RESTRICTED

TM 4-210

WAR DEPARTMENT

TECHNICAL MANUAL

COAST ARTILLERY WEAPONS AND MATÉRIEL

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COAST ARTILLERY WEAPONS AND MATÉRIEL

Prepared under direction of the Chief of Coast Artillery

SECTION I

INTRODUCTION

1. Purpose.—The purpose of this manual is to familiarize the Coast Artillery officer with the various types of weapons that are employed by the Coast Artillery Corps in carrying out the missions assigned it by the War Department.

2. Missions of the Coast Artillery Corps.—The missions of the Coast Artillery Corps are the attack of enemy naval vessels by means of artillery fire and submarine mines, and the attack of enemy aircraft by means of fire from the ground. The Coast Artillery Corps includes all harbor defense artillery, all railway artillery, all antiaircraft artillery, and all tractor-drawn artillery especially assigned for coast defense purposes.

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3. Scope.—*a.* No attempt is made in this manual to achieve a thorough technical presentation of the entire field embraced by coast artillery matériel. It is designed to cover the *general* principles of the design and functioning of fixed and mobile seacoast weapons, railway artillery, and antiaircraft artillery weapons.

b. For study, weapons have been subdivided into their principal parts. For instance, seacoast guns have been divided into—

Cannon.
Breechblocks.
Firing mechanisms.
Recoil and counter-recoil systems.
Carriages, proper.
Elevating and traversing mechanisms.
Accessories, such as Waterbury speed gear, power rammers, etc.

After a study of the principal parts, definite examples of each type of armament will be described.

c. At the end of the sections on seacoast artillery and antiaircraft artillery (secs. VIII and X), tables I and II, respectively, are incorporated giving the pertinent facts regarding each individual weapon, including—

Caliber, model, length, and weight of gun.
Model, type, weight, and characteristics of carriage.
Firing tables for different guns.

d. It is believed that a study of this manual will give the officer a well-rounded general knowledge of the subject, which may be supplemented by a study of more detailed publications dealing with the armament to which the individual is assigned.

e. No description of position finding equipment has been given. This information may be found for seacoast artillery in FM 4-15 and for antiaircraft artillery in FM 4-110. The subject of submarine mines is also omitted.

Section II

CANNON

4. **History.**—*a.* A pictorial summary of the history of artillery is given in figure 1. At the lower right are illustrated the predecessors of the cannon, the rock throwing ballista and onager, employed in ancient times to batter holes in city walls. Next comes the early cannon that followed the discovery of gunpowder. Finally, we have the modern designs, exemplified by the 155-mm gun and the 14-inch railway gun.

b. During the nineteenth century a number of very significant developments in the art of artillery design were made. One was the design of a practical breech loading cannon, and another was the use of rifled cannon. The effect of these advances on range can be seen in figure 1, where the Armstrong and the Whitworth cannons of British design had a maximum range of some 10,000 yards. During this same period great strides were made in gun construction. The desire for great power led to the use of heavier powder charges which in turn demanded stronger cannon. It was found by the costly method of trial and error that an increase in thickness of cannon wall did not give a corresponding increase in strength. Examination of cannon developing enlarged bores due to overstress disclosed that the part of the cannon wall next to the bore always failed first, indicating that the inner part of the wall was failing before the outer part developed its full strength. An American, Parrott by name, first used the idea of shrinking on a jacket to strengthen the cannon, and so might be called the father of the modern built-up gun. Another American, Rodman, accomplished a similar purpose by casting the cannon upon a hollow core, cooling the inner surface by a flow of water, so that each successive layer of metal was compressed by the shrinkage of outer layers.

c. Passing on to the World War period, we find heavy mobile artillery in use in great numbers for the first time. Railway and tractor-drawn artillery weapons were developed in calibers up to 42 cm. It became commonplace to place fire on enemy lines of communication as far as 15 miles behind the front. Projectiles filled with chemical came into general use.

d. Since the World War the development of better matériel has gone steadily on. Note in the lower part of figure 1 an improved 155-mm gun with a range of 26,000 yards, as compared to the 17,400 yards of its predecessor, and the improved railway gun of the Coast Artillery Corps, a 14-inch cannon with a range of 47,000 yards. In the comparative graph in the upper half of the same figure, note the range of the most powerful of American weapons, the 16-inch gun on barbette carriage.

5. Types.—Cannon are divided into three types—the mortar, the howitzer, and the gun. A mortar is a short, stubby weapon operating between the elevations of 45° and 65°, using many different sizes of powder charge and a low muzzle velocity; a howitzer is a medium-length cannon operating between 0° and 65° of elevation, using a few different powder charges and employing a medium muzzle velocity; a gun is a long-barreled piece, utilizing elevations between 0° and 65°, and a few—generally three—different sizes of powder charge and a high (2,200–2,700 f. s.) muzzle velocity. In fact, a gun might today be called a long-barreled howitzer.

The resemblance between the gun and the howitzer came about through the struggle to secure the last yard of range from artillery weapons during and after the World War, which raised the elevation of guns up to 45° and in addition gave the gun certain characteristics formerly possessed by the mortar and the howitzer only. Modern gun carriages for fixed mounts now permit fire at angles of elevation up to 45°, 50°, or even 65°. In an effort to decrease erosion and lengthen the life of the gun, powder charges of differing weights were furnished. With the present-day gun, the battery commander has a choice of most of the alternatives formerly possessed by the howitzer or mortar commander. To hit a certain point he may use a heavy powder charge and a low angle of elevation, a medium powder charge and a medium angle of elevation, or a small powder charge and a high angle of elevation. Within the ranges covered by all powder charges, a battery commander shelling ships that are particularly vulnerable to high-angle fire will use the small powder charge; if against ships deficient in side armor, the heavy charge.

