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

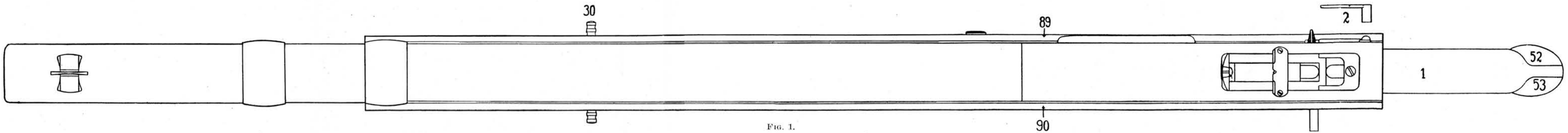


FIG. 1.

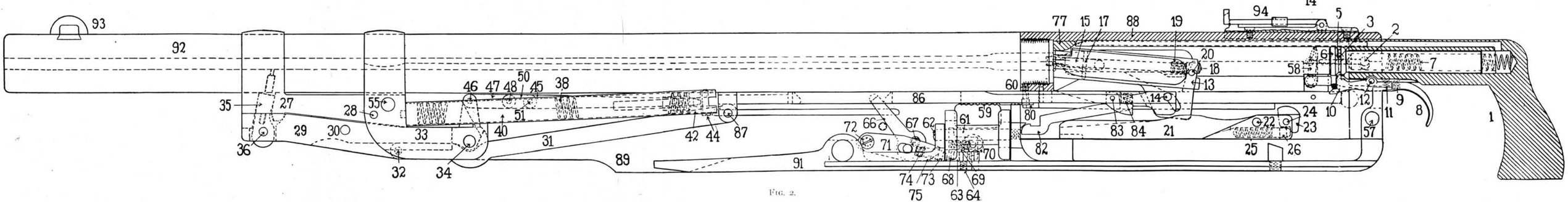


FIG. 2.

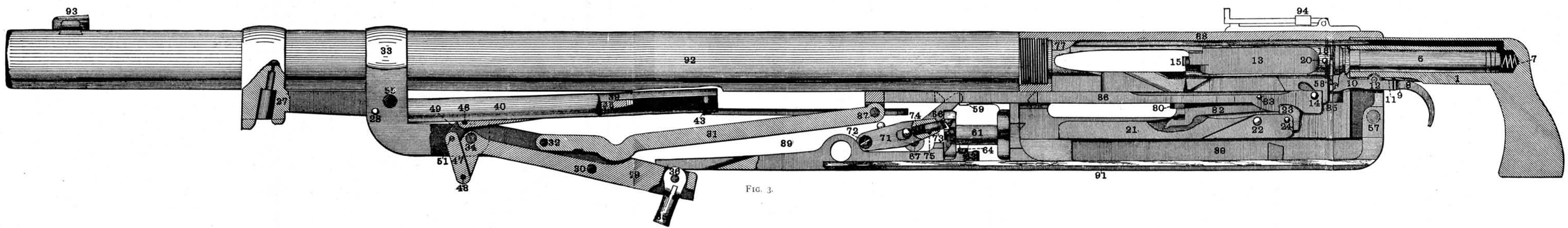


FIG. 3.

Page 252b
Back of Large Foldout MG Plate
Faces Page 253

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.)

11. 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

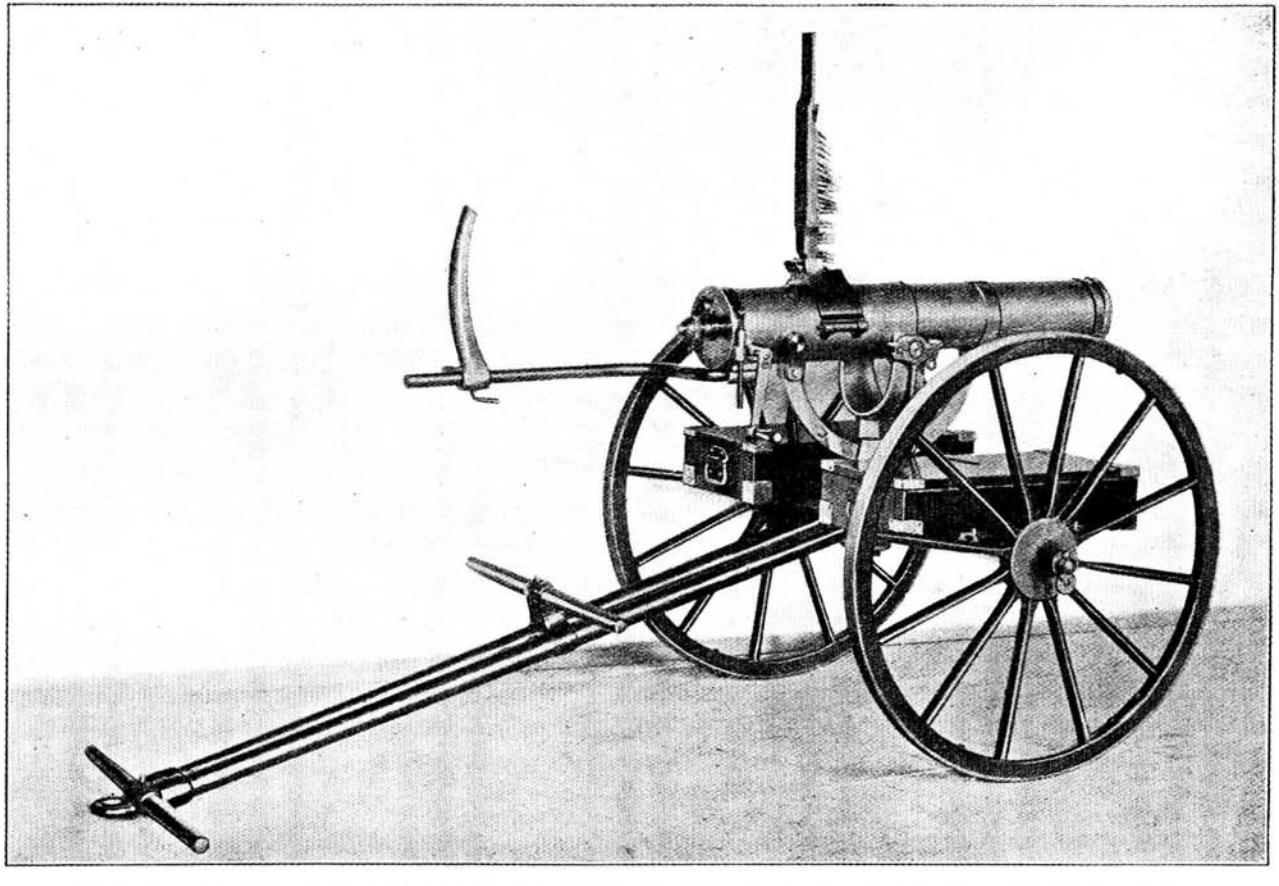
all the mechanism and barrels are encased in a brass casing. The ammunition for the last design is the same as for the .30-calibre Colt and the .30-calibre rifle. The sight is of the plain bar type, graduated to 2000 yards.

