MODERN UNITED STATES ARTILLERY.

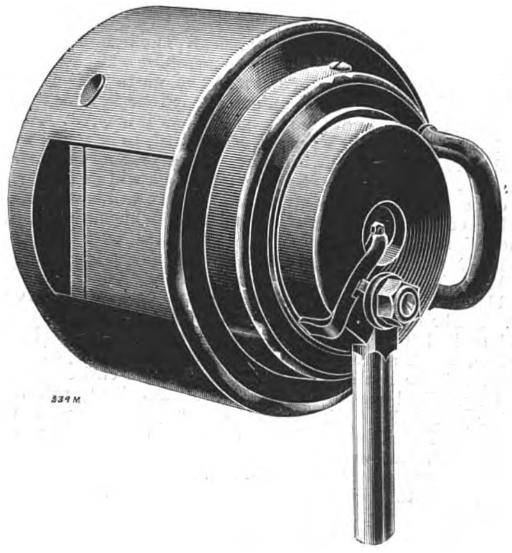


FIG. 165.

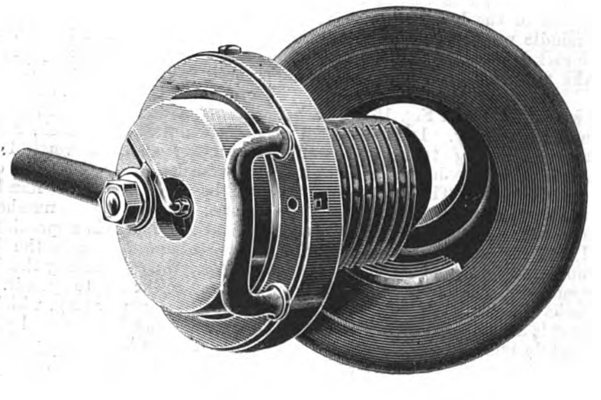


FIG. 166.

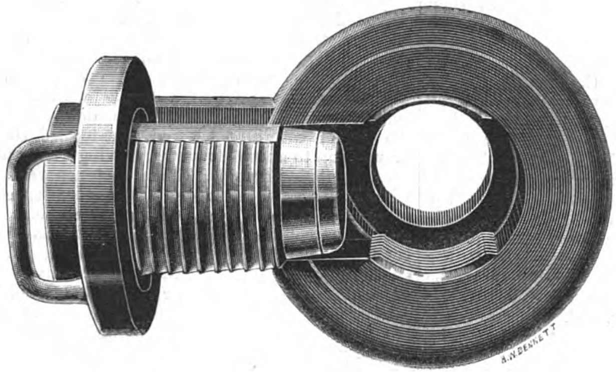


FIG. 167.

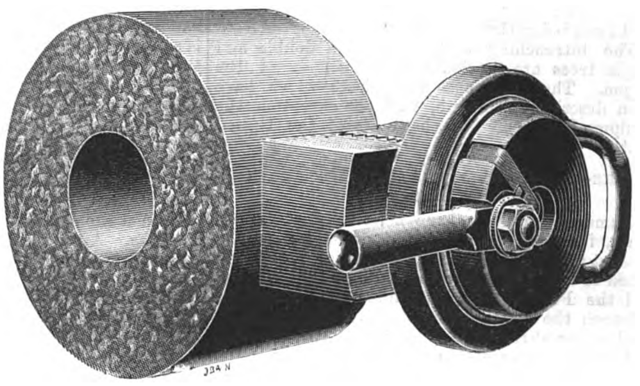


FIG. 168.

THE GERDOM SYSTEM OF BREECH MECHANISM.

In cooling, the rails do not touch each other, hence there is little straightening required. In fact one is impressed with the many devices to facilitate the work, and to reduce the handling of the material to a minimum.

On that portion of the property lying east of the Bessemer and rail department an extensive plant of open-hearth furnaces is projected, the product of which will be distributed among the blooming mills, plate and structural shape mills to be erected in connection with them.

The marine department, although not complete in its varied details, is in active operation. On the fitting-out pier, alongside which vessels will be taken as soon as launched, to receive their machinery and outfit, is being erected a machine shop, also hoisting sheers of 100 tons capacity. The other buildings comprise the tool shed, smith and machine shop, joiner and paint shop, and dry house. There are now completed four slips for vessels 250 ft. to 300 ft. long, others for larger vessels to be added as required. One steel seagoing tugboat has been recently completed and is now in active service; another is nearly finished. A side wheel steamer 210 ft. long, and a propeller steamboat 305 ft. long for the service of the Baltimore Steam Packet Company between Baltimore and Norfolk, are now under way.

The machine shops, one section of which is now erected and partly in operation, are intended to produce the apparatus required for the extension of the manufacturing plant, and the engines and other machinery required by the shipbuilding department. The present shop is one of three bays, of which the other two will be used as erecting and light tool shops.

In this building heavy castings for the works and for the vessels at the shipyards are being made daily and handled by hydraulic cranes, to be aided by a 50-ton electric travelling crane which is nearly completed.

A brick manufactory with a daily capacity of 25,000 is operated by this company, and on the property is located a lumber company manufacturing 250,000 ft. per day. The buildings have been constructed with a view to extension and reflect the greatest credit on their designers. This inspection closed the day's excursion, and there was yet another trip to be chronicled, and that was to Indian Head on the day following, to see the United States proving grounds to witness some tests. Shots were fired from the rapid-fire guns, and from the 6-in. and 8-in. rifles. The 6-in. shot passed through a Carnegie 6-in. plate. The smokeless and cocoa powder were examined, and from thence the party visited the United States Navy Yard at Washington, to see the gun shops, and to admire the lathes and rifling machines for guns from 6 in. to 12 in. These guns were shown in various stages of completion, and the heart of the American citizen dilated with pride, and he felt almost like wishing for a war to show foreigners what an American gun can do when needed.

The arrangements for this meeting, it may be said in closing, were most carefully planned and completely carried out. The local committee covered themselves with credit and deserved all the thanks they received. Their souvenir book giving an account of Baltimore, its industries, its geological characteristics, and accompanied by an excellent map of the city and a geological map of the section, was a work of care and was greatly appreciated. It will, undoubtedly, find a permanent place in the libraries of the members and remind them that the Baltimore committee are men to be proud of.

MODERN UNITED STATES ARTILLERY.—No. VII.

WAGON AND FORGE FOR FIELD BATTERIES.

(FIG. 164.)

THE battery wagon and forge for use with the field batteries have been combined in one carriage, thus reducing by one the number of carriages in the battery. While the advantage of such a reduction is great, the full value is not obtained, since this combination has required the addition of an artillery wagon. The battery wagon consists of a limber and body, generally similar to the caisson. The fore-wheels or limber carries everything that pertains to the forge, except the sledge, anvil, and vice; these are carried by the hind-wheels, which also carry everything which relates to the battery wagon.

The battery wagon body, made of white wood and oak, has three compartments; two lids on top open into one of the compartments, and a door at the front end into the other two. These last two compartments each contain a chest of tools, one containing the saddler's tools and the other the carpenter's and wheelwright's tools. The tools are so arranged that any one can be taken out without disturbing the others.

The anvil is carried on the middle rail.

In the top compartment is carried a grindstone and stand closets packed, also stones and spare parts for the repair of the battery. The vice is attached to the middle rail in front of the anvil. A folding forage rack in the rear of the wagon and a rail around the top provide space for carrying forage.

The artillery wagon, shown in Fig. 164, is rather a novel addition to the battery. It is designed to carry knapsacks, intrenching tools, and water. On the large canvas cover is painted the name and designation of the battery. The wagon has the same tracks as the other artillery carriages, and the rear wheels are of the same diameter as those of the 3.2 in. field gun. The fore-wheels are smaller in order to go under the body of the reach. The wagon has a capacity of 227 cubic feet, and can carry 120 knapsacks of about 25 lb. each.

The driver's seat is a box, which has three compartments, the middle one of which carries a few tools, and the other two spare revolvers and cartridges.

In the rear of the wagon is a 25-gallon water-keg, slung by chains and resting on a cradle built out from the rear of the wagon. It has a large bronze bung for filling and a faucet from which water may be drawn while on the march.

The wagon has a double cover. The first is a waterproof canvas covering the top only, while the second of cotton duck extends down the side and far enough in rear of the wagon to be lapped over, so by lacing it up by means of eyelets which are provided, the end is closed. A stout canvas curtain in rear of the driver's seat prevents the load from being thrown to the front.

The intrenching tools and spare double and single trees are carried under the body of the wagon. These carriages and pieces which have been described, complete, with one exception, the equipment of the field batteries of the United States.

The Gerdom Breech-loading Mechanism.
(Figs. 165 to 168.)

Numerous methods have been tried, at various times, for closing the breech of guns, but at the present time the number has practically been reduced to two, the Krupp, or sliding wedge system, and the French, or interrupted screw system. Between the advocates of the two systems there has been great rivalry. It may, however, be stated that, with the exception of Germany, the various nations have generally adopted the interrupted screw system.

Among the latter nations is the United States. All the guns that have been built at the National Foundry have breech-closing mechanisms of the interrupted screw system. This system has been adopted after long and careful criticism of the two methods. The United States in its isolated position has felt that it could wait while the conflict between the two systems was going on, and Congress was loth to appropriate money for the building of heavy guns until the superiority of some one system became evident. It can hardly be said with fairness that such a superiority has become manifest. It can be said, however, that both systems have proved themselves reliable, serviceable, and durable; each has its advantages over the other, and it becomes merely a matter of choice as to which advantage a nation considers the most desirable. The principal advantage of the Krupp system is its simplicity. It is, on the other hand, obliged to employ a much inferior gas-check. A few grains of sand or slight fouling is sufficient to allow the slight escape of gas, and the erosion once begun will soon destroy the gas-check. The Krupp block has a motion of translation only at right angles to the axis of the piece, while the interrupted screw system has a motion first of rotation about the axis of the piece and block, then of translation to the rear in the direction of the block, and finally of rotation about a vertical axis. These three motions complicate the devices necessary to regulate them. The carrier ring, or the tray, which replaces the carrier ring in the larger carriers, has to be locked and unlocked automatically. This requires some delicate device, such as the latch-pin that has been described with the 3.2-in. breech-loading rifle. On the working of this latch depends, practically, the working of the breech. A new mechanism has recently been devised by one of the mechanics at the National Foundry, which promises to supplant the interrupted screw system in guns of the smaller calibres, if not in the larger ones. It is being tried in a field gun, but the official result will not be arrived at for some time. It is known as the Gerdom breech mechanism. Four views are shown in Figs. 164 to 168, and from them can be seen the various steps in the opening of the breech. The locking is done by an interrupted screw, and the motions of the block are two, one of rotation about the axis of the block and piece which locks or unlocks the block, and a second motion of revolution about a vertical axis. The motion of translation is entirely dispensed with. It will be seen that the number of screw sectors is two, and the same number of slotted sectors, so that the block is approximately rectangular in cross-section. To open the block it is revolved 90 deg., thus unlocking the block, which is then revolved to the left to open it. The breech-block is carried by a carrier ring, which on its left side has attached to it a longitudinal piece, which serves as a hinge. The hinge-pin goes through the left side of the piece and through this longitudinal part of the carrier ring. The only other part of the block is the vent closer, which is a strip of steel, rectangular in longitudinal cross-section, and which slides in a radial slot. It is constantly forced outward by a spring, but in all, except the locked position of the block, its outer end presses against the carrier ring, while its inner end closes the vent. When the block is locked the vent closes, arrives opposite a slot in the carrier ring, and is forced by the spring outward into this slot, uncovering the vent and locking the block to the carrier ring, so as to prevent any tendency of the block to rotate when the piece is fired. To open the breech the vertical handle is revolved to the left and upward. There is a slight play allowed to this handle, so it rotates through several degrees before the block begins to move. During this period the vent is closed in the following manner. On this handle is a small key fitting into a slot in the vent closer. The revolution of the handle to the left causes the key to press against the vent closer, forcing it inward, closing the vent and unlocking the block from the carrier ring. As soon as this is done the handle arrives at the end of the play allowed and the block revolves. After a revolution through 90 deg. the screw threads are disengaged and the breech can be opened by revolving the block around to the left to the position shown in Fig. 168. The breech is closed by the reverse motion, first being swung around into place and then the handle is pressed downward. When the vent closer arrives opposite the slot in the carrier ring it is forced outward by the spring with a snap, opening the vent and locking the block. The gas-check used is the Du Bange. A stop-bolt passing through the top of the carrier ring limits the rotation of the block to the proper angle. The whole mechanism is very simple and very ingenious, and will undoubtedly prove successful. It will require an exhaustive test to determine whether it is advisable to replace the interrupted screw mechanism now in use by it.

THE TANSA DAM.

OUR two-page plate illustrates the great dam that has been built in connection with the Bombay Water Works, and which has been some 5½ years in building. A good idea of the appearance of this structure at its deepest part will be gained from Fig. 1, whilst in Fig. 2 we give a cross-section of the dam, at the same place, and in the remaining figures longitudinal profiles. The tinting in the latter shows the progress of the work at different dates, the stippled portion representing the work done up to June, 1889, whilst the hatched part shows what was accomplished between that date and June, 1890. The dam, which was opened on March 31 by the Viceroy of India, is situated about 65 miles north from Bombay, to impound water in the Tansa Valley, for the purpose of giving Bombay a new supply. This was greatly wanted, since the former supply almost entirely depended on the Vehavi Lake, in which the water was held up by earthen dams which have from time to time caused the officials in Bombay much anxiety from their leaky condition. The supply was also growing totally inadequate in consequence of the increased and growing population, and the enormous strides in the trade of recent years in Bombay.

The Tansa Dam, now constructed, is known to be the largest masonry dam in the world. It is a little under two miles long, 118 ft. high, and about 100 ft. thick at its greatest depth, with a top width of 15½ ft. The bottom of the inside face is slightly battered for a short distance, the balance being perpendicular. The bottom of the outside face has a straight slope, above which it is curved, with a radius of 160 ft. The waste weir is 3 ft. below top of dam, and about 1600 ft. long. The dam has been so designed that it may, at some future time, be raised, if required, to impound water up to R^{b} 420, or 15 ft. above present level, in which case the height of the dam will be 133 ft. above the bed of river, and the lake will cover an area of 8 square miles, and the catchment basin, in which the rainfall will be collected, over 52 square miles; whilst the available supply, after deducting for evaporation, &c., will then equal 68,000,000 gallons per day for 365 days, or practically 100,000,000 gallons per day, because allowing for the fall during the rainy season, the supply stored is only required to meet the demand of 240 days instead of 365.

Foundations.—The entire foundation of this dam is solid rock throughout, and care was taken to remove every possible part where the least doubt existed on this point, and to this end the foundations have in some cases been carried down 45 ft. below original ground level. In the course of this work the quantity of excavation actually carried out in soft boulders, bastard rock, and rock amounted to 6,780,428 cubic feet, as against an originally estimated quantity of only 4,084,347 cubic feet, equivalent to 66 per cent. over and above the originally estimated quantity in foundations.

Masonry.—The whole of the masonry in the dam consisted of uncoursed rubble, anything approaching horizontal joints being carefully avoided; and good bond was carefully seen to throughout the whole of the work. Every stone was carefully laid in mortar and driven home with a light mallet. The top course of the dam was, by the use of carefully selected, flat-topped stones, brought up to a uniform level, having the appearance of rubble paving. The face stones were laid without priming in front, and were specially selected of a larger size, to insure good beds, and of uniform colour. They were laid so as to tail back, and bond well into the body of the work, and no face stone had a greater height than either its breadth on the face, or length of tail in the work. The face work, when completed, was equal to and had the appearance of coursed rubble. The quantity of loose rubble stone used in the dam amounted to 14,707,000 cubic feet. The mortar used in the masonry consisted of one part of kunker lime to one and a half of clean, sharp sand, with the exception of the lower and thickest portion of the dam in the bed of the river, where a proportion of Portland cement was added to the above. The mortar was ground in steam mortar pans for fifteen minutes before being used, the proportions of lime and sand being carefully gauged by specially made frames. The lime was all burned and prepared by Messrs. Glover and Co., most of it at the site of the works. The kunker nodules, out of which the lime was made, had to be excavated from some feet underground where they were quarried, and after being exposed in the sun and thoroughly dried, were separated from all extraneous matter, such as earth, &c., by beating, washing, &c. The kunker used in this work is well known for its special hydraulic properties, and has a high reputation. After being cleansed as described, it had to be carted to the railway stations an average distance of 10 miles, then by train about 70 miles to Atgaon Station, G. I. P. Railway, and again in carts, 8 miles to the mortar mill sheds at Tansa. The total quantity of lime used was 2,206,000 cubic feet. The sand was clean, hard, and sharp from quartz and trap formations, and was carefully washed to remove dirt, &c. It was carted from about 1½ miles in the first season, the distance increasing in each subsequent season up to 12 miles of carting, over most difficult country without made roads. The total quantity of washed sand used in the work amounted to 3,309,000 cubic feet. During the working season as many as from 700 to 900 carts were employed in the conveyance of sand, lime, &c., to the works. Regularly during the progress of the works, portions of the mortar were sampled, by being made into 4-in. cubes and submerged in water after lying damp for forty-eight hours. These cubes were tested by hydraulic pressure after lying submerged for from six to eighteen

MODERN UNITED STATES ARTILLERY.

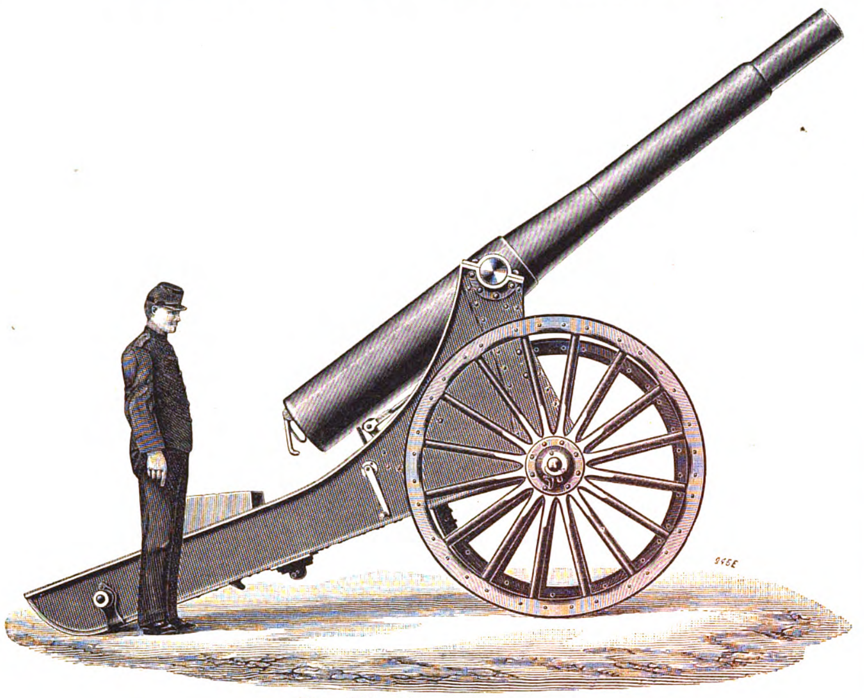


FIG. 169. 5-IN. SIEGE GUN.

century, that island certainly owed no allegiance to China, or at least the Chinese Government had never attempted to extend their regular government there. The savages, who then occupied the coast region, were well treated by the Dutch, who established very cordial relations with them, the consequences of which are still apparent in the decidedly friendly attitude almost invariably adopted by the savages towards their infrequent European visitors to the present day. When the piratical Chinese patriot (Kochunchinga) drove the Dutch out of the island in the latter half of the same century, and made Formosa the head-quarters of his expeditions against the mainland, undertaken in vainly trying to oust the obnoxious Tartar interlopers, the savages were left to themselves untrammelled by any control. But although the Chinese Government never established any permanent sway in the island, except within the last 50 years, the Chinese people had secured a footing in the north and all along the west coast ever since the time of the patriot pirate, under whose auspices a number of adventurers from Amoy and Quantung were attracted to establish themselves in the principal ports. The Quantung settlers were mostly hillmen (Haccas), and have been chiefly instrumental in driving the savages back into the mountain fastnesses, and in occupying, clearing, and bringing into cultivation most of the arable land skirting the west coast. The savages have been driven away from the sea comparatively recently, as settlers are still living who recollect the time when they still had possession of the district between Oulan and the oil wells, the latter being now well within the Chinese lines. Between 20 and 30 years ago a member of a well-known tea firm obtained a concession from the savages of the land about the oil wells, and held it for some time with their help against the Chinese authorities—but yielded eventually to superior numbers. The hardy Chinese settlers, inured for generations to border warfare of the most pitiless kind, and to life under family and communal institutions and customs outside Government control, have proved a constant source of difficulty and danger to the Chinese rule. They have on several occasions broken out into open rebellion, and have besieged the Chinese regular soldiers in the walled towns of Teukcham and Chiangwha — routing them in almost every engagement; but these rebellions have been like most rebellions of agriculturists elsewhere, spasmodic and desultory, so that the Government have invariably resumed their somewhat nominal authority as soon as the exigencies of the crops called the fighting farmers back to their farms. The most recent and most known rebellion occurred as late as 1888 and lasted some months. Its immediate cause was an attempt to impose the imperial land tax on the Chiangwha farmers after a preliminary survey of their land, and ended very nearly in the expulsion of the Government garrisons, who would have yielded but for the timely assistance of the crews of several ships of the North China fleet who effected a landing. Some of the ringleaders of the revolt were still at large in 1889, and fell into the hands of the authorities through the instrumentality of the savages who, tempted by a large reward, caught them and gave them up. They were taken to Taipeh in cages, loaded with irons, under strong military escourt, tortured in the governor's presence for about a month, then sent to be beheaded to various towns and villages in the neighbourhood. One was sent by train to Suetinka, but the poor wretch died *en route* from the effects of previous torture, his joints being all swollen to four times their natural size.

The savages in the north of the island for some years past have been reported to be thoroughly pacified and friendly to the Chinese, and Liu-ming Chuang has obtained considerable kudos for his management of them. His method has been to subsidise them regularly with rice and money, in exchange for work performed on border estates specially appropriated by the governor himself and laid out as tea gardens, but this admirable arrangement failed at last owing to the ill-timed dishonesty of the general in charge, who, in accordance with ordinary Chinese precedent, appropriated a very large proportion of both rice and money for his own use. The wily savages objected and remonstrated in vain, as their remonstrances never reached head-quarters; so, tired of fruitless representations, they proceeded from words to deeds, and availing themselves (last October) of the occasion of the visit of a detachment of 300 soldiers from Kelung, sent to repair the military road along the east coast, they surrounded and wiped it out, officers and all—the governor's own nephew being in command. This was a bad blow to the governor's reputation, and being followed by the blowing up of the Government Arsenal at Taipeh, which occurred in the same month, and destroyed 10 million rounds of cartridge, several thousands of new Remington magazine rifles, war rockets, torpedoes, &c., created a very unfavourable impression in Pekin, and called forth an immediate and extensive expedition into savage territory. This met with very serious reverses, and among others the wholesale destruction of one of the columns of 500 men by poisoned stream water. According to accounts dated March, 1890, the governor in despair took personal command of what threatened to be a forlorn hope, and he had very shortly afterwards to patch up a truce decidedly favourable to the savages. This truce lasted till last year, 1891, when owing to the brisk demand for camphor for smokeless powder, &c., factories were sought to be established within the savage boundaries. This invasion of their territory once more fanned the smouldering hostility to a flame, and brought about the massacre of the Chinese adventurers and the destruction of the factories. The truce has now been resumed till further invasion shall provoke new outbreaks. So what with the savages and the semi-independent Chinese settlers the imperial rule in Formosa is by no means so assured as the Pekin authorities would have foreigners believe.

6. *The Value of Chinese Agreements.*—The writer and his two companions, who were informally engaged by the London consulting engineers to the Formosa Railway, were sent out for regular engagement at Tamsui (Formosa) by the British consul there, under agreements approved by the Governor, translations of which were handed to the parties on leaving England. The terms being briefly two years' engagement terminable after nine months, by three months' notice on either side, one and a half month's salary in lieu of passage money, for passages both out and home, quarters, interpreters and bearers free. They landed in Formosa on March 2, and signed their agreements the same day at the Consulate Tamsui before the consul, who, though a party to the agreements as agent for the governor, witnessed the signatures but did not sign it himself. No Chinese signature was attached, but the governor's official seal was appended to the Chinese originals in token of assent. These originals were subsequently discovered to be neither dated nor witnessed, and they did not even contain the names of the parties to whom they referred. Consular fees amounting to 13½ dols. were paid on signing each original. On dispute arising with reference to these agreements, when the governor sought to rescind two of them, the writer found that they were of no legal value, as according to Chinese law no official can be sued without being first deprived of official rank, and that no remedy offered but proceeding by way of a petition of right through the slow and uncertain diplomatic channel, and that in any case should the petition be even successful, no damages or expenses would be allowed, only the bare claim. This should be a warning to professional men seeking engagements under the Celestial Government. With the Chinese merchant the matter is quite different, as the merchant can be sued without difficulty, and moreover possesses some intention of straightforwardly fulfilling his engagements.

(*To be continued.*)

MODERN UNITED STATES ARTILLERY.—No. VIII.

5-IN. SIEGE GUN. (FIGS. 169 to 218.)

THE siege gun adopted for service in the United States is a 5-in. breechloading steel rifle (Fig. 169).

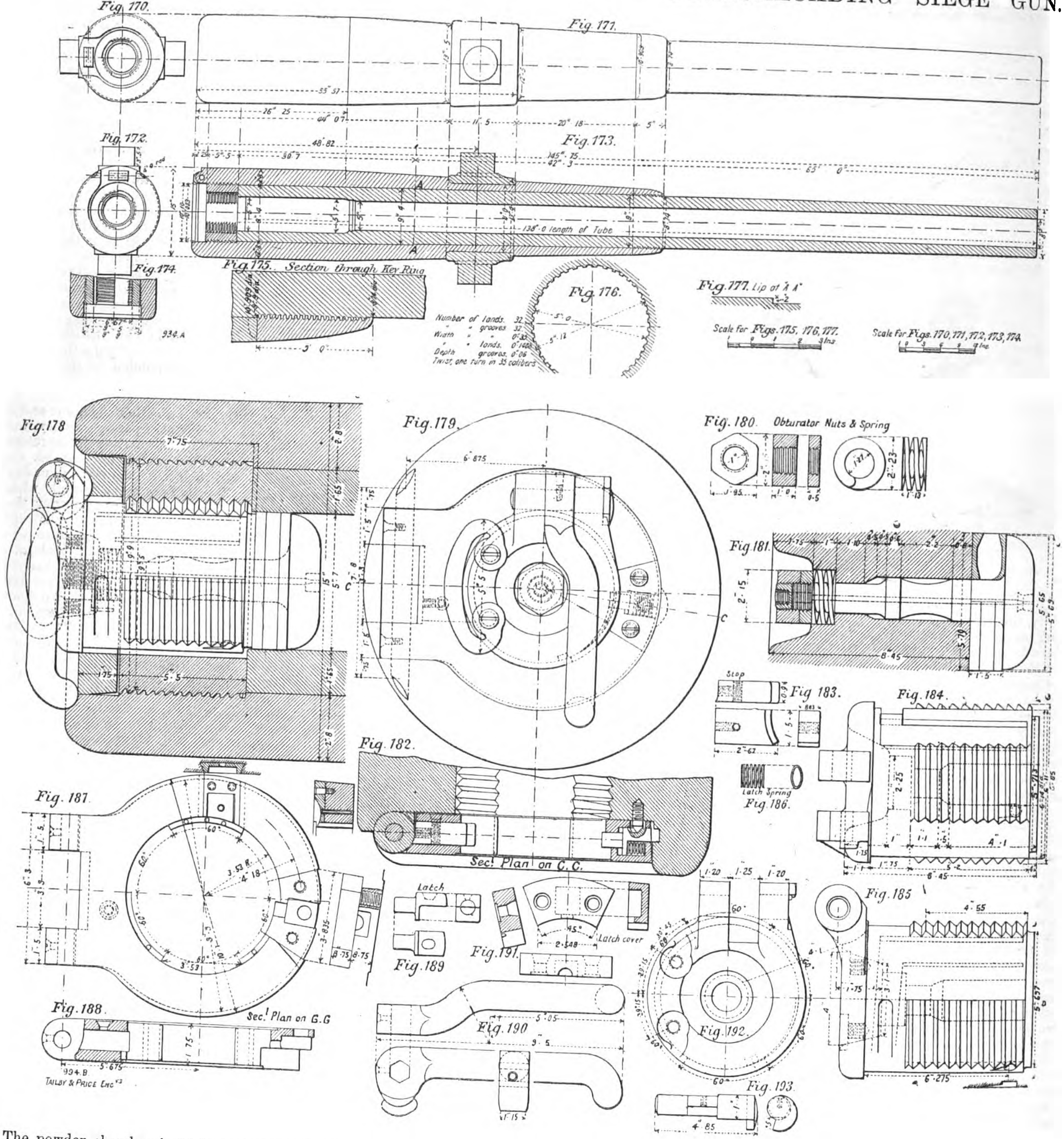
It consists of a tube, jacket, trunnion band, key-ring, base-ring, and sleeve. The forgings, as is the custom, are obtained from private firms, and before delivery are oil-tempered and annealed. Test pieces were sent from each forging and were required to exhibit the following qualities:

Part.	Elastic Limit.	Tensile Strength.	Elongation.
	lb.	lb.	per cent.
Tube	42,000	88,000	20
Jacket	50,000	95,000	18
Trunnion band..	48,000	95,000	15

The other parts were required to have the same qualities as the jacket.

The tube is 138 in. long, with a minimum diameter of 8 in., and a maximum diameter of 9.414 in. The jacket is 59.3 in. long with a minimum diameter of 13.5 in. and a maximum diameter of 15 in. The front end of the jacket is recessed to receive the trunnion band, which is shrunk over it. In front of the jacket is shrunk a tapering sleeve, and this is secured in place by the key-ring, which is screwed in place. In front of the key-ring to the muzzle, a distance of 65 in., the tube is left unsupported.

MODERN UNITED STATES ARTILLERY: 5-IN. BREECHLOADING SIEGE GUN.



The powder chamber is 26.25 in. in length and 5.7 in. in diameter. It is connected by a spherical surface with the shot chamber. The forging for the tube was first bored to within 0.05 in. of the finished bore. The jacket was turned and bored, and then the exterior of the tube was finished. The jacket was first heated and shrunk on the tube. As soon as this was cool the recess for the trunnion band was then turned and the band shrunk in place. The sleeve was then shrunk on the tube in front of the jacket and trunnion band, and secured by the key-ring. It will be seen, by examining the figures, that the key-ring prevents any forward movements of the parts, and the shoulder on the tube prevents any tendency to move to the rear. The rifling is uniform with 32 lands and grooves. The twist makes one turn in 35 calibres, or at an angle of 5 deg. 9 min.

The breech mechanism is similar to that used with the field guns. The De Bange obturator is used. The spindle of the obturator, instead of being made solid, is pierced by an axial vent. At the front end is a copper bushing to decrease the erosion, and at the rear end are screw threads for the obturating primer. The breech-block is 8.2 in. long and 6.66 in. in diameter, and has the three screw sectors and three slotted sectors. The rearmost thread is not cut away, and serves to protect the block against dirt and weather when it is closed.

The latch-pin is similar to that used in the 3.2-in. gun. Its head moves in a narrow longitudinal and circumferential groove deepening towards the ends. On closing the block the latch-pin is lifted from the hole at the front end of the longitudinal groove by a pin projecting from the rear end of the base-ring, in the same manner as described for the 3.2-in. field gun.

The handle for rotating the block is curved to allow room for the insertion of the obturating primer.

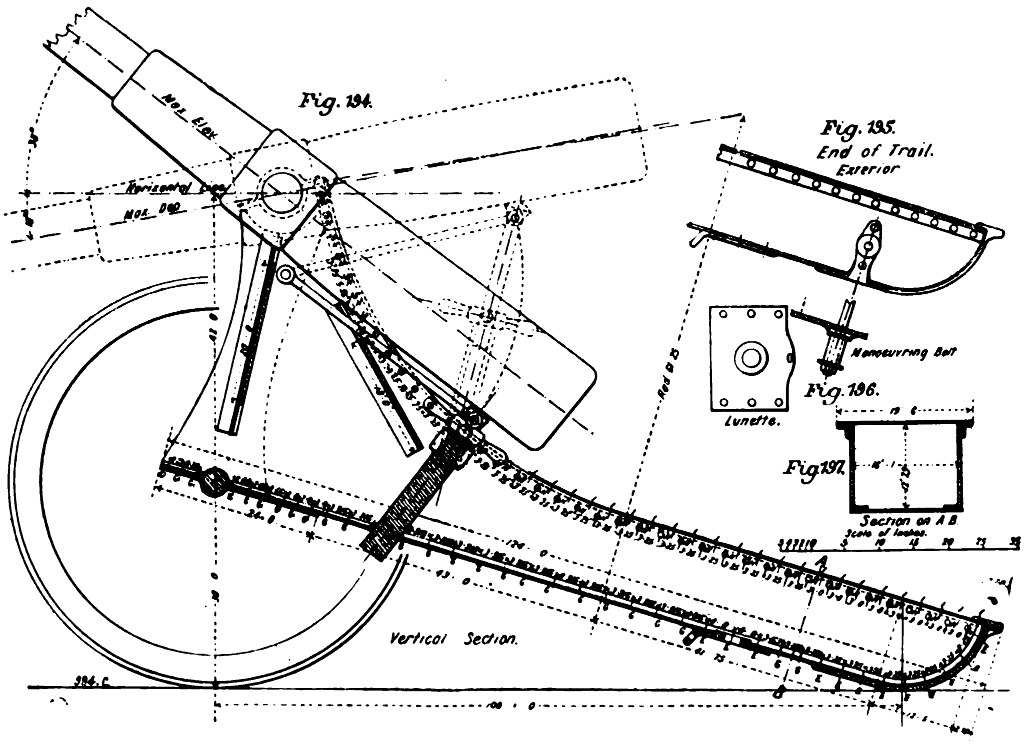
It will be noticed that the latch-pin is secured in the carrier ring by a plate called the latch cover, which is held by two screws. By this means it is easily accessible, so in case of injury it would require but a few moments to replace it by a new one.

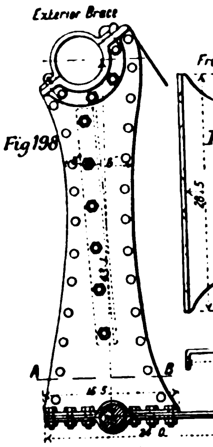
The spindle of the mushroom-head passes through the central cavity in the breech-block, and is held by a nut, against which presses a spiral spring, thus keeping a constant pressure on the asbestos pad. By removing the nut the spindle can be withdrawn and a new pad put in place.

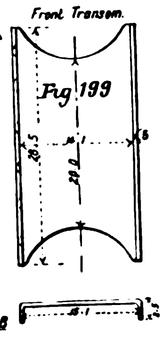
The type gun (or the first one made) was sent to the proving ground at Sandy Hook, N.J., as is the custom, and was tested by firing 1000 rounds.

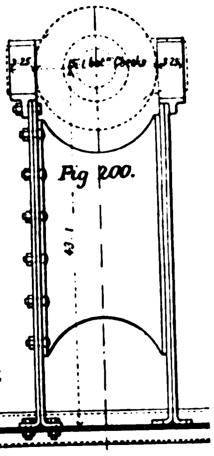
The diameter of the bore was gauged after

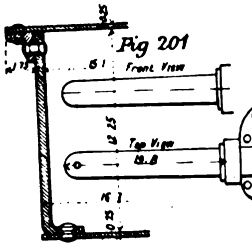
MODERN UNITED STATES ARTILLERY: 5-IN. BREECHLOADING SIEGE GUN.

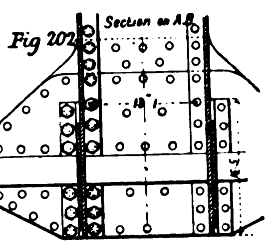


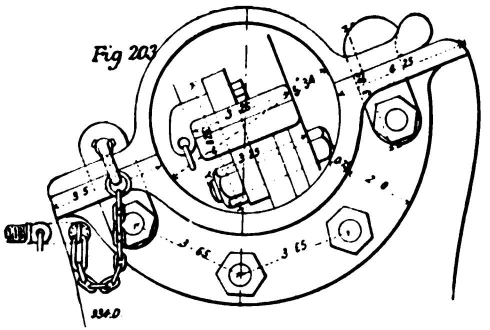


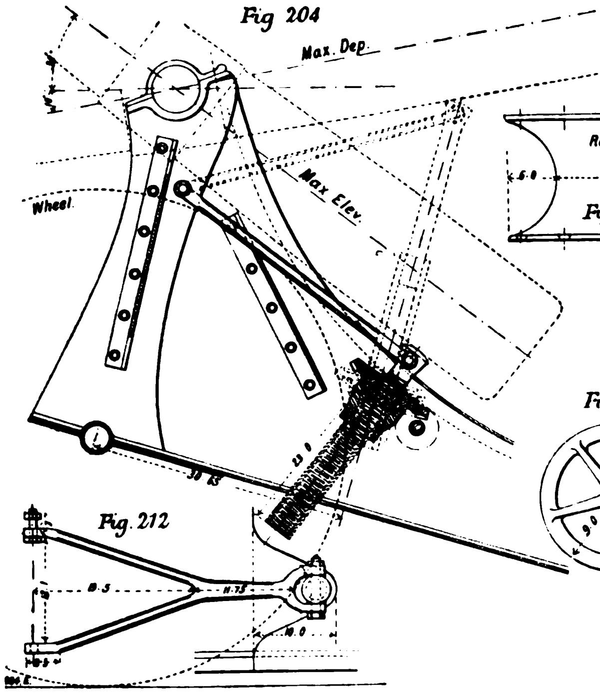


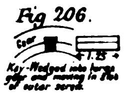


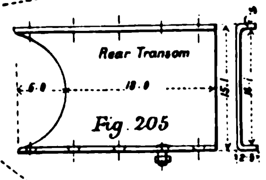


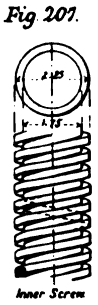


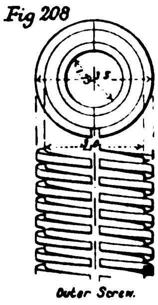


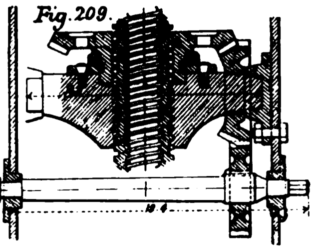


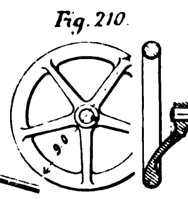


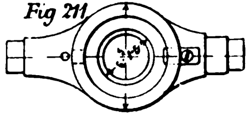


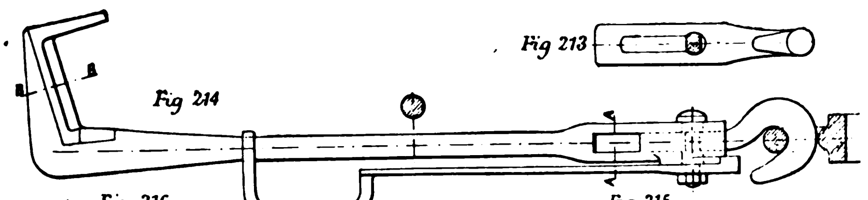


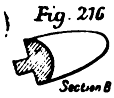


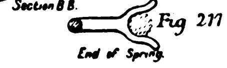


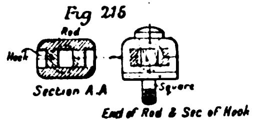


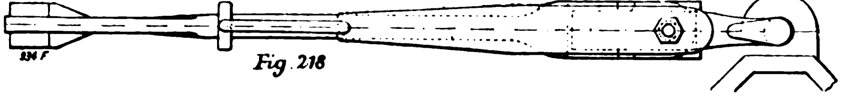












different rounds. At the end of the test the only apparent damage noticed, that in any way affected the serviceability of the piece, was slight erosions in the shape of fine lines on the slope of the shot chamber, but they were entirely too slight to affect the serviceability of the piece in any way.

TABLE XVI.—*Ballistic Data of 5-in. B.L. Steel Siege Gun* (*Figs.* 169 *to* 193).

Calibre		5 in.
Weight		3660 lb.
Total length		12.1 ft.
Length of bore		23.5 cal.
Weight of powder charge		12.5 lb.
Weight of projectile		43 lb.
Ratio of weight	of charge to weight of projectile	1 to 3.4
	of projectile to weight of piece	1 to 85.1
Initial velocity		1829 ft.
Muzzle energy foot-tons	Total	997.1
	per ton of gun	611.7
	per pound of powder	79.6
Pressure, pounds per square inch		35,575

CARRIAGE FOR 5-IN. STEEL SIEGE GUN.
(FIGS. 194 TO 218.)

The carriage for the 5-in. breechloading steel siege gun was designed with the object of embodying the desirable features of a modern metal siege carriage, among the more noticeable of which are the high trunnions, and as small weight as is consistent with strength and durability.

It is so designed that when unlimbered the axis of the trunnions will be 72 in. above the ground and 10 in. in rear of the vertical through the axis of the wheels.

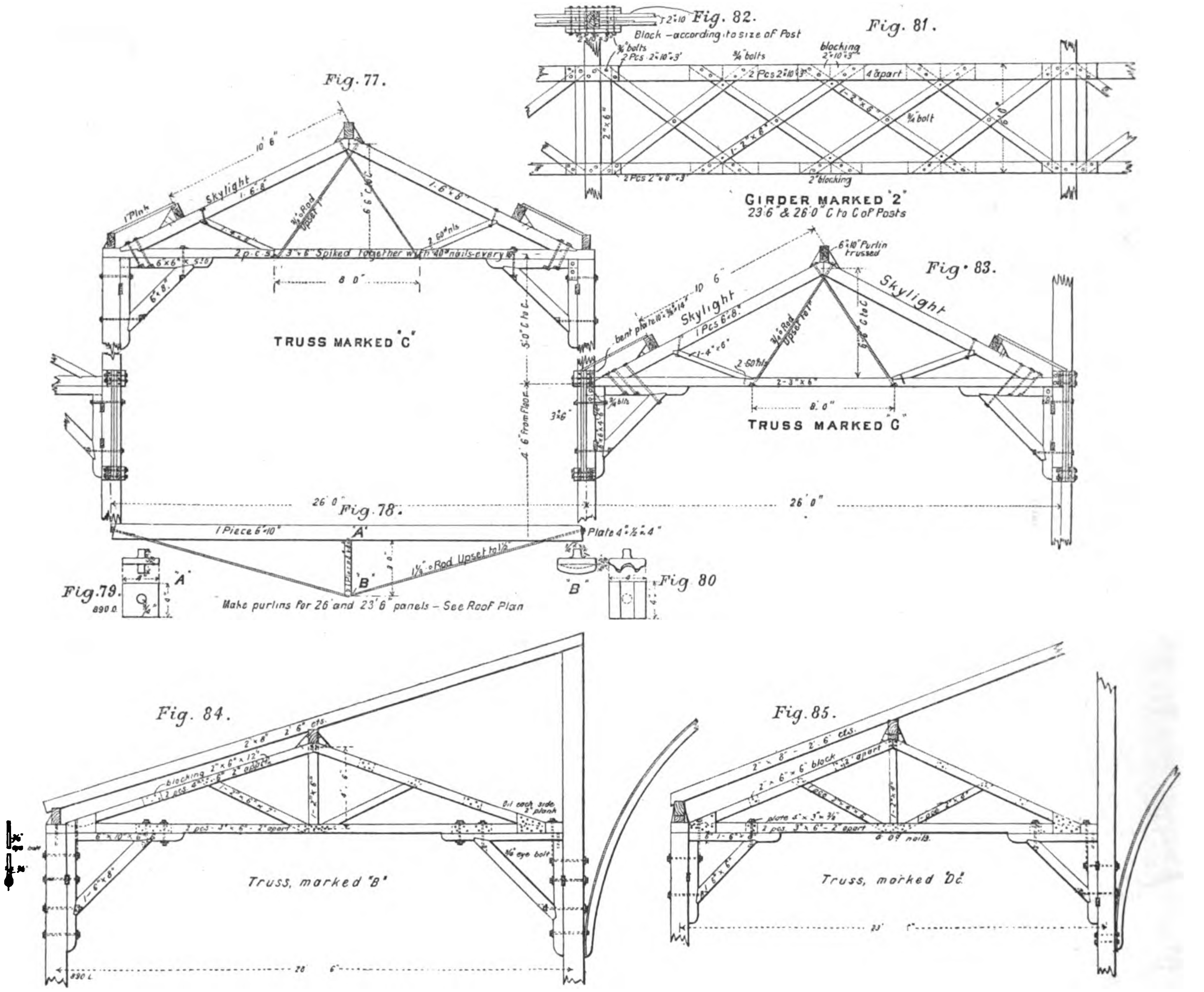
When limbered the axes of the trunnions and of the wheels are in the same vertical plane, so the centre of gravity of the system composed of the gun and carriage will fall well between the axles of the carriage and limber, and the whole, consequently, will be stable on the march.

All metal parts of the carriage are made of steel, so as to combine strength and lightness.

The carriage consists essentially of two flasks parallel throughout, and connected by top and bottom plates and transoms. Directly under the trunnions the flasks are reinforced by two vertical braces of the form shown in the figure. The axle is embraced by two trapezoidal-shaped axle-plates, similar to the ones used in the field carriage, and to these plates the flasks are bolted. The flasks are stiffened by flanging at the bottom, and at the top by riveting on steel angles 1.75 in. wide. The flasks are ½ in. in thickness. The bottom plate, secured by rivets to the flange of each flask, extends from the trail to the lower axle plate, lapping over the latter 4 in. and secured to it by rivets. Under the trail is a shoe-plate 0.5 in. in thickness with a pro-

THE WORLD'S COLUMBIAN EXPOSITION OF 1893: AGRICULTURAL BUILDING.

(*For Description, see Page* 552.)



jection to allow the engaging of a handspike. The top plate, 0.25 in. thick, secured to the steel angle by rivets, extends from the trail towards the front as far as possible without interfering with the elevating of the piece. The steel angles continue to the trunnion beds. On the outside of each flask, below the trunnion, is riveted an exterior brace, flanged at the bottom and riveted to the axle-plate. Between these braces is the front transom ½ in. in thickness, and hollowed out above to allow the elevating and depressing of the piece. A rear transom is added to prevent the buckling of the flasks between the trunnions and the elevating screw. The trunning beds are made by curving T-irons and by bolting them on by passing bolts through the webs, braces, and flasks.

The wheels are of the Archibald pattern, previously described. They are 5 ft. in diameter, having sixteen spokes 3 in. thick, and a dish of 1.5 in. The tyre is of steel 4 in. wide and ⅝ in. thick. The nave is of malleable iron. The weight of the wheel is about 375 lb. The elevating screw is the double screw used in the field gun carriage. The head of the screw is attached to a foot pivoted below the axles, so as to keep the screw as nearly as possible perpendicular to the axis of the gun, and thus diminish the tendency to bend under the blows from the breech when the piece is fired. The brake is similar to the one described with the field carriage. The hook and brake are held together by the bolt passing through the steel spring lever, the brake, and the slot in the hook. The form of the bolt does not allow it to slide in the slot when the spring is in place, as shown in the figure. If, however, the spring be revolved until it is at right angles to the brake, the cross-sections of the slot and bolt are then the same, and the bolt will slide in the slot, and by so doing the brake is lengthened. This is necessary to loosen the brake after firing or after descending a hill. A more complete description of this brake will be found under the description of the full carriage.

The principal weights and dimensions are as follows:

Height of axis of trunnions above ground	72 in.
Width of wheel track	60 „
Distance from line joining points of support of wheel to that of trail ...	100 „
Weight of gun carriage without wheels	2072 lb.
„ one wheel	374 „
Total weight of gun carriage	2820 „
Weight of gun carriage with piece ...	6480 „
„ trail without gun, pressure on horizontal plane	728 „
Weight of trail with gun, pressure on horizontal plane...	1102 „
Angle of elevation, the gun being on level plane	38 deg.
Angle of depression, the gun being on level plane	10 „

TESTS OF REFRIGERATING MACHINES.

