

CHAPTER XX.

AUTOMATIC AND MACHINE GUNS.

1. **An Automatic Gun** is one in which the explosion of each cartridge successively and continuously operates the mechanism to eject the empty case and to load and fire another cartridge so long as ammunition is properly supplied,—no manual effort, other than holding back the trigger, being necessary after the gun is once loaded and the first shot fired. Automatic guns are usually single barreled and provision is made against overheating in sustained firing. In the two systems employed in the U. S. Navy the ammunition is fed to the gun in belts. The automatic guns used by the Navy are:

(a) The *Maxim-Nordenfeldt* 37 mm., or 1-pounder, which is properly called an automatic *rapid-firing* gun. A description, with instructions on its care and manipulation, has been published by the Bureau of Ordnance.

(b) The *Colt*, of rifle calibre only. Those first constructed were of 6 mm. calibre; the later ones use the 30-calibre service rifle ammunition and the others are being converted to the same size, but will have a few minor differences in the working parts.

2. **A Machine Gun** is one in which the continuous operation of the mechanism by means of a crank or lever, worked by hand or by motive power, ejects the empty cases and loads and fires continuously as long as ammunition is supplied and the mechanism kept in operation. Thus in a machine gun, the energy which works the mechanism comes from an external source and in an automatic gun, part of the force of explosion of one cartridge loads and fires the next. A machine gun—the term is generally applied to guns of small-arm calibre only—has usually more than one barrel. Those in use in the U. S. Navy are:

(a) The *Hotchkiss revolving cannon* of 37, 47 and 53 mm. calibre. The gun has five barrels which revolve about a common

axis and fire successively; few of these guns are now in use and none have been built for years.

(b) The *Gatling*, a ten-barreled gun, one of the first really successful machine guns invented, was formerly supplied as a 45-calibre gun; those now being furnished use the service rifle—calibre .30—ammunition.

3. **Machine Guns of Small Calibre** have been used with good effect in actions between ships and shore fortifications (war between Chili and Peru, and the British bombardment of Alexandria), by driving the crews of exposed guns to cover. Boarding, a prominent feature of actions held less than a century ago, is no longer thought of, and it is doubtful if ships in the future will ever approach each other, or shore batteries, sufficiently to permit the use of such guns—at least not until the latter stages of an action, when all exposed guns will have been destroyed. However, most ships carry a few automatic or machine guns, mounted in exposed places—often in the tops—which have large arcs of train. Considerable reliance is placed upon them, particularly on those firing explosive shell of 1-pound weight or upward, in repelling torpedo attack. Guns of these types are extremely valuable to small craft that closely approach the shore, or operate in rivers, in warfare with savage or semi-civilized peoples; rifle-calibred guns have been very effective in actions afloat and ashore in the Philippines.

The Colt Automatic Gun (Plate I).

(Fig. 1 is a plan, gas lever back; Fig. 2 is part in section and part in profile, gas lever closed; Fig. 3 gives a view of the working parts, the side plates having been removed, with the gas lever back.)

4. The Colt automatic gun is one in which the force required to perform the several motions of firing, extracting and loading is derived from the powder gases, a portion of those from each discharge passing through a small vent in the bore near the muzzle and actuating the mechanism of the gun through the medium of a lever or pendulum. Thus, a feed belt being entered in position, the gun loaded and the trigger pulled, the energy derived from the explosion of the first cartridge sets in motion the mechanism

which extracts and ejects the empty case, advances the feed belt one pocket, withdraws a cartridge from the belt, places it in the chamber, closes the bolt on it and fires it.

The gun consists of a single barrel (92) attached to a frame or receiver (88), the mechanism being contained in the latter and cased in by the side (89 and 90) and bottom (91) plates. The barrel is made much heavier than the barrel of the small arm, to reduce vibration, retard heating and expedite cooling; the greater mass of the barrel causes it to heat more slowly, while its greater surface facilitates radiation.

5. Fig. 2, Plate I, shows the gun closed and with empty chamber; in this state, the vent in the bore is closed by the piston (35), which fits into a recess in the gas cylinder (27); the latter embraces the barrel snugly, but is not secured to it by any fixed connection; the gas-cylinder pin (28) joins the gas cylinder and gas-cylinder bracket (33) while the front side-plate screw (55) passes through both and through both side plates.

The *piston* (35) is pivoted to the gas lever (29), by the gas lever piston pin (36), and has enough motion about this center to allow of its moving freely in and out of the recess in the gas cylinder, when the gas lever swings about its pivot at 34.

It should be noted that no parts are rigidly connected with the barrel except the receiver; consequently, when the barrel is heated by rapid firing, its expansion does not affect the relations of the other parts; it slides through the gas cylinder and bracket, which are made as light as possible so that they will expand more quickly than the barrel and allow the latter to move through them. The aperture in the gas cylinder is made of such a size and is so located with reference to the gas vent, that the latter is not masked by the expansion of the barrel. The gas cylinder and bracket, being tied together, expand in unison, while the somewhat loose expansion of the gas lever does not affect its action, as the freedom of the piston is sufficient to cause it always to enter the aperture in the cylinder.

The *gas lever* being pivoted as stated, and moving about the gas-lever bracket pin (34), is, when at rest, held as in the cut by the action of two springs (37 and 38), which are known as the retracting springs and are contained in the tubes (39 and 40).

These springs are kept in partial compression by the followers (41 and 42), and the pressure exerted by them is communicated through the retracting connection (45), the short links (49 and 50), and the long link (47), to the crank arm of the gas lever, thus keeping the latter firmly in the closed position.

If, now, the gas lever be moved about its pivot (34), its motion takes place in the vertical plane passing through the axis of the bore and the system of bell-crank lever, links, connecting rod and follower compresses the retracting springs. When the lever has been swung down until it strikes the forward end of the bottom plate (91), it can move no further, and, if released, will be thrown back to the closed position by the action of the springs as above described. The retracting-spring tubes are tenoned into the gas-lever bracket (33), as shown in the cut; their rear ends are free and open.

When the gas lever is swung down, the rod (31), called the gas-lever connection—being pivoted to the gas lever at the point 32 and to the slide (86) at the point 87—transmits the motion of the gas lever to the slide, which latter is constrained to move fore and aft in grooves in the interior walls of the receiver, and is further guided by the rectangular ends of the pin (87), which move in slots in the two side plates.

On the right side of the slide, near its forward end, are two projecting lugs, shown in dotted lines in the cut; as the slide moves to the rear, actuated by the connection (31), the forward one of these lugs strikes the free end of the feed lever (66) which pivots about its screw (67); a stud on the face of this lever, moving in a slot in the ratchet lever (71), causes the latter to swing about its screw (72); the free end of the ratchet lever rises and the pawl (73) is pressed in against the pawl spring (74), the face of the pawl being beveled so as to slide along the face of the feed wheel (61).

The front end of the latter consists of six radial teeth of peculiar form, and as the ratchet lever rises, the pawl, having reached the upper and flat side of a tooth, springs out and rests on the tooth. The slide now having reached its extreme rear position, on its return motion the rearmost of the two lugs strikes the feed lever and the ratchet lever is forced down, the projecting pawl

engaging the tooth of the feed wheel and turning the latter to the right.

A *spring dog* (63), pivoting about a screw (64) in the bottom plate, is of such shape that it permits of the revolution of the feed wheel to the right, but prevents motion in the other direction. A device is provided for permitting the feed wheel to be turned backward when desired; it consists of a throw-off (68), (not well shown in the plate), operated by a knurled screw head (70) on the right side plate, just below the belt exit; if this screw head be pushed forward, the throw-off draws the dog out of engagement with the feed wheel, which can then be rotated backward, thus allowing of the removal of a partially empty belt.

The *belt guide* (59) prevents the "bunching" of the belt into the channel between the two sides of the slide. It is secured to the receiver by the screw (60) and by a tenon near its rear end.

The *cartridge extractor* (82) is pivoted to the slide at 83; the rearward motion of the slide causes this extractor to draw a cartridge from the feed belt and to deposit it on the carrier (21), which, at 22, is pivoted to the receiver. On the same pivot with the cartridge extractor is borne a cartridge guide (80), and when the slide is in its forward position this guide engages the cartridge, in connection with the cartridge extractor, and holds it in a central position.

The function of the *carrier* is to receive cartridges from the extractor, raise and present them in front of the breech bolt (13) for loading into the chamber. The slide in its rearward motion strikes the carrier dog (23), which pivots about its pin (24); the first effect is to compress the spring (25); when the slide has moved so far to the rear that the extractor (82) has withdrawn the cartridge entirely from the belt, the dog spring has been so far compressed that the slide passes over the dog, causing only a slight depression of the rear end of the carrier, and a corresponding elevation of the front or free end. When the cam surface of the slide lug (seen just below the number 14, Plate I) has passed over the carrier dog, the latter is freed and is sprung back to its normal position, that shown in the cut. The return motion of the slide now begins, the slide lug strikes the rear face of the dog and sharply raises the front end of the carrier, presenting the

cartridge in front of the breech bolt; passing over the dog, the slide cam lug strikes the flat upper surface of the carrier forward of its pivot and forces it down into horizontal position, ready to receive a second cartridge.

6. Passing next to the consideration of the breech bolt (13), it is seen that it is cylindrical in form, with a central guide rib on its lower side at the rear, which depends into a slot in the rear end of the slide, and is there secured by the bolt pin (14). This pin, instead of rigidly pivoting the bolt, passes through a cam-shaped slot, so that a certain amount of motion of the bolt is allowed, both vertically and fore and aft, about the pin.

Starting, as before, with the gas lever up and slide in forward position, the breech bolt is seen to be entirely closed, with its rear face lying against the recoil shoulders in the frame; the first effect of the rearward motion of the slide is to cause the rear end of the bolt to rise, owing to the action of the pin in the cam slot; this clears it from the recoil shoulders, and it then moves directly to the rear with the slide, leaving the way clear for a cartridge to be fed up by the carrier. On the forward motion of the slide, the reverse operation takes place, the bolt first moving forward horizontally, pushing a cartridge before it, and finally canting into the locking position.

The *bolt* carries the firing pin (18) and extractor (15); the former is held to the rear by the spiral spring (19), its rear end projecting from the bolt, and is driven forward against the primer by the blow of the hammer (6) against its projecting end, when the latter is released by the trigger and sear. The extractor (15) is carried in a slot on the right side of the bolt and grasps the head of the cartridge as it is forced up by the carrier; it has a slight rotary motion about the vertical pin (17), a small spiral spring under its rear end holding the nib so as to engage the rim of the cartridge.

The *ejector*, not shown in the plate, is located in a groove in the left side of the receiver, in such a position that a projecting lug on its inner side is struck by the head of the case when the latter is clear of the chamber; the blow releasing the case from the extractor and throwing it violently out, through the opening provided for the purpose in the right side of the frame.

The *hammer* (6), firing spring (7), sear (10), sear spring (11), trigger (8), and trigger spring (9) are carried in the handle (1). When the hammer is free from the trigger and sear, it lies with its head against the rear end of the bolt and firing pin; when the bolt moves to the rear with the slide the hammer is forced back into the handle, compressing the spring, until the notch around its head is engaged by the trigger and sear nibs; it is then held in the position shown in Fig. 3 until released by the trigger and sear.

As both trigger and sear engage the hammer, both must release it before it can fly forward; the necessity of both trigger and sear is plain when it is considered that in automatic firing the trigger is held back continuously, the sear alone holding the hammer until the moment of firing. For releasing the sear automatically the following device is employed:

An *oscillating lever* or trip lies in a slot on the left side of the frame, being pivoted at its middle point, and having the lug end forward. With the slide in its forward position, the pin on the forward end of the trip lies on top of the slide, just forward of the number (14) in Fig. 2; this end being thus elevated, the rear end is correspondingly depressed and the pin at that end forces down the toe of the sear, out of engagement with the hammer; this leaves the hammer held only by the trigger, and upon this being pulled, the hammer flies forward, discharging the gun. If, now, the slide be moved to the rear, the cam on its left upper side allows the pin on the forward end of the trip to drop, and the pressure of the sear spring, meeting no longer with resistance, forces the sear up against the hammer, raises the after end of the oscillating lever and depresses the forward end. The rearward motion of the slide continuing, the bolt forces back the hammer, compresses the main spring, and the cocking is completed just before the end of the rearward motion, the hammer being held by both the sear and trigger. The slide then moving forward, the release of the sear takes place, as above explained.

In automatic firing, the hammer is released when the pin on the forward end of the trip reaches the top of the cam cut on the slide, which extends from 14 to near 60 (see Fig. 2).

7. An inspection of Fig. 3 will show a channel in the upper

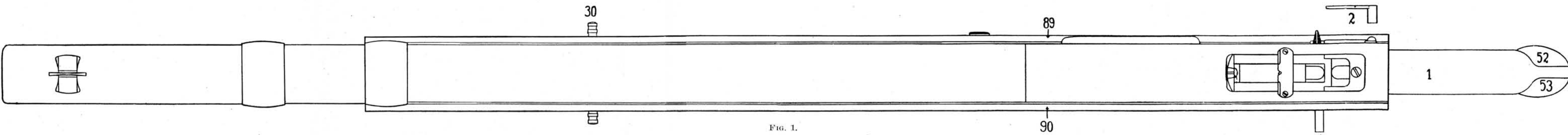


FIG. 1.

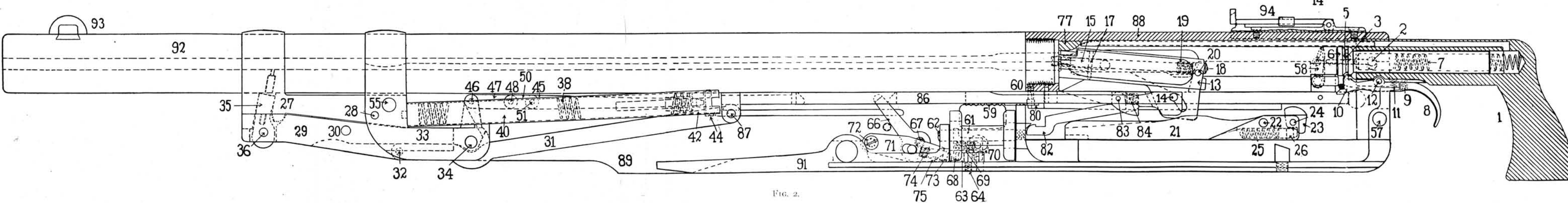


FIG. 2.

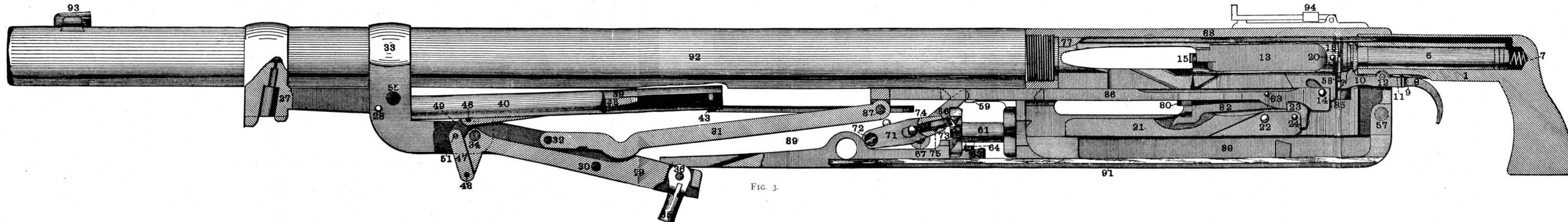


FIG. 3.

part of the receiver, connecting the hammer casing with the chamber of the gun; a small brass tube forms the connection as shown; the rapid alternating motion of the hammer in its casing forces a jet of air through this tube into the chamber of the gun, which is found to be practically serviceable as a cooling agent and for cleaning the chamber of grains of unburnt powder.

The *safety latch* (58) has a thumb piece on the right side of the outside of the receiver and a lever, at right angles to it, inside; when the thumb piece is pushed forward, the lever inside rises in front of the hammer and restrains it if both sear and trigger are released; this is the "safe" position; with thumb piece of safety latch pushed to the rear, the lever lies below the face of the hammer and does not prevent its moving forward when released.

8. The gun is sighted up to 2000 yards with plain open sights much like those of the service rifle; there is no wind or drift connection. The sights are marked for single shots,—in automatic firing the shots will fly high—about one foot in 200 yards.

9. The gun, as furnished to ships, is seated in a cradle which in turn rests in a saddle with a pivot; there is a suitable cradle clamp. It may be mounted on a tripod, a field carriage, a 1-pounder pivot stand, (with an adapter), or in a permanent socket on the rail. The gun should not, except in emergencies, be left mounted where exposed to the weather. The canvas feed belts, containing 250 cartridges each, are laid down "clear for running" in a box attached to the left side of the mount. The cartridges must be inserted in the belt to exactly the proper distance, to prevent their jamming in the gun, and this is best done by a belt-loading machine.

10. **Manipulation.**—The outer end of the feed belt has a brass tip which is entered in the cartridge-shaped aperture in the left side plate and drawn through the belt exit,—the rectangular hole in the right side plate,—as far as it can be drawn. The feed wheel (61), having six teeth at each end, forms six cradles, one of which is always at the top, so that a cartridge lying in it, is in the middle line of the gun and horizontal. The first cartridge of the belt is stopped in this position, and the belt can be drawn no further, on account of the rear end of the cartridge bringing up against the feed roll wall, which is seen in the plate just in rear of the feed

wheel; the cartridge cannot cant in the cradle, the bullet being held by the bullet guide, which is secured to the inside of the left side plate just forward of the cartridge-shaped opening.

The belt being thus entered, and a cartridge in the feed wheel, the gas lever is swung by hand through its full arc to the rear and released, when it flies back into the closed position, under the tension of the retracting springs. The backward swing of the lever moves the slide to the rear, as already explained.

In the first three-eighths of an inch of motion of the slide, three operations are accomplished: the head of the first cartridge is gripped by the cartridge extractor and by the cartridge guides; the bolt is unlocked by the raising of its rear end; and the sear, released by the trip, rises against the hammer.

In the next one and one-half inches of motion the main spring is compressed; at this point the forward lug on the right edge of the slide strikes the feed lever and begins to move it to the rear. After another seven-eighths inch, the slide strikes the carrier dog, and at four inches, the cocking is completed, the feed lever is in its extreme position, the cartridge is raised slightly out of the extractor, the trigger and sear snap over the head of the hammer, and the bolt is fully drawn back.

The forward swing of the gas lever draws the slide forward, the first effect being to throw up the front end of the carrier,—the lug on the under side of the slide striking the carrier dog as before explained. This raises the cartridge diagonally and stops it with the bullet pointing into the chamber and the head presented in front of the bolt which is again moving forward; the slide lug, having passed over the dog, strikes the upper surface of the carrier and begins to push it down, and at the same time the bolt face strikes the cartridge and pushes it into the chamber, the bullet being guided by the *chamber guide* (77).

Shortly afterward the rear feed lug strikes the feed lever and pushes it over to its forward position, turning the feed wheel one-sixth of a turn to the right and presenting another cartridge to the extractor; the last operations are the locking of the bolt by the depression of its rear end, and the bearing of the sear off the hammer by the forward pin of the trip riding up the incline at the rear end of the cut on the slide.

The gun is now loaded, a cartridge in the chamber ; another one ready to be gripped by the cartridge extractor ; the main spring is fully compressed, and the hammer restrained by the trigger alone.

If, now, the trigger be pulled and let go, the cartridge in the chamber is discharged and all the operations above described are repeated, the gas lever being thrown back by the pressure of the gas through the vent and returned to position by the retracting springs. The empty case is also extracted and ejected as heretofore explained. The gun is thus fired, the empty case ejected, another cartridge loaded into the chamber, a third presented to the cartridge extractor, and the gun cocked, all by simply pulling the trigger and releasing it.

If, now, instead of being released after pulling, the trigger be held back, the operations above described will be performed in precisely the same way up to that point, in the forward swing of the lever and forward motion of the slide, where the trip forces the sear off the hammer ; when this stage of the motion is reached, the trigger no longer restraining the hammer, and the sear being forced off by the trip, the hammer is released, flies forward, and discharges the gun ; the same operations are then repeated, and automatic action is obtained as long as the trigger is held back and ammunition is furnished by the belt.

The belt is drawn through by the feed wheel and is dropped out on the right side of the gun when empty ; if it be desired to remove a partially empty belt, it can be drawn out to the left on pushing forward the knurled button on the right side of the gun, which allows the feed wheel to be rotated backward.

(In the "Gun and Torpedo Drill Book," 1900 edition, may be found extensive notes on the care and management, procedure in the event of jamming, etc.)

The Gatling Gun, Mark II, Calibre .30.

(See Plates II, III, IV, V and VI.)

II. The Gatling gun is a machine gun in which the operations of entering the cartridge in the chamber, firing the cartridge and ejecting the empty shell are all performed mechanically by the simple turning of a crank. In the Navy type of the Gatling gun

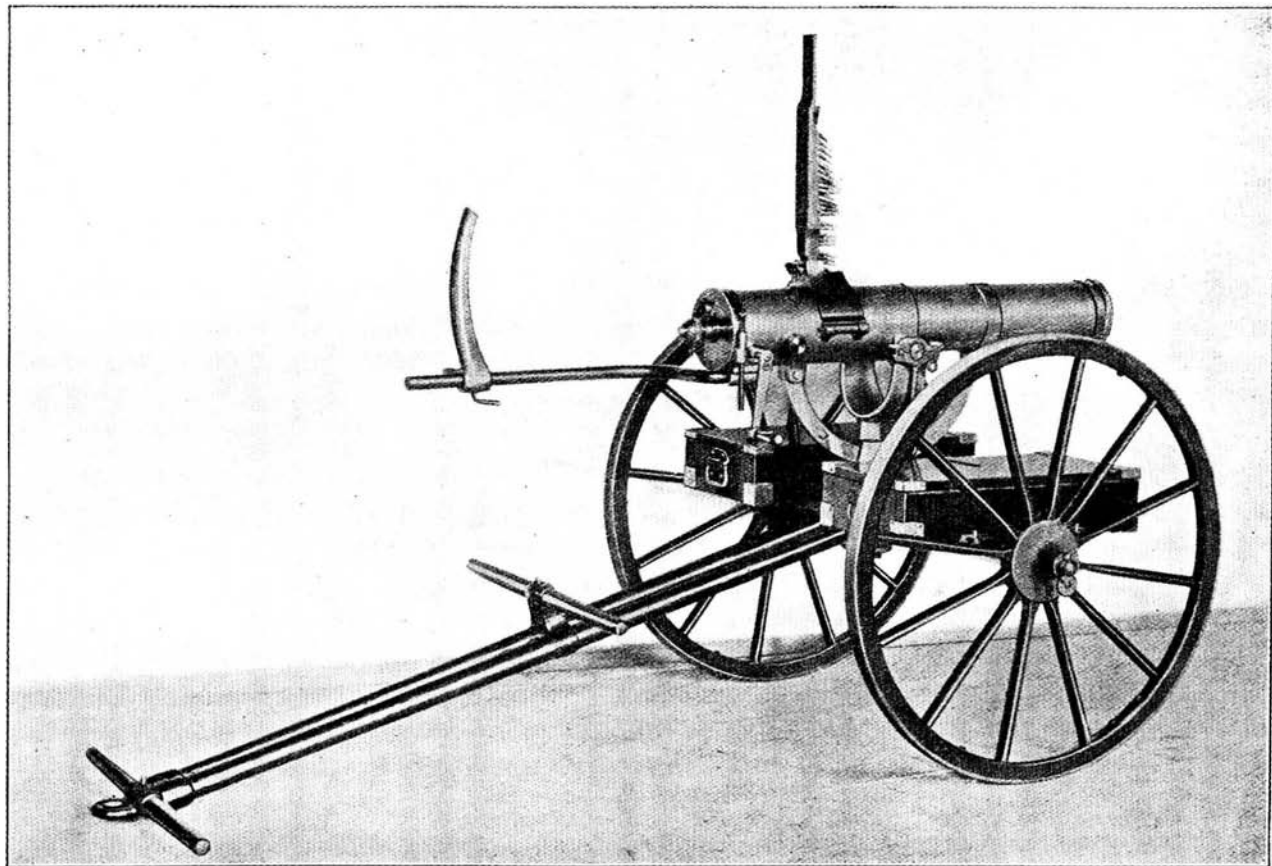
all the mechanism and barrels are encased in a brass casing. The ammunition for the last design is the same as for the .30-calibre Colt and the .30-calibre rifle. The sight is of the plain bar type, graduated to 2000 yards.

The *casing* (Plate II) is a hollow brass cylinder open at both ends. It is bored to two diameters, the forward diameters corresponding to the diameters of the barrels plates (18 and 19, Plate III), and the rear diameter corresponding to the diameter of the cam cylinder (6) and diaphragm (5) (Plate III). On the front end of the casing is screwed the front bearing (21, Plate VI), which receives the forward end of the main shaft (89) and furnishes it with a bearing. There is a lug on the forward end of the casing for the front sight, lugs on the rear end for the hopper hinge pin (37) and for the crank-shaft bearing, and lugs on the under side for the arc and pointing lever. There is a key-way cut in the casing on its inner surface, after end, for the cam cylinder key (7, Plate V). This key, when in place, locks the cam cylinder (6) and diaphragm (5) against rotary movement in the casing. The rear end of the casing is threaded to receive the cascabel plate (16), which is also threaded; these threads are half cut away in the interrupted screw fashion.

12. Referring now to Plate III, it will be seen that the barrels (56), ten in number, are symmetrically located about the main shaft; the front ends of the barrels resting in the front barrel plate (19) and the rear ends being screwed into the rear barrel plate (18). Both barrel plates are keyed to the main shaft so that they must revolve with it, carrying with them the barrels. The hexagonal shape of the barrels, immediately in rear of the front barrel plate, is for receiving a wrench when screwing them home.

On the after face of the rear barrel plate is a hub on which the carrier block (38) assembles. The carrier block is still further held in place by a longitudinal dowel pin (39, Plate VI), the forward end of which protrudes into the rear barrel plate and the after end of which protrudes into the lock cylinder disk (2). The carrier block is best seen in Plate VI; the grooves shown are guideways for the locks and for the cartridges.

The *lock-cylinder* disk (2) and body (3), assembled as one part, are axially bored to fit the main shaft and are keyed thereto



GATLING GUN, MOUNTED ON NAVY FIELD CARRIAGE, WITH THE DIRECTING BAR, SHOULDER REST, CRANK EugeneLeeSlover.com SHIPPED.

immediately in rear and abutting against the carrier block; thus the lock-cylinder body is the rearmost piece which revolves with the main shaft, barrels, etc. The rear guide nut (9) screws on the main shaft in rear of the lock cylinder and prevents its longitudinal displacement. The lock cylinder has ten guide grooves in which the locks travel through the ten holes in the disk which have the same profiles as have the locks. These guide grooves are continued on the surface of the carrier block (38), and are there sloped away at the top to form pockets which take up and bear the cartridges. In Plate III, the lock cylinder is concealed by the cam cylinder (6), but the disk (2) is shown just in rear of the carrier block; the locks (78) may be seen protruding through the disk—a cartridge is shown in front of one at the moment of being pushed into the barrel. It will be noted that the main shaft, ten barrels, two barrel plates, carrier block and lock cylinder are all rigidly locked together, none having any motion independent of the others, and are revolved with the hands of a clock by a crank.

13. The Locks (7), ten in number, are best seen in Plate IV. They are of irregular section and are provided with T-shaped guide ribs which travel in the grooves of the lock cylinder and carrier block; there is a radially projecting lug on the rear end of each which engages the cam of the cam cylinder (see Plate IV), by which the locks are moved back and forth. The outer side of the lock is slotted nearly its whole length to receive a straight extractor which, to obtain elasticity, is secured only at its rear end. The center of the lock is bored out to receive the spiral firing spring and the straight firing pin; on the rear end of the latter is formed a knob which engages the groove of the cocking switch. A loose sleeve around the front end of the firing pin has two arms which project forward enough to strike the front shoulder of the lock when the pin goes forward and thus causes it to rebound slightly after striking the primer.

The *cam cylinder* (7), (Plates III and IV), surrounds the lock cylinder, abutting against the rear face of its disk, and is keyed to the casing so that it cannot revolve. The cylinder has a recoil plate (14) (Plate V) screwed to its front lower edge, against which the rear ends of the locks abutt, and are supported, during

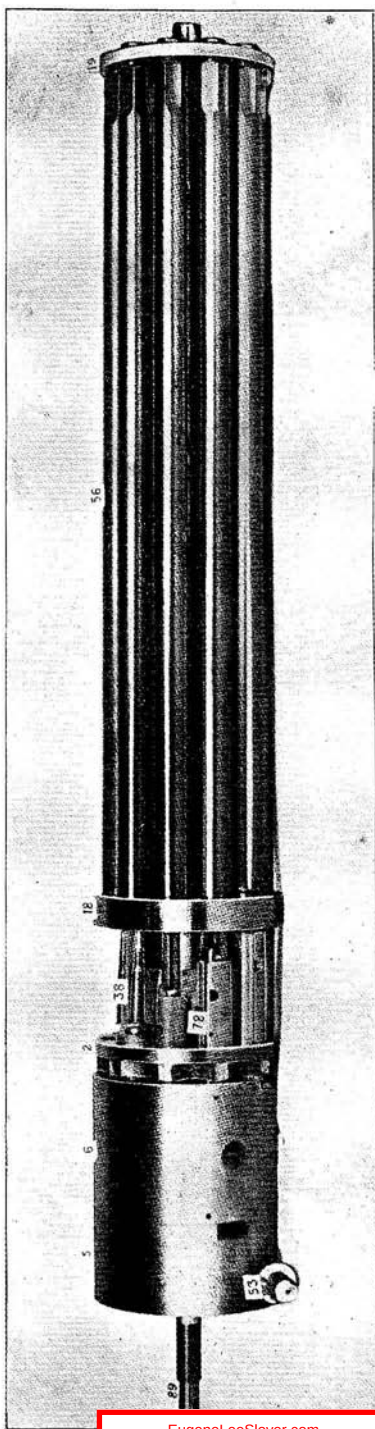
firing. On the inner surface of the cylinder a spiral cam is cut which operates the locks by the lugs on their rear ends. The cocking switch (63) is held in a longitudinal dovetailed slot in the cam cylinder; it is held forward by a light spiral spring, but may be moved rearward by turning a milled head, called the cocking-switch knob, on the right-hand side of the gun (see Plate II); when moved to the rear the switch is out of action and will not cock the locks.

14. Immediately in rear of the cam cylinder, and abutting against its after end, is the diaphragm (5, Plates III and V), keyed to the casing with the same key as the cam cylinder. It is bored axially for the rear bearing of the main shaft and transversely, on its lower side, for the crank shaft. In its upper left-hand portion is a sleeve for the lock plug (44), the use of which will be explained.

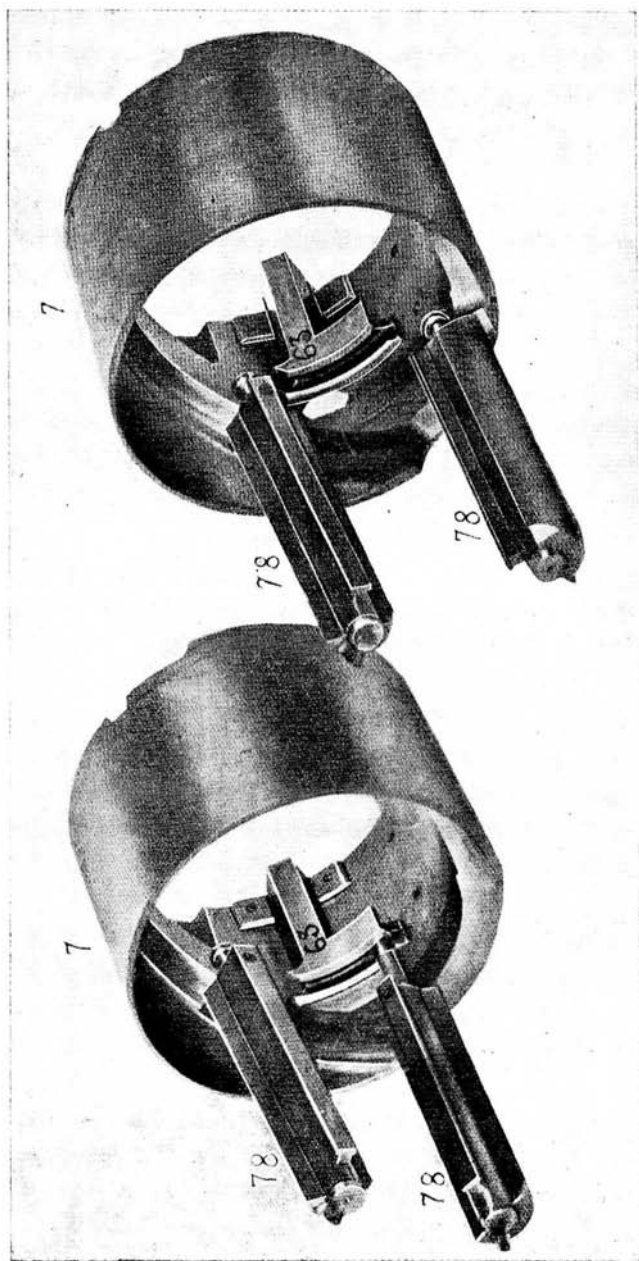
The *main-shaft worm wheel* (12, Plate V) assembles on the main shaft, to which it is keyed immediately in rear of the diaphragm, and engages the crank-shaft worm wheel (13), which is carried by and keyed to the crank shaft (53), immediately below the main shaft.

The *cascabel plate* (16, Plate V), assembling next in rear of the diaphragm, has a lug for the rear sight; it is threaded to correspond with the threads on the rear end of the casing. On its upper inner surface is a small steel stop plate, which, when the cascabel plate is screwed in position, abuts against a small screw in the casing and thus assures the correct position of the cascabel plate which carries the rear sight.

The *adjusting-knob collar* (51, Plate VI), adjusting-knob collar spring (52), and adjusting knob (50) are assembled on the main shaft in rear of the cascabel plate, the adjusting knob screwing on. The collar is keyed to the main shaft and revolves with it; its forward side abuts against the cascabel plate, while the adjusting knob abuts against its after side; the spring serves to lock the adjusting knob in position on the shaft. The use of these parts is to regulate the breeching up. The adjusting knob is screwed on to the main shaft until it abuts against the collar with a sufficiently firm bearing; the more it is "set up" the more the barrels will be drawn aft, or the less distance there will be between the forward end of the lock in its firing position and the after



GATLING GUN, WITH CASING REMOVED.



TWO VIEWS OF CAM CYLINDER AND COCKING SWITCH.

end of the barrel. If it is screwed up too tight there will not be room for the cartridge head, or, if there is room, there will be so much friction that the gun will turn hard. If the adjusting knob is not screwed up far enough, the cartridge will not be fully entered in the chamber, and, when firing, the cartridge case may bulge under the rim, or even burst, and thus cause a jam.

15. The Hopper (23, Plate VI) is hinged to the casing and is slotted to receive the feed-guide way, and to provide a passage-way for the ammunition into the gun. The function of the hopper plow (24) is to assist in ejecting the empty cases. The hopper-feed walls (30 and 33) provide bearings for the hopper-feed wheel (35) and serve to guide the cartridges into the grooves of the carrier block.

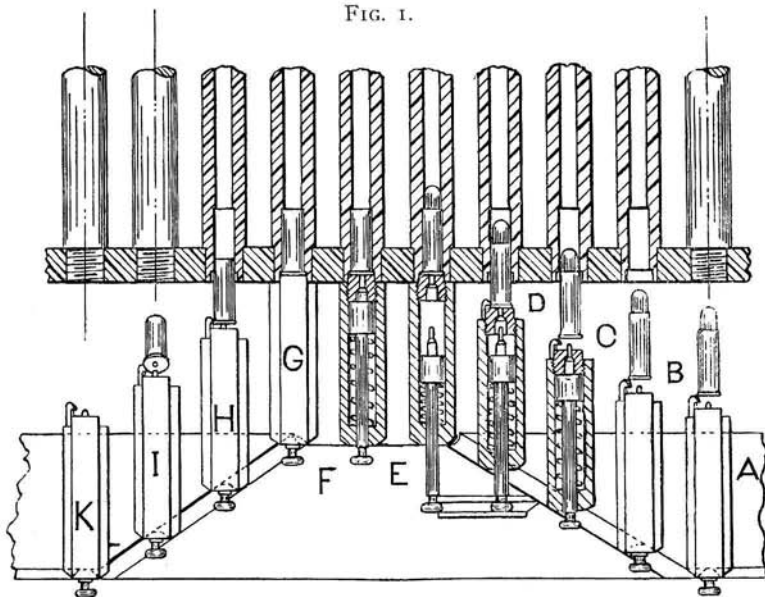
The *feed guide* (constructed on the Bruce Feed System), shown in place in Plate II, contains two channels for the cartridge rims and ships over the opening in the hopper. The cartridges are inserted from the top, travel downward by gravity, and drop off one by one to the grooves of the carrier block, through the medium of the feed wheel.

Operation of the Mechanism (see Fig. 1).

16. The gun being assembled, directing bar, crank and feed guide shipped, the cocking-switch knob should be turned with the arrow pointing forward to put the switch in action, if this has not already been done. The ammunition is entered in the feed guide directly from the pasteboard boxes in which it is furnished; the two channels in the feed guide engage the rims of the two rows of cartridges in the box, the box is pulled off and the cartridges drop down in place until the first one rests on the hopper-feed wheel, and the gun is ready for firing. If the crank is then turned, the force of gravity will cause the hopper-feed wheel to turn so as to deposit one cartridge in each groove of the carrier block. The position of the locks in the grooves of the carrier block and lock cylinder are regulated by the cam of the cam cylinder, so that the locks in their uppermost position are also in their rearmost position; the cartridges are deposited in the grooves of the carrier block in front of the locks. As the crank is turned, the lock cylinder and carrier block revolve, carrying with them

the locks and cartridges. The cam lugs on the locks engaging the cam on the inner surface of the cylinder,—which cylinder does not revolve,—causes the locks to move forward, each one pushing in front of it a cartridge. This forward motion of each lock continues until the cartridge in front of it is seated in the chamber, the extractor is cammed out over the cartridge head so as to grasp it, and the rear end of the lock presses against the recoil plate,

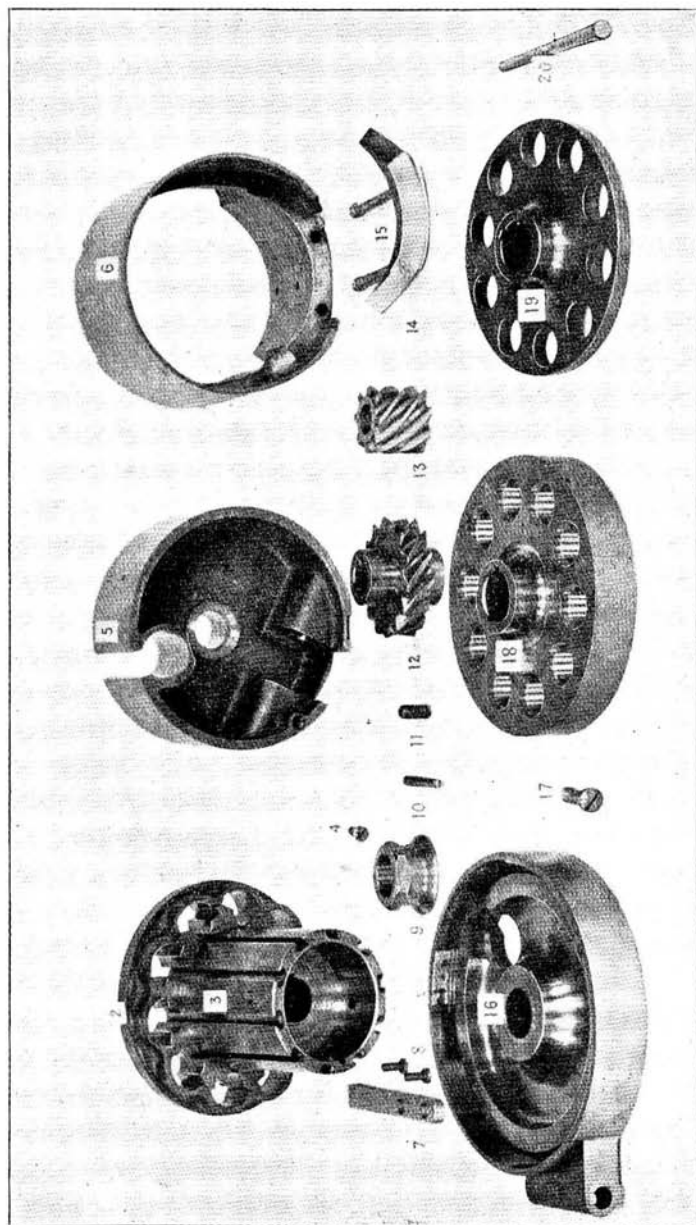
FIG. 1.



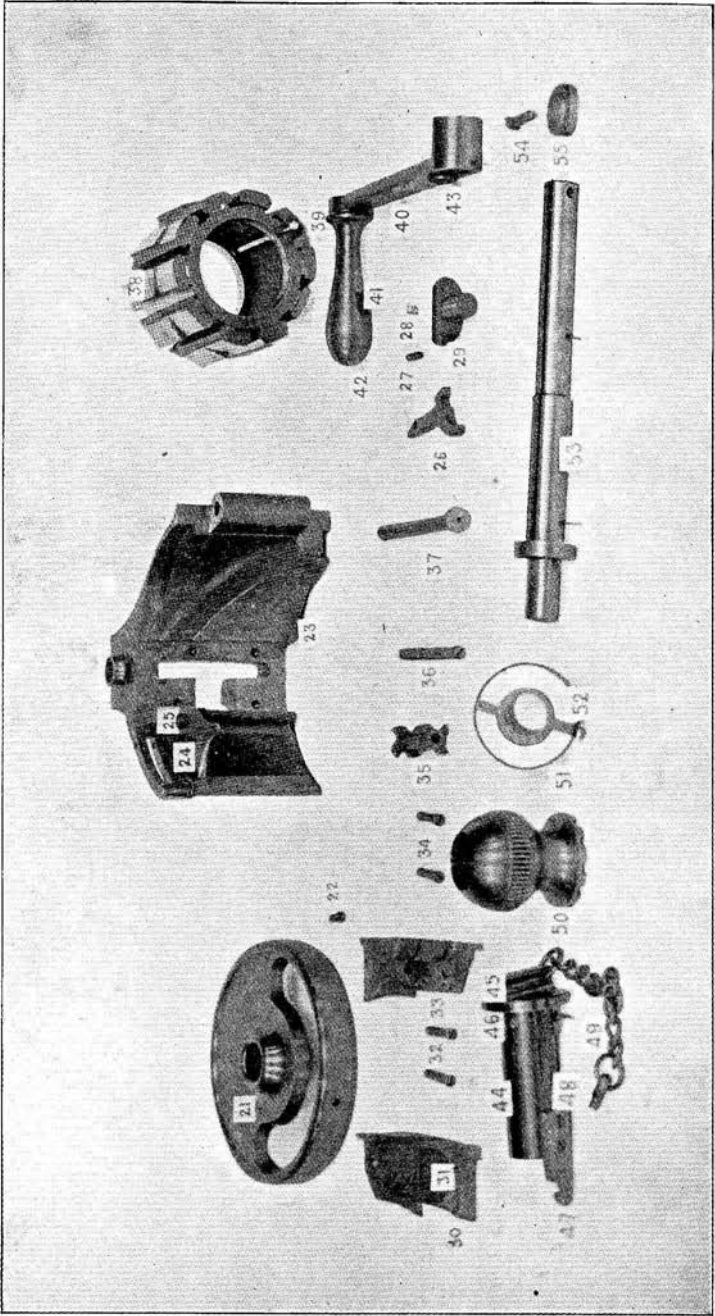
DEVELOPMENT OF CAM CYLINDER FOR GATLING GUN.

Showing operation of the locks diagrammatically.

which is secured to the cam cylinder as shown in Plate IV. As the lock travels forward, the cocking switch (see Plate IV) grasps the knob of the firing pin and holds the firing pin to the rear while the lock travels forward, thus compressing the firing spring. This compression of the firing spring and holding to the rear of the firing pin continues until the lock arrives in its forward position, at which point the cocking-switch groove ends and the knob of the firing pin is released, whereupon the firing pin



PARTS OF GUN AND ACCESSORIES.



PARTS OF GUN AND ACCESSORIES.

flies forward and fires the cartridge in its barrel; the recoil of the lock being taken on the recoil plate. It will be noted that the recoil plate extends through a considerable arc, and that the lock remains in its forward position during revolution through the same arc; this provides against accident due to hangfires, as it will rarely occur that a hangfire will last long enough to permit the lock to travel off the recoil plate. As soon as the lock leaves the plate, the cam lug on the lock, which may be plainly seen in the left-hand figure of Plate IV, engages the rearward sloping portion of the cam. The revolution continuing, the lock travels to the rear and carries with it the empty cartridge case, which is held between the carrier block, extractor and casing, until the cartridge case is opposite the exit on the left side of the casing, when it is ejected.

In Plate IV it will be seen that two different positions of the cocking switch are shown. In the left-hand figure, the cocking switch is shown in its forward position, so that as each lock travels down the cam in the direction contrary to the hands of a watch, the switch will grasp the knob of the firing pin; it will be noted that the upper lock is approaching the cocking switch and that the lower lock has its firing pin about to be released by the switch. In the right-hand figure it will be seen that the cocking switch is withdrawn to the rear so that the firing-pin knob of the upper lock does not engage it, and consequently this lock will not be cocked.

When the crank is shipped in rear, each revolution of the crank causes one cartridge to be fired from each barrel. When the crank is shipped on the crank shaft, 4 revolutions of the crank cause 23 cartridges to be fired from the barrels; the lower right-hand barrel is the firing barrel. When the gun is firing, the tendency of the recoil of the locks causes the cam cylinder to be set back against the diaphragm, which is securely held against the cascabel plate by the cascabel-plate screw (17).

17. There is no safety arrangement in this gun so long as there are cartridges on the carrier block. If the cocking-switch knob is turned with the arrow pointed aft and the crank is revolved, one cartridge will probably be fired and no others after that, but this switch is, however, not designed as a safety arrangement, but

merely to enable the mechanism to be operated without cocking the locks.

In case the cartridges stop feeding into the carrier block, it will probably be found that they are clogged just above the feed wheel. To clear them, lift the cartridges slightly clear of the feed wheel and allow them to fall back in position.

In case of hangfire, the cartridge case may explode and cause a jam of the mechanism. This can nearly always be overcome by putting extra force on the crank and continuing to turn until the deformed case is ejected. It is not considered desirable to fire the gun at a rate exceeding 700 shots a minute.

18. The Lock Plug (44), Plate VI, which has a hook on its front end, lies normally in a longitudinal slot through the upper left-hand side of the diaphragm and cascabel plate (see Plate V); it projects to the rear enough to be easily handled. As the locks come in succession in line with the lock plug, they are engaged by the hook on its end and, being at that particular point disengaged from the cam cylinder, may be pulled to the rear. Hence, to remove locks, turn crank until the qualifying mark on casing opposite rear end of barrel corresponds with a qualifying mark on rear barrel plate; turn lock plug to the right and draw it to the rear; this will withdraw one lock, through the lock-plug recess; the others may be withdrawn in the same manner.

19. Feed Systems.—The first feed system devised consisted of a long tin case of trapezoidal cross section, containing 40 cartridges lying one above the other which fall by gravity directly on the carrier block. The cartridges do not always fall parallel to the guide grooves and in very rapid firing do not fall quickly enough—hence jamming is likely to occur; besides, depending on gravity, it does not work regularly for different angles of elevation. The *Bruce* feed is also a gravity feed and open to the latter objection but it delivers its cartridges parallel to the barrels by passing them over the hopper feed wheel (35). The *Accles* feed consists of a large drum holding the cartridges by each end in spiral grooves in the heads; they are forced out of the spirals and into the gun by a revolving set of radial arms which is revolved inside the feed drum by projections on the carrier block. The latest feed, like the *Accles*, is positive and certain in its action but is much lighter and

less cumbersome. The cartridges are held in long tin strips by tongues punched out and bent around the cartridge body. These strips are fed through the hopper from left to right and the carrier block picks the cartridges off from the under side, bending the light tongues downward, as the feed strips go past.

(The Notes on the Gatling Gun in the Gun and Torpedo Drill Book of 1900, pages 77 and 78, refer principally to the Mark I, 45 calibre Gatling.)

CHAPTER XXI.

FIELD ARTILLERY.

1. **The Field Artillery**, or guns carried by U. S. Ships for operations on shore, is composed mainly of 3-inch field pieces and machine or automatic guns of rifle calibre, on field carriages. All guns of these types often have, in addition to their field carriages, ordinary mounts on board ship on which they are mounted when not prepared for shore operations, and are included in the ship's battery.

2. **The Colt and Gatling Guns**, described in the preceding chapter, are supplied with field carriages which permit elevation and a large arc of train without moving the trail. There being practically no recoil, brakes, spades, etc. are not necessary and the carriages are of simple construction and as light as possible, keeping in view the contingency of work over rough ground. A Gatling on its field carriage is shown in the preceding chapter; the carriage for Colt guns is very similar. Two ammunition boxes on the carriage hold 1320 rounds, in the case of the Gatling, and 2000 rounds for the Colt gun. A limber, or ammunition carrier, consisting merely of a rack for holding the boxes, which is mounted on an axle, with wheels exactly like those of the carriage, is supplied with each Gatling field carriage. When the limber is used, the trail of the gun carriage is hooked to its axle and the drag ropes are attached to the trail of the limber; the latter has a total capacity of 12,000 rounds; if the spare part and accessory box is carried, a case containing 1000 rounds is removed from the limber to make room for it.

A tripod mount is sometimes furnished with Colt guns, which is used both as a ship's mount and in shore operations; the saddle and pivot of the mount ship in a socket at the top of the tripod, the rear leg of which is longer than the others and bears a seat for the gun pointer. The gun and tripod make a fair load for two men and may be carried anywhere; thus mounted, it is prac-

licable to use the gun over very rough country in which a wheeled carriage could not be used.

3. The Construction of a Limited Number of Field Carriages, to be designated Mark III carriages, with limbers, for the 3-inch 50-calibre gun is about to be started. The slide trunnions of the ship's mount rest in seats on a heavy trail which bears the elevating gear; the trail, which has no trail wheel, is secured to an axle mounted on heavy wheels,—the rear end of the trail being hooked up to the limber, while on the march, and resting on the ground while firing. The piece has an arc of elevation of 15 degrees, with 10 degrees depression, when mounted in this manner and train is effected wholly by moving the trail around. The recoil is absorbed by the carriage through the recoil cylinders in the usual manner and the carriage is restrained from running to the rear from the shock of recoil by a brake on each wheel and by wire cables running from strong pegs driven into the soil to two spring buffers, one at the axle and one at the lower end of the trail.

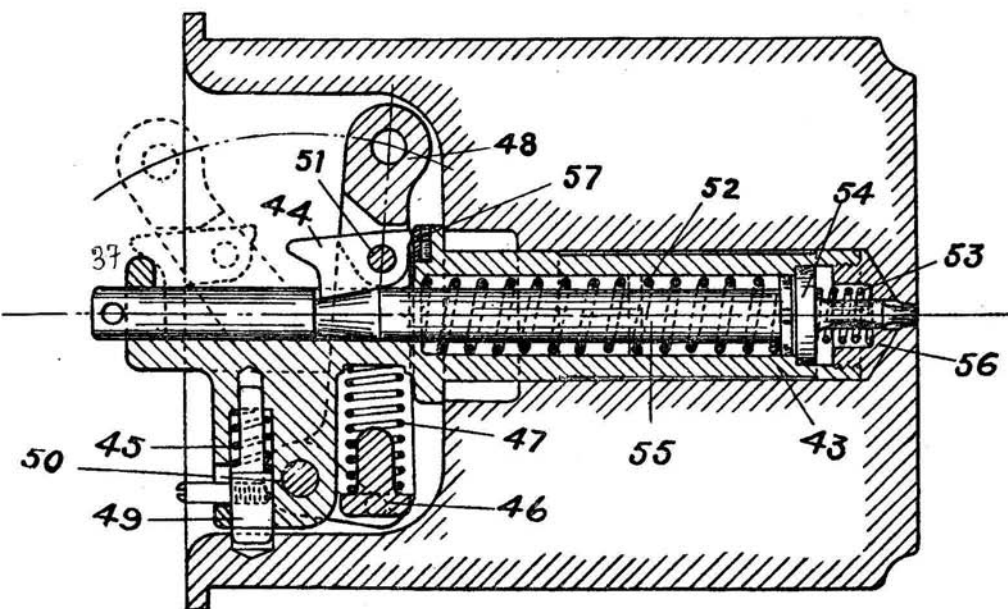
The limber holds ten ammunition boxes, each containing four cartridges, and two more boxes are borne by the carriage; there are places on the limber for five or six men who are to be carried there principally for balancing purposes. The gun and field carriage weigh about 8000 pounds—too great a weight to be dragged by men—and the piece is designed to be drawn by horses hitched to the limber.

The 3-inch R. F. Field Piece and Carriage.

4. The gun is a low-powered gun—as are most field pieces when compared with ship's guns—23 calibres in length, weight about 400 pounds, forged from a single piece of steel; the muzzle velocity is fixed at 1250 f. s. The first 100 guns were mounted on the Mark I field carriage and 60 now being completed have Mark II carriages; the guns themselves are, however, alike in all the principal features and are fitted with the Fletcher breech mechanism; the operating lever is bent down considerably to clear the firing lock and there is a lock on its handle to prevent the block from jarring open.

5. The Firing Lock is a special device, in which cocking the firing pin, compressing the firing spring and firing are all effected

by a single pull of the firing lanyard. The lock fitted to the first 100 guns is shown below, in place in the breechblock; it consists of a case (43) that carries all the firing mechanism, and is readily put on or taken from the breech plug, being held in its seat by a locking bolt (49) and spring (45). It will be observed that the firing point is not on the firing pin, but is a part of the plunger (54), a separate piece that is struck by the firing pin (55). A spring



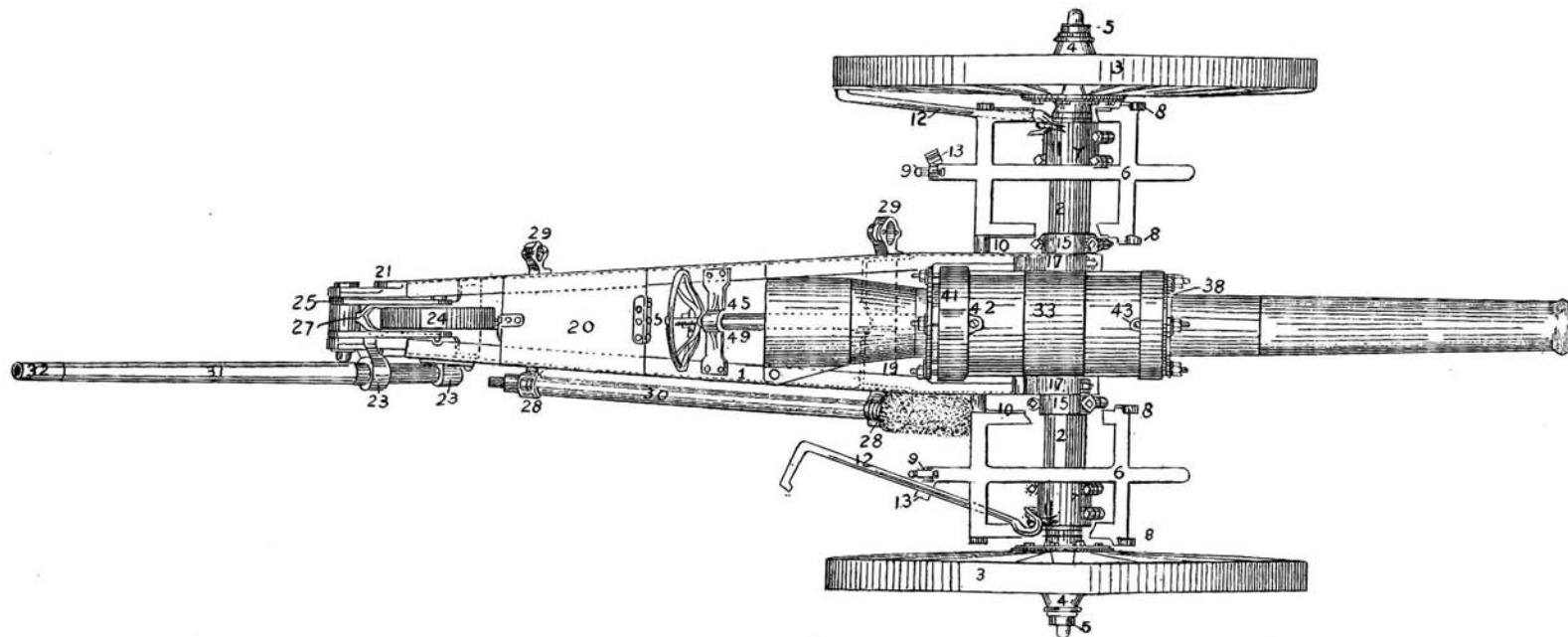
FIRING LOCK. Par. 5.

(53), surrounding the plunger, is supposed to keep the point within the nose of the plug ordinarily, and acts against the firing spring which, when the pin is not cocked, has practically no compression,—so that, in closing the plug, no blow is given to the primer; the firing pin and plunger are retained in the case by a cap (56) screwed in the front end. The cocking lever (48) is ordinarily kept in the forward or uncocked position by a spiral spring (47), seated under the case, acting on a cradle (46) that is pivoted between the jaws of the lever forward of the lever's (axis) pin (50); on the upper end is an eye for attaching the firing lanyard. The cocking pawl

(44) is pivoted in the upper part of the cocking lever, with its lower rear corner resting ordinarily against the cocking shoulder of the firing pin, and a toe on the upper rear end is provided, which is tripped by a toe (37) on the firing case when the cocking lever is brought to the rear enough to cock the firing pin. The action is as follows: When the lanyard is jerked smoothly to the rear, the firing pin is brought to the rear by the cocking pawl compressing the firing spring until the pawl is lifted by the trip toe on the rear end of the case, when the firing pin flies forward, striking the plunger, the front of which strikes the primer of the cartridge.

