow pointing to the front.

By turning this knob so that the arrow points to the rear, the cocking rib is moved away from the cam groove, so that the knobs on the firing-pins no longer engage in the cocking rib as the barrels revolve, and consequently the piece is not fired. This is the safety device.

The kinds of feeds used with this gun are two in number, the Bruce and the Accles.

The Bruce feed consists of a vertical frame which holds a swinging plate, pivoted at the point A, Figs. 531 and 532; on the front face of this plate are two undercut grooves or channels, which catch and hold the heads of the cartridges. The cartridges for the use of the troops are put up in boxes of 20, each box having two rows. The cover having been torn off of the box, the flanges of the cartridges can be slid into the channels, and pulling the box forward leaves the cartridges behind. One column is fed down into the gun, and when that channel is empty the weight of the column in the other channel causes the plate to swing to the other side, and the second channel is fed down into the gun. In the lower part, B, of the feed is a coarse-toothed wheel which revolves and directs the cartridges, one by one, into the gun. This feed acts very well for its kind, but has the objection common to all gravity feeds, that when the gun is being fired at high angles of elevation or depression, the cartridges will not slide down the feed.

The Accles feed, shown in Figs. 533 to 536, is independent of the action of the gravity, and will feed equally well at all angles of elevation and depression. It is in the form of a drum, on each head of which, as shown in Fig. 534, are ribs at such a distance apart that a cartridge can be held between them. The width of the drum is equal to the length of a cartridge. These ribs, as shown in Fig. 536, are spiral in form. Within the drum is a revolving vane or paddle, shown in Figs. 533 and 534, the width between each wing or blade being equal to a diameter of a cartridge. The drum is filled by feeding in the cartridges, one by one, between the blades of the paddle, and the spiral ribs gradually work them towards the centre. When the feed is in place on the gun, and the latter is revolved, a coarse cog-wheel on the gun engages the blades of the paddle and causes it to revolve at the same rate, thus feeding the cartridges into the gun.

In Fig. 536, barrel 1 is on the point of being loaded, in 2, 3, and 4 the cartridges are being forced into the barrel, 5 is being fired, 6, 7, and 8 are having the cartridges extracted, 9 is having the cartridge rejected, and 10 is ready for loading.

This feed holds 104 cartridges, and is perfect in its action; it has been fired at a rate of 3000 shots a minute.

While of American invention and manufacture, this gun has been used by many different nations, and has been in many actions on both land and water.

The Hotchkiss Revolving Cannon.
(Figs. 537 and 538.)

One battery of the United States light artillery is equipped with Hotchkiss revolving cannon. These, with the Gatling guns, form the only equipment of machine guns in the United States Army.

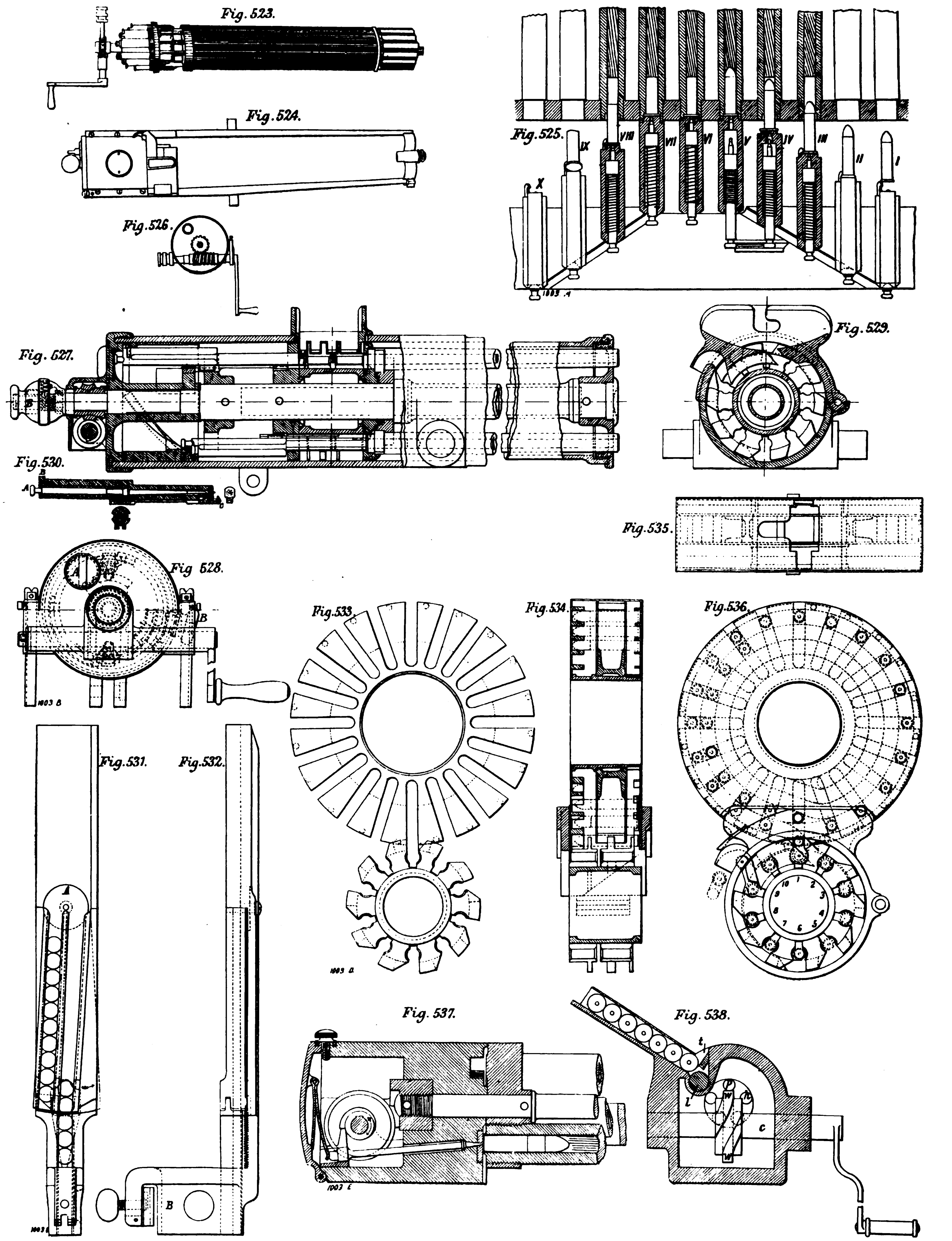
The Hotchkiss guns are so widely known, and have been so fully described before, that a short description of the general principles seems to be all that is necessary. The main works of the Hotchkiss Company are in France, but the wish to furnish a number of their guns for the United States Navy, which were required to be of domestic manufacture, led them to establish a branch works in the United States.

The gun, Figs. 537 and 538, consists of a group of five barrels assembled around a main shaft by being screwed into two bronze assembling discs, which discs being bolted to the mainshaft cause barrels, discs, and shafts all to revolve together. The rear ends of the barrels come just even with the rear face of the rear disc, while the main shaft goes completely through the breech-piece.

The breech-piece is a cast-iron block to give strength and weight for resisting the shock of discharge, and hollowed in rear to form a chamber for the breech mechanism.

The turning of the handle of the crankshaft *c* causes the revolution of the barrels, the loading, firing, and extraction of the cartridges. The revolution of the barrels is caused by a simple gear movement. There are a number of pinions attached to the main shaft, in which engages a wormwheel, which is rigidly secured to the crankshaft. This wormwheel is so arranged, that with one revolution, the barrels are given one-fifth of a revolution, and then remain stationary for an instant. While stationary, one barrel is being fired, one loaded, and one is having the empty shell extracted. The firing is done in the following manner. The

MODERN UNITED STATES ARTILLERY: GATLING AND HOTCHKISS GUNS.



main-spring presses against the end of the firing-pin, and an arm on the latter presses against a spiral thread on the crankshaft, so that as the crank is revolved, the firing-pin is forced back, and the main-spring compressed. A sudden termination of the spiral thread causes the main-spring to force the firing-pin forward, thus discharging the piece.

The loading and extraction are dependent upon each other. An arm on the crankshaft, not shown in the figures, forces the extractor forward and back; during its forward motion it hooks on to the rim of the cartridge, and when drawn back extracts it. To the extractor is attached a toothed rack, a similar rack is attached to the rammer *l*, and between the two racks is a stationary gear-wheel,

TIMBER STRUCTURES ON WESTERN AMERICAN RAILROADS: HOWE TRUSS OF 250-FT. SPAN.

CONSTRUCTED FROM THE DESIGNS OF MR. W. A. GRONDAHL, RESIDENT ENGINEER, OREGON DIVISION, SOUTHERN PACIFIC RAILROAD.

(*For Description, see Page 446.*)

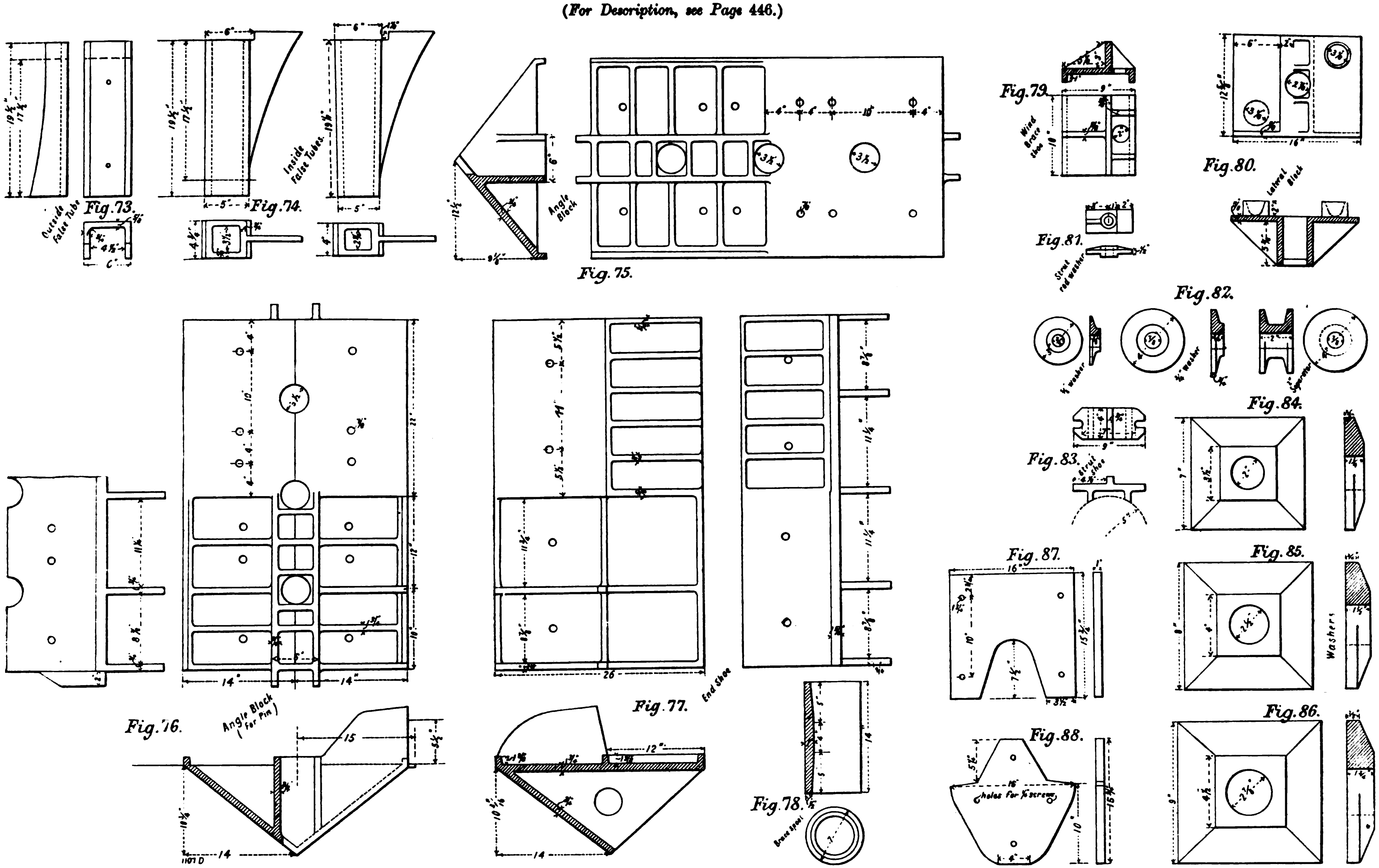


Fig. 73. Fig. 74. Fig. 75. Fig. 76. Fig. 77. Fig. 78. Fig. 79. Fig. 80. Fig. 81. Fig. 82. Fig. 83. Fig. 84. Fig. 85. Fig. 86. Fig. 87. Fig. 88.

The forward motion of the extractor thus causes the rammer to move to the rear and the converse.

Table XLVIII.—*Ballistic Data of the Hotchkiss Revolving Cannon Used in the United States Service.*

Calibre	1.457 in.
Length of bore	4.2 ft.
Rifling, one turn in	4 ,,

(Twist and depth of grooves uniform.)

Number of grooves	12
Length of shell with fuze	3.66 in.
Weight ,, ...	16.05 oz.
Charge of powder	4.3 ,,
Weight of complete cartridge ...	25.04 ,,
Length ,, ,, ...	6.58 in.
Weight of piece	1047 lb.
,, carriage complete ...	1092 ,,
,, limber	661 ,,
,, 460 rounds of ammunition	720 ,,
Total weight	3561 ,,

The cartridges are fed by gravity in front of the rammers; a small wing or shutter *t*, which is lifted as the extractor moves forward, prevents jamming, which might be caused by a second cartridge dropping down on top of the first. The whole mechanism is very simple and accessible. The recess for the breech mechanism is close by a hinged plate, which is held closed by means of a screw on top. If this screw be withdrawn, the plate drops to the rear, and all of the mechanism is in sight and reach. Both solid shot and shell are used.

The carriage, made principally of steel, is of peculiar construction, and is well adapted both for travelling and as a stable support for the piece when firing. Attached to the frame supporting the breech-block and barrels is a turntable, which connects the cannon to a trunnion saddle, arranged in such a manner that, without displacing the carriage in the least, a certain amount of lateral motion, as well as of elevation, may be given the piece.

THE USE OF TIMBER ON WESTERN AMERICAN RAILROADS.

In our review of the use of timber on Western American railroads we have already dealt with trestles and miscellaneous structures (page 633 of last volume), and with the Howe truss (page 382 *ante*). It has generally been supposed that the limit of length that could be employed with satisfactory results for a timber railroad bridge was 150 ft. The engravings on our two-page plate and on page 445, are those of a truss, recently erected on a branch line of the Southern Pacific Railroad in this State, which has the unprecedented length for a railroad bridge of 250 ft. This length is the more remarkable when we consider the rolling load for which it is designed, viz., two 100-ton locomotives, followed by a train load of 3000 lb. to the foot, or what is known as Cooper's Extra Heavy A.

The bridge was designed by Mr. W. A. Grondahl, M.E., C.E., Resident Engineer of the Oregon Division of the Southern Pacific Railroad, who has recently replaced all the older Howe trusses of the road with spans of this type. The type is an improved Howe truss; and it is the counterpart of the Baltimore truss, which may be called an improved Pratt truss. It has the essentially American characteristics of great depth of truss, wide panels, and single intersection. The weak point in long-span Howe trusses of the old type lies in the tendency of the bottom chord to stretch, the spliced sticks pulling apart; and the tendency of the angle blocks to slide on the chords; the natural result of which was that the truss lost its camber, and was condemned. The sliding of the angle blocks was obviated by reducing the inclination, and increasing the number of the braces; but this, in trusses that were rarely more than 20 ft. to 22 ft. deep, involved an increase in deadweight, that was prohibitive of any increase of span above 150 ft. A common proportion of width to depth of panel in the older trusses was 10 ft. to 20 ft.; the top lateral system being placed just high enough to clear the train, with its train hands.

It will be seen that Mr. Grondahl has struck out on entirely original and bold lines in his treatment of the Howe truss, greatly increasing the depth of the truss, enlarging the main panels from 10 ft. to 30 ft., and adopting in most of his trusses an inclination of 45 deg. for the braces. This has resulted in a great lessening of the deadweight, and the increased depth has reduced the strains in the chords (hitherto the weak spot in a Howe truss). These changes, with the adoption of the pin connections (shown in detail) for taking the thrust of the braces, and for splicing the chords, have met the difficulties attending long span timber bridges. The main panels of the truss are 31 ft. 3 in. wide, subdivided by ties and ½ in. braces into panels 15 ft. 7½ in. wide. These ties consist of two single rods 1½ in. in diameter which are secured by nuts and gibplates below the chords, and pass up and over a "brace spool" (see Fig. 65), returning to the chords again. The spool is 7 in. in diameter, and is let into each main brace 5 in.; and upon it rests a cast-iron shoe to receive the foot of the top chord stiffening strut. The strut is associated with a ⅞-in. tie rod that passes round under the same spool and is secured on the upper side of the top chord. The half-braces are boxed and dowelled into the main braces, as shown.

The increased obliquity of the braces called for special provision to meet the horizontal thrust. To this end a pin 3½ in. in diameter is driven through the chords immediately in front of the angle block, and engages five flanges that are cast on the angle block and project between the chord leaves. After the chord has been packed and bolted it is bored with an auger designed for the purpose, which cuts a clean hole through both wood and iron. Into this a turned 3½-in. pin is driven to a tight fit. This pin, together with the letting in of the angle block tubes into the chord leaves, enables a moderate unit of longitudinal shearing and crushing stress to be used.

The use of pins for splicing the chord sticks is shown in Figs. 67 to 72. From three to six pins are driven through each stick, and cast-iron plates are adjusted on each side, so that a pull on the outside pin will be transmitted to all of them. The furthest pins are connected by eye-bars, at one end of which is an eccentric with a ½-in. throw. The pins and eye-bars are adjusted first with the eccentric thrown over towards the joint, after which the eccentric is drawn back with a long spanner, bringing the abutting sticks tightly together. Each clamp is supposed to completely reinforce the cut stick.

The wind and lateral bracing are of the usual type.

This truss, despite its great length, has shown remarkable stiffness. The deflection under a work-train loaded with gravel was a scant ½ in., a surprising and gratifying result.

It must be borne in mind that bridges such as this presuppose an abundance of large and sound timber within easy reach and at low prices. Sawmills in this locality will readily undertake the supply of such huge sticks at from 11 dols. to 12 dols. per 1000 ft. B. M.

CONVERTED MARINE ENGINES.

The illustration on page 452 represents sets of marine engines on the steamships Pallion and Stranton. These vessels were built in 1879 and 1880 for the West Hartlepool Steam Navigation Company, and were fitted with engines by Messrs T. Richardson and Sons, of Hartlepool, the sizes of the cylinders being 33 in. and 61 in., with a stroke of 2 ft. 9 in.; the working pressure was 75 lb.

These engines have recently been converted to triple expansion by the same firm, the method of alteration being as follows:

The original boilers were removed and replaced by two of the single-ended type, 12 ft. 9 in. in diameter and 9 ft. 9 in. long, the working pressure being 170 lb. Each boiler was fitted with two of Morison's suspension furnaces of 3 ft. 9 in. in external diameter, and there is no doubt that the high evaporative efficiency obtained from the boilers is due to the furnaces being of large diameter and of minimum thickness, with a comparatively short grate bar. This arrangement allows of more perfect combustion than is possible in a small furnace, and at the same time it offers a length of fire which is easily worked by an average fireman.

The old engines were utilised as far as possible, the original cylinders being retained and used as the intermediate and low-pressure cylinders, the latter being reduced in diameter to 56 in. by means of an independent liner. The condenser, soleplate, and pumps were also retained, with the exception of the feed pumps, which were replaced by others suitable for the increased pressure.

A new horse-power engine complete was fitted to the forward end of the crankshaft, which was altered and provided with an additional crank, the three cranks being set at angles of 120 deg. The original high-pressure column was removed and replaced by one binding the new high-pressure cylinder to the intermediate, as shown on the engraving, and a casting was bolted to the condenser at the back of the engines and forms the back support of the high-pressure cylinder. The reversing shaft was lengthened to operate the high-pressure valve gear, and a new reversing engine, of the all-round type, was provided.

The chief feature of the engine, however, is the novel arrangement of the high-pressure cylinder, the improvement being based upon the fact that the greater the circulation over a heat-giving surface the greater is the amount of heat transmitted. The cylinder is jacketed with steam at boiler pressure and the outside of the jacket is surrounded by the first receiver, the design in this respect being similar to the practice in the early days of compound engines, in which the exhaust steam from the one cylinder flowed directly to the steam inlet of the next. The defect in this arrangement was that only a small portion of the steam came into actual contact with the jacket, as the circulation was practically confined to the steam in the direct line of passage from the exhaust port of the high-pressure to the steam port of the low-pressure cylinder. In this engine, however, the receiver is provided with a number of circulating channels which cause the steam to flow uniformly over the whole heat-giving surface of the jacket on its passage to the intermediate pressure engine. The channels are formed by vertical partitions, and the direction of flow being consequently of a zig-zag nature, the steam is continually mixed up, and not only does it abstract a large amount of heat by means of its rapid flow, but the whole body of steam being continually intermingled, it is thoroughly dried before entering the intermediate-pressure cylinder.

It is well known that in the ordinary design of triple-expansion engines a large amount of condensation takes place in the high-pressure cylinder, and that a great deal of water enters the intermediate pressure cylinder. This is evidenced by the amount of leakage past the piston-rod and valve spindle glands, and by the rapid destruction of fibrous packing. With the circulating receiver, however, the steam is so thoroughly dried before entering the intermediate pressure engine that there is no water carried into that cylinder. In the case of these vessels registering drain traps were fitted, but practically no water was drained off.

Another feature in the arrangement is the combination of an evaporator for producing fresh auxiliary feed water with a steam jacket. In this case a Morison's evaporator is connected to the high-pressure jacket at its lowest part, thus making the jacket drain directly into the heating coils of the evaporator, and in addition to automatically draining the jacket, increasing the circulation of steam therein by the amount used by the evaporator, which steam is still further utilised to heat the feed water on its passage from the hotwell to the feed pumps.

The value of these arrangements, which have been designed by Mr. D. B. Morison, the manager of Messrs. T. Richardson and Sons, is shown by the results obtained. In order to obtain reliable data from ordinary working at sea, 140 tons of average coal was put into one of the bunkers at Blyth. All the coal used on the voyage to Port Said was taken from this bunker, and on arrival it was found that the average consumption per day had been 8½ tons with an average speed of 8.6 knots. Formerly the consumption of coal was 12½ to 13 tons per day, with a speed of 8½ knots.

The reduction in the coal consumption was, therefore, 4½ tons per day, or in other words for the same speed, the coal consumption with compound engines was fully 50 per cent. in excess of the present consumption with the tripled engines. In dull times such as these, the fact that such results can be obtained by tripling the machinery of many of the older ships should cause shipowners to give the matter their careful consideration. There seems no doubt that many ships now working at a great disadvantage with compound engines might be made to show a satisfactory dividend if the machinery was converted as successfully as in the cases we have related.

TRIALS OF REAPERS AND BINDERS IN DENMARK.

A series of important and exhaustive trials of harvesting machines, held under the auspices of the Royal Danish Agricultural Society, and in connection with this society's pentennial show next year, has been going on for some time, and has now been completed. The result of these trials will, no doubt, have a material bearing upon the reaper and binder trade in Scandinavia for several years to come, and this trade bids fair to assume unexpected dimensions. The results will, no doubt, interest our readers.

There were eight judges, chosen for their knowledge of the subject, and the trials, which extended over several weeks, have attracted much attention. The following binders put in an appearance: Adriance Platt, and Co., McCormick and Co., William Deering and Co., R. Hornsby and Sons, the Johnston Harvester Company, the Massey Company, Toronto, with a Massey and a Harris binder, D. M. Osborne and Co., J. F. Seiberling and Co., and Walter A. Wood. The trials of automatic reapers comprised fourteen machines, principally from the same firms.

The trials with rye commenced at Constansborg, Jutland, on August 10. The order was decided by drawing lots, and the start was made by measuring the power required in a very uniform crop. Both reapers and binders were tested in this way, and these trials occupied almost the whole day. The following day the proper working trial took place in good and fairly heavy rye.

Two or three machines very soon asserted their superiority. Osborne's and Wood's bound furthest from the ground, but according to the Jutlandish opinion they all bound too near the root. The McCormick high binder, Hornsby's, Johnston's, and the two Massey machines went fairly well, whilst the Adriance-Platt low binder, the McCormick low binder, the Deering, and the Empire (Seiberling's), were less successful.

On August 12 the automatic reapers were tried with rye, and Johnstone's and Wood's succeeded best.

On August 13 several of the machines were again tried, and on the following day the "technical" judging took place. This comprised all the machines. They were weighed all with the same man. The weight of the binders, including the man (150 lb.), varied between 1466 lb. (Adriance Platt and Co.), and 1745 lb. (the Massey binder).

On August 29 the trials with wheat commenced at Höivang; the wheat was very heavy, the weather was unsettled, and it soon transpired that very few of the binders could properly handle the crop, especially where the straw was a little green. The Wood and the Osborne binders managed, however, to go through without any stoppages. McCormick's (both high and low binders), the Adriance Platt, and Hornsby's, could not efficiently handle the heavy wheat. Measurements of power required were also made here, and Wood's and McCormick's were apparently the heaviest to pull. The automatic reapers worked about the same in the wheat, as they had done in the rye.

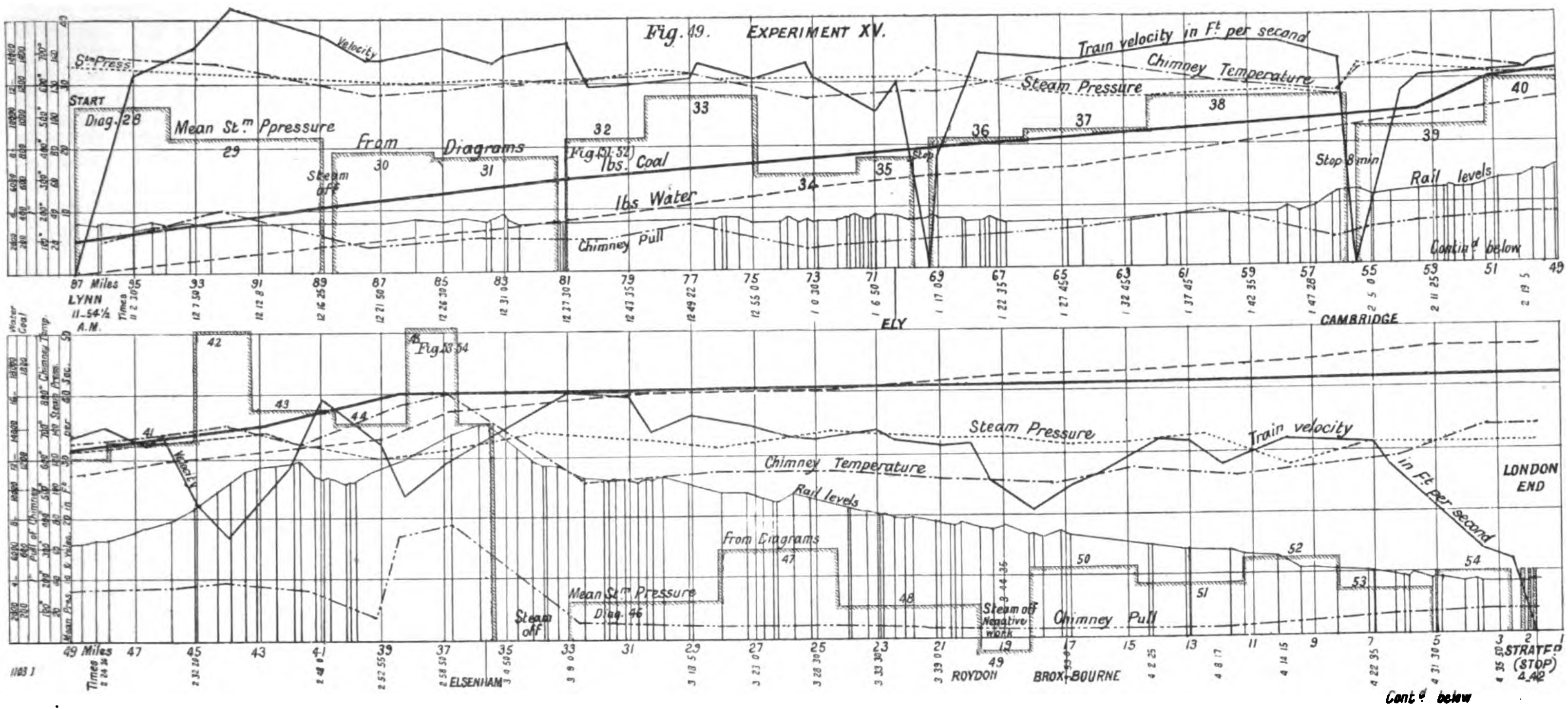
The trials with oats were not completed on account of rain, but those machines that were tested went over the whole well.

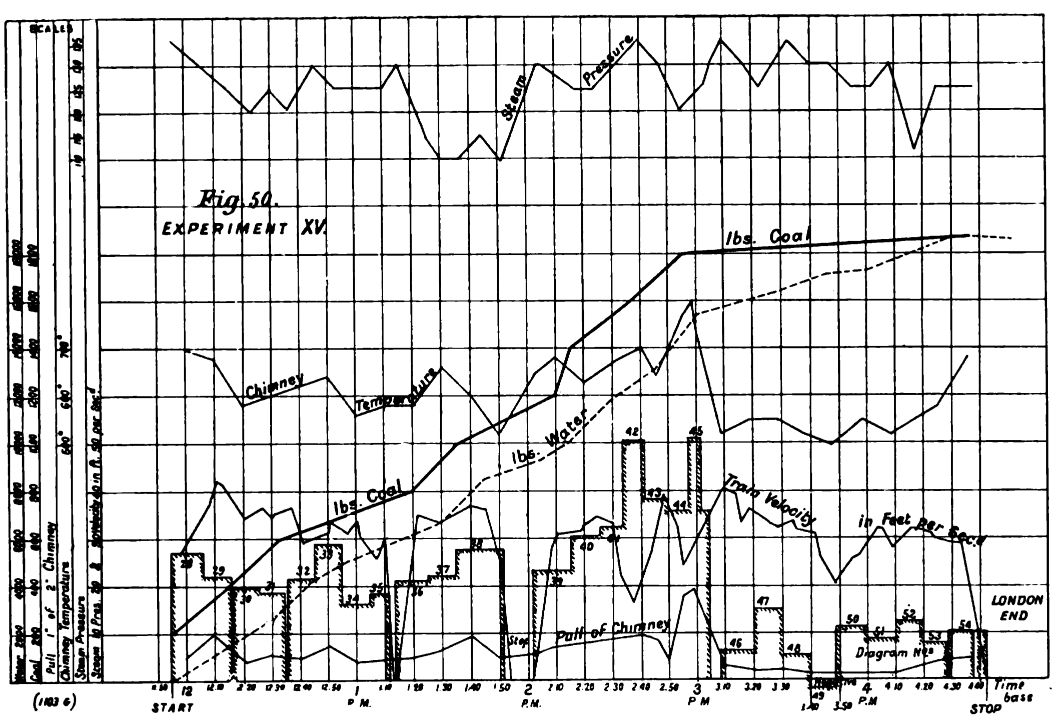
When the results have been properly digested and commented upon (the official report will not be forthcoming till probably next year) they will materially tend to settle the question, whether binders are likely to find a market worth speaking of in Denmark and the rest of Scandinavia.

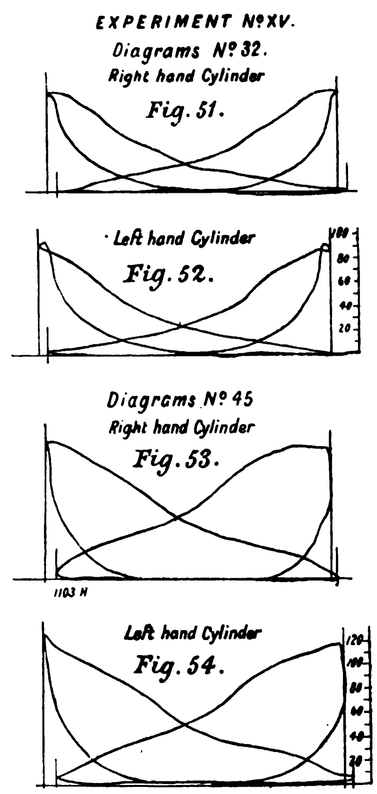
In the mean time, the present year has no doubt beaten the record, as far as the sale of harvesters goes; it is estimated that about a thousand machines have been sold in Denmark, and Woods, Hornsbys, and Johnstones have probably sold the best.

Also in thrashers and portable engines a large trade

STEAM BOILER EXPERIMENTS.







agree closely. Before the running tests a rehearsal was made to Broxbourne and back, of about an hour each way, to get all the apparatus in working order, and the hands well accustomed to the different duties allotted to them. About twenty-seven sets of diagrams were taken in the up and down journey; four indicators were used in the stationary trials, and two in the running tests.

The Table on page 504 gives the chief results of the trials for the up and down journeys, as also for the stationary trial. It will be seen that they form a good check upon each other. Graphic delineations of the two running trials are set out in four diagrams, two for the up and two for the down journey, one on a *time* base in hours, the other on a *distance* base in miles. The diagrams Figs. 45 and 46 on page 502 are those relating to the down journey, while those marked Figs. 49 and 50 on the present page refer to the up journey. These diagrams not only give the rail levels plotted out, but also the pounds of coal and pounds of water to boiler, the steam pressure and mean of diagram pressures, the pull and temperature of the chimney, and the velocity of the train in feet per second. Examples of the indicator diagrams taken during the down journey are given in Figs. 47 and 48, page 502, and of those taken during the up journey by Figs. 51 to 54 annexed.

MODERN UNITED STATES ARTILLERY.—No. XXVIII.

The Dreggs-Schroeder Rapid-Firing Gun.

(Figs. 539 to 555).

"Rapid-firing guns" are now generally understood to mean single-shot guns using metallic ammunition with the primer, projectile, and ammunition combined, so that the loading is performed by one operation. The breech mechanism is generally operated by levers, and the opening and closing are done easily and quickly. The aiming is usually done by the gunner by means of a stock in a manner similar to a small arm (Fig. 539); the stock is so arranged that the recoil is not communicated to it, so that the gunner can fire the piece without removing his shoulder. The recoil is very slight, and the return to battery very quick. By this means a rapid succession of aimed shots can be fired. Since 1886, the development of the quick-firing gun has been very considerable. All warships are designed to carry a number of these guns, and in some cases, the armament consists entirely of them. Whether rapid-firing guns shall be adopted for land service, and if adopted, what part they shall play, does not seem to be definitely decided, but their place is well fixed in naval warfare, especially when used against unarmoured ships.

They are specially intended to destroy the unarmoured ends of ironclads, to disable unprotected guns and machinery, and against gun shields, tops, and gun ports. It is also claimed that by striking the long unprotected chase of a heavy gun, the gun will be spiked.

Their special duty, however, is to protect the vessel from the attacks of swift torpedo boats. The rapidity of fire of the guns and aiming, together with their power, eminently fits them for this duty.

STEAM BOILER EXPERIMENTS: RESULTS OF EXPERIMENTS Nos. XIII., XIV, AND XV.

(See Page 501.)

PARTICULARS AND DIMENSIONS OF LOCOMOTIVE BOILER.

Date:
August 19, and October 19 and 20, 1887.

Place:
First experiment. Engine stationary at Great Eastern Railway Works, Stratford.
Second ,, ,, running, Stratford to Lynn.
Third ,, ,, ,, Lynn to Stratford.

Type:
Steel locomotive boiler (tank goods engine) with copper firebox. 223 tubes.

Heating Surface:
Heating surface of boiler (taking *internal* tube surface) ... 859 sq. ft.

Firegrate:

Dimensions of firegrate ...	3 ft. 3 in. by 3 ft. 10 in.
Area of grate ...	12.4 sq. ft.
,, air spaces...	3.47 ,,
Ratio of air space to area of grate ...	0.28
,, boiler surface to grate surface ...	69.2

Flues:
Kind of flues and direction of gases ... No brickwork. Gases direct through boiler to chimney.

PRINCIPAL OBSERVATIONS.

Conditions of experiment, &c.	August 19.	October 19.	October 20.
	No. XIII.	No. XIV.	No. XV.
	Engine Stationary in Shops.	Engine Running. Stratford to Lynn.	Engine Running. Lynn to Stratford.
Time:			
Duration ... hours	8.31	4.88	4.76
Steam Pressure:			
Mean steam pressure above atmosphere ... lb.	130.3	119.0	125.0
,, absolute steam pressure ... ,,	145.0	133.7	139.7
Temperature Fahr. corresponding to this pressure ... deg. Fahr.	355.6	349.3	352.7
Feed Water:			
Temperature of feed ... deg. Fahr.	56.5	50.7	52.0
Total feed water evaporated ... lb.	37,010	17,588	19,011
,, ,, ,, per hour ... ,,	4,454	3,620	4,000
Coal and Ashes:			
Total coal used, including ashes and clinker ... lb	3663	1701	1871
	Ash. Clinker.	Ash. Clinker.	Ash. Clinker.
Per cent. of ash and clinker in total coal used ... per cent.	4.58 1.14	3.8 1.7	4.2 1.4
,, moisture in fuel ... ,,	0.6	0.5	0.5
Total weight of pure and dry coal used per hour ... lb.	413	327	369
Ratio of total pure and dry coal to coal including ash, &c. ...	0.937	0.940	0.939
Total coal used including ash and clinker per hour ... lb.	441	348	393
	Ash. Clinker.	Ash. Clinker.	Ash. Clinker.
,, weight of ash and clinker ... ,,	168 42	64.5 28.5	78 26
Stoking:			
Thickness of fires ... in.	5 to 6	4 to 5	
Number of times each fire stoked per hour ...	3	5	5.3
Temperature of Air:			
Temperature of external air ... deg. Fahr.	61.2	48.5	55.5
Temperature of Gases:			
Temperature of furnace gases at base of chimney ... deg. Fahr.	...	570	617
Draught:			
Chimney draught ... inches of water, mean	1.03	1.07	1.26

PRINCIPAL OBSERVATIONS—*continued.*

Conditions of experiment, &c.	August 19.	October 19.	October 20.
	No. XIII.	No. XIV.	No. XV.
	Engine Stationary in Shops.	Engine Running. Stratford to Lynn.	Engine Running. Lynn to Stratford.
Radiation Experiment:			
Coal per hour necessary to maintain steam pressure only ... lb.	17.0	17.0	17.0
Per cent. of total coal used, including ashes and clinker, per hour	3.85	4.9	4.3

ANALYSIS OF FURNACE GASES, &c.

	Experiment XIII. By Wgt.	Experiment XIII. By Vol.	Experiment XIV. By Wgt.	Experiment XIV. By Vol.	Experiment XV.
Analysis of Dry Furnace Gases:					
Carbonic dioxide, CO_2 ... per cent.	17.94	12.4	14.9	11.2	Experiment No. 15 assumed to have same analysis as Experiment No. 14.
,, oxide, CO ... ,,	1.02	1.1	0.0	0.0	
Oxygen, O ... ,,	6.53	6.2	6.6	7.8	
Nitrogen, N... ,,	74.51	80.3	78.5	81.0	
Carbon:					
Per cent. weight of carbon to dry gases ...	5.33		4.06		
Air:					
Pounds of dry air per pound of carbon...	18.2		24.0		
,, ,, ,, coal ...	16.1		21.3		
,, ,, ,, pure and dry coal ...	16.7		22.0		
,, furnace gases per pound of pure and dry coal ...	17.3		22.6		
Ratio of air used to air theoretically required ...	1.56		2.05		
Temperature of Gases:					
Rise in temperature of gases from temperature of air on day, approximate ... deg. Fahr.	573		522		562
Carbonic Oxide:					
Per cent. of carbon burnt to carbonic oxide ...	8.25		0		

PRINCIPAL RESULTS.

Combustion			
Experiment number ...	XIII.	XIV.	XV.
Pounds of coal burnt per square foot of grate surface per hour ...	35.5	28.1	31.7
,, ,, ,, ,, heating ,, ,, ...	0.514	0.406	0.458
Transmission of Heat:			
Thermal units per square foot of heating surface per hour ...	6040	4930	5440
Evaporation:			
Pounds of water evaporated per pound of coal from feed temperature	10.10	10.34	10.16
Equivalent evaporation per pound of coal from and at 212 deg. Fahr.	12.18	12.51	12.29
,, ,, ,, pure and dry ...	13.0	13.3	13.1
,, ,, square foot of grate per hour ...	433	353	390
,, ,, ,, heating surface ...	6.25	5.10	5.62
Factor of evaporation ...	1.206	1.208	1.208

Balance Sheet of Heat. Percentages.

Heat Evolved.	—	Heat Absorbed.	Experiment XIII.	Experiment XIV.	Experiment XV.
Heat from pure and dry coal ...	per cent. 100	Heating and evaporating water	per cent. 80.7	per cent. 82.6	per cent. 81.3
		,, furnace gases...	15.9	18.6	20.0
		Evaporating moisture in coal	0.0	0.0	0.0
		Radiation by experiment ...	3.0	3.9	3.4
		Lost by imperfect combustion	4.9	0.0	0.0
Total ...	100	Total ...	104.5	105.1	104.7

There are, at present, a number of well-known systems of rapid-firing guns, some of the most prominent of which, as the Maxim, Hotchkiss, and the comparatively new Driggs-Schroeder systems are of American origin. The first two were not developed in the United States, though the first order for a weapon of this kind that the Hotchkiss Company received came from the United States, and the guns now mounted in the new ships, Boston, Atlanta, and Dolphin, were delivered under it. Three calibres were made, the 6, 3, and 1-pounder, as they are known in the United States Navy, while in other countries they are classified as the 57, 47, and 37-mm. guns.

The Hotchkiss Company has filled its contract for 94 guns and ammunition. It was required that the guns for the United States should be of domestic production. The Hotchkiss Company made satisfactory arrangements, and the guns were quickly constructed. The Midvale Steel Company furnished the necessary forgings, and the guns were constructed by the Pratt and Whitney Company of Hartford, Connecticut. The ammunition was made by the Winchester Repeating Arms Company of New Haven in the same State.

The Dreggs-Schroeder Rapid-Firing Guns.—The Dreggs-Schroeder system was invented by two officers of the United States Navy, and has been developed entirely in that country.

Some four years ago, anticipating the great advantages of the rapid-firing system of guns, Lieutenants W. H. Dreggs and Seaton Schroeder, by careful study and experiment, developed a quick-firing gun, which, while still comparatively new, may be said to rival and in some points to excel the older systems. Many defects were naturally discovered in the first gun built, a 3-pounder, but the merits of the system were plainly seen, and improvements have continually been made until the present system has been reached. The official tests of the guns were so flattering that the United States Government has given an order for a number of this type.

The company are now building rapid-firing guns of the following dimensions :

TABLE XLIX.—PARTICULARS OF DREGGS-SCHROEDER QUICK-FIRING GUNS.

Number Building.	Weight of Projectile.	Calibre.	Remarks.
	lb.	in.	
75	36	4.00	Building at Washington Navy Yard for United States Navy; 50 more to be built.
1	13	3.2	Building at Watervliet Arsenal for test for United States Army.
120	6	2.24	Building at Colt's Armoury by the Dreggs Ordnance Company for United States Army and Navy.
10	3	1.85	Ditto
15	1	1.46	Ditto

A number of these guns have already passed the test, and have been accepted by the Government. The steel used is the best quality furnished by the Midvale Steel Company and the Bethlehem Iron Company. The records of the Government Inspector at these works show the steel used in the forgings to possess the following qualities :

Tensile strength	...	90,000 lb. to 135,000 lb. per square inch.
Elastic ,,	...	50,000 lb. to 80,000 lb. per square inch.
Elongation ...	...	15 to 30 per cent. of its length.
Contraction ...	...	20 to 50 per cent. of its length.

The gun consists of a tube 45 calibres long, over which is shrunk a jacket, and in front of the jacket is a sleeve. The jacket and sleeve are screwed together. A shoulder on the tube transfers the stress from the tube to the jacket, and from thence it is transferred to the trunnions. Figs. 539 and 554 show the two sides of the gun mounted on a crinoline non-recoil mount. Fig. 540 shows the various working parts of the breech mechanism. The upper surface of the breech-block A is provided with bands *a* which fit in recesses a^1, Figs. 541 and 542, in the interior surface of the breech of the gun, and which extend downward a suitable distance within the walls of the chamber A^2. These bands and the grooves, into which they fit firmly, hold the breech-block in position and prevent the downward movement of the block during firing.

The breech-block, Figs. 541 to 545, is formed with a cavity A^3 extending from front to rear, the general detailed views as well as in the perspective is represented in the engraving, Fig. 555. Formed in the front part of this cavity is a wall 1, 2, which merges into an upwardly inclined wall 2, 3, and in the rear part of the rectangular portion of this cavity is a round shoulder 4, which may either be an integral part of the breech-block, as shown, or a round pin immovably secured therein, the use of the latter permitting more ready slotting or cutting of the block, and being a detail of construction rather than of operation. The central front face of the breech-block containing the cavity is left open until the latter is finished and ready for use, and the cam is introduced, after which the cavity is covered by a strong face-plate 5, held in place by locking lugs 6 screwed into it and into cheeks of the cavity. The construction of the breech-block has been found to be convenient and advantageous in forming the interior parts of the cavity and in introducing the cam.

In the sides of the breech-block are formed cam or guide grooves 7, 7, which are of the form shown by the dotted lines in Fig. 541, and by the full lines in Fig. 544. Their lower or rear path 8 to 9 are nearly vertical, but slightly inclined forward. From the point 9 these guide grooves continue on in curved lines from point 10 to point 11, the latter two points being concentric with the axial bolt when in the upper part of the elongated slot in the breech-block. Projecting into these grooves are guide studs 12, 12, Fig. 543, secured to the walls of the breech. The elongated slot 13 is also formed in the breech-block in its lower portion, and is inclined upward and forward two or three degrees from the vertical, so that in moving down the block will, at the same time, move slightly to the rear and conversely when closing or moving up. A strong axial bolt B, Fig. 541, passes through this slot, fits into openings in the cheeks of the breech, and extends outward beyond the left cheek, where it is provided with an operating handle *b*, Fig. 543.

In the upper part of the cavity is arranged the firing-pin C, which is provided on its rear end with a finger loop *c*, and at its front end with an upturned head c^1. On the under side of the firing-pin towards its rear end are formed half-cock and full-cock studs c^{11} and c^{111}, as shown in Figs. 541 and 542. In front of the full-cock stud, near the middle of the firing-pin and extending downward, is the cocking lug C^{1111}. In the top portion of the cavity above the firing-pin is arranged a spiral main-spring D, the front end of which abuts against the upturned end of the firing-pin, and the rear end against the rear wall of the cavity, so that it constantly exerts a forward pressure on the firing-pin. Before screwing in place the face-plate 5, the cam E, firing-pin C, and spiral main-spring D are introduced through the front of the cavity A^3. The breech-block is then placed in the breech, and the bolt B inserted and securely keyed to the cam. In the upper left end of the cam E and extending its full width is a circular recess, which has the same radius as the rounded shoulder 4 in the block. Beneath the recess and in the middle of the upper part of the cam is formed a large curved and walled recess e^1, as shown in dotted lines in Fig. 541, and also in rear view in Fig. 543.

In this recess works the cocking lug c^{1111} on the firing-pin. The upper front end of the cam terminates in the point e^{11}, which, when the breech is closed, rests beneath the horizontal wall 1, 2 of the cavity, and supports the block in its raised position. At the rear lower end of the cam is a toe e^{111}, which, when the cam is turned backward, exerts a downward pressure on the lower wall of the cavity in the block.

In the rear of the block is located the sliding leaf F, which holds and releases the firing-pin, and which fits in a mortise cut in the rear face of the block, and extending downward from the hole for the firing-pin. Side views of this sliding leaf are shown in Figs. 543 and 549, and transverse sections of it and its mortise in Figs. 550 and 551, which are respectively views on the dotted lines *x x* and *y y* of Fig. 543. The upper end of the leaf is bevelled on the front side, so that the inclined half and full-cock studs on the firing-pin will press the leaf downward when the firing-pin is retracted. The rear side of the upper end of the leaf is straight, so as to catch the straight front sides of the studs of the firing-pin, and hold the latter at half or full cock. The spiral spring *f* is placed in a vertical cylindrical recess f^1 in the rear wall of the block, and presses the sliding leaf up against the firing-pin. From the rear face of the leaf projects an arm G, which terminates in a lip, having a rounded rear face. A vertical slot is formed in the arm, and the screw stud passes through the same and into the wall of the breech, whereby the vertical sliding leaf is held in proper alignment in its mortise. A small rock shaft H, Fig. 543, passes transversely through the right wall of the gun breech, and its inner end terminates in a recess in the wall, in rear of and out of line with the side of the breech-block. On the inner end of the shaft is a finger *h*, Fig. 541, which is normally in contact with the rounded lip *g* of the arm G of the sliding leaf, while the outer end of this rock shaft is secured to a trigger h^1, Fig. 543, which projects downward and beneath the usual pistol grip h^{11}, and which, on being pressed by the finger, causes the trip to bear downward upon the lip *g*, and thus slides the leaf downward against the resistance of the coil spring *f*, and liberates the firing-pin C, which then flies forward against the primer and explodes the cartridge.

The cartridge shell extractor consists of two upwardly extending arms I, Figs. 547 and 548, provided with pivots *i*, which project into openings in the inner surfaces of the breech forward of the axial bolt B. As the breech-block takes up the whole width of the breech chamber the sides of the block along its bottom and front surfaces are formed with recesses J J, which are of a depth inward from the sides of the block, equal to the width of the long or main portions of the extractor arms I I, sufficient room being provided at the upper ends of the recess to permit the block to descend slightly along the extractor arms previous to the commencement of its rotary movement. On the inner sides of the extractor arms are formed curved projections i^1, which extend into recesses J^1, formed along the lower front and bottom parts of the breech-block, and which are still deeper or cut further in from the sides of the block than the recesses J. These deeper recesses when the breech block descends to its revolving position will bring their upper curved walls *j* in contact with the curved projections i^1 on the inner sides of the extractor arms. These upper walls *j* are circular in form for a certain distance, as shown in Fig. 6, and are slightly eccentric with respect to the centre of rotation of the block, so that during its rotation the walls will press slightly and slowly against the curved projections i^1 on the inner sides of the lower ends of the extractor arms, and thus cause the heads i^{11} of the arms to move slowly to the rear and pull the shell along with them. At the rear ends j^1 of the deeper recesses the upper walls *j* change in curve abruptly downward, and hence these abrupt curves coming in contact with the curved projections on the extractor arms will, when the block has rotated sufficiently to the rear to fully expose the bore of the gun, cause the extractor heads i^{11} to suddenly pull or jerk the cartridge shell and throw it quickly to the rear.

In an opening in the operating handle *b* attached to the projecting end of the axial bolt is a spring catch K, which, as the cam is completing its forward movement and the bore is being closed by the breech-block, takes into a recess *k*, Fig. 553, formed in the exterior surface of the wall of the breech. The rear end of this recess is so sloped as not to retard too much the rear movement of the spring catch when opening the breech, and yet there is sufficient resistance between the catch and the sloping part of the recess to prevent any backward movement of the breech-block by any jar or concussion arising from the firing of neighbouring guns.

The front end of the recess terminates against a vertical wall K^1, which, in connection with the spring catch, prevents more rotation of the handle *b* and the cam E than is necessary to close the breech; also when the catch strikes against the vertical wall a clicking sound is produced, indicating that the breech is completely closed and secure.

Secured within the interior surfaces of the breech walls and suspended therefrom at the extreme rear of the gun breech is a strong tray L, which receives and sustains the weight of the breech-block when it is turned back and the bore is open for loading.

Operation of the Parts.—In Fig. 541 the breech of the gun is represented as closed, or as it would appear after a discharge. To open the bore the handle is pulled to the rear, thereby turning the axial bolt B and the cam E, when the latter is turned back a sufficient distance to cause its front

THE DREGGS-SCHROEDER HOTCHKISS QUICK-FIRING GUN.