In our issue of August 28 last we published Tables giving particulars of some careful trials of refrigerating machines made by a committee of experts in Germany. Unfortunately, some errors had crept into these Tables in translation, so we now republish them in a corrected form on the opposite page. The machines tested were of the Pictet and Linde types respectively, of which the principal particulars are given in the annexed Table.

—	Linde Machine.			Pictet Machine.		
	Steam Engine.		Com-prsrs.	Steam Engine.		Com-prsrs.
Diameter of cylinder in.	12.01		9.96	12.45		11.26
„ piston-rod „	1.91		2.17	1.97		1 97
Effect. piston area { front sq. in.	110.75		72.59	118.8		96.6
Effect. piston area { back „	113.61		76.26	118.8		99.6
Stroke .. .. in.	27.56		27.56	24.41		24.41
	Evaporator.		Cond.	Evaporator.		Cond.
	I.	II.		I.	II.	
Mean exposed surface sq. ft.	681.4	684.6	643.7	727.7	727.7	653.4

THE HAMILTON DOCK AT MALTA.

On page 545 we give illustrations of the new dry dock, which was recently opened at Malta, H.M.S. Victoria being the first vessel to enter it. The dock has been built by the Government to the designs of General P. Smith, R.E., and has been named after the First Lord of the Admiralty. From the outset the execution of the works has been in charge of Mr. Charles Colson, M.I.C.E., and his son, Mr. C. H. Colson, A.M.I.C.E. Our illustrations are from photographs taken from opposite ends of the dock and show clearly the principal features. The dock is 520 ft. long on the blocks, when the caisson is in its pegs were incontinently shifted to avoid it; if cuttings were deep, gradients were at once steepened to render them shallow; if lime and cement ran short, or their cost could be saved for the constructor's benefit, mud was used, and foundations, being wholly against Chinese ideas and practice, were almost invariably omitted. The result was a show of much work done and a reality of but a very little that would not have to be undone or done over again. The western chief, however, accomplished wonders; he altered the line from Taipeh to Kelung as far as the existing work would admit, and took a corrected section and prospected, laid out, and levelled a preliminary line south of the capital down to Chiangwha (12 miles south-west of the proposed new capital); he designed and started the erection of several of the principal bridges, the headings for the tunnel were well in hand, the rails and rolling stock for 20 miles of line were on their way from Germany at a cost of 100,000 dols. A consulting engineer had been appointed in England, and was engaged designing the more important bridges and special locomotives and rolling stock to comply with the governor's latest ideas. An assistant had been arranged for and was on his way out—everything was apparently progressing favourably—but the prospect of more stringent supervision, the stoppage of scamped work and of convenient, if unsuspected, "squeezes," alarmed the doughty military constructors, and taking advantage of the engineer's temporary absence in Hong-Kong a cabal was formed, which very shortly after his return whispered into the governor's ear, "Your engineer spends his time too much indoors, too much in travelling away from the line, too much in attending to family affairs instead of to the railway, he should reside on the line and not down the river, &c. There is excellent accommodation at the arsenal with your trusty Teuton manager, which he seems to be too stuck up to occupy."

Notwithstanding the engineer's very reasonable contention that he lived away from the line because the quarters which had been promised when he first came, had never been even commenced, and that unavoidable and unnecessary office work had latterly limited his personal supervision of the work, the governor appeared to have completely changed his attitude, and from most friendly had become bitterly hostile, with the result that the hard-working chief was grossly insulted and told to leave the island as speedily as possible. This he shortly did, after a stay of a little over eight months, but unfortunately for himself and those who came after him, without enforcing his claim to payment of salary for the balance of his unexpired agreement, which the governor had peremptorily declined to entertain, and which the departing engineer was counselled to forego by the firm who had engaged him on "His Excellency's" behalf, as, doubtless, their future prospects in the contract line would have been seriously interfered with by their nominee proceeding to extremities with that autocratic magnate.

An interregnum now occurred during which the Teutonic influence of the manager of the arsenal was once more felt on the railway, but the newly arrived and energetic British acting consul at Tamsui began to take a strong interest in the embryo line, which his predecessor, more experienced in the fate of Chinese concerns, had severely let alone. In the mean time Chinese mismanagement of the tunnel works at Kelung had brought about the inevitable result, in the shape of a huge slip where a whole hillside had moved down and entirely blocked the northern approach to the tunnel. This accident so frightened the general in command that he advised the abandonment of the work and the shifting of the line to the northward; an alteration which had been so far foreseen by the late chief, that he had laid out and placed marks along the necessary diversion. The governor instructed the acting consul to forthwith obtain a substitute, and an engineer was procured from Hong-Kong, who very shortly was able to take charge. The European manager of the Government colliery, at Kelung, who was also an engineer, was appointed superintendent manager of the railway, and with the help of the assistant procured by the first chief engineer, who had arrived before the latter's departure, a new spurt was made with the railway, early in 1888, and bid fair to be ultimately more successful than the previous one. The new chief, who had some experience of Chinese ways, warned by the fate of his predecessor, adopted a more easy policy towards the military constructors, but it very soon appeared that this did not suit the governor so well as the previous *régime*, and the result was the exit of chief No. 2 after a brief reign of less than six months. The governor, after the experience he had had on a former occasion of the ease with which engineering employés could be dismissed, and their agreements disregarded, was even more peremptory in his behaviour than before, and chief No. 2, being anything but combative in character, left the island without an effort at claiming his rights. Thereupon the acting consul, notwithstanding the comparative failure on the part of his first importation, still desirous of keeping the control of the line in British hands, once more stepped into the breach and offered to obtain a stopgap from Hong-Kong, while another chief engineer and an additional assistant could be sent for from England. The governor was, by the united influence of the consul and the European manager, persuaded to adopt this course, and to intrust the selection of the engineer to a well-known consulting firm in the city of London, who had been unofficially appointed consulting engineers to the railway in succession to the nominee of chief No. 1. The stopgap was forthcoming in the engineer of the Hong-Kong Peek Tramway, who very soon came over and took charge, but wisely confined his attention almost entirely to survey, and the selection of new line, leaving all attempts at controlling the construction to the new-comer, whose more permanent position alone could warrant the undertaking of what all previous endeavours had proved to be so hopeless.

(*To be continued.*)

MODERN UNITED STATES ARTILLERY.—No. IX.

7-IN. BREECHLOADING HOWITZER. (FIGS. 219 TO 270, PAGES 580 AND 581.)

THE siege artillery of the United States consists of the 5-in. breechloading steel rifle, which was described in the preceding article, and the 7-in. breechloading steel howitzer.

The 7-in. howitzer, as is shown in the sectional view (Fig. 241, page 580), consists of a steel tube, jacket, base-ring, trunnion band, key-ring, sleeve, and De Bange breech mechanism.

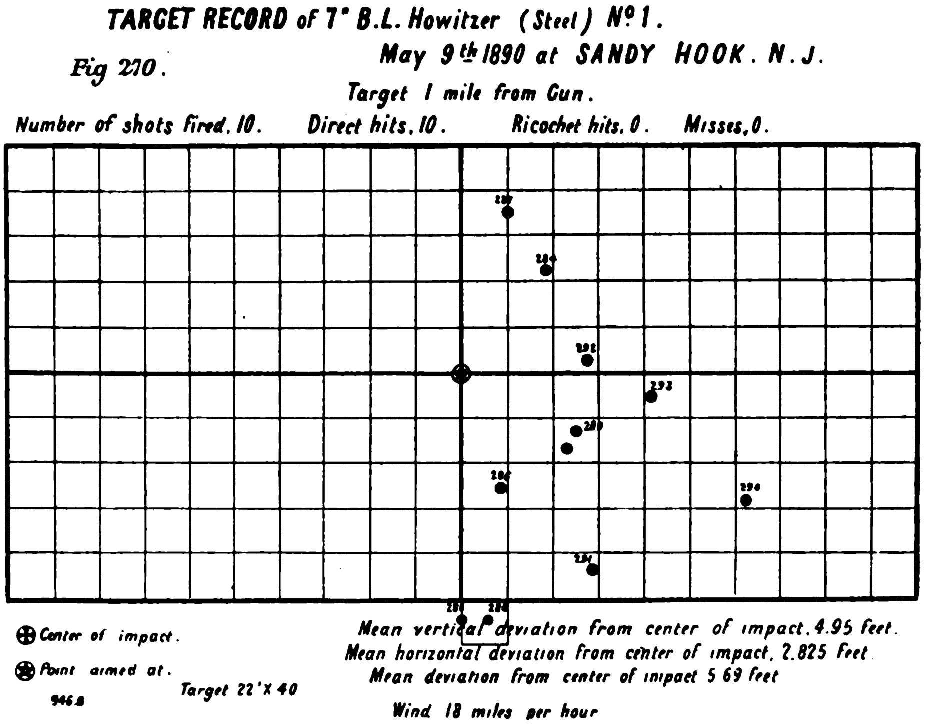


Fig 220.

As is usual in all the United States guns, the forgings were obtained from private firms and were required to fulfil the following requirements.

The forgings to be of open hearth steel of American production, oil-tempered, and afterwards annealed and to have the physical qualities set forth in the annexed Table.

TABLE XVII.—*Requirements for Forgings for 7-in. B.L.S. Howitzer.*

Tube	Elastic limit, 42,000 lb. per square inch. Tensilestrength, 88,000 lb. per square inch. Elongation after rupture, 20 per cent.	The results of the test of no one specimen to be below—	Elastic limit, 36,000 lb. per square inch. Tensilestrength, 80,000 lb. per square inch. Elongation after rupture, 17 per cent.
Jacket, sleeve, breech-block, and other small forgings	Elastic limit, 52,000 lb. per square inch. Tensilestrength, 95,000 lb. per square inch. Elongation after rupture, 18 per cent.	The results of the test of no one specimen to be below—	Elastic limit, 46,000 lb. per square inch. Tensilestrength, 88,000 lb. per square inch. Elongation after rupture, 15 per cent.
Trunnion-hoop	Elastic limit, 48,000 lb. per square inch. Tensilestrength, 95,000 lb. per square inch. Elongation after rupture, 15 per cent.	The results of the test of no one specimen to be below—	Elastic limit, 43,000 lb. per square inch. Tensilestrength, 85,000 lb. per square inch. Elongation after rupture, 12 per cent.

The tube is 86.9 in. long, and over the powder chamber is 2.23 in. in thickness, and the exterior of the tube is cylindrical to the front end of the chamber, where a locking shoulder A occurs. The thickness of the walls is then reduced to 2 in. and continues of this thickness to the forward part of the sleeve, except where a groove ½ in. in depth is cut for the key-ring.

From the front of the sleeve to the muzzle the tube gradually tapers, until, at the muzzle, the thickness of the walls is reduced to 1.5 in.

The seats for the De Bange gas check and the powder chamber are cylindrical for a distance of 10.64 in., and throughout this distance the diameter is 7.2 in.

For a distance of 2.4 in. the bore then becomes conical, the diameter decreasing 0.05 in. The cone then meets the bevelled ends of the lands of the rifling, and in 0.25 in. the bore decreases to 7 in. measured between the lands, or 7.12 in. from the bottom of the grooves.

This conical slope serves to centre the projectile and also to connect the powder chamber with the rifled part of the bore. There are 40 grooves and lands. The lands are 0.16 in. in width, and the grooves 0.39 in. in width, and 0.06 in. in depth (see Fig. 244). The jacket (Figs. 220 to 223) is 29.9 in. in length, and is practically cylindrical as far as the locking lip under the trunnion band, though the diameter of the walls is slightly increased in thickness at the locking shoulder. Over the powder chamber the thickness of the jacket is 2.42 in., making a total thickness of metal over the powder chamber of 4.65 in. It will be noticed in the enlarged drawing of the locking shoulder at B (Fig. 229) that, at the rear end, the diameter of the contact surfaces is 13.75 in., and at the front end it is 13.824 in., an increase of .074 in., consequently, when the trunnion band is shrunk on the jacket, the two parts practically become one.

Directly in front of the trunnion band is a key-ring (Figs. 238 and 239) 0.9 in. in thickness, which is laid in the groove in the tube cut for that purpose. The key-ring is cut in two parts by a cut parallel to the axis of the ring, the two halves are laid in place and secured by the shrinking on of the sleeve. The tube is subjected to sufficient strain from the radial pressure of the powder gas without being further strained by being ca'led upon to carry the breech-block. To carry the breech-block a base ring is screwed in the jacket, and on its inner surface screw threads are cut corresponding to the threads on the block. The circumference is then divided into six equal sectors, and three are then planed off so as to form the slotted sectors for the insertion of the block. In front of the trunnion band is shrunk a sleeve 25 in. in length (Figs. 225 and 226), and 2 in. in thickness. It is cylindrical for 20 in., and then gradually slopes off so as to avoid a sudden jump to an unsupported tube. The various figures show very clearly the detailed construction of the gun. The breech mechanism is on the interrupted screw system, and in its general features it is similar to those previously described. The breech-block (Figs. 245 to 248) is 10.5 in. in length, and has the three-threaded and three-slotted sectors. On its surface is cut the longitudinal and transverse groove deepening at the ends (Figs. 249 and 250), in which works the latch-pin which locks and unlocks the block automatically. Its action is precisely the same as described for the 3.2-in. field gun. The ears on the block, to which the lever handle (Figs. 257 and 258) is hinged, are situated to the right of the vertical plane through the axis of the block (Fig. 246), so that when the block is locked the lever handle (Figs. 255 and 256) will not hang down over the vent.

The lever has a cam on the upper end, which serves the double purpose of locking the block, when in the firing position, and of acting as a lever to start the block when it is revolved, so that the screw threads are unlocked.

When the block is locked the handle arrives opposite a recess in the carrier ring (Figs. 264 to 267) into which the cam fits, and the lever can then drop close to the block. In all other positions it would project at an angle, and would serve to indicate that the block was not properly locked, and thus prevent any premature insertion of the primer. On the lever handle pin is mounted a friction spring (Fig. 259), which, pressing against the ears on the block, increases the friction between the handle and the ears. This is necessary to prevent the shock of discharge from throwing up the handle, and also to prevent the handle from dropping away from the piece, when the piece is fired at a high angle of elevation, as is usually the case. The vent is axial, running through the spindle of the mushroom head (Figs. 252 to 254). The outer end is enlarged and screw threads cut on the surface for the obturating primer. The obturation is performed by the asbestos pad in the same manner as heretofore described. The proper pressure is kept on the pad by a steel spring encircling the spindle of the mushroom head and recessed into the block. It presses against a nut screwed on the spindle. To prevent this nut from unscrewing when the block is turned, a second locking nut is screwed on the outside of the first nut; the screw threads of the second nut run in the opposite direction from those on the first nut. Heretofore there had been no piece in the United States, except a 42-pounder, that had a calibre of 7 in. In selecting this calibre the following method was adopted:

The weight of the piece was first fixed by the considerations relating to the transportation over ordinary roads and over the pontoon bridge. This fixed the weight of the piece at about 3750 lb., its finished weight being 3710 lb. A range of 6000 yards was then selected and the mass of metal so distributed as to give for this mass the most powerful piece. A piece of equal power could have been made with less metal, but on account of its lightness the recoil would have been excessive, and the strain on the carriage would have been toc great. With a mass of metal weighing 3710 lb. a more powerful howitzer could have been made, but the same question of the strain on the carriage would have arisen. In guns of this nature a certain extra weight must be added, and it is so done in all services.

Table XVIII.—*Ballistic Data of the 7-in. B.L.S. Howitzer.*

Calibre		7 in.
Weight		3710 lb.
Total length		8 ft.
Travel of base of shot in bore		81.2 in.
Length of bore		12.4 calibres
Twist in number of calibres		35
Number of grooves		40
Width ,,		.99 in.
Depth ,,		.06 ,,
Width of lands		.16 ,,
Powder chamber	Length	10.64 ,,
	Diameter	7.20 ,,
Charge		9.75 lb.
Projectile		105 ,,
Ratio of we'ght	of charge to weight of projectile	1 to 10.7
	of projectile to weight of piece	1 to 35.3
Initial velocity		1085 ft.
Pressure per square inch		28,200 lb.
Muzzle energy foot-tons	Total	856.8
	per ton of gun	519.2
	per pound of powder	87.8
Density of loading		0.861
Powder	Kind	Dupont I.K.K.
	Density	1.725
	Granulation	200

The type howitzer was fired in all 658 rounds; 58 preliminary rounds were fired with reduced charges, and 600 rounds with full charges. At the conclusion of the test the piece was pronounced practically uninjured.

Tests for accuracy and rapidity of fire gave the following results.

Table XIX.—Rapidity.

Number of Test.	Number of Shots Fired.	Time.
		m. s.
1	17	22 40
2	20	23 10
3	20	22 25

Table XX.—Accuracy.

a. Direct Fire.

Number of Target.	Range.	Weight of Powder.	Weight of Projectile.	Elevation.	Mean Horizontal Deviation.	Mean Vertical Deviation.	Mean Deviation.
	yds.	lb. oz.	lb.	dg. min.	ft.	ft.	ft.
1	1760	9 4	105	4 5	2 82	4.95	5.69
2	3000	9 4	105	8 5	2.76	5.06	5 76

b. High-Angle Fire.

Number of Target.	Mean Range.	Weight of Powder.	Weight of Projectile.	Elevation.	Mean Lateral Deviation.	Mean Longitudinal Deviation.	Mean Deviation.
	yards	lb. oz.	lb.	deg.	ft.	ft.	
1	1824	2 0	105	40	8.4	100.4	
2	2488	2 8	94	40	9.5	133.4	
3	3433.5	3 8	96	35	8.1	102 6	
4	4311	4 10	105	35	9.95	93	

The result of the fire for accuracy at the target, 22 ft. by 40 ft. at a distance of one mile, is shown in the diagram of the target (Fig. 270).

The carriage for the 7-in. breechloading steel howitzer, as shown in the general view (Fig. 219), and in the detail (Fig. 268), is radically different from any heretofore used in the United States service. It really consists of a "top carriage" and a "chassis." The "top carriage" consists merely of the trunnions (*a*) which are allowed a recoil along the inclined slides (*b*) of about 6 in. The recoil is checked by the hydraulic cylinder (*c*) and the piece returned to the original position by means of the Belleville springs (*d*), whose compression by the recoil also tends to limit the path over which the trunnions slide. The springs rest against the travelling trunnion beds (*e*), and the rods upon which the springs are strung pass through holes in this bed.

The travelling trunnion beds, situated as they are well to the rear, bring the centre of gravity of the system between the axles of the carriage and limber, and render the system perfectly stable on the march.

The flasks are made of sheet steel flanged, as shown in the section (Fig. 269), to increase their strength. As an excess of strength would occur slightly in rear and below the trunnions, a triangular piece is cut out, and so the weight is materially lessened. The flasks are joined by three single transoms (*g*) and one double transom (*h*). To this latter transom is attached the piston-rod of the hydraulic buffer. The flasks are bolted to two iron forgings (*i*) which rest on the axle. Two plates (*j*) serve to further strengthen the flasks. The hydraulic buffer is attached to a pintle situated between the wheels. When the piece is fired it first recoils with the trunnions (*a*) along the slide (*b*) until the pressure on the springs is such that the carriage is set in motion. The recoil of the carriage is checked by the hydraulic buffer, and thus the total recoil of the piece is very slight.

The piece can be elevated 40 deg. or depressed 5 deg. The elevation is performed by means of an elevating rack (*l*) which is attached to the piece, and a worm (*m*) which is attached to the right trunnion. The worm is turned by means of a shaft (*n*) and an elevating wheel (*o*). The worm can slide along the shaft (*n*) but by means of a spline is caused to rotate with it. When the piece is fired the piece, rack, and worm slide to the rear until the recoil is checked.

The weight of the wheels is 375 lb. each; weight of carriage complete 3200 lb.; pressure of trail on platform 1300 lb.; height of trunnions 6 ft.

THE INSTITUTION OF MECHANICAL ENGINEERS.

On the evenings of Thursday and Friday of last week, the 5th and 6th inst., an ordinary general meeting of the Institution of Mechanical Engineers was held in the theatre of the Institution of Civil Engineers by permission of the Council of the latter society. The programme consisted of three items, namely, the President's inaugural address, Professor Kennedy's "Report on Trial of the Steamer Ville de Douvres," made by the Research Committee on Marine Engine Trials, and a paper by Lieutenant-Colonel Thomas English, of Jarrow, "On Condensation in Steam Engine Cylinders during Admission." The chair was taken on both evenings by Dr. William Anderson, F.R.S., the chairman of the Institution.

After the usual formal business had been transacted and the list of new members read out, Dr. Anderson proceeded to read his

Presidential Address.

As we commence the publication of this address in full in the present issue, we need not give an abstract of it here. As was natural, the Director-General of Ordnance Factories said a good deal about his department. Our readers are aware that the Government departments under Dr. Anderson's control have been subject to some criticism of late, and remarks have been made, not altogether favourable, upon the way in which business is conducted. Dr. Anderson appears to think that the hostile critics are mostly disappointed inventors who have failed to impress the Government officials with the value of their devices. Perhaps this is true to a great extent, but if we read the recent correspondence aright, the grievance was not so much that Government officials failed to recognise the importance of certain inventions, but that they valued them only too highly, so much so that they were apt to appropriate these inventions without sufficient acknowledgment. This, however, was a point upon which the President did not touch. He had not much difficulty in making out a good case in defence of the alleged unwillingness of Woolwich to adopt new ideas. One of the most difficult tasks for a public department—such as the engineering branch at the Admiralty or the War Department—is to discriminate between the claims of rival inventors, or perhaps rather to determine what is and what is not worthy of a trial. Of all the legion of inventors and schemers who carry the results of their lucubrations to "the Government," it would perhaps be safe to say that not one in a hundred is worthy of attention. Out of that 1 per cent. possibly not more than 10 per cent. are of sufficient value to warrant their adoption. As an inventor's appraisement of his work is often—perhaps generally—in an inverse ratio to its value, it may be easily understood that "the authorities" are not well spoken of by inventors at large. If some of the severe critics of the departments had for a time the weary task of wading through the mountains of nonsense that forms so large a part of the bulk of submitted ideas, they would be less caustic in their remarks, and more lenient if now and again an invention of true merit is not at once recognised. Nevertheless, it would be a serious matter if the nation were denied the advantage of outside invention. After all, the great bulk of the advance in war material has been winnowed out of that monstrous mountain of chaff; and it is the duty of the professional advisers of the two great spending departments to perform this service. Supposing, how-

MODERN UNITED STATES ARTILLERY: 7-IN. BREECHLOADING HOWITZER.

(*For Description, see Page* 578.)

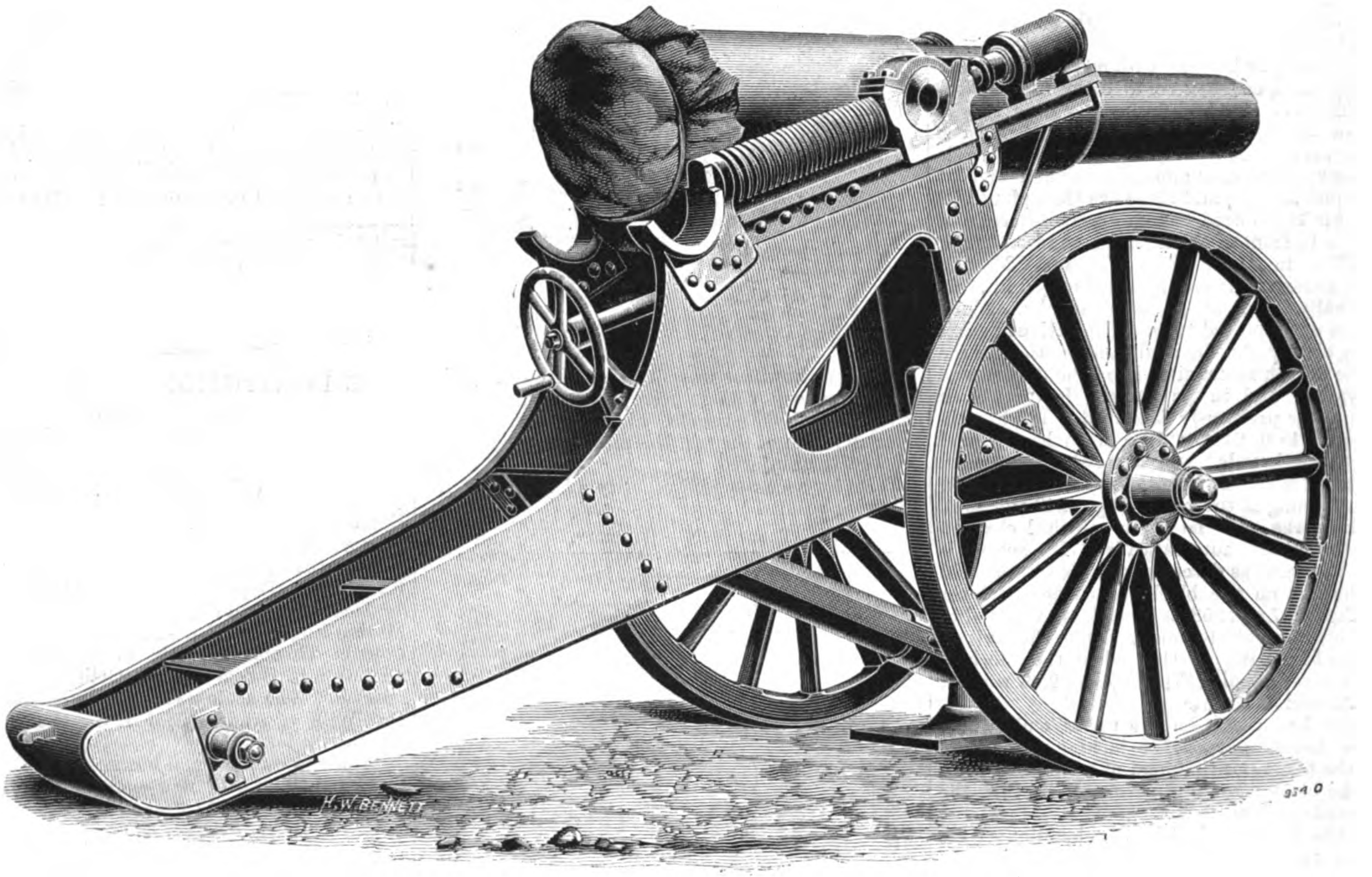
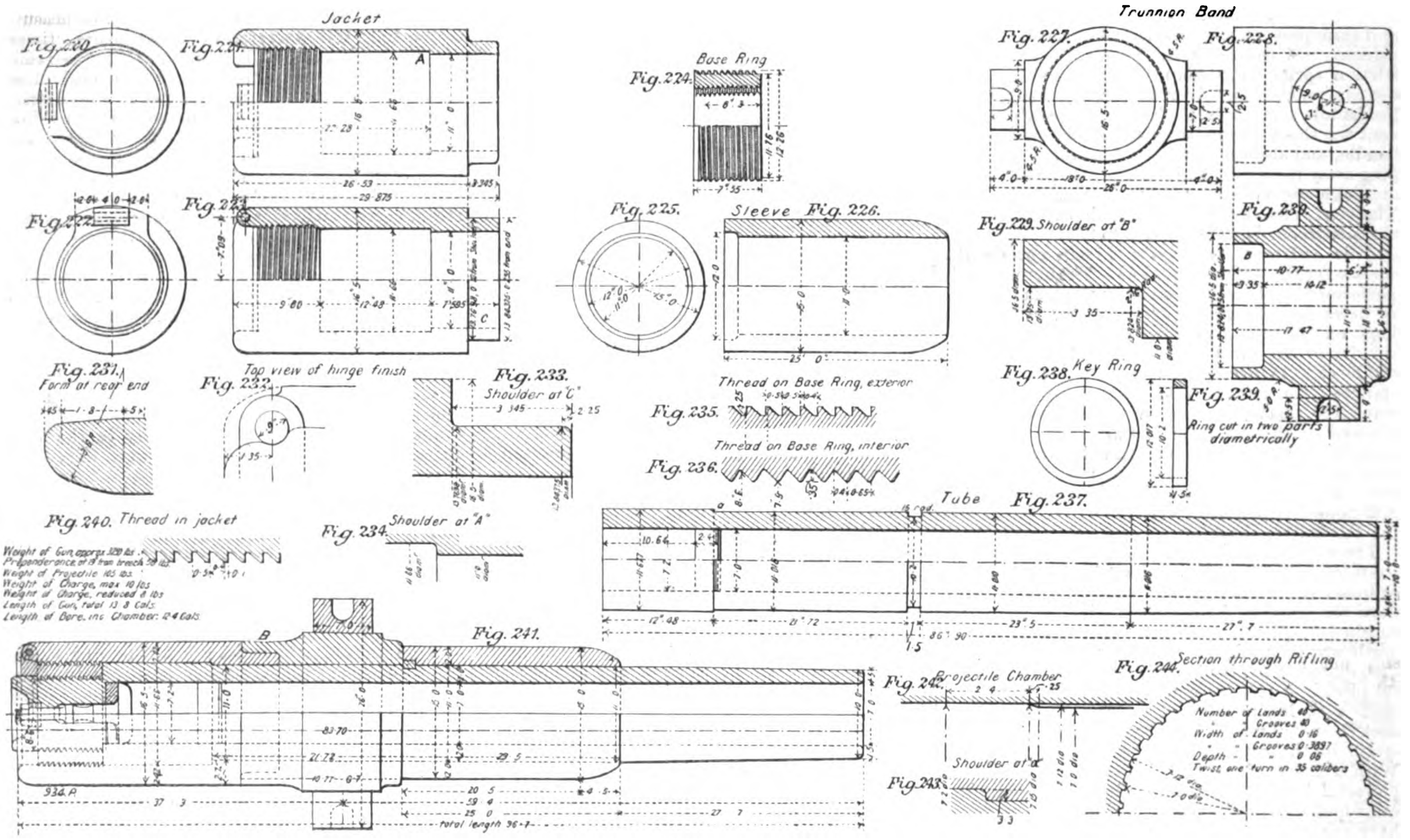


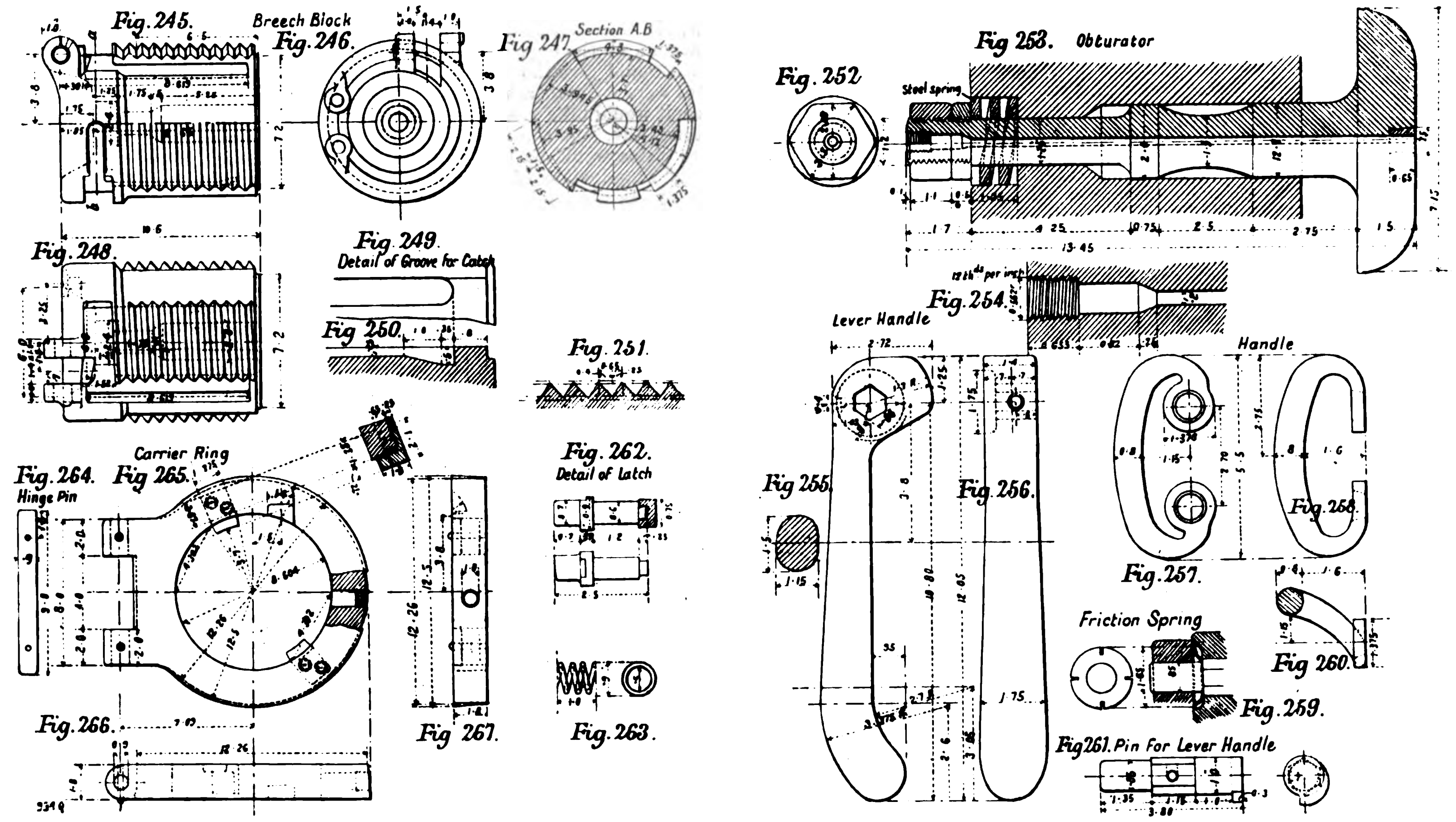
FIG. 219.

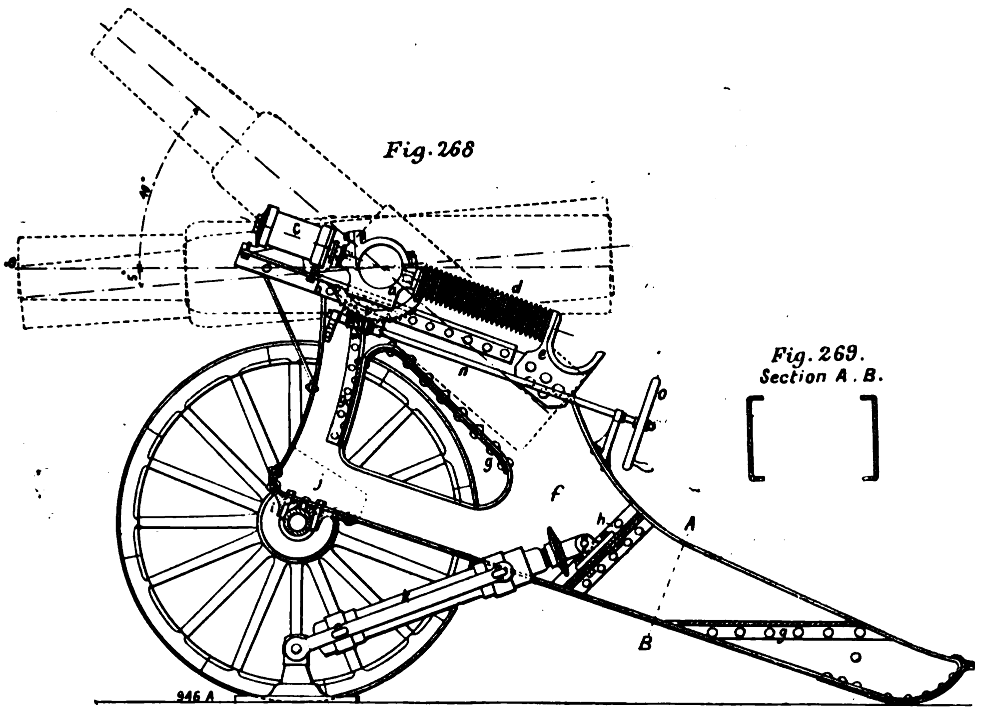


ever, a real improvement in some store or arm has come to light it is not always advisable it should be adopted. Dr. Anderson gives an instance of this. "A difficulty," he says, "which stands in the way of adopting new arms, or improvements in those already existing, is the necessity of incurring the enormous expense of changing the stores all over the world; and, what is almost as bad, the alteration of drill and tactics thereby involved; so that hesitation is only natural, and is even proper, until absolute necessity for change becomes apparent. Warlike stores are now made as far as possible to uniform patterns, and the components are interchangeable not only in each service, but also, when practicable

MODERN UNITED STATES ARTILLERY: 7-IN. BREECHLOADING HOWITZER.

(*For Description, see Page* 578.)





between the various services; so that, for example, a ship might in the event of necessity be armed with fortress guns, or might fill up her ammunition from stores intended for the land service; and therefore all fittings and appliances must be made, as far as possible, common to all." These are very good arguments, but they must not be pushed too far. The ideal official will strike a just balance between the advantages and disadvantages of any proposed change.

The vote of thanks to the President for his address was moved by Sir Frederick Bramwell and seconded by Mr. Carbutt, who said he hoped the Institution would continue to spend its funds in so useful a manner as the prosecution of research on prominent matters of engineering practice. He was by no means one of those who considered the accumulation of a large capital a desirable policy.

MARINE ENGINE TRIALS.

The next business was the reading of the report of the Research Committee on Marine Engine Trials made upon the trial of the paddle steamer Ville de Douvres, which had been drawn up by the chairman of the Committee, Professor Alexander B. W. Kennedy, F.R.S. This report we print in full on page 586 of our present issue, and we therefore need make no abstract of it here. This probably will be the last report of the Committee, which may be now considered to have concluded its labours. Professor Kennedy expressed a hope that now it had been shown trials could be made in course of the ordinary running of a vessel that owners would attempt such trials on their own account. The last trials have shown that a properly designed water meter is efficient for measuring the feed, and this does away with the most cumbersome and difficult part of the test apparatus, the measuring tanks. Mr. Druitt Halpin has several times advocated the adoption of meters for this purpose, and it is a great step in advance to have put them actually in practice; in fact, it would be a useful thing if a water meter to measure the feed could be fitted as a matter of course to all important steamers. Indicator gear has for long been an ordinary fitting, and on well-conducted steamers a set of cards is taken daily. It would not be very difficult for certain bunkers to have weighed quantities of coal put into them, and then we should have the three great elements necessary for judging of the performance of marine engines, namely, fuel consumption, indicated horse-power, and consumption of feed. Funnel temperatures also are not difficult to ascertain, either by the pyrometer or by the time-honoured method of melting metals or alloys in the uptake. Doubtless many shipowners would scoff at these suggestions. They would say that their object was to make money, and not carry out scientific experiments, whilst their superintending engineers would meet the proposal with equal or greater scorn. Owners and engineers of this class are, however, becoming more and more relegated to the smaller fry, who have, at respectful distance, to follow in the wake of their more enlightened contemporaries; picking up the unconsidered trifles of employment found in out-of-the way places. If they employed one-half the energy in deserving business that they spend on looking after it they would profit most in the long run. It is to those managing important lines of steamers that we would appeal in the present case. Unfortunately the Research Committee were not able to include a big liner in their series of experiments, and it is therefore more necessary that the owners of these craft should take the matter into their own hands. All lines of steamers have superintending engineers in whom must necessarily be placed great confidence; and, as an almost invariable rule, well is the confidence deserved. Nevertheless these able men must necessarily often feel themselves somewhat at a loss in advising upon the purchase of new machinery, and owners must recognise how much they are in the hands of their contractors. At present the rough general results obtained are the only guide, but if the performance of the boiler could be separated from that of the engine it would

The important point for an engineer to consider is, what is best to be done under such circumstances to prevent a work which is showing signs of giving way from becoming a total ruin. Usually failures of the class illustrated are somewhat gradual, and if precautionary measures are taken in time, the work can be saved by the expenditure of a comparatively small sum of money.

The simplest and most economical manner of procedure is to resort to grouting and stock-ramming, whereby the foundations may be increased in width and depth, and the strata rendered firmer. Should the wall be founded on sand or gravel, all that would be necessary would be to put down a series of boreholes of, say, 3 in. to 6 in. diameter at intervals along the line of the wall, and several in the width of the wall as shown by the sketches. These bores go to the bottom of the wall and several inches into the strata underneath, if such be of sand or gravel. Pipes would be placed in the boreholes and thick neat Portland cement grout then passed through the pipes or forced down if necessary, and would thus find its way into the various crevices which might be in the bottom portion of the wall, which it would fill up, rendering the wall solid; it would likewise cement the wall to the stratum of sand or gravel on which it was founded, and this stratum would also for several inches in thickness be cemented together, thus adding a new foundation course below the wall, the breadth of which would be determined by the positions and numbers of the boreholes and grouting pipes used. After a short interval the boreholes could be carried a little lower, and a second solidified stratum added below the first. A third, fourth, or indefinite number of added layers, or foundation courses, could thus be made to the wall, and if the outer boreholes were put down at convenient angles sloping outwardly, each successive layer would be wider than the previous one, and the weight of the wall thus distributed over a greater bearing area.

This means of grouting and solidifying the lower portions of structures is also equally applicable for stopping leaks or runs of water through or under walls or dock entrances. It is necessary, however, in using it for that purpose that the run of water should be temporarily stopped during the operation of grouting, and for a sufficiently long time afterwards, to enable the grout to become thoroughly set. To attempt grouting whilst the leak or run of water continued, would be useless, as the cement would be carried off by the water, and thus never have the opportunity of solidifying. If, however, the run of water should be very weak, probably by adding some Medina or quick-setting cement to the Portland cement, or by using partly set neat Portland cement, the leak could be stopped, although in all likelihood some cement would be lost before this was accomplished.

In a number of cases it is quite practicable to temporarily stop the leak or run of water to enable grouting to be done with Portland cement. For instance, in dealing with leaks in graving dock floors and walls, the walls of wet docks, or of dock entrance works, all that is required is to keep the dock gates open so that the water inside the dock may be at the same level as that outside, when, of course, there would be no run of water through or under the walls or entrance works. Grouting could then be proceeded with, and after the cement grout is set the dock gates could be closed, and when the work is subjected to its usual head of water it will be found that the leaks are stopped, that is, if the grouting has been properly done. I have stopped many leaks in that way during the past thirty-three years, and since I gave an account of my experiments and practice with Portland cement for such purposes at the Institution of Civil Engineers in 1865-6 (see Minutes of that session, vol. xxv., page 125), many other engineers have adopted it with the most successful results, although in some other cases there have been engineers who, owing to improper preparation of the grout or to inferior quality of the cement, or to having mixed sand with the cement, have obtained results which proved to be failures instead of successes. I shall refer subsequently to the quality of cement and the preparation of grout when describing the work of underpinning the Hermitage Breakwater at Jersey.

If the stratum on which the wall which is giving way is founded should be of clay or a clayey nature, then instead of forcing cement grout under the foundations, stock-ramming should be resorted to, using as materials for the purpose either clay worked up with hydraulic lime, sand mixed with iron filings and sal ammoniac, partly set neat Portland cement or fine Portland, and Medina cement concrete. Such materials should be made up into convenient sized balls or rolls, put into the tubes and rammed down hard with a heavy ram or monkey, worked, say, by a hand or steam ringing or pile-driving engine, so as to force them into the soft stratum, and thus form under the wall a stratum of harder material extending the full width of the base of the wall, and such additional width beyond the base as may be deemed suitable. When one layer has been completed the boreholes can be carried lower down and another layer added, and so on as shown by Figs. 1, 2, 3, 4, and 5.

This system of stock-ramming is especially applicable for stopping leaks, or runs of water in, through, or under reservoir embankments (see Fig. 5), without requiring to empty the reservoir, or reduce the head of water in it. I have used it for similar purposes with the most successful results. All that is required is to ascertain the position of the leak, as nearly as possible, put down some boreholes in the vicinity of the site, and ram the clay or other material down very hard. It is not necessary that the boreholes should be exactly on the line of leakage, or water run, as the stock-ramming, although it be done at some distance from the run, will force out the strata if sufficiently near to the leak and entirely close it up. It is astonishing the power which can be exerted by stock-ramming. In one case I lifted a portion of a dock side by this means, although my object was not the raising of the dock side but rendering secure the foundations. However, stock-ramming could be utilised for the purpose of raising walls, piers of bridges, factory chimneys, &c., or for bringing such structures back to plumb lines should they, as is sometimes the case with factory chimneys, get out of plumb.

I might give a number of instances (see Fig. 4) of dock entrances where stock-ramming could be used with advantage, but perhaps if I refer to the case of the Sutton Dock, near Wisbech, that will afford a sufficient example. At this dock the entrance works gave way shortly after the dock gates were closed. The strata upon which the works are founded is of a fine sandy or silty nature and seems to me exceedingly well adapted for treatment by stock-ramming. From what I know has been and can be done by stock-ramming I have no hesitation in recommending that system to be adopted in restoring the entrance works, and so enabling the docks to be utilised, and some return obtained for the large amount of money which has been expended in connection with these works.

The works to which I have so far made reference have been situated either on shore or, if in connection with harbours, have been in sheltered positions, such as dock walls and entrances.

Works in exposed positions, such as breakwaters, sea-piers, and lighthouses, are subjected to such heavy action of the sea that their construction has to be specially adapted to resist those forces. The conditions under which the work of construction has to be done, and the forces which have to be resisted, render it imperative that solidity and massiveness be obtained. Durability otherwise could not be secured. For lighthouses, when of solid construction and exposed to the full force of the sea, a special form of construction has long been in use, and from experience has been found most satisfactory.

The case is otherwise with regard to breakwaters, for subsidences, settlements, and breaches of such works during or after construction are comparatively common, and I think it is by no means creditable to the engineering profession that such should be the case.

It is not that failures of such works are due to scamped work, or to niggardly expenditure, unduly limiting the amount to be spent, and thus forcing the engineer to adopt too weak a design. On the contrary, the cost of the work per yard run is unusually high, and as it is generally done directly by a Government department, or harbour board, without the intervention of a contractor, there is no object in scamping the work. The failures which take place are not to be attributed to such causes, but to the design itself, which for recent breakwaters of importance may be described as consisting of a rubble base, or mound, surrounded by a wall constructed of large-sized blocks of concrete, with open joints between all blocks, and on the top of the blocks a capping of concrete *in situ*. It is high time that this system of construction was abandoned. It has been attended with failures of greater or less extent in the past, and I have little doubt will be so in future, even although some of the structures of this type have, up to the present time, shown no signs of yielding. It is a question of time, a repetition of big storms, or a storm of exceptional severity, the effects of which, extending to a lower level than usual, disturb the comparatively small and loose materials of the rubble, and being so dislodged, the heavy structure on top becomes undermined and gives way, either piecemeal as in some cases, or in masses of over 1000 tons in weight as at Wick. Were such failures unavoidable it would be useless to find fault, but with a constructive material like Portland cement at the disposal of the engineer, breakwaters ought to be constructed with as little liability to failure as any other class of works, and their durability and small cost for maintenance ought to be on an equal footing. This can only be obtained in exposed positions (and it is to such I refer), by making the work monolithic from foundation to cope. Absolute security would thus be obtained, and not only security, but saving in cost, as the minimum section of breakwater could be adopted where the work consisted of one mass, which cannot be done with an open-jointed or disjointed structure, where each block or portion of the work has to depend on its own weight for stability, assisted perhaps by the additional weight of a superimposed mass. But in reality comparatively little aid to any particular block, or series of blocks, can be counted upon with certainty from such mass or capping, as although its weight upon the blocks may be considered to be fairly and uniformly distributed immediately after completion of the work, yet the slightest settlement of the foundation afterwards at any part (and this is a common occurrence), immediately relieves the top of the blocks from the weight of the superincumbent mass, and the blocks have only their own weight to depend upon for stability. So that in structures of this class the stability of the blocks themselves can only be relied upon. A help to a certain extent is obtained by means of cramps, and also of grooves and joggles, but this is only a small step in the direction of the monolithic system of construction, which without doubt is the proper one to adopt.

(To be continued.)

MODERN UNITED STATES ARTILLERY.—No. X.

8-IN. COAST GUN. (FIGS. 271 TO 278.)