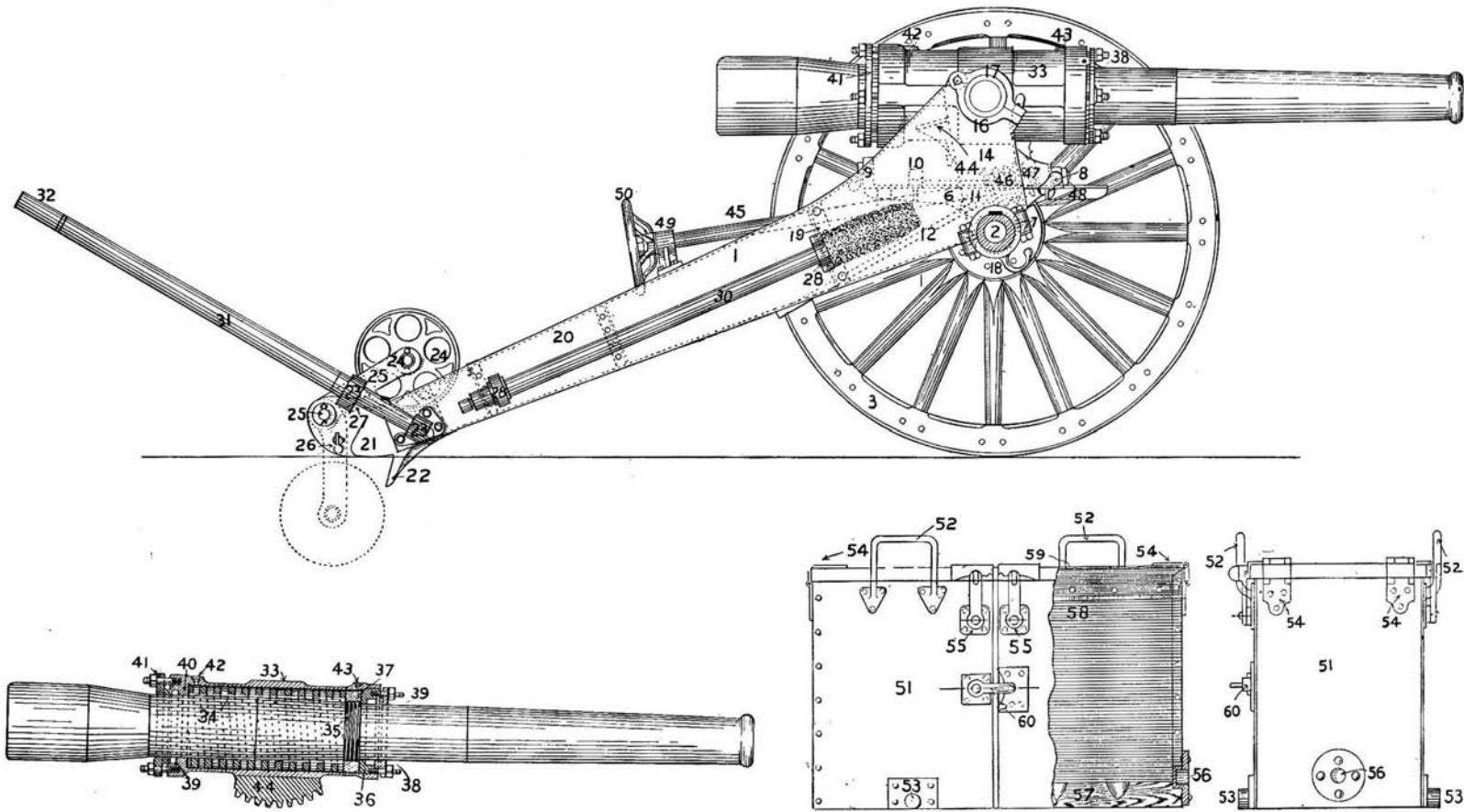
Caution.—The lock, as at present designed, will permit of the gun being fired before the plug is turned for locking, if the lanyard be pulled, which, of course, would lead to a serious result. One fatal accident (at least) has so happened. Hence great care should be taken to see that the firing lanyard is *clear* and is hanging so that it *will not be pulled in closing the breech* and that it is *not pulled before the word "ready" is given by the man operating the mechanism.*

The later guns are being fitted with a modification of the lock described above; the new device is sometimes called the "Tasker" lock and in its main features is not greatly different. The firing pin is held in the cocked position, main spring slack, by a sear; when the cocking lever, which is relatively much longer, is pulled to the rear, a sleeve which surrounds the firing pin is forced forward, compressing the spring, until it trips the sear and the firing pin flies forward and strikes the primer with its own point. When the firing lanyard is released, the firing spring, still slightly compressed, brings the entire mechanism to the rear to its former position, the cocking lever straightens up and the sear reengages the firing pin. This lock also may be pulled off before the breech is closed and, except that a longer pull on the lanyard is required, the same dangers of premature discharge exist as given above. The same precautions, as given above, must be taken in manipulating the lock. This type of firing lock is, of course, only applicable to guns used on shore, where there is no movement of the gun platform, and where, consequently, it is not important to minimize the interval from the pull on the lanyard to the explosion of the charge.



FIELD CARRIAGE FOR 3-INCH, MARK I, R. F. GUN.

Top View.



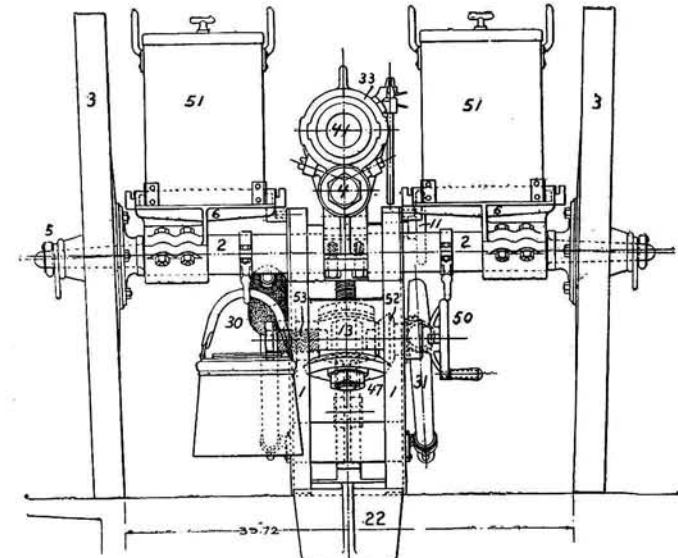
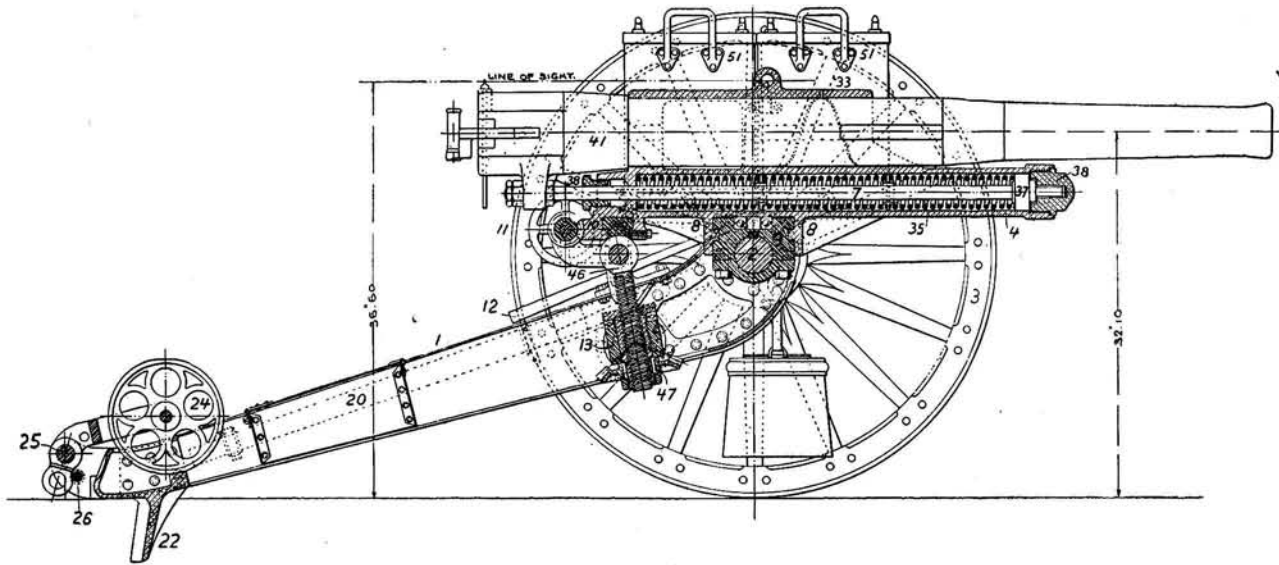
FIELD CARRIAGE FOR 3-INCH AMMUNITION BOXES.

6. The Mark I Field Carriage (see Plates I and II). In this mount the sleeve combines the functions of sleeve and recoil cylinder and the elevating arc is formed on a projection on its under side. The gun body where it passes through the sleeve is a true cylinder and a collar (37), screwed and keyed to it, acts as a piston while the gun is its own piston rod. The sleeve (33) bears on the gun only at its ends, where stuffing boxes (39) are fitted, and the annular space between it and the gun is filled with recoil liquid through the filling hole (42). The counter-recoil spring (35) is held, in the usual state of slight initial tension, between the piston and the rear cylinder head. The inside of the cylinder is rifled with grooves of the common form and ribs at the top and bottom fit into recesses on the edge of the piston and prevent the pressure of the projectile on the rifling of the bore from rotating the gun. The trunnions (17) are parts of the sleeve and rest in seats in the trail (1) where they are held by cap squares. The trail is mounted on a heavy axle (2) which is in turn supported by the wheels (3); the latter are secured by linch pins (5) which are easily removed when dismounting the carriage. The rear end of the trail is supported when on the march by the trail wheel (24)—shown in its dotted position. Before firing, the pin (26) is removed and the wheel hinged upward, as shown, to permit the spade (22) to rest on the ground and help restrain the carriage from running to the rear during recoil; in this the spade is assisted by a brake (12) acting on the tire of each wheel. The trail contains an accessory box (20), sockets for the trail bar (31), racks (28) and (29) for bar and sponge staff and bearings for the elevating shaft (45). The latter, worked by its hand wheel (50), bears an elevating worm (46) which gears with the elevating arc (44) of the sleeve; the worm spring (47) surrounds the shaft between the worm and the front bearing (48)—its function is to take up the jump. It is to be noted that the gun cannot be trained with respect to the mount, the trail must be moved by means of the trail bar. The sights (not shown) are of the open type and are fitted to the gun and sleeve—the sight bar is marked up to 3200 yards. The ammunition is carried in four ammunition boxes (51), each containing eight rounds, which rest on the carriage, two on each side, where they are secured on the racks (6). With

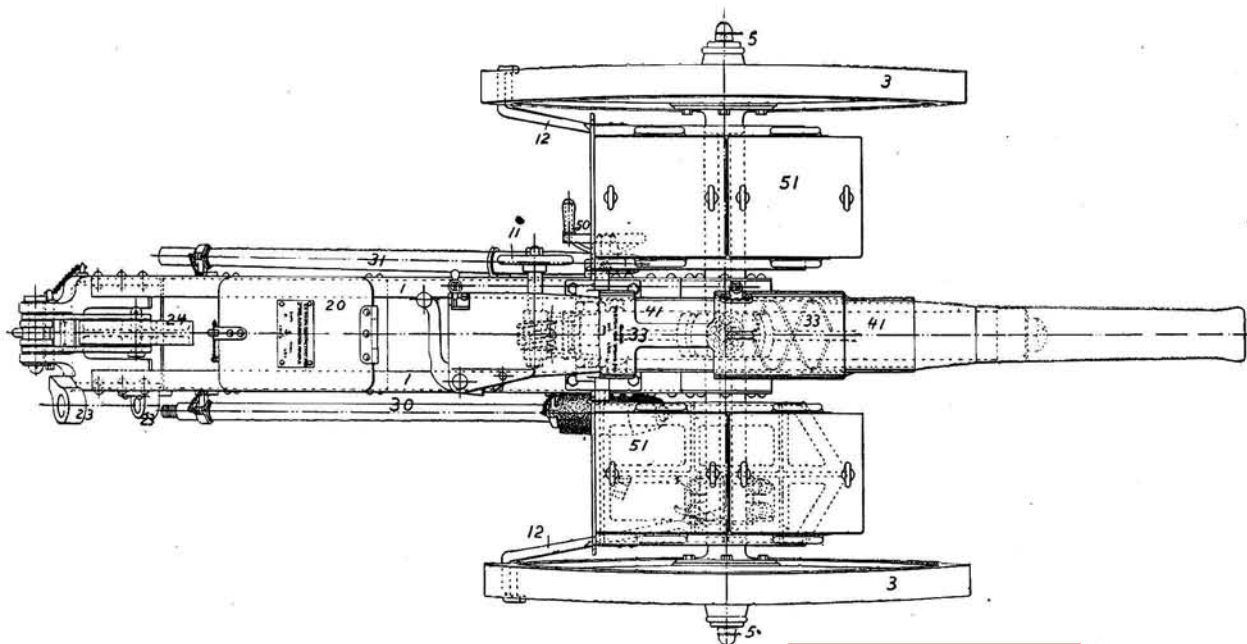
this mount the recoil is only seven inches which is rather too short for a light carriage and in some cases the sleeve has been damaged. A small air chamber is now being fitted on the top of the forward end of each cylinder; this will allow for the expansion, as the recoil mechanism becomes heated from continued firing. The total weight of the gun, carriage and thirty-two rounds of ammunition is 1830 pounds.

7. **The Mark II Field Carriage** (see Plate III) differs from the Mark I carriage principally in the form of the elevating gear, the recoil mechanism and in giving the gun a small arc of train independent of the carriage. The axle, wheels, ammunition boxes, trail wheel, spade, brakes, etc., of the older design are retained and the trail is in general the same, except at its upper end where it conforms to the new arrangements mentioned above. Forged on the lower side of the breech of the gun is a lug to which the piston rod (7) is attached. The gun recoils through a bronze sleeve (33), cast in one with the recoil cylinder (4), and is prevented from turning, from the action of the projectile on the rifling, by a key on each side which fits in grooves in the slide. The recoil cylinder is of the common hydraulic type, with counter recoil spring divided into three sections, separated by disks, and a counter-recoil checking device in the forward bonnet; it is to be noted that the cylinder is long and of small diameter—the normal recoil is fifteen inches, much longer than have ship's guns of equal power; it is impracticable to control the recoil in a field mount, which is kept as light as possible, in the short space usual with ship's mounts—besides this, lengthening the recoil reduces the jump of the carriage.

Instead of trunnions, there is employed a device for securing the slide to the rest of the mount which is characteristic of the carriage. From the lower side of the cylinder a heavy lug projects downward and an interrupted collar is cut on its inside surface; a similar collar is cut around the block (9), which embraces the axle (2) but turns on it as the gun is elevated; the collars of the two parts are engaged by a bayonet joint and ball bearings between them, as shown in the plate, reduce friction in training. The rear end (10) of the cylinder is dovetailed over a T-shaped bar (49) to which the elevating shaft (46) is indirectly secured,



Front View.



but which has no lateral motion; the shaft of the training wheel (11) turns in bearings in the same part and its worm gears in an arc on the cylinder and slide casting. By the training wheel the gun may be moved through an arc of three degrees—larger arcs of train are given by moving the trail around. The elevating wheel (50), placed near the training wheel, turns a shaft on which is a bevel wheel (52); the end of the shaft, projecting through, and the heavy bolt (53) screwed through the opposite side of the trail, act as trunnions to hold the collar (13) of the elevating nut—the device must permit a slight angular movement of the nut as the gun is elevated or depressed. The elevating nut (47) gears with the elevating wheel through bevel gearing, and, being restrained from all but circular motion, works the threaded shaft (46) up or down as it is turned. This shaft is coupled to the framing which bears the training gear and elevates or depresses the gun by swinging the whole of the upper mounting on the axle (2).

A *limber*, carrying 48 rounds, in boxes like those carried on the mount, is supplied with the Mark II carriage. These guns, being low powered, have only a small charge of 400 grams of smokeless powder. Shrapnel, with combination time and percussion fuzes, are the only projectiles furnished with the field piece; the ammunition is “fixed”—put up in a short cartridge case.

CHAPTER XXII.

SMALL ARMS.

1. The expression "*small arms*," probably of naval origin, has long been used by sea-faring men to distinguish hand weapons from "*great guns*," or cannon. As applied to firearms, it comprises shoulder rifles and pistols.

2. **Rifles.**—At present there are two kinds of rifles in use in the U. S. Navy: The "Lee Straight Pull" rifle of 6 mm., or .236-inch calibre, and the "Krag-Jørgensen" rifle of .30-inch calibre—both of which are modern high powered weapons.

The Lee rifle belongs to the straight pull type, that in which the bolt comes straight to the rear in opening without the rotation of any of its parts to unlock. The magazine is beneath the bolt and holds five cartridges; it has no "cut off" to put the magazine out of action and therefore the weapon is not, strictly speaking, a magazine rifle and can be used as a single loader only when the magazine is empty. The length of bore is 28 inches and the sight is graduated to 2000 yards; the charge of about 33 grains of smokeless powder gives the 112 grain bullet about 2460 f. s. velocity at the muzzle, maximum powder pressure, 49,000 lbs. per sq. in. The cartridge belt, to which the knife bayonet is attached, holds 180 rounds of ammunition which is put up in clips holding five each; in loading, the clip with its cartridges is inserted in the magazine and, after being released, drops out through an opening at the bottom. These rifles have given little satisfaction in the few years they have been in use and are now being called in and replaced as rapidly as possible.

The U. S. Magazine Rifle—called the Krag-Jørgensen from its inventors—of .30-inch calibre, has been adopted by the Navy; it is in all particulars like that used by the U. S. Army. The cartridge belt, bearing the knife bayonet, holds 100 cartridges which are not put up in clips. (For "Description and Rules for Management" see U. S. Army Ordnance Department publication.

There are also notes on "Care and Handling" in the Gun and Torpedo Drill Book of 1900, pages 154-157.)

The elongated lead bullets used in modern small calibre rifles are "jacketed" with a thin envelope of harder metal,—soft steel being most used. This is necessary because lead would strip through the rifling, where long bullets are propelled at such high velocities—nearly double that obtained in the older arms using bullets without jackets; the rifling in modern rifles has a much more rapid twist than was formerly in use. The 6 mm. rifle uses cannellured cartridges, in which the extractor nib snaps into a groove cut around the base. The .30-inch calibre rifle uses the ordinary rim cartridges; the charge of about 40 grains of smokeless powder gives the 220 grain bullet about 2000 f. s. velocity at the muzzle, maximum powder pressure about 38,000 lbs. per sq. in. In addition to the "ball cartridge" shown in the figure below, the following kinds of ammunition for secondary purposes is manufactured:

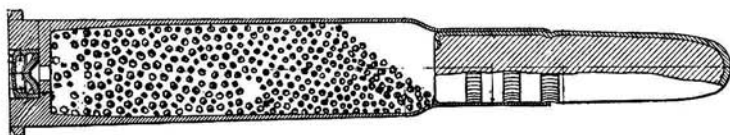


Fig. 1.

Dummy cartridge, consisting of a case, containing no powder, with dummy primer and service bullet. The cartridge has generally six longitudinal corrugations and a hole drilled through in front of its head.

Blank cartridge consisting of service case, with ordinary primer and containing 5 grains of smokeless powder. The bullet is made of paraffined paper partially filled with compressed smokeless powder to give it the necessary stiffness and to break it into fragments when fired.

Gallery practice cartridge consisting of regular service case, primed and loaded with 5 grains of black or smokeless powder and a spherical bullet, weighing 42 grains, made of 16 parts lead to 1 of tin.

3. Pistols.—The naval service weapon is a six-shot revolver,

calibre .38-inch, length of barrel six inches. There are two kinds in use, the Colt and the Smith & Wesson. While the two patents differ considerably in their working parts, the essential features and manner of operation are nearly alike. The cylinder, holding the six cartridges, is revolved automatically, as the hammer is worked, and brings the cartridges in succession under the hammer; it is firmly locked, with one of the chambers in exact line with the barrel, at the moment of firing. To eject the empty cases or to reload, the cylinder swings out of the receiver on the crane, retaining its axis parallel with the barrel. Both revolvers are "double acting"; that is a single pull on the trigger will raise the hammer to its cocked position, release it and revolve the cylinder, or the hammer may be cocked by the thumb and be retained in this position until the trigger is pulled, as in the "single acting" type. The barrel is rifled and the weapon is accurate at short ranges. Center-fire rim cartridges are used, which contain from 18 to 20 grains of fine black powder; the weight of the lead bullet is 150 grains. (Notes on Handling, Dismounting, etc., for both revolvers are given in the Gun and Torpedo Drill Book of 1900, pages 147-153, inclusive.)

The principal use of small arms is in boat and shore operations, and even in these cases the pistol is, because of its short range and inaccuracy, of very doubtful utility; as much of the fighting force as possible must be armed with the rifle. However, pistols are small and light and may be carried on the person without incumbrance; for this reason they are retained for the use, in emergencies, of those men—such as the special details—whose particular duties make direct fighting a matter of secondary importance. Officers, the crews of field pieces, etc., who would be too much encumbered by rifles, are armed with revolvers. Hence, pistols and proficiency in pistol marksmanship, for its own sake, are of comparatively little importance.

The Colt Automatic Pistol.

4. A limited number of Colt automatic pistols (Browning patent) are being manufactured for the Navy. (See Plates I and II.) The calibre is .38-inch, length of barrel six inches; it uses cannelured cartridges loaded with about 8 grains of smokeless pow-

der and a 105-grain jacketed bullet, having a muzzle velocity of about 1300 f. s. The action of the pistol is automatic except that the trigger must be pulled to fire each shot; it is, notwithstanding, simple in construction, easy to operate and is capable of a sustained high rate of fire. The velocity is very high and the range and accuracy are good; one advantage that automatic pistols have, over revolvers, is in the absence of such a joint as that between the cylinder and barrel, which can never be tight and results in a loss of gas; besides, when the parts become worn, the cylinder chambers may not stop accurately in line with the barrel.

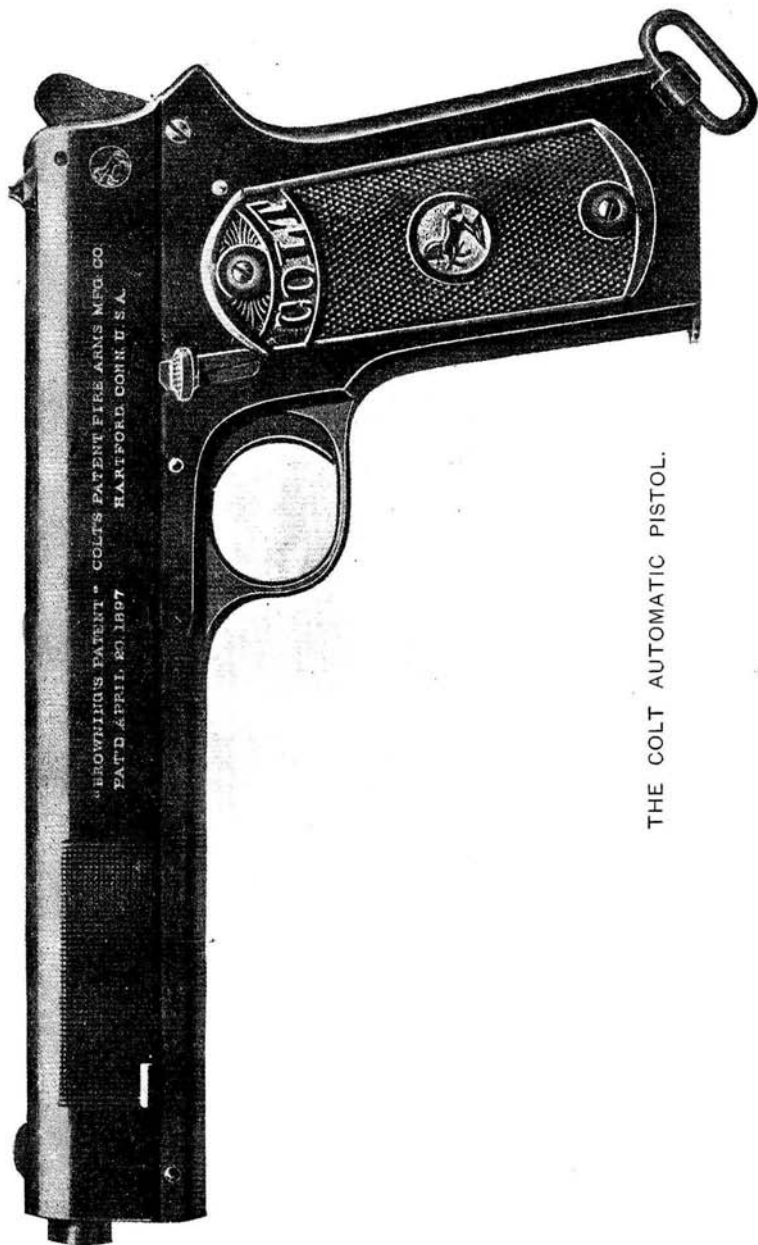
The three main parts of the pistol are the *receiver* (1), the *barrel* (2) and the *slide* (3).

The receiver has suitable guides for the reciprocating slide, and below is the handle which is hollow and encloses the cartridge magazine (34); this is inserted from below and is there held by the magazine catch, which slightly projects from the bottom of the handle; this projection serves to release the magazine at will, when it may be readily drawn from the handle for recharging.

In front of the handle is the trigger guard in which the trigger is located; in the rear, and above the handle, is arranged in the receiver the firing mechanism, consisting of the hammer, the sear, a safety device and the main spring; also the sear, safety and trigger spring (20). The lower part of the latter serves to actuate the magazine catch.

The top of the receiver extends forward from the handle and to it the barrel is attached by two short links, one near the front end of the barrel and one at its rear end; these links are attached to the receiver and to the barrel by link pins, and allow the barrel to swing rearward thereon. As both links are of the same length, the rearward movement of the barrel in swinging carries the barrel slightly downward, but its longitudinal axis, during all the movements, remains parallel.

Below the barrel the receiver has a tubular seat for the retractor spring (26), which in front is closed by a plug, fastened in the receiver by the lower link pin. The retractor spring consists of a spiral spring, the rear end of which rests against a short stiff recoil spring located between the retractor spring and the receiver; the front end of the retractor spring carries a follower (27).



THE COLT AUTOMATIC PISTOL.

The top surface of the receiver and two longitudinal grooves on its sides form the seat for the slide, which is guided thereon in rearward and forward movements. The rear part of the slide forms a bolt, the forward extension of which is a partially tubular cover enclosing the barrel. In the forward part of the receiver is a transverse mortise extending through the retractor-spring seat, and transverse recesses, in the forward part of the slide, serve to admit the slide lock which, passing through the sides of the slide and through the mortise, serves to lock the slide to the receiver. The rear face of the slide lock has a slight recess, and when the lock is in its place, the front end of the follower rests in the recess, thereby confining the slide lock laterally; thus the tension of the retractor spring is exerted to force the slide to its forward position, while the recoil spring serves to receive any excess of recoil of the slide.

Upon the barrel are three transverse ribs, and in the interior of the slide are three corresponding recesses. These serve to lock the barrel and the slide firmly together, when in their forward or closed position. Between the locking recesses and front of the bolt, the slide has an opening on the right side for the ejection of the empty shells. The bolt is provided with an extractor, a firing pin (4) and a firing-pin spring.

The magazine is a tubular holder in which the cartridges are placed one above the other, resting upon a follower acted on by a spring, which presses upward. The upper end of the magazine is open to permit the escape of the cartridges; the side walls at the rear of the opening are turned inward and engage the rim of the topmost cartridge to prevent its escape from the magazine when it is pushed forward.

5. Operation.—The magazine can be loaded with any number of cartridges from one to eight, its full capacity; as many loaded magazines as desired may be carried. Insert the magazine in the handle until the magazine catch acts, hold the pistol in the right hand, grasp the slide with the left at its cross-hatched portion and draw it sharply to the rear. This movement cocks the hammer, and when the slide is in this position the magazine follower and follower spring raise the topmost cartridge so as to bring it into the path of the bolt; the slide on being released is carried forward

by the retractor spring and the bolt places the cartridge in the chamber. As the slide approaches its forward position, the front of the bolt encounters the rear end of the barrel and forces the barrel forward; during this movement the barrel also swings upward on the links and thus the locking ribs on the barrel are carried into the locking recesses in the slide; the barrel and slide are thereby positively interlocked and the pistol is ready for firing.

A pull on the trigger now serves to move the sear so as to release the hammer and fire a shot. The force of the powder gases, driving the bullet from the barrel, is rearwardly exerted against the bolt, overcoming the inertia of the slide and the tension of the retractor spring, and, as a result, the slide and the barrel recoil together. After moving rearward together for a distance, enough to insure the bullet having passed from the barrel, the downward swinging movement of the barrel releases it from the slide, leaving the former in its rearmost position. The momentum of the slide causes it to continue its rearward movement, thereby cocking the hammer and compressing the retractor spring until, as the slide arrives at its rearmost position, the empty shell is ejected from the side of the pistol and another cartridge is raised in front of the bolt. During the return or forward movement of the slide, caused by the retractor spring, the cartridge is placed in the chamber and the slide and barrel are interlocked, thus making the pistol ready for another shot. These operations may be continued as long as there are cartridges in the magazine, each discharge requiring only the slight pull on the trigger. After firing the last cartridge, the slide remains open, being caught by the slide stop,—shown in rear of the trigger on Plate I. To reload, insert the charged magazine in the handle and press downward on the slide stop with the right thumb, whereupon the slide will go forward and insert a cartridge in the chamber as in first loading.

6. Safety.—It is impossible for the firing pin to discharge or even touch the primer except under the full blow of the hammer.

The pistol is provided with a safety device which makes it impossible to release the hammer unless the slide and barrel are in their forward position and safely interlocked; this safety device also serves to control the firing and to prevent more than one shot from being fired for each pull of the trigger. It consists of a

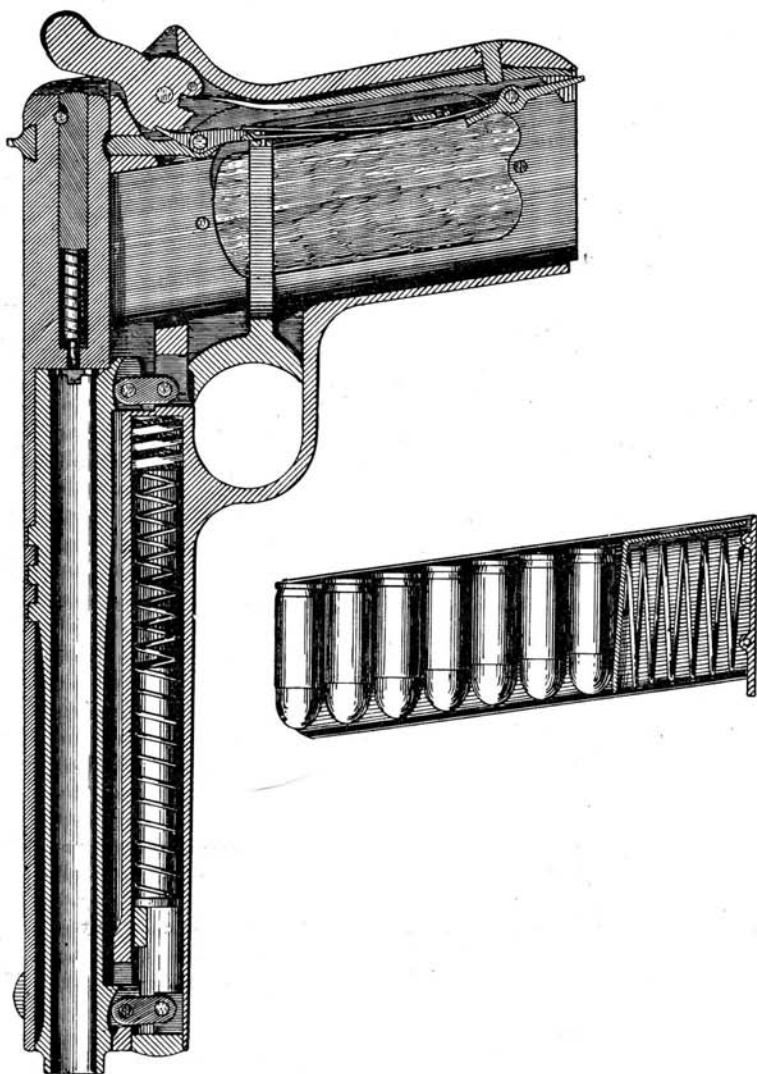
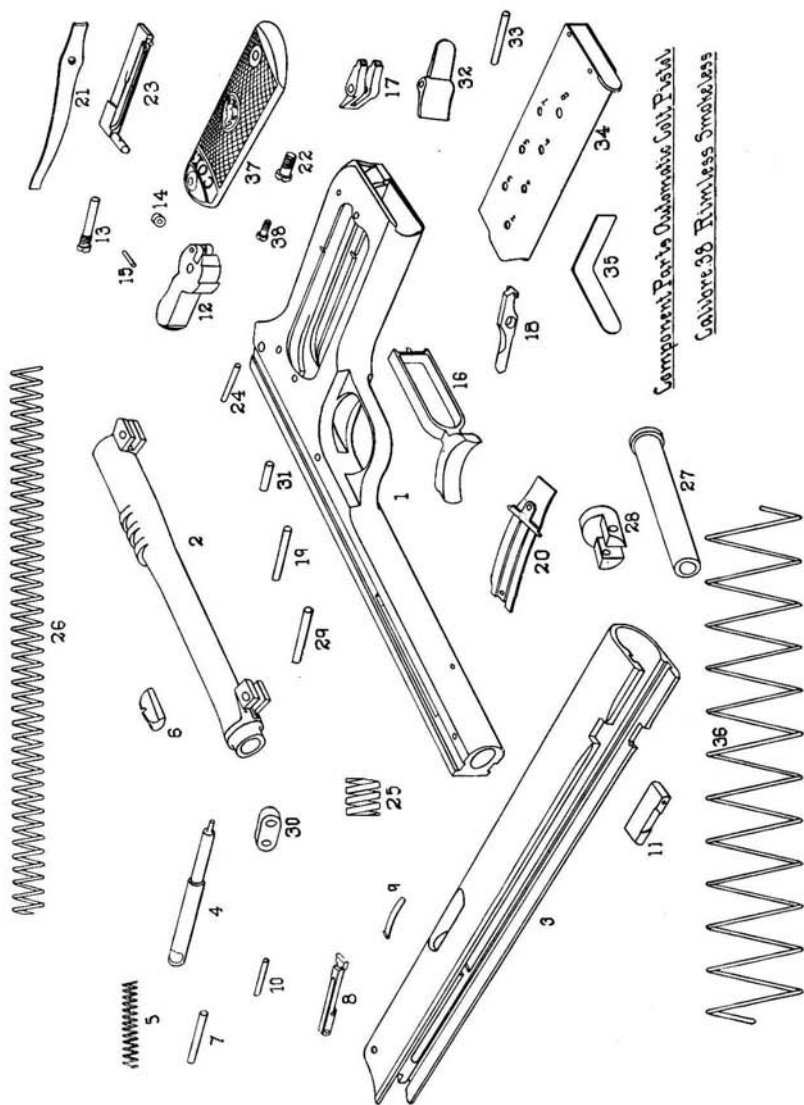


Fig. 1.

SECTION OF COLT AUTOMATIC PISTOL.



Components Parts Automatic Colt Pistol
Calibre .38 Rimless Smokeless

Fig. 2.

small vertical piece, mounted in front of the sear in the receiver, the end of which slightly projects from the top of the receiver; in its raised position, when the bolt and slide are in the forward position, interlocked with the barrel, it finds a corresponding recess in the bottom of the bolt. In this position, the safety piece does not interfere with the operation of the trigger, but when the slide is moved rearward the bottom of the bolt depresses the safety piece which, in that position, prevents the movements of the trigger from operating the sear, and thus the hammer cannot be released until the slide is again in its forward position, locked to the barrel.

7. Dismounting.—To take the pistol apart, the hammer is cocked and the slide is drawn to the rear until the slide lock has passed above a small hole in the bottom of the receiver leading into the retractor-spring seat. By inserting a pin into this hole, the retractor spring and follower are prevented from moving the lock forward and the lock (13), thus freed from the pressure of follower, will readily pass from the left side of its seat in the receiver and slide; the lock thus removed, the slide may be drawn off the receiver from the rear.

To remove the barrel from the frame, it is only necessary to drive out the link pins which hold the barrel links to the frame. This also releases the plug (28) which may then be removed from its seat; then the retractor spring, the follower and the recoil spring may be readily removed from their seat in the receiver.

After removing the scales from the handle, by turning out the screws, all the parts of the firing mechanism may be readily removed on taking out the screws and pins holding them in receiver.

To assemble the pistol, proceed in the reversed order.

CHAPTER XXIII.

EXPLOSIVES.

[*From Ingersoll's Text-Book of Ordnance and Gunnery, revised.*]

1. **The Explosive** now most commonly used for all guns is smokeless powder.

2. **General Discussion.**—Since the elastic strength of guns to withstand powder pressure has a limit very much below that attainable by the explosion of smokeless powder in a confined space, the effort of powder makers is to produce an explosive that will not give a maximum pressure, with a given weight of charge and projectile, greater than the safe working limit set for the gun—usually from sixteen to seventeen tons with guns of the present type—and which will at the same time give a high initial velocity to the projectile.

3. **The Ideal Powder** is that which would, on ignition of the charge, burn in such a manner that the pressure would rise rather quickly to the maximum allowed, and thereafter maintain that pressure throughout the bore while the projectile is traveling from its seat to the muzzle. In this case the guns would be made in the form of a cylinder. That they are not so made is due to the fact that in practical experience the pressure falls from the maximum point to the muzzle, the amount of fall depending upon the character of the powder, the size and shape of the grain, the law of burning and many other practical causes.

The present aim of the powder manufacturer is, therefore, to make powder so that it will reach quickly the known pressure which guns of the proper thickness will withstand, and so that it will maintain this pressure as nearly as possible while the projectile moves out of the bore. It is apparent, therefore, that the powder should not flash off too quickly at first, and that it must burn with increasing rapidity after the shot begins to move.

4. **Progressive Powder.**—Such powder is called *progressive*.

A glance at any gun will convince the observer that perfection is not yet by any means attained.

The subject of gunpowder is treated in Chapter XXIV.

DEFINITIONS.

5. Explosion.—An explosion may be considered as the result of a chemical change in a solid or liquid body, by which a great volume of highly expanded gas is suddenly or very quickly produced from it.

6. Explosives may be defined as a class of bodies the molecules of which are in such a state of unstable equilibrium that a slight disturbing agency will cause a chemical change among them, the effect of which change is to produce suddenly a very large volume of highly expanded gas.

7. Explosive Reaction is the term applied to the chemical change which takes place in explosives when their equilibrium is destroyed.

8. Explosive Effect.—The blow, or impulse, given by the sudden production of the large volume of gas is called the explosive effect.

9. Classes of Explosives.—There are two classes of explosives, viz., explosive mixtures and explosive compounds.

10. Explosive Mixtures.—An explosive mixture consists of combustibles and supporters of combustion, mixed so that by their mutual action a large quantity of gas is developed. The most important explosive mixture is ordinary *gunpowder*.

11. Explosive Compounds.—An explosive compound is a single definite chemical compound, the particles of which rearrange themselves to form the gases evolved by explosion.

The more important of the explosive compounds in extensive use for various purposes are *fulminate of mercury*, *fulminate of silver*, *nitro-glycerine*; *gun-cotton*, and most smokeless powders are also chemical compounds. Explosive compounds are much more sudden, and, weight for weight, are usually much more violent in their action than explosive mixtures.

12. Classes of Explosive Mixtures.—The combustible bodies that may be used are very numerous, but practically there are only two bodies which are used to supply the oxygen necessary

for burning the combustible. These are *potassium nitrate*, or saltpetre, and *potassium chlorate*. Therefore all mixtures may be divided into two classes, namely, nitrate and chlorate mixtures.

13. Nitrate Mixtures.—The most important one under this head is that composed of saltpetre, sulphur and charcoal. In various proportions this mixture is employed for very many purposes; the action is the same in all cases, so that the explosion of gunpowder fully illustrates them all. Nitrate mixtures are not greatly susceptible to friction, concussion or percussion. In general, the explosion of these mixtures is comparatively slow.

14. Chlorate Mixtures.—In general, the explosion of these mixtures is much more sudden and violent than that of nitrate mixtures, and they are also much more sensitive to percussion, concussion and friction. Generally speaking, all chlorate mixtures are unsafe, and dangerous to handle or transport on account of their susceptibility to accidental explosion. It is stated, however, in the annual report of H. B. M. Inspectors of Explosives for 1900 that several chlorate compositions have passed the storage stability tests and are now licensed for use and carriage in Great Britain.

15. Orders of Explosion.—When an explosive is ignited by heat and converted into gas by gradual combustion, as is the case with gunpowder, the explosion is said to be *low*, or of the second order. When, however, the whole mass of the body is suddenly and violently converted into gas, the explosion is said to be *high*, or of the first order.

16. Means of Causing Explosion.—The application of heat, either directly or indirectly, is the principal means of causing an explosion: directly, as by a match, a red-hot iron, etc.; indirectly, by friction, where the mechanical energy of rubbing is converted into heat; by percussion, where heat is generated by the direct application of a blow; or by concussion where heat is generated by a jar or shock communicated through a second body.

17. Method of Producing Explosion.—The circumstances under which an explosion takes place create a marked difference in the effect produced. Everyone is familiar with the different effects produced by firing gunpowder in the open air and firing it in a confined space; but, apart from this, the mode by which it is

fired exercises immense influences both upon the force and the rapidity of its explosion.

Suppose that a quantity of *fulminate of mercury* be exploded within a mass of any other explosive. Apart from the flame produced, a blow will be given by the gas suddenly formed by the fulminate, which will act upon the surrounding explosive *percussively*, like the blow of a hammer upon an anvil. The very rapid motion of the particles of gas will give them a force, as regards any resisting body, similar to that exercised by a solid having a great velocity, against any obstacle in its path.

18. Detonation.—When the flame of the fulminate is applied directly to the explosive, the chemical change is initiated at the point of application, and if the flame alone were considered, would gradually spread from this point through the mass; but the percussive blow is extended through all parts of the body with very great rapidity, greatly expediting the explosion of the charge. In certain cases the effect is practically simultaneous throughout the whole mass of the body, thus producing *detonation*, the effect of which is much more powerful than that of an ordinary explosion. Thus we see that detonation is really nothing more than an exceedingly rapid explosion. In an ordinary explosion, like that of powder in a gun, much force is lost by the slowness of the action. As gases expand heat is absorbed, so that if the gases can expand as they are formed, much of the heat of the chemical reaction is absorbed, diminishing the sharpness of the explosive effect, which is therefore not sudden, but gradual. With a force gradually generated and exerted, we have a propulsive effect, but a detonation has a disruptive violence, which may become almost irresistible.

19. Explosives Capable of Detonation.—Each explosive body that has been experimented with seems to have a particular mode of detonation, and probably all explosives may be detonated if the right method of doing so be known. It is claimed, however, that the U. S. Navy smokeless powder cannot be detonated. Gun-cotton seems to have a greater range of susceptibility to different modes of firing than any other explosive agent. It can be made to burn slowly without explosion, and the rapidity of its combustion can be increased up to the point of detonation. Nitro-glycer-

ine, as before stated, appears always to detonate. (It is not sensitive to flame as directly applied.) Fulminate of mercury is a detonating substance, but the quantity of gas given off is comparatively small, hence the limited range of its destructive effect. Gunpowder is said to be capable of detonation, but it is more difficult to obtain detonating effects with it than with any of the others.

20. Detonation, how Produced.—Detonation can only be produced by the application of the requisite blow or shock, and this is usually accomplished by means of a detonating fuse containing the required amount of *fulminate of mercury*, the amount differing for each explosive.

“Fulminate” is the general name for a class of explosives which are compounds of fulminic acid with a base. They are all more or less explosive by the action of the heat of friction. The fulminates of mercury and silver are the most important.

21. Fulminate of Mercury has been found to be by far the best agent for producing detonation; less of it is required than of any other explosive. Nitro-glycerine is much more powerful than fulminate of mercury, but while a certain amount of the latter will detonate gun-cotton, seventy times as much nitro-glycerine will not accomplish it. *Chloride of nitrogen* and *iodide of nitrogen* are much more violent than fulminate of mercury, yet a larger quantity of them is required to produce detonation. These facts indicate that there is some peculiarity in the impulse given by the firing of fulminate of mercury that affects other explosives more powerfully than that given by any other body, though the latter may be the stronger. It may be considered that this is owing to a peculiarity of vibration, or *wave motion*, due to the explosion of fulminate of mercury, which causes greater disturbance among the molecules of other explosives than the vibrations produced by any other detonators.

22. Preparation of Fulminate of Mercury.—Fulminate of mercury is prepared by dissolving one part of the mercury in twelve of nitric acid, sp. gr. 1.42, aided by a gentle heat. As soon as the mercury is dissolved, add eleven parts of alcohol, sp. gr. 0.87. A brisk action will ensue, and the solution will become turbid from the separation of crystals of the fulminate. Dense,

white clouds are also evolved at the same time. When the action has subsided the vessel may be filled with water and the fulminate allowed to settle, after which it is collected on a filter, washed, and dried by exposure to the air. When dry it must be handled cautiously, as it explodes by friction or percussion, especially when in contact with particles of sand or glass. It is also exploded by heating to about 300° , by the electric spark, and by contact with concentrated nitric acid or sulphuric acid.

When wet it will not explode. Its explosive force is not much greater than that of gunpowder, but it is much more sudden in its action.

The readiness with which it is fired makes it an excellent agent for exploding other substances, and this gives it its value. It is used in percussion caps, primers, and fuses—not pure, but mixed with nitre, mealed powder, and other substances, because it is necessary to moderate its explosive property, since it is otherwise too rapid and violent for the purpose. It is sometimes mixed with chlorate or nitrate of potash, and ground glass is often added to increase the sensibility of the mixture to explosion by percussion.

A new fulminate has recently been invented in Austria, intended to replace fulminate of mercury for military purposes. It is claimed to be quite as effective as a detonator and much less sensitive than fulminate of mercury. If so, the gain will be very great, as the danger from handling explosives and ammunition generally will be lessened by the introduction of a safer fulminate. The composition of the new substance is secret, but it is said to contain copper, ammonium nitrate, potassium nitrate, sulphur and aluminum.

23. Illustrations of Explosion by Detonation.—The practical value of this mode of developing the force of explosive agents is very great. The necessity of confining gunpowder and other explosive materials in strong receptacles for the purpose of developing their explosive force, is greatly reduced, and indeed entirely dispensed with in the case of charges fired under water, when detonating fuses are used as the exploding agents.

Masses of hard material of great size or strength, such as blocks of hard rock, large iron castings, or thick bars of iron may

be broken up by simply placing upon one of their surfaces a comparatively small charge, quite unconfined, of compressed gun-cotton, or of a nitro-glycerine preparation, and exploding it by means of a detonating fuse.

In such operations the destructive effect of the detonation will be increased by covering the charge with sand or other material, but in hurried operations good results may be obtained with either of the materials specified, by detonating them when freely exposed to air.

For hasty demolition of buildings and of military works, the explosion by detonation affords most important facilities, reducing the difficulties, dangers, and cost of such operation to a minimum.

24. The Phenomenon of Explosion of Gunpowder may be divided into three parts, viz., *ignition*, *inflammation*, and *combustion*. By ignition is understood the setting on fire of a particular part of the charge; by inflammation the spread of ignition from grain to grain; and by combustion, the burning of each grain from its surface to center.

25. Ignition.—Ordinary gunpowder may be ignited by the electric spark, by contact with an ignited body, or by a sudden heat of 572° F. A gradual heat decomposes powder without explosion, by subliming the sulphur. Flame will not ignite brown powder unless it remains long enough in contact with the grains to heat them to redness. Thus the flame from burning paper may be touched to grains of brown powder without igniting them, owing to the slight intensity of the flame and the cooling effect of the grains. It may be ignited by friction or a shock between two solid bodies, even when they are not very hard. Experiments show that gunpowder may be ignited by the shock of copper against copper, copper against iron, lead against lead, and even lead against wood; in handling gunpowder, therefore, violent shocks between all solid bodies should be avoided. The time necessary for igniting powder varies according to circumstances. For instance, damp powder requires a longer time than powder perfectly dry, owing to the loss of heat consequent on the evaporation of the water; a powder, the grain of which has an angular shape and rough surface, will be more easily ignited than one of

rounded shape and smooth surface; a light powder more easily than a dense one.

Smokeless powder is not ignited as easily as black or even brown powder, and for this reason an *ignition charge* of the former is used for each charge of smokeless.

26. Inflammation and Combustion.—When grains of powder are united to form a charge, and fire is communicated to one of them, the heated and expansive gases evolved insinuate themselves into the interstices of the charge, envelop the grains and ignite them one after another.

The propagation of ignition is called *inflammation*, and its velocity, *the velocity of inflammation*. It is much greater than that of combustion, and it should not be confounded with it. When powder is burned in an open train, fine powder inflames more rapidly than coarse; such, however, is not the case in firearms, owing to the diminution of the interstices. If a charge were composed of mealed powder, the flame could no longer find its way through the interstices, and the velocity of inflammation and combustion would become the same. The ignition charge used with smokeless powder serves not only to ignite the powder but to increase the velocity of inflammation.

Now, supposing one grain or particle alone be ignited, it will first be inflamed over its whole surface, and the progressive combustion will take place from the exterior to the interior. Its *rate of combustion* will therefore depend upon both its shape and size, leaving out entirely, for the present, the question of density and hardness. A grain of spherical or cubical form will expose less surface to ignition in proportion to its volume than one of an elongated or flat shape, and will consequently require a longer period for the combustion of its entire mass; the larger the grain also, the longer will be the time required for its combustion.

Looking, then, at one grain of powder by itself, we may say that the larger it is, and the more nearly its form approaches a sphere, the longer will its combustion take and the slower will be the evolution of the gas. When, however, we come to regard the action of an aggregation of such particles, as in the charge of a gun, the *rate of ignition* of the whole charge is also affected by the size and shape of the grain.

The part of the charge first ignited is that near the vent, and the remainder is inflamed by contact with the heated gas generated by the combustion of this portion, so that the rate of ignition of the whole mass will be regulated by the greater or less facility with which the gas can penetrate throughout the charge, which is itself dependent upon the shape and size of the interstices between the grains. If the grains be spherical and regular in form, the interstices will be comparatively large and uniform, and the gas will penetrate the mass with facility; again, the larger the grains, the larger the interstices between them. If, on the other hand, they be flat or flaky and irregular in shape, the passage of the gas will be more difficult, and the rate of inflammation of the charge will be reduced.

We see, therefore, that the considerations which affect the more or less rapid combustion of an individual grain of gunpowder, also affect the rate of ignition of a charge of such grains, but in an opposite direction; so that a form of grain which will individually burn rapidly, may offer an increased resistance to the passage of the heated gas through the charge, and thereby retard its ignition, while a grain which will burn more slowly may allow of the charge being more rapidly ignited. In the case of perforated grains, however, the rates of ignition and combustion are both increased by the perforations.

By varying the size and shape of the grain alone, a powder may therefore be obtained, a charge of which shall be ignited rapidly throughout, but burn comparatively slowly, or one which will be ignited more slowly, but when once inflamed burn very rapidly. It is necessary to draw a clear distinction between a rapidly igniting and a quickly burning powder.

27. Velocity of Combustion.—The velocity of combustion is the distance passed over by the surface of combustion in a second of time, measured in a direction perpendicular to this surface.

The velocity of combustion varies with the purity, proportions, trituration, or incorporation of ingredients, density, and condition of the ingredients, also with the pressure and temperature under which the powder is burned.

28. Effect of Temperature on Combustion.—The heat developed increases with the charge, and as the velocity of the gases

increases with their temperature, it is therefore evident that a large charge is consumed quicker than a small one; it is also true that the quantity of heat absorbed by the surface of the bore is much less sensible when the charge is great than when it is small; that is, the heat absorbed is proportional to the surface, or the square of the calibre of the gun, and the heat developed increases as the cube of the calibre.

29. The Resistance of the Projectile.—When the projectile offers a great resistance its motion in the bore is less rapid, and it evidently follows that the inflammation takes place in a space which diminishes as the resistance increases. The smaller this space, the more heat is generated, the higher the temperature of the gases, and the greater their velocity; and there follows from all these causes a train of effects which accelerates the inflammation and combustion of the charge.

30. The Point of Ignition.—When a quantity of powder is contained in a closed space all the sides of which offer an equal resistance, it is evident that the complete inflammation will be quickest when the fire is applied to the center of the charge.

In cannon, however, the force developed does not meet with the same resistance in all directions; the projectile yields as soon as sufficient force acts upon it; and as the combustion of the powder requires a definite interval of time, it follows that a great part of the charge is not consumed until after the displacement of the projectile.

Now, the position of the interior orifice of the vent may influence the time required to displace the projectile, and this influences the inflammation of the charge. For example, with the regulation vent, it is the rear part of the charge which first takes fire; the inflammation is communicated to the adjacent parts and promptly reaches the projectile; the gases expanding displace it, and the inflammation takes place in a larger space than that at first occupied by the charge.

31. Density.—The density and hardness of the grains of powder are of quite as vital importance as their size and form, in determining the rate of ignition and combustion of a charge.

By density is meant the quantity of powder actually present in a given bulk.

It is important that this quality should not be confounded with hardness. A substance may be very hard and yet be of a low density. A powder with a very hard surface may be really less dense than another the surface of which is softer. Of course, very high density cannot be communicated without producing a considerable degree of hardness; but powder can be made hard without rendering it very dense, by pressing the dust in a comparatively dry state.

32. Hardness seems to bear a direct relation to the power exerted in compressing, while density does not. Black powder dust, at a high degree of moisture, say six per cent, can be made very dense by application of moderate pressure, while that of 1 per cent can only be brought to the same point in density by the exertion of enormous force. Of the two, the latter will be the harder powder.

The action of gunpowder in guns is theoretically treated in works on "Interior Ballistics."

High Explosives.

33. High Explosives are used in naval warfare for the charges of torpedoes, submarine mines, for the bursting charges of special shell, and for the destruction of the enemy's resources in machinery, fortifications, buildings, bridges, etc., when necessary and desirable.

There are numerous high explosives, the principal ones being nitro-glycerine, gun-cotton, explosive gelatine, dynamite, picric acid and its compounds, lyddite, maximate, dunnite, emmensite, etc. Of these, gun-cotton, maximate, and dunnite are preferred in the United States for military purposes. Many others are used in Europe, and new forms are being constantly produced for which extravagant claims are made.

34. Nitro-glycerine * was discovered in 1847 by A. Sobrero, and is a nitro substitution produced by the action of nitric and sulphuric acids on glycerine. In order to insure stability and reduce its sensitiveness to shock to a minimum, no cheap materials should be used in its manufacture; the glycerine should be above

* *Naval Intelligence Annual*, 1890.

proof, the nitric acid of a specific gravity of 1.5 and the resulting explosives carefully washed to remove all traces of free acid. When ignited in small, unconfined quantities it burns, but with close confinement it explodes either by ignition or when heated to 257° F. It freezes at 40° F., in which state its sensitiveness to concussion and detonation is very much reduced. It can be detonated by shock, gunpowder fuse or detonator, and generates six times as much gas as gunpowder, which is expanded by the great heat produced to occupy thirteen times the volume. It is insoluble in water. Its use is now generally confined to the dynamite and gelatine forms.

35. Gun-cotton was first manufactured by Schönbein in 1845, but proved dangerous to handle until it was rendered safe by the method of purifying, pulping, and compressing it. It is produced by the action of sulphuric and nitric acids on cellulose in the proportion of three parts of sulphuric to one part of nitric acid. Under the action of these acids, according to their strength and methods employed, trinitro, binitro, and mononitro cellulose are produced, gun-cotton being the first-named, viz., trinitro cellulose. It is only soluble in acetone; unconfined and ignited it burns away rapidly; struck with a hammer on an anvil a part of it explodes, the remainder being blown away; when heated to a certain temperature it explodes, and when confined or compressed, it explodes from shock, heat, or detonation.

To Mr. E. O. Brown is due the credit of discovering that wet unflammable gun-cotton is capable of being detonated by a strong detonator, or by an ordinary detonator with a priming charge of dry gun-cotton, the size of which depends upon the percentage of water contained. This discovery greatly increases the value of gun-cotton as a military explosive, not only for submarine work, but also as an explosive for shells; for wet gun-cotton is not affected by shock, will not explode when penetrated by rifle bullets, nor upon shock of discharge when loaded in shells; it is comparatively insensible to sympathetic explosion, and is not exploded by heat. In 1871 the English government tested this last-named quality by burning in bonfires two lots of a ton each, of gun-cotton, containing thirty per cent moisture. In one case the explosive was in disks in a closed tank, and in the other it was

divided among eighty closed packages. In both cases the gun-cotton burned away without explosion.

Steps have been taken to coat disks of wet compressed gun-cotton, in order to prevent decomposition by the evaporation of moisture. In 1883 Von Forster and Wolff patented the process of dipping gun-cotton in acetic acids for a few seconds which dissolves the cotton on the surface and forms a coating. But this was found to crack, so they now coat the disk with paraffine, and only treat the hole in this manner to facilitate detonation. Schulhof has patented a so-called weather-proof gun-cotton which is said to possess non-hygroscopic qualities, to be insensible to shock or blow, and to be capable of exploding by detonation or heat of over 300° F. He impregnates dry gun-cotton with molten tallow or mutton fat, getting rid of the superfluous grease by pressure and washing with bisulphuret of carbon and benzine.

The details of the manufacture of gun-cotton are given in the chapter on smokeless powder.

36. Wet Gun-cotton is known to be a perfectly safe uninflam-mable and inert explosive in the absence of a strong detonating force. It may consequently be stored aboard ship, or conveyed and used with land forces, without any special precautions and without the slightest risk from any cause. Its keeping qualities are excellent.

Wet gun-cotton contains about 20 to 25 per cent of water. With a delay-action fuse it has given excellent results as a bursting charge for shells, having been fired through comparatively thick armor plate before exploding. It seems to be superior to the English lyddite in this respect, the latter being more locally violent.

Wet gun-cotton charges for torpedoes are usually made up of small blocks or disks to fit the head. Recently, however, foreign manufacturers have pressed the charge into one solid mold exactly fitting the head of the torpedo, with a hole through the center for the primer.

37. Gun-cotton in Shell.—Dry gun-cotton may not resist the shock of discharge of a powder gun under service conditions. Experiments in England from 1864 to 1867 showed that charges of 3 pounds in specially lined shell, when fired with an initial velocity of 1300 f. s., were exploded prematurely; and although

18-pound charges have been successfully fired from a 24-pounder gun, and 6½-pound charges from a 20-pounder gun at the Torpedo Station, it simply indicates the perfection reached in its manufacture at that place.

When wet or saturated with paraffine, gun-cotton is safe for use and will penetrate armor without explosion. When a small percentage of water is used, the detonation produced by impact is of a low order. Wet gun-cotton cannot be ignited by rifle bullets fired into it at short range.

As generally used for explosive charges of shell, wet gun-cotton is compressed into disks and prismatic or cylindrical grains. When used in the latter form, the charges are about one-third less weight, and compactness is produced by paraffine, or mixtures of it and canauba wax, poured in at a temperature of 180° F., a hollow space being left in the axis of the shell for the detonating charge. This detonating charge is composed of a fuse and dry gun-cotton, and must be of sufficient size to produce an explosion of the first order.

38. Gun-cotton for Submarine Mines.—Experiments in England have shown that with a ship of the Hercules type, with double bottom empty, and coal bunkers full, 95 pounds of gun-cotton exploded in contact will sink her; 220 pounds at 30 feet horizontal distance inflicted no serious damage; and 500 pounds at a horizontal distance of 100 feet will probably seriously damage the pipes and machinery. Wet gun-cotton, in addition to the fulminate primer, requires about 1 pound dry gun-cotton disks to cause an explosion of the first order.

39. Blasting Gelatine was invented by Nobel in 1879, and is composed of finely divided nitro-cotton dissolved in nitro-glycerine at a temperature of 100° F., the effect of the combination being to supply the requisite amount of oxygen to insure complete combustion. It contains from 93 to 95 per cent of nitro-glycerine, being more and more gelatinous in proportion to the quantity of nitro-cotton, the thinner being the more susceptible to detonation and liable to liquefy and exudate. When slowly heated it detonates at 400° F. It is less sensitive to blows than either nitro-glycerine or gun-cotton, and requires a strong detonator and close confinement to develop its full force, not being sensitive to deto-

nation by influence. It is unaffected by water, and is more sensitive when in a frozen state. Pure ingredients are essential to insure its stability. It freezes at a relatively low temperature and is then more sensitive to explosion by concussion.

40. Explosive Gelatine is blasting gelatine with the addition of a certain amount of camphor, which reduces its sensitiveness. The proportion generally used is nitro-glycerine 89 per cent, nitro-cotton 7 per cent, and camphor 4 per cent. It burns at 570° F., requires special strong detonators or ordinary detonators with gun-cotton or dynamite primers, and is less sensitive than most of the high explosives. It is insensitive to shock, rifle balls having been fired into it at short range without exploding it, and it is believed to be as stable as gunpowder when manufactured of pure ingredients. It is unaffected by immersion in water.

41. Dynamites are explosives in which 75 per cent nitro-glycerine is absorbed by some porous substance, thus rendering it safer to handle and less liable to explosion from shock. They are of two classes, viz.: (1) those with an inert base; and (2) those with an explosive or combustible base.

42. Dynamite No. 1 is the one most commonly used and belongs to the first class, consisting of nitro-glycerine absorbed by kieselguhr, or rotten stone, from which the water and organic matter are driven out, in the proportions of 75 per cent nitro-glycerine and 25 per cent kieselguhr. It can be detonated by shock, and by a metallic gunpowder fuse or detonator, its sensitiveness increasing with the temperature, and it explodes at 360° F. It freezes at 40° F. and remains frozen at a considerably higher temperature, in which state it is insensitive to shock, being unaffected by rifle bullets fired into it, but is more susceptible to explosion by ignition. Great care is necessary in thawing it, as the records of mining accidents show that 95 per cent of them are caused by this operation. Frozen cartridges are not susceptible of detonation, but loose and granular dynamite, even when frozen, can be detonated, its violence being diminished. Compacted it is more sensitive to explosion by ignition than when loose, and water disintegrates it. In tropical countries it loses its strength by gradual evaporation of the nitro-glycerine. Herr

Edward Liebert and Baron von Dahmen have produced so-called safety or non-freezable dynamites. Liebert's invention consists in adding a small per cent of isoamylic nitrate either to the nitro-glycerine itself or to the dynamite, but the substance Dahmen uses is not known. The latter explosive, after being subjected to a temperature of from -20° to -15° C. for 24 hours, remained perfectly plastic, exploded with almost as much force as ordinary dynamite, and also by influence. Under ordinary temperatures it is less sensitive to shock than ordinary dynamite and is slightly stronger.

