roughing slope bit; fourth, by a finish packed bit; fifth, by a finish slope bit; and lastly, by a taper-reamer for the gas-check slope. The finishing bits are long, of the exact diameter of the chamber (that is, ground so as to bore to the exact diameter). For guns having the enlarged chamber, as the 6-inch, Mark VI, and 12-inch, Mark III, a different method is pursued. The chamber is first roughed out with a hog bit, then two packed bits are used and two slope bits. The powder chamber being larger than the mouth (or entrance) must be bored with a special boring bar and tool. This bar is hollowed, and is provided with a cutter that can be set out any desired amount by means of internal gearing worked from the outside clear of the breech. Finally the gas-check slope is finished with a taper-reamer.

The chambers for R. F. guns are tapered to receive fixed ammunition. Usually they are roughed out to desired taper, using a boring bar carrying a cutter fed in by hand, the rear end of bar being thrown out of line with gun's axis. Chambers having a straight part, and the compression slope, are roughed out with a packed bit. The finishing cut is now taken with a long packed bit, or reamer, ground so as to bore the chamber to exact dimensions. This bit must be very accurately made and carefully inspected by the officer supervising the work. The bit is entered a certain distance, which must be accurately looked out for, and if practicable the assistant inspector should see to it personally. The chamber is now measured at the rear end, and if correct it may be assumed that the gun is properly chambered.

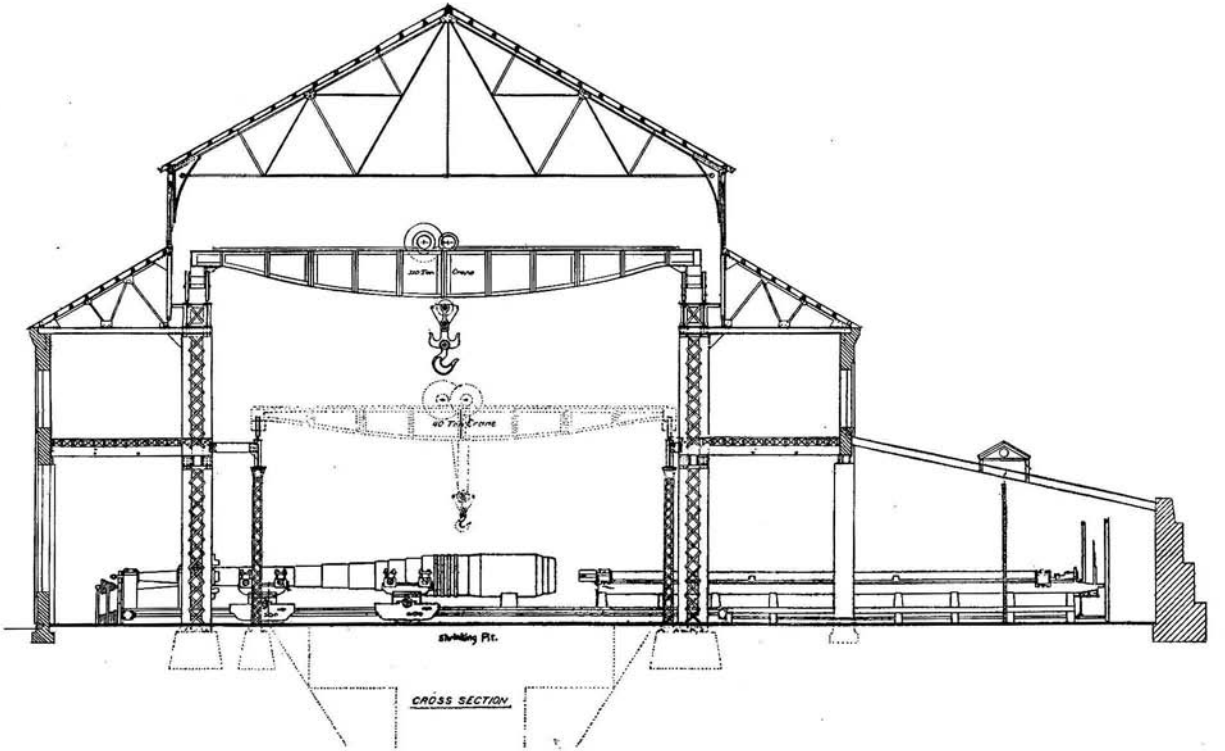
22. Threading the Screw Box.—The gun is in proper position for this operation. The lathe is geared to pitch of thread desired, and the proper tool fixed to tool post. The lathe revolves while the carriage for tool moves along laterally at the proper speed, and the cutter being properly adjusted, the thread is cut in the screw box. The point for beginning the thread is clearly shown on the working drawing. Some are chased left handed (as for most R. F. guns), others right handed, as per directions on the drawing. The threads are inspected by means of sheet-steel thread gauges, the diameters by points. The length of the threaded part is verified and particular care is paid to the point of commencing the thread, a special gauge being provided for this. Before the gun

is removed from the lathe the screw box should be inspected by the officer, and a brass plug representing the service breech plug as to threads, lengths, and any flanges, is screwed in to try the screw box or threads for screw box collar. Any defect can easily be remedied while the gun is in the lathe. In the case of certain new guns (models 1898 up) of or below 6-inch in calibre, the screw box threads are cut within a ring or screw box collar, which in turn is screwed into the gun. The method for chasing the outside thread is the same as before. For chasing the Welin, or stepped thread screw box, see par. 35.

23. Stargauging Gun after Finish-Boring and Chambering.—The gun is now removed from the lathe and landed on skids or blocks. The bore and chamber are carefully stargauged, the former for each inch of length, the latter for each half inch, and the record noted on the manufacture sheets. The gun is lighted with the electric bore searcher, and a careful examination is made for all defects in the metal, tool marks and rough places, the latter especially about the front end of the chamber for R. F. guns where the mouth of the cartridge case seats on the compression slope; and for ordinary chambers, the gas-check slope. Any roughness is, if possible, removed, using emery paper on revolving cylinders. The gun may now be rifled, or the screw box slotted, which ever is more convenient.

24. Slotting the Screw Box.—The first operation is to "lay off" the screw box. This is done by screwing a plug into the screw box and attaching to it a *division wheel* graduated into degrees and provided with a lever, or working arm, with a set screw. The line for commencing the screw thread is then found and lightly traced on the breech face of the gun, the marking arm being used for a guide for the scratcher (a brad awl). The drawing for the screw box is then consulted and the number of degrees to the first division is found, also the number of sections to the screw box. The marker is then successively placed on these divisions, and lines traced on the breech face. The top and bottom lines—the vertical line and the horizontal line of the gun—are then traced on the breech face. The vertical line is transferred to the top of the gun in the fore and aft direction.

If the vertical and horizontal lines on the muzzle face have not



TRANSVERSE SECTION OF 13-INCH GUN SHOP,
Showing 110-ton and 40-ton Cranes with Gun in Rifling Machine.

Page 70b

been placed while the gun is in the lathe, they are now transferred there from the breech. This may be done as follows: The gun is leveled, bringing the horizontal line on the breech level by using spirit levels on the marking arm of the division wheel; a plug is put in the muzzle bearing two cross-arms; these are brought horizontal and vertical, respectively, and the lines traced on the muzzle.

The gun is now taken to the slotting machine. In the case of 10-inch, 12-inch and 13-inch guns the slotter is in rear of the rests that support the gun for rifling, so that the gun does not require moving until it is rifled and the screw box slotted. For 4-inch, 5-inch, 6-inch and 8-inch guns the rifling and slotting machines are separate. The gun lies horizontally on rests with the axis of the bore in exact coincidence with the head of the slotter. The latter is provided with a head which is given a reciprocal movement by suitable machinery. The head has a circular feed and is provided with one, two, three or four cutters, according to the divisions of the screw box and convenience of the work. For small guns having four blanks, for instance, all four will be cut at the same time. The cutter is set exactly on one of the divisions, length of stroke adjusted, etc., and machinery started. Light cuts are taken, and hence several passages with increased depth of cut are necessary. As a rule, blanks are cut about 0.06-inch wider than the threaded sections to give clearance in entering and withdrawing the plug. Gauges of the exact width and radius of the blanks, and points for the diameters are supplied to the workman. Careful inspection is made for the width and diameter of blanks.

For special mechanisms of those other than the slotted screw type, the manner of shaping the breech box or mortise differs with the type.

25. **Rifling a Gun** consists in cutting spiral grooves in the surface of the bore from the compression slope to the muzzle end by means of the rifling machine. All guns at the gun factory are rifled from the muzzle end. The rifling embodies the rifling machine guide plate, rifling bar, rifling head, and cutters, and suitable gauges and points for the guidance of the workman.

26. **The Rifling Machine** consists of a cast iron bed and shears,

stationary rests or supports to hold the gun, one stationary and two movable rests to support the rifling bar, and the machinery to move the rifling bar, consisting principally of a screw and cogged gearing driven by ordinary pulley belts and wheels. The rifling head is attached to the rifling bar by a taper socket and key. The bar is supported by three rests, one stationary at the front end (next to the muzzle of the gun), having on top a stud which fits into the rifling groove on the bar by which the latter is turned while it passes back and forth through the gun; a moveable rest near the center of the bar to support the weight of the latter, which is actuated by the screw of the machine, and the third or rear rest, to which the rifling bar is held, and which is driven by the screw giving the fore and aft movement. For the heavy guns a bronze semi-circular trough is provided, in which slides the bar, to facilitate lubrication and to act as a guide.

27. **The Rifling Bar** is made of steel, slightly less in diameter than the bore of the gun and of a length somewhat greater, and upon its outer surface the rifling groove is cut. This groove is the exact counterpart of those to be cut in the gun, and is in fact the template, guide or cam. One rifling bar generally serves for two or more marks of guns of the same calibre (sometimes of two calibres), the different grooves being cut thereon clear of each other and suitably marked for identification. For guns having the same width of groove throughout the bore, such as all "plain section" grooves, but one groove is necessary on the bar. Other guns having the "hooked section" require two grooves, one to cut the groove of equal width throughout, the other to increase the width at the rear end, tapering to original width at the muzzle. These grooves are cut on the rifling bar, using a guide plate, the general principle of which is as follows:

28. **The Guide Plate** represents the developed spiral of the rifling on a plane surface and is a cast iron plate having one edge cut accurately to said curve, forming a *cam,* while the other is parallel to the axis (of the rifling or gun). The rifling bar is placed in position on the rifling machine and the guide plate is bolted on one side of the machine with its straight edge parallel to the axis of the bar. By means of a special mechanism the curve of the rifling is transferred from the guide plate to the

outer surface of the rifling bar and the groove is cut upon the latter. Each new mark of rifling requires a separate guide plate and separate groove on the bar. The latter is used indefinitely. The guide plate must be very accurately made, and the guide grooves on the rifling bar very accurately cut, working to the nearest one-half thousandth (0.0005-inch), if possible. Drawings are supplied giving full data for the rifling of each mark and calibre of gun, showing in general the developed rifling for the guide plate, and with directions for making the latter, etc.

29. **The Rifling Head** consists of a cylinder very nearly equal to the diameter of the bore, on which are placed three or four cutter boxes carrying the cutting tools. The cutters are made of the exact form of the groove in the gun, and are set out simultaneously the desired amount by an independent screw with a cone bearing in the center of the head. It is usual to set each cutter equally from the center; then by using the cone, the depth of the cut is regulated.

30. **The Method of Rifling.**—The gun is placed in the machine on the stationary rests, muzzle end to the rifling head, with its bore exactly in prolongation of the axis of the rifling bar. The cutters of the rifling head are set out by the cone to cut the desired depth. As an aid for regulating the cut, there is a graduated circle on the front face of the rifling head, and an indicator arm on the screw regulating the cone bearing, which shows the extent of raising or lowering the cutter. The full depth of the groove is not taken in one cut, but several passages of the rifling head are necessary. The rifling bar is advanced by the screw of the machine, the head enters the bore of the gun and travels the distances regulated, while the stud on the forward rest, entering the groove on the bar, causes the latter to turn as it advances, thus cutting the desired spiral. The first lot of grooves having been cut, either the rifling head, or the gun itself, is revolved the necessary amount for cutting the next group, and so on. Guns of and above 8-inch in calibre remain fixed, while the cutter head is revolved on the bar by means of a worm wheel and worm, the former having an index to show amount of turn. Smaller guns are revolved while the cutter head remains fixed. The muzzle end of the gun is secured in a revolving rest, which is turned by a worm wheel.