IN a previous article we have given a description of the smooth bore and converted rifled guns, that are still retained in the United States service for the defence of minor seaports. With this article we will begin the description of the breechloading built-up steel rifles intended for the defence of the principal harbours. The smallest calibre intended for use on the sea coast is the 8-in. rifle.

This gun is composed of one tube, one jacket, eight C hoops, three D hoops, seven A hoops, a base ring, and the breech mechanism. It should be noticed that the tendency of modern gun construction is towards the increase in the length of the hoops used, and the decrease in the number. A few years ago the hoops used were much smaller than at present, and the system much more complex. Longitudinal stiffness is of great importance in a built-up gun, especially to-day, when the lengths of the guns are being so greatly increased. Many of the modern guns, particularly the longer calibres, are found to droop at the muzzle. Short hoops will not give as much longitudinal stiffness as long ones, and consequently each new model has fewer hoops than the preceding model.

In the first model of the United States 8 in. breechloading rifle the chase was not hooped, but the test of the gun showed that, with the progressive burning powder used, it was necessary to extend the row of C hoops to the muzzle. Of the A hoops there were twelve, and outside of them were shrunk a second row of hoops, called B hoops, ten in number.

With the present gun, this row of B hoops has entirely disappeared, and the other hoops are much reduced in number. The model of 1891 now building, has a further reduction. Five C hoops cover the same length of tube as the eight C hoops shown in the section (Fig. 272); two hoops replace the three D hoops; and five hoops the seven A hoops. There is talk of a still further reduction in the number of the hoops, but it will require the experience of experiments to determine whether any departure from those already made shall be definitely adopted.

The tube is 261.5 in. in length and varies from a thickness of 2.75 in. over the powder chamber, 1.75 in. at the muzzle. Starting from the rear end of the bore there is a conical slope for a distance of 2.5 in., in which distance the diameter decreases from 9.7 in. to 9.5 in. This slope forms the seat for the gas check pad, and assists in starting the pad, if it is stuck after firing, since a slight motion to the rear will free the pad from contact with the walls. The powder chamber proper is 44.25 in. long when the breech is open, or 41.25 in. long when it is closed. Its diameter is 9.5 in. The powder chamber is connected with the shot chamber by a conical slope of 10 in.

The shot chamber consists of two parts; first, a cylindrical part 2.626 in. in length, and 8.32 in. in diameter; second, a conical part, 1.816 in. in length, in which distance the diameter changes from 8.32 in. to 8.053 in. Referring to the detailed drawing of the chamber it will be seen that the cylindrical part of the shot chamber contains that part of the projectile in rear of the rotating band. The conical part of the shot chamber is very important, since it is for the purpose of centering the shot. The rotating band on the projectile is cut with the same slope as this conical part of the shot chamber. When the piece is loaded the projectile is shoved in as far as possible, and since the rotating band is concentric with the projectile, and since, when the projectile is rammed home, the band is in contact with the bore at all points, the axis of the projectile is accurately in the axis of the bore. This will naturally increase the accuracy of fire. In front of the shot chamber comes the rifling, which for a distance of 31.558 in. is conical, sloping .06 in. This causes the band to be deformed gradually instead of suddenly, thus reducing the maximum pressure on the rotating band, and also the maximum pressure on the gun, since the projectile, starting under less pressure, will give a greater space for the same volume of powder gas to expand in.

For the rest of the distance of the bore, 168.75 in., the diameter is 8 in., the grooves being .06 in. in depth. There are 48 grooves and lands, and the rifling has an increasing pitch. The form of the developed curve of the rifling is a semi-cubic parabola, whose equation is of the general form

$$y^{\frac{3}{2}} = 2px + C.$$

The twist at the breech is one turn in 50 calibres, and increases toward the muzzle to a point 16 in. from the face of the piece, where it is one turn in 25 calibres. From this point to the muzzle the twist becomes uniform, in order to steady the projectile. The exterior of the tube for a distance of 80 in. is cylindrical. From this point to the muzzle the thickness of the tube gradually decreases, the decrease being made by a series of steps. Each step falls approximately under the centre of a hoop. Over the end of the tube is shrunk the jacket. This is 109.10 in. in length, and projects 12.5 in. in rear of the tube in order to allow for the screwing in of the base ring, which holds the breech mechanism. In front of the jacket are shrunk the eight C hoops, whose exterior surfaces form a conical surface, whose diameter, next to the jacket, is 17.6 in., and at the muzzle it is 14 in. The manner of locking the C hoops together should be noticed. The front end of the lip is thicker than the rear end, so that when once shrunk on they cannot be pulled apart. This manner of locking the hoops gives much longitudinal stiffness to the gun. The three D hoops are next shrunk over the jacket and C hoops, and finally the A hoops are shrunk on. The trunnions are carried by the A_2 hoop. The base ring completes the assembling of the gun. This screws into the jacket, but as shown in the detailed drawing (Fig. 278) does not abut against the end of the tube, but between the tube and base ring is a small space, and at the bore this is closed by a copper ring. It was found that, on firing, the powder pressure lengthened the jacket, so that, if the base ring abutted against the tube, it would be forced away from it by the pressure, and, when the pressure was relieved, the base ring would strike a blow on the tube, and would be liable to crack the jacket. To prevent this the space was left, and the copper ring put in to act as a packing.

In the smaller calibre guns it has been seen that the breech-block, when withdrawn, was supported by the carrier ring, by means of which it was swung around out of the way for loading. In these guns the various operations of unlocking the screw threads on the block by revolving it, the withdrawing and swinging around of the block, were all done by hand. In the 8-in. gun and guns of larger calibres, the breech-block becomes too heavy to be carried by a carrier ring, and to be unlocked and withdrawn without some mechanical appliance, whereby the power is multiplied. The general construction resembles the smaller guns, but the details are much more complex. In order to unlock the block there is a device for rotating the

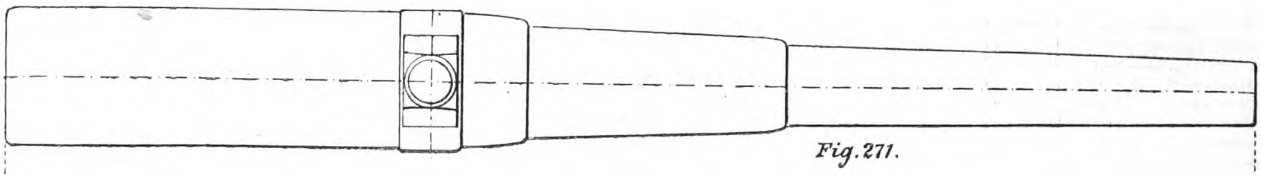


Fig. 271.

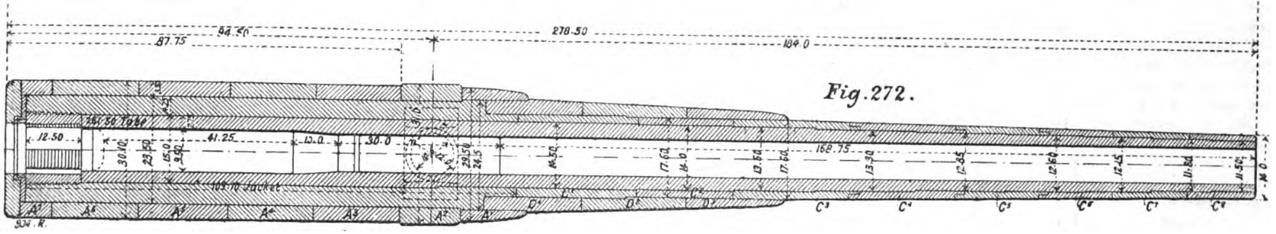


Fig. 272.

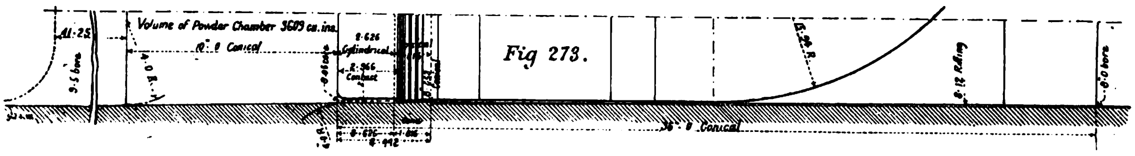


Fig 273.

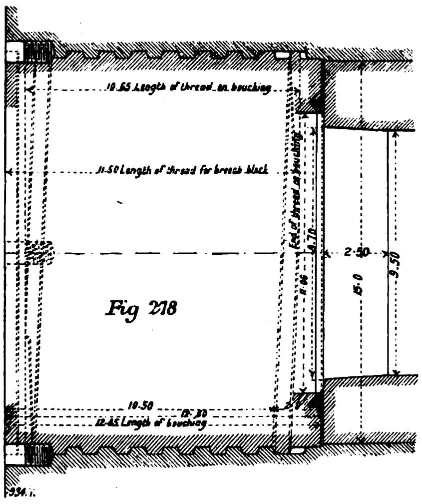


Fig 278

Fig 274 STAGES OF ASSEMBLAGE.

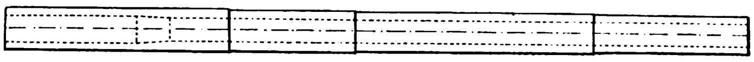


Fig. 275.

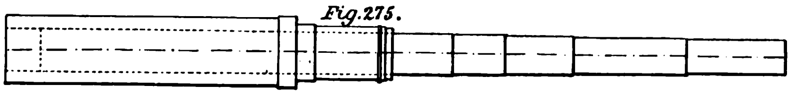


Fig. 276.

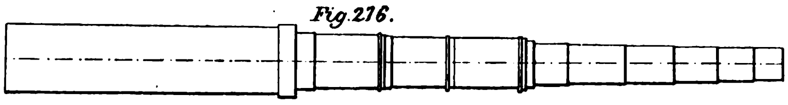
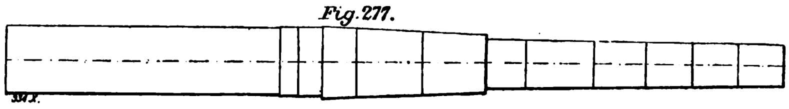


Fig. 277.



8-IN. BREECHLOADING 14¼-TON GUN.

MODERN UNITED STATES ARTILLERY: 10-IN. BREECHLOADING GUN.

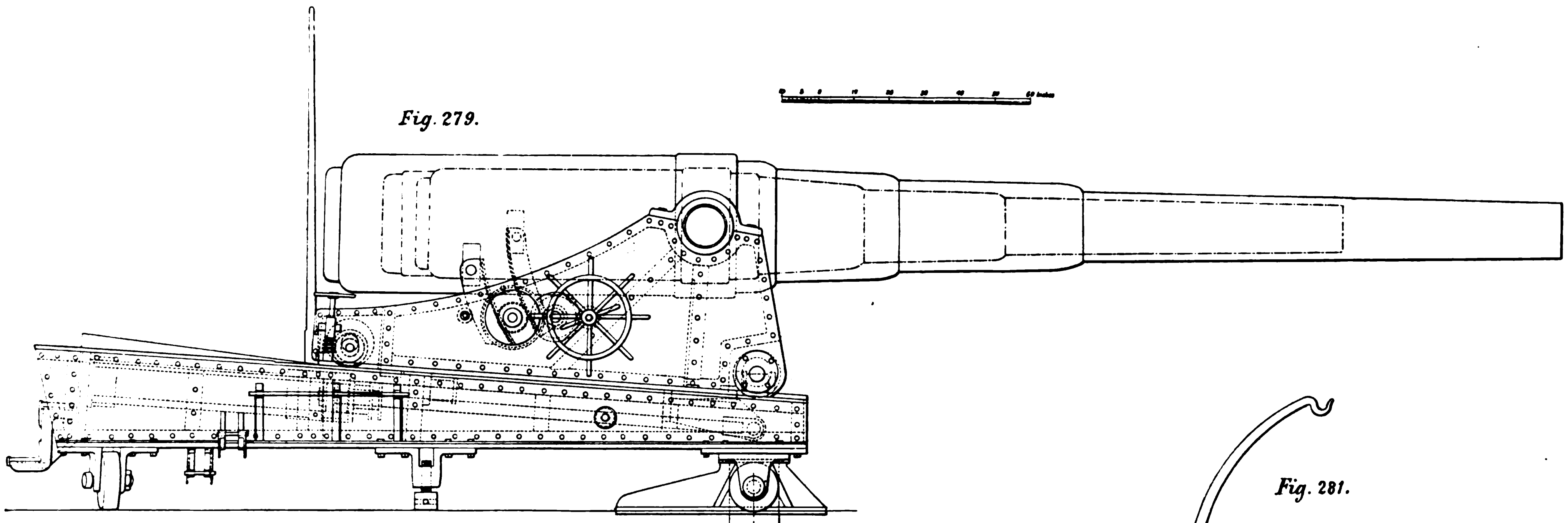


Fig. 279.

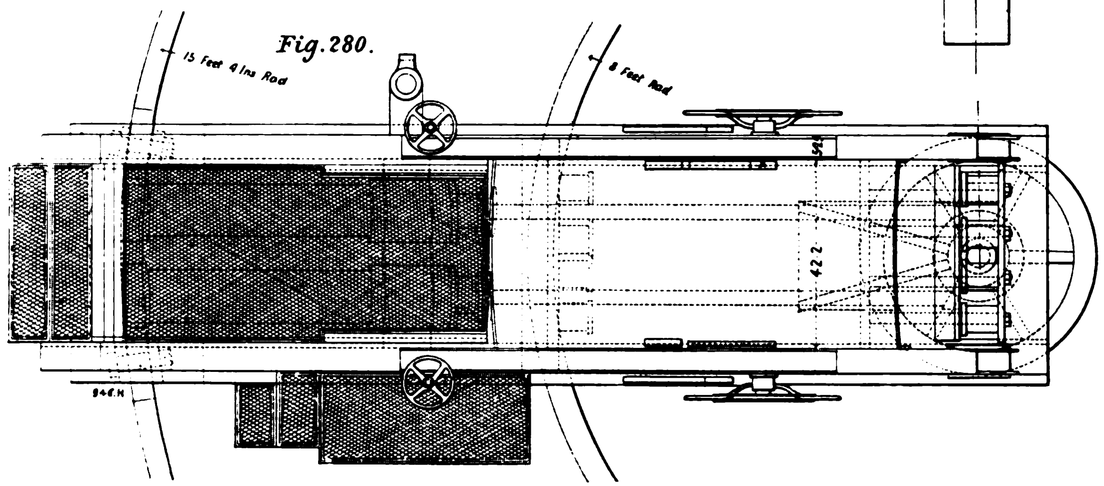


Fig. 280.

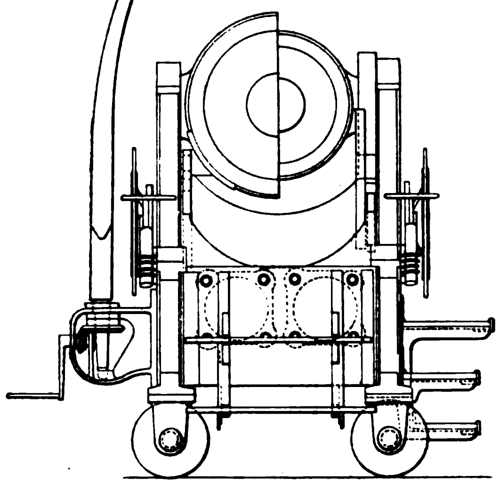


Fig. 281.

block through an angle of 60 deg. There is a second device for withdrawing the block. When withdrawn the block rests on a tray, which can be swung around out of the way for loading, thus replacing the carrier ring. This piece also has a vent cover. Figs. 274 to 277 illustrate the various stages of assembling the different parts of the 8-in. coast gun.

10-IN. BREECHLOADING COAST DEFENCE GUN.
(FIGS. 279 to 285).

The 10-in. breechloading rifle followed the 8-in. breechloading rifle, which has been described above. The type gun of this calibre was completed in April, 1890. In this gun the tube, jacket, and trunnion hoop were of Whitworth steel, the remaining parts of American steel. The large steel works in the United States have since so enlarged their plants, that it is no longer necessary to import the steel for the larger forgings. The 10-in. rifle is composed of one tube, one jacket, nine C hoops, four D hoops, seven A hoops, seven B hoops, one filling ring, one copper calking ring, four coupling pins and caps, and the breech mechanism.

The total length of the tube is 327 in. The powder chamber is 11.8 in. in diameter and the cylindrical part is 53.5 in. in length when the breech is closed. The powder chamber is connected with the rifling by a conical slope, which serves to centre the projectile in the same manner as described in the 8-in. gun. In front of this slope the rifling is made conical for a distance of 45 in. in order to reduce the maximum pressure on the rotating band. The rear ends of the lands have the same slope as the powder chamber. Over the powder chamber the tube has a thickness of 3.2 in. and this thickness decreases to 2.25 in. at the muzzle. The decrease is accomplished by a series of steps, the first two coming under the middle of the D hoops and the others under the middle of the C hoops.

Now the rear end of the tube is shrunk on the jacket which is 137 in. in length. It will be noticed that the jacket projects 16.75 in. in rear of the tube, and that the threaded and slotted sectors which carry the breech-block are cut directly in the jacket, instead of in a base ring as in other guns. The jacket is cylindrical and 4.9 in. in thickness. To prevent any relative motion between the jacket and tube, four coupling pins, 90 deg. apart, are driven through the jacket and sunk 0.337 in. into the tube. After being driven in, each pin is held in place by a screw cap which is screwed down on top of it.

On the tube, directly in front of the jacket, is a shoulder against which abuts the C 1 hoop. The C 1, C 2, C 3, C 4, C 7, C 8, C 9 hoops merely abut end to end, while the C 4, C 5, C 6, and C 7 hoops are locked together by a lip on the rear hoop entering a recess in the front hoop, the diameter of the lip in front being greater than that in rear, so that once locked by shrinking they cannot come apart. Fig. 285 illustrates to a large scale the arrangements of joints near the trunnion ring. The D 1 hoop locks the jacket and C 1 hoop together, by having

MODERN UNITED STATES ARTILLERY: 10-IN. BREECHLOADING GUN.

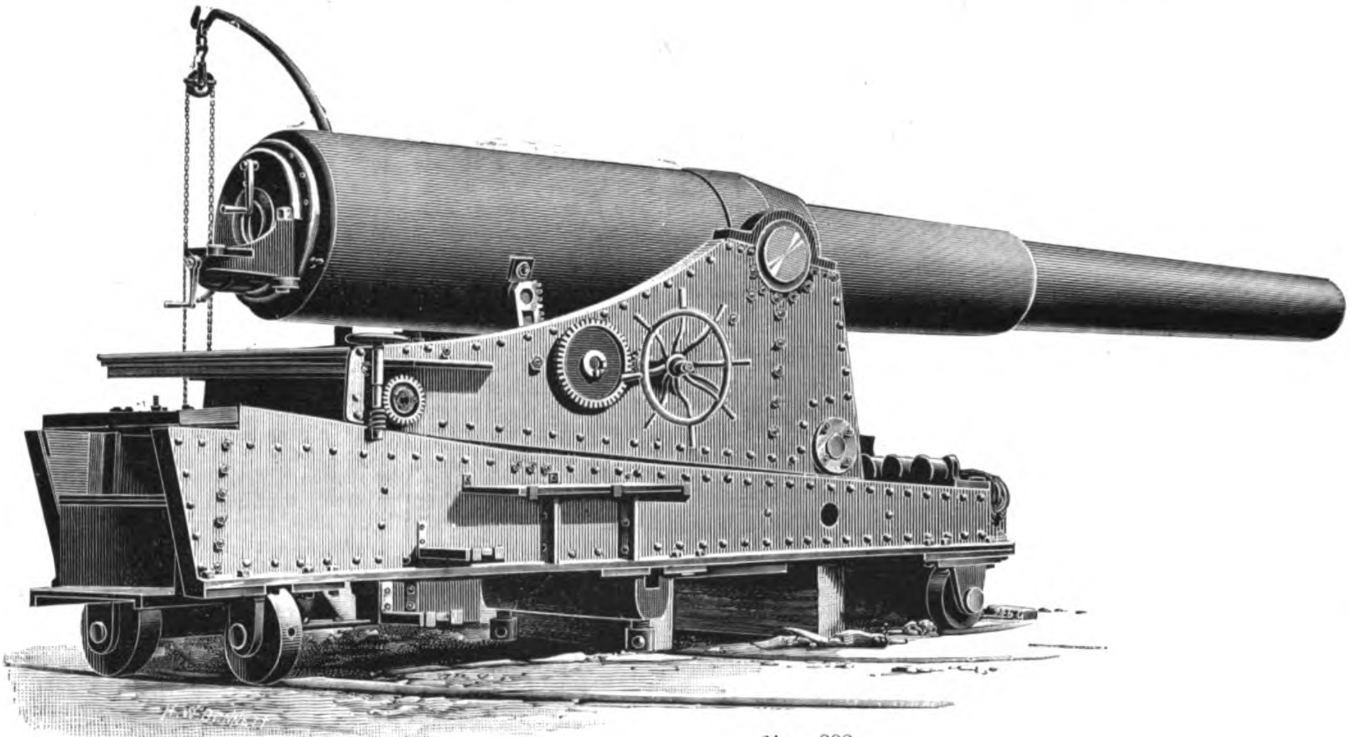


FIG. 282.

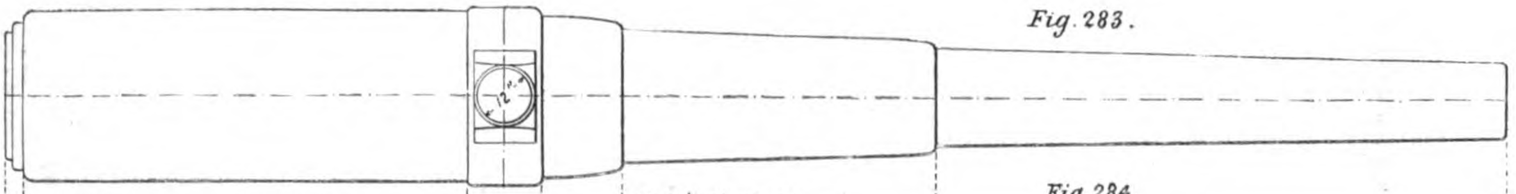


Fig. 283.

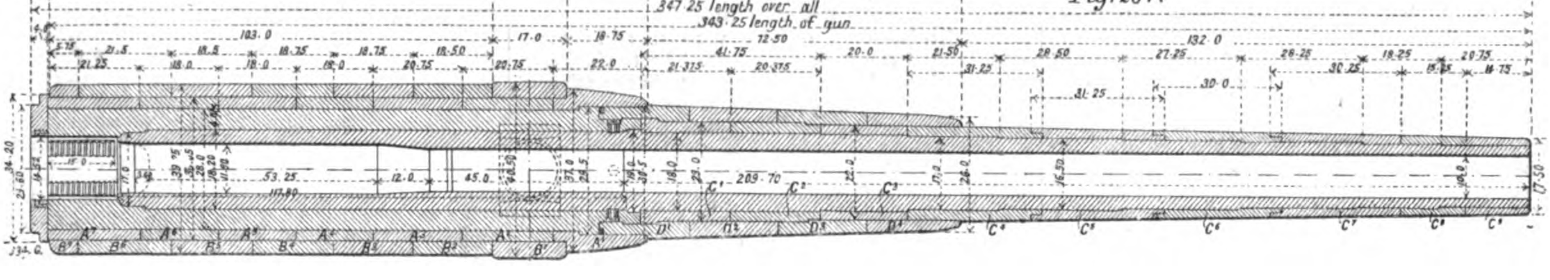


Fig. 284.

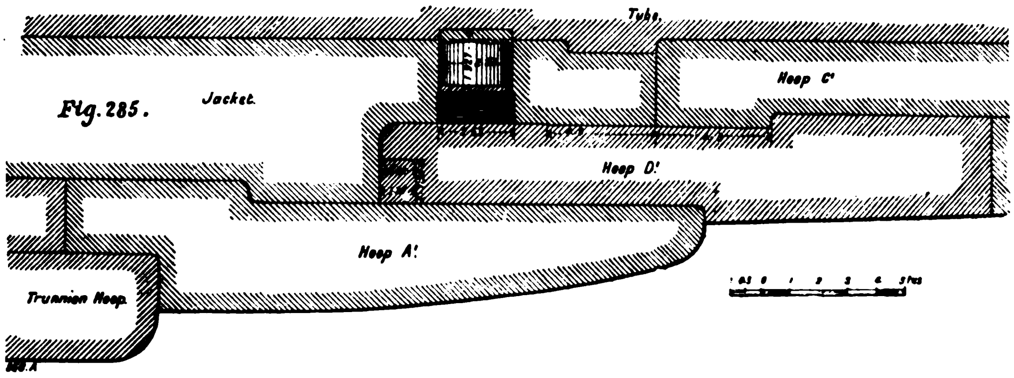


Fig. 285.

a recess in it which fits over corresponding shoulders on the jacket and C 1 hoop. The D 1 hoop, being heated sufficiently to give it the necessary expansion to pass over the shoulders on the C 1 hoop and jacket, will naturally, on cooling, shrink away from the jacket and a space will be left at the joint. In order to fill this a recess is cut in the D 1 hoop and a split filling ring placed in it. This filling ring is held in place by the A 1 hoop which is shrunk over it. The other A hoops, which are then shrunk over the jacket, are practically cylindrical and all 2.525 in. in thickness. Over the A hoops, and breaking joints with them, are shrunk the B hoops. The B 1 hoop, since it carries the trunnions, is made heavier than the others, which are cylindrical and 3.1 in. in thickness. The total length of the gun is 347.25 in.

The 8-in. gun has recently been tested with a smokeless powder at Sandy Hook proving grounds. The ordinary charge of 130 lb. of Du Pont's brown prismatic powder gave a velocity of 1947 ft. per second with a pressure of 35,823 lb. per square inch. A charge of 48 lb. 8 oz. of smokeless powder gave a velocity of 2059 ft. per second with a mean pressure of 32,000 lb. per square inch. Both of these velocities were measured at a distance of 175 ft. from the gun.

TABLE XXI.—*Ballistic Data of the 8-in. Sea Coast B.L. Rifle.*

Calibre		8 in.
Weight		14.25 tons
Total length		23.2 ft.
Length of bore		32 calibres
Twist in number of calibres		50 breech 25 muzzle
Number of grooves		48
Width		.373 in.
Depth		.06 in.
Width of lands		.15 ,,
Powder chamber	Length	44.25 ,,
	Diameter	9.5 ,,
,, charge	Weight	130 lb.
	Nature of powder	brown prismatic
Weight of projectile		300 lb.
Ratio of weight	of charge to weight of projectile	1 to 2.3
	of projectile to weight of piece	1 to 106.4
Initial velocity		1935 ft.
Muzzle energy, foot-tons	Total	7786.5
	per ton of gun	546.4
	,, pound of powder	59.9

TABLE XXII.—*Ballistic Data of the 10-in. B. L. Rifle.*

Calibre		10 in.
Weight		28½ tons
Total length		30.6 ft.
Length of bore		34 calibres
Twist in number of calibres		50 breech 25 muzzle
Number of grooves		60 .
Width ,,		.373 in.
Depth ,,		.06 ,,
Width of lands		.15 ,,
Powder chamber	Length	53.25 ,,
	Diameter	11.8 ,,
Weight of powder charge		256 lb.
Nature of powder		brown prismatic
Weight of projectile		575 lb.
Ratio of weight	of charge to weight of projectile	1 to 2.2
	of projectile to weight of piece	1 to 116.8
Initial velocity		1953 ft.
Muzzle energy, foot-tons	Total	151.13
	per ton of gun	500
	per pound of powder	58.5
Pressure per square inch		37,285 lb.

In a recent trial at the Government proving grounds, 80 lb. of smokeless powder gave to a 571 lb. projectile an initial velocity of 1960 ft. with a pressure of 34,960 lb. per square inch. The 12-in. and 16-in. sea-coast rifles, which will be referred to in a later article, with the 8-in. and 10-in. rifles already described, constitute the coast defence guns of the United States.

CANET *v.* KRUPP.

BY A FRENCH ARTILLERIST.

THE recent contribution of Mr. Krupp to ENGINEERING is for the most part a translation of an article that was published a short time since in the German magazine, the *Jahrbücher für die Deutsche Armee und Marine.* As it advanced but few new statements, and certainly brought to light no new facts in replying to the ENGINEERING article, I shall also be replying to that in the *Jahrbücher.*

The German writer assumes that he places himself upon a technical platform ; now it will be seen at a glance that he does not reply to any of the arguments thrown into relief by my first answer to Mr. Krupp's strictures in ENGINEERING (*vide* pages 68, 98, 126, and 159 *ante*). His essay contains only vague affirmations of the class which we in France sometimes call *des potins.* In my original reply I placed myself entirely upon a basis of facts; and this is what I again propose to do in the remarks that follow.

The German author asserts that only very innocent artillerists can be caught by the arguments I set forth in my first reply. The number of such innocent artillerists must certainly be very great, or Mr. Krupp would not feel that there is a real necessity for again attacking the Canet system, and for reproducing many of the same arguments which it now appears were not so convincing on the former occasion, as he had expected them to be. It is more reasonable to suppose that the really innocent artillerists are those who for so many years have been contented to accept everything that came out of Essen ; who have taken for granted, and without confirmation, the statements made by the German manufacturers, and who have not even insisted on the right of proving the truth of those statements, nor of thoroughly inspecting the war material ordered at Essen while it was in course of construction. Whatever else may be the value of this discussion, it will have the good effect of awaking new ideas and of bringing to light precise facts ; it will help to remove in some measure the veil of mystery that has too long been thrown over the practice of the modern gunmaker; it may very likely dispel some illusions ; and at all events it will keep in public notice one of the most interesting and important industries on which the security of nations is supposed so largely to depend.

The *Yacht* is not a journal open to pecuniary conviction (*un journal de réclame*) ; it is the best recognised organ in France for the discussion of marine questions ; it, as little as any paper published in Europe, has the habit of stating as facts those things that cannot be absolutely proved. The German publication, *Jahrbücher für die Deutsche Armee und Marine*, in its issue of last February takes up the theme of the *Revue Internationale* (see its number for October, 1891), and casts discredit on the statements made in the *Yacht* of December, 1891. The author, to some extent, plays with the meaning of words, and he entirely distorts the character of certain negotiations. We will reply to him, not by explanation nor by corrections, but by facts. The writer in the *Jahrbücher* accuses the *Yacht* of maintaining a theme based on falsehood, when pretending that preference had been given to the Canet system in Greece, in Chili, in Japan, and in many other countries, and that this preference was the result of a series of long and careful comparative trials made between guns of French and guns of German construction.

Of course, no one would suppose that these trials had been made with guns placed side by side in the same polygon ; those would be impossible experiments, impossible, at all events, for cannon of large calibre. What actually took place was that various committees, after having studied the proposals submitted by the manufacturers, and after having followed with care and on several occasions, experiments carried out at Essen, at Elswick, and at Havre, reported in favour of the Canet system, because they were convinced that it offered more powerful guns, a better system of breechclosing, carriages and mountings possessing many special advantages, and other points of superiority. It is scarcely probable that the greater number of those countries which, up to the date of this Committee, had placed their orders with Krupp, would, out of caprice or for some equally light motive, undertake so serious a matter as the complete change of their armament.

The German author ascribes the orders for Canet guns given by Chili, to the fact that the ships being constructed by the Société des Forges et Chantiers de la Mediterranée "it appeared more convenient to order the artillery from the same firm." This explanation is absolutely correct, but by advancing it Mr. Krupp condemns himself. It is an old truth, well recognised by technical people, that in the actual development of naval artillery, the ships for which the guns are built are in one sense only floating carriages ; the ship and its guns should be made one for the other, and each with special reference to the other. It is in this fact, more perhaps, than in any other, that lies the undoubted superiority of the two great naval and military establishments, the only two in the world that can deliver a war vessel complete with its armament—that of Armstrong in England, and that of the Forges et Chantiers de la Mediterranée in France. In this important respect, Mr. Krupp finds himself in so unfortunate a position that it would be sufficient to account for a nearly entire cessation of foreign orders for heavy naval guns. It is only reasonable to assume that engineers who are thoroughly *au courant* to the requirements of naval ordnance, are more likely to produce weapons that fill all the necessary requirements. And perhaps herein lies the reason why the Krupp establishment designs its naval carriages on the same heavy and inconvenient lines, which may be excusable or even desirable on land, but which are wholly inadmissible on board ship. Such material for the marine is obsolete, and it was simply because the Canet system for naval guns and carriages represented the most advanced type, best adapted for modern warfare, that they were adopted for the three Greek ironclads. The guns proposed by the Krupp factory were less powerful than those of Canet ; they occupied more space in the ironclad redoubt, and this involved an increase in the displacement of the vessels, and consequently an increase in their cost. As to the intervention of the Comptoir d'Escompte in the affair of the Greek ships, nothing could be more natural or necessary, whenever it happens that a financial establishment acts as the intermediary between a manufacturing company that requires to be paid in gold, and a Government which prefers, on account of financial questions only, to pay in paper, or on the receipt of certain taxes. But the Essen factory shows bad taste in complaining of the purely financial assistance given by a French banking establishment to a great French industry, when such very different means were employed at Essen. The agents of Mr. Krupp, when these contracts were still in the market, went to Greece as well as to other countries in the name of Prince Bismarck, and a certain president of a foreign commission was summoned to Berlin, where Prince Bismarck informed him that if the order for ships and guns, which was about to be made, was not given to Germany, that country would not renew the commercial treaties which would shortly lapse. But even this did not avail, and the order was after all given to the Forges et Chantiers de la Mediterranée. Everybody *au courant* of this question knows how much pressure German diplomacy always tries to bring in favour of German manufacturers, especially for orders to be executed for European powers. We may add that there was nothing astonishing in Chili having ordered coast-defence guns as well as field artillery from Mr. Krupp, because the order came from the Minister of War, and contrary to what had been done by the Admiralty Department, the War Department had not nominated any commission to examine for themselves French war material ; if this had been done it is not by any means clear that Essen would have obtained the order. As for Japan, it should be mentioned that up to the present time this country has only manufactured a very small number of cast-iron guns, and those of moderate dimensions ; all her heavy guns have been ordered either in France or in England, and the screw block is invariably used for closing the breech.

Mr. Krupp always finds excellent diplomatic or financial reasons to explain how it is that almost every country has abandoned the wedge for the screw system ; the causes are much simpler than he would have us believe, and they are purely technical. However that might be, one fact is certain ; Greece and Chili, Japan and Brazil, Sweden and Norway, Denmark, Russia, Spain, Portugal, Servia, &c., to say nothing of England and the United States, are unanimous in their condemnation of the Krupp system of breechclosing. An eminent artillery officer said to the writer a short time since, "There is an irresistible tendency towards the screw system, and a corresponding abandonment of the wedge system." That is the fact. Now this is more significant than appears on the surface, because for those countries which have armed themselves with Krupp breechloading guns, a very serious cost must be incurred in making the desired change for the better. It must be admitted that if French artillerists are, according to Mr. Krupp, wholly of no account, the French diplomatists and financiers are, on the other hand, unusually clever.

Mr. Krupp has been very badly informed on the subject of the orders given to the Forges et Chantiers by Russia. The War Department of that country ordered a 6-in. gun of 50 calibres, and not one of 35 calibres, for coast defence. As to the adoption of the Canet quick-firing guns by the Russian Naval Department, a fact which Mr. Krupp persists in denying, to put an end once for all to further discussion of this point, the writer appends translations of the letters written by Monsieur le Commandant Rimsky-Korsakoff, Russian naval attaché, and by Admiral Popoff, announcing the adoption of the Canet system and the intention of the Russian Government to construct this class of gun in Russia.

Naval Attaché at the Russian Embassy, 6, Rue Marbeuf.
Paris, June 8, 1891.

Sir,—I have the honour to inclose you herewith the textual translation of the order from the Minister of the Imperial Russian Navy, which I have just received.

I am happy to inform you, that your systems of quick-firing gun and carriage have been recognised as superior to those of other manufacturers, and I beg you to be good enough to send me, with the least possible delay, the reply asked for by the Minister of the Imperial Navy.

(Signed) COMMANDANT RIMSKY-KORSAKOFF.

Monsieur Canet, Directeur de l'Artillerie,
Société des Forges et Chantiers de la Mediterranée,
3, Rue Vignon.

Ministère de la Marine, Bureau Central
de Construction et d'Armament,
May 22-June 2, 1891. No. 4832.
To the Naval Attaché in France.

Sir,—The Technical Committee, after having examined the report of the commission of artillery officers of marine, which was instructed to visit the different establishments, to study the best system of quick-firing gun, has made its selection in that of the Canet type . . .

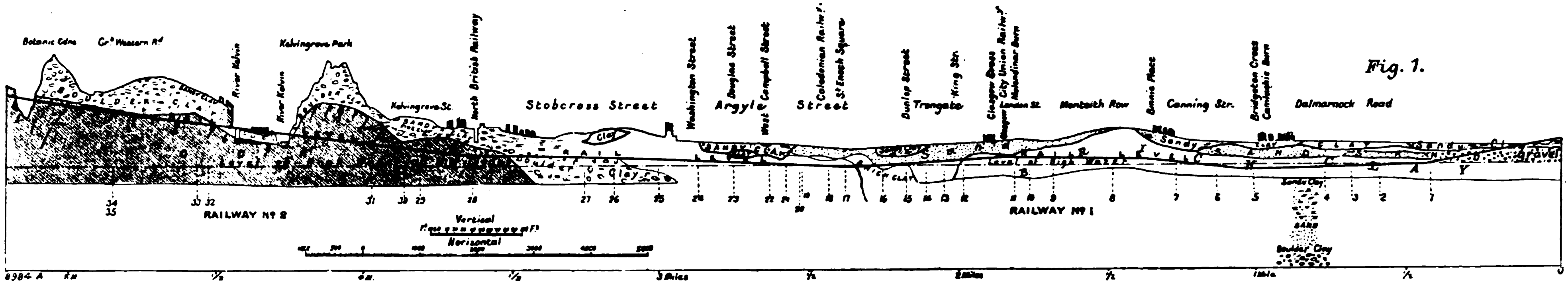
The General Direction therefore requests you to communicate to M. Canet the decision taken by His Excellency the Minister, and if M. Canet consents to send to the Russian Government the detailed drawings and the models of these guns, with the right of allowing them to be manufactured in Russia . . . You will request him to make known in writing his conditions, &c. . . The Direction requests you to communicate the reply of M. Canet as soon as possible in order that the Direction may make a report to His Excellency the Minister of Marine.

(Signed) VICE-ADMIRAL POPOFF.
COLONEL KONOKOTIN.

The convention was definitely concluded on August 22, 1891. As Russia wished to manufacture the gun herself, she requested the Société des Forges et Chantiers to furnish the department with working and shop drawings, specifications for the reception of steel and other material, plans and model of breech mechanism, full size, templates, &c. As for the turrets and carriages, the Canet system has also been fully adopted, and these are being constructed in the Russian Government factories, with which the Forges et Chantiers have made suitable arrangements. It will thus be seen that there is no question of preliminary arrangements. The letter of Admiral Popoff reduces to their actual nothingness the allegations of Mr. Krupp, who pretends that there was never anything like a competition between the different systems of quick-firing guns ; that there were no technical reasons to assist the decision of the Russian Government ; and that there was no adoption of the Canet system. And we cordially request Mr. Krupp to pay a visit in a year or two to Russia, and to go on board the new Russian ships —the Gangoute, the Georgui, the Trois Eveques— and let him satisfy himself if the turrets and the quick-firing armament on these vessels are on the Krupp or on the Canet system.

(*To be continued.*)

GLASGOW CENTRAL RAILWAY: GEOLOGICAL SECTION ON LINE OF ROUTE.



sewer is for a great part of its length 6 ft. 6 in. in diameter, and crosses under the old London-road and Central Railways immediately south of Dalmarnock-road Station. Tunnelling has had to be resorted to throughout a great part of the length of the sewer where it passes under the sidings of the Caledonian Railway in their Dalmarnock-road depôt; but in the streets the work has been done in open cut. The outlets of all the other sewers are wrought-iron tubes bedded in concrete.

The construction of the railway was let in four contracts. The following figures afford some general indications of the extent of work in each contract:

—	Bridgeton.	Trongate.	Stobcross.	Kelvinside.
Total length lin. yds.	2,550	2,715	2,313	3,650
,, tunnels ,,	—	—	700	750
,, cut & cover ,,	1,443	2,625	—	—
,, open cutting ,,	1,107	90	—	—
Excavations cub. yds.	221,430	277,970	290,000	390,765
Number of stations ..	3	3	2	5
,, bridges over	3	—	4	3
,, ,, under	—	—	—	3
Length of principal bridges .. ft.	—	—	400	750
Contract price	650,000*l*.		220,000*l*.	150,000*l*.

It is interesting to note here that the contract price totals 1,020,000*l*. for the 7½ miles of railway, of which ¾ mile is in tunnel and 3¾ miles in cut and cover, and the Parliamentary estimate for work (exclusive of land) prepared by Mr. Charles Forman showed a total of 1,005,000*l*. Messrs. C. Brand and Son, Glasgow, are the contractors for both the Bridgeton and Trongate contracts. They also constructed a large length of the existing underground railway in Glasgow, while Mr. James Young, who constructed the western section of the existing line, is the contractor in this case for the Stobcross contract. The Kelvinside contract was let to Mr. A. H. Boyle.

In an underground railway the strata become an important consideration, and we give above a geological section of the route of the railway prepared for Parliamentary purposes by Mr. R. T. Moore, Glasgow. The line for the greater part of its length is about 20 ft. below surface level, although in some parts there is but a few inches between the top of the railway covering and the street level. In the Kelvingrove Park and in the Hillhead district—Great Western-road and Botanic Gardens—the contour rises to a considerable height, and the rail level reaches a depth of 100 ft. under the surface, while the line rises on a gradient of 1 in 100 to clear the River Kelvin. The ruling gradient is 1 in 80, and here it may be noted that the sharpest curve is 13 chains radius. The borings, of which 35 were originally made, indicated that for the first two miles at the east end of the railway the subsoil was mostly clay of various degrees of fineness, principally brick clay, the depth varying from 12 ft. to 35 ft., and that it was overlaid by sand of about a 12 ft. average depth. For the next mile and a half the subsoil is sand, and in the centre of this section—in Argyle-street, at a depth of 12 ft. to 14 ft., the level of the subsoil water is reached. Special precautions had therefore to be taken to which we shall refer later. In Stobcross-street there is dry sand, and the line of railway gradually passes into boulder clay, with rock underneath, which continues until the termination of the tunnelling.

The nature of the strata therefore offered difficulties at intervals, while the proximity of high buildings on either side of the street, distant in some places only 6 ft. or 7 ft. from the site of the tunnel walls, necessitated not only extensive underpinning, but extreme care. Many of the buildings in Argyle-street had been reconstructed from time to time. What some may regard as the degeneracy of the times has demanded great displays in shop windows, so that the fronts of the old buildings were taken away and the upper part of the wall supported with columns, so that large plate-glass windows might be introduced to supersede the old windows divided into small panes. These columns supporting the front walls have not always such good foundations as might be constructed. Hence the necessity for care. The engineers of the railway, therefore, deemed it necessary before starting tunnelling operations to drive sheet piling along each side of the streets, in some cases close to the kerb, and even on the footpaths. The pile-driving machines required to be of such a construction as to cause no inconvenience to traffic, and at the same time not offend the artistic eye of the citizen. The gantry illustrated on page 641 affords an idea of the construction. The width or span varies according to the section of tunnel. Four gantries were at work, and the maximum width was 35 ft. 6 in. They were constructed of timber with iron knee-pieces and buckle plates. On the platform, which was about 28 ft. above street level, there were on each gantry two donkey boilers and two steam winches, each working independently a piling machine. The hammers were of 3 ton weight and the drop was restricted to 2 ft. There were two independent frames, the lower running on rails laid on longitudinal runners on the street, while the upper frame ran on rails laid on the top beams of the frame. This arrangement allowed the piling to be done for the whole length of the gantry, 15 ft., without moving the complete structure. The piling has been carried out for a total length of over 2 miles on either side of the street. The piles are 12 in. by 6 in., of pitch pine, and are driven to a depth of from 25 ft. to 32 ft. below street level. Only where the strata are satisfactory, or the buildings sufficiently well founded, or far distant from the tunnel walls, has sheet piling been dispensed with.

Considerable underpinning has had to be done. In several cases where buildings were really interfered with, the company bought them and razed them, leaving open spaces in some parts, and thus materially improving the amenities of the surroundings. At the eastern extremity of the line a heavy retaining wall had to be underpinned and strengthened. The new line commences with a junction with the London-road branch of the Caledonian line, and this latter branch is connected with the main line by a junction near Rutherglen, so that trains can be passed from the new underground railway over the whole Caledonian system. The new line commences with a falling gradient until it reaches a level suitable for tunnel, while the old line rises on a steep incline, both running parallel. The retaining wall between them has a batter of 1 in 8, and attains a height of 35 ft. In was this wall that required underpinning. The mode of procedure may be briefly described as follows: Spaces not exceeding 4 ft. in length were excavated under the foundations and the wall carefully timbered and supported. Intervals of about 16 ft. were left undisturbed between each excavation. After it had been carried to the necessary depth, which varied from 7 ft. to 20 ft., the space was filled with brickwork in cement and levelled 9 in. below the footing. The foundations consisted of cement concrete 2 ft. deep. The brickwork was allowed to stand for 36 hours, and the remaining 9 in. was closed with wedge-shaped bricks built up firmly against the foundations. Another length of 4 ft. was done in a similar way, with 16 ft. intervening space left undisturbed, including, of course, the 4 ft. first done, and so on with the two remaining lengths of 4 ft. each. The walls meanwhile were supported by inclined struts 12 in. by 12 in. Near the top of the wall 2½ in. tie-rods with cast-iron washers of large area were passed through the embankment and walls and bolted. There was a double row of these tie-rods placed so that no two were further than 10 ft. apart, although at different heights. Traffic was never interrupted on the railway at the top of the retaining wall during the operations.

(*To be continued.*)

MODERN UNITED STATES ARTILLERY.—No. XI.

BREECH MECHANISM OF THE 8-IN. COAST GUN.

(FIGS. 286 to 332.)

THE breech mechanism of the 8-in. gun may then be said to consist of the following parts:

The breech-block. See Figs. 304, 305, 312, 313, and 317.

The obturator. See Figs. 305, 308, 311, 315, 316, and 317.

The console or tray. See Figs. 318, 318*a*, 319, and 320.

The breech-plate. See Figs. 286, 287, 288, 289, 293, 298, and 299.

The Breech-Block.—It will be seen from the figures that the breech-block consists of the following parts, either attached to it or forming part of it:

The two handles. See Figs. 304 and 305.

The threaded sector, the slotted sector, and the guide grooves. See Figs. 304, 305, 306, and 307.

The vent cover and screw. See Figs. 304 and 310.

The translating stud and screw. See Figs. 322, 323, 328 to 332.

The base for spindle and nuts of obturator. See Figs. 305 and 308.

The two handles (Figs. 304 and 305) are forged in one piece with the block, and afterward cut out. They are used for swinging the block around when on the console, and for other purposes.

The threaded and slotted sectors, as in other guns, are three in number. The guide grooves are for the purpose of guiding the block when it is being drawn out on the tray. Their cross-section is of the same size and shape as the cross-section of the guide rails of the tray (Figs. 304 and 318).

The grooves are cut 30 deg. from the centre line and on opposite sides, and are 70.1 in. in length.

The vent cover (Figs. 304 and 310) fits in a slot in the block, being held by its screw, around which it turns freely, so that it always tends to hang vertically.