43. Carbo-dynamite, invented by Boreland and Reid, belongs to the second class of dynamites, and consists of 20 parts of specially prepared cork carbon containing 90 parts of nitro-glycerine.

44. Emmensite was invented in 1888 by Dr. S. H. Emmens and belongs to the picric powders. The compounds bearing the name emmensite all contain a nitrated carboic acid which is produced by dissolving, at a gentle heat, an excess of commercial picric acid in concentrated fuming nitric acid (50° to 52° C.), the solution, on evaporation, depositing it in yellow prisms. These prisms are heated in a dish until they become semi-liquid, and are then mixed with a mineral salt, some other ingredients being added for special purposes. There are four grades, the best, No. 1, consisting of equal weights of the nitrated carboic acid, nitrate of soda, and nitrate of ammonia. The cake so produced is then pulverized in a mortar, the smaller the grains the more rapid being the explosive action. When heated it melts into a resinous state without exploding, and a match ignites it with great difficulty. When struck by a hammer on an anvil, or a rifle bullet at short range, only the part immediately in contact explodes, and it has been fired as a projectile from small arms against iron plates without exploding on impact, thus proving its insensitiveness to shock. Its keeping properties have been put to a two years' test without its deteriorating, and when mixed with some substance to act as a reducer it can be used as a propellant. Its specific gravity is said to be 1.8. Although it is hygroscopic, its strength is but slightly affected by repeated saturation with water, and subsequent drying.

Experiments have been made with emmensite as the bursting

charges of high explosive shell and it has been generally successful.

45. Picric Acid forms the basis of a great many "ites," no less than thirty being shown in the English "Dictionary of Explosives," and on account of its peculiar qualities it has shown itself to be a very potent instrument in the hands of charlatans for deceiving the uninitiated.

Picric acid is nitrated indigo, and the color of the product is yellow instead of blue. It was used as a dye before it was known to be a high explosive.

At the present time picric acid is made, not from indigo, but from nitrated coal-tar products, and is known chemically as "trinitro-phenol."

When pure picric acid is loaded into an armor-piercing shell it will usually detonate by the time the point has penetrated about three inches, although there have been instances where VI shell charged with pure picric acid have penetrated a 5-inch plate.

The addition of dinitro-benzol—a substance similar to picric acid but which melts more easily—renders picric acid less sensitive, and vaseline still further reduces its sensitiveness. For armor-piercing shells a mixture of:

87% picric acid,
10% dinitro-benzol,
3% vaseline,

is sufficiently insensitive, it is claimed, to penetrate almost any thickness of armor with a proper delayed-action fuse.

46. Lyddite.—The English lyddite is a picric acid compound modified with dinitro-benzol and vaseline. Remarkable claims are made for this explosive, and it has been used so extensively by the British that it merits attention. It is claimed that it may be stirred with a red-hot iron, thrown into a furnace or boiled away in a saucepan without explosion. It may be melted in hot water and then poured into shells, where it forms a dense, compact mass, and may be fired through thin armor. When set on fire with a hot iron it will burn while the iron is in contact with it, but the flame will go out when the iron is removed. As a bursting charge it is violent and blows the shell into many very small fragments.

The effect of lyddite against ships is terrific when the shell penetrates between decks. It will be very effective against unarmored or thinly armored ships, but as yet it has not penetrated as much armor as some other high explosives.

47. Lyddite in the Boer War.—The British used lyddite extensively for bursting charges in shell against the Boers. A writer on this subject states: "The lyddite shell has proven one of the distinct disappointments of the war. It has no effect whatever against intrenchments. On exploding, which it almost always does as far as I could judge, it only makes a small hole about a foot deep and two feet in circumference, and breaks into a few fragments. . . . The poisonous gases confined in a close space would be very destructive, but in the open air they are too quickly dissipated to do any injury." Another writer on the same subject says: "The results obtained by the large lyddite shells have been slight. Their effect on men sheltered behind boulders or posted in deep trenches was nil. This was proved at Paardeberg, when 98 pieces of various calibres bombarded Kronje's camp—a square of less than 1000 yards—at 2500 yards' range for eight days and nights, and only put *hors de combat* some 100 men out of 4140. The demoralization produced by the noisy explosion of the lyddite soon passed away, the effect of the shell being so feeble. Boers were seen to be thrown down by the wind of the projectile bursting close by them and even their clothes were torn off, but they got up again without a scratch. *The effect of shrapnel on the contrary was always dreaded.*"

This testimony regarding high explosive shell in the open is significant. In confined spaces, like the decks of a ship, the effect may be very different.

48. Maximite.—Maximite has given such remarkable results as the bursting charge in armor-piercing shells that it may come into general use for that purpose.

The composition of maximite is a secret. It is claimed that it cannot be exploded by ignition or shock, and when heated in an open vessel it will evaporate like water so that the temperature cannot mount to the explosive point. The shells are filled by pouring the explosive into them. Its expansion while solidifying into a dense and solid mass packs it so hard as to prevent the formation

of air spaces. The terrific force of the explosion is shown by the regularity and character of the 7000 fragments into which a 12-inch fused shell weighing 1000 pounds has been blown. So far as experimented with maxinite appears to have excellent chemical stability and keeping qualities. Shells loaded with it have been fired through armor plates from three to twelve inches thick and either exploded in the plate or just beyond it, showing that it will stand the shock of impact. The fuse used with it is the secret invention of Captain Dunn, U. S. Army.

An account of its action, in the experiments at Sandy Hook, will be found in the chapter on "Penetration of Projectiles."

49. Dunnite.—The composition of dunnite is a secret. As a bursting charge for shells it promises to rival maxinite when used with a proper delayed-action fuse.

50. The Use of High Explosives in Warfare.—As the utility of high explosives in warfare is now recognized, the desirability of regulating their sensitiveness is very apparent. The various dirigible and automobile torpedoes carry large charges of explosives, but they are limited as to range and accuracy.

The first successful steps toward accomplishing this problem were where very heavy charges of high explosives were projected at low initial velocities and moderate ranges, as by the Zalinski pneumatic gun; but the use of projectiles so discharged, containing 60 per cent by weight of high explosive is limited to torpedo effect, to countermining, to mortar or high-angle fire against forts and to use against the unprotected sides or exposed decks of ships.

This was a great step, but progress required a still greater advance. Direct fire and penetration are desired; and in order to increase the danger space it is necessary to reduce the height of the trajectory, and therefore increase the initial velocity which increases the range. To accomplish the penetration of modern armor, armor-piercing shell, with very thick walls, must be used; and as the space containing the bursting charge is proportionally reduced, the necessity of a more violent bursting charge than gunpowder; and one that is not so liable to explode by the heat generated before perforation, is evident.

For use against exposed bodies of men gunpowder is still an

excellent agent, being less local than the high explosives and not breaking the shell into such small fragments, it being maintained that to disable a man a shell fragment should weight not less than 1 ounce and have a velocity of 500 f. s., which is equivalent to one-eighth foot ton. The high explosive, however, in addition to its great moral effect is capable of throwing pieces of the shattered projectile to the rear, which principle is used by the Germans against men protected by bomb proofs.

As bursting charges for thick armor-piercing (a. p.) shells, or for large demolishing charges in thin shell to be thrown inside fortifications and engineering works, the high explosives are most efficient. But when employed against armored vessels the effect is very slight unless the projectile penetrates a certain distance before explosion, in which case it attains its maximum effect. Charges as high as 500 pounds of gun-cotton have been exploded against the face of vertical armor without producing any material damage, and it is not believed that the heaviest projectile yet fired from the Zalinski pneumatic gun will seriously damage a vessel if exploded in contact with the face of the armored sides.

For use against torpedo boats, Chalon states that high-explosive projectiles from rapid-fire guns are very much more effective than gunpowder projectiles from large guns. He shows that projectiles containing 22 pounds of gelatine dynamite will sink a torpedo boat within a radius of 37 feet of the explosion, and 13 pounds, at 29 feet distance. Hence, the object to be accomplished is to so deaden the explosive that it may remain inactive until the desired moment, when it is exploded by a fuse. This has been effected to such a degree that an initial velocity exceeding 2000 f. s. has been reached; penetration of 12 inches of steel before explosion has been accomplished; and successful delayed-action fuses are now in use.

For use in projectiles the requirements of an explosive are essentially the same as for submarine use, excepting that the quality of being unaffected by water is unnecessary, and its effectiveness is not decreased by being quick in its action; but non-sensitiveness to shock is of the most vital importance.

51. Résumé.—The question of high explosives is by no means definitely settled, but there can be no doubt that they will have very important uses in

For submarine mines, gun-cotton and explosive gelatine seem to give the best results. They are safe and very powerful when exploded under water.

For general naval use, gun-cotton is at present unexcelled. Its stability, safety, and its powerful effect when exploded by a suitable primer all combine to make it most acceptable.

The results obtained in the trials at Sandy Hook, described in the chapter on "Penetration of Projectiles," were apparently very favorable to maxinite and the Army high explosive as bursting charges for shells, as well as a triumph for Captain Dunn's delayed-action fuse. No trials abroad have as yet given better results than these.

CHAPTER XXIV.

GUNPOWDER.

Prepared by LIEUTENANT JOSEPH STRAUSS, U. S. Navy.

1. **A Description of the Military Gunpowders** of to-day would, so far as they relate to the propulsion of projectiles, exclude all but smokeless powder. Black powder, which has been in use for nearly six centuries, is little used except for igniting smokeless powder charges, for explosive shell, for primers and fuses and for saluting charges. Brown, or cocoa, powder so named from its peculiar color, came into extensive use some twenty years ago, but is no longer manufactured.

2. **Black Powder** is an intimate mixture of 75 parts of saltpetre, 15 of charcoal and 10 of sulphur. The proportion of ingredients has been varied from time to time during the history of gunpowder, but it is a notable fact that we are using to-day the same relative quantities that were in use at the earliest times.

The ingredients after being incorporated in a suitable mill, are caked and then broken up into granules. Shell powder and powder for fuses and primers are very fine grained; ignition charges for guns up to 6-inch are made up of similar powder; while ignition charges for the larger guns are formed from the large hexagonal prisms or from a single cake of suitable size and shape. Saluting charges are made up of irregularly shaped grains considerably larger than the shell powder.

3. **Brown Powder** has played such an important part in the development of the modern gun that it merits a word in passing. Its composition is similar to that of black powder, except that the proportion of saltpetre is increased and the amount of sulphur is decreased to 2 or 3 per cent; a small amount of sugar about equal to that of the sulphur is also incorporated. The light color is due to the fact that the charcoal used is underburnt.

The incorporated ingredients are formed under heavy hydraulic

pressure into regular hexagonal prisms having one or more axial perforations. These prisms are packed into powder bags so as to form a solid mass with the perforations continuous and parallel to the axis of the gun. The result of the peculiar composition of the powder, the size and arrangement of the grains, is to make the mass burn slowly and *progressively*, that is, to increase the ratio of burning surface to weight of unburnt powder as the shell moves forward in the bore. By this means the pressure exerted on the walls of the gun is lessened at the breech and increased at the chase.

4. Advantages of Smokeless Powder.—When black or brown powder is exploded in a gun, only about 35 per cent of its weight is converted into gas, the remaining 65 per cent being mainly dissipated in dense smoke, while a portion of it remains in the bore as solid residue. The smoke and residue are entirely inert, and instead of aiding in the propulsion of the projectile, actually reduce its initial velocity by taking away from the expanding gases sufficient force to eject the solid particles from the gun. Thus, taking the 6-inch gun firing a projectile of 100 pounds with a charge of 50 pounds of brown powder, 17.5 pounds of gases are formed which must not only do the work of expelling the projectile at a velocity of 2100 f. s., but 32.5 pounds of solid material must also be expelled, making the projectile weigh, for the moment, virtually 132.5 pounds. Now if the propellant were of a material that could all be turned into a gas of equal force, we would have gained: 1st, the considerable advantage of a less weight of ammunition to stow and handle; 2nd, a greater velocity; 3rd, no fouling of the bore, and 4th, no smoke and an unobstructed view of the target after firing each shot.

These advantages were recognized quite early in the last century, when attempts were made to obtain a substitute for black powder, and gun-cotton was the first material extensively used for the purpose. In order to control its rate of burning, the gun-cotton fibre was spun into threads and then twisted or braided. Considerable success attended these attempts, but owing to irregular ballistic results and other accidents, the use of this material as a propellant was finally abandoned.

5. Gun-cotton Powder.—Gun-cotton is of several varieties,

depending upon the degree of nitration the cellulose attains in the process of manufacture. A fairly sharp dividing line may be drawn between the grades of high and low nitration in that the latter are soluble in a mixture of ether and alcohol, while the former are not. In general, this division occurs when the percentage of nitrogen amounts to 12.75; above that point gun-cotton is insoluble. Gun-cotton containing less than 12.75 per cent nitrogen may be perfectly dissolved into a jelly-like substance, which, after the solvent is evaporated off, becomes a hard, tough, translucent mass. In this condition it burns regularly in parallel layers without smoke; it may be pressed into any desired shape, and it cannot be detonated. This material pressed into grains of the required form constitutes the U. S. Navy smokeless powder.

6. Manufacture of Smokeless Powder.—Perfectly clean dry cotton is digested for 30 minutes in about fifty times its weight of a mixture of strong sulphuric and nitric acids. During this time a reaction between the cellulose and nitric acid takes place in which nityl (NO_2) takes the place of the hydrogen in the cellulose and water is liberated. The function of the sulphuric acid is merely to combine with the water, thus keeping the strength of the nitric acid up to the standard necessary to obtain the proper degree of nitration.

The strength of the acid mixture, its temperature, the duration of the digestion period, the dryness of the cotton and the condition of the mass of fibres as to agglomeration all exert an influence on the resulting product, both as to its nitration and solubility. The digestion is usually performed in a centrifugal wringer, and after its completion the acid is drained off and the gun-cotton is freed from residual acid as much as possible by the revolution of the centrifugal basket. When in this state it is removed from the wringer and "drowned" in a large tank of fresh water, after which it is given a rough washing in fresh water while being revolved in the basket of another centrifugal.

7. Purification of Gun-cotton, Pulping, Poaching.—The gun-cotton is now transferred to large tanks and steamed for two days, the water being changed several times during the process. It is then removed to the *pulping machine*, where it is ground between knives into a fine pulp, the water being constantly changed and

sodium carbonate added from time to time in order that any free acid in the cotton may be neutralized. This process generally requires about seven hours.

The pulp is next transferred to large circular vats called *poachers*, and is then steamed and stirred for a period of about two days. During this time fresh water is frequently added, and after a certain period of stirring the pulp is allowed to settle and the top water decanted off. This operation is repeated until all trace of alkalinity has disappeared and the pulp passes the required heat test for stability.

8. Dehydration of Gun-cotton.—Before being capable of solution in ether-alcohol it is necessary to free the gun-cotton from water. To accomplish this it may be first wrung out in a centrifugal which reduces the amount of water to about 25 per cent; or, if partially freed from water, it may be run through a "wet machine," an apparatus used in paper mills for a similar purpose. The latter process leaves 40 or 50 per cent of water in the pulp, but it is nevertheless in good condition for treatment in the dehydrating press. This press consists of a vertical cylinder with a removable bottom over which an inverted hydraulic cylinder is arranged. The overhead cylinder has a piston head which plays in the barrel of the first cylinder below it. The piston is raised and a charge of about 50 pounds of the wet cotton is put in the press. The piston is then forced down under a pressure of about 200 pounds per square inch; this presses out some of the water and leaves the pulp in a compact mass. Twenty-five pounds of alcohol is poured in on top of the pulp, the cylinder is closed and an air pressure of 100 pounds per square inch is admitted over the alcohol. Under this pressure the alcohol is forced to percolate rapidly throughout the mass and has the effect of leaching out the water in its passage through the cotton.

After all the alcohol has been forced through, the cotton is subjected to a pressure of from 2500 to 3000 pounds per square inch in order to squeeze out the surplus alcohol. An amount of alcohol is allowed to remain equal to about 25 per cent of the alcoholized cotton. When in this condition it is only necessary to add ether to the amount of half the weight of the mass in order to provide the necessary solvent.

9. Mixing.—The cotton is next thoroughly ground up in the mixing machine. This apparatus consists of a cast-iron box with a bottom consisting of two half cylinders in which helicoidal steel blades are revolved. The operation of the machine for about an hour serves to thoroughly mix the solvent with the cotton and leaves it at the end of that time in a condition much resembling damp cornmeal. It is removed from the mixer and pressed into cakes weighing about 50 pounds each. The material now has the consistency and appearance of stiff glue or jelly, and is therefore referred to as *colloid*.

10. Pressing.—In order to further complete the solution, the colloid is forced through a thick steel strainer under a pressure of 5000 pounds per square inch. It is again reformed into a cylindrical cake under 200 pounds pressure and is then inserted in the graining press to be formed into grains.

11. Graining.—The graining press consists of a horizontal steel cylinder fitted with a piston operated by an hydraulic press. The colloid is gradually forced through a die under a pressure varying from 4000 to 6000 pounds per square inch, depending upon the size of the grain. The colloid issues in a continuous grain which is chopped into lengths usually about twice the diameter, and is then ready for the dry house.

12. Form and Size of Grain.—The size of the powder grain varies with the calibre; the larger the gun the larger the grain; in general terms, the lineal dimensions of grains of similar form are in direct ratio to the calibres of the guns in which they are employed. As compared to the old forms of powder, smokeless powders produce relatively large volumes of gases per unit weight of material, yet they burn away more slowly; the result is that grains of smokeless powder for a given calibre are smaller than those of the black and brown varieties.

Naval smokeless powder is translucent and varies in color from a light lemon to a deep brown, almost black. These variations in color depend generally upon variations in the process of manufacture, and possibly upon the water used. The material possesses a marked degree of toughness, which operates to render the powder regular and progressive in action and prevents the unconsumed portion of the charge from crumbling or disintegrating in

the gun, under the influences of heat and gas pressure due to those portions of the charge already consumed.

The form of grain in use for the .236-inch small arm is the flat rectangular; for the .30-calibre Krag it is in the form of small short cylinders; for all other calibres the multi-perforated cylinder is at present employed, there being seven holes through each grain. Some powder for 1-, 3- and 6-pounders has been in the form of thin ribbons about 2 inches long and $\frac{1}{2}$ inch wide. The perforations of cylindrical grains are for the purpose of keeping the burning surface practically constant, thus securing the quality of progressiveness which is of prime importance.

When smokeless powder is employed in the form of a sphere or a cube, the cube burns smaller in all directions; consequently the surface upon which the flame is operating is rapidly diminished in all directions and the quantity of gas diminishes. If, however, the powder is formed in long strips, the amount burning from the ends is immaterial; consequently the reduction only takes place in one direction—that is, in the thickness, and therefore the reduction of the burning surface is much less rapid than in the case of spheres or cubes. For this reason powder that is formed in flat strips, or in long tubes, is more *progressive*; that is, it evolves equal quantities of gas in equal intervals of time. In the case of the multi-perforated grain, the burning surface decreases from the outside and increases from the inside. This form is, therefore, the most progressive of all.

13. Drying the Powder is accomplished in buildings fitted with trays with wire net bottoms, air being admitted underneath the trays; or the powder is placed in large bins through which warm air is forced by blowers. For powder of the large calibres five or six months are required to dry out the solvent down to 3.5 per cent. It is extremely difficult to reduce the volatiles to a lower point in thick-walled grains; in powders for the minor calibre guns the volatiles are reduced to about 2 per cent in a month or six weeks of drying.

The diameter of the grain is reduced about one-third and the length shortened one-tenth as a result of the drying. After tests have shown the powder to be dry enough, it is carefully blended and then packed in air-tight cases ready for shipment and proof.

14. Ballistics of Smokeless Powder.—An example of the ballistic value of smokeless powder is shown in the fact that in a 6-inch 40-calibre gun, 20 pounds of navy smokeless gives a velocity of 2000 f. s. with 10.8 tons pressure, whereas 45.5 pounds of brown powder are required to produce the same velocity, while the resulting pressure is 15 tons. With brown powder, 2100 f. s. is the greatest velocity obtainable in the 6-inch 35-calibre gun, while the smokeless easily produces a velocity of 2300 f. s. with less pressure and a charge weighing 25 pounds. The 12-inch 35-calibre gun gives a velocity of 2100 f. s. using 425 pounds of brown powder. Exactly half this weight of smokeless will produce the same velocity.

In general, the new type large-chambered guns of 40 and 50 calibres length require a charge of smokeless weighing about 40 per cent of the weight of the projectile. In the 12-inch 40-calibre gun this charge gives a velocity of 2800 f. s.; in the 6-inch 50-calibre gun the velocity for such a charge is 2900 f. s. These velocities would be impossible with black or brown powder.

It is certain that the powder is absolutely progressive in its burning. When small charges are used with consequent low pressures and rates of burning, it frequently happens that partially burned grains are recovered in front of the muzzle of the gun. In all cases it has been observed that the outside diameter has been reduced and the inside diameter of the perforations increased in exactly equal amounts. The walls may be reduced to the thinness of paper, but the general structure of the grain remains intact.

15. The Ignition Point of smokeless powder is about 185 degrees C, and notwithstanding that this is lower than that of brown or black powder, the material is less inflammable, and the charge requires a starting or ignition charge of black powder. High pressures are sometimes produced when the charge is ignited imperfectly, and it is therefore necessary to fill the chamber with a burst of flame so that ignition may take place simultaneously throughout the mass. In the 12-inch gun, one or two pounds of black powder are sufficient to supply the necessary amount of flame, and this is divided equally among the four powder bags, the ignition powder being placed at the bottom of each bag.

16. Nitro-glycerine Powders.—There are practically but two

kinds of smokeless powder in use to-day, the powder described above and which is classed as a *gun-cotton powder*, and another class known as *nitro-glycerine powder*, which is made of a mixture of gun cotton and nitro-glycerine.

17. **Cordite and Ballistite** are the two best known examples of nitro-glycerine powders. The former consists of a mixture of 58 parts of nitro-glycerine, 37 parts of trinitro cellulose, and 5 parts of vaseline. Acetone is used as a solvent, and the resulting composition, after the acetone is evaporated out, has the consistency of very hard beeswax and varies in color from a dark yellow to brown. *Ballistite* is very much the same kind of powder. The action of cordite, as compared with gun-cotton powder, is very brusque, hence, the powder is pressed out into solid cords and the charge is made up of bundles of these cords. By this means, the ratio of burning surface to weight of powder is less than it would be were the grains provided with longitudinal perforations; but this entails the loss of the quality of *progressiveness* which obtains with a multi-perforated grain. Hence, guns using cordite cannot attain the high muzzle velocity that can be had with gun-cotton powders.

18. **Advantages and Disadvantages of Nitro-glycerine Powder.**—Cordite possesses a considerable advantage in that a very much lighter charge is required for *ordinary velocities* than is required with gun-cotton powder. Besides this, its power admits of the grains or cords being arranged in a uniform way in making up the charge, which, other things being equal, would give more uniform ballistics. It is, however, extremely sensitive to heat and cold, the velocity dropping with its temperature, and its pressure rising under the reverse condition. A very strong objection to its use lies in the fact that the rifling is rapidly eroded, causing an increasing and permanent loss of velocity that finally compels the relining of the gun. One more objection obtains with nitro-glycerine powder, and that is, that the nitro-glycerine exudes, or evaporates out, and impregnates the powder bag; thus the danger from free nitro-glycerine is added to the disadvantage of a powder with a decreasing velocity and variable pressure.

Powders of this class have been made with only 25 per cent of nitro-glycerine. They were brittle, and gave very erratic and

sometimes disastrous results, and in general have been abandoned, although the great consideration of reducing the weight of the charge for field guns has led to further experiments.

19. Erosion.—Erosion of the bore seems to depend upon the amount of heat imparted to the metal. As might be expected, when the work is so largely increased, smokeless powders raise the temperature of the gun to a much higher point than do black or brown powders. As has been stated, nitro-glycerine powders are very objectionable in this respect, and in the thinner-walled guns where the firing is very rapid and sustained, considerable erosion takes place even with the navy smokeless powder.

Special gas checks have been devised abroad, which prevent the escape of the gases beyond the rotating band of the projectile. This of course preserves the uniformity of the velocity within limits, but does not prevent the ultimate erosion and consequent disabling of the gun.

20. Pressures and Velocities.—Both the pressure and velocity vary directly with the weight of charge, when the charge is not too small to prevent sufficient pressure being developed to burn up all of the grains before the shell leaves the bore, or, when the charge is not so large as to give pressures exceeding 17 or 18 tons. At that point there seems to be a deflection in the pressure curve, and a small increase in the charge may produce a very great pressure. The residual volatiles contained in the smokeless powder act as a deterrent, and if they are permitted to escape after the powder has been proved and a charge assigned, excessive pressures will result. It is, therefore, of great importance that the charges be always kept hermetically sealed; and conversely, it is necessary to protect the powder from the deposition of moisture on its surface or it will become "slower" and fail to give the designed velocity.

21. Stability.—Certain tests for the stability of nitro-cellulose powders are given which depend upon the fact that decomposing powder evolves the fumes of nitrous acid. In these tests the powder is heated above the atmospheric temperature to a point where all powders, no matter how stable, would eventually decompose. The *time* between the beginning of the heating and the appearance of the first signs of decomposition is taken as a

measure of the stability. Instability is generally caused by insufficient purification of the gun cotton of which the powder is made; but subjecting the powder to direct sunlight, or permitting it to sustain an abnormally high temperature for a protracted period will cause any powder to decompose.

22. Effect of Instability on Pressure.—Instability does not manifest itself in *higher pressures* in the gun. On the contrary one would look for *lower pressures* in a powder that had lost considerable oxygen and nitrogen. A strong odor of ether in the charge is often erroneously taken as an indication of decomposition. But it may be of no importance whatever, as a very minute quantity of ether is sufficient to strongly impregnate the atmosphere of a large room.

23. Tests for Stability.—In making the tests for stability, it is necessary to observe such directions as are given, with the greatest care and accuracy. All of the tests now known are entirely empirical and if the standard method is departed from in the slightest particular the value of the test is nullified.

CHAPTER XXV.

PRIMERS, EXPLODERS, CARTRIDGE CASES, DISTANCE PIECES, POWDER BAGS, IGNITION CHARGES, AMMUNITION BOXES AND POWDER TANKS.

Primers.

1. The primer of any gun or firearm is the specially constructed device which, when exploded by the direct action of the firing mechanism, ignites the powder charge by its flame or discharge and fires the gun. The primer, for R. F. ammunition, is in the center of the base of the cartridge case; for B. L. and Q. F. ammunition it is placed in the firing lock and its flame travels through the mushroom stem to the powder charge. There are at present three varieties of primers in use: *percussion*, *electric*, and *combination* primers.

2. **Percussion Primers** are those containing a sensitive explosive which is fired by the jar or friction resulting from the blow of the firing pin or hammer. The explosive in commonest use is fulminate of mercury which explodes by percussion, by friction, by the electric spark, by heating to about 300 degrees or by contact with concentrated nitric or sulphuric acid. It is extremely sensitive, particularly when mixed with sand or ground glass, and is very sudden in its action, though its explosive force is, weight for weight, not much greater than that of gun powder. It is the best known substance for detonating dry gun cotton; equal weights of much more violent explosives will, when substituted for it, often fail to produce an explosion of the first order. For use in primers, the fulminate is usually mixed with nitre, meal powder or other substances to moderate its explosive properties.

The simplest example of the percussion primer is the well-known "cap" shown in Fig. 2, Plate II. The end of the outer case is bent inward to form an anvil against which the fulminate is forced by the blow of the firing pin. On percussion and the

friction of the particles on each other cause an explosion, the flame from which passes through the small holes in the anvil and ignites the powder. The cap is "vent sealing," on the same principle as the cup gas check, and, unless it is pierced by a too violent blow of the firing point, there will be no "blow back" of gas. The cap shown by Fig. 2 gives enough flame of discharge for small arm cartridges but not for larger ammunition; for the latter purpose the primer comprises a small magazine of mealed black gun powder, a very inflammable substance, which multiplies the effect of the cap.

The percussion primer used in all 1-, 3- and 6-pdr. ammunition is shown in Fig. 1, Plate I; the magazine contains 42 grains of powder and is closed by a paraffined paper wad.

The percussion primer, shown in Fig. 1, Plate II, was formerly used in main battery R. F. ammunition; that employed in all 3-inch, 50-calibre, ammunition is similar to it. These primers are driven into the primer pockets of the cases before the powder charge is put in. The use of B. L. percussion primers will be discontinued.

3. Friction Primers, still supplied in a few instances for the impulse charge of Whitehead torpedoes, were for a time used in B. L. guns as an alternative for the B. L. percussion primers. They contain a roughened wire running through the fulminate and ending in a loop at the rear end; the firing lanyard is attached to this loop and, when it is sharply pulled the roughened wire is drawn out creating friction enough to explode the fulminate.

4. Precautions.—All ammunition containing fulminate primers is sensitive to shock and must be handled with great care. A swinging breechblock should not be closed too forcibly, as its blow on the base of the cartridge case may give shock enough to fire the primer and cause a premature explosion with disastrous results. The jar given by closing the breechblock in an ordinary manner, on an empty chamber as it happened, has been known to explode a fulminate primer in the firing lock.

5. Electric Primers, containing no fulminates, superseded the percussion primers of main battery guns, as being safer, more reliable in themselves and because they materially reduced the firing interval. A R. F. primer which came into extensive use is

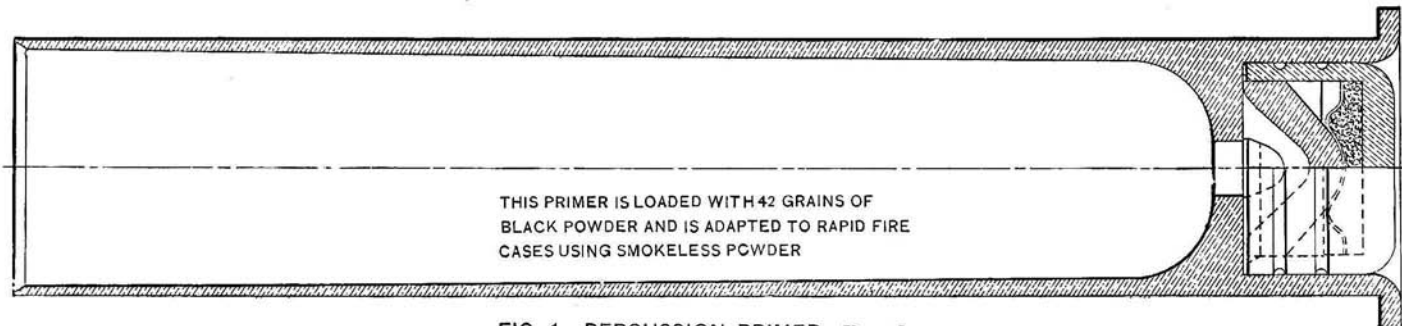


FIG. 1. PERCUSSION PRIMER. Par. 2.

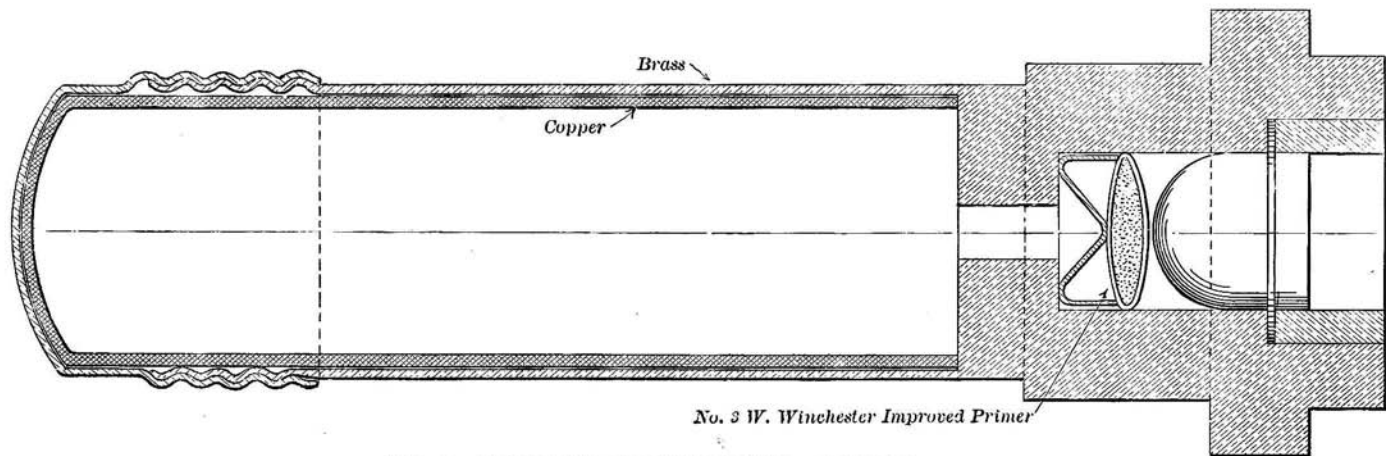
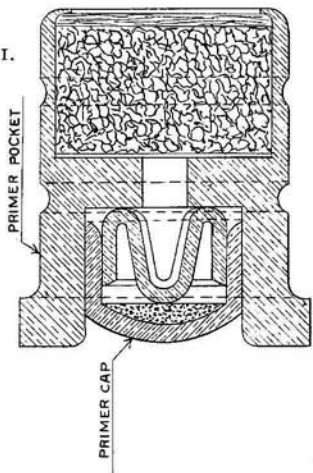
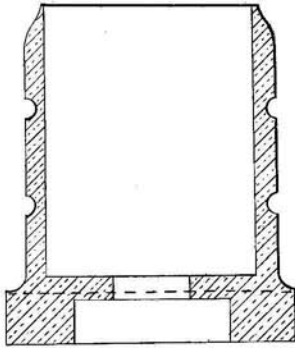


FIG. 2. EXPLODER FOR WHITEHEAD TORPEDO. Par. 7.

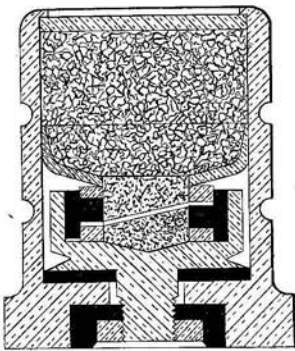
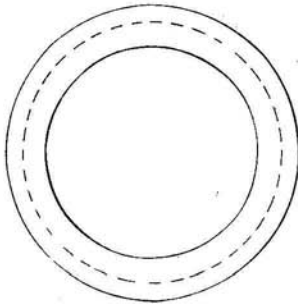
Fig. 1.



PERCUSSION PRIMER FOR 4-INCH, 5-INCH AND 6-INCH R. F. CARTRIDGE CASES. Par. 2.



ELECTRIC PRIMER FOR 4-INCH, 5-INCH AND 6-INCH R. F. CARTRIDGE CASES. Par. 5.



PRIMER CAP FOR PERCUSSION AND COMBINATION PRIMERS. Par. 2.

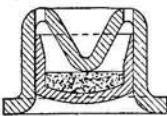
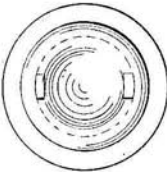


Fig. 2.

Fig. 3.

POCKETS FOR PRIMERS.

	Percussion.			Electric.		
	Dim.	Plus.	Minus.	Dim.	Plus.	Minus.
Total length.....	.745	.015	.000	.760	.000	.015
Diameter of powder chamber.....	.489	.003	.000	.4865	.000	.001
Diameter of counterbore.	.3445	.000	.0005	.344	.0005	.000
Depth of counterbore.....	.300	.002	.000	.117	.000	.003
Depth of powder chamber.....	.345	.015	.000	.....	.....	.....
Diameter of flash hole.....	.100	.005	.000	.158	.003	.000
Stud-diameter .....	.....	.....	.....	.450	.000	.003

shown in Fig. 3, Plate II. In outward form, it is exactly like the percussion primer of Fig. 1. The firing point rests against a portion which is insulated by vulcanite and air spaces from the main body of the primer but is electrically connected to it by a thin platinum wire, the *bridge*, which, as shown, runs to the checking cup. The current flows from the insulated firing point, over the bridge to the primer, thence through cartridge case, gun and mount back to the firing battery. When the current is admitted by the firing key, the bridge instantly becomes hot, fires the wisp of dry gun cotton and mealed powder around it which in turn ignites the primer magazine and thus the main powder charge. It is to be noted that it is the heat generated in the bridge and not an electric spark that effects the explosion; the firing battery and one end of the bridge are grounded and the return is through "earth."

Electric B. L. primers, with ground return and also some having double leading wires, were supplied; but all are now being replaced by combination primers.

6. A Combination Primer is in itself an electric primer and a percussion primer, combining the functions of both in one case. As long as all the mechanism and attachments are intact these primers are used electrically and the percussion feature is the alternative; the firing mechanism, as we have seen, is arranged to work in either manner.

Combination primers are furnished for B. L., Q. F., and R. F. guns of the main battery; the different varieties as shown in Plate III. Fig. 1 is the R. F. "drive" primer and Fig. 2 the R. F. "screw" primer; the only difference between them is in the way of attaching them to the cases; in general, screw primers are for the largest calibres and drive primers for the others. The B. L. and Q. F. primer is shown in Fig. 3. The details are clearly shown and require no description if the principles of simple electric and percussion primers are known; all of them are vent sealing. When firing by percussion the cap is not directly struck by the firing pin but by the point of a plunger forced inward by its blow.

These primers have given great satisfaction in service—it is to be kept in mind that they contain fulminate and the precautions

PRIMER
FOR
3, 4 AND 5 INCH CARTRIDGE CASE

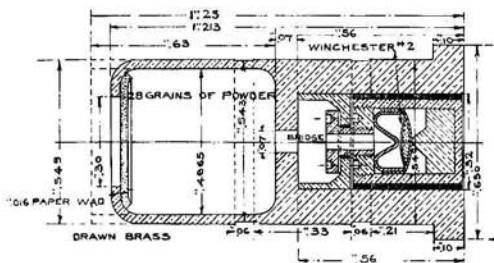


Fig. 1.

PRIMER
FOR
6 INCH CARTRIDGE CASE

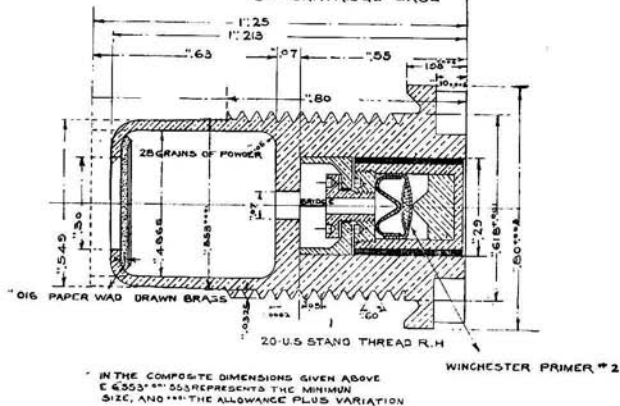


Fig. 2.

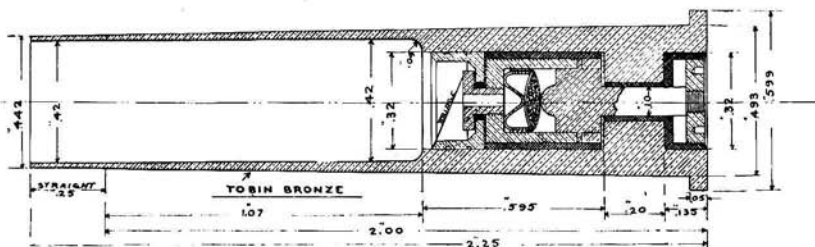
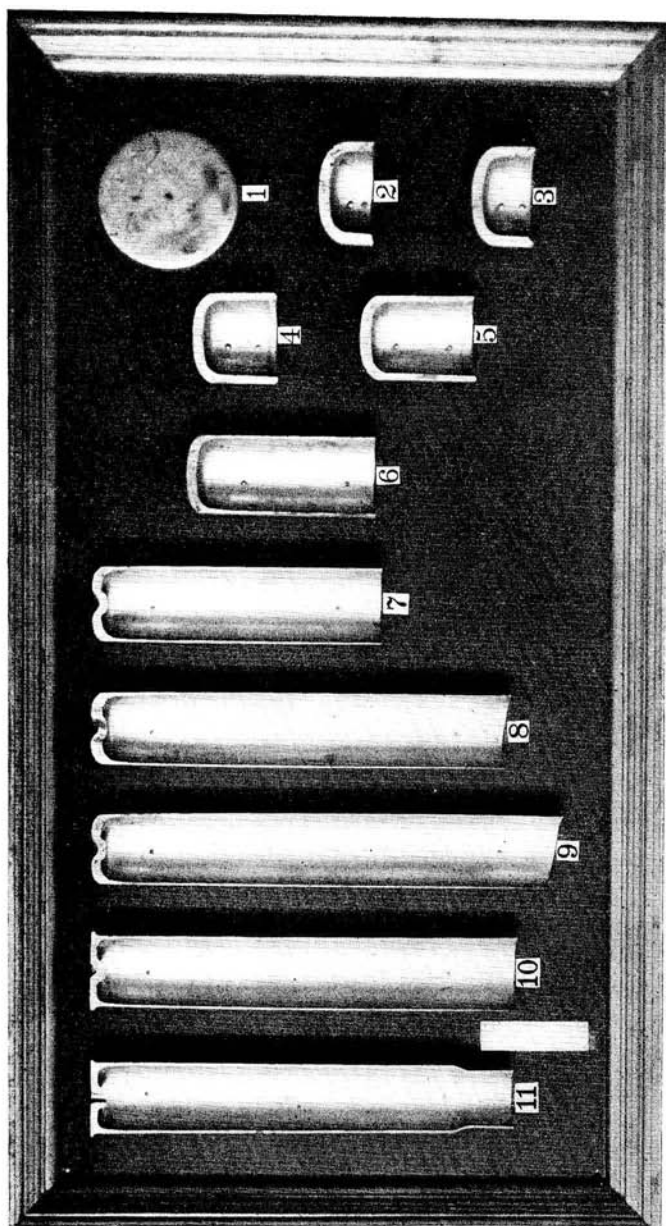


Fig. 3.

COMBINATION PRIMERS.



needed in the use and handling of ordinary percussion primers are called for.

7. **Exploders** are the devices which detonate the gun-cotton charges of torpedoes—for Whitehead torpedoes, they correspond, perhaps more nearly to *fuses* than to primers. The Whitehead exploder is shown in Fig. 2, Plate I; it is carried in the war nose and is fired by percussion. When the torpedo strikes, the firing pin of the war nose drives in the small striker which is held in place ordinarily by a brittle shearing pin as shown. This striker explodes a cap which in turn fires the 35 grains of fulminate in the attached copper magazine; the *dry* gun-cotton primer is detonated by the exploder and in turn detonates the main charge of *wet* gun cotton in the warhead.

The exploder for the service gun-cotton mine is of the same size and shape as the above but is fired electrically. There are two leading wires from the firing battery to the primer which, within the latter, are reduced to a thin bridge; the explosion is caused by heat as in the simple electric primer.

8. **Metallic Cartridge Cases.**—The metal is 70 parts Calumet and Hecla copper and 30 parts zinc. It is cast in slabs from which disks, called “blanks” are cut, and each blank is then put in a vertical press and forced through a die by a plunger forming the first cup. This process is repeated once or twice according to the size of the case, and the second or third cup is then placed in horizontal draw presses and forced through successive dies by plungers, its length being gradually increased and its thickness diminished to the desired dimensions.

The case is then taken to an indenting machine which puts a dent in the center of the head of the case, thus raising a portion of metal on the inside of the head to provide a seat for the primer.

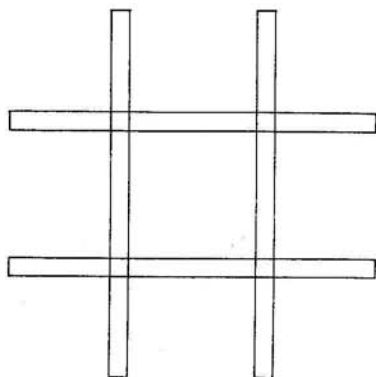
The case is then placed in a vertical heading machine which strikes a blow and forces the metal into a die to form the head, and it is next placed in a lathe, turned to exact dimensions, gauged and stamped.

After each drawing the case is annealed by heating in a furnace and cooling slowly. Scale is removed by acid. Plate IV shows the successive steps in drawing the case from the first cup.

9. **Primers for Cartridge Cases.**—These are described under

the head of "primers." They are always counter sunk a short distance below the head of the cartridge case for safety in handling. Sometimes failure to explode the percussion primer has been attributed to its being counter sunk too far. It is more likely that such failures are due to insufficient throw of the firing pin in electric or percussion firing, or to injury to the pin.

10. Fit of Shell in Cartridge Case.—The base of the shell should fit tightly and be perfectly secure in the cartridge case in fixed ammunition. When the shell is loose there is danger and delay in loading, and the space in the cartridge case being increased, the ignition charge may work away from the primer and cause hang or missfires.



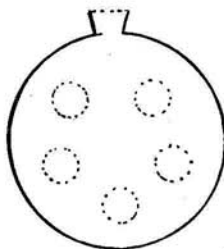
PASTE BOARD DISTANCE PIECE.

11. Distance Pieces for Cartridge Cases.—The space between the powder and the base of the shell in 3-, 4-, 5-, and 6-inch cartridge cases was sometimes filled with excelsior. This made smoke and was objectionable. To replace the excelsior, *distance pieces*, made by crossing and locking four pieces of pasteboard, are used. The distance piece can be cut to any length desired.

When the powder is confined in a bag the distance piece extends from the tie end of the bag to the base of the shell. When no bag is used a wad is placed over the powder and the distance piece extends from the wad to the base of the shell, or to the cover of the metallic cartridge case in case there is no shell.

12. Powder Bags.—Powder bags for charges of smokeless powder are made of unbleached muslin, two thicknesses at the bottom, and with chafing bands at each end. They are stiffened by longitudinal strips and circular bands of tape, the latter being securely tied around the bag. *It is most important that the bags should be stiff and that they should fit the chamber.* The powder should be well shaken down and the bag tied tightly above the powder, extra material being cut off the tie end. Stiffening tape is sometimes omitted from the powder bags for small calibres. To this there is some objection.

Charges which are flabby, or loosely put up, cause trouble and serious delay in loading. For this reason it is well to examine, and, if necessary, re-tie charges before sending them up. This precaution may be taken in anticipation of target practice or active service.



IGNITION POCKET FOR Q. F. CHARGES. Par. 14.

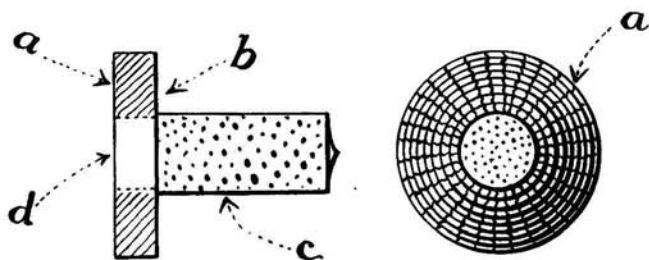
A circular piece, about 4 inches in diameter in the case of large bags, is usually cut out of the center of the bottom and a piece of *scrim* is sewed in through which the flame from the primer penetrates to the ignition charge. The bottom of the bag is sometimes strengthened by six radial strips.

13. Ignition Charges for Large Calibre Powder Bags.—The ignition charge for 8-inch, 10-inch, and 12-inch charges consists of seven grains of black prismatic powder cemented together with a thick solution of shellac and alcohol, and placed upon the scrim at the bottom of the bag and inside a small cylindrical pocket which is sewed to the bag around the scrim on the inside. The mouth of the pocket is then secured, thus holding the ignition grains close against the scrim in the center of the bottom. The powder

is then poured in on top of the ignition charge, shaken down well, and the bag tied tightly. (See Plate V, Figs. 1 and 2, 10-inch ignition charge. Bureau of Ordnance Blue Print, 18999.)

14. Ignition Pocket for Small Calibre Powder Bags.—For powder bags of 5-inch and 6-inch quick-fire guns, a flat circular pocket of muslin with a filling hole for small grained black powder, is sewed to the bottom of the bag on the inside close against the scrim.

In order to keep the pocket flat and prevent the powder from falling down to one side away from the central line, five small circles are stitched through the pocket as shown in the sketch.



IGNITION POCKET. Par. 15.

a, a. pulp disk. b. scrim. c. powder pocket. d. hole in disk.

The flame from the primer passes through the scrim in the bottom of the bag, penetrates the ignition pocket and ignites the black powder which in turn ignites the smokeless powder which is poured in on the top of the pocket. It is important that the powder should be well shaken down and the bag tied tightly.

15. Ignition Charges for Metallic Cartridge Cases.—There are three different kinds of ignition charges in use, or proposed, for metallic cartridge cases.

In the first form an annular disk made of pulp, with scrim over the opening, is used, a small muslin pocket being sewed to the scrim and the latter glued to the disk. The pocket is filled with small grained black powder and then tied securely. The disk is then dropped into the cartridge case, the primer projecting into the hole in the disk toward the scrim, and the smokeless powder

without a bag is poured into the cartridge case on top of the ignition pocket (see sketch)

In this form it is evident that the pocket may become displaced, throwing the ignition charge out of line with the primer and causing miss or hangfires.

16. Ignition Grains.—In this form, which is preferable to the preceding, the charge of powder is confined in a bag which is placed in the cartridge case. The ignition charge is composed of from one to three grains of black prismatic powder secured together and sewed to the cartridge bag on the inside of the bottom immediately over the scrim. An annular papier maché disk about $\frac{1}{2}$ -inch thick and nearly equal in diameter to the powder bag is secured to the bottom of the latter on the outside. This disk serves to stiffen the bottom of the bag and to hold the ignition grains opposite the primer which projects through the hole in the disk nearly to the scrim. This form for 6-inch case is shown in Plate VI. (See Bureau of Ordnance Blue Print, 18861.)

17. Ignition Disks of Black Powder for Cartridge Cases.—The latest form of ignition charge, to be used in cartridge cases where no bag is used to confine the charge, is shown in Plate VII. (Blue Print No. 19475.)

A paste board or pulp disk, of section shown in the figure, is placed in the bottom of the cartridge case and held firmly in position by the primer which fits tightly in and projects through the hole in the center of the disk. A cake of black powder, pressed into the shape shown in the figure, with seven .2-inch holes parallel to the primer, is cemented to the disk by a thick solution of shellac and alcohol.

In a later design the pulp disk is increased in diameter to that of the inside of the case to still further prevent all chance of displacement, and thus ensure the ignition cake being held opposite the primer.

18. Fixed Ammunition Boxes.—For the 4-inch and 5-inch R. F. guns each round is in a box by itself. The boxes are made of poplar wood with a becket at one end, the cartridge being held by corner wedges, and one side of the box being easily removed by cutting the three lashings which hold it in place, as shown in Plate VIII.

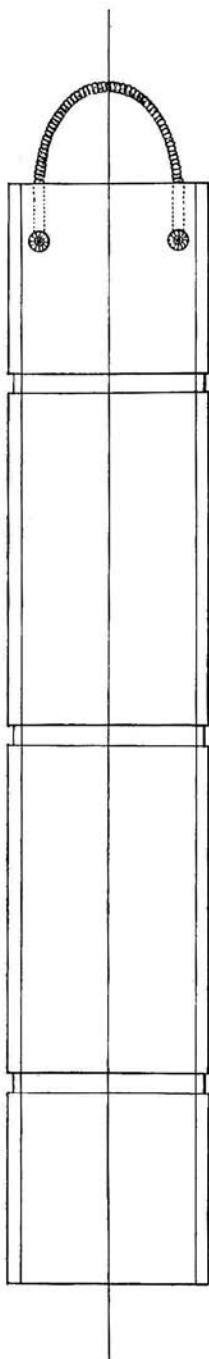


Fig. 1.

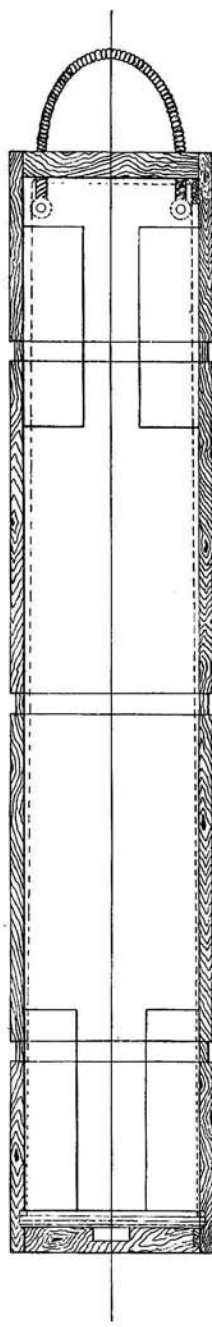


Fig. 2.

WOODEN FIXED AMMUNITION BOX FOR 4-INCH AND 5-INCH

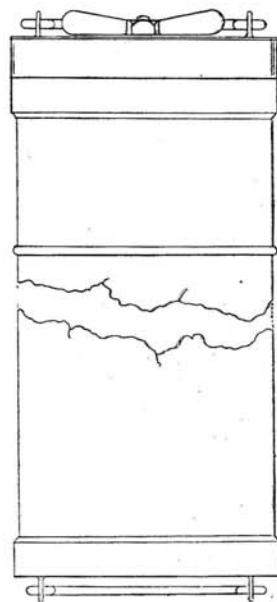
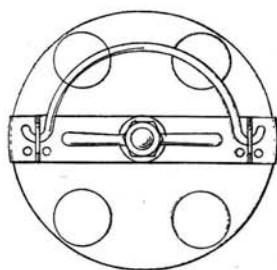
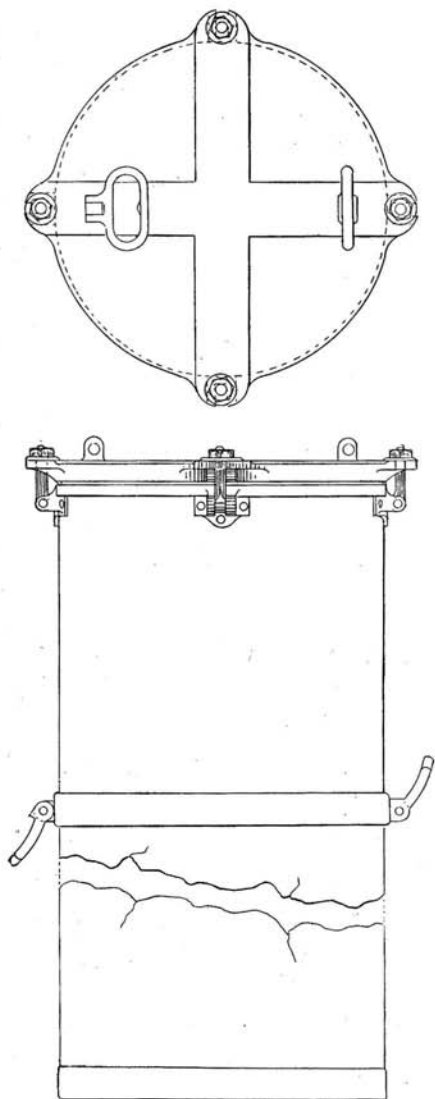


Fig. 2.

These boxes are painted to indicate the projectile, as follows:

Armor piercing All black.
 Steel, common All lead color.
 Shrapnel All white.

Boxes for drill cartridges are half white and half black.

19. Fixed Ammunition Boxes for Minor Calibres.—The fixed ammunition for minor calibres R. F. guns is placed in chests, the number of rounds for each being as follows:

1-pounder (light and heavy)	60	rounds
3-pounder	16	"
6-pounder	11	"
3-inch field gun	17	"
3-inch field gun (new)	8	"
3-inch 50-calibre R. F.	4	"

These chests are painted as follows:

Armor-piercing rounds Black, white letters.
 Steel, common rounds Lead, red letters.
 Cast iron, common rounds Red, black letters.
 Shrapnel rounds White, black letters.

Blind 3-, 4- and 5-inch boxes, red band 12 inches deep at each end and both ends red.



DRILL CARTRIDGE.

20. Drill Cartridge for Small R. F. Guns.—For exercise or for target practice using small-arm ammunition, a drill cartridge of the same general shape as the regular cartridge is provided. It has a metallic base and point, and in the axis a short length of a rifle barrel, calibre .45, is inserted. The body of the drill cartridge is a hard, close-grained wood.

Drill cartridges are packed in chests painted half black and half white, the dividing plane being parallel to the ends of the chests.

21. Drill Cartridges for 4-inch and 5-inch R. F. Guns are the same in shape and size as the regular complete cartridge, and similar in design to those for the secondary battery, with the same provisions for sub-calibre practice with .45-calibre ammunition.

22. Boxes for Metallic Cartridge Cases.—Metallic cartridge cases, when separate from the shell, are stowed in boxes made of poplar wood. The boxes have corner wedges at the ends to keep the cases from moving, and are stowed in bins in the magazines. There is a strong becket in one end of each box with which to handle it.

In the New Orleans and Albany, the metallic cases were not kept in boxes originally, but were stowed in racks in the magazines and sent up in leather buckets to the guns.

23. Powder Tanks.—The tanks for the powder charges of heavy guns are shown in Plate IX, Figs. 1 and 2. They are made of copper. The covers for 12-inch and 13-inch tanks are secured by bolts, as shown in the plate, and close down on rubber washers. For smaller calibres the cover goes on with a bayonet joint and is secured by a wing nut and disk upon a ground seat without washer.

In recent designs the tanks are protected by vertical wooden battens held in place around the tank by three copper bands, and the cover for all but the largest calibres has a raised rim to protect the handle and wing nut from injury.

Care should always be taken not to tear powder bags in removing them from the tanks. Such accidents are dangerous and have caused delay in loading during target practice. If the bottom of the bags are torn the ignition charge may be spilled or thrown out of line, thus causing hangfires.

24. Drill Charges for Q. F. Guns.—The drill charge for a Q. F. gun consists of a bronze tube with a flange at each end, the space around the tube and between the flanges being filled by longitudinal strips of wood segmental in section. The flanges are connected by small brass rods which also serve to keep the wooden strips in position.

Drill charges will be of the same weight as the powder charge of the gun for which they are supplied.

CHAPTER XXVI.

PROJECTILES.

1. **Manufacture of Armor-piercing Projectiles.**—Material selected for the melting operation is first prepared in convenient size to be shaken in a plumbago crucible which has a capacity of about 90 pounds of steel contents and weighs in itself about 30 pounds. The melting furnace is of the Siemens gas regenerative type, with a capacity of 30 to 48 or more pots, in several holes, each of the latter holding six pots.

2. The filled pots are lowered at one time by means of hand tongs into the melting holes and in about four hours are ready to teem or pour. The molds are of cast iron and are cylindrical in form, being split in two lengthwise, and the bottom of the mold following generally the curvature of the shell point; the extreme point end being continued in a square projection, which later serves as a hold for the tongs in the hammer forging.

3. The pots are pulled out of the furnace by means of hand tongs and the fluid steel surface carefully mopped to remove floating impurities, and then, by means of other hand tongs, the teeming is accomplished by pouring pot after pot slowly into the top of the prepared mold, the stream of molten steel never being allowed to stop for an instant until the proper weight of steel to make the required ingot is contained in the mold.

4. When the steel has solidified, and before losing its heat, the rings are stripped from the mold and the red-hot ingot is exposed and at once removed to the reheating furnace (coal-fired reverberatory), near the forging hammer. The latter is of the ordinary type of steam hammer and has a striking blow of 16 tons.

5. The forging dies are formed to follow the curves desired in the finished shell, and the ingot is given a uniform reduction therein so that the forging, as completed, is from $\frac{1}{2}$ to $\frac{3}{4}$ inch larger in diameter dimensions than is required in the finished shell.

6. A heat treatment next follows to take out all hammer stresses and to prepare the steel in suitable condition for machining; this

operation takes a week's time, after which the forgings are removed to the machine shop and after being centered in a special machine are chucked in a special turning machine and the outside metal removed, leaving the shell surface finished completely, with the exception of the swell of the point (the bourrelet), which is left full.

7. The shell is now removed to the cutting-off machine, where the top of the ingot is cut off and the serial number is transferred to the band score.

8. The shells are next chucked in a special machine and the boring out of the chamber cavity accomplished.

9. After cutting the score for the cap on another special machine, the shell is ready for the hardening process, which is secret.