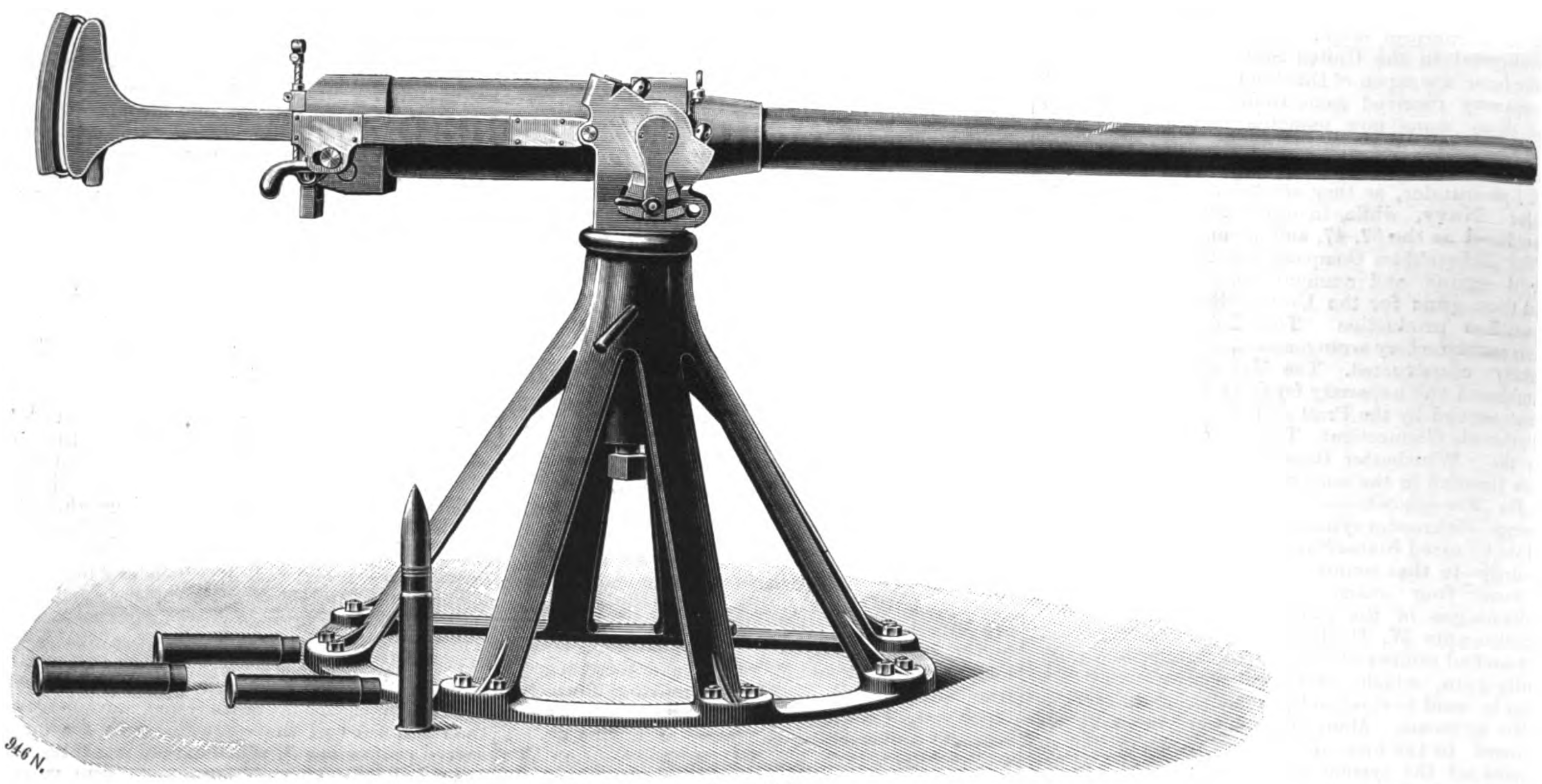


FIG. 539.

point e^{II} to pass out from beneath the horizontal wall 1, 2 of the cavity in the breech-block, the toe e^{III} of the cam will press downward upon the bottom wall of the cavity and will force the block down, this movement being permitted by the point e^{II} of the cam moving along the inclined wall 23 of the cavity. After further turning the cam, its circular recess *e* embraces the round shoulder 4 in the cavity, and after this the further rotation of the cam is necessarily accompanied by the rotation of the block, which by this time has descended far enough for its bolt to move to the upper part of the elongated opening 13, and for the bands *a a* to clear their grooves in the gun breech. After this the movement of the block is rotary, and to the rear around the axial bolt. During the first part of the downward movement of the block its guide grooves descend over the pins 12, 12 until the latter occupy the points 9, 9 in the grooves, and during the further rotary movement of the block, these pins successively occupy the positions 10 and 11 in the guide grooves, at which last points the grooves are concentric with the axial bolt when in the upper part of the elongated opening 13.

The block in this position is shown in Fig. 555. To close the breech the handle is moved forward. At first the rounded shoulder 4 remains engaged in the circular recess *e* of the cam, and causes the block to swing upwards. In the mean time the guide grooves 7, 7 in the sides of the block move over the pins 12, 12, and change position from point 11 to point 10. On reaching the latter position, in consequence of the change of the curves of the grooves, the upper surfaces of the grooves take against the pins, and the block is moved upward, thus disengaging the rounded shoulder 4 from the circular recess of the cam. The front point e^{II} of the cam then commences to impinge at the point 3 in the cavity, and the rotary motion of the cam continuing, moves along the inclined wall 2, 3, and forces the breech-block upward. In the mean time the guide-pins change position in the grooves 7, 7, moving from points 9 to points 8; also the bolt B changes position from the top to the bottom of the elongated opening 13. The point e^{II} of the cam finally supports the breech-block in its raised and closed position. Further forward motion of the cam is prevented.

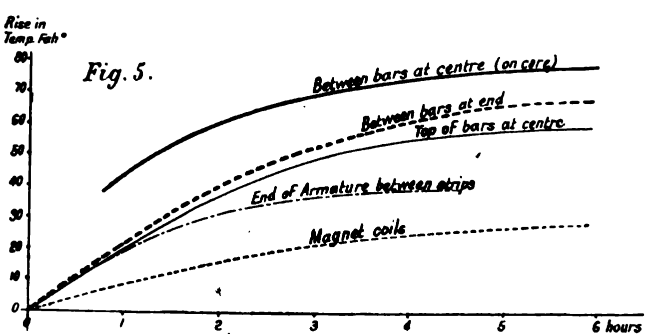
As the cam E rotates rearward, and the block descends, the cocking lug c^{IIII} of the firing-pin takes against the bottom of the curved recess e^{I} formed in the middle of the upward rear part of the cam, and is moved rearward, the portion of the cam in front of the recess passing up into the curved front part of the cocking lug. This retracting movement imparted to the firing-pin is effected against the resistance of the spiral spring D, which is thereby contracted, and the movement continues until the circular recess in the cam embraces the rounded shoulder 4 in the cavity, when the motion of the cam and the firing-pin ceases. When the recess in the cam comes in contact with the rounded shoulder, the full-cock stud c^{III} of the firing-pin has passed to the rear of the block and is caught by the sliding leaf.

The construction and arrangement of the parts of the breech-block in relation to the breech are such as to resist the backward and downward pressure upon the face of the block resulting from the force of explosion.

ELECTRIC LIGHT INSTALLATION AT THE PEOPLE'S PALACE.

THIS installation has been put down at the expense of the Drapers' Company, who have generously presented it to the governors of the People's Palace. The palace, as is well known, is situated in the Mile End-road, and is provided for the instruction and recreation of the dense population in the east end of London. As will be gathered from the size of the installation, the palace covers a large area, and consists of several distinct departments.

The generating plant is fixed in a separate engine-house, which is at the back of the grounds, and which was built to the specification of Mr. Charles Reilly, the Drapers Company's surveyor, the installation having been designed and carried out under the superintendence of Mr. William Slingo, the Drapers Company's engineer, of 65, Chelsham-road, Clapham. A plan of the engine-house and its contents is given in Fig. 2 on page 510. There are three engines of the fixed horizontal compound non-condensing type. In a separate room are three multitubular boilers. The engines and boilers are each of 20 nominal horse-power, but capable of developing upwards of 70 indicated horse-power, so that the total brake horse-power is about 200. The main steam pipes connecting the boilers and engines are quite straight, the engines and boilers being all in line, but the piping is doubled, and a number of stop valves are provided, to enable any particular section of the piping to be cut off from the remainder without interfering in any way with the working. The arrangement also allows any one, any two, or all three boilers to steam any one, any two, or all three engines, and also provides that an accident to any one engine or boiler shall not affect the others. All the boilers and steam pipes have been well coated with Keenan's non-conducting compound, and so far this has proved very satisfactory. The water tank, supported on girders over the front of the boiler-room, has a capacity of 6000 gallons. Two powerful Worthington pumps are provided; they are used alternately, one of them being sufficient for the work, and they drive the cold water into the boilers through a heater of large capacity, which is fixed at the back of the boiler-room, the water being heated by the exhaust steam on its way to the flues, into which it is finally discharged. Each boiler is provided with a separate iron uptake 25 ft. long. The fireboxes are exceptionally large to allow the use of coke for fuel, the object being to avoid the production of smoke. A little Welsh coal is mixed with the coke, and there is absolutely no smoke emitted by the uptakes which rise straight from the tops of the smokeboxes. The coal store, boiler-room, and engine-room are all on the ground level, so that the minimum labour is involved, and a direct road from the main street is provided for the vans and coal



Temperature test of 36 ⁰/B dynamo Nº 3011 at People's Palace, Feb. 2nd 1892.
(101 c) Ran on Full Load for 6 hours.

THE DRIGGS-SCHROEDER QUICK-FIRING GUN.

(*For Description, see Page* 503.)

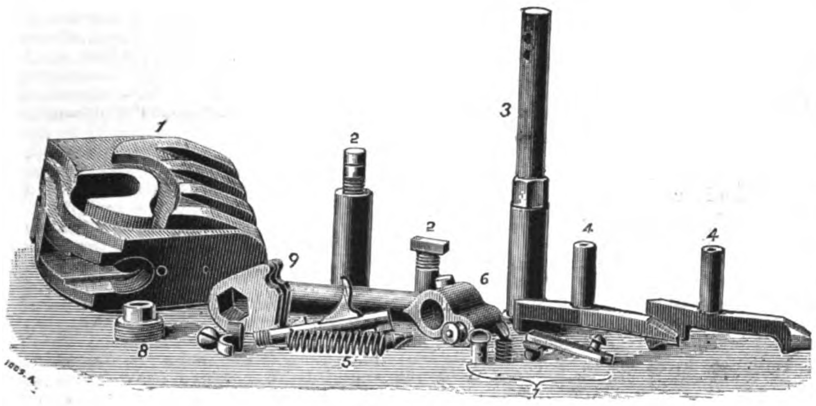


Fig. 540.

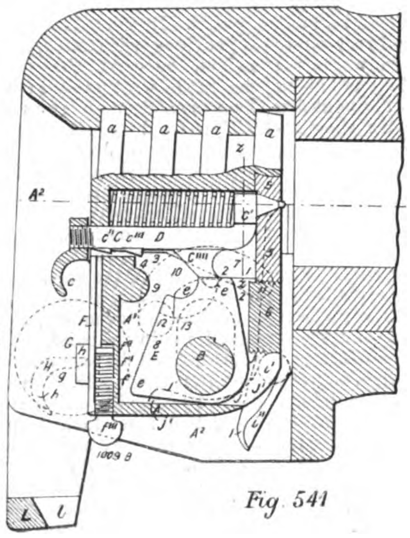


Fig. 541

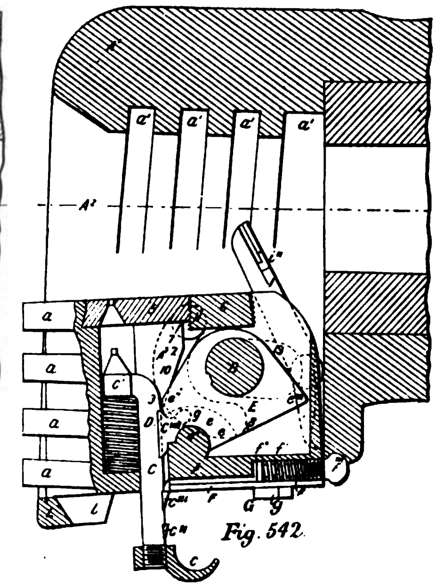


Fig. 542.

Fig. 543

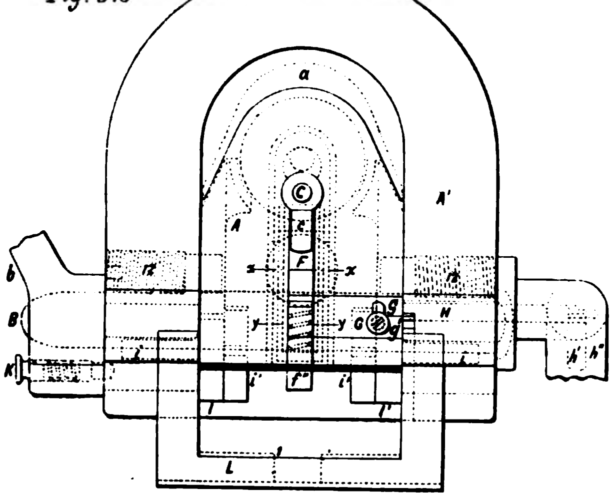


Fig. 544.

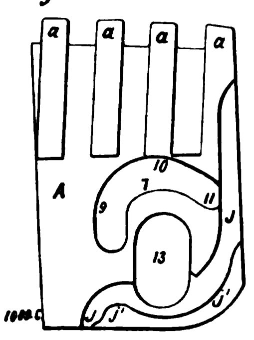
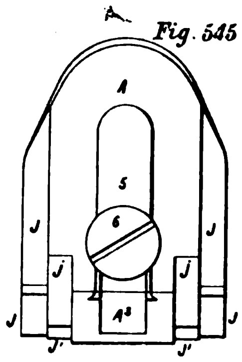


Fig. 545



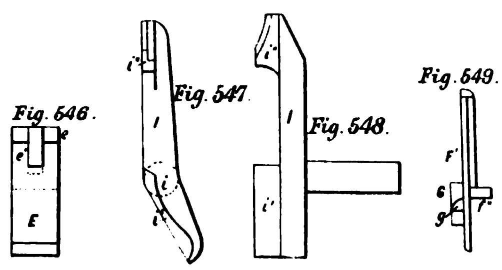


Fig. 546. Fig. 547. Fig. 548. Fig. 549.

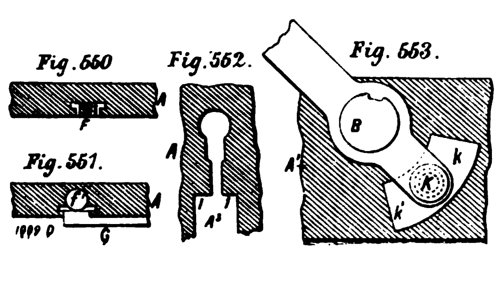


Fig. 550. Fig. 551. Fig. 552. Fig. 553.

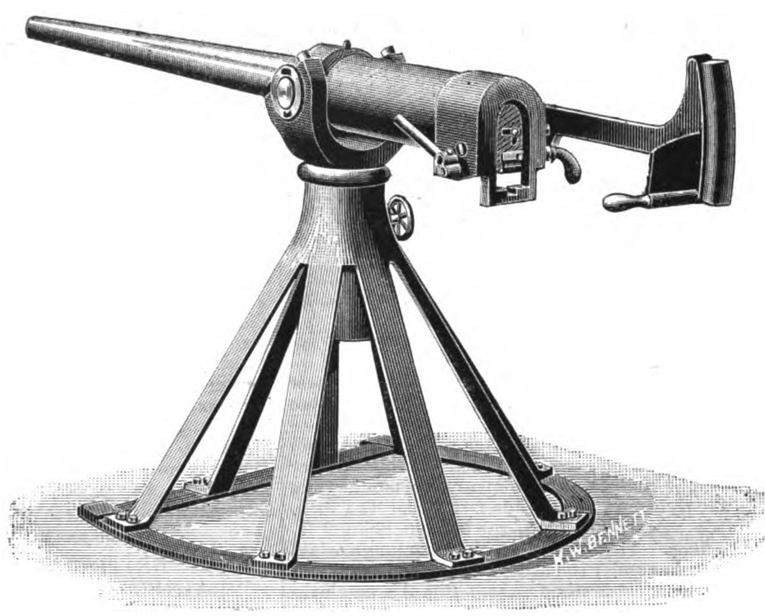


Fig. 554.

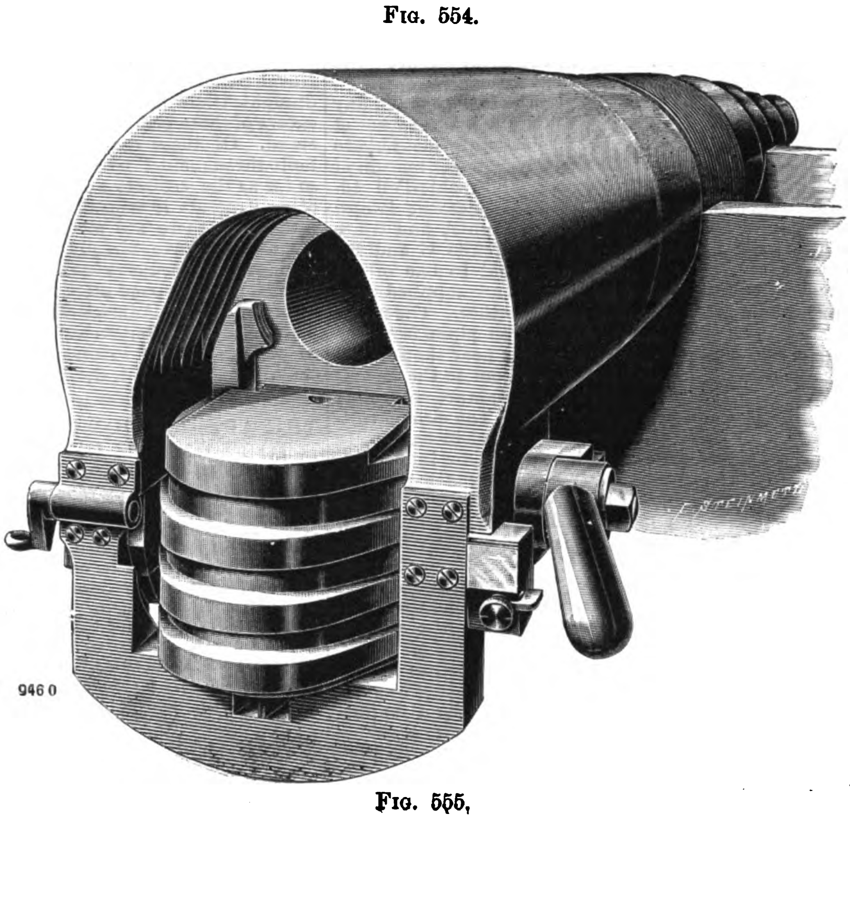


Fig. 555.

THE DRIGGS-SCHROEDER QUICK-FIRING GUN.

(For Description, see Page 536.)

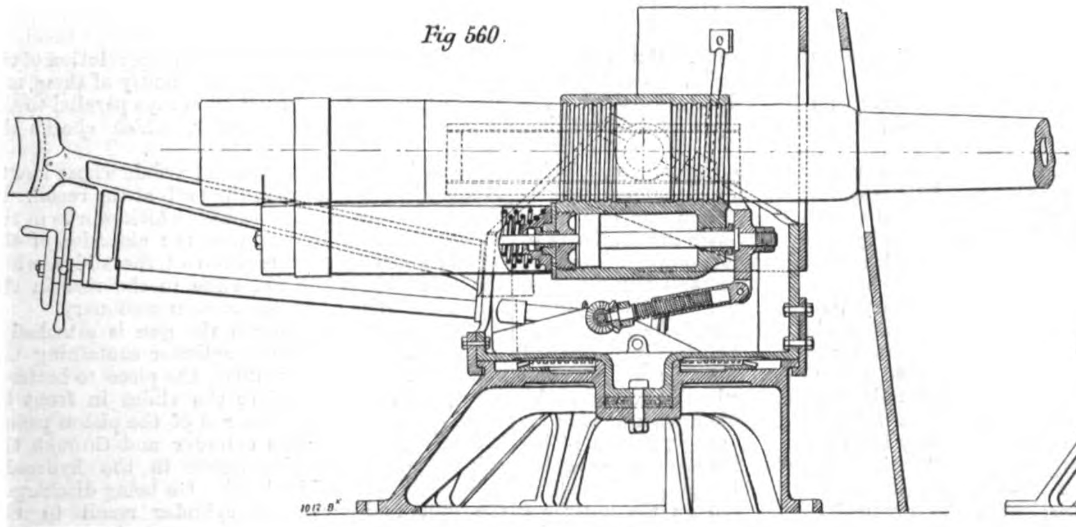


Fig 560.

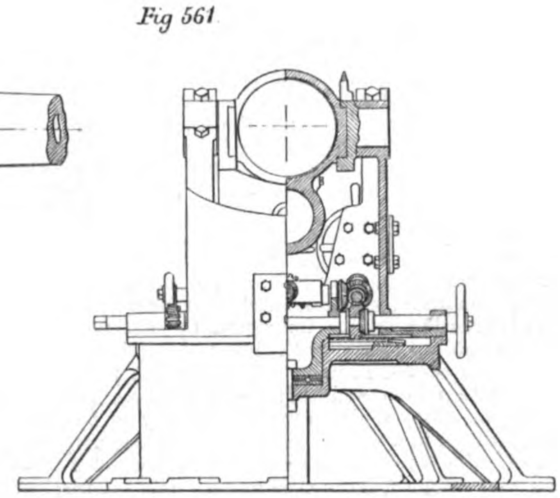


Fig 561.

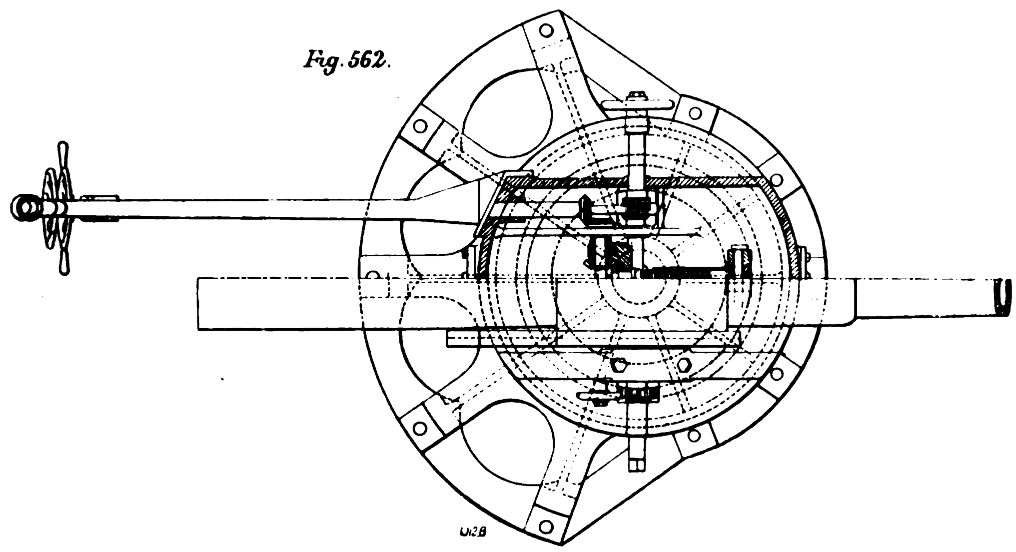


Fig. 562.

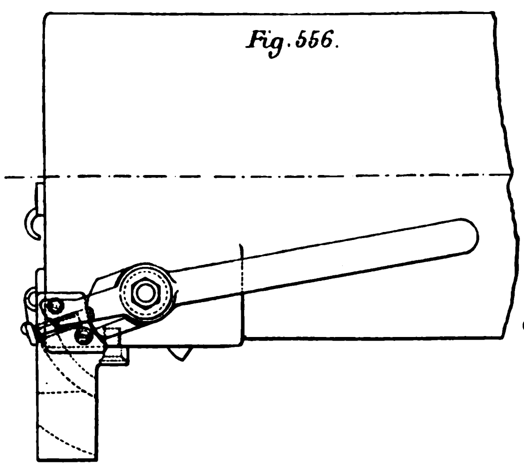


Fig. 556.

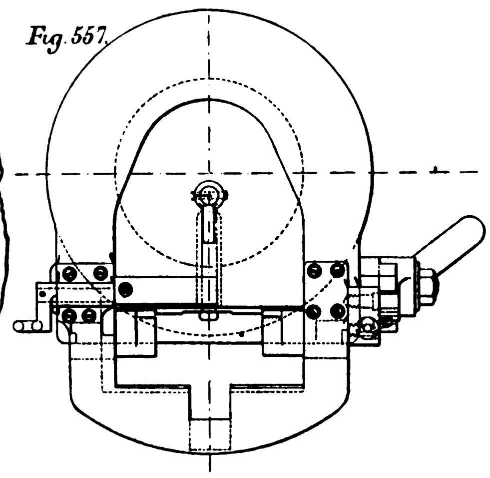


Fig. 557.

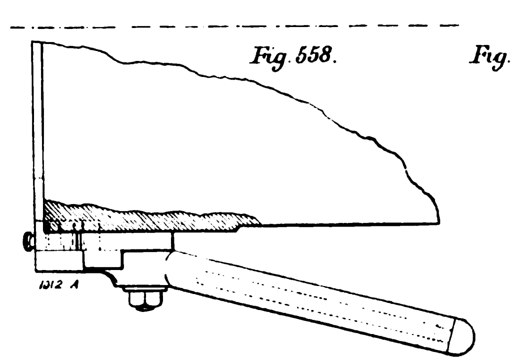


Fig. 558.

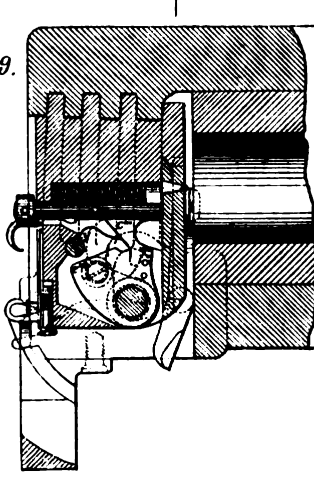


Fig. 559.

gress, and Brigham Young was appointed governor. There were then 30,000 people in the territory and 5000 of them at Salt Lake City. The territory continued to grow, and in 1870 the last rail was laid and the last spike driven, of the Utah Central Railway, by Brigham Young. With this railroad came the usual number of new settlers, and Mormonism was doomed in 1880; the population of Salt Lake City was then 20,678, and in 1890 46,259, while to-day it is upwards of 55,000. The valuation of property has risen from 16,600,000 dols. in 1889 to 54,350,000 dols. in 1890. It has also 65 miles of electric railways.

The climate of Utah is extremely mild, and the air is fresh and pure. The boast of the territory is the great age of its inhabitants; one of the common mottoes is, "We believe it is a duty to live past seventy," and under this are frequently placed a row of photographs of well-known inhabitants, some of whom are ninety, and all bearing the proud look due to a consciousness of duty well performed. The following extract serves to confirm this statement: "'Old Folks' Day' is a Utah Mormon institution, which might well be made national in its scope and observance. It was established by Bishop Hunter, of the Mormon Church, who died at the age of ninety years. It comes on June 22, and is observed as a general holiday. An excursion is given to people of seventy years and upwards, winding up with a banquet, a dance, and a generous distribution of presents. In 1887, when Salt Lake City had but about 30,000 population, she sent 750 of these ancient jollifiers over the Rio Grande Western Railway to Ogden. Of the number, 112 ranged in age from eighty to ninety-seven. A seventy-year old papa, trundling a baby chariot, with a springy tread of a young game rooster, is no uncommon sight on city street or country road." The country seems prolific in every way. For instance, one man raised in 1890, on 20 acres of land, 1920 bushels of oats averaging 96 bushels to the acre, and the year previous he had raised 104. Another man raised in 1890, 90 bushels of barley to the acre; 112 bushels of corn to the acre were also raised, and again, 947 bushels of potatoes, while at another point a farmer cleared 1200 dols. per acre on strawberries; 7 tons of clover per acre is not unusual, and they frequently cut four crops of it in a season. The following extract from the last Chamber of Commerce report may be cited at this point:

"The earth is absolutely wanton in fecundity. Rye yields an average of from 60 to 70 bushels to the acre; turnips, from 400 to 600 bushels; carrots, from 700 to 1000 bushels; apricots, 350 to 500 bushels; peaches, from 500 to 700 bushels; apples, 450 to 600 bushels; pears, 500 bushels; plums, from 300 to 400 bushels; blackberries, raspberries, currants, and gooseberries, from 300 to 350 bushels to the acre, and everything else in like profusion. Cherries grow wild in great abundance. Hops are indigenous to the soil. Nectarines flourish everywhere, and figs are raised in the southern valleys. Cotton grows luxuriantly in the lower counties, and a cotton mill established by the Mormons at Washington has long been in successful operation. It uses about 75,000 lb. of cotton yearly and manufactures good domestics." Nor does the human race claim any exception to this law. "Be fruitful and multiply" is the rule everywhere, and as an evidence of this it may be said that at Pleasant Valley, where the population numbers 2300, there are over 800 children of an age to attend school and 378 of younger years.

As a mark of courtesy, the officers of the society were presented to the rulers of the Mormon Church, President Woodruff and the two counsellers, President Cannon and President Smith, the latter being a nephew of the celebrated Joseph Smith, founder of the order, who was shot by a mob in Nauvoo, Illinois, when the people of Illinois rose and expelled all the Mormons from their borders. President Cannon is about ninety years old, but looks like a man of seventy. All of these gentlemen were well-preserved, stout men, in a most excellent physical condition, with fine intelligent faces and a look of shrewdness which impressed the spectator with their ability to deal with almost any problem in a most successful manner. Knowing the party to be eastern men and thoroughly loyal to the Government, they spoke in the kindest way of the administration in a rather soft deprecatory manner, more of sadness that they should be so misunderstood and maligned, but to the writer's mind there seemed to be an undercurrent of intense hatred, bitter and uncompromising. Nor is it to be wondered at. Their claim in general is, that they found an absolute desert, and bent their skill to its improvement; that they solved the irrigation problem, collected people of their way of thinking, and by economy and prudence have created a populous and fertile land which they think belongs to them; that when their efforts had made this desirable, the cupidity of the Gentiles had seized upon it, passed laws against their church holding the property it has created, and, as they believe, are fairly entitled to; attacked their religious beliefs by prohibiting polygamy, and reduced them to a condition of vassalism by sheer power of arms. There is something to be said on their side beyond a doubt, and that they are a frugal and industrious people no one can deny; that they have solved the Indian problem far better than the nation at large is also true, perhaps because they had a lower order of red men to treat, but certainly to a great extent because they were kinder in their methods.

The only answer to all this is the general statement that no nation, least of all a republic, can tolerate within its borders a separate system of government which owes no allegiance to the general government, that polygamy is abhorrent to all nations of this age, and is opposed to good citizenship, and that Mormonism, wherever it was against the public good of the nation, was by that very act a doomed institution, and could not be tolerated. That from a purely religious standpoint, independent of any conflict with the laws of the land, it is not disturbed so far as it is a belief, and that if they used their power and wealth to oppose the Government, as they undoubtedly did, they were in a state of rebellion, and by that very act forfeited any claim to consideration.

This discussion on Mormonism may be most fittingly closed with the grave of its greatest apostle, and probably its most shrewd and competent leader, which is shown in Fig. 28, inclosed by an iron fence. The cemetery is located pleasantly on a side hill, and but a short distance from the temple, whose corner stone he laid, but which, like the religion he founded, he was never to see complete and established.

In the afternoon the party visited the Great Salt Lake. This wonderful body of water, whose only parallel is the Dead Sea, to which the Mormons love to liken it, contains 18 per cent. of solid matter, mostly salt and soda. It was once as large as Lake Huron, and is now 100 miles long, with an average width of from 25 to 30 miles. Hundreds of thousands of tons of salt are made by natural evaporation along the shores of the lake, and at one place near Salt Lake City, a windy night never fails to pile up many tons of soda, eliminated by the movement of the waves. Four large rivers pour fresh water into it without raising its surface or diminishing its saltness. It was formerly supposed that no creature could live in its waters, but lately scientists have discovered there a few of the lowest orders of microscopic organisms.

It was a great disappointment to us on our arrival at Garfield Beach, to learn that the weather was far too cold to admit of bathing, for the first bath in the Great Salt Lake is said to be an exciting event. The human body cannot sink; you can walk out in it where it is 50 ft. deep, and your body will stick out of it from the shoulders upward; you can sit on it; men lie and smoke with their arms crossed under their heads. But the great difficulty is to move gracefully, to keep from turning somersaults and remaining heels up. The water is said to contain powerful medicinal virtues.

The likeness of Utah to Canaan, which led Brigham Young and his 20,000 Mormons to settle there, is indeed very striking when the two maps are placed side by side. But with the similarity of contour the likeness ends unless one considers the methods of the old Israelites, and there indeed a similarity may be discerned. From a purely artistic standpoint also the Salt Lake is interesting; the waters are of the most lovely and varied shades of blue and green, and the surrounding country is fertile and beautiful. We left the lake as the sun was setting, and looked back at it as we steamed away from the city, gazing across plains white with salt to its placid waters, over which was a pale green sheen; the high purple cliffs stood like a gateway in the west, and on the horizon a broad band of gold cast a stream of glory upon the waves.

The party soon reached Ogden, and were delayed there from bad management on the part of a railway official who sent out the regular train, which made frequent stops, and held back our special, which only stopped for fuel and water, until the other train was well out of our way. However, we did start finally, and were soon going toward the home of the setting sun at a fair speed, having a proud consciousness from our pleasant impressions of Ogden that it meant something to be an American citizen. Our course up to this point may be noted by examining the map shown in Fig. 29.

(To be continued.)

MODERN UNITED STATES ARTILLERY.—No. XXIX.

Driggs-Schroeder Rapid-Firing System.

(Figs. 556 to 562.)

The Driggs-Schroeder Company are furnishing under contract a number of 1, 3, and 6-pounder rapid-firing guns to the United States Government, while the Government itself has acquired the right to manufacture guns of 4 in. in calibre and have begun their manufacture at the Naval Gun Factory at Washington, D.C.

The breech mechanism of the 4-in. gun is somewhat different from that of the smaller calibres described in our last article.

The form of the cavity in the block, as shown in Fig. 539, is somewhat changed. The upper surface, instead of being several plane surfaces, is curved, and therefore a continuous motion is given to the block instead of having the motion abruptly changed. The cam is somewhat changed in shape. The upper point e^{ll} is changed and made more rounding, while the toe e^{lll} is brought up much higher and the lower surface of the cam is made much more rounding, and consequentlty the lower surface of the cavity in the block is changed in shape. The downward pressure exerted by the cam, when revolved on the block, is gradual and increasing. The cocking lug c^{llll}, on the firing pin where it presses against the cam, is also made rounding, so that the pressure is not brought against a point as in the smaller calibres. In this gun the shoulder 4 is a round pin secured in the block instead of being an integral part of the block. The operating handle is placed on the right side of the piece instead of on the left, and acts in the same manner as previously described. The whole action of the breech is the same as that described for the smaller guns.

The 1, 3, and 6-pounder guns can be mounted on crinoline mounts as shown in a preceding article; for the 4-in. gun, however, it was advisable, on account of the greater energy of recoil, to provide a recoil mount.

The carriage for the 4-in. rapid-fire gun is shown in Figs. 560 to 562. The lower cone on which the carriage and gun rest, is a heavy casting bolted securely to the deck of the vessel or to the platform. The carriage rests on this cone and is prevented from jumping, on the discharge of the piece, by means of clips bolted to the carriage and fitting over flanges on the cone. The pivot, about which the piece is trained, is central, and the friction at the pivot is reduced as much as possible by the introduction of a disc of white metal between the carriage and cone.

As shown in Figs. 561 and 562, the piece is mounted on trunnions but is not fixed to them, so that while elevated by means of the revolution of the trunnions, it can recoil independently of them, and the direction of the recoil is always parallel to the axis of the hydraulic buffer, which checks the recoil.

To each trunnion is attached a slide whose length is somewhat greater than the path of the recoil. To the piece is attached a saddle which works in the slides. By this arrangement the elevation of the gun is given by the elevation of the slides, while the gun and saddle can slide to the rear in the slides while the trunnions remain stationary.

To the saddle beneath the gun is attached a hydraulic buffer and the cylinder containing the spiral spring which returns the piece to battery. The piston is attached to the slides in front by means of a transom. The rod of the piston passes through the hydraulic cylinder and through the spiral spring. To the piston in the hydraulic cylinder is attached a head. On being discharged the gun and hydraulic cylinder recoil to the rear, the piston-rod remaining stationary. The recoil is checked by means of the hydraulic cylinder, incidentally assisted by the spiral spring, which is compressed as the piece recoils. When the recoil is checked, the force exerted by the compressed spring returns the piece to battery.

The piece is aimed by the gunner, whose shoulder rests against a stock attached to the carriage. The training and elevating is done by handwheels within easy reach of the gunner. A light shield is attached to the carriage for the protection of the cannoneers from light projectiles.

The breech-block used in the Driggs-Schroeder system is lighter than that used in any other system. In the 3-pounder there is sufficient strength to support a pressure of 60 tons per square inch, and in the 6-pounder 70 tons, without passing the elastic limit of the metal; the working pressure is only about 15 tons. In the official report of the test on the 3-pounder, dated February 15, 1888, it is stated that the maximum pressure developed was 18 tons, and under that, and frequent repetition of lower pressures, no weakness was developed, and it was concluded that the block was sufficiently strong in itself and its supports. The breech-block of the 3-pounder weighs only 16 lb. and that of the 6-pounder only 26 lb.

Careful experiments were made, and the impossibility of exploding the charge before the block was fully closed was definitely demonstrated. The gun has the advantage of being able to be left at half-cock with perfect safety, and can be full-cocked again when desired without movement of the block or handle. Since the breech-block revolves on an interior axis, the full weight comes on the handle only for a short distance, being for the 6-pounder $\frac{6}{10}$ in. Also for a greater portion of its motion the block revolves in unison with the handle, and thus its motion is more rapid than it would be if a lever was used to gain in power.

The official test at the naval proving grounds gave to the 3-pounder a rate of 36 rounds a minute, and to the 6-pounder a rate of 24 shots a minute. This was with an unpractised crew, and it was assumed that with practice a much greater rate could be attained. With the 6 and 3-pounders the rapidity trials were made with but two men working the gun and a third passing ammunition, and it was shown that this number of men was quite sufficient except in cases of long-continued firing, when a relief would be necessary, as in any system, for the loader. This is a reduction of one from the usual number of men required to serve a rapid-firing gun. It was found on testing to determine the distance that the cartridge, in loading, had to be shoved home, that if the head of the cartridge was within $\frac{3}{4}$ in. of the extractors there would be no danger of jamming.

The saving of weight in the breech-block allowed an increase of weight in the barrel, which was, therefore, made 45 calibres long, the result being to increase the muzzle velocity. The mean velocity in the 44-calibre 3-pounder obtained from five shots was 2048 foot-seconds, using the Hotchkiss common shell of 1500 grammes.

In the 3-pounder the twist of the rifling begins with one turn in 100 calibres and ends in one turn in 25 calibres; in the 6-pounder it begins with one turns in 150 calibres, and ends with one turn in 27 calibres. The developed curve of the rifling is a semi-cubic parabola. The length of the bore allows the twist to be more gradual and consequently the strain is reduced.

The two extractors are an important feature. The strain on the head of the cartridge is made symmetrical, and any tendency to slew is avoided, the strain on each extractor being half what it would be on a single extractor, so that the liability to shear off the cartridge head is avoided. Should one extractor break, the gun can still continue firing, as one extractor will eject the cartridge.

With the exception of the operating handle, the whole mechanism, whether the block be open or closed, is protected by the hood, and therefore is not liable to injury by accidental blows, dirt, &c.

The gun has perfectly stood the test of endurance. The various parts work well and easily. The rectilinear motion of the firing pin causes the blow on the primer to be struck in the line of motion, so that no bending strain is brought on the pin, which allows the point to be made much smaller, and thereby the support given to the cartridge head is much greater.

Before any downward motion of the block occurs the point of the firing pin is entirely retracted within the block, so that it is thoroughly protected from being bent or broken. The premature discharge of a cartridge is naturally prevented by the position of the cam, which is always interposed to prevent the firing pin from striking the cap until the breech is entirely closed.

In May, 1889, the first official test of a 6-pounder was conducted at the Naval Proving Ground, and resulted in the contract to furnish a number of guns to the Government being made.

The possibility of firing before the breech is closed and securely locked was tested, and, as before stated it was found impossible to fire before the breech was properly closed and locked; a number of rounds were fired to test the general working of the breech mechanism, and afterwards trial was made to find the greatest number of rounds that could be fired in one minute, the crew consisting of three men, one to aim and fire, one to work the breech mechanism and load, and one to pass ammunition. Eighteen rounds were actually fired, and one missfire occurred; making an allowance for the time required to withdraw the loaded cartridge in excess of that required for an empty case, this would place the number of rounds per minute with an unpractised crew at 20. The shortest time between fires was 2 seconds, and the longest 7 seconds, when the missfire took place.

After a number of rounds to test the facility of loading at different elevations, the continuous fire test was made, during which 63 rounds were fired in 4 minutes and 23 seconds.

The total number of rounds fired during the trial was 101, and the duration of the trial was about 1 hour. The breech mechanism remained cool, and no injury was detected either in the breech-block or grooves. The locking device for holding up the breech-block when closed appeared to be satisfactory, and the strength and endurance of the breech mechanism was found to be ample.

As a result of the report of this trial, given in substance above, a contract was made, and in July, 1891, an exhaustive test was made of the first 6-pounder furnished the United States Navy under the contract. Two hundred rounds were fired in about 4 hours. About 78 were for the purpose of determining the rapidity of fire and the effect of heat on the breech mechanism. The crew for this test consisted of three men, one, who loaded and worked the breech mechanism, having received a short instruction with dummy cartridges the day before, and the others not having had any practice with a rapid-firing gun.

The first volley for rapidity was five rounds in 16½ seconds, the second five rounds in 15 seconds, then eight rounds in 20 seconds, or a rate of 24 a minute. It was conceded that with practice 30 rounds per minute could easily be attained. A test for endurance and accuracy was then made, consisting of the rapid firing of 61 rounds. The time occupied was 3 minutes and 35 seconds, the best record being in the second minute with 20 rounds.

During the firing the muzzle of the piece heated up to about 300 deg. Fahr., while the breech mechanism remained cool, but later in the test it became very hot. Some deliberate firing was then made, about 40 rounds being fired at the rate of 15 a minute. Tests for accuracy were then made, all of 20 shots, falling inside a lateral distance of 6 ft. at 1500 yards.

From start to finish the gun worked perfectly, nothing having given out or failed in any way. At the conclusion of the test the mechanism was critically examined and found perfect; the bore was star gauged, and no alteration was detected, so that it may be said that the gun came out of the test in as good a condition as it entered it, and that it never for a moment failed to work perfectly.

Table L.—*Ballistic Particulars of the Driggs-Schroeder Rapid-Firing Guns.*

——	1-pdr.	3-pdr.	6-pdr.	33-pdr.
Calibre .. .. in.	1.457	1.85	2 244	4
Length of bore .. ,,	35	81.45	100.98	157.29
,, ,, .. cals.	24	44	45	39.32
Length of rifling .. in.	30.768	65.75	98.3	128.12
,, gun .. ,,	38	87.26	107.98	164.4
Length of gun with shoulder-piece .. .. in	52	105 75	128.9	
Number of grooves ..	12	20	24	30
Depth of ,, .. in.	0.015	0.0158	0.015	.025
Width of ,, .. ,,	..	..	..	.279
,, lands .. ,,	0.0594	0.0787	0.0737	
Chamber { Length .. ,,	..	..	..	25.38
Chamber { Diameter ,,	..	..	..	{ 4.44 / 4.09
Chamber { Capacity cu. in.	..	..	..	329
Total capacity of bore ,,	..	..	..	1994
Travel of projectile .. in.	..	..	..	132.12
Twist of rifling	1 turn in 30 cals.	1 turn in 100 cals. to 1 in 25 cals.	1 turn in 150 cals. to 1 in 27 cals.	zero to 1 turn in 25
Weight of gun complete lb.	73	497	800	8400
,, ,, tons	..	..	..	1.5
,, breech-block lb.	6	16	26	
,, shoulder-piece ,,	6	12	25	
,, projectile ,,	1.1	3.3	6	33
,, powder .. oz	2.82	27.53	31.5	
,, powder .. lb.	..	..	..	12 to 14
Total weight of fixed ammution .. .. lb.	..	2050	..	58
Muzzle velocity ft.-sec.	1375	..	1880	2000
Remaining velocity at .. { 1000 yd. ,,	..	..	..	1651
{ 1500 ,, ,,	..	..	..	1501
{ 2000 ,, ,,	..	..	..	1364
{ 2500 ,, ,,	..	..	..	1246
Muzzle energy .. ft.-tns	..	..	..	915
Thickness of steel which shell will perforate at muzzle .. .. in.	..	..	..	7.18
Ditto at 1500 yards .. ,,	..	..	..	4.77
Number of fires per minute	..	30	..	..

THE COLUMBIAN EXPOSITION.

We have already described in full detail the great Hall of Manufactures and Liberal Arts, which is not only the largest building in Jackson Park, but the largest covered structure in existence. There is, therefore, no reason for our repeating any minute particulars of this triumph of engineering, but the present week is essentially the proper time for us to publish the exterior and interior views on pages 538 and 539. The former, engraved from a photograph by Mr. C. D. Arnold, is indisputable evidence that the engineers of the Exhibition have made good their promise to complete the building by October 1, while the great Dedication Ceremonies of which we have lately heard so much, were held within the great hall of the building before 120,000 people. The space covered is 30½ acres, and the four outer sides are occupied by courts about 200 ft. deep. An internal rectangular space is thus left, 1268 ft. long, and 368 ft. wide, and this is covered by a single span arched roof rising to a height of 206 ft. in the centre and 245 ft. to the top of the lantern. At the date when the photograph, from which our engraving is made, was taken, the structure was practically complete, as is shown by the almost entire absence of scaffolding. The rapidity with which the great central roof was erected, is certainly without a parallel. The weight of ironwork is 6000 tons, and the contract for manufacture and erection was signed by the Edgemoor Bridge Works, Wilmington, Delaware, on December 24, 1891; by this contract the roof was to be delivered complete by August 15 last. Thus the whole work had to be finished in less than eight months, the material being transported almost 1000 miles. On May 24 a large amount of the ironwork was on the ground, and by that date the first complete bay of two great ribs, with the complicated longitudinal girders and bracing was in place, the time of erection having been fourteen days. The subsequent work progressed at a better rate, until a complete bay was finished every ten days, and the building was substantially finished by the date assigned in the contract. It is needless to say that every detail of erection had been thought out with as much care, as the details of construction had been by Mr. Burnham, the engineer of the Exhibition, and his staff. Before the contractors for the ironwork had taken possession, the floor of the building was laid complete, so that a firm and level platform was available. The travelling stage by which the girders were erected was a formidable affair; it was 50 ft. deep, 360 ft. wide, and about 250 ft. high; 100 ft. from the ground was a broad level platform, on which the upper halves of the ribs were erected, the lower halves being built up from the ground; then the former, hinged to the latter, were hoisted from the middle of the staging till they were in place, and the longitudinal framing could be erected. Then the staging was traversed on its rail for a distance sufficient to erect the next pair of ribs, and the same work was repeated. The lesser labour of match-boarding the roof, fixing skylights, and adding the sheet-iron covering, proceeded simultaneously, so that not an hour of invaluable time was lost. The upper figure on page 538 gives a good idea of the interior of the building, although there is little to indicate its vast dimensions. The lower engraving is a detail of one of the bases of a roof rib. It will be noticed that this very closely resembles, except in lightness, the springing of the rib of the Machinery Hall of the 1889 Paris Exhibition. It will also be noticed that a vertical member on each side of the rib extends downwards to a point near the floor where it is turned round and dies into the base. To these vertical members are secured one series of the great system of longitudinal framing, on which the hall depends for its stiffness. The system of horizontal diagonal bracing between these ribs is also indicated in the illustration.

The capacity of the hall was well tested by the many thousands who crowded it on Friday last on the occasion of the Dedication Ceremonies, which appear to have been arranged on a scale corresponding with the entire undertaking, although they were shorn of much of their intended picturesqueness.

The inauguration of an exhibition six months before it is opened to the public, is an innovation that possesses at least one advantage to set off against many inconveniences. The buildings have to be practically complete long in advance of the time they will be used by the public; more time can thus be given to exhibitors to instal their exhibits, and one of the great drawbacks hitherto inseparable to international exhibitions it is hoped, will be averted, that of incompleteness for weeks and even months after the opening. Of course there still remains a vast amount of structural and decorative work to be done, but next week the gates of the Exhibition will be opened to receive exhibits, so that the work of installation may go on without interruption till the end of April. If manufacturers are as well forward with their exhibits as the Exposition authorities are with the buildings to receive them, the World's Fair of 1893 may hope to claim, besides being the greatest and most beautiful of exhibitions, the merit of being completely ready on the date of opening.

THE NEW SIGNALLING SYSTEM AND ALTERATIONS AT WATERLOO STATION.

(*Concluded from page 366.*)

To conclude the series of articles which appeared in our issues of May 27, June 24, and September 16 last, we have to describe this week the special form of "lock and block" instrument adopted at Waterloo Station, with diagrammatic illustrations of the leading features of novelty connected with its mode of application, and lastly a few other of the numerous specialities and plans for safe-guarding both normal traffic and shunt movements.

The reader is advised to turn back to the illustrations on page 649, vol. liii., more especially for Figs. 6 and 7. The situation there portrayed comprised three "up" and three "down" lines, with a remarkable complication of intersecting cross-over roads diverging to a more numerous and extensive range of dead ends or terminal bays than probably any other railway station in the whole world possesses.

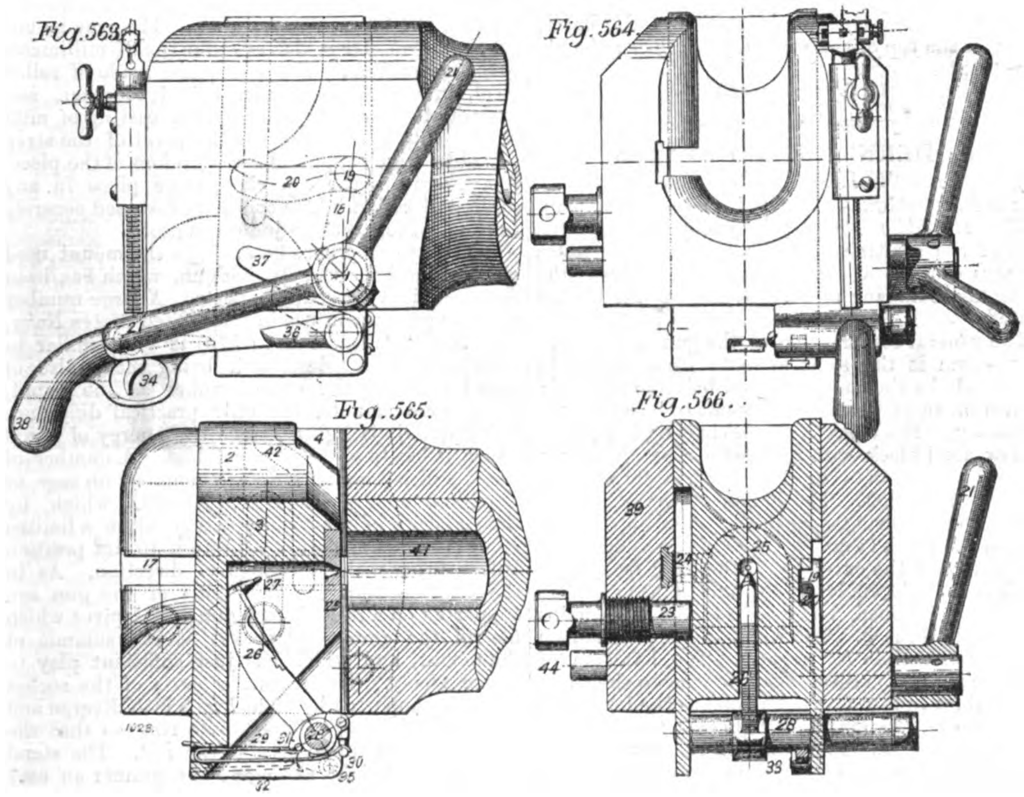
Next also for the better comprehension of Fig. 28, the plan of Fig. 6, the situation just alluded to may be summarised as:

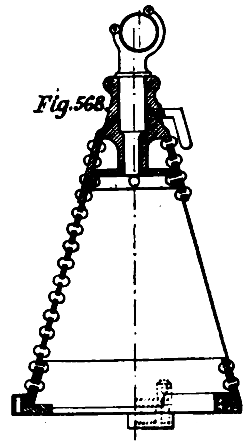
Line F (up Windsor) entering twelve terminal bays.
,, E (down Windsor through) departing from twelve terminal bays.
,, D (down Windsor local) departing from fifteen terminal bays.
,, C (up main through) entering thirteen terminal bays.
,, B (up main local) entering ten terminal bays.
,, A (down main) departing from seven terminal bays.

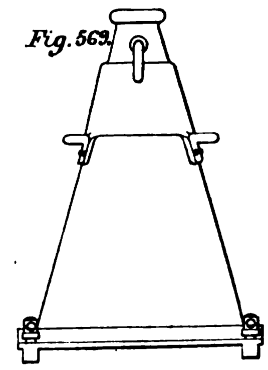
These six lines serve departures from and arrivals

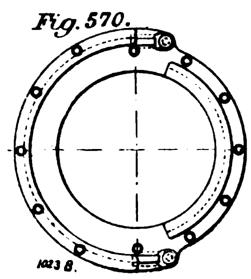
MOUNTS FOR QUICK-FIRING GUNS.

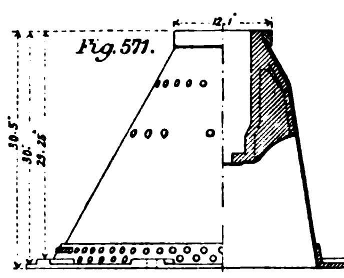
(*For Description, see Page* 566.)