As the rifling head moves through the bore it is lubricated liberally with oil. After each passage, the cuttings are scraped out of the bore from the breech end.

31. Lapping the Bore.—To remove the burrs caused by the cutters of the rifling head, the bore of the gun is "lapped out," first the grooves, then the tops of the lands, the gun being placed in the "lapping machine" for this purpose. Small guns, or those under 4-inch in calibre, are lapped by having the gun rested on skids. The lapping may be postponed until after the breech mechanism is fitted, according to the convenience of the shop.

There are two sets of tools. The lapping tool for the grooves consists of a head or spider having four arms, each bearing a copper lap fitting in the grooves, which are held out to their work by flat coach springs. The lapping tool for the tops of the lands, usually called "bore lap," is a half cylinder of lead of nearly the radius of the bore.

The operation is as follows: The groove lapping tool is entered in the muzzle of the gun, drawn through the bore to the origin of rifling, and then back again to the muzzle, the motion being reversed by suitable gearing. The gun is well slushed with emery powder and oil, and the lap is drawn backward and forward until the surface and edges of the grooves are smooth. This requires two or more passages, when the tool is shifted to lap four more grooves, etc. The bore is lapped in a similar manner, using the half lead cylinder, the gun itself being turned now and then, so as to cover the whole surface. The stargauge record after final boring is consulted, and should the bore be a little small it can be lapped to the proper size, trying the diameter from time to time with the stargauge, cleaning out the bore first, however. Care is taken not to injure the compression slope nor to lap out unevenly. Experience is the guide. In some cases emery cloth may be put on the lapping tool, for instance, to remove burrs after the gun has been fired, for then the surface of the bore becomes very hard.

32. Tolerances; General Notes.—The following tolerances are usually allowed in machining: (1) Shrinkage surface, a variation of 5/1000 of an inch from assigned diameters, but a variation of not more than 1/1000 of an inch from the assigned *shrinkage* at any point. (2) Diameter of bore and compression slope,

3/1000 inch above; chamber of guns of an above 6-inch in calibre 5/1000 inch; and 2/1000 of an inch for smaller guns (not small arms). (3) Exterior diameters, 1/100 inch, more or less, from drawing size. Drawing lengths of hoops, screw box, chamber, compression slope, finished bore 1/100 inch, more or less, from drawing size. (5) Diameter of screw box, 3/1000 inch above assigned diameter; diameter of breech plug, 3/1000 inch, more or less.

33. **Stargauging and Calipering for Shrinkage Surfaces** are done at every inch. All measurements for length are made from the rear end of the tube. Figured dimensions on drawings are used. The method of construction shown on drawings is never deviated from without authority from the Bureau of Ordnance. All measurements originate from the standard scale in the gun shop (for guns made at gun factory). All screw holes for sights placed on gun, holes for fitting breech mechanism, and all parts of breech mechanism are drilled to templates or fitted to templates to insure interchangeability. All gauges used for calipering must be subjected to the same conditions of temperature, so that gun and gauge will be of as nearly the same temperature as possible; hence when using snap gauges especially, holding them unduly in the hand, or allowing them to rest on steam heaters, lie in the sun, etc., should be avoided.

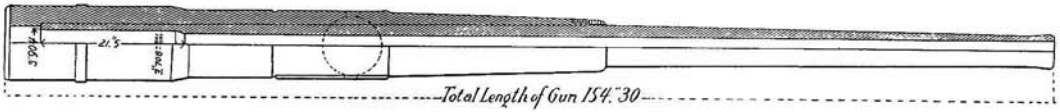
34. **Fitting the Breech Mechanism** varies according to the gun and type of mechanism, a detailed description of which would be out of place here. The general character of the various mechanisms is described and illustrated in succeeding chapters. The following general remarks will apply to all.

A cast iron working template or dummy of the breech of each type and calibre of gun below the ten-inch, is provided, made as accurately as possible. After the experimental gun and mechanism has been completed and proved and the detailed drawings altered to meet all changes, such parts as would unduly wear are faced or bushed with steel. Each mechanism, after completion, is fitted to this template, and hence they will be interchangeable. All parts of the breech mechanism where possible are provided with suitable jigs, templates, formers, and the necessary tools if special are manufactured. In some cases, as for the Vicker's mechanism,

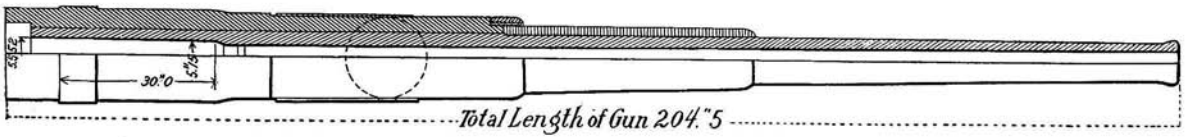
special inspection jigs, templates, etc., are provided, and each part must be a true fit. The above are usually made of steel. Certain portions liable to wear are made of hardened steel, or hardened bushings and pieces are let in, according to standard drawings, and rigidly inspected by the assistant inspector of ordnance having supervision of the work. It is now usual to use milling machines and tools for all parts of modern R. F. and Q. F. breech mechanisms, thus reducing the cost of work and the time consumed, and insuring greater accuracy and absolute uniformity. When the breech of a gun requires certain holes to be bored, it is usual to have a cast iron jig placed over the breech, and clamped to a certain line; then the holes are drilled, so that all guns are alike. In fact, every precaution is taken to insure uniformity. The screw box and all parts of the mechanism are smoothed and slightly polished with fine emery paper.

35. **The Method of Chasing the Welin Thread** differs somewhat from that of the ordinary interrupted screw, and hence the following outline description is given. The Welin plug, instead of being threaded on one diameter, has a number of steps of different diameters, and therefore the number of blanks cut is less than usual; thus an ordinary breech plug, having twelve sections, would have six blanks, while the Welin has but three, or it might be four. An ordinary six section plug would have three blanks, while the Welin has but two. It will thus be seen that there is about fifty per cent more holding or threaded surface on the Welin plug, should the maximum length of an ordinary plug be retained. Therefore, for the same holding strength, the length of the Welin plug may be considerably reduced, and hence the weight is less.

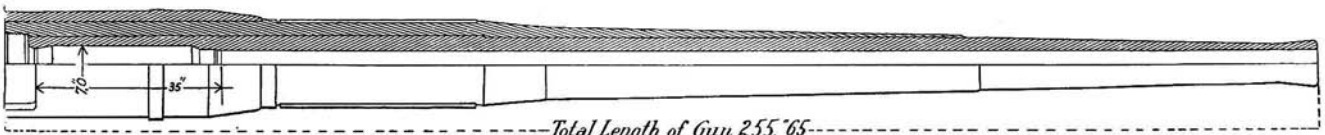
The chasing is done in the ordinary engine lathe. The plug is first bored to the finished size, then turned to the finished outer diameter and the ends squared up. The steps are then laid off according to drawing, using a copper or sheet steel gauge made for that purpose. The plug is then placed in the slotter, and the steps and blanks cut, leaving the radii of the steps slightly greater than the finished size, a small longitudinal clearance groove cut between the threaded sections (usually about 0.15-inch) for convenience in chasing, and placed on a mandrel secured in the lathe centers in the usual way. In order to chase the thread on two or



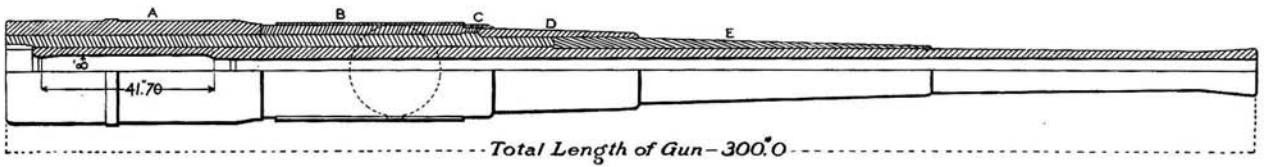
3-INCH RAPID FIRE GUN, MARK III.



4-INCH BREECH-LOADING RIFLE, MARK VII.

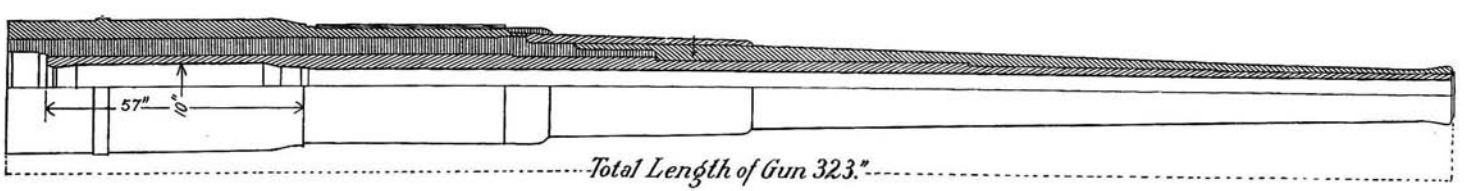


5-INCH BREECH-LOADING RIFLE, MARK V.



6-INCH BREECH-LOADING RIFLE, MARK VI.

6-INCH BREECH-LOADING RIFLE, MARK VIII.



7-INCH BREECH-LOADING RIFLE, MARK II.

more different radii with the plug revolving constantly in the same direction, a special device is attached to the lathe which holds the tool on the step, and automatically releases it as soon as the clearance groove is reached ready for the step of the next radius.

36. The Elevating-Band, When Used.—This is lightly shrunk on, and keyed to prevent its turning.

A key is screwed into the gun through the bottom of the trunnion band for the same purpose.

37. Center of Gravity.—The position of the center of gravity of the gun is now determined by balancing it on a knife-edge—if the gun is a light gun—otherwise it is computed. The breech mechanism and also the sights, if possible, should be in place when the center of gravity is obtained.

38. Weight.—The weight of the gun, marked on the breech, includes the weight of the breech mechanism and sights, but not that of the elevator arcs and bolts. The preponderance at the center of the elevating band is also determined. The gun is then finally inspected; all outside dimensions being verified, breech mechanism set up and worked, and all hand-work thoroughly examined.

After final inspection, the gun is marked, and then goes to the Naval Ordnance Proving Ground for proof firing. (See chapter on Proving Ground.)

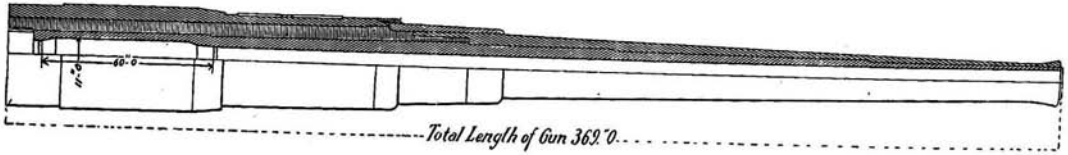
39. Recent Designs.—The Mark VI 50-calibre 6-inch Guns (Plate V), comprise Nos. 204 to 253, inclusive, and are for the battleships Maine, Ohio, and Missouri. These guns will all be quick-firing, loaded in the ordinary manner, and fitted with Vickers quick-firing breech mechanism known as Mark VI. They will be mounted on the Mark X or XI pedestal mounts.