10. In the meantime the steel for the base plug has been cast and forged into round bars, which are cut into blanks, and these later threaded and finished in turret lathes, the finished plugs awaiting the hardened shells.

11. Ballistic selection is made by the inspector from the completed lots as they come from the hardening operation, and after the Bureau has signified its acceptance, the shells are chased to receive the base plug, the base receives its markings with steel stamps, the shell is ground on its bourrelet to within specified tolerances, the copper band is hammered and pressed into the band score, and the shell again chucked in the lathe for turning the band. The hydraulic press then secures the soft steel cap to the point of the shell and completed lots are given the official inspection and stamped with the acceptance stamp, after which all that remains is to box and load in cars for shipment.

The copper for bands and small brass fuse plugs is prepared elsewhere, and so is generally the soft cap, these being furnished the manufacturers.

SHELL, A. P.

	6-inch.	8-inch.	12-inch.
Length:			
Without cap.....inches.....	18.82	25.82	40.31
With cap.....inches.....	19.76	27.00	41.37
Weight:			
Without cap.....pounds.....	98.00	250.00	848.00
With cap.....pounds.....	108.00	257.20	868.40

12. Specifications for Armor-piercing Shell.—Designs of shell may be submitted for the Bureau's approval, or the Bureau's drawings may be used. If drawings are submitted, the exterior dimensions and tolerances must correspond with the Bureau's drawings in respect to diameter of body, of band, and position of band. In case the Bureau's drawings are accepted, the shape of the interior cavity may be changed, if desired, subject to the Bureau's approval.

13. The shell must be of domestic manufacture and must be finished to the dimensions shown on the drawings approved by the Bureau within the limits of tolerance stated thereon. The cavities must be concentric with the exteriors and of ample capacity to insure a satisfactory fragmentation when the shell is burst with black powder.

14. The right is reserved by the Bureau to alter the shape of shell not in course of manufacture should it develop at any time that such alteration is desirable. All such changes are to be made at the expense of the contractor.

15. They must be made of the best quality of steel, and must be sound and free from cracks, blowholes, and all other defects seriously affecting their resistance and value as projectiles; this condition to be determined by the Government inspectors.

16. At the specified distance from the base a groove or band score is to be turned for the rotation band with the necessary roughening to prevent the band from turning on the shell. The rotation band must be of the best quality of copper, must be properly pressed into the before-mentioned band score, preferably by hydraulic pressure, and must then be finished to the dimensions shown on the approved drawings.

17. If fitted with base plugs, a forged steel base plug with external thread fitting closely in a corresponding thread cut in the base of the shell, and with an internal thread to take the fuse, is to be set home in each shell, the exterior threads of base plug and interior threads in the shell being first coated with red lead. This base plug must fit gas tight. The Bureau reserves the right to have the shape or dimensions of the base plug changed at any time, which shall be done without extra charge.

18. Shell of 8-, 10-, 12-, and 13-inch calibres must have an an-

nular groove turned in the face of the base, to be of the dimensions prescribed by the Bureau for fitting base covers.

19. All shell must be capped with caps of soft steel furnished by the contractor, fitting into a score cut or ground around the head and being secured in place by proper methods approved by the Bureau.

20. Maximum and minimum gauges will be furnished for the fuse hole.

21. All shell must be thoroughly cleaned, the cavities carefully coated with a suitable lacquer.

22. The shell shall be subject to Government inspection during all the process of manufacture, and the contractor shall furnish all necessary facilities to the Government inspector to enable him to properly perform his duties.

23. Except when specifically provided to the contrary, all tests, measurements, etc., shall be made at the expense of the contractor, under the supervision of the Government inspector and with the contractor's gauges and instruments.

24. Chemical and physical tests may be made for the purpose of insuring uniformity in each lot, and the requirements shall be as follows:

(a) A specimen from each forging or casting shall be analyzed for carbon, chromium, or other hardening element, and as shown thereby, the carbon percentage of no shell in any lot shall vary more than ten one-hundredths of 1 per cent from the mean carbon percentage of the entire lot, and the chromium percentage or percentage of other hardening element in no shell in any lot shall be less than that fixed by the contractor as a minimum percentage suitable for the class of shell constituting the lot.

(b) Transverse specimens may be taken from the base of three shell of each lot after annealing, and, as judged by their test, all the shell of each lot shall be of substantially uniform quality of metal.

25. After final treatment and before submission to ballistic test, each shell shall be subjected to an internal hydraulic pressure of 500 pounds to the square inch, and any shell which develops unsoundness, holes, or cracks, or leaks around base plug will be rejected.

26. The shell shall be presented for acceptance completely fin-

ished, except banding, lacquering, and capping, in lots of 500 3-inch, 400 4-inch, 400 5-inch, 250 6-inch, 250 7-inch, 250 8-inch, 200 10-inch, 200 12-inch, and 200 13-inch.

27. The ballistic test for acceptance shall be as follows: Three shell shall be selected from each lot; shall be banded and capped, and shall be fired against a hard-faced armor plate from 1 to 1½ calibres thick with the velocity given in the following table, with the requirement that two of the shell shall go through the plate unbroken and then be in condition for effective bursting:

Calibre of shell.	Thickness of plate.	Striking velocity.	
		Harvey.	Krupp.
	Inches.	Foot-secs.	Foot-secs.
3 inches (14-pounder).....	3	2,025	.....
	4	2,550	.....
	4.5	2,800	.....
4 inches.....	4	1,925	.....
5 inches—50 pounds.....	5	2,075	.....
	6	2,400	.....
	7	2,700	.....
5 inches—60 pounds.....	5	1,900	.....
	6	2,200	.....
	7	2,500	.....
	7.5	2,625	.....
6 inches.....	6	1,870	1,990
	7	2,100	.....
	8	2,321	.....
	9	2,533	.....
7 inches.....	7	1,795	.....
	8	1,995	.....
	9	2,170	.....
	10	2,360	.....
8 inches.....	8	1,730	.....
	9	1,890	.....
	10	2,050	.....
	11	2,200	.....
	12	2,350	.....
10 inches.....	10	1,625	.....
	11	1,750	.....
	12	1,875	.....
	13	2,000	.....
	14	2,125	.....
	15	2,250	.....
12 inches.....	12	1,600	1,880
	13	1,700	.....
	14	1,800	.....
	15	1,900	.....
	16	2,000	.....
	17	2,100	
13 inches.....	13	1,550	
	14	1,650	
	15	1,750	
	16	1,850	
	17	1,950	

For intermediate thickn

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ained by interpolation.

See Plates I, II and III.

28. Specifications for Forged Steel Common Shell.—Designs of shell may be submitted for the Bureau's approval, or the Bureau's drawings may be used. If drawings are submitted, the exterior dimensions and tolerances must correspond with the Bureau's drawings in respect to diameter of body, of band, and position of band, and the over-all length shown on the Bureau's designs will not be exceeded. In case the Bureau's drawings are accepted, the shape of the interior cavity may be changed, if desired, subject to the Bureau's approval. (See Plates I, II and III.)

29. The shell must be of domestic manufacture and must be finished to the dimensions shown on the drawings approved by the Bureau within the limits of tolerance stated thereon. The cavities must be concentric with the exteriors. The ratio of the cubic capacity of cavity to total volume of shell including cavity shall not be less than a minimum to be fixed by the Bureau.

30. The right is reserved to alter the shape of shell not in course of manufacture should it develop at any time that such alteration is desirable. All such changes are to be made at the expense of the contractor.

31. The shell must be made of the best quality of steel, and must be sound and free from cracks, blowholes, and all other defects seriously affecting their resistance and value as projectiles; this condition to be determined by the Government inspectors.

32. At the specified distance from the base a groove or band score is to be turned for the rotation band with the necessary roughening to prevent the band from turning on the shell. The rotation bands must be of good quality of copper, must be properly pressed into the before-mentioned grooves, preferably by hydraulic pressure, and must then be finished to the dimensions shown on the approved drawings.

33. Shell will preferably be made with bases turned in. If fitted with base plugs, a forged steel base plug with external thread fitting closely in a corresponding thread cut in the base of the shell, and with an internal thread to take the fuse, is to be set home in each shell, the exterior threads of base plug and interior threads of the shell being first coated with red lead. This base

plug must fit gas tight, and must be so set home that it would require great force to start it out again. The Bureau reserves the right to have the shape or dimensions of the base plug changed at any time, which shall be done without extra charge.

34. Shell of 8-, 10-, 12-, and 13-inch calibres must have an annular groove turned in the face of the base, to be of the dimensions prescribed by the Bureau for fitting base covers.

35. Maximum and minimum gauges will be furnished for the fuse hole.

36. All shell must be thoroughly cleaned, the cavities carefully coated with a suitable lacquer.

37. Each shell shall be suitably tempered.

38. The shell shall be subject to Government inspection during all the process of manufacture, and the contractor shall furnish all necessary facilities to the Government inspector to enable him to properly perform his duties.

39. Except when specially provided to the contrary, all tests, measurements, etc., shall be made at the expense of the contractor, under the supervision of the Government inspector and with the contractor's gauges and instruments.

40. After final treatment and before submission to ballistic test, each shell shall be subjected to an internal hydraulic pressure of 500 pounds to the square inch, and any shell which develops unsoundness, holes, or cracks, or leaks around base plug will be rejected.

41. The shell shall be presented for acceptance completely finished, except banding and lacquering, in lots of 500 3-inch, 4-inch, 5-inch, and 6-inch, 250 7-inch, 250 8-inch, 200 10-inch, 200 12-inch, and 200 13-inch.

42. The ballistic test shall be as follows: Three shell shall be selected from each lot; shall be banded and lacquered, and submitted to test. One shell of the three submitted shall be brought to standard weight by filling with sand, and shall be fired with suitable velocity against a face-hardened nickel steel plate, unbacked, of thickness equal to one-half the diameter of the shell. This shell must pass through the plate unbroken and then be in a condition for effective bursting. Another shell shall be fired unloaded down the range at service velocity, and must not break

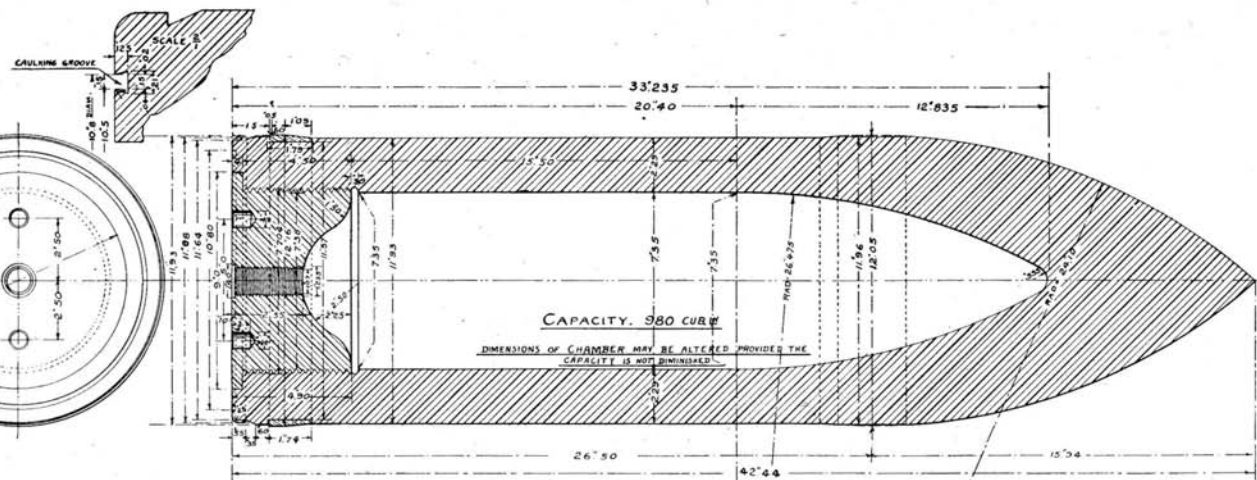


FIG. 1.—COMMON SHELL. Par. 71.

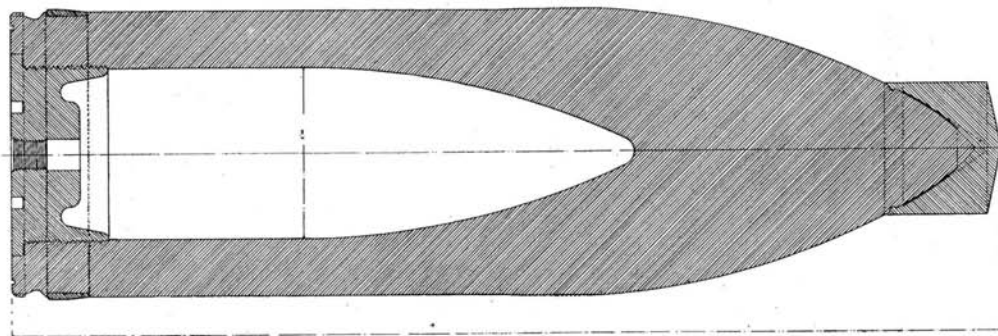


FIG. 2.—A. P. SHELL. Par. 70.

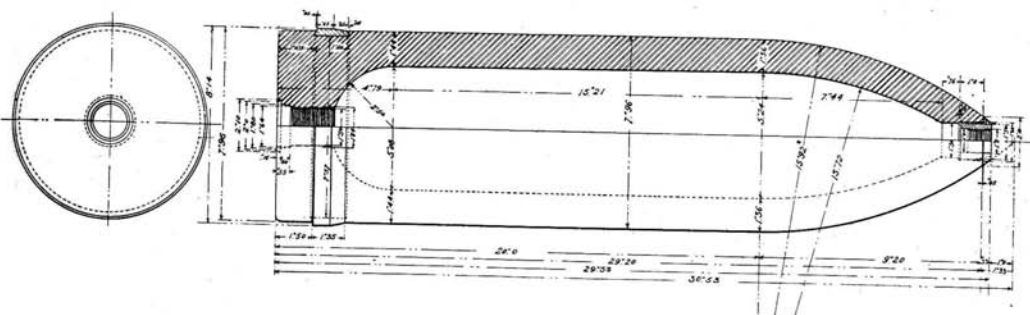


FIG. 1.—COMMON SHELL. Par. 71.

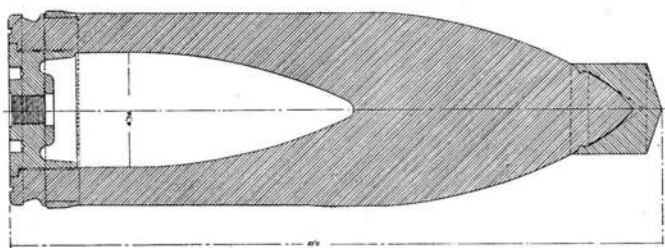


FIG. 2.—A. P. SHELL. Par. 70.

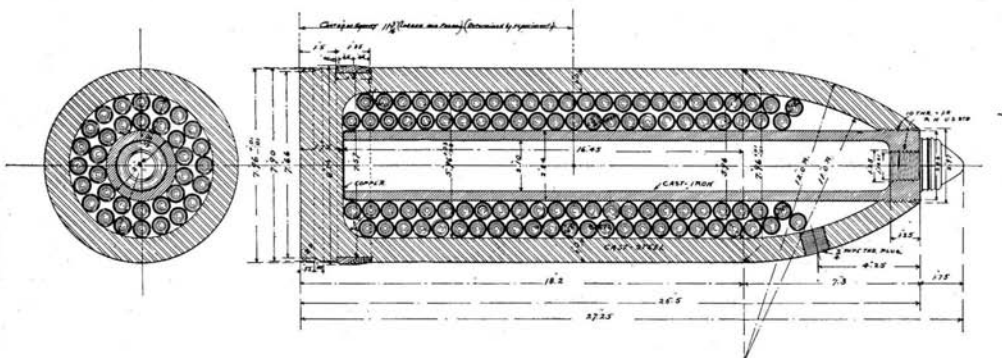


FIG. 3.—SHRAPNEL. Par. 75.

8-INCH PROJECTILES.

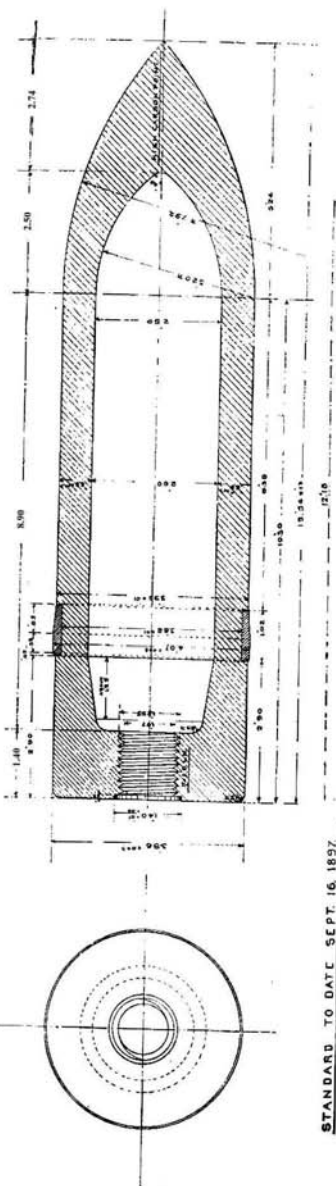


FIG. 1.

COMMON SHELL. Par. 71.

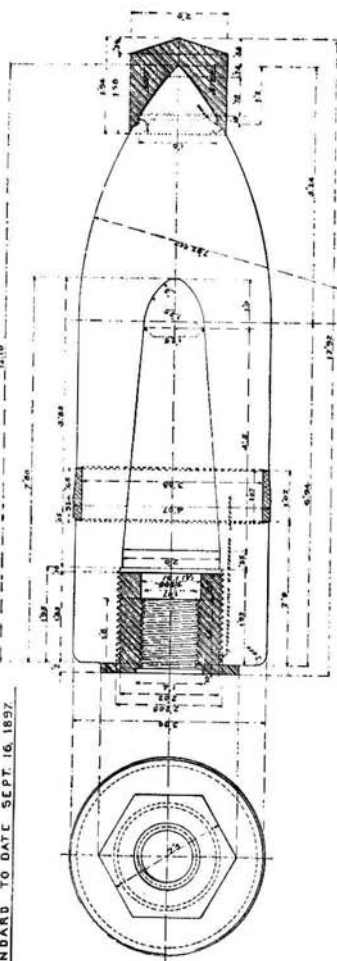


FIG. 2.

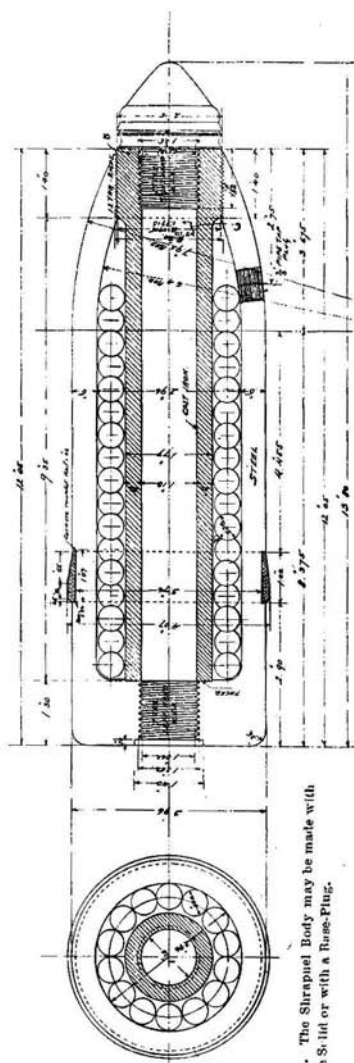
A. P. SHELL. Par. 70.
4-INCH PROJECTILES.

FIG. 3.

SHRAPNEL. Par. 75.

NOTE. The Shrapnel Body may be made with Base S, lid or with a Base-Plug.

up in the gun or in flight. The remaining shell shall be loaded with ordinary shell powder and exploded, and must give a satisfactory fragmentation without either the base plug or fuse blowing out.

43. Specifications for Minor Calibre Steel Shell.—The body of the shell shall be made of steel of the best quality for the purpose, and shall be properly hardened or treated.

44. The rotating bands shall be made of the best quality of seamless copper tubing, annealed and forced into the band scores by hammer or press.

45. The base plug shall be made of steel, and must be a tight fit in the shell. When assembled they must be set home so as to require great force to start them out again.

46. The shell after tempering shall show no signs of flaws or cracking.

47. The band scores must be suitably roughened so as to prevent the bands from slipping.

48. Shell shall be submitted for final inspection in lots of 1000, and each shall have the name of maker and the year of its manufacture stamped on the base. With each lot ten additional shell shall be furnished by the contractor for use in the acceptance tests.

49. One per cent of each lot shall be selected by the inspector for proof firing. Of these, a certain number, to be designated by the inspector, shall be loaded and fused, with their proper bursting charges. When fired, with the service powder charge, through a $\frac{3}{8}$ -inch steel plate, all shell must burst properly and break up well. The remaining shell shall be blind loaded to service weight, and shall be fired at a steel plate placed normally to the line of fire and 30 yards from the muzzle of the gun. The material of this plate as used shall have a tensile strength of at least 70,000 pounds per square inch, and its thickness shall be 1 inch for 1-pounder shell, 2 inches for 3-pounder shell, and $2\frac{1}{2}$ inches for 6-pounder shell. All shell must perforate the plate, and none must break or crack so as to open the powder chamber, or develop serious defects of any kind.

50. After acceptance by the inspector the shell shall be lacquered on the interior and oiled on the exterior. A mineral oil or grease

must be used, preferably cosmoline. When finally accepted each shell shall be stamped with the inspector's stamp on the band.

51. Specifications for Shrapnel.—The body of the shrapnel must be of cast steel and the powder tube of cast iron, and must be finished to the dimensions shown on drawings approved by the Bureau of Ordnance, and within the limit of tolerances stated thereon.

52. The fuse holes must be tapped, unless otherwise arranged, and the shrapnel banded.

53. The steel used must be of the same quality and grade as that used for cast-steel shell.

54. The castings for the powder tubes must be of good quality, free from defects, and as smooth on the interior as the best iron castings, and rejection for such defects shall be final.

55. The bullets must be uniform in size within tolerances determined by the inspector, and none are to exceed in diameter the dimensions shown on the prints.

56. The shrapnel and all parts, including hidden threads, are to be subject to inspection by the Government inspectors during all the processes of manufacture and to inspection and tests before acceptance; and the contractors shall furnish the inspectors with all facilities for such inspection and tests.

57. The shrapnel of each calibre are to be presented for acceptance in lots of 500.

58. One per cent of each lot presented, to be selected by the inspector, to be tested as follows for acceptance of the lot:

59. When practicable, a lot of fuses shall be tested for acceptance with each lot of shrapnel, and in that case one or more of the shrapnel, loaded and fused and with the fuse set for percussion firing, shall be dropped in an explosion chamber, the fuse wire having first been cut, to observe the character and completeness of burst, and the remainder of the test shrapnel shall be fired over a range with service charges to observe the time action of the fuses.

60. When fuses are not tested in conjunction with the shrapnel, the acceptance tests of the latter will consist of bursting one or more of the selected shrapnel in an explosion chamber, by any suitable means, and firing the remainder, blind loaded, with ser-

vice charges, over a range. Those burst in the explosion chamber must break up well, and those fired over the range must not break or set up in the gun; their flight must be smooth, and their rotating bands must not come off in flight.

61. The powder chambers of the shrapnel must be suitably lacquered, and the balls must be bedded in a suitable matrix, approved by the Bureau.

See Plates II, III, V and VI.

62. **Preparation of Shell for Service.**—The following is a summary of the instructions of the Bureau of Ordnance regarding the preparation of armor-piercing and common shell for issue to service:

(a) Only blind shell will be assembled in 1-pounder ammunition for use in sub-calibre practice. These shell are to be brought to standard weight by filling with sand, and the fuse holes plugged with metal plugs, each marked "plug."

(b) All loaded shell except for 1-pounder, 3-pounder and 6-pounder calibres will be loaded with burster bags.

(c) All armor-piercing shell will be loaded with fine black powder and fused, except that armor-piercing shell above 6-inch calibre will not be loaded unless fitted with base cup gas checks. Unloaded armor-piercing shell issued to service will have the fuse holes plugged with metal plugs, each marked "plug."

(d) All common shell (cast iron, cast steel and forged steel), above 6-inch calibre, fitted with base plugs or base fuses, are to be fitted with base gas check covers. Common shell of and below 6-inch calibre will not be so fitted. Cast-iron shell when so fitted may be issued as common shell.

(e) In loading shell having base plugs, great care is to be observed to see that the base plug, after having been given a thin coat of red lead and oil, is set home tight, and that the fuse is set home tight, after being luted with small-arm shellac. f

63. **General Remarks on Shells.**—The foregoing specifications and instructions of the Bureau of Ordnance contain nearly all the necessary information regarding service projectiles. Additional information regarding the development of modern projectiles, the action of the steel cap, ballistics, etc., will be found in the chapters on "Armor" and "Penetration of Projectiles," by Lieutenant Cle-

land Davis, U. S. Navy, and the details are shown in Plates I, II, III, IV, V and VI.

64. Radius of the Ogival.—The radius of the ogival in service shells is not fixed, but varies from 2 to $2\frac{1}{2}$ calibres. The Firth-Sterling armor-piercing shell have an ogival head of $2\frac{1}{2}$ calibres. In nearly all other shell the radius is 2 calibres.

65. Base Plugs.—Nearly all shell are fitted with base plugs, but some are cast or forged with solid bases, as shown in the plates.

66. Fuses.—As a rule base fuses only are used, except for shrapnel, which are fitted with Sweet's combination nose fuse. There are, however, some common shell in service fitted with nose fuses, as shown in Plate II.

67. Base Covers.—Nearly all loaded shell of large calibre, both armor-piercing and common, are fitted with base covers (see Plate IV, Fig. 3). The holes for the spanner in the base of the plug are first filled with lead, and a lead disk is then placed over the base of the shell, covering the plug and fuse. A copper disk is then placed over the lead and caulked into the base of the shell, the caulking groove being filled with a lead wire, as shown in the plate.

68. Steel Cap for Armor-piercing Shell.—In order to assist the shell in its attack on hard-faced armor, and to assist in biting into an armor plate, all armor-piercing shell are now fitted with a soft steel cap of the shape shown in Plate IV. The steel cap protects the sharp point of the shell and supports the head on its first impact with face-hardened armor. The method of attaching the soft steel cap is shown in Plate IV. The cap *C*, Fig. 1, Plate IV, is placed in a hardened steel die, *D*, the projectile is then placed on it vertically as shown, and under the hydraulic pressure of a 25-ton ram, *H*, is forced downward until the die is about to touch the projectile. No machine work is necessary, the surplus metal on the exterior of the cap being just sufficient to fill the score in the projectile.

69. Driving or Rotating Band for Projectiles.—The rotating band for all shell and shrapnel is of copper, shaped as shown in the plates, and which is forced into an undercut score on the surface of the projectile, near the base, by hydraulic pressure, after which it is machined to size. The standard band is a few hundredths of an inch larger in diameter than the calibre of the gun,

the soft metal being forced to flow into the grooves when the projectile is fired. It is important that the band should not slip, since it is the velocity of rotation that keeps the shell steady in flight and prevents tumbling.

70. Remarks on Armor-piercing Shells.—Plates I, II and III show the general details of 4-, 8- and 12-inch armor-piercing shells. The fact that armor-piercing shells now contain bursting charges which make them similar to common shell in effect may result ultimately in the abolition of the common shell. The weight of the armor-piercing shell is the same as the common shell of that calibre.

71. Remarks on Common Shell.—Common shell have been made of cast iron, cast steel, and forged steel. Cast-iron shell will not be manufactured hereafter, and cast steel will be replaced by forged steel except for small-calibre guns. The forged-steel shell being tough and having good penetrating power, has sometimes been called “the semi-armor-piercing shell.” The term common shell is preferred, however. Plates I, II and III show the details of three sizes of common shells.

72. Bursting Charges for Common Shell.—The following are the approximate weights of the bursting charges of small-grained black powder for common shells:

Gun.	Weight of Shell.	Weight of Bursting Charge.
1-pdr. and 37 mm. R. C.....	1 lb.	250 grains.
47 mm. R. C.....	3 lbs.	600 grains.
3-pdr.....	3 lbs.	900 grains.
6-pdr.....	6 lbs.	1450 grains.
4-in.....	33 lbs.	2 lbs.
5-in.....	50 lbs.	3 lbs.
6-in.....	100 lbs.	3½ lbs.
8-in.....	250 lbs.	10 lbs.
10-in.....	500 lbs.	30 lbs.
12-in. Cast Steel.....	850 lbs.	60 lbs.
12-in. Forged Steel.....	850 lbs.	36 lbs.
13-in. Forged Steel.....	1100 lbs.	50 lbs.

73. High explosive shells have not been issued to service, but the subject is under consideration and is touched upon in the chapter on “Penetration of Projectiles.”

74. It has been proposed to place smoke-producing materials of different colors in the different calibres of shells so that the bursting of the shells would indicate, by the color of the smoke, where each calibre fell. This plan might be of use in bombard-

ments to discover the correct range and to show what shell strike over or short.

75. Shrapnel.—Both cast iron and steel shrapnel have been issued for guns from 4- to 8-inch in calibre, but in future steel shrapnel only will be issued.

Plates II, III, V and VI show the details of shrapnel of three different calibres. It will be seen that the body of the shrapnel is made of steel of comparatively thin walls and that the details are different for the several calibres. Sometimes the bursting charge is in the point, sometimes in the base, and again in the central tube.

The number of balls varies with the calibre; in the 4-inch shrapnel it is about 270, and in the 5-inch, about 360, of .52 inch diameter. The 6-inch shrapnel has about 210 balls of .82 of an inch diameter.

76. Fuse for Shrapnel.—Sweet's combination time and percussion fuse for shrapnel is described in Chapter 27.

77. Shrapnel for 3-inch Field Gun.—The following is a description of the shrapnel for the 3-inch field gun:

It consists of a thin cylindrical body about two-tenths inch in thickness, with a cast-iron head, containing the cavity for the bursting charge, a threaded hole for the fuse, and a base plug, also of cast iron. (See Plate V.) Within the body of the shrapnel are packed 135 balls, $\frac{1}{2}$ inch in diameter, which are held in place by two cast-iron supporting disks, Fig. 2, Plate V, and by six cast-iron separator disks, Fig. 3, Plate V. The separator disks are cut radially into five sectors. The fuse screws into the fuse hole in the cast-iron head.

78. New 3-inch Shrapnel.—The latest 3-inch shrapnel is shown in Plate VI.

79. The Bursting Charges of Shrapnel.—The bursting charges, as compared to shell of the same calibre, are very small, a few ounces only, the amount being just sufficient in each case to crack the walls of the shrapnel, allowing the balls and fragments to be carried forward by the remaining velocity at the instant of bursting, the cone of dispersion being due to the small bursting charge and the impinging of the balls on each other. The charges are as follows: 4-inch, $\frac{1}{3}$ pound; 5-inch, $\frac{1}{2}$ pound; 6-inch, $\frac{3}{4}$ pound, approximately.

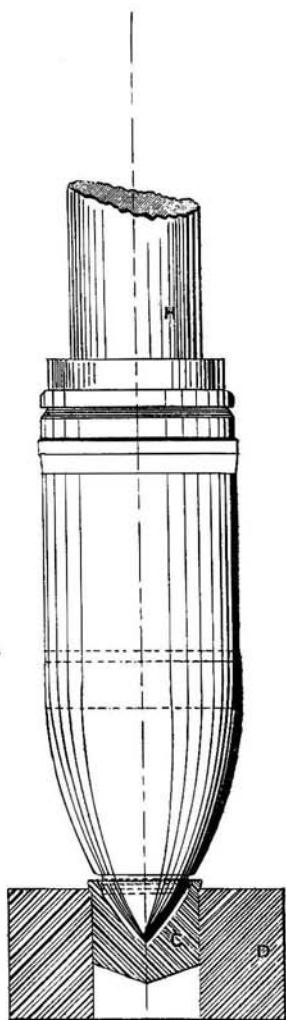


FIG. 1.
METHOD OF CAPPING ARMOR
PIERCING SHELL. Par. 68.

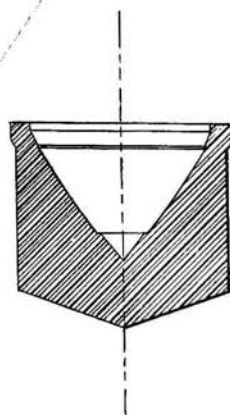


FIG. 2.—STEEL CAP. Par. 68.

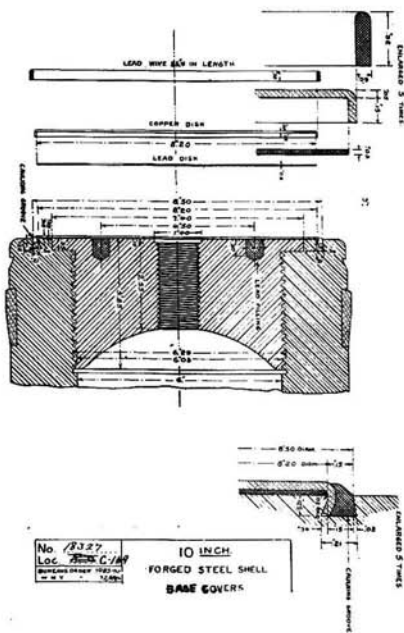


FIG. 3.
BASE COVER FOR SHELLS. Par. 67.

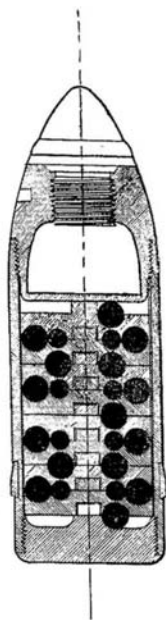


FIG. 1.

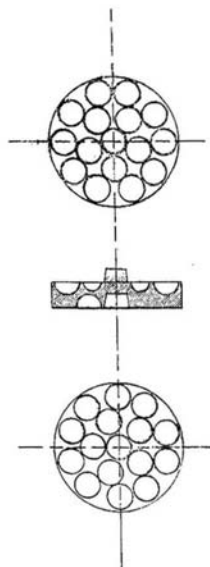


FIG. 2.

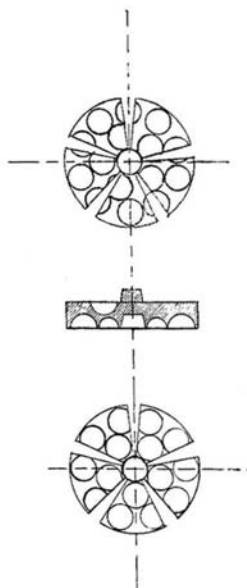


FIG. 3.

3-INCH SHRAPNEL FOR R. F. FIELD GUN.

CHAPTER XXVII.

FUSES.

1. **The Navy Base Percussion Fuses** are shown in Plate I, Figs. 1 and 2, and the action of the fuses is as follows: The shock of firing causes the inertia of the plunger to break the wire holding the plunger, and on impact the plunger flies forward and explodes the primer cap. Fitted with these fuses, shell of 4-inch, 5-inch and 6-inch calibre are exploded by passing through $\frac{1}{4}$ -inch steel plates, while the 1-, 3-, and 6-pounder shell explode on passing through three-sixteenths inch plates. The larger shell require somewhat thicker plate than $\frac{1}{4}$ -inch to explode them. All base fuses have a left-handed thread.

2. The short fuse, Fig. 2, for minor calibre shell, differs from the long fuse used in large shell in having no magazine, and the base of the fuse cavity is conical instead of cylindrical.

3. **Safety in Handling.**—It has been found that a drop of 30 feet upon well supported half-inch steel plating does not arm these fuses, but that a drop of about 12 feet upon a heavy armor plate does. Consequently, while, under usual conditions, a fused shell dropped from a considerable height will not explode, it is advisable to take great precautions against dropping one. As the greatest velocity with which a shell can be rammed home does not equal that due to even a small drop, there can be no danger whatever that the shock of a shell bringing up on the compression slope will cause the fuse to be armed.

4. **Frankford Arsenal Fuse.**—The Frankford Arsenal base percussion fuse, of which a large number will be issued to service, is shown in Plate II, Fig. 1. The action is simple and requires but little explanation.

The igniter plunger (7) rests against the rear end of the fuse cavity, and the sleeve (6) against the forward end. The plunger and sleeve are held together with the point of the former clear of

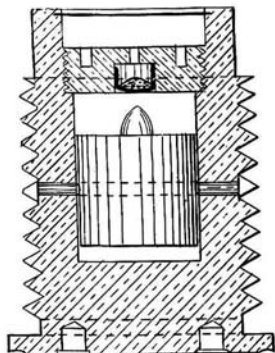


FIG. 1.

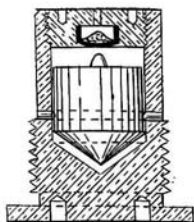


FIG. 2.

NAVY BASE PERCUSSION FUSES.

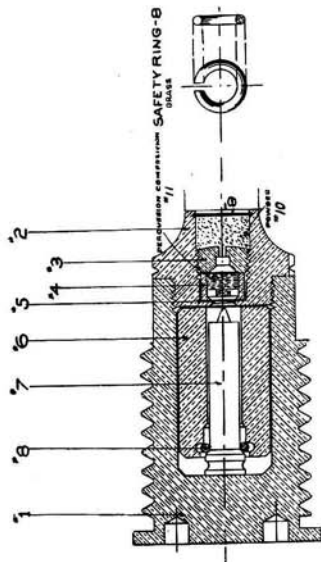


FIG. 1.

FRANKFORD ARSENAL FUSE. Par. 4.

- | | |
|----------------------------|----------------------------------|
| 1. Body. | 7. Igniter plunger. |
| 2. Closing cap screw. | 8. Safety ring. |
| 3. Primer closing screw. | 9. Closing disk (power chamber). |
| 4. Primer. | 10. Powder. |
| 5. Restraining disk. | 11. Percussion composition. |
| 6. Igniter plunger sleeve. | |

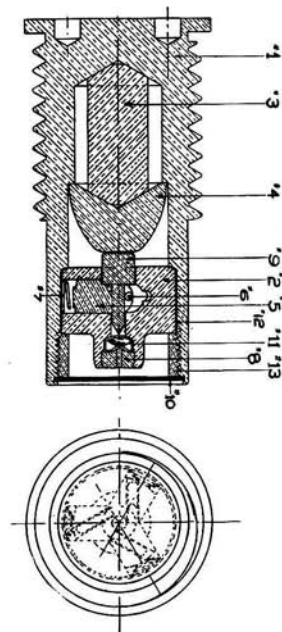


FIG. 2.

MERRIAM FUSE. Par. 6.

the restraining disk (5), which covers the percussion composition, by the split safety ring (8). This is the position of safety.

When the shell starts from its seat the shock of discharge carries the sleeve to the rear, opens out the safety ring and forces it back into the groove around the rear end of the plunger where it springs into place and again locks the sleeve and plunger together, both resting against the rear end of the fuse cavity. When the shell strikes, the sleeve and plunger fly forward against the primer, exploding the latter and igniting the powder in the fuze magazine, from which the flame is communicated to the bursting charge.

5. Broderick Fuse.—The Broderick base percussion fuse for minor calibre R. F. shell is practically the same as the Frankford Arsenal fuse in principle and in action. The magazine is omitted, and the rear end of the fuse cavity is conical instead of cylindrical.

6. Merriam Fuse.—The Merriam base percussion fuse, of which 100,000 have been ordered for issue to the service, is shown in Plate II, Fig. 2.

The *striker* (9) and the *primer* (11) and *anvil* (8) are carried in a block (2) held in the forward part of the fuse cavity by a screw sleeve (13). The flame from the primer communicates with a small powder chamber, the powder being confined by a thin copper disk (10).

The point of the striker is held back from the primer in the block by three radial keys (5) which are pressed against the striker by spiral springs, as shown in the plate. When the shell leaves the gun the centrifugal force due to the rotation of the shell causes the keys to fly back against the springs and unlock the striker, which is then free to move forward against the primer.

The plunger, which gives force to the striker, is in two distinct parts (3 and 4). The rear plunger (3) is designed to cause the fuse to act upon oblique or side impact. Being of smaller diameter than the fuse cavity and its ends being conical where it bears against the cavity and against the forward plunger (4), it is evident that a side impact would cause the plunger to move sidewise and impart a forward movement to the forward plunger (4), driving the latter against the striker (9).

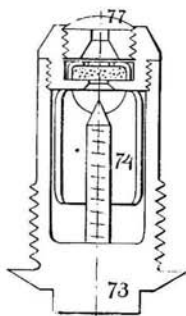
The action upon direct impact will be evident from the plate. The centrifugal locking or safety arrangement and the device for side impact are the distinguishing features of this fuse.

7. **Hotchkiss Fuse.**—The Hotchkiss fuse, Plate III, for small calibre shell, consists of a cylindrical fuse body containing a plunger, and having a small fulminate cap and magazine (76) screwed into its front end. The plunger is a brass cylinder filled with lead (74) and having a stout corrugated steel striker passing through it. The point of this striker is covered by the front end of the plunger, which, in the safety position (Fig. 1) rests against the front end of the fuse cavity (75), while the rear end of the striker projects beyond the plunger and rests against the rear of the cavity. The shock of discharge drives the plunger to the rear along the striker (Fig. 2), the lead holding the two together, leaving the point of the striker projecting from the front end of the plunger. Upon impact, the plunger, carrying with it the striker, drives forward, exploding the cap and communicating the flame to the bursting charge of the shell. (See Plate III, Figs. 1 and 2).

8. **Driggs Fuse.**—In the Driggs fuse, Plate III, the plunger is held back (Fig. 3) against the rear end of the fuse cavity by two tempered steel springs (Fig. 4) having circular lugs which fit into a score around the rear end of the plunger, the forward ends of the springs being joined to a ring which rests against the forward end of the cavity. Thus the point of the plunger is held clear of the cap until the rapid rotation of the shell causes the springs to fly out by centrifugal force so that the lugs are free from the score in the plunger, leaving the latter free to fly forward upon impact. (See Plate III, Figs. 3 and 4).

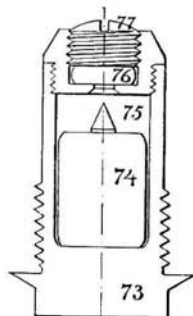
9. **Time Fuses.**—A *time fuse* is one which explodes by its own internal action after a definite time of flight which fixes the *distance* from the gun at which the shell will burst; this interval may be varied within large limits by the operation of “cutting” or “setting” the fuse.

Any time fuse depends upon its train of compressed slow-burning powder; this composition is made as uniform as possible, and, if accuracy is to be attained, equal lengths of it should be consumed in equal intervals of time. When the fire reaches the end of the time train, it ignites the quick powder of the fuse magazine and bursting charge, and the projectile instantly explodes. The time of burning a particular size or variety of fuse depends upon the distance of the point at which the train is lighted from its end.



Position of plunger
before firing.

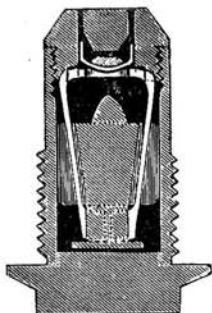
FIG. 1.



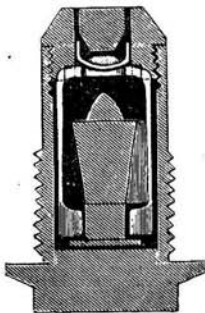
Position of plunger
during flight.

FIG. 2.

HOTCHKISS BASE PERCUSSION FUSE. Par. 7.



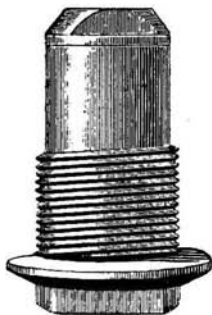
Position of Spring
before firing.



Position of Spring
during flight.

FIG. 3.

DRIGGS BASE PERCUSSION FUSE. Par. 8.



Plunger.



Springs.

FIG. 1.

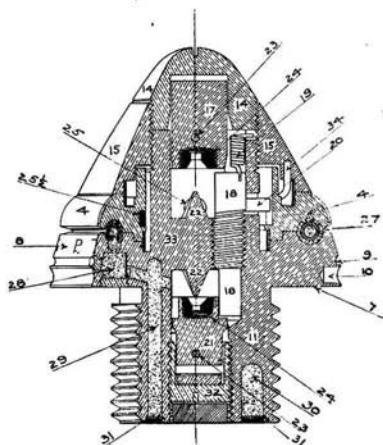


FIG. 2.

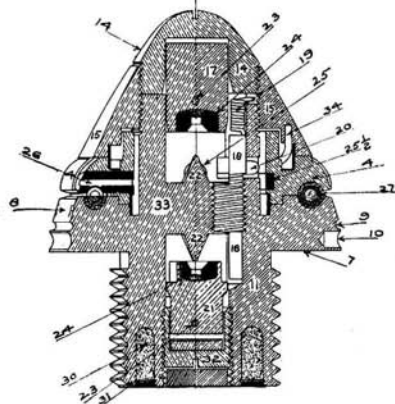
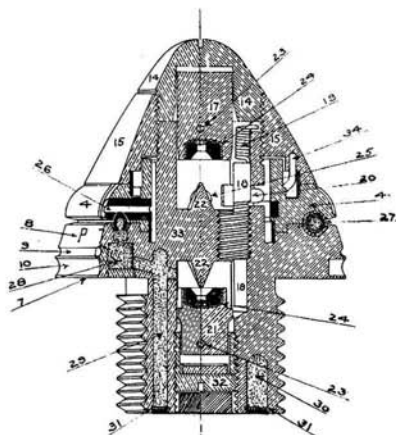


FIG. 3.

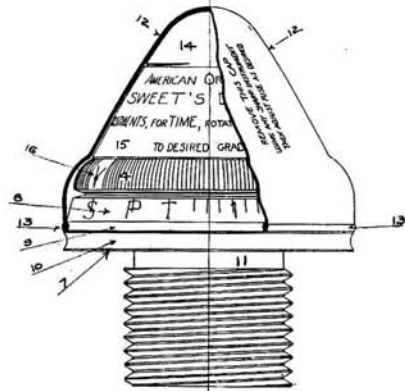


FIG. 4.

SWEET'S FUSE.

The first fuses used for bursting projectiles were time fuses which depended upon the slow-burning powder train; since that time, the only progress, as far as principles are concerned, lies in the method of igniting the time train. These old-fashioned fuses, formerly used with common shell, were ignited by the flame of the gun's powder charge which came into contact with the exposed time train—if it had been “cut.” Their bodies were sometimes made of wood, and the time of burning was varied by sawing off a few inches of the end. This method of ignition answered very well, but for modern guns the fuse would have to be in the base of the projectile, and the high powder pressure would crush one of such construction or at least derange it so as to interfere with its working. The modern method of ignition is self-contained, and is in all respects similar to that of the percussion fuses shown in Plate I.

Time fuses are used in the Navy for shrapnel only, and are invariably carried in the nose of the projectile. The one shown in Plate IV is a combination time and percussion fuse now commonly used for shrapnel of all sizes. Figs. 1 and 2 show the same section but with different settings; Fig. 3 is a section a few degrees from the others, while Fig. 4 is a profile showing the graduations.

10. Sweet's Fuse, see Plate IV, is a combination fuse, and may be adjusted to act by percussion on striking, or by time. In the latter case, if the time device fails, the percussion feature will cause an explosion just as if the fuse had not been set for time. The fuse may also be set so that it cannot be exploded by careless handling.

11. The Percussion Feature of the fuse is like that of the fuses on Plate I; the plunger (21) containing the percussion cap (24) is held by a brittle wire (23); the shock of discharge breaks this and the plunger sets to the rear, arming the fuse; when the projectile strikes, the plunger is carried forward by its momentum, and the cap is exploded by the firing point (22) which ignites the magazine (29) and produces an immediate burst.

12. The Time Action is as follows: The shock of discharge breaks the other shearing pin (23) and the time plunger (17), strikes upon the point (22) which explodes the cap (24) and fills

the cavity with hot gas. The flame passes through the hole (25) to an annular space and ignites the ring of powder ($25\frac{1}{2}$); the flame is finally communicated through the hole (26) to the time train (27) which burns slowly and finally reaches and ignites the powder in (28) and (29). The hole (26) is in the setting ring (4) and may be moved around with it, thus igniting the time train at the desired point; this comprises setting it for time.

13. The Safety Lug (18), screwed into the body of the fuse, suffices to put the time plunger out of action, thus setting the fuse for percussion firing, or to put both plungers out of action, making it insensitive to shock; it is revolved by the action of a stop, on the setting ring, against the small lug (20). In Figs. 1 and 4 the fuse is set at "safety"; in Fig. 3 for percussion firing and in Fig. 2 it would explode, by time, close to the gun.

14. The Setting Ring is fitted with pawls which do not permit it to turn in the direction induced by the rotation of the projectile; needless to say, its setting would be changed otherwise. The lead cap (12) protects the fuse from dampness; it is removed before the fuse is set.

15. Specifications for Shrapnel Fuses.—Shrapnel fuses shall be made in accordance with drawings approved by the Bureau.

16. The fuse stocks, caps, adjusting ring, and plungers shall be of any good commercial brass composition and shall be finished as well as the best machine methods permit.

17. The time train shall be of suitable composition enclosed in a uniformly drawn or rolled lead tube.

18. The parts of the fuse shall be subject to a visual inspection only, with the exception of the shank thread, which must qualify in approved standard gauges. The inspector, however, shall witness the shop tests of time trains as a means of satisfying himself as to their uniformity.

19. The fuses shall be presented for test in lots of 500, and from each lot five fuses shall be selected by the inspector for test as follows:

20. One or more of the fuses shall have their percussion elements tested either by dropping loaded and fused shrapnel in an explosion chamber, or by firing through a $\frac{3}{16}$ -inch steel plate or its equivalent. The remainder of the fuses shall be fired with service charges over a range to test the time element.

21. For the time test the fuses will, generally, be cut for times between 2 and 8 seconds, and the elapsed time between the appearance of smoke at the muzzle and the explosion of the projectile shall be noted by chronographs or stop watches. The least time noted shall be taken as the true time, and this must not differ more than one-third of a second, plus or minus, from the time for which the fuse was set.

22. The failure of any fuse tested to function properly, or a discrepancy of more than one-third of a second between the set time and the burning time, shall be sufficient cause for the rejection of the lot.

CHAPTER XXVIII.

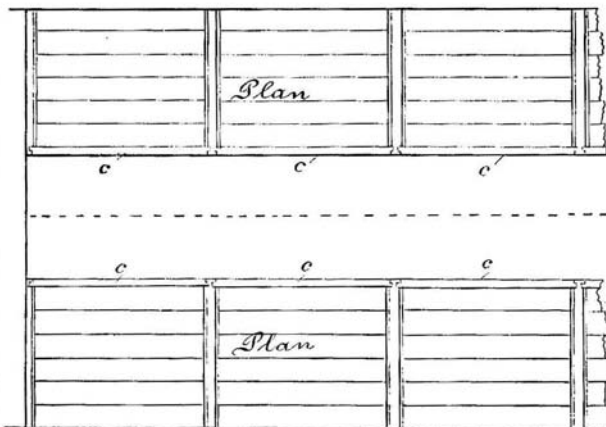
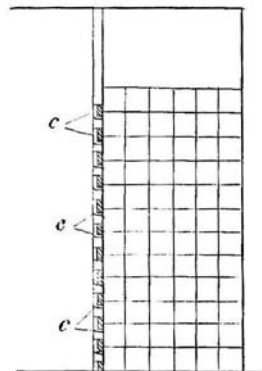
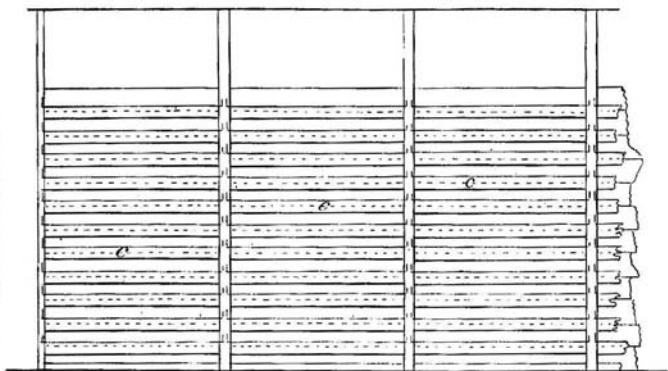
STOWAGE AND SUPPLY OF AMMUNITION.

1. With the exception of the detonators and dry gun-cotton primers for torpedoes, all ammunition, of whatever character, is stowed in specially constructed rooms set apart for that purpose alone; a few projectiles are often stowed in racks around the gun emplacements or below decks, where they can be expeditiously supplied to all guns in emergencies. The ammunition rooms are commonly distinguished in name by the kind of ammunition they contain as well as by their regular numbers; for example, compartment A 37 M is one of the forward 12-inch magazines; compartment D 33 M is the "small arms" magazine.

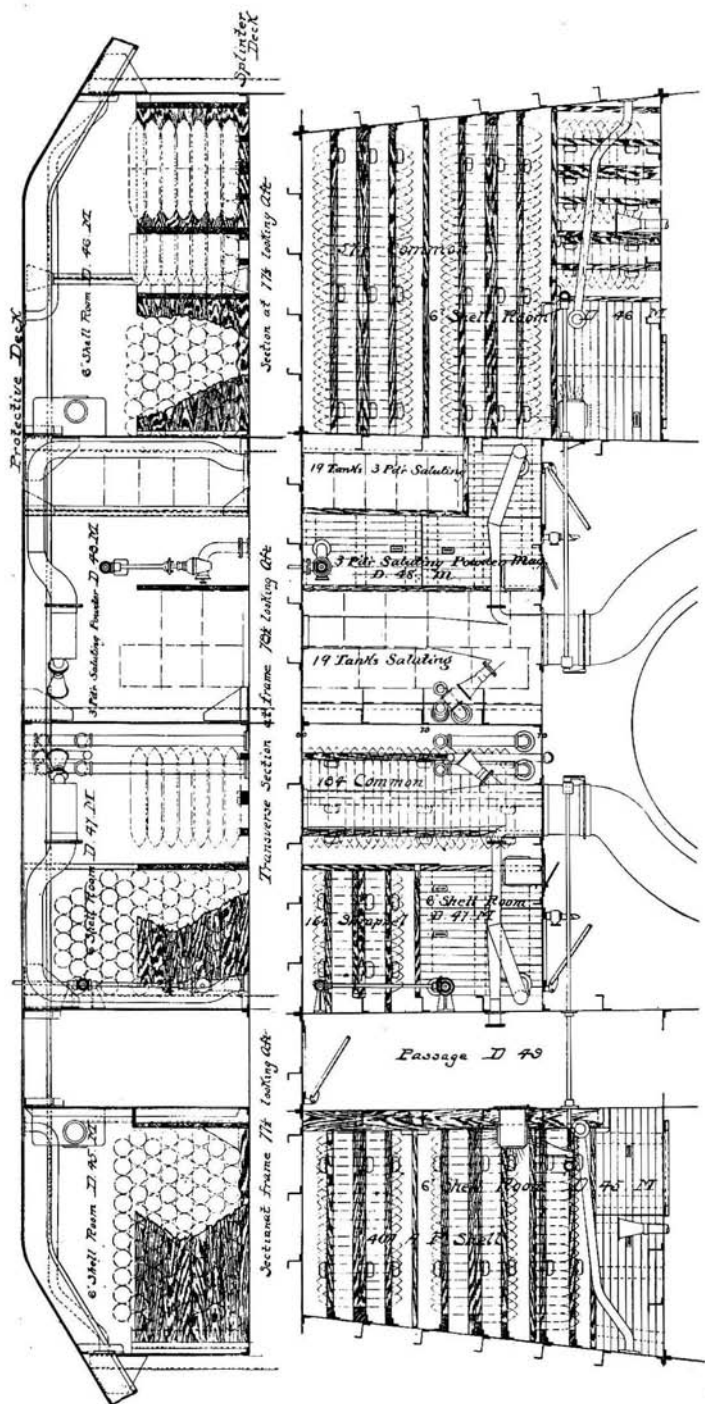
2. **Flooding and Draining.**—All ammunition rooms are water-tight compartments and are placed below the water line; to prevent explosions in case of fire below decks, arrangements are made for admitting sea water to each room; such rooms as are unavoidably built *above* the water line have flood pipes leading from the fire main. The flood pipe, of a size sufficient to fill the empty magazine in about twenty minutes, leads from the outer skin of the ship below the water line directly to a flood valve, which is worked either in the magazine itself or from the berth deck. A spindle leads from the valve to a plate on the berth deck and ends



in a square section on which is shipped a large key for turning the valve; the key or wrench is kept near at hand in a locked rack, the key of which is kept with the magazine keys. The deck plate is stamped with the name and the compartment number it floods and an arrowhead that opens the valve.



STOWAGE OF 4-INCH, 5 INCH AND 6 INCH R. F. AMMUNITION BOXES.



6-IN. SHELL ROOMS OF U. S. S. MAINE.

In addition, a specially shaped plate, with a red ground, secured to the beam above, gives the same information (see figure). The air escapes from the magazine through the exhaust ventilating duct; if none is fitted, a special escape pipe is provided to allow the room to fill. Those compartments flooded from the fire main have relief valves to prevent the accumulation of a pressure that would make the bulkheads collapse.

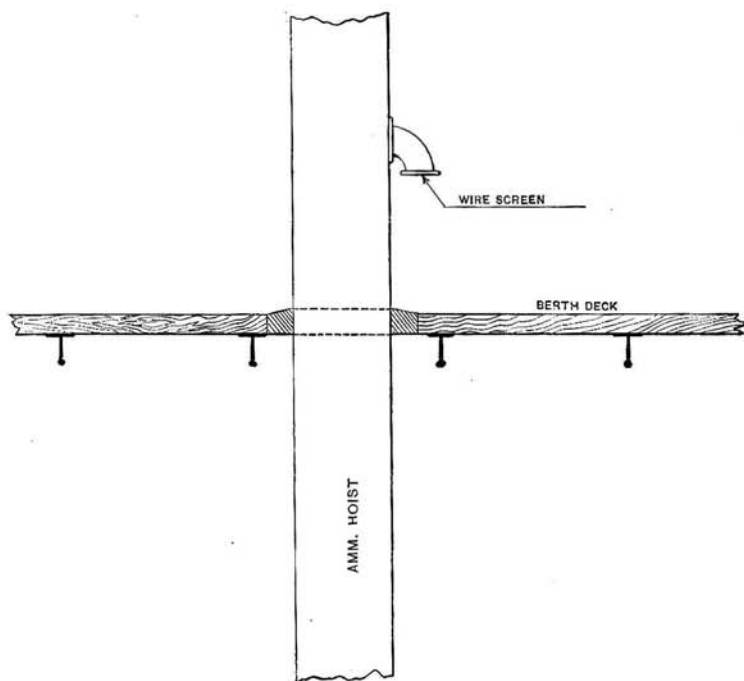


FIG. 1.

Ammunition rooms in the hold drain into bilge wells, from which suction pipes lead to drain manifolds. Upper compartments sometimes have individual drain pipes to drain wells or lower compartments; in other cases, they can be freed of water, that happens to find its way into them, only by portable pumps.

3. Ventilation.—The adoption of a smokeless powder which, in the process of manufacture, is colloided with a very volatile liquid, makes the subject of ventilation a very important one; the ether

fumes are inflammable and must be carried off and, in addition, the powder must be kept cool. To this end, every ammunition room is fitted to receive, directly from the ship's artificial ventilating system, a supply sufficient to renew the air once in about eight minutes. A natural exhaust pipe of greater area than the supply duct is placed in each room as far away from the supply as possible; the upper end is carried up at least above the berth deck and terminates in a gooseneck covered with wire mesh. When ammunition hoists open directly into the magazine, the trunk of the hoist itself is used for natural exhaust ventilation (see figure); a gooseneck outlet, covered with wire mesh, is fitted at a height at least above that of the berth deck. Piping in ammunition rooms is generally of brass.

4. Lighting.—Each magazine and shell room is lighted by one or more light boxes, of standard Navy pattern, which throw light in three directions through round ports covered with double glass plates. The boxes are water-tight and are separate compartments opening *only* from the deck above or from some passage or compartment outside the magazine. The light boxes each contain incandescent lamps and are arranged to burn candles if the others fail; in the latter case, enough water to cover the bottom is introduced.