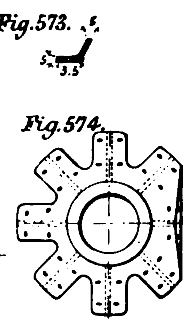


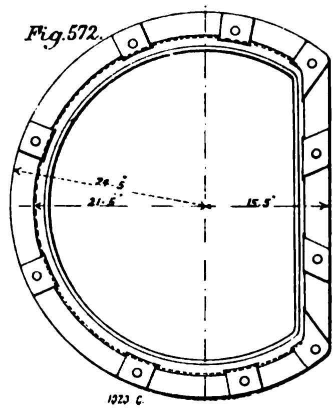


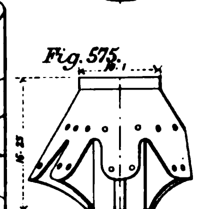


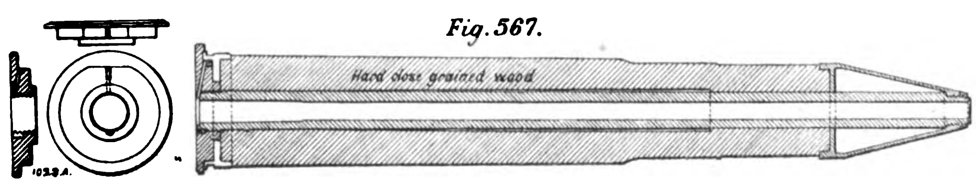


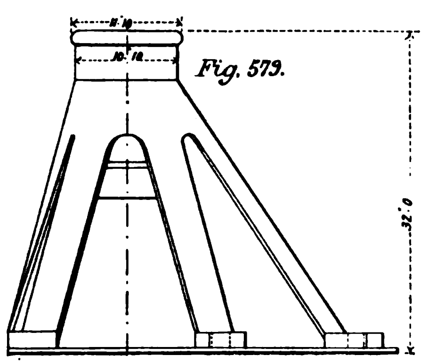


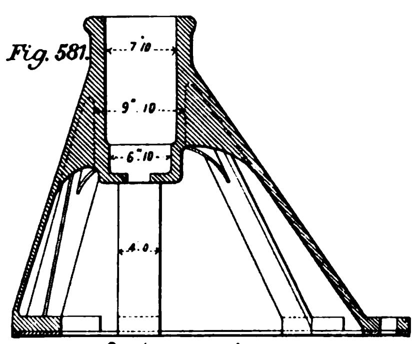




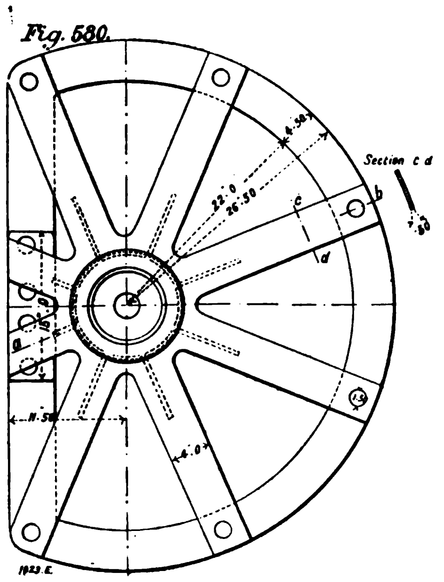


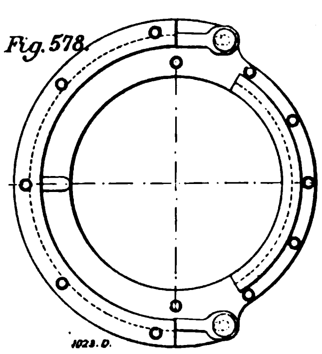


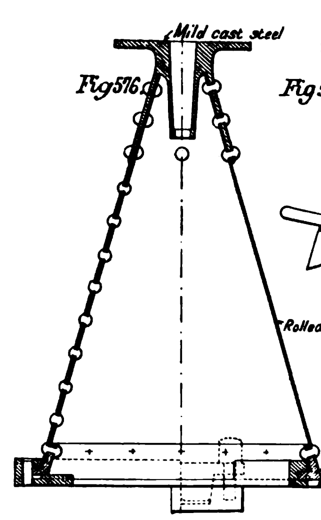


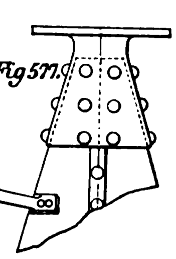


Section on a. b.









one side of the house is a portico draped with huge white roses, and the wall beside it is covered with mammoth heliotrope.

Sea bathing is enjoyed all the year round, and not far from the hotel is a handsome pavilion, designed for those who find the outdoor bathing too bracing. This contains four immense swimming tanks of varying temperature, and is roofed with glass, floored with marble, and decorated with numerous palms. When there is added to this a beautifully appointed hotel, with every provision of comfort, good service, a great variety of tempting food, well cooked, and appetisingly served, is it a wonder our party found it most difficult to leave the spot? Or that it remains a distinct feature in the many pleasant recollections of this attractive journey?

In the afternoon, many of the party visited the quaint old town of Monterey, distant about a mile from the hotel. The mind at once ran back to that great and noble struggle carried on in these crooked streets and lanes, nearly three centuries ago, and we may quote at this place from the historical record.

"From the earliest period of California's history," says Harrison in his "History of Monterey County," "Monterey has been conspicuous as the objective point of navigators and explorers, and the arena where were enacted many of the important political and historical events of the county. As early as 1602, Don Sebastian Vizcaino, sailing under instructions from Philip III. of Spain, entered Monterey Bay, and landing with two priests and a body of soldiers, took possession of the country for the king. A cross was erected and an altar improvised under an oak tree, at which was celebrated the first mass ever heard in the land now known as California. The place was named in honour of the Viceroy of Mexico, Gaspar de Zuniga, Count of Monterey, the projector and patron of the expedition. The departure of this expedition returned the place to its primitive condition, and the silence in its history was not broken for a period of 168 years. When Father Junipero Serra, president of the band of Franciscan missionaries sent to the coast in 1768, was planning his work in California, the most cherished object of his expedition was the founding of a mission at the Monterey of Vizcaino's discovery. In 1770, this cherished dream was realised, and the Mission de San Carlos de Monterey was established on the 3rd of June of that year, 'being the holy day of Pentecost,' as the Father expresses it. About the end of the year 1771, the mission was moved to Carmelo Valley, some five miles from the Bay of Monterey, and called the Mission San Carlos de Carmelo. This was done by order of His Excellency the Marquis de Croix; and here, on the banks of the Carmelo River, still stands the old stone church then erected, beneath whose sanctuary repose the remains of Father Serra and three of his co-workers, including Father Crispi, his trusted friend and adviser (Fig. 33). The presidio, or military establishment, still remained at Monterey. In its inclosure was the chapel, which is the site of the present Catholic church; while on the hill overlooking the bay was erected a rude fort, the remains of which are still discernible." We also noted with interest the building shown in Fig. 34, which was the first capitol of California.

After this trip, we went on a most wonderful excursion known as "the eighteen mile drive." After going for some distance through the gently rolling fields, strewn with wild flowers, we reached the pine forests, where the pale yellow moss waves from the branches of the trees, then climbed a hill, and through a gap in the branches gazed far out across the ocean. Thus for the first time we saw the great Pacific, and as we reached the summit of the hill, and before us the vast expanse of the blue waves rolled to the bluer sky, we wondered what must have been in the mind of the "eagle-eyed" discoverer when he and his followers stood in wonder "silent upon a peak in Darien."

Many of us went down on to the shore, to pick up the curiously marked round pebbles, and to watch the long slow waves foam gently up the beach. Soon we came to the far-famed cypress trees (Fig. 35), which writhe and twist their gaunt limbs along a stretch of wild rocky coast. It has been suggested that these strange uncanny trees sprang from the seeds of the cedars of Lebanon brought by the first missionaries, but many of them give evidence that they are even more ancient than the earliest settlers. Distorted in every conceivable shape, and hung with pale moss, they hardly seem ilke trees, but rather wild creatures of the waves hung with dripping seaweed and struggling to escape from some invisible chain. A little further on, the seal rocks come into view, covered with waddling flapping beasts, and surrounded by others lithe and graceful in the water, while on the top of the rock perched flocks of ugly cormorants.

(To be continued.)

MODERN UNITED STATES ARTILLERY.—No. XXX.

Rapid-Firing Guns—*concluded*. (Figs. 563 to 600).

The Hotchkiss Rapid-Firing Guns.—A large part of the armament of the new United States cruisers consists of rapid-firing guns made by the Hotchkiss Company and constructed in the United States.

The general construction of the guns and breech mechanism is the same as that ordinarily used in guns made by the company, and being so generally known a short description seems to be all that is necessary. The block (Figs. 563 to 566), is a square hollow steel block with rounded corners, having a vertical motion in a mortise which is cut entirely through the jacket. The hollow of the block contains all of the firing mechanism. The upper front part of the block (Fig. 566) is cut away to allow for the motion of the extractor. The front face of the block is at right angles to the axis of the gun, the rear face is inclined. The weight of the block helps to open the breech. The whole of the mechanism is easily accessible for repairs. The left side of the block contains three shallow grooves shown in dotted lines in Fig. 564. The one to the left is the guide groove, the one to the right (42), the extractor groove, whose sudden inclination to the rear at its upper end, causes the ejection of the cartridge, and the groove in the middle (3) is the stop groove, in which works the stop bolt 23, Fig. 566, and which limits the motion of the block.

On the right side of the block is another guide groove and a stud-way 19, 20, beneath which is a wide triangular recess, the crank-way.

To the main crankshaft 1, on the right side of the breech, is secured a double lever 21. The main shaft passes through the side of the breech and terminates in the crank 18, on the upper end of which is the stud 19. The hub of the double lever carries the cocking toe 37. Passing through the block and extending to the right, where it carries the cocking arm 38, is the rocking shaft 28, to which shaft is secured the hammer 26, by means of a spline, so that it may be assembled with the rocking shaft and yet surely revolve with it; 38 and 37 revolve in the same plane. The double-leaved main spring 29 presses upon the hammer at 31, and pulls down at 30, thus diminishing the friction on the rocking shaft. A sear is pivoted to the block just below the rocking shaft and is constantly pressed up by a sear-spring. When the block is in place the extremity of the sear comes in contact with the front end of a bent lever forming the trigger 34.

The gun is aimed by means of the usual stock. To open the piece the most convenient handle is turned to the rear. In the first portion of its movement the crank stud 19 travels in the concentric portion of the stud-way and no movement of the block occurs. During this time 37 presses down on 38 and cocks the piece. When this is accomplished the stud 19 arrives at a non-concentric portion of the stud-way, and the block falls until its motion is arrested by the stop-bolt. The breech is then open and the gun ready for loading.

To close the piece the rotation of the levers is reversed and the block raised.

The ammunition used is fixed, *i.e.*, projectile and powder contained in the same metallic cartridge similar to small arm ammunition. This ammunition is very expensive, so that for drill purposes it was necessary to devise the drill cartridge shown in Fig. 567. The cartridge is of the same shape and size as the full-charge cartridge, but the ammunition is replaced by a cylinder of hard close-grained wood which holds, in the axis of the cartridge, a gun barrel of the standard small arms calibre, and which can receive the standard small arm ammunition. In drilling, practice is obtained in handling a cartridge of the same size as the full charge cartridge, while the cost of each discharge is merely that of a small arm cartridge.

Mounts for Rapid-Firing Guns used in the United States Navy.—For the smaller calibre guns—viz., 1, 3, and 6-pounders, it is found that by providing a strong rigid mount the recoil can be checked instantly without damage to either the piece or the mount, if the platform or deck be sufficiently strong. Figs. 571 to 577 show the cone mounts used for the 1, 3, and 6-pounders. The cone mount for the 1-pounder is also used for the 37-millimetre revolving cannon. The cones are made of rolled steel, in several segments, bolted together, and surmounted by a cap made of a casting of mild steel. Into this casting fits the pivot of the strap or saddle which supports the trunnions of the piece. A setscrew in the cap clamps the piece in any desired direction. The cones are fastened securely to the decks so that no jump can occur.

Reference may here be made to the mount used on shipboard for the Gatling gun, which has been described in a preceding article. A large number of these guns are in use in the United States Navy. The mount (Figs. 568 to 570) is very similar to cone mounts just described, being made also of rolled steel in the same manner as the rapid-firing cone mounts, the only practical difference being that it is lighter, since the energy of recoil which it has to absorb is much less. A number of the 3 and 6-pounder guns are mounted on cage or crinoline mounts (Figs. 578 to 581), which, by the elasticity of their construction, allow a limited recoil and immediate restoration to its position before firing without change of direction. As in the cone mounts the trunnions of the gun are supported on a fork-shaped gun-metal pivot which fits in the gun-metal socket at the summit of the mount, and which has just sufficient play to rotate freely. The mount consists of the socket which is supported by eight legs which diverge and are attached to a D-shaped base ring so that the gun can be mounted close to the rail. The stand is of such a height as to give the gunner an easy position in aiming.

Sometimes it is necessary to use a recoil mount. This would be the case when the guns were to be mounted on torpedo boats, steam launches, or decks whose beams would be of too light scantling to resist the firing strains of a non-recoil mount. The recoil mount for the 3-pounder is shown in Figs. 582 to 586. It is so arranged that the gun can be trained and fired directly from the shoulder and at all angles of elevation and depression; the axis of the gun and recoil cylinder are parallel, so that the cylinder absorbs all shocks on the mount and platform. The lower part of the mount may be either the cone or cage mount previously described.

The pivot is a fork-shaped casting which supports the gun slides by means of trunnions. These slides constrain the piece to recoil in the direction of the line of fire. The trunnion boxes receive the trunnions of the piece and rest on the slides, to which they are secured by means of stout clips. The recoil cylinders form part of the trunnion boxes and recoil with the piece. The piston-rod is attached to the gun slides and projects to the rear of the cylinder and supports a spiral spring, and on its end carries a nut. On being fired the recoil cylinder checks the recoil and the spiral spring is compressed, thus storing up energy which returns the piece to battery.

The shoulder-piece is attached to the slides. It can thus give direction and elevation to the piece, and yet has no shock of recoil imparted to it.

Figs. 587 to 591 show a similar style of recoil mount. The main difference between this and the one just described, is that this mount has two recoil cylinders, and the spiral spring surrounds the hydraulic cylinder, thus shortening the length of the mechanism to check the recoil.

Figs. 592 to 597 show the recoil mount for a 6-pounder gun. It is practically the same as the first one described for the 3-pounder, with the parts correspondingly increased in strength and an alteration of a few minor points. It will be noticed that all of these mounts carry inclined shields for the protection of the gunner against light projectiles.

Figs. 598 to 600 represent a preliminary design for a 6-in. rapid-firing mount. A is the baseplate in which fits the hollow central pivot B. The rotation of the carriage is made easier by means of ball rollers *r*, which with the traverse circle C support the carriage. The carriage is prevented from jumping by clips K. The gun is mounted in a rocking slide D, which is pivoted to the carriage by the trunnions *t*. The gun is free to move to and fro in the slide. M and M[1] are the elevating and training motors respectively. M sets the vertical motor shaft a in motion, which by means of an endless screw a^1, communicates the motion to the gear wheel b^1 on the shaft b, whose motion is transmitted to a toothed arc d on an arm of the rocking slide through the media of an endless screw b^2 and gear wheels c^1 and c^2. The training gear is worked by a horizontal shaft c, an endless screw e^1, a gear wheel f^1, and from thence to the carriage by means of an endless screw which works in a gear wheel g on the pivot B.

Both elevation and direction are given, and the gun is fired by a man seated on the gun carriage at K, the electric circuit being made or broken by movements of the directing bar R and the trigger T. The recoil cylinder E is securely attached to the gun by the bands F, F, and consequently recoils with it. The forward end of the piston-rod is secured to the gun slide, and its rear end to the rear head of the cylinder H, which contains the spiral spring I. The rear end of the cylinder E, when the gun recoil takes against this spring, compresses it, and stores up energy, which afterward returns the piece in battery. The fluid in the cylinder E passes from the front to the rear side of the piston head during recoil, and in the reverse direction during counter recoil through two diametrically opposite grooves in the cylinder.

A 5-in. rapid-firing gun has been designed, whose fixed cartridge weighs less than 100 lb., which weight can be handled without difficulty. This gun gives excellent ballistic results, and it is extended to make it the standard quick-firing piece of large calibre. It would be a desirable piece to mount on board merchant vessels in time of emergency.

Table LI.—*Ballistic Particulars of Rapid-Firing Guns.*

——		50-pdr.	6-pdr.	3-pdr.	1-pdr.
Calibre	in.	5	2.24	1.85	1.46
Weight	lb	7000	800	506	73
Total length ..	ft.	17.4	8.12	6.72	2.76
Total length of bore	in	191.50	89.8	74.0	29.1
Length of rifling ..	,,	164.40	76.89	58.47	24.68
Twist of rifling ..		zero to 1 in 25 cals.	1 to 6 deg.	5.40deg.	6 deg.
Grooves: Number..	..	30	0.24	20	12
Grooves: Width ..	in.	0.349	0.22	0.22	0.31
Grooves: Depth ..	,,	0.025	0 01	0.015	0.015
Chamber: Length ..	,,	32.00			
Chamber: Diameter	,,	5.55 / 5.10	2.71	2 28	1.57
Chamber: Capacity	cu. in.	655			
Total capacity of bore	,,	3965			
Travel of projectile ..	in.	168	79.5	60.5	26.1
Weight of charge ..	lb.	28 to 30	1.95	1 71	0.18
,, projectile	,,	50	6	3.32	1.11
,, fixed ammunition..	lb.	95	9 62	6.37	1.48
Muzzle velocity	ft.-sec	2250	18.20	2002	1319
Remaining velocity at .. 1000 yds.	,,	1847	1319	1361	819
1500 ,,	,,	1673	1136	1138	726
2000 ,,	,,	1516	1012	991	659
2500 ,,	,,	1374	935	9 9	613
Muzzle energy ..	ft.-tns	1754	138	92	13
Thickness of steel perforated at muzzle	in.	9.00	8 96	3.5	0.89
1500 yds.	,,	5.90	1.98	1.48	0.71

THE INSTITUTION OF MECHANICAL ENGINEERS.

The Value of the Steam Jacket.

In our last issue we gave an account of the first part of the proceedings at the meeting of the Institution of Mechanical Engineers, held on the evenings of Wednesday and Thursday of last week, the President, Dr. William Anderson, being in the chair. We now take up the discussion on the report of the Steam Jackets Committee at the point at which we broke off last week.

The next speaker was Sir Frederick Bramwell, who said that many years ago he attended an unpremeditated trial upon the efficiency of the steam jacket. He had designed a steam engine which was erected at Bankside, and for years worked satisfactorily. One day he was sent for in a great hurry, and on arriving at the engine house he found the engine would not work. It was some time before he could make out the reason, but happening to place his hand on the pipe leading from the jacket, he found it quite cold. This led to investigation, when it was found that the pipe had become stopped up. When it was cleared the engine went on again all right. Experiments with water in the jacket, and an engine not at work, gave a measure of the loss due to imperfect cleading. He saw no statement in the paper as to the point at which it became dangerous for the jacket pressure to exceed the initial pressure, so that cutting of the cylinder would ensue from overheating. He remembered many years ago that a system of superheating steam was introduced from America. In order to have control over the degree of superheat, recourse was had to the use of what was called "combined steam," which consisted of a comparatively small volume of steam being superheated and mixed with the ordinary saturated steam from the boiler before going into the engine. This was the Weatherhead system, and it was tried on a Government steamer with economical results. The cylinders were not at all cut.

Mr. Phillips said that he had tried Weatherhead's combined steam arrangement with much advantage in economy. He saw no case mentioned in the report of the pistons being jacketed. He had known instances in which the required power had not been developed until the pistons had been arranged to take steam inside. He would also jacket the piston-rods, for they must carry off a good deal of heat by passing from the interior of the cylinder to the air. Further, as boilers were liable to prime, he would jacket the steam pipe. At Rennie's they had increased the power of an engine from 41¾ horse-power to 49½ horse-power in five minutes by putting the steam jacket into action. He had found a saving very near some of the figures given in the paper due to jacketing, and in one case of an engine working at low pressure, the saving of coal reached the remarkable figure of 30 per cent., due to the use of the jacket. He had found excellent results by superheating also, and he was a great believer in its advantages.

Mr. Bryan Donkin said that jacketing the piston had been tried, and the results published.

Mr. Schönheyder pointed out that in considering the relative advantages of jacketing for small and large cylinders respectively, the element of time must be taken into account. As to the remarks of Sir Frederick Bramwell in regard to jacketing with a higher temperature, he remembered that twenty-six years ago Mr. David Thomson had attempted this, using a small supplemental boiler for the purpose. The result was that, when the engine started, all the steam came out of the little boiler, and nearly all the water too. In the experiment on the triple-expansion engine of the East London Water Works, at Waltham Abbey Station, experimented upon by Mr. Davey and Mr. W. B. Bryan, the results of which were embodied in the report, the jacket of the high-pressure cylinder received steam at full boiler pressure, and, by means of reducing valves, the pressures in the jackets of the intermediate and low-pressure cylinders were maintained a little higher than the pressures in their respective steam chests. Each cylinder was therefore jacketed with steam a little above its own initial pressure. This cause, the speaker thought, was the reason for the poor economy; the indicated horse-power without the jackets in use being 140 and with the jackets 138. In regard to the experiments with this engine it was stated in the report that "it was possible to test from time to time whether or not jackets were perfectly drained, as the water traps passed a little steam if the drain pipes were opened too much, and great care was taken to get all the jacket water out without wasting any steam." In regard to this, Mr. Schönheyder thought it would have been better had some steam been wasted. In dealing with the experiments made on the compound horizontal engine at Woolwich Arsenal by Lieut.-Col. English, Mr. Davey, and Mr. Bryan Donkin, the report said that "an air cock was placed at the highest point of each jacket." He felt some difficulty in criticising the work of so influential a committee, but he could not help thinking there was a great error shown in placing an air cock at the highest part of the jacket when it was desired to extract air and leave steam. If the principle were followed it would be impossible to work an air pump in conjunction with a surface condenser, or there would be no vacuum, as the pump would first take water and then steam, leaving the air. It was, therefore, quite possible to have the jacket almost full of air in the experiments, as the air would be at the bottom, and the jacket was drained from the highest point.

Professor J. Hudson Beare was the next speaker. He said he had carried out trials on the economy of the steam jacket. These had been described *in extenso* in Engineering of last year.* The overhaul of the laboratory engine at University College had afforded a convenient opportunity for carrying out a series of comparative tests, both with the engine uncovered without jackets and with them, and also when well lagged with felt and wood. With the engine uncovered and no jacket in use, with a boiler pressure of 82 lb., the engine exerting 12.20 indicated horse-power, the consumption of steam was 32.91 lb. per indicated horse-power per hour, the ratio of expansion being 6.83 and the revolutions 95.09 per minute. This gave an actual efficiency of 7 per cent. On another trial, with an earlier cut-off and lower pressure, 72.5 lb., the efficiency was 7.20. With the jackets connected up, the engine being still unclothed, with steam at 70 lb. and 9.06 expansions, the total steam consumption per horse-power per hour was 28.51 lb., and on another trial, with somewhat different conditions, 28.35 lb. The actual efficiencies of the engine on these two trials was 8.04 and 8.10 per cent. respectively. The saving in steam used expressed as a percentage of the mean steam used in the first two trials mentioned was 12.3 per cent. With the engine clothed and jackets on several trials were made. The saving in steam used, expressed as a percentage of mean steam used during the first two trials (when the engine was unclothed and the jackets were not in use) was 15.9 per cent. on one trial, 17.4 per cent. on two other trials (when the pressure more nearly approached that of the first two trials), and 21.1 per cent. on two more trials. With the engine clothed, but with no jackets on, the saving in steam compared to that used in the first two trials was 4.5 per cent., but with higher pressure the saving was 3.5 per cent. Professor Beare's figures are of great value, and a reference to them in connection with the present subject will be well repaid. The engine experimented upon was a small tandem compound made by Bryan Donkin and Co., having 6 in. and 10-in. cylinders with a 12-in. stroke. For convenience we may here repeat the actual efficiencies under the various conditions of trial, although, to thoroughly appreciate their significance, the whole of the facts should be considered. With engine unclothed and no jackets 7.00 and 7.20 per cent., with engine unclothed and jackets on 8.04 and 8.10 per cent., with engine clothed and jackets on 7.18 (this was at a very low pressure and low ratio of expansion), 8.47, 8.55, 8.60, 8.76, and 9.20 per cent. Engine clothed and no jackets 7.45, 7.57, and 7.40 per cent. After each jacket trial, when the engine was standing thoroughly hot, steam was turned into the jackets and the amounts condensed in an hour measured. The quantity was about 23 lb. per hour when the engine was not covered, and 15 lb. per hour with the engine lagged. Jackets were not fitted to the cylinder covers.

Mr. Aspinall, in answer to the President, said that they had no experience of jacketed engines at Horwich, but he would be pleased to give the Committee facilities for trying experiments on a locomotive. Mr. Donkin and Mr. Davey said they gladly accepted Mr. Aspinall's offer.

Professor Kennedy said that he had been particularly interested in Mr. Morison's description of the mechanical means whereby circulation of steam was insured in the jacket; the more so that he had had difficulty in this direction himself. He had no doubt that the measurement of the feed water had been quite up to the standard of accuracy in these trials, but the records showed the difficulty of measuring feed water into a boiler, and he believed the right thing to do was to measure the condensed steam out of the boiler after it had passed through the engine rather than the water before it was pumped in. It was a singular thing how little engines appeared to suffer by superheating compared to what was generally supposed to be the case. In some tests he had made with the Serpollet boiler he had used highly superheated steam, but the cylinder did not suffer from this cause, the interior being in perfect condition after use.

Mr. Phillips said that in the steamers of the Royal Mail Company, to which he had previously alluded, the temperature of the steam was not allowed to exceed 330 deg., as the packings of those days would burn. They had no difficulty with the cylinders and slide valves.

Mr. Thornycroft, referring to the question of the circulation of steam in jackets, said that French marine engineers passed the steam for the auxiliary engines through the jackets. He considered that it would be a good thing to jacket the cylinders of engines in the Navy, as the jacket was very efficient when working at low powers, and much of the steaming in war vessels was done at much less than the maximum power.

* See Engineering, vol. xlii., page 744.

the true curve of the machine, and in this case is substantially a sine curve. Fig. 19 is the curve of the small alternator, Fig. 1, without iron in the armature; Fig. 20 shows the effect of introducing iron into the armature, whilst Fig. 21 is a curve obtained from a small alternator built on the principle of Gramme. The presence of iron in the small Siemens armature is very marked, and the similarity between the curve of the first machine without iron, and the Gramme pattern with iron, is very striking.

In the following experiments the small Siemens alternator was used without iron in the armature.

Figs. 22 and 23 represent an alternate current before entering an artificial cable, and after leaving the same. The amplitude is decreased one-third, thereby partly showing how it is that one is limited to distance in the case of telephony.

The effect of self-induction is very well shown in Figs. 24 and 25. Fig. 24 was taken with an external circuit of 423 ohms, and without self-induction. Fig. 25 represents the same when three electro-magnets with vibrating armatures, and having the same ohmic resistance, 423 ohms, were placed in circuit. The diminution in amplitude is worthy of consideration, the same effect in the case of steady currents being only brought about by an increase in the ohmic resistance. The amplitude increases with the speed of the machine, and from this experiment the effect of electro-magnets in telephone lines is easily foreseen.

We now come to perhaps the most interesting part of this article—namely, phase difference, which plays such an important part in alternate currents. In order that this effect can be clearly shown a vertical wire was stretched before the screen and was placed at the point where the maximum ordinate occurred. Any phase difference was at once noticed on making the required change in the circuit.

The first experiment consisted in connecting up the primary of the induction coil, already mentioned, to the alternator, and so arranging matters that the telephone could be quickly changed from the primary to the secondary circuit, taking care that the vertical wire was placed on the maximum ordinate of the primary curve.

Fig. 26 shows the primary current with the vertical wire alluded to, when the core was removed. Fig. 27 is the resulting secondary current. The phase difference is very marked, and roughly amounts to 53 deg.

Figs. 28 and 29 show the primary and secondary currents with iron core in position. Here the phase difference is very much reduced, and with these curves is scarcely measurable.

Phase difference is shown very strongly in the case of alternate currents in two parallel circuits—the one being free from self-induction and the other containing self-induction. In the first-mentioned circuit ordinary inductionless resistances were employed, whilst parallel with it was placed the primary winding of the induction coil.

Fig. 30 gives the current in the induction, less circuit. Fig. 31 the current in the primary of the induction coil without core, and with secondary open.

Figs. 32 and 33 show the corresponding curves with iron core in position, the secondary being closed. In the first case the phase difference amounts to about 35 deg., whilst in the last it is very small indeed.

In the same manner one can find the phase difference at different points in a cable. Figs. 34 and 35 show the current before entering and after leaving the artificial cable already alluded to. Here the phase difference is about 64 deg., and the amplitude of the second curve is about .68 that of the first. With curves which are taken from circuits containing no capacity the self-induction can be calculated, and the effects of hysteresis studied.

(*To be continued.*)

LITERATURE.

The Cleaning and Sewerage of Cities. By R. BAUMEISTER, Professor of the Technical Institute of Carlsruhe. Adapted from the German, with permission of the Author, by J. M. Goodell, Associate Editor *Engineering News*. New York: *Engineering News* Publishing Company.

MR. GOODELL has rendered a distinct service in translating and re-publishing this work. The subject is of ever-growing importance, Germany has taken a leading position in this branch of engineering, and Professor Baumeister's book is one of the standard works on the subject, although the author is not a practising engineer. The treatment of the subject is practical, dealing with elementary principles, not theoretical; and a freedom from bias certainly enhances its merit. The book deals with sewerage, sewage disposal, and street cleaning. After stating the general features of the various systems of sewerage, the author deals with the carrying of waste water, mentioning that in designing water works in Germany the practice is to allow 40 gallons per day per person, and in England 28 imperial gallons. Proceeding to deal with construction, special consideration is given to the shape and material of sewers, formulæ for determination of flow, &c., and to the details of construction, manholes, lampholes, junctions, overflows, syphons, and outlets, &c., and here it may be stated that the practice does not differ in general principle from that in use in Britain. In the chapter dealing with cost of works we note that the cost of construction of sewerage systems is in Berlin over 20s. per foot, in other German towns it is as low as 15s. or 16s., in Stralsund it is 8s. 9d. In London the cost is given as 24s., in Liverpool 27s., and in Paris 41s. In the three last towns, however, the figures are for 1879. The results are now admittedly less.

On the subject of the purification of sewage, all the processes are described and their merits and demerits considered with impartiality, while the cost of carrying out the works and of maintenance is given. The annual cost of chemical precipitation in Germany ranges from 5½d. to 1s. per capita. Aëration, filtration, and irrigation are all similarly treated, with special reference to results and costs, rather than to methods and details. The data as to cost and maintenance has evidently been collected with great care. In comparing the treatment by irrigation with the other methods the author deems it best to reduce the units of comparison to the cost per 100 cubic feet, and the annual expense for each inhabitant. In this case not only the proceeds of the process are considered but also the expense of preparing the fields and their original cost, the interest on the capital invested and possibly a sinking fund. There is generally a loss, as in Berlin. Special reports of nine English cities, he states, show that this ranges up to 2½d. per 100 cubic feet, or to 2s. 1d. per resident annually. Those figures show a greater range than those for chemical precipitation, partly explained by the cost of land, and partly by the variable value of the crops. In the very satisfactory fields of Breslau, leased at from about 32s. to 44s. an acre annually, and paying about 1½ per cent. on their cost, the loss is only 3d. per resident annually. In Berlin the figures for 1885-86 are rather over ½d. per 100 cubic feet and 8d. per resident, and these rates are slowly decreasing. The opinion, indeed, prevails there that chemical precipitation would be more expensive and give less satisfactory results. If no chemicals are employed and the mere mechanical precipitation will answer all requirements, the expense is much less than that of irrigation. In any case it is to be noticed that suitably designed and conducted irrigation fields come nearer to both sanitary and agricultural standards than any other method of sewage precipitation, and the method is capable of greater improvement, while the future of precipitating plants is uncertain as regards the removal and value of the sludge.

In the third part of the volume the problems of general municipal and domestic sanitation—street cleaning, garbage, and excrement removal and disinfection—are discussed, and the practice in Germany is particularly interesting, as it differs largely from that obtaining in this country. There is also a chapter in the work dealing with American practice in street cleaning and sewerage.

Coal and What We Get from it. By RAPHAEL MELDOLA, F.R.S. London: Society for Promoting Christian Knowledge, Northumberland-avenue, Charing Cross, W.C. [Price 2s. 6d.]

This work, forming part of the Society's "Romance of Science" series, is characterised by the author himself as a romance of dirt, and yet it is fascinating alike for the popular manner in which it is narrated and for the splendid results attained by the suitable treatment of that dirt. Professor Meldola, in his first chapter, tells the story of the carboniferous age, and generally of the formation of coal seams, treats of the chemical composition of the best-known varieties of coal, and generally shows that the chief source of the energy contained in coal is carbon which formed part of the plants that grew during the carboniferous period, that the carbon thus accumulated was supplied to the plants by the carbon-dioxide existing in the atmosphere at that time; that the separation of the carbon from the oxygen was effected in the presence of chlorophyll by means of the solar energy; and that thus the heat which we get from coal is sunlight in another form, or, as George Stephenson put it, "bottled up sunshine." Casually the author mentions how far short mechanical energy is of utilising the full extent of this bottled up sunshine, and this suggests the idea that perhaps better results would be got if all who use it were educated as to the chemical composition and possibilities of coal. The chemist has certainly made good use of the dirt resulting from the burning of coal, and foremost amongst the number is Perkins, to whom, as the founder of the coal-tar colour industry, the book is appropriately dedicated. The process of making gas and of recovering all by-products is graphically told; but, as in the case of all "romances," it would be unfair to the prospective reader to reveal too much of the *dénouement*. Speaking of gas and the possibility of it being superseded by electricity because it may be cheaper, Mr. Meldola points out that notwithstanding the increased application of electricity for lighting, more gas is used, partly in consequence of the greater number of gas engines employed and partly owing to its use for heating and cooking. As to cost, too, it will ultimately be a question between electricity and gas plus tar, ammoniacal liquor, and other by-products. Indeed he says it may pay the mineowner to distil coal at the pit's mouth for the sake of these by-products.

BOOKS RECEIVED.

Spons' Engineers and Contractors' Illustrated Book of Prices of Machine Tools, Ironwork, and Contractors' Material. London and New York: E. and F. N. Spon.

A Short Treatise on Labour, Strikes, Liberty, Religions, Political and General Public Questions. By W. E. KOCHS, C.E. Cardiff: W. Jones. [Price 2s.]

MODERN UNITED STATES ARTILLERY.—No. XV.

PNEUMATIC DYNAMITE SEA COAST GUNS; MODEL OF 1890. (Figs. 365 to 376.)

Projectiles for Dynamite Gun.—The full calibre projectile has a charge chamber whose outside diameter nearly fills the bore of the gun. The head is of ogival form, the body is cylindrical and its bore is of a somewhat elongated figure prepared at its rear end to receive the tail tube. The tail consists of a long tube 4 in. in diameter, and at its extreme end is a bronze casting fitting outside the tube and having twelve spiral wings of 7 ft. pitch.

The head and base are prepared to receive the same electrical fuzes will be described later, the only difference being in some lengths of the fuze in the head; 7 is the contact cone (Fig. 371), and 8 is the diaphragm, 9 and 11 are the cases to form pockets for the primary charges, 10 is the conducting tube, 12 are the vulcanised fibre runners for preventing metallic contact with the barrel, 13 is the gas check; it is a leather ring under which the pressure passes forcing it against the surface of the bore like the lip of the cup packing.

In case of the projectile being charged with gelatine, one diaphragm is used, but if the charge be gun-cotton, none is needed.

Sometimes instead of a full calibre projectile, a projectile known as a sub-calibre projectile is used.

This projectile, Figs. 375 and 376, consists of a cylindrical body considerably inferior in diameter to that of the gun from which it is fired. It has an ogival head, but generally a square base, though some of them have a base similar to the head and somewhat truncated to give stability to the gascheck. Since the gun is not rifled, it becomes necessary to give to the projectiles, which are oblong, some device such as a tail, or wings, to give a rotary motion, in order to insure stability in flight. The latter method is found preferable, and is accomplished in the following manner: A light cast ring with spiral blades is put on the base of the projectile outside of the tube, the blades being eight in number, 5½ in. in length, 14⅞ in. in diameter, and having a pitch of 15 ft.

In order to fire this projectile several accessories are necessary. The projectile is inferior in diameter to the bore, and consequently must be supported, so that its axis will be in the axis of the bore. The wings are very light, and must not be

PROJECTILES FOR 15-INCH PNEUMATIC DYNAMITE GUN.

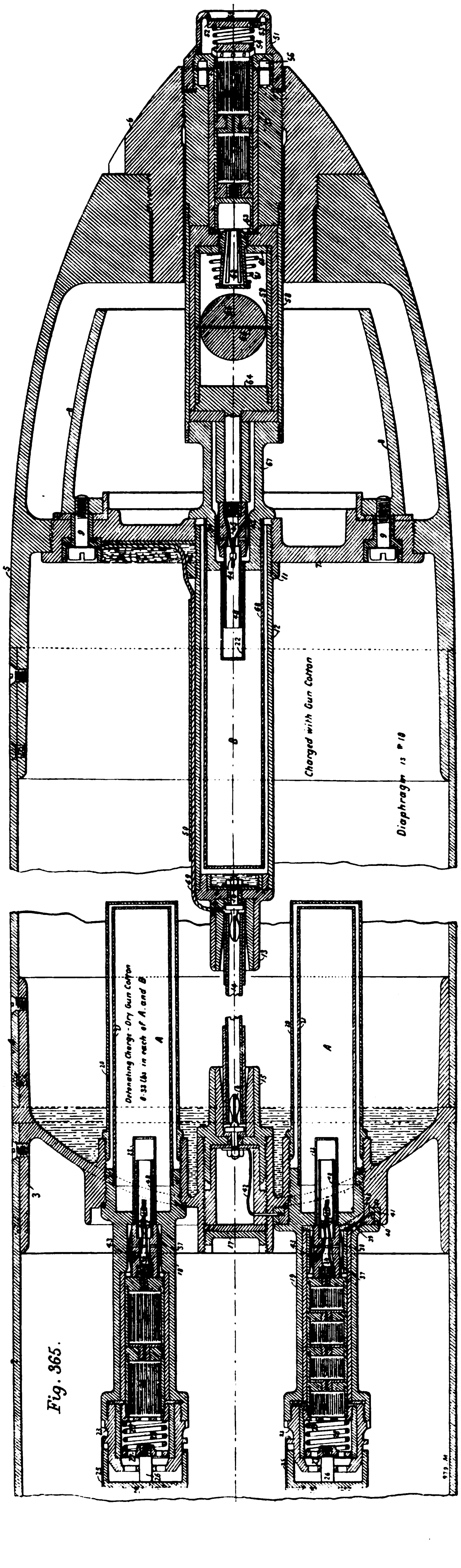


Fig. 365.

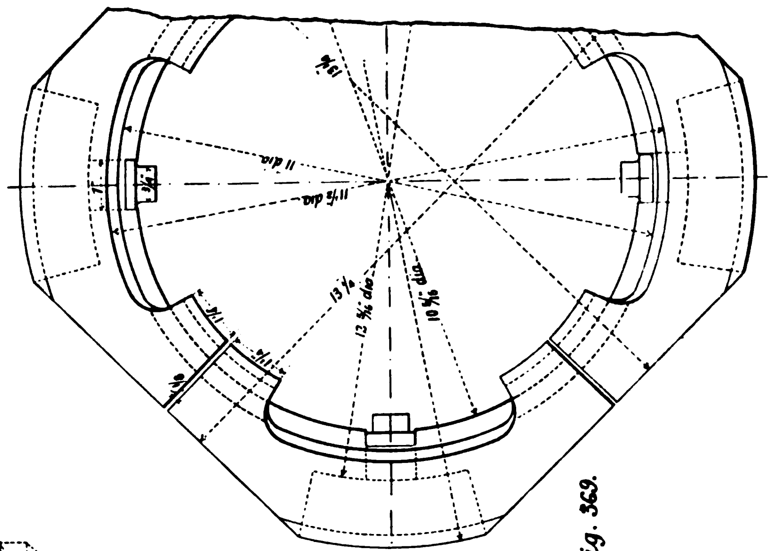


Fig. 369.

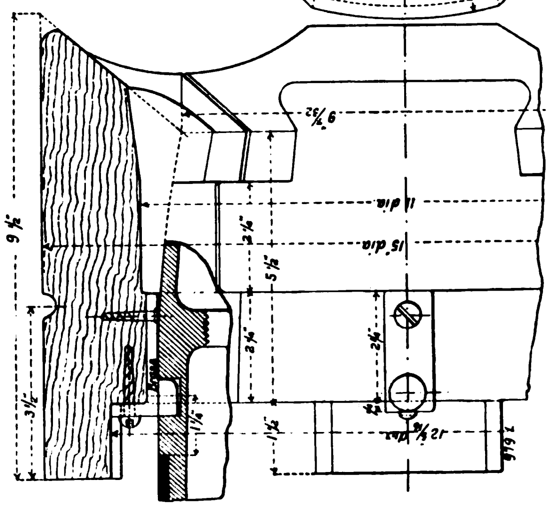


Fig. 368.

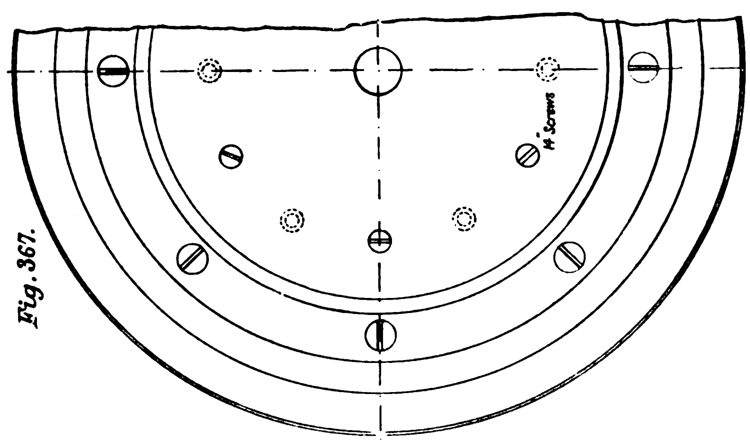


Fig. 367.

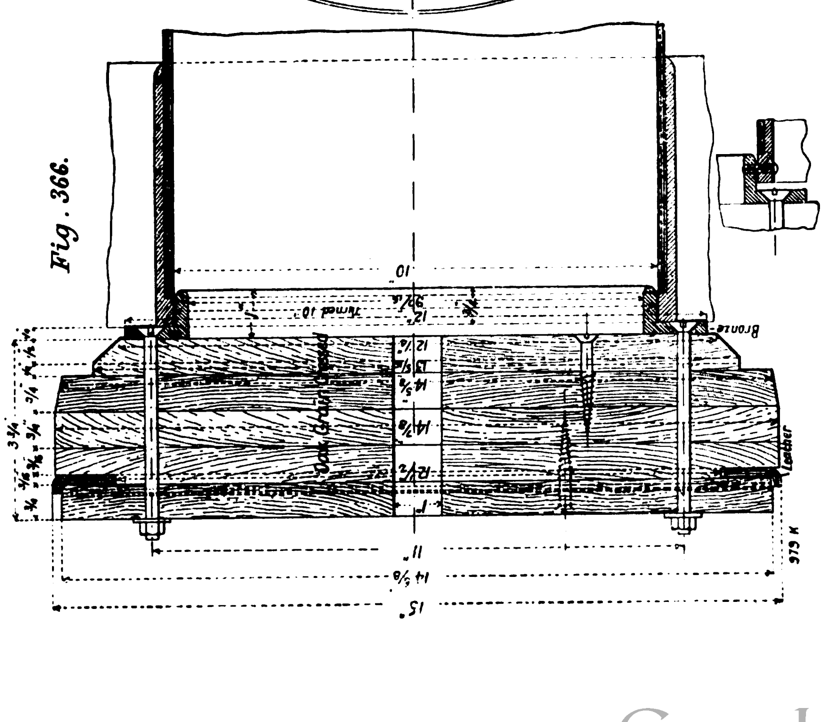
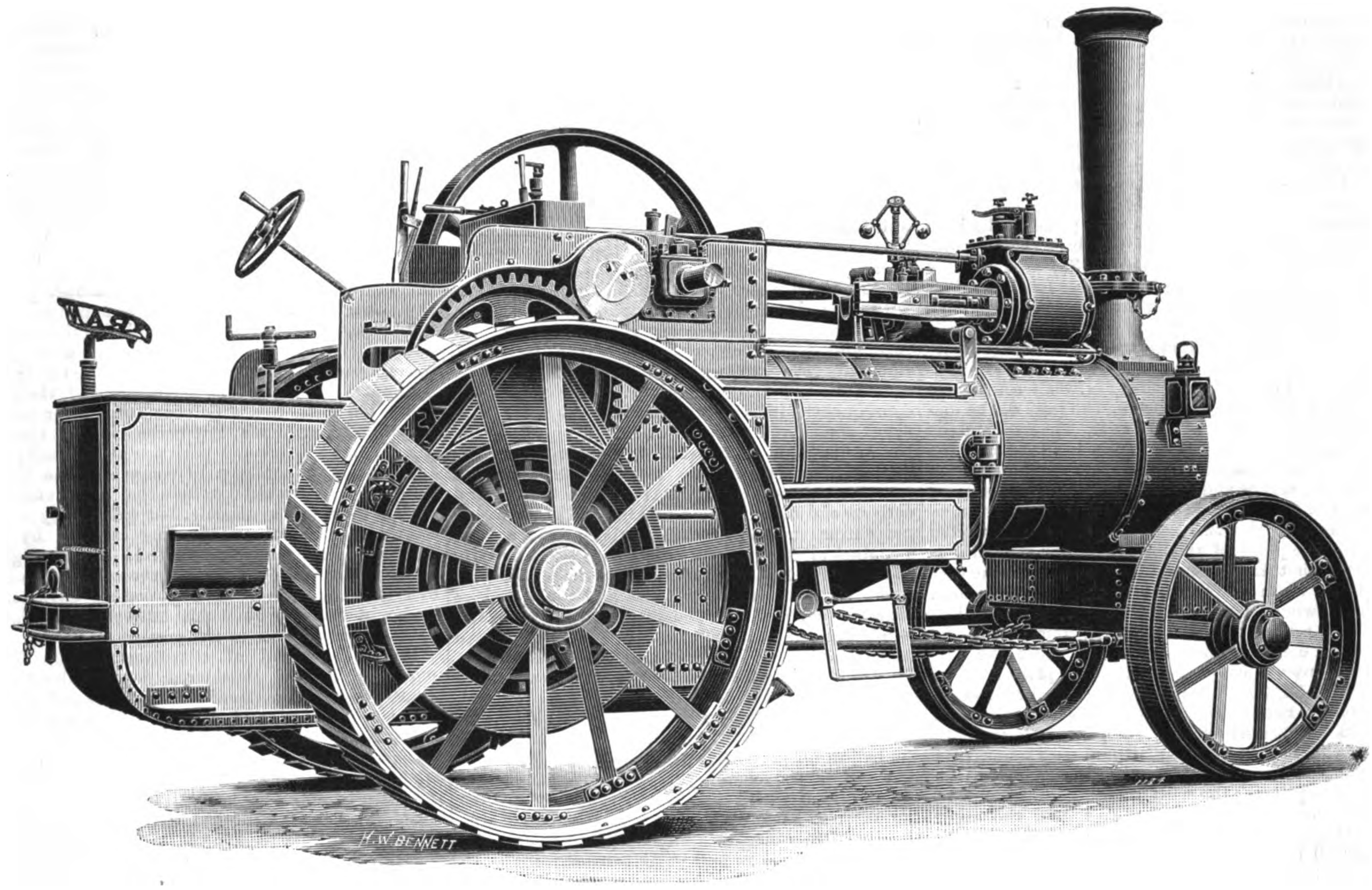


Fig. 366.

TRACTION ENGINE AT THE WARWICK SHOW.

CONSTRUCTED BY MESSRS. RANSOMES, SIMS, AND JEFFERIES, LIMITED, ENGINEERS, IPSWICH.

(*For Description, see Page* 41.)

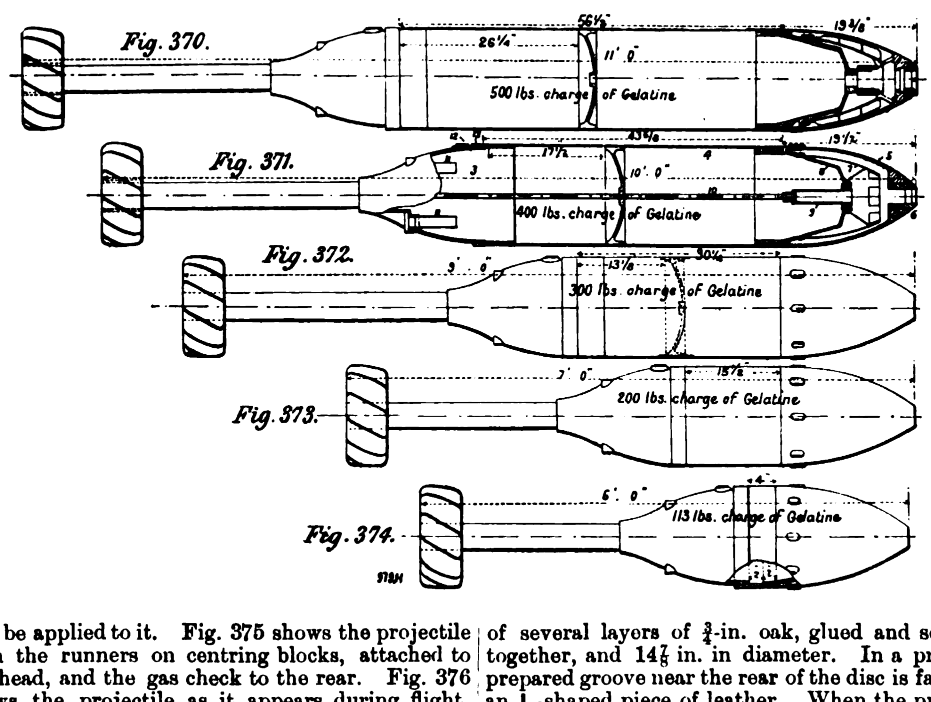


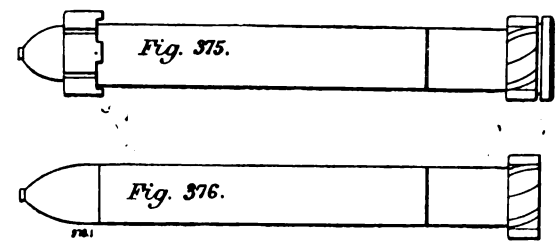
allowed to come in contact with the bore, since they would be deformed and the bore scored.

On account of the difference in diameter of the projectile and the bore there must be attached to the projectile a gas check, to prevent the escape of air past the projectile, so that the full motive force will be applied to it. Fig. 375 shows the projectile with the runners on centring blocks, attached to the head, and the gas check to the rear. Fig. 376 shows the projectile as it appears during flight, both runners and gas check having become detached at the muzzle when the projectile left. The gas check (Figs. 366 and 367) is attached to the projectile by means of a flange which enters the rear of the projectile about $\frac{3}{4}$ in., but leaves a space between the bearing surface of the projectile and that of the gas check, equal to the diameter of the fastening screws, which screws are put in radially through the rear of the projectile and enter the flange.

The flange is bolted to a disc (Fig. 366) made up of several layers of $\frac{3}{4}$-in. oak, glued and screwed together, and $14\frac{7}{8}$ in. in diameter. In a properly prepared groove near the rear of the disc is fastened an L-shaped piece of leather. When the pressure enters the gun the bolts, which hold the gas check to the projectile, are sheared off, and the flange of the gas check slides forward. The pressure forces the L-shaped piece of leather against the bore of the gun, so that no air can escape past the projectile. The full force of the pressure is thus exerted on the base of the projectile, and it is also centred at this point.

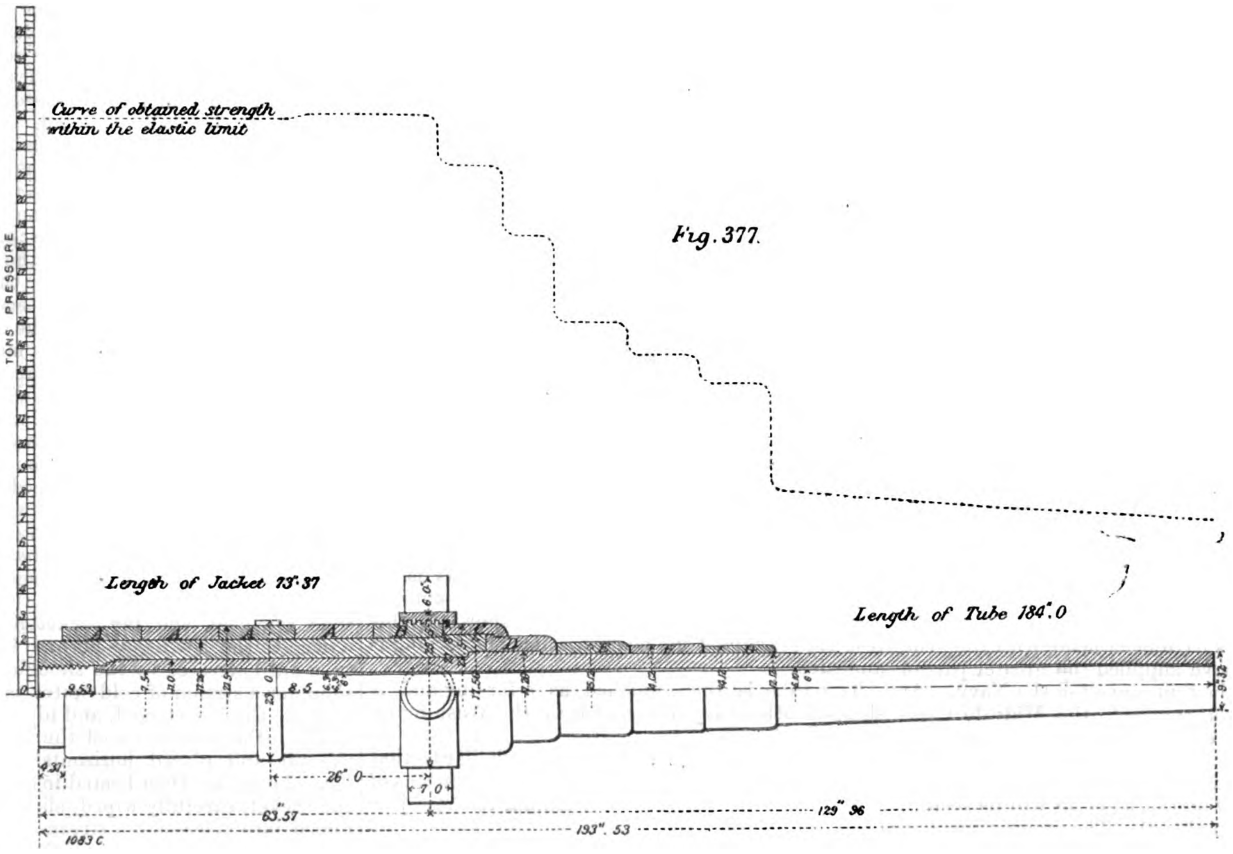
After leaving the bore the front pressure of the air on that portion of the disc of the gas check which projects beyond the body of the projectile retards the gas check sufficiently to cause the check to drop off.



