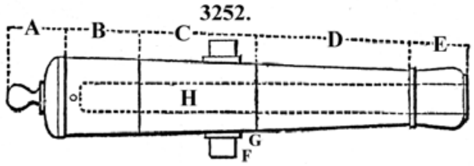
ORDNANCE, CONSTRUCTION OF. The term ordnance includes artillery of all kinds in its most comprehensive signification. Within the last twenty years the art of using a gun and developing its power has been virtually transformed by the aid of scientific research and mechanical skill. This process of evolution is in active progress. The production of a gun more powerful than any hitherto known serves but as a challenge to the manufacture of armor capable of resisting the shot from that weapon; and success in this last involves efforts toward the construction of cannon of still greater penetrating energy. With the enormously heavy guns of modern times, new discoveries in the strength of gun-metals, in the art of making projectiles, in the nature of explosives, and in the resistance of various forms of armor, are made. These in turn react upon principles of gun construction previously deemed settled, and produce modifications in them ; and thus advancement is accomplished by the light of experiment alone.

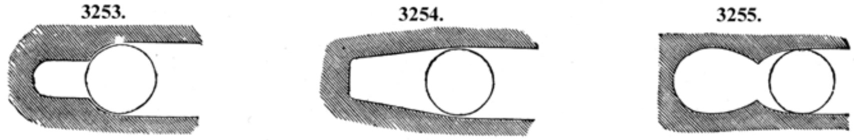
THEORY OF CONSTRUCTION.--*Constituent Parts*.-Cannon are classified as guns, howitzers, and mortars, or as field, mountain, prairie, siege, and seacoast cannon. Fig. 3252 represents an old form of cannon, which exhibits clearly the five principal parts into which nearly all guns are regarded as divided. These are the breech, ***A*** ; the first reënforce, ***B***; the second reënforce, ***C***; the chase, ***D*** ; and the swell of the muzzle, ***E***. The breech is the solid part of the piece in the prolongation of the axis; its length should be from one to one and a quarter time the diameter of the bore, ***H***. The first reënforce extends from the base-ring to the seat of the ball, and is the thickest part of the piece, for the reason that the pressure of the gas is found by experience and calculation to be the greatest before the ball has moved far from its place. The second reënforce is that portion of the piece to which the trunnions are attached, and extends from the first reenforce to the chase; it is made thicker than is necessary to resist the pressure of the gas, in order to serve as a proper support for the trunnions and to compensate for defects likely to appear in all castings of irregular shapes. The chase extends from the end of the second reënforce to the muzzle, or to the swell of the muzzle, which is now generally omitted from large cannon. Trunnions, ***F***, are cylindrical arms attached to the sides of cannon for the purpose of supporting them upon their carriages, and permitting them to be elevated and depressed in action. On the supposition that the strain upon the trunnions is proportional to the weight of the charge, it is laid down as a rule that the diameter of a gun's trunnions should be equal to the diameter of its bore, and of a howitzer's equal to the diameter of its chamber. The axis of the trunnions is placed in the same plane with the axis of the piece in all the cannon of the United States service; and in this position the force of the charge is communicated to the trunnions directly, without producing any other than the inevitable strain on the carriage, and without checking the recoil. Were the axis of the trunnions above or below that of the piece, the force of the discharge would act to turn the

3252.



piece slightly upward or downward, producing unequal strains. In many cannon the axis of the trunnions passes also through the centre of gravity of the piece. This arrangement was introduced by Gen. Rodman, who has shown that cannon constructed in this way may be fired with accuracy, and, although easily moved, do not when fired sensibly change their position before the projectile leaves the bore.

The interior of cannon may be divided into three distinct parts: the vent, or channel by which fire is communicated to the charge; the chamber, or seat of the charge; and the bore, or that part of the cylinder passed over by the projectile. The size of the vent should be as small as possible, in order to diminish the escape of the gas, and the erosion of the metal which results from it; and experiment shows that the interior orifice of the vent should be placed at a distance from the bottom of the chamber equal to a quarter of its diameter, or at the junction of the sides of the chamber with the curve of the bottom. The form of the chamber, or seat of the charge, has an effect upon the force of the gunpowder, as well as upon the strength of the piece to resist it; and experience has shown that its length should in general be equal to its diameter, and its surface should be as small as possible compared with its volume. The charges with which solid projectiles are fired being generally greater than one-sixth of their weight, the cartridge occupies a space the length of which is greater than the diameter; the form of the seat of the charge is therefore simply the bore prolonged. This arrangement reduces the length of the charge so that its inflammation is as complete as possible before the projectile begins to move. To give additional strength to the breech, the bottom of the bore is generally rounded into an arc of a circle, but is sometimes hemispherical, tangent to the surface of the bore. All cannon of the newest models have the bottom of the bore finished as a semi-ellipsoid, this form being thought to give greater strength than the hemisphere. The accompanying figures illustrate the various forms of chambers in use. Fig. 3253 represents a cylindrical chamber; Fig. 3254, a conical chamber; and Fig. 3255, a spherical chamber.

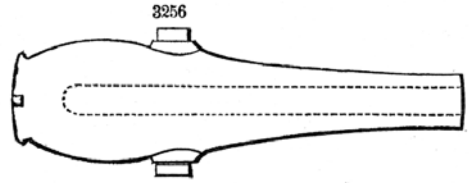


3253. 3254. 3255.

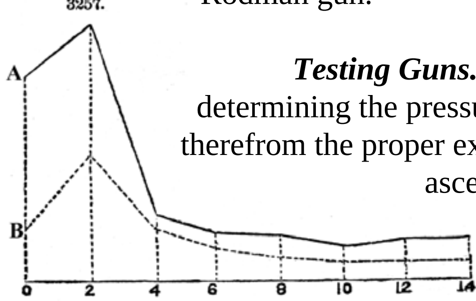
Length of Bore.-Originally, when mealed powder was habitually used, it was believed that the longest pieces gave the greatest range. In accordance with this idea, culverins were made of great length, and were only shortened after repeated experiments showing that the range increased at each reduction in length. The length of the bore has an important effect upon the velocity and range of the ball. This will be clearly seen by a consideration of the forces which accelerate and retard its movements. The accelerating force is due to the expansive effort of the burning powder, which is greatest when the grains are completely converted into gas, which in turn depends upon the size of the charge and the size and constitution of the grains. The retarding forces are the friction of the projectile against the sides of the bore, the shocks of the projectile striking against the sides of the bore, and the resistance offered by the column of air in front of the projectile. As the accelerating force of the charge increases up to a certain point, or till the combustion is completed, and rapidly diminishes as the space ih rear of the projectile increases, and as the retarding forces are always opposed to its motion, it follows that there is a point where these forces would become equal, and the projectile move with its greatest velocity; it also follows that after the projectile passes this point its velocity decreases, until it is finally brought to a state of rest, which would be the case in a cannon of great length. Experiments made by Maj. Mordecai show that the velocity increases with the length of bore up to 25 calibres, but that the gain beyond 16 calibres gives an increase of only one-eighteenth to the effect of a 4-lb. charge. Taking the calibre as the unit of measure, it has been found by experience that the length of bore is greater for small arms which fire leaden bullets than for guns which fire iron shot, and greater again for the latter than for howitzers and mortars which fire hollow projectiles. In the earlier days of artillery, when dust instead of grained powder was used, the weight of the charge was equal to that of the projectile; but it is now admitted that a charge of powder equal to one-fourth of the weight of the projectile, and a bore of 18 calibres long, are the most favorable combination that can be made in smooth-bored cannon, to obtain the greatest range with the least strain upon the piece and its carriage.

Strains.-The kinds of strain to which a cannon is subjected are: 1. A tangential strain, tending to split the gun open longitudinally, and similar in its action to the force which bursts the hoops of a barrel; 2. A longitudinal strain, tending to pull the gun apart in the direction of its length, which tendency is a maximum at the bottom of the bore, and diminishes to zero at the muzzle; 3. A strain of compression exerted from the axis outward, tending to crush the truncated wedges of which a unit of length of the gun may be supposed to consist, and to diminish the thickness of the metal to which it is applied; and 4. A transverse strain, tending to break transversely the staves of which the gun may be supposed to consist, and similar in its action to the force which breaks the staves of a barrel. A formula embodying the strains, the pressure of the gas, and all other elements entering into the question, was deduced by Gen. Rodman from a series of original experiments. Its solution for particular cases gives a series of curved lines, a specimen of which is shown in Fig. 3256, which represents a Rodman gun.

3256



3257.



Testing Guns.--Various methods have been resorted to for determining the pressure of the gases throughout the bore, and deducing therefrom the proper exterior form for different kinds of cannon, and also of ascertaining the safety of the gun. Among the most successful of these is a modification of a plan first used by Col. Bamford in 1841, and subsequently improved by Gen. Rodman. It consists in boring a series of small holes through the sides of a cannon at right angles to its axis, at intervals of one calibre, and loading them with steel balls, which are projected by the force of the charge into a ballistic pendulum. The pressure at the various points is calculated from the velocity given to the balls. Gen. Rodman's modification consists in substituting for the bullets a steel punch which is pressed by the force of the gases into a piece of soft copper. The weight necessary to make an equal indentation by the same punch in the same copper is then obtained by machinery for each hole in the side of the gun, and a curve is constructed by plotting the results thus obtained, as in Fig. 3257. The ordinates of the curve *A* show the pressure on the bore at intervals of two calibres, commencing at the bottom of the bore for grain-powder; and those of the curve *B* show the same for cake-powder. The latter produced only about one-half the mean pressure on the length of the bore, and gave nearly the same velocity to the projectile. The sources of uncertainty in this form of gauge, however, are various, and the limits of error can never be predetermined.

In 1853-'56 a series of elaborate experiments was made at the Washington Arsenal, upon an apparatus devised by Dr. W. E. Woodbridge, termed a "piezometer" or pressure-measurer. Renewed attention has lately (1879) been directed to these trials, and a full record of them has been published in "Ordnance Notes, No. XC., dated Nov. 20, 1878.

Rifling.-The object of rifling a gun is to increase its accuracy of fire, and, by enabling elongated projectiles to be substituted for spherical ones, to obtain longer ranges. To rifle a gun, spiral grooves are cut in the surface of the bore, into which the projections or soft-metal coating of the projectile are made to enter. The spaces between the grooves are called "lands." Where the grooves are very wide and the lands very narrow, they are termed "ribs." The calibre of a rifled gun is measured across the lands; in the case of a rib-rifled gun, it is measured to the bottom of the grooves. Most of the systems of rifling that have been adopted may be divided into the following classes: 1. Muzzle- or breech-loading guns having projectiles of hard metal, fitting the peculiar form of the bore mechanically; 2. Muzzle- or breech-loading guns with projectiles having soft-metal studs or ribs to fit the grooves; 3. Muzzle-loading guns with projectiles having a soft-metal envelope or cup, which is expanded by the gas in the bore; 4. Breech-loading guns with projectiles having a soft-metal coating larger in diameter than the bore, but which is compressed by the gas into the form of the bore.

To the first class belong the Whitworth, Vavasseur, Scott, and Lancaster systems. The Whitworth gun has a hexagonal spiral bore, the corners of which are rounded off. The form of the bore is not, however, strictly hexagonal. The interior of each gun is first bored out cylindrically, and when the rifling is completed a small portion of the original cylindrical bore is retained along the centre of each of the sides of the hexagonal bore, and the other parts of each side recede or incline outward toward the rounded angles; hence the diameter of the hexagonal bore is greatest at the rounded angles. In Vavasseur's system, the rotation is given by means of raised ribs in the bore, while the projectile itself has corresponding grooves cut along its cylindrical surface. The ribs are three in number, and there are no sharp angles either in the projectile or the bore of the piece. The twist is one turn in 30 calibres for all sizes. In Scott's system, the bore is rifled with narrow shallow grooves, deeper on the driving than on the loading side. The projectile is one iron casting, having ribs almost triangular in section, extending the whole length of the cylindrical body, and set to the angle of the rifling. Lancaster's system may be described as that of the usual circular bore with two wide grooves, each about one-third the circumference in width, the shoulders of the grooves being shaved off so as to form an ellipse. The cross-section of the bore is oval, only a trace of the original bore being left at the minor axis. This system has not been successful in competition with other systems.

To the second class of rifling systems belong the Woolwich or French rifling and the shunt system. The Woolwich system is a modification of the French, and consists of deep broad grooves, each of which receives two soft-metal circular studs. The grooves are three or more in number, according to the calibre of the piece. The shunt system is one of Armstrong's methods. Its peculiarity is that the depth and width of the grooves vary at different parts, the object aimed at being to provide a deep groove for the studs of the projectile to travel down when the gun is being loaded, and a shallow groove through which they must pass when the gun is fired, so that the projectile may be gripped and perfectly centred on leaving the muzzle. This is obtained by making one side of the groove (the driving side) shallow near the muzzle.

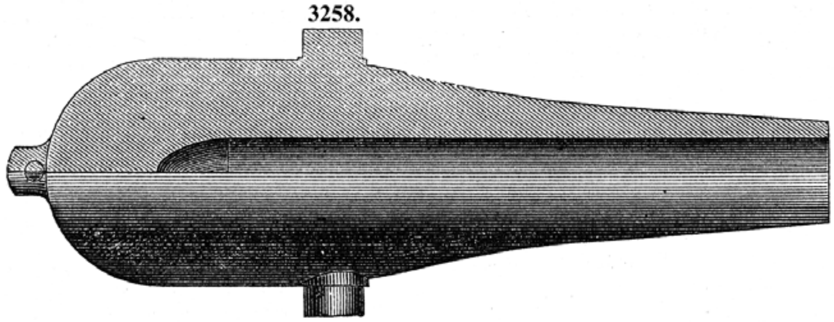
The third class of rifling is represented by the Parrott system. In this the grooves and lands are of equal width, the former being one-tenth inch deep for all calibres. The bottom corners of the grooves are rounded to facilitate cleaning and to avoid sharp angles. The projectiles are recessed around the corner of the base to receive a brass ring, which is expanded into the grooves of the gun by the explosion of the powder.

The fourth class of rifling is illustrated by the German system or Krupp's method. In this system, the grooves are usually 30 in number for all calibres, and are quite shallow. The sides are radial, forming sharp angles with the bore. The rifling has a uniform twist of one turn in 25 ft. The grooves are wider at the bottom of the bore than at the muzzle, so that the compression of the leadcoated projectile is gradual, and less force is expended in changing the shape of the projectile. This change of shape is effected by making the whole groove of the same size as at the muzzle, and then cutting away gradually on the loading edge of the groove. Of course, as the twist is uniform, the driving side of the groove cannot vary.

FORMS OF CANNON. – MUZZLE-LOADING SMOOTH-BORE. — The construction of smooth-bore guns is explained under ORDNANCE, MANUFACTURE OF. The principal forms are the Dahlgren and the Rodman.

The Dahlgren Gun is represented in Fig. 3258, which shows the form of the navy

3258.

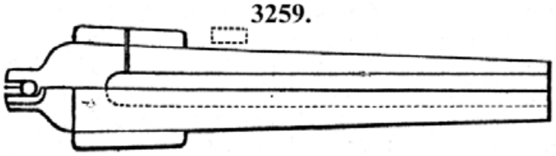


15-inch, such as is commonly used in monitor turrets. The principal data regarding these guns will be found in the table on page 21. The same table exhibits the dimensions, etc., of Rodman guns. The general form is shown in Fig. 3256.

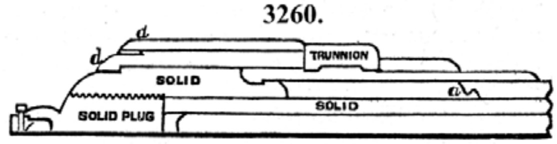
MUZZLE-LOADING RIFLES. — *The Parrott Gun*, Fig. 3259.-This is an American cannon, hitherto fabricated exclusively by the inventor, the late Captain Parrott of the West Point Foundry. Its peculiarity consists in the fact that the gun is a cast-iron piece, strengthened by shrinking a coiled hoop of wrought iron over that portion of the body which surrounds the charge. None of these guns have been manufactured since 1865.

The Armstrong Gun. — -To Sir William Armstrong is due the credit of employing wrought-iron coils shrunk together to form the gun. His principles are: (1) to arrange the fibre of the iron in the several parts of the gun so as best to resist the strain to which they are respectively exposed; and (2) to shrink the successive parts of the gun together so that

3259.



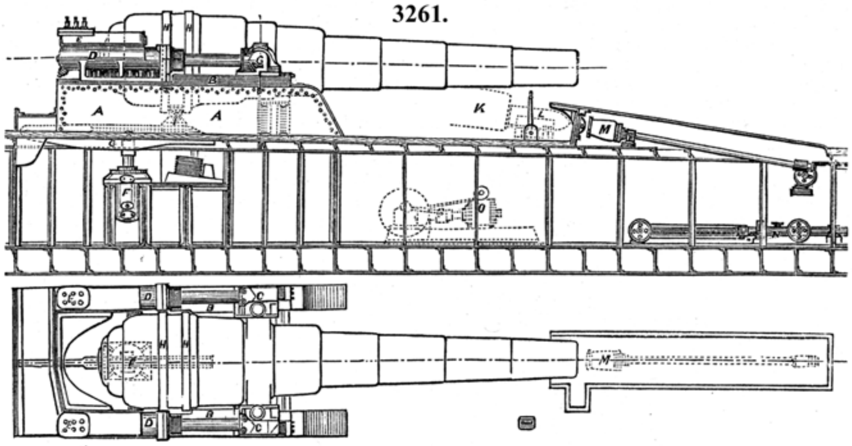
3260.



not only is cohesion throughout the mass insured, but the tension may be so regulated that the outer coils shall contribute a fair share to the strength of the gun. A section of this weapon is shown in Fig. 3260. The barrel is made of solid steel ingot bored out and tempered in oil, by which its brittleness is decreased and tenacity increased. That part of the barrel at and in rear of the trunnions is enveloped by three layers of wrought-iron tubes, not welded at the ends, but hooked to each other by shoulders and recesses. This is accomplished by heating and expanding the end of one tube and slipping it over the shoulder of another, upon which it contracts by cooling. The breech is closed by a cylindrical forged block with a bevel screw-thread cut upon it; this is screwed into the breech-coil and made to bear fairly against the solid end of the steel ***A*** tube; this also forms the cascable of the gun, and is called the *cascable-screw*. The first guns constructed by Armstrong were breech-loading, but his system of *fermeture* could not be applied to the larger calibres. This principle was therefore abandoned, and the muzzle-loading gun adopted.