5. Stowage, Location of Magazines, etc.—The ammunition rooms, as a rule, form two groups, one in each end of the ship, next forward and abaft the engine and boiler spaces. To the greatest extent practicable, the ammunition compartments are below the water line and are always beneath the protective deck for protection and for facility in flooding; their arrangement must be such that the contents may be gotten out and sent to the guns expeditiously. If the groups of magazines, etc., contain any rooms that are next to boiler or engine rooms, they are separated from such sources of heat by double bulkheads, separated by a narrow air space which has an outlet to the upper deck. The problem of location varies greatly for the different designs of ships. In large ships which have splinter decks, the two groups of ammunition rooms are connected by long wing compartments on this level, called the ammunition passages; many of the rooms open on these passages, which are just inside and above the machinery spaces,

and they are particularly useful in *supplying* ammunition to the battery. There is sometimes a third group of magazines about midway between the two main groups which open on the ammunition passages and supply the waist guns; these rooms are small and are called the "ready" or auxiliary magazines.

The ammunition rooms of turret guns open into a common handling room, beneath the turret, from which the hoists convey their contents to the guns. For other magazines and shell rooms the same plan is followed where space permits; the ammunition passages are really handling rooms. The shell room doors swing into the handling rooms and are kept open while projectiles are being supplied; but the magazine doors are kept closed and the charges are passed through small openings in them which are in turn closed by shutters; this arrangement is to prevent, as far as possible, an explosion in the handling room from reaching the powder. When there is no space for handling rooms, the hoists open directly into the magazines and shell rooms; it is, in this case, usual to place the hoisting motors and controlling panels outside, to obviate any possibility of an explosion by the ignition of ether fumes from electric sparking. All magazines are floored with ash gratings; the wood used in the racks and bins for the ammunition is of non-fireproof yellow pine.

6. Rapid-fire ammunition is stowed in its boxes in bins in which the charges of the same character are kept separate; thus, in a 3-inch magazine, one bin will contain armor piercers, another common shell, etc. Also the different calibres are stowed in separate magazines; miscellaneous ammunition, such 1-pounder, .30-calibre machine-gun, rifle and revolver ammunition is stowed together. These magazines are frequently called "fixed ammunition rooms"; the boxes are piled in tiers as is most convenient in transferring to the hoist. The sides of the bins are formed from battens shipping in vertical channels (see Plate I).

Projectiles for other than R. F. guns are stowed in separate shell rooms. The bins are strong and the projectiles are stowed in bulk in tiers, the same kinds being left together. If there are two rows in the same bin, they are stowed base to base, and, in any case, the bins are lined with wood against which the sharp noses bring up (See Plate II). Overhead rails, for the cars of the

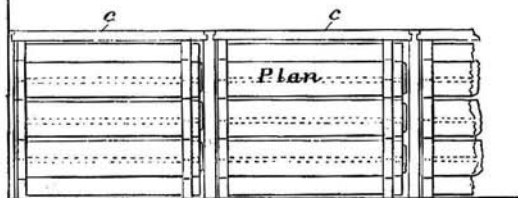
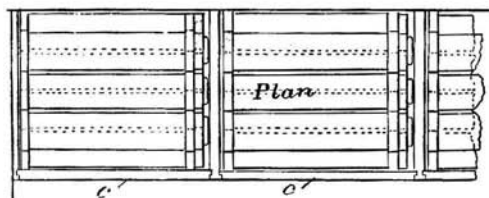
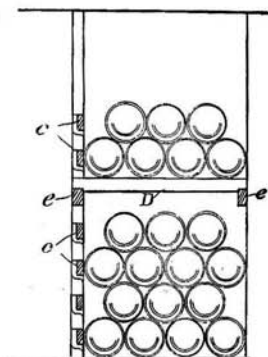
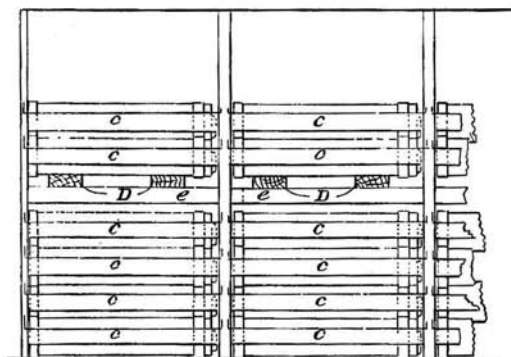
differential lifting purchases, lead from the bins of the large calibre shell rooms through the doors to the hoists; smaller projectiles are transferred by hand. In the few ships in which hand whips only are used, the projectiles are often stowed with straps running longitudinally around each and seized together to form an eye at the nose, into which the whip hooks; this is a convenient, though expensive, way of handling projectiles during shipment. All 10-, 12- and 13-inch projectiles are shipped in strong boxes which are removed before stowing in the shell rooms.

Powder tanks are also stowed in bins, usually on their sides (see Plate III). The older cases are not strong and, as shown, can be stowed only a few tiers high; in this case, horizontal wood battens (D) support the upper layers. Wooden battens bound together by brass rings run along the sides of the new tanks and so strengthen them that they may be piled up to the deck beams. Tanks should be stowed so that their contents can be removed without disturbing them; it is usual to arrange them, particularly those for the turret guns, with their heads to the passage. The bins are built up from stationary vertical channels and rolling boards, which are removed to get at the tanks. Bins are arranged in the different magazines with a view to accessibility in supplying powder to the hoist and, where necessary, alleys are run between them. While the ship is rolling, projectiles, powder tanks and charges are more secure if stowed parallel with the keel, but the tanks and charges should be perpendicular to the passages.

The ammunition rooms of small ships are simply arranged, in two groups, in the hold forward and aft. Of this type the "Baltimore" carries the following ammunition:

TOTAL STOWAGE.

In Magazine..	6" Shells	2160 R'd's.
On Deck	6" " "	240 " "
In Magazine..	6" Charges	2400 " "
" " " "	3" Amm.	459 Boxes (Including 9 Boxes 3" Field Gun Amm.).
" " " "	3 Pdr. Amm.	244 Boxes
" " " "	1 " " "	40 " "
" " " "	30 cal. Machine Gun	50 " "
" " " "	30 " Ball Cartd'g's.	100 " "
" " " "	30 " Blank " "	10 " "
" " " "	30 " Gallery Practice	10 " "
" " " "	38 " Ball Cartd'g's.	10 " "
" " " "	45 " " " "	5 " "
" " " "	Common Powder	19 " "
" " " "	Primers	1 " "



STOWAGE OF 6-INCH POWDER TANKS.

This ammunition is handled by one secondary battery hoist and four 6-inch hoists at each end of the ship.

7. The stowage and means of getting up the ammunition necessary for the large battery of a battleship is a more intricate problem. Plate V shows the plans of the new "Maine" as regards the stowage and supply of ammunition; her battery consists of four 12-inch, sixteen 6-inch, six 3-inch (50-calibre), two 3-inch field guns, eight 3-pounder, six 1-pounder and two Colt automatic guns. The allowance and possible capacity of all kinds of ammunition is given in the following table (pages 344 and 345).

The magazines and shell rooms are in three groups—one around the base of each turret and a smaller one in the waist; all are below the protective deck, the top or crown of which is a little above the water line.

The waist group comprises two 6-inch charge and shell magazines, designated the "ready" or auxiliary magazines, on each side at the level of the splinter deck. These rooms, four in number, open on the ammunition passage which is on the same level. The other two groups are on three flats—splinter deck, platform and hold.

The 12-inch ammunition rooms (see Plate IV), all on the platform deck, open into the handling rooms at the same level. The powder charges are distributed among eight magazines in the forward group and the same number aft: the projectiles are carried in two shell rooms forward and two aft.

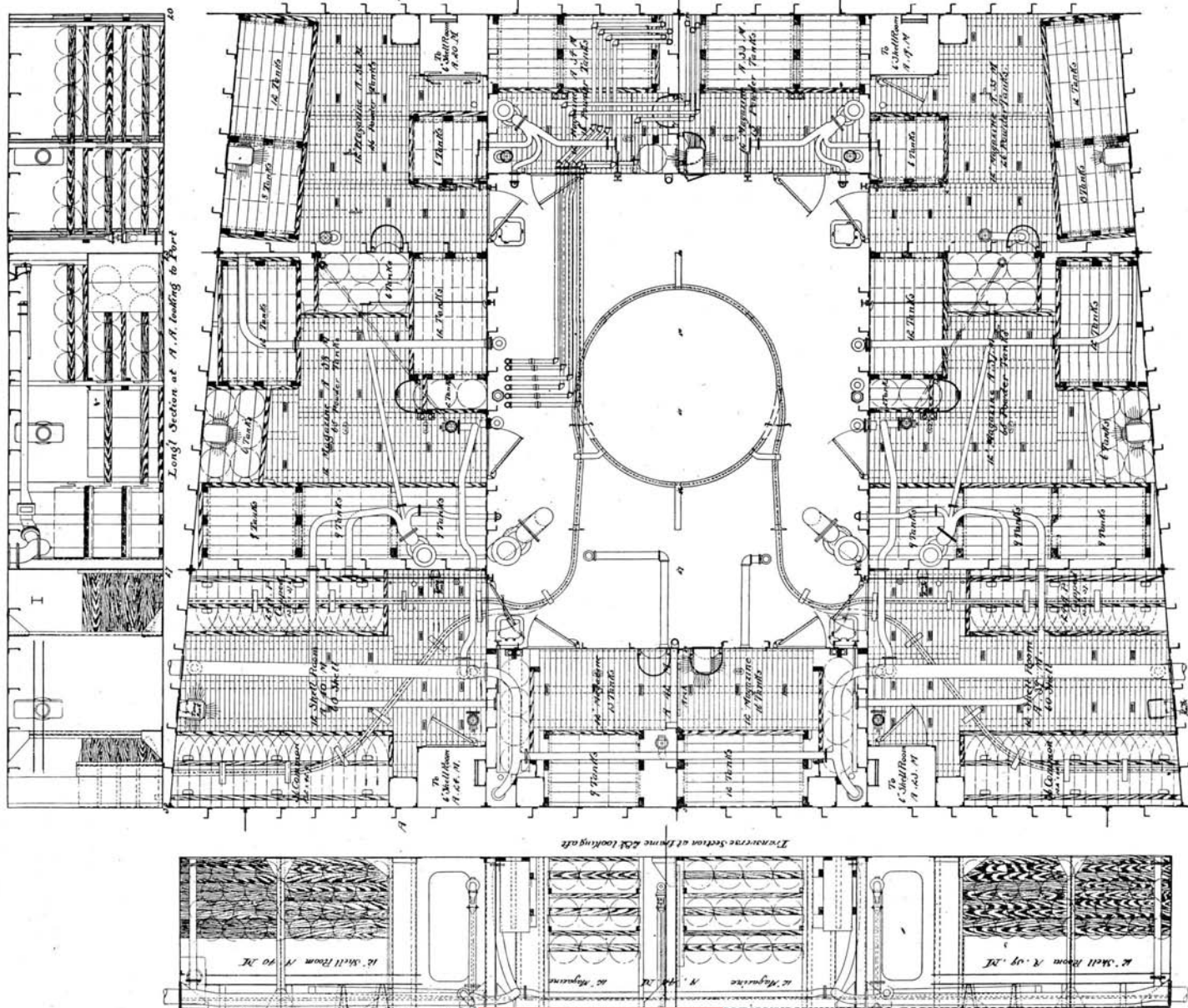
Besides the 6-inch auxiliary magazines in the waist, there are in the hold five other magazines for 6-inch charges—three forward and two aft. A few 6-inch projectiles are stowed in the auxiliary magazines and around the gun emplacements, but the bulk of them is carried in five shell rooms in the fore hold and three on the splinter deck aft. Some 6-inch charges are stowed in the saluting powder magazine.

The 3-inch and 3-pounder ammunition stows in two fixed ammunition rooms forward and two aft—all on the splinter deck. One-pounder ammunition and a small amount for 3-pounders and Colt automatic guns is stowed in two magazines on the forward splinter deck. Small-arm ammunition has a room by itself just abaft the after 12-inch magazines.

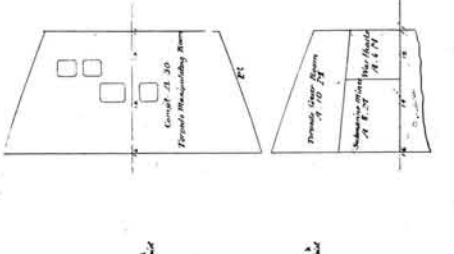
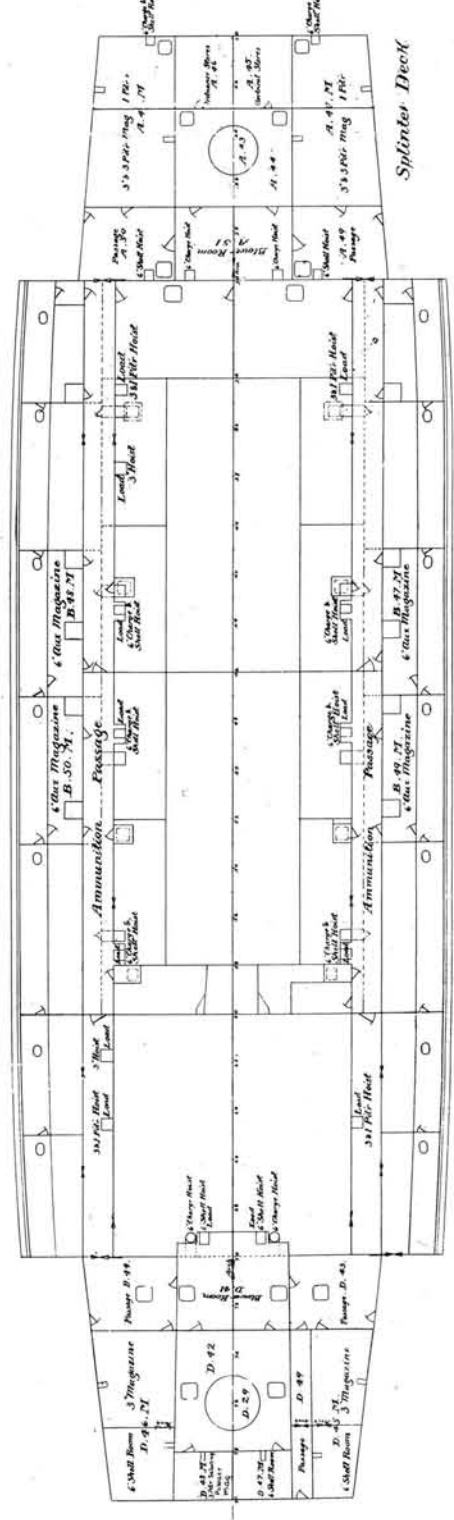
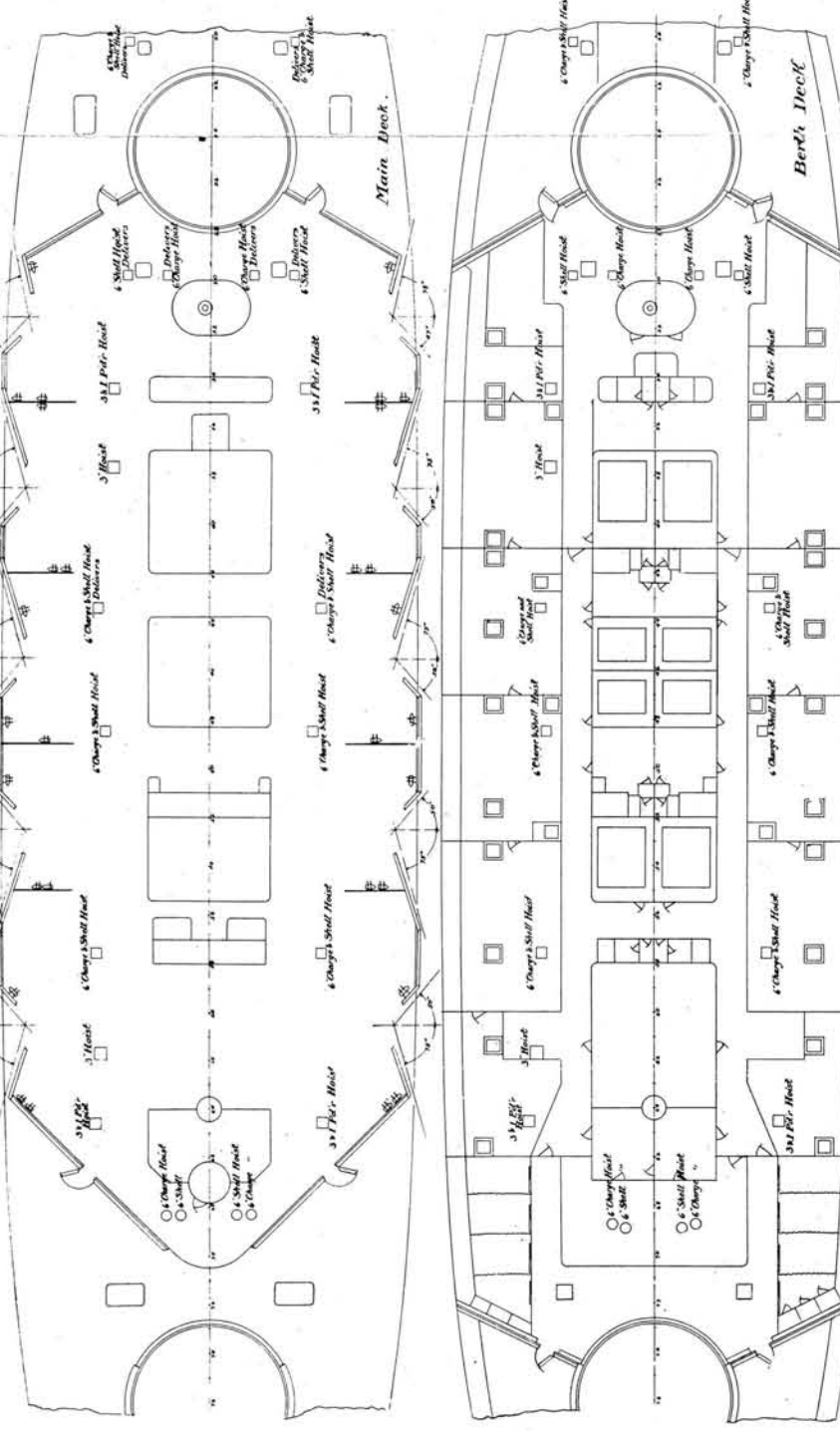
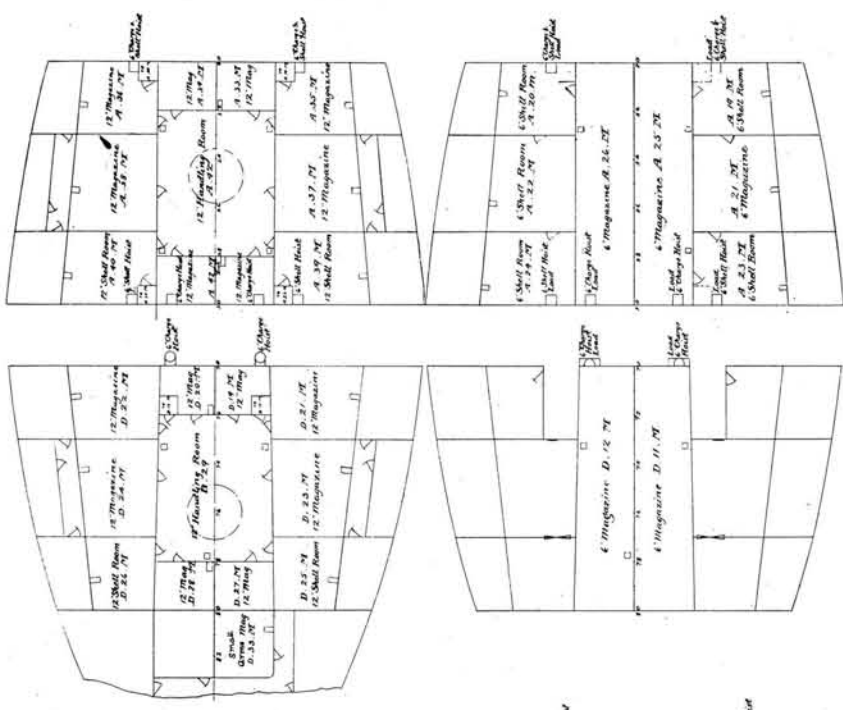
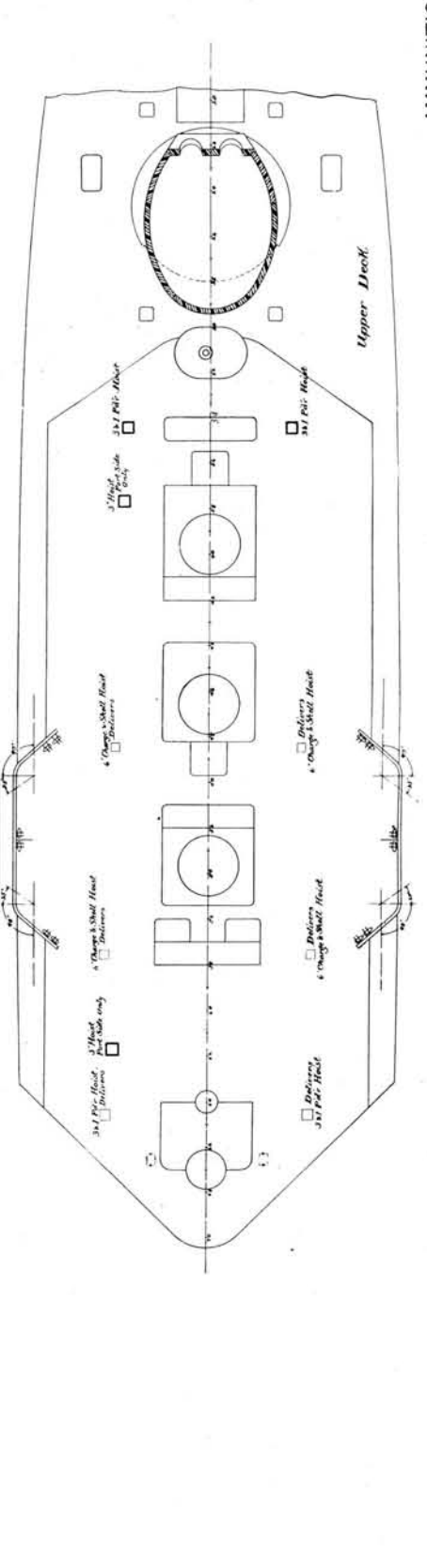
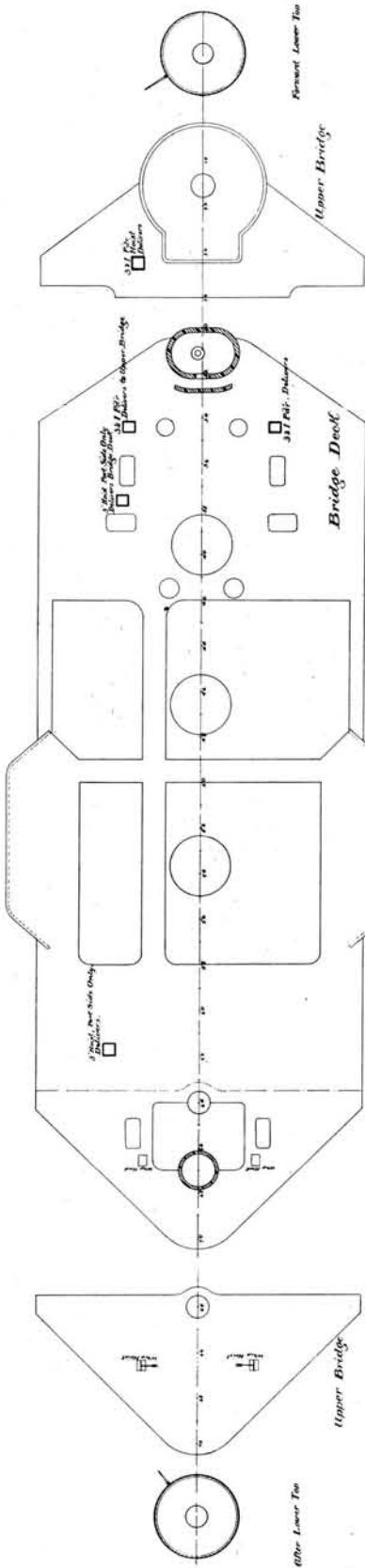
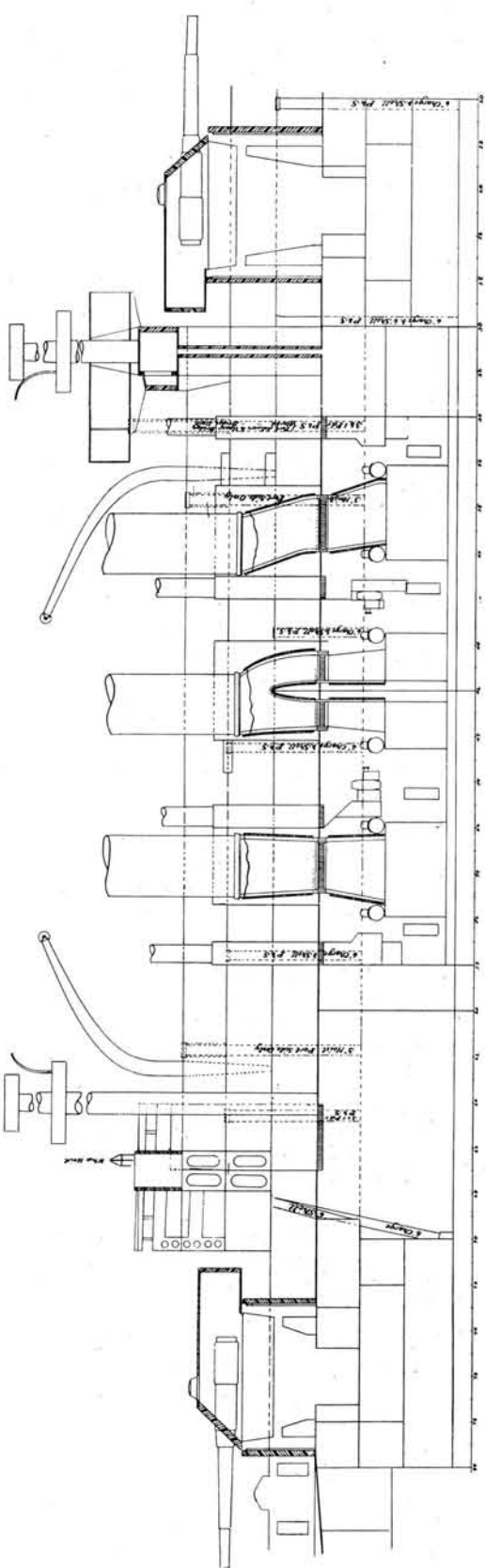
The "Maine" has two under-water torpedo tubes in a compartment, which also stows the allowance of torpedoes, on the platform deck forward of the magazine group; underneath it on the port side are the two gun-cotton magazines (see plate). The ammunition passages on the splinter deck may be utilized to stow extra projectiles and, with proper precautions, a supply of charges as well, but they should not be kept there for a long period.

8. Ammunition Supply.—In the efficient use of a ship's battery in action, the supply of ammunition is next in importance to the correct use of her guns; the excellence of the gun pointers and crews will avail nothing unless they can receive the ammunition in exactly the proper way. Save for a few projectiles, it is unsafe to stow any ammunition near the guns; in fact, we have seen that it is imperative to stow it in definite places, *below* the water line, which are a long distance from some of them. The problem, then, which varies in its intricacy in each class of ships, is to maintain a supply of ammunition to each gun—firing several rounds per minute—as fast as it is needed, without allowing it to accumulate on deck, as, for instance, when the gun, to which a particular chain of supply leads, is silenced. All practicable precautions against powder explosions from the enemy's fire must be enforced.

Obviously, the simplest and surest solution of the problem is to install a magazine and shell room directly beneath each gun, with hoists leading upward to it. This would involve placing a line of magazines along each side, extending the whole length of the machinery spaces at least, which cannot be carried out because many rooms would be too near sources of heat and the space and weight is not available, anyhow; these necessary restrictions as to weight and space are responsible for transforming the comparatively simple problem of gun installation on shore, where space and weight are unlimited, into an exceedingly complicated one. The ideal arrangement of individual magazines and hoists is, in general, attained only for turret guns which, as it happens, are mounted over spaces available for magazines; the tendency, however, is to provide a hoist for each main battery gun and a sufficient number for the smaller pieces; the hoists cannot lead very obliquely, and for some of them ammunition must be transported



FORWARD 12-INCH MAGAZINES AND SHELL ROOMS OF U. S. S. MAINE.



by hand over considerable distances, both below decks and at the guns; however, it is the best that can be done, and the same degree of incompleteness is present in all naval ships.

Ammunition stowage and supply is a factor to which the designer devotes much thought and care, but when he has exhausted his ingenuity and the finished ship possesses the best possible system, the matter of efficient *supply* is still only partially taken care of; by far the more important part is concerned with *personnel* rather than with materiel. It remains, for those charged with the duty—the “Powder Division,” containing many good men and many not suitable for work at the guns—to manipulate the machinery of supply to the best advantage. The best thought of those officers in direct command is needed right at this point and complete success will come only when all the details have been minutely and patiently worked out. Care in stationing every man according to his fitness, small, readily-made changes, improvisations, etc., will often give good results from a manifestly imperfect system if the desire to make the best of it exists—and there is room for the exercise of a large amount of that sort of spirit in some of our ships.

9. Ammunition hoists for turret guns were described in a previous chapter. Hand whips for getting up ammunition are relied upon in some of the older ships and, for a few supply chains of minor importance, in later designs. In all other cases, a power hoist, which works somewhat like grain lifts in elevators, is employed. Plates VI and VII show a 5-inch R. F. hoist; the same general system is used for Q. F. charges and projectiles, secondary battery ammunition boxes, etc.

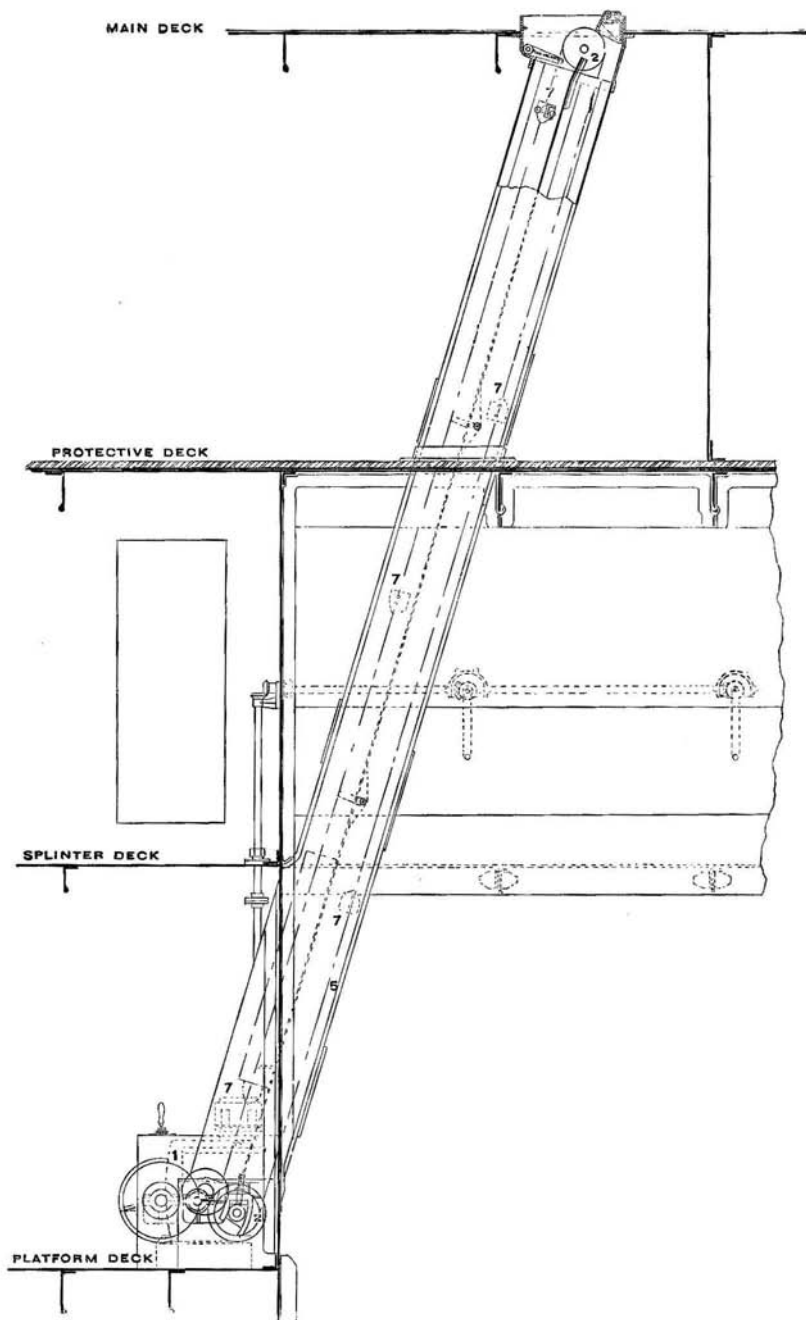
A steel trunk (5) extends from the main deck through the protective and splinter decks to the platform on which the magazines for 5-inch R. F. ammunition are situated. The trunk has two compartments, divided by a partition in the direction of its length; at each of its upper and lower ends a pair of sprocket wheels (2), which carry endless sprocket chains, are fitted. Attached to the sprocket chains are five carriages (7), fitted with rollers, which support the ammunition boxes. Power is applied by suitable gearing from an electric motor (1) to the axle of the lower pair of sprockets, or hand power can be used from a deck above.

At the lower end of the trunk is fitted a loading table (3) on which the ammunition boxes are first landed on end; guides (4), at the sides of the trunk, insure accurate placing of the boxes. The boxes are picked up by the carriages as they pass the table and rest on the carriages and against the partition between the compartments of the trunk. Just above the protective and splinter decks, pawls (6) are fitted which are tripped as the boxes pass and drop back into place as the carriages pass, thus preventing the fall of an ammunition box below the pawl, in case of accident. A pawl (6) with a light spring is attached to the front side of the trunk at the upper end to assist in tipping the ammunition box on the rollers at the top of the trunk; the carriage passes the upper sprocket wheels, pushes the box on to the deck, and then continues down the other compartment of the trunk on its return to the magazine.

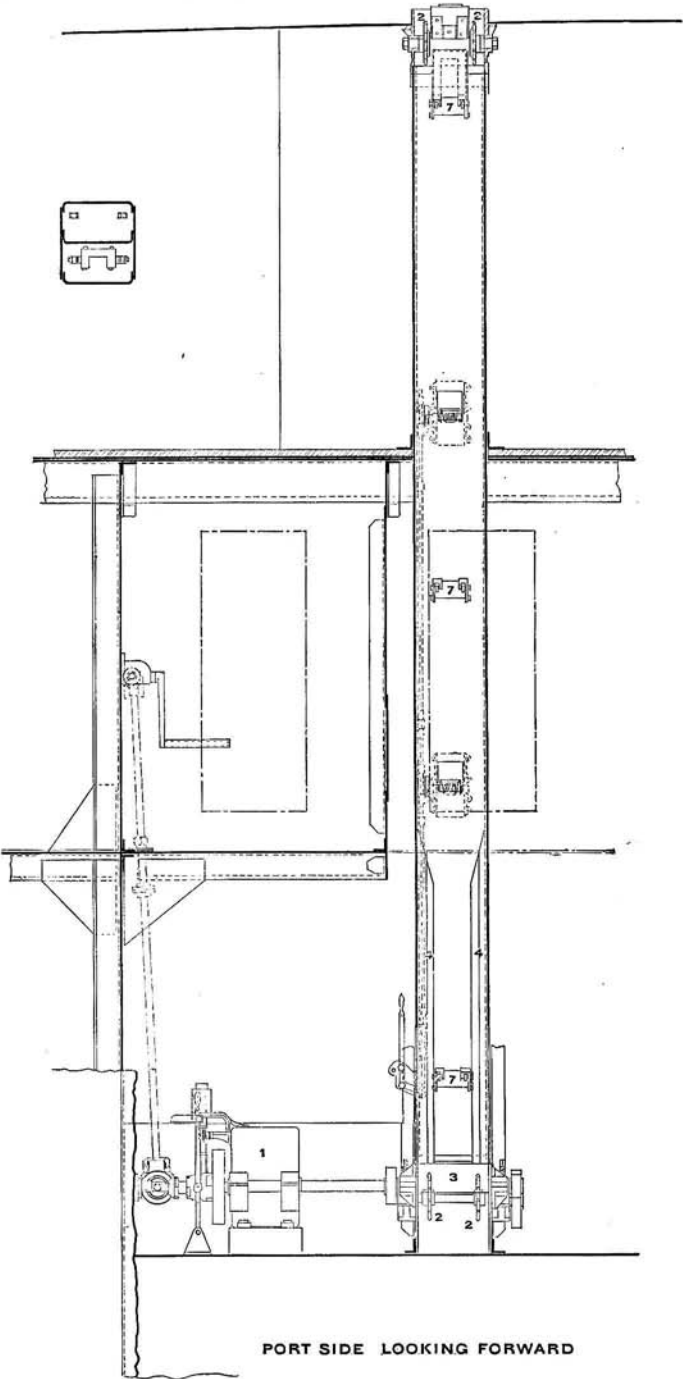
By this arrangement, when one box has just started from the magazine, one is half-way up the trunk and one is about to be delivered on the main deck; two carriages are on their way down to the magazine.

10. The supply system of the "Maine" is shown in Plate V. The hoists for the 12-inch guns lead upward from the handling rooms as previously described; those for the other kinds of ammunition are of the same general type as the 5-inch hoist of Plates VI and VII.

The four 6-inch guns on the upper deck are each supplied by a charge and shell hoist which loads in the ammunition passage and delivers near the gun it supplies. The forward pair of main-deck 6-inch guns (which, being well forward of the turret, do not appear in the plate) also each have a charge and shell hoist which leads from the forward end of the forward 6-inch magazine group and delivers on the main deck at some distance from the guns. In addition to the six already mentioned, there are ten 6-inch pieces mounted in broadside on the main deck within the citadel. Ammunition is supplied to these guns by two charge and shell hoists which lead from the ammunition passages and deliver at about the center of the battery, and by four charge and four shell hoists leading from the forward and after 6-inch magazines and shell rooms and delivering at each end of the citadel. It is not likely



5-INCH AMMUNITION HOIST. PORT SIDE. LOOKING OUTBOARD.



PORT SIDE LOOKING FORWARD

Mark.	Name.	Description.	Material.	Remarks.
1	Motor	To specification		3¼ H. P. at 375 revs.—Shunt wound. 160 volts
2	Sprockets	9,659" Pitch-diam.: 12 teeth	Cast-steel	
3	Loading-table		Naval brass	
4	Guides		Wood	
5	Trunk		Steel	
6	Pawl		Cast-steel	Fitted with spiral brass spring
6	Pawls		Cast-steel	
7	Carriages	Fitted with		of carriages on each hoist

that both sides of a ship will be engaged at the same time—at least not for a long period—and all hoists of the unengaged side may be utilized at need for the supply of the engaged guns.

The 3-inch ammunition is delivered to its guns on the bridge deck by two hoists leading from the *port* ammunition passage and delivering at that level. On each side are two hoists for sending up 3-pounder and 1-pounder ammunition in its boxes; these four hoists are all loaded in the ammunition passages. The after ones deliver on the upper deck; ammunition for the guns on the after bridges and in the top is hoisted from the upper deck by hand whips. The starboard forward hoist delivers on the bridge deck and the port one on the upper bridge; from here it is whipped up to the top by hand.

11. A handling table, with accessories, for 8-inch turrets is shown by Plate VIII. In many of the earlier turrets of this size one hoist was originally fitted by which the single car was hoisted to a crane in the turret and then swung over to the loading position. It was found that ammunition could not be supplied with sufficient rapidity and the system was unsatisfactory for other reasons as well. Because of the restricted size of the turret and ammunition tube it was not possible to substitute two independent hoists, but the arrangement finally adopted has resulted in a much higher rate of fire.

The tracks for the ammunition cars lead to the center of the turret and at a half-way point, between the turret and handling room, the tracks spread sufficiently to allow the two cars to pass each other, one car (loaded) coming up while the other (empty) passes it going down, both being operated by the same wire rope and a single electric motor. The car being at rest, the projectile is pushed out of the shell compartment on top of a table *A* (see Plate VIII), and brings up by the base against a stop at the rear end of the table. The projectile, *M*, is then rolled into side rests, *N*, on the top of plates, *B*, which pivot at the lower end, *C*, to the turret floor, and which are allowed to swing off from the table, a distance controlled by the chain, *g*, bringing the projectile opposite the bore of the gun, *E*. The projectile is then shoved home by the rammer. The powder charges are removed from the car by hand and passed to the loader who places them in the chamber.

By this arrangement, with a projectile in each of the pair of guns, three on the table and side rests, and one in the loaded car, six projectiles are ready for use. Overhead cranes are done away with and the supply of ammunition is much more rapid and more easily handled.

12. Communications for Battery Control.—The electric system of communications which has been adopted for U. S. naval ships is shown diagrammatically by Plate IX. The order indicators which are installed at the guns and at their principal ammunition supply stations are brass boxes with round pieces of ground glass set in their fronts. The orders are printed on these glasses in heavy black letters and in a pocket behind each is an incandescent lamp of low candle power, the glow of which, when lighted, shows through and thus indicates the order transmitted. This shows clearly in darkness, and, while of course the orders on all the glasses, lighted or not, can be plainly read in daylight, those which *are* lighted are the plainer and mistakes in reading cannot occur. The lamps have each an individual leading wire and a *common* return (see heavy line) running to the transmitter in the conning tower; the leads of each indicator are enclosed in an ordinary pipe conduit. The current is taken from the dynamo at the voltage of the ship's lighting circuit.

The *transmitter*, in the conning tower, is a regular switchboard with the standard orders written down its middle. Its switches are arranged so that an impossible order cannot be transmitted; thus the two upper orders may be transmitted to every indicator, but the guns cannot be ordered trained on bearings *not* in their arcs of fire; similarly, shrapnel can be ordered only for those guns for which they are provided. The several indicators, moreover, will only show such orders as apply to the stations they are installed in.

The indicator of each supply station is connected in parallel with the indicators of those guns which receive their ammunition from that station. Such indicators show only the orders to commence and cease firing and the kind of ammunition to be sent up. In many cases, provision is made for transmitting orders to the magazines and shell rooms directly from the batteries to which they belong; this will prove useful in the case of a breakdown in

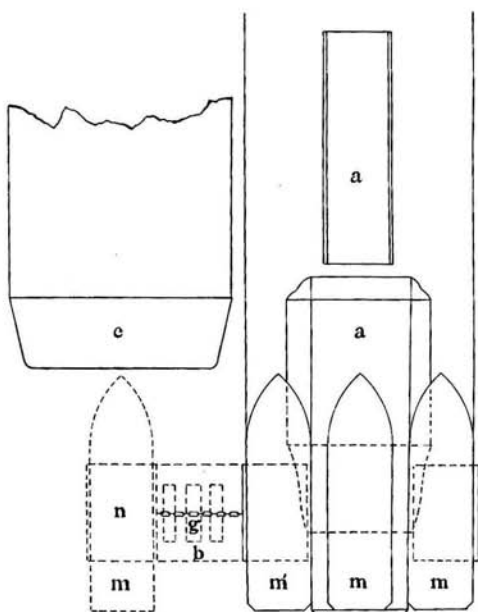


FIG. 1. TOP VIEW.

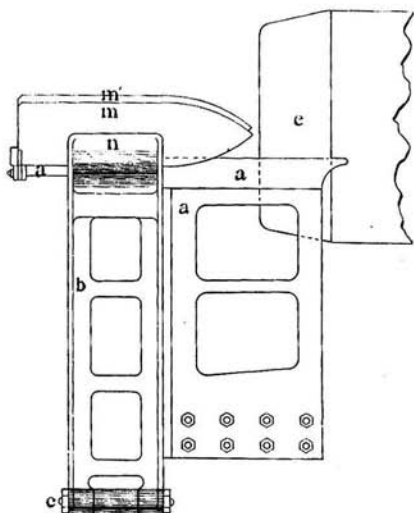


FIG. 2. SIDE VIEW.

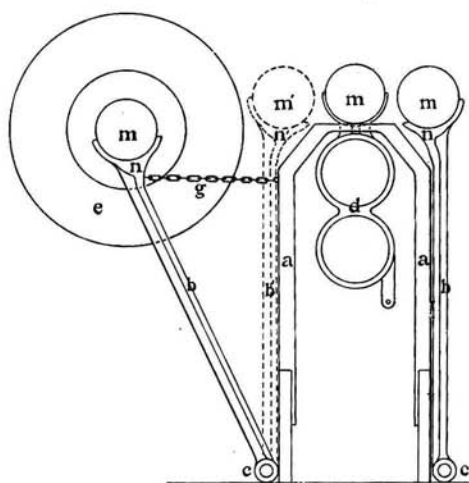


FIG. 3. REAR VIEW.

UPPER END OF AMMUNITION HOIST FOR 8-INCH TURRETS.

TRANSMITTER

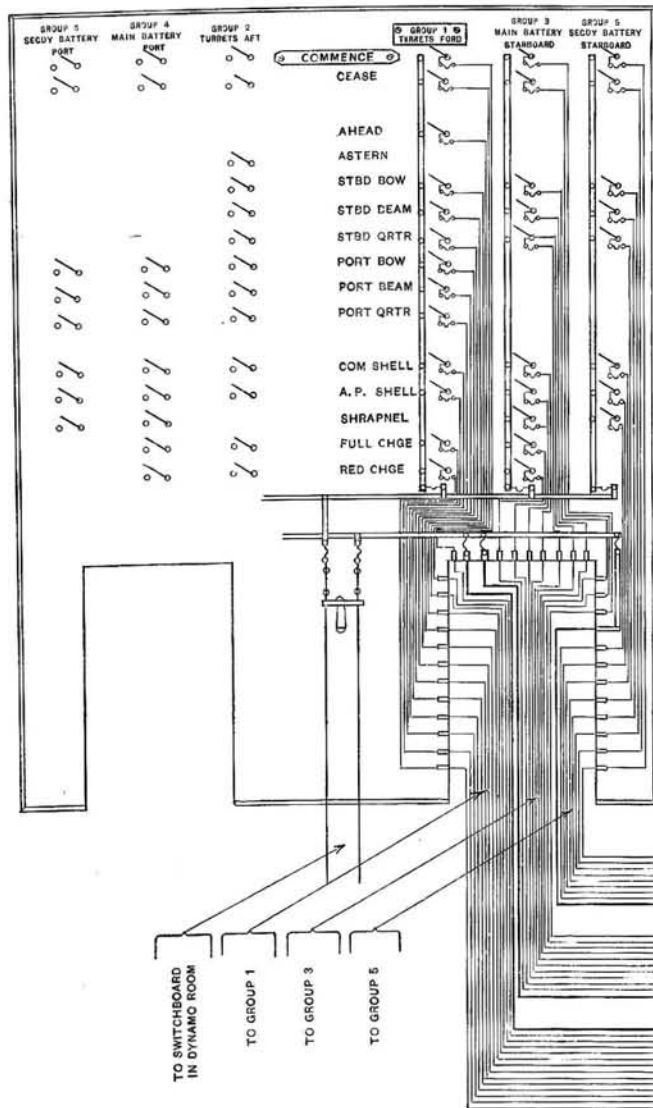
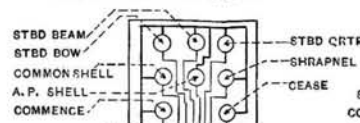
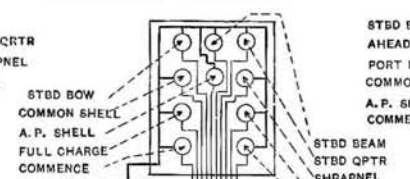
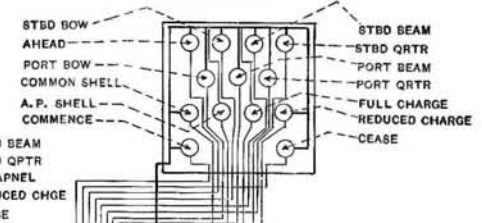
TYPES OF INDICATORS FOR
GROUP 5
SEC'DY BATTERY STBD.TYPES OF INDICATORS FOR
GROUP 3
MAIN BATTERY STARBOARDTYPES OF INDICATORS FOR
GROUP 1
TURRETS FORD

DIAGRAM OF ELECTRIC COMMUNICATIONS.

the connection to the conning tower. Everything about the systems is as positive in its action as an electric device can be. Orders may be transmitted as long as current can be fed to the lamps; the latter are sensitive only in same degree as ordinary ship's lamps.

CHAPTER XXIX.

ARMOR PROTECTION FOR SHIPS AND GUNS.

BY LIEUTENANT CLELAND DAVIS, U. S. Navy.

1. **Historical.**—In so far as it is of record, John Stevens, of Hoboken, New Jersey, was the first to propose the use of armor for the protection of vessels of war. In 1812, he designed a vessel whose battery was protected by inclined armor. This plan, however, like nearly all innovations, was not seriously considered. The Stevens family then began a series of investigations and experiments with armor that extended over many years, and in 1842, Robert L. Stevens submitted a report to a committee of Congress containing the results of these experiments, being deductions concerning the laws of the resistance of armor and the penetration of projectiles. These results were of great value to naval architects, and the principles therein set forth are to this day, many of them, applied in naval construction.

In 1854, Congress appropriated money for an ironclad on the Stevens design, and construction was begun, but the vessel was never finished. The development of the gun, however, in energy, range and accuracy, and the introduction of explosive shell rendered the use of armor imperative, and thus we see the construction in 1855 immediately after the laying of the keel of the Stevens Battery, by France and England, of armored batteries and ironclad vessels. This marks the adoption, generally, of wrought iron armor. The United States quickly followed.

Still further improvements in "Ordnance," especially the adoption of the rifled gun, made it apparent that wrought iron armor applied to vessels of war was of little avail against improved projectiles fired from rifled guns, so that strenuous efforts were made to increase the resisting power of armor, with the result that compound armor was adopted in England, and all

steel armor in France. The efficiency of these two types was about equal. The former had greater resisting power, but the tendency of the steel face to flake off over considerable areas made it unsatisfactory. However, the two about held their own until 1889 when the introduction of nickel into steel materially increased its toughness and power of resistance, so that homogeneous nickel steel plates showed marked superiority over the compound type. Almost immediately thereafter, in 1890, the Harvey process was developed in the United States. The success of this process marked the greatest advance in the history of armor, and it was soon adopted by all the naval powers. The Krupp process, which followed in 1895, effected an improvement over Harvey, though the principle of resistance remained the same.

During all this time numerous experiments were made in the effort to produce novel types that would effect a saving in weight and cost of armor. Target structures of almost every conceivable description were made and subjected to ballistic test. There were homogeneous cast iron and wrought iron plates, and built up targets of every description, including sheets of metal bolted together and presented flat or edgewise; alternating layers of metal and wood; of metal and rubber disposed in various ways, and of springs behind solid plates and between the laminations of built up plates. The targets were fired at vertically, and inclined at various angles.

These experiments demonstrated the following general principles:

1. That, to be efficient, armor must be homogeneous as to mass, so as to concentrate the resistance.
2. That armor should be rigidly attached to the structure, and that devices such as springs or rubber cushions do not add to its resisting qualities, but are in reality a source of weakness.
3. That inclined armor, designed to deflect the projectile upon impact, is more efficient for purposes of protection (when the angle of inclination is greater than the biting angle of the projectile) than vertical armor of equal weight, but when the angle of inclination is not greater than the biting angle, vertical armor of equal weight is more efficient. The introduction of the cap

has not altered this principle. Considering the plate as opposed to capped projectile, the biting angle is reduced to about 20° .

2. **Resistance of Face-hardened Armor.**—Modern hard-faced supercarbonized armor is the logical development of the principles of compound armor. With the advent of the modern armor-piercing projectile it was recognized that to be defeated the projectile must be made to expend its energy upon itself. In other words, the resistance must be so concentrated as to greatly reduce the velocity of the projectile in a short space. The ideal armor plate, therefore, would be composed of a metal homogeneously hardened so as to make it as hard, if not harder, than the projectile itself, and at the same time so tough as not to be shattered upon impact of the projectile. But this was then, as it is now, metallurgically impossible of attainment. Thus the idea of *compound armor* was evolved, which consisted essentially of a high-carbon steel face and a wrought-iron back. It was manufactured by casting steel upon wrought iron, the latter being heated and otherwise prepared to make as intimate a union as possible. This was a distinct advance upon the homogeneous wrought-iron armor, and compound armor was immediately adopted by nearly all the leading powers. The limitations of manufacture, however, made it practically impossible to obtain an intimate union between the two metals and so prevent flaking off of the steel plates, and caused the compound type to be superseded by homogeneous steel and homogeneous nickel-steel plates in the latter part of the 80's. Advance in the art of manufacture of steel enabled the manufacturers to produce steel of what was then considered a very superior quality.

The application by Mr. Harvey of the well-known process of cementation to homogeneous steel plates quickly followed, and the result was the perfection of the compound armor principle, namely, *an integral plate supercarbonized to a considerable depth, giving an extremely hard, elastic face, bound together and supported by a tough back, having a minimum tendency to crack.* The action is as follows: when the point of the projectile strikes the face of the plate, the hard inextensible surface does not immediately give way, but there occurs an elastic or diaphragmatic dishing, in diameter equal to about three times the calibre of the pro-

jectile. The stress of impact is thus distributed over a considerable area, and the concentrated resistance works to suddenly stop the projectile and causes it to break up through its own inertia. Krupp armor has exactly the same ballistic characteristics as that produced by the Harvey process. Its superiority is due to its composition, which makes it susceptible to treatment that improves the ballistic qualities. For example, Krupp armor has a greater affinity for carbon than the manganese nickel-steel used in the Harvey process, so that although the cementation may be accomplished in exactly the same way, carbon will be absorbed to a greater depth in Krupp than in Harvey plates, giving a greater depth of hard face in the former and thus increasing its resisting powers accordingly. Another point of superiority is a less tendency to crack in Krupp plates.

In both Krupp and Harvey processes it is impossible to regulate the depth to which carbon is introduced or to increase that depth beyond a certain point. The reason of this is that the carbon is absorbed decrementally—that is, it begins to shade away from the surface, the carbon in each successive layer being absorbed from that immediately preceding it, so that the limit in the surface layer being fixed to retain the characteristics of steel, the depth to which carbon is introduced is determined by that limit.

Theory of the Cap.—The introduction of the cap which is now fitted to all armor-piercing projectiles materially reduced the resisting power of hard-faced armor. For so simple a device, its effect is marvelous. It is efficient only against hard-faced armor, and it is a question whether its action has been satisfactorily explained. The most plausible theory is as follows: When the mass, consisting of projectile and cap, meets the hard face of the plate, the latter is elastically dished and the resistance concentrated. The cap is strong enough to transmit the stress of impact, and at the same time the projectile proper is not stopped suddenly as is the case with an uncapped projectile; it continues to advance through the cap, its passage through the latter being comparatively easy, and when the point reaches the plate it finds the latter already dished, perhaps, to its elastic limit. The resistance then becomes purely local, and the effect

is similar to the impact of an uncapped projectile against a homogeneous plate, save the flow of displaced metal to the front which occurs in the latter.

3. General Discussion.—The prime function of armor as applied to vessels of war is to keep out shell, and the qualities sought to be obtained are first, resistance to penetration, and second, a minimum tendency to crack. With modern methods of securing armor the importance of the latter is not so great as formerly. It is, however, an element of weakness in that it makes the plate more vulnerable to the next hit, so far as resistance to perforation goes.

The question of racking effect on the structure of the ship and on the machinery, main and auxiliary of the vessel is not now considered. Proving Ground experiments have shown that the shock of impact is dissipated by work on the projectile, or is absorbed by the armor plate and its supports.

4. Method of Securing.—Wood backing is used for the purpose of insuring a good fit and to provide a sufficient length of armor bolt. It is being gradually reduced in thickness, and the tendency is to discard it altogether. In battleships of the Virginia class, and in subsequent designs, it has been given up for barbettes. It is not used for conning tower armor, signal tower, interior armor, or gun positions outside the casemate, except turrets. The four-inch side and casemate armor of the St. Louis class is being fitted without backing, the plates being disposed vertically, 8 feet wide and about 17 feet long, extending from the armor shelf to the port sill.

5. Armor Bolts.—The following table shows the size of bolt for each thickness of armor:

Size of bolt.	Thickness of armor.
1.5 inches	To and including 5 inches.
2.0 inches	From 5 inches to 9 inches.
2.4 inches	From 9 inches to 13 inches.

Armor bolts are so spaced as to provide one bolt for every five square feet of surface, so far as the framing behind armor will permit, except in the case of 3-inch armor for which one bolt for about six square feet of surface is used.

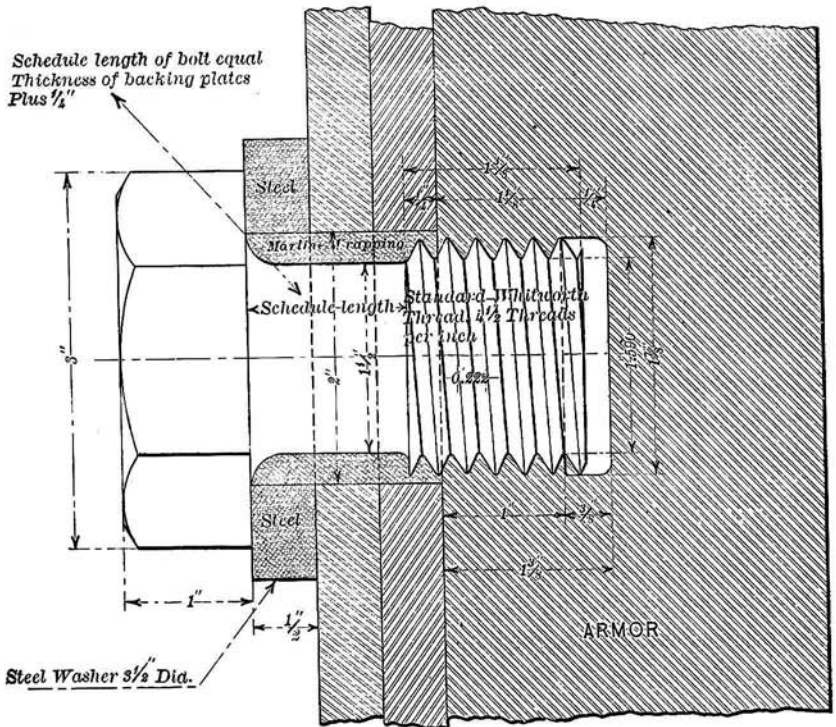


FIG. 1.

1.5-INCH BOLT FOR THIN ARMOR, WITHOUT BACKING.

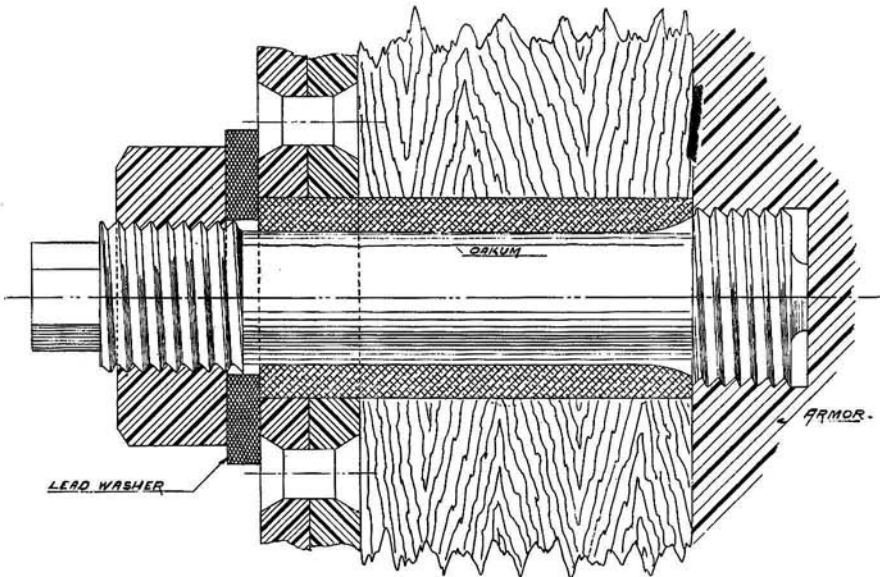


FIG. 2.

STANDARD ARMOR BOLT.

Plate I, Figs. 1 and 2, show types of bolts for armor with and without wood backing.

The bolts are made of nickel steel of such remarkable toughness that the plate will remain in place even if severely cracked.