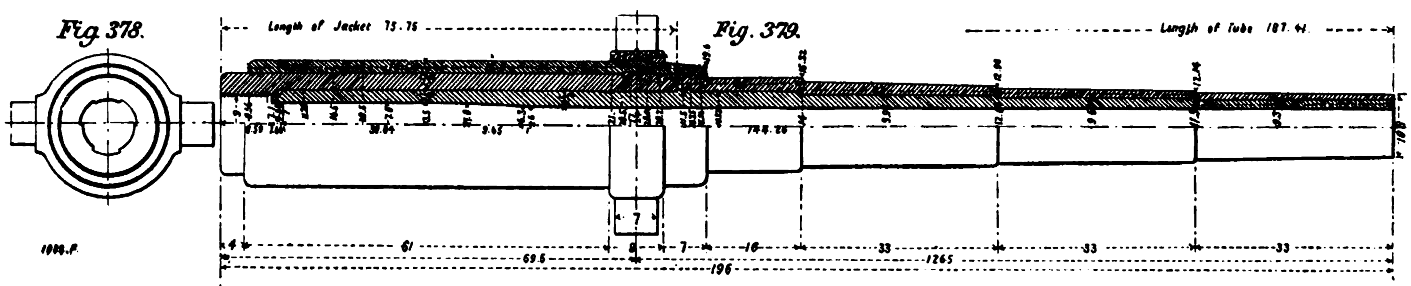


The head of the projectile is centred by means of carriers or runners. These runners, Fig. 368, are blocks of wood properly conformed to the head of the projectile; they are four in number, and are located by projecting pins, which enter corresponding holes in the head. The pins are screwed to the runners near their rear end. During handling the runners are held on the projectile by means of a wire wrapped around the groove on their exterior when the projectile is ready for loading, and in the trolley the wire is removed. While in the bore of the gun the shape of the runners, with the bore as a guide, keeps the runners from coming off, and the pins keep them from dropping back on the projectile. On leaving the bore the air impinges against the inclined front faces of the blocks, causing them to fly off radially. The gas check having dropped off, the projectile is left, as shown in Fig. 372, so that the air offers as little resistance as possible to it during the rest of its flight.

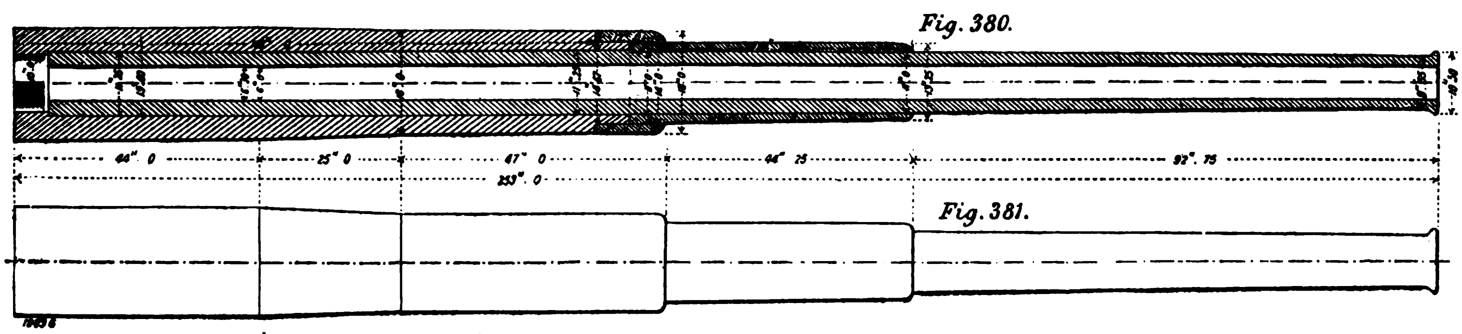
MODERN UNITED STATES ARTILLERY.



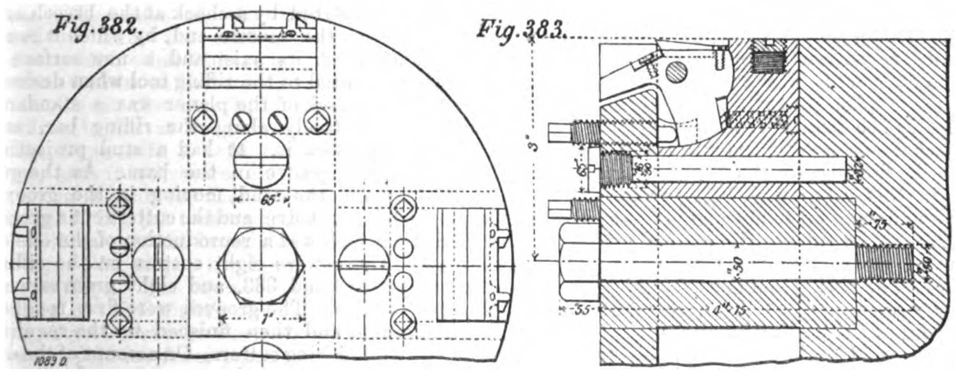
6-IN. BREECHLOADING GUN; MARK II.



6-IN. BREECHLOADING GUN; MARK III.



6-IN. BREECHLOADING GUN OF 40 CALIBRES.



BORING HEAD FOR 6-IN. BREECHLOADING GUNS.

normal the measuring drum registers too large a quantity of spirit, but the float expanding more than the spirit in which it is placed registers somewhat too high a density, and thus underestimates the amount of spirit present. In this way the two errors are made to compensate each other very accurately, the residual errors being very small, and these, if desired, can be eliminated by calculation.

MODERN UNITED STATES ARTILLERY.—NO. XVII.

(FIGS. 377 TO 385.)

THE NAVY 6-IN. BREECHLOADING RIFLE.

THE 6-in. breechloading rifle may be termed the pioneer of the high-power navy guns. As early as September, 1881, bids were requested for the furnishing of steel forgings for the purpose of

TABLE XXX.—TEST OF METALS IN GUNS NOS. 1 AND 18.

Part of Gun.	Tensile Strength. (lb.)		Elastic Limit. (lb.)		Elongation after Fracture. (per cent.)		Reduction of Area after Fracture. (per cent.)		—
	No. 1.	No. 18.	No. 1.	No. 18.	No. 1.	No. 18.	No. 1.	No. 18.	
Tube	74,768	84,530	29,833	42,149	28.52	23.87	39.41	46.05	
Jacket ..	75,000	88,300	34,065	44,200	27.58	22.80	42.23	38.50	
A	102,·67	116,700	44,733	68,700	18.78	14.92	26.79	25.90	
A	88,465	..	39,810	..	25.53	..	37.41		
A	93,733	121,769	41,235	68,980	23.71	15.95	36.72	31.05	
A	86 436	..	41,030	..	29.40	..	45.60		
A	91,523	108,112	52,337	63,025	..	15.20	..	29.18	
A	94,607	..	49,553	..	18.67	..	28.35		
A	90,799	107,543	41,694	59,854	20.80	16.45	32 37	32.65	
A	109,881	..	44,117	..	12.32	..	12.31		
B	107,314	101,672	46,297	53,618	18.17	16.70	24.19	29.20	All in No. 1
C	93,030	99,608	33,104	54,932	16.45	17.42	21.16	39.36	A¹ ,,
D	93,956	103,297	49,569	53,287	25.51	16.42	37.78	29.56	B ,,
E	110,574		44,869	55,200	15.13	17.30	18.73	33.10	C_1 ,,
	102,380	102,700	44,727	..	18.90	..	26.49	..	C_2 ,,
F	88,555	119,738	29,254	62,631	22.36	18.05	32.59	35.26	D_1 ,,
G	101,879	103,171	42,755	61,148	17.20	17.77	20.90	36.61	D_2 ,,
Tr	82,501	81,191	45,701	41,600	12.30	12.10	22.00	13.32	

building a 6-in. gun. Of the fifteen steel firms to whom the request was made only two responded. The contract was awarded, but, as in May, 1884, it had not been filled, except in a very minor part, it was cancelled.

In June of 1882 a contract was awarded to the Midvale Steel Works of Pennsylvania for steel forgings for two 6-in. guns. Since that time a number of contracts have been made with the firm, and in fact they have supplied the greater part of the steel used for the 6-in. guns for the Navy. At the time of the first contract, the Midvale Company had had but comparatively little experience in the forging of gun steel, but the result of experience since that time has been a vast improvement in the quality of the steel, as will be seen in Table XXX. (given above). The improvement in plant and processes that the Company has made has been such that now it is able to turn out with comparative certainty steel for this calibre gun fully equal to that of any market.

The steel for No. 1 was annealed, while that for No. 18 was both annealed and oil tempered.

Several designs have been made for the 6-in. guns; the first design for Mark I. was made in 1881, but only one gun was constructed from this design. In 1884 the design for Mark II., Fig. 377 was made and a number of guns have been constructed from it.

The tube, which is 184 in. in length, extends the whole length of the bore. Over the tube is shrunk a jacket 73.37 in. in length, which projects 9.53 in. in rear of the tube and is threaded to receive the breech plug.

The actual characteristics of the metal are determined and on these is based the actual shrinkage, which shrinkage is so calculated that for a certain internal pressure the tube jacket and hoops will all reach their elastic limit at the same time. The formulas of Virile were employed in determining the thickness of the walls at various points and the shrinkage to be used. The ingot, from which the tube is forged, is made of cast steel, 30 in. square, and about 55 in. long, with a longitudinal hole 12 in. in diameter and 36 in. in length. The weight of the ingot is 15,000 lb. The metal from which the ingot is cast is made for the ordinary open hearth Siemens process, and just before tapping is stirred with hickory rods.

Test bars are cast at various times from the metal, and are broken, and by the fractures the carbon and solidity of the metal are determined.

When everything is ready the metal is tapped into a ladle and from that it is poured into the mould. The gate enters the mould from the bottom until the mould is partially filled and then it is poured in at the top. As the metal cools and contracts the mould is kept full by pouring in crucible steel, charcoal being kept on top of the mould to keep the metal liquid.

The casting, when cooled, is ready for forging. For the first forging the ingot is heated for 24 hours and then gently hammered to close the blow-holes. It is then reheated by aid of a blast in 18 hours to a bright forging heat, and then hammered until its cross-section is an octagon about 17 in. on a side, after which the ingot is allowed to cool, and then chipped with a chisel to remove all cold shuts and other surface defects.

The heating and hammering on a V-shaped anvil is then continued until the forging is reduced to its required dimensions. To effect this reduction requires about a dozen heats and 12 hours hammering. As long as the forging can be heated all over at one heat it is also hammered all over, but when it becomes too long for the furnace, one end is heated and hammered at a time. When the forging is completed the excess of metal at the ends is removed, and from this excess test bars are cut and tested. From the physical qualities shown in this test is determined the heat at which the forging is annealed.

The tube is then finished as a forging and is shipped to the Navy Gun Factory at the Washington Navy Yard.

The jacket is made from a casting similar to that from which the tube is made, and the operations of forging and heating are very similar to those just described for the tube.

The ingots for the hoops of the first few guns were cast about 13 in. square, and weighed about 1000 lb. They were heated and, after forging into a rough cylinder, pieces, weighing about 400 lb. were cut off from the tops and the remainder were then upset to a cheese shape and 11 in. holes punched through their centres. After this each ingot was reheated, placed on the horn of an anvil and hammered into shape, being frequently changed end for end on the horn of the anvil. As it approached a finished shape a special tool was interposed between the hammer and the hoops. The hoop was finally laid on top of the anvil and hammered on the ends, and then annealed.

At present the ingot for a hoop is 15 in. square, 4 ft. long, and weighs 3100 lb. It is heated and the upper third cut off. The remaining two-thirds is then cut into three or four pieces, according to the width of the required hoops. These pieces are reheated, hammered to an octagonal shape, upset and hammered to discs about 1 ft. in thickness. They are then punched nearly through with a conical punch, reversed and punched again from the other side. The operation is then repeated with a larger punch. The imperfections are then chipped off leaving hoops 10 in. or 12 in. thick, pierced by holes about 10 in. in diameter. They are then hammered on a tapering mandrel and V-shaped anvil, and then finally hammered in a die of proper width. They are then oil tempered and test bars are submitted for inspection. It was first intended to make the trunnion hoops of forged steel, but after two attempts and failures it was decided to cast them, and all of them are accordingly made in this way.

When the tube is received at the Naval Gun Factory it is put on a lathe, centered with great care, and rough-bored and turned to within ⅜ in. of the finished diameters. It cannot be rough-bored and turned to within closer margins of the diameters, on account of the slight warping which usually takes place during oil tempering, which consequently necessitates recentering.

The jacket is rough-turned and bored to within ¼ in. of the finished diameters, a less limit being allowed in this case, since, being a shorter piece, the warping during oil tempering is not as great as in the case of the tube. The method employed is the same as the case of the tube, except that in boring a hollow boring tool is used, which removes a solid core weighing 900 lb., from which may be made a 3-in. breechloading howitzer.

The tube and jacket are now oil tempered. This is done by heating them in a wood fire to a heat determined by previous tests of the metal, and immersing them in oil a number of times, the number also depending on previous tests. No. 1 gun had none of its pieces oil-tempered, and was built up as the piece came from the works. This oil tempering is one of the most important steps in the manufacture, and on its success depends to a great extent the physical characteristics of the metal.

The pieces are now finally tested, and if satisfactory, are provisionally accepted.

The jacket is now placed in the lathe and finished, bored as near as possible to the established diameter, and then star-gauged. As it is much easier to turn an exterior diameter than an interior one, the tube is turned after the jacket, its diameter being equal to the diameter of the jacket plus the shrinkage. For the same reason the interior of the hoops are turned first, and afterward the corresponding shrinkage surfaces. The interior measurements of the jacket do not vary more than .002 in. or .003 in. from the required diameters.

The tube and jacket are now removed to the shrinking pit. The tube is placed in it, muzzle down, so as to be in the centre of the pit, and a wooden box built around the shoulder. The jacket is thoroughly cleaned and placed, breech end up, in a wrought-iron flask, around which a wood fire is kept burning, until the operator, by inserting a gauge in the jacket, finds that it has been sufficiently expanded to allow for shrinkage with sufficient clearance to slip easily over the tube. The flask is then removed and the jacket lifted by a crane, moved to the shrinkage pit and lowered over the tube until arrested by the shoulder on it. At this shoulder a stream of cold water is now turned on to make the jacket cool, and nip first at this point.

When the jacket is cool the gun is lifted from the pit and placed horizontally on skids. The chase hoops are then heated in the same manner as the jacket, carefully wiped, slipped over the tube, forced into place, and a stream of water turned on the trunnion end of the hoop to make it nip first at that circle, and so make a close joint with the hoop next to it.

When all of the chase hoops are shrunk on, the gun is again put in the lathe, the jacket turned to the diameter prescribed for shrinkage, and the chase hoops and chase turned to the finished dimensions. The C, A, and B hoops are then shrunk on in the same manner as the chase hoops, the C hoop being put on from the muzzle and the others from the breech end. The gun is again put in the lathe, fine turned, the thread cut on the gun and the screw on the trunnion hoop, which hoop securely locks the B and C hoops. The muzzle and breech faces are then faced off to the proper length and the chamber reamed out. The reamer for this purpose is made the exact shape of the bore, and cuts the two cones at each end of the powder chamber, and the intervening cylindrical surface of the chamber all at the same time.

The gun is now ready for rifling. The rifling bar used is 5 in. in diameter, with a groove cut in it whose twist is the same as that of the rifling. To cut this groove the developed curve of the rifling is laid off on a horizontal plate at the side of the lathe. A groove is cut along the curve, in which travels a stud, which moves a ratchet gearing into a wheel on the end of the bar. As the bar travels along the lathe the stud and ratchet move out in the groove, causing the bar to revolve, and the stationary cutter cuts the required groove. The rifling head carrying the cutters is fitted on the end of the bar.

During the manufacture of the first lot of guns there was no special rifling machine at the Navy Gun Factory, and consequently the rifling was done on a planing machine. The gun was laid on a planer table, and supported by a chock at the breech end and a collar at the muzzle end, by which it could be revolved about its axis, and a new surface of the bore presented to the rifling tool when desired. On the muzzle end of the planer was a standard, which passed freely along the rifling bar, and served to support it. It had a stud projecting down into the groove in the bars. As the gun moved forward, the stud, moving in the groove, cause the bar to revolve, and the cutters cut a groove in the gun which was a reproduction of the one on the bar. There were eight cutters on the rifling head, Figs. 382 and 383, and eight grooves were thus cut at once. The grooves were first roughed out all around, and then finished to the required profile, with finishing cutters. On account of the difference in the width of the grooves at the breech and muzzle, a second groove has to be cut in the bar, having the diminished twist of the reverse edge of the groove. The rifling is finished with this groove and the finishing cutters. The elevating band is now shrunk on, and the screw box for the breech plug cut and slotted out, and the breech mechanism is fitted.

The bore of this gun is 30 calibres long, and its total capacity is 5604 cubic inches. The capacity of the powder chamber is 1414 cubic inches, so that the number of expansion volumes is 3.96. The cone between the chamber and the bore is made long to prevent the erosion caused by the gas rushing against a shoulder made by a sudden change in diameter. The various dimensions of the breech-plug are calculated by empirical formulæ based on throughout the bore, and preventing the gases from getting by the land and causing erosion. The developed curve of the rifling is a semi-cubic parabola.

Mark I. was the same as Mark II. in all essential points, and differed from it only in certain details. The grooves in Mark I. were the same width throughout.

No. 1 gun was the only one made on the Mark I. design. The next guns were made from Mark II.

The gun is designed to fire projectiles weighing 100 lb. with a charge of 50 lb. of powder, this giving a density of loading of 0.99 in Mark I., and 0.98 in Mark II. (See Figs. 386 to 388.)

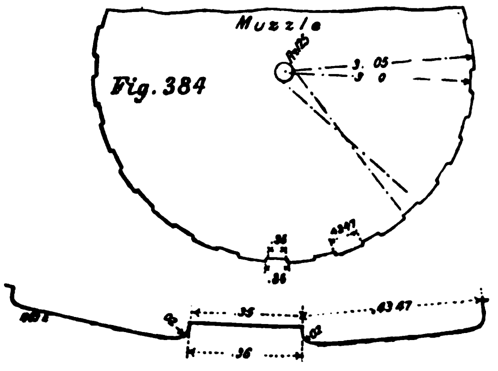


Fig. 384

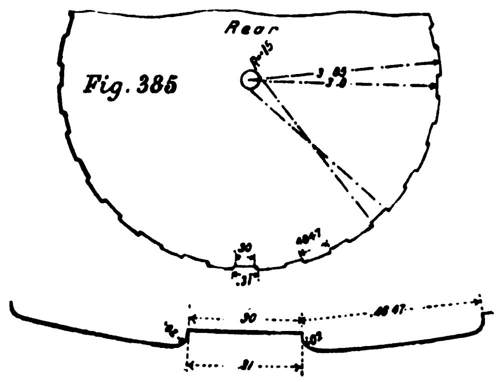


Fig. 385

RIFLING FOR 6-IN. GUNS.

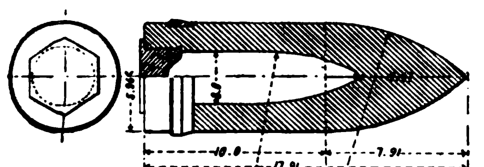


Fig. 386.

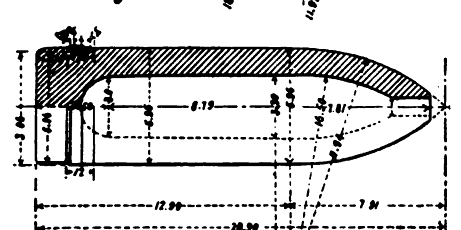


Fig. 387.

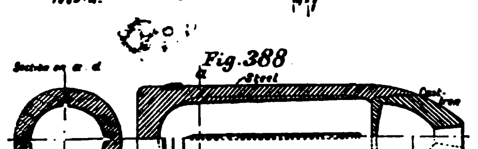


Fig. 388

PROJECTILES FOR 6-IN. GUNS.

experience with the interrupted screw system of fermeture, both in the United States and in other countries. The elevating band is shrunk on, and adds but little, and is not intended to contribute any, to the strength of the gun. The gun is rifled with 24 lands and 24 grooves, the former 0.3 in. and the latter 0.4847 in. wide at the breech end. The grooves are 0.05 in. deep, and the corners formed by arcs of circles 0.02 in. radius. The sides of the lands are slightly inclined in from the centre, and when produced cross each other and are tangent to a circle at the centre 0.15 in. in diameter in rear and 0.125 in. in diameter at the muzzle, Figs. 384 and 385. The rifling begins at the forward end of the compression slope with a twist of one turn in 180 calibres, and, in a distance of 134 in., increases to one turn in 20 calibres; thence to the muzzle, a distance of 9.85 in., the twist is uniform and one turn in 30 calibres. At the breech the grooves run into the compression slope, the lands being cut away with that slope. The reverse edges of the grooves are given a twist slightly less than that of the driving edges in order to decrease the width of the grooves by 0.05 in. from breech to muzzle end of bore. This decrease is made to allow for the wearing of the land and insuring a good hold on it

In Mark III., Figs. 378 and 379, it will be noticed that the gun and all its parts have been much lengthened, and the hooping of the chase extended to the muzzle. The length of the tube is 187.41 in., an increase of 3.41 in. The jacket is increased 2.38 in., being 75.75 in. long. The number of A and B hoops have been decreased by one, being in this design four.

The general method of construction has, however, remained unchanged.

Figs. 380 and 381 show the design of the 6-in. breechloading rifle 40-calibre gun, its total length being 253 in. It is very simple of construction, consisting merely of a tube, jacket, sleeve, and locking hoop. It gives excellent ballistic results and has sufficient strength to withstand the pressure.

SPECTROSCOPE FOR THE HALSTED OBSERVATORY.

No branch of astronomical research has made greater strides during the past few years than that of astronomical spectroscopy, and in no other branch have the appliances used been subject to greater improvement. Now that the spectroscopic work of astronomers covers so much ground and embraces such a variety of investigations, such as solar work, the measurement of the motion of stars in the line of sight, the study of the spectra of stars, comets, and nebulæ, &c., the tendency in the future will probably be towards the construction of instruments specially designed for one class of work only; but that such departmental spectroscopes, as they may be called, are not a necessity even for the carrying out of investigations of the very highest class is proved by the instrument forming the subject of the present article. This beautiful instrument, which we illustrate on pages 102 and 103, is one constructed by Mr. John A. Brashear, of Allegheny, Pa., for the use of Professor C. A. Young, at the Halsted Observatory, connected with Princeton College, where it is used in connection with the large equatorial telescope of 23 in. aperture.

This spectroscope has been designed to cover a large range of work, and it may be regarded as the most complete instrument of the kind which has as yet been constructed. In solar spectroscopy it can be used for the study of either sun-spot or chromospheric spectra, or for the examination of prominences; it can be used with high dispersion for the measurement of stellar movements in the line of sight; it is available for the study of stellar spectra; and with a low dispersion the spectra of comets or other faint objects can be examined. Moreover, both the collimator and the view telescope are each furnished with two objectives, the one corrected for the D line and the other for the H line, so that the instrument can be employed either for visual observations or for photographic purposes. The objectives, which are mounted on steel cells, are 2½ in. in diameter with 30½ in. focal length, and they have been made by Mr. Brashear to curves calculated by Professor Hastings.

The dispersion equipment of the instrument comprises, first, a set of four Rutherford prisms, each measuring 4 in. at the base by 2¼ in. high; second, a magnificent 5-in. Rowland grating ruled with 14,440 lines per inch on a speculum metal plane prepared by Mr. Brashear; and, third, a single prism of 30 deg. angle, made of flint glass, and arranged to be mounted on the table which carries the grating. This is intended for use in observing the spectra of comets or other faint objects.

The general construction of the instruments is shown by the perspective view (Fig. 1) on page 102, which represents it as arranged for use with the grating. Figs. 2 to 13, on page 103, show various details, to which we shall refer in due course. As will be seen from Figs. 2, 3, and 4, the central part of the frame of the spectroscope consists of a tube I, 4¼ in. in diameter, which is firmly attached to two castings H H[1], these castings having eyes through which the four carrying tubes G G G G extend. It is by these carrying tubes that the instrument is connected to the telescope, its position on the tubes being fixed by the clamping screws shown in Fig. 3. J J are two steel tubes which also extend through the castings H H′, their outer extremities being braced to the latter casting by the diagonal steel tubes K K. To the tubes J J is fixed the casting L, which serves to carry the rotating table C (as shown in Fig. 5), for use with the grating or single prism. Or the table D for the train of prisms can be attached to the tubes J J, as shown by Figs. 11, 12, and 13.

The collimator B carries at one end the slit A, this being mounted on a short tube which can be firmly clamped in position. The focussing of the slit to suit the objective of the great telescope is accomplished by turning the milled head *a*, the position of the slit being read upon an iron scale *p* fastened to the tube I. The collimator slides in bearings in the castings H H′. It may be noted here that the focal length of the 23-in. objective for the violet portion of the spectrum near the lines H and K, is about 3 in. longer than that for the green rays, so that provision is made for a longitudinal movement of the collimator through a range of about 4 in.; thus the slit plate can be brought into the focal plane of rays of any colour. The objective of the collimator is screwed into a tube *g*, Fig. 4, which slides in bearings on the collimator and is focussed by a screw *c* which is operated by the milled head *c′* acting through the system of rods *c″ c‴*. These rods are connected by Hooke's joints, and are arranged so that the rod *c″*, which carries a small circle, travels past a scale fixed near *c*, and thus indicates the position of the objective with reference to the slit. The rod *c″* also carries a small pinion *d*, which communicates motion to another pinion *e* carried by a short spindle *e′*, which is coupled by a rod *e″* to the screw *e‴*, which moves the tube *g′*, carrying the objective of the observing telescope. The latter is thus focussed simultaneously with the collimator. Owing to the great size of the prisms (which was not contemplated when the drawings from which Figs. 2 and 4 have been prepared were first got out), the rod *e⁗* (Fig. 10) had to be added, and the other rods altered, as shown by that figure. These jointed and sliding rods are used in all positions of the telescope.

The slit, which is a beautifully finished piece of work, is a single motion one, with a maximum opening of 1 in. by ½ in. It is provided with an auxiliary side motion to bring the large aperture central when required, and also for convenience in observing the solar prominences. End diaphragms are also provided, by means of which the length of the slit can be reduced from 1 in. to ⅛ in. A finder is carried under the slit to observe the slit and a star simultaneously, the arrangement being shown by Fig. 1. This view also shows the spark arrangement and Geissler tube-holder for furnishing a comparison spectrum, which is thrown into the slit by a comparison reflector. In connection with the slit there are also provided a set of coloured screens which can be interposed when desired, and also a "rotation prism" which enables the observer to bring any part of the sun's limb parallel with the slit without rotating the spectroscope. The view telescope is shown by the perspecsteam pipe could be repaired by lapping it with canvas and rope yarn. Subsequently the side-lever type suggested the beam engine for the early screw steamers. The pistons of the two cylinders placed on the port side worked a beam athwart the ship, the other end working a large wheel which geared into a pinion on the screw shaft. The principal types of engines are thus described. We are sorry the author, who has clearly shown his ability to deal with the subject, has not been able to devote more space to it. The great importance of the subject merited more, for only 9½ pages of letterpress are given up to this review. It is followed by a detailed description of the machinery of the Teutonic, which is certainly worthy of the attention given.

"The men who have made and conduct the Atlantic ferry" is the suggestive title of the twelfth chapter, and here are neatly written biographies of such renowned shipowners as Cunard, Burns, McIver, Collins, Inman, Guion, Ismay, Spence, and others, who will ever be remembered as among the founders of Britain's supremacy in shipping, and to whom scarcely less credit is due than to the architects of Britain's mercantile fleet—Napier, Elder, Sir William Pearce, Thomson, Harland, Kirk, and others. In giving portraits of the others named the author has omitted to present us with one of the designer and builder of the Alaska, Oregon, and the other early "Greyhounds of the Atlantic." This can only have been an oversight, as a biography is included. The portraits are really good and life-like. Indeed, the illustrations which have been prepared by process, are all very satisfactory; but the lines in some of the drawings reproduced are not so "clean" as they might have been. Amongst the illustrations there is an excellently arranged diagram which affords at a glance a splendid idea of the progress in marine construction, for not only is the growth in the size of vessels represented, but the increase in power, speed, and consequent coal consumption and the decrease in time taken to the passage. It covers a wide field.

Altogether the work is one of great merit as a well-told story of the evolution of the steamship, and particularly as a work of reference, since the tables, to which we have already referred, give all data in a concise and convenient form. Here, too, is a record of losses, which the author has wisely refrained from enlarging upon except to point out the lessons which have invariably been accepted and resulted profitably to the general public.

BOOKS RECEIVED.

Elementary Plane Trigonometry; that is, Plane Trigonometry without Imaginaries. By R. C. NIXON, M.A. Oxford: Clarendon Press. [Price 7s. 6d.]

Bulletin of the United States Fish Commission. Vol. IX., for 1889. Washington: Government Printing Office.

The History of the Band Saw. By W. SAMUEL WORSSAM. Manchester: Emmott and Co., Limited. [Price 1s. 6d.]

Das Räumliche Wirken und Wesen der Elektrizität und der Magnetismus. Von MAX MÖLLER. Hanover—Linden: Manz and Lange.

The Applications of Elliptic Functions. By ALFRED GEORGE GREENHILL. London and New York: Macmillan and Co.

THE UNION STEAMSHIP COMPANY'S WORKS, SOUTHAMPTON.

THE Union Steamship Company have recently erected new repairing shops within the precincts of the Southampton Docks, and as they represent the latest thing of the kind, and moreover have been planned by a very competent engineer with a full knowledge of the wants of the case, a description of them will be both of interest and appropriate at the present time, as the Institution of Mechanical Engineers have visited them during this week. The Company have always had repairing shops in the Docks, and there could hardly be a greater contrast than that between the old and the new. The old shops are what we are sure the Company will excuse us for calling—now they have got these beautiful brand-new works—a congeries of tumble down sheds. No doubt very good work can be done on very shabby looking premises, but the difficulties in the present case must have been very great, and the risk of fire an ever-present nightmare to the manager.

A visit to the new shops was a part of yesterday's programme, but unfortunately the works are not yet quite in going order, some of the machinery not yet being in place. The works are most symetrically contained within the boundaries of a rectangular plot of ground. There are two principal buildings, the walls of which form the boundary, and an open yard runs down the centre. Lines are laid here which connect the premises with the South-Western Railway system, and there are two turn-tables, so that wagons can be taken into the shops. The entrance to the works is through the time office, where an attendant is placed to take a visitor's card, and, if necessary, get an inkling of his business. The attendant is in telephonic communication with the manager's office, which is placed at the extreme corner of the premises. Having penetrated to the innermost recesses of the works the visitor finds a set of offices consisting of a clerk's office; Mr. Griffiths', the works manager's, office; and beyond this again the office of Mr. Du Sautoy, who, as superintendent engineer to the company, is chief of the whole department. The telephonic arrangements here are very complete, there being a public exchange connection, another connection for the works, and yet another, by means of which communication can be made with the marine superintendent of the company without fear of being overheard. In this office are two Trotter's compensating thermometers, by means of which the temperature of the cold stores belonging to the company, which are 175 ft. distant, is recorded. On the floor above these offices is the drawing offices, and above this the photographic room. The iron store is placed at the same end of the works. At the time of our visit it was chiefly occupied by charcoal, which is to supply insulation for the Trojan's cold-air chambers. The pattern shop is next, but the machinery is not yet in, though the shafting is rigged, and the foundations for a lathe bed are in place. The electricians will also be accommodated in this part.

Passing to the opposite side we enter the big machine shop. Here again the arrangements are not yet complete, but some of the tools are in place, including a radial drill and a planing machine. The big shaft lathe has yet to come. The shop is served by a 20-ton traveller, and at the end are a couple of return tube boilers to supply steam to the engines. A good deal of this is required for the refrigerating machinery. This is by Haslam, of Derby, and is of 20,000 cubic feet capacity. The cold stores by which this machinery is served are built against the external walls of the main buildings, so that they are not within the rectangle of the works proper, although the machinery is within the boundaries. In these stores are placed the fresh provisions which are required by the various ships, which latter, naturally, are not at all times ready to receive them.

Returning to within the walls we pass to what is to be the tinsmiths' shop. At present it is occupied by carpenters, the tinsmith work being still carried on at the old premises close by. The brass finishers will also be in this department, provision being made for their various machine tools. The tinning shop is adjoining. Here is the bath for dipping articles to be tinned, and a forge for shaping. The range shop for making or repairing ships' ranges is in the same department. The brass foundry comes next, where castings up to 15 cwt. have been made. The coppersmiths' shop comes next. This naturally is an important department in a marine engine repairing works, and is fitted with the necessary appliances, including a lead bath for filling pipes and an hydraulic press for bending them. There is a good airy smithy containing two steam hammers, one 12 cwt. and one of 4 cwt. There are nine smiths' fires, &c.

On the opposite side is the boiler shop with the usual machinery necessary for repair work. Here is a Root's blower which supplies blast for all the works. There is a plate furnace which will take a plate 14 ft. by 7 ft., and adjoining an annealing furnace large enough to take a boiler furnace. At the end over the time office is the general working store, where is to be seen a most extensive collection of bolts, nuts, studs, rivets, &c. It is really remarkable what a number of things of this kind have to be kept. Of course it is impossible to say what may be wanted at any time. A ship may be brought in to which any kind of mishap may have occurred, from the bursting up of her bottom to the breaking of a bolt in her engines. If parts to make good the damage had to be ordered and waited for, it might involve delay that would cost many hundreds of pounds. There is no branch of marine engineering practice more interesting than that of the repairing shops, and there is no position which requires knowledge and resource to a higher degree than to be chief of such an establishment.

The Union Company own twenty-four ships, the twin-screw vessel Scot, of 6850 tons and 12,000 indicated horse-power, heading the list. It will be remembered that the Scot was fully illustrated and described on pages 10, 38, and 87 of vol. lii.

MODERN UNITED STATES ARTILLERY.—No. XVIII.

BREECH MECHANISM FOR THE 6-IN. BREECH-LOADING RIFLE (FIGS. 389 TO 400).

THE United States Navy, like the United States Army, has adopted the interrupted screw system of breech mechanism. It was at first intended to use the cup gas-check, but before the first gun was completed this plan was abandoned and the De Bange system was adopted.

The mechanism for the Mark II. 6-in. breech-loading rifle consists of the block, cut out on the interior to receive the shank of the mushroom head. This head is held by a shank nut A, against which presses the locking-nut B and prevents it from unscrewing (Fig. 400). The shank is pierced by an axial vent. The tension on the pad is secured by means of a spring encircling the shank and pressing against the shank nut. The pad, between the mushroom head and the block, is made of asbestos and mutton suet covered with canvas and pressed into shape by means of hydraulic pressure. In the early guns this pad was held between two sets of rings made of tin, copper, or other soft metal. On testing the guns, however, it was found that these rings were liable, after firing, to stick to the walls of the gun and prevent the ready withdrawal of the breech-plug. The necessity for rings of harder metal was plainly necessary, and as a result the soft metal rings were replaced by steel ones. After thorough trial these rings were found to be perfectly satisfactory, and were adopted as standard. The pad also gave a good deal of trouble in sticking to the walls of the powder chamber, and thereby preventing the revolution of the block. To remedy this defect an important modification was made in the mechanism by omitting the spring and replacing it by the frictionless ring C (Fig. 393). This consists of two grooved cups, fitting together with a thin thimble between them and the shank of the mushroom head; the grooves inclose a number of spherical balls made of steel, thus enabling the rings to revolve independently about their axes without grinding together. By this means the block can be revolved independently of the mushroom head and pad, and the pitch of the interrupted screw is sufficient to start the pad from its seat. A lever D is used to turn the breech-block; the lever is eccentric with its pivot, so that a curved part of the lever turns into a slot in the face of the breech, and absolutely prevents the block from turning till the lever be again raised. The lower part of this lever (Fig. 399) is bent to the left to leave the vent free.

In order to prevent a premature insertion of the primer, the vent, in all except the locked position of the block, is covered by a sliding shutter. When the handle D is raised to open the block, the pinion E engages in a rack on the vent shutter (not shown), forcing it down over the vent, where it remains until the block is again closed, when the lowering of the handle locks the block, and at the same time raises the shutter free of the vent. The handle F (Fig. 399) assists in withdrawing the block.

To check the revolution of the block at the proper points there are two stops G on the breech. In the position shown, Fig. 399, the block has been revolved to the left until it was checked by the unlocking stops, and the screw threads are disengaged so that the block can be withdrawn. The locking-slot on the jacket, into which the eccentric part of the handle D drops when the block is locked, is shown at H.

To support the block when withdrawn there is a tray I, having on its upper surface two guide rails K, which fit into the guide slots L, when the block is withdrawn. A latch M hooks on to the train catch N, and holds the train against the breech of the gun. The tray is hinged to the gun at P, so when the block is run out on the tray, by releasing the catch M, the block and tray can be swung around to the right, so as to not interfere with the loading. A spring O keeps the latch pressed down over the catch. The breech mechanism for the

MODERN UNITED STATES ARTILLERY: MOUNTINGS FOR 6-IN. NAVAL GUNS.

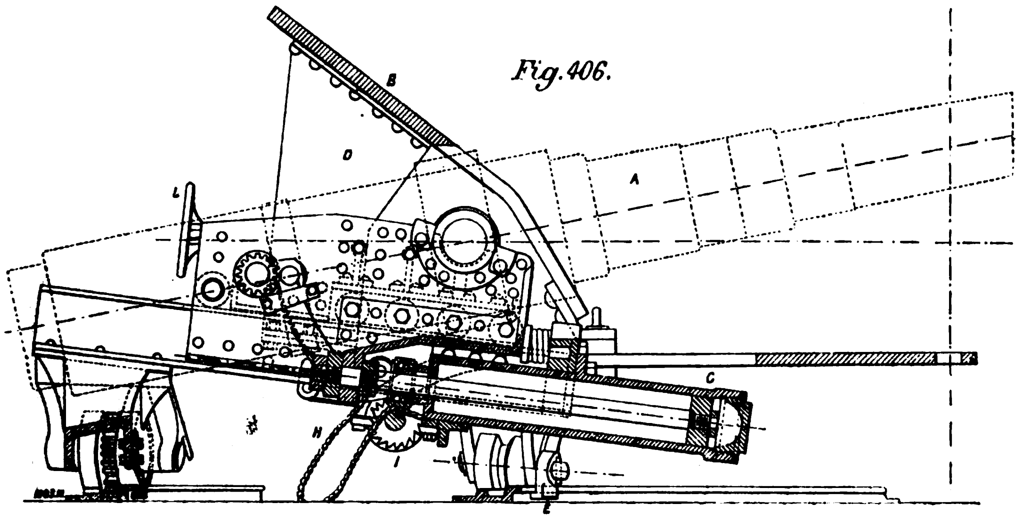


Fig. 406.

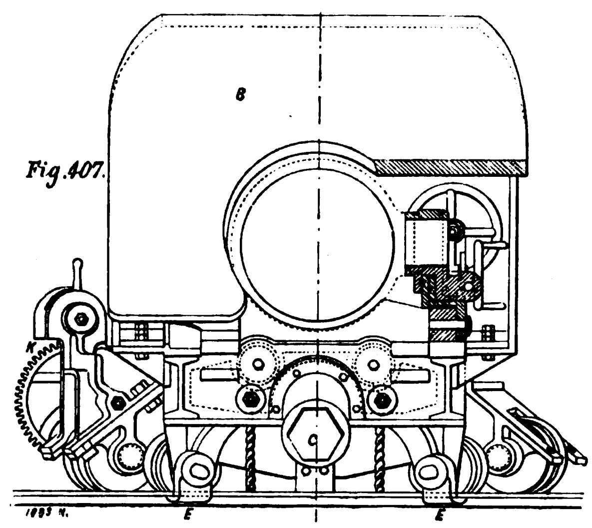


Fig. 407.

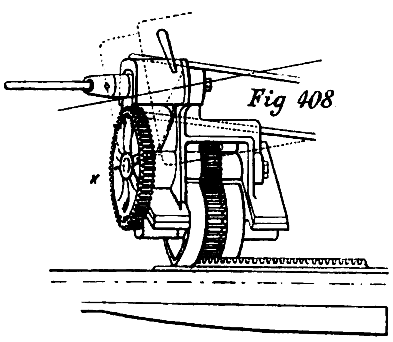


Fig. 408

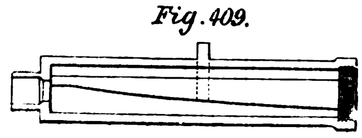


Fig. 409.

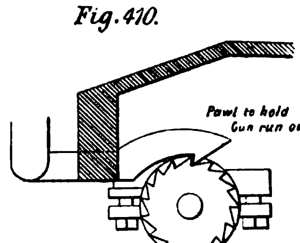


Fig. 410.

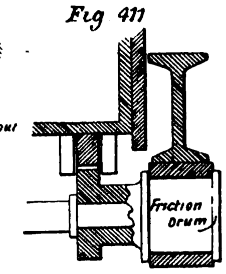


Fig. 411

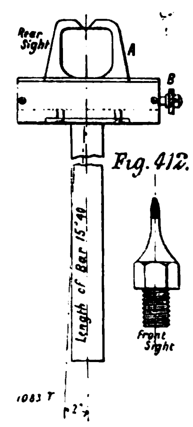


Fig. 412.

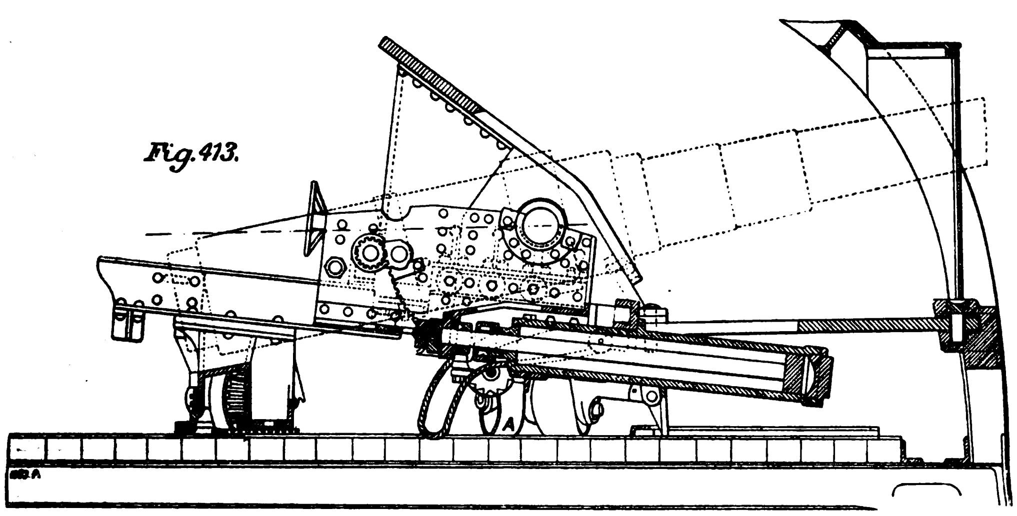


Fig. 413.

Mark III. gun differs mainly from that of the Mark II. gun in the method of locking and unlocking the breech-block. The weight of the block combined with sticking of the pad and the friction of the various parts, made at times the unlocking so difficult that it was found advisable to replace the simple lever by a rack and pinion (see Figs. 389 and 393).

The plug lever A is attached to the block, and through its upper end passes the bolt to which the pinion B is fixed. This pinion is turned by means of a crank C and handle D. Through this handle runs a bolt catch F surrounded by a spring E, by means of which is checked any tendency of the block to rotate on the discharge of the piece.

The pinion B engages in a rack I, which is bolted to the jacket of the gun, and thus furnishes the power for the rotation of the block. The rotation is checked in one direction by the locking-stop K, and in the other by the unlocking-stop L. M is a plunger held in the plug lever A by a retaining screw P, which fits in an elongated slot in the plunger, allowing a limited play. N is the plunger slope bolted to the jacket of the gun by means of the screws O (see Fig. 396). As the block is being revolved in one direction or the other the plunger rides up the slope on one side and down on the other, thus allowing the lever crank C to be locked to the plug lever A only at either end of the revolution.

When the tray, which is similar to that of the Mark II. gun, is swung around, a back latch G catches on a notch and prevents the tray from swinging back. This latch is constantly pressed upward by means of the spring R. S is the primer seat screwed into the rear end of the breech-plug.

CARRIAGES FOR 6-IN. NAVAL GUNS (FIGS. 401 TO 412).

The importance of providing the most perfect naval gun carriages is second only to the considerations relating to the guns themselves. The unsteadiness of the platform necessitates many complications not found in land gun carriages.

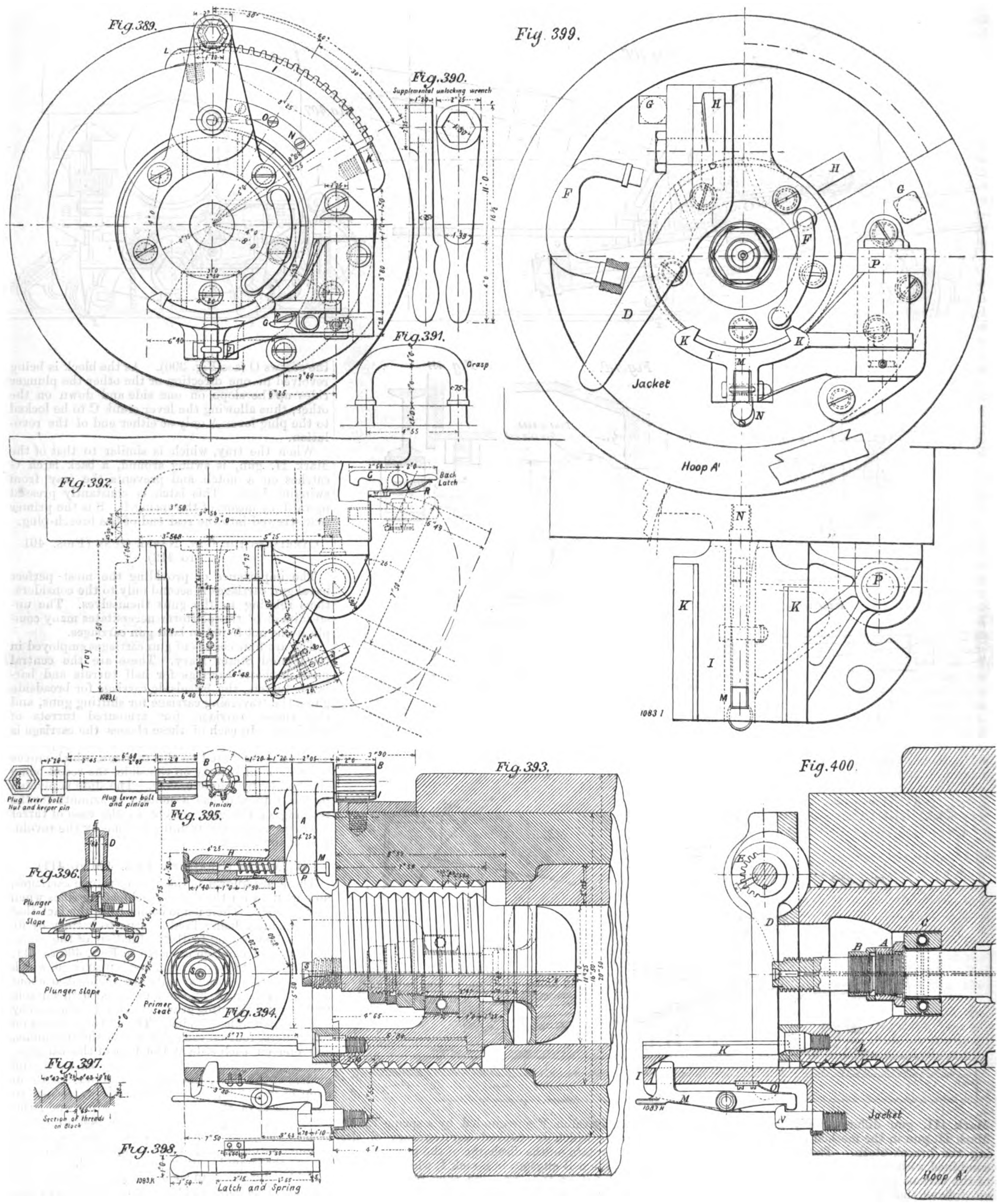
The are four classes of gun carriages employed in the United States Navy. These are the central pivot barbette carriage for half turrets and barbette turrets, the broadside carriage for broadside guns, the traversing carriage for shifting guns, and the turret carriage for armoured turrets of monitors. In each of these classes the carriage is composed of two parts, a slide and a carriage proper. The gun is mounted on the carriage, which moves in and out of battery on the slide, the recoil being checked by hydraulic brakes. The slide is pivoted to the ship and has a motion in azimuth for the training of the gun, except in the case of turret mounts, where the training is done by the revolution of the turret.

BROADSIDE CARRIAGES (FIGS. 406 TO 411).

These are known as the gravity return carriages, and are used for the 6-in. breechloading rifles when in broadside. Their name comes from the fact that the gun, after being fired returns to battery by its own weight, owing to the inclination of the slide. This style of carriage is shown in Figs. 406 to 411.

The general features are a low top carriage, which rests on a slide whose rails are inclined at about 8 deg. to the deck-line and provided with suitable training and elevating gear. The recoil is checked by a single hydraulic cylinder. The carriage moves on ten rollers, four on each side under the trunnions, and one on each side at the rear of the carriage. The recoil cylinder C is midway between the girders of the slide, and projects half its length in front of the slide. The piston-rod is attached to the transom of the carriage at its after end; the transom, at this point, bends down to allow elevation to be given to the gun. The piston fits the cylinder rather loosely, and the aperture, through which the liquid passes during recoil, is made variable, and varies in such a way as to keep the pressure constant, thus reducing the maximum strain on the carriage. To maintain a given constant pressure, grooves are cut in the cylinder, the shape of which, when developed, is shown in Fig. 409 being widest at the beginning of the recoil. The grooves are three in number. The depth of the grooves is 0.15 in. The cylinder is filled with a

MODERN UNITED STATES ARTILLERY: BREECH MECHANISM FOR 6-IN. NAVAL GUNS.



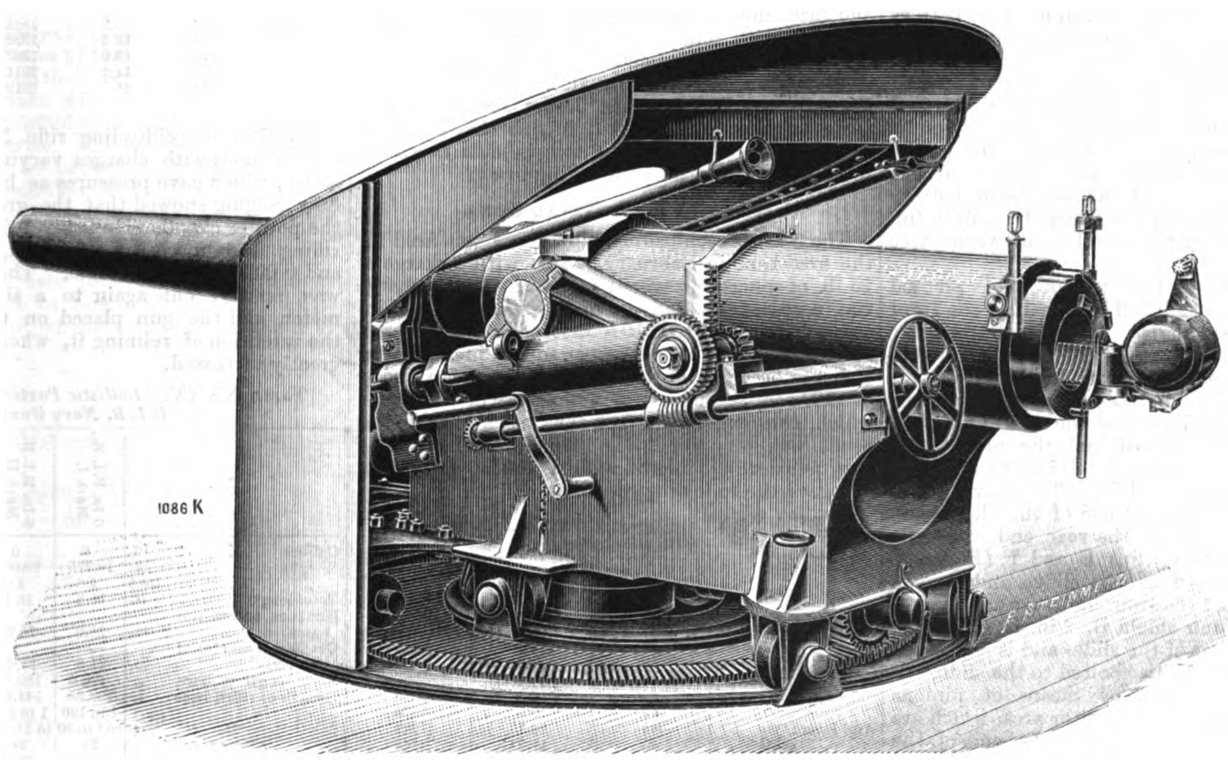
mixture containing 80 parts of glycerine to 20 parts of water.

Two steel wire breechings H, Fig. 406, are attached at either end to bolts which are placed at the rear of the carriage transom and the front transom of the slide on each side of the cylinder. These breechings are for the purpose of checking the recoil in case of accidents to the hydraulic cylinder. To ease somewhat the great strain, which in case of such accident, would be brought on the slide and carriage, powerful steel springs are placed between the bolt-heads and the transoms. Buffers at the front ends of the slide prevent shock when the piece is run in battery.

The friction drum and toothed wheel I, Figs. 406,

MODERN UNITED STATES ARTILLERY: 6-IN. NAVAL GUN AND CARRIAGE.