The gun is composed of a tube, jacket, chase hoop *E*, chase-locking hoop *D*, jacket hoops *B* and *A*, and a short jacket-locking hoop *C*, merely screwed on. The tube 293.74 inches long has shrunk over its rear end for a length of 124.74 inches the jacket (total length 131 inches). The screw box in assembling being of smaller diameter than the tube brings up on the rear face of the latter. The screw box is afterwards bored out to a larger diameter than the tube to receive the breech collar box. A locking shoulder 3 inches long is left on the jacket near the front end,

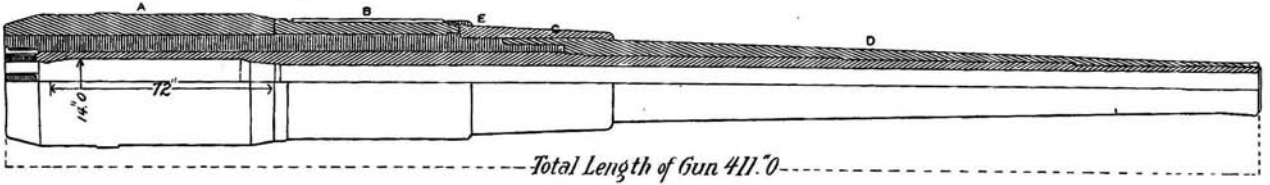
forward of which to the end (18 inches) the jacket is turned down to a diameter of 15½ inches, leaving a large front shoulder and jog. The *E* (chase) hoop, 90½ inches long, is shrunk over the tube forward of and abutting the jacket, and also abutting a small radius at the same point on the tube, which is turned cylindrical under *E*. The *D* or chase-locking hoop 39 inches long is shrunk on over the rear-end of *E*, the turned-down end of the jacket abutting the shoulder on *E;* also a hook 2 inches long brings up on a shoulder left on the *E* hoop, thus locking the chase hoop to the jacket. The jacket hoop *B* abuts and covers the shoulder on jacket, and abuts the rear face of *D*. The *A* hoop covers the jacket to the breech face. That part of the *B* hoop's outer surface over the jacket shoulder for a length of 3 inches has turned on it a right-hand thread, and a short locking-hoop *C* (7 inches long) is then screwed on. A hook brings up on a shoulder left on *D*, thus locking together the whole system. Over the gun's center of gravity for a length of 44 inches the gun is cylindrical on a diameter of 22.30 inches. It is planed off to a diameter of 21.75 inches, leaving a longitudinal key 3 inches wide at the top and bottom to prevent the gun turning within the sleeve cylinder of the recoil slide. The maximum diameter of the gun body is 24 inches, extending from 7 inches to 47.5 inches forward of the breech except for the yoke shoulder (2½ inches wide, diameter 24½ inches) which is 24 inches forward of the breech face. The muzzle of the gun is bell-shaped, diameter of bell 10½ inches, diameter of neck 9 inches. The gun is otherwise shaped as shown. Total weight of gun including breech mechanism is about 18,900 pounds.

A hinge plate to carry the breech mechanism is bolted to the right side of the breech in a slot cut in the circumference of the *A* hoop and is held by four radial screws, such that the center of the hinge-pin hole lies without the gun.

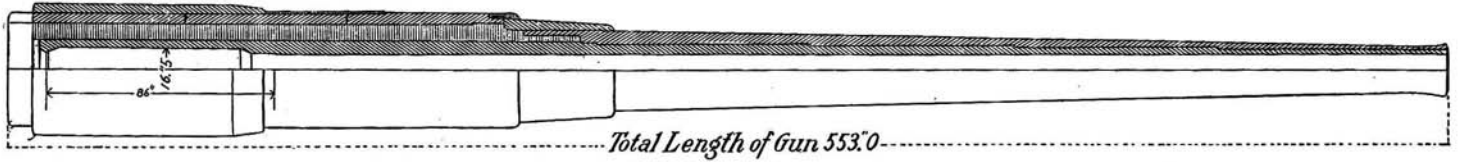
The screw box is formed in the collar. The collar, 6.258 inches long and 12.8 inches diameter, is screwed into the recess in the jacket to the rear of chamber. The screw box is of the Welin or stepped-screw type, being planed out to form nine sections, a blank and two steps in three groups. The diameters of the blanks are 10.75 inches and threaded sections 10 inches and 9.25 inches. The threaded sections are separated by a space of ⅛ inch to facilitate



8-INCH GUN, MARK VI.



10-INCH GUN, MARK III.



12-INCH GUN, MARK V.

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manufacture. The threads are right-handed abutment thread, pitch 0.5 inch, depth 0.25 inch.

The chamber has a total length of 48.416 inches from the rear face of the tube to the rifling at front end of compression slope. It is of the enlarged type, with restricted mouth and a double loaded slope. The mouth consists of the gas-check seat 1.35 inches long, tapering from a diameter of 7⅞ inches at the rear face of the tube to 7¼ inches, and thence cylindrical for ½ inch. This is joined by a straight taper 4 inches long to the powder chamber, which has a diameter of 8 inches, the end of the taper being curved with an inside radius of 4 inches. The powder chamber is cylindrical for 34.7 inches to the first loading slope, which is a straight taper 4 inches long to a diameter of 6½ inches, the ends being rounded by inside and outside radii of 4 inches and 1 inch, respectively. Then comes the second loading slope (3.83 inches long) a straight taper to 6.14 inches diameter ending at the compression slope. This slope is composed of a taper (0.28 inches long) to a diameter of 6.10 inches; thence cylindrical for 0.556 inch to the second slope; then tapers (0.20 inch long) to 6 inches diameter formed by inside and outside radii of 0.21 inch to the rifling. The total length for powder charge is about 40½ inches.

The rifling conists of 24 equal grooves, hooped section, 0.4847 inch wide at the rear end and decreasing to 0.4147 inch wide at the muzzle and 0.05 inch deep. It is a right-hand twist increasing from 0 at the origin to one turn in 25 calibres at the muzzle. The length of rifled bore is 245.526 inches.

40. Latest 6-inch Gun.—The 6-inch 50-calibre mark VIII gun is shown in Plate V. A comparison of this gun with the Mark VI, described in the previous paragraph, illustrates the tendency to strengthen the chase of new guns. It will be noted that the chase hoop in the Mark VIII gun extends from the forward end of the jacket to the muzzle; that the exterior diameter at a distance of one foot from the muzzle is increased from 9 inches to 10 inches; that the swell of the muzzle is longer, and that the diameter at the top of the swell is increased from 10½ inches to 11 inches. In other respects the differences in these two marks are immaterial.

41. New 7-inch Gun.—The 7-inch 45-calibre Mark II gun is

shown in Plate V. It will be noted that, in the general features of its design this gun is similar to the 6-inch Mark VIII. The parts and principal dimensions are shown in the figure.

42. The Latest 8-inch, 10-inch and 12-inch Guns are shown in Plate VI. In all these guns we find a long chase hoop carried to the muzzle, with the same general method of construction and arrangement of locking hoops as for the 6- and 7-inch guns. In reducing the number of hoops in comparison with guns designed a few years ago, and in carrying the chase hoop from the jacket to the muzzle the girder strength is greatly increased to resist drooping in long guns. There is also more metal, and greater strength from the shrinkage of the chase hoop to resist the increased or sustained pressure along the bore, due to smokeless powder. The locking system, and the stiffness of the construction, gives great longitudinal strength, and foreshadows the next change in gun construction which will doubtless be the adoption of two tubes continuous from breech to muzzle.

In the 12-inch gun a D hoop is shrunk on over the rear jacket hoop, giving four thicknesses over the powder chamber.

43. Table of Elements.—A table of elements of U. S. Naval guns of all calibres which was correct to April 1, 1903, will be found at the end of this chapter.

Guns.	Cal.	Mark.	Length in in.	Capacity of powder chamber in cu. in.	Travel of projectile. In.	Weight of projectile in lbs.		Initial velocity F. S.	Maximum pressure. Tons.	Maximum wt. charge S. P. Lbs.	Weight desired. Lbs.	Weight ballistic sample. Lbs.	Remarks.
						Common.	A. P.						
1-Pdr. (H. Light, Short).....	20	I	33.15	4.69	25.90	1	1	1450	8	40 gms.	35 gms.	10	Guns No. 1 to 26.
1-Pdr. (" Long).....	35	I mod.	....	4.69	....	1	1	1450	8	40 "	35 "	10	27 to 30.
1-Pdr. (D. S. Light).....	..	II expl.	....	.....	....	1	1	....	....	.....	.....	....	14, 15.
1-Pdr. (" Heavy)..... ...	40	II	61.08	7.43	53.36	1	1	2100	11	70 "	65 "	10	1 to 13, 19, 33, 34.
1-Pdr. (" ").....	40	II mod.	....	7.43	....	1	1	2100	11	70 "	65 "	10	20 to 26, 31, 32.
1-Pdr. (H. Heavy).....	40	III	62.00	7.43	53.00	1	1	2100	11	70 "	65 "	10	1 to 25, 27 to 53, 55 to 58.
1-Pdr. (D. S. Heavy).....	50	IV	75.98	7.43	67.93	1	1	2100	11	70 "	65 "	10	27 to 30.
1-Pdr. (H. ").....	40	V	62.37	7.43	53.07	1	1	2100	11	70 "	65 "	10	26, 54, 59 to 274, 376 to 425, 476 to 575.
1-Pdr. (M. N. Heavy Aut.)...	40	VI	89.50	7.43	57.07	1	1	2100	11	70 "	65 "	10	275 to 375.
1-Pdr. (" Lt. Long Aut.).	30	VII	69.35	4.69	40.42	1	1	1450	8	40 "	35 "	10	1 to 51.
1-Pdr. (H. Semi-Aut.).....	40	VIII	62.37	7.43	53.07	1	1	2100	11	70 "	65 "	10	426 to 475.
1-Pdr. (M. N. Light Short)...	..	IX	....	.....	....	1	1	1450	8	40 "	35 "	10	1 to 13.
3-Pdr. (H.).....	40	I	80.63	46.42	60.30	3	3	2200	15	400 "	360 "	20	1 to 39.
3-Pdr. (H. French).....	..	I mod.	....	46.42	....	3	3	2200	15	400 "	360 "	20	70 to 83.
3-Pdr. (D. S.).....	45	II	87.95	46.42	69.49	3	3	2200	15	400 "	360 "	20	1 to 10.
3-Pdr. (M. N.).....	..	III	....	46.42	....	3	3	2200	15	400 "	360 "	20	114 to 116.
3-Pdr. (H. Semi-Aut.).....	50	IV	99.05	46.42	78.74	3	3	2200	15	400 "	360 "	20	172 to 221.
3-Pdr. (D. S.).....	..	V	....	46.42	....	3	3	2200	15	400 "	360 "	20	11 to 20.
3-Pdr. (M. N. Semi-Aut.).....	..	VI	....	46.42	....	3	3	2200	15	400 "	360 "	20	117 to 171.
3-Pdr. (H. Armstrong).....	..	VII	....	46.42	....	3	3	2200	15	400 "	360 "	20	40 to 69, 84 to 113.
6-Pdr. (H.)	40	I & II	97.63	50.52	79.17	6	6	2240	15	600 "	550 "	20	....
6-Pdr. (")	45	III	108.86	50.52	90.39	6	6	2240	15	600 "	550 "	20	54 to 153.
6-Pdr. (D. S. Field)..... ...	30	IV	72.00	32.99	59.87	6	6	....	....	.....	.....	....	2, 4, 5.
6-Pdr. (" ").....	30	IV mod.	72.00	32.99	59.87	6	6	....	....	.....	.....	....	6 to
6 Pdr. (Field, Lynch Mech.).	30	V	72.00	32.99	59.87	6	6	....	....	.....	.....	....	1, 3.
6-Pdr. (D. S.).....	45	VI	107.33	50.52	90.39	6	6	2240	15	600 "	550 "	20	1 to 110, 65 & 68 have Mark VIII B. M.
6-Pdr. (H.).....	45	VII	108.86	50.52	90.39	6	6	2240	15	600 "	550 "	20	154 to 443.
6-Pdr. (D. S.).....	50	VIII	118.55	50.52	101.60	6	6	2240	15	600 "	550 "	20	111 to 208.
6-Pdr. (M. N. Semi-Aut.)....	45	IX	103.25	50.52	84.25	6	6	2240	15	600 "	550 "	20	446 to 561.
6-Pdr. (Nord.).....	..	X	...	.....	....	....	....	....	....	.....	.....	....	....
6-Pdr. (D. Sea'by S-A.).....	50	XI	120.00	50.52	101.46	6	6	2240	15	600 "	550 "	20	562.
6-Pdr. (H. Armstrong).....	..	XII	....	.....	....	....	....	....	....	.....	....	....	.....