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 keyway 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 AND FEED GUIDE-WAY SHIPPED.

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Faces Page 257

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

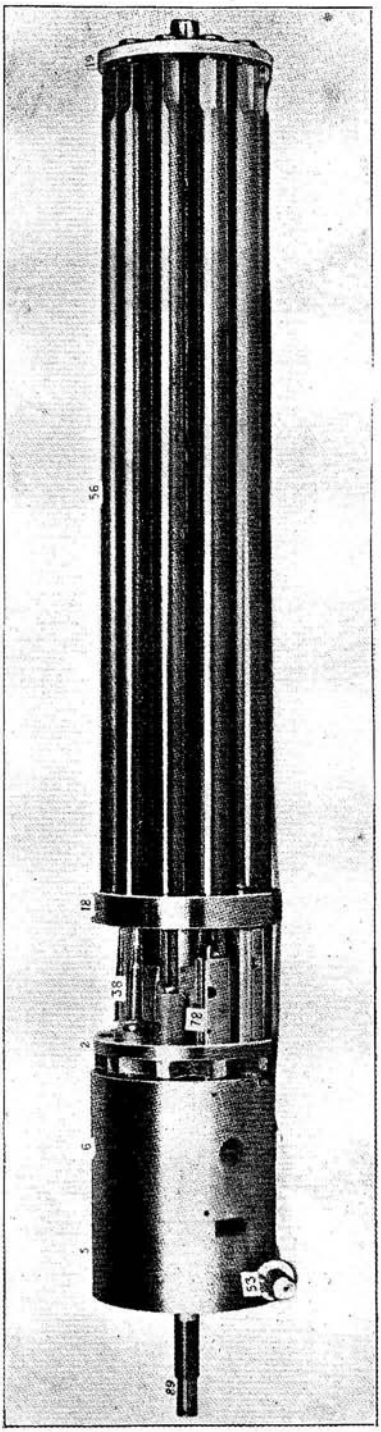
firing. On the inner surface of the cylinder a spiral cam is cut which operates the locks by the lugs on their rear ends. The cocking switch (63) is held in a longitudinal dovetailed slot in the cam cylinder; it is held forward by a light spiral spring, but may be moved rearward by turning a milled head, 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.

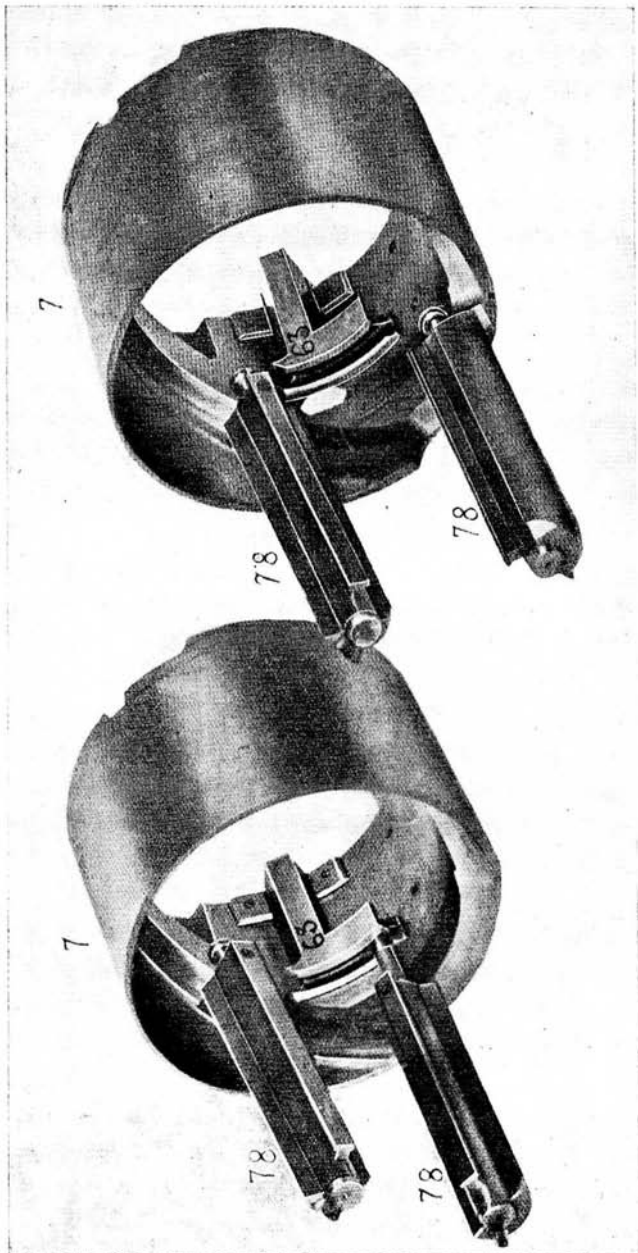
The *main-shaft worm wheel* (12, Plate V) assembles on the main shaft, to which it is keyed immediately in rear of the diaphragm, and engages the crank-shaft worm wheel (13), which is carried by and keyed to the crank shaft (53), immediately below the main shaft.