(*For Description, see Page 126.*)



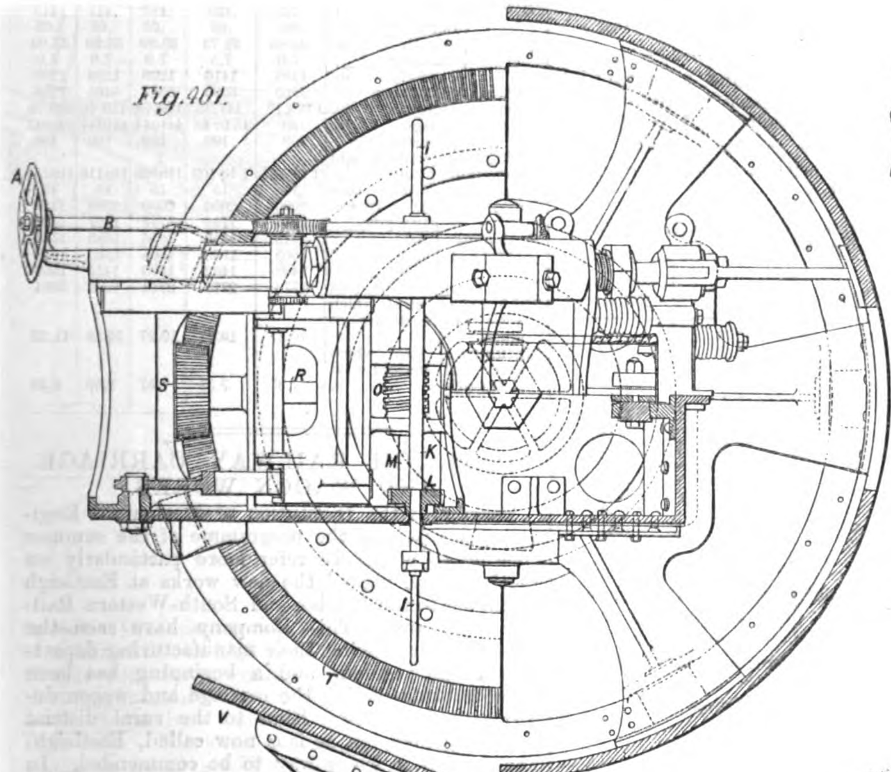


Fig. 401.

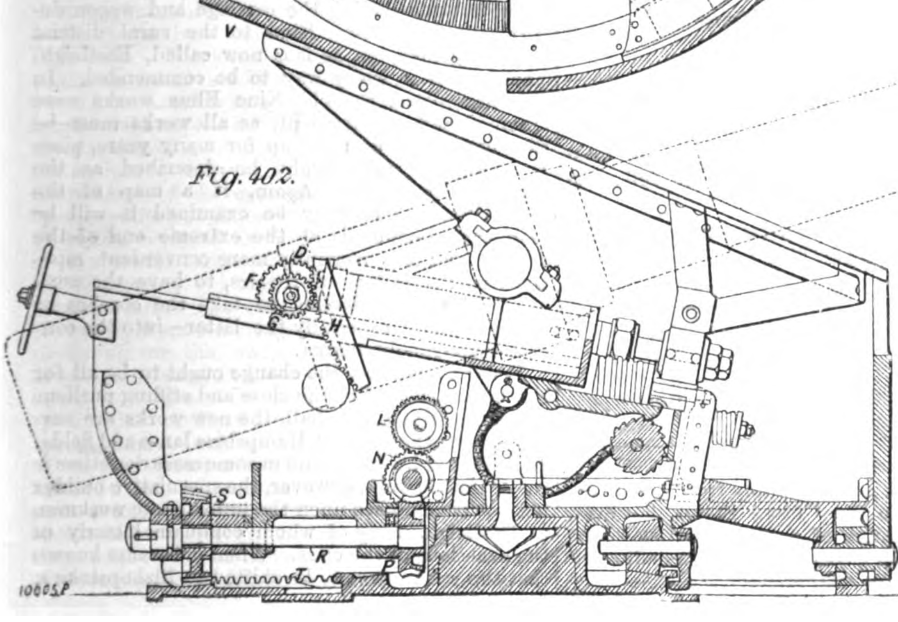


Fig. 402.

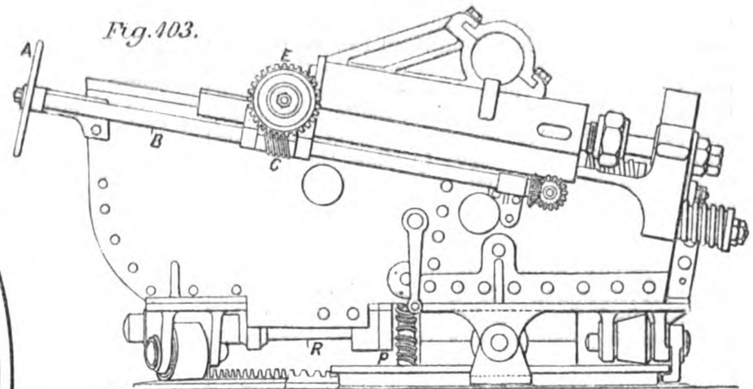


Fig. 403.

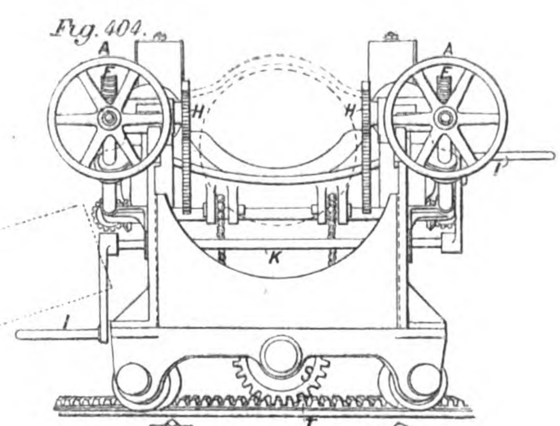


Fig. 404.

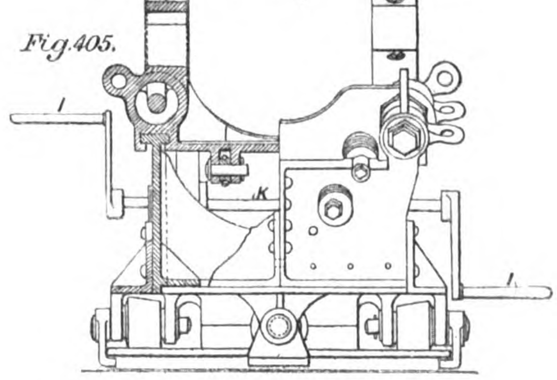


Fig. 405.

410, and 411, are for the purpose of holding the gun in battery when there is motion on the ship. Attached to the slide is an axle having at one end the toothed wheel, and the drum fitted with friction straps which are set up by means of a screw bolt against the drum. When the gun is out of battery a pawl attachment on the carriage engages the toothed wheel, and retains the gun in that position. When the gun is fired the energy of recoil is sufficient to overcome the friction on the drum, and the gun recoils until checked by the hydraulic brake, the axle turning and freeing the pawls. After the recoil is checked, the friction on the drum is sufficient to hold the gun from battery even though the ship is rolling heavily. With full charges the length of the recoil is between three and four calibres.

The slide moves on four trucks and is pivoted by a yoke to the port sill. The wheels of the front trucks have a raised flange, to fit which they are scored. The wheels of the rear truck, Fig. 408, are made up partly of plain surfaces, whose diameter is such as to support the weight, and of ratchet-wheels by means of which, and the gearing shown, the rear trucks are moved and the piece thus traversed. The gearing can be shifted to the most convenient side of the slide. To prevent the excessive jump of the front end of the slide when the piece is fired, and of the rear end when the piece is run in battery, clips E and F (Figs. 406 and 407) are attached to the slide, and project under the flanges of the front and rear clip circles. An inclined steel gun shield B, 2 in. in thickness, is bolted to the front of the slide, and is supported at the side by plates D, also bolted to the slide.

The elevation is given by means of pinions gearing into the teeth of elevator arcs, which are attached on each side to the elevating band of the gun. The axles of the pinions project outside the brackets, and by means of pinions and worm gearing the handwheels L give the elevation. The gearing connected with either handwheel can be thrown out of gear, and the elevation given by the other handwheel alone. The length of the slide is such that when the recoil is checked, the breech of the gun projects beyond the rear ends of the slide girders a sufficient distance to allow the breech-block to be swung around and the gun loaded at several degrees of elevation.

Gravity Return Carriage.

The gravity return shifting carriage for the 6-in. breechloading rifle is very similar to that just described, the main difference consisting in the front shifting trucks, with three axle pins and seats.

Central Pivot Carriage (Figs. 401 to 405 and 412).

The central pivot carriage, Figs. 401 to 405, for the 6-in. breechloading rifle, Mark III., is also similar in its main features to the carriage just described. A A are the elevator handwheels, B the elevator worm shaft, and C the elevator worm; D and E are friction discs, F the elevator wormwheel, and G the elevator pinion, H is the elevator rack attached to the gun. The training is accomplished by means of the training cranks I, whose shaft K carries the spurwheels L. M is the training wormshaft which also carries spurwheels N. O is the training worm on the same shaft gearing into the training wormwheel P on the training pinion shaft R, by means of which the motion of the cranks I is transmitted to the training pinion S, and the latter working in the combined rear truck circle, training rack, and clip circle T, gives the training to the piece. V shows the segmental shield, top, and post.

The front sight, Fig. 412, is screwed into the piece and is fixed, the elevation being given by the rear sight. On the top of the bar of the rear sight, Fig. 412, is mounted the traverser A and traversing nut B for allowing for drift and wind.

Projectiles (Figs. 386 to 388).

The projectiles used with the 6-in. breechloading rifle (see Figs. 386 to 388, page 101 *ante*), are the battering shell, common shell, and shrapnel.

Quite a number of steel shells have been experimented with, the most successful being a chrome steel one; it is 17.91 in. in length, 5.96 in. in diameter, and has an ogival head struck with a radius of slightly less than 2 calibres. The weight of the shell is 101.5 lb. The common shell is made of cast iron, and is 3.48 calibres long, with a mean thickness of walls of 0.47 calibre. It weighs 100 lb. when loaded, with a bursting charge of 7 lb. of powder. The shrapnel consists of a steel body, which holds the balls, and a cast-iron head, which holds the charge and fuze, and which screws into the body. The body is fluted with four grooves to facilitate breaking up. The expansion band is made of copper tubing or cast brass, forced on by an hydraulic press and then turned down to the proper size. The diameter of the bands is 6.12 in., as this has been found sufficient to give the compression necessary to make the band take the rifling firmer.

Tests of 6-In. Naval Guns.

The 6 in. breechloading rifle No. 1 was fired for the first time in February, 1884, with a charge of 25 lb. of sphero-hexagonal powder. As the charge was increased gradually up to 45 lb. the velocities increased from 1252 to 1910 foot-seconds, and the pressures from 6.2 to 16 8 tons per square inch. Later a charge of 45 lb. of black powder gave a velocity of 1927 foot-seconds with a pressure of 17.3 tons, which, considering the fact that black powder was used, was very good. In May another brand of this powder was tested with a 100-lb. projectile, and gave the following results:

TABLE XXXI.—*Firing Tests of 6-In. Naval Gun, with Black Powder.*

Powder.	Charge.	Pressure.	Muzzle Velocity.
	lb.	tons	foot-seconds
Duponts' sphero-hex. (56)	40	12.8	1825
	43	14.8	1892
	45	15.4	1951
	46	16.2	1970
	47	15.6	1978
And later:	44	16.1	1922
	45	17.2	1948
	46	16.4	1987
	45	21.9	1948
	48	20.9	2005

This powder was too violent, and gave too high pressures, but in the meantime cocoa powder had been developed in Europe, and the Navy Bureau of Ordnance ordered some samples, which, when fired from the 6-in. gun with a 100-lb. projectile, gave the following results:

TABLE XXXII.—*Firing Tests of 6-In. Naval Gun, with Cocoa Powder.*

Powder.	Charge.	Pressure.	Muzzle Velocity.
	lb.	tons	
Cocoa "A" Westphalian	25	5.2	1277
	30	6.9	1406
	35	8.7	1555
	38	9.4	1624
	41	10.4	1705
	43	11.1	1773
	45	11.7	1808
	47	12.2	1836
	48	12.8	1890
Cocoa "B" Rothwail	35	10.3	1666
	40	10.5	1717
	45	12.7	1841
	47	13.9	1925

The powder charge finally adopted for this gun was 50 lb. of C_{82}, which gave an average initial velocity of 1915 foot-seconds. A number of shots were then fired to range the gun with the following results:

Elevation.	Mean Range.
Deg.	Yards.
4	3714
5	4375
6	4990
7	5550
8	6057
10	7008

In February of 1885 several shots were fired with increased charges of C_{81} with the following results:

TABLE XXXIII.—*Firing Tests of 6-In. Naval Gun, with C_{82} Powder.*

Charge.	Pressure.	Muzzle Velocity.
lb.	tons	
45	9.5	1630
50	11.3	1835
52	11.9	1860
54	12.6	1906
56	12.8	1960
58	14.1	2000

As a result of these experiments the U.S.S. Atlanta received its powder supply from Germany. Messrs. Dupont, in the United States, however, as a result of a series of experimental powders, submitted one which gave the following results, the test being made in November, 1885:

TABLE XXXIV.—*Firing Tests of 6-In. Naval Gun with American Powder.*

Powder.	Charge.	Pressure.	Muzzle Velocity.	Projectile Weight in Pounds.
	lb.	tons		
Cocoa	50	12.2	1881	100
	54	13.2	1928	100
	56	13.9	1967	100
	58	14.2	2011	100
	58	15	2019	101.5

The 6-in. breechloading rifle No. 1 was fired in all 271 times with charges varying from 25 lb. to 58 lb., which gave pressures as high as 21.9 tons. Star gauging showed that the greatest increase of the powder chamber was only 0.014 in., while the rifling had increased 0.042 in. at the breech and 0.003 in. at the muzzle. The powder chamber was reamed out again to a slightly larger diameter, and the gun placed on the dolphin, with the intention of relining it, when the scoring had greatly increased.

TABLE XXXV.—*Ballistic Particulars of the 6-In. B.L.R. Navy Guns.*

—		6-In. B.L.R., Mark I.	6-In. B.L.R., Mark II.	6-In. B.L.R., Mark III., of 30 Cals.	6-In. B.L.R., Mark III., of 35 Cals.	6-In. B.L.R., Mark III., of 40 Cals.
Calibre	in.	6	6	6	6	6
Weight	lb.	10,775	10,900	10,800	11,554	13,370
"	tons	4.8	4.9	4.8	5.2	6.0
Total length	ft.	15.8	16.1	16.3	18.8	21.3
Distance across rim bases	in.	25.0	25.5	24.0	24.0	24.0
Greatest diameter of gun body	in.	21.5	21.5	20.5	20.5	21.0
Total length of bore	"	176.0	180.08	183.75	218.75	243.75
Length of rifled bore	"	136.65	144.85	147.26	177.26	207.26
Twist	in.	1 in 180 to 1 in 30	1 in 180 to 1 in 30	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25
Grooves: Number		24	24	24	24	24
Grooves: Width	in.	.485 to .435	.485 to .435	.485 to .415	.485 to .415	.485 to .415
Grooves: Depth	"	.05	.05	.05	.05	.05
Chamber: Length	in	36.85	32.73	33.99	33.99	33.99
Chamber: Diameter	"	7.0	7.5	7.0	7.0	7.0
Chamber: Capacity	c. in.	1408	1410	1299	1299	1299
Total capacity of bore	"	5360	5595	5552	6404	7256
Travel of projectile	in.	139.15	147.35	149.76	179.76	209.76
Weight of charge	lb.	50	45 to 48	44 to 47	44 to 47	44 to 47
" projectile	"	100	100	100	100	100
Ratio of projectile weight to weight of gun		1 to 108	1 to 109	1 to 108	1 to 116	1 to 134
Chamber pressure	tons	15	15	15	15	15
Muzzle velocity	ft.-sec.	2000	2000	2000	2080	2150
Remaining velocity at 1000 yds.	"	1735	1735	1735	1807	1865
Remaining velocity at 1500 "	"	1616	1616	1616	1680	1737
Remaining velocity at 2000 "	"	1505	1505	1505	1565	1618
Remaining velocity at 2500 "	"	1402	1402	1406	1458	1507
Muzzle energy	ft.-tons	2773	2773	2773	2990	3204
Thickness of steel which shell will perforate at muzzle	in.	10.27	10.27	10.27	10.86	11.38
Thickness of steel which shell will perforate at 1500 yards	in.	7.57	7.57	7.57	8.00	8.39

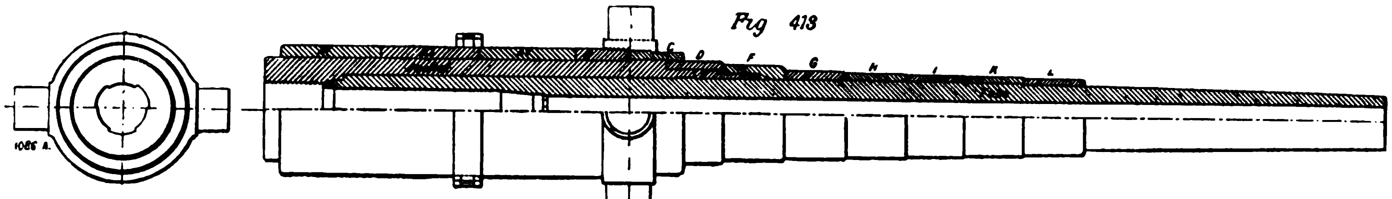
EASTLEIGH RAILWAY CARRIAGE AND WAGON WORKS.

Yesterday the Institution of Mechanical Engineers, as a part of the programme of the summer meeting to which we refer more particularly on another page, visited the new works at Eastleigh belonging to the London and South-Western Railway Company. This Company have seen the wisdom of removing their manufacturing department from London, and a beginning has been made by transferring the carriage and wagon department from Nine Elms to the rural district of Bishopstoke, or, as it is now called, Eastleigh. The move is in every way to be commended. In the first place, the old Nine Elms works were cramped and inconvenient, as all works must be that have been growing up for many years, piece by piece, on what might be described as the accretion principle. Again, if a map of the South-Western Railway be examined it will be seen that London is at the extreme end of the system, and it is naturally more convenient, especially in the matter of repairs, to have the work executed without having to take the coaches or wagons—more especially the latter—into the congested metropolitan area.

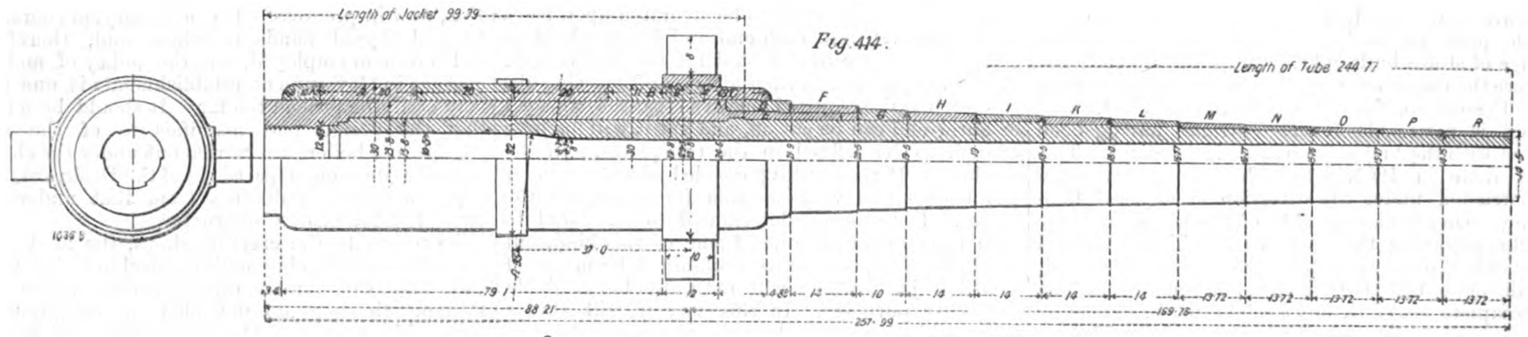
For the men, too, the change ought to be all for the best. Instead of the close and stifling purlieus of Lambeth and Vauxhall, the new works are surrounded by the pleasant Hampshire lanes and fields. Rent should be lower, and in some cases doubtless is so. Unfortunately, however, the speculative builder has got his clutches upon the unfortunate workmen at Eastleigh, many of whom complain bitterly of the exactions of the class. When it became known that the works were to be shifted to Bishopstoke a

MODERN UNITED STATES ARTILLERY: 8-IN. NAVAL GUNS

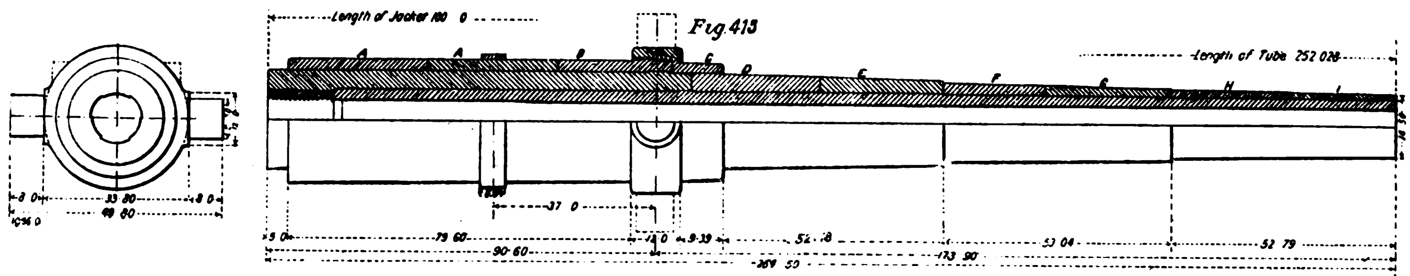
(*For Description, see Page 162.*)



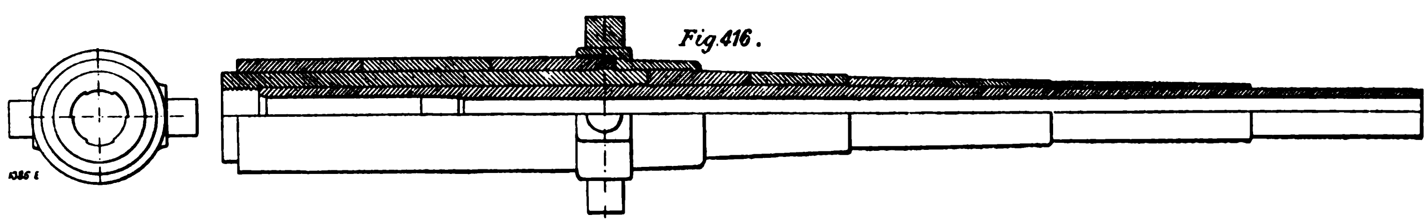
8-IN. BREECHLOADING NAVAL GUN; MARK I.



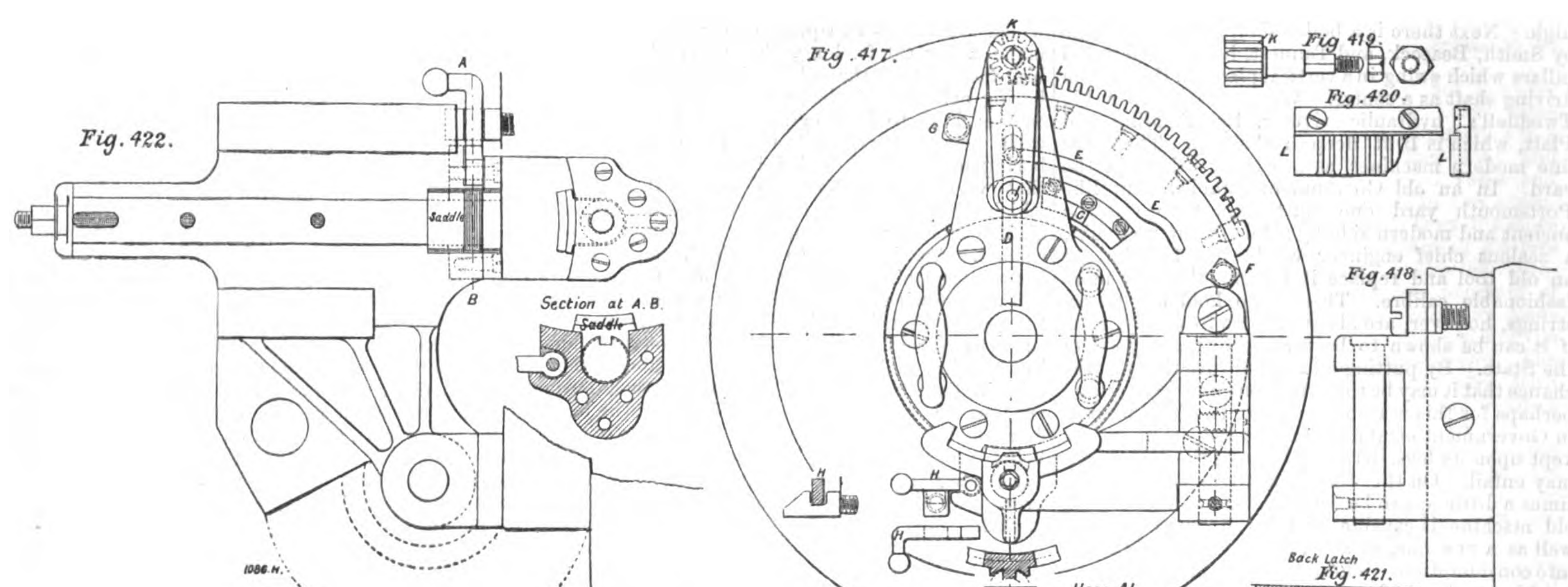
8-IN. BREECHLOADING NAVAL GUN; MARK II.



8-IN. BREECHLOADING NAVAL GUN; MARK III., 1888.



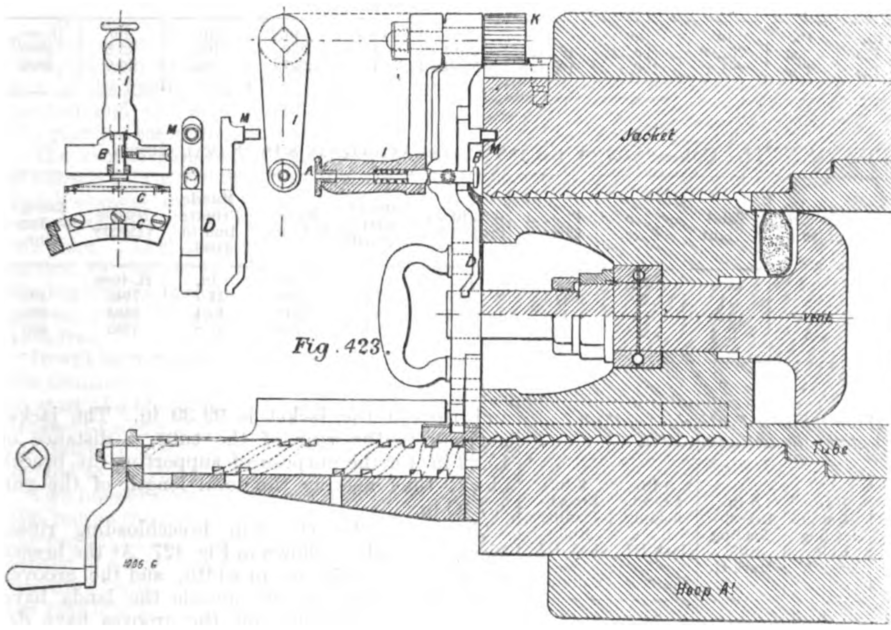
8-IN. BREECHLOADING NAVAL GUN; MARK III., 1889.



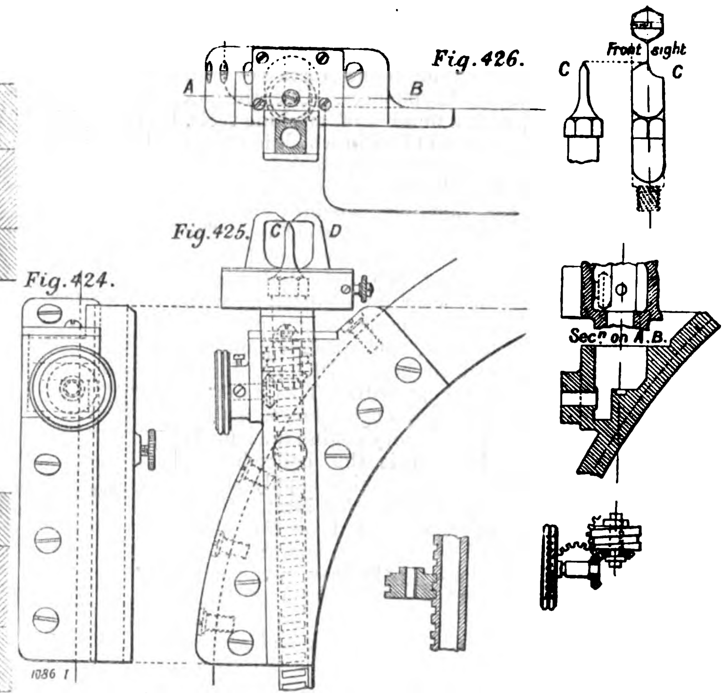
DETAILS OF BREECH MECHANISM FOR 8-IN. BREECHLOADING NAVAL GUN.

MODERN UNITED STATES ARTILLERY; 8-IN. NAVAL GUNS.

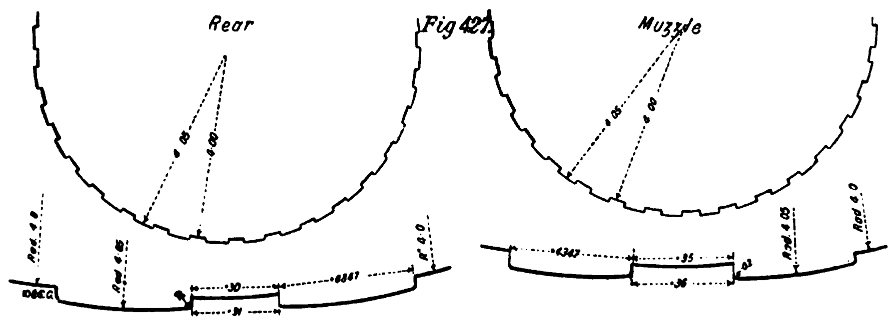
(*For Description, see Page* 162.)



BREECH MECHANISM FOR 8-IN. NAVAL GUNS.



SIGHT FOR 8-IN. NAVAL GUNS.



RIFLING OF 8-IN. NAVAL GUNS.

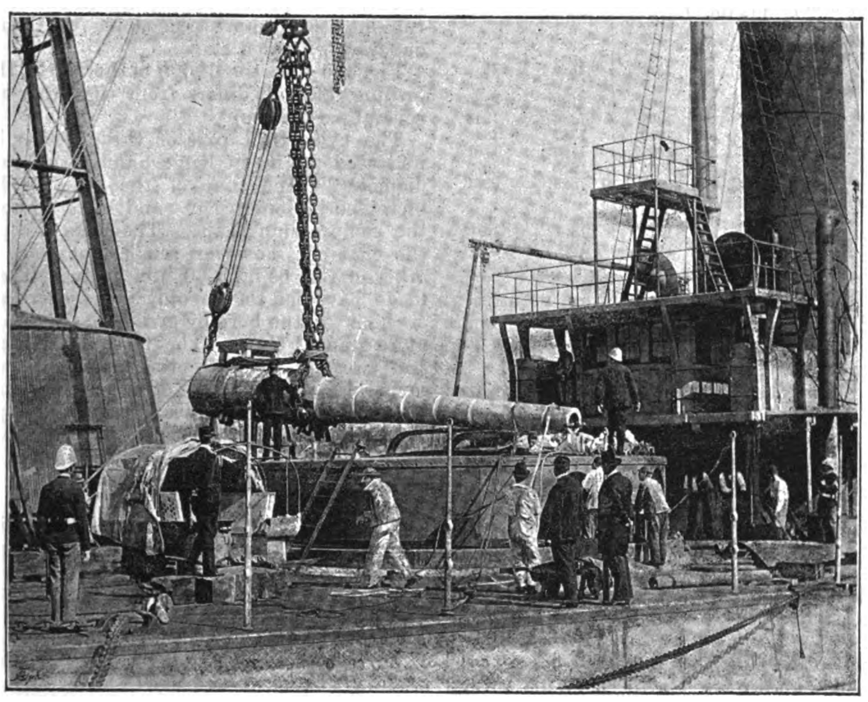


Fig. 428. 8-in. gun for the U.S. cruiser "Atalanta."

down about a thirty-second of an inch, and an annular space is thus left between the ferrule and the tube for that distance. This form of ferrule will unquestionably afford a shield to the tube end and recent experiments have all gone to prove its efficiency in this respect. The point to determine is how long the ferrules—which are made of malleable cast iron—will last. To partially test this point the Thunderer has recently made a full-power run to Madeira and back, and we understand with most promising results. As we stated, however, in our previous article the ferrule is a very good remedy for a defective boilers but the fact nevertheless remains that such defect, should not be inherent in the design of the boiler. If, however, the new ferrules enable many existing boilers, which would otherwise be condemned, to be retained in their vessels, they will do an enormous service and save a vast outlay. Whilst speaking on this subject we may state that an opinion seems to be gaining ground that Mr. Yarrow was not far out in his idea as to the effect of thickness of tubeplate influencing this question, as expressed by him in his paper read last year before the Institution of Naval Architects. It may also be said that American naval opinion—and the Americans have been fairly successful in their boilers—tends in the same direction.

Among other tools in the department with which we are now dealing are screwing machines, capstan lathes, milling machines, &c. Here also is the gauge-testing department and a section devoted to the manufacture of donkey pumps, ships' telegraphs, small centrifugal pumps, and like appliances; so it will be seen that while Portsmouth Dockyard can deal with the big it does not despise the little.

We now pass to another building where the engineering operations, which are under the direction of the Construction Department, are carried on. In the armour-plate shop there are some heavy machine tools. First we notice a radial drill by Buckton and Co. that will work over a radius of 10 ft. Further on is another radial drill of modern construction, the spindle of which has an angular adjustment in a vertical plane. There are several other drilling machines of fair size and a big double table planing machine which will take 14 ft. between uprights and will make a cut 22 ft. long. This is not a modern tool. Next is a shaping machine of 21 in. stroke, after that a treble-geared screw-cutting lathe with 26 ft. bed. There is another large planing machine which was engaged planing a bar for an ammunition hoist which was 26 ft. long from end to end, and which will take 8 ft. by 8 ft. under the bridge. There is also here a 2000-ton hydraulic press for bending plates. This bears date 1863, and works at a pressure of over 3 tons to the square inch. At the end of the shop is a big slotting machine of 24-in. stroke. Altogether in this shop there are several large machine tools, but nothing very striking on the score of novelty.

The angle iron smithy is in another building where there are the usual appliances. From here we pass to what was formerly No. 4 slip, but which has been turned into No. 3 shipbuilding shop, the old roof forming a lofty and spacious cover. Here are many machine tools driven by an engine of 60 horse-power. One of the latest appliances is a countersinking machine, having a horizontal swinging arm like a radial drill, which will cover any part of a plate 20 ft. long without shifting the work. The countersink is brought down to the work by a lever, and is carried back by a spiral spring encircling the spindle. This arrangement gives a quick action, and is found to much expedite the work. Opposite this building is the North saw mill, where there are the usual appliances. Over this is a large fitting shop, with a number of machine tools.

We next pass to the building in which is placed what is known as the factory engine, which drives the machinery in the West Factory already described. There are, however, auxiliary engines in each department, to be used in case of accident. The factory engine is of the vertical compound type, jet condensing, and is of 350 indicated horse-power. There is also gear for connecting with pumps, so that they can be used for pumping out docks in case of necessity, and also for pumping into the fire tank, which holds 770 tons of salt water, and is always kept full. This tank is situated on the top of the fire-engine house, not far from Anchor-lane. The factory engine was made in the dockyard. Beyond is the boiler-house, with two return-tube boilers, which supply steam for the steam hammers and fans for blast. Close by is the No. 1 smithy, marked J on the plan, where are a number of smiths' fires, and the usual appliances. This smithy, by the way, was partly built of materials from the Exhibition of 1851. Beyond is the forge where there are several steam hammers, the largest 7½ tons, and served by two 40-ton cranes by the Hydraulic Engineering Company, of Chester.

The foundries are situated on the south of the steam basin where also are the coppersmiths' shops. In the brass foundry is a 10-ton air furnace and another of 2 tons capacity. Rudder frames, stems, stern frames, shaft brackets, &c., are here cast from the Admiralty standard mixture, consisting of 83 parts of copper, 7 parts of phosphide of copper, and 10 parts of tin. The output here may be roughly stated at 40 tons per month. The heaviest brass castings, however, are made in the iron foundry, which is the next building. In this latter department there are hydraulic pumps, power driven, for working lifts, &c. There are three cupolas, and air furnace for brass. Brass castings up to 30 to 40 tons have been made here. The naval people are very fond of brass castings. The pattern shop is above and has the usual wood-working machinery.

The machinery used for compressing air for power purposes was described in Mr. Corner's paper, read at the meeting, and which we shall publish *in extenso*, and there is therefore no occasion for further reference to be made to it here, although the whole system is one of the most interesting features of the dockyard. We pass on to the gun-mountings store, where the mountings for quick-firing and machine guns are kept and repaired. Here are some machine tools, such as milling machines, lathes, &c. In No. 1 shipbuilding machine shop, on the east side of the steam basin, are some of the heavier machine tools used for constructive work. A heavy punching and shearing machine is being erected which will punch a hole 2 in. in diameter through a 2-in. plate. This is by Craig and Donald. The heaviest tool of the kind, now in place, will punch a 1½-in. hole in a 1½-in. plate, and is by Hulse and Co. The largest edge-planer will take a cut 30 ft. long. There is a Muir's oval hole-cutting machine, which will cut ovals from 18 in. to 4 ft. 6 in. in length. An angle bar-cutting machine, with punch and shears, by Embleton and Co., is also in course of erection.

In the above notice we have given some details of the manufacturing part of the dockyard regarded from an engineering point of view. Our description is necessarily partial and incomplete. To describe Portsmouth Dockyard adequately would require far more space than we have at our command. The papers by Messrs. White, Corner, and Deadman treat of other features in the dockyard, the visit to which afforded the chief object of interest in the 1892 summer meeting of the Institution of Mechanical Engineers.

MODERN UNITED STATES ARTILLERY.—No. XIX.

United States Naval Guns (Figs. 413 to 428).

Eight-Inch Breechloading Rifle.—The first 8-in. breechloading rifle for the United States Navy was begun in September, 1883, and completed in March, 1886, thus being twenty-nine months in process of manufacture. Of the 8-in. rifles there are probably more designed than of any other gun in the United States service.

In the original design (Fig. 413) the gun consisted of a tube, jacket, three A hoops, one B, C, and trunnion hoops, and chase hoops out to include I. During the construction, however, the progressive powder was being developed and it was found that with this powder the chase would not be sufficiently strong to endure the strain with a sufficient margin of safety, and consequently two hoops, K and L, were added. In the next construction of guns of the same mark the hoops were carried to the muzzle, which necessitated the moving of the trunnions to the front.

The guns on the United States ship Chicago were of the design known as Mark II. This design (Fig. 414) differed from the Mark I. design last described only in the arrangement of the hoops. The F hoop in the Mark I. design comes down on the tube at its front end. In Mark II. design the G hoop abuts against the E hoop, and the F hoop has been straightened out and covers this joint. The trunnion band and all of the hoops in rear of it have been moved forward, and as a space was thus left at the breech end, it was finished by adding the narrow hoop X.

In this gun the length of the tube is 244.77 in. and that of the jacket is 99.39 in. The jacket projects to the rear of the tube, a distance of 13.22 in. for the purpose of supporting the breech block, thus making the total length of the gun 257.99 in.

The rifling for the 8-in breechloading rifles, Mark I. and II., is shown in Fig. 427. At the breech the lands are 0.30 in. in width, and the grooves 0.4847 in., while at the muzzle the lands have increased to 0.35 in. and the grooves have decreased to 0.4347 in. This, as explained for the 6 in. breechloading rifle, is for the purpose of allowing for the wearing of the rotating land as it passes through the bore. Unless the grooves were decreased in width the gases would escape past the band and erode the bore. This decrease is accomplished by giving to the reverse edge of the grooves a twist slightly less than that of the driving edge and by this means the decrease of 0.05 in. from the breech to the muzzle end of the bore is accomplished.

There are 32 lands and 32 grooves. The rifling begins at the forward end of the compression slope with a twist of one turn in 180 calibres, and in a distance of 181 in. increases to one turn in 30 calibres, thence to the muzzle, a distance 13.16 in.; the twist is uniform, one turn in 30 calibres. This is for the purpose of steadying the projectile before it leaves the piece. At the breech end the grooves run into the compression slope, the bands being cut away with that slope.

Fig. 415 gives the design of the Mark III. breechloading rifle. It differs from the other marks in several particulars.

The cylindrical part of the chamber has been increased 2.6 in. in length, and decreased 1 in. in diameter. The cone of the chamber has been increased in length 1 in., and made uniform up to the compression shape. The cubical contents of the chamber, however, remain the same as in the other marks, being 3600 cubic inches. The changes made have had for an object the decrease of the erosions of the bore by giving to the cone a much more gradual slope. The travel of the projectile and capacity of the bore remain practically the same, also, as that of the other marks, being for the latter, 13,544 cubic inches, giving 3771 expansions. The length of the hoops has been increased, and consequently their number has been decreased. The A hoops have been decreased from three to two, and the chase hoops from thirteen to six.

The total length of the gun has been increased 6.51 in., while the exterior diameter of the cylinder has been decreased 1.25 in.

A general comparison of the two marks is given in Table XXXVI.

In the design of 1889 the length of the gun was again increased, and made 35 calibres, thereby increasing the muzzle velocity to about 2100 ft. The chase hoops in this design, Fig. 416, are not increased in length, so that the muzzle end of the chase is not hooped.

In a still later design the length has again been increased to 40 calibres with a gain of another 100 ft. in velocity.

The breech mechanism is shown in the illustrations on pages 160 and 161, and from its similarity to the breech mechanism of the 6-in. gun previously described will readily be understood. The block is shown (Fig. 417) in its unlocked position,

TABLE XXXVI.—Particulars of 8-In. United States Naval Guns.

Mark.	Weight.	Powder Charge.	Projectile.	Lengths.					Diameters.			Initial Velocity.
				Over all.	Jacket.	Rifling.	Chamber.	Compression Slope.	Exterior over Chamber.	Interior of Chamber.	Tube under Jacket.	
	lb.	lb.	lb.	in.	in.	in.	in.	in.	in.	in.	in.	ft.-sec.
II.	28,077	125	250	257.99	99.39	194.16	49.61	1	30.0	10.5	15.8	2000
III.	25,720	125	250	264.5	100.0	195.795	53.21	1	28.75	9.5	15.0	2000

TABLE XXXVII.—Comparison of United States and Other 8-In. Naval Guns.

Nation.	Calibre of Gun.	Total Weight.	Length of Bore.	Powder Charge.	Weight of Projectile.	Ratio of Powder to Projectile.	Muzzle Velocity.	Muzzle Penetration in Steel.	Muzzle Velocity.	Energy per Ton of Gun.
	in.	tons	calibre	lb.	lb.		ft.-sec.	in.	ft.-tons	
England	8	14	30	118	210	1.78	2200	14.7	7048	503
Germany	8.24	13	32	103.6	308.6	2.98	1738	13.4	6464	497
United States	8	13.1	35	110	250	2.22	2129	15.8	7855	600

Table XXXVIII.—*Ballistic Particulars of the 8-In. United States Breechloading Rifle.*

—	8-In. Breechloading Rifle, Mark I.	8-In. Breechloading Rifle, Mark II.	8-In. Breechloading Rifle, Mark III., 35 Calibres.	8-In. Breechloading Rifle, Mark III., 40 Calibres.
Calibre .. .. in.	8	8	8	8
Weight .. .. lb.	27,600 / 28,800	291,100	29,400	34,000
„ .. .. tons	12.3 / 12.9	13.	13.1	15.2
Total length .. ft	21.5	21.5	25.4	28.7
Distance across rim bases .. .. in.	33.8	33.8	33.8	33.8
Greatest diameter of gun body .. in.	30.0	30.0	28.75	28.75
Total length of bore .. .. in.	239.91	239.91	290 52	330.52
Length of rifling „	195.16	195.16	242.77	282.77
Twist „ in.	1 in 180 to 1 in 30	1 in 180 to 1 in 30	0 to 1 in 25	0 to 2 in 25
Grooves — Number ..	32	32	32	32
Grooves — Width in.	.485 to .435	.485 to .435	.485 to .415	.485 to .415
Grooves — Depth „	.05	.05	.05	.05
Chamber — Length „	42.05	42.05	45.05	45.05
Chamber — Diameter „	10.5	10.5	9.5	9.5
Chamber — Capacity cu. in.	3,569	3,569	3,176	3,176
Capacity of bore „	13,541	13,541	15,548	17,564
Travel of Projectile in.	197.86	197.86	245.47	285.45
Weight of charge lb.	105 to 115	105 to 115	105 to 115	105 to 115
„ projectile „	250	250	250	250
Ratio of weight of projectile to weight of gun	1 to 110 / 1 „ 115	1 to 116	1 to 118	1 to 136
Chamber pressure tons	15	15	15	15
Muzzle Velocity ft.-sec.	2000	2000	2129	2150
Remaining velocity at 1000 yd. „	1808	1808	1850	1943
Remaining velocity at 1500 „ „	1719	1719	1787	1848
Remaining velocity at 2000 „ „	1634	1634	1700	1757
Remaining velocity at 2500 „ „	1554	1554	1615	1670
Muzzle energy ft.-tns	6932	6932	7855	8011
Thickness of steel which shell will perforate at muzzle	14.51	14.51	15.8	16.10
Same at 1500 yards ..	11.69	11.69	12.4	12.97

being checked in this position by the stop G. To lock the block the handle I is revolved in the direction of the hands of a watch. The pinion I, engaging in the rack L, causes the block to revolve to the right until checked by the locking stop, F. In order to revolve the handle I, the bolt A must first be withdrawn. One revolution of the handle brings it again into its locking position, but in the meantime the plunger B has ridden up the plunger slope C, and prevents the bolt A from dropping into its locking recess. A second revolution of the handle brings it again into its locking position and the bolt drops into its recess, since the plunger has ridden down the slope C.

The vent is closed in all but its locked position by the shade D. On the upper end is a lug M, Fig. 423, which engages in a groove E, which at all points except its lower end is concentric with the axis of the piece. As the block is being locked there is no motion to the shade which covers the vent until the lug arrives at the non-concentric portion of the groove, when the shade is withdrawn leaving the vent free.

It will be noticed that the pitch of the screw on the translating roller is at first small, to give power to start the block from its seat, and afterwards increases to give speed. When the block is withdrawn the latch H is raised and the block and tray swung around to the right.

Two lines of sight have been provided, Figs. 424 to 426, one on the left side for long ranges, and one over the central line for close quarters. The side sights consist of a finger point C on the left side of the trunnion band, and a bar D working in a box on the rear face of the last hoop, Fig. 426. This bar is raised and lowered by means of a worm, so that it requires no clamp screw to fix it at the height given. The drift is compensated for by giving to the screw bar a set at a permanent angle of 45 minutes to the left of the vertical (Fig. 425), and in addition to the incline it is set bodily to the left 0.17 in. By this arrangement a very accurate line of sight is secured. On the top of the bar is an open sight notch, so that the target can be seen above and below the line of sight. There is also a sliding leaf, which is graduated in degrees of a horizontal angle, simply for convenience, as it has no reference to the adjustment of drift or any other permanent inaccuracies of sighting, but is simply for making corrections for the wind, speed of ship, or speed of the enemy, and is to be set experimentally.

The central line of sight is available only for ranges up to 4000 yards. The rear sight of this line has two short bars, one marked up to 2000 yards and the other from 2000 yards to 4000 yards. There is but one sighting head, which is attached to the bar in use. The sliding leaf of the rear side sight is omitted from the rear central sight.

The first trial of the first 8-in. gun was made at Annapolis, Mich., on July 31, 1886.

A comparison of the 8-in. gun with English and German guns of nearly the same calibres is given in Table XXXVII. (data of 1890).

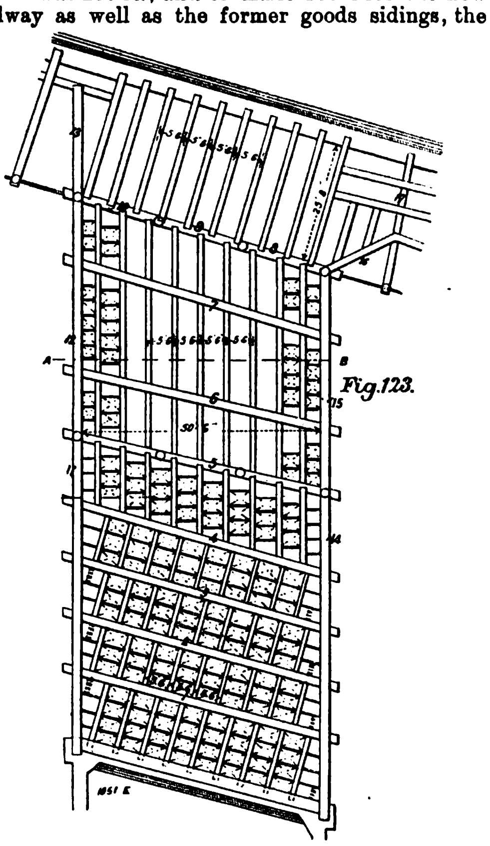
GLASGOW CENTRAL RAILWAY.

(*Continued from page* 105.)

THERE are a large number of interesting bridges on the railway, notwithstanding that it is essentially an underground line. These may be taken in their order from the eastern end of the line to its double termini in the west. Where the new railway branches off the old line a bridge has had to be altered to suit the new line. This bridge formerly carried Strathclyde-street over the old goods and mineral depôt there. The length between abutments was 100 ft., and to make room for the new railway as well as the former goods sidings, the length had to be increased to 145 ft. The enlargement was made by taking away one of the old abutments, constructing a new pier 20 ft. high by 3 ft. in its place, and building a new span with new abutments (Fig. 117). The abutments and pier are of masonry with steel superstructures, the girders being of the plate type. The details are shown on Fig. 117. There are nine girders, the span for both siding and main line being 27 ft. Over the girders are buckled plates as shown by Fig. 119, while the making up of the roadway and kerb are illustrated by the cross-section (Fig. 118).

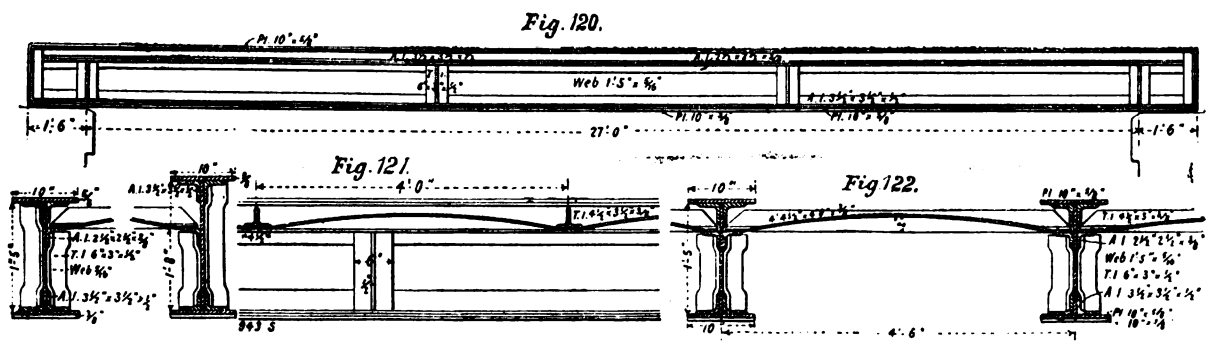
There are three road bridges to carry thoroughfares over the open cutting in which the Green Station is laid out; but these have been dealt with in connection with the station. They really form part of the covering over the station, the girders being nearly all alike.

The railway passes under Stobcross-street for its whole length; but at the western end it was desirable to have several branches leading off into the Queen's Dock Mineral Depôt, and instead of continuing the line in tunnel under the street it was decided to carry the street on a bridge with cross-girders resting on the one side, that to the north on abutment walls, and on the other, the south side, on a series of columns, between which it would then be possible to carry the branch lines into the depôt. From the point where the line leaves tunnel or underground work until it enters tunnel again the distance is about a quarter of a mile. The bridge may therefore be said to be a quarter of a mile long. It varies in width owing to the sidings branching off for the depôt. The abutment walls on the north side are 6 ft. thick while the columns to the south side are built up of Lindsay's troughing and bolted to ⊥ irons to fit into the troughing, the whole being fixed by lewis bolts 12 in. long to granolithic blocks 4 ft. thick and 5 ft. 6 in. square, according to the loads to be carried. The construction does not differ materially from the covered way roofed in with main girders and jack arching, which we have already described at length in connection with the Trongate and Argyll-street works. In this case, however, one side is entirely carried on columns, as shown in Figs. 131 to 134. The general arrangement is clearly indicated, so that there is no need to enter into details. The granolithic blocks are made of two parts of broken granite to one of cement, and instead of building the bolts into the blocks as they are being made, wooden boxes of thin boarding are hung and the concrete filled all round. After it has set the box is broken out and the lewis bolts are set into the spaces and thoroughly grouted up. Part of the bridge is made up of main web-plate girders (Fig. 131), the longest span being 45 ft. with cross-girders resting on the top flange of the main girders, and the space between the cross-girders refilled with jack arching, the whole being covered with concrete and the street restored.



PLAN OF FINNIESTON AND STOBCROSS-STREET BRIDGE.

Finnieston-street crosses Stobcross-street, at an angle of about 75 deg., and owing to the branching off of the lines, part of Finnieston-street also has had to be carried on girders. The bridges at right angles involved some interesting details. A plan of the structure (Fig. 123) will help to an appreciation of the position; the wider part carries Finnieston-street. The bridge is 140 ft. long by 52 ft. wide between centres. It is supported on abutments at each end, and the main girders are carried on intermediate columns as shown on plan. The longest span is 65 ft. The main or longitudinal girders are of the web type 8 ft. deep, the details of construction of one of the principal of the girders (14) being shown on Figs. 127 and 128. The detail of the junction of the main girder (15) with the girders for carrying the bridge at right angles, as shown in plan on Fig. 123, is interesting, and is shown in detail by Fig. 130. Between the main girders are eight cross-girders (Fig. 129). To retain the level of the street as much as possible, and not encroach on the head room under the bridge, which was limited, these iron girders, as shown on Fig. 124, do not rest altogether on the bottom flange but are partly hung, the details of the connection being shown on Figs. 129. Between the cross-girders there are smaller girders again running parallel to the main structure. These are carried on gussets resting on the cross-girders (Figs. 125 and 126). The gussets are built up of ½ in. plates. The bridge is to be covered partly with jack arching and partly with buckle plates according to the head room available (Figs. 124 to 126). The columns carrying the girders of the bridge are illustrated by Figs. 135 to 140. They are built up of channel irons.