Cannon are also classified as to caliber. Those 12 inches or more in caliber are called major-caliber weapons or primary armament; those of less than 12 inches in caliber are called minor-caliber weapons or secondary armament.

6. Subdivision of the interior.—As shown in figure 2, the interior of the bore of a cannon is subdivided into six parts. Starting from the breech (left to right) these are as follows:

The breech recess, which is the space designed to receive the screw box in which the breechblock turns. Next comes the gas check seat, which is a portion of the bore especially finished to fit the gas check pad and split rings, and with them to provide a gastight seal. Then the powder chamber, made slightly larger than the bore itself in order to attain greater volume in shorter length. When the gun is loaded with full charge, the chamber is almost full of powder. Forward of the powder chamber is the centering slope. As its name indicates, it is a gradual contraction of the bore designed to lift the projectile from the level of the powder chamber floor and center it in the main bore. The forcing cone is made by cutting away the rifling at the rear of the main bore. It assists in centering the projectile in the bore, and

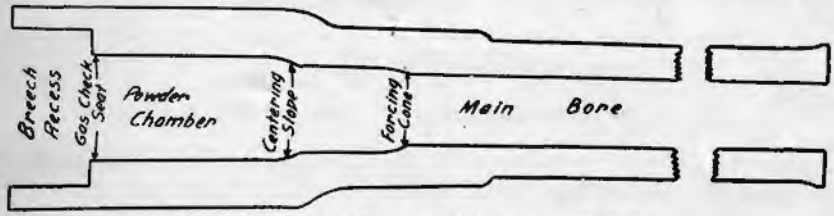

FIGURE 2.—Subdivision of the interior of a cannon.

provides a surface on which the rotating band may gradually stop the forward motion of the shell when it is rammed. Here is one of the points of greatest wear in a high-velocity gun. The sixth part, the main bore, is rifled throughout, and extends from the forcing cone to the muzzle. It is in this portion of the cannon that the projectile is accelerated up to muzzle velocity and is given its rotational velocity.

7. Rifling.—*a.* When oblong projectiles are fired from a smoothbore weapon they turn end over end in flight and have a dispersion many times that of shells fired from a rifled gun. Rifling is used to impart a rotary motion to the projectile to keep it head foremost in flight. The number of revolutions per minute (r. p. m.) necessary to accomplish this result is a definite value, depending on the projectile and the muzzle velocity used; the higher the muzzle velocity and the longer the shell (with reference to its diameter) the greater the r. p. m. required. On some of our smaller high-velocity weapons, speeds approaching 20,000 r. p. m. are necessary.

b. Rifling steepness is designated as "one turn in 25 calibers" or "one turn in 40 calibers." Thus, for a 12-inch gun, one turn in 25 calibers means one turn in 25 feet of gun length. Manifestly, the one turn in 25 calibers is the steeper rifling. Rifling design has become standardized so that most modern cannon are rifled with uniform twist, somewhere between one turn in 30 calibers and one turn in 40 calibers. The effect of rifling steepness on land pressure is shown in figure 3.

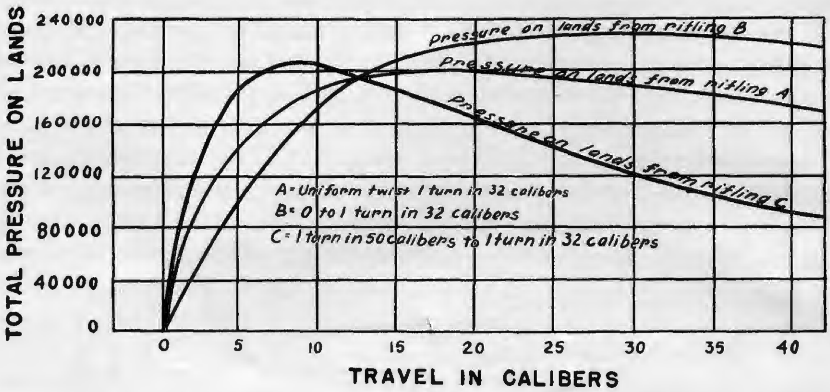

FIGURE 3.—Variation of land pressure with rifling.

Several different profiles of lands and grooves were tried, and at present the rib rifling, with equal widths of land and groove, is generally used. (See fig. 4.)

FIGURE 4.—Modern rib rifling.

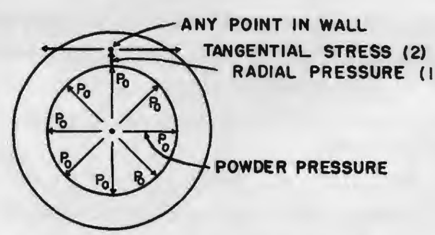

FIGURE 5.—Stresses in cannon walls.

8. **Manufacture.**—*a.* (1) If we take a cross-section of a cannon (fig. 5) and imagine a powder pressure acting at right angles to the bore, we find that there are two stresses set up. One is a radial compressive stress, acting outward (1). The other, and the greater test of the strength of the cannon, is the tangential stress (2)—a tension tending to rupture the walls of the gun. There is also a longitudinal stress tending to elongate the cannon.