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.

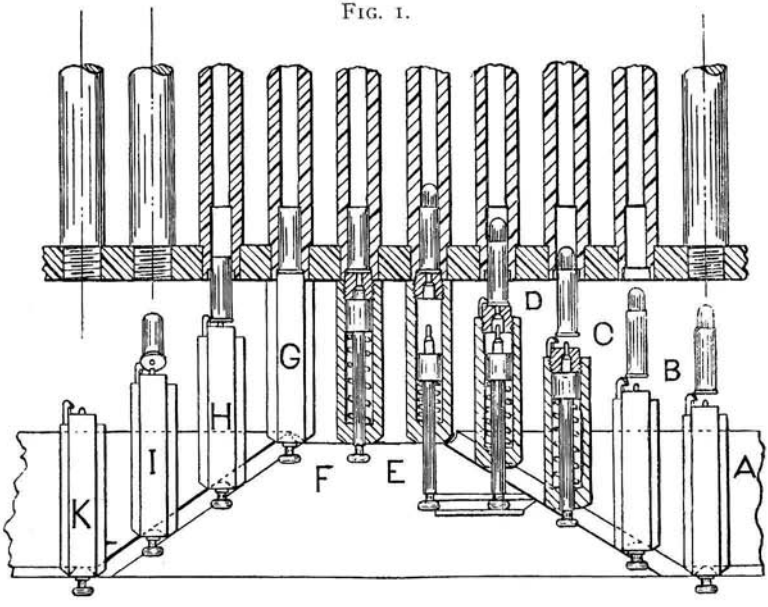
The *feed guide* (constructed on the Bruce Feed System), shown in place in Plate II, contains two channels for the cartridge rims and ships over the opening in the hopper. The cartridges are inserted from the top, travel downward by gravity, and drop off one by one to the grooves of the carrier block,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

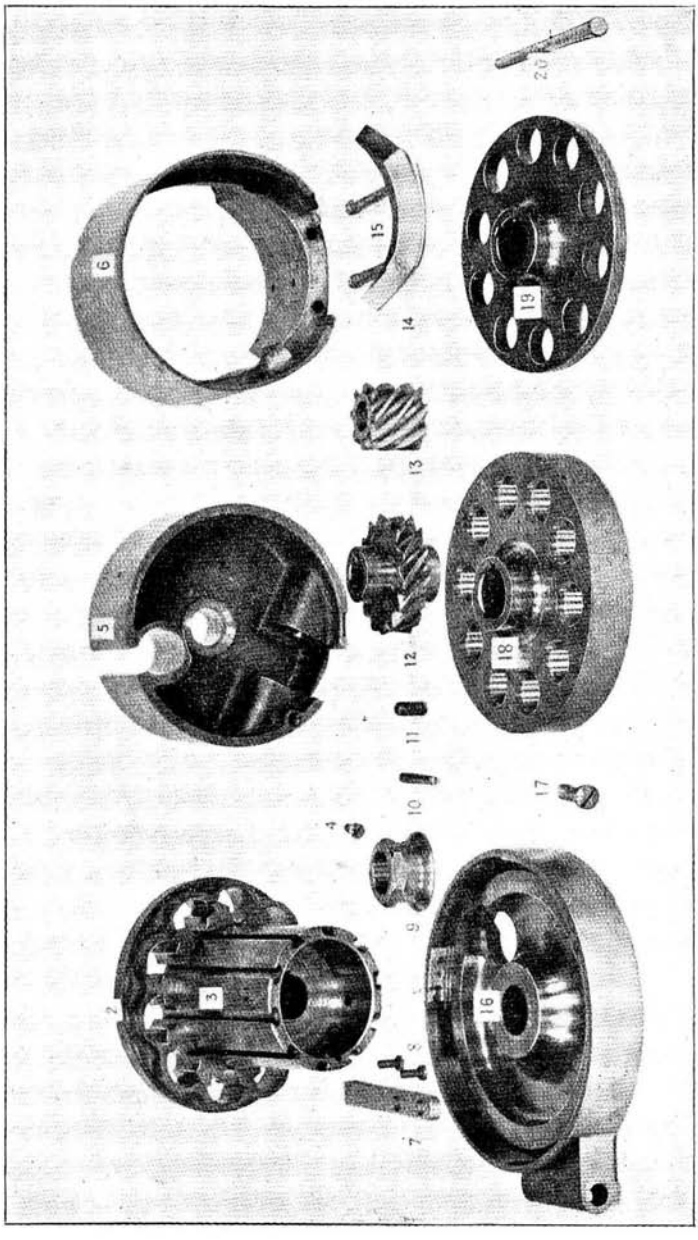
the locks and cartridges. The cam lugs on the locks engaging the cam on the inner surface of the cylinder,—which cylinder does not revolve,—causes the locks to move forward, each one pushing in front of it a cartridge. This forward motion of each lock continues until the cartridge in front of it is seated 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.