DETAILS OF ELDON-STREET BRIDGE.

The part of the bridge to the west of Finnieston-street crossing is pretty much of the same design as the eastern part which we have already described (Figs. 131 to 134). The station widens out to about 52 ft. to accommodate Stobcross Station, which also we have illustrated and described (page 104 *ante*). Under this bridge branch off the lines to the Queen's Dock Depôt.

Beyond Stobcross Station a railway is about to be constructed of twelve miles in length, passing directly west through Partick and Clydebank to Dumbarton. The engineers for this scheme, also, are Messrs. Forman and McCall; but the state of the works do not admit of detailed description at present.

PARTICULARS OF WEAR OF LONDON CARRIAGE-WAY PAVEMENTS.

Vestry.	Street wherein is the Heaviest Traffic.	Number of Vehicles Passing through Street	Length of Time Elapsing from Laying New Pavement of Yellow Deals to First Signs of Wear.	Length of Time from First Signs of Wear until Pavement is Worn Out.	Cost Covering Concrete already Laid with Yellow Deal Blocks per Superficial Yard.	Cost Covering Concrete already Laid with Australian Hard Wood per Superficial Yard.	Average Depth to which Pavements Wear before Renewal.
Chelsea	King's-road, near Sloane-square	3600 in 24 hours	4 years	5 to 6 years	About 5s. 3d. for 5-in. plain blocks	..	6-in. deals wear to average of 3 in.; have been found to wear down to 1½ in. in places.
Hammersmith..	Broadway (now laid with Australian "jarrah")	10,000 in 24 hours	About 2 years (in the case of yellow deals)	About 6 years	About 6s. for 6-in. blocks	About 11s. for 5 in. blocks	6-in. deals wear away some 3 in. to 4 in. in about six years.
St. James's, Westminster	Piccadilly, near Regent's Circus	13,269 from 8 a.m. to 8 p.m.,§ 1938 from midnight to 8 a.m.	..	..	..	..	6-in. deals wear to average depth of 2½ in. before being renewed, but have found to be worn as thin as 1 in. in places.
St. Marylebone	Oxford-street	14,459* 11,890† from 9 a.m. to 10 p.m.	About 2 years	About 3 years	About 6s. for 6-in. blocks with boiling tar poured over surface	..	6 in. deals wear down to average depth of 3 in., though in many places found to be worn down to 1½ in. in thickness.
St. Mary Abbott's, Kensington	High-street and Brompton-road	One omnibus every three-quarters of a minute from about 8 a.m. to 8 p.m.	2½ years	6 to 6½	7s. 9d. for 5-in. creosoted deals	10s. for 4-in. blocks uncreosoted	5-in. deals wear down to an average depth of about 3 in.
St. Martin's-in-the-Fields	Strand§	16,100 from 6 a.m. to midnight	1 year	2½ years	About 6s. 6d. for 6-in. blocks	10s. for 5-in. blocks	6-in. wood wears down to 2½ in. average.
St. Margaret and St. John's, Westminster	Parliament-street	No record	About 2 years	About 6 years	About 6s. for 6-in. blocks	..	6 in. deals wear down to 2½ in. on average, in places often worn as thin as 1½ in.

* Oxford-street, east of Regent's Circus—police return for April 1, 1890—fine day. † Oxford-street, east of Marble Arch, the omnibus traffic has increased greatly since date, April 2, 1890—fine day. ‡ Police return for May 7, 1889; but the omnibus traffic has increased largely since that date. § In surveyor's opinion the pavements of the Strand would wear one year longer were they not disturbed so often by the laying of and alteration to gas and water mains.

HORSEOWNERS' OPINIONS REGARDING PAVEMENTS.

Wood and Asphalte.	London Road Car Company's Answers.	Messrs. Carter, Paterson, and Co.'s Answers.	London General Omnibus Company's Answers.	Pickford and Co.'s Answers.
1. Upon which of the two pavements do the greatest number of falls occur?	Asphalte	In summer asphalte; in frosts wood		We much prefer wood pavement to asphalte. There is not much difference in traction, nor is a fall much more probable on one pavement than on the other. The consequences, however, of a fall are more likely to be serious on asphalte than on wood.
2. Upon which of the two pavements do the greatest number of horses get hurt?	Ditto	Asphalte	From want of statistics are quite unable to express an opinion upon the six questions	
3. Upon which of the two pavements do the greatest number of horses get permanently crippled?	Ditto	Of rare occurrence		
4. Upon which of the two pavements do the greatest number of horses get killed?	Ditto	Of rare occurrence		
5. Upon which of the two pavements does the greatest wear and tear of horseshoes and wheel tyres occur?	Ditto	Asphalte		
6. Upon which of the two pavements does the greatest wear and tear of horses' legs occur?	Ditto	Ditto		
7. Which is the best pavement for traction?	Wood	Ditto	Asphalte gives but little friction whilst wood gives a better foothold. In perfect order no doubt it is the best, but it does not last long in that condition	
8. Which is the best pavement for general purposes from a horseowner's point of view?	Ditto	Wood		

ing or pickling process; it may be eventually found advantageous to treat it by some preservative which will effectually close the pores, as the wood in its untreated state has proved to be very absorbent and elastic. Although untreated jarrah does not swell as much as untreated yellow deals, it swells more than creosoted pine, and is apt to push tram rails and copings of pavements out of place.

The questions in the Table immediately above were submitted to Messrs. Carter, Paterson, and Co., Messrs. Pickford and Co., the London General Omnibus Company, and the London Road Car Company, and their answers are placed under their names. At a personal interview the manager of the London Road Car Company stated that from permanent injuries to horses falling on asphalte it is sometimes necessary to kill them. One night, in Newgate-street, after a shower, two horses fell upon the asphalte and each had a leg broken, and in consequence had to be slaughtered. A broken pelvis from a horse's hind legs slipping apart is an accident which is not uncommon from slipping upon asphalte; the horse dies very quickly after the accident. The results of his observations are that with horses running mostly over asphalte the shoes last about 15 days, while with horses running over wood for the greater part of the journey, the shoes last 18 days; and, that if asphalte were in more general use it would necessitate one set of wheel tyres per annum more than is now needful, as the proportion of the running is mainly over wood. His belief is that wood is the best pavement for traction, owing to the horses' foothold being better than on asphalte.

The managing director of the London General Omnibus Company is of opinion that most falls result from bad and careless driving, and that more accidents result to horses from slips and struggles to regain their footing than when their legs actually slip from under them and they go down; ruptures of the gut near the flank are a frequent form of injury resulting from mere slipping upon the pavement. His view is that one of the great advantages asphalte possesses over wood at present in vogue, is that it lasts nearly three times as long, and the traffic is not being often diverted as is the case when a street has to be frequently repaved. He regards the extra work entailed by the diversion of the regular traffic for this purpose as being a more serious money loss to the company than the death of a horse by falling.

Messrs. Pickford and Co. state that the falls upon asphalte are almost always more serious than falls on wood. Splendid horses from their stud have been killed by their hind legs slipping apart upon asphalte and a broken pelvis resulting, which caused death in a few minutes.

Colonel Haywood, the City Engineer, in the year 1873 carried out a most exhaustive series of observations of accidents to horses on different forms of carriage-way pavements: granite, wood, and asphalte. The gathering of the records extended for over 30 days, and was equal to the observation of the running of 478,523 miles of horse traffic. The observations showed* that a horse might be expected to travel 132 miles over granite, 191 miles over asphalte, and 446 miles over wood, without an accident, and the report states: "It was noticed also, that whatever was the nature of the accident, the horses recovered their feet more easily on wood than they did either on asphalte or granite." Regarding gradients upon the streets wherein the observations were taken, "The asphalte pavement was, therefore, as regards gradients, more favoured than the others. The next in order was granite. The wood pavement was, on the whole, the least favoured." As regards weather during the observations: "The weather, therefore, on the whole, was very favourable to asphalte; there having been a great absence of that weather which creates a damp surface and causes that material to be in its most slippery state; and was very unfavourable to granite, inasmuch as that material, if clean, during dry cold winds is in its most slippery condition. As regards wood the absence of rain was decidedly favourable to it, although moisture does not appear to render that material relatively so slippery, or to play so important a part as regards safety, as it does with asphalte and granite." . . . "*Taking the whole group of conditions into account*, the asphalte was the most advantageously placed. The wood was the next so, and the granite was the worst placed." . . . . "That of those accidents which are most obstructive to the traffic, as well as most injurious to the horses, asphalte had the greatest proportion, granite the next, and wood the least."

In March, 1889, The Horse Accident Preventive Society (Slippery Roads) was established. The Society, in order to gather statistics as to the relative values of the different varieties of pavements from the men who are continually in all weathers and conditions using them, issued a circular to the drivers in the employment of the London General Omnibus Company; the London Road Car Company; Messrs. Carter, Paterson, and Co.; and Messrs. Tilling, omnibus and cab proprietors, asking the following questions:—1. Which do you consider the best form of roadway to drive over? 2. Which is the worst?

1 {
750 men considered wood the best.
219 " " macadam the best.
197 " " granite cubes the best.
51 " " asphalte the best.

2 {
122 men considered wood the worst.
1 man " macadam the worst.
13 men " granite cubes the worst.
1045 " " asphalte the worst.

MODERN UNITED STATES ARTILLERY.—No. XX.

GRAVITY RETURN MOUNT FOR THE 8-IN. BREECH-LOADING RIFLE. (FIGS. 429 TO 434.)

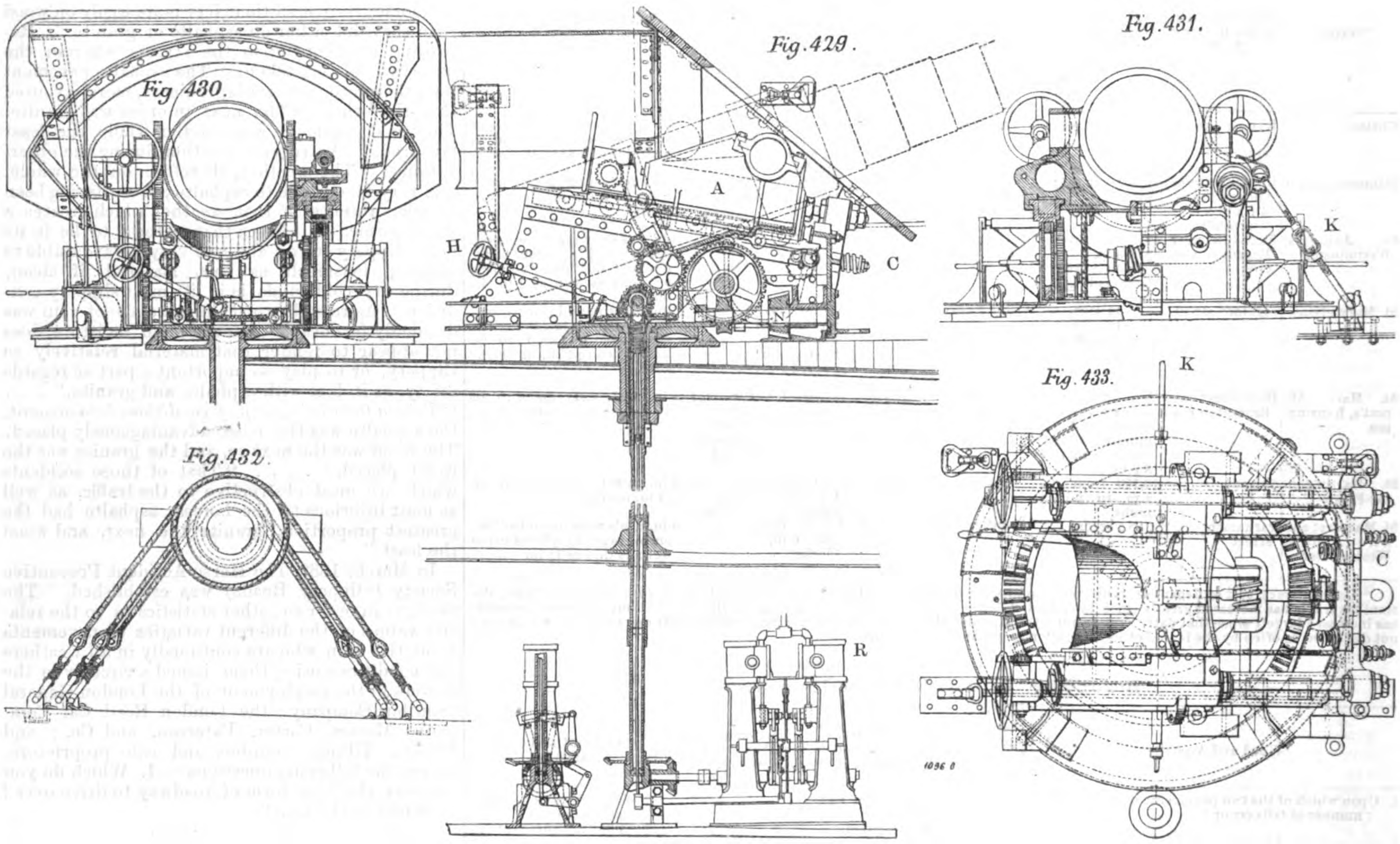
THE barbette, gravity return, central pivot carriage for the 8-in. breechloading rifle is shown in Figs. 429, page 190, to 434, page 192. The carriage is supported on six trucks, two in rear and four in front, under or near the trunnions. Its recoil is checked by two recoil cylinders, and direction is given either by hand or steam training gear and double elevating attachments. The recoil cylinders A are attached to the carriage, and the piston rods to the front of the slide. By means of grooves cut on the surface of the bore of the cylinder, presenting a variable aperture for the passage of the liquid, the pressure is made constant throughout the path of the recoil.

The carriage is secured for sea on the slide by turn-buckles. This carriage is also fitted with steel-wire breechings, shackled to bolts which are fitted with steel springs to relieve the strain. The elevating gear is similar to that previously described. Although the guns work easily by hand, it is, however, considered desirable to apply electricity to them. An electric motor tried on U.S.S. Chicago with the 8-in. carriage, has proved very successful. Steam power is used for training, the engine R being placed on the orlop deck, the vertical shaft connecting directly with the slides. The engine is controlled at will by a handwheel H, which works a shaft and pinion, which pinion operates the starting gear on the orlop deck by means of a rod through the hollow shaft. The securing bolt X

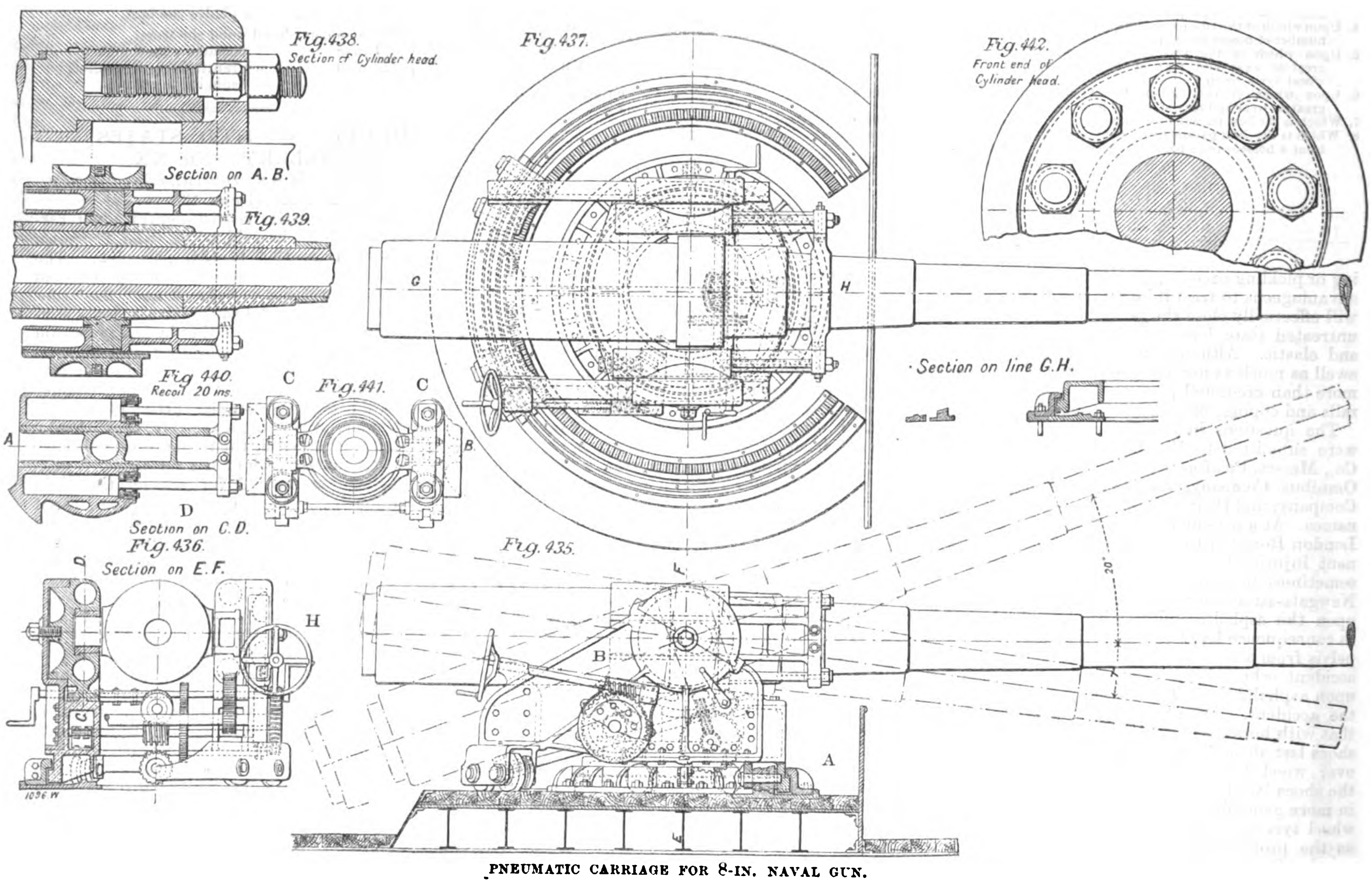
* Report to Commissioners of Sewers, City of London Accidents to Horses on Carriage-Way Pavements, by William Haywood, Engineer and Surveyor to Commissioners, page 70.

MODERN UNITED STATES ARTILLERY: MOUNTINGS FOR 8-IN. NAVAL GUNS.

(For Description, see Page 189.)

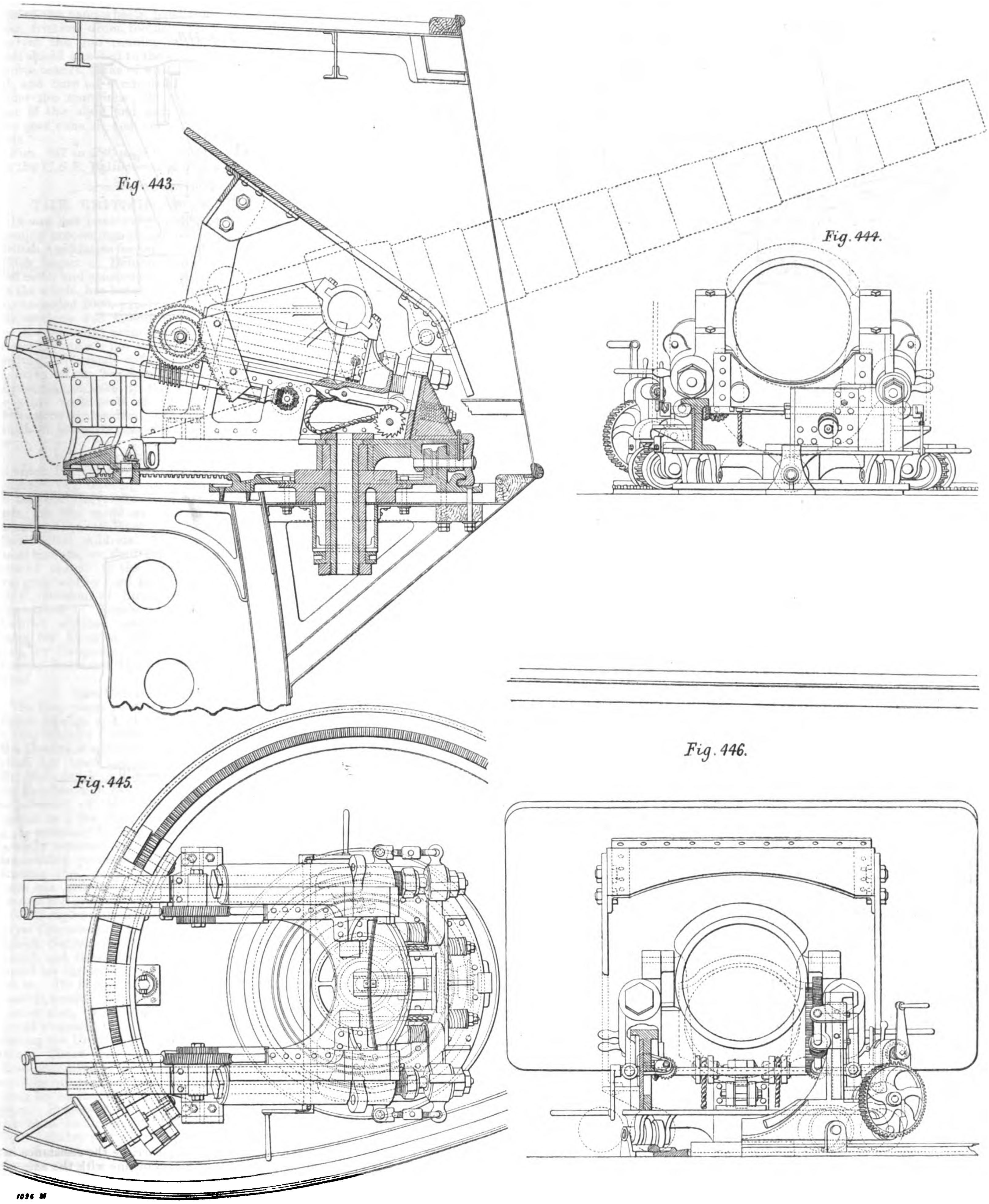


GRAVITY RETURN BARBETTE CARRIAGE FOR 8-IN. NAVAL GUN.



PNEUMATIC CARRIAGE FOR 8-IN. NAVAL GUN.

MODERN UNITED STATES ARTILLERY: MOUNTINGS FOR 8-IN. NAVAL GUNS.



CENTRAL PIVOT CARRIAGE FOR 8-IN. NAVAL GUN; U.S. CRUISER "CHICAGO.

fastens the slide to the deck for sea. The piece can be easily trained by hand, by disconnecting the steam power and by turning the cranks K which turn the worm shaft, by means of gearing. The worm gears into a pinion on the shaft N, on the other end of which is the large pinion wheel which gears into tracks on the deck.

The gun shield is of steel, 2 in. thick, and is attached to the slide. The clips P P check the jump of the carriage on the discharge of the piece, or when the gun runs out. The carriage rests on rollers which are let into the slide, the surfaces

MODERN UNITED STATES ARTILLERY: MOUNTINGS FOR 8-IN. NAVAL GUNS.

Fig. 447.

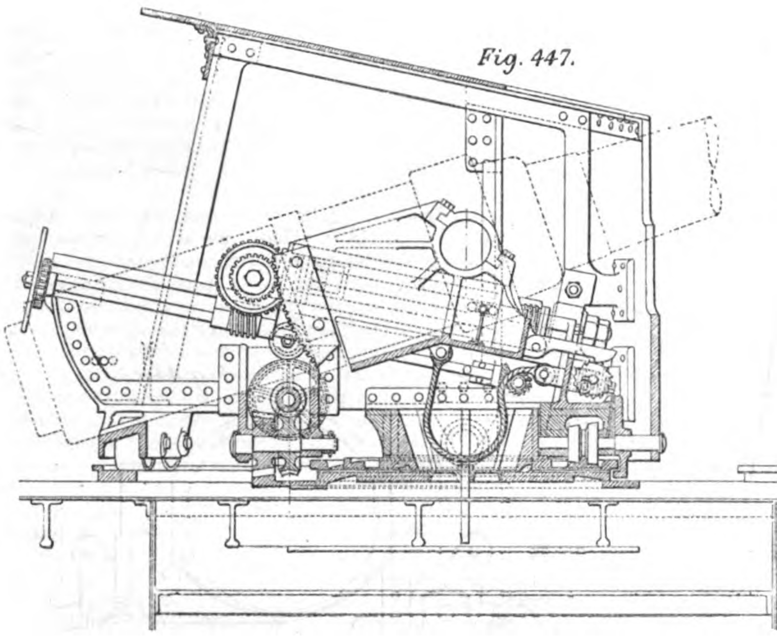


Fig. 448.

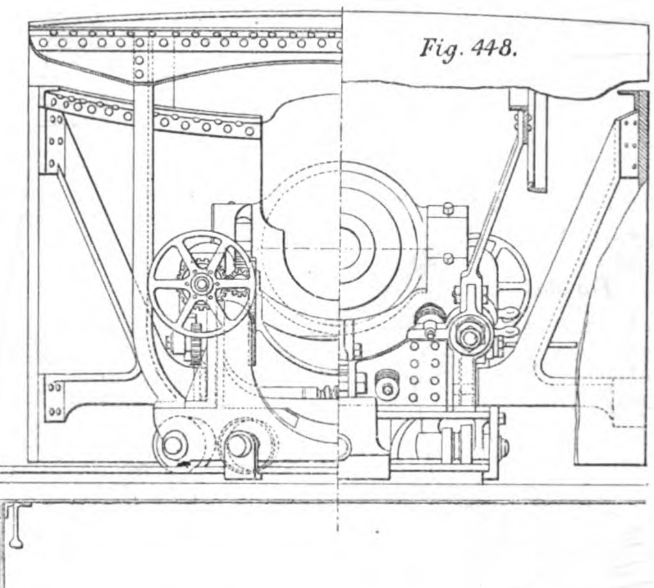


Fig. 449.

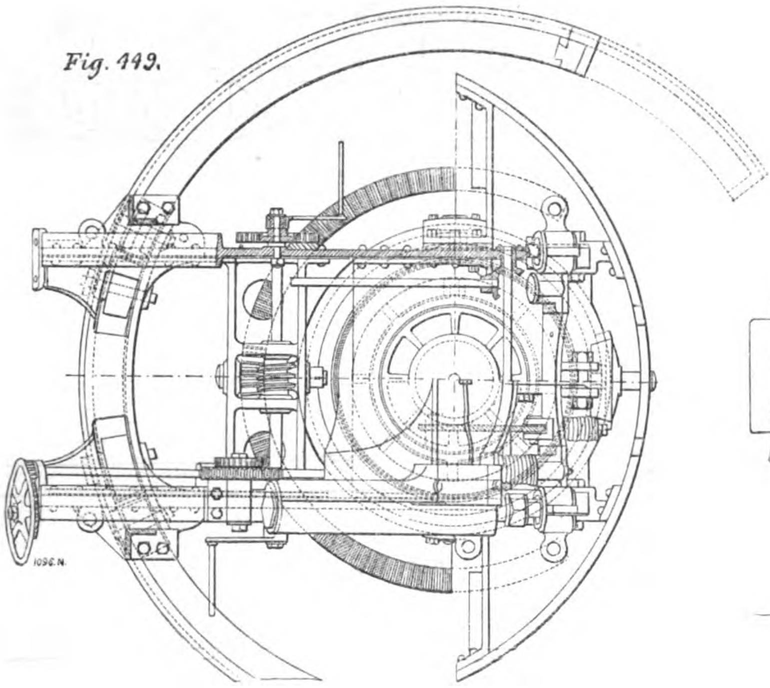
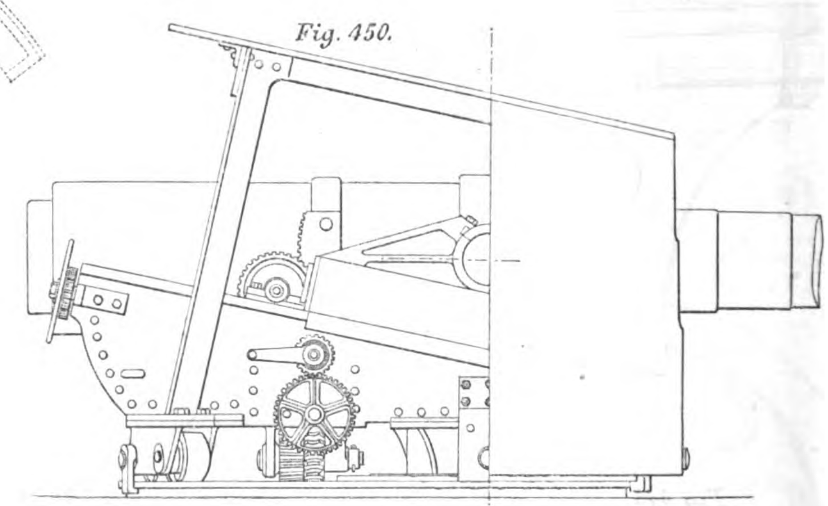
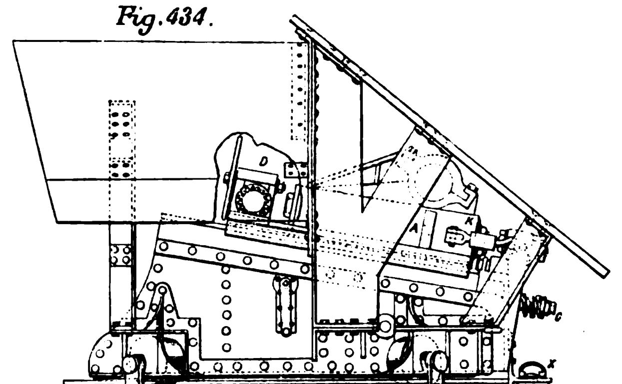


Fig. 450.



CENTRAL PIVOT CARRIAGE FOR 8-IN. NAVAL GUN; U.S. CRUISERS "BALTIMORE" AND "CHARLESTON.

Fig. 434.



GRAVITY RETURN BARBETTE CARRIAGE FOR 8-IN. NAVAL GUN.

projecting slightly above the faces of the upper plates of the slide girder.

Pneumatic Carriage for 8-In. Breechloading Rifle. (Figs. 435 to 442, Page 190.)

Figs. 435 to 442 show a carriage for an 8-in. breech-loading rifle designed by the Pneumatic Gun Carriage and Power Company, of Washington, D.C.

This carriage is what is termed a centre pintle carriage, having a circular bed that is mounted on rollers which run on a roller path. The circular bed is provided with a hook flange and a circular clip A for preventing the lift of the carriage when the gun is fired. The cheeks are shown at B; they are securely bolted to the circular bed, are extended to the rear, and are supported on a rear transom and rollers. The recoil cylinders C, are four in number, and are arranged two on each side of the gun; each pair of these are cast together on a connecting plate, having large trunnions which rest in bearings formed in the top of the cheeks B, and having square caps to secure the trunnions. The gun is mounted by its trunnions in slides which work in ways formed between the cylinders. These slides have cross-heads to which are connected piston rods D and pistons which work in the recoil cylinders for taking up the recoil of the gun. This carriage does not retain the gun out of battery, as in the case of the disappearing carriage, but it is immediately returned into battery by means of the differential areas of the two sides of the piston, air being allowed to escape to the opposite side of the piston by means of a relief valve arranged in the piston and cylinder, which forms a cushion for the counter recoil of the gun. The traversing is performed by the ordinary means, and the elevating and depressing of the gun is performed by racks that are attached to the rear end of the lower recoil cylinders, and worked by the customary worm gearing by the hand-wheel H.

In this construction of carriage the resistance in taking up the recoil is also in line with the axis of the gun, dispensing with top carriages and slides, and the vertical strains incidental thereto.

Central Pivot Carriage for 8-In. Breech-loading Rifle. (Figs. 443 to 446, Page 191.)

Another design for a central pivot 8-in. carriage is shown in Figs. 443 to 446. It is for use in the half turrets of the U.S.S. Chicago. Its general features are: Double recoil cylinders, steel wire breechings, elevating gear fitted so that the gun may be fired when the elevating numbers of the gun's crew have hold of the hand-wheels, hand and electric training gear, friction drum, toothed wheel and pawl, to prevent the gun running in by its own weight, a steel shield attached to the slide. The slide rests on five trucks, three of which are secured to fit the rib, and turn on a circular track of small radius under the trunnions; the other two support the rear of the slide and gear into training tracks. The gear runs in and out on rollers let into the slide.

Figs. 447 to 450, page 192, show a similar design for the U.S.S. Baltimore and Charleston.

THE BRITISH ASSOCIATION.

In our last issue we gave a brief account of the opening proceedings at the recent meeting of the British Association for the Advancement of Science, which began at Edinburgh on Wednesday, the 2nd inst., and concluded yesterday. The meeting, on the whole, has been successful. The attendance has exceeded 2000, papers have been plentiful, and the sections well attended. The weather was fine for the Saturday excursions; of the excursions of yesterday we are not able to speak at the time of writing. We made reference to the Presidential Address in our last issue, and we now, according to our custom, take up the work of the sections, selecting such parts as are most likely to be of interest to our readers. We commence with that which most nearly concerns us, namely, Section G, or

The Mechanical Section,

of which Professor W. C. Unwin, F.R.S., was president. The meetings were held in a large room in the old University Buildings. The first business, on the members assembling on Thursday morning, the 4th inst., was the reading of the Presidential Address. This, according to our usual custom, we shall print in full shortly. The vote of thanks to the President for his address was proposed by Lord Kelvin and seconded by Mr. G. F. Deacon, of Liverpool. There was a large attendance of members to listen to Professor Unwin's address, among those on the platform being Sir Douglas Galton, Sir Frederick Bramwell, Sir Benjamin Baker, Sir Henry Wood, Mr. Preece, Professor Hele Shaw, and Mr. Jeremiah Head.

The Chicago Exhibition.

The first paper read was a contribution by Mr. James Dredge and Mr. Robert S. McCormick on "The World's Columbian Exposition for 1893." Mr. Dredge is a member of the Royal Commission which has been appointed by the Crown, whilst Mr. McCormick is the American representative of the Exhibition in England. We print on page 213 an abstract of this paper. The discussion was opened by a few words from Sir Henry Wood, who is the secretary to the Royal Commission. He had recently returned from Chicago and referred to the remarkable progress which had been made in erecting the buildings. He said, however, that there was little to add, as the paper had so well covered the ground.

Sir Douglas Galton, who is also a member of the Royal Commission, said he was anxious that the British Nation should be thoroughly well represented, and thought the exhibitors would be well repaid for the trouble and expense they would be put to. He hoped that as many English people as possible would visit the Exhibition. It was his opinion that, whenever possible, no young engineer should commence his professional career without visiting the United States and seeing what was done there. There were many conditions so different to those prevailing in this country, and these led to so different results, that there was always very much for an Englishman, especially an engineer, to learn. Professor Unwin, in proposing a vote of thanks to the authors, said that when he was in the United States nothing struck him more forcibly than the evident anxiety of Americans that Englishmen should think well of them. This is, at any rate, a gratifying sign to Englishmen, for it shows that their good opinion is respected, and therefore that their friendship is valued.

Refuse Destructors and Electric Light.

A paper by Professor George Forbes on "The Application of Destructors, especially to the Electric Lighting of Edinburgh" was next on the list, but in its place the professor gave what was really a lecture on the subject; indeed, there was no proof that "the paper" had ever any existence as a written document. This plan of giving lectures instead of reading from a paper is seldom quite satisfactory. It invariably leads to occupying more of the time of the meeting than would be taken up were the author confined to his text. On the other hand, if successful, it is more agreeable to a popular audience, many of whom will turn away at the threshold on seeing a long manuscript laid out on the desk beside the time-honoured decanter. The power of accurate and agreeable extemporaneous speaking is a gift that is comparatively rare, even among those whose business it is to give frequent addresses, as a visit to our law courts and churches will show, and engineers who attempt it are apt to distress both themselves and their audiences. Professor Forbes's matter was, however, sufficiently interesting if his manner of putting it forward was open to objection. He proposes a scheme whereby Edinburgh will be lit by electricity for next to nothing, or, rather, at next to nothing in the matter of fuel, so that the price of electricity will be brought down to less than the price of gas. That would be a great thing, and this is how it is to be done. Professor Forbes proposes to collect all the domestic refuse of the city and burn this in a destructor raising steam for the electric machinery by means of the otherwise waste heat. The steam is not to be applied directly to driving engines to work dynamos, but it is to be used for pumping water to a height which water is afterwards to be used for driving turbines which in turn will drive the dynamos. The main object is to obtain an accumulator, an hydraulic flywheel as it were, so that the work of the motors forming the original source of power may be constant in spite of the demand for lighting being intermittent. Professor Forbes proposes to use Arthur's Seat for his purpose. At the top of this eminence he would form a reservoir by blocking up a gulley which exists at the summit. From thence he would take a pipe line to Lochend which was 605 ft. below the site of the proposed reservoir. The contents of the reservoir will be about 2,000,000 cubic feet; and if the efficiency of the turbines, including friction in pipes, were 75 per cent. there would be an available energy equal to 28,000 horse-power hours. We understood the lecturer to say that by working the steam pumps day and night throughout the year, as compared to working only when the light were required, a saving in fuel of 20,000*l.* a year would be made, and a saving in first cost of steam machinery 200,000*l.*; but against the latter would have to be put 35,000*l.* for the hydraulic installation. No doubt the professor will be called upon to do something more than was done in his lecture to substantiate his estimates, before he can persuade his constitutionally cautious fellow-countrymen to embark on the scheme of pumping water to the top of Arthur's seat to bring it down again to work turbines. A good many more figures were given, but owing to the effort made to state them without reference to notes, the delivery was very confused and we found it impossible to follow them. The second part of the lecture was devoted to destructors in general. At Leeds, where there is a refuse destructor the heat is wasted. At Southampton there are two locomotive boilers placed in the flues, but no effort is made to drive the gases through the tubes, so that 75 lb. of refuse is required to produce 1 indicated horse-power for an hour. To get the best results in burning refuse the speaker said that heated air and forced draught should be used. There was one curious fact that had come out in the course of his investigations, namely, that the refuse of a city about equals in steam generating capacity its demand for lighting by electricity. In his investigations at Paddington he found that by using refuse each inhabitant might have a 16 candle-power incandescent lamp burning for one hour and three quarters each day.

Refuse Disposal.

The next paper was by Mr. G. Watson, of Leeds, and was on "Refuse Disposal." This paper we shall print shortly in full with the diagrams. The author strongly advocated the use of destructors for disposing of refuse, and pointed out the evils which follow from the present system employed.

The two last mentioned papers were discussed together. Mr. J. Binnie, the engineer to the London County Council, was the first speaker. He said that there was no doubt destructors would be more used for getting rid of undesirable matter, the nuisance of which in large towns was yearly becoming a more serious matter. The experience in London was that they could burn town refuse by itself, but there was no heat to spare in raising steam, as the heat produced by combustion was required to dry the material. From the southern outfall works 30 to 38 tons of sludge were sent to sea each day. This contained 90 per cent. of moisture so that it would not be possible to burn it.

Mr. Deacon said he had made the first refuse destructor in 1872. That was at Liverpool, and doubtless many improvements had been since made on the design. It had been proposed to take the refuse out to sea, but there were difficulties in the way, and he, therefore, adopted the alternative of burning, using a destructor based on the principle of the regenerative furnace. As a result, it was found that the cost of disposal by the latter method was greater than by dumping at sea for all districts in the neighbourhood of the docks, but if there was any long cartage to get the material to the barges, it was cheaper to erect the destructor and burn. For a longer time they used to deposit the refuse in pits, made in the clay for the purpose of getting material for bricks. That was satisfactory so long as the pits lasted, but they soon became filled up. General Webber pointed out that if dust-bin refuse were more carefully looked after its calorific value would be less.

Major Cunningham stated that the use of refuse for producing heat had been carried on for ages in the East. In India the wood supply would be speedily exhausted if it were burnt for domestic purposes, and practically the only fuel of large districts was dried cow-dung. In large towns the great difficulty of disposing of sewage by any other means than that of sewers arose through cartage. In Paris they had almost come to a deadlock on this account.

Mr. A. Rigg thought the proposal of Professor Forbes quite practicable, but if it were objected to use the top of Arthur's Seat, there were plenty of sites lower down, but sufficiently elevated for the purpose. He strongly opposed the erection of destructors in different quarters of the city, on account of the nuisance that would arise. He thought there ought to be one large destructor at a remote spot. In close calm weather, especially foggy weather, the fumes from the destructor would be a great nuisance. In answer to the last statement, Mr. Deacon said that with the regenerative system there was no smoke and no smell, but he thought there would be difficulty if the heat were taken to raise steam.

Professor Forbes read a passage from an official report, in which particulars were given of the Southampton destructor.* This apparatus had been at work for six years, the charge for repairs being *nil*, and no obnoxious fumes being given off. That, the speaker said, was the universal experience when a properly designed destructor was used in a proper manner, without large quantities of animal matter being thrown on at once. No doubt the sludge could be burnt with ashbin refuse, but he did not advocate the burning of sludge when steam was to be raised. His reservoir would do nothing to detract from the beauty of Arthur's Seat.

Mr. Watson, in replying to the discussion, said that Mr. Binnie had pointed out that the Crossness sludge contained 90 per cent. of moisture. That was also the case at Ealing, but at the latter place the sludge was successfully burnt by mixing it with refuse, so as to absorb the moisture. Many people seemed to think that it was not possible to raise steam by means of destructors without allowing noxious fumes to escape. He did not see that the argument could be supported. The heated gases were there and were allowed to escape. Why should they not pass through a steam boiler, which would be placed at a distance from the furnace. If the heat were not used it would be cheaper to send the refuse to sea in many cases, but, counting the saving of fuel in raising steam in this way, the use of the destructor was the more economical.

Absorption and Filtration of Sewage.

A paper by Mr. R. F. Frantham, M. Inst. C.E.,

* This destructor was the subject of a paper read by Mr. Bennett at the recent Portsmouth meeting of the Institution of Mechanical Engineers. We shall publish this paper in full shortly.

being 180 ft. as shown on plan. (Fig. 213.) The span of each main arch is 38 ft. The piers are 7 ft. thick at bottom, and have a batter on both sides of 1 in 40, so that the thickness at springing level is 5 ft. 6 in., the height being 31 ft. (Fig. 214). They are built of ashlar, and have cutwaters. The springers are 6 ft. 6 in. by 1 ft. 7 in. The arch, which is 2 ft. thick, has a rise of 15 ft., the radius being 19 ft. 6 in. The soffit is 4 ft. 6 in. below rail level. There are seven spandrels (Fig. 213), the outside walls being 2 ft. 7½ in. and the inside 2 ft., with voids between. Each of the six voids, which are 2 ft. 4 in. broad, are covered with flagging, with asphalte over the top, and the way made up to formation level in dry material.

The smaller arches are semicircular in section, 5 ft. radius. The piers are 4 ft. 6 in. thick, while the arch is 16 in. thick. The viaduct terminates in curved wing walls, 7 ft. thick at bottom, and, having a batter of 1 in 12, are reduced to 3 ft. at top (Fig. 215). The rate of slope is 1½ to 1. The parapet is shown by the section (Fig. 218). The rails on the viaduct are laid on a grade of 1 in 70.

A wooden service bridge was built across the river for conveying material to the different parts of the work.

Beyond the bridge the line is in open cutting to the terminus, which is about half a mile from the bridge; but in this stretch there is yet another girder bridge, carrying the Garriochmill-road over the railway. On account of sidings branching off under the bridge, one side is wider than the other, but the difference in the length of span did not require the same treatment as in the case of the Kirklee-road Bridge. Abutments 6 ft. thick, with large wing walls, carry the main girders, which are 71 ft. 6 in. and 64 ft. 6 in., with a depth of 7 ft. 3 in. The method of building up these plate girders is as shown on Figs. 219 and 220. The cross-girders are 31 ft. 6 in. and 2 ft. 3 in. deep, with a ⅜-in. web-plate joined in the middle with angles 4 in. by 4 in. by ⅜-in. They are placed at 12 ft. centres. Lindsay's troughing is used as shown on Fig. 219.

It may be interesting to describe the method of placing in position the girder, as the means adopted was similar to that resorted to under the same conditions on the various other bridges for roads. The girder was taken on lorries and placed alongside the road. On the formation level rails were made in line with the road. Running on this rail was a wooden trestle, which was placed hard up against the abutment, with the top rather higher than the abutment. One end of the girder was placed on the trestle by means of a crane, and the trestle was then drawn along the rails, carrying the girder with it. On the trestle reaching the other side, the girder was lowered into position.

The Maryhill Barracks terminal station with good sidings, turntable, &c., is built in a rock-cutting close by the main thoroughfare between Maryhill and Glasgow; but the work does not call for description.

In concluding our articles on these works we have to acknowledge our indebtedness to the chief engineers of the work for permission to reproduce the drawings, and to the resident engineers, formerly Mr. Thomas Nisbet and now Mr. Donald A. Matheson, and to their assistant, Mr. W. A. Tait, who accompanied our representative on his various visits to the works and gave every facility for acquiring information.

MODERN UNITED STATES ARTILLERY.—No. XXI.

16-In. Breechloading Rifle.

The 12-in. breechloading rifles and mortars are at present the largest guns that have been completed for the United States Army. These having been tested and found satisfactory, the next step will be the manufacture of a 16-in. breechloading rifle. The proposed gun is to be about 49½ ft. in length, with a bore 35 calibres long, and will weigh 125 tons. The charge of powder will be about 1000 lb. in weight and the projectile over one ton. The muzzle penetration in iron is estimated at about 3 ft., and the maximum range at 15 miles.

Sea-Coast Carriages for Breechloading Rifles.

The barbette carriage has been described. A number of these carriages are being constructed, and it is intended to place them in elevated positions where a disappearing carriage will not be necessary.

Among the proposed disappearing carriages, the pneumatic disappearing 10-in. carriage, previously described, is being tested. Three other disappearing carriages are being manufactured for test, viz.: a 10-in. disappearing carriage of the Gordon type; it is composed largely of cast iron with the working parts of steel; one 8-in. and one 10-in. disappearing carriages of the Buffington-Crozin type; these are composed principally of steel.

These carriages will all soon be ready for test, and when completed, their details, which are at present kept secret, will be made public.

In addition to the above-mentioned carriages, there is being manufactured at Le Creusôt, France, a 12-in. carriage for a gun lift. This is essentially a barbette carriage in which an increased length of recoil is allowed to adapt it to the gun lift.

Sea-Coast Carriages for 12-In. Breechloading Mortars.

The sea-coast carriages for 12-in. breechloading mortars, proposed or being tested, are the Canet, the Spiller, and the Raskazoff.

The Canet 12-In. Mortar Carriage.

This carriage is so arranged that the hydraulic buffers are always parallel to the direction of the recoil. In this mount the top carriage is semi-circular in form, being essentially a large trunnion. Elevation is given to this piece by the revolution of this top carriage in its circular bearing. The hydraulic cylinders are attached to the piece and rest on slides or rails of the top carriage, which are parallel to the axis of the piece, and along which the cylinders move when the piece is discharged. Clips prevent any tendency of the top carriage to jump. Energy, for the return of the piece in battery, is stored up by means of a pneumatic buffer, which is situated under the piece. The air is compressed by means of the recoils and the energy so stored up is sufficient to return the piece in battery. Illustrations and a full description of this carriage were published in Engineering, vol. l., page 137.

MODERN UNITED STATES ARTILLERY.

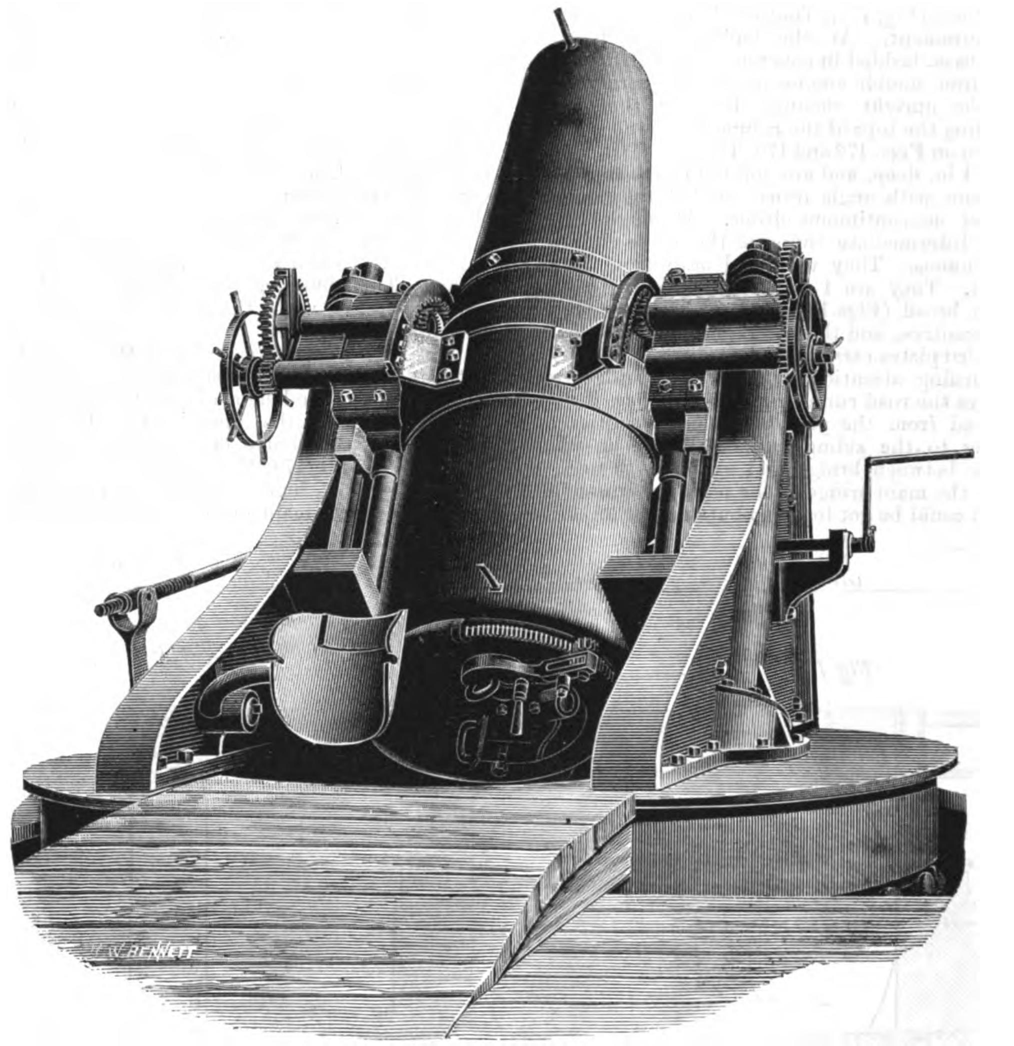


Fig. 451. Raskazoff and Anderson's Mount for 12-in. Mortar.

Raskazoff and Anderson's Mount for 12-In. Breechloading Mortar (Fig. 451).

1. The mounting consists of a base ring or lower roller path 10 ft. 6 in. in diameter to the centre of the path, secured by 12 foundation bolts to a masonry foundation at a level of 3 ft. 4½ in. below the floor level of the emplacement. The ring is of cast iron, composed of four segments truly fitted together, and the roller path is turned so as to serve both as a vertical support and lateral guide.

2. Upon the base ring reposes a circle of 20 cast-steel live rollers, securely held between two concentric frame rings, and furnished with double flanges; the object of which is to hold the upper portion of the mounting concentric with the base, and to take the lateral thrust resulting from the discharge.

3. The base frame of the carriage also is of cast iron made in two parts united together by means of bolts. On the lower side is formed a roller path truly turned and corresponding exactly to that on the base ring. The base frame is of cellular structure, and upon it is bolted a pair of carriage sides about 7 ft. high, formed to receive the gun and recoil apparatus.

4. The mortar has a range of elevation between 45 deg. and 75 deg., and it recoils down slides placed at an angle of 60 deg. with the horizon. The slides are formed on the inner faces of the disc spring-cases cast in the carriage sides. The cases are cylindrical and inclined at an angle of 60 deg. with the horizon. The slides in form are somewhat like the bed of a lathe, and the carriages which carry the trunnions of the mortar embrace them so as to be supported in every direction. The carriages (which are of cast steel), are provided with bearings for the trunnions, and with cap squares, packed with elastic material, introduced for the purpose of softening the shock in running up after the recoil. The upper ends of the carriage have formed on them brackets projecting right and left into the spring chambers, these rest on the

MODERN UNITED STATES ARTILLERY.

Fig. 452.

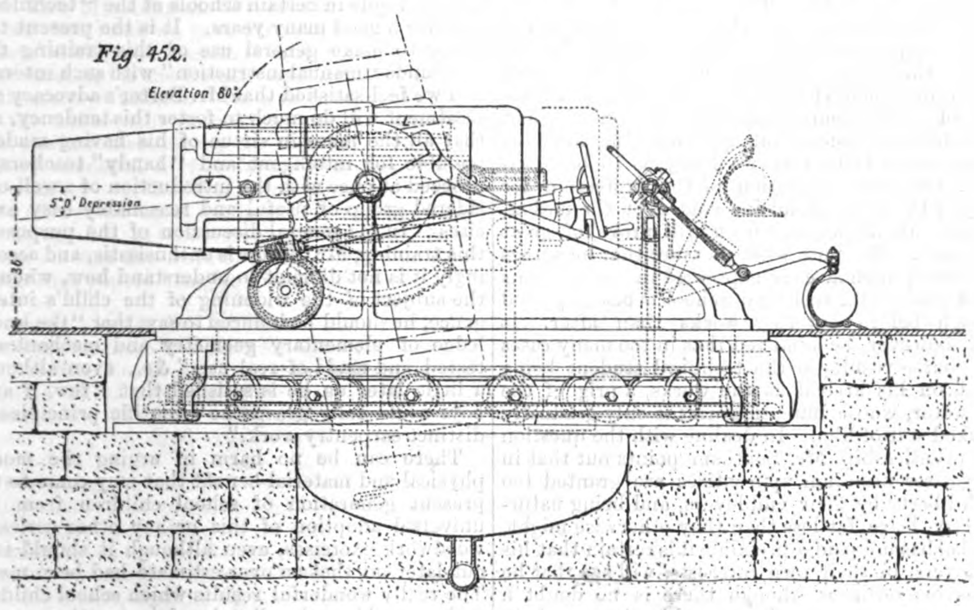


Fig 453.