6. Specification for Armor 1903.—The following extracts from circular and specifications, etc., 1903, shows the precautions taken by the government to insure as far as possible ballistic efficiency and uniformity of service armor.

The armor defined in these specifications shall, for the purpose of distinction, be classed as follows:

Class A, consisting of armor plates having a thickness greater than 5 inches, to be manufactured, reformed, and face-hardened by the best and most improved process, to be satisfactory to the Bureau of Ordnance.

Class B, consisting of armor plates having a thickness of 5 inches or less, to be manufactured, reformed, and face-hardened by a process satisfactory to the Bureau of Ordnance.

The tests for acceptance shall be made as strictly as practicable in accordance with the following tables, the Department reserving the right to use guns of other calibers than designated for any plate, if it is deemed advisable, the velocities being deduced for Class A armor by the De Marre formula for the perforation of homogeneous steel plates of the thickness of the plates to be tested and increased by the same percentage as that used in establishing the velocities given in the tables.

Class C, consisting of thin plates and hollow forgings, such as turret tops, doors, communication and ammunition hoist tubes, to be oil or water tempered and annealed, but not face-hardened. Class C armor is not subject to ballistic test.

Class D, consisting of armor bolts and nuts.

The ballistic test for acceptance of armor of Class A shall in no case be less severe than the following:

There shall be three impacts with striking velocities as given in the following table, capped armor-piercing projectiles being used:

Caliber of gun. <i>Inches.</i>	Thickness of plate. <i>Inches.</i>	Striking velocity. <i>Foot-seconds.</i>
4	4	1,603
5	5	1,804
6	6	1,658
7	7	1,625
8	8	1,601
8	9	1,739
10	10	1,565
10	11	1,608
12	12	1,506

The first impact shall be located near the central portion of the plate, and on this impact no portion of the projectile shall get entirely through the plate and backing, nor shall any through crack develop to an edge of the plate.

There shall be two other impacts with capped armor-piercing shell to be located as may be directed by the Bureau; no impact, however, to be nearer another impact or an edge of the plate than $3\frac{1}{2}$ calibers of the projectile used. On these impacts no shell or fragment thereof shall get entirely through the plate and backing.

For plates having a thickness not shown in the tables, the striking velocity shall be determined by interpolation, the Bureau to decide whether the caliber of gun next greater or next smaller shall be used.

The velocities for the test of Class B armor shall be those given in the following table, the impacts to be located as for Class A armor and the requirements as to cracking and perforation the same:

Caliber of gun. <i>Inches.</i>	Thickness of plate. <i>Inches.</i>	Striking velocity. <i>Foot-seconds.</i>
4	4	1,394
5	5	1,556
6	6	1,442

7. Ballistic Tests for Class A Armor.—The ballistic test is the chief one, and the object of all the other tests of plates is to insure, so far as possible, that the remaining plates of a group

are capable of standing as severe a test as that to which the test plate has been subjected; and the uniformity required among the plates of a group will be only such as may be necessary for this purpose. The plates from each group intended for the ballistic test will be selected by the Department, after all the plates of the group which are subject to ballistic test have received their final treatment and passed satisfactory tests for uniformity. Plates having gun ports or torpedo ports and face-hardened to be excluded from ballistic test after the ports are cut.

8. The bolt holes in the ballistic-test plate will be arranged, when conveniently practicable, in the same manner as for fastening a similar plate to the vessel's side.

9. Ballistic plates will be bolted to a backing of 6 inches of oak and one 5-8 inch ship plate. The backing, including oak and plate and studs for holding in bolts, must be furnished, fitted, and secured by the contractor, but the Department will defray the actual expenses thereof. If the plate is tapered, or otherwise intentionally varied in thickness, the backing will be maintained of full depth behind the thickest part. The whole structure will be braced from the rear, and the bolts will be of the same kind as are to be used on shipboard.

10. In ballistic tests the projectile shall be fired through screens to determine its velocity, when practicable.

11. Steel-capped projectiles of service type in use at time of test shall be used in the ballistic tests of armor. If a new and improved type of armor-piercing projectile should be adopted for service use, such modifications of the striking velocities will be made by mutual consent as shall appear fair and reasonable.

12. Firing at a plate will be stopped whenever, in the opinion of the inspector, the plate has demonstrated its incapacity to stand the full test.

13. If the group represented by the successful test plate has shown a close uniformity in quality, it shall be accepted as far as the ballistic test is concerned.

14. When the plates of a group do not show a close uniformity, if the first plate subjected to ballistic test passes, the Department may test two more before giving a decision as to acceptance of the group, but if all these plates pass, the Department

will pay for them all; if one or both of these plates fail, the successful plate or plates only will be paid for, and the acceptance of the group will be at the discretion of the Department.

15. After a group of plates is accepted, the Department may still test therefrom, ballistically, as many plates as it may desire and only such as pass will be paid for.

This paragraph will only apply when the Department has reason to believe that there is a lack of uniformity in the accepted group, or that defective plates are contained therein.

16. If the test plate shall fail to pass, the contractor may demand that another plate of the same group shall be selected by the Department and submitted to test. Should the second plate fail to pass, the group shall be rejected, unless, for good reason, the Department considers it desirable to continue the test.

If this plate successfully passes the test, the group may, at the discretion of the Department, be accepted; but if the Department so desires, it may select another plate (third) from the group, and on this test the acceptance or rejection of the group will definitely rest.

17. When more than one plate of any group is tested all those that pass the prescribed test shall be paid for at the contract price; provided the group to which they belong is accepted, but not otherwise.

In case of rejection, the contractor must replace the group within a reasonable time.

18. The success of the test plates defines the status of the group in a ballistic sense, but does not secure the individual plates from condemnation for causes which seriously impair their resistance, or which are referred to herein as objectionable.

19. **Bolts and Nuts.**—A number of nickel-steel armor bolts will be needed. The bolts and bolt holes are to be made and threaded, of dimensions, in numbers, and in the direction shown on the drawings to be furnished the contractor, or as stated by the Department.

20. Both the bolts and nuts will be of the best quality of nickel steel, oil or water tempered and then annealed, to contain about 3.25 per cent nickel.

21. The bolts shall be tested as follows: Two specimens shall

be taken from the bolts manufactured from each heat. If more than one hundred bolts are made from a single heat, the inspector shall select two bolts for test after forging and final treatment. If less than one hundred bolts are made from a single heat, the inspector shall select one bolt from which the two specimens shall be taken. The specimens shall be taken longitudinally, and for acceptance shall show not less than 80,000 pounds tensile strength and 27 per cent elongation in 2 inches.

22. The bolts of a heat to be presented for test shall be oil or water treated together and receive their final annealing in the same furnace charge, as far as practicable.

23. The bolts will be required to be of standard dimensions and interchangeable before provisional acceptance. Before shipment the bolt holes shall be packed with waste soaked in white lead and tallow, or protected by other suitable means; the bolts and nuts shall have their machined surfaces coated with white lead and tallow, and they shall be suitably packed for shipment.

24. Nuts shall be treated and tested by heats in the same way as bolts, except that the two specimens shall be taken in the direction of the height of the nut, and shall show for acceptance not less than 80,000 pounds tensile strength and 17 per cent elongation in 2 inches.

25. Arrangement and Disposition of Armor on U. S. Battleships.—The arrangement or armor of various classes is as follows:

1. Plates above 5 inches in thickness consist of cemented or supercarbonized steel plates, face-hardened by the Krupp process, comprising, on battleships, the main side-belt armor, turrets, barbettes, conning tower, casemate, and intermediate-battery protection.

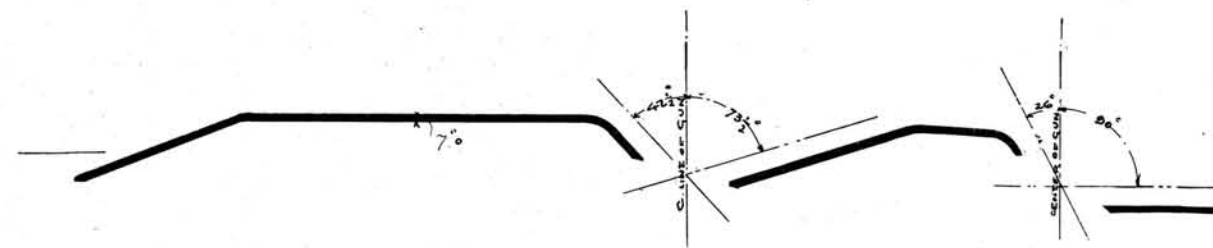
2. Plates not over 5 or less than 3 inches in thickness consisting of steel plates, face-hardened by the Harvey process, comprising the side armor plates forward and aft, when the thickness tapers to 5 inches or less, fore and aft and athwart-ship bulkheads, etc.

3. Thin plates, such as splinter bulkheads, protective decks, protection for minor-caliber guns, turret tops, sighting hoods, signal towers, ammunition and conning-tower tubes are made of homogeneous ni

4. Small, thick pieces, such as armor doors, strips above gun ports, etc., are made of Krupp noncemented steel.

The thickness depends first upon the importance of the position it is designed to protect and next on the resisting power of the armor. For the purpose of design, it is assumed that Kruppized armor will keep out projectiles of caliber equal to its thickness at moderate fighting ranges. Such, indeed, would be the case were it not for the assistance of the cap on projectiles, which is at once, probably, the simplest and most effective device ever developed in the history of ordnance. At normal impact and up to an angle of about 20 degrees the cap increases the perforating power of the projectile about 15 per cent with respect to velocity, and over 20 per cent with respect to thickness of armor, but it has another very important advantage in that it decreases the tendency of the shell to break up, preserving the latter so that it is well conditioned for exploding after passing through the armor. Its influence on the design of battleships is not yet materially felt, save, perhaps, in somewhat increased thickness and amount of armor carried. It is probable, however, if nothing is developed in armor that will defeat it, that it may induce a tendency to a more extended use of turrets with inclined front plates, so as to present an angle for impact beyond that at which the projectile will bite.

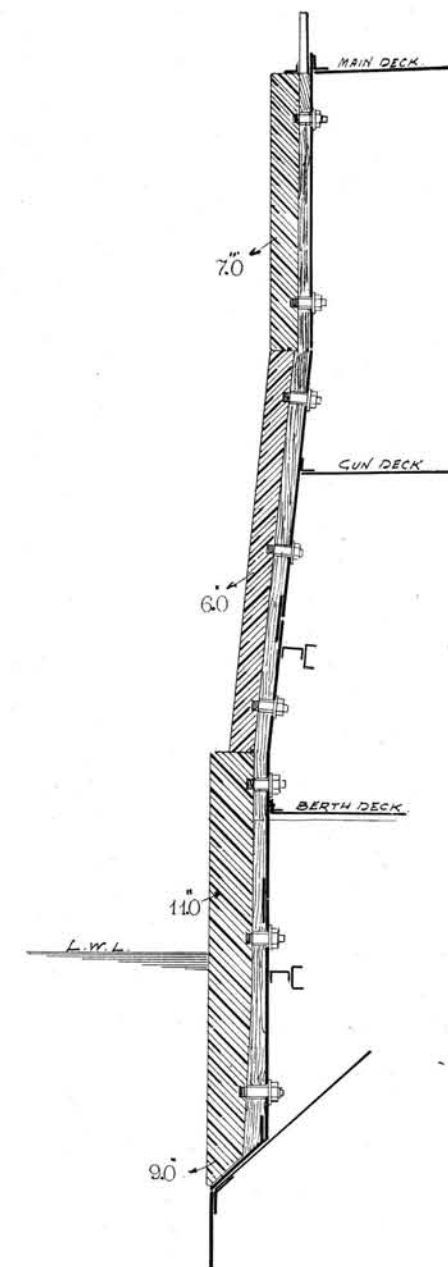
26. Armored Battleships—Oregon.—The evolution of design with reference to armor is brought out by a consideration of the types from the Oregon to the Connecticut class. The former has a very heavy water-line belt, 18 inches in thickness, extending along the machinery, magazine, and boiler spaces. At the ends of this are the barbettes, 17 inches thick, rising on the center line above the main deck. These barbettes protect the turret turning gear, and ammunition supply. Mounted over the barbettes are the turrets for the 13-inch guns, with 15 inches of armor at the sides and back and 17-inch port plates. The casemate armor is 5 inches thick, but is of limited extent, and but poorly protects the two broadside 6-inch guns. The quadrilateral 8-inch turrets have $8\frac{1}{2}$ inches of armor, the barbettes are 10 inches and the ammunition tubes 3 inches thick. The secondary battery is protected by 2-inch armor, and thin gun



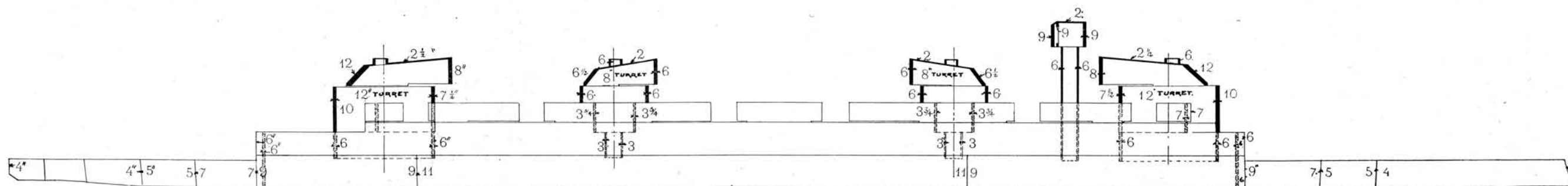
UPPER CASEMATE SIDE ARMOR

ESTIMATED WEIGHTS.

	Thickness.	Tons.
Side belt armor.....	11"	686.34
Side belt armor.....	9	254.04
Side belt armor.....	7	66.36
Side belt armor.....	5	52.78
Side belt armor.....	4	126.60
Lower casemate side armor.....	6	505.24
Upper casemate side armor.....	7	321.06
Triangular athwartship armor.....	6	13.80
Lower casemate athwartship armor.....	6	102.94
Upper casemate athwartship armor.....	7	69.74
Conning tower.....	9	39.00
Conning tower top.....	2	2.90
Conning tower shield.....	9	11.13
Conning tower shield top.....	2	.85
Conning tower armor tube.....	6	38.54
Signal tower.....	6	17.21
12-inch barbettes.....	10	318.42
12-inch barbettes.....	7½	79.72
12-inch barbettes.....	6	152.86
12-inch turrets.....	12	35.46
12-inch turrets.....	8	120.88
12-inch turrets.....	2½	35.46
12-inch turrets, sighting hoods.....	6	12.06
8-inch barbettes.....	6	94.16
8-inch barbettes.....	4	21.04
8-inch barbette tubes, upper.....	3¾	93.92
8-inch barbette tubes, lower.....	3	22.76
8-inch turrets.....	6½	33.40
8-inch turrets.....	6	131.52
8-inch turrets.....	2	30.02
8-inch turrets, sighting hoods.....	6	15.98
Total.....		3505.65 tons



MIDSHIP SECTION



CONNECTICUT AND LOUISIANA.

shields. There is a conning tower, 10 inches thick and a 7-inch communication tube. These vessels were designed before the Harvey process had been adopted for armor.

27. Iowa, Kearsarge and Kentucky.—The Iowa followed, the armor being distributed on the same general lines, but thinner in corresponding positions. In the Kearsarge and Kentucky we find a slight decrease in thickness to 16 inches and an extension of the water-line belt to the bow, tapering in thickness to 4 inches. The barbette and turret armor were slightly decreased in thickness and more importance given to the casemate armor, 5 inches thick, which was made to cover all the space between the barbettes. The conning tower, tubes, etc., remained practically the same.

28. Illinois Class.—Next came the Illinois class, including the Alabama and Wisconsin. The principal features of the armor design of these vessels was the abandonment of the 8-inch turrets, a more extensive use of the casemate armor, which was made 5½ inches thick to protect the 6-inch battery, the introduction of splinter bulkheads, and what is very important, the adoption of the inclined port plate for the 13-inch turret guns.

29. Maine Class.—The Maine class followed. The general design of these vessels is similar to that of the Illinois; 5½-inch armor was used for the casemates, and Krupp armor being at this time adopted, the armor protection was considered to be very much superior to the Illinois class. See Plate II.

30. Virginia Class.—In the Virginia class there is a return to the 8-inch turrets, two being superposed on the 12-inch like the Kearsarge and Kentucky and two being placed in broadside. The inclined port plates, however, of the former which permits of a minimum port opening, and at the same time are inclined at a sufficient angle to deflect projectiles, give very much better protection though the thickness is only 6½ inches against 8 inches for the Kearsarge. The 12-inch belt was retained, but was carried all the way aft, tapering to 4 inches at the stern as well as at the bow. The casemate was still further extended, being carried forward and aft with athwartship bulkheads so as to include the 12-inch barbettes.

31. Connecticut and Louisiana.—In the Connecticut and

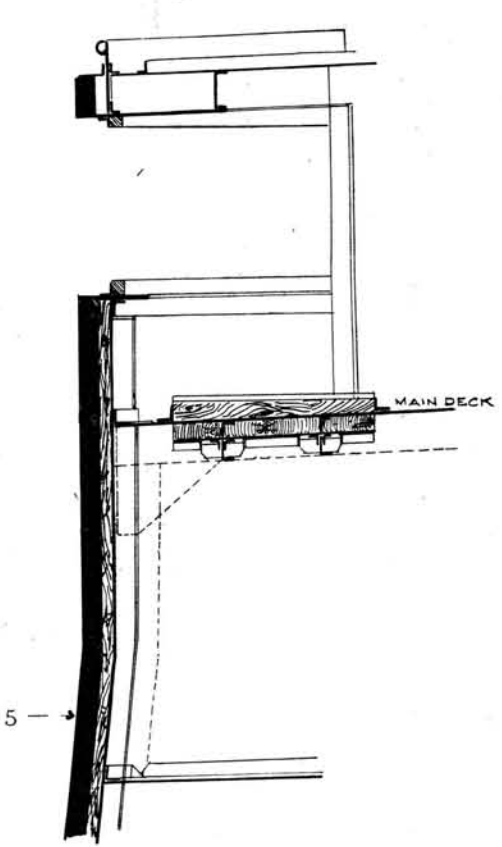
Louisiana, we find a reduction in thickness to 11 inches in the water-line belt, the 8-inch turrets are disposed quadrilaterally, the upper casemate armor is made 7 inches thick to protect the 7-inch guns. The general arrangement and disposition of the armor with the weights of each class are shown in Plate III.

32. Distribution of Armor on Monitors.—It has been demonstrated that such craft are only efficient in smooth water. They are now considered only as a means of harbor defense, and as other methods are more efficient for the purpose, the type has been abandoned. Future design need not therefore be considered. As a matter of fact there has been no change in the principle of design, since the original monitor. The essential features are: A complete water-line belt of maximum thickness in wake of the machinery and magazine spaces, tapering to the ends; a deflective and protective deck, similar to that worked in battleships; turrets mounted on the center line, revolving in heavy barbettes.

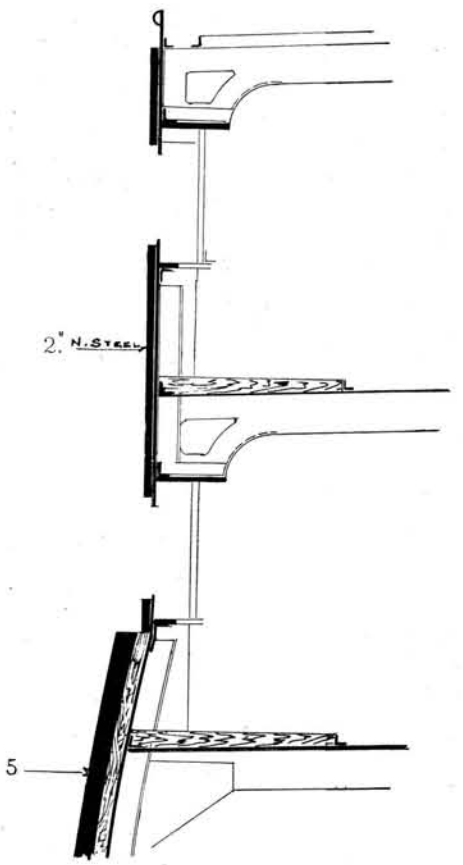
33. Armored Cruisers.—The evolution of the armored cruiser from the New York and Brooklyn to the latest type represented by the Tennessee class, Plate IV, has developed what is in reality a battleship. To compare the Tennessee and Connecticut, for example, we find the same principles applied in the distribution of armor in the one as in the other; namely, a water-line belt 5 inches thick; casemate armor, continuous with the belt and of the same thickness, completely enclosing the broadside battery; protective decks; turrets with 7-inch sides and 5-inch back, and 9-inch port plates; 7-inch maximum on barbettes; splinter bulkheads, conning tower, armored tubes, etc., all being very much lighter.

Many are of the opinion that the limit has been reached in this type and that the logical principles of attack and defense, in war ship design, which means using the most efficient weapon to the end, have not been exemplified in this type.

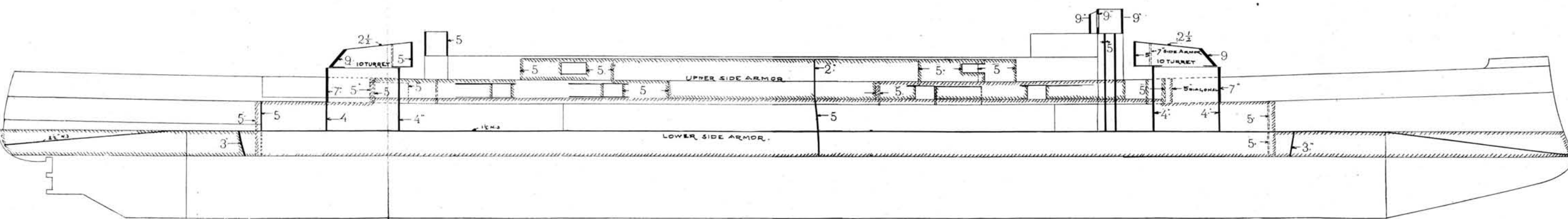
34. Milwaukee Type.—The Milwaukee type, called protected cruisers, but in reality armored cruisers, carry 4 inches of armor to protect the water-line amidships and the broadside battery, and the armor forms in effect a central citadel or casemate of uniform thickness extending from below the water-line to the



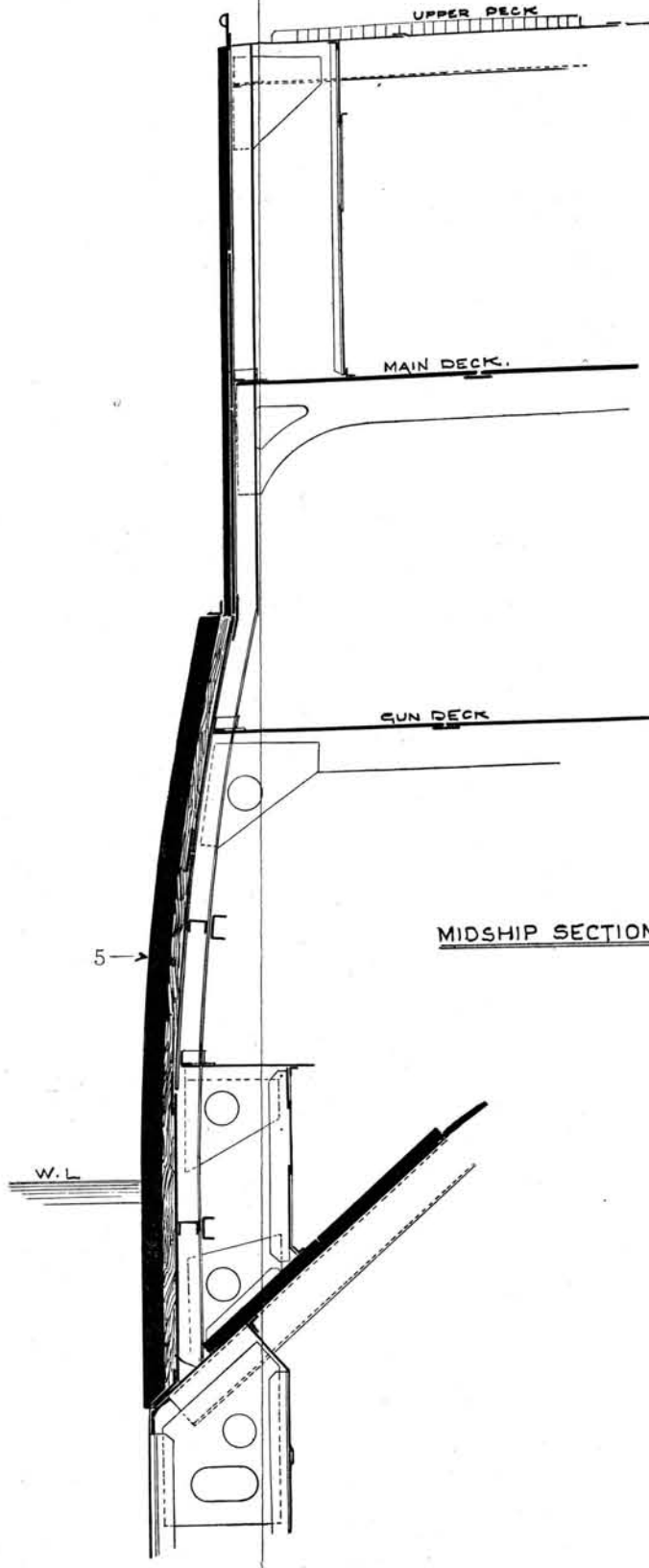
SECTION THROUGH 6" GUN PORT
— MAIN DECK. —



— SECTION THROUGH 3 1/2" GUN PORT. —



ARMORED CRUISER TENNESSEE.



MIDSHIP SECTION

upper deck and completely enclosing the central portion of the ship. This protection is supplemented by the usual protective deck, cofferdams containing cellulose, and coal bunkers.

35. Gun Shields.—Opinion is divided as to the efficacy of gun shields for guns in positions unprotected by armor. On the one hand it is argued that such shields serve merely as means for bursting shell, thus menacing the personnel of the gun's crew, whereas without the shield, the shell would pass harmlessly by. Others maintain that it is better to be certain of defeating smaller calibre projectiles and take chances of being struck by shell that will pierce the shield.

If properly disposed, shields form the best possible protection for the guns. The inclined port plates of turrets are in reality shields. The round shields covering the guns in the reentrant ports of the casemate guns in battleships are absolutely necessary as protection against fragments of shell.

In general it may be said to be good policy to fit shields to all guns where it is possible to make them sufficiently resisting to give complete protection against all shell of the same or less calibre than the gun to which the shield is fitted.

36. Tendency of Battleship Design.—Armor serves two purposes; first, protection for the personnel, which involves that of the gun positions and armament, and second, protection for the flotability and interior mechanism of the vessel. The latter includes protection of the hull and machinery. The present system is to protect the water-line area by an armor belt about 8 feet wide, $3\frac{1}{2}$ feet below the water-line and $4\frac{1}{2}$ feet above, extending the whole length of the ship, of maximum thickness in wake of the machinery and magazine spaces, and tapering to about 4 inches at the bow and stern. This belt is supplemented by a deflective or protective deck, sloping from the bottom of the armor belt, the whole length of the ship, flat in the center amidships, and crowned fore and aft as indicated on the type sketch of the Connecticut. There are also cofferdams filled with cellulose, and coal bunkers. The principal function of the coal is to smother fragments of bursting shell, and its value as protection is only incidental. Modern methods of construction have so minimized the effect of a water-line hit that it is doubtful

if it would be possible to seriously affect the stability or even the trim of a battleship by a single impact at the water-line. And the chances of such a hit are extremely small, as witnessed by the recent actions at the Yalu and during the Spanish War. Hence more importance is being attached to the protection of the personnel, so that we see a steady decrease in thickness of the water-line belt, and an increase in thickness of the casemates. It is generally agreed that the best method of protecting the heavy guns is to mount them in turrets rising out of heavily armored barbettes. The casemate method of protecting the intermediate or broadside battery (guns of calibre less than 8 inches) has been used from the beginning of modern construction, but many well-informed officers believe that present direction of development will induce a more extended use of turrets.

Future design as regards armor protection will be influenced by (1) Increase in the calibre of broadside guns (7-inch guns have recently been adopted for the broadside battery of the Connecticut), which will involve a commensurate thickness of armor for protection; and for guns above 7-inch calibre, perhaps mechanical appliances for operating; (2) Improvement in the quality of A. P. projectiles whereby a capped projectile, at any range within 3000 yards, and for the larger calibres than 6 inches at considerably greater ranges, will, if striking normally, perforate the best armor a calibre in thickness and burst inside. This will involve an increase in thickness of armor, or some method of inclining it beyond the biting or efficient angle of the cap; (3) Improved methods of construction that minimize the danger to flotability and stability if struck in the water-line region, and the effect of bursting shell in portions of the ship other than gun positions, which involves a decrease in thickness of water-line armor, and a concentration of protection at the gun positions. (4) The use of electrical machinery for sighting the guns and supplying ammunition, whereby it is possible to handle the larger calibre guns (above 6-inch or 7-inch), with great ease and nicety, so that it is not too much to hope to get as good results in the matter of rapidity and accuracy of fire as could be obtained from the smaller calibre guns handled by hand.

(5) Possible improvement in the quality of armor. It is doubt-

ful, however, if such improvement will keep pace with the gun and projectile.

All these considerations would, so far as armor protection goes, seem to point to a more extended use of turrets, with inclined port plates. In the matter of armor disposition the present design of turret could hardly be improved upon, having its port plate inclined at an angle beyond that at which projectiles will bite, and with minimum openings for the guns.

37. Outside Explosions.—The use of high explosives in the the form of the aerial torpedo in the attack on armor formerly had many advocates, but recent experiments have shown that this method is not efficient. In November, 1901, at Sandy Hook, N. J., a Gathmann 18-inch aerial torpedo was fired from an 18-inch powder gun, especially constructed for the purpose, at an 11½-inch Kruppized armor plate. The projectile weighed 1834 pounds, including 497 pounds of wet gun cotton, and the fuze was so designed as to detonate the mass of gun cotton upon impact. The impact was at a velocity of 1650 foot-seconds, corresponding to an energy of 34,610 foot tons. The gun cotton detonated on striking the plate, and the effect on the plate due to the explosion was nil. The plate was attached to a structure built to simulate a section of the side of a battleship, and the effect of the explosion on the structure seemed to indicate that the detonation of 500 pounds of high explosion against the armored side of a battleship would not seriously affect the structure of the vessel. Two succeeding impacts of projectiles containing the same amount of explosive confirmed the result of the first round.

The result of this test raises the question whether it would not be practicable to armor the bottom of a battleship so as to secure immunity from automobile torpedoes.

38. Penetrating Power of Naval Guns.—The following table shows the power of our naval guns with respect to the perforation of modern armor.

TABLE OF ELEMENTS OF NAVAL GUNS (MODELS OF 1899), GIVING PERFORATION OF FACE-HARDENED ARMOR, SERVICE VELOCITIES, AT RANGES UP TO 3000 YARDS, WITH SMOKELESS POWDER, CAPPED AND UNCAPPED ARMOR-PIERCING PROJECTILES, AT NORMAL IMPACT.

Caliber of Gun	Weight in tons	Length in caliber	Total length in inches	Total length of bore	Approximate charge of smokeless powder for maximum velocity	Weight of projectile	Muzzle velocity	Muzzle energy	Perforation at muzzle				Remaining velocity at 1000 yds.	Perforation at 1000 yds.				Remaining velocity at 2000 yds.	Perforation at 2000 yds.				Remaining velocity at 3000 yds.	Perforation at 3000 yds.				
									Harvey nickel-steel		Krupp armor			Harvey nickel-steel		Krupp armor			Harvey nickel-steel		Krupp armor			Harvey nickel-steel		Krupp armor		
									Projectiles		Projectiles			Projectiles		Projectiles			Projectiles		Projectiles			Projectiles		Projectiles		
									Capped	Uncapped	Capped	Uncapped		Capped	Uncapped	Capped	Uncapped		Capped	Uncapped	Capped	Uncapped		Capped	Uncapped	Capped	Uncapped	
3-inch, Mark I	.87	50	154.3	149.7	5.	13.	2800	709	4.4	3.6	4.4	3.6	2130	3.1	...	3.1	...	1620	...	...	...	...	...	...	...	...	...	...
4-inch, Mark VII .	2.56	50	204.5	200.	15.	32.	2900	1870	6.7	5.7	6.4	5.6	2380	5.3	4.4	5.2	4.4	1955	4.	3.4	4.	3.4	1605	3.2	...	3.2	...	
5-inch, Mark V ...	4.4	50	255.	250.	27.	60.	2900	3503	8.6	7.5	8.4	6.6	2460	7.	6.	6.7	5.6	2085	5.7	4.7	5.5	4.7	1770	4.6	3.9	4.6	3.6	
6-inch, Mark VI ..	8.37	50	300.	293.74	46.	100.	2900	5838	10.9	9.3	10.9	7.3	2525	8.9	7.7	8.8	6.8	2185	7.4	6.4	7.2	6.	1895	6.2	5.3	5.9	5.2	
7-inch, Mark I	13.33	45	315.	307.	74.	165.	2900	9046	13.2	11.8	13.2	10.5	2580	11.4	10.1	11.4	8.9	2295	9.8	8.6	9.7	7.6	2040	8.5	7.4	8.3	6.5	
8-inch, Mark V	18.	45	343.	335.	115.	250.	2800	13602	15.0	13.6	15.	12.1	2530	13.2	11.8	13.2	10.4	2290	11.7	10.4	11.7	9.1	2070	10.3	9.	10.3	7.9	
10-inch, Mark III ..	33.4	40	400.	389.	240.	500.	2800	27204	20.	18.6	20.	17.1	2585	18.3	16.7	18.3	15.	2390	16.5	15.	16.5	13.5	2210	15.	13.	15.	11.5	
12-inch, Mark III ..	52.	40	493.	480.1	385.	850.	2800	46246	25.	23.4	25.	21.7	2620	23.	21.4	23.	19.4	2450	21.2	19.6	21.2	17.9	2295	19.5	17.9	19.5	16.2	

NAVY DEPARTMENT,
BUREAU OF ORDNANCE,
August 20, 1901.

CHAPTER XXX.

PENETRATION OF PROJECTILES.

By LIEUTENANT CLELAND DAVIS, U. S. Navy.

1. General Discussion.—When a projectile strikes a target, and its motion is destroyed, the motion must be dissipated by (1) heating the target; (2) heating the projectile; (3) changing the form of the projectile; (4) changing the form of the target. All of these but the last are, from the artillerist's standpoint, a waste. The amount of energy which takes the form of heat in the projectile and target is not known, but could be approximately ascertained by the use of bodies which ignited or fused at known temperatures. It is known that the temperature of the shell is sufficiently great to ignite the bursting charge (540° F.), and this indicates an amount of energy which must have been reached or exceeded.

No accurate experiments have as yet been carried out in order to determine the coefficients of resistance for the different materials of projectiles and plates, so that it is difficult to study the subject in a rigidly mathematical way. But practically the amount of penetration, whether for iron or steel plates, masonry, or for earth, has been determined by experiment. A number of formulas have been proposed, based on various hypotheses, and which agree more or less closely with the results obtained in actual firing. The diversity of the formulas proposed testifies to the difficulty of expressing the law of resistance of armored shields to perforation; and it is very doubtful if it be possible to express this law by an exact formula, since the resistance of the plates and the power of projectiles to overcome that resistance depend on so many conditions that escape calculation. Plates vary in different foundries; the same foundry cannot always deliver plates exactly alike, and any single plate is not perfectly homogeneous. The same may be said, to a less degree perhaps,

of the projectiles; in addition may be mentioned the variation in shape of the projectile on impact, the possibility of the projectile breaking up, and the amount of heat developed on impact; all of these varying conditions make it practically impossible to apply strictly analytical investigations and deduce a law which will stand the test of general application.

2. The Penetrative Effect.—Generally speaking, the penetrative effect depends on the shape and material of the projectile, on its energy, diameter, and the direction in which it strikes the target.

3. Form of Head.—Several forms of head have been extensively experimented with, viz., flat, ogival, hemispherical, and conoidal. For piercing plates by shot striking normal to the surface of the plate, the ogival head of two to two and a half diameters is considered to have given the best results.

4. The Steel Cap.—A soft steel cap is now being fitted to all A. P. projectiles. This cap is in diameter about half the calibre of the projectile, and is about 4 per cent of the weight. Its action is fully explained in the preceding chapter. It adds about 15 per cent to the efficiency of the projectile with respect to the thickness of the plate and about 20 per cent with respect to the striking velocity.

5. Material.—Chilled iron, wrought iron, and steel have been experimented with to ascertain their respective merits for materials to make projectiles for piercing armor plates. Although chilled iron has been used on account of its easier manipulation, its great hardness, and its cheapness, the best material for projectiles to pierce armor is that which will neither break up on impact nor change its shape; this metal is a forged oil-tempered steel of special treatment and of special alloy which fulfills these conditions better than any other metal.

Various elements have been and are used to alloy the steel in order to obtain the requisite qualities for a good armor piercing projectile; these include principally nickel, chrome, manganese, and tungsten, and are combined in various ways to produce the desired results, namely a maximum of hardness combined with a maximum of toughness.

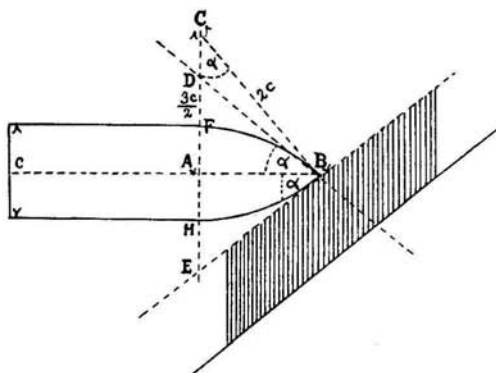
6. Change of shape means a loss of energy uselessly expended

ERRATUM.

Page 371, Par. 8; Text-Book of Ordnance and Gunnery, 1903, and the figure on the same page illustrating the *biting angle*.

The line CB, which is the tangent to the ogival, is *not co-incident with the radius* for this ogival and is *not equal* to $2c$ in length. And the computation of α for different radii on pages 371 and 372 is incorrect.

Substitute the following figure for that in the book, and the following computation of α for that contained in the last two lines on page 371 and the first four lines on page 372.



The figure shows the shell striking the plate at the *biting angle*, i. e., with the tangent EB in the plane of the plate's surface. Radius of ogival two calibers.

$$CB = 2c = \text{radius of arc HB} . AC = \frac{3c}{2} .$$

The angle $ACB = ABE =$ the biting angle, α , because its sides are perpendicular, respectively, to AB and BE.

$$\text{From the triangle ABC, } \cos \alpha = \frac{\frac{3c}{2}}{2c} = \frac{3}{4} \therefore \alpha = 41^{\circ} - 24' - 30'' .$$

From the above it will be seen that the value of α may be expressed as follows:

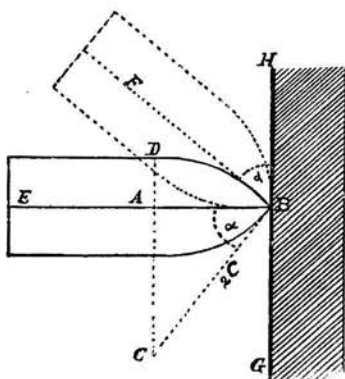
$$\alpha = \cos^{-1} \frac{n - \frac{1}{2}}{n} \text{ where } n = \text{radius of the ogival in calibers} .$$

$$\text{Thus, for } n = 2\frac{1}{2}, \alpha = \cos^{-1} \frac{4}{5} = 36^{\circ} - 52' .$$

$$n = 2, \alpha = \cos^{-1} \frac{3}{4} = 41^{\circ} - 24' - 30'' .$$

$$n = 1\frac{1}{2}, \alpha = \cos^{-1} \frac{2}{3} = 48^{\circ} - 11' , \text{ etc., etc.}$$

in heating the projectile; and if the projectile breaks up, it generally fails to impress all its energy on the armor plate. Tough steel more nearly answers the requirements for armor-piercing than any other metal. Forged steel is better than cast steel, as it does not break up on impact; and if the power of the armor for resistance nearly equals the power of the projectile for penetration, it is the only metal that will carry a bursting charge through the plate. With nickel steel armor, Harveyized, or with Krupp process armor, it is even more necessary to have forged steel projectiles of special treatment and of special alloy, since experiments show that those constructed of other materials break up on impact.



7. **The best weight** for a projectile of given diameter is generally found by giving a value to the ratio of $\frac{W}{d^3}$, where W = weight of shot, d = diameter. The latest researches give .45 to .5 as the value of this ratio. Thus for a 6-inch gun the weight would be not less than 97 pounds.

8. **The Biting Angle.**—It is evident that the point of an ogival-headed projectile will not bite thick armor at a less angle than that made by the tangent to the projectile at its point and the axis of the projectile. This will be seen from an inspection of the figure, and this angle is called the *biting angle*.

The angle made by the tangent CB with the axis of the projectile is equal to the angle ABC , and when the head is struck

with a radius of 2 diam. if c be the diam., we have $\sin a = \frac{3}{4}$, . . . $a = 48^\circ 30'$, about. Similarly, it may be shown that when the head is struck with a radius of $1\frac{1}{2}$ diam. that the angle will be about 42° . If the plate is of comparatively soft metal, such as wrought iron and low steel, the shot will bite at a slightly less angle, owing to the fact that the plate bends slightly on impact and increases the angle between the tangent and the surface.

It has been demonstrated experimentally at the N. O. P. G., heads of various shapes having been used, that the flat-headed projectile is the superior of all others, at short ranges, against armor inclined at small angles to the line of fire.

9. Biting Angle of the Cap.—Proving ground experiments have demonstrated that the cap is not efficient at angles of impact above about 20° from the normal. In other words this is the biting angle of the cap. Taken in connection with the theory of the cap, the reason of this is susceptible of explanation. Assuming that the normal component only of the total striking energy is useful in smashing in the hard face, there is a point at which this component is not sufficient to give the desired result, so that the effect is the same as if the projectile were not capped.

10. Empirical Formulas for Penetration.—For thin plates which can be easily penetrated, experiment seems to show that the projectile acts as a punch, cracking the plate *circumferentially*, at the same time bulging it on the inside, where it also commences to crack. In this case the method of estimating the resistance per inch of projectile's circumference gives good results, but in cases where the projectile acts as a wedge, and drives the resisting material before it, the method of estimating the resistance per square inch of sectional area gives approximately better results. The truth probably lies between the two; inclining the more to the one or the other according as a punching or wedging action is brought into play.

The following formulas, by Th. Jacob de Marre, Capitaine d'Artillerie de la Marine, France, are those now in use, and have been deduced from the results of experience.

In these formulas,

v = striking velocity in f. s.

p = weight of projectile in pounds.

c = diameter in inches.

E = thickness penetrated in inches.

The quantities in brackets are the logarithms of constants.

For penetration of wood backing,

$$E^{0.6} = [7.79013 - 10] \frac{p^{\frac{1}{2}} v}{c^{0.9}}. \quad (1)$$

For penetration of wrought iron,

$$E^{0.65} = [7.03838 - 10] \frac{p^{\frac{1}{2}} v}{c^{\frac{3}{4}}}. \quad (2)$$

For penetration of thin steel plates, not Harveyized, by steel shell from 6-pounder R. F. guns, and smaller calibres,

$$E^{0.7} = [6.86572 - 10] \frac{p^{\frac{1}{2}} v}{c^{\frac{3}{4}}}. \quad (3)$$

For penetration of thick plates, not Harveyized,

$$E^{0.7} = [6.99066 - 10] \frac{p^{\frac{1}{2}} v}{c^{\frac{3}{4}}}. \quad (4)$$

To find the striking velocity necessary to penetrate a given thickness of plate and backing, solve the proper formulas for v . If v_1 is the striking velocity necessary to penetrate the plate, and v_2 the striking velocity for the backing, the required velocity is

$$v = \sqrt{v_1^2 + v_2^2}.$$

The use of formula (4):

* "Formula (4) can be put in the form

$$v = K \frac{c^{\frac{3}{4}}}{p^{\frac{1}{2}}} E^{1.0}.$$

It is still used to represent the average resistance to the armor-piercing projectile when it penetrates the armor plate without being deformed, the plate being oil tempered and annealed. The value of K is 1022. for practical purposes.

With a face-hardened plate it has come to be the practice to use this formula with its velocity or the thickness of the plate multiplied by some factor. For some time, for example, our government shot at plates as if they were 1.15 times their thick-

* Discussion by J. F. Meigs, Artillery Engineer of the Bethlehem Iron Co.

ness, but at present it is the practice to multiply the velocity as derived from de Marre's formula, as formula (4) is called, by a factor, which factor has been 1.38 on thin plates of 5 inches and 6 inches in thickness, and about 1.30 on thick plates of 12 inches to 15 inches in thickness. These factors are used only in the case of Krupp process plates. With ordinary hard-faced plates, which were called Harvey plates, the factor could not reach so high a value.

The difficulty of measuring resistance of the hard face plate is much greater than in the case of the soft plates, because it becomes largely a question between the temper of the plate and the projectile.

If the temper and toughness of the projectile could be made perfect they would unquestionably penetrate the existing armor plate, but in existing armor plates the hard face is relied upon to destroy the projectile and thus prevent its penetration. It will be noted that the head and point of the projectile are hard and its base end soft and tough, and that it presents itself in just the same way to the impact as does the plate."

11. Recent Formulas.—Other formulas for the penetration of both homogeneous and face-hardened armor have been proposed both in this country and abroad, but the de Marre formula is the one on which ballistic tests are based universally, and this is of value to all governments in that it affords a basis of comparison as to the quality of armor each is getting.

The following formulæ were deduced by Lieut. Cleland Davis, U. S. Navy, from experiments made under the direction of the Bureau of Ordnance, for the perforation of Harveyized Armor:

Projectiles without caps. Capped projectiles.

$$V = \frac{c^{\frac{1}{2}} \varepsilon^{\frac{3}{2}}}{p^{\frac{1}{2}}} K \quad (1) \quad V = \frac{c^{\frac{1}{2}} \varepsilon^{\frac{3}{2}}}{p^{\frac{1}{2}}} K' \quad (2)$$

$\log K = 3.34512$, $\log K' = 3.25312$ using notation as before.

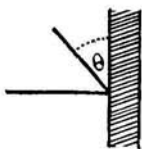
In these, the thickness of armor given just matches the velocity, so that under normal conditions of plate and projectile the latter would just get through, being itself destroyed in so doing. No satisfactory formula has yet been deduced for the perforation of Krupp armor. For capped projectiles, however, a fairly good

approximation may be obtained by adding a constant of from 100 to 150 foot-seconds to the velocity obtained from (2).

The velocities for the acceptance test of projectiles by the Bureau of Ordnance are based upon (2).

For uncapped projectiles, a fair approximation may be obtained for plates equal in thickness to the calibre of the attacking gun by adding 200 to 250 f. s. to the velocities given from formula (1).

12. Oblique Penetration.—When a target is penetrated by oblique fire, it is generally found that the projectile turns and penetrates nearly normal to the plate. The normal velocity is then $V \sin \theta$, if θ is the biting angle with the face of the plate. In formulas in which V is used, the value $V \sin \theta$ must be substituted.



13. Kinds of Projectiles.—Three kinds of projectiles are in use in the U. S. Navy for the large calibre guns: Armor piercing, common or semi-armor piercing, and shrapnel. The latter would only be used in the attack of exposed bodies of men on shore. The specifications for the two former require that armor piercing shell shall perforate face-hardened armor plate of thickness equal to the calibre, and remain in a condition for effective bursting. Semi-armor piercing, or forged steel shell, must pass through half a calibre of face-hardened armor and remain in a condition for effective bursting.

14. Development of High Explosive Shells.—Great Improvements have recently been made in armor piercing shell, and the fact that it is possible to send an armor piercing shell loaded with a high explosive through a thickness of plate equal to its calibre and detonate it behind the plate may result, eventually, in the adoption of but one type of shell for the Navy. The most striking example of this result was in the test of the 12-inch Army rifle in comparison with the 18-inch Gathmann Torpedo

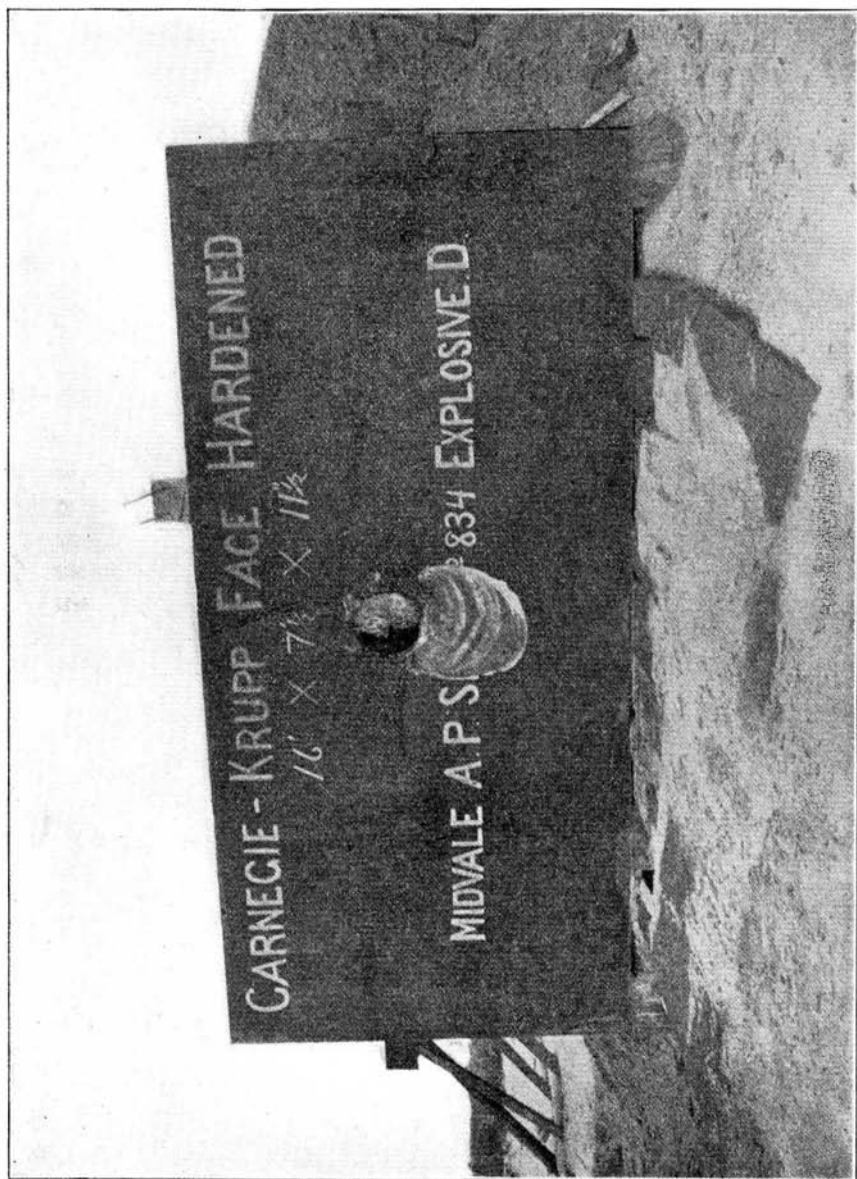
Gun. This test marked such an important advance in the attack on armor that the result is given in full together with photographs. The target was an 11½-inch Krupp plate, 16 feet long by 7½ feet wide attached to a structure which represented a section of the side of the Iowa.

Round one.—An armor piercing shot weighing 1001 pounds and 7 ounces, including 19 pounds 7 ounces of army high explosive, struck the center of the target with a velocity of 1800 feet per second, corresponding to a range of 4400 yards. The striking energy was 22,500 foot-tons. This shot penetrated the plate and was detonated just in the rear. The backing, the skin plates, frames, and cofferdam plates were completely demolished in the line of this impact. The crater formed in the sand butt in the rear of the structure measured 15 feet by 6½ feet. Pieces of the plate and projectile passed through the structure, through the butt, and were recovered at distances of 150 to 200 feet in rear of the butt. The rivets in the top plate were sheared, the side plates of the cofferdam were buckled about 3 inches, and the plate was forced back bodily about three-fourths of an inch. See Plates I and II.

Round two.—An army 12-inch armor piercing shot weighing 1006 pounds, including 23 pounds of Maximite, struck the right center of the plate with a velocity of 1804 feet per second, corresponding to a range of 4400 yards. The striking energy was 22,500 foot-tons. The shot detonated in the plate, completely wrecking the right-hand portion and demolishing the frames behind the armor and the plates of the cofferdam. See Plates III and IV.

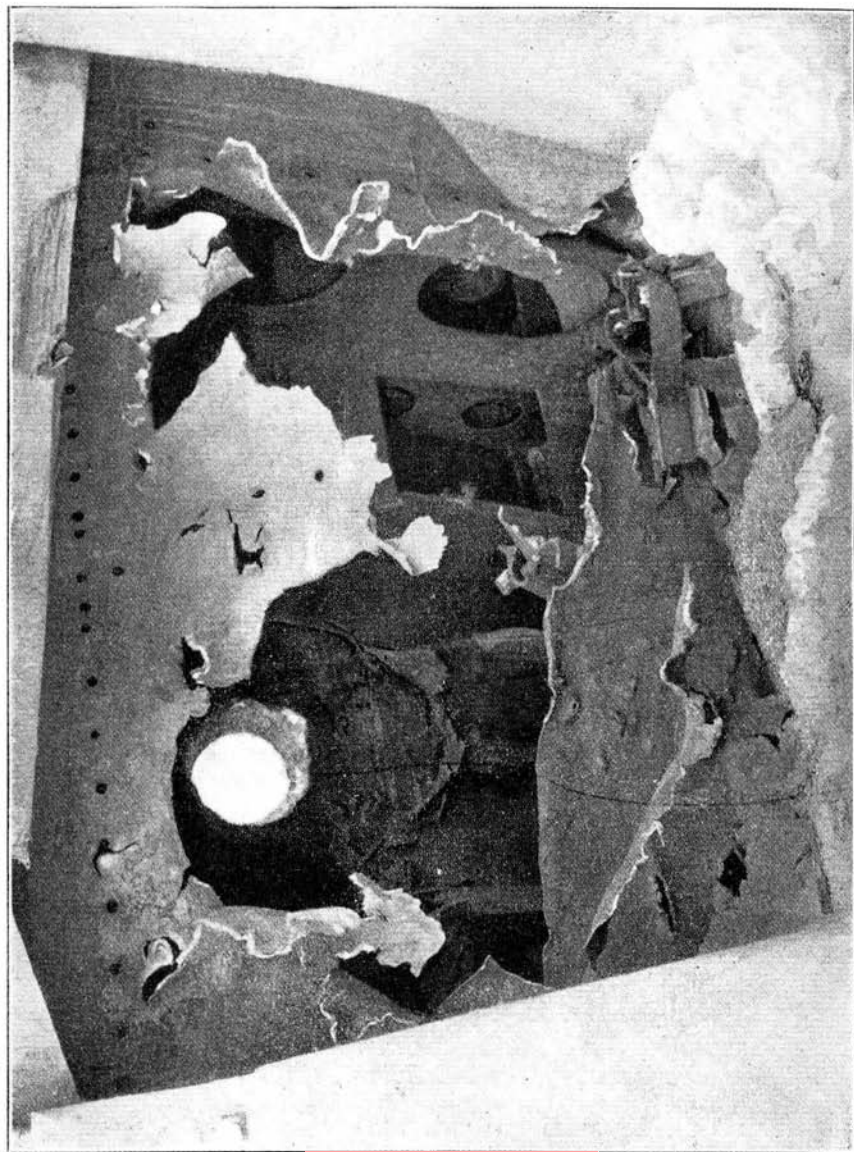
Round three.—A 12-inch armor piercing shell weighing 1045 pounds, including 60 pounds of army high explosive, struck the lower left-hand center of the plate with a velocity of 2073 feet per second, corresponding to a range of 1880 yards. The striking energy was 31,100 foot-tons. The shell penetrated and detonated in the plate: As a result of this impact the plate was totally wrecked and the backing, frames, beams, and cofferdam plates of the structure were completely demolished. An opening was made through the plate 4 feet wide by 8 feet long.

The lower left-hand quarter of the armor plate was broken



12-INCH ARMY SERVICE RIFLE TARGET. FIRST ROUND.

Front of Plate.

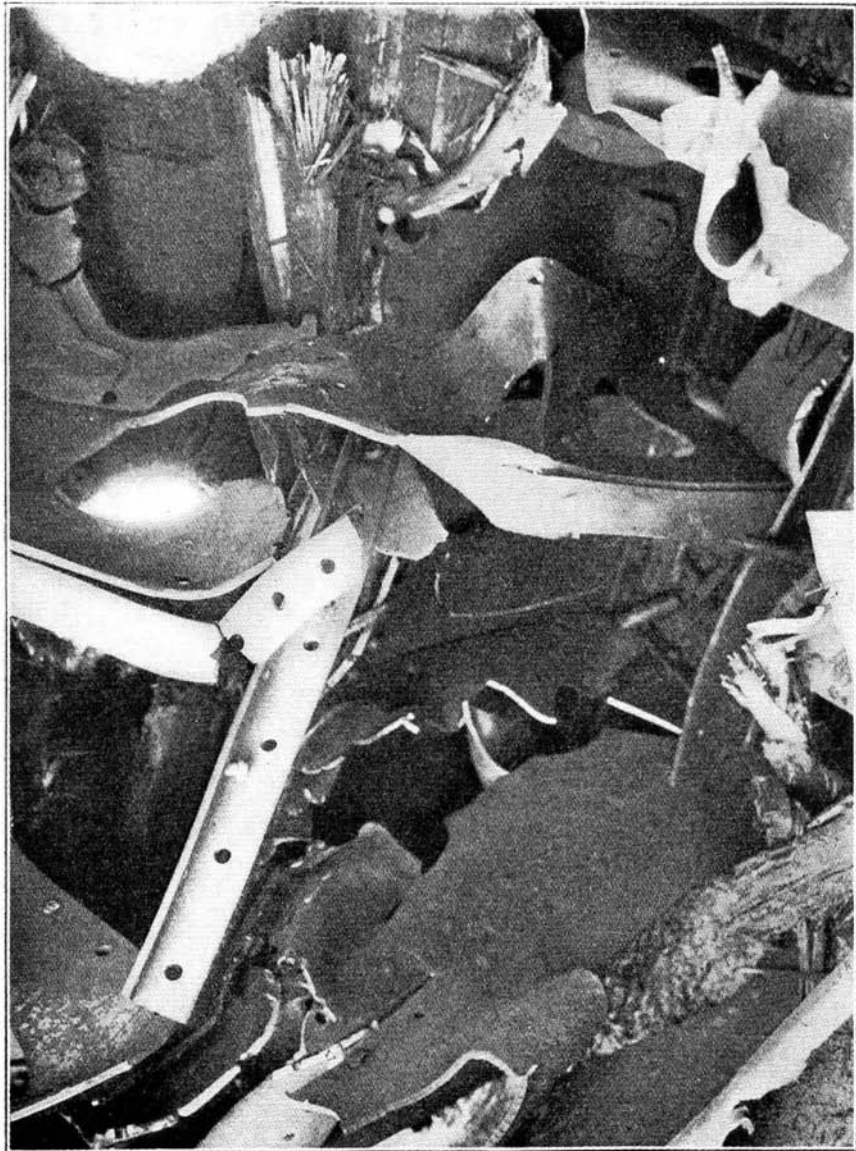


12-INCH ARMY SERVICE RIFLE TARGET. FIRST ROUND. Back of Plate.