BALLISTIC ELEMENTS OF U. S. NAVAL GUNS.—Continued.

Guns.	Cal.	Mark.	Length in in.	Capacity of powder chamber in cu. in.	Travel of projectile. In.	Weight of projectile in lbs.		Initial velocity F. S.	Maximum pressure. Tons.	Maximum wt. charge S. P. Lbs.	Weight desired. Lbs.	Weight ballistic sample. Lbs.	Remarks.
						Common.	A. P.						
3-inch Gun	25	I & I mod.	69.60	32.51	59.60	13.2-	Shrapnel.	1150	11	250 gms.	230 gms.	20	Guns No. 1 to 100.
3-inch Gun	50	II	153.80	219.61	128.32	13	13	2800	15	5.5 lbs.	5 lbs.	100	102 to 201.
3-inch Gun	50	III	154.30	219.61	127.92	13	13	2800	15	5.5 "	5 "	100	1 to 101.
4-inch Gun	40	I con.	163.75	331.22	131.61	33	32	2300	14	7.70	7	100	1, 3, 6.
4-inch Gun	40	I con.	159.75	331.22	128.00	33	32	2300	14	7.70	7	100	2.
4 inch Gun	40	II	164.00	331.22	132.00	33	32	2300	14	7.70	7	100	4, 5.
4-inch Gun	40	III	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	7 to 69, 71, 73, 74, 82, 84, 87.
4-inch Gun	40	IV	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	108 to 117, 180 to 209.
4-inch Gun	40	V	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	70, 72, 75 to 81, 83, 85, 86, 88 to 98.
4-inch Gun	40	VI	164.00	331.22	134.50	33	32	2300	14	7.70	7	100	99 to 107, 118 to 179, 256, 282 to 291.
4-inch Gun	50	VII	204.50	652.25	168.27	33	32	2900	15.5	15.75	15	100	213 to 254, 257 to 281.
4.7-inch Gun	45	I	....	....	....	45	....	....	....	13.75	13.0	100	.....
4.7-inch Gun	45	II	....	....	....	45	....	....	....	13.75	13.0	100	.....
4.7-inch Gun	50	III	236.20	480.61	205.30	45	....	2600	14.9	13.75	13.0	100	.....
4.7-inch Gun	..	IV	....	.....	.. .	....	.. .	....	...	.....	.....	....	.....
5-inch Gun	30	I con.	159.97	656.07	121.73	50	50	2200	14	16	15	200	1, 2.
5-inch Gun	40	II	206.00	656.07	167.76	50	50	2550	14	16	15	200	3 to 70.
5-inch Gun	40	III	205.83	656.07	167.76	50	50	2550	14	16	15	200	87 to 199.
5-inch Gun	40	IV	206.00	656.07	167.76	50	50	2550	14	16	15	200	71 to 86.
5-inch Gun	50	V	255.65	1200.00	215.67	60	60	2900	15.5 to 16	26	24.5	...	.....
6-inch Gun	30	I	189.70	1420.52	139.05	100	103.9	2150	14	26	24.5	300	1.
6-inch Gun	30	II con. A.	193.53	1317.89	142.93	100	103.9	2150	14	26	24.5	300	2 to 21.
6-inch Gun	30	III	196.00	1311.04	149.66	100	103.9	2150	14	26	24.5	300	22, 25, 26, 28, 30, 38, 39, 40, 41, 43 to 48. 81 to 86, 89 to 98, 104, 105, 107, 109, 112.
6-inch Gun	30	III con. A.	196.00	1317.89	145.40	100	103.9	2150	14	26	24.5	300	16 Guns from this drawing no No.
6-inch Gun	30	III con. B.	196.00	1317.89	145.40	100	103.9	2150	14	26	24.5	300	23, 24, 27, 29, 32 to 37, 42, 49 to 80, 87, 99 to 103, 106, 108, 110, 111, 113 to 119, 122 to 124.
6-inch Gun	35	III mod. 1	226.00	1311.04	179.66	100	103.9	2300	14	26	24.5	300	126, 129 to 132, 88.

Guns.	Cal.	Mark.	Length in in.	Capacity of powder chamber in cu. in.	Travel of projectile. In.	Weight of projectile in lbs.		Initial velocity F. S.	Maximum pressure. Tons.	Maximum wt. charge S. P. Lbs.	Weight desired. Lbs.	Weight ballistic sample. Lbs.	Remarks.
						Common.	A. P.						
6-inch Gun	40	III mod. 2	256.00	1311.04	209.66	100	103.9	2400	14	26	24.5	300	Guns No. 120, 128.
6-inch Gun	40	III con. D.	256.00	1317.89	205.40	100	103.9	2400	14	26	24.5	300	121, 127.
6-inch Gun	40	IV mod.	256.41	1317.89	205.81	100	103.9	2400	14	26	24.5	300	135 to 153, 155 to 196, 260 to 263.
6-inch Gun	40	IV mod.	256.10	1317.89	205.50	100	103.9	2400	14	26	24.5	300	133, 134.
6-inch Gun	50	V	309.25	1091.47	267.30	100	103.9	2600	14.8	26	24.5	300	198 to 209.
6-inch Gun	46	VI exp'l.	276.258	2101.02	223.78	100	103.9	2900	15	44	40	300	197.
6-inch Gun	50	VI	300.00	2101.02	247.52	100	103.9	2900	15.5-16	44	40	300	210 to 259. 277 to 360.
6-inch Gun	40	VII	254.11	1317.89	205.81	100	103.9	2400	14	26	24.5	300	264 to 276. Bethlehem.
6 inch Gun	50	VIII	300.00	2101.02	247.52	100	103.9	2900	15.5-16	44	40	300	361.
7-inch Gun	45	I	315.00	3631.87	251.21	165	....	2800	15.5	70	65	600	.....
7-inch Gun	45	II	323.00	3631.87	259.21	165	....	2800	15.5	70	65	600	.....
8-inch Gun	30	I	257.99	3574.40	197.83	250	257	2200	14	63	59	600	2. At W. N. Y.
8-inch Gun	30	I	257.99	3661.01	196.83	250	257	2200	14	63	59	600	4. " "
8-inch Gun	30	I con. A.	254.61	3517.24	196.84	250	257	2200	14	63	59	600	1, 3. On the Atlanta.
8-inch Gun	30	II con. A.	255.60	3517.24	197.83	250	257	2200	14	63	59	600	5, 6 On Boston. 7, 8. W. N. Y.
8-inch Gun	30	III exp'l.	261.00	3185.31	201.93	250	257	2200	14	63	59	600	15 only.
8-inch Gun	35	III	304.50	3185.31	245.43	250	257	2300	14	63	59	600	9 to 14, 16 to 21.
8-inch Gun	35	III mod. 1	304.50	3185.31	245.43	250	257	2300	14	63	59	600	34 to 50, 53 to 68.
8-inch Gun	40	III mod. 3	344.50	3185.31	285.43	250	257	2300	14	63	59	600	33 & 51.
8-inch Gun	35	IV	304.50	3185.31	245.43	250	257	2300	14	63	59	600	22 to 26, 28 to 32.
8-inch Gun	35	IV mod.	303.84	3185.31	244.77	250	257	2300	14	63	59	600	27.
8-inch Gun	35	IV mod.	304.50	3185.31	245.43	250	257	2300	14	63	59	600	69 to 76.
8 inch Gun	35	IV mod.	304.50	3165.07	245.43	250	257	2300	14	63	59	600	77 to 82.
8-inch Gun	40	V	343.00	5250.22	272.65	250	257	2800	16.5	115	110	1000	.....
8 inch Gun	45	VI	369.00	5250.22	298.65	250	257	....	....	.....	.....	....	....
10-inch Gun	30	I	329.10	6906.29	249.91	500	511.6	2200	14	135	125	1200	1, 2.
10-inch Gun	34	I mod.	365.60	6906.29	286.41	500	511.6	2200	14	135	125	1200	3, 4.
10-inch Gun	30	II	329.10	6860.09	249.91	500	511.6	2200	14	135	125	1200	5 to 8, 11 to 14, 17 to 26.
10-inch Gun	40	III	411.00	10221.93	325.84	500	511.6	2800	16.5	240	225	1500	.....
12-inch Gun	35	I	441.00	12145.33	344.80	850	868.4	2250	14	205	190	1500	1 to 8.
12-inch Gun	35	II	441.00	12145.33	344.12	850	868.4	2250	14	205	190	1500	9 to 14.
12-inch Gun	40	III	493.00	17623.60	388.80	850	868.4	2800	16.5	370	350	2500	15 to 40, 46, 47.
12-inch Gun	40	III mod.	493.00	17167.76	390.80	850	868.4	2800	16.5	370	350	2500	41 to 45, 48 to 56.
13-inch Gun	35	I	479.10	15289.85	373.19	1100	1116	2300	14	295	275	2000	1 to 25.
13-inch Gun	35	II	479.10	15241.72	373.19	1100	1116	2300	14	295	275	2000	26 to 34.

Correct to April 1, 1906.

CHAPTER IV.

BREECH MECHANISMS.

1. **Definition of Breech Mechanism or Fermeture.**—This is a mechanical device for closing the rear end of the chamber or bore of a breech-loading gun. The term includes the breech plug or block, the mechanism contained in or with it, and the necessary operating gear.

2. **Requirements for a Breech Mechanism.**—The following may be said to be the principal requirements of a breech mechanism:

(1) *Safety.*—Under this head will be included: (a) The stopping of all escape of gas to the rear; (b) the gun must not be weakened by the attachment of the breech mechanism; (c) the breech plug must be securely locked to avoid *deculassment* on firing; (d) there must be no danger from premature discharge; (e) there must be strength to prevent any part being blown to the rear; (f) the obturation or sealing to prevent the escape of gas to the rear must be automatic, greater pressure insuring better obturation.

(2) *Ease and Rapidity of Working.*—Otherwise, rapid and continuous fire can not be maintained. Hence this would include facility in loading and certainty of extraction for rapid-fire guns.

(3) *Not Easily Put Out of Order.*—In other words, it must be able to meet service conditions and hard usage. Parts should have a reserve of strength. All the mechanisms should be so designed as to be protected by the gun itself.

(4) *Ease of Repair.*—Parts most exposed to wear should be so designed as to permit of being replaced. This will also include accessibility to parts, so that breakage of a part will not disable a mechanism for a long time.

(5) *Interchangeability.*—Not only should individual parts be made interchangeable by accurate workmanship, but the whole mechanism should be capable of being mounted on similar guns. This is to meet service conditions.

3. **The Breechblock or Plug** is the movable piece closing the breech of a gun, withdrawn for loading, and closed before firing. It is carried in "built-up" guns by the jacket, within a screw box, mortise, or housing. The term applies to any shape of piece, or any system of closure.

In small arms and certain special guns the term breech "bolt" is often used instead of plug or block; and "breech action" is a better term in this case than "breech mechanism."

4. **Breech Piece** is a term sometimes used (as in the Krupp system) for a heavy piece of metal on the breech of a gun, which contains the breech plug or block.

5. **Systems of Breechblocks for United States Navy Guns.**— There are seven (Plate I) principal systems of breechblocks used in the United States Navy for both service and foreign built guns, viz.: (1) The interrupted screw (Fig. 1), (2) the sliding wedge (Fig. 2), (3) the rotary block (Fig. 3), (4) combined rotary and sliding system (Fig. 4), (5) the conical spiral thread (Fig. 5), (6) the sliding-bolt and turn-bolt systems (Figs. 6, 7 and 8), and (7) special fermetures.