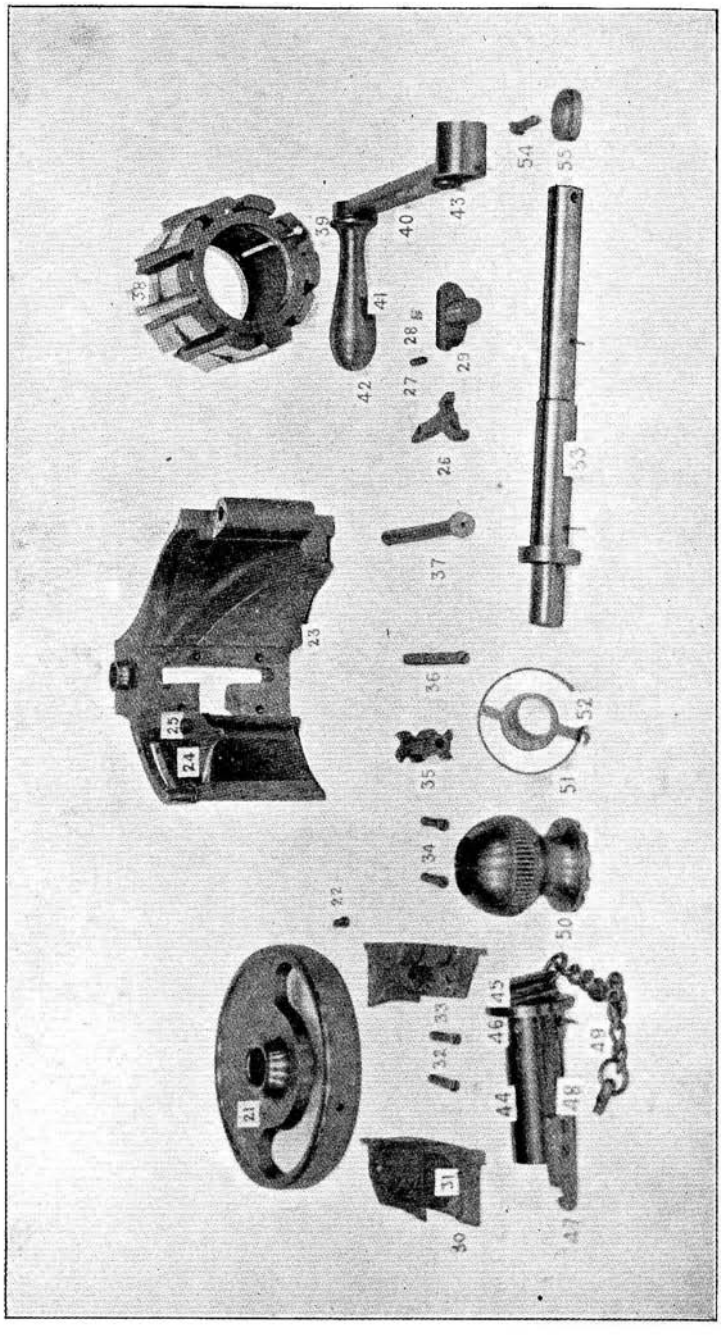


DEVELOPMENT OF CAM CYLINDER FOR GATLING GUN.
Showing operation of the locks diagrammatically.

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 diaphram 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-

ticable 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.

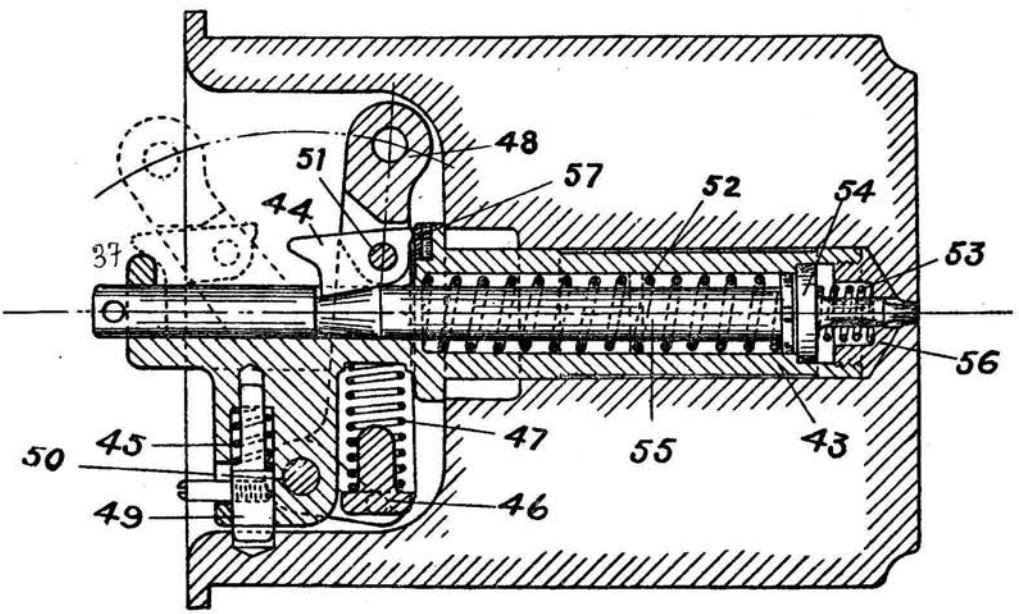
The limber holds ten ammunition boxes, each containing four cartridges, and two more boxes are bourne by the carriage; there are places on the limber for five or six men who are to be carried there principally for balancing purposes. The gun and field carriage weigh about 8000 pounds—too great a weight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