A 100-ton gun of the Armstrong type has been constructed for the Italian armored vessel *Dandolo*, and is represented in a full-page engraving. (See ***ARMOR***.) The following are the leading particulars and dimensions : Total length over all, 32 ft. $10^{1}/_{2}$ in.; greatest diameter over chamber, 77 in.; diameter at muzzle, 29 in.; diameter at end of trunnion-coil, 45 in.; diameter of bore, 17 in.; length of bore, 30 ft. 6 in.; number of grooves, 27; twist at chamber, 1 in 150 calibres, increasing thence to a point near the muzzle to 1 in 50, after which it is uniform; preponderance, 4 tons; weight of projectile, 2,000 lbs.; powder charge, from 300 lbs. upward. The gun is built with a steel ***A*** tube made in two lengths, and of

3261.



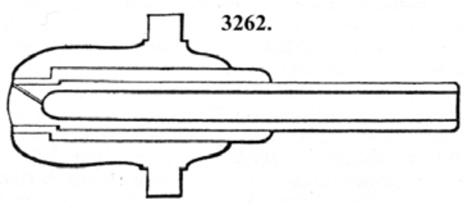
varying thicknesses increased in steps from the muzzle to the chamber. Around the chamber three coils are placed over the ***A*** tube as far as the trunnion-coil, where they are reduced to two, and finally to one for rather more than half the total length of the gun. The carriage upon which this monstrous piece of artillery is mounted consists of two blocks on which the trunnions rest, and which are free to slide in guides on the floor of the turret; behind these blocks are placed the hydraulic-brake cylinders, so as to take up the force of the recoil in the simplest and most direct manner. The gun was loaded and worked entirely by hydraulic power, as shown in Fig. 3261. ***A*** is the gun-platform, ***B*** the slide on which the gun recoils, ***C*** the sliding trunnion-blocks carrying the gun, and ***D*** the recoil-presses. ***E E*** are the chests containing the valves by which the resistance to recoil is regulated, ***F*** the elevating press, and ***G*** the hinged beam through which the elevating press acts on the gun, and upon which the breech of the gun slides in recoiling ; ***H H*** are iron bands connecting the gun with the sliding-block ***I***; ***K*** shows the position of the muzzle of the gun when depressed for loading after recoil ; ***L*** is the projectile on its trolley ; ***M*** the hydraulic telescopic rammer with sponge-head; ***N*** the chain and press for withdrawing the rammer ;

and ***O*** the engine for supplying the hydraulic power. The following table exhibits the results obtained from the trials of the 100-ton gun

Summary of Experiments wit the 100-*Ton Gun.*

NUMBER OF ROUND.	Weight of Powder Charge.	Weight of Projectile.	Muzzle Velocity in Feet per Second.	Total Energy in Foot-Tons.	Foot-Tons of Energy per Inch of Shots Circumference.	Foot-Tons of Energy per Pound of Powder.	Mean Pressure in Chamber in Tons per Sq. Inch.	Elevation.	Recoil.
									In.
1	300	2,000	. . . . .	. . . . . .	. . . . . .	. . . . .	. . . .	5.00	36
2	300	"	. . . . .	. . . . . .	. . . . . .	. . . . .	16	2.00	34
3	300	"	. . . . .	. . . . . .	. . . . . .	. . . . .	. . . .	. . . .	. . . .
4	330	"	1,446	28,990	544.05	87.85	. . . .	. . . .	. . . .
5	300	"	. . . . .	. . . . . .	. . . . . .	. . . . .	16	1.48	35.5
6	300	"	1,374	27,656	490.10	85.26	16	1	37.5
7	320	"	1,458	29,391	550.30	89.06	20.8	1	44.5
8	319	"	1,422	28,035	525. 00	87.S8	18.0	1	42.5
9	319	"	. . . . .	. . . . . .	. . . . . .	. . . . .	. . . .	6.5	44
10	336	"	. . . . .	. . . . . .	. . . . . .	. . . . .	19.4	1.5	46.25
11	340	"	1,475	30,163	564.80	88.7	. . . .	. . . .	. . . .

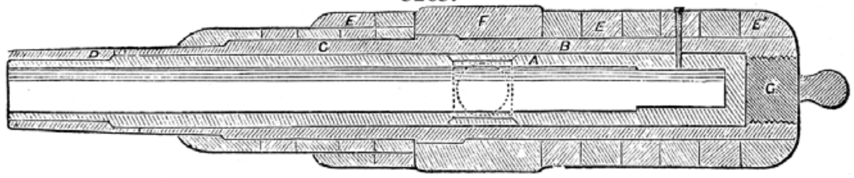
The Blakely Gun, Fig. 3262. – In this gun the inner tube or barrel is formed of low steel; the next tube consists of high steel, and is shrunk on the barrel with just sufficient tension to compensate for the difference of elasticity between the two. The outer jacket to which the trunnions are attacbed is of cast iron, and is put on with only the shrinkage attained by warming it over a fire. The steel tubes are cast hollow and hammered over steel mandrels by steam-hammers, by which process they are elongated about 130 per cent, and the tenacity of the metal at the same time is increased. They are made to throw 700-lb. projectiles, with a calibre of 12 in., and weigh as much as 40,000 lbs.



3262.

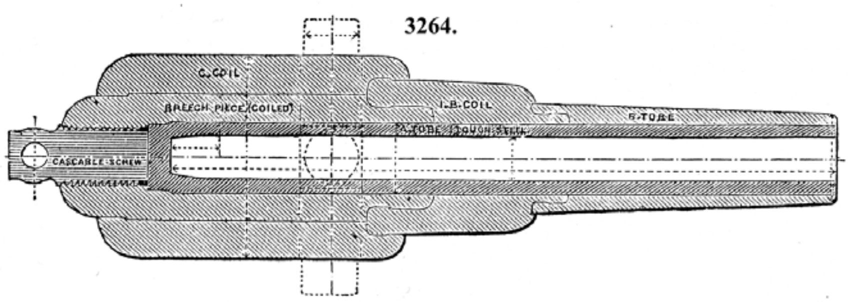
The Vavasseur Gun, Fig. 3263. – This gun is manufactured entirely of steel. The inner or ***A*** tube is rough-bored, left solid at its breech end, turned down nearly to its finished dimensions, then tempered in oil; after which it is again turned and fitted for the jacket ***B***, which is shrunk over the breech end of the ***A*** tube; the proper amount being allowed for shrinkage, which amount is carefully ascertained by gauging the surfaces to be joined. The ***B*** tube is heated over a pit, the furnace being constructed around it. When sufficiently heated the ***A*** tube is quickly lowered into its place by means of a crane, and the whole allowed to cool, the fire being smothered with sand. Any longitudinal movement of these surfaces is prevented by a shoulder abutting. Coiled steel hoops are then shrunk over the chest, and the gun turned for receiving the trunnion-hoop and the remaining front and rear ones. The hoops are short, being from 6 to 8 in. in length, and can therefore be thoroughly worked and more easily and accurately adjusted. The rifling is upon the rib system, 1 turn in 30 calibres, uniform for all sizes of the gun, requiring no studs upon the projectile, giving more bearing surface for it, and rendering the bore less liable to foul.

3263.



The Woolwich Gun, Fig. 3264. – This gun now forms mainly the type used for English armaments, and is built upon the Armstrong principle modified and improved by Mr. Frazer, who reduced the cost of the gun as well as the number of parts. These guns have been constructed of various calibres, viz., 7 in., 8 in., 9 in., 10 in., 11 in., 12 in., 16 in. The last named is known as the 81-ton gun, a description of which will suffice to show the method of construction for all sizes. The interior of the gun was formed by a solid-ended steel tube, weighing $16^1/_2$ tons, and having no flaws. The material used was entirely crucible steel, being melted in about 240 small crucibles, whose contents were run into a large mould. Over the rear end of the steel tube was shrunk a very powerful coil of wrought iron, called the *breech-piece*. This was made of a single bar, 12 in. thick from inside to outside, hammered, rolled, and coiled – forming a cardinal point in the mode of construction. The cascable was next screwed in, so as to abut firmly against the solid end of the tube, and the ***B*** coils were then shrunk on into their places. The ponderous ***C*** coil, carrying the trunnions, was made of two coils, one outside the other, and was 18 in. thick. These coils were welded together under the 40-ton hammer. It should be stated that, in order to obtain greater certainty of soundness and ease of manipulation, both the breech-piece and the ***C*** coil were made in two pieces, which were welded together, end to end; care being taken that the weld of the breech-piece was not inconveniently near that of the ***C*** coil. The shrinkage of the powerful coiled breech-piece caused the bore to contract .020 in., and the compression of the massive outer coil carrying the trunnions was so great that it was transmitted through the breech-piece, and caused a further contraction of .023 in. in the bore.

3264.



This gun was first constructed with a calibre of 14.5 in., and tested. Its bore was then enlarged, and further tests were made at 15, and finally at 16 in. When first completed its weight was nearly 82 tons; length of bore, nearly 24 ft.; total length, 27 ft.; number of grooves, 11, spiral, increasing from 0 to 1 in 35 calibres at the muzzle. The inner and trunnion coils are respectively 10.5 in. and 13.5 in. thick. The diameter of the gun at its different lengths is 72 in., 54.5 in., 37.5 in., 3' 3.3 in., and 25 in. After the tests upon the experimental gun modifications were introduced in those subsequently made. The rifling was altered to conform to the polygroove principle, and has a gaining twist commencing at 0 at the front of the powder space and terminating in 1 in 50 at the muzzle. There are 32 grooves 1 in. wide and $^1/_{10}$ in. deep with $^1/_2$-in. lands. The gun has at present a uniform calibre of 15.5 in. The rate of advance of the rifling was arranged so that the curve of resistance given by it approximately follows the curve of pressures afforded by the explosion of the powdercharge during the passage of the projectile through the bore of the gun. The forces at work within the gun are thus practically balanced, the moment of greatest resistance o£ the shot being coincident with that of the greatest force of the powder.

***The Whitworth Gun*. —** This gun was invented by Sir Joseph Whitworth, and is manufactured of homogeneous iron or of steel, the smaller calibres being forged solid, and the larger ones built up. The 7-inch Whitworth is constructed of a central steel tube, covered by a second tube extending its entire length, over which hoops or jackets of steel, cast hollow and hammered out over a steel mandrel, are shrunk. The hoop for the trunnions is shrunk on separately. The inner jacket laps the rear of the tubes, and is screw-tapped; the outer jacket is fitted in the same manner, and the rear end of the tube is also tapped. Into these fit the breech-plugs, which have three corresponding shoulders made to enter the tapping in the tube and outer and inner jackets. The vent is through the breech-plug and in prolongation of the axis of the bore. The rifling, as has already been explained, is radically different from that of other guns, the motion being given by spiral hexagonal surfaces, requiring the projectile to be fitted with corresponding exterior surfaces. This method admits of the more rapid twist which is necessary, together with a higher initial velocity, than with the rib or groove rifling; this necessitates greater strain, but increases range and admits of greater accuracy. The gun was designed for use of heavier charges of powder and longer projectiles than used with other guns. To make the gun endure the strain occasioned by the use of high charges and long projectiles, Sir Joseph Whitworth now manufactures his gun of a superior steel known as the "Whitworth metal." This metal is compressed while in its molten state by applying a heavy pressure, thus increasing its density and tenacity.

II. BREECH-LOADING RIFLES. — England has adopted the muzzle-loading system. France, Germany, Russia, Austria, Italy, Turkey, and Sweden adhere to breech-loaders. Among the chief advantages which breech-loading is claimed to possess, as compared with muzzle-loading, are the perfect fitting of the projectile in the bore, the true centering of the shot, the quicker and more convenient serving of the gun, and the greater security to the gunners, and, as the consequence of these advantages in combination with a suitable class of rifling with uniform twist, far greater endurance of the gun. higher initial velocity of the projectile, increased accuracy, and better powers of penetration.

***The Krupp Gun*. –** The. guns constructed by Mr. Friedrich Krupp at Essen, Prussia, are built up by shrinking hoops of steel over a central tube with initial tension. In large calibres the layers of hoops are double.

3265.

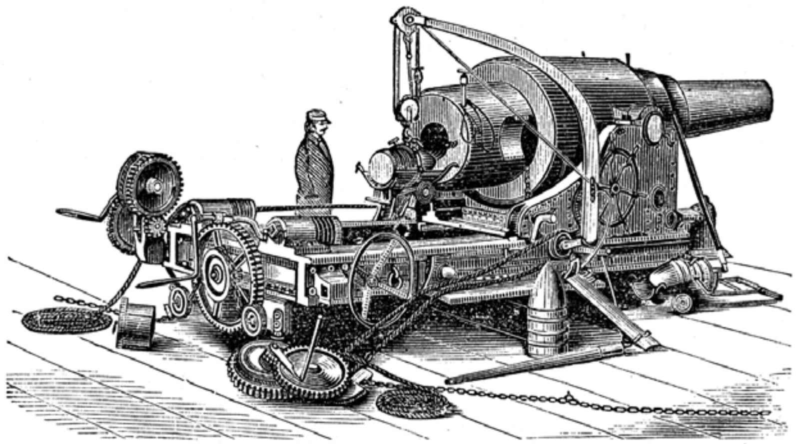
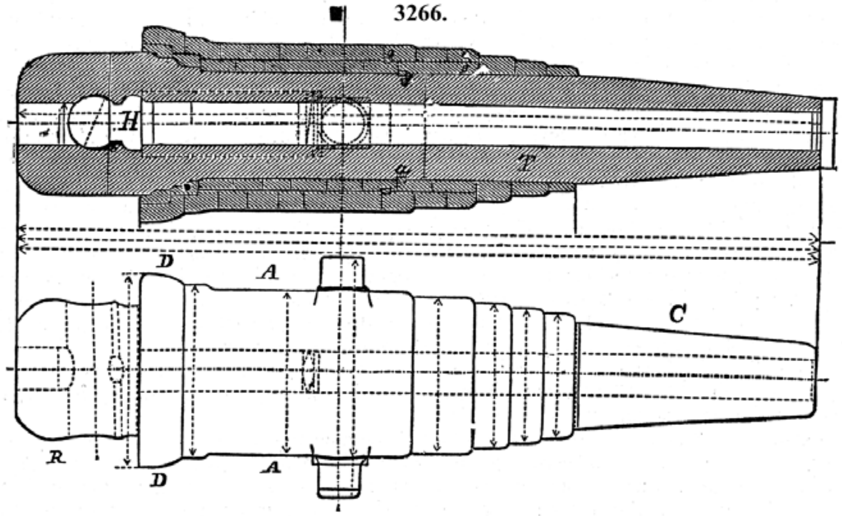


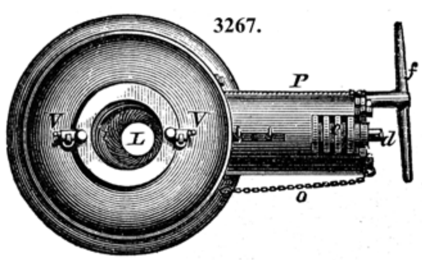
Fig. 3265 exhibits the gun on its carriage, and the construction of the piece is shown in Fog. 3266. ***R*** is the breech or bottom piece; ***A***, the hooped or middle piece; and ***C***, the cone or chase. The breech-piece immediately in rear of the hooped piece contains the wedge-hole ***H***, cutting through at right angles to the axis of the bore. In the base of the breech is the hole, ***L,*** for loading, Fig. 3267; and on the side of this aperture is a hook, ***V***, with two slots for the hinges of the loading-box and hooks for the shell-bearer. The hooped piece, diminishing in front by steps toward the chase, has in its rear the protruding end hoop, ***D***. The central tube, ***T***, is very massive, and is forged and turned from a single ingot, losing half its weight in the lathe. The hoops are made with an endless fibre, and are kept from working on the gun by key-rings. The breech-plug is a steel cylindro-prismatic wedge, which slides in a mortise on the breech-piece. In the Krupp, as well as in nearly all modern breech-loading guns, the Broadwell gas-check, Fig. 3265, is used. This consists of a plate, ***H***, and ring, ***L***. The latter is of steel, and fits into a groove at the bottom of the bore close to the wedge mortise. In the face of the breech-block is a circular recess, the diameter of which corresponds with the outside diameter of the ring. In this recess is placed the steel-plate, and against this the ring takes its bearing. The cylindro-prismatic block is moved to and fro by means of two screws. The first of these is a quick-motion screw with several threads upon it This screw is merely used for running the block easily in and out, and is dispensed with in all calibres less than 8 in., in which handles are attached to the end of the block, which is moved by hand. The second screw is employed for jamming and locking the block, and it works into a large cylindrical nut let into a socket made in the broad end of the large block. A portion of the thread of this screw is cut away, so that as it is turned the thread may either engage or disengage with the breech of the gun, and the block is thus locked or unlocked.

3266.