The interrupted-screw and the conical spiral-thread systems are used for all guns of and above 3 inches in calibre. Secondary rapid-fire guns use systems (2), (3), and (4). Small-arm rifles, as well as certain automatic and machine guns, generally use the "sliding-bolt system." "Special fermetures" will be referred to as described.

Special guns, such as automatic, automatic rapid-fire, machine guns, etc., more properly use "breech actions," in which there are different methods of closing the breech and operating the mechanism. The systems in these cases are defined by the names of the guns.

In our service the interrupted-screw system is represented in nearly all of the main-battery guns; the sliding wedge by the Hotchkiss 6-pounder, 3-pounder, and 1-pounder rapid-fire guns, Maxim 6-pounder and 3-pounder semi-automatic rapid-fire guns; the rotary block in the Driggs-Schroeder 6-pounder, 3-pounder, 1-pounder, and two 4-inch rapid-fire guns; the combined rotary and sliding-wedge system by the Nordenfelt 6-pounder and 3-pounder rapid-fire guns; and the conical spiral thread, experi-

FIG. 1. INTERRUPTED SCREW.
ALL MAIN BATTERIES.
4" PLUG.

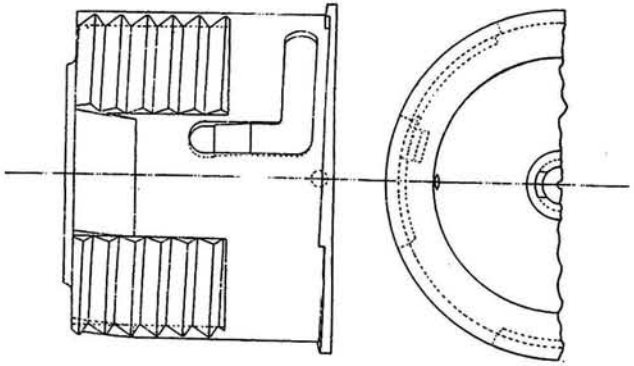


FIG. 2. SLIDING WEDGE.
HOTCHKISS 6-PDR.

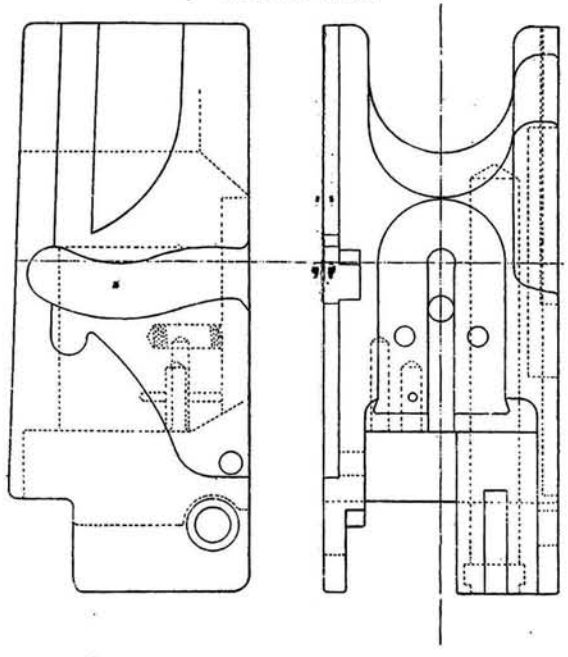


FIG. 3. ROTARY BLOCK.
BRIGGS-SCHROEDER 6-PDR.

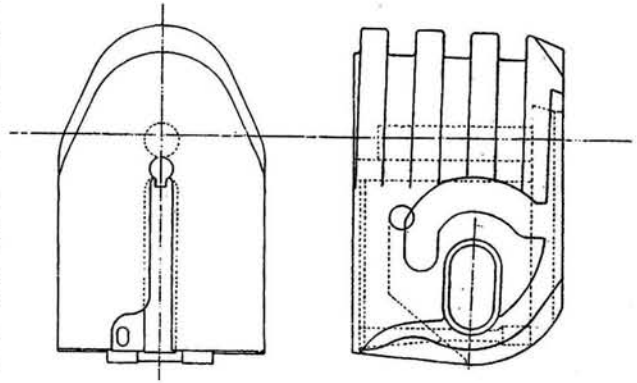
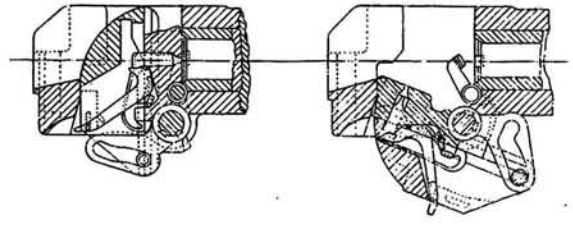


FIG. 4. COMBINED ROTARY AND SLIDING WEDGE
NORDENFELT 6-PDR.



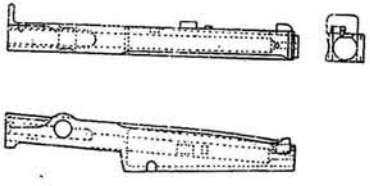
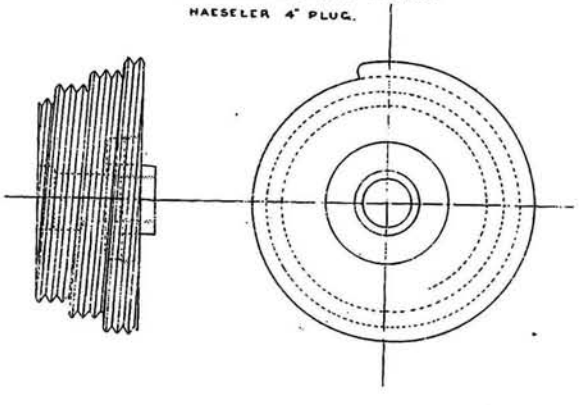


FIG. 6. SLIDING BOLT SYSTEM.
LEE STRAIGHT PULL.

FIG. 5. CONICAL SPIRAL THREAD.
HAESELER 4" PLUG.



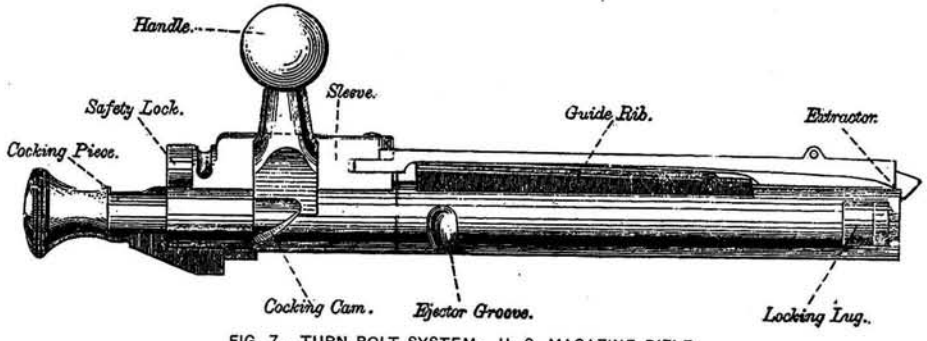


FIG. 7. TURN BOLT SYSTEM. U. S. MAGAZINE RIFLE.

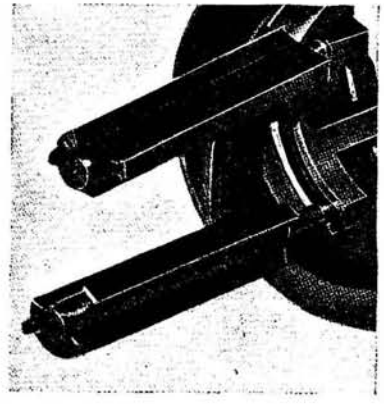


FIG. 8. SLIDING BOLT SYSTEM.
GATLING, MARK II, .30 CAL.

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mentally in an 8-inch nickel-steel gun (one was made and tried previously in a 4-inch gun).

6. The Interrupted-screw System, also called "slotted-screw," is divided into four classes (Plate II): (1) French interrupted screw (Fig. 1), (2) Elswick interrupted screw (Fig. 2), (3) Welin interrupted screw (Fig. 3), and (4) Maxim-Nordenfelt Mark M, or the Melstrom, interrupted thread (Fig. 4).

In general, an interrupted-screw plug means that the plug, having been threaded, has two or more sections of the thread removed in the direction of the axis. Similar interruptions are made in the female thread of the screw box in the gun, in order that the plug may be entered or withdrawn in one motion, and only a portion of a turn given to lock or unlock the same in the screw box.

(1) *The French interrupted screw* (Fig. 1) is the ordinary system of fermeture and has been long in use. The breech plug, cylindrical in shape, has a male screw thread cut on its circumference the character of which varies according to particular designs. It is then divided into a number of equal sections in the longitudinal direction (always divisible by two, usually six, eight, or twelve) and the threads of alternate sections are then slotted out. The female thread in the screw box is similarly slotted. In closing the breech, the threaded sections of the plug are brought opposite to the blank sections of the screw box; the plug is pushed in either by hand or by some sort of mechanism to the proper distance, and a fraction of a turn to the right or left is given to interlock the threaded sections. The amount of turn necessary depends upon the number of divisions; six divisions would require sixty degrees, eight divisions forty-five degrees, etc. The system is independent of the methods of operating the mechanism.

(2) *The Elswick interrupted screw* (Fig. 2) differs from the French, or ordinary, in that the forward part of the plug is conical and the rear part cylindrical. The threaded sections of the coned portion correspond longitudinally with the blank or planed sections of the cylindrical part. The advantages claimed for this arrangement are: (1) The working of the mechanism is facilitated, as the translation and swinging out or in can be accomplished in one motion; (2) the arrangement of the threaded sections dis-

tributes the strain throughout the entire circumference of the plug; (3) the cone shape distributes the engagement over a large transverse section of the gun.

(3) *The Welin interrupted screw* or "stepped-thread" system (Fig. 3) has the block divided circumferentially into six equal sections, each semicircle having a blank and two stepped-threaded sections. The blanks have the greatest diameters and the stepped-threaded sections are in two smaller diameters, the larger step being diametrically opposite the smaller step in the other semicircle. The blanks are cut concavely and convexly, with the hinge pin as a center, and the upper part of the teeth of the first step, with the adjoining edges, are also cut, both cuttings being to give clearance in swinging the plug.

(4) *The Maxim-Nordenfeldt interrupted screw* (Fig. 4) has the following peculiarities: The plug is slightly conical, larger end at the front, having a V thread of slight pitch, and interrupted, not by planing down to the root of the thread, but by cutting off the metal of the plug equally on opposite sides parallel to the axis, forming, more or less, a square cross section. The screw box is similarly shaped. The advantage claimed is that the plug is less likely to be blown out with excessive pressures. There is no doubt that the method of interruption considerably weakens the plug, and to make up in holding power the length of the plug is a trifle longer than it would be with other systems.

7. **The Sliding-wedge System** (Plate I, Fig. 2), exemplified in the Hotchkiss guns, has a rectangular wedge-shaped block (containing the firing mechanism) that slides up and down in a vertical mortise within the square-shaped breech of the gun, and is guided by vertical ribs. It is moved by means of a crank, journaled in the right cheek of the mortise; a stud on the other end of the crank moves in a cam groove in the side of the block. The wedge completely closes the mortise when up, and gives a sliding movement to the cartridge case in shoving it home.

Some field guns have the block working transversely to the axis of the gun, instead of vertically.

8. **The Rotary-block System** (Plate I, Fig. 3).—In this system, whatever the shape of the block, method of operation, or locking, the block rotates on an axis (generally transverse), to close or open

FIG. 1 FRENCH INTERRUPTED SCREW.