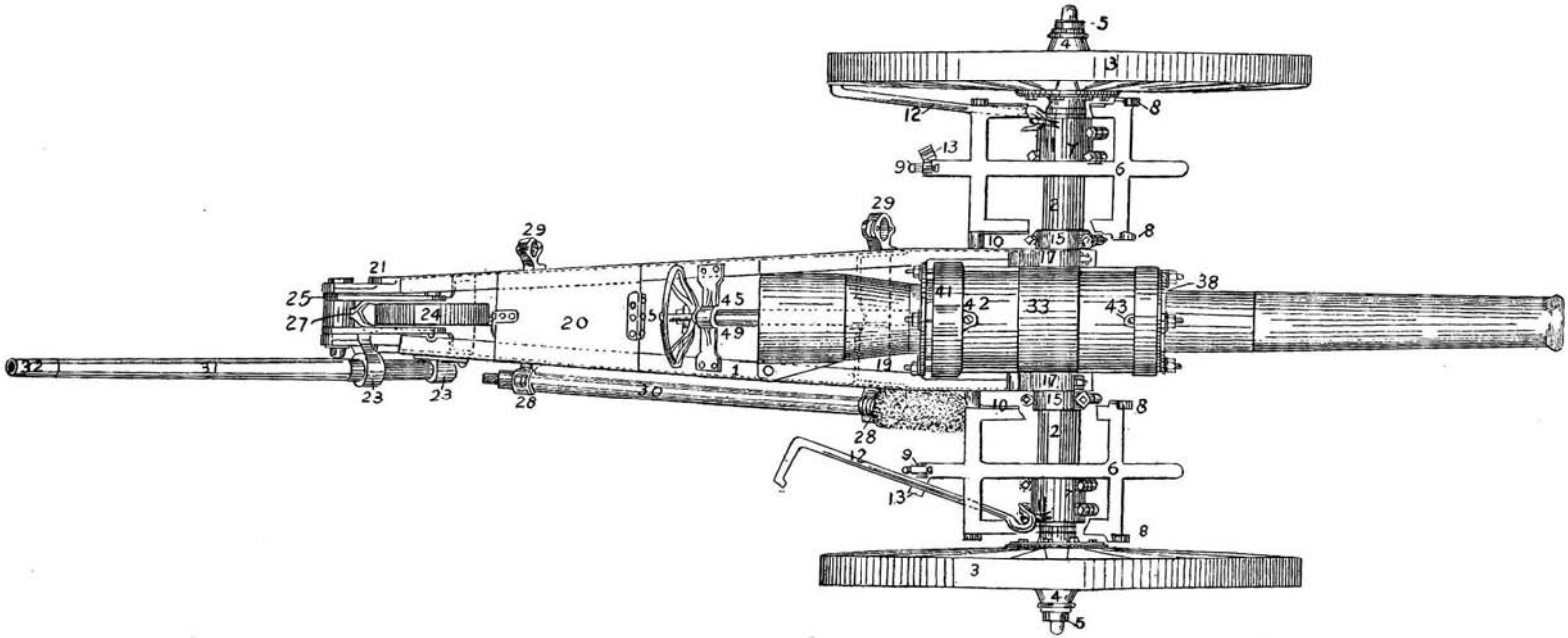
FIRING LOCK. Par. 5.

(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.

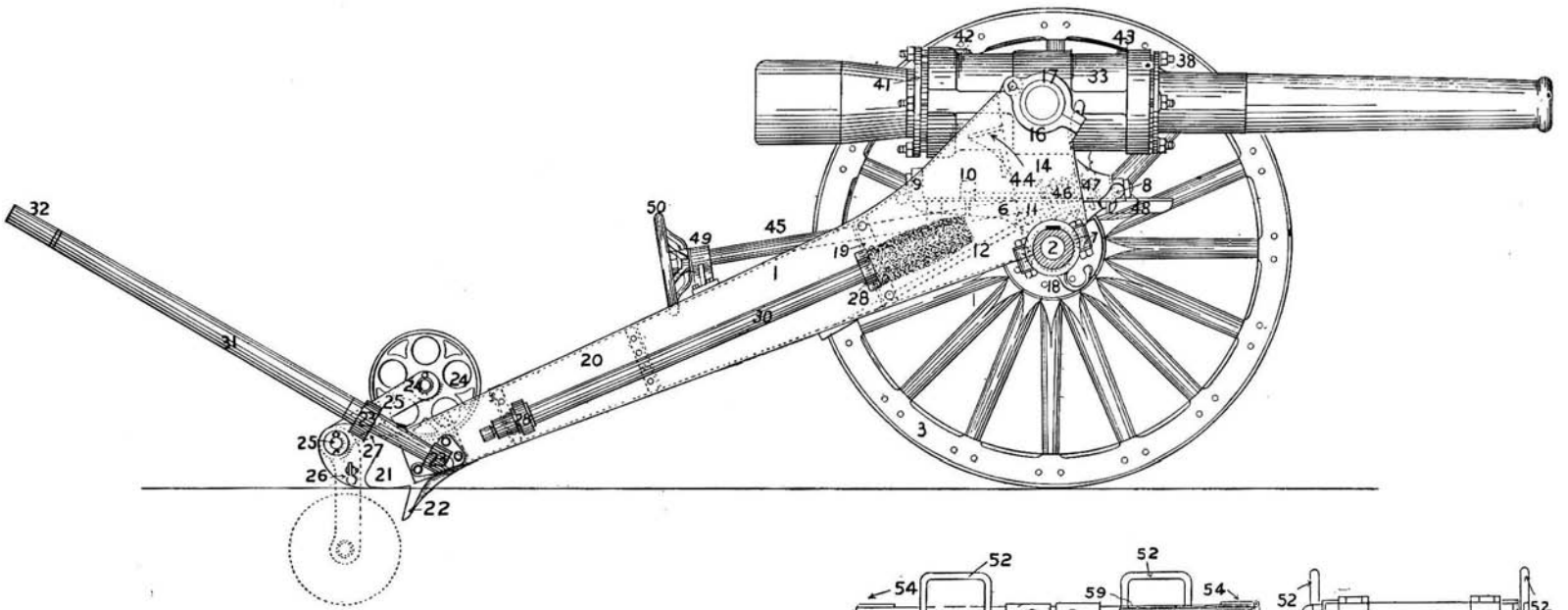
Caution.—The lock, as at present designed, will permit of the gun being fired before the plug is turned for locking, if the lanyard be pulled, which, of course, would lead to a serious result. One fatal accident (at least) has so happened. Hence great care should be taken to see that the firing lanyard 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.