(2) If it were practical to manufacture the theoretically ideal cannon, it would be made of an infinite number of very thin cylinders, each shrunk on over the next smaller, and each exerting a compression on the smaller cylinder. Every one of these layers would be under full working stress, each doing its full part in carrying the load. Such a cannon wall is much stronger than a solid wall of the same thickness.

b. Difficulties of manufacture render it impractical to make a gun of this kind, but all of the usual processes of gun manufacture try to

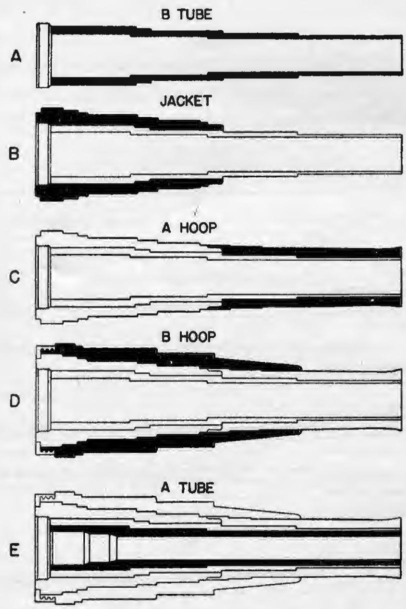

FIGURE 6.—Order of assembly, built-up cannon, 16-inch howitzer, M1920.

reproduce these conditions as closely as possible. In order of their appearance, the four processes of gun manufacture are the—

(1) Built-up process.

(2) Wire-wrapping process.

(3) Cold-working (or auto-frettage—or radially expanding) process.

(4) Centrifugal-casting process (plus cold working afterward).

c. In the built-up process, the outer tube (or B tube) is first machined to its finished dimensions as shown in A, figure 6. On top of this is shrunk the jacket and the A hoop, as illustrated in B and C. On the outside of it all is shrunk the B hoop (D) which gives added strength over the powder chamber, makes the whole unit more rigid, and by its weight brings the center of gravity of the cannon farther to the rear. The gun is now complete except for the inner (or A) tube containing the rifling. To insert this the cannon is heated, the cold A tube is lowered into place, and the whole unit cooled progressively from the breech forward by means of water jets, thereby progressively shrinking the rest of the cannon on the A tube (E, fig. 6). In this cannon there are only three cylinders at the muzzle and four at the breech in place of the infinite number in the perfect gun. It represents the best compromise between theory in design and practice in manufacture.

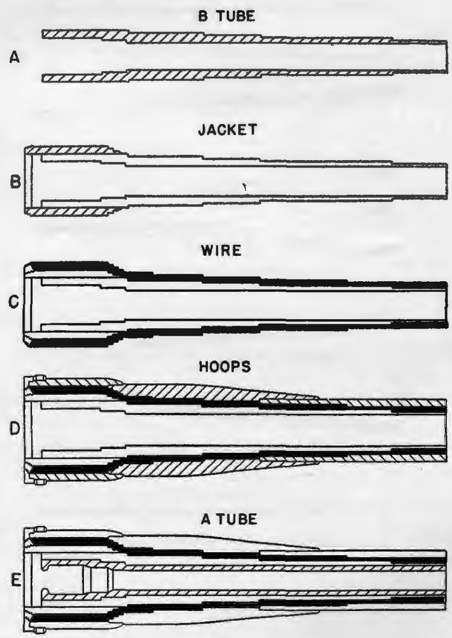

FIGURE 7.—Order of assembly, wire-wrapped cannon, 16-inch gun, M1919.

d. (1) In the wire-wrapping process, we start with the B tube as shown in A, figure 7. Over this may or may not be shrunk a jacket, depending on the design of the gun. Over the B tube the winding machine starts winding wire, which is square in cross-section and about $1/10$ inch on a side. As the wire is wound at constant tension more layers of wire are wound over the powder chamber than over the rest of the bore in order to secure greater initial compression over this section. It may be well to point out that the wire is fulfilling the same function here as do the shrunk-on hoops and jackets in the built-up process.

(2) As it is possible to manufacture wire with an ultimate strength of 200,000 pounds per square inch, the wire-wound gun represents the lightest major caliber gun today. However, the wire-wound gun has less longitudinal rigidity and consequently more droop than the built-up type. In addition, the cannon is much more difficult to reline. Our Navy uses the built-up gun, and it is unlikely that any more major caliber wire-wound guns will be built by the Army.

e. (1) The cold-working process (also known as the auto-frettage or the radially expanded process) reached a state of usable development during the World War. So far in this country it has been applied to one-piece guns up to 6-inch or 155-mm caliber, and to 8-inch

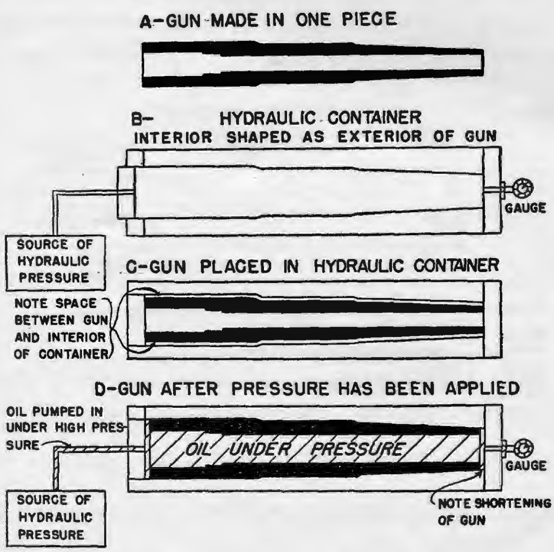

FIGURE 8.—Cold-work process (container method).