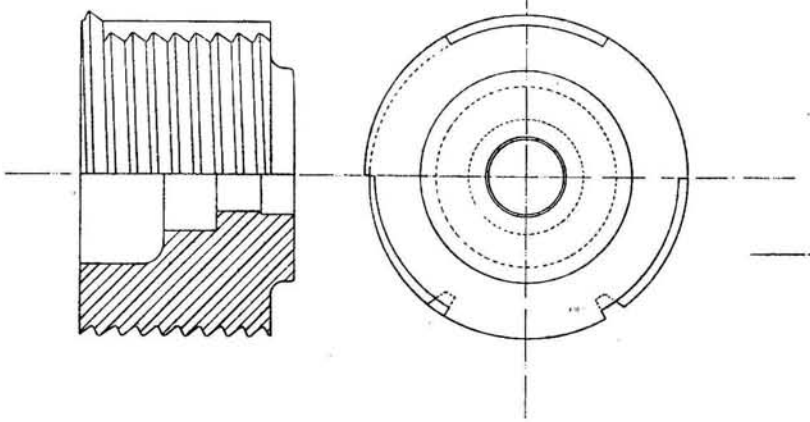


FIG. 3. WELIN INTERRUPTED SCREW.

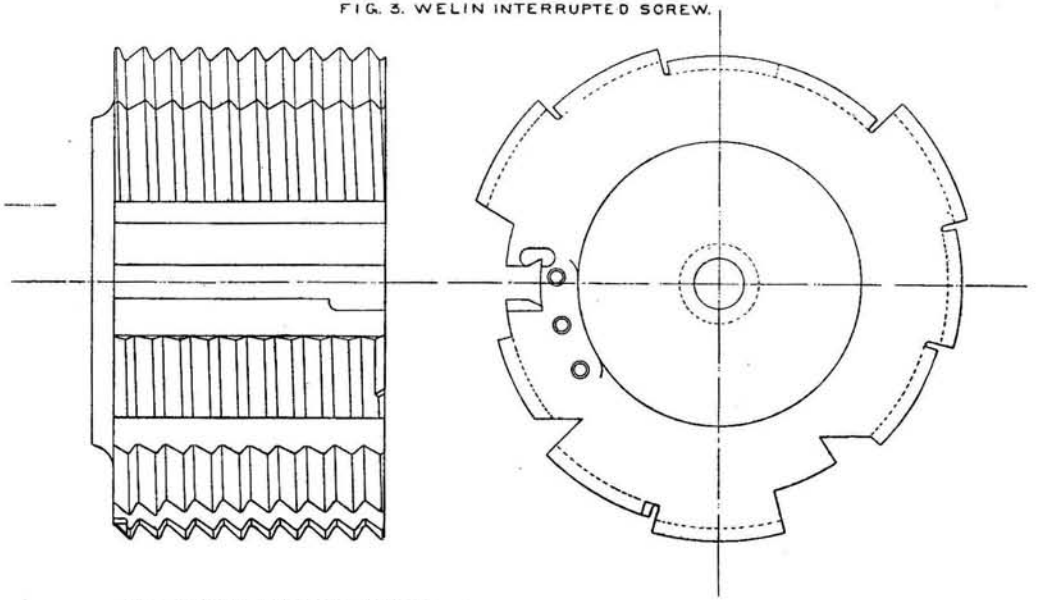


FIG. 2. ELSWICK INTERRUPTED SCREW.

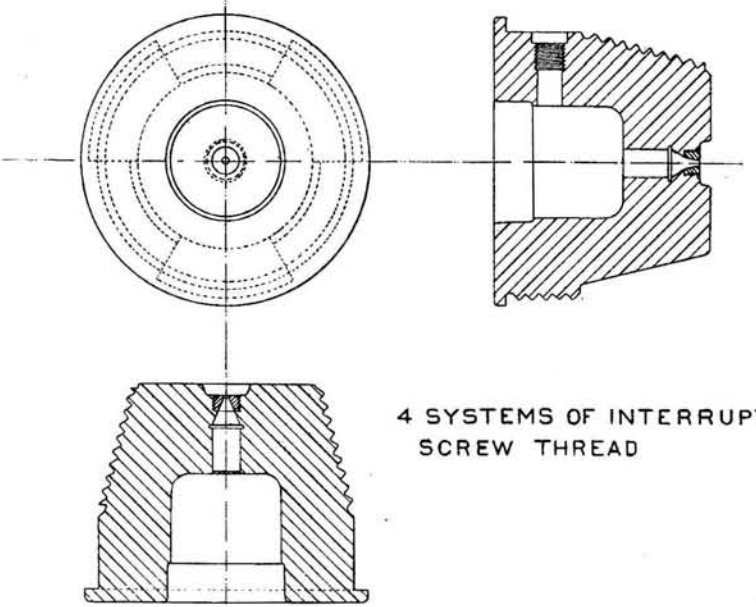
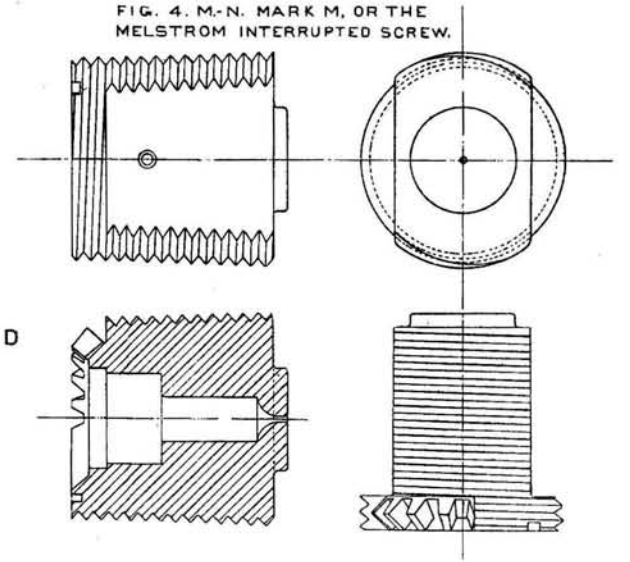


FIG. 4. M.-N. MARK M, OR THE MELSTROM INTERRUPTED SCREW.



4 SYSTEMS OF INTERRUPTED SCREW THREAD

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the breech, the upper part of the block falling to the rear in opening. There may be some vertical movement for the locking or unlocking.

This system is exemplified in our service by the Driggs-Schroeder guns. It has a rectangular block with rounded top, working entirely within the breech housing, and is locked by means of collars on the top of the block engaging in corresponding grooves in the housing. The grooves are inclined slightly to the front, so that the final movement in closing is upward and to the front, pushing the cartridge case home. The operation is through a cam within the block, moving against curved surfaces in the block's recess. The cam is moved by a transverse axis.

9. **The Combined Rotary and Sliding-wedge System** (Plate I, Fig. 4) is exemplified in our service in the Nordenfeldt 6-pounder and 3-pounder rapid-fire guns. The breechblock may be said to consist of two parts, the block and the wedge, the latter slides on the front face of the former in the locking or unlocking movement, while, to cover or uncover the breech, both rotate about a transverse axis, the top falling to the rear in opening.

10. **The Conical Spiral-thread System of Breechblock** (Plate I, Fig. 5) is represented by the Haeseler patent, and consists of a short cone, on which is chased a continuous multiple thread. The threads are parallel, of equal diameter and axial pitch. The advantages of this system may be said to be, (1) only a small height of tooth is necessary, requiring but a small revolution of the plug to disengage or engage; (2) only two motions are necessary to open the breech, viz., rotation and swing; (3) ease of manufacture; (4) lightness, and short length of block.

The advantages become more apparent as the size of the gun increases, especially as to (4).

11. **The Sliding-bolt and Turn-bolt Systems** (Plate I, Figs. 6, 7 and 8).—In these systems a more or less cylindrical piece, containing at least the firing pin and spring or hammer, moves longitudinally in a "receiver" attached to the gun barrel, and may be worked either by hand, as for small-arm rifles, or by certain mechanism, as in the Colt automatic gun. The bolt may have only a direct movement to the rear and front, giving the name "straight pull," or may have a part attached which is turned for locking or

unlocking, giving the name of "turn bolt." These systems are exemplified in the Lee straight-pull rifle, the Krag-Jorgensen rifle, in the lock for each barrel of the Gatling gun, and in the Colt automatic gun.

12. **Special Fermetures.**—Under this head will be grouped various methods of closing the breech for secondary guns used in our service, exemplified in the vertical sliding carrier of the lock in the Maxim automatic guns, and in the solid breechblocks of the revolving cannon. They will be specially described for those guns.

13. **Systems of Operating Breech Mechanisms.**—It may be said that there are two general systems, (1) ordinary, (2) quick-acting. Each of these is subdivided into certain types. These types often give the name of the gun, coupled, perhaps, with the name of the inventor or manufacturer.

It may be noted here that the names of the sub-divisions of the systems given above are sometimes used with reference to the manner in which the ammunition is put up or loaded. Such names give the name to the gun.

Even the gun carriage sometimes gives the name to the gun. Thus, a rapid-fire gun may be so called from the fact that fixed ammunition is used, but it would still be possible to use an ordinary system of operation of the breech mechanism, and a slow-working gun movement, and vice versa. Properly speaking, however, a rapid-fire gun would not only use fixed ammunition, but a quick-acting breech mechanism, and be mounted on a quick-working gun mount. Thus the terms "rapid-fire gun mount," "rapid-fire breech mechanism," "rapid-fire guns," have arisen.

14. **Distinction between Ordinary and Quick-acting Breech Mechanism.** The distinction may be said to lie solely in the movement. *Ordinary mechanisms* are operated in not less than three motions, viz., rotation, translation, and swinging, accomplished by continued revolutions of some crank, or by crank and actual hand movement in a relatively slow manner. Each motion is a distinct operation, even though accomplished by a continued movement of the crank.

Quick-acting breech mechanisms are worked by the simple swing of a lever, requiring less than a complete turn to completely

open or close the breechblock and such that the motions are quickly and continuously accomplished. There may be three motions, as in the ordinary system, but in all later-designed breech mechanisms there are but two—rotation and swinging. For heavy guns a crank may be used with interposed gearing, on account of great weight; but this crank must have only a limited movement, so that a hand lever could be substituted for it and the gearing without reducing the time of the operation, provided a corresponding direct power be applied to it.

15. Types of the Ordinary System of Operation.—There are three types: (1) Service; (2) modified Farçot; (3) improved Farçot. The difference between (2) and (3) is so slight that it is usual to class both under (2).

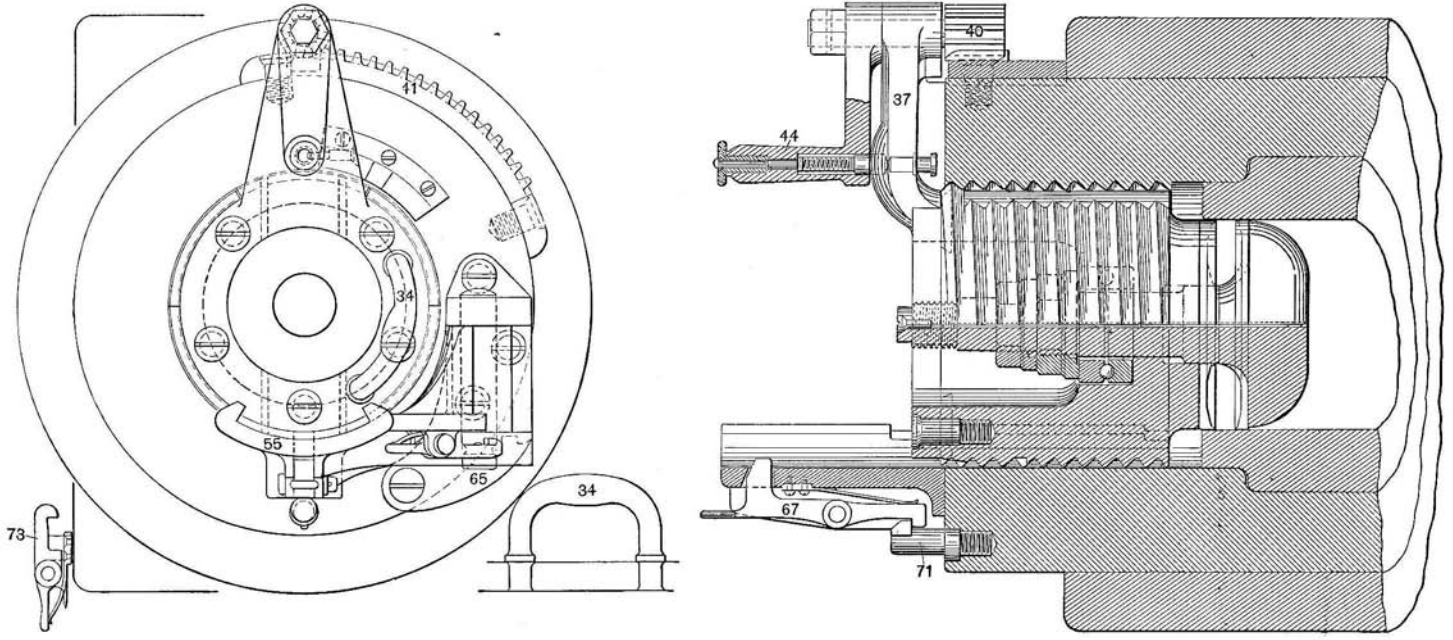
16. The Ordinary Service Types of Operation are exemplified in the 6-inch Mark III, 8-inch Mark II, 10-inch Marks I and II, and 12-inch Mark II breech mechanisms. The 6-inch and 8-inch represent one method, the 10-inch Mark I a second method, and the 10-inch and 12-inch Mark II a third.