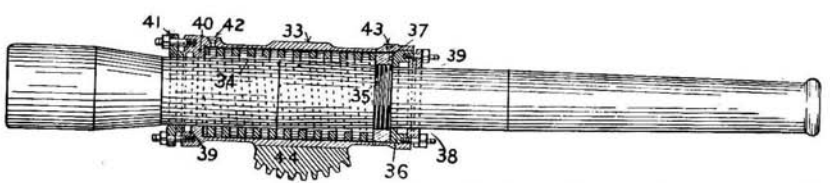
The later guns are being fitted with a modification of the lock described above; the new device is sometimes called the "Tasker" lock and in its main features is not greatly different. The firing pin is held in the cocked position, main spring slack, by a sear; when the cocking lever, which is relatively 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.

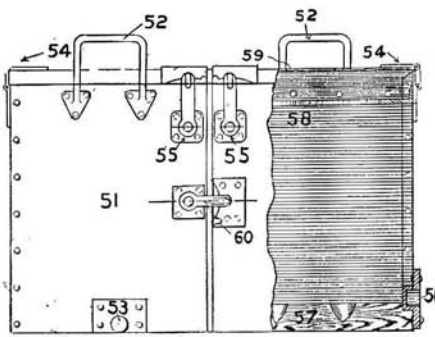


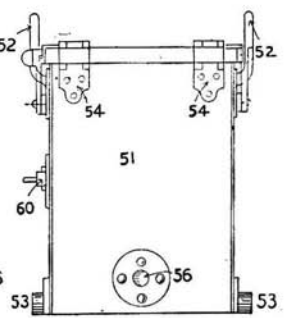
FIELD CARRIAGE FOR 3-INCH, MARK I, R. F. GUN.

Top View.









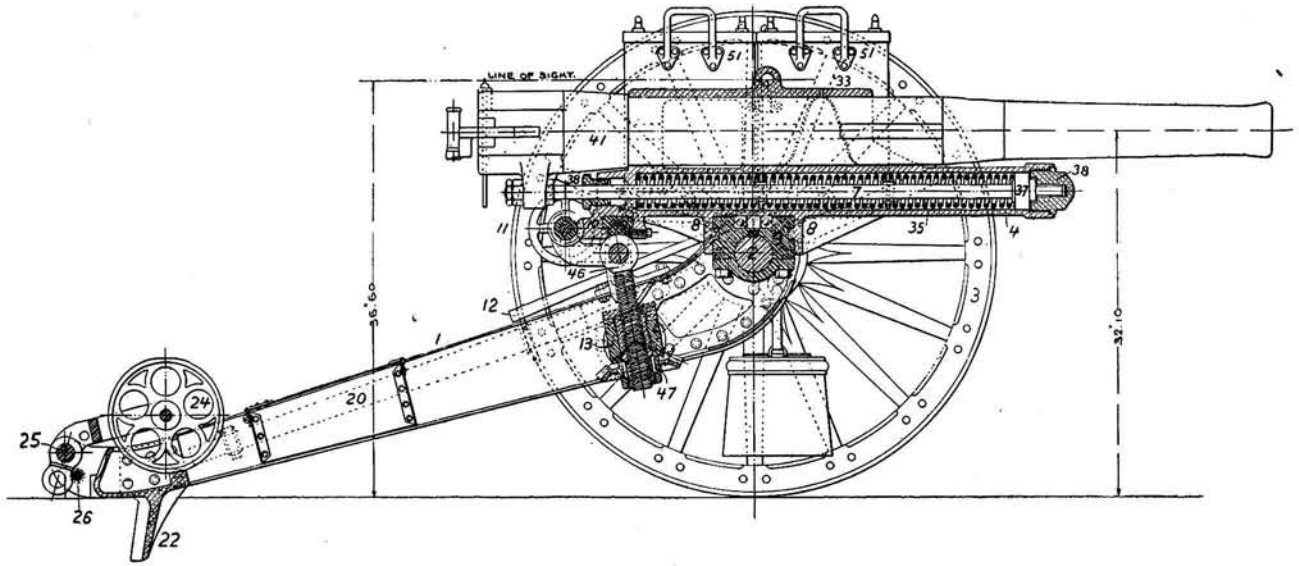
FIELD CARRIAGE FOR 3-INCH R. F. GUN, MARK I, AND AMMUNITION BOXES.