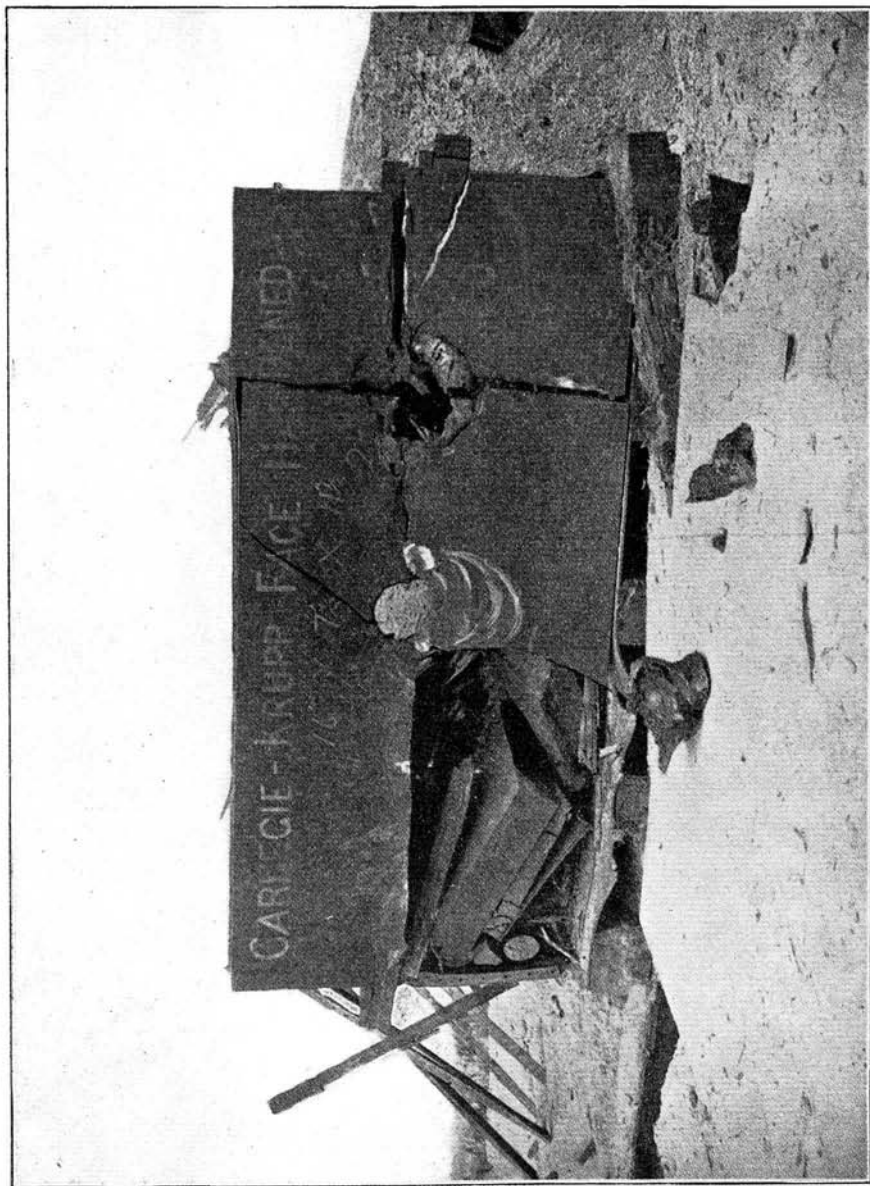


12-INCH ARMY SERVICE RIFLE TARGET. SECOND ROUND.

Front of Plate.



12-INCH ARMY SERVICE RIFLE TARGET. SECOND ROUND. Back of Plate.



12-INCH ARMY SERVICE RIFLE TARGET. THIRD ROUND.

Front of Plate.

into six large fragments and numerous small ones, the largest being about $4\frac{1}{2}$ feet square, which, with the backing and skin plates, was torn loose from the structure and turned inward, so that the left-hand edge of this fragment was in the plane of the original face of the plate. One large fragment about 2 feet by $2\frac{1}{2}$ feet by $11\frac{1}{2}$ inches, and weighing about 2500 pounds, was hurled through the target, through the butt, and was recovered 135 feet in the rear of the butt. Numerous fragments of the plate and projectile passed through the target structure, through the butt, and were recovered in the rear. The effect of this shot would have resulted in serious injury to a battleship. The comparative harmlessness of the Gathmann shell loaded with 500 pounds of gun cotton when exploded against this plate is referred to in the previous chapter. See Plate V.

15. The Attack of Armored Ships.—No academic rules can be laid down as to methods of attacking armored vessels. There are now but two classes of projectiles available, the armor piercing and the common or semi-armor piercing. All the former are now being filled with bursting charges, and the quality is being so much improved that those that will in future be issued to the service will possess the perforating power of the present armor piercing shell and at the same time have sufficient capacity for well-conditioned bursting. Assuming that the object is to explode the shell on the inside of the enemy's vessel, the rule would be to use whatever could accomplish that object. If the enemy is unarmored, semi-armor piercing or common shell should be used. If armored, it may be said in general that the heavier guns with A. P. shell should be used against the most important positions, which would be the most heavily armored, and the lighter calibre guns against the corresponding positions of the enemy. Whether A. P. or S. A. P. shell would be used in the latter case would depend upon the vulnerability of the protection. Of course, if only one type of shell were issued to the service the question would resolve itself into one of choosing what portion of the enemy to attack.

16. Experiences of Modern Warfare.—The battles of the Yalu of the China-Japan war, and the battles of the Spanish-American war, afford the only experiences of recent years in which armored vessels

In the battle of the Yalu, the heavy armor of the Chinese battle ships was not materially damaged, and so far as the life of the ships was concerned, they were effective at the close of the battle.

At the battle off Santiago, between the Spanish armored cruisers Maria Teresa, Oquendo, Viscaya and Colon, and the United States fleet, the Spanish cruisers, except the Colon, were totally destroyed, not by the piercing of their side armor, but by the destruction of their unarmored parts by the terrific effects of shell fire and by the fires created by bursting shells. The side armor, so far as is known, was not pierced, but the upper works, battery decks and all unarmored parts were riddled and torn to pieces, by the fire of common shell principally, the wood work being set on fire, fire mains and hose cut, the crews demoralized with great loss in killed and wounded; the ships finally being run ashore. The Colon was run ashore and surrendered after being hit but six times without material damage, in her attempt to escape by flight.

The conclusion reached is that there should be greater protection for the gun positions in armored cruisers than obtained in the Spanish ships, that casemates and splinter bulkheads are a necessity, that the chances of penetrative hits on water-line armor, except in very close actions is small, and that wood and inflammable material must be reduced to a minimum in ship construction.

CHAPTER XXXI.

THE PROVING GROUND.

Prepared by LIEUTENANT JOSEPH STRAUSS, U. S. Navy.

1. All guns, gun carriages, ammunition, armor and new devices in naval ordnance are tested at the proving ground before being accepted for the service.

2. **The United States Naval Proving Ground** is situated at Indian Head, Md., and comprises a tract of land of nearly one thousand acres, on the left bank of the Potomac river, about twenty-five miles below Washington. There is a clear range over the water six and one-half miles long.

3. **The Proof of Guns.**—After a gun is completed it is sent to the proving ground and fired five times, with pressures ranging up to one and one-quarter times the service working pressure it is designed to withstand. Thus, a gun which is to be habitually used with a maximum pressure of sixteen tons will be subjected to a final pressure during proof of not less than 20 tons per square inch. The proof velocities must also be correspondingly high, in order that the chase and muzzle may be tested for their ability to withstand high pressures. After proof the gun is stamped with the letter P and the initials of the officer in charge of the proving ground, after which it is returned to the gun factory at Washington.

Every gun manufactured for the naval service is submitted to this proof; in the case of those guns manufactured by private concerns equipped with a proving ground, the proof is conducted by the Inspector of Ordnance attached to the works.

4. **Proof of Powder.**—An “index” of powder is, generally speaking, the largest lot of a single kind of powder that the capacity of the manufacturing plant is capable of blending. Blending houses are usually large enough to mix from 25,000 to 30,000 pounds, and these figures, therefore, represent the weight

of one index. Small arm and machine-gun powders are usually made up into indices of less weight.

After the index is boxed and ready for shipment, a sample of prescribed weight is sent to the proving ground for proof. A careful chemical analysis of the sample is made at the laboratory in order to ascertain whether the stability, percentage of nitrogen, residual volatiles and solubility are in accordance with the specifications. The powder is then fired in the gun for which it is intended, beginning with small charges and working up to the required velocity, unless the proof is halted by the development of pressures in excess of those permissible. For a required velocity the weight of charge used must not exceed a given amount, nor must the pressure exceed that for which the gun is designed. After fixing the charge, a report of the ballistic and chemical qualities are forwarded to the Bureau of Ordnance, upon which the powder is either accepted or rejected. If accepted, an index number is assigned, and this, with the manufacturer's name, date of manufacture, weight of charge, and manufacturer's lot number, is stenciled on the boxes and the index shipped to a magazine.

5. Proof of Shell.—Two kinds of shell are at present purchased for the Navy: armor piercing and common. The armor piercing are all capped down to and including the 3-inch. The inspector at the factory selects one shell from every lot manufactured, and this is shipped for test. It is fired with a striking velocity (fixed by the Bureau of Ordnance) at an armor plate which is set up at a distance of about 100 yards from the gun. The conditions for acceptance are, that it must completely perforate the plate, no fragment of it to remain in front of the plate.

Common shell are fired at nickel-steel plates having a thickness of half the caliber of the shell, with just sufficient velocity to get through. They must completely perforate the plate without sustaining any fracture that will open up the shell cavity. After this test, the shell is loaded with fine-grained black powder and exploded in a suitable chamber. If the fragmentation is satisfactory, the lot is accepted.

6. Cartridge Cases.—One case out of every lot of 100 is proved by firing it six times with service pressures, after which

it must be in perfect condition. It must enter and extract easily during and at the end of the proof.

7. **Fuzes.**—Minor calibre fuzes are fired against a 3-16-inch plain steel plate and must not have more than a fixed per cent of failures to a lot. Larger calibre fuzes are fired against a $\frac{5}{8}$ -inch steel plate under similar specifications. Both fuzes must withstand a drop from a height of 30 feet when inserted in blind shell, without arming.

8. **Shell Powder** must be well incorporated, clean and free from dust, and exhibit a proper glaze. It is tested in small-arms for velocity.

9. **Armor.**—Face-hardened armor is tested by firing armor piercing projectiles against it with normal impact. The plate is always backed with 12 inches of oak backing secured to two $\frac{5}{8}$ -inch skin plates by armor bolts spaced at normal intervals. It is set up against the target structure at a distance of about 100 yards from the gun. The velocity of impact and calibre of shell are fixed with reference to the state of the art of armor manufacture, and the plate must be able to resist a given number of blows without developing through cracks or permitting any shot to penetrate through the skin plates.

Protective deck plates are of nickel-steel and are set up so that the projectile strikes them at an angle of from 7 to 9 degrees from the tangent to their surface. The plate must not fracture under the single blow delivered.

10. **Ranging Guns.**—The powder charge is carefully ascertained a short time before the ranging is to be conducted, in order to eliminate any changes in velocity that may have occurred since the last proof of the powder. The gun is laid at an exact angle of elevation of 1° and trained on a fixed mark and fired. The fall of the shot is plotted from observations, with the theodolite and plane table, made by observers stationed at various points down the range. This operation is repeated at $3^{\circ}, 5^{\circ}, 7^{\circ} \dots 15^{\circ}$, and back again through the same angles. The height of tide is noted in order to reduce the height of gun above the water to zero. The barometer, temperature, direction and force of wind are also recorded, although, if possible, the ranging is conducted in calm weather. After plotting all of the shots

and reducing the range for each to a normal temperature and barometer, these ranges are plotted on section paper and a smooth curve drawn through the positions. This curve then forms the basis for the range-table. A drift curve is also plotted from the position of the shot on a horizontal plane. The "jump" of the gun on modern carriages is inconsiderable or variable, and is measured by firing the projectile through a paper screen.

11. Instruments Used at the Proving Ground.—For velocity work, three Boulengé chronographs are used. A separate circuit and screen are provided for each instrument. The Boulengé chronograph is operated, briefly, in the following manner: Two electro-magnets are each provided with a separate circuit which are cut in turn by the passage of the projectile. The wires that are cut are placed 30 meters apart; when the first circuit is broken a metal rod is dropped from the first magnet and when the second is broken a weight drops from the other magnet, which releases a knife that springs out laterally and cuts a nick in the first rod which is still in the act of falling. Before firing, a datum point is secured by breaking both circuits at the same time with a suitable key; the distance between the datum point and the second nick furnishes a measure of the elapsed time between cutting the first and second circuits. From this time the mean velocity of the shot is calculated, and for all practical purposes represents the remaining velocity at the middle point between screens. A correction which reduces this velocity to the muzzle of the gun is readily taken from the ballistic tables.

12. In order to insure the cutting of the circuits, each wire is arranged in the form of a screen, the mesh being continuous and parallel at a distance apart depending on the calibre of the shot. The triple screens are placed a few inches apart, the first of a set being exactly 30 meters from the first of the second set. The use of three chronographs permits the selection of the most probable result in case the results vary.

13. Schultz Chronograph.—Besides the three Boulengé chronographs, a Schultz chronograph is used for time measurements where more exact results must be obtained, such as velocities of recoil and counter-recoil, or in any case where several consecutive intervals m

This instrument consists, essentially, of a nickel plated cylinder revolving by means of a falling weight, and the rotation of which is controlled with more or less constancy by means of a fan which is in gear with the mechanism: a stylus is fastened to one prong of a tuning-fork and the tuning-fork kept in vibration by means of a small electro-magnet, much in the same manner as electric trembler bells are arranged. The breaking of an electric circuit is the means employed to mark successive intervals of the measurement, the break causing a spark to leap across from a point near the stylus on the tuning fork to the metal cylinder, the latter having been coated lightly with lamp black just before the measurement is to be made. As the cylinder revolves and the tuning fork vibrates, a wavy line is traced on the surface and each spark is marked on the line by a small bright dot whenever the current is broken.

The speed of vibration of the tuning-fork is nearly constant and equal to about 250 a second. The distance between two sparks in terms of the vibrations would then measure $N.004$ seconds. By means of a magnifying glass and micrometer N may be measured quite accurately to $\frac{1}{100}$ thus permitting the determination of time intervals of $\frac{1}{25000}$ of a second.

14. For the Ranging of Guns it is necessary to employ the following instruments: 1. A gunner's quadrant, which consists of a level which is hinged at one end, the other end sliding on an arc and provided with a tangent screw and vernier. The movable end is tilted up to the required angle and clamped and the quadrant is then placed on some part of the gun or carriage that is parallel with the axis of the bore. The gun is now elevated until the bubble in the level comes back to the center, and the gun is then at the elevation required.

2. Theodolites or plane-tables for plotting the fall of shot as they strike the water. 3. A stop-clock which measures tenths of seconds to record the approximate time of flight of the projectiles.

15. Pressure Gauge.—The pressure gauge consists of a cylinder of steel closed at one end with a screw plug and copper washer, and made strong enough to resist great collapsing pressure. Into this cylinder is loosely inserted a circular prism of

copper, with its base resting against the closed end. Into the other end a solid piston of steel is inserted and just presses against the other base of the copper prism. This steel piston is not packed in any manner, but is made to fit the cylinder with great nicety. A cupped disc of thin copper is gently pressed into the open end of the cylinder and serves to prevent any gases from flowing through beyond the piston. These gauges are of two kinds: those which screw into the mushroom of the breech mechanism, called mushroom gauges, and those which are dropped into the bottom of a cartridge case before the powder charge is put in, called cylinder-gauges. Before inserting the prism, its length is carefully measured by means of a micrometer caliper, and after the gun is fired it is again measured, the diminution of its length furnishing a measure of the pressure it has been subjected to.

The area of the prism is, for all guns down to the 6-pounder, $\frac{1}{6}$ -square-inch; for guns below that calibre, prisms having an area of 1-30 square-inch are used, as the larger gauges would seriously alter the apparent density of loading where the chamber is so small.

For pressure measurements up to 9 tons, copper prisms are made $\frac{1}{2}$ -inch in length. At the Naval Gun Factory, where they are made, sample prisms of that length are gradually shortened in a testing machine, and the pressure corresponding to a given shortening noted from time to time, from which data a table is constructed which is used with that lot of prisms at the proving ground. For pressure measurements above 9 tons, prisms that have already been subjected to that pressure are used.

CHAPTER XXXII.

SUBMARINE MINES.

NOTE.—Much of the information in this chapter was taken from Bucknill's "Submarine Mines and Torpedoes," and from Armstrong's "Torpedoes and Torpedo Vessels."

1. **Definition.**—A submarine mine may be defined as a charge of explosive confined in a strong case moored beneath the surface of the water in rivers, channels, and sometimes in outer roadsteads for the purpose of preventing or delaying the passage of hostile ships. The charge need not necessarily be so powerful as to completely shatter a ship, but its explosive effect should be sufficient to blow a hole in a double bottom and sink any ship that strikes, or passes near, the mine.

Mines are of several different classes. Each class has its peculiar uses, and the class to be used and the weight of the charge to be employed, depend upon the time and facilities available, the depth of water, the rise and fall of the tide, the strength of the current, and other conditions that may exist at the port to be defended.

2. **History and Development.**—Submarine mines were first used with effect by the Confederates during the Civil War, 1861-1865, and, notwithstanding the crude and imperfect appliances at that time, and the use of gunpowder, which was often rendered harmless by the leakage of mine cases, more than thirty ships were destroyed or seriously damaged by these mines.

Noting this fact, European nations took up the subject and began extensive experiments which have resulted in a steady development and improvement of submarine mines. This auxiliary method of harbor defense is now of great importance.

3. **General Abbot's Experiments.**—General Abbot, Corps of Engineers, U. S. Army, contributed greatly to the knowledge regarding submarine explosions, and his report to Congress giving

the results of his exhaustive experiments at Willets Point is regarded as a classic.

4. The Oberon Experiments.—In England, an important series of experiments was conducted by exploding mines of different sizes, and at various distances, against the hull of H. M. S. Oberon, a large number of crusher gauges being used to record the pressure of each explosion in order to discover a law connecting the pressure with the weight of the charge and the distance of the latter from the ship.

5. As a result of the Oberon and other experiments, various opinions have been advanced as to the pressure necessary to destroy or blow a hole through the double bottom of a modern ship. Some authorities put this pressure as low as 6000 pounds per square inch; but Colonel Bucknill, who was a member of the "Committee on the Experiments against H. M. S. Oberon," expressed the opinion that the pressure required is nearer 12,000 pounds per square inch. Considering the increased strength of modern ships, Colonel Bucknill's rule would be the safer one to adopt.

6. Explosives for Mines.—High explosives have replaced gunpowder, and are now exclusively used for submarine mines. Their explosive action is not seriously affected by moisture, leakage of the mine case is not so liable to render them ineffective, and they are from four to six times as powerful as gunpowder.

Gun-cotton and explosive gelatine are preferred, and the former, being extensively employed for military purposes, is more generally used for submarine mines, though it is not quite so powerful as gelatine.

7. Destructive Radius.—As a result of a careful study of submarine experiments, several formulæ have been proposed to determine the distances at which different charges of the various explosives would be effective against a double bottom. It is evident that such a formula can only be approximately correct; but an approximate rule may be useful. Assuming that a pressure of 12,000 pounds per square inch will be fatal against a modern ship's bottom, the following rule may be used to obtain the distances at which mines containing gun-cotton should be effective:

For distances between 20 and 50 feet from the ship's bottom,

multiply the distance in feet by 12 to get the effective charge in pounds; for distances less than 20 feet, multiply by 8. Thus at 30 feet, 360 pounds, and at 10 feet, 80 pounds of gun-cotton would be effective against a double bottom. Or, given the weight of the charge in pounds, to find the distance at which it will be effective, divide the weight by 12. Thus, 480 pounds would be effective at about 40 feet.

It is recorded that in an experiment conducted by Danish naval officers, 660 pounds of gunpowder, exploded at a distance of 24 feet, tore a hole 100 feet square in the outer bottom of a ship and sank the ship. Assuming gun-cotton to be about four times as powerful as gunpowder, 170 pounds of the former would have produced the same result. The rule stated above would give between 200 and 300 pounds of gun-cotton for a distance of 24 feet, and it would appear, therefore, that the rule gives an ample charge.

8. Classes of Mines.—Submarine mines are of two general classes:

- (a) Buoyant mines.
- (b) Ground mines.

Buoyant mines are moored to the bottom so that they may be held above their anchors a certain distance beneath the surface of the water. Ground mines rest directly upon the bottom, where they should be securely anchored.

9. Buoyant Mines.—There are several kinds of buoyant mines, as follows:

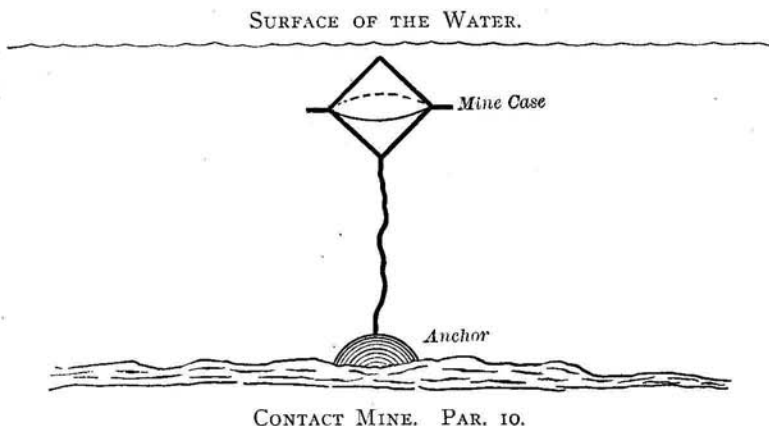
- (1) Contact mines.
- (2) Electro-mechanical mines.
- (3) Electro-contact mines.
- (4) Observation mines.

The different kinds of buoyant mines will be briefly described in the order named, which is the inverse order of their safety and effectiveness.

10. Contact Mines.—The contact mine is the simplest and crudest form of submarine mine. It consists of a strong water-tight case containing the charge, moored at a certain depth below the surface of the water, the case having a number of projecting levers or firing pins, which, if struck by a passing vessel, may be

driven in, thus exploding the charge by direct percussion and in immediate contact with the vessel's bottom. Such were the mines used by the Confederates during the Civil War.

It is evident that contact mines are dangerous alike to friend and foe, and should only be used, therefore, where other and safer forms are not available. The firing pins, or levers, have often been rendered ineffective by the adhesion of barnacles, or by other causes, as was the case with the Spanish mines at Guantanamo. Leakage may destroy a percussion primer and thus prevent explosion, even when the firing pin is driven in.

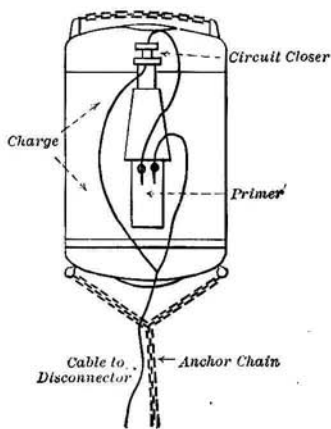


11. Electro-mechanical Mines.—The electro-mechanical mine is a modification of the ordinary contact mine in which, instead of firing the charge by a percussion primer, the firing pin (or any other form of circuit closer) completes the circuit of a firing battery carried within the mine case. This form may be rendered somewhat safer in handling, and more certain of action, than the percussion form of contact mine, but when once moored it is equally objectionable in that it is under no control from the shore.

12. Electro-contact Mines.—The electro-contact mine differs from the electro-mechanical mine only in having the firing battery on shore instead of at the mine. This brings the mine under control from the shore and removes one of the great objections to

contact mines. When hostile ships are not in the vicinity, the firing circuit may be broken at the shore station so that an accidental blow will not fire the mines, and a friendly ship may pass in safety. When the enemy appears, the firing circuit may be closed at the shore station and the mines will then be operative upon contact.

13. **Laying Electro-contact Mines.**—To reduce the number of firing batteries and electric cables as much as possible, electro-



ELECTRO-CONTACT MINE. PAR. 12.

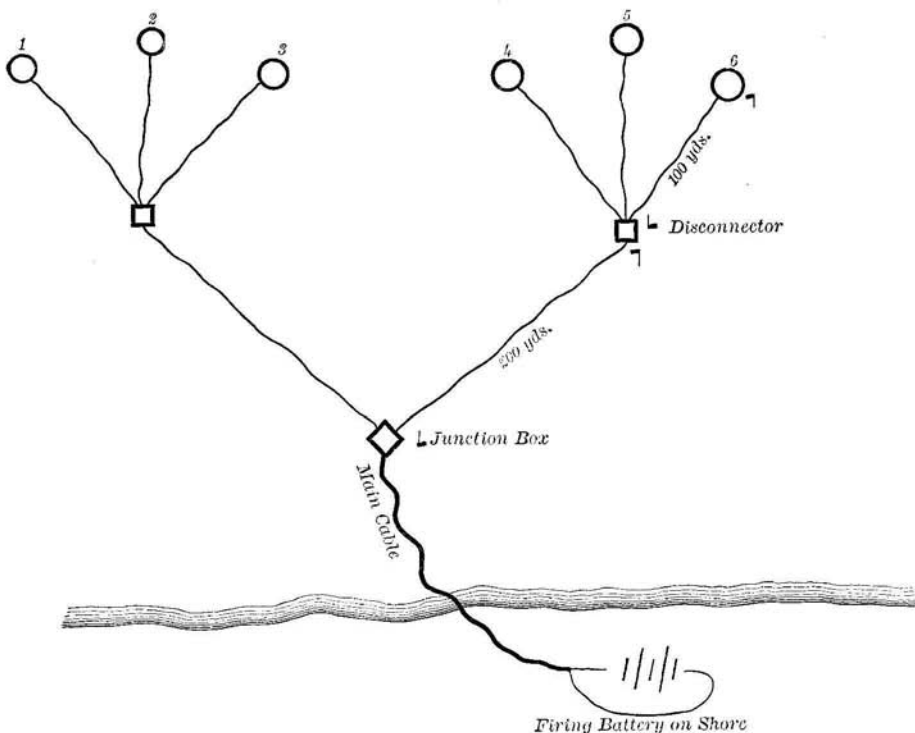
contact mines should be laid in groups of three or more, as shown in the sketch.

Three or more mines may be joined by electric cables to a disconnector box 100 yards distant, and two or more disconnector boxes may be joined by 200-yard lengths to a common junction box, the main or group cable leading from the junction box to the firing battery in the station on shore. By means of the disconnector a mine which has been fired or destroyed may be cut out.

14. **Anchors.**—Mushroom anchors are preferred for all kinds of submarine mines.

15. **Firing Electro-contact and Electro-mechanical Mines.**—Instead of using projecting levers or firing pins to fire electro-contact and electro-mechanical mines, the firing circuit may be

closed at the mine by a rolling ball, or by mercury contained in a cylinder. When the mine is tilted through a certain angle, or is struck with sufficient force, the ball or the mercury will rise in the cylinder, complete the circuit and fire the mine. This form of circuit closer renders electro-mechanical and electro-contact

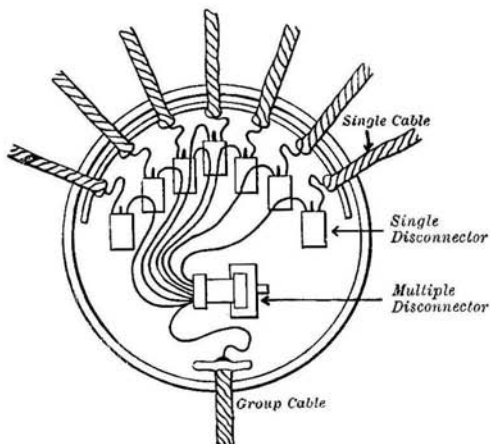


GROUPS OF CONTACT MINES. PAR. 13.

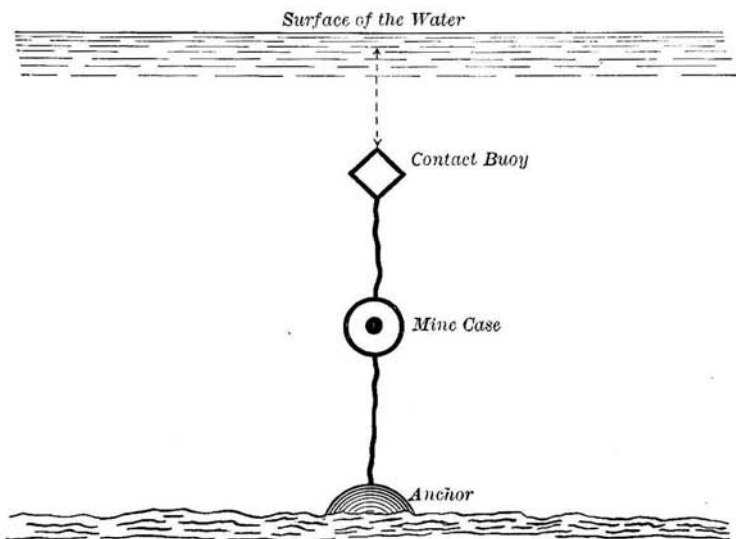
mines much more certain of operation, because there are fewer holes in the mine case and less chance of leakage than with projecting firing pins or levers; and rust or the adhesion of barnacles will not cause failure.

16. Contact Buoys.—Instead of placing both the explosive charge and the circuit closer in a single case, it is usual and preferable in all forms to place the circuit closer

and firing mechanism in a separate buoy called a "contact buoy" which is connected with the mine case and is held a few feet above



JUNCTION BOX. PAR. 13.



MINE WITH CONTACT BUOY. PAR. 16.

the latter, and at the desired distance below the surface of the water, as shown in the sketch.

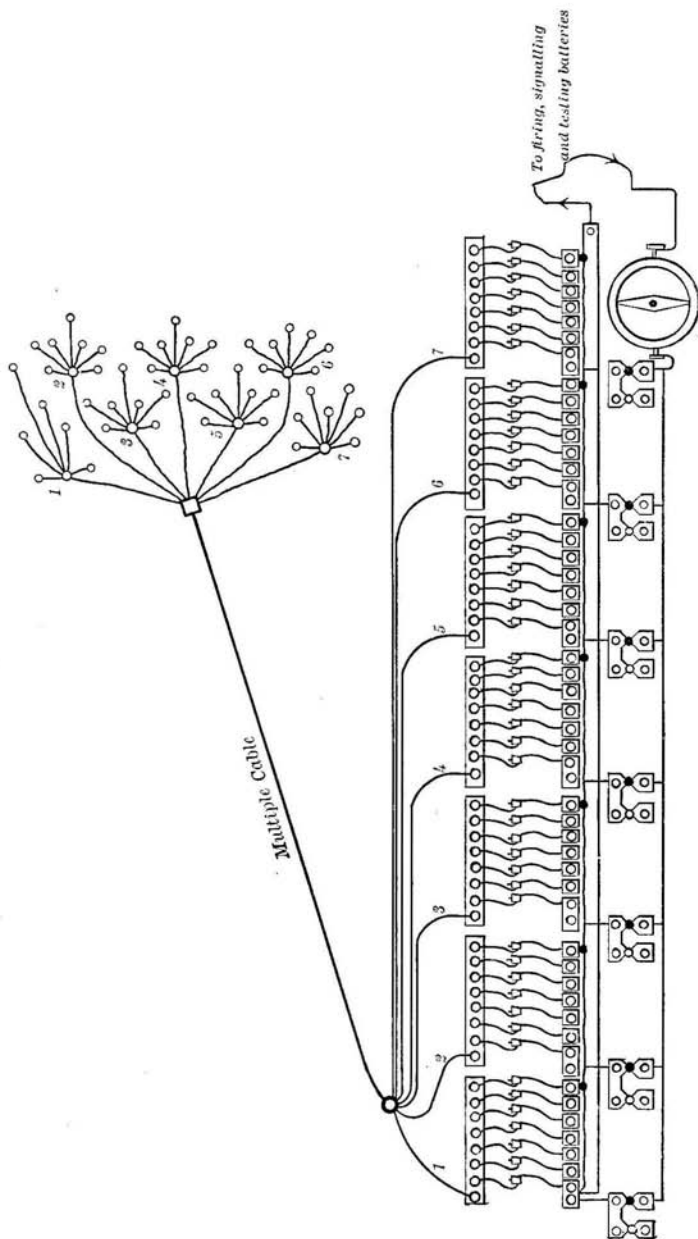
The use of a contact buoy permits a smaller and lighter case for the explosive charge. In electro-contact and electro-mechanical mines a blow upon the contact buoy closes the firing circuit, and the current passes down an electric cable through the primer of the mine and explodes the latter.

17. Observation Mines.—Observation mines are so called because each mine may be regarded as an observer which signals to the shore when its contact buoy is struck, and because such mines are completely under the control of an operator or observer at the firing station. This is the standard form of buoyant mine used by all nations for permanent harbor defenses.

Each mine is moored, with its contact buoy above it, in the same general manner as electro-contact mines. But with observation mines there are usually two distinct electric circuits—the signaling circuit and the firing circuit. When the contact buoy is struck, or sufficiently tilted, the circuit closer in the buoy closes the signaling circuit, which rings a bell, lights an electric light, or causes a shutter to drop over a keyboard in a firing station on shore. The operator may then touch the corresponding key beneath the signal, thus closing the *firing circuit* and exploding the mine. It is not necessary that the operator shall see the enemy. The firing station may be underground, quite safe from hostile fire. Thus an enemy striking the contact buoy of an observation mine may signal his own destruction.

18. Groups of Observation Mines.—Observation mines are usually moored in groups of about seven. Each mine has its own anchor, mine case and contact buoy. The electric cable for each mine passes from the circuit closer in the contact buoy down through the mine case, then to the anchor and along the bottom to the junction box of the group, from which the main cable leads to one key of the firing station on shore. Disconnecter boxes might be interposed between the mines and the junction boxes, as in the case of electro-contact mines.

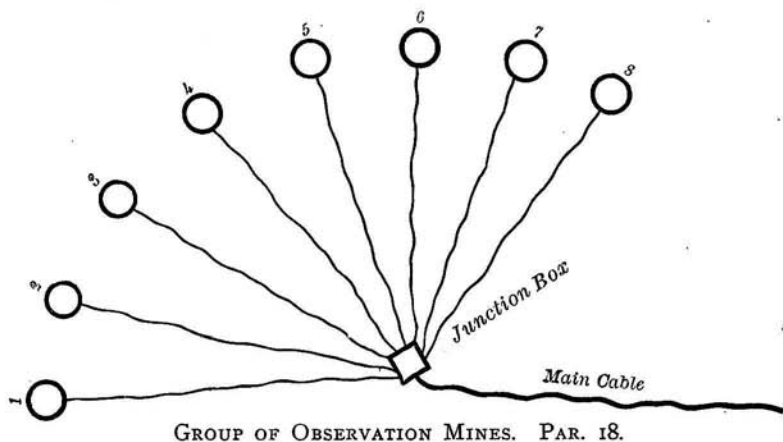
It is evident that arrangements may be made by which all the mines of a group may be fired simultaneously, or the explosion may be limited to the mine whose contact buoy has been struck. The size of the mines and the general system of laying them will determine whether all or only one mine of a group should be fired.



FIRING KEYBOARD.

When the mines are large, for instance, only one mine of a group may be expended at a time; if small mines are used, a whole group may be fired simultaneously to insure the destruction of a ship. Some nations use very heavy charges—500 pounds of gun-cotton—in observation mines.

19. The Firing Keyboard.—Plate I will give an idea of the arrangement of a firing keyboard. It is not drawn to scale, but the lead of the cables and the connections are shown for seven groups of mines.

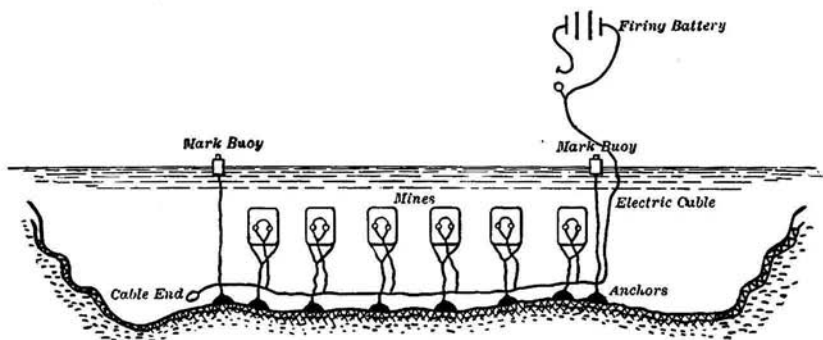


20. Automatic Firing.—It is possible, in the absence of the operator, or at any time if thought desirable, to so arrange that the shutter which drops by the closing of the signaling circuit when the contact buoy of a mine is struck, may fall upon the firing key and close the firing circuit at the station, thus firing the corresponding mine, or group of mines, automatically.

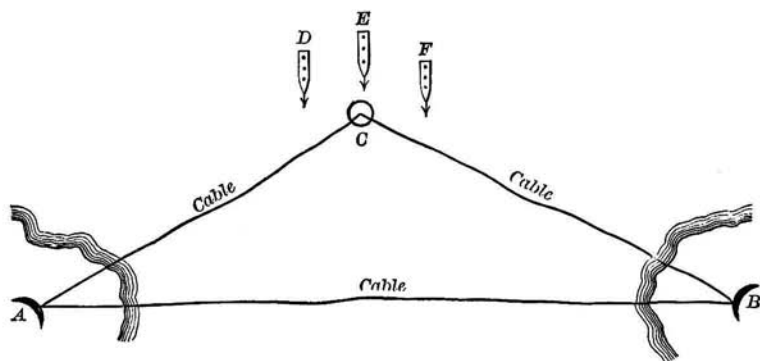
21. Judgment Firing.—The firing station may not be underground, in which case the operator may be so stationed at some convenient point that he may command a good view of the mine field. By the aid of ranges, buoys, etc., he may determine when a ship is in the proper position, and fire a mine or group of mines without the aid of contact buoys or a signaling circuit. This is called "judgment firing." It is evident that it might fail at night, or under some conditions of weather, etc. The operator is liable

to error. But this plan may be resorted to when other facilities are not available.

22. Lines of Mines.—A narrow channel may be defended by a simple system of several lines of mines, each line of six or more mines being on one cable.



LINE OF MINES ON ONE CABLE. PAR. 22.



FIRING GROUND MINES BY CROSS BEARINGS. PAR. 23.

Mark buoys, in addition to ranges, may indicate when an enemy approaches the line, and all the mines may be fired simultaneously by the operator on shore. Six 500-pound mines in a line, properly spaced, would thus defend a channel about 700 feet wide, as each mine would be effective at a distance of about 50 feet.

Judgment firing may be used for a line of mines.

23. Ground Mines.—Ground mines rest on the bottom. They may have contact buoys above them and be fired in the same

manner as buoyant mines. If contact buoys are not used "judgment firing," or fire by cross bearings, must be resorted to.

Ground mines are usually placed in shoal water. Sometimes, however, very heavy charges are moored in comparatively deep water, especially when swift currents or a considerable rise and fall of the tide would render buoyant mines ineffective. In such cases there may be two stations on shore to fire by cross bearings, as shown in the sketch. The observers at A and B may have plane tables showing the bearings of the mines, and each may direct a telescope at an approaching ship and close a break in the firing circuit whenever a ship is on the proper bearing. The two stations should be connected by telephone. Unless a ship is on the proper bearing from both stations at the same time, the two breaks in the circuit, one at A and one at B, will not be closed simultaneously, and the mine will not be fired. This would be the case with the ships at D and F, neither of which would pass over the mine. But the ship at E, continuing her course, would pass over the mine, the breaks in the circuit at A and B would be closed simultaneously, the circuit would be completed and the mine fired.

24. Groups of Ground Mines.—In shoal water comparatively small charges, without contact buoys, may be used in ground mines, and they may be planted in groups, or lines, to be fired simultaneously, as described for a line of mines, either by cross bearings or by "judgment firing."

25. Ground Observation Mines.—Ground mines may be supplied with contact buoys and with a signaling as well as a firing circuit, the cables being taken to the shore station, where the mines may be fired, singly or in groups, in the same manner as observation mines. In this case they are called "ground observation mines."

26. Advantages of Ground Mines.—Ground mines, if securely moored, may not be affected by swift currents which would carry down and render buoyant mines quite useless. And if the rise and fall of the tide is not excessive, ground mines especially with large charges, will be effective at all stages of the tide. If contact buoys are not used, friendly vessels may pass over ground mines with no injury either to ships or to the mines.

27. Rise and Fall Mines.—When the rise and fall of the tide

is excessive, buoyant mines which would be effective at high water might be on the surface at low water. Various methods have been

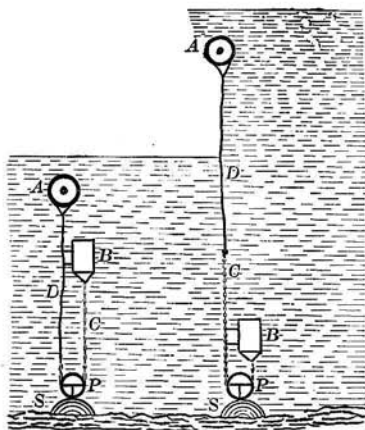


FIG. 1.—RISE AND FALL MINES. PAR. 27.

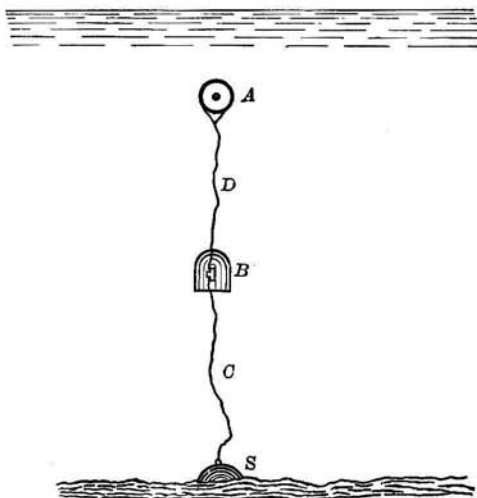
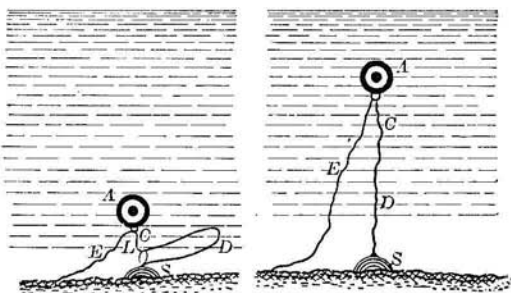


FIG. 2.—RISE AND FALL MINES. PAR. 27.

proposed to keep buoyant mines, automatically, at a constant depth below the surface of the water, and although none of these inven-

tions have been perfect in their action, the subject is of importance. One of the most reliable devices for tidal mines is shown in Fig. 1. A is the buoyant mine case; B is a buoyant counterpoise filled with air; C is a chain made of links varying in weight, the heaviest links being furthest from B; D is a mooring rope attached to the chain; S is an anchor with a pulley attached through which the chain C reeves; to prevent twisting, the counterpoise is attached to the mooring rope by rings, or guides, which permit it to rise and fall along the rope or chain.

The action is as follows: Beginning at low water, as the tide rises the increased water pressure compresses the air in the counterpoise, reducing its buoyancy; B sinks and A rises, therefore,



DORMANT MINES. PAR. 28.

until equilibrium is restored by some of the heavy chain passing around the pulley. When the tide falls, the reverse action takes place.

In another device, shown in Fig. 2, a buoyant regulator, B, contains a spiral wheel and a drum on a single axis, the part of the cable, D, being wound on the spiral wheel and being continuous with the lower part, C, which is wound on the cylindrical drum. The rise and fall of the water inside the regulator, which is open at the bottom, increases or diminishes the air pressure and causes the drum and spiral to turn by the varying tensions on the parts of the cable. The relative buoyancy of the mine case and the regulator, B, determine the diameter of the drum and the varying diameter of the spiral, so that the mine may be kept at a fixed depth below the surface.

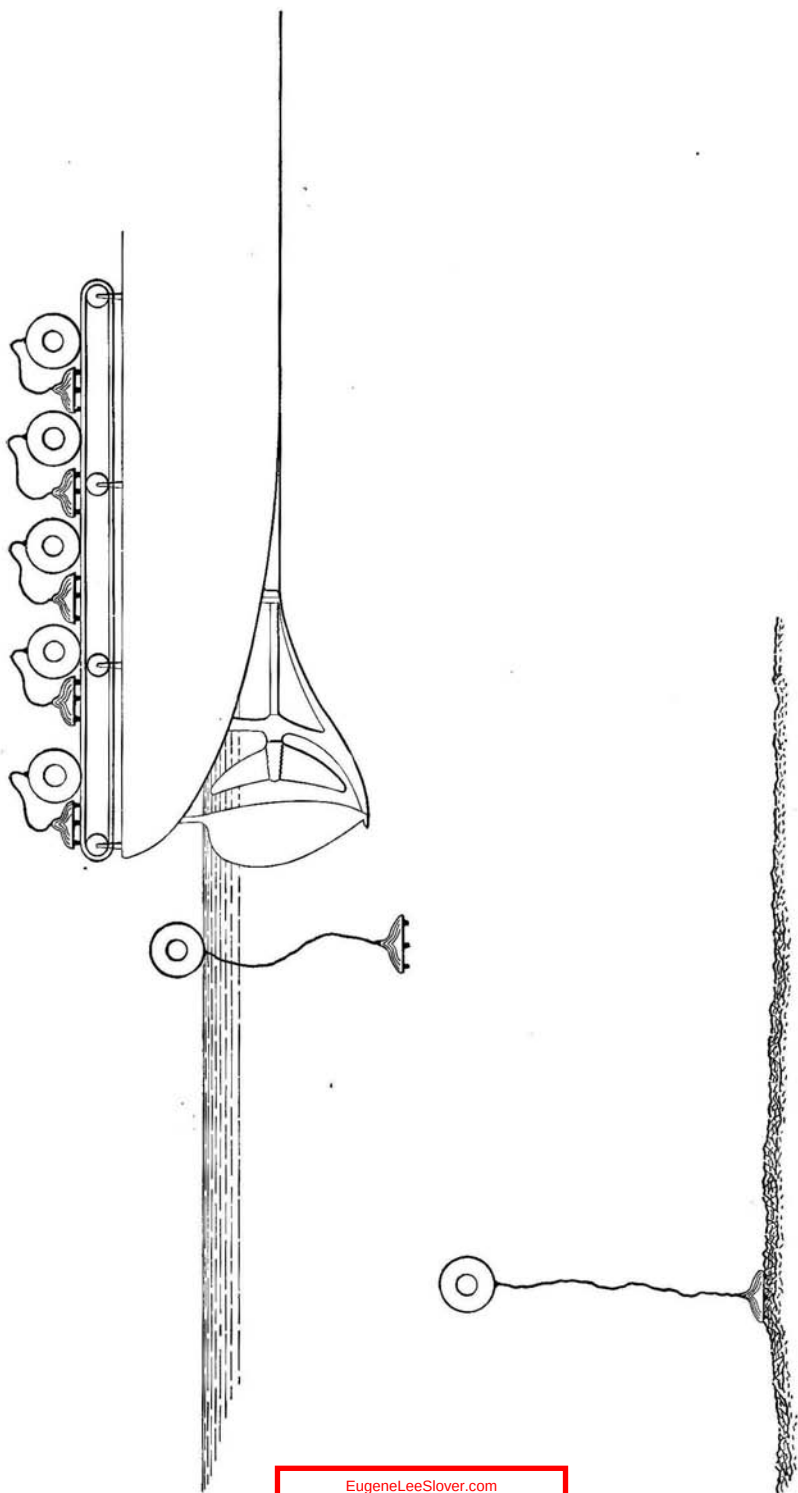
28. Dormant Mines.—In order that friendly ships may use one or more channels with safety in entering or leaving port, the use of dormant mines has been suggested.

The figure shows the general principle of dormant mines. The mine case, A, is held down near the anchor, S, by an explosive link, L, which contains a small charge of explosive. When a hostile force appears, or an attack is anticipated, an electric current may be passed through the link, exploding the charge, destroying the link and permitting the mine to rise and become active. E is the electric cable for firing the mine.

29. Blockade Mines.—Until recent years submarine mines were regarded solely as a feature of the fixed defenses of seaports, and their employment by naval forces in active offensive and defensive warfare was not seriously considered. The practicability of their use by ships or fleets was not admitted until the activity of inventors resulted in such a perfection of mechanical details in the application of electrical, safety and self-anchoring mechanisms that the problem of handling mines—laying them and picking them up—has been greatly simplified. At the present time nearly all navies are being supplied with “naval defense” or “blockade mines,” which are to be used by fleets in time of war, and it is reported that in one foreign service all large ships are to carry from 20 to 30 mines of an improved electro-mechanical or electro-contact type, with self-anchoring devices.

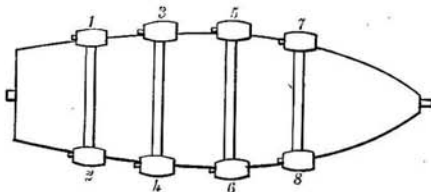
30. Mine-laying Vessels.—Although it is expected that each ship, with its own boats and resources, may lay its supply of blockade mines in case of necessity, special mine-laying vessels have been suggested to accompany each fleet for the purpose of handling the mines with greater ease and expedition. Plate II will give an idea of one method of fitting a mine-laying vessel for this work.

The mines may be placed upon an endless traveling platform, similar to the floor of a treadmill, which will carry them with their anchors successively to the stern of the ship, where they may be permitted to drop off and anchor themselves at intervals and at a certain distance below the surface of the water, the ship moving at high speed. It is claimed that such a ship can anchor a large number of mines and pick them up again with ease—lay them in the forenoon and pick them up in the afternoon.



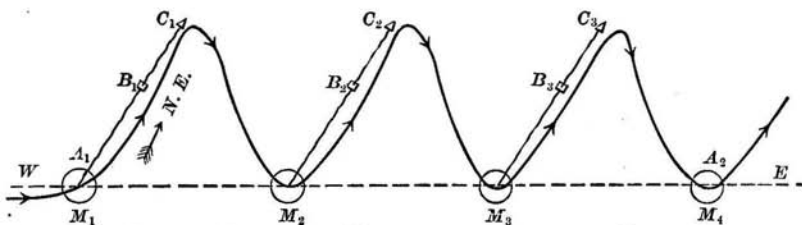
VESSEL LAYING SELF-ANCHORING BLOCKADE MINES.

31. Laying Blockade Mines with a Launch.—In case a cruising ship is required to lay a number of blockade mines with its own resources, there are several methods which may be adopted. The mines, with their anchors, batteries and safety breaks, may be placed in a ship's launch at the ends of the thwarts as shown in the sketch, each being ready to slip at short notice. A steam cutter may then take the launch in tow.



LAUNCH LOADED WITH MINES. PAR. 31.

Suppose the mines are to be laid in a line, A_1, A_2 , from west to east, M_1, M_2, M_3 , etc., being the mines, B_1, B_2, B_3 , the batteries, and C_1, C_2, C_3 , the safety breaks for the several mines. Arriving at A_1 , the first mine, M_1 , with its anchor, is slipped, and the tow steers N. E. until B_1 and C_1 are dropped successively.

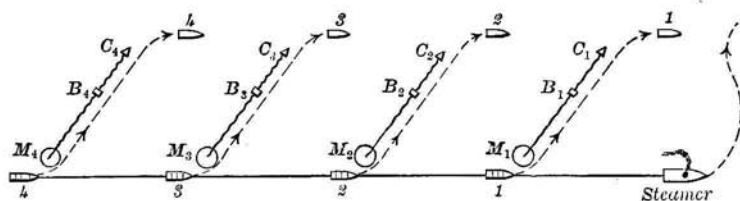


LAYING A LINE OF BLOCKADE MINES WITH LAUNCH IN TOW. PAR. 31.

The helm is then put hard over and the tow returns to the E and W line where M_2 is dropped, and continues to steer a zigzag course until all the mines are laid.

32. Laying Blockade Mines with Several Boats in Tow.—Another method, which would be preferable under some circumstances, is to place each mine with its battery and safety break in a separate boat, the mine and its anchor slung over the stern ready for slipping, and the crew seated on the thwarts ready to get

up oars. Take all the boats in tow of a steamer, the lengths of the tow lines or painters being equal to the distances at which the mines are to be spaced when anchored. The tow then proceeds, as before, to the point where the mines are to be laid and steers along the line, the crew of each boat being ready to slip its mine. When in position the towing boat makes a signal and all the mines are slipped simultaneously and *all tow lines are cast off*. If the mines are dropped promptly, it will not be necessary for the boats to anchor. In case of a hitch, however, a boat may anchor in position until its mine is dropped. All boats then get up oars and pull on parallel courses at 4 or 8 points from the line of mines and drop their respective batteries and safety breaks as before. The steamer may then take the boats in tow again and return to the ship, if necessary, for another lot of mines.



LAYING BLOCKADE MINES WITH BOATS IN TOW. PAR. 32.

In this manner each ship of a squadron may quickly lay a line of mines in accordance with a plan previously decided upon, and each ship's force, knowing exactly how and where its mines were planted, may pick them up without delay. The sketch illustrates this method, the boats, mines, batteries and safety breaks being numbered as before.

33. The Future of Blockade Mines.—If the claims of inventors are even approximately realized, submarine mines may play an important part in future naval wars. A squadron, or a single ship, may protect itself from attack by quickly mining the approaches to a harbor in which it takes refuge; or an inferior naval force may successfully blockade an enemy in port by laying lines of mines across the entrance, and then protecting the mine field from countermining operations. With such a system of blockade mines, Cervera's squadron might have been effectively blockaded

in the harbor of Santiago, leaving the greater part of Admiral Sampson's fleet free to engage in other operations. The subject is one of growing interest and importance.

34. Plan of Mine Defense.—The plan of mine defense to be adopted for any particular seaport can only be decided upon after a careful study of the conditions peculiar to that port—the character of the channels, the depth of the water, strength of currents, rise and fall of the tide, etc. All these points having been carefully noted, the positions of the mines, or groups of mines, are laid down on the chart. As a general rule, ground and contact mines, singly or in groups or lines, are placed in shoal water, the former being preferred wherever the currents are strong. Groups of observation mines, or electro-contact mines, are usually placed in deep water and at outlying points, and the groups are so spaced that a ship passing between the groups of one line will pass over those of the line next inside. The mines are all numbered and a table of angles is given to the officer who lays the mines, so that they may be laid in accordance with the plan.

35. The Mine Field.—The whole space occupied by mines is called the "mine field." It should be swept by the fire of small guns to protect it from countermining operations, and by electric searchlights to guard against night attacks upon the mine cables. Plate III, Figs. 1, 2, and 3, shows the general plan of a mine field and the group formations used for observation and electro-contact mines.

36. Spacing of Mines.—If the plan of the mine defense does not contemplate that all the mines in one group, or line, are to be fired simultaneously, it is evident that care must be used to plant the mines at such intervals that the explosion of one may not cause those adjoining it to explode, or even to signal in the case of observation mines. It is not easy to give a rule for this distance, but one authority states that mines containing 100 pounds of gun-cotton should be spaced about 100 feet apart. The larger the mines the less desirable will it be to fire more than one mine at a time, and the greater must be the distance between them. Mines containing 500 pounds of gun-cotton should be spaced about 320 ft. apart. For these reasons it is obviously wise to distribute the mines over a wide area and in many different lines. The com-

FIG. 1

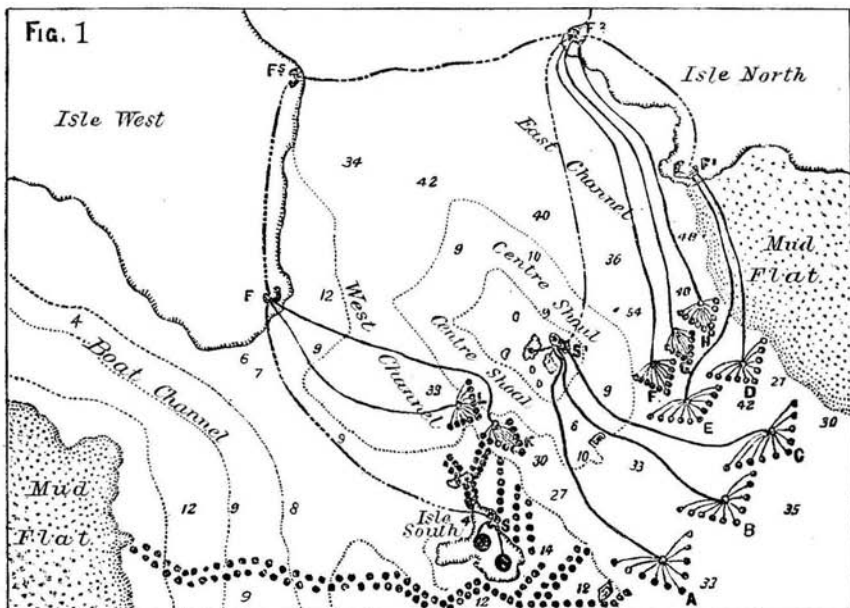


FIG 2

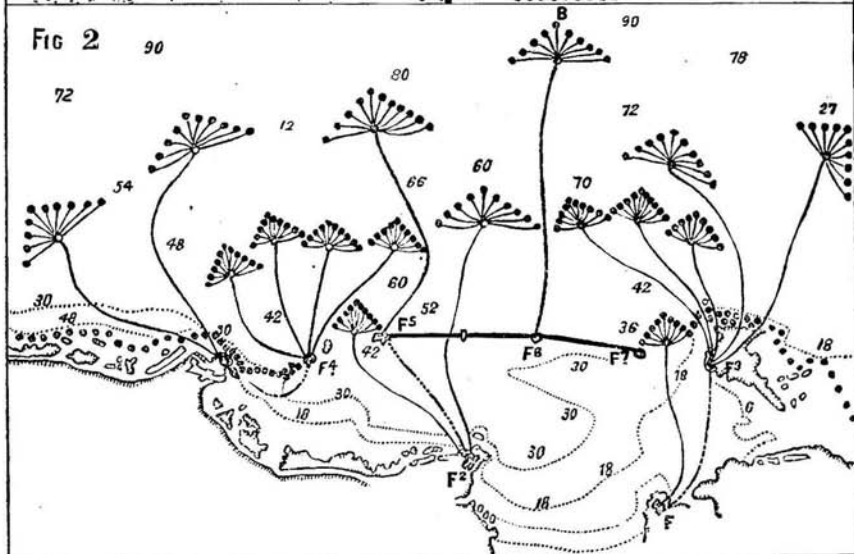
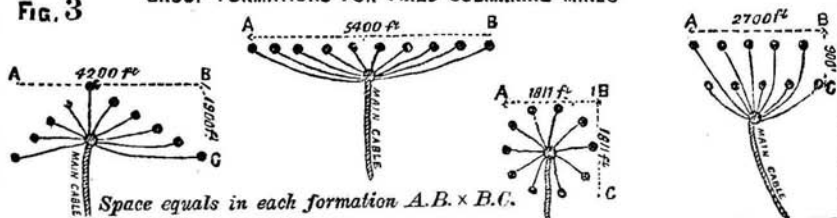


FIG. 3

GROUP FORMATIONS FOR FIXED SUBMARINE MINES



PLANS OF MINE FIELDS.

plete removal of the mines by an attacking force will thus be rendered more difficult, and the expenditure of a few mines to beat off one attack may not destroy the whole mine field, leaving the entrance open to a second attack. An enemy would prefer to pass over a limited field thickly planted with mines, because the leading ships might clear the way for those in rear. But he will dread the passage over a field of great extent where each mine acts singly—where no ammunition is wasted.

37. Friendly Channel.—A special channel across a mine field is sometimes designated for the use of friendly vessels. It may be planted with ground or dormant mines to prevent its use by an enemy, while friendly vessels may pass over such mines with safety.

38. Testing Mines.—It is most important that a mine field should be kept in an efficient condition by providing all facilities at the observing station on shore for testing, daily, the firing circuits of all electrical mines.

39. Mine Destroying.—The quickest way to put a mine field out of action would be to cut, near the shore, the cables that lead to the observing stations. This of course would only be possible at night under peculiarly favorable conditions and in the absence of a defending force. If this plan of attack is impracticable, there are three other methods that may be resorted to:

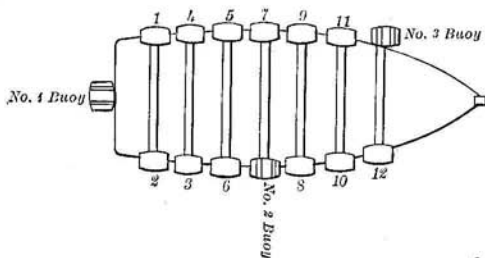
- (1) Creeping.
- (2) Sweeping.
- (3) Countermining.

All these methods of removing or destroying mines to clear a passage for ships are difficult and dangerous, inasmuch as the force engaged in the work may be under the fire of guns that command the mine field, or may be attacked by vessels specially assigned to protect the mines from destruction. As a rule, such operations should only be attempted at night.

40. Creeping.—This consists in supplying boats with grapnels with which to drag the mine field for cables, junction boxes and disconnectors. Sometimes explosive grapnels are used with which to destroy the cables or connections. This method is used in shallow water and as near the shore as possible in order to get hold of the cables.

41. Sweeping.—This consists in dragging a weighted rope, chain or long iron bar between two boats some distance apart. Grapnels and explosive charges are sometimes attached to the sweep. If cables, or junction boxes, are brought to the surface they may be cut or destroyed. Anchors may be pulled up so that the mines will come to the surface and float away.