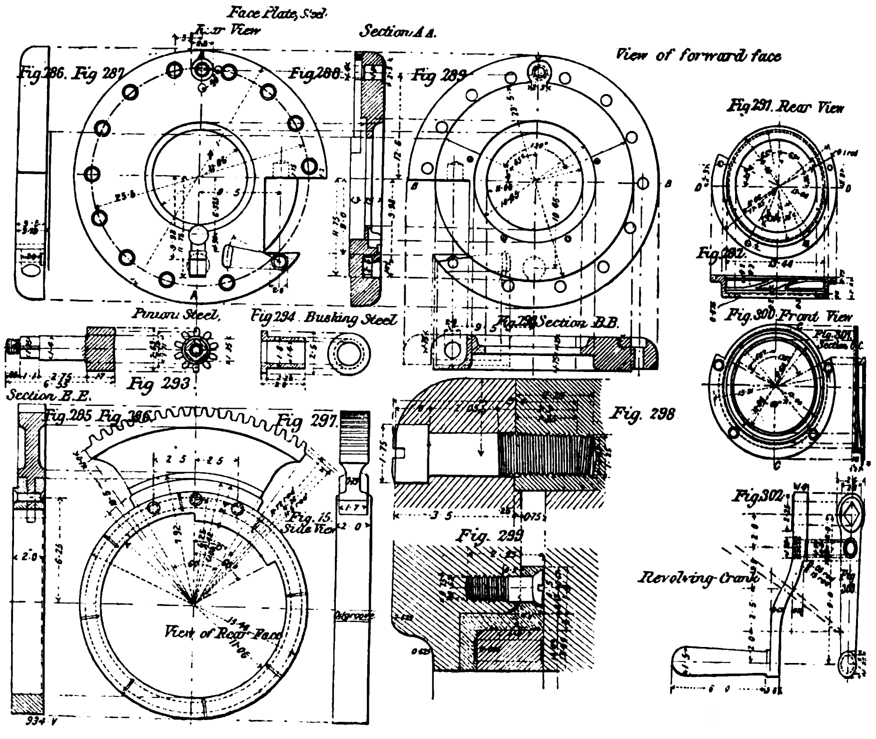
The translating stud fits in a mortise in the under side of the block, and, when the threads on the block are disengaged, the stud engages in the thread of the translating screw (Figs. 305, 327 to 332), and by this means the block is withdrawn. The section of the face of the breech-block (Fig. 314) shows clearly the two guide grooves and mortise for the translating stud on the lower side, and the irregular shaped slot for the vent cover above. The mushroom head (Fig. 311) is similar to those described with the other guns, also the asbestos pad and caps (Figs. 315 to 317). The spindle of the mushroom head is pierced by the vent 0.2 in. in diameter (Fig. 308), the rear end being enlarged and cut with a screw thread for the insertion of an obturating friction primer, and the front end being bushed with copper.

At the rear end of the spindle are cut two screw threads (Fig. 308), one a left-hand thread, and the other a right-hand one.

The rear thread is smaller in diameter than the front one. Fitting around the spindle in front of the screw threads, as shown in the detailed drawings of the breech mechanism, are four anti-friction washers (Fig. 308), two of steel and two of brass. These cross-sections are elliptical in shape, and consequently their bearing surfaces are small. These washers are necessary, if in withdrawing the block after firing, the pad sticks to the sides of the bore. The first nut carries a steel cap or spring, whose shape is shown in the detailed drawing. This cap rests against the block when the nut is screwed in place, and by this means a proper initial pressure is brought on the pad. The revolving of the block would tend to loosen this nut, and to prevent this a second or locking nut is screwed on, the threads of the screw, as stated above, running in an opposite direction to the first screw threads.

The action of the parts just described, when the piece is fired, is as follows: The powder gas pressing against the mushroom head forces it back, compressing the asbestos pad and sealing the joint against the escape of gas. By this compression of the pad the nut no longer bears against the anti-friction washers. The breech is to be opened and we will suppose the pad stuck to the sides of the bore and spindle. To unlock the screw threads the block is revolved 60 deg. to the left. As the block can revolve independently of the spindle there will be no trouble in starting the block, the spindle and pad remaining stationary. In unlocking the screw threads the block is given a slight longitudinal motion to the rear, which, before the threads are wholly unlocked, brings the anti-friction washers against the nut, thus bringing a direct pull to the rear on the spindle. The shape and material of the anti-friction washers reduce the friction to a minimum and the power is sufficient to start the pad from its seat. It will be remembered that the gas check seat is slightly conical, consequently when once started the pad is almost instantly freed from contact, and the rest of the withdrawing of the block is comparatively easy.

The obturator cups shown in the detailed drawings (Figs. 305, 315, 316, and 317), are made of special steel of high elasticity and fit accurately the mushroom head and spindle. The pad is made of asbestos and tallow, and is given the proper shape by a heavy pressure. It is then covered with canvas and subjected to a second high pressure by means of which the pad and cover are firmly united. In order to revolve a block of this size, some device for multiplying the power must be applied. For this purpose there is a crank attached to a pinion (Figs. 291, 302, 303, 304, and 305), which engages in the toothed sector of a gear ring. This gear ring (Figs. 295, 296, 297, 304, and 305) is so arranged as to allow the block to slide through it longitudinally, but any revolution of one necessarily causes the revolution of the other. In the view of the rear face of the ring (Figs. 286, 287, and 288) will be seen a projection on the inside. This projection is of the same shape and dimensions as the corresponding slotted sector on the block. The block can be shoved through this ring from rear to front until the projection comes to the end of the slotted sector, which is not cut entirely through the block. In this position the block and gear ring must revolve together.



Into the teeth in the toothed sector on the gear ring engage the teeth of the pinion, which is turned by a crank. The action is shown in the rear view and section of the breech mechanism (Figs. 304 and 305). The position shown in these figures is that of the breech mechanism locked and ready for firing. Revolving the crank revolves the gear ring and block, thus unlocking the block. When the block is locked the handle of the crank hangs vertically downwards, when unlocked the handle is in a horizontal position, and so does not interfere with the withdrawing of the block.

The breech-plate, which is an entirely new feature used for the first time with this gun, is intended to connect the tray with the breech mechanism of the gun, to carry the gears which are necessary for the rotation of the block, and to protect the various parts from the weather and injury. It is of steel, and attached to the face of the breech of the gun by thirteen bolts (Figs. 287, 289, 298, 299, 304, and 305), which enter the A 7 hoop. It is bored out to the same diameter as the breech recess at the bottom of the slotted sectors, in order to allow the block to pass in and out in opening and closing the breech.

On its right side, below the centre, the breech-plate is cut away (Fig. 287), in order to allow the hinge of the tray to enter. The hinge pin enters the breech-plate from below, passes up through the hinge in the tray, and again enters the breech-plate, where it has a bearing of 1.75 in.

There are proper recesses (Fig. 289) cut in the breech-plate for the pinion, which rotates the gear ring, for the head of the translating roller (Fig. 287); for a projection on the tray which forms a support for the tray and block; for the tray latch; for the securing latch and handle; for the counter bore, which fits accurately that part of the A 7 hoop which projects over the rear of the jacket, thus serving to support and centre the breech-plate; for the bronze bushing; and for the gear ring. In order to form a bearing for the gear ring a bronze bushing is inserted in the recess in the inner face of the breech-plate and bolted to it.

To allow the gear ring to rotate both the breech-plate and bronze bushing are cut away for an angle of 130 deg., so that the gear ring rests against the breech-plate only along this arc. The bushing is grooved in order to allow oil to reach all parts of the bearing (Figs. 296 and 297).

In the revolving crank is a small spring and bolt, whose head rests in recesses in the breech-plate, in the locked and unlocked positions of the breech, thus holding the revolving crank. (Figs. 304 and 305.)

The tray, as seen in Figs. 304, 305, 318 to 320, is of an irregular shape, consisting of the part which suppports the block and the hinge. The former has two guide rails, which fit the guide grooves on the block when it is withdrawn, a recess for the translating roller, and a recess for the tray latch.

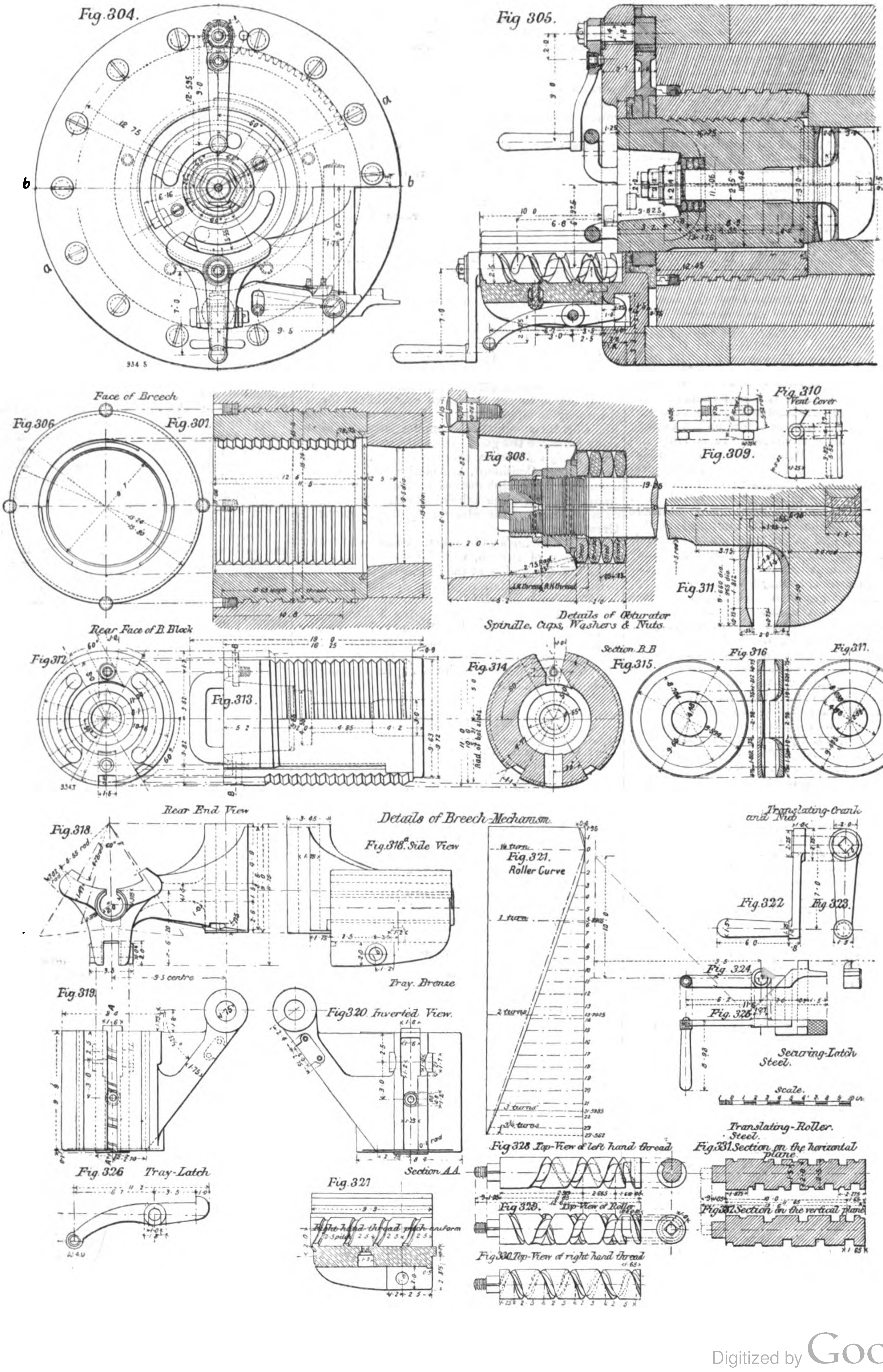
The translating roller (Figs. 328 to 332) has cut on it one large screw thread and one small one, running in opposite directions. The small thread engages in a corresponding thread in the recess in the tray (Figs. 305 and 327), while in the large one engages the translating stud on the breech-block. In order to allow the translating stud to engage, a slot is cut in the tray. The roller is turned by a crank. (Figs. 322 and 323.) It will readily be seen that the roller moves out and also draws the block; the distance that the block is drawn out on the tray is equal to twice the distance that the roller moves out. By means of this ingenious device, the length of the roller is just one-half of that of former rollers, on which there was but one thread.

Under the tray is the tray latch (Figs. 305 and 326), which serves to hold the tray against the breech-plate, while the block is being forced in or out. To prevent the latch from coming unfastened there is a bolt passing through the tray, one end of the bolt resting against the latch and the other against the roller. A spring around the bolt forces it always against the latch. At either end of the roller is a recess, one of which arrives over the bolt when the block is in the gun, and the other when the block is out on the tray. In either of these positions the latch can be raised, the bolt entering the recess in the roller, and the tray can then be swung around. The face of the latch, which engages in the notch in the breech-plate, is cut at a slight angle, so that when the block is run out on the tray and strikes the projections at the end of the rails, the component of the force parallel to the engaging face is sufficient to throw the latch down and allow the tray to swing around. When swung around a second latch catches and holds it. (Figs. 324 and 325.)

The vent cover (Fig. 310), whose shape is shown in the detailed drawings and action in the rear view of the breech (Fig. 304) is hinged by means of a screw. When the breech is unlocked the vent cover hangs in the vertical plane containing the axis of the block, and the lower end of the cover is over the vent. This is the position when on the tray, or when in the gun, and the threads of the block disengaged. When in the gun the upper end of the vent cover is cut accurately to fit the bronze bushing against which it rests. In locking the block it is revolved to the right, and the vent cover, since

MODERN UNITED STATES ARTILLERY: BREECH MECHANISM OF 8-IN. GUN.

(*For Description, see Page* 643.)



it always tends to remain in a vertical position, would drop away from the vent, did not its upper end bear against the bushing. When the block is completely locked the vent cover arrives opposite a recess in the bushing, into which drops the upper end of the vent cover, allowing the lower end to swing clear of the vent.

LITERATURE.

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The *Year Book of Science* is a new candidate for public favour, and notwithstanding the vast field covered by annuals the work before us has a *raison d'être* which is unquestionable. It is truly impossible, as Professor Bonney points out in his preface, to keep pace in knowledge with the progress being made by specialists in all branches of science, and have time to engage in original work. In the papers read before technical societies there are embedded most valuable data; but time is needed to "win" them, and when they are got skill is required in classifying them for easy and handy reference. This is what is undertaken by the compilers of this work, amongst whom, by the way, are included men of note in the different branches of natural science. A desire to write to suit the lay reader enhances the value of the work. The sciences treated are physics, chemistry, geology and mineralogy, and animal and botanical geology. Taking as an example of the treatment of these various subjects physics, we find the general branches of the question are considered, then heat, light, electricity, magnetism, physical astronomy, and meteorology, the various advances made during the year being succinctly yet clearly narrated in alphabetical order. Appended, too, is an index, by which one can refer to the work done by any particular scientist, while also finding out the reference to the paragraphs dealing with the progress under each section. No attempt is made to give lists of papers; but references are given to fuller reports of the different steps in advance.

The Official Year Book of the Scientific Societies of Great Britain and Ireland is in its ninth year, and has become indispensable to workers in all fields of science, for in the volumes can be found a complete, conveniently arranged, and accurate directory to all papers read before learned societies of the kingdom, so that before beginning investigations of discovery it may be possible to consult the results of labour by confrères, the papers read by these being frequently finger-posts pointing the way in the dark places. For convenience the societies are divided into fourteen sections dealing with different branches of science, and, besides lists of papers, the book gives other data regarding the societies.

Laxton's Price Book in addition to giving the standard prices of various makers for all ordinary materials used in buildings of all kinds and sizes, affords guidance as to the rules of trade and as to measurements; while appended to the work are the general conditions of building contracts, and Acts of Parliament for the regulation of buildings. The details as to electric lighting plant are particularly interesting, the subject being dealt with generally, and prices given for all items included in the several types of installation now in use.

Lockwood's Price Book has an interest for others than those engaged directly in the building trade, for while here either the architect, contractor, or engineer may find data to assist in the drawing up of a specification, or the measurement of work, in which the extensive tables given make arithmetical work very easy and accurate, the general reader will find much of interest in the methods of carrying out work, and may even be able to check the jerry builder. The tables regarding the value of leases, stamps, &c., and the extracts from Acts of Parliament as to building, ownership, and tenancy of properties, are valuable for reference. All this is given in addition to prices, and there is a good index.

The Colonial Year Book has this year been slightly rearranged. Instead of the colonies being dealt with in alphabetical order, they are grouped geographically under Canada, Australasia, Africa, Crown Colonies, East Indies, West Indies, Malay Peninsula, &c. We have had frequent opportunity of commending this book. The political, historical, and statistical information of the past year have been added, and now that the colonial question is engrossing so much attention there is particular need for such a work. The enormous value of our colonial possessions is too often lost sight of, if, indeed, it is on all hands appreciated, and a perusal of this book might awaken both colonists and Britons to a due measure of the importance of strengthening the bond between the two. In this connection, too, we commend the vigorous appeal for an ocean penny post by Mr. Henniker Heaton, which forms the introduction to this year's volume. An exchange of letters must keep alive any kindred feeling between the mother country and the colonies, and a penny post would stimulate such. Sentimentalism cannot outweigh financial considerations, but if to the latter we can add the former there may be an advantage. In any case it were well that we should both commercially and financially cultivate the good wishes of the colonist.

In *Berly's Directory* there is a list of electrical firms on the Continent, in America, and in Britain arranged both alphabetically and according to trades, with a large tabular statement giving all data of the various electric lighting stations in Great Britain.

The *Electrician's* publication gives in addition to a directory of British, colonial, and foreign electrical firms, a review of the year, with tables, rules, prices, and other data regarding electric plant.

The Export Merchant Shippers is edited by a Custom House employé, and gives a directory of shippers in the principal British ports, with other information for exporters and those who wish to export goods from Britain, information as to Acts of Parliament dealing with the export and import trade being added.

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Fuels: Solid, Liquid, and Gaseous, their Analysis and Valuation. For the Use of Chemists and Engineers. By H. JOSHUA PHILLIPS, F.I.C., F.C.S. Second Edition, revised and enlarged.
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Gas Works, their Construction and Management, and the Manufacture and Distribution of Coal Gas. Originally written by SAMUEL HUGHES; re-written and much enlarged by WILLIAM RICHARDS. Eighth Edition, revised, with Notice of recent Improvements. London: Crosby Lockwood and Son.
Edwin Octavius Tregelles: Civil Engineer and Minister of the Gospel. Edited by his Daughter, SARAH E. FOX. London: Hodder and Staughton. [Price 10s.]
Annual Reports of the Board of Regents of the Smithsonian Institution showing the Operations, Expenditures, and Condition of the Institution for the Year ending June 30, 1889. *Report of the National Museum.* Washington: Government Printing Office.
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Die Hauptbahnhofs-Anlagen in Frankfurt, a.M., bearbeitet von H. WEGELE. *Und das Empfangsgebäude des Hauptbahnhofs.* Von G. EGGERT. Mit xix. Kupfertafeln und vielen dem Text beigegebenen Holzschnitten. Berlin: Wilhelm Ernst und Sohn.
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UNDERPINNING BY MEANS OF GROUTING AND STOCK-RAMMING.

By WALTER ROBERT KINIPPLE, M. Inst. C.E.

(*Concluded from page* 610.)

IN my lectures to the Royal Engineers at Chatham, to which I have already made reference, I gave a brief description of the monolithic system of construction. I adopted it in the extension of the Hermitage Breakwater at Jersey, and which proved so successful as regards reduced cost, rapidity of execution, and soundness of work obtained, but as the present articles have reference more especially to repairs to, and securing the stability of, existing works, I shall now describe what has recently been done with respect to securing a portion of that breakwater constructed prior to 1877 under Sir John Coode, which will, I think, show very clearly the advantages and simplicity of the grouting system, and how well suited it is to render secure existing structures.

Figs. 6 and 7, page 648, are elevations of the sea and harbour faces, respectively, of the Hermitage Breakwater, from the Hermitage rock seawards, and Figs. 8, 9, and 10 are cross-sections of that work. The shallower or landward portion of an average length of about 560 ft. represents what was constructed under Sir John Coode prior to 1877. The seaward or deep portion of 525 ft. in length represents what was constructed in accordance with my design, between the years 1887 and 1889.

It will be seen from the engravings, Figs. 8 and 11, that the work carried out under me is monolithic from foundation to cope, consisting first of a foundation bed, on top of the rock formed of rubble and shingle grouted into a solid mass with thick neat Portland cement grout, and levelled off on its upper surface for the reception of the blocks after the bed had firmly set. The blocks, which have grooves and projections, Fig. 11, are faced with granite ashlar and placed on top of the bed in inclined courses, Figs. 6 and 7. The horizontal and vertical joints between the blocks themselves, and between the first course of blocks and the foundation bed, were grouted together with neat Portland cement, thus making the entire structure with the bed one solid mass throughout, and firmly cemented to the granite rock on which it stands. In the landward portion of the work constructed under Sir John Coode, the ordinary system of construction, such as that exemplified in Madras, Colombo, and Wick breakwaters was adopted.

Figs. 9 and 10 represent cross-sections of that portion of the work. It will there be seen that below low-water level the preparation of a level bed for the blocks was effected in another manner. The system adopted was to use bags of concrete of sizes varying from about 3 tons to about a couple of hundredweights according to the irregularities in the rocky surface, and to adjust the upper surfaces of these bags so as to get a bearing area as nearly level as possible, any gaps or spaces between the bags of concrete being filled up with broken stone or pieces of rubble, or some concrete deposited *in situ*. On top of the foundation bed thus prepared large blocks of concrete from 50 to 90 tons in weight were placed, and stacked one on top of another (Fig. 9), without bond, and with spaces or joints between them in a longitudinal and transverse direction of several inches in width. These large blocks were brought up to above water level. On top of them up to coping level solid work was constructed with blocks 9 to 12 tons in weight,

AMERICAN GUN CARRIAGES.

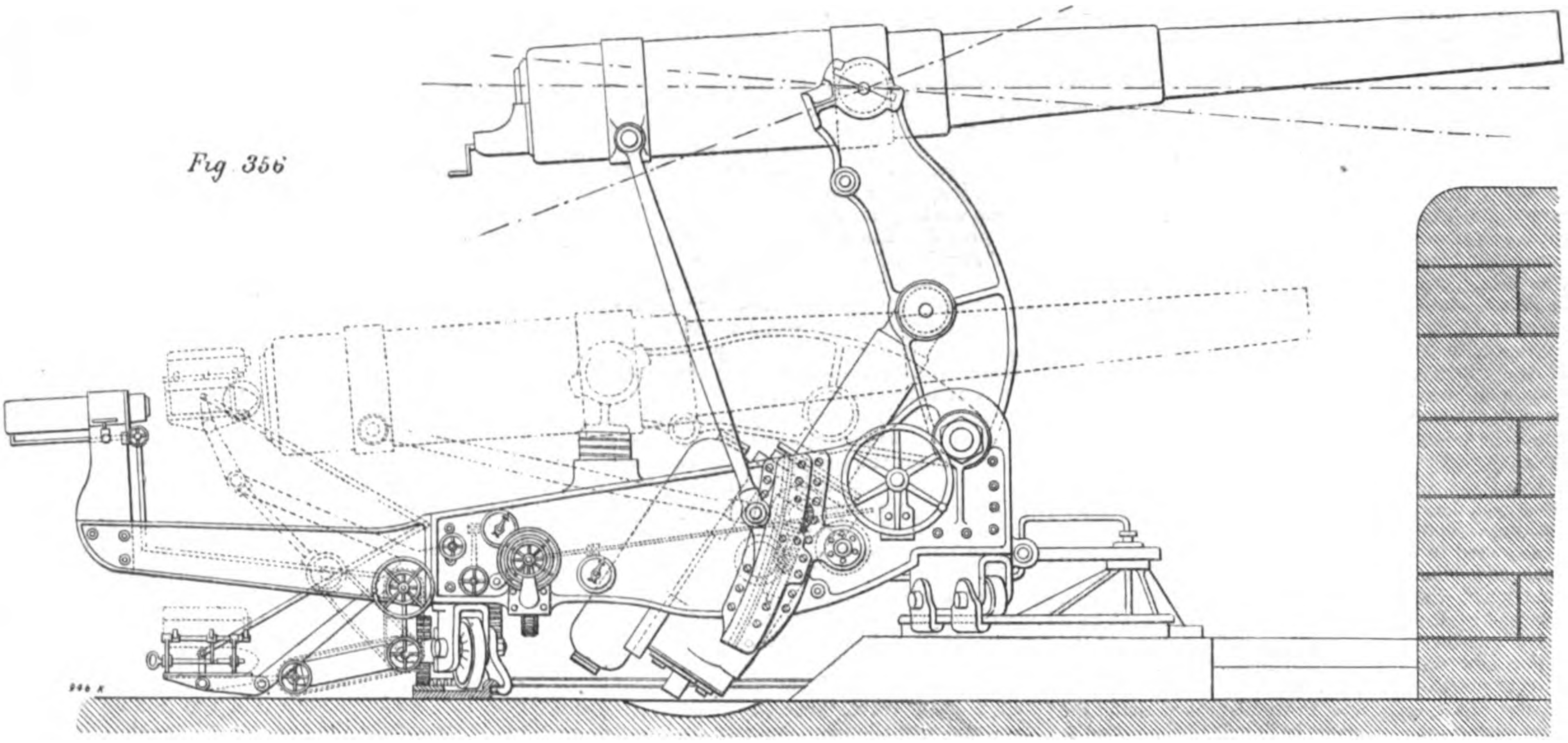


FIG. 356. PNEUMATIC DISAPPEARING CARRIAGE FOR 10-IN. GUN.

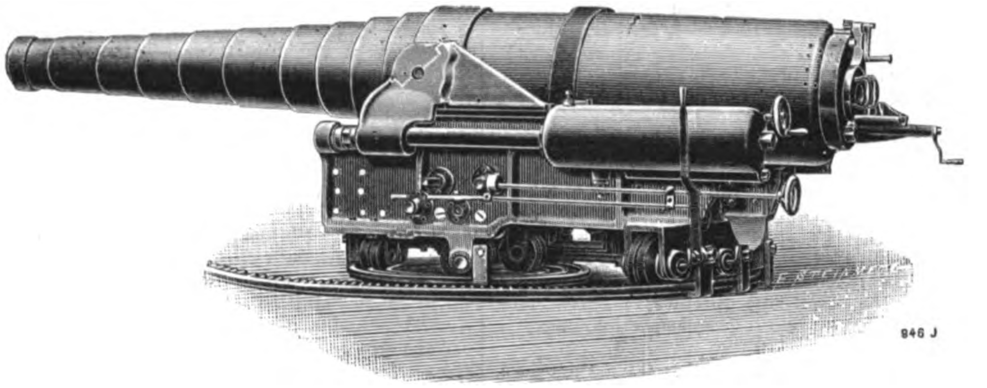


FIG. 357. PNEUMATIC CARRIAGE FOR 8-IN. NAVAL GUN.

long, 10 ft. in diameter outside and 9 ft. inside the flanges (Figs. 6 and 10). It is built of rings 1 ft. 6 in. long of segmental plates with inside flanges, the details being shown on Figs. 15, 16, and 17. There are in the circumference ten segments 3 ft. by 1 ft. 6 in., each weighing about 4 cwt., and the key-piece on each ring (Fig. 15) is 10 in. by 1 ft. 6 in., weighing about 1 cwt. The thickness of the segments is $1\frac{1}{16}$ in., and the space between the flanges is left tapered in order to retain the Portland cement, with which these are caulked. The junction between the tunnel and the shafts is clearly shown on Figs. 4, 5, and 6, so that it is not necessary to enter into details.

When the full supply is being drawn from Lake Vyrnwy there will be three pipes through the tunnel, but there is at present one steel tube of $\frac{5}{8}$ in. in thickness and 32 in. in diameter, as shown on Figs. 1 and 3. It may be noticed that the steel pipe is 10 in. less in diameter than the aqueduct pipes. Provision has been made in this section for a greater fall per mile than elsewhere, so that the steel pipes through the tunnel might be reduced in diameter without loss of discharge in power. The steel tube enters through eye-holes on the Cheshire and Lancashire shaft, shown on Figs. 6 and 14, with a 10-ft. sweep, and hangs vertically down the shafts supported on trunnions on cast-iron girders. The curve to the Lancashire shaft is of cast-iron pipes with deep sockets and connected together by links over trunnions as shown on Fig. 3. The curve to the Cheshire shaft is of steel pipes, with a triple-ported horizontal valve. This curved pipe is formed of steel bevel plates quadruple riveted. As shown on Figs. 1 and 2, cast-iron girders are placed in the shaft, and these are shown in detail in Figs. 7, 8, and 9. The main girder spanning the shaft is of ⊥ section, and the dimensions are given on Fig. 9. On the bottom flange there rest two cross-girders with plummer blocks (Figs. 7 and 9), and on the pipe is a trunnion which engages in the block. Another 10-ft. radius bend at the bottom of the shaft, Figs. 22 to 25, in both cases of steel, connects the vertical and horizontal portions of the steel tube (Figs. 18 to 21). The horizontal part is carried through the tunnel on the up-stream side, and rests on greenheart bearers, as shown on Fig. 10. The centre, however, is left free, the cradle being made with two timbers wedge-shaped in section. The cradles again lie on greenheart timbers, 6 in. thick placed, at 6 ft. intervals, across the tunnel. On the down-stream side there is a 12-in. cast-iron by-pass pipe, which is connected to the main before it enters and as it leaves the tunnel (Figs. 22 to 24.) This is to admit of repairs without stopping the supply. Between the steel tube and the by-pass there is a chequered plate footway (Fig. 11) with side railing (Fig. 10). There are iron ladders and platforms on both shafts (Figs. 1 and 3), while on the top of each shaft a ventilating tower is erected, through doors in which access to the tunnel is obtained.

There is a fall from the Cheshire to the Lancashire shaft of 6 ft. 3 in., and in the latter shaft a sump is constructed, as shown in Fig. 3, into which any water in the tunnel will drain. To raise the water in order to pass it into the river, a hydraulic pump worked by the pressure from the main is placed in a cast-iron engine chamber built under ground level, on the Lancashire side, entered from the shaft. This chamber is shown on Figs. 2, 12, and 13. The detailed drawings of the hydraulic machinery and piping in connection with it are reproduced on pages 749 and 752.

This pumping machinery was designed by Mr. Deacon and constructed by Messrs. Easton and Anderson, Limited. Figs. 26 and 27 show the general arrangements, Fig. 31 being a plan at the top of the shaft. A hydraulic engine, which we shall illustrate and describe in our next article, works the pump. A connecting-rod from this hydraulic engine actuates the cast-iron rocking beam, shown in detail on Figs. 33 to 39. This beam, as will be seen by reference to Figs. 26 and 27, is carried on pedestals at the top of the tunnel shaft. Each end of the rocking beam has attached to it the cast-iron pump-rods working on separate rising mains attached to gun-metal barrels on either side of the shaft, 20 ft. above the bottom of the sump (Figs. 26 and 40). The clack and bucket valves are made of gun-metal with Delta metal spindles. They are of the double-beat pattern and can be removed without lowering the water. On Fig. 27 there is shown a copper float in the sump. By means of this float the valve of the hydraulic engine is actuated. The float rising with the influx of water into the sump opens the connection between the main aqueduct and the valve and sets the engine in motion. The pressure is again shut down when the water is pumped down until the sump is nearly emptied.

(*To be continued.*)

MODERN UNITED STATES ARTILLERY.—No. XIII.

CARRIAGES FOR THE 8-IN. AND 10-IN. SEA-COAST RIFLES.

(FIGS. 356 AND 357.)

ONE of the carriages designed for use with the 10-in. rifle known as the 10-in. proof carriage, has an attachment by means of which the 8-in. rifle can be mounted on it. The carriage, of which figures were given in Figs. 279 to 282, pages 612 and 613 *ante*, representing the plan, section, and elevation, also its general appearance with a 10-in. rifle mounted on it, consists of a top carriage and a chassis. In the figure showing the elevation, the rifle represented by the full line is the 10-in., and that represented by the dotted lines is the 8-in. (see page 612 *ante*.) The cheeks of the top carriage are formed by riveting to a wrought-iron forged frame, whose cross-section is a rectangle 4 in. wide and 3 in. deep, two plates of boiler iron $\frac{5}{8}$ in. in thickness. The frame and plates have the same shape except in front, where the frame has a re-entering angle, while the plates extend beyond and cover the front wheel, and in rear where the frame has attached to it a knee-piece, and the plates continue beyond the frame, covering the knee-piece and inclosing the rear wheels. The frame is strengthened by a vertical and a diagonal brace which run from the trunnion beds to the bottom of the carriage. The trunnion beds are roughly forged in the frame, and after the cheeks are finished they are turned to receive the gun rings or trunnion bushings, by means of which the carriage is adapted for the support of either the 10-in. or the 8-in. gun. The 10-in. gun rings are of forged steel, and on the exterior cylindrical surface each has a collar, which fits in a corresponding groove in the trunnion bed and cap square. The 8-in. rings are similar to the 10-in., but are made of cast steel, and have flanges 4 in. thick in order to bear against the cheek-plates and rim bases of the smaller gun. The inside diameters of the rings are made 1 in. larger than the corresponding diameters of the trunnions of the guns for which they are intended, in order to allow the insertion of a ring of soft metal between the rings and the trunnions of the guns.

The front wheels are made of wrought iron, and are keyed to steel axles which revolve in bronze bushings. The bore being eccentric, the wheels may be adjusted to the rails by revolving the bushings. Each rear wheel revolves on an eccentric axle of steel which has keyed to its outer projecting arm, a wormwheel. This wormwheel is operated by a worm cut on a steel shaft, which carries at its upper end a 12-in. bronze handwheel. In its lowest position the wheels clear the rails by quarter of an inch, and in its highest position the rear part of the carriage is lifted 1¾ in. from the chassis rails. Any amount of clearance between these limits can be given by means of the worm gear, and by this means the length of sliding friction during recoil can be regulated.

The elevating gear consists of three steel axles. The first carries a handwheel and clamp, and a pinion; the other two each carry a pinion and spur-wheel, the pinions on one axle gearing in the spur-wheel of the next. The pinion of the rear axle gives the elevation directly by gearing into a toothed rack fastened to the guns by means of trunnions. In the case of the 10-in. gun, the rack has its teeth on the concave surface; in the case of the 8-in. gun the teeth are on the convex surface. The racks are pressed against the pinion by means of rollers.

The chassis rails are built-up beams, on the rear part of whose top rails are bolted wedges inclined at an angle of 4 deg. The rails are strengthened by braces and joined by a number of transoms, which serve to support the two hydraulic cylinders between the rails. The front and rear transoms each carry four rubber buffers. Two hydraulic cylinders between the chassis rails serve to check the recoil. The ammunition is raised by means of a crane and differential pulley. The platform and steps are made of No. 5 woven wire. The total weight of the carriage and chassis is 37,327 lb.

PNEUMATIC CARRIAGE FOR 10-IN. GUN.

The pneumatic gun carriage was constructed in a similar manner to the one described, but differs from it in being worked by compressed air instead of by hand.

The elevating apparatus is similar to that of the proof carriage just described, but it is operated by means of a pneumatic cylinder under each trunnion, with valves so arranged that they can operate a rack and pinion, by means of which the elevation and depression are given. Pneumatic cylinders between the rails of the chassis have valves by which compressed air can be introduced in front or in rear of the piston head, and by this means the gun can be run from or in battery. Before firing, the pressure in the cylinders is set at any desired amount, and the length of the recoil will vary inversely with the pressure. (See Fig. 357.)

The Pneumatic Gun Carriage and Power Company, of Washington, D.C., has recently submitted a disappearing gun carriage, which is at present being tested at the Government proving ground with a 10-in. breechloading rifle.

The object aimed at in designing this carriage was to provide means by which the gun could be moved rapidly to and from battery, the recoil and counter-recoil taken up gradually, and the piece protected during loading. As shown in Fig. 356, the gun is mounted on two strong steel elevating trunnion levers, the lower ends of which are pivoted to the slide or chassis, the pintle being situated well to the front in order to give a large horizontal angle of fire, through an embrasure. The elevating levers are connected by a crosshead, both ends of which are provided with friction rollers, working in extended bearings in the levers, in order that the arc motion of the latter may permit the straight line motion of the crossheads. The gun is elevated to the position shown in the full lines by means of the piston of an air cylinder connected to the crosshead. An engine working an air compressor in the ordinary way provides the necessary supply of compressed air. For drills, a hand compressor is provided, by means of which the gun can readily be raised to the firing position. To raise the gun from its lowered position, compressed air is supplied from the receiver to the cylinder at a pressure of 1100 lb. per square inch, and in raising the gun the pressure is reduced to 325 lb. per square inch. The depression of the carriage by the recoil compresses the air in the cylinder, and this acts as a cushion. By this means the pressure in the reservoir is kept up, and since very little is lost, the pressure does not have to be renewed until a number of rounds have been fired. When the gun is to be raised a by-pass valve, operated by a handwheel, admits the air to the under side of the piston. Side buffers support the gun when it is down. To train and elevate or depress the gun, a small reversible air engine, located in a protected position under the gun, is employed. The compressed air is supplied from the receiver, and the supply regulated by a stop motion valve, controlled by a handwheel. The chassis or slide is traversed by bevelled gears engaging in a rack and worm gears connected with a cross-shaft which gears to the crankshaft of the engine. The elevation or depression of the gun is effected by a rod extending from near the breech to an adjustable connection with the rack, the rod working in line with the elevating levers after the manner of the arms of a parallel ruler.

The loading of the piece is accomplished by a compressed air apparatus. When the gun is in the depressed position, a carriage, carrying a projectile, is raised, by the opening of a proper valve, to the proper position for pushing the projectile into the open breech, which work is done by a pneumatic rammer. In like manner the powder charge is elevated and forced home behind the projectile.

The weight of the carriage, including powder and projectile lift, telescope rammer, air reservoir, differential hand pump, circles, clips, &c., is 50 tons.

The drop of the gun is 8 ft. The Pneumatic Gun Carriage and Power Company, who have, in addition to the carriage just described, designed a 12-in. mortar carriage and several naval carriages, which will be described in later articles, claim many advantages for their pneumatic system over other systems at present in use or undergoing trial. In the gun carriages, which are in almost universal use for guns of medium calibre, the chassis or cheeks have an inclination upward toward the rear of the carriage of sufficient degree to enable the gun to return into battery by gravitation after recoil. This inclination gives a perpendicular shock nearly at right angles with the line of its axis, which shock increases in proportion with the elevation of fire, and is anything but beneficial to guns made under the present system of building up from tubes and hoops.

This is overcome by the pneumatic system of taking up the recoil, and the automatic return of the gun with battery, which allows of the construction of horizontal slides (as in the 8-in. pneumatic naval gun carriage), or by arranging the recoil cylinders in such a manner that the resistance offered by them will always be in line with the gun's axis (as in the 12-in. pneumatic mortar carriage), and which also relieves the deck of vessels (when used on shipboard) of a great amount of the downward thrust, caused by the instant elevation of the gun, by the inclined sides of the chassis.

In most mounts for heavy guns from 10 in. and upwards in calibre, the gun is secured to a sliding carriage which moves with it, in its recoil, on side levers or frames, which are pivoted in front to sustaining brackets, and which carry the hydraulic recoil cylinders. The resistance in taking up the recoil is in the line parallel with and below the gun's axis; but the return of the gun into battery cannot be effected without the addition of some mechanical appliances, such as a force pump and the additional incumbrance of some form of an accumulator, which carries with it weight and complexity.

In the pneumatic system this work is performed by the automatic return of the gun into battery by the recoil cylinders alone, at any angle of fire that may be required, without the aid of any other mechanical device. In the naval carriages the telescopic rammer is mounted on an extension of the side levers of the carriage, and with it is elevated and depressed, thus being always in line with the gun's axis. The ammunition is raised from the hold of the vessel direct to the breech, and the gun can be loaded in any degree of elevation without change of position when firing, thus saving a great amount of time and increasing proportionately the efficiency of the gun. These advantages are obtained in the carriages, &c., that the Pneumatic Gun Carriage Company are installing in the United States.

The pneumatic system is particularly applicable to mortar carriages, where the firings are done at all elevations up to 60 deg. or 70 deg. The recoil is taken up and the gun is automatically returned into battery with a simple set of pneumatic recoil cylinders, the resistance offered by them being always in line of the recoil and without the assistance of any additional system, as is the case with other systems of construction where hydraulic cylinders are employed.

In the construction of disappearing carriages the single system of pneumatics has been adhered to, using only compressed air for elevating the gun into firing position, and taking up its recoil on its descent out of battery into the loading position. By this system the gun is easily worked, allowing reduced charges to be used, without pumping the gun down into the loading position.

By simply opening a by-pass valve, the air that is not forced into the receiving chamber by the recoil is forced by the weight of the gun through a side passage into the annular space around the piston-rod, and the gun gravitates into the loading position.

LONDON SOCIETIES.—No. XXVI.

THE ROYAL INSTITUTION—*continued.*

IN the year 1818 Faraday delivered six lectures before the City Philosophical Society, the subjects of which were as follows: 1. On Gold, Silver, and Mercury. 2. On Copper and Iron. 3. On Tin, Lead, and Zinc. 4. On Antimony and Arsenic. 5. On Alkalies and Earths. 6. Observations on the Inertia of the Mind. During the same year he published no fewer than eleven papers in the *Quarterly Journal of Science.* During this period he was, besides lecturing, learning to lecture, for he attended a course of lectures on oratory given by Mr. B. H. Smart, and of these lectures he took very elaborate notes.

In May of this year (1818) we find Faraday engaged upon researches in Atmospheric Electricity, and a highly interesting letter in his handwriting still exists; it was addressed to Dr. Flaxman, of South Moulton, in Devonshire, in which the following account of his experiments is thus recorded:

"I have this evening been busy with an atmospherical electrical apparatus. It was a very temporary thing, but answered the purpose completely. A wire with some small brush-wire rolled round the top of it was elevated into the atmosphere by a thin wood rod having a glass tube at the end, and tied to a chimney-pot on the housetop, and this wire was continued down (taking care that it touched nothing in its way) into the lecture-room; and we succeeded at intervals in getting sparks from it nearly a quarter of an inch in length, and in charging a Leyden jar so as to give a strong shock. The electricity was positive. Now I think you could easily make an apparatus of this kind, and it would be a constant source of interesting matter; only take care you do not kill yourself or knock down the house."

In the autumn of the same year he was engaged upon a process for the preparation of illuminating gas from fish oil, which he describes in a letter, dated October 6, 1818, to Professor de la Rivi.

One of the most important of Faraday's early lectures was given before the City Philosophical Society in 1819 when he was twenty-seven years of age, the subject was "The Forms of Matter," in which he reads to scientific inquirers and theorisers a few lessons which modern expositors might with a small percentage of carbonic oxide on the mains and gas pipes. This accounts for the hitherto unexplained black stain so frequently observed on steatite and other burners. Compressed coal gas is very much used now in the place of hydrogen for the production of limelight, and the discoloration of the lime cylinders is very marked, being, it is almost needless to say, somewhat of a drawback to its employment.

In a January number of the *Comptes Rendus* (cxiv. 3) will be found a most important paper by M. Guntz, dealing with the action of carbon monoxide on iron and manganese. He first refers to the work of Slammer, who found that on passing carbonic oxide over oxide of iron at the temperature of the softening of glass, reduced iron is obtained on the one hand, and a considerable quantity of voluminous coke on the other. M. Schützenberger has since found that pure iron decomposes carbonic oxide with formation of carbonic acid and carbide of iron,

$$2\,CO = C + CO_2.$$

In his own experiments, carbon monoxide was passed over very pure iron, produced by distilling its amalgam *in vacuo* at a low temperature (480 deg. to 540 deg. Fahr.). Towards a red-heat, the iron seemed to absorb carbonic oxide, being at the same time blackened by a deposit of carbon, and carbonic acid was also disengaged in small quantity.

The same experiment was repeated with the more energetic metal manganese. Pure manganese, prepared in the same way as the iron, was heated to 750 deg. Fahr. in a glass tube in a current of carbon monoxide. The manganese, at a particular moment, was found to glow at one end; the heat was then withdrawn and the current of gas increased. The metal burned in the gas, and the heat disengaged was sufficient to carry it to a white heat; at the same time the carbon monoxide was totally absorbed, and so rapidly as to produce a partial vacuum in the apparatus.

This absorption of carbonic oxide without production of other gas can be explained in two ways: (1) that they combined to form manganese carbonyl,

$$Mn + 5CO = Mn\,(CO)_5\,(?);$$

or (2) that the gas was decomposed with oxidation of the metal

$$Mn + CO = MnO + C.$$

This last is the only reaction possible, taking into account the great heat produced, and analysis proves that it is actually the case. Carbide of manganese appears, however, to be formed at the same time in small quantity.

This action of manganese on carbonic oxide allows us to give the theory of what passes in the case of iron; there is at the point of contact with the finely divided iron, decomposition of the carbonic oxide, with formation of oxide of iron and carbon,

$$Fe + CO = FeO + C.$$

The carbon monoxide in excess reacts partially on the iron oxide formed, giving carbonic acid, and this explains the invariable presence of carbonic acid in the gas, and that of oxide of iron in the metallic iron. If the reaction is simple and complete with manganese, it holds, as M. Moissan has shown, that its oxide is irreducible by carbon monoxide, which is not the case with oxide of iron, and, moreover, M. Guntz has verified the fact that manganese burns in carbonic acid with the same facility as it does in carbonic oxide,

$$2\,Mn + CO_2 = 2\,MnO + C.$$

It is to be remarked that at very high temperatures, the oxides of iron and manganese heated with carbon give the metal and carbon monoxide, or the inverse reaction to that which passes at 930 deg. Fahr.

By means of these results M. Guntz explains what takes place in the blast furnace, although he does not take into account the part played by iron carbonyl as follows: The spongy iron, encountering carbonic oxide, is oxidised, giving carbon and oxide of iron; this last, in another zone, is reduced by carbon monoxide to form metallic iron and carbonic acid, and finally, in passing through the hottest part of the furnace, the iron, in contact with finely divided carbon, is carburetted with facility.

The chemical world is awaiting the further study of the carbonyl series with the greatest interest. Their existence already gives us a clue to the mysteries of the cementation process, in which bars of iron are imbedded in powdered charcoal, and kept at about the melting point of copper (2192 deg. Fahr.) for eight or ten days. The principle of all steelmaking is the same. Carbon has to be added to soft iron in such a manner as to cause a true chemical combination. As previously mentioned, the maximum limit is 1.5 per cent. If that be exceeded the tensile strength becomes rapidly reduced until the brittle character and granular structure of cast iron is assumed. If the metal were melted in contact with the charcoal it would be impossible to prevent an excess of carbon being taken up which would separate out into granules or scales of graphite on cooling. In the cementation process the carbon monoxide, formed by the air in the pores of the charcoal, permeates right through the bars, and is decomposed by the metal; the released oxygen then travels back to the charcoal for more carbon, which is again combined with the iron, the carbonic oxide thus acting as a carrier of carbon to and fro in the mass of the metal until the chemical affinity of the iron is saturated, and the whole is converted into nearly uniform steel. This form is known technically as "blister steel," owing to the peculiar appearance caused by the penetration of the gas. These carbonyls play a very important part, too, in both the Siemens and the Bessemer process, especially the latter. In this case steel is made from cast iron. All the carbon and impurities are first burnt out of the molten metal by blowing air through until the sheet of flame which issues from the converter, finishing its cycle of changes from yellow to blue or violet as the carbon monoxide increases, suddenly drops from its cessation; a definite quantity of a highly carburetted iron, in the form of spiegeleisen or ferro-manganese, is then thrown in, which effects the desired carburation.

Attention has been recently directed, both in our own country and in Germany, to some volatile compounds of platinum with chlorine and carbon monoxide, originally described by M. Schützenberger in 1868. They are formed by the action of chlorine on platinum sponge at 480 deg. Fahr., and are at once broken up by water with deposition of pure platinum, thus forming a possible way of extracting the metal from its ores. If a volatile gold compound, in any respect similar to these or to iron and nickel carbonyls were discovered, as is not at all unlikely, it would revolutionise the mining industry, not merely by simplifying the present methods of working and reducing the cost of production, but by rendering possible the manipulation of pure ores, which, though now valueless on account of the difficulty found in recovering the metal, would then yield a substantial profit.

MODERN UNITED STATES ARTILLERY.

Fig. 2. 15 INCH S. B. GUN (Model 1861)

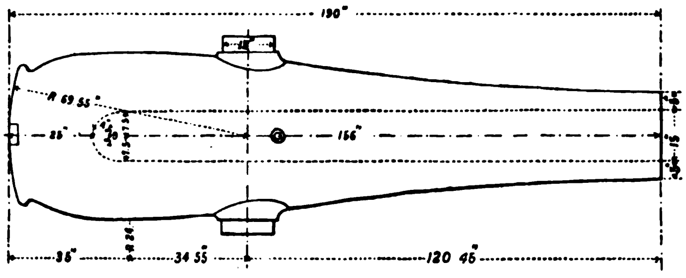


Fig. 1. 10 INCH S B RODMAN SEA COAST.