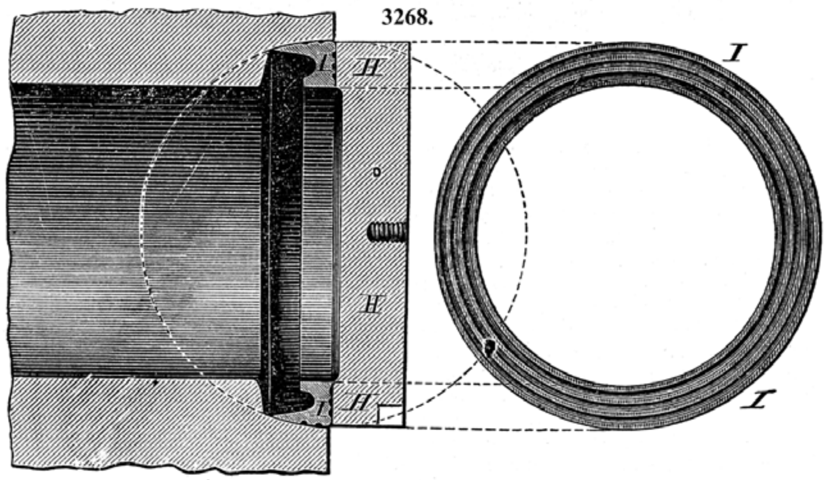


As the block is run home (and this can be done easily without the screws, and by one hand even in the 12-in. gun), the circular plate and the back of the ring come into close contact, and from their form it is impossible that either can be displaced. The rifling is polygroove, and a slightly different twist is given to the sides of the grooves, being 1 turn in 64 ft. 2 in. on one side, and 1 turn in 64 ft. 10 in. on the other, thus making the grooves of diminishing width toward the muzzle, and insuring the tightness of the gas-check. The vent passes through the breech-block, and is in line with the axis of the bore. The chamber is eccentric to the bore, the lower surface being level with the lands, which admits of the projectile moving readily and taking the grooves immediately upon starting from its seat, and preventing gas-escape. These guns have proved superior to all others in endurance, and in trials with the Armstrong gun, at Tegel in Prussia and Steinfeld in Austria, they stood the full test, while the latter failed after comparatively few rounds.

3267.



3268.

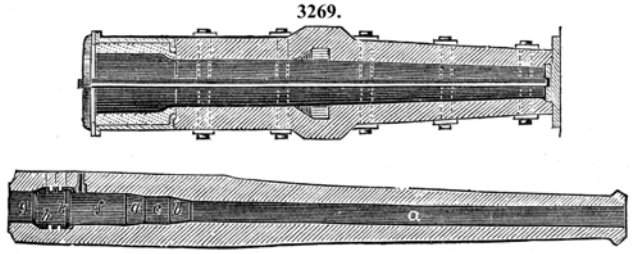


The largest steel gun yet (1879) constructed has been built by Mr. Krupp. It weighs 72 tons, and has a calibre of $15^3/_4$ in.; length of the gun 32 ft. 8 in., and of the bore 28 ft. 6 in. The length of bore in the Krupp gun is thus apparent, being $21^3/_4$ calibres, as against 18 calibres in the English 81-ton gun. The material of which the Krupp gun is composed is steel throughout. The core of the gun consists of a tube running its entire length, as in the Woolwich gun, but open at the rear, the loading being at the breech instead of the muzzle. The tube of this large weapon being of such great length, it has been made in two portions, the joint being secured in a peculiar manner.

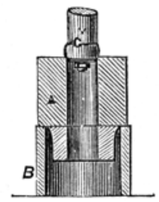
The charge for this monster gun is 385 lbs. of prismatic powder, the projectile being a chilled-iron shell of 1,660 lbs., with a bursting charge of 22 lbs. of powder. The velocity of the projectile as it leaves the muzzle of the gun is calculated to be 500 metres, or 1,640 ft., per second, corresponding to an energy of very nearly 31,000 foot-tons. It is estimated, rather as a matter of curiosity than otherwise, that if the gun were fired with its axis raised to an angle of 43˚ with the horizon, it would send its projectile to a distance of 15 miles. Great accuracy is also claimed for this weapon, as for all the Krupp breech-loading guns.

The Dean-Uchatius Bronze-Steel Gun. — This gun, constructed on a system devised by Mr. S. D. Dean of Boston, is composed of an alloy of 8 per cent. tin and 92 per cent. copper, cast in a cast-iron mould, in which is placed a cylinder of copper, which by absorbing part of the heat of the molten metal causes rapid chilling of the central portion. A sand-mould is added so as to form a deadhead, in which, owing to the use of the sand, the metal remains in the molten state for a comparatively long time, and so fills up any recess that would otherwise be formed in the chilled portion underneath. In short, the dead-head performs the usual function of feeding the casting under these special conditions. In Fig. 3269 is shown the mould ready for casting a field-gun with the interior copper cylinder. The core is eventually entirely removed by the boring bit, whose size is sufficient to cut the copper entirely away. In a gun whose bore is nearly $3^1/_4$ in., the bronze is compressed by the introduction in succession of six steel mandrels, which are forced home by hydraulic pressure, The mandrel, which is well tempered, is formed at the end into a truncated cone, so as to force the metal outward and enlarge the bore. ***B***, Fig. 3270, represents an annular support on which the gun ***A*** rests. After compression the bore has a diameter of nearly $3^{1}/_{2}$ in.

3269.

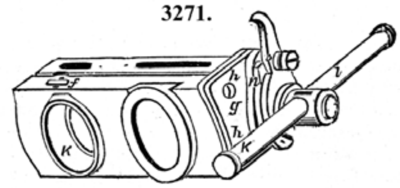


3270.



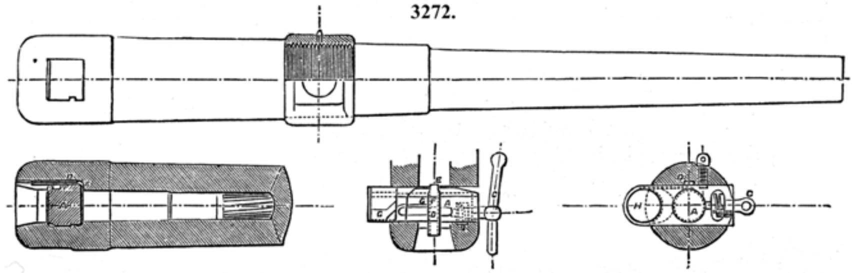
The breech-block, Fig. 3271, is also of bronze-steel, and rectangular. The loading-cylinder, ***K***, is also of bronze, cylindrical, and dovetailed into the breech-block as shown, so as to be capable of movement backward and forward. To the left end of the breech-block is attached the arrangement for moving it, and for securing it in position. This consists of the plate ***g***, secured by the screws ***h h***, through which passes the spindle of the square-threaded screw ***l***, which carries the cross-handle ***k*** at the outer end. The thread of the screw ***l*** is so cut that when the handle ***k*** is horizontal, no part of the thread projects beyond the rear face of the block, and the latter can be moved laterally in the slot until this thread comes opposite the female thread cut for its reception in the rear face of the breech-block slot; a half turn of the cross-handle, bringing the same vertical, then causes the screw to bite, and sends the breech-block well home.

3271.



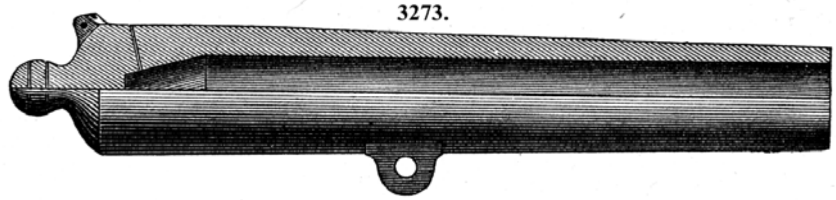
The cannon produced in the manner described are declared to possess all the hardness, homogeneousness, and resistance of steel tubes. The compressed bronze is not more liable to wear than steel, and is much less affected by atmospheric agency. The cost of bronze guns is much less than that of steel, if the value of the old metal be taken into account. One of these new bronze guns has borne several hundred discharges, with the ordinary charge, successively, without the slightest deformity or injury being apparent in any part of the piece.

3272.



The Hotchkiss Gun. — The construction of this gun is based upon the application of a metallic cartridge, forming the gas-check in the gun, the extraction of the empty cartridge-ease being performed automatically by opening the breech. The Hotchkiss cannon of all calibres are made of Whitworth's fluid-compressed steel ; those above 2.7 in. bore are jacketed with the same material. Mountain guns of smaller calibres are made of a solid forging, only the trunnion-ring of wrought iron being shrunk on. The breech-loading arrangement consists of a simple prismatic block ***A***, Fig. 3272, with a locking-screw ***B***, working in a recess in the breech and operated by a lever-handle ***C***, with which the block is at the same time drawn out and closed. As a metallic cartridge is used, tightening up the breech is unnecessary, and the breech-block simply forms a backing for the bead of the cartridge. In this manner the special gas-eheck is avoided. The cartridge-extractor ***D*** is a prismatic piece of steel, forming at its farther end the hook ***E***, and working in a recess on the upper part of the breech-slot, and parallel to the bore of the gun. It has on its under side a stud, ***F***, which works in a groove, ***G***, on the upper side of the breech-block. The stud of the extractor for a time runs in the straight portion of the groove; but as soon as the wedge is so far withdrawn that the loading-hole, ***H***, coincides with the chamber, the stud runs in the inclined part of the groove, and the extractor is consequently moved back quickly, and the empty cartridge-case is in this manner thrown out of the gun.

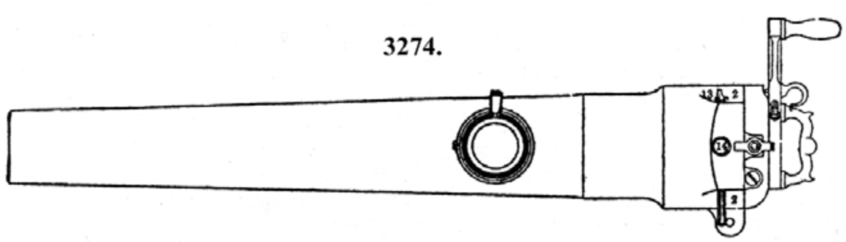
3273.



HOWITZERS are small cannon, usually made shorter and lighter than other guns of similar calibre, and intended for light charges, comparatively large projectiles, and moderate angles of elevation. Shells are most commonly used as projectiles, and the bore is chambered for the reception of the charge. United States naval howitzers are of bronze, and of the form shown in Fig. 3273. The piece is mounted on its carriage by the bore shown beneath.

Fig. 3274 represents the breech-loading naval howitzer, which is fitted with the French system of breech *fermeture*. In this system the breech is closed by a screw-plug of cast steel having 14 threads, which is screwed into the rear part of the bore. Were it necessary in firing to screw and unscrew the whole length of the plug at every

3274.



round, much time would be wasted; but this is obviated by dividing the screw into six parts in the direction of its axis, the threads being removed from every other one, both from the plug and from the breech of the gun. When the breech is to be closed, the threaded portions of the plug are presented so that they come opposite the smooth parts of the bore-hole. The slug is then pushed in, when a sixth of a turn with the handle brings the screw of both parts together.

MORTARS. — A mortar is a piece of ordnance with thick walls and large bore, designed to throw shells at high angles of elevation, usually 45˚, thus obtaining a vertical fire. On this account, and for convenience in loading, they are made stronger and shorter than other kinds of ordnance. They are chambered, and small charges of powder are employed, sufficient only to cause the projectile to reach the object. The shell usually contains combustible material for the purpose of firing structures, besides exercising also an additional destructive effect by the velocity of its fall. Mortars are mounted upon a carriage fixed upon a revolving platform, and are used afloat in small vessels especially fitted for them.

Rifled breech-loading mortars are now used by the principal European nations. Russia has a large number of bronze pieces of this type, fitted with the Krupp method of *fermeture*, but having the gas-ring of pure copper instead of steel. They are mounted with trunnions upon an iron carriage, consisting simply of two brackets united by a rear transom and several transverse bolts. The elevating gear is a pinion-wheel upon a revolving transverse shaft forward of the trunnions, working in a cogged arc under the piece, and capable of giving it 70˚ elevation. The Austrians and Prussians also have breechloading pieces of a similar type, and, though termed mortars, more nearly resembling howitzers of large calibre, designed to be used at high elevations.

PERFORMANCES OF HEAVY GUNS. — Fig. 3275, compiled by Major S. C. Lyford, Ordnance Department, U.S.A., shows the penetrative power of projectiles fired from English guns against iron-clad ships of war. Each target represents a certain class of vessels at a distance of 70 ,yards, except where the range at which projectiles would penetrate is stated. Where the target is shown perforated, but no range is given, it includes all distances up to 2,000 yards. It will be observed that the penetrative power of the German, French, Italian, and Russian guns is practically the same as that of the English, calibre for calibre. The Russian guns have the same power as the Italian 9.4-in., the 15-ton breech-loading rifle, and the 8.2-in., 11-in., and 12-in. German breech-loading rifles. The targets represent the armor and backing of different ships, as follows:

Targets A, B. — American iron-clads, *Miantonomoh, Canonicus*; English, *Minotaur, Resistance, Defence, Black Prince,* and *Repulse*; French, *Solferino, Peilio, Embuscade*; Russian, *Sevastopol, Pervenetz*; Austrian, *Kaiser Max, Ferdinand Max*; Danish, *Rolf Krake*; Turkish, *Orkanea*; Italian, *Ancona*; Spanish, *Saragossa*; Brazilian, *Herval, Silvado*.

Target C. — English, *Bellerophon, Penelope, Lord Warden*; French, *Alma, Flandre*; Russian, *Admiral Greig, General Admiral*; German, *Hausa*; Austrian, *Lissa*; Turkish, *Avni Illah*; Italian, *Venezia*.

Target D. — English, *Audacious*; French, *Ocean, Marengo*; Russian, *Minin*.

Target E. — English, *Hydra*; German, *Kaiser Wilhelm*; Austrian, *Archduke Albert*; Danish, *Odin*.

Target F. — French, *Friedland*; Dutch, *Duffel Tiger*; Turkish, *Fethi Bulend.*

Target G. — French, *Cerbere*; Italian, *Custozza*; Chilian, *Almirante Cochrane*.

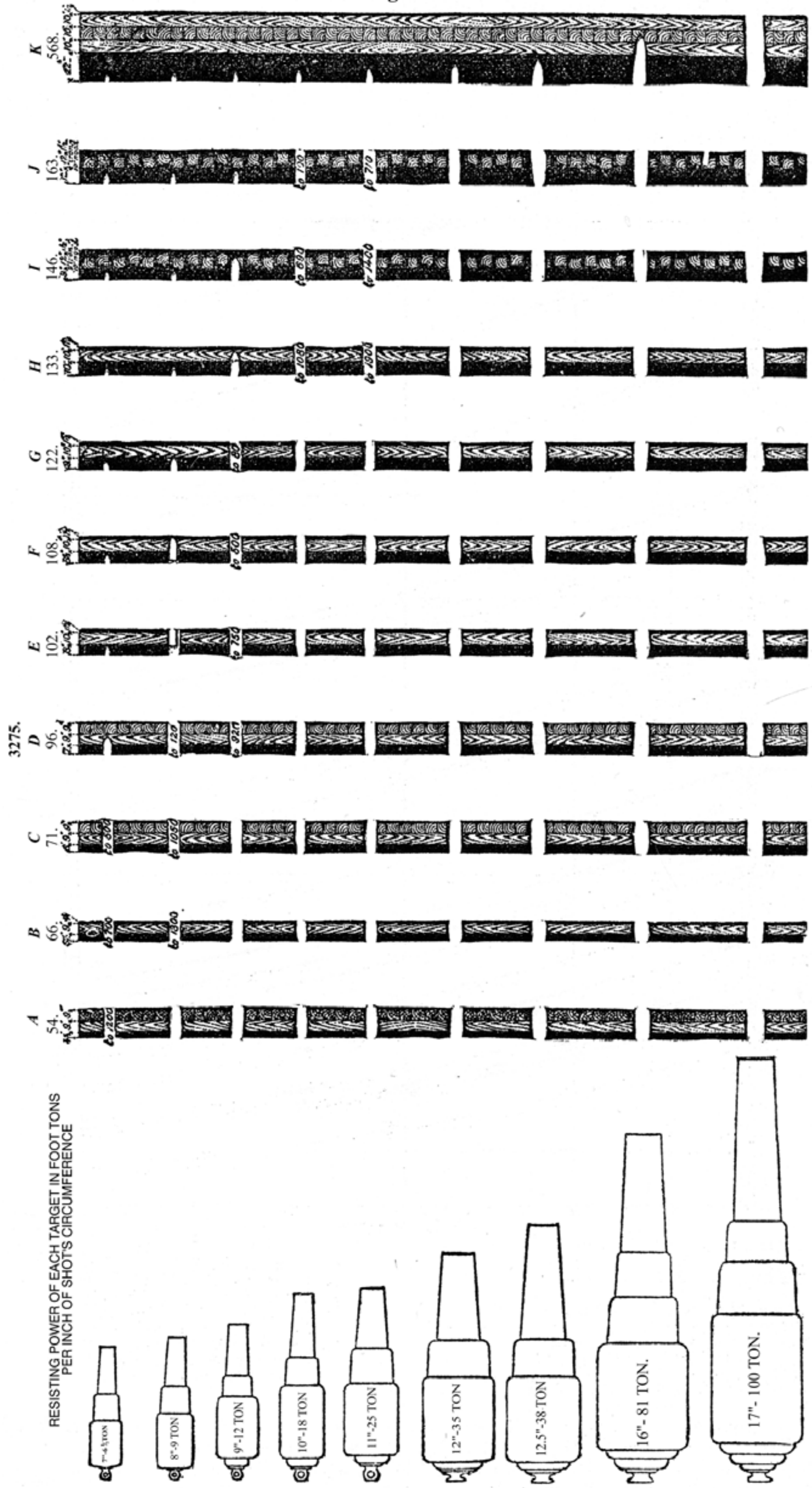
Target H. — German, *Kaiser*; Brazilian, *Independencia*.

Target I. — English, *Hercules, Hotspur*; Russian, *Novgorod*.