In the first, a lever is secured to the rear face of the plug, and carries a small pinion (operated by a crank) that engages in a circular rack secured to the circumference of the breech; on turning the pinion the plug revolves, locking or unlocking the threaded sections. The plug, being unlocked, is withdrawn into a tray hinged to one side of the gun (in the 6-inch it is withdrawn by hand, in the 8-inch by a translating screw in the tray). The plug and tray are then swung clear of the screw box by hand. Other suitable mechanisms are used in connection with latching the tray, keeping the plug locked, etc. (Plate III).

In the second method, the pinion is on the breech face of the gun, and a circular rack is on the face-plate of the plug. The plug, being unlocked, is started out by a cam on a lever pivoted to the rear face of the block and working against the gun, and then withdrawn by hand onto a carrier hinged to the gun mount, the gun being at extreme elevation. The carrier or tray is then moved to one side by a hydraulic or a pneumatic motor.

Both the first and second of the "ordinary" types are being rapidly replaced by the Farçot method.

The third of the ordinary service methods is the same in principle as the modified Farçot fully described in chapter V.



"ORDINARY" BREECH MECHANISM FOR 6-INCH B. L. R., MARK III.

34. Grasp.
55. Plug tray.
37. Plug lever.
65. Hinge bolt.
40. Plug lever pinion.
67. Latch.
41. Rack.
71. Tray catch.
44. Plug lever crank handle.
73. Back latch.

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17. The Modified Farçot Operating Gear.—The name Farçot is from the inventor, and the adjective "modified" is prefixed to denote that a change or improvement was made in the original.

18. The Improved Farçot Operating Gear.—This differs from the "modified" principally in that the worm wheel and pinion are in *one piece*, and are not keyed to, but turn on, the vertical shaft as an axis. This brings the crank-shaft lower down, the number of pieces is reduced, the manufacture is somewhat simplified, and it conduces to smoother working.

For the details of the Farçot gear, see chapter V.

19. Types of the Quick-acting System.—There are five principal types: (1) Rapid fire; (2) semi-automatic rapid fire; (3) automatic rapid fire; (4) quick fire; and (5) machine-gun breech action.

A *rapid-fire* breech mechanism is a quick-acting one, *without a gas check*. It is provided with an extractor and special firing mechanism for use in guns using primed metallic cartridge cases, or in other words, for rapid-fire guns.

A *quick-fire* breech mechanism is a quick-acting one provided *with a gas check* and a firing lock for use on guns where the charge is not put up in a metallic case, or in other words, when loaded in the "ordinary manner."

There is in reality no distinction between the rapid fire and quick fire, so far as the operating gear is concerned, but the name is given because the guns differ in their ammunition, or rather the manner of putting up the same. The firing mechanism differs, no extractor being necessary for the latter.

The term *quick fire* is apparently indiscriminately used abroad for guns having a quick-acting mechanism, whether using metallic cartridge cases or powder charges in bags. It is well that a distinction should be made, as in the United States Navy.

Semi-automatic rapid-fire breech mechanisms are quick-acting, part of the operation being by hand and part automatic. This gives rise to the name; it also names the gun as semi-automatic.

Automatic rapid-fire breech mechanisms are those in which all the operations are performed automatically by utilizing the energy of recoil. The name also defines the gun.

See "Definitions of rapid-fire guns," Chapter II.

The breech actions of machine guns are necessarily quick-acting, and they will be spoken of in the description of these guns.

20. Gas Check.—This is a device to prevent the escape of powder gas to the rear around the breech mechanism, or through the vent.

A *vent check* is used with some old guns to prevent escape of gas to the rear through the vent. No special vent check is necessary for modern guns, because in those using "firing locks" the character of the lock around the vent-sealing primer prevents escape of gas. For rapid fire guns the primer case seals all escape of gas to the rear.

21. Systems of Gas Checks (Plate IV).—There are four systems in use in the United States Navy: (1) The Broadwell ring (Fig. 1); (2) the De Bange (Figs. 2 and 3); (3) the cartridge case (Fig. 4); (4) cup gas check (Fig. 5). The second and third are used in modern guns, the cartridge case of course being for rapid-fire guns.

22. The Broadwell Ring is the invention of Broadwell, an American, and has been largely used abroad by Krupp. It consists of a ring made of copper, recessed on the forward side. The flange fits in a correspondingly shaped recess in the gun at the front end of the screw box. The flange extends a slight distance forward to give a good bearing surface in the recess. The rear face is perpendicular to the axis of the gun, has three shallow grooves to collect any residuum, and extends from 0.01 inch to 0.02 inch to the rear of the recess wall. The diameter of the inner flange is less than that of the chamber, to avoid displacement in sponging. On closing the breech, the nose of the plug, or a nose plate thereon, bears tightly on the rear face of the ring, making the joint with the gun and also the bearing with the plug gastight. On firing the gun the powder gas expands the flanges and sets the ring back hard against the plug.

This check, in our service, is used in the old 3-inch breech-loading field gun or howitzer. It is being experimented with, however, to determine whether the system, or some modification of it, may not be applicable to high-power guns. These experiments are the result of several failures of the De Bange check in recent guns using smokeless powder. It is possible that some combina-

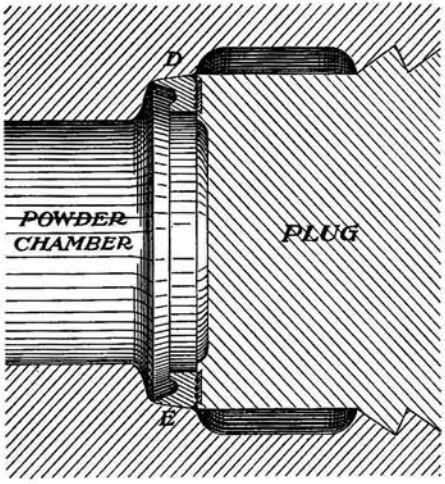

FIG. 1. D. E. Broadwell Ring.

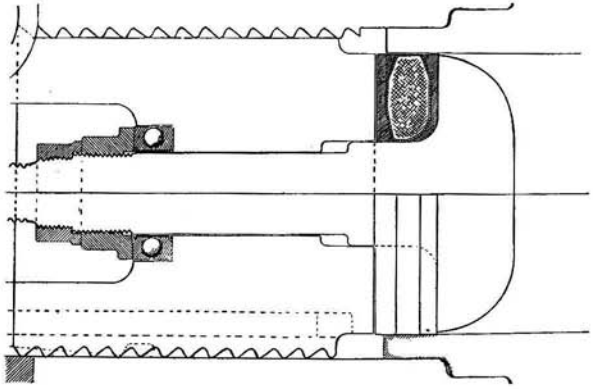

FIG. 2. The De Bange Gas Check, with Disks.

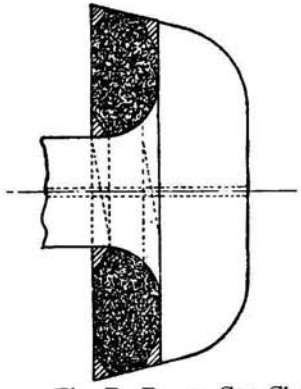

FIG. 3. The De Bange Gas Check. Later form, showing split rings.

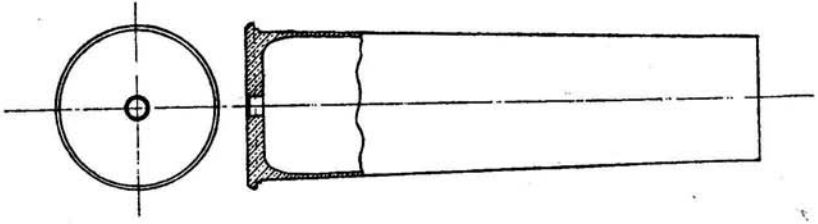

FIG. 4. Cartridge Case.

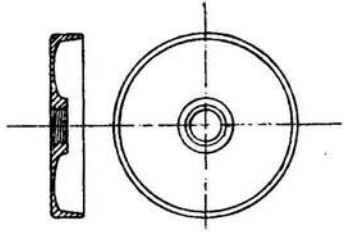

FIG. 5. Cup Gas Check.

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tion of the Broadwell ring principle with the pad of the De Bange check may be adopted which will prevent the injury of the pad in the case of abnormal powder pressure.

23. **The De Bange Gas Check,** or "pad obturator," is the type used in the United States Navy for all modern guns that are not rapid fire. It is the invention of Colonel De Bange, of France, and in many special forms has been, and is, used by practically all countries. The De Bange system of breech mechanism, considered by the French as the original interrupted-screw system, does not take its name from the gas check.

The De Bange check consists of a mushroom-headed piece of steel with a shank passing through an axial hole in the breech-block. Between the rear face of the mushroom head and the nose of the block, surrounding the shank, are two steel disks or rings inclosing an "obturator pad" of asbestos and tallow within a canvas cover suitably shaped. Nuts screwed on the rear part of shank within the recess of the plug bind the parts together.

The pad and mushroom project beyond the screw box into the chamber, the front disk and pad bearing on a smooth-sloped surface of the gun chamber, called the *gas-check slot or slope.*

The action is as follows: On firing the gun, the powder gas acting on the front face of the mushroom forces it back, compressing the pad between the disks or rings against the breech plug. This causes the pad and the front disk or ring to expand radially and equally all around against the gas-check slope, sealing all escape of gas to the rear. This check is effective in large as well as in small guns, though it took many years to prove it practically. It is commonly supposed that the pad alone checks the escape of gas. This is erroneous. The front disk assists materially in checking the gas, the pad acting as a cushion, or buffer, to prevent the front disk from getting a permanent set which might result from the compression of the disk against a steel surface.

The advantages of this type are durability, certainty of action, easy adjustment, no great accuracy of fitting, and ease with which replaced. Some pads have stood a thousand rounds; all should stand two hundred.

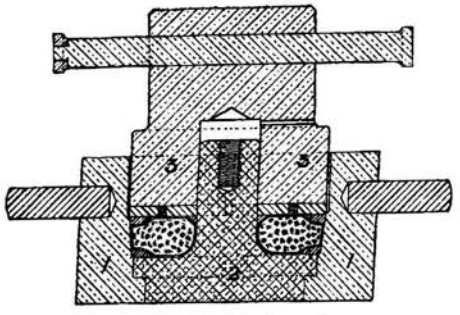
The canvas on the edges of the pad wears from the working

of the mechanism, but the cover can be replaced. It is better to put on a new cover instead of a patch.