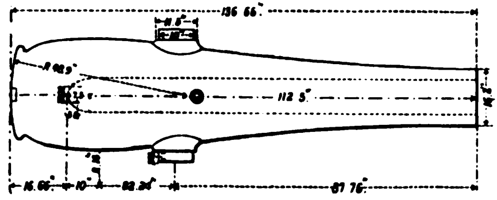


Fig. 3. 8. INCH S. B. RODMAN. SEA COAST

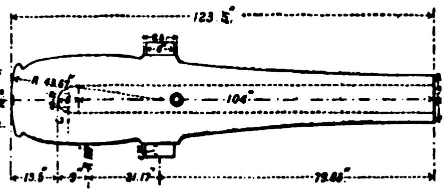
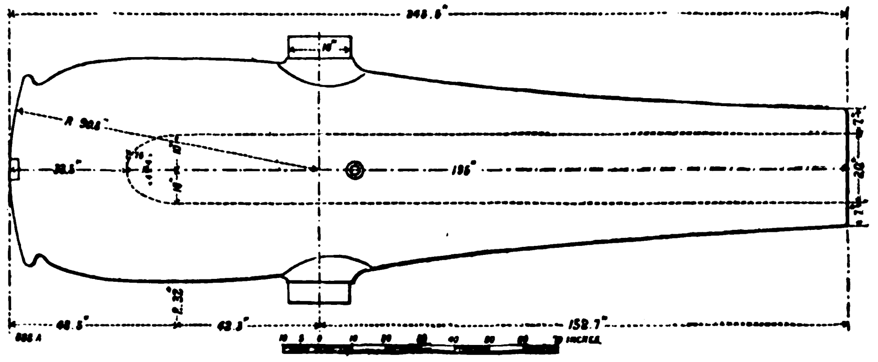


Fig. 4. 20 INCH S. B. GUN.



CAST-IRON SMOOTH-BORE RODMAN GUNS FOR COAST DEFENCE.

MODERN UNITED STATES ARTILLERY.—No I.

CAST-IRON COAST GUNS AND MORTARS.

In 1860 the artillery of the United States occupied a leading position among the heavy gun systems of the world. This was due entirely to the genius of Lieutenant Rodman, whose investigations led to the development of a theory, upon which were built guns that embodied, as far as cast guns could, the principles of gun construction of the present day. Such guns are still retained in the United States service, either in their original form or converted into muzzle-loading rifles of a smaller calibre, intended for the defence of less important places.

Lieutenant Rodman realised that, as the principal stress a bore had to stand from the pressure of the powder gas, was one of extension, every effort should be made to prevent any such strain from being developed during the manufacture of the gun. He suggested that, instead of allowing guns to cool from the exterior, inward, the manner of cooling should be reversed, and that the bore should be cooled first. To accomplish this object he cast his guns hollow, and through the bore he caused a stream of water to circulate, thus hastening the cooling at that point, while around the exterior of the casting he built fires to retard the cooling. The layers of metal on cooling contracted, thus compressing those layers between them and the bore which had already cooled; this stress of compression transmitted inward left the surface of the bore in a

COAST DEFENCE CARRIAGE FOR 15-IN. RODMAN SMOOTH-BORE GUN.

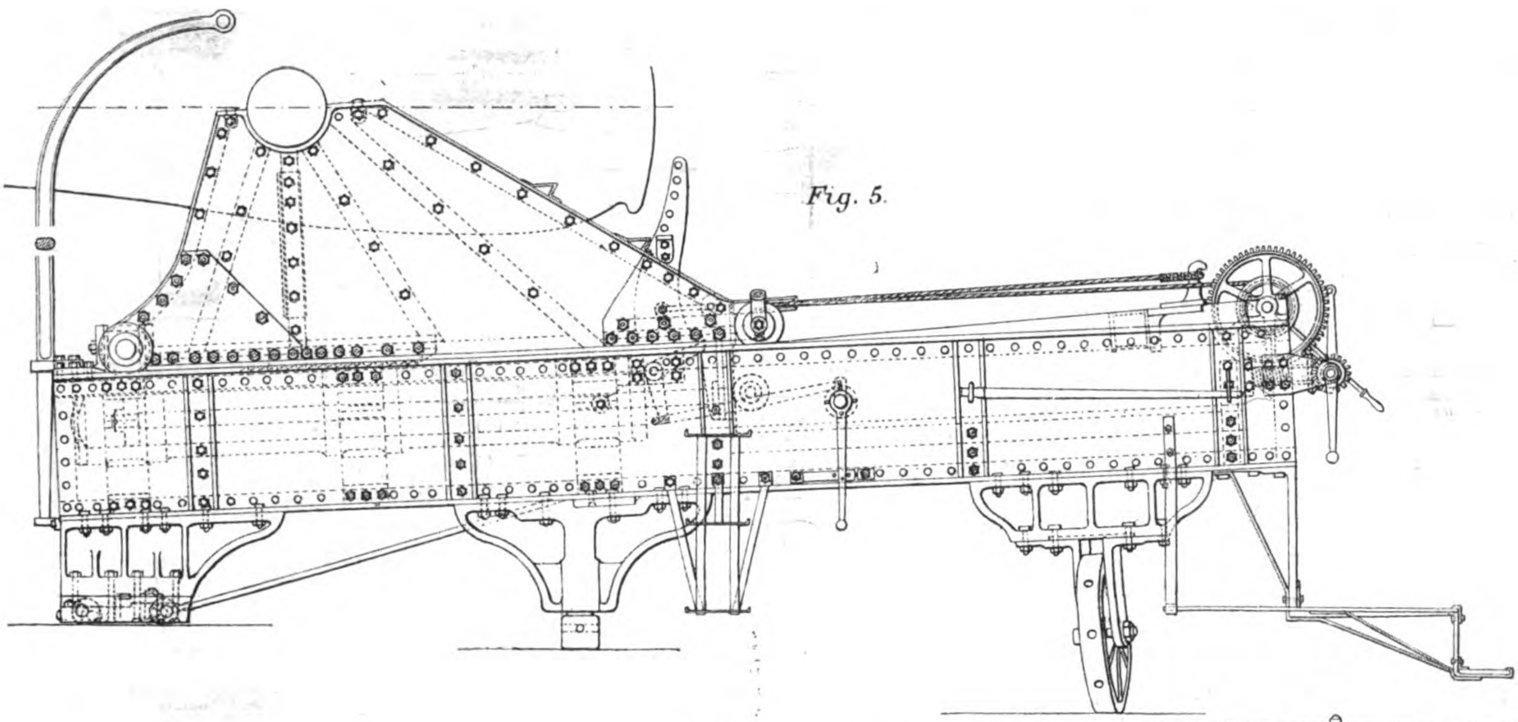


Fig. 5.

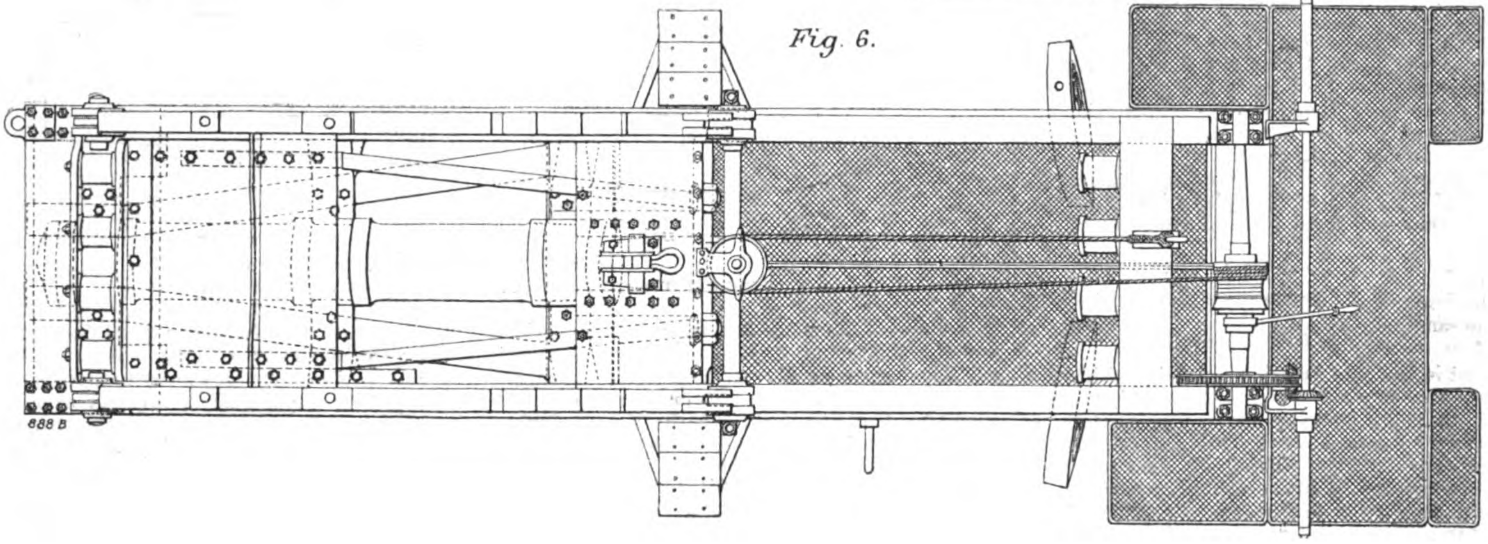


Fig. 6.

state of compression; this state is produced at present by shrinking hoops on the tube.

Referring to a gun cast on this principle, that had withstood 1500 rounds, he said: "The object of my improvement was in part, if not fully, attained, viz., to throw a strain upon the gun, such that each one of the indefinitely thin cylinders composing the thickness of the gun, shall be brought to the breaking strain at the same instant."

It could not be expected to attain the perfect state indicated by this theory, as the investigations relating to the proper degree of temperature to be maintained at the exterior, and the rate of cooling from the interior, had been carried out in a very crude manner. The initial compression desired in theory was about 20,000 lb., while in practice it was found to vary from 3000 lb. to 28,000 lb. for the 10-in. guns and from 4000 lb. to 25,000 lb. for the 15-in. guns. These great variations would show the unreliability of Rodman's theory, but it was much superior to any upon which guns had previously been built.

Rodman Guns still in Service.

The Rodmans still retained in the United States service are the following, 10-in. and 15-in. S. B. coast defence gun, Figs. 1 and 2. (See page 341.)

As this gun would be useless for armour-piercing, it is designed to use it in defence of minor points and torpedo lines.

In 1883, through experiments made at the Government proving ground at Sandy Hook, N.J., the charge was increased to 130 lb. of hexagonal powder, which gives an average pressure of 25,000 lb. per square inch in the bore, and imparts to the projectile an initial velocity of 1700 ft. per second. With an elevation of 20 deg. this charge gives a range of 3¾ miles, and it was found that at 1000 yards the projectile would pierce 10 in. of iron.

Fig. 7.

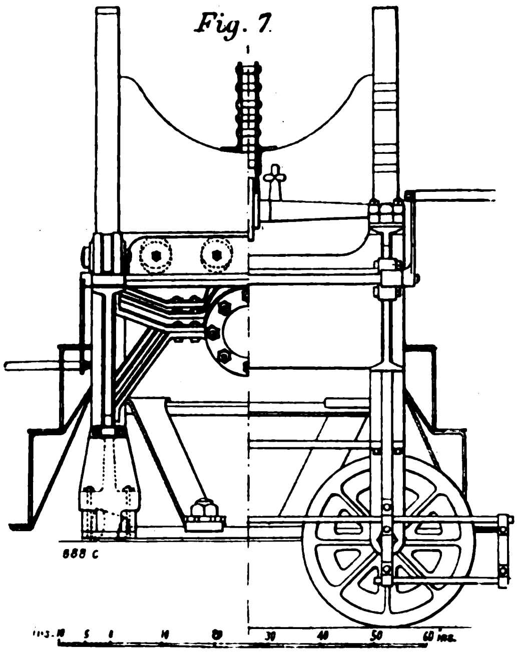


Table I.—*Particulars of Rodman 10-in. Coast Defence Gun (Fig. 1).*

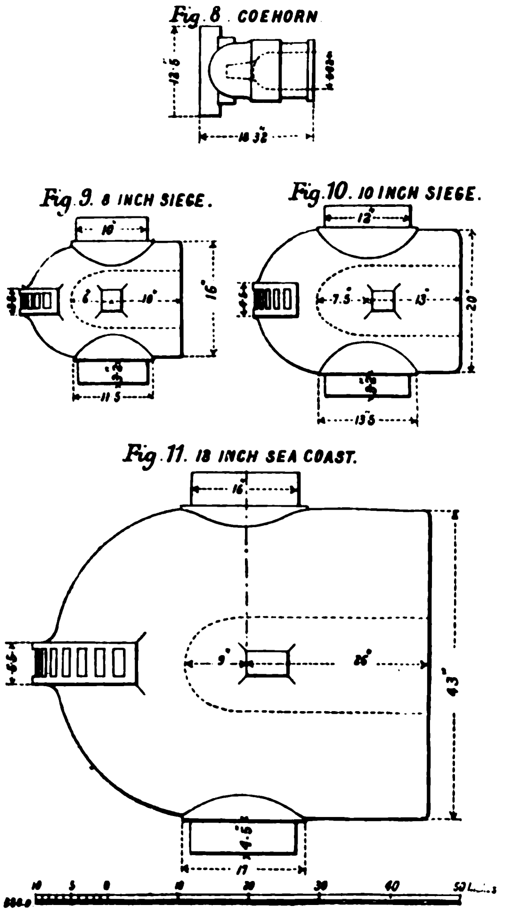
Designation.	—	Pounds.	Inch.
Calibre	..	..	10
Length of piece	..	..	136.6
Maximum diameter	..	..	32
Minimum "	..	..	16 2
Length of bore (calibre) .. .	10.5		
Windage	..	..	0.13
Initial velocity (feet)	1275		
Charge (cannon powder)	..	25	
Solid shot	..	128	
Shell	..	102	
Weight of piece	..	15,000	

Table II.—*Particulars of 15-in. Rodman Coast Defence Gun (Fig 2).*

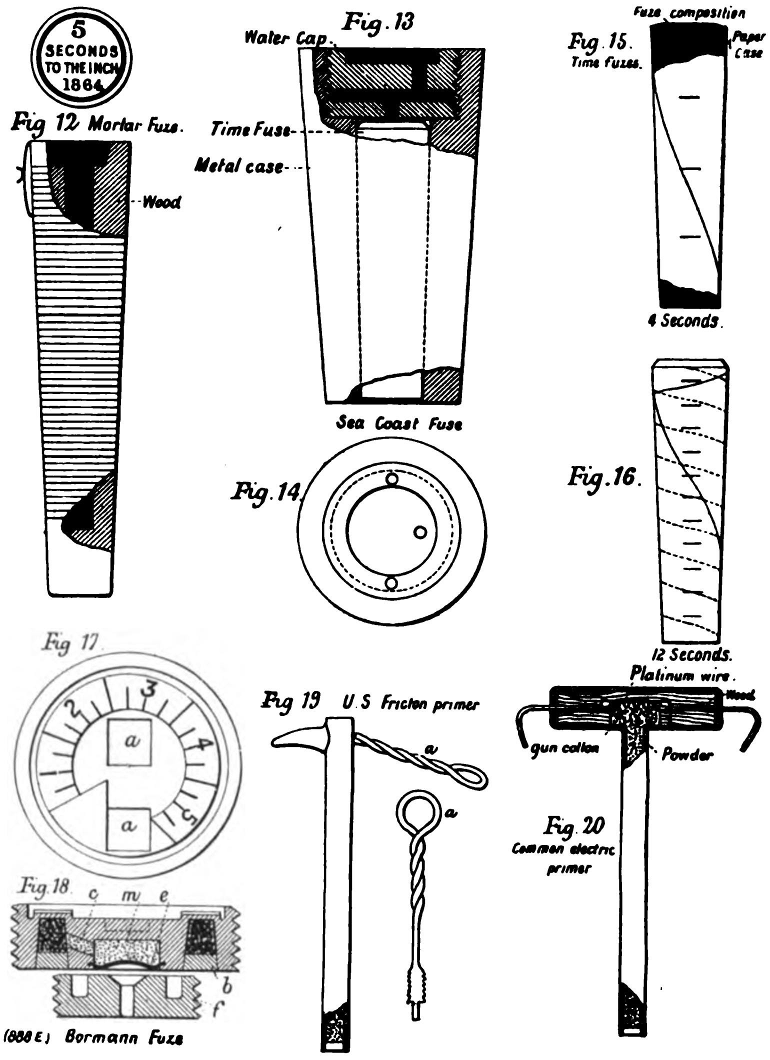
Designation.	—	Pounds.	Inch.
Calibre	..	..	15
Weight	..	49,000	
Preponderance	..	00	
Length of piece	..	..	190
" bore (calibre)	11		
Maximum diameter	..	..	48
Minimum "	..	..	25
Windage	..	..	0.13
Charge (mammoth) for shot ..	..	100	
" for shell	..	60	
Solid shot	..	450	
Shell	..	330	
Initial velocity	..	1534	

The sights are two in number, one placed on the breech and one on the upper surface of the piece in front of the trunnions. The front sight is a single piece of brass fastened to the gun by two

MODERN UNITED STATES ARTILLERY: FUZES AND MORTARS.



SIEGE AND COAST CAST-IRON MORTARS.



DETAILS OF FUZES.

screws, its upper extremity terminating in a blade in the vertical plane containing the axis of the bore.

The breech sight consists of a vertical brass limb in the same plane, secured by screws to the gun at 55.55 in. from the axis of the trunnions. It is 16.6 in. in height, and cut by a longitudinal slit, containing three holes 0.2 in. in diameter, one at each end of the slit and one in the middle. These sights are merely to give the direction to the piece, the elevation being given by means of a graduated arc fixed to the base of the breech, and an index attached to the elevating fulcrum on the carriage. Figs. 3 and 4 show the form and dimensions of the 8-in. and 20-in. Rodmans.

Carriage for 15-in. Rodman Gun.

The carriage (model of 1888) for the 15-in. S.B. gun, consists of a top carriage and chassis (Figs. 5, 6, and 7). The chassis consists of two rails, each composed of two plates of boiler iron, the top and bottom surfaces being formed by flanges of T bars, the web of the latter passing between the edges of the plate. Short channel bars, perpendicular to the edges of the chassis rails, are bolted at intervals to the exterior of the rails and add strength and stiffness. Between the rails lies a cast-iron hydraulic cylinder, supported on transoms, which are bent to a circular shape, and accurately turned to fit the corresponding cylindrical surfaces of the cylinder. These transoms are bolted to the chassis rails. The cylinder contains a loose-fitting piston head perforated with four holes circular in cross-section, and their longitudinal section being conic frustra of cones joined at their smaller bases. The piston-rod, after passing through a stuffing-box in the rear cylinder head, passes through a vertical elongated slot in the crosshead of the top carriage, and terminates in an eye. Through this eye passes a steel pin carrying two steel rollers, thus permitting the automatic adjustment of the piston as the carriage runs up the inclined rails while recoiling. In rear of the cylinder are three transoms, between which diagonal braces are situated. Beginning about the middle of the chassis rails, and extending to the rear ends, are inclined wedge-shaped rails, intended to increase the resistance in recoiling, and to assist in running the piece into battery, as the rear truck wheels of the top carriage rise on these while recoiling. A flat transom is fastened to the top of the chassis rails in front, and carries a plate, to which are attached four rubber buffers intended to prevent any severe shock when the gun runs into battery. A similar device is found in the rear to provide for a similar emergency in case the gun should recoil to the full extent of the rails. To draw the carriage from battery there is at the end of the chassis an axle bearing a drum, and actuated by a bevelled gearing. A rope, attached to a hook on the rear transom, passes through a pulley on the carriage and then around the drum. As the gun is loaded while from battery it is necessary to hold it in this position when it recoils. For this purpose there is a retaining apparatus consisting of a pawl and lever. On the bottom of the top carriage is a toothed rack, in which the pawl engages. Against the pawl presses a steel spring, so arranged that it will always retain the top carriage at the point to which the recoil carries it. By pulling the lever the pawl is released and the carriage, actuated by the inclined rails, will readily run in battery. A crane is attached to the front part of the chassis, to which a block and tackle are attached to raise the shot to the muzzle of the piece.

The piece is traversed by means of two traverse wheels under the rear of the chassis, running on traverse circles and having holes in their periphery for the insertion of manœuvring handspikes. For convenience of the cannoniers side and rear platforms of wire netting are added. The gun carriage has two cheeks connected by four transoms, one of which is placed almost vertically below the trunnion beds. The other three transoms connect the lower part of the cheeks; the front one bears clips to prevent the carriage from jumping the rails, and also a plate to strike against the front buffers; the middle transom forms a support for braces connected with the crosshead. The rear transom bears clips and a heavy crosshead which connects the piston-rod of the hydraulic cylinder to the top carriage.

Each cheek is composed of two triangular pieces of boiler iron, separated by radial struts of bar iron so arranged as to assist in resisting the weight of the gun and the shocks due to recoil. Between the edges of the plate the web part of a T bar is inserted; the flange overlying the edges adds stiffness to the front and rear, and on the bottom acts as a shoe upon which the carriage rests while in battery.

To the lower front angle of each cheek is bolted a heavy bronze casting bored to form boxes for the concentric axles of the front truck wheels. Similar bronze castings in rear receive an eccentric axle, to which two steel truck wheels are attached. When it is necessary to run the gun from battery by hand the eccentric axle is thrown in gear by means of handspikes inserted in the bronze sockets at the extremities of the axles. The shoe is cut away slightly in the vicinity of the front truck wheels so as to allow them to bear slightly on the chassis rails when the gun is in battery. When the carriage recoils the rear truck wheels ascend the wedge-shape rail, and tipping the carriage slightly to the front causes it to move on rolling friction.

If the piston-rod were firmly attached to the crosshead of the top carriage, the rising of this on the inclined wedge would tend to bend the rod. This is avoided by means of the elongated slot and rollers on the steel pin, which allow the piston-rod to adjust itself. On running into battery, when the rear wheels leave the inclined wedge rail, the carriage rests on the shoe and moves by sliding friction. The forward motion is thus diminished gradually, and finally ceases when the front transom strikes the buffers. The trunnion beds are made by bending a T bar into the proper shape. The upper surface of the flange forms the bed, while the web is bolted between the cheek plates. To the rear transom is bolted a wrought-iron ratchet post to provide a fulcrum for an elevating bar.

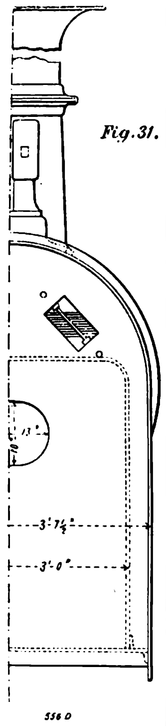
Efficiency of 15-in. Rodman Gun.

In 1882 the 15-in. gun was tested to determine

STEAM BOILER EXPERIMENTS.

(*For Description, see Page* 346.)

Fig. 31.



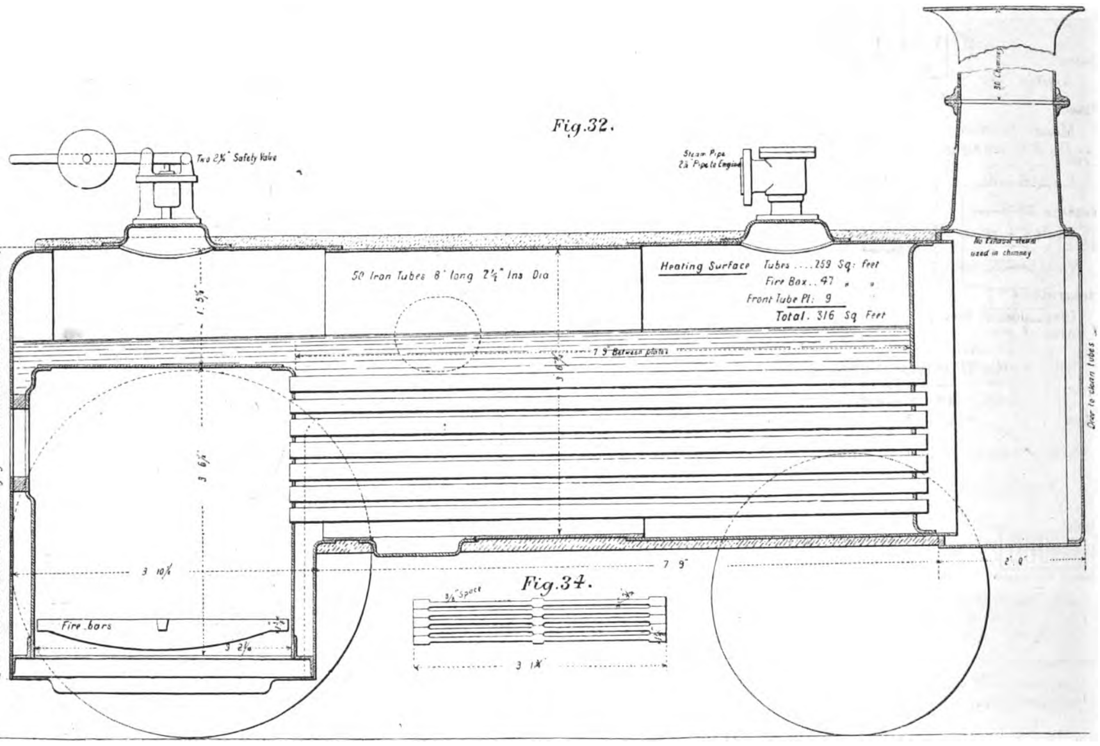
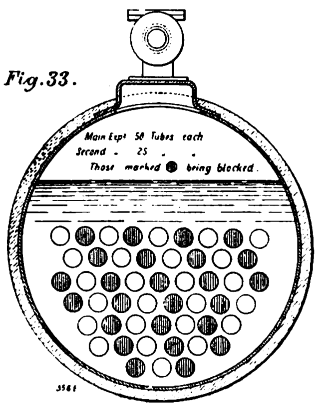
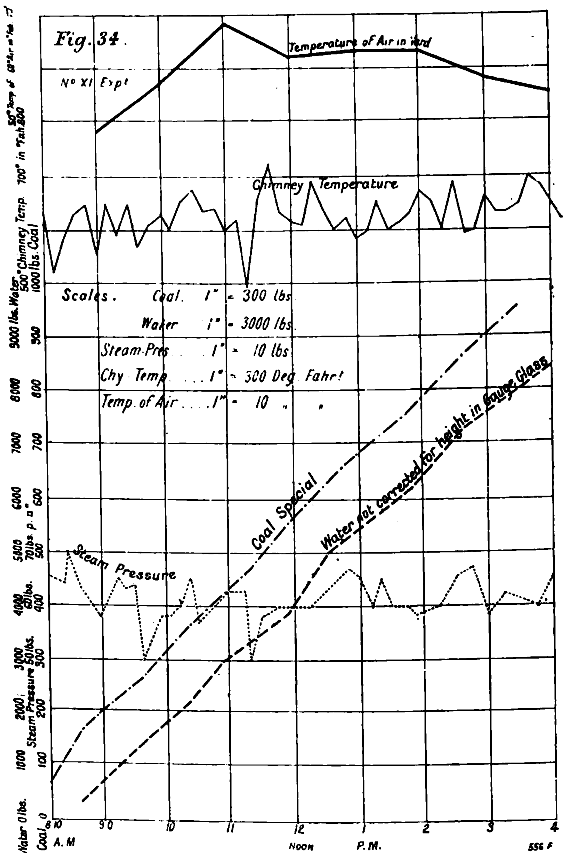


Fig. 33.





its effect on wrought-iron armour. The target was 6 ft. by 11 ft. and was composed of three plates, two of which were 4 in. thick, the third was 2 in. thick, making a total thickness of 10 in. The plates were backed by two layers of oak timber, each 10 in. square, and a 1-in. skin plate of wrought iron. At 100 yards this target was completely perforated, and at 1000 yards the shot lodged 19¼ in. from the face of the plates.

Table III.—*Firing Trials of* 15-*in. S.B. Rodman Sea Coast Gun.*

(Weight of Shot 455 lb. Initial Velocity 1706 ft. Powder Charge 130 lb.

Distance of Object.	Angle of		Remaining Velocity.	Energy.	Penetration, Wrought Iron.
	Elevation.	Fall.			
yards	deg. min.	deg. min.	ft.	foot-tons.	in.
100	..	0 7	1652	8522	11.4
1000	1 7	1 27	1266	5005	8.7
2000	2 54	4 18	980	3054	6.8
3000	5 14	8 48	822	2110	5.7
4000	8 39	15 51	704	1546	4.8
5000	13 14	23 49	622	1207	4.22
6000	18 46	36 17	557	969	3.8

Besides the 15-in. and 10-in. Rodman there remained in the service of the United States a few 8-in. and 20-in. guns of the same kind. They are similar to the guns described, and the number in existence is quite limited.

Mortars.

The smooth-bore mortars that are still in service are the following.

The Coehorn mortar (Fig. 8) is a small bronze mortar of which particulars are appended.

Table IV.—*Particulars of Coehorn Mortar* (*Fig.* 8).

Calibre	5.8 in.
Weight of piece	164 lb.
Extreme length	16.32 in.
Maximum charge	12 oz. mortar powder
Weight of shell	16.8 lb.
Charge to fill shell	1 lb.

The carriage is simply a block of wood weighing 132 lb. The total weight of piece, equipments, and

STEAM BOILER EXPERIMENTS OF MR. B. DONKIN, JUN., AND PROFESSOR KENNEDY.

(*See Page* 346.)

RESULTS OF EXPERIMENT No. XI.

PARTICULARS AND DIMENSIONS OF BOILER.

Date:	
April 28, 1887.	
Place:	
Messrs. B. Donkin and Co.'s Works, Bermondsey.	
Type:	
Portable boiler, locomotive type.	
Heating Surface:	
Heating surface of boiler alone	316 sq. ft.
,, ,, economiser	none
Total heating surface	316 sq. ft.
Firegrate:	
Dimensions of firegrate	3 ft. 1¼ in. by 3 ft.
Area of grate	9.68 sq. ft.
,, air spaces	2.5 ,,
Ratio of air space to area of grate	0.258
,, boiler surface to grate surface	32.6
,, total heating surface to grate surface	32.6
Flues:	
Kind of flues and direction of gases	No brickwork. Gases from firebox, through small tubes, up chimney.

PRINCIPAL OBSERVATIONS.

Time:	
Duration	8 hrs.
Steam Pressure:	
Mean steam pressure above atmosphere	61.0 lb.
,, absolute steam pressure	75.7 ,,
Temperature Fahr. corresponding to this pressure	308.2 deg. Fahr.
Feed Water:	
Temperature of feed	56.3 deg. Fahr.
Total feed water evaporated	8700 lb.
,, ,, ,, per hour	1087 ,,
Coal and Ashes:	
Total coal used, including ashes and clinker	960 lb.
Per cent. of ash and clinker in total coal used ...	1 ash, 1.4 clinker per cent.
,, of moisture in fuel	1.8 ,,
Total weight of pure and dry coal used per hour	115 lb.
Ratio of total pure and dry coal to coal including ash, &c. ...	0.958
Total coal used including ash and clinker per hour	120 lb.
,, weight of ash and clinker	10 lb. ash, 13 lb. clinker.
Stoking:	
Thickness of fires	4.5 in.
Number of times each fire stoked per hour	3.73
Temperature of Air:	
Temperature of air in boiler-house	59 deg. Fahr.
,, ,, outside ,, ...	59 ,,
Temperature of Gases:	
Temperature of furnace gases at base of chimney	625 deg. Fahr.
Draught:	
Chimney draught	0.20 in.

PRINCIPAL OBSERVATIONS—*continued.*

Radiation Experiment:	
Coal per hour necessary to maintain pressure only	9.3 lb.
Per cent. of total coal used, including ashes and clinker per hour	7.75 per cent.

ANALYSIS, &c., OF FURNACE GASES.

Analysis of Dry Furnace Gases:

	Weight.	Volume.
Carbonic dioxide, CO_2	16.50	11.34 per cent.
,, oxide, CO	0.21	0.23 ,,
Oxygen, O	7.76	7.33 ,,
Nitrogen, N	75.53	81.10 ,,

PRINCIPAL RESULTS.

Carbon:	
Per cent. weight of carbon to dry gases	4.59 per cent.
Air:	
Pounds of dry air per pound of carbon...	21.2 lb.
,, ,, ,, coal	18.8 ,,
,, ,, ,, pure and dry coal	19.4 ,,
,, furnace gases per pound of pure and dry coal	20.0 ,,
Ratio of air used to air theoretically required	1.81
Temperature of Gases:	
Rise in temperature of gases	566 deg. Fahr.
Carbonic Oxide:	
Per cent. of carbon burnt to carbonic oxide	1.96 per cent.
Combustion:	
Pounds of coal burnt per square foot of grate surface per hour ...	12.4 lb.
,, ,, ,, ,, heating ,, ,, ...	.38 ,,
,, ,, ,, ,, total heating surface ...	— ,,
Transmission of Heat:	
Thermal units per square foot of heating surface per hour, boiler only	3920 T. U.
Evaporation:	
Pounds of water evaporated per pound of coal from feed temperature	9.06 lb.
Equivalent evaporation per pound of coal from and at 212 deg. Fahr.	10.78 ,,
,, ,, ,, pure and dry	11.25 ,,
,, ,, square foot of grate per hour	133.5 ,,
,, ,, ,, heating surface (boiler)	4.05 ,,
Factor of evaporation	1.193

Percentage Balance Sheet of Heat.

Heat Evolved.	Per Cent.	Heat Absorbed.	Per Cent.
Heat from pure and dry coal ...	100	Heating and evaporating water	69.8
		Heating furnace gases... ...	18.0
		Evaporating moisture in coal	.1
		Radiation	5.7
		Lost by imperfect combustion	1.2
		Unaccounted for	5.2
Total	100	Total	100

---

carriage, is 311 lb. The carriage or block upon which the Coehorn mortar is mounted, is provided with two handles on each side by means of which it is readily carried by four men. They have been used by troops in the field against an intrenched enemy. The ground is generally sufficiently firm for the carriage to rest upon.

The 8-in. siege mortar (Fig. 9). This is a cast-iron, smooth bore, unchambered.

TABLE V.—*Particulars of* 8-*in. Siege Mortar* (*Fig.* 9).

Calibre	8 in.
Weight	1010 lb.
Preponderance	0
Length of piece	22 in.
,, bore	2 calibres
Windage	0.12 in.
Maximum charge	2.25 lb. mortar powder
Weight of shell...	46 lb.
Charge to fill shell	2.5 ,,
Weight of carriage	900 ,,

To transport this mortar there is a platform wagon serving as a mortar wagon. One mortar wagon drawn by eight horses will carry three mortars and carriage.

The 10-in. siege mortar (Fig. 10). This is a cast-iron smooth bore, unchambered.

TABLE VI.—*Particulars of* 10-*in. Siege Mortar* (*Fig.* 10).

Calibre	10 in.
Weight	1900 lb.
Preponderance	0
Length of piece	28 in.
,, bore	20.5 ,,
Windage	0.13 in.
Maximum charge	4 lb. mortar powder.
Weight of shell	90 lb.
Charge to fill shell	5 ,,
Weight of carriage	1313 ,,

This piece is also carried on the mortar wagon.

The 13-in. sea coast mortar (Fig. 11). This is a cast-iron smooth-bore, unchambered.

TABLE VII.—*Particulars of* 13-*in. Siege Mortar* (*Fig.* 11).

Calibre	13 in.
Weight	17,120 lb.
Preponderance	0
Length of piece	54.5 in.
,, bore	35.1 ,,
Windage	0.13 ,,
Maximum charge	20 lb. mortar powder.
Weight of shell	216 ,,
Charge to fill shell	11 ,,
Weight of carriage	4140 ,,

The carriages for the 8-in., 10-in., and 13-in. mortars consist of two triangular-shaped cheeks, made of wrought-iron plates, strengthened with T irons and transoms in a similar manner to the top carriage of the 15-in. gun (Fig. 5). They have no chassis.

FUZES AND PRIMERS.

The fuzes that are used with the shells of the pieces described above, are of three kinds: (*a*) The mortar fuze (Fig. 12). This is made of a close grained hard wood, such as beech. It is turned to a conical shape to prevent its being dislodged backward into the shell by the shock of discharge. It is bored nearly through to receive the time composition, and to preserve it in store, it is capped with a waterproof paper, on which is marked the rate of burning. To prevent the fuze from being extinguished when firing over water the sea coast fuze *b* is used (Figs. 13, 14, 15, and 16). It consists of a metal case, the fuze composition being contained in a paper case, which fits in the metal cap. The water cap is then screwed on; this is perforated by a zig-zag channel filled with mealed powder and gun spirits. The irregular channel prevents the entrance of the water when the shot ricochets.

When the time of burning is not long the Bornann fuze *c* (Figs. 17 and 18) is used. This consists of a circular pewter disc, on the surface of which is the scale of time, and two holes *a a* to be used in screwing the fuze in the shell. The time composition lies in an annular-shaped cavity below the scale of time. A hole is punched at the point indicating the desired time of burning. The composition is ignited at this point and burns around to zero, where it connects, by a channel *c*, to a powder magazine *m*, and thence, through the channel *r* to the bursting charge. The time composition is held in position by the pewter disc *b*. As the threads of the pewter case might be sheared off by the shock of discharge, a wrought-iron disc *f* is first screwed in the fuze hole to act as a support.

The primers used to discharge the pieces are of two kinds, friction and electric.

The friction primer (Fig. 19) consists of two brass tubes soldered at right angles to each other. The short tube contains the friction composition, consisting of Sb_2S_3 and $KClo_3$, surrounding the roughened end of a wire *a*, whose nib is folded over the end of the short tube, so as to prevent any danger of premature discharge. The long tube is filled with fine powder, retained by a wad of wax. The hook of the lanyard is inserted in the eye of the wire. The electric primer is made in a similar way, the wire and friction composition being replaced by a platinum wire surrounded by guncotton (Fig. 20).

STEAM BOILER EXPERIMENTS.

No. VIII.

By Mr. BRYAN DONKIN, Jun., and Professor KENNEDY, F.R.S.

No. XI., April 28, 1887.—Experiments on a Locomotive Type Boiler at Bermondsey.—This eight hours' experiment was made on a new portable locomotive type of boiler with a steel shell and ordinary chimney, 36 ft. high, constructed by Messrs. Marshall, Sons, and Co., of Gainsborough, and forming one of their usual types. It was worked in the yard of Messrs. Bryan Donkin and Co.'s factory at Bermondsey, without brickwork round it, and not housed in any way. Professor Osborne Reynolds was present during the whole trial, as also one of the authors. The steam was used to drive a compound steam engine, and the feed water was measured by the standard can, holding 100 lb., and then emptied into the feed tank. As usual the gases were analysed, and a larger percentage of CO was found just after firing.

In this particular experiment the time was noted in getting up steam. The fire was lit at 7.23 A.M. with 32 lb. of wood, all parts of the boiler being cold, and the water in the boiler at starting having a mean temperature of 85 deg. Fahr. At 2½ minutes past 8, or after 39½ minutes, steam of 70 lb. was registered, the weight of coal consumed being 110 lb., which with the 32 lb. of wood mentioned above, is about equal to 126 lb. standard coal. The firebox was covered externally with loam 1½ in. thick.

The general dimensions of the boiler were as follows: Firebox inside, 3 ft. 3 in. by 2 ft. 11 in. by 3 ft. 1 in. high from firebars; diameter of barrel 3 ft. 7 in. by 7 ft. 9 in. long, with 50 tubes 2½ in. in diameter and 7 ft. 9 in. long; chimney, 13 in. in diameter, 36 ft. high above firebars. No exhaust steam was used in chimney, only natural draught.

Firing by hand in small quantities, by means of a light hand shovel, was very frequent, and the firedoor was kept open as short a time as possible. The feed water was fed in by means of an injector. The boiler was lagged in the usual way with felt and sheet iron. The average thickness of fire was about 4½ in., and a mean steam pressure of 61 lb. was kept up during the trial, which was perfectly satisfactory in all respects. Views of the boiler are given on page 344, as also time diagrams of the coal, feed water, temperature of gases, &c. A tabular statement of the results of the experiment is also given on page 345. As usual there was no damper in chimney, but an inlet to ashpan could be stopped or regulated by doors.

On May 24, 1887, the following additional experiment was made with the same coal and the same stoker, and under exactly similar conditions to those of the main experiment above described, but with this difference, that 25 of the 50 tubes marked in Fig. 33 on page 344, or every other one alternately, were stopped at the firebox end, thus reducing the total heating surface 41 per cent. The result was that the evaporation of water, which was carefully measured, was only 6 per cent. less per pound of coal than in the main experiment, and the escaping gases were only about 5 deg. Fahr. hotter.

CHERITON SEWERAGE.—A Local Government Board inquiry was held by Mr. Arnold Taylor, R.E., at the Folkestone Town Hall, on February 26th, to consider an application from the Elham Rural Sanitary Authority for sanction to borrow 5000*l*. for the sewerage of Cheriton. The Folkestone Corporation also applied for various sums for extension of sewage outfall, extensions and repairs of sewers, &c. It was proposed to lay sewers through Cheriton district and connect the same with the Folkestone sewerage system. Mr. W. H. Radford, C.E., of Nottingham, is engineer to the Cheriton scheme, and the late borough engineer's assistant explained the Folkestone scheme.

THE COLUMBIAN EXPOSITION: FINE ART GALLERIES.

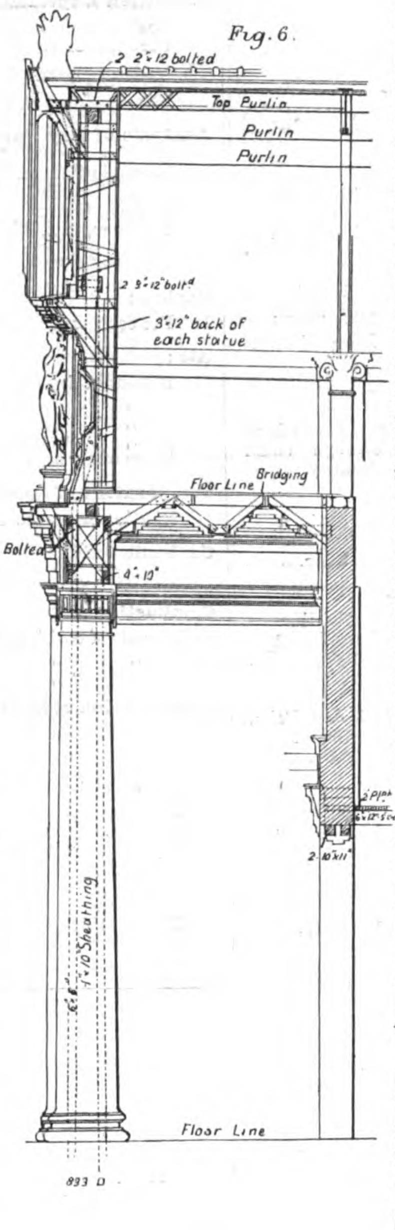


Fig. 6.

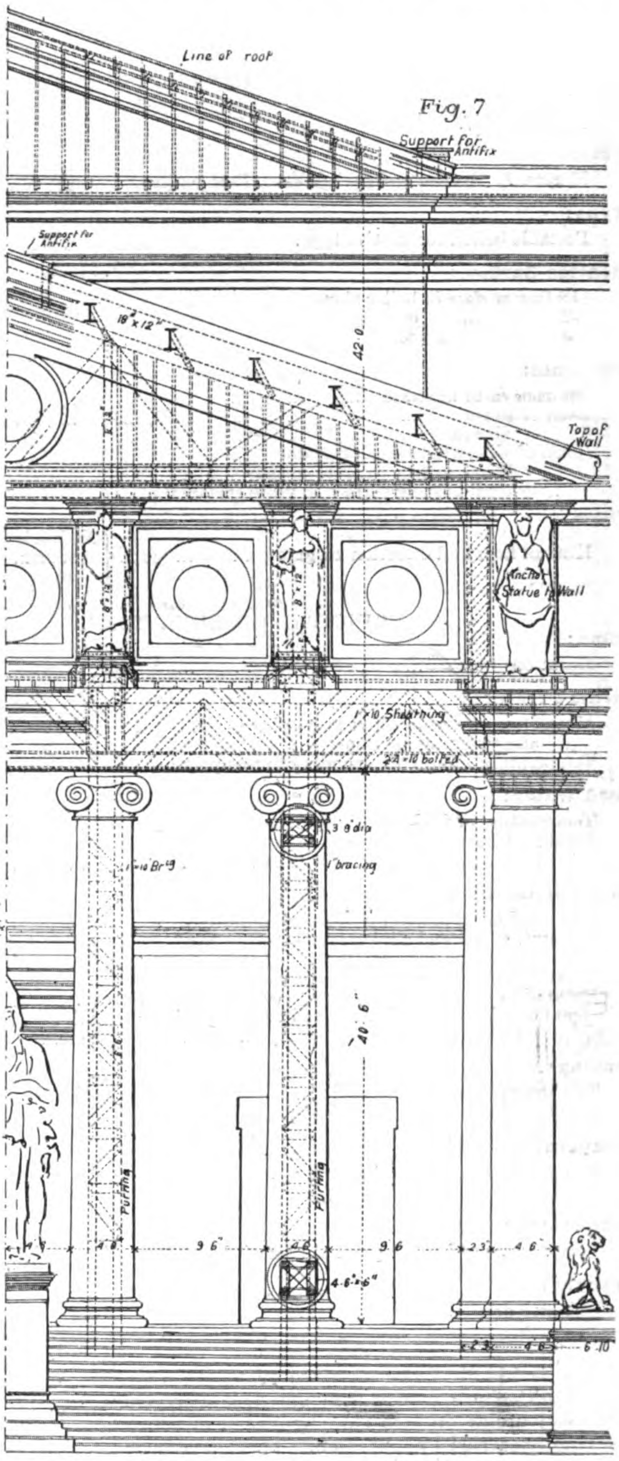


Fig. 7

THE WORLD'S COLUMBIAN EXPOSITION.

THE FINE ARTS GALLERIES.

WE publish this week some details of the Art Galleries at the Columbian Exposition, of which we gave a general description last week. Figs. 6 and 7 are views of the main entrance, and show the manner in which the framework of the column and entablature is built up to receive the covering of staff. Figs. 8 to 17 are details of the steel stanchions and girders of which the structure is composed. We shall postpone our description of the work till the publication of further details.