Navy guns of two-piece construction. In this method of manufacture we start with the full size cannon in one piece, with a bore of smaller diameter than finally desired (A, fig. 8). The cannon is placed in a container (B) leaving a space between cannon and container, as shown in C. Hydraulic pressure is applied to the bore by the intensifier (a source of hydraulic pressure) as shown in D, figure 8. If the normal powder pressure for the cannon is 40,000 pounds per square inch, a hydraulic pressure of some 60,000 pounds or more per square inch would be applied. The real function of this hydraulic pressure is to stress the inner fibers of the cannon way beyond their elastic limit. The other fibers of the gun are stressed in proportion to their distance from the bore. When the pressure is released, the gun tends to assume its former size, but having been overstressed, the bore remains larger than it was before the pressure was applied. As the inner fibers were stressed or cold-worked beyond their elastic limit, their ultimate strength has been increased. In addition, the inner fibers (which have been deformed the most) have been placed under initial compression by the outer fibers. We have then the closest approach to our theoretically perfect gun—all in one piece. The process is sometimes repeated several times, with a final mild heat treatment to equalize internal stresses. After the cold working is complete, the gun is machined to its final dimensions and rifled as in the other processes.

(2) In producing an 8-inch cold-worked gun, the Navy found difficulty in getting perfect forgings of sufficient size. This difficulty was overcome by making the gun in two pieces, tube and jacket,

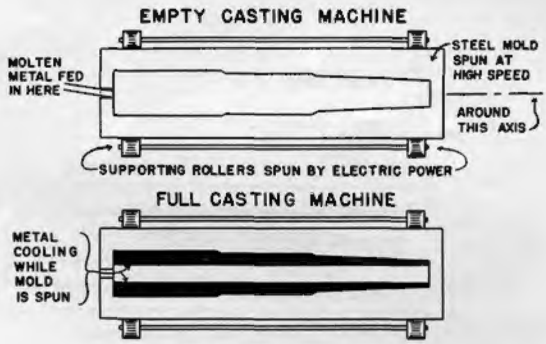

FIGURE 9.—Centrifugal casting.

treating each part by hydraulic pressure separately and then shrinking the jacket over the tube.

(3) This process affords considerable saving in the weight of the finished gun. For instance, the 8-inch naval gun built by the autofrettage process weighs 14 tons less than a built-up gun of the same size and strength. In addition, the hydraulic pressure tests the gun at a pressure at least 150 percent of that of normal firing, thus weeding out all defective cannon.

f. (1) In the effort to improve the technique of gun manufacture, there was evolved the idea of casting guns centrifugally, as cast-iron pipe had been cast for years. There were many difficulties to overcome, but at the present time many of our minor caliber guns are being manufactured by this process.

In the ordinary method of gun manufacture, a solid ingot is forged (hammered and/or squeezed) to a shape roughly approximating the finished product. Then the rough forging is placed on a lathe, is machined on the outside, and has a hole bored on the inside. This process is costly in both time and money, and the centrifugal casting process saves considerably on both.

(2) Briefly, the casting machine is much like those used in producing cast-iron pipe as shown in figure 9. While the cylindrical mold is rotated at high speed, molten steel is poured in one end. Acting as any liquid would under centrifugal force, the molten metal hugs the surface of the mold, forming a hollow cylinder of molten metal. During the cooling process, and while the mold is kept spinning, two important effects of centrifugal force on the molten metal take place. First, high outward pressure engendered in the metal by centrifugal force prevents the formation of blow holes, cracks, and other defects during cooling, and forces impurities

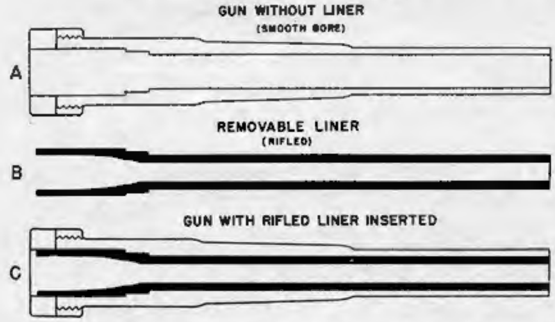

FIGURE 10.—Cold-worked gun with removable liner, 3-inch, caliber .50 AA gun.

to the inner surface of the casting. Second, the same outward pressure produces a desirable graduation in the metallic structure of the casting, making it hard inside (at the bore) to resist wear, and ductile outside (next to the mold) to give great strength and elasticity. After cooling, the casting is ready for the slight machining work required and for further handling by the cold-working process.