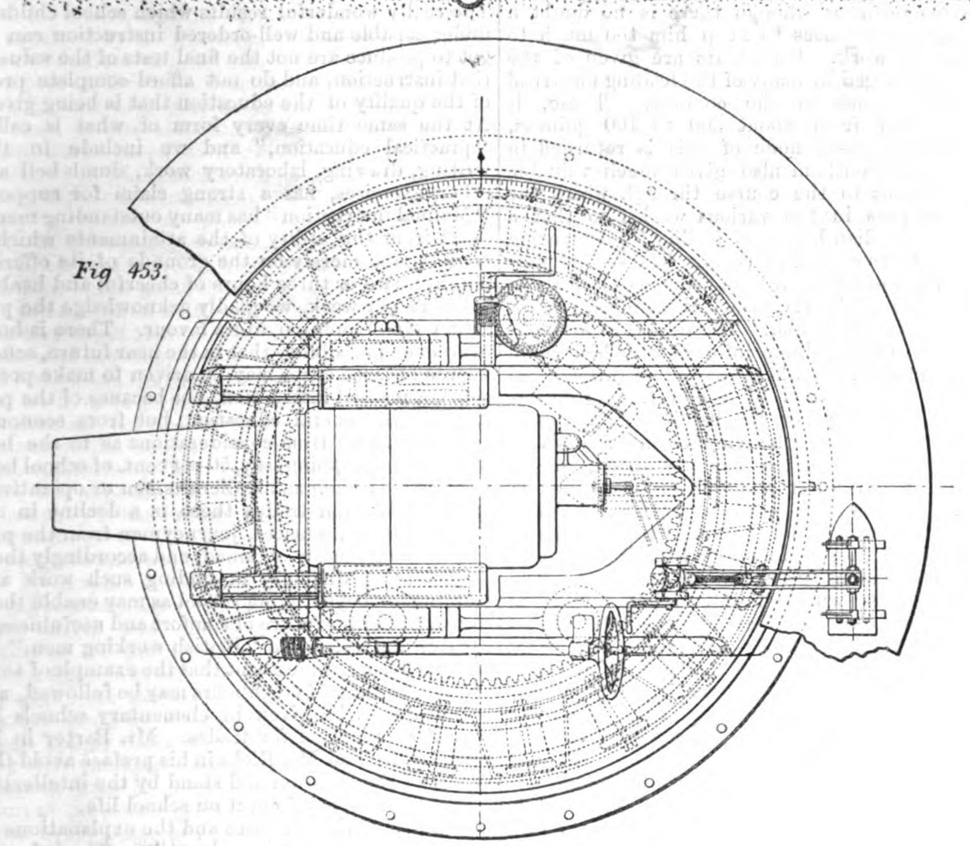
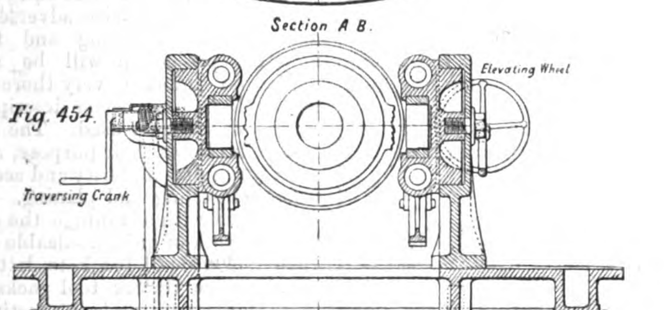


Fig. 454.



SPILLER'S MOUNT FOR 12-IN. MORTAR.

upper ends of the piles of disc springs, and by that means transfer the weight of the mortar to them. The slides are slotted to allow these brackets to traverse down the full length of recoil, that is 2 ft. 6 in. The spring-cases in the carriage slides are not sufficiently long to accommodate the requisite number of springs, they therefore are produced downwards by means of cast-iron cylinders secured to the sides at their upper ends by means of flanges and bolts, and have their lower ends closed and fitted with 2½-in. adjusting set screws, the object of which is to enable the springs to be compressed sufficiently to insure the mortar running out completely.

5. The power required to compress the springs is, however, not nearly so great as the energy of recoil and the work done by the falling gun, hence a pair of hydraulic compressors are secured to the spring casings immediately below the trunnion carriages. These cylinders are of cast steel, 7 in. in diameter, and are fitted with 3½-in. steel piston-rods, which work through hemp-packed stuffing-boxes at either ends of the cylinders. The upper end of each rod is keyed into a socket formed in the carriage immediately under the trunnions, while about the middle of the rod a piston is formed out of the solid, and is an easy fit in the cylinders. A connecting passage is formed between the two ends of the cylinders; it enters the upper end immediately below the gland, and the lower end some 6 in. above the gland. The upper face of the piston is recessed, and into the recess fits an annular piston, secured to the upper end of the cylinder. The force of recoil is taken up by the resistance which the fluid offers to being driven from one end of the cylinder to the other, the passage is free during the first part of recoil, but when the piston passes the lower opening of the passage, it partially shuts it off, so that the water in the lower 6 in. of the cylinder is able to escape only by the windage between the cylinder and piston. At the end of the running up of the gun, on the other hand, the annular piston enters the recess in the main piston, and the water thus imprisoned is also able to escape only by the windage. In this way, the mortar is stopped quietly at the end of both motions. Means are provided for adjusting the size of the connecting passage.

6. As the carriage buffers and springs on each side are not connected, cast-steel lateral guides are secured to the carriage sides and adjusted so as to bear against the body of the mortar at its breech end; by this means any tendency to move out of the vertical plane is counteracted.

7. The elevating gear consists of a wrought-iron circular rack secured to a hoop shrunk on to the mortar just in front of the reinforcing hoops. A wrought-iron pinion gears into this rack, and is carried by a spindle working in bearings attached to one of the carriages; this wheel is driven by another pinion attached to the carriage in a similar manner, and, at its outer end, its spindle is fitted with a handwheel of convenient dimensions. The wheel on the rack pinion spindle is graduated on its face, and an index is attached to the carriage which enables the degrees of elevation to be read off. The gear is fitted to both sides of the mortar.

8. The traversing gear consists of a cast-iron annular internally geared spur ring, attached by flanges and bolts to the base roller path. A shrouded pinion gears into this and is keyed on to the lower end of a vertical spindle, which passes upwards through a long bearing, bolted to the base frame of the carriage, and is supported also by a bracket bolted to the inner side of one of the carriage sides. The upper end of the spindle carries a bevel wheel, which gears into by a pinion keyed on to a horizontal shaft, which passes through the carriage side, and is fitted with a winch handle, and is supported by bracket bolted to the carriage side at its outer face. The speed of rotation may be made anything that is found convenient, though a revolution in two minutes appears to be the most advantageous, as such a speed makes it easy to adjust the training with great accuracy.

9. To protect the edge of the masonry, and also to furnish a large graduated circle for training, a cast-iron ring made in four segments is fitted to the edge of the aperture in the floor in which the mounting works, it is held down by lewis bolts with countersunk nuts, and will have its inner horizontal face clearly graduated in degrees, a pointer being fitted to the top frame for the purpose of indicating the degrees of training.

10. The loading gear consists of a short tray carried on the end of a bow lever, the lower end of which is pivoted to one of the carriage sides. The pivot passes through the side and carries a lever, the upper end of which is fitted with a swivelling nut, through which works a diagonal screw spindle, extending to the front of the mounting, where it is supported in a suitable bearing and carries a hand-wheel, by operating which the shot is raised into a proper position for being rammed into the gun. For loading and cleaning the mortar is brought to an angle of 15 deg. elevation. The shot or shell is carried in a suitable truck which delivers it direct to the loading tray when the latter is depressed.

11. The height of the centre of the trunnion

above the floor of the emplacement when the gun is in the firing position, is 4 ft. 8 in. In the loading position the centre of the bore at the back end is 3 ft. 6 in. above the floor. There are no valves of any kind, and only glands to pack with hemp in the usual manner. A cock and small funnel at the upper end of each cylinder admits of fluid being poured into the compressors, and the only care necessary in using the mounting, is to see that the cylinders are full of fluid, which for a cold climate should be a mixture of methylated spirits, water, oil, and carbonate of soda.

SPILLER'S MOUNT FOR 12-IN. BREECHLOADING MORTAR (FIGS. 452 TO 454).

In this gun mount or carriage, the mortar is supported by its trunnions in slide blocks, which move with the gun in its recoil.

These slide blocks work in ways formed between pairs of recoil cylinders, arranged on each side of the gun, which are cast in pairs on strong plates, and have large trunnions that turn in bearings made in the upper ends of top of the A-shaped cheeks of the carriage. These bearings are made open for the admission of the trunnions, which are secured in place by square caps in the usual manner.

The above-named side blocks are made with crossheads on their front ends, to which are secured piston-rods, that work through packing glands in the heads of the recoil cylinders. On these piston-rods are made pistons which are chambered, from which small passages communicate with the annular spaces around the piston-rods above the pistons. To the heads of the lower or rear ends of the recoil cylinders are secured tapered cylindrical valves, over which the pistons and piston-rods pass in their descent; the tapered form of the valves giving a differential opening for the passage of a portion of the air from under the pistons in their descent, to form a sufficient cushion to check the counter recoil of the gun.

At each end of these cylindrical valves are made parallel portions of sufficient length to close the passages in the pistons in time to form permanent cushions at both ends of the recoil cylinders to prevent the pistons from striking the heads. A small clearance is allowed for the passage of the air, allowing the gun to gradually arrive into battery.

The cheeks of the carriage are securely bolted to a bed or table circular in form, which is mounted on a roller ring, that runs on a circular roller path. The rollers are equally spaced, and kept in position by internal and external rings, connected by journals, upon which the rollers turn. They also have strong flanges at their ends, to secure proper traction on their path.

The circular table is prevented from lifting by strong clips, which are locked into and securely bolted to projections, which projections are cast on the table, and hook under a projecting flange formed on the roller path. Upon the inside edge of the roller path is fitted a circular toothed rack, into which gears a pinion that is driven by a vertical shaft, having a bearing formed in the table. On the top end of this shaft is keyed a worm gear, which is turned by a worm secured to a horizontal shaft, that extends outside of one of the cheeks; this shaft is turned by a pair of bevel gears, inclined shaft, and handwheel; this constitutes the traversing mechanism.

The elevating and depressing of the gun is accomplished by means of circular racks, which are bolted to the under side of the lower recoil cylinders, and engage pinions which are mounted on a cross-shaft, having bearings in the cheeks. A friction worm gear is mounted upon one end of this shaft outside of the cheek, which gear is turned by a worm, shaft, and handwheel. Both of these handwheels are arranged at the rear of the carriage, in order to be under the hands of the man working the gun.

Beneath the carriage and having bearings in cross stays running under the cheeks are centralising rollers, which run on a circular blank space formed below the teeth of the circular rack. At the rear end of the cheek on one side of the carriage is fitted a bracket for supporting a crane for hoisting the ammunition to the gun.

LITERATURE.

Electrical Engineering as a Profession, and How to Enter It. By A. D. SOUTHAM. London: Whittaker and Co.

IN spite of the fact that the great pecuniary prizes of the world are won now, not by manufacturers or professional men, but by the traders, the engineering profession still continues to attract to its ranks an increasing number of the sons of the middle—and, indeed, in many cases of the upper—classes of society. The engineer has in the main to study nature, and the trader, man, and the latter study is, alas! the more profitable. Nevertheless, the engineer's work has a satisfaction of its own in a material result being the accompaniment of one's labours, and in the elation of spirit which follows a successful fight with the forces of nature, and it is to this, we fancy, is to be attributed the great attraction of the profession for many of the most promising youths of the nation. To such Mr. Southam's book will prove of great assistance. We note with pleasure that he agrees with the opinion already expressed in our columns that a course at a technical school is better passed through before entering works than after. It must, however, be admitted that in too many cases this course results in the technical student being found, on his arrival at the works, a prig of the first water, whose bumptiousness is only gradually knocked out of him. In dealing with the question of apprenticeship, Mr. Southam points out that in many cases premium apprentices are granted too much liberty by their employers, and being naturally lazy, learn far less than they otherwise might. If a lad has not paid a premium it is certain that his employers, in their own interests, will see that he learns his business, though there is no doubt a tendency in such cases to keep him too much to one class of work. Particulars are given of the premiums charged by many of the leading electrical engineering firms in the country. These, it appears, vary from about 500 to 100 guineas, and in many cases none of this is returned in wages. Mr. Southam also gives much valuable information as to the course through which the pupil will pass in the various works, so that a parent or guardian has every facility for comparing the advantages offered by them. The second portion of the work describes the courses of study at and fees charged by the principal technical schools of the United Kingdom. There is thus brought together into one volume information which could only be obtained elsewhere by wading through the numerous prospectuses of the various colleges. Unfortunately, however, the list is not complete, such institutions as the engineering schools at Cambridge and Dundee being omitted, whilst others of much lower standing are described at length. A second edition of the work is, however, promised in which the author will, no doubt, supply information as to other technical schools, and these omissions may then be amended. The book concludes with an interesting review of American practice in educating engineers. Practically speaking premiums are unknown; "we never have any work done that we do not pay wages for, and of course we receive no premiums or bonuses from any of our employés," being the reply received by the author from American engineering firms. As far as appreciation on the part of employers goes, students from technical schools seem to be better off in America than here. It is stated that such persons are usually paid at the rate of 10 dols. a week instead of receiving nothing for the first year as is often the case in this country, if, indeed, the unlucky student hasn't to pay for the privilege of working, as frequently happens. American technical schools are, therefore, well attended, and have proved very successful. Several of them are described by Mr. Southam in his book.

Manual Instruction—Woodwork. (The English Slöjd.) By S. BARTER. With 302 Illustrations. Prefaced by GEORGE RICKS, B. Sc. London: Whittaker and Co. [Price 7s. 6d.]

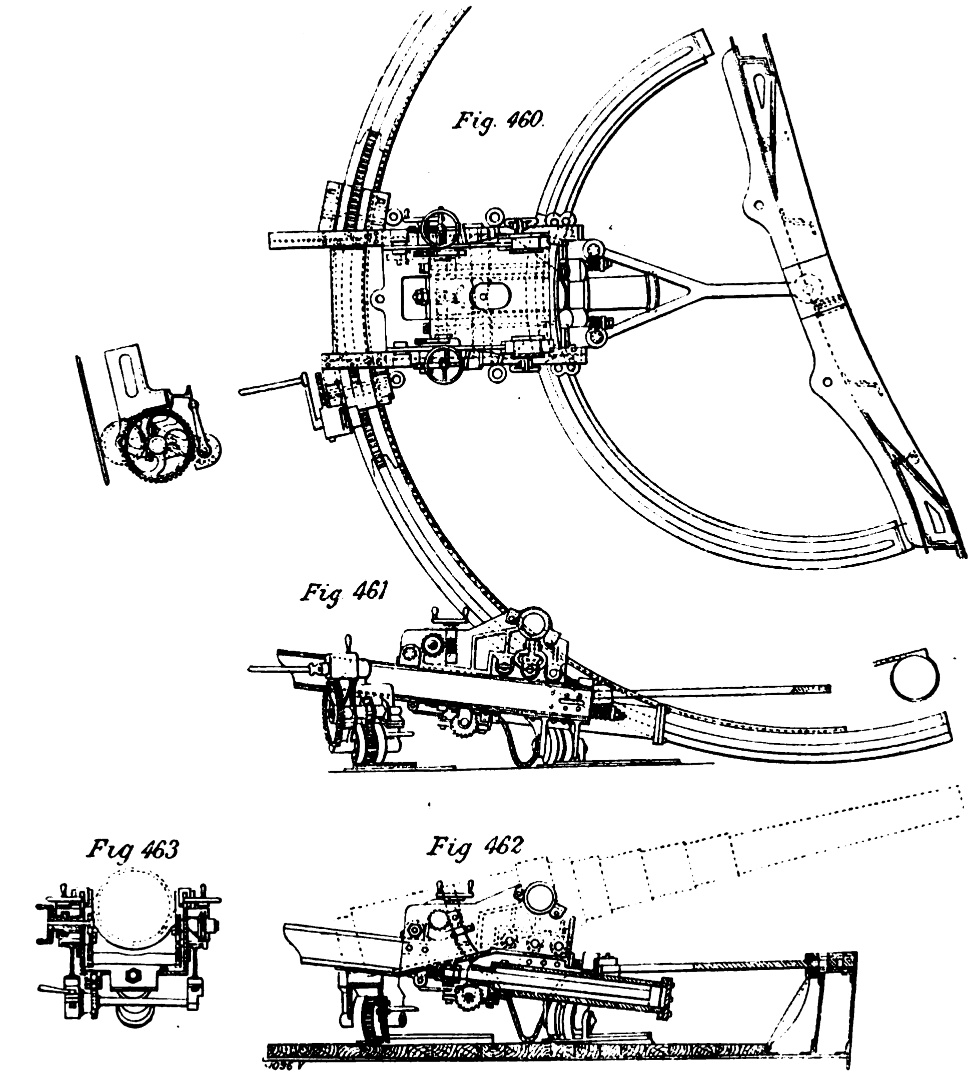
This is a full, clear statement of "the new departure" in education, or rather in London School Board school education, and Mr. Barter, the accomplished organiser of this work for the School Board, has done great service, in placing before teachers and all interested in school affairs, a book which is at once interestingly written, beautifully illustrated, well arranged and containing specific tradesmanlike instructions and remarks. Mr. Ricks writes the preface. In it he recognises our indebtedness to the Swedish Slöjd and claims to have been the first to suggest the introduction of the Nääs Slöjd into the woodwork classes conducted under the joint auspices of the City and Guilds of London Institute and the School Board. While this is no doubt in accordance with fact, it is clear that the English Slöjd, so far as regards tools used and work executed, differs in no appreciable degree from the carpentry and joinery work which has been in vogue in certain schools of the "technical" type for a good many years. It is the present tendency to make general use of this training that surrounds "manual instruction" with such interest, and we feel satisfied that Mr. Barter's advocacy and treatment will do much to foster this tendency, and that all the more in virtue of his having made it possible for intelligent and "handy" teachers to proceed at once with the introduction of a well-considered group of useful and reasonably easy exercises. In his general discussion of the purpose of this training, Mr. Barter is enthusiastic, and accordingly it is not difficult to understand how, when on the subject of the widening of the child's intelligence, he should be induced to say, that "the knowledge of elementary geometry and mechanics is tested and made of real use," &c., even although a little later on he is satisfied that "few, if any, boys could fully grasp the scientific principles of distinct carpentry work."

There can be no harm in urging the moral, physical and material benefit that may come to the present generation of school children from the universal adoption of this or any other series of woodwork exercises, even although it should turn out later on that an over-estimate had been made. The really wonderful results which school children under capable and well-ordered instruction can be got to produce are not the final tests of the value of that instruction, and do not afford complete proof of the quality of the education that is being given. At the same time every form of what is called "practical education," and we include in this writing, drawing, laboratory work, dumb-bell and other exercises, has a strong claim for support. "Manual instruction" has many outstanding merits apart from the utility of the attainments which it confers, and merely on the grounds of its offering children two or three hours of cheerful and healthful work per week, we gladly acknowledge the present wave of opinion in its favour. There is however some probability that in the near future, school boards of large cities may be driven to make provision for manual instruction, not because of the part it plays in general education, but from economic reasons arising from considerations as to the best manner of equipping, say, 50 per cent. of school boys for bread winning as handicraftsmen or operatives. In most London trades there is a decline in the demand for apprentices, journeymen from the provinces being readily obtained, and accordingly there is increasing difficulty in finding such work and training for boys leaving school as may enable them to reach readily a future of comfort and usefulness as capable and well-to-do "British working men." It may, therefore, come about that the example of some of our Continental neighbours may be followed, and opportunities be given in elementary schools for special preparation for trades. Mr. Barter in his introduction and Mr. Ricks in his preface avoid that aspect of the question and stand by the intellectual gain and the general effect on school life.

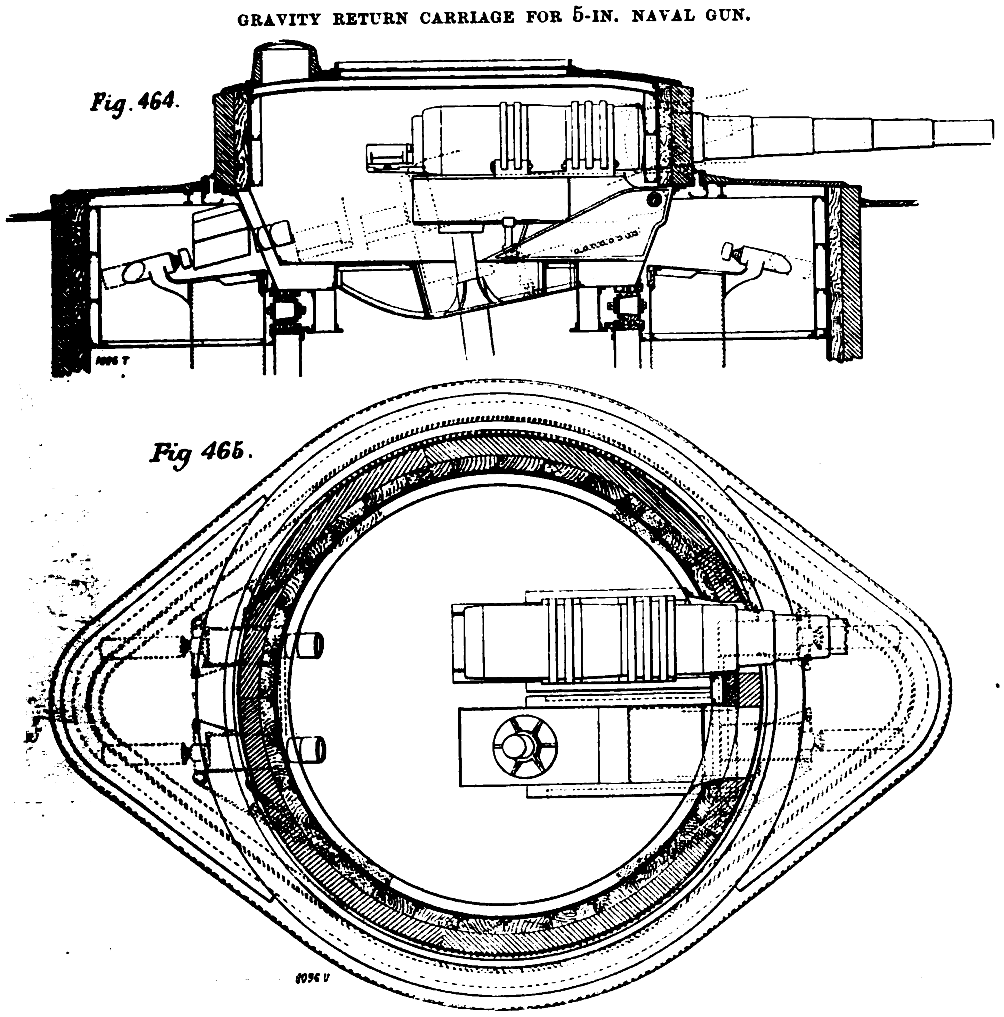
Looking at the exercises and the explanations we find nothing to criticise adversely. The information regarding drawing and the treatment of isometric projection will be serviceable. The chapter on timber is very thorough, and it seems impossible to have better descriptions and pictures of the various tools used. The early exercises are most suitable for their purpose, and the pupil will speedily acquire dexterity and accuracy in marking, sawing, chiselling and planing. As soon as it can be managed with advantage the children are set to turn out work of quite a saleable character. Tooth-brush racks, small brackets, letter cases, elliptical mats, picture frames, tool racks, bookcases, &c., are examples of most interesting and attractive objects on which the boys are encouraged to test from time to time their command over the elements of joiner-work. One striking feature of this book is a set of photographs illustrating the fundamental processes, and from these photographs alone the teacher who is not a trained mechanic will learn more than any letterpress, however lucidly written, can tell him. The correct attitudes for work, the holding of the tool, the methods of sharpening, the arrangements of the bench and the disposition of the material, are most satisfactorily represented in these photographs. In the last pages we have a table of the equipment requisite for the course which Mr. Barter has described, and an estimate of the cost per pupil.

MODERN UNITED STATES ARTILLERY.

(*For Description, see next Page.*)



GRAVITY RETURN CARRIAGE FOR 5-IN. NAVAL GUN.



TURRET MOUNT FOR 10-IN. NAVAL GUN.

Messrs. Siemens Brothers is worthy of attention as it is simple in construction, and takes up very small wall space for a given number of indicators.

Fig. 69 is a part sectional elevation, and Fig. 70 a sectional side view of the board arranged for four indicators.

The indicator itself consists of a small electro-magnet having an iron core of H section (Fig. 71), which is pivoted between centres, and is inclosed in a cylinder of thin metal. Upon the core are wound two insulated conductors—one of which is used for "indicating," and the other for "re-setting." The indicator is pivoted so as to turn freely between the póles of a permanent magnet, so that a current of given direction round the core causes it to complete the magnetic circuit in such wise that the lines of force induced by the current coincide in direction with those of the permanent magnet. A current sent in the opposite direction changes the polarity of the core, which thereupon turns over on its axis, again making the direction of the lines of force coincide.

Indicator boards can be arranged for any number of indicators on this principle, and where two or any multiple of two are required, one permanent magnet is placed above and one below each pair of indicators, as is shown in Figs. 69 and 70.

Each of the bell pushes 1, 2, 3, 4 is connected by a separate conductor, through the terminals 1, 2, 3, 4 on the board, to one of the windings on the core of the respective indicators 1, 2, 3, 4. The other ends of these windings are joined to a common conductor through the bell to one pole of the battery—the other pole being connected by return wires to the several pushes.

If, therefore, one of the pushes be "made," a current passes through the winding on the core of the corresponding indicator, causing it to turn on its axis, at the same time ringing the bell, which continues to ring so long as the push is made.

The "re-setting" device is very simple. One pole of the battery is connected through the terminal Z on the board with the spring push *p*. On "making" the latter a current passes from the battery through the other windings on the cores of the several indicators in series to the terminal C and back again to the battery. If, therefore, one of the indicators has been turned over by a depression of one of the pushes 1, 2, 3, 4, the "making" of *p* re-sets it.

The portion of the cylinder which is visible when "indicating" is painted a conspicuous colour in contrast with the colour shown at the "re-setting" position.

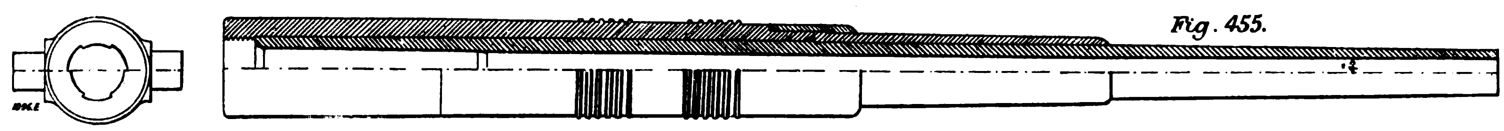
SIEMENS' ELECTRIC FIRE ENGINE.

The carriage and frame are of the usual pattern and construction as used by the Metropolitan Fire Brigade, and were made by Messrs. Merryweather. A full description of the Siemens fire engine, as exhibited at the Royal Naval Exhibition, was given with illustrations in ENGINEERING, vol. liii. p. 67; but since then it has been refitted with a new pump and motor, to which the following remarks apply.

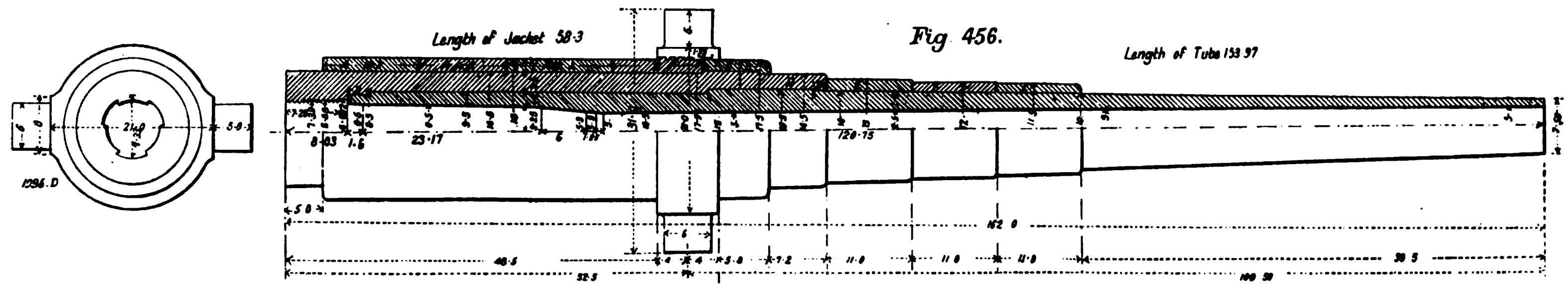
The current for working the motor is taken from the distributing mains. An iron pillar, similar to a hydrant, or wall hose (see ENGINEERING, vol. liii., p. 67), is fixed at any convenient position in the street, and two branch wires from the electric mains are led up to a concentric union to which a flexible concentric cable can be attached. These electric unions, both on the pillar and fire engine, are made to screw up in the same way as the unions on the hose pipes. Inside each half union there are two insulated metal pieces in connection with the branch wires or concentric conductors; the metal pieces are conical plugs and conical tubes in the two halves respectively, so that when two half unions are screwed up good contact is made. Successive lengths of concentric cable can thus be jointed up in case the engine has to work at some distance from the junction pillar.

The motor is series wound and is of Siemens' usual H B $^{12}/_{12}$ type. It is coupled directly to an Oddie rotary pump, made by the Patent Pump and Blower Company, and shown in the accompanying illustrations. Fig. 72 is a section through the pump. The suction inlet is shown at A and the delivery at B. The pump consists of a disc C, which revolves on an axis eccentric with that of the main cylinder. The disc is provided with arms, to the ends of which are hinged blades, as shown, the outer ends of these blades are again

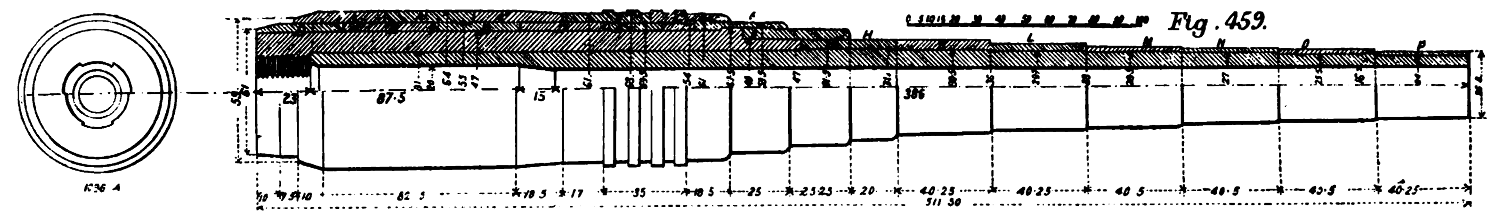
MODERN UNITED STATES ARTILLERY.



4-IN. (40 CALIBRES) BREECHLOADING NAVAL GUN.



5-IN. HOOPED BREECHLOADING NAVAL GUN.



16-IN. BREECHLOADING 110-TON GUN.

hinged into shoes which are portions of segment plates, as shown in Fig. 74. The segment plates revolve round a hardened taper pin F, which is fixed in a boss cast on the cover of the pump, this boss being concentric with the main cylinder. This is shown in Figs. 73 and 74, where E E are the segment plates, F the pin, and H the boss. The segment plates serve to open and close the blades as the disc revolves, owing to the eccentricity of the axis of the disc. The shoes E are made so as to just clear the inner periphery of the cylinder, thus forming a practically tight joint, but without friction, as the segments are held in the boss H.

The action of the pump can be seen from Fig. 72. The space W is supposed full of water, the suction is just cut off, and the discharge is just opening. The chamber X is filling, and Y has nearly finished emptying. It is thus evident that the quantity of water pumped per revolution will be found by multiplying the excess of the capacity of W over Y by the number of blades in the pump. The disc, blades, and segments, are made of phosphor-bronze, and the pin of hardened steel.

The motor was worked off a circuit with a potential difference of 105 volts. With this potential, when running at about 450 revolutions per minute, the motor absorbed 215 ampères, and the pump gave a jet of water from a 1-in. nozzle to a height of 100 ft.. with a pressure of 75 lb. per square inch. With two delivery hoses on at once, having nozzles respectively 1 in. and ⅞ in. in diameter, the motor ran at 550 revolutions per minute, absorbing 160 ampères. The pressure was in this case 45 lb. per square inch, and the two jets rose to a height of about 80 ft.

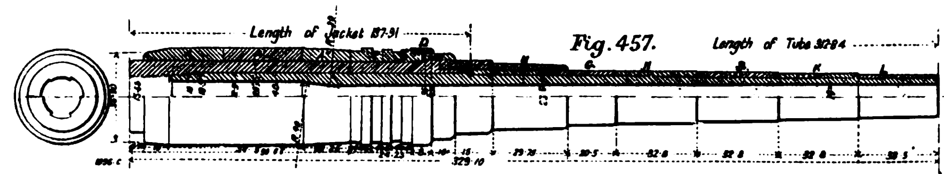
(To be continued.)

MODERN UNITED STATES ARTILLERY.—No. XXII.

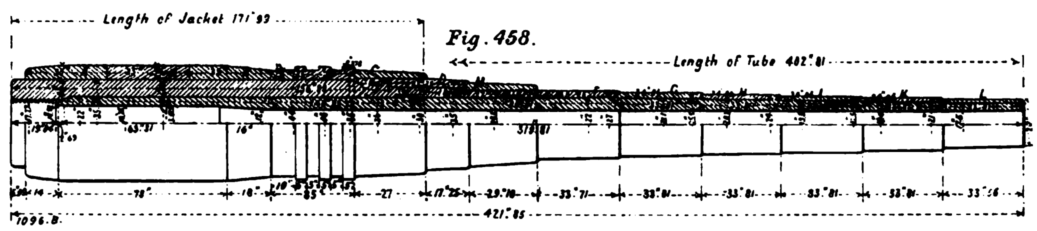
NAVAL GUNS—*concluded*. (FIGS. 455 TO 476).

FROM the complete descriptions given in previous articles of the 6-in. and 8-in. naval guns and their mounts, the other naval guns and their mounts will readily be understood from their designs with only a short description of any points essentially different from any of those previously described.

4-*In. Breechloading Rifle.*—This gun, Fig. 455, is 40 calibres in length and weighs 1.5 tons. As the weight of its projectile is 33 lb., the ratio of the weight of the latter to the weight of the gun is only 1 to 102, being relatively the lightest in the service, or firing relatively the heaviest projectile of any of the navy guns. In construction it is very simple, consisting of a tube, jacket, sleeve, and a locking ring. Although it is a small gun it is designed to be mounted by means of a saddle instead



10-IN. HOOPED BREECHLOADING NAVAL GUN.



12-IN. HOOPED BREECHLOADING NAVAL GUN.

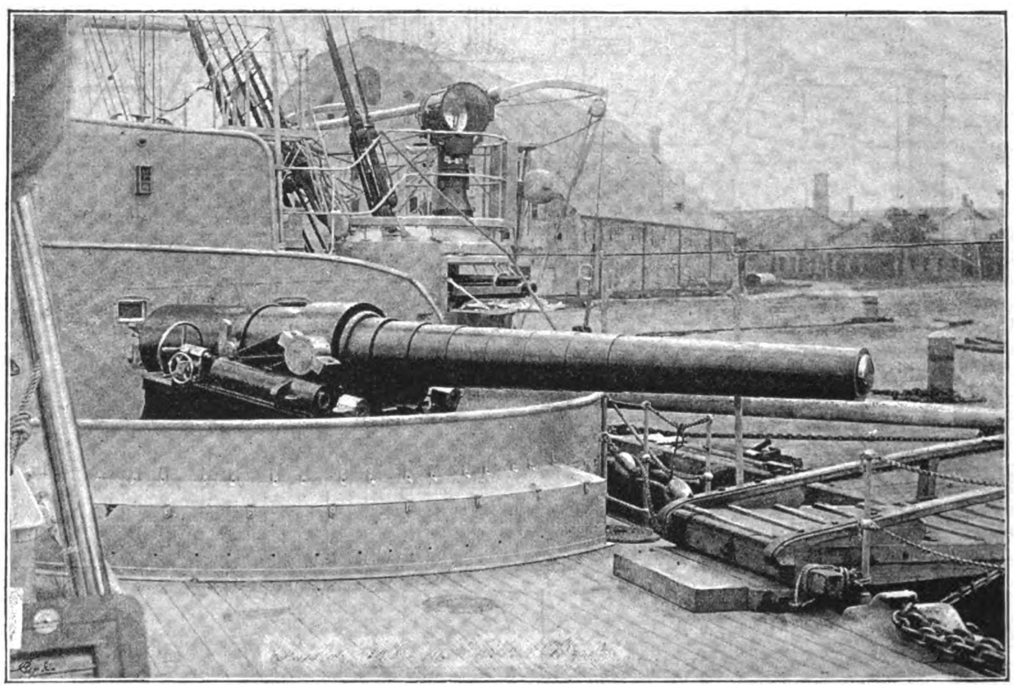


FIG. 476. 8-IN. NAVAL GUN AND CARRIAGE.

of trunnions. Its ballistic qualities will be found in Table XXXIX.

5-*In. Breechloading Rifle.*—The 5-in. breechloading rifle, Fig. 456 (weight 6200 lb.) is precisely the same in construction as the 6-in. gun already described,* differing only in its size. Its breech mechanism is similar to that of the 6-in. breech-

* See page 99 *ante*.

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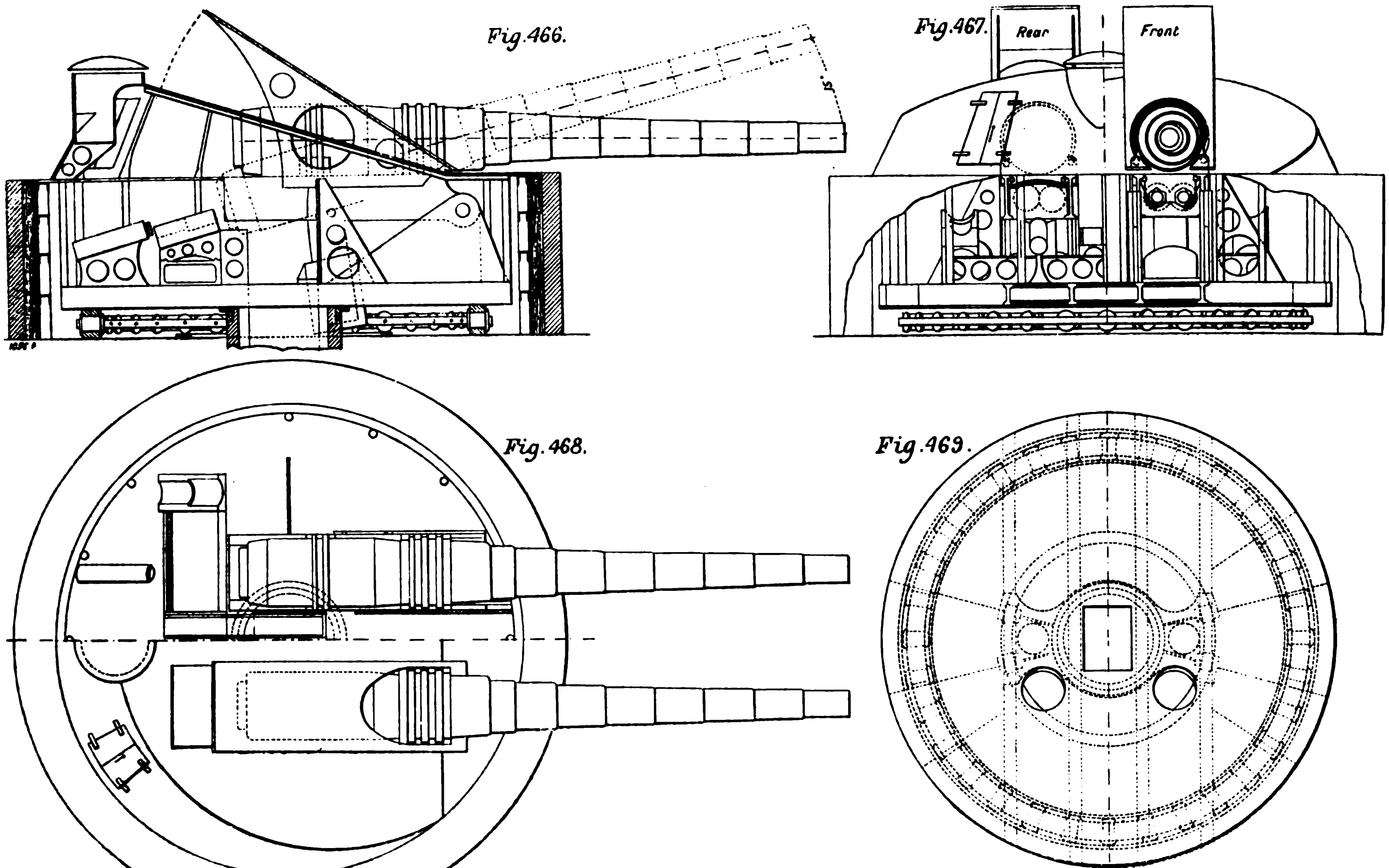
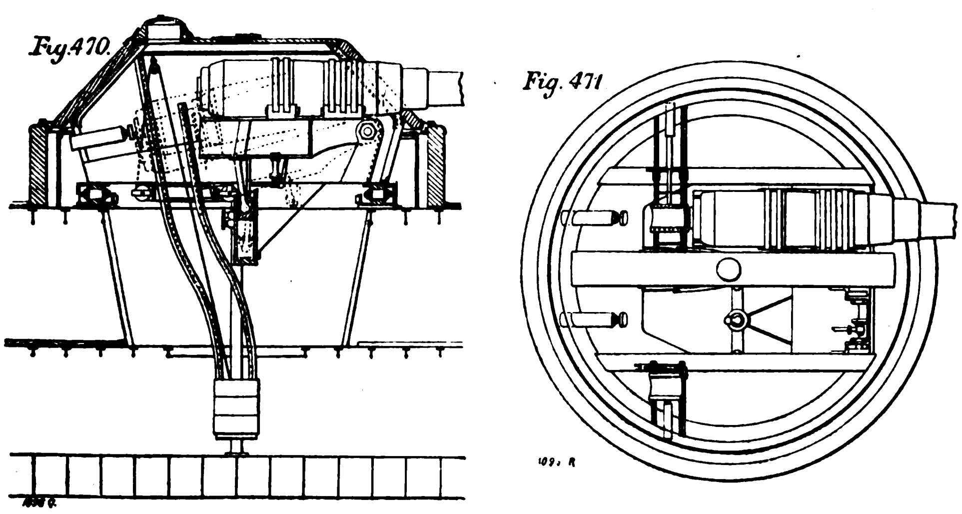
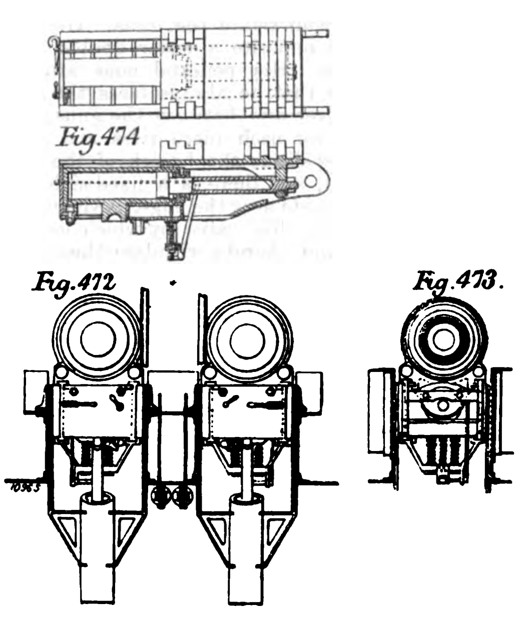


BARBETTE MOUNT FOR 10-IN. AND 12-IN. NAVAL GUNS.



TURRET MOUNT FOR MONITORS; 10-IN. NAVAL GUN.



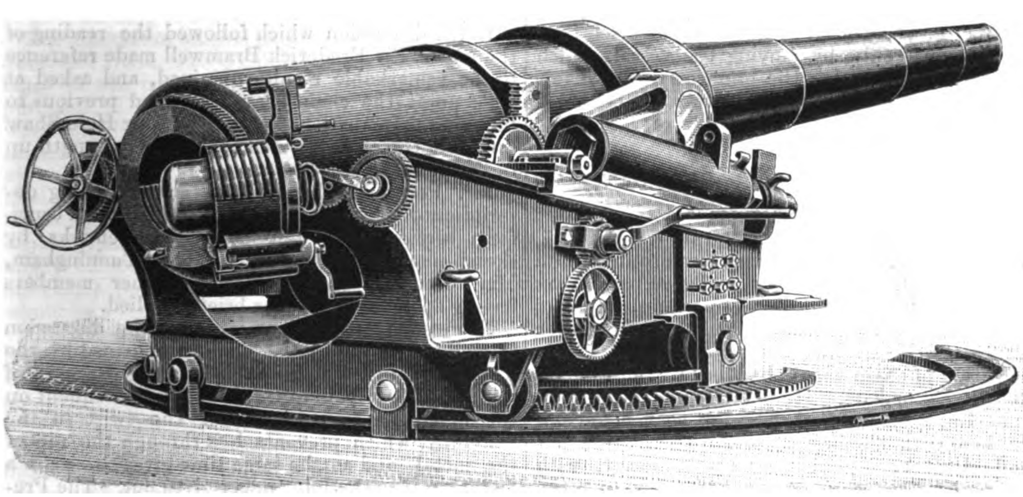


FIG. 475. 10-IN. NAVAL GUN AND CARRIAGE.

loading rifle.* The block is rotated and withdrawn by hand, being supported, when withdrawn, by the tray. The vent cover is made so that when the handle is raised to unlock the block, the ratchet engages in teeth on the cover, forcing it down and covering the vent. When the handle is lowered to lock the block, the vent cover is raised so that a primer can be inserted.

10-*In. Breechloading Rifle.* — There are five designs of the 10-in. breechloading rifle differing from each principally in length and details of hooping. Mark I. of 30 calibres is shown in Fig. 457 (weight 25.7 tons).

Of Mark I. of 35 calibres there are two designs

* See page 128 *ante*.

differing from each other mainly in exterior form. The first is the lighter and weighs 27.1 tons, while the second weighs 28.2 tons. Besides these there are two designs of Mark II., one of 30 calibres and one of 35 calibres, weighing 25.1 and 27.6 tons respectively.

12-*In. Breechloading Rifle.*—This is next to the largest navy gun built, weighing 45.2 tons, and being 37 calibres in length. It fires a projectile weighing 850 lb. with a muzzle velocity of 2100 ft. per second, or an energy of 26,000 foot-tons. At the muzzle it can pierce 24 in. of steel, and at 1500 yards it can still pierce 21 in. Two of these guns are to be mounted in the turrets of the new coast defence vessel Monterey now fitting out at San Francisco (see Fig. 458).

13-*In. Breechloading Rifle.*—This gun is probably the largest gun that will be used in the United States Navy. It weighs 60½ tons, is 43 ft. long, and at the breech is 4 ft. in diameter. With a charge of 550 lb. of powder it fires a 1100-lb. shell, with a muzzle velocity of 2100 ft. per second, or with a muzzle energy of 33,627 foot-tons. At the muzzle it can penetrate 26.6 in. of steel, and at a distance of a mile 23 in., so that there is no vessel yet built, or likely to be built, which carries sufficiently thick armour to prevent complete penetration by the 13-in. gun.

16-*In. Breechloading Rifle.*—A 16-in. gun has, however, been designed, Fig. 459. It will be 42.6 ft. in length, will weigh 110 tons, and will fire a projectile of one ton in weight. It is very doubtful if this gun will ever be built.

TABLE XXXIX.—Ballistic Particulars of Breechloading Guns of the United States Navy.

—		4-In. Breech-loading Rifle.	5-In. Breech-loading Rifle.	10-In., Mark I., 30 Calibres.	10-In., Mark I., 35 Calibres.	10-In., Mark II., 30 Calibres.	10-In., Mark II., 35 Calibres.	12-In. Breech-loading Rifle.	13-In. Breech-loading Rifle.
Calibre	in.	4	5	10	10	10	10	12	13
Weight	lb.	3380	6190	57,500	60,660 / 63,100	56,400	61,900	101,300	135.500
„	tons	1.5	2.8	25.7	27.1 / 28.2	25.1	27.6	45.2	60.5
Total length	ft.	13 7	13.5	27.4	30.5	27 4	31.2	36.8	40
Maximum diameter of gun body	in.	13	18	40	40	39	39	45	49
Total length of bore	„	157.29	150.27	306.26	343.76	307.26	354 91	419.2	454.46
Length of rifling	„	130.29	120.75	247.26	283 76	247.26	294.91	343.12	370.46
Twist „		0 to 1 in 25	1 in 180 to 1 in 30	1 in 180 to 1 in 35	0 to 1 in 25	0 to 1 in 26.8	0 to 1 in 25	0 to 1 in 25	0 to 1 in 25
Grooves — Number		30	20	40	40	40	40	48	52
Grooves — Width	in	.279	.485 / .436	.485 / .435	.485 / .415	.485 / .415	.485 / .415	.485 / .415	.485 / .415
Grooves — Depth	„	.025	.05	.05	.05	.05	.05	.05	.05
Chamber — Length	„	24.74	27.07	57.17	57.17	57.17	57.17	74.14	80.88
Chamber — Diameter	„	4.30	6.5	12.5	12.5	12 5	12.5	14.5	15.5
Chamber — Capacity	cub. in	367	899	6380	6880	6831	6831	12,043	15,059
Capacity of bore	„	2037	3326	26,639	29,480	26,590	30,3[illegible]0	51,355	64,857
Travel of projectile	in.	132.55	123.20	250.43	286.93	250.43	298.08	316.06	373 58
Weight of charge	lb.	12 to 14	26 to 29	225 to 240	225 to 240	225 to 240	225 to 240	425	550
„ projectile	„	33	60	500	500	500	500	850	1100
Ratio of weight of projectile to weight of gun		1/102	1/103	1/115	1/121 / 1/126	1/113	1/124	1/119	1/123
Pressure	tons	15	15	15	15	15	15	15	15
Muzzle velocity	ft.-sec.	2000	2000	2,000	2,080	2,000	2,100	2,100	2,100
Remaining velocity at 1000 yds.		1651	1697	1,848	1,922	1,848	1,940	1,961	1,977
Remaining velocity at 1500 „		1501	1563	1,777	1,848	1,777	1,865	1,900	1,918
Remaining velocity at 2000 „		1364	1439	1,708	1,777	1,708	1,793	1 837	1,860
Remaining velocity at 2500 „		1246	1323	1,642	1,707	1,642	1,724	1,777	1,805
Muzzle energy	ft.-tons	915	1660	13,864	14,996	13,864	15,285	25,985	33,627
Thickness of steel which shell will perforate at muzzle		7.18	8.67	18.75	19.83	18.75	20.10	24.16	26.66
Thickness of steel which shell will perforate at 1500 yards		4.77	6.09	15.84	16.75	15.84	16.97	20.94	23.42

Mountings for Naval Guns.

The carriages for the guns described above are shown in Figs. 460 to 475. The 5-in. gravity return broadside carriage is precisely the same as the 6-in. carriage, except that it has eight instead of ten rollers between the top carriage and slide (Figs. 460 to 463). The designs for 10-in., 12-in., and 13-in. mounts are similar to each other, the main difference being in weight. Several designs are shown in Figs. 466 to 469, and Figs. 475 and 476. The turret mounts are quite different in principle from the mounts previously described.

Above the centre of each turret rises a low dome heavily armoured, having small horizontal slits cut through. This dome is the conning-tower, in which stands the officer commanding the turret—the captain in the forward turret and the executive officer in the aft one. Near at his feet, on a pedestal, sits the lieutenant who sights the guns. His low seat brings his eye opposite a wider double slit, shaped like a cross. His pedestal goes around with the turret, so that he always faces the slit, which is directly over and between the guns. A movable sight-bar for each piece rises and falls opposite the sighting slit as the breech of the gun is raised or lowered, and there is a fixed sight on top of the turret outside near the edge. Alongside of this officer is a dial-like valve by which he can lower the breech and thereby regulate the range of the gun; and in each hand he holds what looks like a rubber bulb, by pressing which he makes an electric contact which fires the gun.

In this same chamber, above the guns, is the lever that revolves the turret, and is worked by the gun pointer. This enormous mass of steel and iron can be made to revolve as fast as one revolution in 40 seconds. This is sufficiently rapid for any emergency, since one gun can be discharged in one direction, and in 20 or 30 seconds the other can be discharged in the opposite direction. The guns, of course, turn with the turret.

In the loading chamber below the turret is found the machinery for hoisting the ammunition to the gun. This machinery revolves also with the turret, and therefore the guns can be loaded in any position, which is a great advantage over turrets which require the guns to be brought to a fixed spot, when they are to be loaded. This ability to load in any position is very important, since the turret during loading can be turned away from the enemy, and thus the guns, which project half their length outside of the turret are protected from injury which might be inflicted upon them by the projectiles of a rapid-firing gun. For each gun there is an ammunition hoist, composed of a truck containing two cylinders, one above the other. When it is at the foot of the hoist a shell is brought to the door of the shell-room by a differential tackle travelling in an overhead slide the whole length of the shell room. When this tackle is hooked to the shell carrier, the shell automatically drops from the upright position in which it is stowed to a horizontal position, and is then run to the shell-room door by the overhead slide. There it loads on a trolley that points it into the lower cylinder of the lift. On the other side of the midship line is the magazine where are stowed the copper cylinder tanks containing the powder charges. Each tank holds half a full charge, so that two are emptied, and the cartridges passed into the upper cylinder of the lift. This latter is hoisted into the turret by a hydraulic ram working a multiplying tackle. This is, in effect, the Canet system.