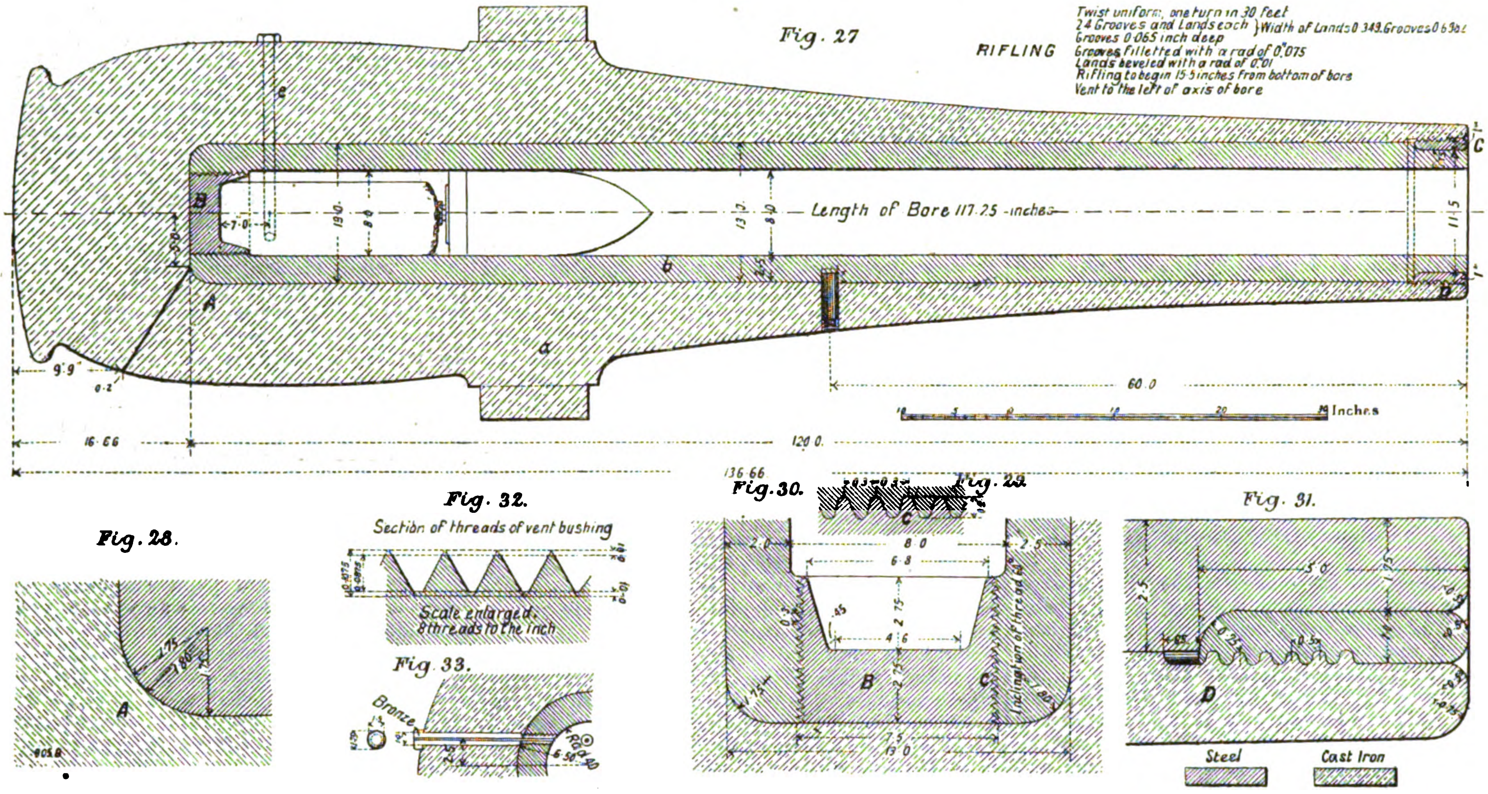
THE MILL OF ASH TUNNEL.

AN interesting piece of work has recently been completed in the removal of a long tunnel on the northern section of the Caledonian Railway, the work being carried out without interfering with the traffic over the railway, which is the main line to the north. We give several illustrations, which will enable the reader to follow our description of the operations. Fig. 1 (page 354) is a plan of the site of the tunnel, Fig. 2 an elevation of the south end of the tunnel, Fig. 3 a section near the centre; Fig. 4 shows the shield used in supporting the arching while it was being demolished from the outside, Fig. 5 is a longitudinal section of the shield, Figs. 6 and 7 are sections of the top part of the shield, showing the screws by which the planking was driven close up to the inside of the crown of the tunnel.

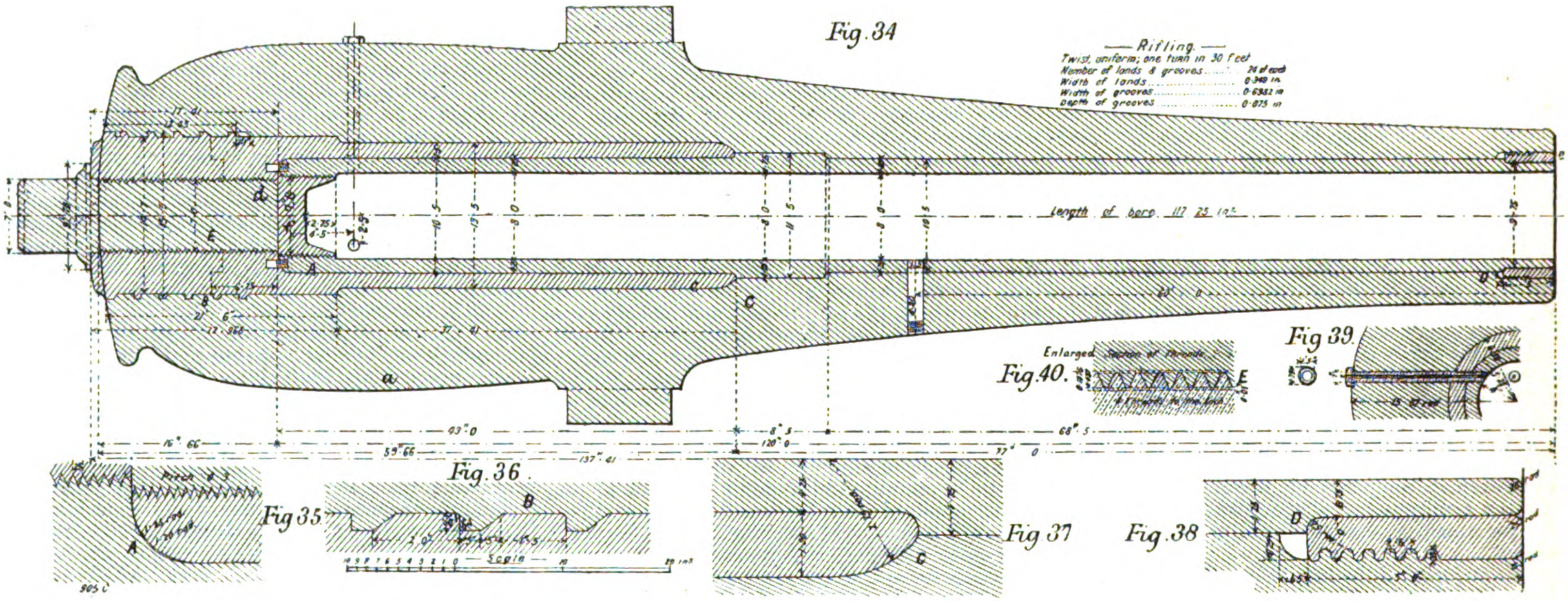
The tunnel, it is interesting to note, was situated on the main line of the old Scottish Central Railway, about six miles north of Stirling. It was made upwards of forty years ago, when the railway was constructed between Greenhill and Perth. The tunnel was 260 yards in length, the rails on a curve of about three-quarters of a mile radius, and the gradient was 1 in 90 falling from north to south. It was 25 ft. in width, and the height from rail level to crown of intrados varied from about 17½ ft. to 20 ft. (see Figs. 2 and 3). At some parts of the abutments the freestone rock showed solid, and had been dressed fair and straight on the face, but by far the largest proportion of the abutments were built of masonry, carried up to a height of about 4½ ft. above the rails, from which the brick arch was sprung; this arch being six bricks, equal to about 2½ ft. in thickness. The height from the crown of arch to the surface above varied from about 30 ft. at the lowest, to about 44 ft. at the highest part.

The arch having shown indications of weakness at some parts, it was decided to open it up, and the necessary Parliamentary powers being acquired, arrangements were made to carry cut the work. There were about 12 acres of low-lying wet marshy ground in a hollow close to the top of the tunnel (Fig. 1),

MODERN UNITED STATES ARTILLERY.



10-IN. RODMAN CAST-IRON GUN CONVERTED INTO 8-IN. RIFLE (MUZZLE INSERTION).



10-IN. RODMAN CAST-IRON GUN CONVERTED INTO 8-IN. RIFLE (BREECH INSERTION).

Tien-Tsin (28 miles), and thence to Pekin (86 miles), the opposition became so powerful that in the case of the latter extension, Li's unique prestige had to give way, and consent to the withdrawal of the imperial leave six weeks after granting; it has been more than once on the cards that the Tien-Tsin branch, where a first-class rapid and paying service of passenger and freight trains is being run, should have been torn up again to furnish materials for colliery line extensions, the only recognised legitimate business of the railway.

(*To be continued.*)

MODERN UNITED STATES ARTILLERY.—No. II.

STANDARD LIGHT 3-IN. RIFLE.

WHEN the Civil War began the United States had no national gun foundry. The manufacture of guns, particularly of small calibres for field use, was undertaken by numerous private firms throughout the country, and in the greater number of cases there was no Government inspector present. Many batteries were gifts of private individuals, many battery commanders organised and equipped their own batteries. As a result there was the greatest variety of types, calibres, and designs. The variety however, soon became much smaller, until finally certain standard calibres were adopted and are still retained in the service. The standard field piece was a 3-in. wrought-iron gun (Fig. 21). This gun was manufactured in the following manner: Rolled staves were laid up in the form of the barrel on an arbor and placed in a lathe. Around these was wound, by the revolution of the lathe, a long bar, rhomboidal in section. Upon this bar was wound a second with spirals running in the opposite direction. The operation was continued until five layers had been applied. To give longitudinal stiffness a thin bundle of staves was bound on the outside. The breech was closed by driving in a plug. The mass was then raised to a welding heat and upset endwise 2 in. in a press and then rolled out from 4½ ft. to 7 ft. in length. The welding on of the trunnions, the turning of the chase, and the boring and rifling, completed the gun. A second method of making this gun was to wrap sheet iron around a mandrel, and then draw it out into a tube.

This formed a light and very serviceable gun, and is the gun with which the light batteries of the United States are at present equipped. They are being replaced by the new steel pieces that are being built, and when completely replaced they will be reserved as pieces to be used in cases of emergency. The principal dimensions of the piece are as follows:

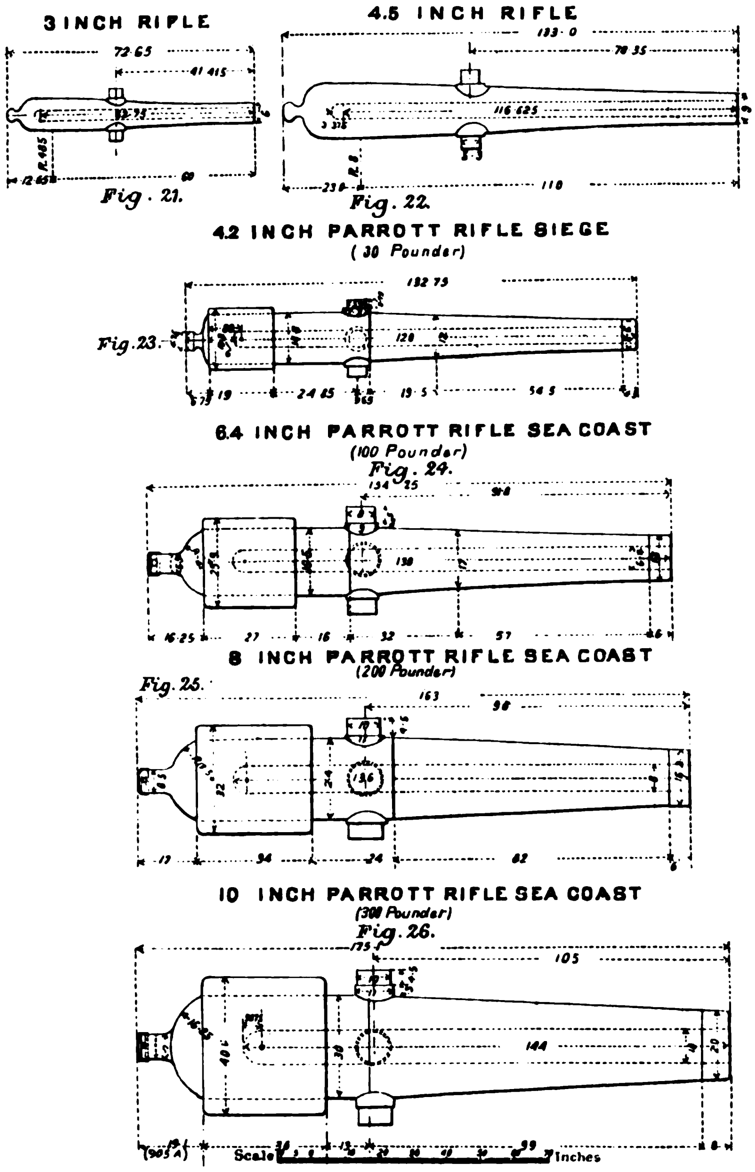
TABLE VIII.—*Particulars of 3-in. Rifle* (*Fig.* 21).

Diameter of bore...	3 in.
Length of bore	21.66 calibres
" piece	73.3 in.
Maximum diameter	9.7 "
Weight	820 lb.
Preponderance	40 "
Weight of shell	9 "
" charge	32 oz.
Initial velocity	1500 ft.

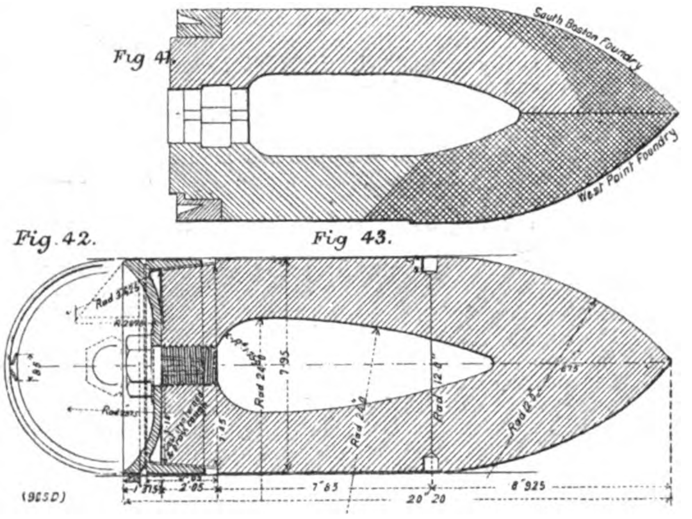
CAST-IRON SIEGE AND COAST GUNS.

The siege gun that is still retained in the service is a cast-iron rifle, 4.5 in. in diameter (Fig. 22). It

MODERN UNITED STATES ARTILLERY.



PARROTT RIFLED CAST-IRON GUNS.



PROJECTILES FOR 8-IN. CONVERTED RIFLE.

is a muzzle-loading rifle with a uniform twist of one turn in 15 ft.

TABLE IX.—*Particulars of* 4.5-in. *Gun* (*Fig.* 22).

Calibre...	4.5 in.
Length	133 ,,
Maximum diameter	15.6 ,,
Minimum ,,	9 ,,
Weight	3570 lb.
Initial velocity	1280 ,,
Weight of shot	35.5 ,,
,, shell	25 ,,
,, charge	3.25 ,,
Range	3600 yds.

The piece is mounted on a wooden carriage provided, as is usual in siege guns, with travelling trunnion beds.

The other cast-iron guns of the date of the Civil War are the Parrott rifles. The 30-pounder, Fig. 23; the 100-pounder, Fig. 24; the 200-pounder, Fig. 25; and the 300-pounder, Fig. 26. These are all cast-iron rifled guns, with a reinforce hoop of wrought iron. A number of them, especially the larger calibres, having failed, they have come to be regarded with distrust, and probably will not be used again except in an emergency.

The wrought-iron hoop was made by coiling a bar into the form of a hollow cylinder, and welding it longitudinally. It was then finished to the prescribed dimensions and assembled by shrinkage. The shrinkage considerably exceeded the shrinkage that is at present considered proper, and probably produced cross-strains in the iron, which weakened it when called upon to resist longitudinal strains. The hoop itself adding but little to the longitudinal strength, will probably explain the cause of the recent failures. These, together with the recent improvements in gun construction, will probably lead to the retirement of the Parrott guns from the service as soon as they can be replaced by the new steel ones.

CONVERTED 8-IN. AND 10-IN. SMOOTH-BORES.

After the close of the Civil War there was but little done in the way of gun construction in the United States until about 1872. It was then proposed to convert the comparatively useless 10-in. smooth-bore into an 8-in. rifled gun, by adding a rifled lining. The 8-in. gun so made proved fully equal to the English guns of the same calibre and led to the hope that the conversion of the larger calibre would also be successful.

The Ordnance Board which considered the subject recommended the trial of the Palliser plan of muzzle insertion, then successfully established in England, and the Parsons (American) plan of breech insertion. For the Palliser system wrought-iron tubes were to be used, and for the Parsons system steel tubes. The wrought-iron tubes were furnished by Armstrong, and the steel tubes by the Bochum Steel Company in Germany. The 8-in. gun made by muzzle insertion was at once a pronounced success; the one made by the breech insertion method failed when fired for 456 rounds. On trial with the larger calibre the muzzle insertion plan proved to be defective in longitudinal support, and led to the adoption of the breech insertion plan. A successful trial of this system gradually led to the same system for the 8-in. gun, and proved very serviceable. Contracts for wrought-iron and steel tubes given to American firms encouraged the production in the United States, and soon led to the acceptance of forgings, which quite came up to the tests of those tubes which had been obtained from abroad.

An attempt to convert the muzzle-loading smooth-bores into breechloading guns, with the Krupp fermeture, was then made. The general manner of inserting the tubing was the same as that which will be described for the muzzle-loading rifle. The jacket of the tube was considerably heavier than that which was used for the muzzle-loading rifle, and projected to the rear to receive the Krupp fermeture. This increased thickness of the jacket necessitated the removal of so much of the cast iron that the strengthening of the breech became necessary. This was done by the shrinking on of a steel hoop. The experimental 8-in. gun withstood over 600 rounds without injury; 8-in. and 11-in. guns were then ordered, differing from the first in the fact that the powder chamber was enlarged to receive an increased charge. The trial guns, however, failed after a few rounds by a fracture of the steel jacket through the front angles of the seat for the breech-block. A second 8-in. gun was made with rounding front corners. It stood the proof for endurance very well until the 127th round, and then burst into many fragments.

The attempt to convert the muzzle-loading guns into breechloaders having proved a failure, did not detract from the muzzle-loading conversion system. A large number of 8-in. rifles were made and are now mounted in the various forts. In 1883 a test of an 8-in. gun at Sandy Hook, gave to a chilled iron projectile, weighing 180 lb., an initial velocity of 1430 f.s., and at 1000 yards penetrated 8 in. of iron, thus proving itself an effective weapon for the protection of narrow channels against vessels carrying 8 in. of armour or less.

The muzzle insertion or Palliser plan of converting the 10-in. Rodman smooth-bores into 8-in. rifles was as follows (Figs. 27 to 33). The parts consisted of:

1. The gun casing bored out to receive the tube (*a*).
2. The rifle steel tube made from a solid forging (*b*).
3. The muzzle collar (*c*).
4. The securing pin (*d*).
5. The gas escape channel (*e*).

The gun was first accurately bored to the mean diameter of 12.999 in.; the gas escape channel, to give warning of the cracking of the tube, was drilled, and the muzzle recessed and cut with screw threads to receive the muzzle collar.

The tube was made of open-hearth steel at the Midvale Steel Works, Pennsylvania. It was of very fine quality and showed great resistance in working. The tube was bored to the proper size, the exterior turned and the breech cup tightly fitted in place. It was then rifled, oiled, and wiped, and the breech smeared with red lead. It was then lifted, swung around in front of the muzzle of the casing, and inserted as far as the slings would admit. The slings were then removed, a block and tackle attached to the muzzle by means of which the tube was forced home.

The necessity of getting a proper contact at the breech while the difference in curvature was preserved, required the insertion and removal of the tube several times before a proper fit was secured.

Before the final insertion grooves were cut on the base of the cup, so that any gas that might find its way between the tube and the cup would collect in the open space formed by the difference in curvatures of the gun casing and tube, and from thence escape by the channel in the casing. The parts were then finally assembled, the vent locking securing pin and muzzle collar screwed in. Figs. 28 to 31 are enlarged details of the various parts, and Figs. 32 and 33 are details of the vent bushing.

The conversion by the breech insertion method was as follows (Figs. 34 to 40).

The parts were :

1. The gun casing bored out to receive the tube (*a*).
2. The rifled coiled wrought-iron tube (*b*).
3. The jacket (*c*).
4. The breech plug (*d*).
5. The muzzle collar (*e*).
6. The breech cup (*f*).
7. The securing pin (*g*).

A boring tool is run in at the muzzle and through the breech. The hole so made is gradually enlarged until it finally reaches the same diameter of 10 in. as the bore. The whole gun is then turned to 10.5 in., is reversed in the lathe and bored to receive the shoulder on the tube and the jacket. The tube is made in four sections and the jacket in three ; the sections are then welded and turned and the jacket is shrunk on the tube. The cast-iron breech plug is then put in and the tube and jacket accurately turned. The shoulders are smeared with red lead and the tube inserted in the casing, screwed home, and the securing pin and muzzle collar screwed into place. The principal data of these pieces are :

Length of bore	117.25 in.
Weight	16,160 lb.
Counter preponderance	630 lb.

The counter preponderance is corrected by an eccentric ring of bronze attached to each trunnion.

Weight of projectile ...	180 lb.
,, charge	35 lb. hexagonal powder.
Initial velocity	1430 ft.
Pressure per square inch	33,000 lb.
Penetration of armour at 1000 yards	8 in.

10 deg. of elevation will give a range of 5000 yards.

These guns are mounted on carriages very similar to the one described in Fig. 3 for the 15-in. Rodman gun. Fig. 35 to 38 are enlarged details, and Figs. 39 and 40 are details of the vent bushing :

Table X.—*Particulars of 8-in. Converted Rifle.*

Table giving Velocity and Penetration of 8-in. Muzzle-loading Converted Rifle at various Ranges.

Range.	Velocity.	Penetration. in.
0	1403	9.96
500	1302	9.08
1000	1214	8.31
1500	1136	7.65
2000	1069	7.08
2500	1018	6.67
3000	980	6.36

Projectiles for Converted Guns.

The projectiles that are used with the rifled guns described in this paper are all made to take the rifling by means of some device expanded by the powder gases. The variety of devices, while large at first, has now practically narrowed down to two, the Butler and the Eureka. The body of the shot is the same in both cases, being made of iron, cast with the point down; the latter being cast in an iron mould, is chilled to quite a depth. The depth of the chill varies with different foundries, as shown in the cross-section of the Butler shot.

The rotating device on the Butler shot consists of a ring made of 70 parts of the purest copper and 30 parts of zinc. Threads are cut on the base of the projectile and run in such a direction that the rotation of the projectile, while passing through the bore, will tend to tighten the ring. The ring has a double lip and the powder gas forces one lip outward into the rifling and the other tightly against the projectile, thus diminishing any tendency to strip. The rotating device on the Eureka projectile is of the form shown in Figs. 42 and 43.

The base of the projectile is cast in a conical form, the smaller base to the rear. The rotating device is also turned on the interior to a conical form but slightly smaller, so that it cannot be forced completely home. It is held on by a screw bolt, and prevented from rotating independently of the projectile by ridges which fit in corresponding grooves in the base of the projectile. The powder gases force the device further on the conical base, thus spreading out the upper edges into the rifling, at the same time the normal pressure on the lower edges will also expand them into the rifling. These projectiles have proved very satisfactory.

AMERICAN INSTITUTE OF MINING ENGINEERS.

(From our New York Correspondent.)

The City of Baltimore is known in the United States as the Monumental City, and this is somewhat of a misnomer, for Baltimore is not particularly rich in the article. There is a fine monument in Charles-street to the "Father of his Country ;" the base of this is 60 ft. square, and the height of the Doric column which surmounts it is 165 ft , and there is also a small monument (as the numbers were limited) about a mile distant to the memory of those who fell when Fort McHenry was bombarded by the British in 1814, but it is not necessary to dwell on this matter here ; certainly the occurrence of such structures in Baltimore is not so frequent as to lead to remark. It is, however, a well-known fact that not infrequently localities take their names from the absence of the article from which the title is chosen ; thus Chestnut-street, Maple-street, Linden place, and the like, have no trees of the name chosen; Philadelphia seems to have a sort of patent right in such anomalies ; we find Mince-street, Cranberry-street, Lemon-street, &c., but we look in vain for the pie. So Baltimore, although the Monumental City, has but few monuments in the strict sense of the word. She has, however, as will appear, monuments to the public spirit of her citizens, enduring, living, working, monuments.

The name of the city is good old English, in fact, to use Mr. Gilbert's phrase in Patience, "early English." Its origin dates to July 14, 1729, and in 1768 it became a county town, to the chagrin of Joppa ; but who, except Jonah, would want to hail from Joppa, and he only did it from force of circumstances, and landed most ignobly in a foreign country before long. Baltimore being at the head of Chesapeake Bay, which has ample depth of water, soon grew to be a commercial city of great importance. In 1812 some of the ancestors of the readers of Engineering attacked the city both by land and sea, and but for this act we should not have had the "Star-Spangled Banner," which was composed by a Marylander detained on a British man-of-war during the bombardment of Fort McHenry.

In 1827 the great Baltimore and Ohio Railroad was chartered, and the construction begun in 1828. In 1853 this line was built to the Ohio River, and in 1857 to St. Louis. Any one who has been over this line wonders at the courage of the engineers who located it, and still more at those capitalists who had faith in the enterprise. It is probably the most difficult railroad line ever constructed, but it opened a most beautiful country, rich in mineral wealth and fertile beyond any other similar section of the United States. Baltimore is a most beautiful city, and rests on as many hills as the City by the Tiber. Its citizens, as was suggested, are public spirited and liberal. The monuments established by them are the John Hopkins University, where probably education is carried as far as in any Institution of the kind in the world ; the Peabody Institute, the Woman's College. Nor should that magnificent gallery of paintings collected by Mr. Walters be overlooked ; in fact the Institute did not overlook it, on the contrary, they looked over it and were greatly pleased at the sight; but we must not anticipate.

Mining Gems in Europe.

At their recent meeting in February the Mining Institute assembled in one of the lecture-rooms of the John Hopkins University, and were welcomed by J. W. Tyson, chairman of the Local Committee, followed by the Mayor of Baltimore, and then Professor Gilman, president of the John Hopkins University, added to these cordial words the welcome of the University, so that the Mining Institute began to feel fully at home, and so signified in the reply of its president. These formalities having been so pleasantly carried out, the real business commenced in a paper by that eminent mineralogist, Mr. George Kunz, the expert for Messrs. Tiffany and Co., of New York, and who is probably known to many of the readers of Engineering as being the gentleman in charge of Messrs. Tiffany and Co.'s exhibit at the Paris Exposition in 1889. The paper was entitled "The Mining of Gems and other Minerals in Hungary, Bohemia, and Russia." This paper was illustrated by lantern slides showing the country, and methods of mining. There was also on the lower floor of the building a fine exhibit of gems, ranging up to 1000 dols. in value, together with castings of iron from the Kasil Iron Works in the Ural Mountains. Among these latter were medallions and a bust of the Czar, looking as fine as though made in bronze. The lecturer proceeded to describe the wonderful mineral deposits of the Ural Mountains between Russia and Siberia. The following extract may be cited on this subject :

"For nearly two centuries the Ural Mountains have been noted for their remarkable productions of gem-like minerals and gems that for beauty and quantity have always given the region a foremost place in the mineralogical collections of the world. The magnificent emeralds, alexandrites, phenacites, gigantic beryls, topaz tourmalines, green garnets, amethysts, and the great variety of jaspers of all colours are among those of the greatest interest. The occurrence of the diamond in the Ural is not firmly believed by some of the Russian mineralogists. In a collection at Nijni Tagilsk I saw a small white crystal weighing one-third of a carat, a twinned hexoctahedron, which was pronounced phenacite by a local mineralogist who had taken its specific gravity, but which is, as the collectors believe, a small opalescent white diamond similar to those found at the Bagagem mine in Brazil. It was found in a small brook known as 'Pologica,' near the village of Kalstchi. The lapidary work of the Urals is all executed either at the imperial lapidary works at Ekaterinbourg by the lapidary masters, as they are termed, who employ the workmen or apprentices, each having his own peculiar style. The product is sold to the dealers at Ekaterinbourg, who visit the Nijni Novgorod, Moscow, and Ekaterinbourg fairs. The lapidary works at Ekaterinbourg are so situated that they have command of an immense water power, by which they are run. These works are on a large scale, so that immense masses of hard stone can be as readily worked as marble is throughout Europe. Many of the machines are of a primitive character and have not been changed during the past century. The facilities for sawing, drilling of large columns, either for ornament or for lightening large masses of stone, &c., are ingenious and are manipulated with the greatest skill."

After the conclusion of this lecture a pleasant social reunion followed under the auspices of President Gilman, of the John Hopkins University.

The next day business commenced in earnest, it having been arranged to hold a continuous session, and thus complete the reading and discussion of papers before visiting "objects of interest."

The Copper Mines of Vermont.

The first paper was entitled "The Copper Mines of Vermont," by Henry M. Howe. He stated that the ancient slates of the Appalachian Range contained a series of extensive beds of iron pyrites, which extend from Alabama to the St. Lawrence. These deposits occur on a very large scale, and though they have many of the characteristics of fissure veins, are not generally thought to be such, but to be true ore beds, their irregularities being due to folding and distortion during metamorphism. In the majority of cases, although there are marked exceptions, these deposits pinch out in depth. In the Southern States the upper part of the ore body has been decomposed, and the copper leached out. Below the gossan is found a rich layer of copper ore, resulting, perhaps, from the reprecipitation of the leached copper. Below this again is the region of undecomposed sulphides which become impoverished in depth.

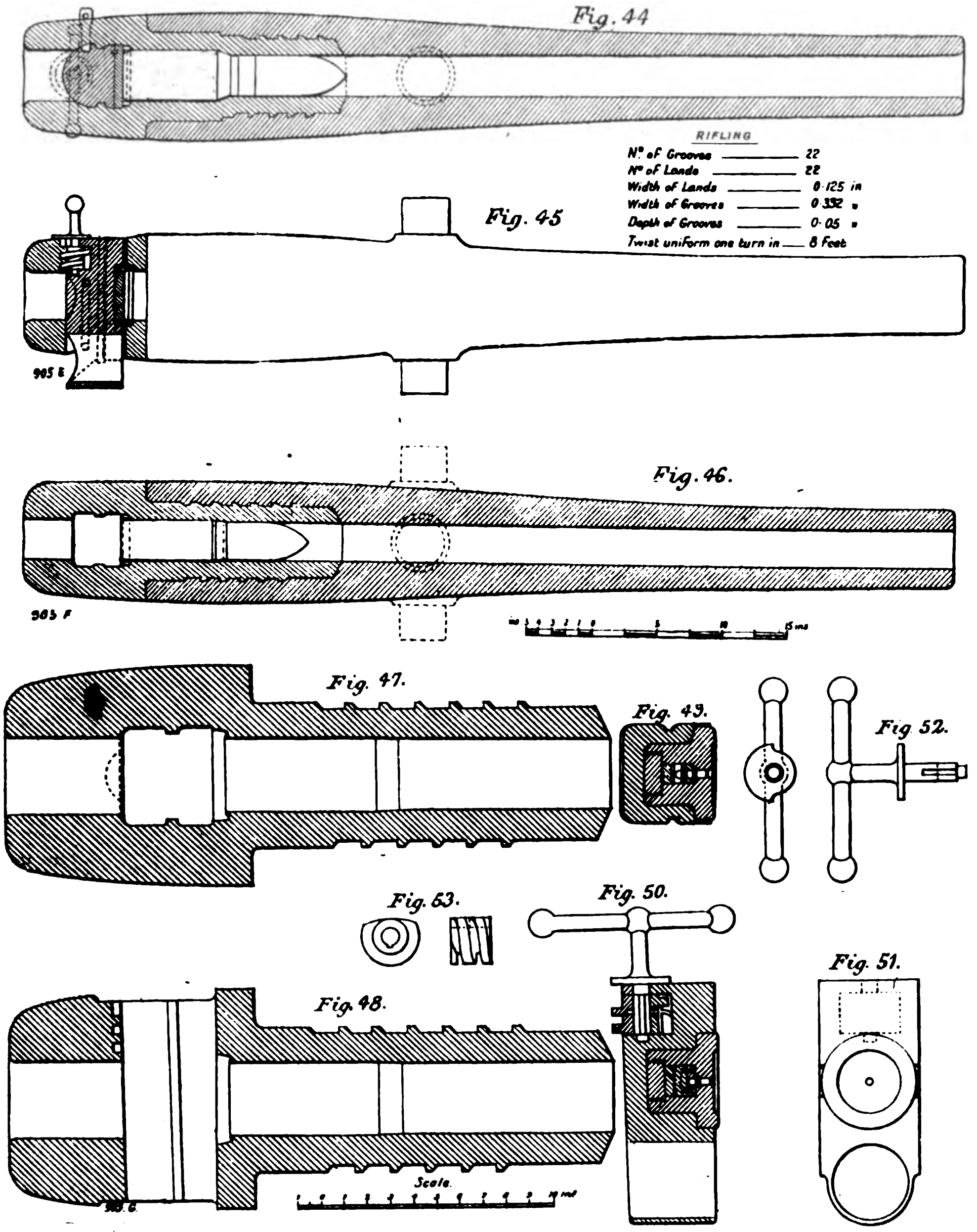
In the Northern States both the gossan and richer portion are eroded, leaving the undecomposed sulphides exposed at the surface. The sulphides continue in depth without loss of their percentage of copper, and in some cases are said to have been enriched. In the Elizabeth mine the ore has been worked down on the pitch for 1500 ft., and in places some 60 ft. in width. At the Union mine, while the ore body does not extend continuously to a great depth, yet continuations of new lenses are found by cross-cutting when the bed pinches.

MODERN UNITED STATES ARTILLERY.—No III.

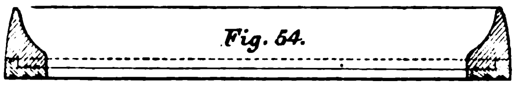
Converting Wrought-Iron 3-in. Guns.

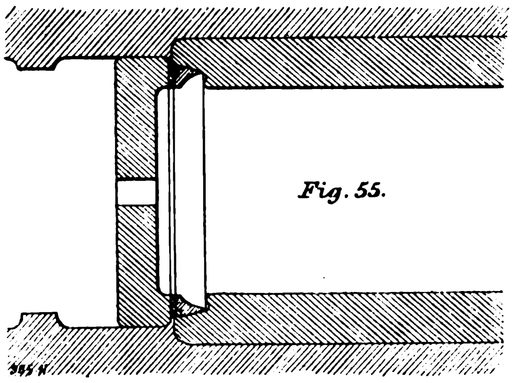
(Figs. 44 to 55.)

While the attempt to convert the smooth-bore cast-iron guns into breech-loading rifles was not a success, different results were obtained by a similar attempt with the 3-in. wrought-iron muzzle-loading rifle (Figs. 44, 45, and 46). This gun was cut off at the breech to a length of 63.15 in. and bored from the breech to admit the steel breech receiver which is united to it by a screw thread. The breech receiver was made of Midvale steel tempered in oil; on being tested, this steel gave a tenacity of 67,600 lb. per square inch and an extension of 0.285 in. per inch at rupture. The receiver was slotted to receive the breech-block; it was bored and a plus thread was cut on it to correspond to the screw thread in the gun casing. Figs. 47 and 48 show this breech receiver separate. It was then screwed in place and secured by a small steel pin inserted at the joint. The rifling of the gun was not altered but the grooves were continued along the breech receiver. The steel breech-block was made on the sliding-wedge system. The front face was perpendicular to the axis of the piece, and the rear face was inclined at an angle of 1 deg. 30 min. The movement of the block was regulated by two guide grooves (Figs. 49 to 51). The only mechanism connected with the breech-block is the locking screw (Figs. 50, 52, and 53), which is placed in a cylindrical recess at the rear of the block, and, when the block is in position, locks into a female thread, which is cut in the rear face of the slot of the breech receiver.



CONVERTED WROUGHT-IRON 3-IN. MUZZLE-LOADER.





The threads of the locking screw are partly planed away so that the block can be pushed nearly home, and then by a turn of the locking screw it is pressed further in and locked. The wrench of the locking screw serves also as a handle to withdraw the block. This is the Krupp system in short. The gas check used was the Broadwell ring. Experiments were made with both copper and steel. The copper proved to be the better metal to prevent the escape of gas, but it sometimes stuck after firing, thus rendering the opening of the breech a difficult matter. The steel ring did not stick but at times allowed a slight escape of gas. In order to remedy the defect of each ring a combination ring was made having the base of steel (Figs. 54 and 55), and a lip of copper, thus insuring the hardness and elasticity of the steel at the base with the extensibility of the copper in contact with the walls at the seat of the gas ring. This construction secures, through the extensible copper, a close gas-tight contact at the sides of the seat of the gas checks in the chamber of the gun, while the steel base prevents any sticking to the breech-block.

Table XI.—*Ballistic Particulars of the* 3.2-*in. Wrought-Iron Converted Rifle.*

Calibre		3.2 in.
Total length of gun		72.65 ,,
Length of bore		64.85 ,,
Weight of gun		826 lb.
,, shell		12 ,,
,, charge		3 ,,
Pressure		25,633 ,,
Muzzle velocity...		1548 ft. sec.
Ranges at different angles	20 deg.	5879 yd. = 3.34 miles
	15 ,,	4978 ,,
	10 ,,	3986 ,,
	5 ,,	2508 ,,

Another conversion of the 3-in. wrought-iron gun was by the same method. The bore was enlarged to 3.2 in., and the powder chamber enlarged. The number of grooves was increased to twenty-two. This increase in calibre appeared to give the best results, and all the field guns that were converted since this one, have been finished to a diameter of 3.2 in.

It was ascertained that the gas check could be relied upon to stand 300 rounds without injury.

The United States National Gun Factory.

During the Civil War the United States had no time for experimenting, and after the close of the war, gun building was comparatively at a standstill. The conversion of guns that has been described was all that was attempted. At various times Boards were appointed to consider different methods of gun construction and to make reports to Congress. It was finally established that the built-up gun, composed of steel hoops, was undoubtedly the gun of the future.

Designs for guns of various characters and dimensions were adopted and appropriations made for their construction.

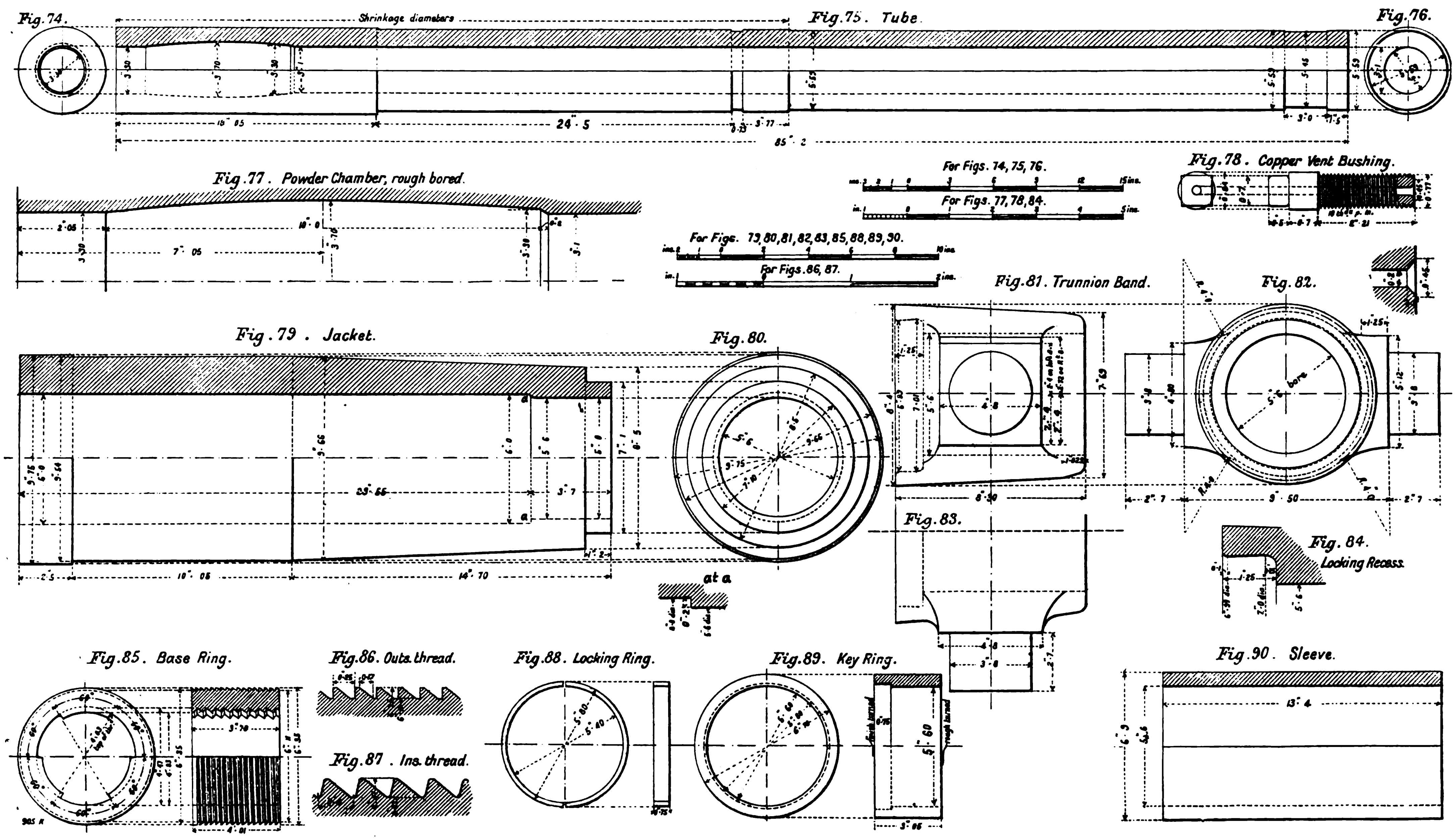
The National Gun Factory was built at the Watervliet Arsenal, near Troy, New York, and though many guns have already been built there, a large increase in the plant is to be made so as to greatly increase the capacity of the works.

The policy of the Government is to get the forgings from private foundries, where they have been prepared, oil-tempered, and rough bored under the direction of a Government inspector stationed at the foundry. The forgings are shipped to the National Factory, and the gun completed.

The first steel built-up gun that was made was completed during the fiscal year ending June 30, 1884, and was a piece designed to be used as a horse artillery piece and had a diameter of 3.2 in.

The first piece was made from open-hearth steel, which was furnished by the Midvale Steel Company, and consisted of a steel tube, forged and annealed, a jacket, trunnion hoop, sleeve, and key ring, all of steel, forged and oil-tempered. Being an experimental gun, a number of changes were necessary during manufacture. The weight of the gun was 793 lb. The gun was subjected to a severe test of 1800 rounds, and still remained in a serviceable condition. It showed a very satisfactory endurance, range, accuracy, and rapidity of fire. The maximum charge fired was 3.75 lb., which gave a mean velocity of 1749 ft., and a pressure (maximum) of 37,250 lb. The mean range for an elevation of 20 deg. was 6479 yards. An average of more than 900 rounds gave a rapidity of fire of 70 rounds per hour. The maximum and minimum rapidity of not less than 46 consecutive rounds were: Maximum, 46 rounds in 26 minutes, or a rate of 120 rounds per hour; minimum, 50 rounds in 79 minutes, or a rate of 38 rounds per hour. The *Revue d'Artillerie*, January, 1885 (the above test of the 3.2 in. breech-loading rifle took took place in 1885), reports comparative trials by the Commission of Belgrave for the Servian Government, with a Krupp 3.3-in. gun of the Dutch model of 1882 and a De Bange 3.15-in. gun, model of the French artillery. The rapidity of fire was: For the Krupp 3.3-in. gun, 30 rounds in 34 minutes, or a rate of about 53 rounds per hour. For the De

MODERN UNITED STATES ARTILLERY: 3.2-IN. STEEL RIFLE, MODEL 1889.



Bange 3.15-in. gun, 30 rounds in 22 minutes, or a rate of 82 rounds per hour.

The maximum enlargement of the chamber after 1800 rounds was .042 in. on the diameter. The maximum enlargement of the rifled portion of the bore was .03 in. on the diameter at 70 in. from the chamber to .008 in. at the muzzle.

The very satisfactory trial of this pioneer steel built-up gun led to its instant adoption, with a few minor changes, as the standard light artillery gun of the modern United States artillery. Its manufacture has progressed rapidly, and at present a large number are on hand.

As changes have continued in the minor details since the proof gun was completed, the most recent model, 1889, will be described.

3.2-in. Breechloading Steel Rifle, Model 1889. (Figs. 56 to 101.)

The steel forgings of the forms and dimensions shown in Figs. 56 to 73 (see page 400) were furnished by the Midvale Works. They were made of mild open-hearth steel, and when received at the National Gun Factory had been forged, rough bored, and oil-tempered. All forgings are carefully examined for dimensions, bending or warping, eccentricity of bores, defects, flaws, cracks, &c. The tube was turned down to 0.1 in. of its finished dimensions, bored both in bore and powder chamber to the same limit. Before the shrinkage surfaces could be turned, the jacket, tube, and sleeve had to be turned, bored, finished, and measured, and to these measured dimensions, the calculated shrinkages were added and the shrinkage surfaces on the tube turned.

Figs. 74, 75, and 76 show the finished sizes of the tube, Figs. 79 and 80 those of the jacket, and Fig. 90 the sleeve. As the tube enters the jacket from the rear it has a shoulder (Fig. 92), which, coming in contact with a similar shoulder *a* in the jacket (Fig. 79) prevents any movement of the tube to the front or of the jacket to the rear. The trunnion hoop (Figs. 81 to 83), which carries the trunnions, is locked to the jacket by a shoulder

MODERN UNITED STATES ARTILLERY: 3.2-IN. STEEL RIFLE, MODEL 1889.

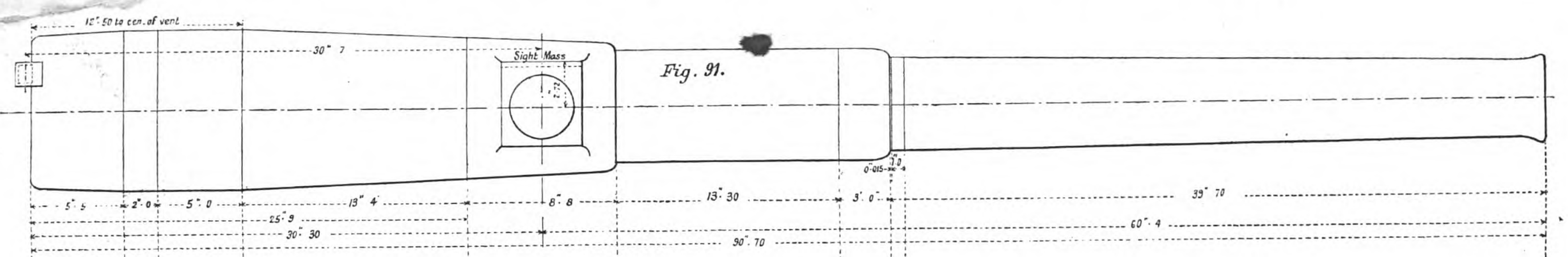


Fig. 91.

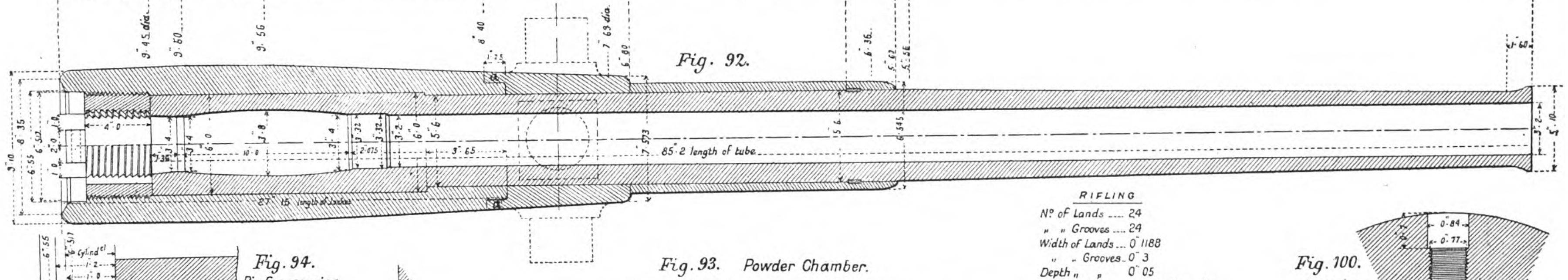


Fig. 92.