9. Removable liners.—*a.* Normally, the tube containing the rifling wears out sooner than the rest of the cannon. When the rifling has become so worn as to interfere seriously with the accuracy of fire, the cannon is generally dismounted and sent back to an arsenal for retubing. To save the time and money that this costs, the removable liner was developed. In this process of gun manufacture, the gun proper is made in the conventional manner, with a large, smooth bore, approximately 4 inches in diameter for a 3-inch gun (A, fig. 10). This gun is cold-worked in the usual manner. From another piece of steel a cylindrical steel liner is manufactured, having conventional rifling on the inside, and a very smooth finish on the outside (B). To form a complete cannon, the liner is inserted in the gun proper as shown in C. Between the inside of the gun and the outside of the liner a very small clearance is allowed, so that as the liner expands with powder pressure it presses against the gun making the gun structure carry a large part of the load.

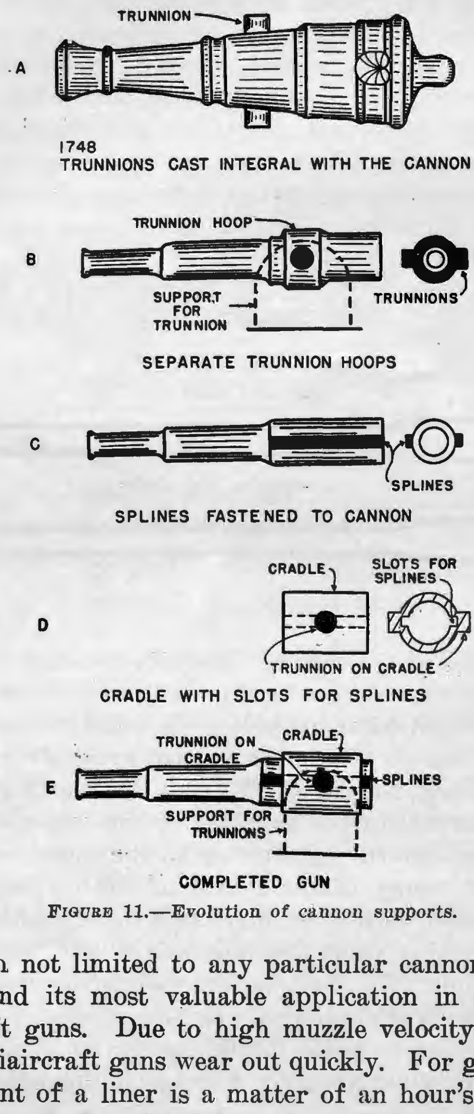

FIGURE 11.—Evolution of cannon supports.

b. Although not limited to any particular cannon, the removable liner has found its most valuable application in the construction of antiaircraft guns. Due to high muzzle velocity and continuous rapid fire, antiaircraft guns wear out quickly. For guns so equipped, the replacement of a liner is a matter of an hour's work by troops in the field instead of a trip back to the arsenal.

Recently, it has been found almost as cheap to build a complete 3-inch gun by the centrifugal casting process as it had been to build a liner. The latest idea for minor caliber weapons is to have a one-piece, centrifugally cast, cold-worked gun, replaceable by battery personnel in the field.

10. Support.—*a.* Early in the development of artillery, it became desirable to be able to alter the range of cannon by changing the elevation. Pivoting the gun on trunnions proved to be the best method of obtaining this change in elevation, and trunnions are used in one form or another on practically all cannon today. In the old cast cannon, the trunnions were cast integrally with the weapon as shown in A, figure 11. The later steel built-up gun had a trunnion band (with integral cylindrical trunnions) shrunk on at the center of gravity of the weapon (B, fig. 11).

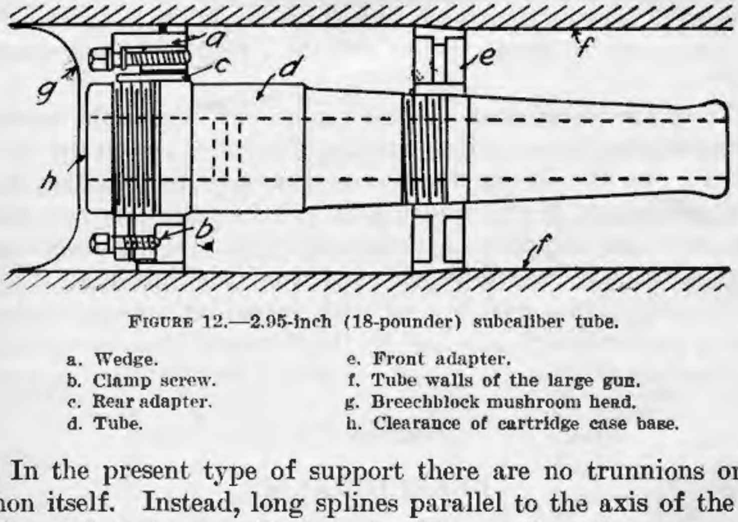

FIGURE 12.—2.95-inch (18-pounder) subcaliber tube.

a. Wedge.
b. Clamp screw.
c. Rear adapter.
d. Tube.
e. Front adapter.
f. Tube walls of the large gun.
g. Breechblock mushroom head.
h. Clearance of cartridge case base.

b. In the present type of support there are no trunnions on the cannon itself. Instead, long splines parallel to the axis of the bore are fastened to the gun (C, fig. 11). These splines fit corresponding slots in a cradle (D, fig. 11), allowing the gun to recoil and counterrecoil, but preventing it from rotating to the left as a reaction to the rotation of the projectile to the right. On the outside of the cradle are mounted trunnions, permitting the gun and cradle to be laid in elevation (E, fig. 11). Some variation of this method is used on most guns today as it permits recoil to take place parallel to the axis of the bore regardless of the elevation of the cannon. Trunnions are generally located at or near the center of gravity of the cannon, so that the gun will be "muzzle light" when loaded (to facilitate elevating) and "muzzle heavy" after firing, when it is desired to depress the piece.