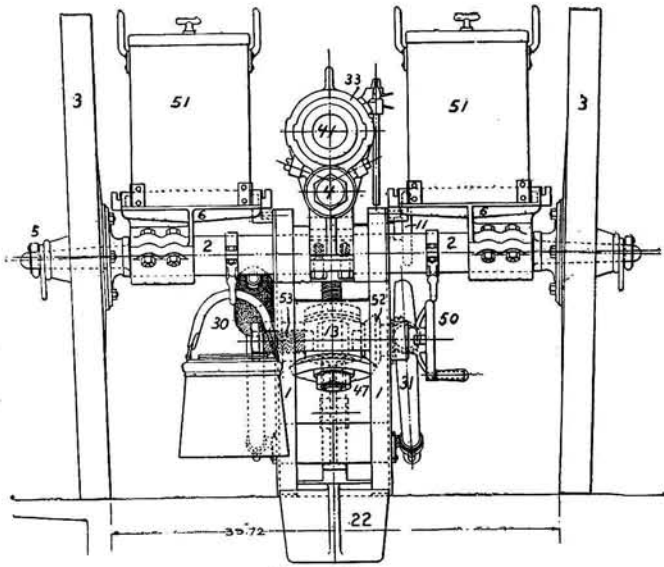
6. The Mark I Field Carriage (see Plates I and II). In this mount the sleeve combines the functions of sleeve and recoil cylinder and the elevating arc is formed on a projection on its under side. The gun body where it passes through the sleeve is a true cylinder and a collar (37), screwed and keyed 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.

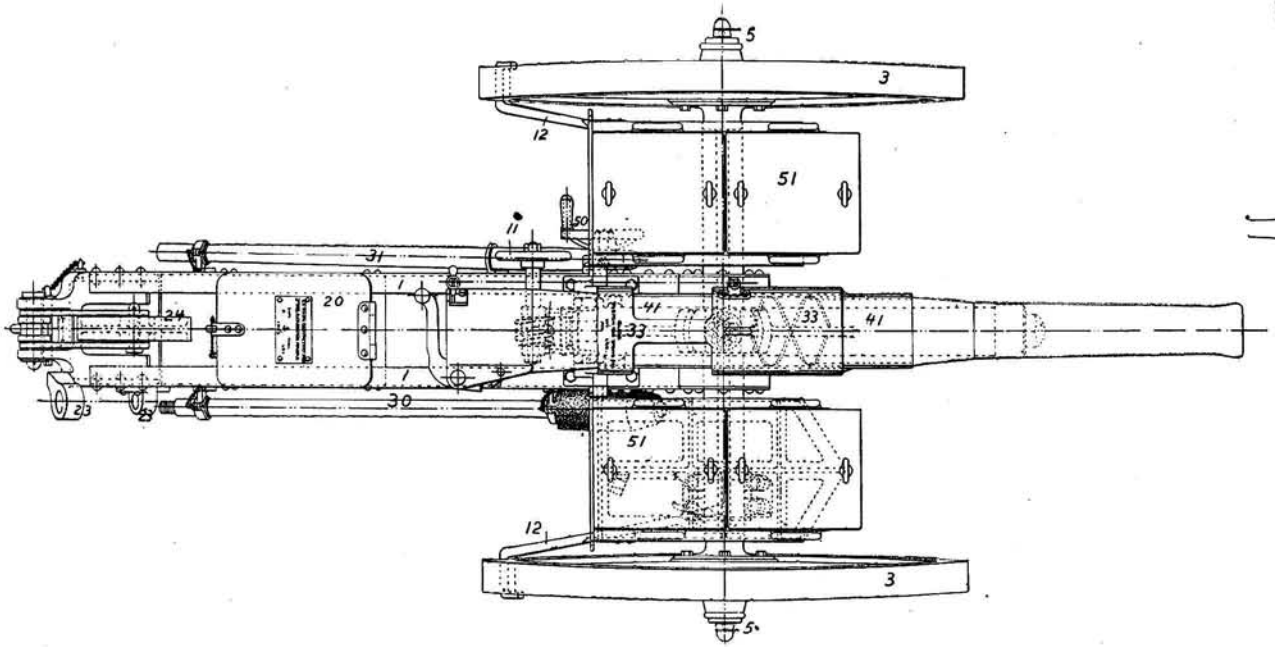
7. **The Mark II Field Carriage** (see Plate III) differs from the Mark I carriage principally in the form of the elevating gear, the recoil mechanism and in giving the gun a small arc of train independent of the carriage. The axle, wheels, ammunition boxes, trail wheel, spade, brakes, etc., of the older 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.



THE MARK II, 3-INCH FIELD CARRIAGE.

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Back of Plate III, Par. 7,
Chapter XXI.

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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-Jörgensen" 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-Jörgensen 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 cannelured 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:

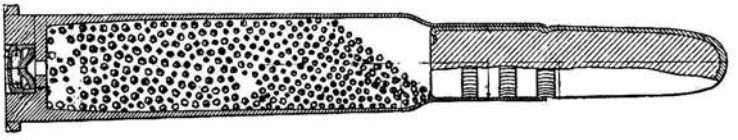

Fig. 1.

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.

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Chapter XXII.