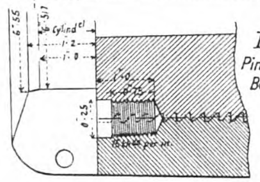


Fig. 94. Pin for securing Base Ring

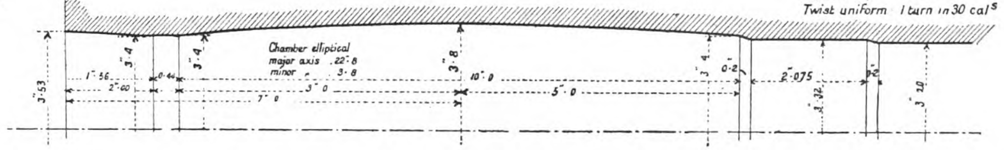


Fig. 93. Powder Chamber.

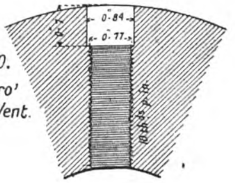


Fig. 100. Secn. thro' cenre. of Vent.

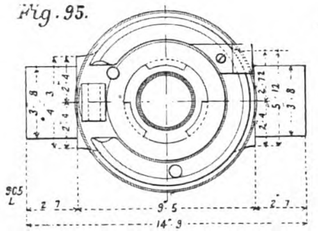


Fig. 95.

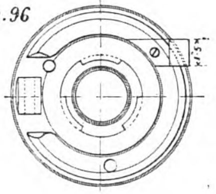


Fig. 96

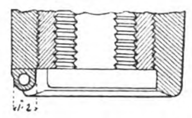


Fig. 97.

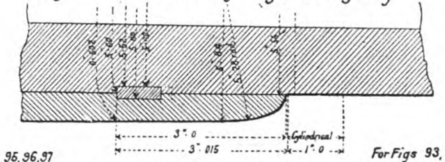


Fig. 98. Secn. thro' Key Ring & Locking Ring.

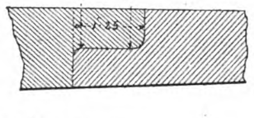


Fig. 99. Lip at "a"

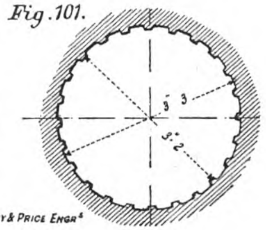


Fig. 101.

For Figs. 91, 92, 95, 96, 97

For Figs. 93, 94, 98, 99, 100, 101.

Tailby & Price Engrs.

that fits over a corresponding lip on the jacket (Figs. 79 and 92). Between the trunnion hoop and sleeve, which is next assembled, is a plane joint. The sleeve adds strength to the tube. The locking ring *b* (Fig. 92 and Fig. 88), which is made in two parts, is then placed in the groove in the tube, preventing any forward motion of the parts. The key ring (Figs. 88 and 92) shrunk over the locking ring secures the latter in position, and all motion between any of the parts is prevented. In front to the key ring, Fig. 89, the tube tapers to the muzzle, where it terminates in a swell (Figs. 91 and 92).

On the interior of the jacket at the breech is cut a base ring (Figs. 85, 86, 87, 92, and 94), which has the interrupted screw for holding the breech-block. The base ring is screwed into place and locked by the securing screw. In front of the base is a conical gas check seat, then a cylindrical surface leading to the powder chamber, which is an ellipsoid (Figs. 77, 92, and 93). A slope connects the powder chamber with the shot chamber and centres the projectile, since the rotating band is made to accurately fit this slope. The shot chamber is cylindrical and connected with the bore by a slope. The vent (Fig. 100) enters radially at the maximum diameter. Figs. 95 to 97 are different views of the breech end; Fig. 98 is a section through key ring and locking ring; Fig. 99 is a section of the joint at *a*; and Fig. 101 is a section through the bore of the gun. We must defer till next week the descrip- of the breech mechanism.

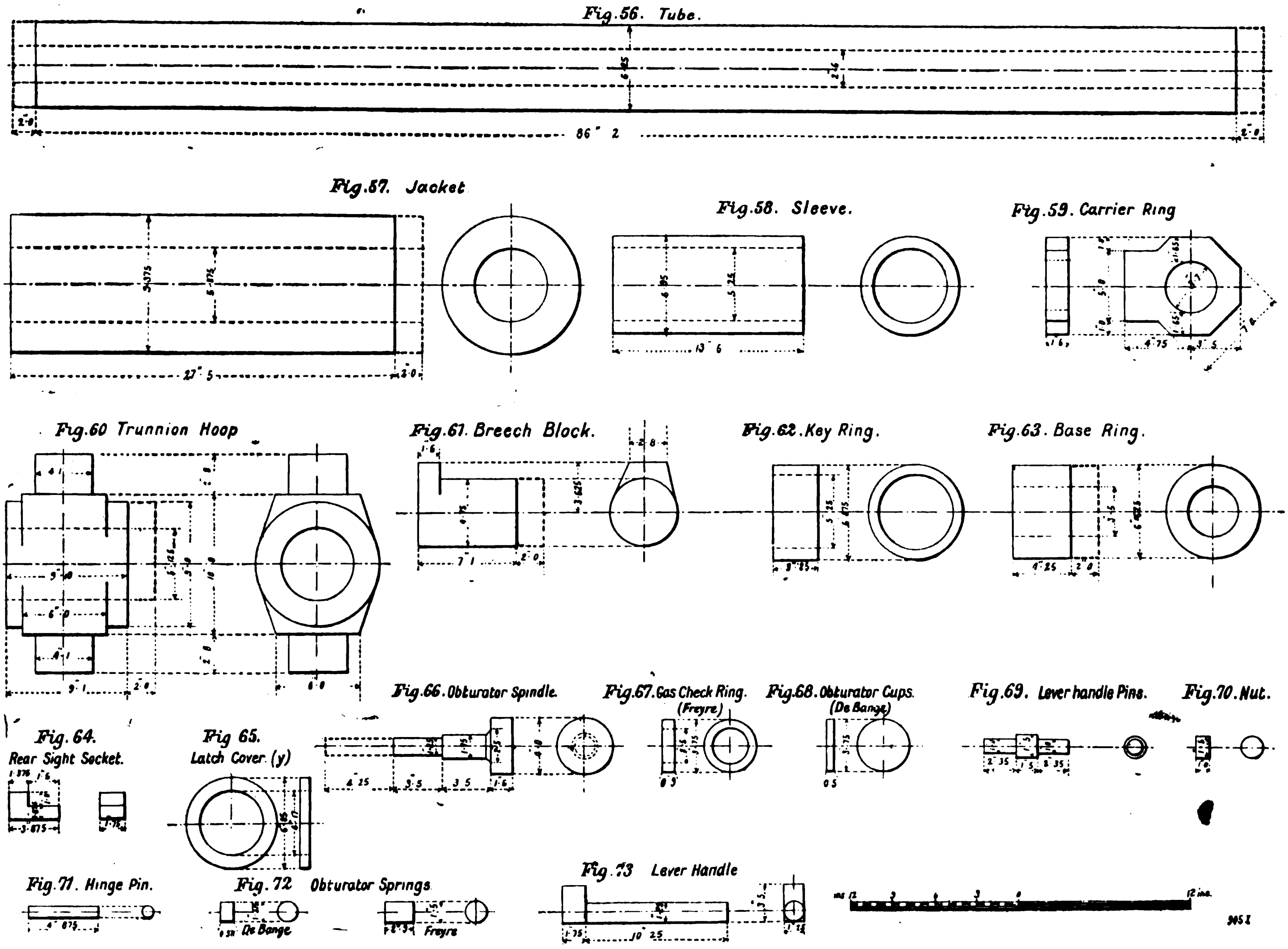
Catalogue.—We have received from the Niles Tool Works, of Hamilton, Ohio, U.S., a copy of a new catalogue. This is quite a large volume, got up in the best American style, with splendid engravings and capital letter-press. It comprises railroad machinery for wheels and axles, screw machines, general lathes, planers, shaping machines, boring and turning mills, boring machines, drilling machines, pulley machinery, bending and straightening rolls, and miscellaneous.

Galveston.—Harbour improvement works at Galveston, Texas, are stated to be making good progress. A contract for jetties has been completed; work has been commenced, and it is expected that 220,000*l.* now available will be expended during the current fiscal year. It is anticipated that by July vessels drawing 20 ft. will be enabled to enter and clear, while in 1893 vessels of 30 ft. draught will be accommodated with two miles of completed wharves.

Irrigation in Victoria.—The last two seasons in Victoria have been so unfavourable that where wheat was irrigated damage rather than good was done, and this untoward circumstance has unsettled a great many people. While the money for irrigation works was being largely spent in the district, farmers chiefly doing the work and business men sharing in the profit, the prospect was entirely rose coloured. Now the works are finished the obligations which have been assumed on account of them are falling due, and no preparation has been made for meeting them, save by such indifferent methods as the irrigation in a few cases of grass lands.

MODERN UNITED STATES ARTILLERY: STEEL FORGINGS FOR 3-IN. RIFLE.

(*For Description, see Page* 397.)



LITERATURE.

Continental Electric Light Central Stations, with Notes on the Methods in Actual Practice for Distributing Electricity in Towns. By Killingworth Hedges, M.Inst. C.E., M.I.E.E. London and New York: E. and F. N. Spon.

The present is a very opportune time for the issue of a work such as that before us. Many municipalities are burdened with provisional orders for electric lighting which they do not quite know how to utilise. To defend their territories from the intrusion of private companies, they obtained from Parliament the right to undertake the work themselves, and now the time has come when they must do something to prevent these powers from lapsing. But immediately they commence to bestir themselves they find themselves bewildered among the advocates of high and low-pressure systems, of alternate and direct currents, of fixed, motor, and battery transformers, of systems with and without batteries, and of two-wire, three-wire, and five-wire distributions. It is not always easy for the electrical engineer to decide which system is best adapted to a certain town, supposing him to be entirely free from prejudice, and it must be nearly impossible for the average alderman to obtain clear ideas on the subject. Even if he come as a deputation from his town to the Exhibition at the Crystal Palace, and listen most attentively to the representatives of the various firms gathered there, he is more likely to lose his faith in the veracity of his fellow-men than to gain a clear conception of the merits and demerits of the various systems. He will probably arrive home more puzzled than he left it. To such a man Mr. Hedges' volume promises aid, as it should show him how far each system is used on the Continent, and afford him some clue to the conditions under which each may be applied. He will, however, need to exercise considerable caution as to this latter point, as the selection of a particular system is often influenced by considerations that are neither mechanical nor scientific.

We learn from the title-page that the accounts contained in the volume are compiled in part from the reports made for the congress of the German municipal authorities, on the occasion of their visit to the International Electrical Exhibition at Frankfort on August 26 to 29, 1891. This fact explains the very unequal way in which the different installations are treated. Some of them are described in considerable detail, while others are dismissed with very brief notices. The engravings likewise vary between good and very bad indeed. The volume is distinctly a medley in which much that is valuable is overlaid with a great deal that is superficial.

Part I. is devoted to high-pressure distribution with alternating currents and transformers. It comprises accounts of nineteen installations, of which nine are by Ganz and Co. Among these are included the Tivoli installation of 23,000 lamps of 16 candle-power, and that at Rome with 24,000 lamps. The Vienna installation of the International Electric Company has 25,000 lamps, and is the largest of the alternate current systems described. All the rest, with the exception of that at Madrid of 18,000 lamps, have less than 10,000, so that they are of very moderate dimensions. The Tivoli station is the most interesting of the series, as its turbines give 2000 horse-power and the current is transmitted 19 miles to Rome at a pressure of 5000 volts, with a fall of potential of 20 per cent. The current is carried on bare copper wires, and is reduced to 2000 volts before it enters the network serving the consumers' transformers. The description of the Roman station contains a fairly complete description of the Ganz machines, and is the most detailed of any in this portion of the book.

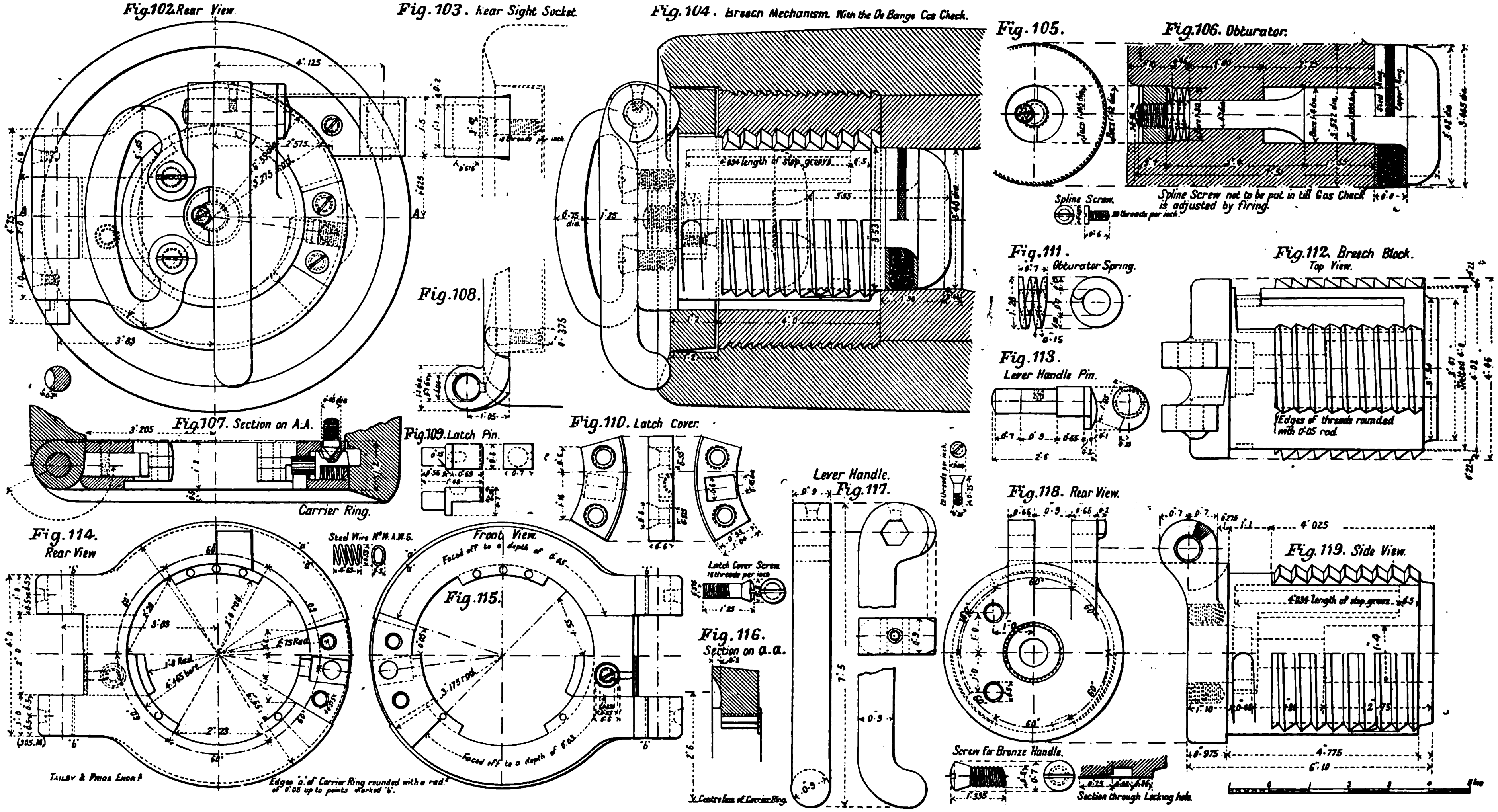
Part II. deals with the low-pressure distribution by continuous currents, either direct or with secondary batteries. The installations exceeding 10,000 lamps are: Hamburg, 12,000; Hanover, 30,000; Dusseldorf, 20,000; Berlin, 140,000; Elberfeld, 14,000; Paris, Place Clichy, 19,500; Vienna, 10,000. None of these are described in any great detail, but sufficient is told to give a general idea of their scope and method of operation. It is perhaps fortunate that these short accounts are from different hands, as this insures some variety in their treatment. In certain cases the cost of construction and working is given with some minuteness, while in others the works, both inside and outside, are illustrated by numerous engravings. In the latter case it is noticeable how large and commodious are the foreign stations compared with our own.

The third part of the volume may be labelled "Miscellaneous." It commences with a good account of the Lauffen-Frankfort power transmission experiment. Then follows an account. with very numerous engravings and but little letterpress, of the measuring instruments of Hartmann and Braun, of Frankfort. Conduits for electric mains occupy the next three pages. Then come load diagrams, load factors, network, interests of gas companies, and the cost of electric light abroad, followed by tables and a glossary of technical terms.

This work is evidently prepared for the use of non-technical readers, and such being the case, it

MODERN UNITED STATES ARTILLERY; BREECH MECHANISM OF THE 3.2-IN. RIFLE, MODEL 1889.

(*For Description, see Page 428.*)



too cold all the sulphur is in the iron. The quality of the cinder and the heat required are important factors. He added some analyses (see next page), showing desirable results and also the weekly run.

The figures for 1887 were got with iron stoves, and in running under a specification requiring silicon not over 0.75 and sulphur not over 0.08. In 1891, they had firebrick stoves, and aimed at silicon not over 0.50 and sulphur not over 0.05.

A pretty lively discussion followed, and each man had a different reason. One thought the proper admixture of the ore was the great thing, while another asserted that his company had this matter under absolute control independent of charge, fuel, heat, or blast pressure, and stated as a clincher that he could change from 0.25 per cent. of silicon to 2.50 on twenty-four hours' notice.

AN AMERICAN TIN MINERAL.

Mr. Titus Ulke read a paper on a "New Tin Mineral in the Black Hills," from which the following extract is made:

"About two years ago in making an examination of the Etta Mine in the Black Hills I discovered the mineral about to be described in a vertical secondary quartz vein in the granite massive of Etta Mountain. The vein was from a few inches to 3 ft. wide, and was exposed for a length of about 15 ft. It was found to contain irregularly massed at certain spots, large crystals of cassiterite, and this apparently new mineral, which for reasons that will presently appear, I shall name cuprocassiterite. The latter seemed to be a pseudomorph of a copper bearing decomposed cassiterite, after staunite or after the brown-black cassiterite found in undecomposed state in the same place. I did not pursue my investigation farther until recently, when I called Professor I. W. Clarke's attention to the mineral. A more accurate investigation developed the following: Cuprocassiterite is a light yellowish to malachite green mineral of an earthy fracture, dull glance, and in the Etta Mine found together with cassiterite, filling cavities in a compact quartz gangue. As is well known there is much doubt as to how the ancients obtained their bronze. In this connection cuprocassiterite, which may have occurred in veins worked in prehistoric times, and being capable of easy reduction to a copper and tin

Selected Casts Showing Remarkably Low Silicon and Sulphur.

Silicon.	Sulphur.
Trace.	0.017
Trace.	0.036
Trace.	0.041
0.035	0.033
0.047	0.047
0.093	0.019
0.093	0.021
0.093	0 028
Trace.	0.025
Trace.	0.039
0.021	0 028
0.047	0 030
0.047	0.033
0.093	0.022
0.093	0.030

Weekly Averages.

Week Ending	Average.		Highest.		Per Cent. of Product above Limit for	
	Si.	S.	Si.	S.	Si.	S.
1887.						
April 16 .. .	0.455	0.052	0.887	0.096	6.75	6.25
„ 30.. ..	0.452	0.065	0.677	0.096	..	7.30
May 28	0.265	0.050	0.653	0.091	..	7 40
June 4	0.281	0.053	0.490	0.088	..	6.25
1891.						
June 6	0.245	0.035	0.747	0.170	6.50	16.00
July 4	0.312	0.024	0.700	0.093	8.25	11.25
August 8 ..	0.350	0.024	0.980	0.082	13.15	10 60
„ 29 ..	0.319	0.020	0.513	0.050	2 50	
September 5 ..	0.285	0.021	0.560	0.083	11.50	7.00
October 10 .	0.298	0.029	0.746	0.148	12.60	13.60

alloy, seems to show us another source whence primitive man might have obtained his bronze."

The mineral was shown and was prettily coloured in yellow and green. Whether its discovery will affect the prohibitory tariff on tin-plate was not stated.

(*To be continued.*)

MODERN UNITED STATES ARTILLERY.—No. IV.

Breech Mechanism of the 3.2-in. Rifle, 1889 Model. (Figs. 102 to 122.)

The principal parts of the breech mechanism are: the breech-block, the carrier ring, the obturator, the lever handle, the bronze handle. The threads of the block are planed off along three sections (Fig. 119, page 429) as is usual in the interrupted screw system, so as to allow the block to slide through the base ring, the locking or unlocking being performed by one-sixth of a turn of the block. It is recessed to receive the obturator spindle (Fig. 106), which passes completely through the block and is held by a nut and spring. The lever handle lugs on the block (Figs. 102 and 104) carry the lever handle whose motion is limited by a projection on the right lug. The front portion of the block is reduced to allow it partially to enter the gas check sector (Fig. 104). On the left of the block is a stop groove, into which a stop enters and permits the longitudinal motion of the block. The latch groove is in two parts, one longitudinal at the front end of the block, and the other transverse at the rear end (Figs. 104 and 119). The stem of the latch drops into the front groove when the block is withdrawn, and into the rear groove when the block is revolved into its firing position, in each case unlocking the carrier ring. At the front end of the longitudinal latch groove is a locking recess. The transverse latch groove gradually increases in depth as it recedes from the longitudinal groove. The guide groove is the cylindrical recess at the rear of the block in which the guide sectors move when the block is rotated.

The carrier ring (Figs. 102, 104, 107, 114, and 115) has three projections on its interior surface which fit in the slotted sections in the block during its longitudinal motion and guide it.

The latch-pin (Fig. 109) fits in a recess in the carrier ring, and by a spring is constantly pressed against the breech-block. As the latch has a length that is greater than the width of the carrier ring it always projects into the jacket or block, so by this means the carrier ring is always locked to the block or jacket. The inner end of the latch-pin rests on the slotted section, locking the ring and jacket, except at the ends of its travel, when it drops into the recesses in the block, thus locking ring and block. The front face of the latch has a recess into which fits a hardened stud, fixed to the rim face of the base ring. This stud forces the latch outward when the block is closed until the outer end is flush with the carrier ring. In this position its inner end is just above the inclined plane leading from the slotted sector part of the way down the locking hole, so that the block can be shoved in, and the inner end of the latch riding up the inclined groove to the slotted sector, forces the latch out into the jacket and locks the carrier ring to it. In order that the stud may act on the latch a hole is drilled through the front face of the carrier ring. The carrier ring supports the breech-block when the latter is withdrawn, and allows it to be swung around out of the way for loading. Either the De Bange or Freyre obturator may be used in this gun.

In the De Bange obturator (Figs. 105 and 106) the spindle has a mushroom-shaped head, and extends through the block, terminating in a screw thread on which is screwed a nut. This nut rests against a spiral spring, which in turn rests against a shoulder in the block. By means of this spring any set, given to the pad by the firing, is taken up, and the fracture of the spindle near the nut is prevented. The spline screw holds the nut on the spindle, and prevents any tendency to come off when the block is rotated and the pad sticks.

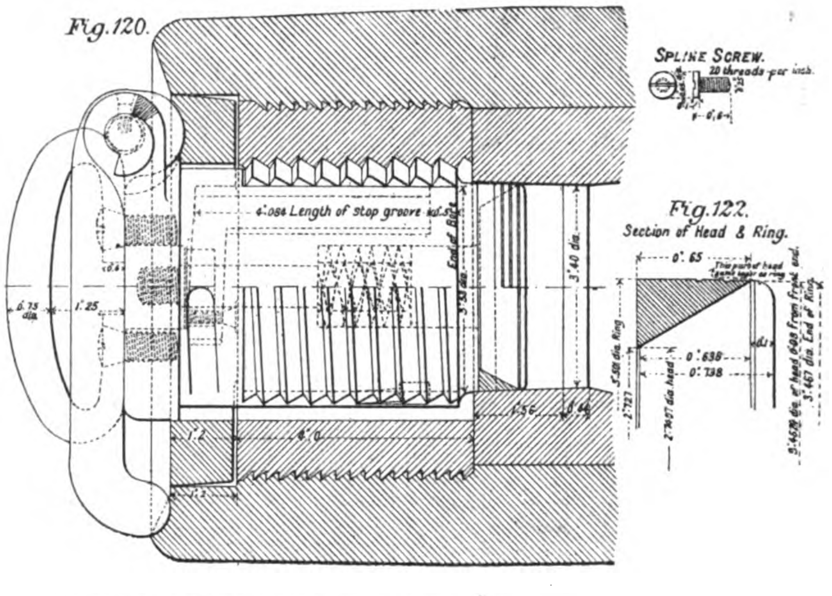
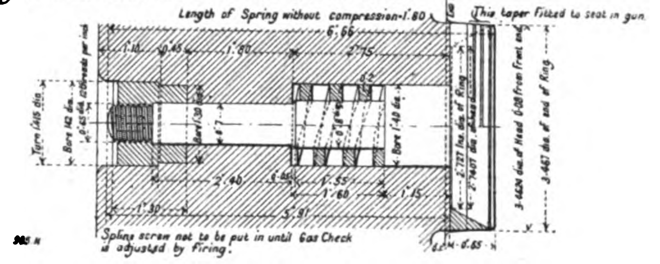


Fig. 120.

Fig. 122. Section of Head & Ring.

Fig. 121. OBTURATOR AND GAS-CHECK RING.



BREECH MECHANISM FOR 3.2-IN. RIFLE, WITH FREYRE GAS CHECK.

The pad is made of asbestos and tallow pressed to shape in a press, and then covered with canvas. It is held by gas check cups of steel, so shaped that the enlarged centre part acts as a reservoir, and the narrower pads in contact with the bore and spindle more effectively prevent the escape of gas.

The Freyre obturator (Figs. 120, 121, and 122) differs from the De Bange obturator in its shape and material. The spindle has a head at its forward end, its front surface plane, and its sides conical with the large base to the front. The gas check ring has the cross-section of a right-angled triangle, and fits accurately the conical surface of the head of the spindle; it is slightly longer than the head in the direction of the axis of the bore. The rear surface of the ring is against the block, but the rear surface of the head is not in contact, and can only be brought so by a heavy pressure which will expand the gas check ring.

The spring around the spindle acts on a shoulder on the block, and one on the spindle, and tends to press the spindle forward, and relieve the sticking. The nut prevents the spring from forcing the spindle too far forward, and also regulates its tension.

The lever handle, when the block is locked, hangs vertically, and in this position locks the block, as a lug or cam on its head fits in a recess in the carrier ring, thus preventing any tendency of the block to rotate. It acts as a lever to rotate the block, and when rotated, if the gas check sticks, by pressing down the lever handle, great power is brought by means of the cam to start the block. To assist in withdrawing the block a bronze handle is attached to it by means of screws.

The action of the breech mechanism is as follows: Suppose the breech closed and the gun ready for firing. In this position the threads on the block have engaged in the threads in the base ring; the gas check is pressed tightly forward in its seat; the lever handle is vertical; its cam in the recess of the carrier ring; the lower end of the latch is at the end of the transverse groove in the block, so that the outer end of the latch is withdrawn from the recess in the jacket, and the carrier ring is unlocked. This prevents any chance of bending the latch. On this delicate pin depends the whole working of the breech mechanism, as it prevents any premature longitudinal motion of the breech-block, by which its screw locking threads might be injured.

To open the breech-block, grasp the handle and lever, raising the latter; rotate the block as far as possible to the left. This rotation frees the screw threads and brings them opposite the slotted sectors, so that the block can be withdrawn. The slotted sectors on the block have come opposite the guide sectors on the carrier ring, and the latch, riding up the inclined transverse recess, has unlocked the carrier ring from the block, and locked it to the jacket. Unless this were done, an attempt to withdraw the breech-block might rotate the carrier ring. Draw the block out as far as the stop bolt will allow, and when out to its full length the latch drops into its recess, unlocks the ring, and the block and ring can be swung around to the left and the breech is open for loading.

To close the breech, swing the carrier ring around sharply into place, and the retracting pin on the base ring will unlock the latch from the block, and allow it to be shoved in, locking the carrier ring and jacket, by forcing the latch out into the jacket. When the breech is shoved in as far as it will go, one-sixth of a turn to the right engages the screw threads, and the dropping of the handle locks it.

The severe test of the proof gun shows how perfectly this breech mechanism works:

TABLE XII.—*Ballistic Particulars of the* 3.2-*in. B.L. Steel Rifle.*

Total length	...	90.70 in.
Length of tube	...	85.20 ,,
,, jacket	...	27 15 ,,
,, trunnion hoop	...	8.80 ,,
,, sleeve	...	13 30 ,,
,, key ring	...	3.00 ,,
,, rifling	...	70.925 ,,
,, powder chamber	...	10.00 ,,
,, shot chamber	...	2.073 ,,
,, breech-block	...	6.10 ,,
Diameter of exterior, maximum	...	9.56 ,,
,, ,, minimum	...	4.60 ,,
Number of grooves	...	24
Twist uniform, one turn in	...	30 cal.
Weight of gun	...	829 lb.
Preponderance	...	50 ,,
Weight of charge	...	3.75 ,,
,, projectile	...	13.5 ,,
Length of travel of base of projectile in bore	...	73.2 in.
Initial velocity	...	1756 ft. sec.
Pressure	...	35,000 lb. per sq. in.
Ranges for different elevations	2 deg.	1608 yards
	4 ,,	2370 ,,
	6 ,,	3040 ,,
	8 ,,	3640 ,,
	10 ,,	4150 ,,
	12 ,,	4835 ,,
	14 ,,	5285 ,,
	16 ,,	5702 ,,
	18 ,,	6100 ,,
	20 ,,	6500 ,,

THE CRYSTAL PALACE ELECTRICAL EXHIBITION.—No. XI.

THE exhibit of the Weymersch Electric Battery Syndicate sets forth the case for primary batteries as a source of current where small or occasional installations are required; and it is claimed that for household use, where the demand for light may be very fluctuating, there are numerous cases in which the generation of current by a primary battery may have real advantages over a dynamo and motor engine.

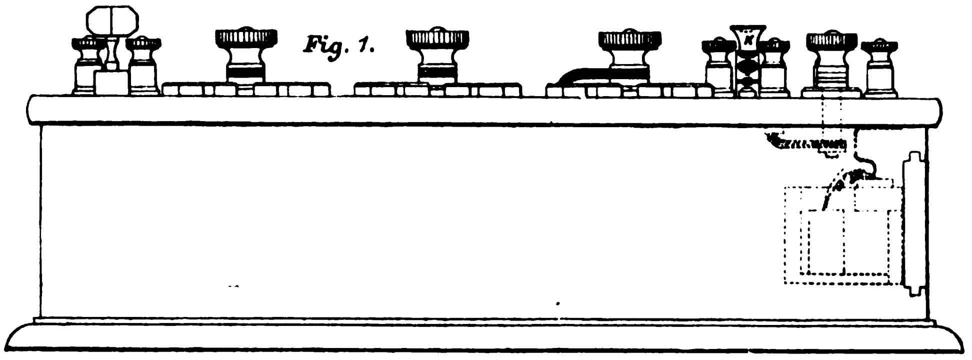


Fig. 1.

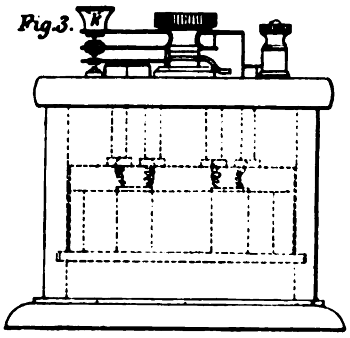


Fig. 3.

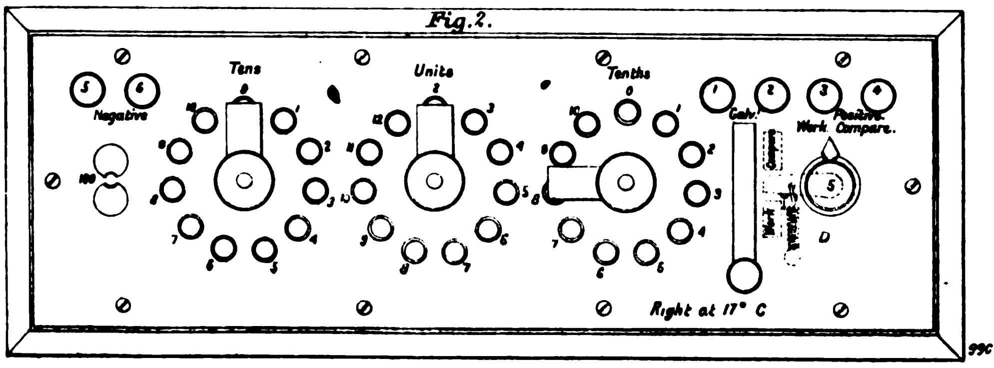


Fig. 2.

The battery is a chromic acid battery in which the chromic depolariser is kept in contact with the carbon plate only, by the use of a porous cell. The outer part of the element containing the amalgamated zinc and the acid (hydrochloric in ordinary cases), is one cell in a varnished teak trough, each trough consisting of six elements and weighing about 1 cwt. Taking the electromotive force of each element at 1.3 volts we have 7.8 volts for each trough of six cells. If one of these troughs of six cells is used to illuminate two 7 volts 16 candle-power lamps, the required current of 15 to 16 ampères is said to be maintained for about twenty hours, and at a cost of about 3s. 4d. for charging materials, and rather less for zinc. This makes the cost of a 10-candle light a trifle over 1d. an hour if the cost of attendance in charging the battery, interest on the cost of the battery (7*l*. 7s.), and depreciation are not reckoned; but these items may often be so trifling as to be almost put on one side. Then again on the small motor side of the question, we should have for about 6s. worth of fluids and zinc, a force of between one-seventh and one-eighth of a horse-power for about twenty hours, a purchasing rate for motive energy which would be exorbitant from the point of view of the regular user of considerable powers, but is by no means prohibitive when a small motor is needed to drive domestic or other small machines for short periods. Exhibited on the same stand as the Weymersch battery is Mr. J. F. Wiles' crescent course-indicator, an arrangement by which the course of an approaching vessel can be recognised at night. An incandescent lamp (or any other light may be used) is inclosed in a lantern, the transparent part of which forms the circumference of a frustratod cone; the circle resulting from the section of the cone being opaque. The axis of the cone is set horizontally, and over the axis of the ship. Under these circumstances a ring of light will be seen when the ship is steering directly towards the spectator, and as the course alters, the opaque centre will shift to the right or left, showing a crescent instead of a ring of light. Lacombe and Co.'s exhibit of carbons at stand No. 114 is small as regards amount, but interesting as regards variety, and includes an assortment of carbons for arc lighting, as, for example, plain, coppered, cored, and fluted. Carbon blocks to be used as brushes for dynamos and motors are also shown, and there are carbon resistances with lead contacts, cells, tubes, plates, battery cylinders, and microphone carbons, in addition to other articles made of hard carbon.

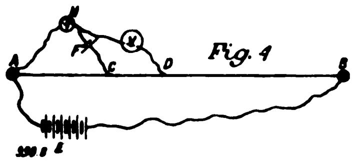


Fig. 4

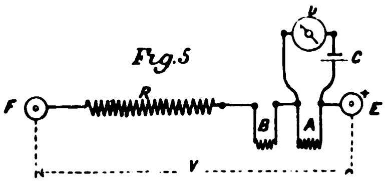


Fig. 5

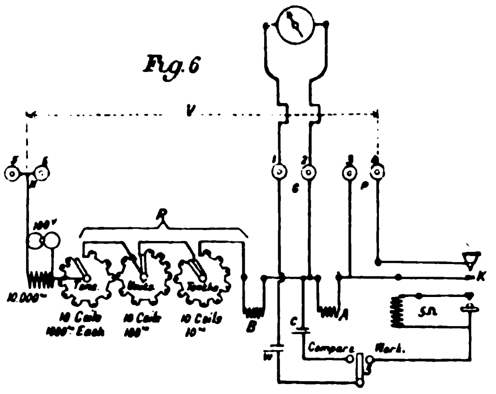


Fig. 6

Waterlow and Sons show paper strips wound into discs for the various recording telegraph apparatus, including oiled paper for use with the Wheatstone high-speed machines. In addition they have rolls of cloth cut into narrow widths, down to ¼ in. Such strips are occasionally more useful than the thick-edged tapes for insulating or distancing; besides being much cheaper.

The two stands of Benham and Froud include some excellent and neat brass and ironwork of ornamental character, also a special exhibit to illustrate church lighting by incandescent lamps, a chancel being fitted up with altar and accessories. The model dining table fitted for incandescent lights by Messrs. Graham and Biddle, of Oxford-street, is interesting as showing some ingenious fittings for connection, besides dealing also with the decorative side. Fowler, Lancaster, and Co. show general fittings, ammeters, voltmeters, and various switches. On this stand is to be found a material which appears similar to the well-known "vulcanised fibre," and is described as Delaware hard fibre. It is shown as tubes, bushings, sheets, rods, washers, gear wheels, and small articles.

Mr. A. P. Lundberg not only shows the "unique" switch which we have already described, the principle of which we have illustrated (see page 146 *ante*), but has also thoughtfully designed switches of other sorts, cut-outs, wall sockets, and other fittings, and near at hand is an exhibit of arc lamp and microphone carbons by Herr Jooss, of Stuttgart.

An electric engraving pen in which the cutting shaft is actuated by a contact breaker motor, and substantially similar in character to that referred to as made by Messrs. Coxeter and Son (see page 314 *ante*) is shown in action at Stand 123. The motor part being somewhat too heavy for convenient handling when the instrument is free, the whole apparatus is suspended by a spiral spring, so that the pencil-like point hangs loosely almost in contact with the metal plate to be engraved.

Mr. P. Howard shows an arrangement for registering the time elapsing between seeing a light disappear and pressing a button; this being intended to be used principally as a measure of personal sluggishness in shooting at a moving object. The arrangement for registering time is a tuning-fork giving 250 vibrations a second and kept in steady vibration by a short electro-magnet and contact-breaking arrangement placed between the branches of the fork. As a shutter drops, a style on one limb of the fork makes contact with a strip of smoked paper on a revolving drum, and the vibrations are recorded until the push of

MODERN UNITED STATES ARTILLERY.—No V.

CARRIAGE FOR 3.2-IN. GUN, 1889 MODEL.

(FIGS. 123 TO 134)

IN a previous article was described the success of the first steel gun built by the United States; the question, however, of providing a suitable carriage was not as easily solved. The gun, of 3.2-in. in calibre, built up of steel, was made according to designs based upon mathematical calculations, and proved an instant success; the carriage for the gun was the result of several years' experiments.

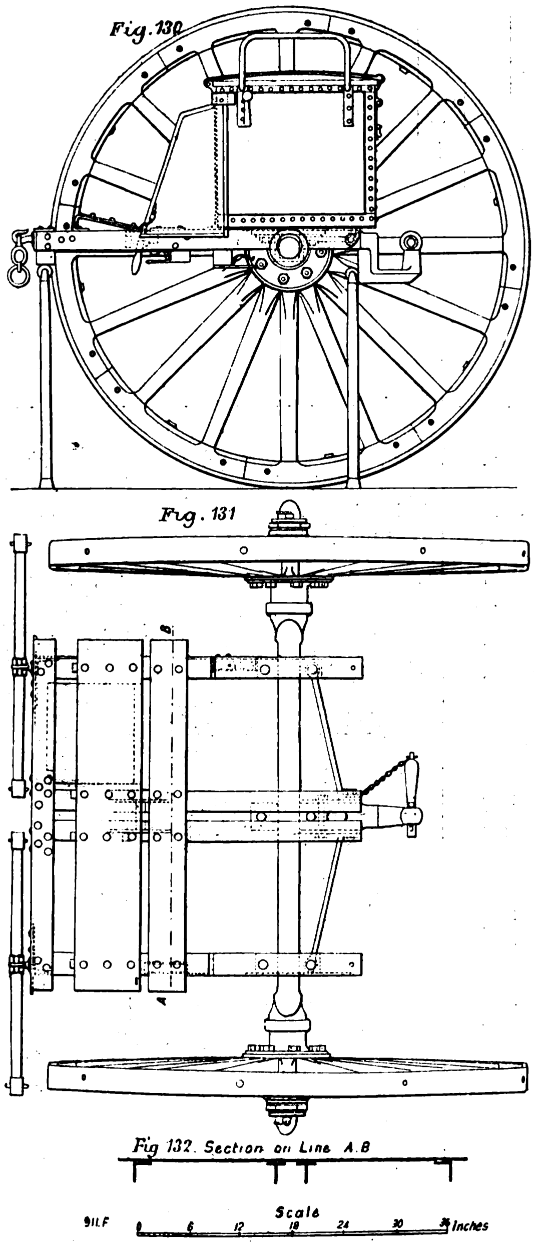


Fig.130

Fig. 131

Fig 132. Section on Line A.B

LIMBER FOR 3.2-IN. FIELD GUN.

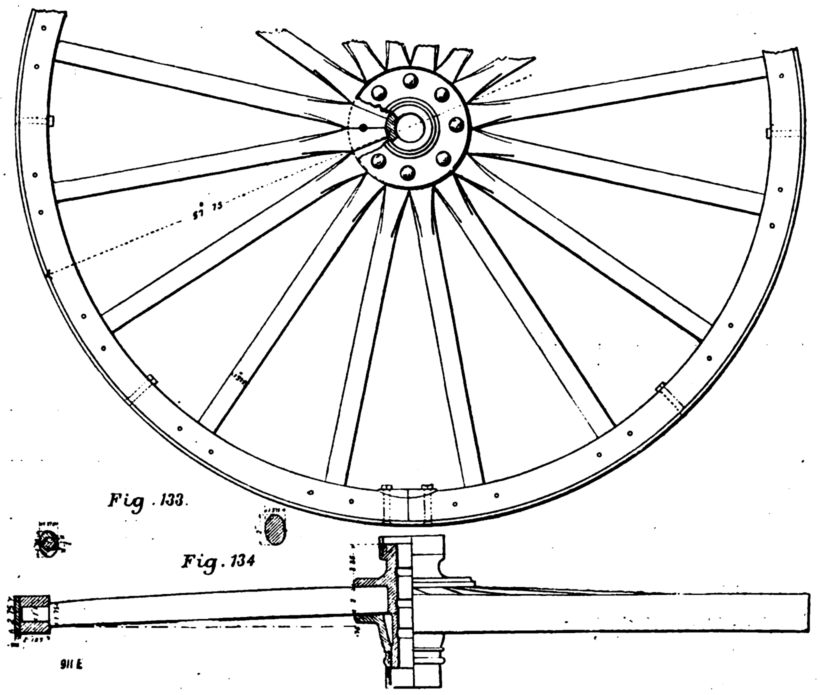


Fig. 133.

Fig. 134

WHEELS FOR 3.2-IN. FIELD GUN CARRIAGE.

The advisability of using iron or steel in the field gun carrriage had long been recognised. In 1866 and 1867 experiments were made by Colonel Rodman and Colonel Benton. It was not, however, until 1880 that the experiments were conducted systematically. At that time the 3-in. wrought-iron field gun, which was the field piece used during the Civil War, was being converted, as described in a previous article, into a breech-loading rifle. Its power was greatly increased, while the increase in weight was small. In its original form, a wooden carriage, built on the stock-trail system, proved to be sufficiently strong, but with the converted gun, it broke up, due to the greater shock of recoil caused by the increase of the charge and muzzle energy of the projectile.

The necessity of an all-iron or steel carriage became urgent, and a carriage was built which has gradually developed into the very serviceable mounting of the present day. The two cheeks were made of $\frac{5}{16}$-in. steel plate, stiffened by angle iron riveted to the inside edge, and also reinforced by a small plate between the axle and trunnions. The axle was of wrought iron and braced to the trail by rods, attached to the axle just inside of the wheel. The elevating device consisted of two screws, the inner one working inside of the outer one, which was hollow, and which worked inside of a nut pivoted to two brass supports attached to the trail. Just in rear of the elevating screw and between the cheeks was a tool-box. The brake was a straight bar of wood, supported by the trail parallel to the axle. At the ends were iron shoes which could be tightened on the wheels by means of clamps. The handspike was of iron, and when not in use folded back on the lid of the chest.

It was found on trial that this carriage developed several points of weakness and required alteration. The material of which the axle was made was changed from wrought iron to steel, and the cheeks were stiffened by flanging instead of by riveting on angle irons. Certain other dimensions were also altered to increase the strength. On account of the lack of proper machinery at the foundry where the cheeks were made, the flanging had to be done by hand, and to this was attributed a certain weakness that developed later. The axle still proved too weak. The initial shock of the recoil was too great for it to stand. The question of adopting some device similar to that used in the Englehardt and Gruson carriages was discussed, but it was decided that until it was shown that a simple axle could not be made strong and light enough, such devices should not be employed. It was acccordingly proposed to strengthen the axle by riveting above and below it two steel boiler plates of the form shown in Fig. 125. On trial it was found that the axle thus altered withstood the test of firing perfectly. The axle being thus determined upon, the question of putting the requisite strength in the other parts was solved with comparative ease, except the details of the brake. A number of experiments led finally to the adoption of a brake, and also to other changes which were applied to the carriage manufactured in 1887, and which, on proving itself fully suitable, was adopted as the carriage for the 3.2-in. breech-loading steel field gun (Figs. 123 to 139).

The flasks (Fig. 127), shown in cross-section in the drawings, were forged into shape while hot, between cast-iron dies 8 ft. long, by one blow of a 15-ton hammer falling through a distance of 6 ft. The male die rests on the anvil, while the female die is bolted by heavy timbers to the head of the hammer. The plates, from which the flasks were to be formed, were heated to a white heat and placed on the male die, and held in place by four spring pins. The hammer was then allowed to descend to the proper distance, and from that point to fall fairly, and rest on the plate until the visible heat had disappeared. This one operation corrugates, flanges, and gives the form to the plates. The trail ends embraced by the trail plates and lunette are then finished by a former, and the flanges trued by means of a gas flame and hammer. The excess of metal on the flanges is first removed by a grindstone, then by a milling machine, and finally fitted with a file. The lower flanges of the outer plates project inwardly, and serve to unite the brackets to the axle-plates (Fig. 125).

The trunnion pieces and cap squares are forged in dies under an ordinary drop hammer. The brackets are further united by transoms, between two of which is the tool-box, for an oil can and necessary tools. In the trials of the various carriages no trail handspike stood the test as well as the wooden one. Even this did not hold out. To further strengthen it, the handspike, made of selected hickory, was sawed in half lengthwise, and to replace the part sawed out, a piece of sheet steel $\frac{1}{16}$ in. thick was laid between the halves and the whole bolted together and secured by bands by iron.

The elevating screw was similar to the one described above, being a screw within a screw (Figs. 123 and 124). The flasks being wide enough to allow the breech of the gun to descend between them, the crank operating the elevating screw was placed on the right side of the trail, so that, when using high angles of elevation, it could be as easily used as at any other time.

The brake, as shown in Figs. 123 and 124, consists of a rod carrying, at one end, a shoe to go over the wheel, and having the other end surrounded by a spiral spring contained within a tube This tube is keyed above the axle, and being eccentric the shoe can, when the brake is held vertically, pass over the tyre of the wheel. As the wheel revolves the brake tightens until finally the friction becomes so great that the revolution ceases and

TABLE XIV.—Comparative Table of Field and Horse Battery Guns and Equipment.