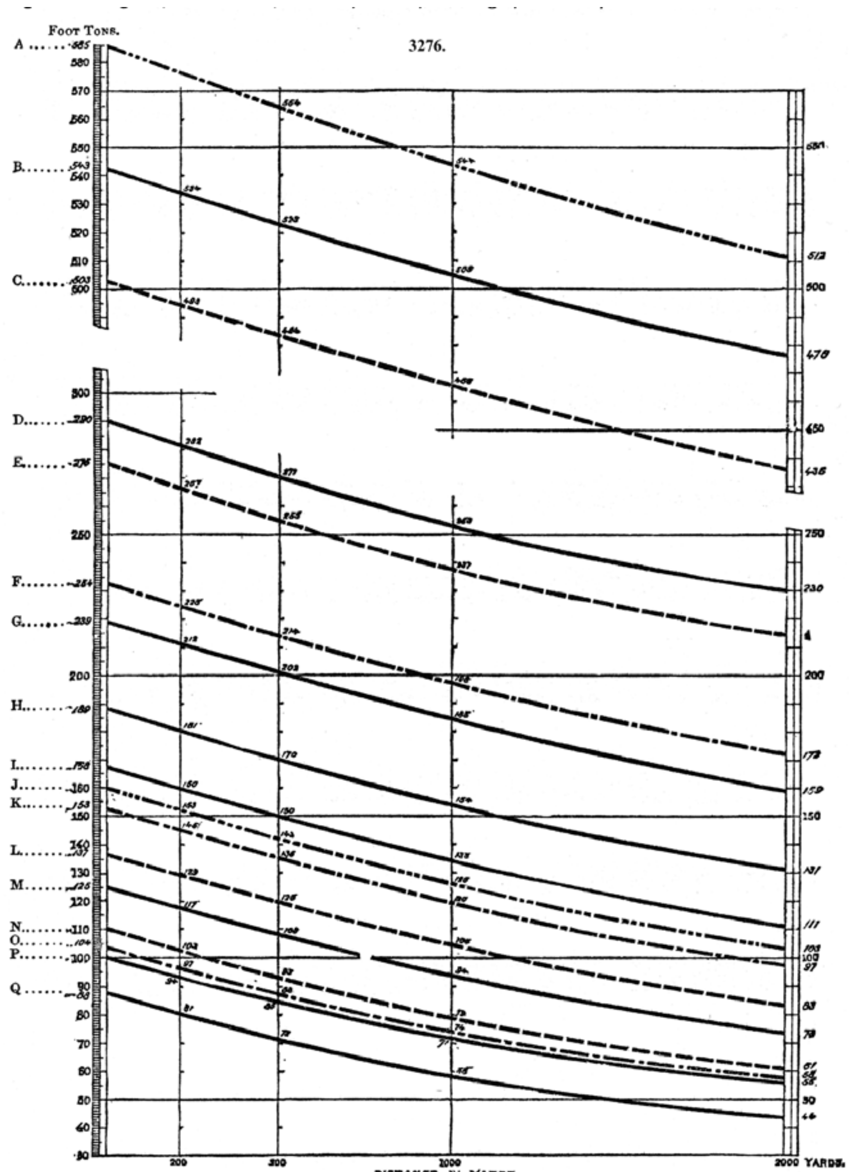
Target J. — English, *Devastation*; French, *Redoutable, Richelieu, Tonnerre*; Russian, *Peter the Great*; Brazilian, *Garavi*.

Target K. — English, *Inflexible*; Italian, *Duilio*.

Fig. 3275.


RESISTING POWER OF EACH TARGET IN FOOT TONS PER INCH OF SHOT'S CIRCUMFERENCE
7"-4½TON
8"-9 TON
9"-12 TON
10"-18 TON
11"-25 TON
12"-35 TON
12.5"-38 TON
16"- 81 TON.
17"- 100 TON.

The diagram, Fig. 3276, also compiled by Major Lyford, exhibits the penetrating energy, in foot-tons per inch of shot's circumference, of foreign ordnance, at ranges of from 70 to 2,000 yards from muzzle of the gun. Guns are indicated as follows: English, ; French, -.-.-.-.-.-.-.-., German and Russian------------- ; Italian, _..._..._..._..._... . The Russian guns are represented in power by the 12-in., 11-in., 9.2-in., and 3.2-in. Prussian breech-loading rifles.



A. 100-ton, 17-in., M. L. rifle—Italian.
B. 81-ton, 16-in., M. L. rifle—English.
C. 56½-ton, 14-in., B. L. rifle—Prussian.
D. 38-ton, 12.5-in., M. L. rifle—English.
E. 36-ton, 12-in., B. L. rifle—Prussian.
F. 34½-ton, 12.6-in., B. L. rifle—French.
G. 35-ton, 12-in., M. L. rifle—English.
H. { 25-ton, 11-in., M. L. rifle—English.
22-ton, 10.2-in., B. L. rifle—Prussian.
21-ton, 10.8-in., B. L. rifle—French. }

I. 18-ton, 10-in., M. L. rifle—English.
J. 15-ton, 9.4-in., B. L. rifle—Italian.
K. 14-ton, 9.4-in., B. L. rifle—French.
L. 15-ton, 9.2-in., B. L. rifle—Prussian.
M. 12-ton, 9-in., M. L. rifle—English.
N. 9-ton, 8.2-in., B. L. rifle—Prussian.
O. 7.8-ton, 7.8-in., B. L. rifle—French.
P. 9-ton, 8-in., M. L. rifle—English.
Q. 6½-ton, 7-in., M. L. rifle—English.

*Table showing Weight, Dimensions, etc., of Ordnance of the United States Land Service.**
Standard and Retained Calibres.

NAME OF PIECE.	Material.	Weight.	Extreme Length.	No. of Grooves	Calibre.	Charge of Powder.	PROJECTILES.		Initial Velocity.	Range in yards.
							Weight of Shot.	Weight of Shell empty.		
SEA-COAST PIECES.										
Guns.		**Lbs.**	**In.**		**In.**	**Lbs.**	**Lbs.**	**Lbs.**	**Feet.**	
Rifle (Model 1873)	Cast iron, wr't iron lined.	89,600	262.8	21	12	110	700	. . . .	1,396	. . . .
Rifle (Model 1870)	"	82,878	240	21	12	100	600	, . . .	1,310	. . . .
Rifle	"	40,681	180	17	10	80	400	360	1,310	. . . .
Rifle (Converted)	Cast iron, with wr't-iron tube.	16,160	136.66	15	8	35	180	150	1,414	. . . .
Rifle (Parrott, 300-pdr)	Cast iron, with wr't-iron jacket.	26,500	175.1	15	10	25	300	250	. . . .	4,290
Rifle (Parrott, 200-pdr)	"	16,300	163	11	8	16	200	150	....	4,272
Rifle (Parrott, 100-pdr)	"	9,700	154.25	9	6.4	10	100	80-100	1,222-1, 335	8,453
Rifle (Banded, 42-pdr)	Cast iron.	. . . . . .	129.4	15	7	. . .	. . . .	. . . .	. . . .	
Rifle (Banded, 32-pdr)	"	. . . . . .	125.20	13	6.4	. . .	. . . .	. . . .	. . . .	
Smooth-bore	"	115,200	243.5	. .	20	200	1,080	725	. . . .	. . . .
Smooth-bore (Model 1873)	"	. . . . . .	......	. .	15	. . .	450	330	. . . .	8,001
Smooth-bore (Model 1861)	"	49,099	190	. .	15	125	450	330	1,735	. . . .
Smooth-bore	"	38,500	177.6125	. .	13	70	283-300	224	1,597	. . . .
Smooth-bore	"	15,059	136.66	. .	10	25	128	100	1,500	. . . .
Smooth-bore	"	8,490	123.5	. .	8	15	68	48	. . . .	. . . .
Mortars.										
Smooth-bore	Cast iron.	33,675	75	. .	15	. . .	. . . .	330	. . . .	. . . .
Smooth-bore	"	17,250	56.5	. .	13	20	. . . .	216	. . . .	4,636
Smooth-bore	"	7,300	49.25	. .	10	12	. . . .	101.67	. . . .	4,536
SIEGE PIECES.										
Guns.										
Rifle	Cast iron.	3,450	133	9	4.5	7	35	25	1,420	. . . .
Rifle (Parrott, 30-pdr.)	Cast iron with wr't-iron jacket.	4,200	132.75	5	4.2	. . .	25-30	29	1,293	6,700
Howitzers.										
Smooth-bore	Cast iron,	2,600	60	. .	8	4	. . . .	45	1,070	2,280
Smooth-bore, flank defense	"	1,476	69	. .	5.82	2.00	. . . .	17	. . . .	1,322
Mortars.										
Smooth-bore	Cast iron.	1,900	29.25	. .	10	4	. . . .	88	. . . .	2,064
Smooth-bore	"	1,050	23.25	. .	8	2.25	. . . .	144	. . . .	2,225
Smooth-bore, Coehorn	Bronze.	164	16.32	. .	5.82	0.5	. . . .	17	. . . .	1,200
FIELD PIECES.										
Guns.										
Rifle	Wrought iron,	1,156	73.84	7	3.5	3	16.75	. . . .	1,314	. . . .
Rifle	"	830	72.65	7	3	2	10	9.5	1,418	
Rifle (Parrott, 10-pdr.)	Cast iron.	890	77.8	3	3	1	10.5	9.75	1,232	5,000
Rifle (B. L), Mountain, Hotchkiss	Steel.	116.85	45.86	10	1.65	. . .	. . . .	. . . .	. . . .	. . . .
Cannon-revolver, Hotchkiss	"	1,212.60	66.75	6	1.457	1,851 grs.	. . . .	7,716 grs.	1,476	
Smooth-bore (12-pdr.)	Bronze.	1,230	72.55	. .	4.62	2.5	12.3	8.34	1,495	2,000
Gatling	Steel.	1,008	68	6	1	325 grs.	3,500 gr	. . . .	. . . .	1,200
Gatling	"	365	60	6	0.5	70 "	450 "	. . . .	1,350	1,000
Gatling	"	195.5	49.7	5	0.45	70 "	405 "	. . . .	. . . .	. . . .
Howitzers.										
Smooth-bore	Bronze.	1,920	82	. .	6.4	3.25	Case 30.75	23.03	1,182	2,344
Smooth-bore, Mountain	"	220	37.21	. .	4.62	0.5	Can'r 12.17	8.34	. . . .	1,005

** Compiled by Lieut. C. S. Smith, U. S. Ordnance.*

† Except for machine-guns and the Hotchkiss mountain B. L. gun, shot and shell for rifled guns are fitted with an expanding sabot, to communicate to the projectile the rotation due to the rifling. No special sabot, however, has as yet been adopted as standard. The Butler, Parrott, Arrick, and Dana all give good results.

Table showing Weight, Dimensions, etc., of U. S. Naval Ordnance.

NAME OF PIECE.	Material.	Weight.	Length.	No. of Grooves.	Calibre.	Charge of Powder	PROJECTILE.		
							Nature.	Weight.	Initial Velocity.
Smooth-bore Guns.		**Lbs.**	**Feet.**		**Inches.**	**Lbs.**		**Lbs.**	**Ft. per**
XV. inch............... .	Cast iron.	42,000	....	....	15	50	Shell.	352	1,100
XV. inch	"	44,000	....		15	100	"	352	1,600
XI. inch................	"	16,000	....	....	11	20	Shot.	166	1,062
XI. inch................	"	16,000	....	....	11	15	Shell.	135	1,240
IX. inch................	"	9,000	....	....	9	10	"	70	1,320
32-pdr..................	"	4,500	....	....	6.4	6	"	26.5	.....
Smooth-bore Howitzers.									
24-pdr..................	*Bronze.*	1,300	....	....	5.82	2	"	18.5	.....
12-pdr......	"	760	....	....	4.62	1	"	8.75	.....
12-pdr..................	"	430	....	....	4.62	0.625	"	8.75	.....
12-pdr..................	"	300	....	....	4.62	0.625	"	8.75	.....
Rifled Guns.									
Parrott...............	Cast iron with wr't-iron reënforce	16,300	13.6	11	8	16	Shell	132	.....
"	"	9,700	13	9	6.4	8	Shell	80	1,140
						10	Shell	100	1,080
"...............	"	5,360	10.5	....	7	6	Shell	48	1,320
Rifled Howitzers.									
20-pdr., heavy........ ..	Bronze.	2,000	....	....	4	2	"	20	.....
20-pdr., light...........	"	1,340	....	....	4	2	"	20	.....
12-pdr..................	"	880	....	....	3.4	1	"	12	.....

NOTE.-A limited number of experimental guns have been constructed by the Ordnance Bureau of the U. S. Navy. The 11-in. smooth-bore has been converted into an 8-in. rifle. 80, 60, and 30 muzzle-loading Parrotts have been converted into breech-loaders by boring out the breech and applying the French system of *fermeture*. A number of small guns of bronze and steel of about 3 in. calibre have also been constructed.

Table showing Weight, Dimensions, etc., of Principal British Ordnance.

NAME OF PIECE.	Material.	Weight.	Length.	No. of Grooves	Calibre.	Charge of Powder.	PROJECTILE.		
							Nature.	Weight Empty.	Initial Velocity.
Royal Arsenal, Woolwich		Tons. Cwt. Lbs.	In.		In.	Lbs. Oz.		Lbs. Oz.	Ft. per sec.
15.5-inch .... !	*Wr't iron.*	81 - 0 - 0	324.00	32	15.5	37 - 0	Palliser.	1,700 - 0	1,520
12-inch, No. I....	“	35 - 0 - 0	191.75	9	12	. . . . . .	Common Shell	. . . . ..	. . . .
" No. II ...	“	25 - 0 - 0	171.50	9	12	50 - 0		460 - 0	1,180, 1,300
11-inch..........	“	25 - 0 - 0	170.00	9	11	50 - 0	“	. . . . . .	1,315
10-inch	“	18 - 0 - 0	170.00	7	10	40 - 0	“	373- 12	1,298, 1,364
9-inch, No. I....	“	12 - 0 - 0	147.00	6	9	30 - 0	“	232 - 0	. . . .
" No IV...I	“	12 - 0 - 0	147.00	6	9	30 - 0	“	232 - 0	. . . .
8-inch. No. I. . ..	“	9 - 0 - 0	136.50	4	8	20 - 0	“	167 - 0	. . . .
8-inch howitzer..	“	0 - 46 - 0	61.00	4	8	. . . . . .	“	. . . . . .	. . . .
7-inch, No. I....	“	7 - 0 - 0	142.75	3	7	14 - 0	“	106 - 12	. . . .
7-inch, No. V....	“	4 - 10 - 0	124.50	3	7	14 - 0	“	106 - 12	1,525
64-pdr., No. I.	“	0 - 64 - 0	111.50	3	6.3	8 - 0	“	57 - 9	1,017
", No. III	“	0 - 64 - 0	111.50	3	6.3	8 - 0	“	57 - 9	1,170
16-pdr...........	“	0 - 12 - 0	74.45	3	3.6	3 - 0	“	14 - 13	. . . .
9-pdr., No. I....	“	0 - 8 - 0	68.50	3	3	1 - 12	“	8 - 8	1,380
9-pdr., No. II.. .	“	0 - 6 - 0	58.00	3	3	1 - 8	“	8 - 8	1,234
9-pdr...........	*Bronze.*	0 - 8 - 0	67.00	3	3	1 - 8	“	8 - 8	. . . .
7-pdr., No. I	*Steel.*	0 - 0 - 150	26.50	3	3	0 - 6 F. G.	“	6 - 14	673
" , No. II...	*Bronze.*	0 - 0 - 200	36.00	3	3	0 - 8 F. G.,	“	6 - 14	. . . .
Sir William Armstrong & Co.									
12-inch, No. I....	*Wr't iron.*	38 - 0 - 0	225.50	9	12	. . . . . .	“	....	. . . .
" , No. 11...	“	35 - 0 - 0	191.75	9	12	. . . . . .	“	575 - 0	1,300
" , No. III ..	“	25 - 0 - 0	161.50	9	12	50 - 0	“	460 - 0	1.300, 1,180
11-inch.	“	25 - 0 - 0	170.00	9	11	50 - 0	“	501 - 4	1,315, 1,247
10-inch	“	18 - 0 - 0	170.75	7	10	40 - 0	“	377 - 14	1.364, 1,298
9-inch	“	12 - 0 - 0	147.00	6	9	30 - 0	“	232 - 0	1,420, 1,336
8-inch.	“	9 - 0 - 0	136.50	4	8	20 - 0	“	167 - 0	1,413, 1,330
7-inch, No. L . . .	“	7 - 0 - 0	141.50	3	7	14 - 0	“	106 - 12	1,561, 1,458
" , No. II....	“	6 - 10 - 0	126.00	3	7	14 - 0	“	106 - 12	1,525, 1,430
64-pdr...........	“	0 - 64 - 0	111.50	3	6.3	8 - 0	“	57 - 9	1,252
40-pdr.	“	0 - 35 - 0	96.00	3	4.75	7 - 0	“	35 - 5	1,357, 1,336
25-pdr.:.........	“	0 - 18 - 0	94.50	3	4	. . . . . .	“	....	. . . .
16-pdr...........	“	0 - 12 - 0	72.45	3	3.6	3 - 0	“	14 - 13	1,352
9-pdr., No. I....	“	0 - 8 - 0	68.50	3	3	1 - 12	“	8 - 8	1,380
7-pdr., No. I....	*Steel.*	0 - 0 - 150	26.50	3	3	0 - 6	“	....	673
" , No. II....	“	0 - 0 - 200	38.90	3	3	0 - 12 F. G.	“	6 - 14	955
10-inch	*Wr't iron.*	6 - 0 - 0	77.25	7	10	. . . . . .	“	....	. . . .
8-inch howitzer..	“	0 - 46 - 0	61.125	4	8	10 - 5	“	167 - 0	. . . .

Table showing Weight, Dimensions, etc., of Principal British Ordnance (continued).