11. Subcaliber guns.—*a.* To familiarize the personnel with the operation of guns and carriages by actually firing without the expense attendant upon the use of regular ammunition, smaller guns are provided. These guns are called subcaliber tubes when mounted in the bore of the larger gun, and subcaliber guns when mounted on the outside and above the large gun.

b. There are two sizes of subcaliber tubes to accommodate the different classes of weapons. Both are mounted in the bore of the larger gun and are similar in principle. They are the 37-mm (1.457-inch) caliber firing 1-pounder fixed ammunition for use in guns, and the 75-mm (2.95-inch) caliber firing 18-pounder fixed ammunition for use in mortars.

These subcaliber tubes have no recoil system but bear directly against the breechblock of the larger cannon, transmitting the forces of recoil to the parent gun. The mortars employ the larger subcaliber shell because the splash from high-angle fire is much smaller than that made by low-angle fire, and the 1-pounder splash would be invisible.

c. There are two sizes of subcaliber guns, mounted on the outside of the larger guns, in use. They are the 37-mm for use on the 155-mm G. P. F., and the 75-mm for use on guns mounted on the 12-inch barbette carriage, M1917, and the 16-inch barbette carriage, M1919. These guns are complete in themselves. They are mounted above the guns with which used by means of bands and brackets.

d. The fixed ammunition used with subcaliber tubes contains an igniting primer which is set off by the flames of the normal primer. The fixed ammunition for subcaliber guns uses percussion primers.

SECTION III

BREECHBLOCKS

12. Obturation.—*a.* Muzzle-loading cannon continued in use for a long time after the advantages of breech loading were realized, because no effective means of preventing the escape of gases to the rear (obturation) had been devised. When means were found for accomplishing effective obturation, muzzle loaders became obsolete.

b. Two general means of obturation are in use today. One is that used by the shoulder rifle or shotgun in which a brass case containing the powder expands under pressure, sealing the chamber and preventing the escape of powder gases to the rear. (See fig. 13.) With this brass case system of obturation a simple form of wedge breechblock is used, its only function being to hold the brass case in place against the pressure of the powder. This system is used in our 3-inch antiaircraft gun. This type is used by the Germans at the

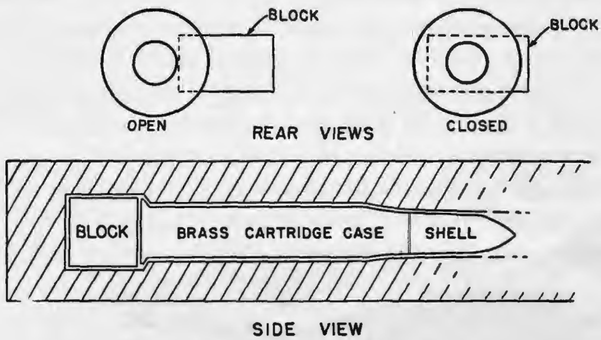

FIGURE 13.—Wedge breechblock.

present time; the 42-cm Krupp howitzer and the long-range gun used it during the World War.

c. DeBange system.—(1) In most countries a system of obturation invented by a Frenchman, DeBange, is used. This system, illustrated in figure 14, makes use of a plastic gas check pad and two triangular split rings to provide a seal for the breech. When not under powder

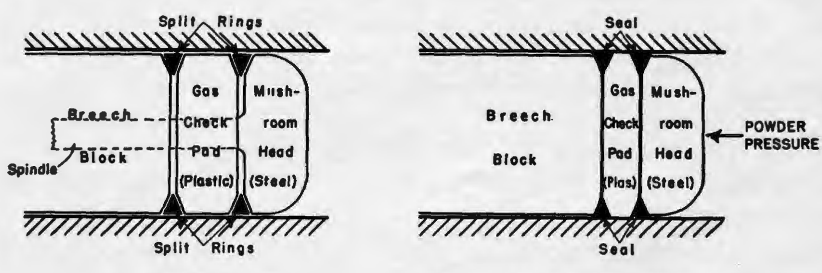

FIGURE 14.—DeBange obturator.

pressure, the system looks as in A, with the split rings making light contact with the gas check seat of the gun and allowing the free closing of the breechblock. When the piece is fired, the gas pressure against the mushroom head compresses the plastic gas check pad, which expands radially, pressing against the split rings, expanding them, and causing them to make a gas-tight seal. After firing, with pressure removed, the plastic pad returns to its original shape, the split rings contract to normal shape and size, and the breechblock is free to open. Sometimes after several rounds there is a tendency for the gas check pad to stick, making the first movement of opening the breech difficult.

(2) The gas check pad, split rings, and mushroom head do not rotate with the breechblock during closing or opening, but the breechblock proper rotates about the spindle-mushroom head assembly as an axle. In actual practice there is always a small split ring around the spindle to prevent the escape of gas check pad composition at this point, and a filling-in disk which forms a bearing between the pad which is stationary and the block which rotates.

13. Slotted screw breechblocks.—*a.* With DeBange obturation, some variety of slotted screw breechblock is always used. The block may be straight (A, fig. 15), tapered (B), or ogival (C), in section.