Calibre of Guns and Model.	Germany. 8-Cent. (3.1-in.) 1873.	Germany. 9-Cent (3.47-in.) 1873.	France. 8-Cent. (3.15-in.) 1877.	France. 9-Cent. (3.54-in.) 1877.	Austria. 7-Cent. (2.95-in.) 1875.	Austria. 9-Cent. (3.40-in.) 1875.	Italy. 7-Cent. (2.95-in.) 1874.	Italy. 9-Cent. (3.43-in.) 1876.	England. 3-in. 12-Pounder 1883 (?)	United States. 3-in. Muzzle-Loading, 1861.	United States. 3.2-in. Breech-loading, 1889.	Russia. Light 3.43 in. 4-Pounder, 1877.	Russia. Heavy 3.43 in. 4-Pounder, 1877.	Russia. 4.21 in. 9-Pounder, 1877.
Weight of gun	858	990	946	1166	658	1071	656	1082	784	830	829	800	1020	1377
,, carriage with gun	1804	2059	2096	2655	1681	2255	1527	2385	(*)	1760	1995	1837	2129	2677
,, limber	1440.3	1435.3	841.86	1193.64	1247.4	1388.3	826.6	1222.1	(*)	983 16	1031.37	140.8	1433	1476.27
,, ammunition ..	555	666	467	555	478	616	450	582	626	573	735	363	545	566
,, caisson	2896	3272	2665	3380	2881	3000	1916	3468	3141	2362	2349	3086	3086	3022
,, ammunition ..	1244	1383	1383	1669	1407	1783	1120	1218	1087	1719	2204	1635	1635	1699
Number of projectiles per gun	154	136	161	141	152	128	142	130	110	200	131	157	167	127
Weight of shell	11.2	15.44	12 33	17.5	9.5	14	9.35	14.8	12.5	7.5	13.5	15.13	15.13	27.5
,, shrapnel ..	12	17.5	12.64	18	10.5	15.75	9.25	14.74	12.5	10.5	13 5	15.22	15.22	24.47
,, charge	2.75	3.3	3.3	4.18	2.1	3.3	1.87	13.19	4.0	1	3.75	3	3	4
Number of projectiles carried on gun and limber ..	43	36	34	29	40	34	44	36	36	50	44	22	32	19
Same on caisson	86	77	87	76	112	94	102	102	72	150	132	90	90	54
Initial velocity ft.-sec.	1325	1456	1607	1492	1386	1469	1381	1489	1720	1232	1756	1350	1450	1550
Ranges	6196	6557	7655	7535	5000	5000	3543	3500	7930	3972	6500	7000	7000	
For elevations of .. deg.	25	25	25	25	17 10	15 12	10	10	25	20	20	25 16	22 5	
Number of horses to team	6	6	6	6	6	6	4	6	6	6	6	6	6	6
Composition of battery .. guns	6	6	6	6	8	8	8	8	6	6	6	6	8	8
Composition of battery .. caissons	8	8	9	9	8	8	8	8	6	6	9	9	12	16
Weight per horse, gun team .. .. lb.	661	712	586	738	570	703	705	712	672	572	632	611	723	786
Weight per horse, caisson team .. .. lb.	690	775	675	841	715	797	759	781	704	680	759	737	726	786

* Weight of gun carriage and limber 2482 lb.

the carriage slides. By running the piece to the front the brake is loosened. When not in use the brakes are held in a vertical position by being keyed to the guard rails of the seats, situated over the axle on either side of the piece. A short sponge and rammer are carried between the cheeks.

A new brake has recently been tested, and having stood the test of 500 service charges will probably replace the one described above. It differs from the old one in the form of the spring, being a bow instead of a spiral spring; while the former did very well in firing, it was not adapted to use when travelling, since after descending a hill, it was necessary to halt in order to remove the brake. With the new bow spring this is not necessary. The spring lever operates a locking bolt in the end of the brake. This bolt has bearings in the brake on each side of a longitudinal mortise, and passes through a slot in the sliding tang of the hook, placed in this mortise. The part of the bolt embraced by the slot has two opposite rectangular grooves, and at the hook end the slot runs into a hole the size of the bolt, so that when in this hole and the grooves at right angles to the slot in the tang, the hook is locked. When turned with the groove parallel to the slot the hook can be drawn out until stopped by the other end of the tang. At the other end of the spring lever is a handle terminating in a fork, which embraces the brake-rod below the shoe. When the fork is over the brake-rod the hook is locked, and in this position the brake is ready for use. A quick pull will loosen the fork from the brake, and then being turned at right angles to the brake, the hook can be pulled out sufficiently to loosen the brake, and the shoe can be removed from the wheel without arresting the progress of the gun.

The wheels used in the United States service are what are known as the Archibald wheels. The nave, as shown in Fig. 129, is in two parts, and is made of malleable cast iron. In case a spoke is broken the nave can readily be taken apart and a new spoke put in. The spokes are made of well-seasoned hickory and shaped at the ends like voussoirs of an arch (Fig. 133). They are set in place by a powerful radial pressure, much greater than they will ever be called upon to bear in practice. A dish is also given to them to give stiffness to the wheel, (Fig. 134). The wheels are made interchangeable in the field service.

In order to bring the working spoke in a vertical position a certain set was given to the axle in order to offset the dish of the wheel. This was found to give good results, and also by this set the mud was thrown clear of the piece.

Limber for 3-in. Rifle, Model 1889.

(Figs. 130 to 136.)

The limber has a steel axle and wheels of the same kind and size as the piece. The axles of both piece and limber are made tubular, thus giving a much greater strength for the same weight of metal. Experiments were made with steel chests for the limber, but it was found that to be as light as required for the service, the steel would not be thick enough to prevent the penetration of a rifle bullet, which would render it irreparable and non-waterproof. A wooden chest was therefore adopted and thoroughly ironed.

The ammunition chest has three compartments. The two end ones for the projectile and the centre one for the cartridges, which are thus in a measure protected. Each limber carries 42 projectiles and 44 cartridges. The chests are covered with heavy cotton duck, thoroughly saturated with raw linseed oil; they form a seat for three cannoneers. The piece is limbered up by means of the usual pintle hook and secured by a key. The projectiles stand on their bases, and the chests are made just high enough to allow the lids to close. The chest is consequently a very low one and the projectiles and cartridges can readily be removed. The centre of gravity is also very low, and therefore the danger of overturning is reduced to a minimum.

Under each end of the limber chest is a cylindrical water-tight iron box for carrying unbroken boxes of friction primers and spare obturators.

The caisson (Fig. 136) is constructed in a similar manner to the limber. It consists of a limber made interchangeable with the limber of the piece, and of a body which is limbered up in the same manner as the piece. The body carries two chests and one spare wheel. The chests are all interchangeable and can be quickly shifted from one position to another. The caisson provides seats for nine cannoneers.

Besides projectiles and cartridges the caisson is arranged to carry:

Two long handled shovels ,, pickaxes	By suitable attachments underneath
One spare pole	
Two spades ... ... ,, axes	Between the chests
Four watering buckets (in "nests" of two each) ...	Bail of outer bucket around "floor-rods" in rear of rear chest
One or two lanterns ... Two paulins	In interior of buckets on the chests
One manœuvring hand-spike	Right side along the side rail
One section of picket rope	Coiled around spare wheel axle bolster
One spare wheel ...	On spare wheel axle

Table XIII.—*Weights of One Section of 3.2-in. Battery.*

	lb.
Weight of gun	829
,, carriage	1300
,, equipments	31
,, limber	957
,, equipments	74
,, ammunition	734
Total weight of piece	3793
Weight per horse	632
,, of caisson	2216
,, equipments	132
,, ammunition	2204
Total weight of caisson	4553
Weight per horse	759

It will be seen from the above Table that the weight per horse is well within the limit required for mobility. During the Civil War the weight of the heaviest field piece used was 645 lb. per horse. In spite of the fact that the roads were poorer than any that the artillery of the future will be called upon to travel over, the piece was found sufficiently mobile to meet all requirements.

The initial velocity given in Table XIV. for the 3.2-in. breech-loading United States gun gave a pressure of 35,000 lb. per square inch; a powder has recently been tested which gave a slightly lower pressure and an initial velocity of 2040 ft. per second. This powder will probably be adopted for the gun, unless a better one is discovered.

Harness for 3 in. Rifle, Model 1889.

(Figs. 137 and 138.)

The harness used during the war was similar to the ordinary draught harness of commerce. This harness had many objectionable features when applied to artillery and with the modern steel field piece was adopted a new harness which has proved itself greatly superior to the old one (Figs. 137 and 138).

The new harness has the same bit, saddle, bridle, halter, &c., as the cavalry, and as far as possible is made similar to the harness of commerce, so the time required in instructing recruits would be as small as possible. All bright metal work is avoided as attracting attention and taking time to keep in order.

The collar is hinged firmly at the top and fastening with a spring catch at the bottom, and to the collar are permanently attached the hames. A stout leather tag, ending in a ring, is attached to the hames, and through the ring runs the trace of the lead horses. A lead horse can thus be quickly taken out without interfering with the motion of the other horses. The breeching is the most noticeable feature. It is in the form of a Y, whose stem passes under the horse's belly, up between his fore legs, and is attached to a neck-yoke, supported on the end of the pole. This arrangement is of great use in stopping suddenly, as it prevents any tendency of the collar to ride up the horse's neck and any oblique pull which might throw the horse. The details of the harness are plainly shown in Figs. 137 and 138.

THE INSTITUTION OF NAVAL ARCHITECTS.

This Institution's annual spring meeting—for we suppose it may now be taken for granted that there will be an annual summer meeting also—which was brought to a conclusion on Friday evening last, was fairly successful on the whole. There were fewer papers than usual, twelve in all, and as there were no more than three in any one of the five sittings, it follows that on each of three occasions only two papers were read and discussed. This we look on as a distinct advantage; it is far better to do a little work well than to do a great deal indifferently. It is to be hoped that the Council will continue the policy of keeping the number of contributions within reasonable limits. The great flaw in the meeting was that there was no boiler paper. Last year Mr. Yarrow's brilliant contribution on this subject was the notable feature of the meeting, but since then the phase of the subject has become far more acute. The trouble with Navy boilers is certainly explainable, and it is equally certain it might with advantage be explained. We believe is was arranged at one time that one of the Admiralty professional officers should contribute a paper on this subject, but the appointment of the Committee of Inquiry which has recently commenced its labours naturally put a stop to this. Perhaps before the next meeting of the Institution is held the evidence and report of the Committee will have been published—for the Government will hardly refuse a Blue-book, as such a course would indicate that things are far worse than we have now any reason to suppose them to be—and such a publication will remove the necessity for silence now imposed on the Admiralty engineers. We may therefore hope that this important question may be well thrashed out at the next meeting.

There were only two purely engineering papers on the list at the meeting. Mr. Yarrow's contribution on "Balancing Marine Engines" and that

LITERATURE.

The Art and Craft of Cabinet-Making, a Practical Handbook. By David Denning. London: Whittaker and Co.

This book is professedly designed "to supply amateurs and young professional cabinet-makers with a reliable guide;" and, doubtless, it is well designed for that purpose, but in the present day, when all the trades are becoming so specialised and sub-divided, there are few who may not find something instructive. Nevertheless, Mr. Denning does not go out of his province, and it may here be as well to indicate what he looks on as the boundaries of that province. "The cabinet-maker," he says, "does not profess to be either a turner, an inlayer or marquetry cutter, a fretsawyer, or a carver; he makes up the things and has plenty to occupy him in so doing. Suppose we take, by way of illustration, a sideboard or a cabinet in which there are turned columns, carved parts, marquetry panels, and one or two bits of fretwork. In addition to the construction of the article, the cabinet-maker would get out the square pieces to be turned, the pieces to be carved, lay the marquetry veneers on the panels, and prepare the pieces for the frets. To a certain extent the turner, the carver, the fret-sawyer, and the marquetry cutter, are subsidiary to him; their work is decorative, his constructive." That is all very well for the conditions of modern trade, but the amateur will prefer to do his decorative work himself, and, indeed, look upon it as the chief element in the construction.

The book opens with a chapter on antique furniture, the manufacture of which is so important and promising an industry in the present day. The author gives some amusing instances. A "grandfather" clock, dating from a period anterior to Huyghens; a mahogany sofa said to have been used by Henry VIII., and a genuine old oak sideboard of the Elizabethan period, the property of a popular actor, and having a plate-glass back. The word Chippendale is responsible for a great deal, as Mr. Denning says. Chippendale chairs, one would think, must have the property, hitherto supposed to be distinctive of the organic part of creation, of reproducing their kind. Even this miracle is exceeded in the case of some Chippendale chairs "black with age, two or three hundred years old, and made of mahogany." Later on we have a hat and umbrella stand of the reign of Queen Anne. The short sketch given of the history of furniture production, which may be said to have commenced, so far as domestic furniture is concerned, with the latter end of the Tudor period, is interesting. The author tells us that most of the old oak furniture was not "richly carved," but that many really interesting ancient specimens are spoiled by the dealers in being prepared to meet the views of uninstructed persons as to what is the correct thing. Even dates are not altogether to be relied on as proving the genuineness of work, for there is no more difficulty in carving them than any other device. The author makes no reference to "worm-holes," which are generally considered a sort of hall-mark of antiquity in the case of furniture. That they are, however, not more reliable than dates, the following incident may serve to show. A gentleman lately, who had made a large fortune, doubtless in cotton spinning, wished for some antique furniture for the ancestral hall he had recently completed. He applied to a dealer who, curiously enough, had just the articles required. As there was some delay in delivering, the gentleman called at the warehouse, and on entering was startled by a loud explosion. "What's that?" he said to the clerk, who must have been a very green hand. "Oh, they are just putting the worm-holes into your antique furniture." Now, although the gentleman was not learned in antiquities he was pretty shrewd, and when he was shown the articles, he asked what the little holes were. "They are made by the worms, sir," said the dealer. The cotton spinner took out his knife and dug a small pellet from the bottom of a hole. "What do you call this?" he said. "Well, sir," replied the dealer, "you see the worms make these holes to lay their eggs in and that must be one that never got hatched."

The author stands up for his craft and has his gibe at the architects, who are by some considered the only persons capable of designing artistic furniture. Such success as they have attained, we are told, is solely due to the fact that when an architect is employed the price admits of good work being done. They cannot "get away from the idea that they are designing buildings." Nevertheless the author has a feeling of strong admiration for Sir Charles Eastlake.

From the interesting chapter on antique furniture the book proceeds to discuss the fundamental question of words used and gives hints on the important detail of buying timber, together with methods of measurement. There are also instructions on such subjects as the methods of seasoning and drying, levelling boards, waste in cutting, &c. A short chapter is given to glue and its preparation, and another to nails, including screw nails and dowels. These are both necessary chapters to the beginner, more especially the former. Perhaps there are more amateur carpenters who go wrong with their glue-pot than in any other way. The subject of tools occupies the larger part of the work. Illustrations and descriptions are given of all the ordinary hand tools; after which there are descriptions given of the appliances which the operator may make for himself. The grinding and sharpening of tools and general directions of the method of using them closes this section of the book. After this we get to the section which gives instructions upon the method of carrying out the general operations, such as making joints of various kinds and other structural details. The construction of parts follows, and there is then a separate chapter on the use of glass in furniture. The problem of designing in its better sense is naturally beyond the scope of the book, but some unpretentious examples are given of the common objects. There is a chapter on veneering and another on cabinet brasswork, the rest of the book being devoted to construction of various types of furniture. On the whole the book is well fitted for the purpose for which it is designed, namely, for amateurs and beginners who require a modest and inexpensive guide; the matter being well selected, the descriptions clear, and the information sound. There are several wood engravings illustrating the text.

BOOKS RECEIVED.

Formulaire de l'Electricien. Par E. Hospitalier. Dixième Année, 1892. Paris: G. Masson.

Les Chemin de fer et les Tramways; Construction, Exploitation, Traction. Par Adolphe Schœller. Avec 90 Figures Intercalées dans le Texte. Paris: J. B. Baillière et Fils.

Transactions of the American Institute of Electrical Engineers, Vol. VIII. New York: Published by the Institute.

MODERN UNITED STATES ARTILLERY.—No. VI.

3.6-in. Heavy Field Gun.

(Figs. 139 and 140.)

The 3.2-in. steel rifle that has been described in preceding articles is intended for use as a light field or horse artillery piece. The carriage, which has been described, and which is at present used with the gun, is eventually to be replaced by a lighter carriage, as soon as a suitable one has been constructed, and thus make the piece and carriage light enough to meet the requirements of mobility which will be demanded of it. The carriage, which has been illustrated, is to be the carriage to be used with the heavy field gun.

This gun is a 3.6-in. steel breech-loading rifle, weighing 1215 lb. It is composed (Figs. 139 and 140) of a tube, jacket, locking ring, and sleeve. The tube is 83.7 in. in length. The powder chamber is 14 in. long, and has a thickness of walls equal to 1.15 in. It ends in a short conical slope connecting it with the chamber in which the base of the projectile rests, which chamber has a diameter of 3.75 in., and terminates in a conical slope connecting it with the bore. The bore is 67.65 in. long. The exterior of the bore for a distance of 34.6 in. is turned concentrically with the axis, and then a shoulder is left against which abuts the jacket.

The jacket and trunnion hoop are in one forging. At the rear of the tube will be noticed a lip, and a corresponding projection on the jacket. By these two shoulders any tendency of the jacket to slip forward on the tube is avoided. Between the jacket and tube is allowed a shrinkage of 0.007 in., the exterior of the jacket being 6.2055 in., and the interior of the jacket 6.199 in. The tube is secured in an upright position, breech up; the jacket is expanded 0.02 in., dropped over the tube, and secured in place. The locking ring, of a cross-section shown in Fig. 140, securely locks the tube and jacket, and prevents any tendency of the jacket to slip to the rear on the tube. The locking ring is cut in halves, longitudinally, placed in position, and secured by the shrinking on of the sleeve. The breech mechanism is the same as described for the 3.2-in. rifle.

Table. XV.—*Ballistic Data of 3.6-in. Field Gun (Figs. 139 and 140.)*

Calibre		3.6 in.
Weight		1215 lb.
Total length		7.5 ft.
Length of bore		22.7 calibres.
Weight of powder charge ...		4.63 lb.
" projectile		20 "
Ratio of weight	of charge to weight of projectile	1 to 4.3.
	of projectile to weight of piece	1 to 61.5.
Initial velocity		1554 ft. sec.
Muzzle energy	Total	334.8
	per ton of gun ...	609.7
	per pound of powder	72.3
Pressure, pounds per square inch		36,800
Range for 20 deg. elevation, yards		6070

At first glance an artillerist would undoubtedly deem it strange that a modern field gun should have been designed to give such a low velocity as 1554 ft. per second. A gun should be designed to meet the requirements of the country where it is to be used. It is almost beyond the bounds of possibility that the gun would be used anywhere but in the western hemisphere. America is largely a rolling wooded country, and the range would generally be much shorter than in Europe. The gun would be called upon, as a rule, to dislodge an enemy from behind entrenchments, or protection of some kind, and a plunging or curved fire would in this case be preferable to a direct one. It will be noticed that the length of travel of the base of the projectile in the bore is less than 20 calibres, and consequently, if compared with a Canet gun, 45 calibres or more in length, it might almost be considered a howitzer. It has a heavy projectile, and the shrapnel it fires contains a large number of balls. It is undoubtedly an excellent gun for the service for which it was designed. Fig. 140a is a view of the 3-in. mountain gun, carriage, and limber.

The projectiles that are to be used in the field guns of the United States are the shell and the shrapnel. The weight for the 3.2-in. piece is 13 lb., and for the 3.6 in. piece it is 20 lb.

Ammunition for 3.6-in. Field Gun.

(Figs. 141 to 144, and 149, 150.)

The shrapnel are of two forms, one with the bursting charge in front (Figs. 140 and 141), and one with the charge in rear (Figs. 142 and 143). The shrapnel, shown in Fig. 140, consists of a drawn steel tube, an independent base, and a receptacle for the powder charge, which also contains the screw thread for the fuze. The tube is slit and bent over the powder charge, thus holding it in place. In order to hold the ball in place, and to prevent the shock of discharge from forming a solid mass of them, it is necessary to separate them by some material. In the earlier forms of shrapnel this was done by filling the shell with the balls, and then pouring in between them melted resin and sulphur. It was found that while this served the purpose for which it was intended, it rendered the shrapnel less effective on exploding, since the balls did not act as individual projectiles, but were held by the sulphur and resin in masses, each containing a number of balls. In the modern shrapnel shown, the matrix consists of layers of cast iron, with cavities in which fit the balls. By this means the matrix, instead of adding a useless weight to the projectile, really increases its efficiency, since, on the exploding of the bursting charge, it will be broken into a number of effective fragments. In this shrapnel the balls are ½ oz. in weight and 152 in number. They are loaded from the rear, alternately a separator and a layer of balls, and when filled the base is screwed in. Between the base and the separator next to it is a disc of cork to act as a cushion, and prevent any tendency of the separator to break when the shrapnel is fired. The bursting charge consists of 2½ oz. of fine powder. This charge is sufficient to open out the slit end of the tube, and as it will then offer a greater surface, it will be resisted more by the air, and the balls will move on. It is found that the lateral dispersion caused by the rotation of the projectile is generally too great, so that the main object is to increase the velocity of the balls in the direction of the trajectory, and to decrease this lateral dispersion. A bursting charge in rear will increase the velocity in the direction of the tangent, but the central tube of powder, to communicate the flame from the fuze to the bursting charge, will add to the lateral dispersion.

The shrapnel shown in Figs. 143 and 144 consists of a cast-steel head and base and a drawn-steel tube body. The screw for the fuze is in the cast-steel head, and is connected with the powder cavity by a drawn brass tube. It contains 145 balls of $\frac{1}{2}$ oz. in weight, which are thoroughly oiled and then imbedded in a matrix of plaster. The bursting charge weighs 3$\frac{1}{2}$ oz., which, being situated in rear by means of the diaphragm just in front of it, sweeps the balls out to the front, thus acting as an aërial gun, increasing the velocity of the balls in the direction of the tangent.

For a field gun to use a solid shot against animate objects would practically reduce its efficiency to that of a small arm. While a shell would be more effective, the number of its dangerous fragments is comparatively small, and hence its principal use is against earthworks. The shrapnel is pre-eminently the projectile of the field gun, and the value of a field gun will depend mainly on the efficiency of its shrapnel. It is interesting to note the development of the shrapnel. The earlier ones consisted of a spherical shell, into which were put the balls, and then the powder poured in. This required a large bursting charge, and in transportation the balls triturated the powder. During the Civil War the form of shrapnel used is shown in Fig. 145, and was known as spherical case. The balls, which were made of lead, were imbedded in a matrix of melted resin and sulphur, and the cavity for the powder was afterwards bored out. The furthest step in advance in the spherical shrapnel was known as the Boxer diaphragm shrapnel (Fig. 146). The shell was of cast iron; the balls imbedded in a matrix of coal-dust which would not hold them as the sulphur did; the powder charge was separated from the balls by a wrought-iron diaphragm. One of the early forms of oblong shrapnel is shown in Fig. 147. It consisted of a cast-iron body B, and wooden head H held to the body by a wrought-iron case. The fuze was screwed in at F, and the flame communicated to the powder charge C by the tube T. The powder cavity was made slightly conical to facilitate unloading. The disc D swept the balls out to the front. The wooden head took up a lot of useful space, and the body was too thick to give a large enough cavity for the balls. These objections marked some of the efforts in the development of the modern shrapnel, of which the one represented in Fig. 143 marks the furthest advance. It was desired to have a strong base to resist the pressure of the powder charge in the gun, and a thin body to give a large cavity. This shrapnel is manufactured as follows: The head and base are of cast steel, which are heated and compressed between dies to increase their density. The head and tube, which are made, as before stated, of drawn steel, are placed in an electric welding machine, and in less than one minute are joined together. Next the brass tube which carries the flame to the powder cavity is crimped in at the upper end. The half-formed shrapnel is then inverted, the oiled bullets placed within, and the matrix of plaster-of-paris poured around them. The diaphragm, which forms the front end of the powder cavity, is then put in, and the tube crimped to it. The base is then welded on, and the projectile is made one piece. It will be noticed that after welding the base has a shoulder that presses against the diaphragm, and supports it against the shock of discharge. Before welding the tube is slightly longer than it is after the operation is finished. The burrs on the outside of the projectile, caused by the welding, are then ground off, but those inside are allowed to remain and strengthen the shrapnel. The groove for the band is then cut, of the form shown in Fig. 148. The band, of a cross-section shown in the same figure, is annular, and is set by a powerful radial press. The canister used is what is known as the Sawyer canister. It consists (Figs. 149 and 150) of a malleable iron case, cut by tangential grooves to facilitate its breaking up at the muzzle. The balls are held in place by a tin disc pressed in on top.

FUZES FOR FIELD GUN AMMUNITION. (FIGS. 151 TO 163.)

The fuze that is used with the shells and shrapnel is known as the Flagler combination fuze, shown in Figs. 151 to 163. It is made of brass, and is conical in shape, as shown in Fig. 153, so that when screwed in place it completes the point of the shell or shrapnel.

The disc C is made of pewter, since it is less affected by atmospheric changes, and contains the time composition. It is graduated in seconds, and, after being set, it is clamped by screwing down the cap A.

The cross-section is shown in Fig. 151. The plunger to ignite the time composition is shown at D, which is held in place during transportation by the copper wire d; d^2 is the fulminate which is ignited by striking the point F; $b\,b$ (shown also in cross-section in Fig. 152) are four radial channels, by which the flame is communicated to the time composition P. O is the channel connecting with the powder at K, by which the bursting charge is ignited.

The impact fuze consists of the base I, shown also in Figs. 159 and 160, against which rests the point h; around this point is cast a lead plunger R, so that the point of h is just below the top. Around the plunger is a fluted brass cylinder H. The fulminate for the plunger is contained in the fluted brass cap G. The same powder magazine K answers for both time and impact fuzes.

The action of the fuze is as follows:

The time composition P can be ignited at but one point, and that is at the end Z. Opposite Z is a cavity closed by a tin cap C^3, which the first gas formed blows off, and thus the composition does not burn under an increasing pressure of the powder gas, and consequently burns more uniformly. To set the time composition the ring C is rotated until the time indicated by the scale comes opposite the zero, which is marked opposite the point o. The cap A is then screwed down tight, holding the composition in place. The wire d, which is sufficiently strong to hold the plunger D during transportation, is narrowed just below the screw thread. The shock of discharge shears it off at this point, and the fulminate slides to the rear. The fulminate d^2 is ignited by the point F, and the flame passes through the radial holes b, and ignites the time composition at Z. This composition burns around until it comes over the channel o, and through this the flame quickly passes to the cavity K, igniting the powder in it, and from there to the bursting charge. The cap G, cylinder H, and base I are fluted, as shown in Figs. 156, 157, and 159, in order to provide channels, through which the flame from K could pass to the bursting charge. Should the projectile strike before the time composition had burnt around to the opening channel o, the bursting charge would be ignited by the impact fuze. Its action is as follows: The lead plunger R, on the shock of discharge, together with the cylinder H, will be thrown back on the base I, thus leaving the point h projecting. During flight the fulminate in G is protected by a thin zinc disc, just above the point h. On impact, however, the point together with the plunger is thrown forward with sufficient energy to pierce this disc, ignite the fulminate contained in the cap G, which ignites the powder K, from which the flame passes through the fluted channels, around the plunger, to the bursting charge. Another fuze in use is a variation of the one just described, and differs from it only in a few particulars. The time plunger D, instead of being held by a wire d, is made with a shank that passes up to the point. Through this shank runs a pin which cannot be broken, and thus the fuze is absolutely safe during transportation. Before loading this pin is withdrawn, and the plunger then is held by several lugs, which are sheared off by the shock of discharge. The time composition is contained in a lead tube wound spirally around the cone. A scale is marked around the tube, and to set the fuze for any time a hole is punched through to an inner cavity. To insure the certainty of ignition of the time composition, a ring of powder is placed around the outside of the channels b. The flame from the fulminate ignites the ring of powder, and the flame from this is large enough to be certain to ignite the time composition. The impact fuze is the same as that illustrated in Fig. 151.

This fuze, on being tested recently, gave most excellent results. At a range of one mile an average of 10 out of 11 burst 80 ft. in front of the

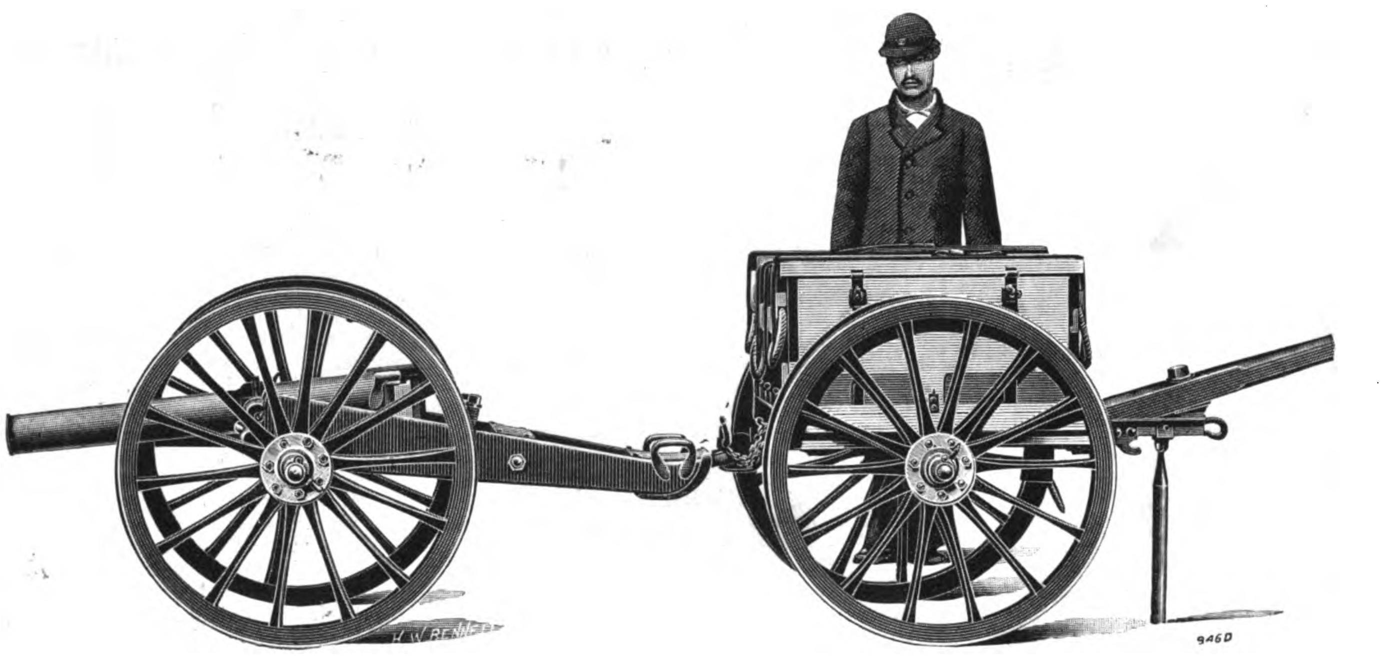


FIG. 140A. 3-IN. MOUNTAIN GUN, CARRIAGE, AND LIMBER.

MODERN UNITED STATES ARTILLERY: 3.6-IN. RIFLE AND AMMUNITION.

(*For Description, see Page* 485.)

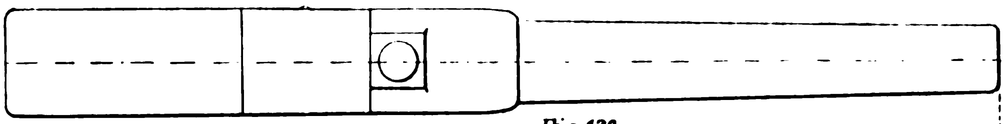


Fig. 139.

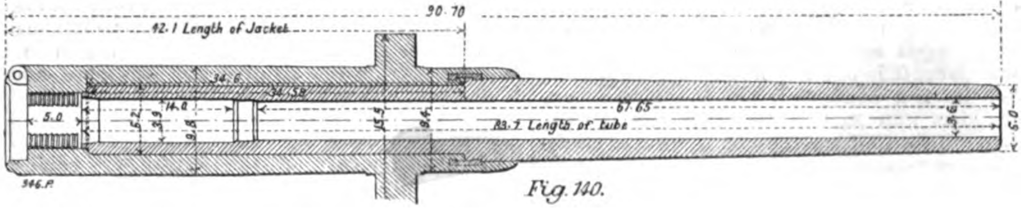
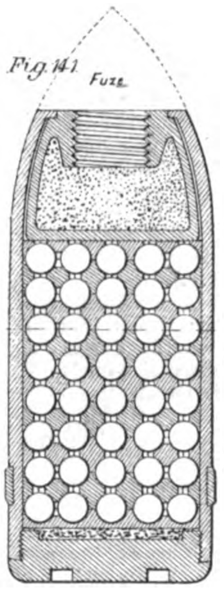
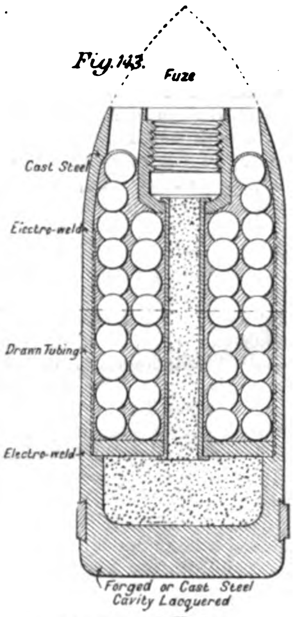
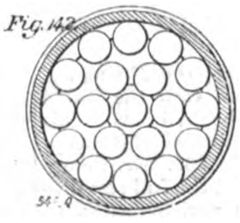


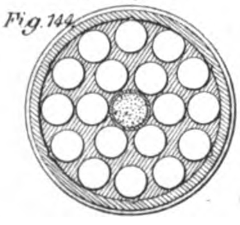
Fig. 140.

3.6-IN. HEAVY FIELD GUN.









SHRAPNEL FOR 3.6-IN. FIELD GUN.

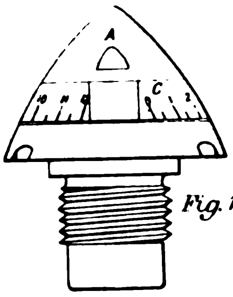


Fig. 153.

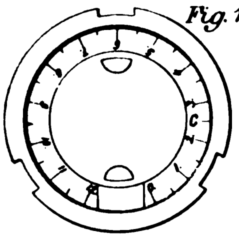


Fig. 154.

Half Size.

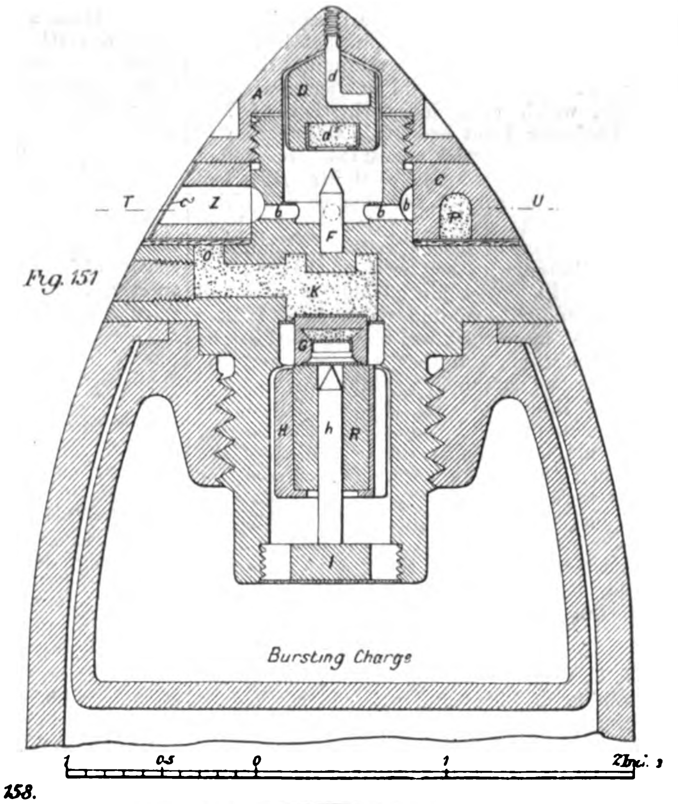
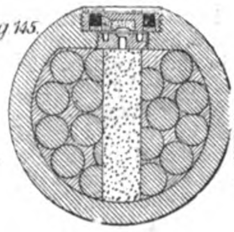
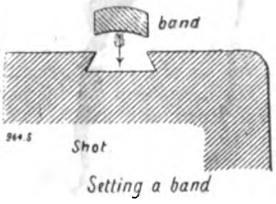
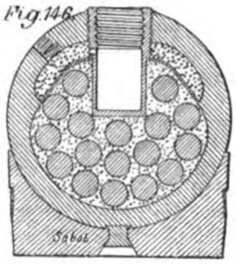
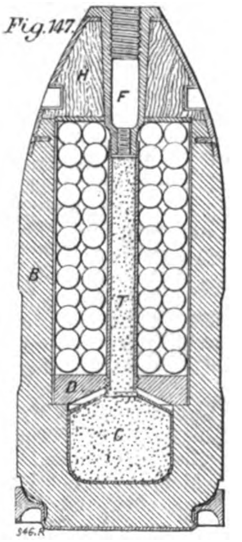


Fig. 151.









EARLY FORMS OF SHRAPNEL.

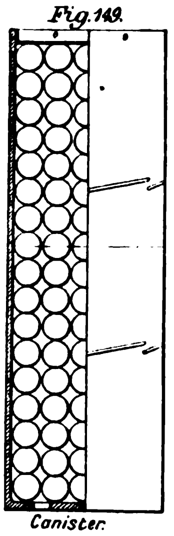


Fig. 149.

Canister.

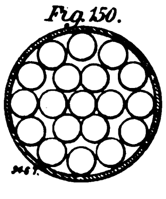


Fig. 150.

CANISTER.

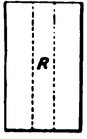


Fig. 155.

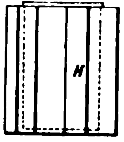


Fig. 156.

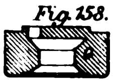


Fig. 158.

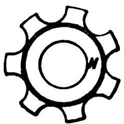


Fig. 157.

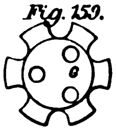


Fig. 159.

Fig. 160.

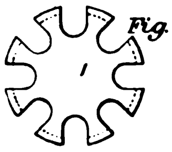


Fig. 161.

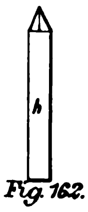


Fig. 162.

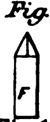


Fig. 163.

346.U

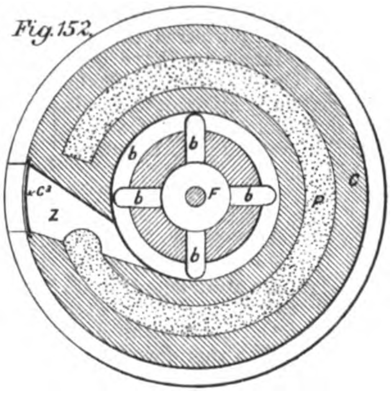


Fig. 152.

Section. T U.

FLAGLER COMBUSTION FUZE.

target. It is probable that in the course of time one fuze will be adopted for general use, but it will require a long test to settle which fuze is the best.

THE INSTITUTION OF NAVAL ARCHITECTS.

(*Concluded from page* 462.)

Continuing our report of the recent meeting of the Institution of Naval Architects we have now to give the proceedings of Friday the 8th inst., the last day of the meeting. On the members assembling at 12 o'clock, Lord Ravensworth again occupied the chair.

The Strength of Steamers.

The first paper taken was Mr. A. Denny's contribution entitled "Some Notes on the Strength of Steamers." Mr. Denny holds the opinion that fine vessels can be built of lighter scantlings than full vessels. This he stated in the discussion on Mr. T. C. Read's paper "On the Variation of Stresses on Vessels at Sea due to Wave Motion," which paper was read before the Institution in 1890. Since then Mr. Denny has made calculations on the subject, and the results he gives in a Table which forms an appendix to his paper. The steamers selected are supposed to be loaded to their legal draught with coal and a homogeneous cargo. When they arrive at the end of their voyage with the coal consumed, they are supposed to meet waves the same length as they are, and of a height equal to one-twentieth of their length. The comparative stress is worked out with the steamer poised upon such a wave, the crest of the wave being amidships; these being the most severe conditions. In one case the Table shows the comparative stress to be 9.76 tons. This vessel is 350 ft. long by 44 ft. wide and 32 ft. deep, and the midship area coefficient is .93. Mr. Denny contends that if it be safe to strain the full vessel to 9.76 tons, it is equally safe, and perhaps safer, to strain the fine vessel the same amount. The author has followed out this method in practice in numerous cases, and found it so far true. The Table shows how much smaller the stresses are in small than in large vessels; and it also shows that, in regard to fine and full vessels, what holds true in large vessels also holds true in small vessels. The effect of the rate of stowage is shown by the Table in vessels of a varying coefficient of fineness.

The discussion on this paper was opened by Mr. T. C. Read, who said that it would have been better had the paper given explanations of the method by which the results quoted had been obtained. It was twenty years since Sir Edward Reed had read the first paper on this subject before the Royal Society. In 1883, Mr. W. M. Smith, of the Admiralty, had made a most important addition to our knowledge of the subject, showing the manner in which the stresses calculated according to Sir Edward Reed's method were in excess, but he anticipated that the author had gone on the plan laid down by Sir Edward Reed. The speaker said that the experience of Lloyd's was that a fine vessel was as likely to be strained as a full one, and though the theory brought forward by the author might be good, it was unfortunate that the facts did not coincide with it. He was of opinion that it would be unwise to build ships on calculations such as these, and ignore experience.

Professor Biles said that no doubt the opinion attributed in the paper to the late Professor Jenkins—"that fine vessels could be built of lighter scantlings than full vessels"—was communicated to the author in a private conversation, for he did not find any confirmation of it in the public statements of the late professor. The author said that "The most difficult position for a ship was when meeting a wave of a length equal to her own, and of a height one-twentieth of her length, the vessel being poised on such a wave, the crest of the wave being amidships." That was supposed to be a fact until Mr. Read read his paper in 1890. On account of the great rise and fall of a fine ship the strain was not greater when on the crest of a wave than when in the hollow, and the sagging strains were really the greatest. He would therefore suggest to Mr. Denny that he should amend his paper by giving the sagging moments beside the hogging moments. It was a question, however, which could not be settled by any elementary calculations, and the speaker at some length reviewed what Mr. Read had set forth in his paper.

Mr. West, of Liverpool, said that he knew something of the great difficulty of arranging tables of scantling so that no anomalies should arise. He had always had a leaning to calculations for scantling being made on a displacement basis, and he very much regretted that Lloyd's had definitely abandoned the plan, which would prevent such difficulties as those to which the author had drawn attention. As to the basis upon which the calculations were made, the speaker would point out that the stresses could not be constant, as, in that case, no riveted structure would support them. It must be remembered that these figures were comparative only. It was necessary to give a word of warning, so that it might not go forth to the world that ships were strained to nearly 10 tons to the square inch in ordinary work. Since the speaker was freed from the restraints of official position he could conceive the value of a rule in which the strain member, according to Mr. Macfarlane Gray's formula, should not exceed a certain limit, and the designer might then be left to produce the longitudinal strength in any way he thought fit, and the authorities rest contented. In the present day shipbuilders were so tied that they were simply contractors for so many tons of ironwork. Safeguards were necessary, no doubt, but now the ship designer was restrained by rules, and his abilities cramped.

Mr. H. Laird, in reference to Mr. Read's remarks, said that his firm had had a good deal of experience with sharp vessels, and they had found that they might safely be constructed with lighter scantling. The thing, however, which was important was that the workmanship should be good. He had never known a ship which had given way through any fault in material, but a great many had doubtless failed from the bad way in which the material was put together.

Mr. Denny, in replying to the discussion, said that if it was Mr. Read's opinion that full ships could be built of the same minimum limit of scantling as fine ones, that did not agree with his experience, which coincided with that of Mr. Laird. Professor Biles had made a correction of what was in the paper with regard to the opinion of the late Professor Jenkins; what Mr. Biles had assumed was quite correct, for Professor Jenkins had communicated his opinion privately; he, however, was able to read from a written communication of the latter, who had written that "a fine vessel would still have some advantage over a full one in longitudinal bending moment." It had been said that more work was required to be done upon this question; and that was true, for Mr. Read's paper had contained a great many assumptions. Mr. Biles had said that he hoped the sagging moments would be added, but the sagging strains should be taken at the beginning of the voyage when the bunkers were full of coal, for then they were the most severe. For his own part, he had always thought that the hogging strains were most severe, and he therefore did not think it necessary to include the sagging moments. He would, however, put them in the Table in certain instances.

A Rapid Stability Rule.

Mr. W. Hök next read a paper "On the Transverse Stability of Ships and a Rapid Method of determining it." After dealing with certain elementary considerations, the author went on to point out that the present practice is to estimate the stability of a ship from the amount of lateral displacement of the centre of gravity; and numerous methods of calculating stability, perfected through the introduction of Amsler's integrator, have been devised for this purpose. On the other hand, the vertical displacement is generally ignored, except in solitary cases, such as in rolling of ships, stability under canvas, &c., but if wanted it is calculated from the curve of statical stability.

Under these circumstances the author stated that he thought it not in the least surprising that this vertical displacement of the centre of gravity is not generally known; for its production, being a sequel to that of the righting arm, entails extra work and time; especially as the knowledge of a ship's stability obtained from the latter is sufficient for most purposes. The author therefore introduced a method which was a reversal of ordinary practice. He calculated the vertical displacement of the centre of gravity first, and then found the curve of righting arm by differentiation.

The reason for following this course was that it was simpler. By it he could substitute the planimeter for the integrator. The time occupied, and consequently the cost of production, was about one-fourth. Although there is a ready and sufficiently accurate method for constructing the curve of righting arm from the curve of vertical displacement, this method might not be required in practice, as the latter curve, in conjunction with the metacentric height for the upright position, might be deemed sufficient for ordinary purposes. What is generally observed in the curve of righting arm is: (1) Its nature near the upright position. (2) The maximum righting arm, and the corresponding inclination of the ship. (3) The angle of vanishing stability. For all practical purposes, the curve near upright is fixed by the metacentric height. Furthermore, the maximum righting arm and the point of vanishing stability occur at the point of inflection, and the maximum ordinate of the curve of dynamical stability respectively, and are, therefore, known with sufficient approximation. Some firms, however, fix also certain minimum values for the righting arm at 30 deg. and 45 deg., and therefrom calculate the point above which the centre of gravity has not to pass. But in such cases minimum values of the vertical displacement of the centre of gravity can as easily be assumed instead—say, for instance, 3 in. at 30 deg., and 4½ in. at 45 deg. It then appears that the dynamical curve of stability can replace the statical curve; and the author therefore proceeded with a method of stability, the aim of which was to find the vertical displacement of the centre of gravity relative to the centre of buoyancy.

The method described consists first of calculating with the planimeter ordinary curves of displacement for the upright position and four inclinations, viz., 10 deg., 30 deg., 60 deg., and 90 deg. One of these displacement curves having been laid down a vertical line drawn from the bottom end of the curve would represent the draught. It would then be necessary to measure with the planimeter the areas between the vertical axis, the displacement curves, and the water lines which cut off equal displacement on the various curves. This process would give for equal displacement the distances of the various centres of buoyancy from their respective water lines. Further, the distances of these centres of buoyancy to lines drawn from the centre of buoyancy for upright parallel to the respective inclined water lines would be measured or calculated.

This would be the whole process; for the distances just referred to are the vertical displacements of the centre of gravity, on the supposition that it coincides with the centre of buoyancy. But as the calculations were carried out only for four different inclinations, it was necessary to draw auxiliary curves, one for each displacement, the abscissæ of which are angles of heel, and the ordinates the vertical displacement of the centre of gravity, in order to find the vertical displacement for 20 deg., 40 deg., 50 deg., 70 deg., and 80 deg. by interpolation. Finally, cross-curves as shown in the paper were drawn, there being one curve for each inclination, the ordinates of which are draught and the abscissæ the vertical displacement of the centre of gravity. The theoretical consideration on which the theory was based was given by the author in an appendix.

Mr. Macfarlane Gray opened the discussion on Mr. Hök's paper. He said he had not considered the details of the methods of calculation proposed by the author. These would be best appreciated by those having daily experience of such calculations. He perceived that Mr. Hök had a thorough grasp of the subject and a fertile mind. In the present paper there was a new form of stability curve for the centre of gravity at the centre of buoyancy. There were two defects in this curve. The angle of inclination was lost sight of, and it required a calculation to make the diagram serviceable for other positions of the centre of gravity. In the Transactions of the Institution for 1875 there was a paper by the speaker on "Polar Diagrams of Stability," in which the pedal of the evolute of the curve of buoyancy for the pole at the upright centre of buoyancy was shown to be a stability diagram. The paper gave the righting arm and also the vertical distance between the centre of gravity and centre of buoyancy for all inclinations on lines at the respective inclinations of the deck and the centre plane of the ship. It was also applicable without calculation for the centre of gravity in any other position without a