NAME OF PIECE.	Material.	Weight.	Length.	No. of Grooves	Calibre.	Charge of Powder.	PROJECTILE.		
							Nature.	Weight Empty.	Initial Velocity.
Breech-loading.		**Tons. Cwt. Lbs,**	**In.**		**In.**	**Lbs. Oz.**		**Lbs. Oz.**	**Ft. per sec.**
7-inch, No. I. . . .	Wr't iron.	0 - 82 - 0	120	76	7	11 - 0	Common shell.	83 - 0 98 - 0	1,165
" No. II. . .	"	. . 72 . . ,	118	76	7	10 - 0	“	98 - 0	1,413
40-pdr., No. I....	"	.. 35 .. .	121	56	4.75	5 - 0	"	37 - 14	1,180
“ No. II...	“	.. 32 .,.	120	56	4.75	5 - 0	“	37 - 14	, . . .
20-pdr., No. I....	“	.. 16 .. .	96	44	3.75	2 - 8	“	20 - 8	1,130
" No. II..	"	0 - 15 - 0	66.125	44	3.75	2 - 8	"	20 - 8	. . . .
“ No. III . .	“	0 - 13 - 0	66.125	44	3.75	2 - 8	"	20 - 8	1,000
12-pdr..........	"	0 - 8 - 0	72	38	3	1 - 8	"	10 - 12	1,150
9-pdr, ... , . . .	"	0 - 6 - 0	62	28	3	1 - 2	"	8 - $2^1/_2$	1,057
6-pdr..........	"	0 - 3 - 0	60.125	32	2.5	0 - 12	“	. . . . . .	1,046
64-pdr.	“	0 - 64 - 0	110	70	6.4	9 - 0	"	60 - 0	. . . .
40-pdr..........	“	0 - 32 - 0	98	56	4.75	5 - 0	"	37 - 14	. . . .
Gatling, No. I. . .	“	0 - 3 - 84	32	7	0.45	85 Gr.R.F. G.	slug	. . . . . .	. . . .
" No. II..	“	0 - 7 - 35	62.5	7	0.65	. . . . .	“	. . . . . .	. . . .

Table showing Weight, Dimensions, etc., of German, French, and Russian Beech-loading Guns

NAME OF PIECE.	Material.	Weight.	Length.	No. of	Calibre.	Charge of Powder.	PROJECTILE.		
							Nature.	Weight.	Initial Velocity.
***German Guns-Krupp*.**		**Tons.**	**Inches.**		**Inches.**	**Lbs.**		**Lbs.**	**Ft. per sec.**
80. 5 centimetre..........	Steel.	35.30	263.7	72	12	132	Common shell	565.5	1,510
28 cm. howitzer	"	9.82	125.9	72	11.02	44	"	437.8	. . . .
Short 26 cm............	"	17.67	204.7	64	10.23	70.4	"	349.8	1,476
Long 24 "..........	"	14.38	205.9	32	9.26	52.8	"	260.7	1,391
Short 24 ".........	"	. . . .	185.3	32	9.26	52.8	"	260.7	1,391
Long 21 "..........	"	9.84	185.3	30	8.24	37.4	"	173.8	1,440
Short 21 ",.........	"	8.84	154.4	30	8.24	37.4	"	173.8	1,440
Long 17 "..........	"	5.5	167.3	48	6.77	26.4	"	100.5	1,526
Short 17 "..........	"	. . . .	133.8	48	6.77	26.4	"	100.5	1,526
Long 15 "...........	"	3.03	135.4	48	5.86	17.6	"	67.0	1,526
" " No. H.....	"	3.9	151.5	48	5.86	17.6	"	67.0	1,542
Short 15	"	2.9	128.7	36	5.86	17.6	"	67.0	1,526
13 cm.................	"	1.37	115.1	18	4.73	7.7	"	33.8	1,476
		Lbs.							
9 ",..., ...	"	937	80.3	16	3.60	1.3	"	15.1	1,056
8 "...............	"	649	76.1	12	3.09	1.1	"	9.4	1,171
6 "	"	235	49.2	18	2.36	0.4	"	5.0	984
French Guns.		**Tons.**							
32 centimetre	Cast iron and steel.	34.5	224.4	. .	12.5	136.6	"	631.1	1,312
27 "	"	21.7	211.8	..	10.8	52.9	"	317.4	1,378
24 "...........	"	13.8		..	9.4	35.2	"	220.4	1,427
19 "	"	7.9	149.6	..	7.6	17.6	"	115.1	1,486
	"	**Cwt.**							
16 "	"	98.4	.....	..	6.4	11.0	"	69.4	1,312
14 "	"	52.2		..	5.4	8.8	"	41.1	1,509
Siege gun of 24 cm	"	40.5			6		"	—	—
Russian Guns.		**Tons.**							
12-inch.................	Steel.	40	252	36	12		"	— —	1,398
8- "...	"	8.7	175	80	8	34.3	"	171.2	1,443
8- " mortar...........	"	3.2	89.9		8		"	171.2	— —
6- "	"	3.9	140.0		6		"	81.1	1,597
		Lbs.							
12.2-pdr. boat gun......	......	792	67.4	..	.....	.....	"	12.2	— —

Works for Reference." On the Physical Conditions involved in the Construction of Artillery," Mallet, London, 1856 ; " Reports of Experiments on the Strength and other Properties of Metals for Cannon, and the Qualities of Cannon Powder," Rodman, Boston, 1861 ; " Reports of Experiments on the Strength and other Properties of Metals for Cannon," Officers of the Ordnance Dept. U. S. A., Philadelphia, 1856 ; " Shells and Shell-Guns," Dahlgren, Philadelphia, 1857 ; " A Treatise on Naval Gunnery," Douglas, London, 1860; " Boat Armament of the U. S. Navy," Dahlgren, Philadelphia, 1856 ; " A Course of Instruction in Ordnance and Gunnery," Benton, New York, 1867 ; " A Treatise on Ordnance and Naval Gunnery," Simpson, 1863 ; " A Treatise on Ordnance and Armor," Holley, New York, 1865 ; " A Text-Book of the Construction and Manufacture of the Rifled Ordnance in the British Service," Stoney and Jones, London; " The Principles and Practice of Modern Artillery," Owen, London, 1871 ; "The Artillerist's Manual," Gibbon, New York, 1863 ; " Traite d'Artillerie Theorique et Pratique," Probert, Paris, 1869 ; "Inspection and Proof of Cannon for the U. S. Navy;" Washington, Government Printing Office, 1864; " U. S. Navy Gunnery Notes," Washington, 1871 ; " U. S. Navy Laboratory Notes," Washington, 1871 ; " Gunpowder as an Element in the Problem of Modern Ordnance," Marvin, Washington, 1872 ; "Mode of Fabricating the XV-inch Guns," Bradford, Washington, 1872 ; " Nicaise's Belgian Field Artillery," Michaelis, New York, 1872 ; " A Manual of Gunnery for her Majesty's Fleet"; " Ordnance Instructions, U. S. Navy" ; "Report on a Naval Mission to Europe," Simpson, Washington, 1873 ; " U. S. Naval Ordnance \Totes-the Reffye Gun," 1873 ; "Naval Ordnance

and Gunnery," Cooke, New York, 1870. See also files of Army abad Navy Journal, Scientific American, Engineering, Engineer, and Journals of the Royal United Service Institution. A. A. B. (in part).

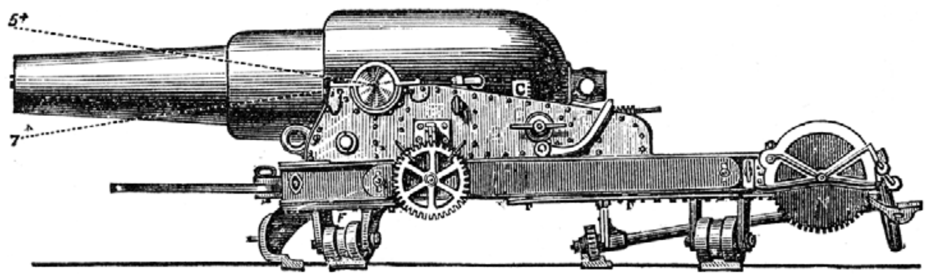
ORDNANCE — GUN-CARRIAGES. The requirements of gun-carriages are: powerful moving machinery, so contrived as to be unaffected by the concussion of firing; self-acting controlling gear, almost independent of human carelessness ; the gradual absorption of shocks rather than resistance to them; the dispersion of concussions over large surfaces; and in vessels of war independence of distortion of or other injuries to the ship's side, smoothness and ease of motion in every direction, and safety under all conditions of the sea.

The duty of providing the most perfect means of working guns seems to be second only in importance to that of adopting the best material, form, and construction for the gun itself. Of two similar guns, that which can fire the greatest number of rounds in a given time is certainly the most effective, and rapidity of fire depends much more upon the gun-carriage and conveniences for loading than upon any peculiarity attaching only to the gun. Owing to the increase in size and power of ordnance since the introduction of armor, gun-carriages have gradually become elaborate machines, and mechanical science has produced carriages and slides which enable the heaviest guns to be easily, accurately, and safely worked on the broadsides of ships. It is scarcely necessary to point out that in the construction of naval gun-carriages, owing to the limited space available, more engineering skill has been necessarily expended than in the designing of those intended for land service.

I. NAVAL CARRIAGES. — The ordinary form of broadside carriage used in the U. S. Navy is the Marsilly, which has trucks only on the front axle. When the carriage is to be trained, a roller handspike is used. This is simply a lever having a metal projection at the lower end, beneath which are stout lignum-vitæ rollers. The metal projection is inserted under the rear portion of the carriage, which is then lifted by the lever and rests on the rollers, which thus serve as trucks. The carriage is thus lifted when the gun is being trained or when it is being run in or out.

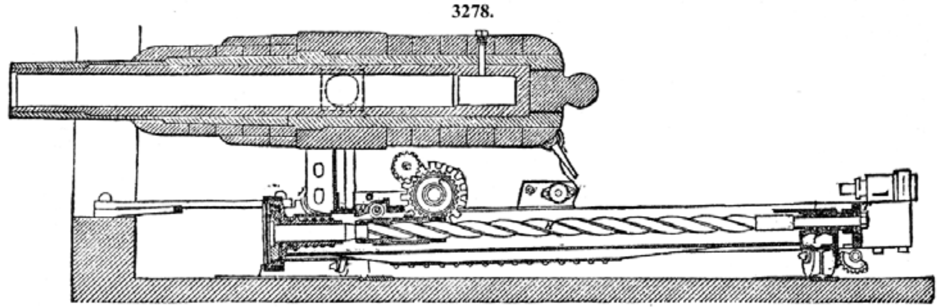
U. S, Navy Pivot-Carriage. – Guns which are to be fired at greater elevations than are admitted by the dimensions of an ordinary port are mounted upon pivot-carriages, which give an elevation of 20˚ to the gun, and a much larger are of train than the broadside carriage.

3277.



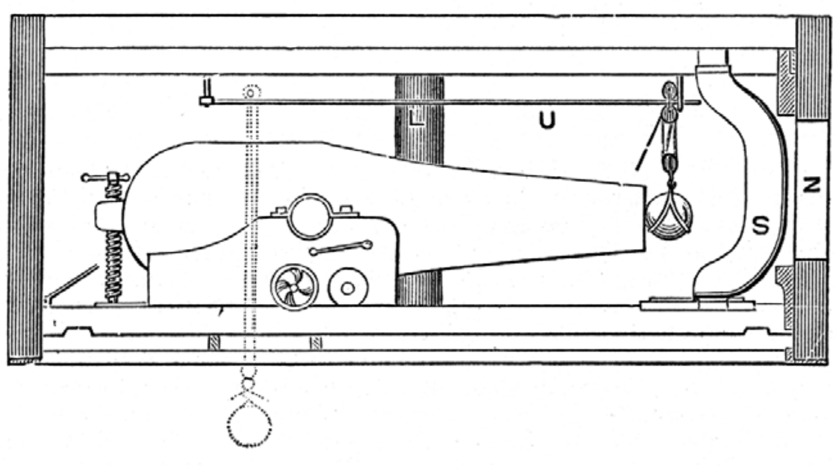
The Broadside Scott Carriage. – Fig. 3277 represents an English naval carriage of the box-girder description, of mixed wrought and cast iron, It is made long and low, thus remedying the rearing-back tendency of short and high carriages, and the consequent downward strain on the deck and slide.

3278.



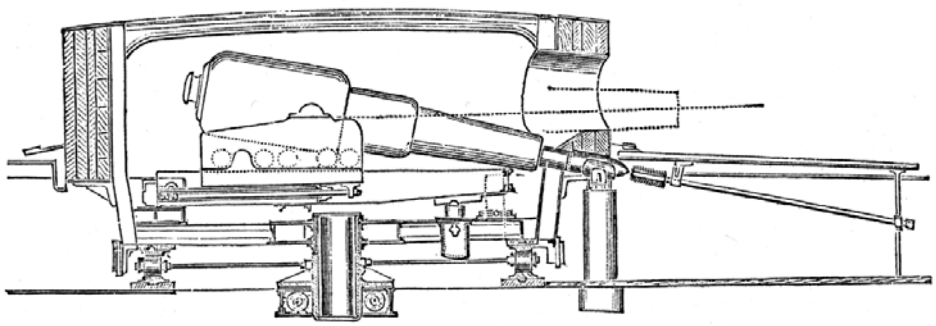
Vavasseur's Carriage is represented in Fig. 3278. The arrangement for checking the recoil of the gun consists of a steel screw, ***H***, square in cross-section and of 30 in. pitch, extending nearly the entire length of the slide. The front end of the screw has fastened to it a short conic frustum, which works on a wrought-iron drum so as to form a friction-clutch.

3279.



TURRET CARRIAGES. — Fig. 3279 shows the arrangement of a U. S. monitor turret carriage. The gun is run in and out by the hand-wheel shown at the side of the carriage, operating rack-and-pinion mechanism. ***Z*** is the port and ***S***, the swinging port-stopper. ***U*** is a movable rod, on which the shell-hoisting tackle traverses.

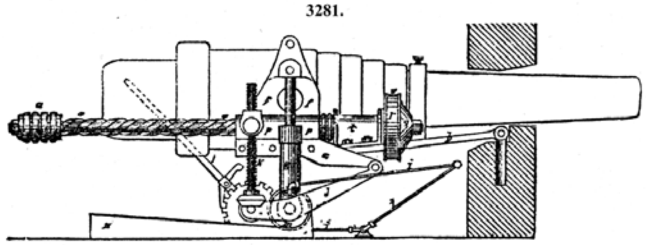
3280.



The Hydraulic Carriage and Loading Apparatus. — The hydraulic system of managing and loading guns, as applied to the turret of *II. M. S. Thunderer*, is represented in Fig. 3280. In this carriage all the mechanism for absorbing and regulating the force of recoil, and for moving the gun from loading to firing position or back, is replaced by a hydraulic press, which acts both to check recoil and to give motion to the gun-carriage on the slide. It is fixed on the slide in the line of recoil, with its piston-rod permanently attached to the carriage. To run the carriage in or out, it is necessary only to admit to one side or other of the piston the water delivered from the steam-pumps. When the gun recoils, the water is driven out of the press through a loaded and partly balanced valve, the resistance of which to the passage of the water arrests the recoil, and can be quickly adjusted so as to regulate the extent of recoil under different conditions. The gun is made partly muzzle-loading by hinging the slide horizontally at the rear, the front end being free to be raised or lowered upon suitable chocks from the floor of the turret at the different heights required to give the desired range of elevation to the gun in the port. The loading is effected by turning the turret so as to bring the muzzle of the gun opposite either one of two distinct sets of loading gear placed on the main deck, and locking it in this position by a catch. The gun is at the same time depressed, so that the charge may be raised to the muzzle and pushed home in the bore at an inclination from below the upper deck. The projectile is brought up to the loading place on a small trolly controlled by a friction-plate, which clamps it to the rails whenever the truck-handle is lowered. It is then run on to a hoist, which rises with it out of the main deck until arrested by stops placed so as to bring the hoist to rest when the projectile is in line with the bore of the gun. It is then pushed off the truck into the muzzle, and rammed home by a hydraulic rammer, consisting of a parallel tube in which runs a piston-rod armed with a rammer-head. A great advantage of this form of carriage is that, instead of a large gun's crew, one man in the turret and one outside may direct and control all the movements of the heaviest gun, and may load and fire it without other help than that involved in bringing up the ammunition; and far greater rapidity of fire is obtained than is possible with manual labor. The loading positions are duplicated, so as to give a reserve in case of accident, or to enable that one to be selected which may best keep the turret-port out of the line of the enemy's fire. In the event of accident to the hydraulic loading gear, the gun may be loaded from below by hand.

The German turret carriage is represented in Fig. 3281. The chase of the gun rests on a strong swingbed ***b***, of forged iron, which is jointed to a bolt in the side of the turret. When the gun is raised or lowered, the trunnions slide on the swingbed, which turns around the joint. The cheeks of the carriage project and rest on the head of the piston of the hydraulic press, ***g***. Below they are fastened to arms. ***e***, which are hinged to a lower arm, ***d***, made fast to the body of the press. The pipes ***i***, communicate from the steam-engine to the press, which is operated by a pump not shown in the engraving. For manœuvring the gun without the use of the engine, a second apparatus is provided, composed of a steel screw, ***k***, which is turned by means of a ratchet and lever, ***l***. In firing, the brake operates in the following manner : The gun recoils, taking along with it the whole hoisting arrangement. In the first instant the screw moves slightly to the rear, which causes the two friction-cones to press firmly against each other; but this motion to the rear is stopped almost immediately by the cylinder, ***t***, which is bolted to the swing bed, ***b***. The screw pulled to the rear by the recoil of the gun causes the screw, ***o***, and the frustum, ***q***, to turn and communicate its motion to the drum, ***r*** ; but this is checked by the action of the friction-band, which must be regulated according to circumstances. A buffer, ***u***, composed of several strong disks of India-rubber, and fastened to the rear end of the screw, ***o***, serves to stop the gun, breaking the shock gradually in case the friction of the brake has not been well regulated.