24. **Details of De Bange Gas Check.**—The pad is composed of an "obturator cake" made of 65 parts of asbestos and 35 parts of pure mutton tallow contained in a linen canvas cover. The tallow is made from kidneys, tried out in pure water on a slow fire, skimming off impurities, and then straining through a muslin cloth. This operation is repeated. In making the cake the asbestos is pulverized, and the proper proportion of it and the tallow having been weighed out, the tallow is placed in a shallow pan and heated over a slow fire, or steam. The asbestos is slowly added and thoroughly mixed with a wooden spatula, and then the cake is allowed to cool. Its color is almost a dark gray. The proper amount of the mixture for the particular sized pad is now weighed out and rounded to the proper shape under a hydraulic press, called the "mould."

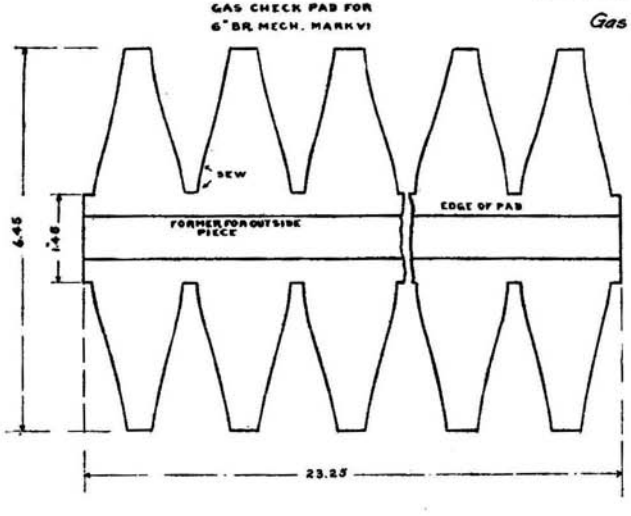
The *moulding apparatus* (Plate V) consists of (1) the mould, (2) the former, (3) the follower, as per figure and notation. The diameter of the mould's bore is that of the finished pad plus 0.01 inch clearance. The upper part of the "former's" flange and the spindle exactly reproduce the front gas-check disk, shank, and fillet, in the case of solid disks; where the front disk is a ring, a ring of the exact shape is let in a recess at the edge of the former's flange. The "follower" is a plunger recessed out to go over the stem of the "former," and neatly fits the mould.

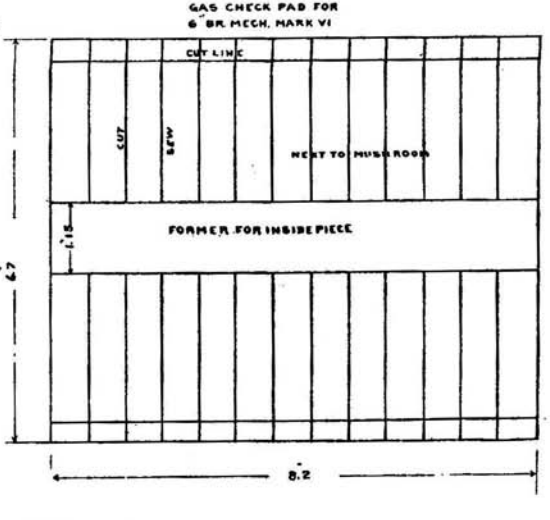
The Moulding.—The "former" being in place, a little powdered asbestos is sprinkled on the bottom, and then the warm cake mixture is put in and patted down equally all around. The rear gas-check disk is then placed over the mixture and the "follower" lowered down on top of the disk and the whole apparatus put on the table of the hydraulic press and subjected to pressure for 15 minutes to half an hour, until cool; the pressure (total) for the 6-inch is 50 tons, 8-inch 65 tons, 13-inch 75 tons, and others in proportion. The cake being moulded and its canvas cover placed on one side, with corners hauled over the opposite side and edges caught by stitches, is brought back to the press, and subjected to a pressure (total) of 100 tons for the 6-inch, 155 tons for the 8-inch, and 200 tons for the 13-inch. The pad is then taken out and



Gas check pad mould.

1- Mould
2- Former.
3- Follower.





MOULD AND FORMERS FOR GAS CHECK PAD.

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sewed on the other side, brought back and again placed in the mould and subjected to a pressure of 50 tons for 6-inch, 65 tons for 8-inch, and 75 tons for 13-inch, when the pad is complete and ready for service. A bent blunt-pointed sail needle is used.

The *canvas cover* is made in two parts, as per figure, the canvas being cut on the bias, so that the stitch will be more uniform and the canvas less apt to pucker while making. The cover is made on a wooden disk the exact shape of the moulded cake. The ends of the long piece are sewed together, hauled over the disk, carefully centered and held by a few tacks driven in the rim of the disk. The points on one side are pulled tightly down and tacked. The short piece, ends having been sewed together, is placed in the hole of the disk and a wooden plug tapered like the mushroom shank fillet is driven in. The points of one side are brought down over those of the outer piece, held by tacks, and then the lapped edges sewed. The tacks are then removed and the cover is ready to receive the moulded cake for the first pressure.

The *disks* are made of special steel, and after being suitably shaped (see disks of gas checks in breech-mechanism drawings) as to the sides, are finely tempered. The edges, rims, or flanges are then carefully ground down to exact diameters or tapers. This is an important point in the manufacture.

All the early gas checks had solid front and rear disks, but the following is the rule at present: All 8-inch gas checks have a solid rear disk and a split front ring; all 10-inch, 12-inch, and 13-inch gas checks have the double split rings, that is, both the front and rear disks are split rings. A third ring is used in these cases around the inner end of the pad's hole for its protection and centering. It is called a "centering ring." None of the 10-inch and few of the early 12-inch gas checks up to July, 1899, were of the double-ring type, but those made after that date will be, new pads being used. In making the split ring, it is cut through broadside at an angle of 45 degrees before hardening; the ends are soldered and then it is finished to final dimensions and hardened, after which the joint is broken.

The *mushrooms* are made of special steel. Their shapes are shown in the different breech-mechanism plates. The vent is bored through the axis of all, and at the rear end of the vent the

primer seat is reamed out. The outer rear end of the shank has a round thread cut on it for attaching the "firing lock." Threads, right and left handed, on different diameters are also cut in the shank for the locking nuts. The diameter of the head is less than that for the chamber, being a loose mechanical fit therein.

A *frictionless washer* is placed between the locking nuts and a shoulder is left in the mushroom shank for all ordinary mechanism, in which the plug revolves about the shank in unlocking. The object is to reduce friction. In quick-fire guns the frictionless washer is omitted.

25. Adjustment of the De Bange Gas Check.—When properly adjusted the pad and front disk, or ring, should have a light bearing on the gas-check slope. The rear disk has no bearing. A play of about 0.005 inch is allowed; but if as much as 0.01 inch is used the pad's cover is liable to be cut by the sharp edges of the disk, in which case the filling would be blown out to the rear.

With the front disk solid, the locking nuts of the mushroom shank should be so set up as to leave a clearance forward of the plug's nose of about 0.03-inch to prevent the pad or front disk from sticking after firing. With the split ring this clearance is not so necessary.

The advantage claimed for split rings over solid disks is that the ring itself can expand more freely, assist in checking the gas, and avoid cutting the pad's cover. With the solid disk the edge may bear on the cover to some extent and possibly injure or cut the latter. The old style, however, has worked well. If the split ring be so made that in expanding it will be *circular,* it will assist more effectively in checking gas.

26. The Cartridge Case as a Gas Check (Plate IV, Fig. 4).—The metallic case used in rapid-fire guns forms a perfect gas check. The heat and pressure of the powder gas on firing expand the mouth of the case against the chamber and thus seal the escape of the gas to the rear. The mouth of the case should neatly fit in the chamber when pushed home, otherwise there may be a slight leak at first. The effectiveness of the cartridge case in checking gas and the fact that it seldom sticks, tend to show that some form of metallic gas check for quick-firing guns may be forthcoming.

When the shell is loaded into the case, the powder gas being confined, will swell the case before the shell leaves it. When the shell is separately loaded, a mouth cup, or heavy wad, is usually used to close the case, in order to confine the gas at first. This point has been fully demonstrated at the proving ground. The mouth cup also serves to retain the charge and protect it from moisture, etc.

27. **The Cup Gas Check** (Plate IV, Fig. 5) was fitted to the old howitzers. Though practically obsolete, it is mentioned in this connection because of the possibility that the great heat, pressure, and other conditions may in the future force a return to some form of metallic gas check.

28. **Method of Operating Quick-acting Breech Mechanism.**—The usual (it might be said universal) method is through the simple swing of a hand, or operating lever, through an arc usually less than 180 degrees. The lever is suitably connected to the breech plug by levers or gearing. This, of course, excludes special methods of machine and automatic guns, the rapid action of which, no matter how complicated the mechanism, entitles it to the name of quick-acting.

29. **Designation or Names of Breech Mechanisms.**—We have seen that there are three general systems used in connection with breech mechanisms: (a) System of breech plug, (b) system of operation, (c) system of gas check. There is still another that might be added—"the firing mechanism." As the latter two may differ in the same general make-up they are not considered. The name or designation may be given for either of the first two systems or both, or for one of their subdivisions. The general rule may be said to be: For all quick-acting breech mechanisms, the name is that of the inventor, to which may be appended whether rapid-fire, quick-fire, semi-automatic, automatic machine, etc., or simply the mark; for others, the system of breech-plug operation, followed by the particular mark, or simply the mark is given. The latter has been alluded to before. The former will follow thus: "Dashiell 4-inch rapid-fire breech mechanism, Mark III" or "Mark V," or simply "Mark III or Mark V breech mechanism, 4-inch;" "13-inch breech mechanism, Mark II," or "Mark II breech mechanism, 13-inch breech-loading rifle;" "12-inch

breech mechanism, Welin type," or "Mark VI breech mechanism, 12-inch breech-loading rifle."

30. The Names or Types of Quick-acting Breech Mechanisms in United States Navy.—(1) Hotchkiss rapid-fire, (2) Driggs-Schroeder rapid-fire, (3) Dashiell rapid-fire, (4) Fletcher rapid-fire, (5) Elswick or Armstrong rapid-fire, (6) Vickers quick-fire, (7) Maxim-Nordenfelt rapid-fire, (8) Nordenfelt rapid-fire, (9) Haeseler rapid-fire or quick-fire, (10) Lynch rapid-fire, (11) Maxim-Nordenfelt automatic, (12) Colt automatic, (13) Hotchkiss revolving cannon, (14) Gatling. In addition to the above there are now in use in the service a number of *semi*-automatic guns of the Hotchkiss, Maxim-Nordenfelt, and Driggs-Seabury types. The two latter are very similar.

Only two guns of the Lynch type have been manufactured. This system is similar to the Hotchkiss.

Of the above types Nos. 1, 2, 3, 4, 5, 6, 12 and 14 will be described in succeeding chapters. Nos. 8 and 9 are briefly described below.

31. Nordenfelt Rapid-fire System of Operation (Plate VI).—The mechanism is made of steel, and consists of the following principal parts: Action lever, action cam, breechblock, wedge, extractor.

(*a*) The *action lever* has a vertical one-third circle motion from front to rear. It is one piece with the main axis.

(*b*) The *action cam* is connected to the main axis and has a slot, a part of which is concentric with the arc described by the action lever. On the rear upper part of the cam is a bearing corresponding to one on the under part of the trigger.

(*c*) The *breechblock* carries the firing pin, mainspring, and trigger. The firing pin has beveled projections or cocking lugs on its base for the wedge to act on, and on its under part is a lug by which the trigger retains it. The mainspring is flat, of great power and strength. The trigger pivots on its pins, and its motion is regulated by a safety lug, moving round a corresponding lug on the wedge. On the arm of the trigger are two lugs, one above and one below, the former is acted on by the wedge, the latter by the action cam.

(*d*) The *wedge* has a vertical motion in the breech. On its lower end is a pin which fits in the slot of the action cam.