The breech of each gun is raised and lowered as if it were a feather by a huge hydraulic ram, which raises not only the gun, but the carriage and slide also. An elevation of 14 deg. can be given to the guns, and when in this position they are directly in line with hydraulic rams which shove the projectiles and cartridges home. The two guns in each turret are separated by a 1-in. thick steel partition, which has an opening by which a man can pass from one partition to the other.

Alongside this partition is a strong car travelling on rails. It may be run across directly in line with the breech of the gun at the loading elevation, and is intended to receive the great steel breech-blocks, which weigh 1000 lb. each.

The recoil is checked in a distance of about 3 ft., and the gun at once automatically returned to battery. Figs. 464 and 465 and Figs. 470 to 474 illustrate turret mountings.

The pneumatic dynamite gun, described in a previous article in connection with army guns, is also used on one vessel in the navy—the United States steamship Vesuvius. These guns are 15 in. in calibre and 55 ft. long; three of them are placed side by side in the bow of the vessel, their muzzles protruding just above the upper deck. They are mounted at a fixed angle of elevation, and consequently the range is regulated by changing the air pressure. Being rigidly fixed to the vessel, they can be aimed only by moving the vessel, which is therefore practically the gun carriage. Their action is about the same as that described before.

THE BRITISH ASSOCIATION.

(*Continued from page 227.*)

Testing Small Chains.

The last paper read on Monday was a contribution by Professor H. S. Hele-Shaw, and gave particulars of experiments he had made to test the strength of small chains. The occasion which led the author to follow up this subject was the testing of a new description of chain which had been submitted to him by the makers. He had found the results obtained so remarkable that he had wished to compare them with standard figures. These were not found altogether suitable, and the author, with characteristic thoroughness, set to work to make his own experiments. The result was that the new chain—which is an American invention, and is known as the "Triumph" chain—proved far stronger than anything yet produced. For instance, samples of English welded chain of .223 in. in diameter (.039 square inch area) had an average strength of 1991 lb. The "Triumph" chain of .22 in. in diameter (.038 square inch area) gave an average strength of 3773 lb. The chain in question is made by special machinery and has a twisted joint to the links so that there is no welding. The gist of the invention naturally lies in the machine by which the link is made. This is a remarkably ingenious piece of mechanism, and we shall deal with it more fully at a later date. In the mean time it may suffice to state that a beautifully flexible chain is produced and there are no projecting ends, although, as stated, there is no welding. Samples of the chain of various sizes were handed round at the meeting. The absence of welding enables almost the full original strength of the whole area of metal to be maintained; and, again in consequence of the absence of welding, a high-carbon steel of great strength can be used if necessary, a fact pointed out by Mr. Jeremiah Head in the course of the discussion which followed the reading of the paper. The tests quoted by the author showed that the strength of the chain was about 1¾ times the strength of a single section of the wire from which it was made; so that on the link (forming, of course, a double wire) there was but a loss of 12½ per cent. As the chain invariably gave way in the straight, it is not quite clear why there should be this loss, unless it is to be accounted for by the difference that one nearly always finds between calculated and observed results. The manufacture has chiefly been confined to smaller sizes, but it was stated that a ¾-in. chain had been made, having a breaking strain of nearly 35 tons.

In the discussion which followed the reading of the paper, Sir Frederick Bramwell made reference to the remarkable results obtained, and asked at what point the chain became injured previous to breaking. In answer to this, Professor Hele-Shaw said that the chain seemed to keep its strength up to the point of breaking.

Mr. Perry F. Nursey gave an interesting description of the manufacture of chain from cruciform section bars, illustrating his remarks by sketches on the blackboard. Colonel Cunningham, Mr. Jeremiah Head, and some other members having spoken, the author briefly replied.

Professor Unwin in summing up the discussion also alluded to the great advantage gained by the form of the link which enabled the full strength of the wire being maintained. This is consequent on the ingenious arrangement of the twist in the fastening, which prevents loss through the nip of the metal, and at the same time gives so secure a fastening that the joint never gives out. The Pre-

MODERN UNITED STATES ARTILLERY; 12-IN. 52-TON GUN.

(*For Description, see Page 286.*)

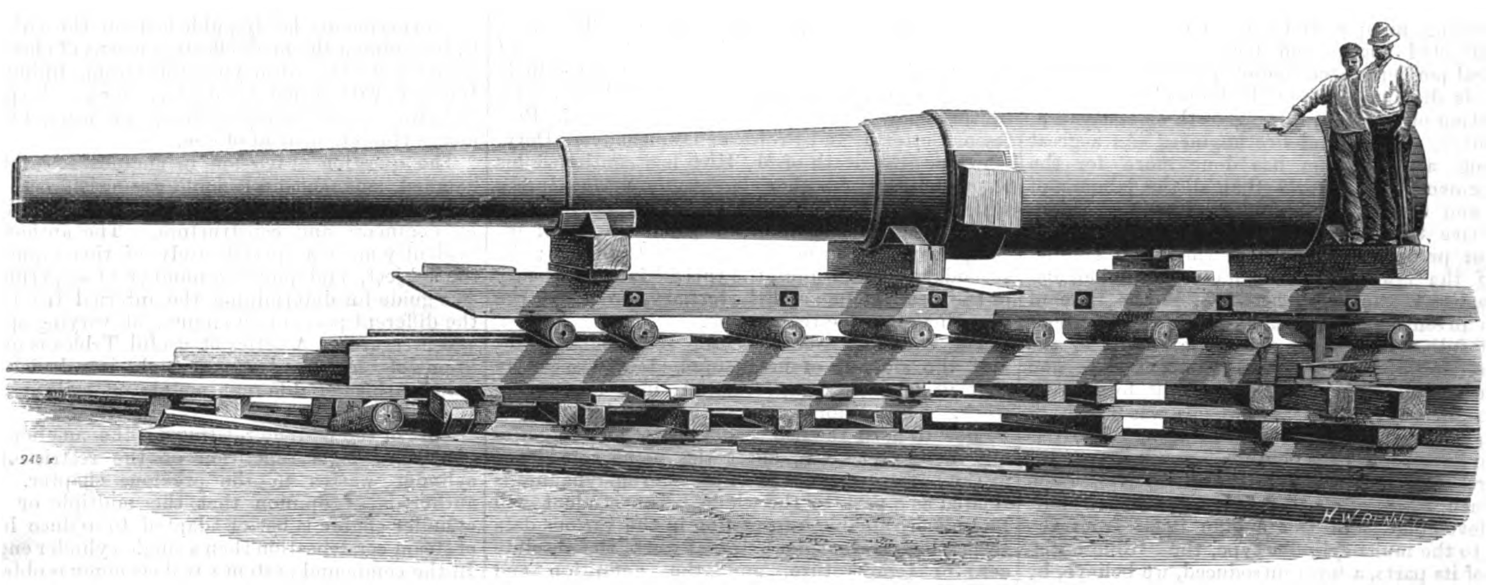
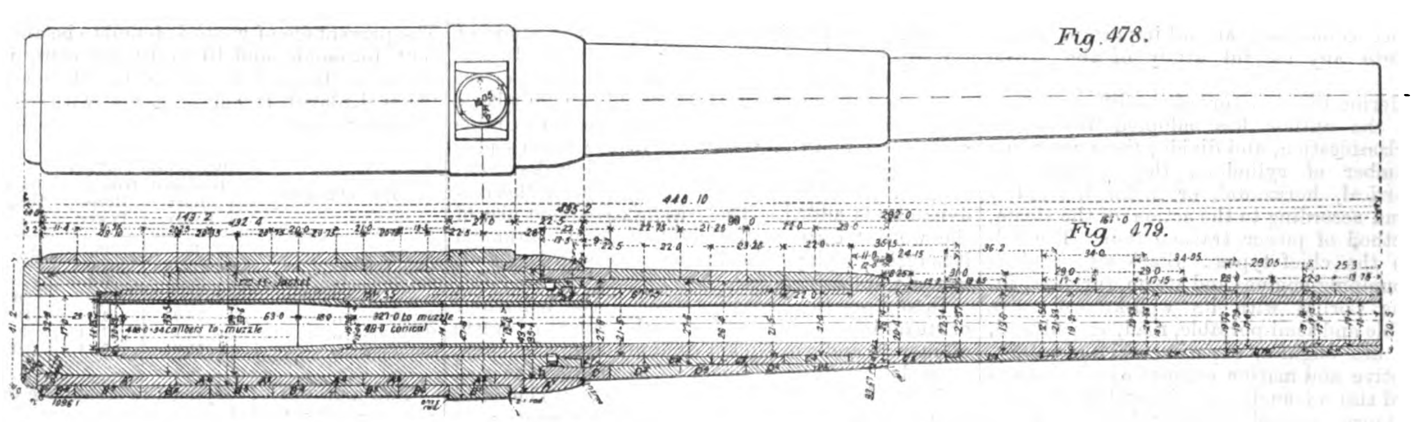
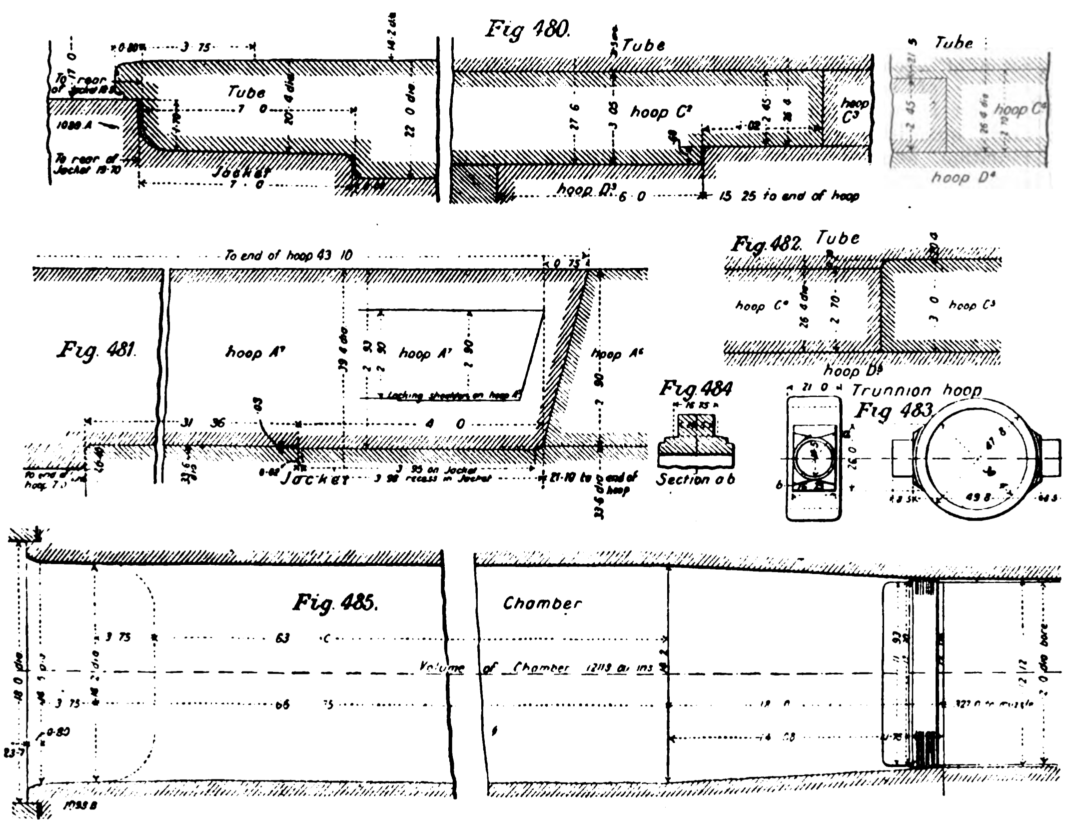
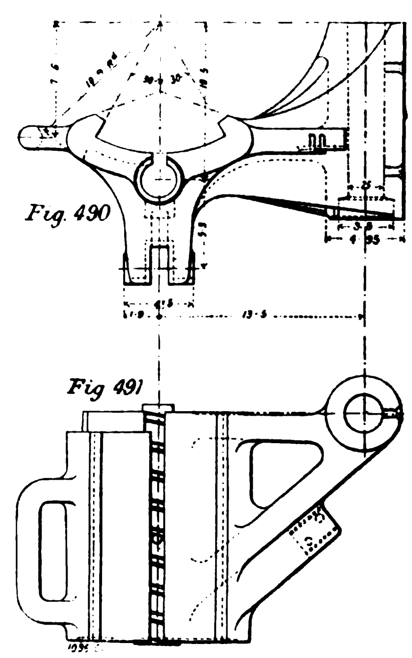


FIG. 477.







In the second volume the author treats his subject less from a theoretical and more from a practical point of view, better suited to constructors and engineers. In the general design of a steam engine the selection of a good type with careful balancing of the parts is, he considers, of great importance. The materials of the structure, distribution of the work, different types of pistons, connecting-rods, crank-pins, condensers, valve gear, flywheels, propellers, paddle-wheels, &c., and all the principal parts of land and marine engines are passed in review and illustrated by good drawings. The size of boilers, chimneys, flues, and grates, and rates of evaporation do not appear strictly relevant to "the design of a steam engine," and the diagrams at page 60, vol. ii., showing the ideal and actual expansion in compound and triple engines, would have been better placed in the first

MODERN UNITED STATES ARTILLERY; 12-IN. 52-TON GUN.

(*For Description, see Page 286.*)

Fig. 486

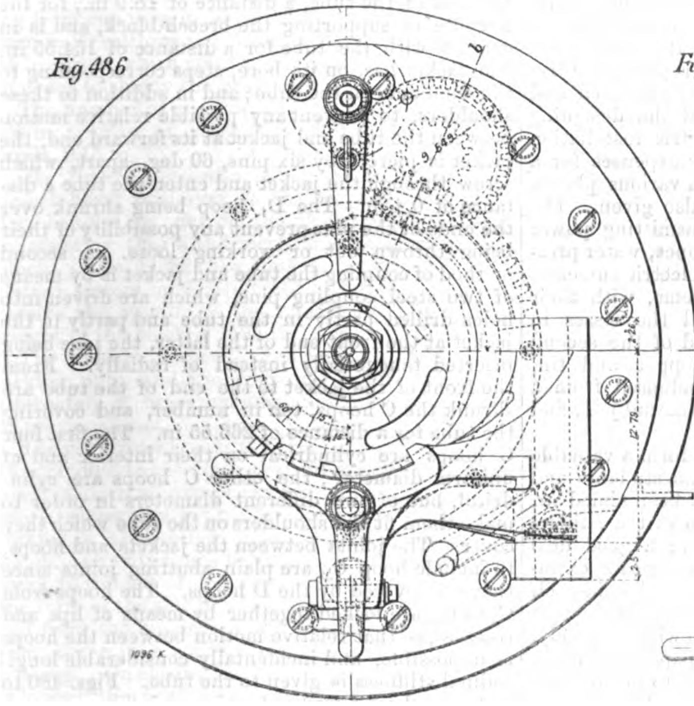


Fig. 488 Fig. 487.

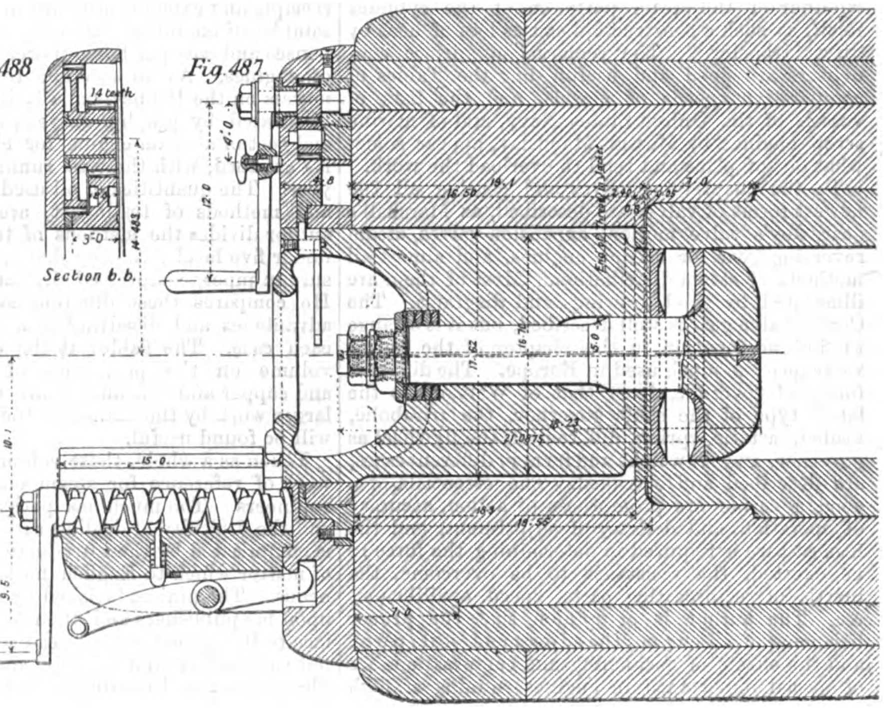


Fig. 489.

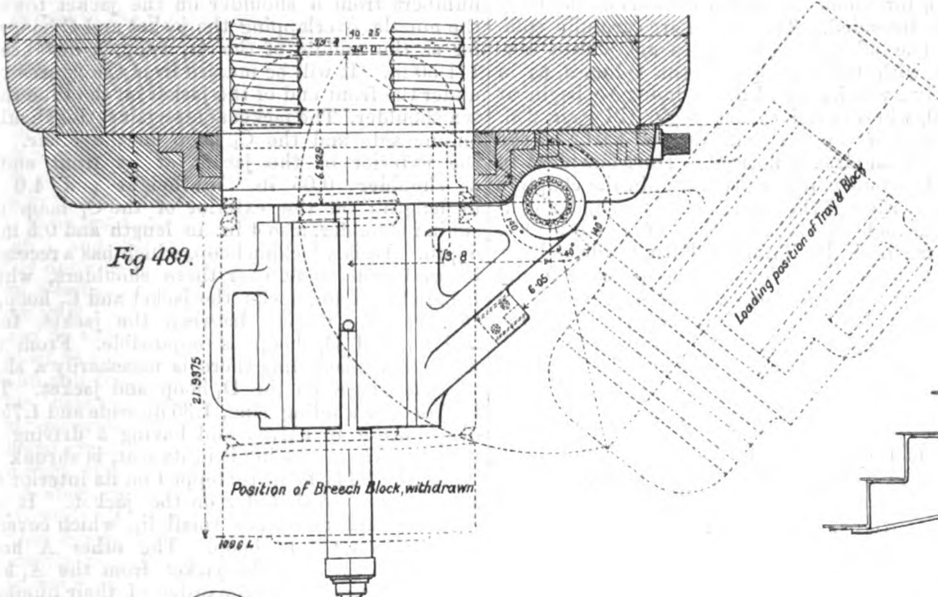


Fig. 493. Rear Elevation.

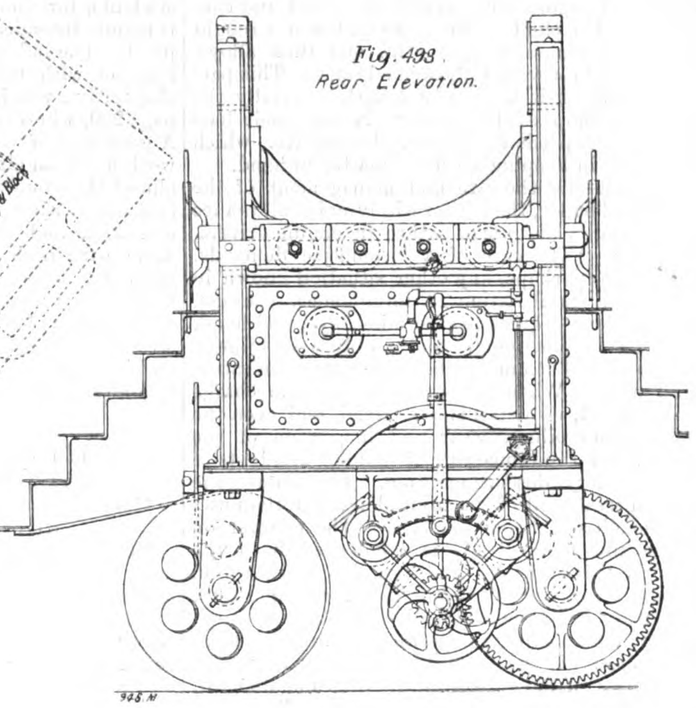
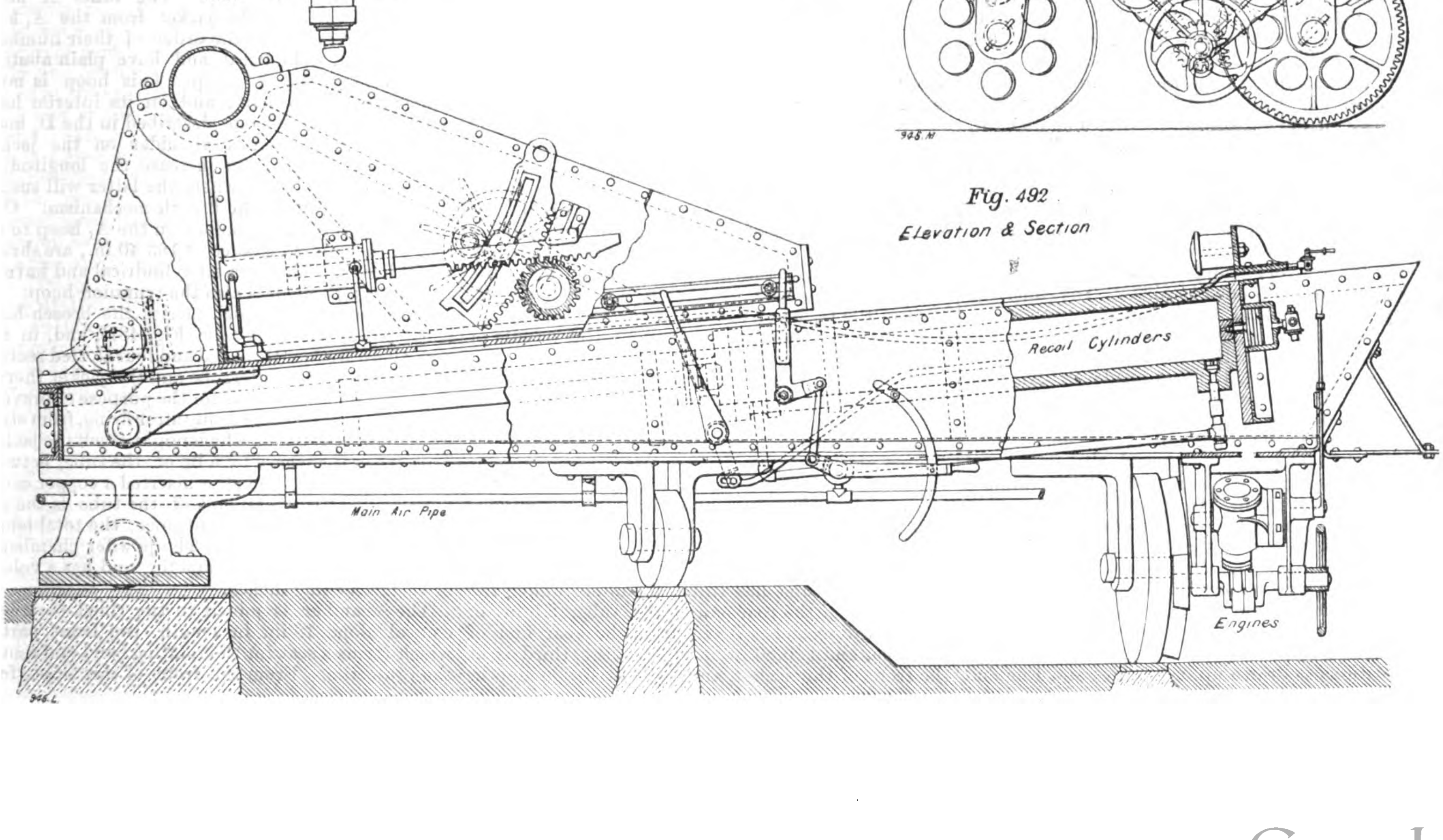


Fig. 492 Elevation & Section



volume, where the subject is discussed at length. Concerning the construction of the exhaus steam passages, the author says: "Exhaust steam passages should not be permitted to traverse the cylinder in contact with the walls of steam spaces, whether of the steam parts or of the cylinder itself, as such a construction causes loss of heat by direct transfer." The remarks on surface condensers are good and useful, but the Tables of comparative speeds of vessels, and the lists of vessels of the United States Navy, and of marine screw engines by Messrs. Maudslay, appear somewhat out of place and tend to overload the work.

In the chapter on valves and gearing all the newest forms of valves are described, as Marshall's gear, Joy's valve motion, expansion valves, steam reversing gear for marine engines, and almost all methods of steam distribution. Most of them are illustrated by good drawings and diagrams. The Corliss valve gear is well described, but it is strange to find no mention in this chapter of the Sulzer valve gear, so much used in Europe. The different forms of governor, from that of Watt up to the latest type of the shaft governor, the parabolic, loaded, astatic, spring, differential, the flywheel as governor, and its weight and form in different cases, are described and classified. The essentials of a good governor are promptness of action, accuracy of operation, and delicacy of adjustment, and the utmost care is required in determining the force to be exerted, the resistance to be overcome, the inertia of reciprocating parts, speed, equilibrium, &c. The author is of opinion that the proper balancing of an engine, the adjustment of its parts, and the effects of cushioning and compression, are of special importance in engines running at high speeds.

The materials to be used for the actual construction of an engine are carefully reviewed and considered. The chief of these are cast iron, wrought iron, steel, brass, copper, tin, and their alloys, manganese-bronze and phosphor-bronze. This part of the subject is treated at length, specially the details of shop steel cutting tools and their hardening, and speeds for boring, planing, &c., which are hardly in keeping with the matter in hand.

In discussing the care and management of the engine and boiler, the author wisely makes allowance for the frailty of human nature in engine-drivers. He says: "The care of a locomotive demands, more than, perhaps, any other situation known in civil life, a combination of intelligence, courage, self-confidence, quickness of mind, eye, and hand, readiness in emergency, and absolute steadiness, such as should command the respect and admiration of all men." When the importance of the charge is considered, no detail is too trivial, and even the packing and oiling, wear and inspection of the engine, and the remedying of sudden accidents to the machinery, deserve mention. The hints on the hospital treatment of the injured are doubtless useful, though a little out of place. The chapter on engine and boiler trials is condensed from the author's "Handbook," and contains much useful advice for carrying out tests. Too much importance can hardly be attached to all the details required to make up a complete experiment, the precautions to be observed, the irregularities avoided, and the correctness of the apparatus and instruments used, especially the indicators and springs. There are various kinds of tests, calorimetric, brake, &c., and different calorimeters are used for testing the quality of the steam or the amount of moisture it contains. The directions given for making a trial, measurement of temperatures, and other instructions are very complete, and in the appendix blank forms are subjoined to fill in. The American Society of Mechanical Engineers has proposed a standard system of conducting trials of engines and boilers, to which the author refers, and he describes in detail many actual trials made in America and England. There are two methods of testing an engine, used separately or together in most trials. In the first, the amount of heat energy supplied by the boiler; in the second, the amount of heat energy rejected by the exhaust. Hirn combined the two, and was the first to exhibit a balance-sheet of the heat going into and coming out of an engine, which has since been very largely adopted.

It is, we believe, the first time that space has been devoted, in a work of this kind, to specifications and contracts, though they are very important from a purchaser's point of view. The author wishes to leave nothing to chance or uncertainty. Specifications as drawn up in America and England are given for the various types of engine, showing the quality of the materials to be used, as iron, bronze, alloys, and tests by an expert for verification and acceptance of the contract are described in detail. Questions of finance, costs and economies, receipts and expenditure, are analysed, and blank samples of engine accounts are given, showing expenses and cost per horse-power of different kinds of engines. As an example the repairs and renewals on the Pennsylvania Railway are cited and illustrated by graphic curves; and the designing and cost of a steam engine for electric installation is described, with the total running expenses for a year. The quantities of oil used in various places, and methods of testing it, are also given. The author divides the methods of transmitting power under five heads, viz., by shafts, ropes, water pressure in pipes, compressed air, and electric currents. He compares these different systems, with their advantages and disadvantages, and the losses in each case. The Tables at the end of the second volume on the properties of copper and tin, and copper and zinc alloys, are condensed from a larger work by the author on the same subject, and will be found useful.

Taken as a whole, these volumes form a valuable work of reference for steam engine students and engineers. Too much has perhaps been aimed at, and the difficulty of dealing with so vast a subject is complicated by the introduction of a good deal of matter which to English notions appears extraneous. The praises lavished by the author himself upon his publishers and their assistants in the preface to the second volume read somewhat strangely, but the book is well got up, and paper, printing, illustrations, and binding leave little to be desired. The price of the work is rather high, and two pounds will appear a large sum for young engineering students, for whom the author informs us the book is mainly intended. The Tables are carefully compiled. The index, however, does not always correspond with the contents of the volumes, as in chapter iv., vol. i., stated in the index to begin at page 290, whereas it does not begin till page 296. A good deal of repetition in various parts of the work has been already noticed. The same ideas in almost the same words are repeated in the chapters (vol. i.) treating of the restriction of cylinder condensation and the amelioration of wastes. The same paragraph beginning "Hirn published his memoirs," occurs word for word on pages 269 and 624 of vol. i., and at pages 672 and 673, vol. i., a page and a half, beginning "superheating the steam," will be found verbatim again on pages 598 and 599. These defects will doubtless be remedied in a later edition.

MODERN UNITED STATES ARTILLERY.—No. XXIII.

United States Army 12-In. Breechloading Rifle. (Figs. 477 to 492.)

The largest gun yet built for the United States army is the 12-in. breechloading rifle, which weighs 52 tons (see Fig. 477).

The gun is composed of the following parts: One tube; one jacket; ten C hoops; five D hoops; seven A hoops; eight B hoops; one filling ring; one copper caulking ring; two coupling pins; the various parts of the breech mechanism.

The tube is 416.3 in. in length, and varies in thickness of walls from 3.9 in. over the powder chamber to 2.55 in. at the muzzle. This reduction is given by a series of steps or shoulders. Under the C_1, C_2, and C_3 hoops the diameter of the tube is uniform, but, at the front end of the C_3 hoop, the diameter is reduced by a step 0.50 in. At the front of the C_4 hoop there is a similar shoulder; the remaining shoulders are under the middle of the other C hoops.

At the breech end of the tube (Fig. 479) will be noticed a lining tube which extends over the powder and shot chambers to a distance of 160 in. This tube is to be inserted in the manner shown, after that portion of the bore has been so eroded as to render the gun practically useless. By this means it is expected that the life of the gun can be considerably increased. The total length of the bore from the head of the mushroom to the muzzle is 408 in. or 34 calibres. In addition to the shoulders under the C hoops the tube has three shoulders under the jacket, one at the rear end of the tube, 2.5 in. in depth; the second is 7.8 in. from the rear end of the tube, and is 0.80 in. in depth; the third is at the front of the jacket, and is 0.25 in. in depth. These shoulders are for the purpose of distributing the longitudinal strain between the tube and jacket, and to reduce the diameter of the bore of the jacket in rear sufficiently to receive the breech-block.

The jacket is 173.45 in. in length and projects to the rear of the tube, a distance of 18.9 in., for the purpose of supporting the breech-block, and is in contact with the tube for a distance of 154.55 in. The jacket has, on its bore, steps corresponding to the shoulders on the tube; and in addition to these shoulders, to prevent any possible relative motion between the tube and jacket at its forward end, the jacket is pierced by six pins, 60 deg. apart, which screw through the jacket and enter the tube a distance of 0.4 in. The D_1 hoop being shrunk over the ends of the pins prevent any possibility of their being thrown out or working loose. A second method of coupling the tube and jacket is by means of two steel coupling pins, which are driven into holes drilled partly in the tube and partly in the jacket at the front end of the latter, the pins being inserted tangentially instead of radially. From the front of the jacket to the end of the tube are shrunk the C hoops, ten in number, and covering the tube for a distance of 266.55 in. The first four C hoops are cylindrical on their interior and of uniform diameter; the other C hoops are cylindrical, but of two different diameters in order to make them fit the shoulders on the tube which they cover. The joints between the jackets and hoops, to include hoop C_5, are plain abutting joints since they are covered by the D hoops. The hoops from C_5 to C_{10} are locked together by means of lips and recesses, so that relative motion between the hoops is impossible, and incidentally considerable longitudinal stiffness is given to the tube. Figs. 480 to 482 are enlarged views of various joints.

The five D hoops extend in the order of their numbers from a shoulder on the jacket towards the muzzle, overlapping the jacket and C hoops as far as the middle of the C_5 hoop, a distance of 111.50 in. It will be noticed from the figures that under the front end of the jacket on the tube there is a shoulder. The jacket abuts against this shoulder on one side and the C_1 hoop on the other. On the exterior of the jacket at its front end is a shoulder 0.05 in. in height and 4.0 in. in length; on the exterior of the C_1 hoop is a similar shoulder, also 4 in. in length and 0.5 in. in depth. D_1 is a locking hoop, which has a recess on its underside to fit over these shoulders, which, being shrunk on, locks the jacket and C_1 hoop, so that relative motion between the jacket, tube, and C_1 and D_1 hoop is impossible. From this method of assembling there is necessarily a slight space left between the D_1 hoop and jacket. This is closed by a filling ring, 1.35 in. wide and 1.75 in. deep, made in halves and having a driving fit. Over this ring, securing it in its seat, is shrunk the A_1 hoop. This hoop is stepped on its interior and abuts against a shoulder on the jacket. It also at its forward end has a small lip which covers a shoulder on the D_1 hoop. The other A hoops are shrunk on over the jacket from the A_1 hoop towards the breech in the order of their numbers. They are all cylindrical, and have plain abutting joints except the A_7 hoop. This hoop is much longer than the others, and on its interior has a recess similar to the one described in the D_1 hoop, and is shrunk over a shoulder on the jacket. The object of this is to increase the longitudinal strength of the jacket where the latter will sustain the greatest pull of the breech mechanism. Over the A hoops from a shoulder on the A_1 hoop to the rear of the gun, a distance of 153.40 in., are shrunk the B hoops. They are all cylindrical and have no shoulders; B_1 hoop is also the trunnion hoop.

The screw thread which carries the breech-block is cut on the jacket in rear (Fig. 487), and, in this gun, there are four threaded and four slotted sectors. Between the rear of the tube and the jacket there is a space of 0.05 in. This is for the purpose of preventing the jacket, on contracting after firing, from striking a blow on the tube which might crack the jacket. This space is covered by a lip on the tube, between which lip and the jacket is inserted a copper caulking ring. At the rear end of the tube is the gas-check seat and its taper entrance, the total length of the two being 4.55 in. The powder chamber is 63 in. long, 14.2 in. in diameter, and has a volume of 12,113.5 cubic inches.

The chamber is joined to the rifled bore by a conical slope 18 in. in length, the front part of which forms a seat for the rotating band and centres the projectile. From the front of this slope, for a distance of 48 in., the tops of the lands are made conical, the diameter in rear being 12.06 in. and in front 12 in. This causes the rotating band to be forced more gradually into the rifling and relieve the strain on the band.

The rifling curve is a semi-cubic parabola, increasing from one turn in 50 calibres at the origin to one turn in 25 calibres at a distance from the muzzle of 24 in., from which point to the muzzle it is uniform in order to steady the projectile.

The number of grooves are 72; depth of grooves, .06 in.; width of grooves, 0.3736 in.; width of lands, 0.15 in.

The Breech Mechanism (Figs. 486 to 489).—The breech-block is similar to that of the 10-in. gun. Two handles cut out from the block itself are of use in assisting the withdrawal and rotation of the block. The block has four threaded and four slotted sectors, and is pierced by an axial hole to receive the spindle of the mushroom head. The weight of the block is 1135 lb.

The mushroom head, obturator pad and cups, locking nuts, and the four anti-friction washers, alternately of brass and steel, are similar to those of previous guns.

The vent cover is similar to that of the 10-in. gun. It is pivoted to the block near its upper end and its lower end, in all except the locked position of the block, closes the vent. To open the block it is rotated in a direction opposite to the hands of a watch. Gravity tends to make the vent cover drop away to the left of the vent; this is prevented by the form of the slot in which the vent cover hangs, and from the bearing of the upper surface of the vent cover in a concentric groove in the bronze bushing. On closing the breech, just as the block is locked, the vent cover arrives at the end of the concentric groove, the motion of the upper end of the cover is checked, and consequently the lower end swings to the right clearing the vent.

The rotating ring, which constrains the block to rotate with it by means of a lug engaging in a slotted sector of the block, and yet which allows the block to be withdrawn through it, is similar to that of the 8-in. and 10-in. gun. The means by which the block is rotated is similar to the same device in the 8-in. gun, except on account of the extra weight of the block a compound gearing is used. The translating roller with its double thread, the latch, and the tray are the same as those previously described, with one exception, in the last.

The weight of the block complete and the tray is over 1800 lb., and consequently there is great friction on the tray hinge, and in order to allow the block to rotate freely this tray hinge is provided with an anti-friction bearing.

This bearing consists of a top and a bottom washer separated by an intermediate washer, all of hardened steel. The intermediate washer is separated from the top and bottom washer by separators of steel, each pierced by twenty-four holes to receive and retain in place balls of hardened steel. By this device the friction on the tray hinge is sufficiently reduced to cause the block to revolve freely when on the tray. The breech mechanism is securely held in place by the breech-plate.

The gun of this type has been completed and delivered at the proving ground at Sandy Hook. Experiments are being made to determine a suitable powder. An imported powder proved unsatisfactory, but Messrs. Du Pont have thus far produced a sample which, with a charge of 440 lb., gave to a 1000-lb. projectile, a velocity of 1862 ft. with a pressure much below the limit, and it is expected that they soon will produce a powder that will give the anticipated velocity of 2000 ft. with a pressure of 37,000 lb.

The Midvale Steel Company will furnish armour-piercing projectiles made by the Holtzer process. A large number of forgings for the manufacture of guns of this type at the Government Factory, and a large number of guns to be built at private works, have been ordered.

Ballistic Particulars of the 12-In. Army Breechloading Rifle.

Calibre	...	12 in.
Weight	...	52 tons.
Length	...	36.6 ft.
Length of bore	...	34 calibres.
Twist in number of calibres	breech ...	50
	muzzle ...	25
Number of grooves	...	72
Width ,, ,,	...	.373 in.
Depth ,, ,,	...	.06 ,,
Width of lands	...	.15 ,,
Powder Chamber	Length ...	63 ,,
	Diameter ...	14.2 ,,
Weight of charge	...	440 lb.
,, projectile	...	1000 ,,
Ratio of weight	of charge to weight of projectile ...	1 lb. to 2.2 lb.
	of projectile to weight of piece ...	1 to 116.5 lb.
Initial velocity	...	2000 ft.
Muzzle Energy	Total ...	26.089 ft.-tons.
	Per ton of gun ...	500.7 ,,
	Per pound of powder ...	59.5 ,,

Figs. 492 and 493 are views of a mounting for the 12-in. 52-ton gun.

THE BRITISH ASSOCIATION.

(*Continued from page 259.*)

THE PHYSICAL AND CHEMICAL SECTIONS.

THE expectations of those who looked forward to the Edinburgh meeting with enthusiasm have not been wholly realised. Certainly the conditions of the meeting were excellent, and the weather was extremely favourable. One day of heavy rain was not an unreasonable hardship; the British Association is accustomed to bad weather. Historical reminiscences, educational institutions, Clyde industry, Glasgow municipal administration, and the Forth Bridge presented manifold and unusual attractions at a distance of eight hours' railway journey from London. The attendance rose once more to a little above 2000. But the sum total of the attendances at the section rooms was disappointing, a fact on which the local press did not fail to comment. The excursion committees had been busy; besides afternoon walks—a somewhat novel creation, for which tickets were exacted, and, of course, not required—seventeen excursions had been provided for Saturday and fifteen for Thursday. A smaller number would have saved a great deal of trouble and annoyance and pleased all sides, local secretaries, guides, hosts, and guests, far better.

The sections were all housed in the Old and New University Buildings, within a few minutes' walk of one another Notice boards to announce the number of the paper being read had been placed at the respective entrances, and the attendants would probably have been willing to mark the numbers, if they had been properly instructed. Several sections, notably E (Geographical) and F (Economic Science and Statistics), issued practically complete programmes on Thursday, August 4. Sections A and G could only give a provisional general scheme, and B had to content itself with a list of papers to be read. That the programme of the day can generally be obtained only an hour or two before the commencement of the proceedings, and is not always adhered to afterwards, is not the fault of the secretaries who have an arduous task to perform, for which they receive little acknowledgment. A notice, conspicuous on the journal, says: "No report, paper, or abstract can be inserted in the volume unless the manuscript is in the secretary's hands by 4 P.M. on Wednesday, August 10." Another notice requests members proposing to read papers to forward the same immediately to the secretaries. This second notice is evidently interpreted as meaning that any time will do. Sixty-four papers, comprising many important contributions, and thirty-five electrical papers, were brought before Section A (Mathematical and Physical Science). Very few of the committee reports, not to mention the papers, had been in the hands of the secretaries early enough to allow of abstracts being printed, and not even the day and hour for reading could always be settled in time. Section B (Chemistry) was less overcrowded with papers, but similar difficulties had to be contended against. Probably the convenience of the eminent scientists is studied too much. Without them the meetings would collapse. But it is not conducive to the interests of the Association that papers embodying years of research should be crowded out, finally to be disposed of in literally five minutes.

Notwithstanding the usual amount of grumbling, the proceedings of Section A were decidedly successful. Professor Schuster, F.R.S., of Owens College, Manchester, was a very able president; occasionally, perhaps, he need not have hesitated to rule with that firmness which he has frequently displayed when temporarily occupying the chair. He was well supported by the secretaries, Mr. R. E. Baynes, M.A., of Christ Church, Oxford; the Recorder, Professor A. Lodge, of Cooper's Hill; and Dr. Peddie, of Edinburgh; and by vice-presidents and committee members from the United Kingdom and abroad. The lists of foreign visitors becomes longer every year. Professor von Helmholtz came accompanied by two of his assistants at the Physikalische Reichsanstalt, Drs. Kahle and Lindeck; Professors Du Bois, of Berlin, and Ostwald, of Leipzic, are now well known at the meetings; the latter's co-worker, Dr. Svante Arrhenius, of Stockholm, paid his first visit; Mr. Otto Pettersson, also of Stockholm, had attended at Newcastle. Germany was further represented by Professors Buhler, Goebel, Preyer, Baron von Richthofen, Schmitz, and E. Wiedemann; France by MM. Bertrand, Demoulins, Baron Jules de Guerne, Guillaume, Jules, Manouvrier, Margerie, Oliver, and Richard; Holland and Belgium by Messrs. Errera, Gilson, Hulin, Renard, Schoute, and Snellen; the United States by Messrs. Arthur and Peterson, of La Fayette, Ind., Fassig and Reilly, of Washington, Gould, of Cambridge, Mass., Edmund James and H. M. Cook, of Philadelphia, Michelson, of Chicago, Rotch, of Boston, Smock, of Trenton, N.J., and Tesla, of New York. Professor Rowland did not come, nor did Lord Rayleigh.

PROFESSOR SCHUSTER'S ADDRESS.

Professor Arthur Schuster did not read his excellent address, but delivered it, and he spoke well. His introductory point was well chosen. "A year is too short a time to allow us to form a fair estimate of the value of a scientific investigation. The mushroom which shoots up quickly only to disappear again impresses us more than the slow-growing seedling which will live to be a tree, and it is difficult to recognise the scientific fungus in its early stage." The progress of science formed one of Professor Schuster's themes. At the very outset, however, he made a digression. "At the beginning of this year there came into the world a being so brilliant that he could, without preparation, take up the work of the most eminent man among us. . . No event has ever happened so striking as that which took place on January 1, when the mantle of Sir William Thomson fell on the infant Lord Kelvin." Lord Kelvin was sitting close to the speaker; and we think Professor Schuster need not have imitated those who have eulogised Sir William in his presence in terms as if he were not a great man, but was anxious to be made one. When we contrast, the President continued, "the refined opportunities of a modern research laboratory with the crude conditions under which the experimentalist had to work at the beginning of the century, we may fairly ask ourselves whether it is possible by means of any systematic course of study or by means of any organisation to accelerate our progress into the dark continent of science. Changes are constantly made and proposed in our institutions, alterations in the curriculum of the science schools of our universities, a national laboratory is suggested, and even our Association has not escaped the evil eye of the reformer." Professor Schuster did not follow the latter point up, and thought we might learn from the way in which Nature improves its organisms. He does not wish to see the weakest points selected and attention drawn to failure or to some point in which other nations excel, not at any rate in such a manner that the nourishment for the weaker organs is taken from those parts which we should specially take care to preserve. Each nation possesses its own peculiarities. No country has rivalled France in the domain of accurate measurements; the International Bureau of Weights and Measures has its home at Paris;* the best work of German universities is to follow up a theory to its logical conclusions, and submit it to the test of experiment. The strongest domain in this country has been that of mathematical physics, and excellent work has been done in astronomy, chemistry, biology. "The distinctive feature which separates this from all other countries in the world is the prominent part played by the scientific amateur, and is it not true that our modern system of education tends to destroy the amateur?" An amateur in Professor Schuster's meaning is a man who has had no academical training, at any rate in that branch which

* Much of the work done by this Bureau remains unknown owing to the miserly way in which its publications are circulated. No copies are supplied even to universities for "want of funds." In other words, England, France, and Germany unite together with other nations to do a certain kind of work, but cannot afford to distribute a few copies to the public for whose benefit the work is undertaken.

MOUNTS FOR QUICK-FIRING GUNS.

(*For Description, see Page 566.*)

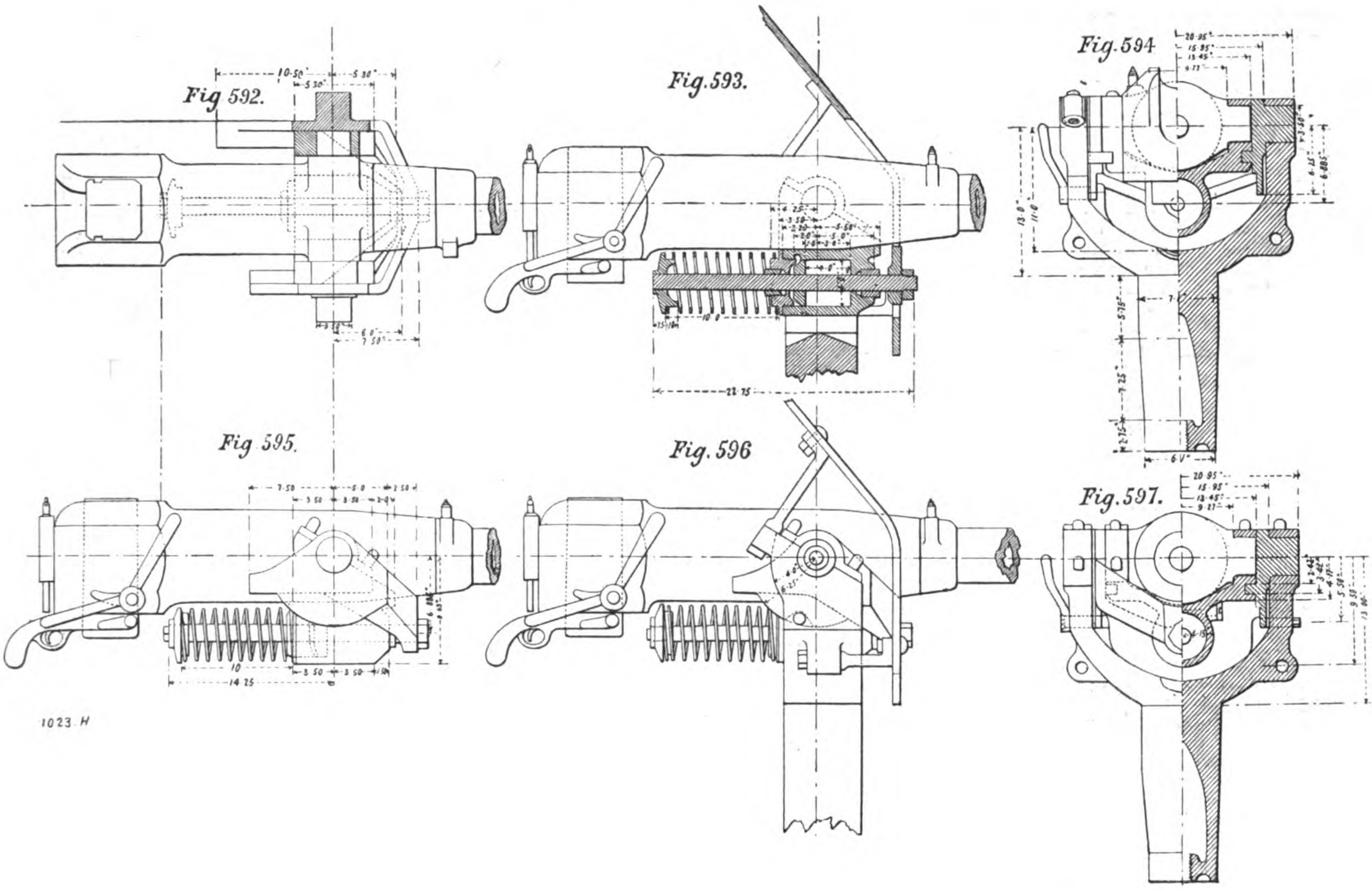


Fig. 592. Fig. 593. Fig. 594. Fig. 595. Fig. 596. Fig. 597.

1023.H

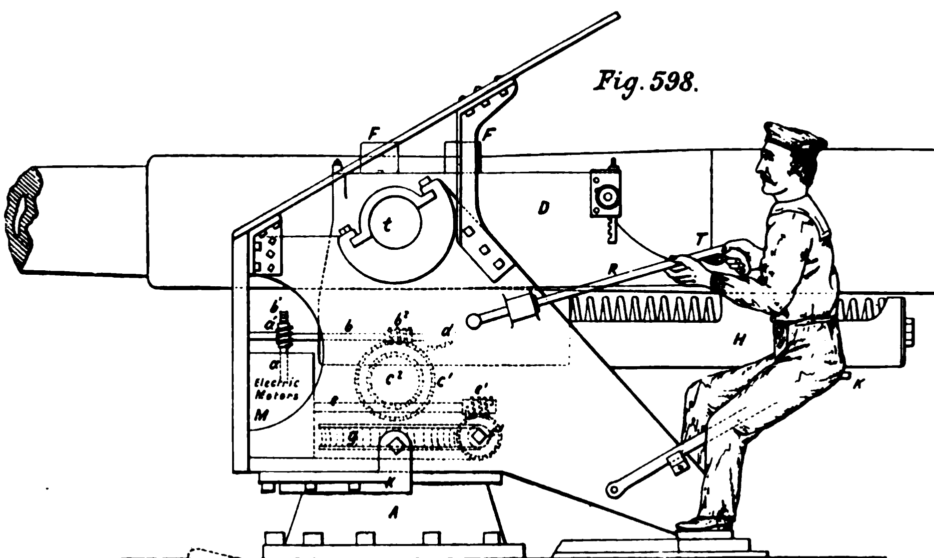


Fig. 598.

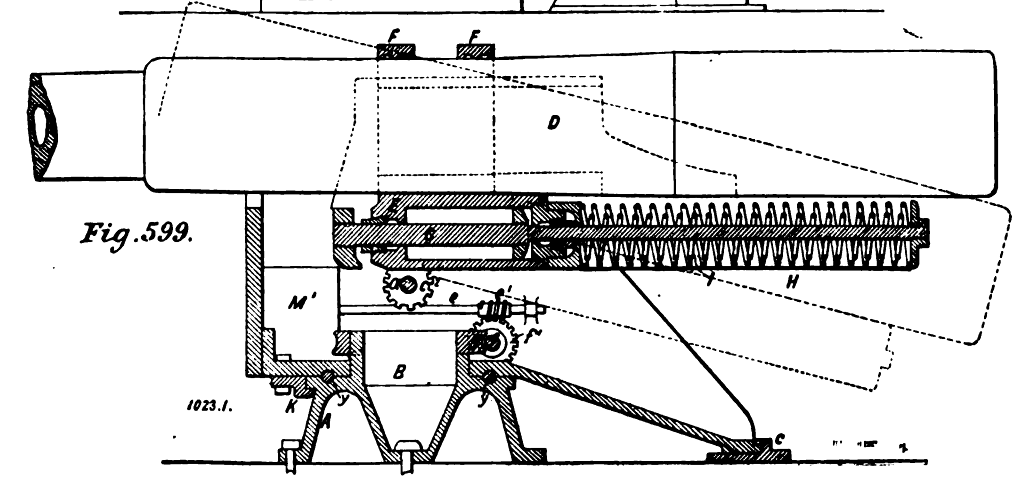


Fig. 599.

1023.I.

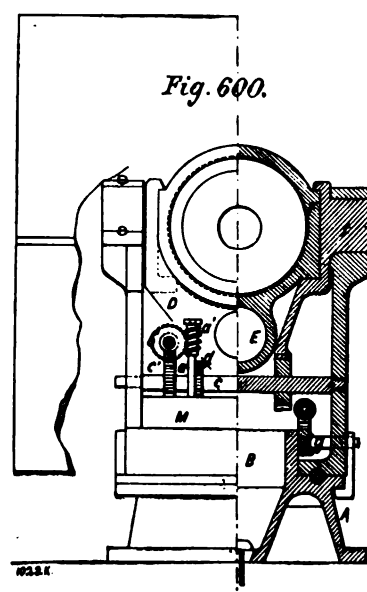


Fig. 600.

Mr. Schönheyder, in reference to what had been said, wished to draw attention to one other point in the paper. It was pointed out that at a speed of about 220 revolutions per minute the cut-off giving the minimum steam consumption with steam in jackets was found to be at one-eighth of the stroke, equal to 4.8 expansions. The consumption of feed water, including jacket water, per indicated horse-power, per hour in this case was 25.2 lb., and the dryness fraction of the steam in the cylinder at release was 96.6 per cent. At the same speed without steam in the jackets, the best cut-off was found to be $\frac{5}{16}$ of the stroke, equal to 2.6 expansions. Here the steam used was 38.7 lb. per indicated horse-power per hour, and the dryness fraction of the steam in the cylinder at release was 73.9 per cent. This seemed to the speaker important, as in so many cases engines required to