3281.

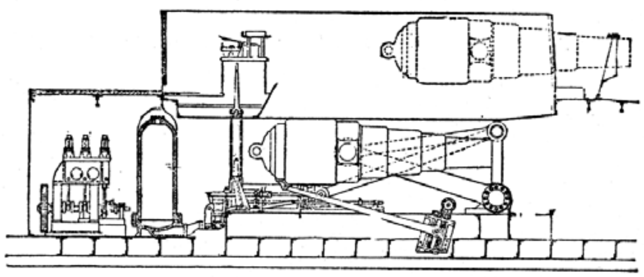


LOWERING GUNS. — Various systems have been devised by means of which the gun is lowered either entirely or partially below the deck, so that the men are in a protected position while engaged in loading.

The Moncrieff system is represented in one form in Fig. 3282, and is constructed on the principle of utilizing the force of the recoil to lower the whole gun, so that it can be loaded out of, sight and out of exposure. That part of the carriage, ***E***, which is called the elevator may be considered as a lever which has the carriage-axle at the end of the power-arm, and the centre of gravity of the counterweight, ***C***, at the end of the weight-arm, there being between them a moving fulcrum. When the gun is in the firing position, the fulcrum on which this lever rests is almost coincident with the centre of gravity of the counterweight, ***C***; and when the gun is fired the elevators roll on the platform. Consequently the fulcrum travels away from the end of the weight-arm toward the end of the power-arm. Thus the resistance to the recoil, least at first, goes on in an increasing proportion as the gun descends, and at the end of the recoil the parts are seized by a self-acting clutch, which when released after the gun is loaded allows the counterweight to bring the piece back to firing position.

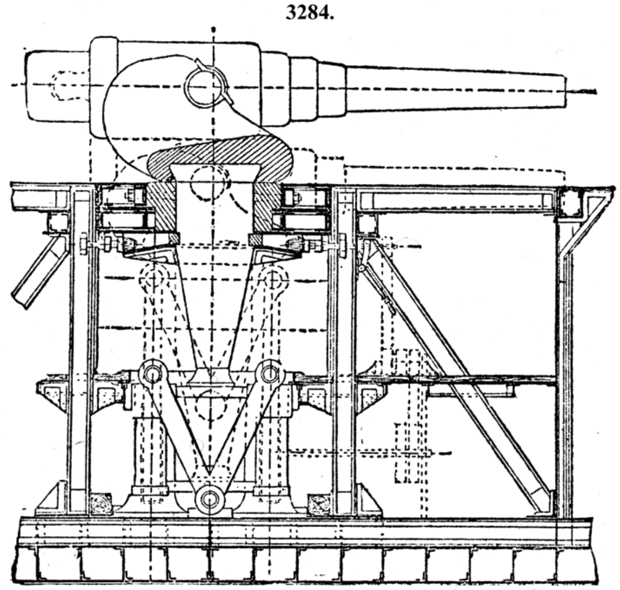
Moncrieff's hydro-pneumatic ship carriage, Fig. 3283, is a depression carriage, in which the force of the recoil is utilized to compress a certain volume of air contained in a close vessel, and this air is afterward employed to raise the gun from under cover to the firing position.

3283.



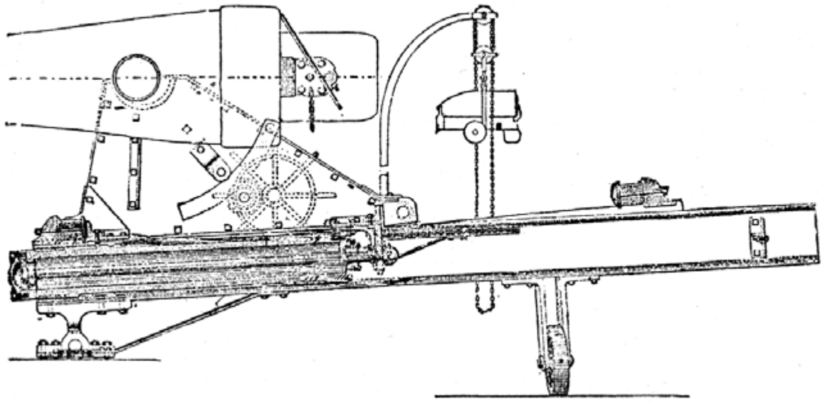
Krupp's system of working heavy guns, Fig. 3284, is essentially one for carrying a gun of considerable size on board a comparatively small vessel. The gun is trunnion-pivoted, and is capable of being lowered below the vessel's deck for the purpose of stowage, or raised so as to be brought with its platform on the same level as the deck. The gun itself has no recoil, the shock being transmitted direct to the hull of the ship. The gun rotates with the pivot to which the carriage is attached, and is thereby capable of being directed to any point of the compass

3284.



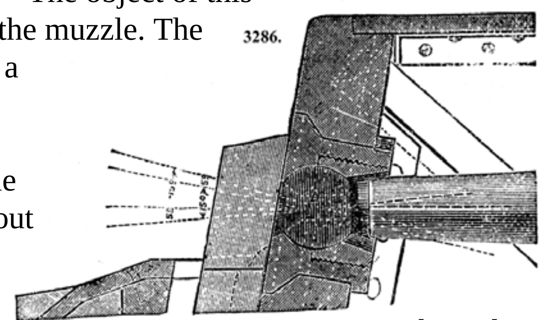
II. LAND CARRIAGES. — ***U. S. Barbette Carriage.*** – Fig. 3285 represents the altered barbette carriage used in fixed fortifications for the 8-inch breech loading rifle. In this, in order to check recoil, a hydraulic buffer is used, which con sists of a cylinder closed at the ends by caps in which are apertures for the introduction and removal of the water.

3285.



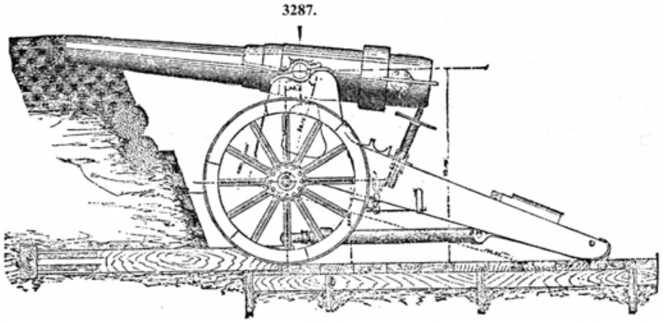
Krupp's Protected Non-recoil Gun, Fig. 3286. – The object of this device is the complete protection of the gun, except at the muzzle. The general idea is that the gun shall pivot at the muzzle in a ball-and-socket joint, fixed into the armor of a casemate, entirely closing the port and preventing recoil. Krupp claims that when once the gun is laid true on the object, it can be fired any number of times without recoiling, jumping, or otherwise changing its position or direction in the least; so that all error in shooting due to inaccuracy of laying is prevented when once the right direction is secured.

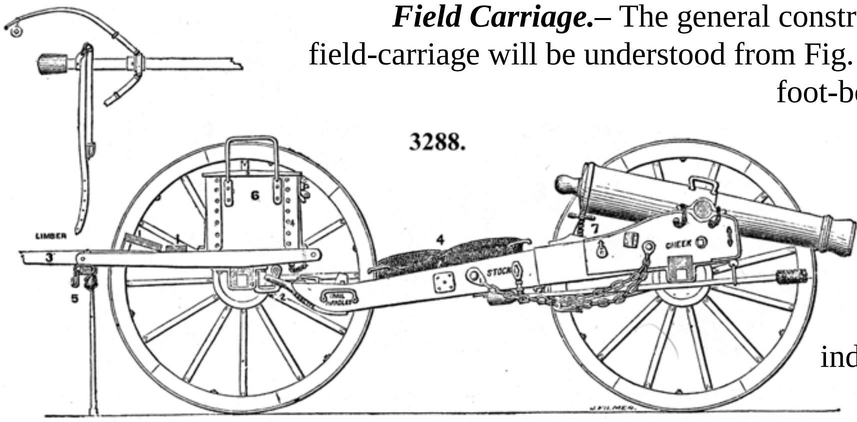
3286.



Siege-Carriage. – Fig. 3287 represents Krupp's 15-centimetre siege-carriage, and will serve as an illustration of this particular type of carriage. It is made of wrought iron, with the exception of the wheels, which are of wood with bronze nave-boxes. The cheeks are continued to the rear, parallel to each other, and joined by transoms from the trail. The elevating apparatus con sists of a single screw with a rim-wheel handle and a female screw with projecting arms terminating in trunnions, which fit in journal-boxes on the sides of the trail. The striking peculiarity of this carriage is the application of the hydraulic buffer for checking the recoil in carriages of this kind, by which means the recoil is controlled within the limits of about one yard.

3287.





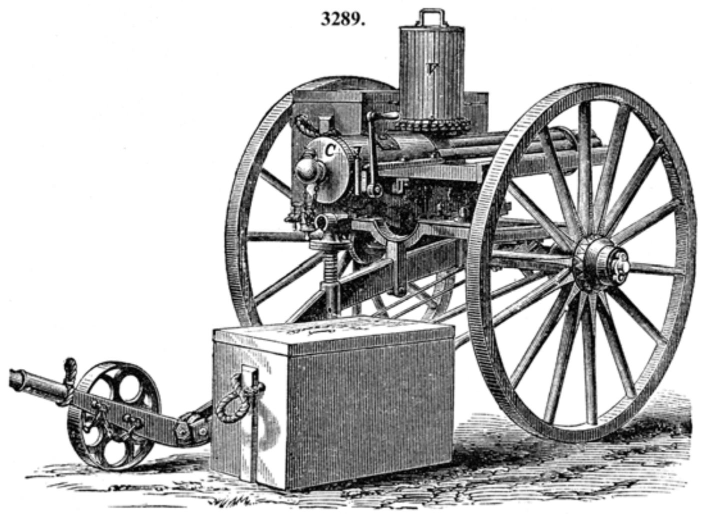
Field Carriage.– The general construction of the U. S. army field-carriage will be understood from Fig. 3288. At 1 are the foot-boards; 2, the pintle-hook ; 3, the pole; 4, the prolonge ; 5, the trace. books; 6, the ammunition-chest; and 7, the elevating screw.

We are largely indebted for illustrations and descriptions embodied in the foregoing article to "Naval Ordnance and Gunnery,"* by Commander A. P. Cooke, U. S. N. (New York, 1875), and to a valuable report by Col. T. T. S. Laidley, U. S. Ordnance Corps, on European gunpowder, guncotton, and gun-carriages, published in "Report of Chief of Ordnance U. S. A." for 1877. To both of these works the reader is referred for detailed information, authorities, etc.

ORDNANCE — MACHINE-GUNS. Machine-guns or mitrailleuses have for their object the throw ing of a continuous hail of projectiles. They may be divided into two classes: the first including those which project small-arm bullets in great numbers, and the second those which throw shells and large projectiles. The first are the mitrailleuses proper; the second, revolving cannon.

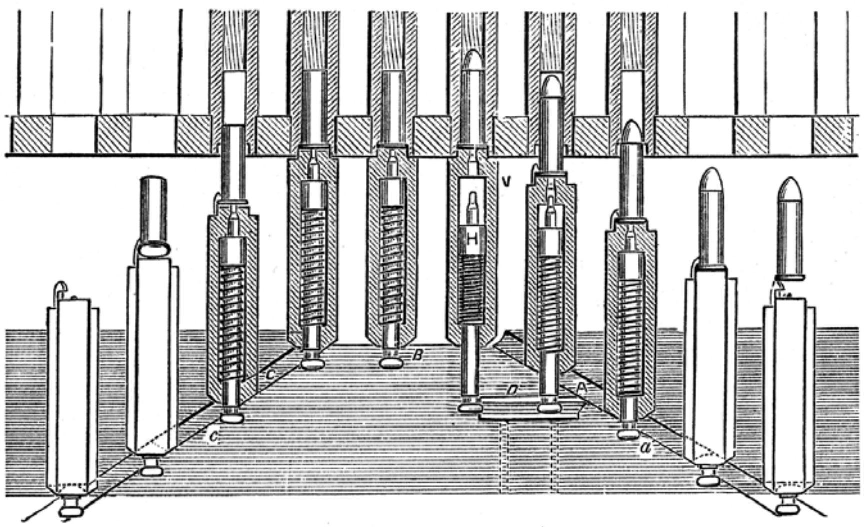
MITRAILLEUSES. – *The Gatling Gun*. – This weapon, which has proved the most successful of its class, was invented by Dr. R. J. Gatling of Indiana in 1861. It has usually five or ten barrels, each barrel having its corresponding lock. The barrels and locks revolve together; but irrespective of this motion, the locks have a forward and backward action. The forward motion places the cartridges in the chambers of the barrels and closes the breech at the time of each discharge, while the backward motion extracts the empty cartridge-cases. The gun can be fired only when the barrels are in motion from left to right; thus the several operations of loading, firing, and extracting are carried on automatically, uniformly, and continuously. The gun is fed by feed-cases which fit in a By permission of John Wiley & Sons, publishers. hopper communicating with the chambers. As soon as one case is emptied another takes its place, and thus continuous firing is kept up at the rate of 1,000 shots a minute. The five-barrel Gatling is mounted on a tripod, weighs only 100 lbs., and fires at the rate of 800 shots a minute.

3289.



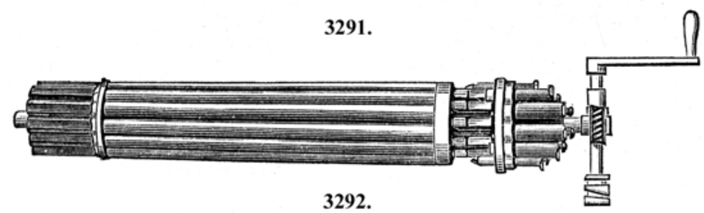
A perspective view of the Gatling gun on its carriage is given in Fig. 3289.

3290.

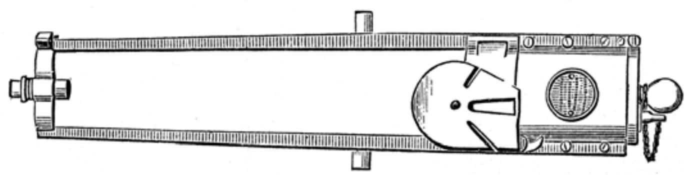


As regards the construction, the shape and position of the cam and grooves may be better understood by reference to the diagram, Fig. 3290, which shows the cam-ring as it would appear if cut open and spread out flat, the lines, ***A*** and ***C*** being the development of the edges of the belicoidal cam surfaces, ***B***, that of the plane surface connecting these, and ***a*** and ***c*** the grooves for holding and drawing back the locks. The ten locks are shown in their relative positions abutting against the cam surfaces, six of them being shown in section. It will be seen that the points of the firing-pins, ***H***, protrude beyond the front of the locks, while the other ends project from the rear, where they are fashioned into knobs, by which the firing-pins are drawn backward while passing through the groove in the rib, ***D***. The diagram shows that the distance of the apex, ***B*** of the cam from the ends of the barrels is such that the locks exactly fill the space, so that each lock there forms an abutment which closes the breech of its barrel and abuts against the apex of the cam, which serves to resist the recoil of the lock when the charge is fired. The position of the cam relatively to the cartridge-hopper is such that each lock is drawn backward to its full extent when it passes the hopper, so that the cartridges may fall into the carrier in front of the locks. The explosion of each cartridge takes place as its proper lock passes over the flat apex of the cam which resists the recoil. The rib, ***D***, restrains the firing-pin from moving forward, while the forward movement of the body of the lock continues; the spiral mainspring is compressed until the revolution carries the firing--pin head beyond the end of the cocking-rib, when the firing-pin will spring forward and strike with its point the centre of the cartridge-head and explode the charge. The point in the revolution at which the barrels are discharged is below and at one side of the axis. Fig. 3291 represents the barrels, and Fig. 3292 the frame detached.

3291.



3292.



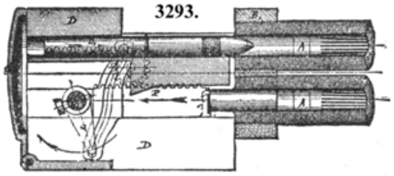
The Lowell Battery-Gun. – The system is composed of two distinct parts, viz. : the barrels, with their trunnions, and the frame or breech containing the mechanism. The barrels, four in number, are mounted between two supporting disks, arranged to revolve in rings. One of the peculiar features of this gun is that the firing is confined to one barrel at a time, requiring but one lock. This barrel is used until heated, disabled, or clogged, when it is rotated aside by a simple lever movement, and another is brought into place.

The Taylor Machine-Gun has in the gun proper a horizontal range of parallel rifle-barrels, five in number, securely united to each other and to a hollow breech, which contains the firing mechanism and supports upon its top the cartridge-hopper. A hand-crank operates a transverse shaft common to the firing mechanism. A full description of this gun, together with records of tests of the Lowell battery-gun above described, will be found in " Report of Chief of Ordnance ti. c. A." for 1878.

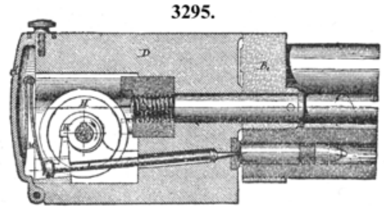
REVOLVING CANNON. – ***The Hotchkiss Revolving Cannon*** is a compound machine-gun, in which it has been sought to combine the advantage of long-range shell-fire with the rapidity of action of the mitrailleuse, and therefore to produce extremely powerful effects in a minimum of time. The gun as arranged for defense against torpedo boats is represented in the full-page engraving. It is constructed to throw a shower of explosive shells with the rapidity of from 60 to 80 rounds per minute, producing as many dangerous explosions; and as each shell bursts into about 25 fragments, the gun furnishes from 1,800 to 2,000 fragments per minute, of sufficient weight to kill or disable the enemy and to damage the material, at distances equal to the range of modern field artillery. The ammunition of the gun consists of a centre-fire, spirally-rolled brass cartridge-case, forming the gascheck in the gun, and holding the powder and the projectile, and a cast-iron shell, having a central brass guiding-band to take the rifling. The bursting-charge is ignited by a percussion-fuse, requiring no preparation before use.