42. Countermining.—This method consists in running lines of mines across the field and then exploding them in order to destroy the connections or cause the defending mines to explode by shock. Countermines sometimes contain very heavy charges—500 pounds of gun-cotton. All the mines in one line are attached to a single cable so that all may be fired simultaneously as soon as the last mine is dropped.



COUNTERMINING LAUNCH. PAR. 43.

43. Countermining Boats.—Ships may be supplied with countermining boats specially designed for the work. It is important that each boat should carry from eight to twelve mines and that arrangements should be made to run out a line of mines quickly. When special boats are not provided, a heavy sailing launch may be fitted for the purpose, as shown in the sketch.

The mines with their sinkers are slung over the sides of the launch at the ends of the thwarts. For a long line of mines three buoys are provided, which, with their separate anchors may remain in position at the extremities and middle of the line after the explosion to mark the ground that has been cleared. All the mines are attached to one strong cable, and are spaced according to the weight of the charges. The cable is coiled clear in the launch and the bights pass under the boat from one mine to another on the opposite side. One end of this cable is carried in a battery

boat which is towed astern of the launch and which anchors before the first buoy is dropped; the other end of the cable is taken on board the steamer, or gunboat, which takes the countermining launch in tow. The mines and buoys are held by slip stops so that they may drop automatically when a strain comes on the cable. It should not be necessary to have a crew in the launch.

44. Running a Line of Countermines.—All being in readiness, the tow starts at full speed for the point of attack. At the proper time the battery boat in rear of the launch slips its tow line, at the same time anchoring and also slipping No. 1 buoy at the stern of the launch. The launch continues on, towed at full speed, the cable being paid out until it tautens and slips No. 1 mine. The other mines and buoys are slipped in turn when the strain comes on the cable, and finally No. 3 buoy drops. The towing steamer then makes a signal and closes the firing battery at its end of the cable; the battery boat, seeing the signal, also presses the firing key and the line of mines explodes. The lines of countermines may be laid with a view to clearing only one channel—that is, lengthwise and near the middle of the channel. In case the channel is wide, two parallel lines may be run at a certain distance apart to insure a safe passage for ships. A channel having once been cleared, the defenders should not be permitted to plant new mines. They may seek to re-mine a channel by using simple contact mines to prevent delay, dropping them at night or in thick weather. This operation will be easier than that of countermining. It is far simpler to defend or replace, than to attack or destroy a mine field.

CHAPTER XXXIII.

FIELD FORTIFICATIONS AND INTRENCHMENTS.

NOTE.—Ingersoll's Text-book of Ordnance and Gunnery and the Manual of Military Field Engineering, by Captain Wm. D. Beach, U. S. Army, were consulted in the preparation of this chapter.

1. **A Judicious Use of Fortifications** may enable the weaker body of men (from whatever cause) to become equal to, or stronger than, a superior force; a knowledge of its principles assists in occupying a position to the best advantage, the artificial construction being so combined with the natural features of the ground as to produce from a minimum of labor a maximum of strength.

All works are made up of two parts, the profile, and the plan or outline.

2. **Trenches and Ditches.**—A trench is an excavation in rear of the covering mass; a ditch is one in front of it.

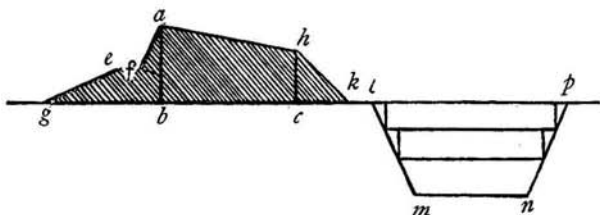
Cover is more rapidly gained by the use of a trench, as it will be obtained by the excavation plus the height of earth thrown immediately in front.

A ditch might provide the earth for the parapet in works of a more important nature, and at points which are purely defensive. The bottom of a ditch may be formed in a V shape with advantage, in order to prevent the attack from accumulating there.

3. **Profile.**—The profile is a section shown by a vertical plane at right angles to the direction of the work. The profile selected will depend upon the object the work has to fulfill, upon the projectiles it may have to withstand, and upon the nature of the surrounding ground.

The profile may be formed also of a trench and a ditch, the men working on each side of the parapet and throwing the earth upon the intermediate space. By these means a considerable thickness of parapet may be obtained in a short time; but in such a case the ditch does not become deep enough for a sufficient

obstacle, but may be subsequently deepened, the earth being thrown upon the crest of the counterscarp and forming a sloping surface called a *glacis*.

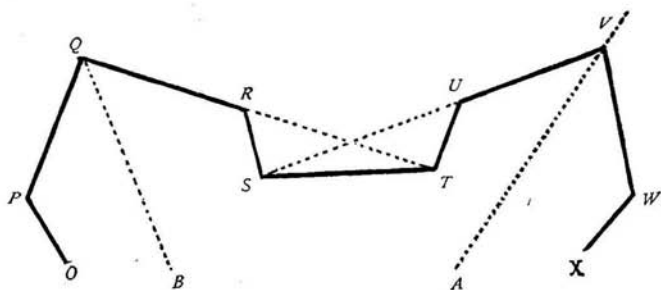


PROFILE. PAR. 3.

The above profile is that of a parapet and ditch. The dimensions are obtained by the following considerations: The *command*, $a b$, by the amount of cover required to screen the interior of the work and the position of the enemy; the *thickness*, $b c$, by the nature of the projectiles likely to be used against it, for field artillery, 12 feet to 15 feet, and for rifles, 4 feet (these dimensions may be lessened, except for rifles, for the rear faces of works); $e f$, the *banquette*, is to enable riflemen to fire over the parapet, and is made 3 feet wide for a single rank of men, and 4 feet 6 inches for a double rank; $e g$, the slope leading to the banquette, has a base equal to double its height; $a f$, the *interior slope*, is *revetted* (it being so steep as to require artificial support); $a h$, the *superior slope*, is sufficiently sloped to enable the defenders to see the top of the *counterscarp*, and, upon level ground, is as 1:6; $h k$, the *exterior slope*, is an angle of 45° ; $k l$, the *berm*, is made sufficiently wide to relieve the escarp from the pressure of the parapet; $l m$, the *escarp*, usually slopes about 2:1 if the soil be strong, and as much as 45° in sandy soil; $p n$, the *counterscarp*, is made as steep as the earth will allow, as it has no weight to bear like the scarp. The ditch is from 6 feet to 12 feet deep, and should be at least 12 feet wide at the top. The slopes of the ditch are obtained by excavating it in steps, as shown in the sketch, the depth and base of the steps being in proper proportions; these steps are subsequently cut away.

4. Outline.—The outline is the general arrangement, or trace, of works upon the ground. As much direct and flanking fire as

possible must be brought to bear upon points of attack. In very uneven ground, where direct fire cannot be given, there will always be found some points from which flanking fire may be obtained. The three points to be considered are: 1st, the object of the work, that fire may be given in the required direction; 2nd, that its own ditches shall not be dead, that is, unseen by the fire of the defenders, and that the ground over which the attack must be made shall be under fire from the work; 3d, that those defending the work shall be protected from oblique, enfilade or raking, and reverse fire.



P Q R and U V W, Advanced Parts.
R S T U, Retired Parts.
P Q, Q R, U V, V W, Faces.
R S, T U, Flanks.
S T, Curtain.

Q T, S V, Lines of Defence.
P Q R, U V W, Salient Angles.
R S T, S T U, Re-entering Angles.
V A, Q B, Capitals.

OUTLINE. PAR. 4.

The outline, therefore, will depend upon the object of the work and the natural features of the ground.

5. Definitions.—The following definitions and simple rules will be found useful:

The extent of the work will be determined by the number of men required for its defense. Two men per lineal yard of the parapet, with half that number in addition as a reserve, were formerly considered an ample garrison in most cases; but in the present day, taking into consideration the greater use of curved fire of shells, the precision of rifled artillery, and the rapidity of fire with breech-loading small-arms, it would be inexpedient to crowd men together. One man per running yard, and half that number in addition as a reserve, will probably be sufficient for most positions. Field guns will each occupy a length of 15 feet

upon the faces of works, and 40 feet (20 feet on each side) at the salient angles.

Splinter-proof Traverses, 4 feet wide at top and 6 feet wide at bottom, may be placed between field guns, and to give protection from enfilade or oblique fire. Those of similar construction, to give cover from reverse fire, are called *parados traverses*; within such traverses magazines may be conveniently formed. When the interior space is limited in a field work, the magazine may be placed under the parapet.

A Salient Angle is formed by two faces projecting outwards, towards the enemy. Such angles, being points of attack, should be as few and as prominent as possible, so that the points of attack may not be doubtful, and may be well prepared for defence. They should be as obtuse as possible, and not less than 60 degrees, in order that a greater extent of ground may be seen from the parapet, and they should be situated upon the higher points of ground, in order that the interior of the work may be the better screened. See P Q R in the sketch.

A Line of Defence is the face of a work, which, together with its ditch, receives flank defence. In detached works which mutually flank each other, it consists of the portion which is flanked, together with its distance from the flanking work. For the close flanking of ditches, lines of defence should never be greater than 300 yards. The distance between detached works, in order that the ground in front of them may be defended by the artillery fire of the collateral works, may extend to 1500 or 2000 yards. Faces of works will usually average from 40 to 60 yards, and should be directed clear of a raking fire from the front; this will usually be the case when the salients are obtuse; the prolongations of all faces of works should, if possible, be directed upon points where it is impossible to establish batteries, such as marshes, etc. See Q T, S V, in the sketch.

An Angle of Defence is the angle contained by the flanking portion and the line of defence. The limits are from 90 degrees to 120 degrees; about 100 degrees is best.

The Capital of an Angle is the imaginary line bisecting it, along which the enemy advances. That portion of the capital under fire should be made difficult by the use of obstacles. See V A.

As a corollary to the rule that salient angles should occupy the higher points of ground, re-entering angles will necessarily occupy the lower points. The openings or communications through works, which may be necessary, are formed near the re-entering angles.

Flanks should never be less than 12 yards long, otherwise the ditch will not be seen, much of this space being occupied by the slopes of the portion which is flanked. When it is advisable to flank with artillery, not less than three guns should be used.



RIGHT PROFILE. PAR. 6.

6. Construction of Single Field Works.—Pickets are to be driven at the salient and re-entering angles, and tape or string passed round them. The lines traced are the crest line (or highest part of the work) and the lines marking the excavation for trenches or ditches. With ditches these lines will be the crest of the work and the edge of the escarp and counterscarp; if with trenches, it will be sufficient to mark the front line of the trench only. "Profiles," or skeletons of the work, are then set up, formed of slips of deal or other wood, secured to pickets driven into the ground; or they may be formed with wood, cut to the proper lengths, for the heights of the various slopes, connected at their ends with rope yarn.

The berm is generally left rough, and dressed upon the completion of the work.

Upon long faces at least three profiles should be set up. At the angles of the work oblique profiles are erected, whose dimensions will, of course, vary with the sides of the angles.

It is advisable to divide the working party into squads of 25 men, each squad having a responsible overlooker. With trenches it is best to place the men at intervals of 6 feet along the tracing line, each man having a pick and shovel. When all is ready, the

work is commenced simultaneously, each digger beginning at the *left* of his task, and getting cover to the required depth as quickly as possible, and then extending the excavation to his right.

With ditches, place the diggers along the escarp line, facing the work, each with a pick and shovel, at intervals of 6 feet. *Shovelers* are placed upon the ground to be occupied by the parapet, in the proportion of two to each set of three diggers (the whole number being, therefore, one-third less than that of the diggers); these have shovels only. *Rammers* are placed in the proportion of one to each pair of shovelers, in order to consolidate the earth; they should not allow more than 6 inches in depth to accumulate without ramming it well. Suitable instruments for their use are of very easy construction. The ramming is not done with a view of resisting projectiles, as loose earth will do this better, but with the object of solidifying the work.

7. Revetments.—Earth newly dug up will not stand at the steep slopes required for some portions of the work; the means used to effect this are called *revetments*; *hurdles* or mats, 6 feet long and 2 feet 9 inches high, and made of brushwood with vertical pieces called pickets may be readily formed; 10 pickets will be a good number for each hurdle. A *gabion* is a cylindrical hurdle, filled with earth when placed in revetment; gabions are 2 feet in diameter and about 3 feet high; *fascines*, or bundles of brushwood, from 7 to 9 inches in diameter, and of various lengths, are very good for this purpose; they are bound together by tough twigs, at intervals of about 18 inches; this revetment is built as the parapet is raised, and secured to it by means of pickets driven into it at angles of 45° , each row of fascines being also picketed to the row beneath; the joints of the rows of fascines should be broken; it is necessary to use revetments for the interior slopes and cheeks of embrasures; if fascines cannot be procured, planks, casks or sand bags may be used for this purpose. Magazines are frequently constructed on the unexposed sides of traverses, as follows: Place strong splinter-proof timbers at an angle of 45° against a well-revetted traverse, strengthened by bags of earth and sods, the whole being covered with tarpaulins.

8. Obstacles.—Obstacles have for their object the holding of an enemy under fire while checking his advance and breaking up his formation.

1. They must be within the effective range of the defender's fire.
2. They should not be visible to the attacking party until the latter is at close range.
3. They should be difficult of removal under fire.
4. They must afford no shelter to an enemy.

To hinder the approach of the enemy, keep him under the fire of the intrenchments, and render an assault as difficult as possible, are most important points in the defense of field works; and it must especially be borne in mind that obstructions should always be placed in the unflanked ditches. *Palisades* made of young trees, or of large ones split into two or three pieces of a triangular shape and pointed, 10 feet long and 6 or 8 inches thick, are very useful when placed either upright in the middle of the ditch, or at the foot of the escarp inclining outwards; they are planted 4 or 5 inches apart, and buried 3 or 4 feet in the ground. The lower ends under ground are connected by a riband or cross piece to prevent them from being torn up separately; another riband is also used to connect them at about 1 foot from the top.

9. **Abattis** are constructed of trees or stout branches having their ends pointed or fastened to the ground with strong pickets, the branches being turned toward the enemy; for putting a village into a state of defence, trees bordering the road can easily be turned into a serious obstacle by sawing half through their trunks and fixing their heads to the ground.

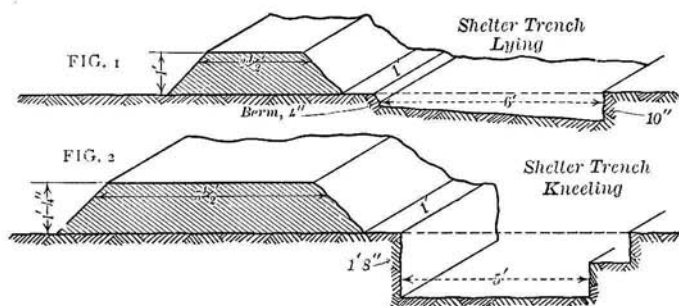
10. **Trous de Loup** are also very useful placed in front of the counterscarp, especially at the salient angles; they are pits of either 3 feet in width and depth, or of double these dimensions; a sharpened palisade is placed in the center, the point is not to project above the mouth of the pit; on no account should the pits be made 4 or 5 feet deep, as the enemy might then turn them into rifle pits.

11. **Barbed Wire**.—Barbed wire fences have been used in recent wars to check an attack. Wire entanglements, both high and low, made by driving stakes into the ground and connecting them by stout wire are also used. All such obstacles are particularly useful at night.

12. **Hasty Intrenchments**.—Hasty intrenchments are such as

may be made with little delay after occupying a position in the field; they consist of cover or shelter trenches for the men, and gun pits or epaulments for artillery.

13. Shelter Trench Lying.—The shelter trench for skirmishers lying down is shown in Fig. 1. It gives a protection of $2\frac{1}{2}$ feet of loose earth, which will stop small-arm bullets under ordinary circumstances. The time required for one man to make 5 feet of this trench with a small intrenching spade is about 25 minutes. Ordinarily two men may use 5 feet of this trench, though three may occupy five feet by lying on their left sides. In firing, the left elbow rests on the berm.



SHELTER TRENCHES. PARS. 13 AND 14.

14. Shelter Trench Kneeling.—To get cover kneeling, deepen the lying down trench to 1 foot 8 inches, and make it 5 feet wide with an embankment in front having a height of 1 foot 4 inches with a resulting thickness of about $5\frac{1}{2}$ feet (Fig. 2). The time for one man to deepen the trench in this manner, with a small intrenching tool, is about 45 minutes.

Men may fire from this trench kneeling in double rank, four rifles for each 5 feet of trench. Four men could make 5 feet of this trench from the beginning in about 20 minutes.

15. Cover for Artillery.—Cover for guns may be obtained by means of gun pits made by digging a hole of a size sufficient to partially conceal the gun and its crew, and forming an embankment in front with the excavated earth. The "Austrian Gun Pit" is often used.

16. Gun Epaulments.—Instead of placing the gun in the

bottom of the pit, it may rest on the natural surface of the ground and be covered by an embankment in front, made by digging two pits, one on each side of the gun. The crew may find cover in these pits.

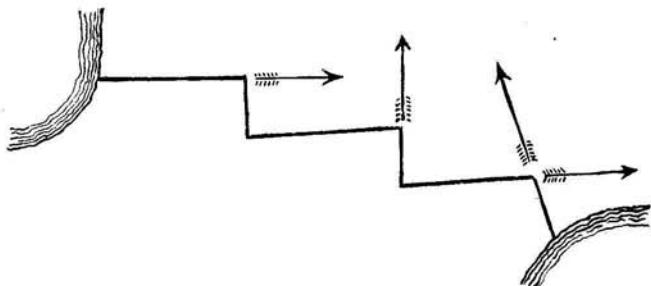
17. Advantages and Disadvantages of Shelter Trenches.—

The advantages are:

1. They stop rifle bullets.
2. They offer a small target.
3. They are quickly and easily made.

The disadvantages:

1. The embankments being low, the field of fire may be limited by small folds in the ground unless care is taken in selecting the position.



INDENTED LINES. PAR. 18.

2. In wet weather they may become untenable by reason of mud and water.

Gun pits have practically the same advantages and disadvantages as shelter trenches.

18. Lines of Works.—A line of works may have *intervals*, or it may be *continuous*. A line with intervals has the following advantages:

1. It involves less labor.
2. The garrison may be smaller.
3. It allows greater freedom of movement for counter attacks

Such works are usually so placed as to mutually flank each other; that is, in echelon.

In the case of continuous works the line may be an *indented line*, or a *right line*. From the latter only a direct fire can be

obtained, while from the indented line both a front and flank fire may be practicable as will be seen from the sketch.

19. A Defensive Position.—A position of perfect defence may not always be possible, but the following general advantages should always be sought:

1. The position should conform to the tactical requirements of the occasion and should favor the effective use of the principal weapon of the defenders.

2. The flanks should be as secure as possible against a turning movement.

3. It should be impossible for the enemy to obtain natural cover during his advance; that is, the defenders should have a free field of fire.

4. The defenders should be protected from the fire and view of the enemy by cover, natural or otherwise, which will not interfere with counter attacks.

5. The position should be such that the defenders may move readily from one part of the line to another.

6. The advance of the enemy should be delayed by obstacles and entanglements.

It was formerly the function of engineers and pioneers to lay out and construct defensive works. It is no longer their exclusive province. It is now accepted as a principle that the men who are to defend a position must prepare it for defense. Cover is of greater importance than ever before in the history of warfare. Modern weapons and smokeless powder have emphasized the importance of cover.

20. To Occupy and Defend a Town.—A town when properly prepared and defended may have the following advantages:

1. It may be rapidly placed in condition for defense.

2. It conceals the strength of the defenders.

3. It provides a certain amount of cover from fire.

4. It affords shelter from the elements.

On the contrary, it has the following disadvantages:

1. The garrison is scattered and not easily controlled.

2. When under artillery fire, splinters and fragments may cause casualties.

3. It may be set on fire by shell fire.

A town may be held for the following reasons :

1. As a supporting point in the main line.
2. As an advanced post in front of the main line.
3. As an independent post.
4. As a reserve station, or rallying point, in rear.

The following are some of the preparations to be made for the defense of a town :

First select some suitable and substantial building as a stronghold, and determine whether it would be best to occupy the whole village, or a part only. Avoid wooden houses and thatched roofs, and prefer brick houses to those of stone, selecting such as mutually flank each other. Take care that the amount of ground occupied be not in excess of the number of men available for the defense. Salient points must be strengthened as much as possible ; all houses not occupied by the defense which may be of the least use to the attack must be demolished. *Outside* the defenses destroy all walls, thick hedges, and any cover which may be parallel generally to the place, and leave such as may be perpendicular to it, and which will therefore be enfiladed and cause obstruction. *Inside* the place, reverse this rule ; *wet* ditches, palings, and thin hedges outside the place may all be left. Hedges, walls, etc., may be incorporated with the general line of defense. Long walls may receive flank defense by means of *tambours* or projecting small angular works or stockades ; communications may also be thus covered. The streets may be barricaded and the houses loopholed ; great care must be given to the communications with the stronghold, and also that barricades be not in positions to be taken in reverse ; in this case other barricades must be formed in rear. Field guns must be placed in commanding and retired positions difficult of access.

A sufficient garrison for a building will be at the rate of 1 man for every running 4 feet of the lower story, 1 man for every 6 feet of the second story, and 1 man for every 8 feet of the upper story, should there be one. All windows and doors of the lower stories should be well barricaded and secured, and ditches cut around the house. Doors may be barricaded by heavy furniture filled with earth or filled sand bags ; doors should, if possible, be made bullet-proof by nailing upon them additional planking. The

glass in all windows should be at once demolished, and the window frames filled up with rolled blankets, carpets, etc. If there be no time to destroy all the glass, blankets secured by forks within the window frames will prevent splinters. Loopholes should be made in the walls and at the angles. The upper windows need not be barricaded throughout, but must be so to a height of 6 feet from the flooring. Balconies may be strengthened and made bullet-proof, being loopholed at the base in order to give fire from beneath to the foot of the wall; suitable overhanging constructions of a similar nature may be formed by means of timber, these being passed through the wall and secured inside to the joists of the flooring; it would be advisable to construct them over outer doors. Especial care must be given to the communications inside the building, staircases being partially removed and ladders substituted. If the outer wall be liable to be weakened by artillery fire, the flooring inside should be supported in addition by stanchions. Plenty of water must be available, in casks, etc., within the building.

Loopholes should be made as small as possible, the width at the neck never being more than 3 inches.

21. Hedges and Walls.—Hedges and walls serve as screens, and with ditches on either or both sides, the earth being thrown against them, they may afford more or less cover. To prevent their being used by the enemy in case they are abandoned or captured, the ditch on the enemy's side should be so deep that he cannot fire through or over them.

22. Concealment of Trenches and Gun Positions.—It is of the utmost importance that all trenches and gun pits, or gun positions, should be covered with branches, weeds, sod, etc., in order that their position and extent may not be discovered. The old rule "fire draws fire" is now changed to "visibility draws fire," and all problems in attack and defense must consider this principle first of all. Smokeless powder is a great aid to the defender in that it does not betray his position.

23. Defensive Tactics of the Boers.—The success of the Boers on the defensive was due not only to the judgment displayed in the selection of a position, but to their skill in concealing it. Their trenches were usually without embankments. After dig-

ging the ditch the earth was leveled off. There was nothing to betray their position. Their artillery was usually dispersed, and every gun carefully screened. The English often found themselves under fire without knowing from what point the fire came. There being no smoke, and the enemy being completely screened, or having burrowed in the ground, the fire could not be returned. It must be evident that such conditions would be extremely trying and demoralizing to the attacking force.

The Boers often occupied widely separated positions, and their trenches were seldom continuous but were placed at all advantageous points where a clear field of fire could be obtained, and sometimes in several lines which would be occupied in turn as they fell back. Their plan was to conceal every rifle and every gun and utilize the full power of every weapon by appealing to the individuality and marksmanship of their men.

24. Successful English Tactics.—Against these tactics of the Boers the English finally won their greatest successes by the adoption of extended order formations at all times. Instead of concentrating and massing their men while on the march from point to point, they often swept over the country in long lines of skirmishers—they marched in extended order. Brigades kept in touch with each other, and battalions of eight companies marched in column, each company deployed as skirmishers at five paces interval, and the companies following each other at distances of about 200 yards. Thus a battalion would be about a mile deep. When one part of this long, thin line would find itself seriously opposed, or under fire, it would usually halt, take cover, and hold its ground until the distant parts of the line, continuing the march, would threaten the flanks and rear of the Boers and force the latter to leave their position. The English line would then resume the march and regain touch. This formation was known as “awaiting shell.” It minimized the effect of the Boer’s artillery and infantry fire, and reduced the chances of a disastrous surprise.

25. Field Intrenchments and Tactics.—It is laid down that the question of fortifications and intrenchments is essentially tactical. The examples of the Boer War demonstrate the truth of this statement. The location and the nature of field fortifications or intrenchments depend primarily upon tactical situations.

26. Naval Brigades on Shore.—It is not to be expected that purely naval forces will be called upon to construct permanent fortifications or to engage in independent operations on shore requiring an extensive knowledge of field engineering. The brief discussion of the subject in this chapter may suffice for most situations in which a naval officer may find himself.

Naval landing forces may be required to man permanent fortifications already constructed, to seize and hold towns or other positions, or to attack the same. The lessons of the Boer War, which have been briefly referred to, both as regards offensive and defensive tactics, should not be forgotten. But it will of course be apparent that the open order formations, and the tactics used against the Boers, who were expert marksmen armed with modern magazine rifles using smokeless powder, may not be practicable against another enemy differently armed.

Formations in mass, for mutual support, both on the march and in action, may be required against an uncivilized or semi-civilized enemy whose tactics are to surround and come to close quarters with his opponent. Such were the squares used by the British in the Soudan.

The officer must choose the formations and make the disposition of his force which may be required by the existing conditions. There is range enough in the Drill Regulations to cover most cases if an officer applies them in a practical manner.

CHAPTER XXXIV.

PRACTICAL NAVAL GUNNERY.

Prepared by Lieutenant-Commander W. S. Sims, U. S. Navy, and Lieutenant Ridley McLean, U. S. Navy.

1. **Definition.**—**Ordnance** is a term ordinarily applied to heavy weapons of warfare, such as great guns, howitzers, artillery, etc. In naval parlance, however, it has grown to be a general term which includes all material used on board a naval vessel for firing projectiles at the enemy.

2. **Gunnery** is the art of using the ships' guns to the best advantage; that is, in such a manner as to make the greatest possible number of hits in a given time.

Principles of Gunnery.

3. **Excellence in Gunnery** is measured by the rapidity of hitting the point of aim. It is evident that however large a percentage of hits a gun may make, if these hits are not made with the greatest possible rapidity, the gun will have failed to attain its highest degree of usefulness. Similarly, the very highest degree of rapidity of fire, with inaccurate pointing, is entirely useless. Excellence in gunnery may therefore be regarded as the product of its two essential elements: 1. Accuracy of fire, and 2. Rapidity of fire.

4. **Accuracy of Fire.**—This depends on:

1. The accuracy with which the gun is pointed at the target or the enemy, or briefly, *accuracy of pointing*.

2. The correctness of the position of the sight each time the gun fires, or briefly, *correct sight setting*.

5. **Accuracy of Pointing** depends on:

1. *The individual skill of the pointer*, which is developed:

(a) By continued preliminary practice at his own type of gun.

(b) By pointing at the horizon, or at floating objects when the ship is rolling, and

(c) In actually firing his gun at target practice.

2. *The condition in which the sight, the gun, the mount, and the various appurtenances which affect accurate shooting are kept.*

Unless the gun, the gun gear, gun mount, and gun sights are maintained in such a condition that the mechanical difficulty experienced by the pointer in aiming and firing the gun is a minimum, the accuracy of pointing will be affected. This applies not only to the condition as regards cleanliness, but particularly to the condition as regards facility of operation, and to the proper functioning of each individual part. A neglected gun mount renders pointing difficult, and hence conduces to inaccuracy. Neglected sights always invite disaster; if they are actually out of adjustment when firing begins they insure a string of misses; if they are weak and liable to derangement they are apt to jar out of adjustment during a string of shots and thus invite disaster in action. Neglected firing connections, locks, etc., invite either hangfires, missfires, or prolonged firing intervals, all of which are serious hindrances to accuracy of fire.

6. Correct Sight Setting depends on:

1. The accuracy of the orders given by the divisional officer, or the gunnery officer, to the sight setter, concerning the setting of the sights. This depends upon the accuracy with which the sight-bar range has been determined, which may be regarded as the most difficult problem in naval gunnery.

2. The promptness and accuracy with which these orders are obeyed.

It is manifest that however perfect the gun, the mount, the crew, and the ammunition, unless the sights are correctly set at the moment each shot is fired the projectile will certainly miss.

7. The Accuracy of the Orders Given to the Sight Setter may for convenience be subdivided under the headings:

(a) When firing guns singly at measured ranges.

(b) When firing guns singly at unmeasured ranges.

(c) When firing all guns of a ship's broadside together at unmeasured ranges.

(a) *Firing Guns Singly at Measured Ranges.*—This is the most elementary stage of target practice. In this case (which is the case under which ordinary record target practice is held) the

entire responsibility for the correct setting of the sights falls upon the divisional officer; he must keep himself informed as to the true distance from the target at every instant of time, and by observation of the fall of the shot he must so correct these varying distances that the sight-bar ranges which he gives to the sight setter will insure that any shot which is accurately aimed at the center of the target, will hit it.

(b) *Firing Guns Singly at Unmeasured Ranges.*—In this case the ranges are determined by the range finding party, by such means as exist on board ship, and are transmitted by the gunnery officer to the battery, by the range indicators, or by such other means as may be provided. In this case the observations of the fall of the shot are made by the gunnery officer and his assistants, and the necessary corrections to the distances determined by the range finding party are applied by this officer, because from an elevated position such corrections can be more accurately estimated, especially at long ranges, than by the division officer from his station near the gun.

(c) *Firing all Guns of a Ship's Battery together at Measured Ranges.*—In this case the range is determined by the range finding party, and transmitted by the gunnery officer to the battery in the same manner as above described. The correction to the various distances would be determined by the gunnery officer from the average center of impact of the various trajectories, and this would be applied by him, and included in the various ranges which are transmitted, so that nothing remains to be done but set the sight to the range and lateral compensation that are transmitted.

In both this and the preceding case, the great importance of every gun pointer being a trained expert, of every pointer aiming directly at the center of the target, and of all sights being set exactly alike (i. e. at exactly the range and lateral compensation ordered by the gunnery officer) is apparent. This will cause the shots to be bunched somewhere, and the gunnery officer can then quickly alter the sights of the battery so that this bunch will fall on the target, whereas, were this not the case, the shots from the battery would be so dispersed that no deductions could be made by the gunnery officer to guide him in the determination of the error existing between the distances determined by the range finder and the actual sight-bar range which should be used.

8. Promptness and Accuracy with which Orders Regarding the Setting of the Sight are Obeyed.—Regardless of the accuracy with which the ranges may have been determined, or of the skill of the gunnery officer in fire control, unless the sights are promptly and accurately set to conform to the ranges given (in the first of the above cases by the divisional officer, in the second and third cases by the gunnery officer) all excellence in other features affecting gunnery are nullified.

Whatever the method employed in carrying out the practice, the sight setter's duty remains the same: it is to set the sight as accurately and as quickly as possible both laterally and in elevation each time a new range or a change in lateral compensation is ordered; and as the pointer always aims at exactly the same place, and as all errors are corrected by altering the sights, it is impossible to attach too great importance to this feature of naval gunnery.

9. Rapidity of Fire.—This depends on:

1. The rapidity with which the gun is loaded after it has been fired, or briefly, *rapidity of loading*.

2. The promptness with which the pointer fires after the gun is "ready," or briefly, *rapidity of pointing and firing*.

10. Rapidity of Loading depends on:

(a) The rapidity with which each member of the gun crew performs his allotted duty.

(b) The "team work" of the gun crew. That is, on each member of the gun crew performing his own duty in the service of the gun at exactly the proper time and in exactly the proper sequence, and then getting out of the way so as not to interfere with the other members of the crew.

(c) The *precision* with which each member of the gun crew performs his allotted portion of the drill.

Accuracy and thoroughness in every detail, even though it may require slightly more time, is an absolute requisite to real rapidity of *continuous* loading, because in the commendable eagerness for excessive rapidity, many serious delays are caused by interference, confusion, and casualties that can be avoided only by precision in every movement; and it must be remembered that some of these delays, such as the raising of one single burr, or the jamming of

one cartridge case, may more seriously interfere with rapidity of fire than the maximum deliberation necessary to surely avoid them.

11. Rapidity of Pointing and Firing depends, like accuracy of pointing, on :

(a) The skill of the pointer.

(b) The condition of the gun, gun mount, sights, etc., but particularly on the condition of the mount and firing connections.

A really skillful pointer will keep a gun of an intermediate calibre, which is mounted on a modern gun mount, continuously pointed at the target, provided the mount is maintained in a perfect condition. In this way the gun is aimed and prepared to fire the instant the pointer is notified that the gun is "Ready." If to this degree of skill and excellence of mount is added a firing mechanism in such thoroughly efficient condition that the gun will fire with certainty at the earliest possible moment after the pointer wills to fire, the rapidity of *aimed* shots is made practically to equal the rapidity with which *unaimed* shots may be fired. So long as this degree of rapidity is possible with any gun, it is evident that any time which elapses between the word "Ready," and the firing of the gun is a clear loss, and its cause must be due either to—

(a) The lack of skill of the pointer in not having his gun accurately aimed before the word "Ready," or,

(b) The inefficient condition of the mount, or of the firing mechanism which prevents him from pointing and firing the gun with facility and certainty.

General Remarks on Naval Gunnery.

12. From the above it is apparent that skill in gunnery—measured by the rapidity of hitting the point of aim—depends not on the pointer alone, but on every person actually participating in the practice; on the gunnery officer, in case he is controlling the fire of the ship, on the divisional officer, the gun captain, both pointers, the sight setter, and on each individual member of the gun crew.

13. The greatest rapidity of hitting can be attained only by the united efforts of each person concerned, working as in an

athletic team, in complete harmony with every other member of the crew. A failure in the slightest detail on the part of any one participant may materially reduce the rapidity of hitting, and thus nullify the greatest possible excellence on the part of the others.

14. In the following epitome of the duties of the various persons participating in the firing of a great gun, attention is confined to the gun crew as a fighting unit. Whether one gun, or all guns, are firing, whether the ranges are determined by the divisional officer himself, as in record target practice, or are transmitted to the divisions by the gunnery officers, the range and lateral compensation are given to the sight setter by the divisional officer (or by some person appointed to assist him in doing this), and the duties of the members of the gun crew remain in all cases the same.

The Divisional Officer.

15. It should be the divisional officer's ambition to obtain from each gun in his division, at each practice, the greatest number of hits per minute possible with his particular types of guns. Having trained his division to this degree of excellence, it is ready to be used as a unit by the senior officers of the ship in the more advanced fighting efficiency practices, simulating action, in which all divisions of a ship are exercised together with a view to bringing the ship itself to its highest degree of excellence as a unit of the fleet. It is evident that until the subdivisions of a ship's force (the gun divisions) have attained a high degree of individual skill, it would be fruitless to attempt to develop a high degree of excellence in the ship as a whole. Therefore a divisional officer's chief duty is the development of his gun division, which in turn requires the development of each individual gun crew in it to the highest possible degree of excellence, and then to use this division to the best advantage as a unit, in the exercises for the development of the efficiency of the ship. In training his division up to a high degree of excellence at record practice, there is not a single feature of naval gunnery, as enumerated above, that a divisional officer can afford to overlook or neglect. Guns, gun crews, ammunition, and the necessary authority are given to him, and with these he is expected, after a limited period of training, to hit the target rapidly.

The duties of a divisional officer in connection with great guns naturally divide themselves into two classes :

1. Duties necessary during the course of training prior to target practice.

2. Duties necessary during target practice.

16. Duties Prior to Target Practice.—These may be divided into the headings :

(a) The acquirement of a thorough knowledge of, and the maintenance of, his ordnance material in perfect condition.

(b) The intelligent training of his gun crews.

17. Knowledge of, and Maintenance of, Perfect Condition of Ordnance.—The very best results can be attained only by an officer who has a thorough and complete practical knowledge of all of the ordnance material under his charge. This does not mean a general knowledge of how the guns and appurtenances are rigged and used ; it means the most complete knowledge, especially practical, that it is possible for him to obtain. Needless to say, he should know more about every detail of his guns, mounts, sights, ammunition, or other ordnance supplies than any other person in the ship. He should ascertain and record the initial velocity for which each of his sights are graduated ; the kind and amount of powder required to give this initial velocity ; the normal pressure ; the pressure to which the gun has been tested ; the length of the gun in calibres ; the permanent angle of the sight, etc. He should construct for each gun a table showing, for the various ranges : (a) The angle of elevation. (b) The angle of fall. (c) The time of flight. (d) The "danger space" for 19 feet (the height of the top of the target). (e) Drift remaining uncorrected. (f) The lateral distance corrected by one division on the sliding leaf. (g) The lateral effects of the apparent force of winds of various strengths on the projectile. (h) The vertical distance at various ranges, corresponding to changes of 100 yards in the sight bar. (i) The effect on the trajectory of a variation of 1 per cent in the density of the air.

He should render himself thoroughly familiar (both practically and by a study of descriptive pamphlets, or other literature) with the construction, use, and means of manipulation of every piece of the mechanism of the gun, mount, or accessories. He should

thoroughly familiarize himself with the regulations for the care, preservation, and precautions to be observed with the ordnance outfit, and should assure himself that these regulations are strictly observed by the members of his division. He must assure himself by frequent inspections that the ordnance and all appurtenances under his charge are always kept in the most efficient possible condition; and if the guns and mounts do not then work with the required facility, it is his duty to take such steps toward their modification as will insure their efficient operation. He must see that the sights are, when at point blank, in adjustment with the bore sights, and not only that they are maintained in as good a condition as when supplied, but also that they are sufficiently secure to withstand the shock of discharge without jarring out of adjustment. Similarly, he must see that his firing connections are strong, and well secured; that the firing mechanism and the batteries are in efficient condition, and that the circuits are complete.

Immediately before a target practice, he should critically examine all ammunition that is to be used, and should assure himself of its perfect cleanliness, good condition, and when practicable (by actual trial in the gun) of its proper size. In all practices, faults in any of the above mentioned items seriously retard the rapidity of fire, and very seriously detract from the efficiency of the division. All delays in firing, caused by faults such as weakness of lanyards, raising burrs, sights out of adjustment, etc., or delays caused by the inherent weakness or delicacy of any device or appliance which has been duly supplied, but the weakness of which could reasonably have been anticipated and remedied by the force on board, are considered faults of the crew, and time occupied in their rectification during a string of shots, counts against the crew. In such cases the fault clearly lies with the divisional officer.

18. The Intelligent Training of his Gun Crews.—To train intelligently the crews of the various guns to the highest degree of efficiency, the divisional officer must himself know each individual duty of every member of the gun crew, and how such duties can best be performed. He must, in all exercises with the various devices for training the gun crews, as well as at actual drill at the gun, insist on the careful observance of all of the

minor details of the drill, bearing in mind that any drill that is carried out without observing every detail which it would be necessary to observe in actual firing, or without striving to attain as great a degree of rapidity as will be sought in target practice or action, *is actually detrimental to the gun crew.*

Owing to the number of gun crews which may be under the command of one divisional officer, each officer should consider as a most important feature of his own duties, the development of the gun captains of the various guns so that they can efficiently drill and, so far as necessary, instruct their own gun crews.

19. Duties during Target Practice.—Assuming that the above duties have been efficiently performed prior to target practice, the score made by the division, or by any single gun crew, depends as much on the efficiency displayed by the divisional officer in the performance of his duties during target practice, as on the efficiency of the pointer, or any other man in the gun crew. These most important duties are:

(a) The accurate determination of the distance of the target at each particular instant during the actual firing.

(b) The display of care and judgment in applying to these distances, corrections based on the observed fall of the shot.

The data obtained by the observation of the fall of the first shot of a string should be adequate to insure the remainder of the shots hitting the target, provided the pointers are well trained, the ordnance in good condition, and the divisional officers well informed as to the trajectory of his gun.

In addition to the training of his division in great guns, it may be well to specify briefly the—

20. Duties of Divisional Officers in Small Arm Practice.—Small Arm Firing Regulations fully explain the general duties of the divisional officer in connection with this form of practice.

The divisional officer is responsible for the strict observance of all regulations laid down for the safety of the men of his division and of other persons who may expose themselves while firing is in progress.

He should see that all regulations are strictly obeyed, and he should attempt to bring his division to a high degree of efficiency in all of the prescribed methods of firing. He should seize every

opportunity to carry out the supplementary forms of practice which are permitted, though not absolutely required by the regulations.

In all "instruction practice," he should bear in mind that the purpose is to *teach his men the correct methods*, and to *teach them the art of using small arms* to the best advantage; not to obtain the highest possible score.

Turret Captains.

21. **A Turret Captain**, as the name implies, is second only to the officers, in his authority in a turret.

This position was created in order that our turret crews might be so organized that their efficiency in action would not depend too much on the presence of the officer of the turret; that is to say, in order to provide some leading man in each of our turrets who could be relied upon to perform the vitally essential duties of receiving orders, adjusting sights, directing the setting of sights, and particularly who could be trusted to carry out the very important regulations in the drill book for insuring safety in all operations during loading, firing, or in the case of missfires, hangfires, or unforeseen casualties.

In his daily duties the turret captain is charged with the care, preservation, and efficient condition of everything belonging to the turret to which he is assigned. He should give the necessary orders to the captains of the respective guns and ammunition crews, or to the gunners mate of the turret as the case may be. He will see that such orders are promptly executed, superintending and assisting with the work as may be necessary. Any duty in connection with the turret devolving upon the gunners mate, or the gun or ammunition crews, whether repairs, cleaning, overhauling, general work, or drill, is under his general charge, and he is responsible to the turret officer for the efficiency and thoroughness thereof.

In the absence of the turret officer, the turret captain assumes charge, carries out the regular drills, the training with mechanical targets, actual target practice, or commands the turret in action in the same manner as the divisional officer would do were he present. In addition to the knowledge and ability necessary to

drill the turret crews and, in the absence of the turret officer, to direct the fire of the guns in action, the turret captain must have the mechanical knowledge and ability necessary to overhaul all parts of the turret and gun gear, and to keep them at all times in efficient condition. His general duties are, therefore, such as to render it indispensable that he acquire a thorough knowledge of the ordnance of his turret, and he should make every effort to obtain and read the detailed instructions describing the various features thereof.

Gun Captains.

22. Each gun crew has a gun captain, who besides his duty in his individual station at the gun is in charge of that gun and gun crew.

During all drills and exercises with the gun, the gun captain must be in a position to superintend and direct the movements of the members of the gun crew; for this reason he is not stationed as pointer (except in guns of the secondary battery), nor can he ever become the pointer so long as he remains gun captain. He can generally best perform his duties as gun captain when stationed as plugman. The fewer men in the crew of a secondary gun, together with the position of the pointer in the rear of the breech, enables the pointer of such guns to act as gun captain.

A gun captain must not be allowed to regard his duties as merely perfunctory. He receives extra pay to act as captain of that gun and gun crew, and he has the same relation to his gun and gun crew as a coxswain has to his boat and boat crew. He is responsible to his divisional officer for the care of his gun, and for the drill of his particular gun crew.

23. While his duties in the instruction and development of his crew have to do very much more with the development of its practical skill in serving the gun, than with its theoretical instruction, he should be thoroughly familiar with his gun, mount and appurtenances, and be able to explain such essentials to the crew as will enable them to gain the best practical results from their exercises. He has immediate charge of all of the exercises with the mechanical devices provided for training the crew, and should therefore clearly understand the purpose, and the object to be

attained by each exercise. As he is responsible to the divisional officer for the practical development of his crew, he should **always** bear in mind that it is his duty to get the very highest performance out of the crew that it is capable of. The principle cannot be too strongly impressed upon either gun captains or gun crews that every movement at gun drill should be made *quickly*, no matter how much time may be then available. This is always necessary at gun drill because the gun crew is being trained for the one great emergency of battle, and at such a time every second, every fraction of a second counts; and the only way to obtain a gun crew which will utilize advantageously every fraction of a second in battle, is to train it to do so in time of peace. When the crew is finally engaged in actual battle, it should be so accustomed to using intelligent speed at drill that it will then do so *mechanically*. Every instant saved in action increases the "hits per minute"; to save instants in action, the crew must be *trained* at saving these instants beforehand. In other words, the crew must be *trained at rapidity of fire*, rather than simply *instructed in it*, and every effort of a gun captain should be directed to that end. It should at all times be remembered that drill is but a preparation for action. Never for a moment permit slouchiness, or inattention on drill. If a crew is permitted to drill slowly or carelessly, it will do so in action unless it is *then made to hurry*, and on being *suddenly hurried* true rapidity will not be attained. Remember always, that a drill is as much for the purpose of instructing men how to serve a gun *quickly*, as how to serve it at all.

24. For the purpose of assisting in the training of gun crews, a certain course of training has been prescribed for pointers and gun crews. The gun captain has the immediate supervision of these exercises, and should see that they are at all times carried out in accordance with the instructions, otherwise the best results will not be attained.

An efficient gun captain will therefore have :

(a) A thorough practical knowledge concerning his gun, mount, accessories, ammunition, etc.

(b) The ability to take charge of, drill and instruct his gun crew in practical details concerning his gun, without the supervision of an officer.

(c) The executive ability to handle a crew of men, make them perform every detail of the drill, and maintain their parts of the gun and mount in excellent condition.

Gun Pointers.

25. **The Gun-Pointer Group** consists of the first and second pointer, and the sight setter, and each of these men must be carefully trained to acquire skill in accuracy and rapidity of pointing. A gun pointer must remember that he has a most important position. A ship is built for the purpose of using her guns, and therefore the pointer is a man of vital importance to the ship. A ship may never be engaged in action more than a few minutes during her whole career, and if in this few minutes a pointer, through over confidence or neglect of any of the details of training, fails to fire accurately or as quickly as possible after the gun is loaded, he fails in his duty to his ship in that he has occupied one of her important positions of offense without doing the enemy the greatest possible injury.

26. Pointers must not, however, misunderstand their duties. It is a pointers duty to fire the gun as soon after it is loaded as he can get his crosswires, or his line of sight, to bear accurately on the *middle* of the target, or on the portion of the enemy that may be designated as the point of aim. He has nothing to do with the correction of his sights; that is done by the sight setter under the orders of the divisional officer. In all cases the pointer must aim exactly as he is directed, otherwise nothing can be determined from the fall of the shot, and corrections made by the divisional officer, based thereon, will be erroneous.

27. The firing pointer must control the pointing of the gun. The training pointer will keep his sight set roughly for the range, but exactly for the lateral compensation ordered, and, unless otherwise directed by the firing pointer, will keep the gun trained continuously on the center of the target. If in the opinion of the firing pointer, the gun is not trained exactly "on," he will give the orders "right," "left," or in the case of an apparently moving target, "a little faster" or "a little slower," and the training pointer must obey the command even though he thereby throws his own sight off. Both pointers will, at all times, keep their

eyes pressed firmly against the rubber guards on the eye pieces of the telescopes, and keep the cross wires or the line of sight constantly on the target when it is practicable to do so.

28. *Skill in pointing* is shown in *bunching the shots* when the sights and the points of aim remain unchanged. If a pointer, firing under the orders herein laid down, bunches his shots in a small area when the sights remain unchanged, it shows that he is a skillful pointer whether the shots hit or miss, as it is the duty of the divisional officer to order the alteration of the sights so as to bring the bunch on the target. A bunched string of shots simply shows that the pointer aims alike each time, and fires each shot at the same corresponding moment in each roll, and if he does this, and does it quickly, it is all that can be required of him. The divisional officer must do the rest.

Skill is required to point the gun in exactly the same manner for each shot, and especially is this the case when the ship is rolling or pitching. In this case the fall of the shot will be so affected by the motion of the ship, that an inexperienced and untrained pointer cannot hit the target. If the wires are "on" when he makes up his mind to fire, they are "off" when the projectile leaves the gun, and in such cases he will fire over, if the ship is rolling away from the target, or short, if rolling towards it. This, the greatest error of naval marksmanship is avoided (1) in heavy guns, by training men to allow for the "firing interval," that is, to judge correctly the proper moment to fire so that the wires will be "on" when the projectile leaves the gun; and (2) in all guns capable of doing so, by keeping the wires "on" during the "firing interval," so as to eliminate the effect of the roll. Much skill and constant practice are essential with either method.

The quickness with which a pointer can aim and fire his gun is a most important factor in his excellence, but a pointer should always remember, in his zeal for rapidity, that if the wires are not *exactly* "on" when the projectile leaves the gun he will surely miss, and he will have actually thrown away the entire time required to load, aim and fire that shot; therefore accuracy must never be sacrificed to rapidity.

The Sight Setter.

29. **The Sight Setter** must keep the sight set exactly as he is ordered (both the lateral and the vertical setting being done by him), and he must keep the training pointer notified as to how the firing pointers sight is set. He must carefully watch the sight during firing to see that it is not jarred out of adjustment by the discharge of the gun. He must realize that unless at each shot the sight is accurately set, the pointer must certainly miss. This most important element in accuracy of fire is too often neglected, the pointer having almost invariably a disposition to correct small changes of range, or small errors both vertically or laterally, by altering his point of aim. This is now absolutely forbidden, therefore all the greater care is required of the sight setter and divisional officer. As previously stated a good pointer will bunch his shots somewhere, if he aims always at the same place. While this is all that can be required of the *pointer*, it is not enough for the *gun*; the gun is for the purpose of hitting the point of aim, therefore when the gunnery or divisional officers observe that the shots are being bunched *off the target*, the range and lateral correction are so changed that the shots are made to hit, the pointer continuing to aim at the same point as before. If, when a change of range or lateral correction is ordered, the sight setter does not promptly and accurately set the sight to conform thereto, he may be, himself, wholly responsible for a series of misses. It should be borne in mind that when sights are not correctly set, the more expert a pointer is the less chance he has for hitting, because *were he a perfect shot he would NEVER hit the point of aim with sights which were incorrectly set.*

While the amount and direction in which to move the sliding leaf will always be given to the sight setter by the divisional officer, it is important that both the gun captain and the members of the gun pointer group thoroughly understand the direction the sight must be moved to correct errors made. The rule is so simple that every one can understand it. It is simply necessary to remember that the shot always falls in the direction the rear sight (or the eyepiece of the telescope sight) is moved. Everyone knows that if we raise the rear sight, we fire higher; if we lower it we

fire lower; similarly, if we move it to the right we shoot further to the right, and if to the left we shoot to the left.

Rapidity of Loading.

30. Having now considered the pointing and sight setting, the rapidity and precision of serving the gun follows.

No pointer can make a high score in hits per minute unless the gun crew is capable of continuous rapid loading; and no gun crew will be capable of loading a great number of times in a minute unless the members of that crew have been trained, as a team, to do their individual duties quickly, thoroughly, and in such a manner as to in no way interfere with each other.

Gun crews, when at drill, are too apt to regard small matters as of no consequence, but these are always the causes of the delays when it comes to actual firing. Therefore every small detail in the gun drill should be zealously practiced by each member of the crew.

Every man should feel that in practicing the small details that are mentioned in the drill book, he is learning to avoid what some one else learned by actual experience.

Summary.

31. Summarizing the above instructions:

1. *Turret captains and gun captains* have complete charge of their guns or turrets under their divisional officer, and their knowledge should be such that they can in action, drill, or target practice, efficiently take the position of that officer in controlling the exercise or fire from their particular gun.

2. *The pointers* sole duty in firing is to keep the cross wires as constantly on the target as possible, and to fire as soon after the gun is loaded as he can hold them accurately "on." He should be oblivious to his surroundings, as his only duty is to point and fire the gun. He has nothing to do with correcting the errors made through incorrect sight setting, except when no sliding leaf is provided, in which case he must alter his point of aim as directed by the divisional officer.

3. *The sight setter* watches the sight constantly to see that it remains at the correct position; alters the setting of the sight as

ordered, and keeps the training pointer informed as to the correct setting of the sight.

4. The other members of the crew must, by careful attention to the details of the drill, attain the greatest rapidity and precision of loading, which is only to be acquired by constant training as a team.

5. Those members of the crew concerned should observe the following rules:

(a) Use every effort to gain the maximum rapidity of hits.

(b) After the gun is loaded, fire the first time the cross wires bear accurately on the target, provided it is possible to hold them "on" momentarily.

(c) Never fire a gun when the sights do not bear accurately on the target.

(d) Whatever any member of the crew has to do in serving a gun, *do it thoroughly*, and time will be saved in the long run.

Ordnance Duties of Junior Officers of Divisions.

32. When midshipmen graduate from the Naval Academy, and go out into the service, they are, in addition to their watch and other duties, assigned to duty, sometimes in charge of divisions on small ships, but usually as junior officer of a division on a large ship.

33. During the course at the Naval Academy, midshipmen have received instruction in all of the theory of ordnance and gunnery that will be of practical value to them in their sea-going duties in the future, but owing to the lack of time and facilities, their instruction in practical gunnery has necessarily been of an elementary character. They have been instructed in the principles of straight shooting; have been drilled at certain classes of guns, and are familiar with the use and advantages of the various devices for the training of gun pointers and gun crews, but owing to the scope of this subject of practical gunnery, owing to the continual changes and improvements in naval ordnance, and to the lack of opportunities for more practical experience, midshipmen, in going out into the service, must realize that they are yet under instruction, and have much to learn, the main difference being that while they are at the Naval Academy they are taught, drilled and made

to recite to their instructors—information being thus placed in their hands, whereas, after graduation, they must study for themselves, and often obtain the desired information only after much research. Before graduation their failure to understand a subject, only affects their recitation or examination; after graduation a lack of knowledge on practical professional matters subjects them to chagrin in exposing their ignorance before the men of their division, whom they are supposed to instruct; it affects their reputation as officers, and it diminishes the efficiency of the ship on which they are serving. If the midshipman happens to be detailed as the officer in charge of a division before he has had experience as a junior officer, with little opportunity to practically learn the duties of a division officer, it is the more necessary that his effort to learn all of his practical duties be diligent and absolutely thorough; for on him alone will rest the responsibility for the efficiency or inefficiency of the division, the merit of which will be clearly shown at the first record practice.

34. The primary duty of any divisional officer is to develop his division as a whole, by drill and instruction, so that it can efficiently perform any of the various duties required of it. The various drills which the divisions have on board ship are for the purpose of perfecting them in each of the exercises, in order that under actual service conditions they can perform these duties efficiently and without further instructions at that time. It is, in short, so that the division may be maintained at all times ready for any service which it might be called upon to perform were a war to break out immediately. This point is frequently lost sight of by young officers. It should always be remembered that the final test of the efficiency of a division is a consideration of the question "If action were imminent, would I desire the division to be more proficient?" If the answer is "yes," now is the time to add to its proficiency. Knowledge is valuable only for its power to produce results. In divisional duties, the entire object is to do practical things, not to teach theory. Practical knowledge of a most detailed kind is necessary to an officer to insure his gaining the highest possible practical results from his division. The standard of excellence in each division, boat crew, or gun crew, is not how much they know, or how well they are instructed in the per-

formance of their duties; it is how well do they *perform* the duties which are required of them; and the nearer a division approaches perfection in its actual drills, the nearer have the officers in that division succeeded in the perfect performance of their duties.

35. No person can efficiently drill or instruct others in any subject unless he himself knows thoroughly and accurately every detail of the drill or the matter under consideration; therefore after reporting for duty on board a ship, the midshipman should at once prepare himself for his divisional duties by thoroughly informing himself on every detail concerning the division to which he is assigned, whether he is in charge or junior officer of it. He should realize that he is now an officer, and that he will be so regarded by both the officers and the crew of the ship, and that so long as his knowledge of every detail of matters under his cognizance is not greater than that of any man of his division, just so long will he fail to command the highest respect from his men.

36. A midshipman should, therefore, immediately after reporting for duty, begin diligently to inform himself on all matters pertaining to his own duties, the duties of his division, and of each individual man in it. He should make out a copy of a complete watch quarter and station bill of the division to which he is assigned. This should show the individual duties of each member of the division at general quarters, fire, collision, boat, company, and landing drills, as well as the cleaning station of each man. If he is to be the junior officer of the division, this bill should be copied from his divisional officer's station bill; if he is to relieve some other officer in charge of a division it should be obtained from that officer in order to avoid any unnecessary changes in the stations of the men. If he can obtain it in no other way, it may be copied from the ship's station bill, but this will not show the individual duty of each man at each exercise. He should as quickly as possible become acquainted with each man of his division, learning their names and rates, their personal characteristics, their individual value and degree of reliability. He should acquire a thorough detailed knowledge of the position of the ordnance and appurtenances supplied to his division; learn the location of the magazines, ammunition hoists and scuttles, pumps, hydrants, fire hose, tarpaulins, hatches, etc., within the limits of

his division, and, by visiting the part of the ship in which his division is stationed, preferably with the division officer or with the officer whom he is to relieve, familiarize himself with each duty that the station bill requires his division to perform, so that at the very first drill he may intelligently perform his duties as an officer. He should, in brief, as quickly as possible, render himself familiar with every detail connected with his division and the duties which it has to perform, and as a test of his proficiency in this respect, he should run over in his own mind the duties of his division at the various drills, and ask himself if he is competent to perform the duties of each man at each drill. An officer cannot be proficient in his divisional duties until he is competent to do this.

37. A thorough detailed knowledge of the guns of his division, their mounts, accessories, firing mechanisms, and ammunition, as well as a detailed knowledge of the drills, practical notes in connection therewith, the place where each article required at drill is stowed, and the exact duty of each member of the gun crews is an absolute essential. He should therefore make a careful study of all available literature descriptive of his guns, mounts, ammunition, etc., as well as all instructions concerning the care, preservation and manipulation of his guns. Instructions for training gun pointers and gun crews, and for conducting target practice, should be matters of perfect familiarity with him, and he should as soon as possible render himself familiar with the current orders of the ship, by reading the Captain's and the Executive Officers order books. As the primary duty of any division is the effective use of the guns of the ship, the details of the duties above given for both the division officer and for each member of the guns' crew are matters of extreme importance to him, and should be strictly observed.

38. As junior officer of a division, a midshipman is the assistant of the divisional officer, and he should by observation of that officer, attempt, in all practical details, to profit by his more extended experience; a midshipman should endeavor to make his manner of carrying out the drills and exercises, and his general method of handling the men of the division, conform as nearly as possible to that of the divisional officer, and he should evince

as great an amount of zeal in the progress and efficiency of the division as he would do were he himself the divisional officer. All instructions governing the divisional officer, apply with equal force, except when clearly inapplicable, to the junior officer of the division.

39. After having thoroughly acquired and mastered all information concerning the duties of his own division, the midshipman should then, like any officer on first joining a ship, devote himself to a study of the details of the entire ship. He should, however, never allow this, which may be regarded as *general information*, to in any way interfere with an absolutely thorough knowledge and performance of his duties in his own division. This is his primary duty; this is where he is stationed; and this is the division which he is responsible for developing.

40. The daily divisional duties of a junior officer, will of course be as required by the divisional officer, but the following may be laid down as general rules:

The junior officer of a division should always be present during the period assigned to cleaning gun-bright work. He should see that all men who are not excused are present, and that those who are present clean all of the bright work of the gun, including that usually cleaned by those who are excused or who are necessarily absent. In the performance of this duty he should, so far as practicable, give his orders only to the captains of the various guns, and should require them to supervise the cleaning of their individual guns, and to detail the individual numbers who are to clean the bright work of the absentees.

At morning quarters he assists in forming and inspecting the division, as required, accompanying the divisional officer throughout the inspection. While at quarters during the temporary absence of the divisional officer, he takes command and sees that order is preserved.

At drills and at all exercises he should be diligent in requiring the performance of every single detail. At any time when the divisional officer is absent, the junior officer succeeds to the performance of all of the divisional duties.

If a midshipman is detailed as junior officer of the Engineer or Powder Division, his general duties are similar to those above

described. His first duty is, in every case, to make himself master of the situation by thoroughly informing himself on every point which falls under his charge, including not only the mechanical arrangement and details of the mechanism in his division, but also of all ship and naval regulations governing his duties, of the customs of the ship, the customs of the service, etc. In whatever capacity an officer may serve on board ship, his duties are laid down in a general manner in the U. S. Navy Regulations, and adequate information on all professional matters are available to him; ignorance of regulations is never an adequate plea for inefficiency.

Therefore, to whatever duty a midshipman is assigned, he should remember that his value, reputation, and ability will depend on his knowledge of his profession, his attention to his own duty, and the exactitude which he requires of his subordinates in the performance of their duties.