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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

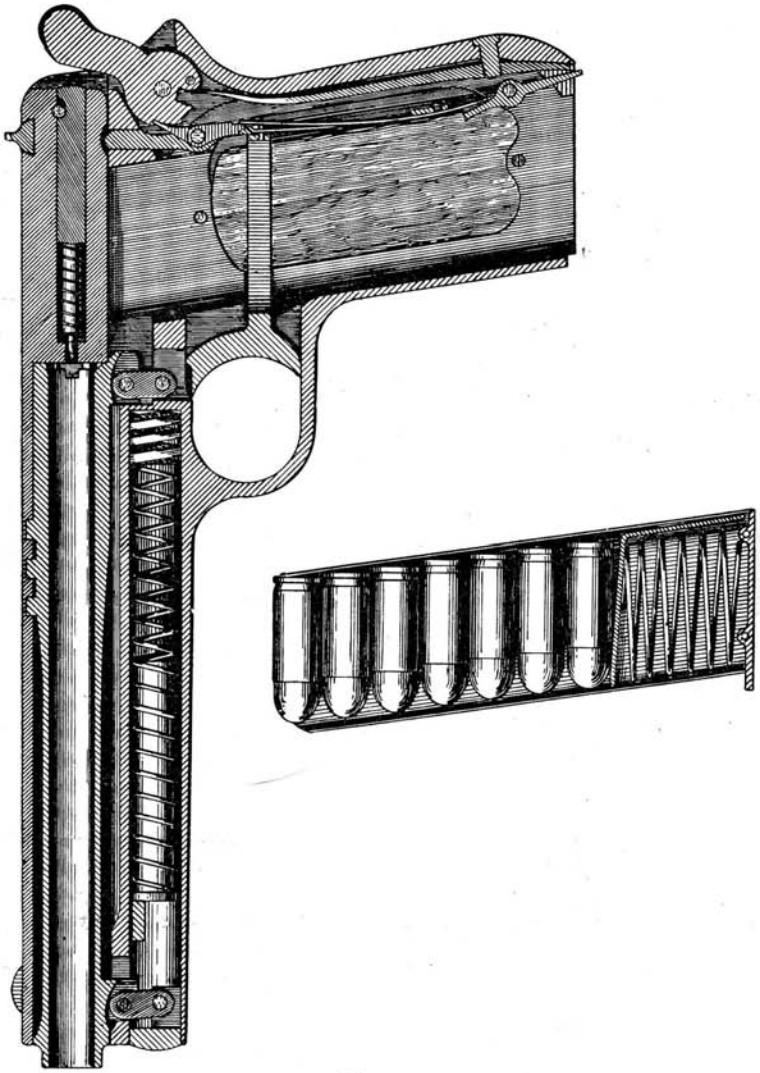

Fig. 1.

SECTION OF COLT AUTOMATIC PISTOL.

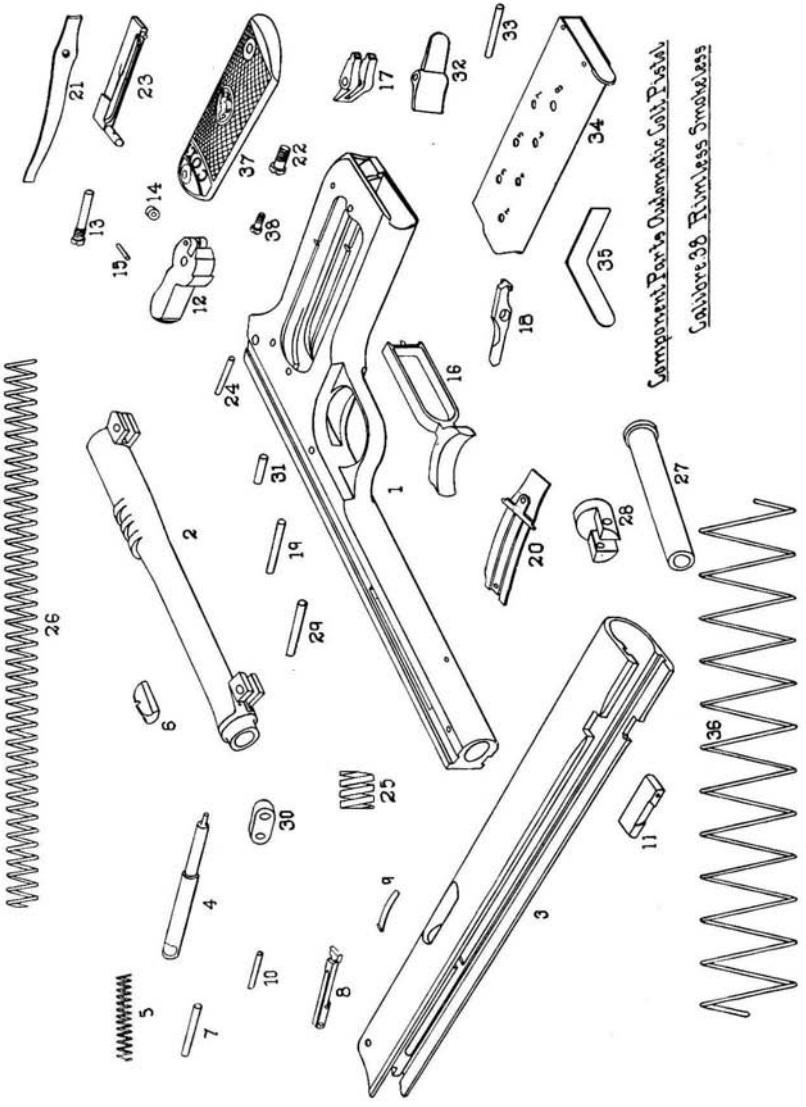
Component Parts Automatic Colt Pistol
Calibre .38 Rimless Smokeless

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 Powders.**—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 it 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 acomplish 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