The revolving cannon is composed of five rifled barrels, ***A A***, Fig. 3293, mounted between two disks, ***B***, on a central axis. The barrels are rotated in front of an immovable breech-block, ***D***. The hollow rear portion, containing the mechanism, is closed by a door through which access may be had to the mechanism. The axis is revolved and controlled, as well as the mechanism for loading, firing, and extracting the empty cartridge-case, by means of a hand-crank, ***F***, Fig. 3294. The mechanism for rotating the barrels, and performing automatically the functions of loading, firing, and extracting, is composed of the crank-shaft, ***G***, carrying a worm, ***H***, Fig. 3295, which engages in a pin-wheel Ion the rotating axis of the barrels. The worm, ***H***, is curved in a peculiar manner, partly helical and partly circumferential, thus imparting an intermittent rotating motion to the group of barrels, while the worm is rotated continuously. The combination of the mechanism is so arranged that the load ing, firing, and extracting take place during the time the barrels remain stationary. The worm, ***H***, Fig. 3295, carries at the same time a cam, ***K***, shaped to a logarithmic spiral. The firing-pin, ***L***, bears against this cam, and is by the rotation retracted and allowed to fly forward at the proper time under the action of the spring, ***M***, and so strikes the primer and discharges the cartridge.

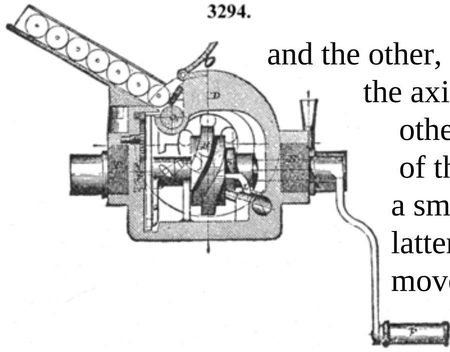
3293.



3295.



3294.

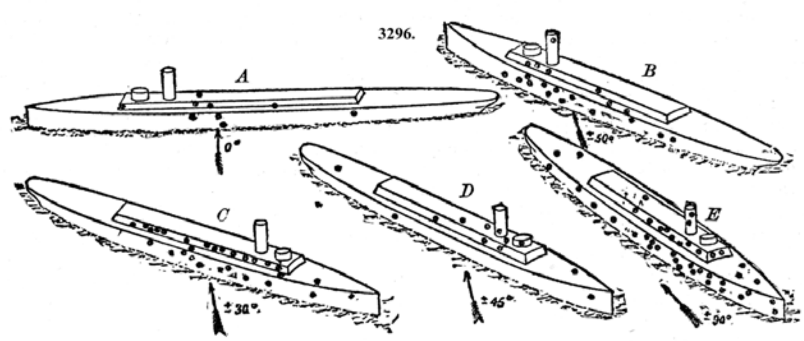


On the interior face of the left side of the breech, a cog wheel, ***N***, Fig. 3293, is mounted, with two horizontal racks, ***O*** and ***P***, running in slides. The rack, ***O***, which is attached to the loading-piston O_1, is placed above, and the other, forming the extractor, under the cog-wheel, and parallel to the axis of the barrels; so that in moving one of these racks the other is moved by the cog-wheel in the opposite direction. Part of the lower rack forms a curved slot' or yoke, in which works a small crank, ***Q***, on the crank-shaft, ***G***. The rotations of the latter consequently impart an alternating and opposite movement to the racks, so that while the one is going forward the other moves back, and reciprocally; thus a fired cartridge-case is extracted, while a loaded cartridge is introduced into the barrel above. The introduction trough, or receiver, in which the loading-piston works, is closed by a hinged gate, ***R***, Fig. 3294, which goes down by the weight of the cartridges, the first of which enters the trough, and then the loading-piston in moving forward raises the gate, and isolates the other cartridges from the one in the act of being loaded into the barrel.

The operation of the mechanism may be described as follows, supposing the crank to be in continual motion : A cartridge is placed in the introduction-trough; the loading-piston, ***O***, pushes it into the barrel; then the barrels begin to revolve, and the cartridge is carried on until it arrives before the firing pin, ***L***, which penetrates the solid part of the breech, and which has in the mean time been retracted by the action of the cam, ***K***; then, as soon as the cartridge has arrived in this position, the barrels cease to revolve, and the primer of the cartridge is struck by the firing-pin and discharged. Then the revolution of the barrels begins again, and the fired cartridge-shell is carried on until it comes to the extractor. This in the mean time has arrived up to the barrels, and the cartridge-head rolls into it. As soon as the head is laid hold of by the extractor, the barrels again cease to revolve, and during this period the cartridge-shell is withdrawn and dropped to the ground. As during every stoppage of the barrels the gun is supplied with a new cartridge, and the firing and extraction are performed during this time, a continuous but slow fire is kept up. By supplying the gun in this manner with single cartridges, about 30 rounds per minute may be fired.

The following data show the capacity, etc. of the largest size of this gun: diameter of barrel, 2.06 in.; weight, 3,300 lbs.; weight of projectile, 56.1 oz.; bursting-charge of same, 1.95 oz.; charge of powder, 3.93 oz.; initial velocity, 1,456 ft. per second; extreme range, 7,466 yards.

A remarkable series of experiments was conducted with the Hotchkiss revolving cannon by the Dutch Government at Helder in September, 1878, the object being to test the gun as a means of defense against torpedo attack. For this purpose a target corresponding in shape to a Thorneycroft torpedo-boat was built, its dimensions being — length, 75 ft. $5^{1}/_{2}$ in.; width, 6 ft. $10^{5}/_{8}$ in.; height above water-line, mean, 33.4 in. The experiments may be summarized as follows, the effects of the hits being noted in Fig. 3296:



Experiment 1, A. — Vessel carrying gun anchored at 1,968 ft. from target, the latter presenting a broadside. No. of rounds fired, 24; time, 80 seconds. Percentage of projectiles which hit, 50.

Experiment 2, B. **—** Vessel anchored as before. Target placed at angle of 50˚ with line of fire. No. of rounds, 28; time, 90 seconds; proportion of hits to rounds, $71^{1}/_{2}$ per cent.

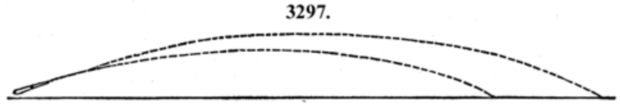
Experiment 3, C. **—** Vessel moving at 10 knots per hour, starting from point 2,624 ft. distant from target, which was laid at an angle of 30˚ with the line of fire. No. of rounds, 46; time, 2-1/2 minutes; proportion of hits to rounds fired, 51 per cent.

Experiment 4, D. **—** Same conditions. Run of 800 ft., beginning at 500 yards from target. No. of rounds, 20; time, 1 minute; proportion of hits to rounds fired, 60 per cent.

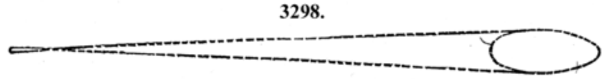
Experiment 5, E. **—** Vessel moving end on to target at 10 knots, starting from point 2,444 ft. distant. No. of rounds, 53; time, 3-1/4 minutes; proportion of hits to rounds fired, 77.4 per cent.

These trials were conducted by the commandant of naval artillery Kruys, who in his official report says that against these guns a daylight attack by torpedo-boats could not have the smallest chance of success, while the danger would be so great and useless that such an attempt would scarcely be made. Four such guns are absolutely necessary to protect a ship on all sides, and to secure the impossibility of any boat approaching without entering the zone of one or other of the guns.

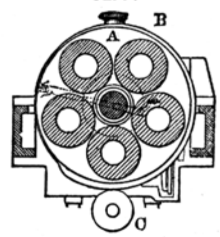
3297.



3298.

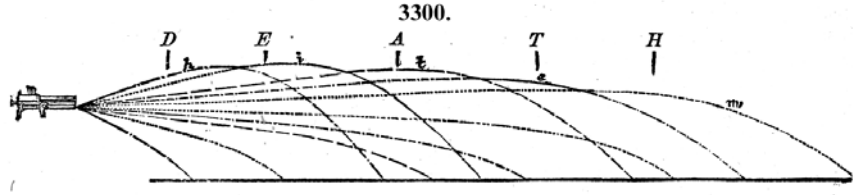


3299.



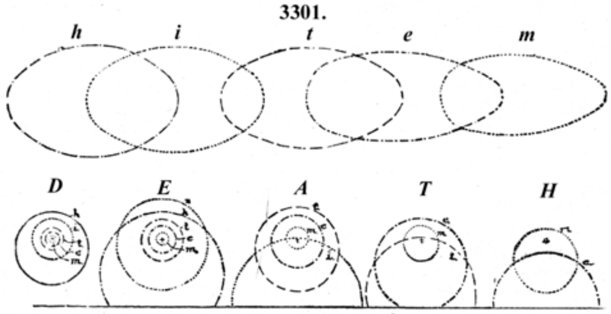
One of the most remarkable capabilities of the revolving cannon is the mode in which it defends ditches or trenches. Actual experiments have determined that the angle of the cone of dispersion of the bullets of case or canister shot, fired from rifled guns, is determined by the pitch of the rifling. It has also been determined in like manner that all of the balls fly near the periphery or outer part of this cone. These facts indicate the inefficiency of ordinary guns for flanking and similar purposes. Figs. 3297 and 3298 show, in sectional elevation and plan, the path of travel of the cone of dispersion of the bullets of case or canister shot fired from an ordinary cannon, from which it will be seen that there is a large space not at all covered by the path of travel of the balls, in which an enemy might pass with impunity. In order to cover the entire space between the longest and shortest range of such a cannon, it must be adjusted at different degrees of elevation. If it were possible to fire such an ordinary cannon with great rapidity, and to change its elevation with like expedition, the result might be accomplished; but in that case, since the cone of dispersion of the balls would always remain the same, no matter at what elevation it was fired, the space covered at short range would be comparatively ineffectually protected. With a machine-gun having two or more barrels automatically loaded and fired, and provided with means for changing the elevation for each barrel discharged, this could not only be accomplished, but would become quite effective in consequence of the rapidity of the firing. In Fig. 3299 is illustrated one means for changing the elevation of a machine-gun just before each barrel is fired. It consists in providing the disk, ***A***, which supports the rear ends of and turns with the barrels, with a cam-surface, ***B***, which rests upon a fixed bearing or a friction-roll, as ***C***, supported by the carriage of the gun. This cam-surface, being properly shaped to support each barrel at a different elevation, will, as the barrels are revolved by the actuating crank-shaft, automatically raise them, as is apparent from an inspection of the drawing.

3300.



To render a gun most effective in protecting the ditch of a fortification, the approaches thereto, and generally for flanking purposes, constitutes one object of this invention. In carrying out this feature of the invention the inventor takes advantage of the fact, as demonstrated by experiments, that the bullets in their course of flight assume the form of a hollow cone, the angle of whose periphery depends upon the pitch of the rifling of the barrel, and constructs a gun having two or more barrels, so that the pitch of the rifling of each barrel varies in degree. With a gun thus constructed, since the cone of dispersion of the bullets from each barrel is of different extent at different distances from the gun, and the trajectory of each cone of bullets will also vary, it becomes evident that if the pitch of the rifling of the several barrels is properly determined any extent of space within the range of the gun may be effectively covered. This will be readily apparent from Figs. 3300 and 3301, in which are illustrated, in longitudinal and transverse sectional outline, the courses of flight and surface deposit of the balls discharged from a cannon having five barrels, which barrels are each provided with rifling of a different pitch. Thus the course of the hollow cone of bullets discharged from the first barrel, supposed to be provided with rifling of a quick twist, will approximate to that marked, ***h***; the cone formed by the bullets discharged from the second barrel, provided with rifling of less rapid twist, will approximate to that marked ***i***; the cones formed by the bullets fired from the third, fourth, and fifth barrels, each provided with rifling the pitch of whose twist diminishes in a regular degree, will approximate to the outlines ***t***, ***e***, ***m***, respectively.

3301.



If, now, the transverse sections taken at the various points be indicated by the lines ***D E A T H*** it will be found that, throughout the whole extent of ground covered by the longest to the shortest range, there is no vertical or horizontal space that is not adequately covered by some one or more of the cones of balls.

ORDNANCE, MANUFACTURE OF. ***MATERIALS*****.** — The fitness of metals for cannon depends chiefly on the amount of their elongation within the elastic limit, and the amount of pressure required to produce this elongation; that is to say, upon their elasticity. It also depends, if the least possible weight is to be combined with the greatest possible preventive against explosive bursting, upon the amount of elongation and the corresponding pressure beyond the elastic limit; that is to say, upon the ductility of the metal.

Cast iron has the least ultimate tenacity, elasticity, and ductility ; but it is harder than bronze or wrought iron, and more uniform and trustworthy than wrought iron, because it is homogeneous. The unequal cooling of solid castings leaves them under initial rupturing strains ; but hollow casting and cooling from within remedies this defect. The best American cast iron has a strength of about 37,000 lbs. per square inch, and yields usually less than 1 per cent.

Wrought iron has the advantage of a considerable amount of elasticity, a high degree of ductility, and a greater ultimate tenacity than cast iron ; but as large masses must be welded up from small pieces, this tenacity cannot be depended upon. Another serious defect of wrought iron is its softness and consequent yielding under pressure and friction. The average tensile Strength of the best qualities of wrought iron is about 60,000 lbs. per Square inch, or about double that of the best qualities of cast gun-iron.

Steel**.** — The obvious defect of high steel for cannon is its brittleness; but if so large a mass is used that its elastic limit will never be exceeded, or if it is jacketed with a less extensible metal, this defect is remedied or modified. Low steel is a much more suitable metal for cannon-making, as it possesses elasticity, tenacity, and hardness. Its tenacity averages about 90,000 lbs. per square inch. Whitworth's fluid-compressed steel, made by Sir Joseph Whitworth & Co. of Manchester, England, has proved of exceeding value for cannon-making. This metal is subjected, while in a liquid state, to a heavy pressure for the purpose of expelling air-bubbles, and is afterward reheated and hammered to secure uniformity and regularity of structure. A record of extended test; of this material will be found in the "Report of the Chief of Ordnance U. S. A." for 1878. The following mean mechanical properties were adduced : Density, 7.855 ; tenacity of piece, area 0.65 sq. in., 110,000 lbs.; elastic limit under pulling stress, piece 10 in. long by .34 sq. in. area, 38,500 lbs.; same under thrusting stress, 28,000 lbs.; hardness, 16.230; hardness of copper, 5.000.

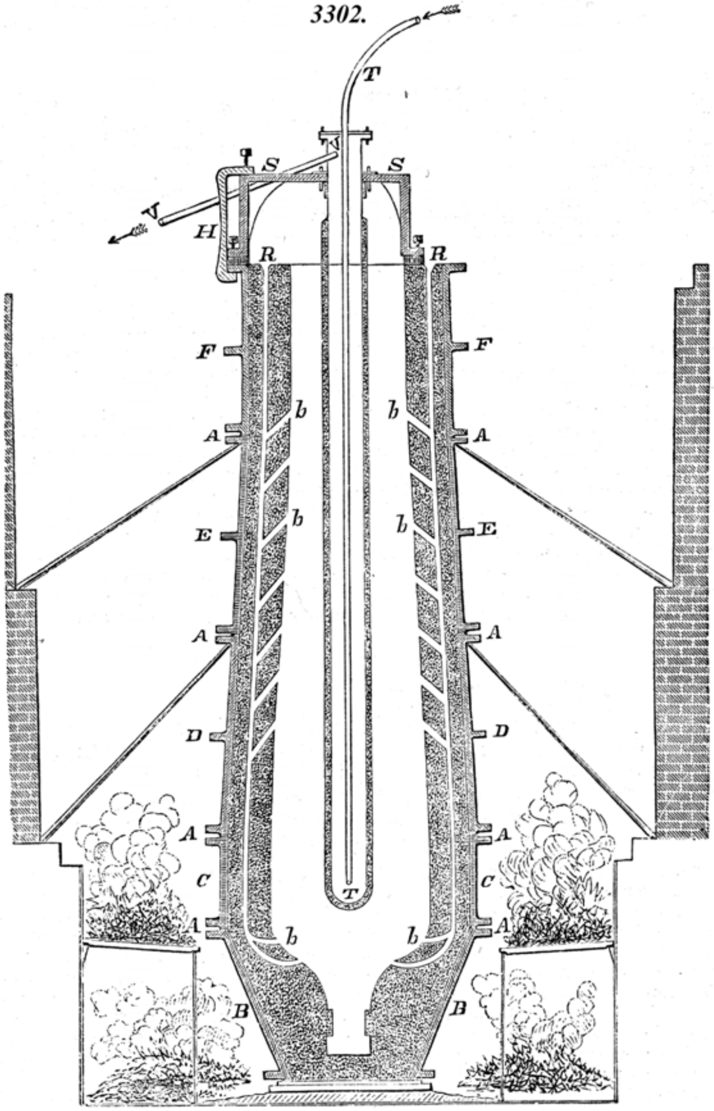
Bronze has a mean ultimate cohesion of about 33,000 lbs. per square inch. It has greater ultimate tenacity than cast iron, but it has little more elasticity and less homogeneity. It has a high degree of ductility, but it is the softest of cannon-metals, and is injuriously affected by the heat of high charges. (See "Admiralty Experiments on Gun-Metals," under ALLOYS.) Additional strength has been imparted to bronze guns by condensation of the metals, as described under Dean's gun in ORDNANCE, CONSTRUCTION OF. This gun is cast solid, bored out, and the bore is then enlarged by forcing mandrels of gradually increasing size through it. The effect is shown by the following figures : Sample of bronze not condensed-density 8.3512, tenacity 38,810 lbs.; condensed-density 8.7065, tenacity 51,571 lbs. The hardness is increased nearly fivefold.