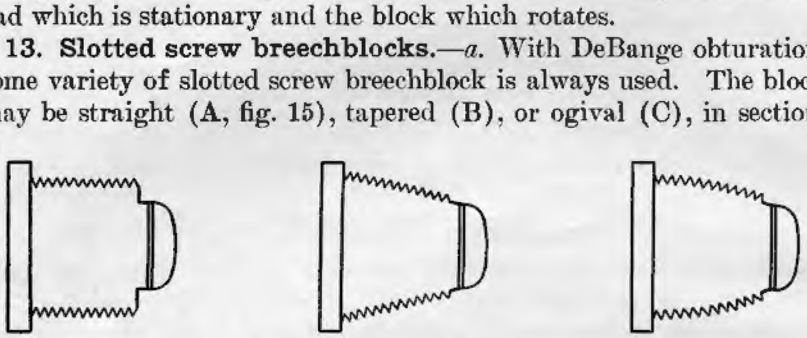

FIGURE 15.—Cross sections of slotted screw breechblocks.

In our services the slotted screw type of straight section is used on most of our cannon employing separate loading ammunition.

b. Method of threading.—In the plain type of block there is an equal number of slotted and threaded sectors as shown in A, figure 16. In this type only half of the circumference (180°) is threaded. In the Welin block (B, fig. 16) there are three threaded sectors to one slotted sector. It may thus be seen that when the ordinary breechblock is completely closed, one-half of the circumference is meshed with the corresponding threads in the breech recess, whereas, under the same circumstances, with the Welin type of breechblock, three-fourths of the circumference is meshed. This means that with the Welin system the block can be made of smaller diameter, shorter, and lighter than an old type plain block of equivalent strength.

c. Types.—Slotted screw breechblocks may be classified according to their mechanisms into two types—the tray-supported (or three-cycle) type and the carrier-supported (or two-cycle) type.

(1) The tray-supported type of breech mechanism (fig. 19) must accomplish three motions in closing or opening the block. Starting from a closed position the mechanism must—

(*a*) Rotate the block until the slotted sectors are disengaged from the threaded sectors.

(*b*) Translate the block to the rear out of the breech recess on to a tray.

(*c*) Swing the block and tray out of the breech recess, leaving the breech completely free for loading.

When the block is locked in the closed position there is no mechanical connection between the block and the tray. The sole purpose of the tray is to support the block when it is in the withdrawn position.

(2) In the carrier-supported type, the opening or closing is accomplished in two cycles. (See fig. 17.) The mechanism must—

(*a*) Rotate the block until the threads are disengaged.

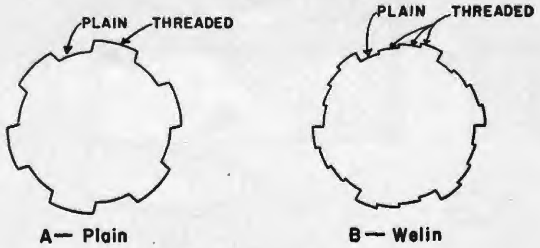

FIGURE 16.—Screw type breechblocks.

(*b*) Swing the block out of the breech recess and clear of the breech.

In this type the block is supported by a carrier, which together with the spindle forms an assembly around which the block itself rotates, as a wheel around an axle. Formerly this type of support was found only on small caliber rapid-fire guns, but modern design has incorporated this principle in blocks of the largest caliber. Blocks using this principle must be specially shaped so that they will clear the breech recess during the swing cycle. They must necessarily be short compared with their diameter, and must have milled-out areas in the slotted sectors of both the block and the breech recess to permit free movement into and out of the breech recess.

(3) The tray-supported type includes most of the older major-caliber blocks of conventional design, while the carrier-supported blocks include the lever-pull types for minor caliber armament and the down-swinging blocks for the latest major-caliber guns.

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d. Lever-pull type.—On guns of 6-inch and 155-mm caliber, the lever-pull type of breech mechanism is used (fig. 18), which is a carrier-supported design. In this type of breech mechanism, the operation of rotating and translating the block and carrying it clear of the breech recess is accomplished by a continuous pull on the operating-lever handle. Several differing mechanisms will be encountered in the service, all employing the same general idea. Figure 17 is a rough sketch of the mechanism pertaining to the opening and closing of the breech on a 155-mm gun. The block is shown inserted in the breech to illustrate the manner in which the block and breech