The following table, from " Reports of Experiments on Metals for Cannon, U. S. Ordnance Department, 1856," exhibits the variations which occur in various qualities of metals

Table showing Maximum and Minimum Strength of Cannon Metals

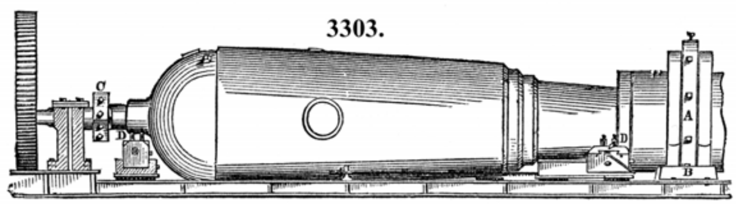
METALS		Density.	Tenacity	Transverse Strength	Compressive Strength	Hardness.
Cast Iron	Least	6,900	9,000	5,000	84,529	4.57
	Greatest	7,400	45,970	11,500	174,120	33.51
Wrought Iron	Least	7,704	38,027	6,500	40,000	10.45
	Greatest	7,858	74,592	....	127,720	12.41
Bronze	Least	7,978	17,698	....	....	4.57
	Greatest	8,958	56,786	....	....	5.94
Cast Steel	Least	7,729	....	....	198,944	....
	Greatest	7,862	128,000	28,000	391,985	....

3302.



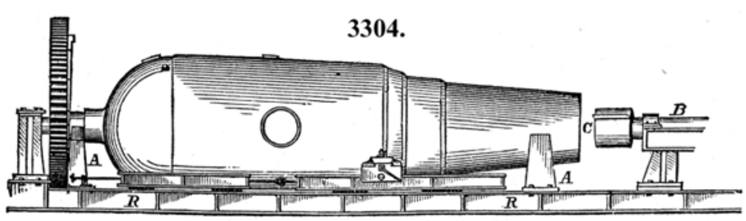
MANUFACTURE OF CAST GUNS. — Commander R. F. Bradford, U. S. N., in " Navy Ordnance Papers," No. 3, gives the following details of the method of casting a 15-inch gun at the Fort Pitt Foundry, Pittsburgh, Pa. Two reverberatory air-furnaces are used for melting the iron of which the gun is made, the draught being produced by 1tigh chimneys instead of a blast. A circular flask, Fig. 3302, is used, consisting of five upright sections, secured together by clamps fitting over flanges ***A A A***, at either end of the sections. Its thickness is 1 in., and it is pierced with holes. The entire length of the flask is 20 ft., and it is made in five sections, viz.: that for the breech, ***B B***; the cylinder, ***C***; the trunnion-section, ***D***; and two upper sections, ***E*** and ***F***, the latter being 3 ft. longer than the required length of gun to admit of a sinking-head. The pattern is in five sections, slightly tapered. The core-barrel consists of a water-tight iron tube about 15 ft. long and three-quarters of an inch thick, its exterior diameter at the head being 12. in. and tapering a quarter of an inch to facilitate withdrawing. It is fluted to allow of escape of gas, and is covered with hemp stuff, a moulding composition, and coke-wash. The pit is circular in form, and has brick walls and a sheet-iron tank at the bottom. After the flask is placed, the core is adjusted by the spider, ***S***, which is of cast iron, having legs which are provided with adjustable screws, which in turn rest on the upper flange of the mould. When adjusted, it is secured by clamps, ***H***. The molten metal is led in troughs to the side gates, ***R***, and enters the mould by the branch gates ***b b b***. As soon after the cast as possible a fire is built in the pit about the bottom of the flask, and kept up for four or five days. Water for cooling is conducted to the bottom of the core-barrel by the tube, ***T***, whence it ascends through the annular space between the tubes, and is discharged from the core-barrel at ***V***. After an interval of 18 hours after casting, the core-barrel is removed and a continuous stream of air is forced into the bore. The cooling occupies about eight or nine days for a 15-inch naval gun, which in the rough state, including sinking-head, etc., weighs 66,000 lbs.

3303.



Gun-boring. — The casting is first placed in a heading lathe, Fig. 3303, where it is prepared for the boring-lathe. The cascable-bearing, base of breech, and a section of the chase are all turned down to finished dimensions while in this lathe, as the chase and rounded part of the cascable-knob form the bearings for the boring-lathe. ***A*** represents the muzzle-ring with adjustable screws; ***B***, the bearing in which the muzzle-ring revolves; ***C***, the chuck or mortise into which the square knob of the cascable is inserted and secured; and ***D***, the tools or cutters with rests. The first cut is usually an inch deep, commencing at the muzzle where the sinking-head is to be cut off, and extending to the trunnions. After the metal is reduced to finishing diameter, the sinking-head is broken or wedged off, and the gun is taken to the boring-lathe, shown in Fig. 3304.

3304.



This consists of a rack, ***R***; journals, ***A***; and boring-rod, ***B***; the supports of which rest upon the rack, and are of such a height that the axes of the journals and boring-rod shall be in the same horizontal plane. In boring a 15 inch gun, the first cutter is 14 in. in diameter, and is secured on the end of the rod, ***B***. When the bottom of the cylindrical portion of the bore is reached, the chamber is roughed out, and a reamer, first for the cylinder and then for the chamber, is introduced. During the boring process (except while reaming) the turning of the exterior progresses. The gun is next placed in the trunnion-lathe, where a hollow shaft is made to revolve about the trunnion, the gun being stationary; and as the turning continues, the shaft moves on its rack toward the gun. The metal in excess between the trunnions is removed by a planing-machine, which is placed on the side opposite the trunnion-machine, and is so arranged that the movable post in which the cutter is secured, ***A***, traverses forward and back over the desired portion of the gun. The gun is turned the width of the cut after each passage of the planer. The desired curve of metal is obtained by introducing a guide-plate, ***C***, of proper form, in rear of the cutter-rest. The surplus metal about the rim-bases, lock, and sight-masses is reduced by chipping and finished by hand. The hole is then cut for the elevating screw, and the vent is drilled. This form of smooth-bore cast gun has been extensively used in the U. S. service, this mode of casting upon a core and gradually cooling from the interior having been first practised by Gen. Rodman, and greatly increasing the strength of the gun. The 15-inch Rodman gun, cast and finished upon this method, weighs 42,000 lbs.

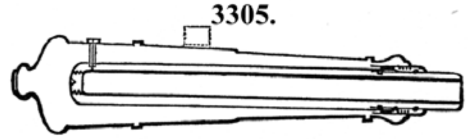
MANUFACTURE OF BUILT-UP GUNS. — The terms built-up and hooped are applied to those cannon in which the principal parts are formed separately, and then united in a peculiar manner. They are not necessarily composed of more than one kind of metal, some of the most important being made of steel alone; and they may be made by welding or by screwing the parts together, or by shrinking or forcing one part over another. The object is to correct the defects of one material by uniting with it opposite qualities of the same or other materials. The defects which follow the working of large masses of iron or steel, such as crystalline structure, false welds, cracks, etc., are avoided by first forming the parts of small masses of good quality, and then uniting them separately. The principal methods of manufacture involve either the shrinking on or the forcing on of the hoops. The difficulties incident to the first process are the necessity of accurately boring the hoops and the unequal shrinkage liable to occur in the separate pieces of metal. Hoops are forced on by hydrostatic pressure with much more successful results. Various methods of constructing built-up guns will be found detailed under the descriptions of the guns in ORDNANCE, CONSTRUCTION OF.

RIFLING HEAVY ORDNANCE. — The machine used for rifling guns for the British service is horizontal, and the gun to be rifled is placed in front of and in line with the rifling-bar, to which a stout head carrying the cutter is fixed. A single groove is cut at a time, each groove being first made roughly and afterward finely finished. The distance apart of the grooves (or width of lands) is regulated by a notched disk fixed to the breech of the gun, the notches being equidistant on the periphery of the disk, and there are as many notches as there are grooves. When one groove is cut, the gun is turned to the next notch, and held by a pawl. The gun remains stationary, and the cutter works up and down the bore; but in order to give the required twist to the rifling, it is made to turn slightly as it moves longitudinally. The cutter is fixed in a head of gun-metal made exactly to fit the bore. It is fastened to a hollow iron bar, which is fixed to a saddle made to move backward and forward, but so arranged as not to prevent the motion of the rifling-bar upon its axis. At the other end, at right angles to the bar, is fixed a rack and pinion, sliding on the saddle. The outer end of this rack is fitted with two friction-rollers, which move along a straight copying-bar attached to one side of the machine, and which may be adjusted to any angle with it, thus regulating the twist; or a curved bar may be used if the gaining twist is desired. The cutter is of steel, and attached to a bar of its own, passing through the rifling bar, the outer end having a system of levers and counterweights, which push the cutter out while the head is emerging, and withdraw it while the head is entering. The movement of the cutter-shaft is regulated by means of another copying apparatus on the other side of the machine. This arrangement consists of two horizontal bars, one higher than the other. A pinion to which is attached a loaded lever works the slide. While the rifling head is passing down the bore, this lever moves along the upper bar; but by reversing the machine, the weight feeds on the lower bar, drawing back the slide and spindle, and forces the tool out. The depth of groove at any point is regulated by varying the upper surface o£ the lower bars.

CONVERTED GUNS. — A large amount of experimenting has been conducted by various nations with a view to convert smooth-bore cannon into rifled guns, by lining-tubes and other devices.

Parsons's method, one of the first proposed to the English Government, consists in introducing into the bore of the cast-iron gun a rifled tube of steel. Palliser's method, which was adopted by the English Ordnance Committee in preference to Parsons's, is substantially the same thing. It is illustrated in Fig. 3305. The tube is of coiled wrought iron, the breech end being a double tube, and the outer envelope being shrunk on the inner lining. The double tube is of the same thickness as the single tube at the muzzle. The gun to be converted is bored up to an increased calibre of about one-third its former diameter, forming a true cylinder or slightly tapering conical form. A slight amount of play is permitted between the tube and casing, which is taken out by a setting-up charge expanding the tube into the casing. The tube at the breech end is closed by a capped wroughtiron plug screwed into it. The tube at the muzzle end is secured by a screw-collar, and prevented from any motion about its axis by a screw tapped through the casing and into the tube. The old vent is closed, and a new one with copper bush passed through the breech-plug. A spiral channel around the outside of the tube, communicating with a small hole in the breech of the cast-iron casing, allows the gas to escape if the tube should split, and gives warning of such defect. This gun, though not considered equal to the built-up gun, has stood severe experimental tests and given satisfactory results, and many English ships and forts have been armed with it.

3305.



Various methods of converting the old cast guns by simply rifling them without the introduction of a tube have been suggested, the difference being simply in the shape and number of grooves, and degree of twist.

A series of experiments has been conducted by the Ordnance Department, U. S. A., Lieut.-Col. Silas Crispin in charge, on various systems of converting smooth-bore guns into rifles by lining them with tubes of wrought iron and steel. A full report of these experiments will be found in "Report of Chief of Ordnance U. S. A." for 1878. The systems tested were as follows

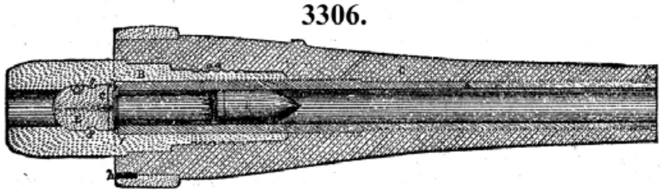
1. A cast-iron body or casing of the Rodman model was lined with a coiled wrought-iron tube inserted from the muzzle, forming a $12^1/_4$-inch rifle-gun.

2. A 13-inch Rodman smooth-bore gun was bored up to a diameter of 17 in., and lined with a coiled wrought-iron tube inserted from the muzzle, so as to form a 10-inch muzzle-loading rifle-gun.

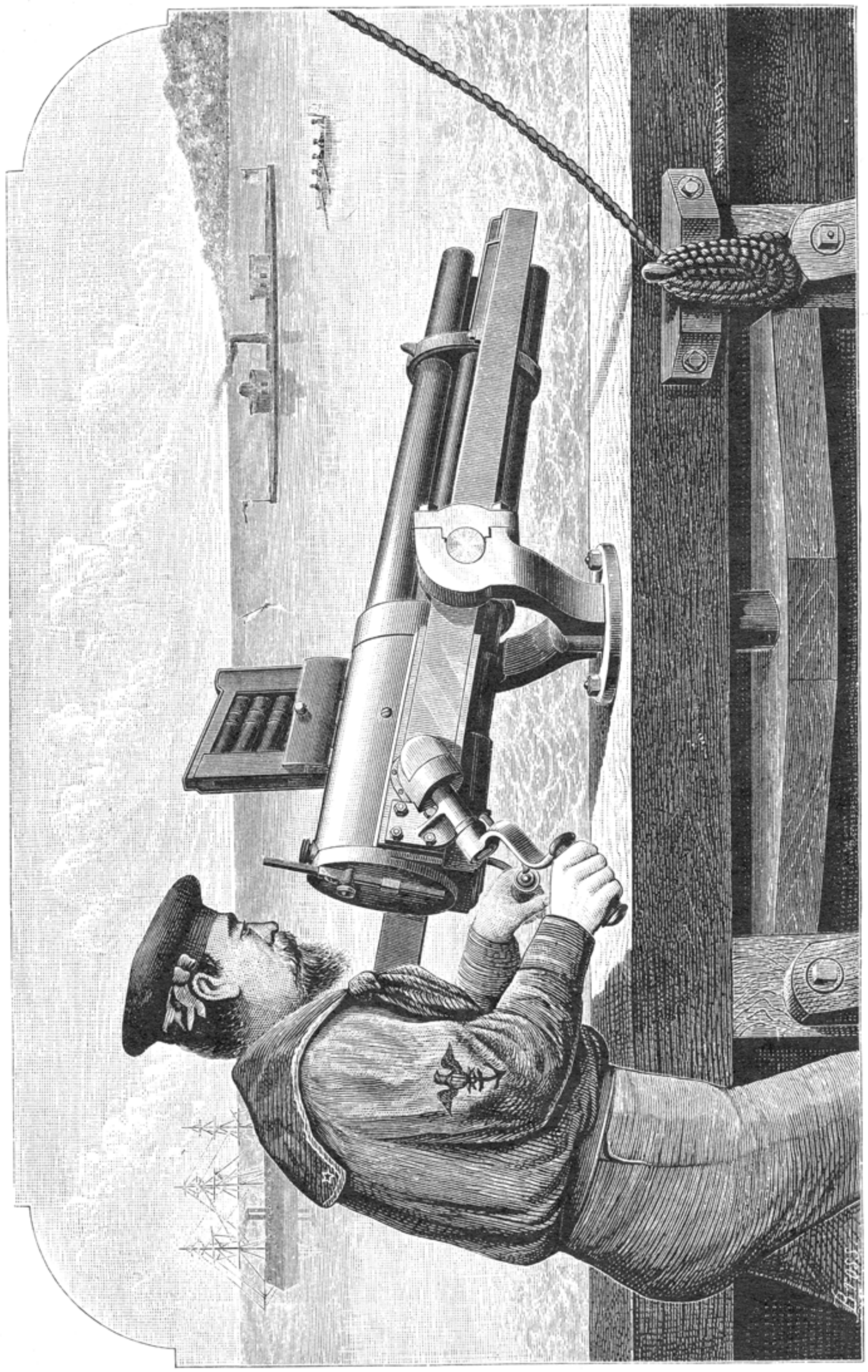
3. Considerable difficulty has been found in securing perfect weldings in coiled wrought-iron tubes, defective welds often resulting in grave accidents in service. Experiments were therefore made upon a mode of construction in which a jacket is shrunk on the tube, and extends continuously with a uniform thickness from a point a short distance in front of the trunnions to the breech-cap of the inner tube, and thence, with an increased thickness, clear through the breech to its face. This arrangement was modified by substituting a jacket which is prolonged to the rear and adapted for the reception of a round-wedge fermeture.

In Fig. 3306, ***C*** is the cast-iron casing, which consists of a 10-inch Rodman smooth-bore gun, cut off at the breech to a length of 123.25 in., and bored up to the requisite diameters to receive the tube, ***A***, with its jacket, ***B***, which is inserted at the breech. The tube is made of coiled wrought iron, and is of equal length with the casing. It is reënforced at the breech end for a distance of 40 in. by a steel jacket, which is united with it by shrinkage. The breech of the jacket is prolonged 24 in. to the rear of the casing and tube, and is fitted for the reception of the mechanism of the breech *fermeture*. The united jacket and tube are inserted in the casing with a shrinkage of 0.006 in. over the jacket, while the tube in front has a play of about the same amount. They are held in position by a thread a a and the muzzle-collar, ***b***, also the shoulder ***c c***. The breech of the casing is reënforced by the steel breech-band, ***D***, which is put on under a shrinkage of 0.08 in. and secured by the pin, ***h***. The breech mechanism works in a slot cut in the prolongation of the steel jacket to the rear of the casing and tube, and is, in all its essential features, the same as that used in the Krupp breech-loading guns of heavy calibre.

3306.



The results of the experiments led to the conclusion that the system described of breech insertion is superior in strength to muzzle insertion ; also that the facilities it introduces for the employment of shoulders, to prevent any accidental blowing out of the tube likely to arise from the common defect of imperfect welding, gives it an important advantage over muzzle insertion. It was recommended that in future conversions of smooth-bore\ guns the breech-insertion plan be employed.



THE HOTCHKISS REVOLVING CANNON.