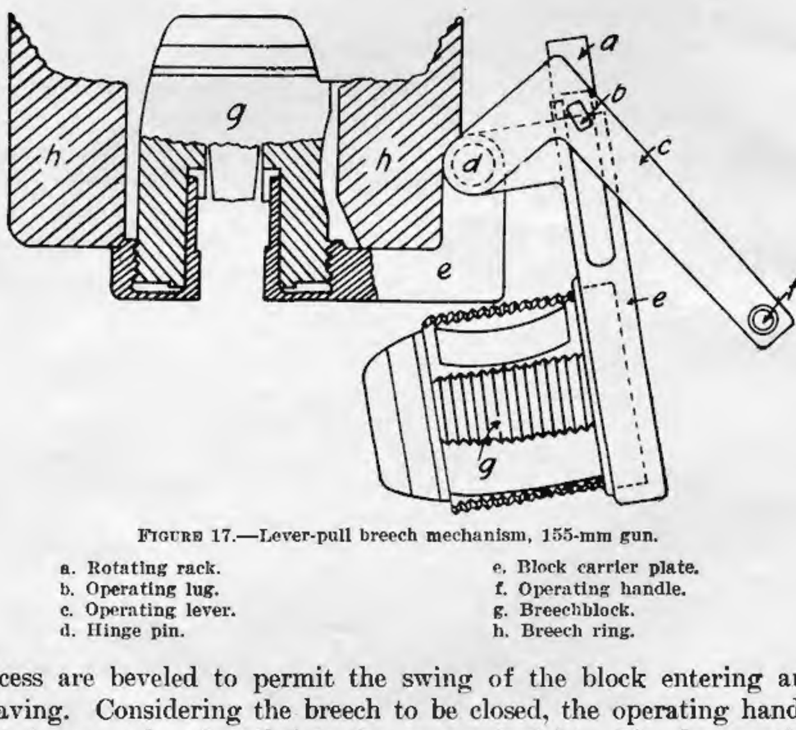


FIGURE 17.—Lever-pull breech mechanism, 155-mm gun.

a. Rotating rack.
b. Operating lug.
c. Operating lever.
d. Hinge pin.
e. Block carrier plate.
f. Operating handle.
g. Breechblock.
h. Breech ring.

recess are beveled to permit the swing of the block entering and leaving. Considering the breech to be closed, the operating handle (f) is grasped and pulled to the rear and right. The first motion of the operating lever (c) causes the lug to pull the rotating rack (a) to the right. The teeth of the rack mesh with teeth on the breechblock and this movement turns the breechblock, disengaging the threaded sectors. Further movement of the operating handle swings the carrier plate and block sideways to the open position, where it is locked open by a latch. When closing, this latch is released by a downward pressure on the operating handle, and the reverse operation takes place as the operating lever is thrown to the left and in

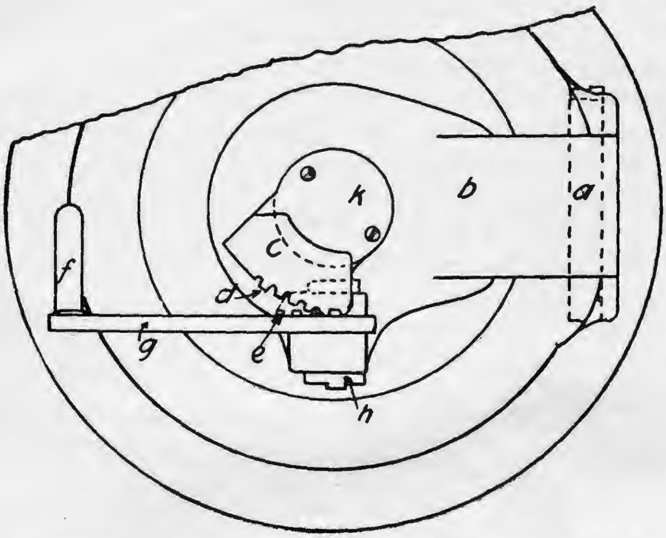


FIGURE 18.—Lever-pull breech mechanism, 6-inch gun, M1900.

a. Hinge pin.
b. Block carrier.
c. Gear segment.
d. Bevel rack.
e. Bevel pinion.
f. Operating handle.
g. Operating lever.
h. Lever pin.
k. Breechblock.

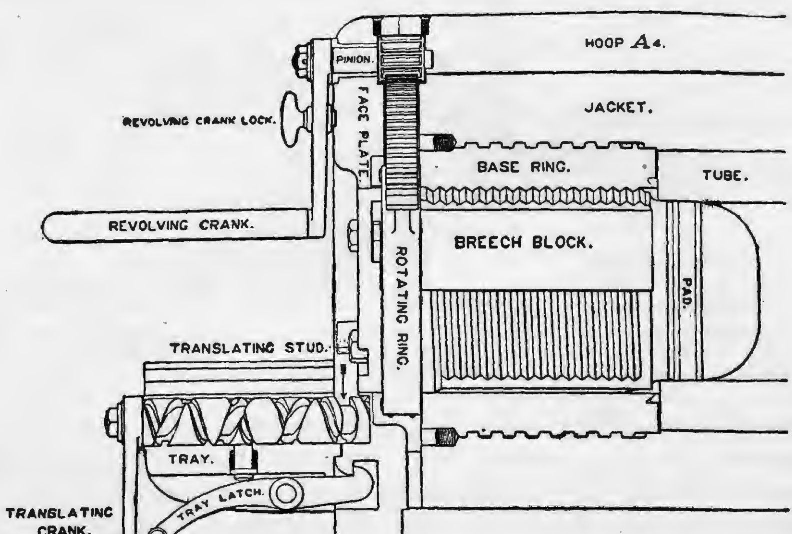


FIGURE 19.—Diagram translating roller mechanism.

against the breech face. In order to facilitate opening and closing the breech on this gun when the gun is elevated, an additional mechanism called the counterbalence is used. (See fig. 89.)

e. Translating roller type.—On older guns of 8-inch caliber and larger, the translating roller type of mechanism (tray-supported) has proved reliable. It is at a disadvantage with regard to later types of mechanism in that two cranks are used, making the operation of opening or closing the block more complicated than in the Stockett or single crank type. As shown in figure 19, one crank is used to

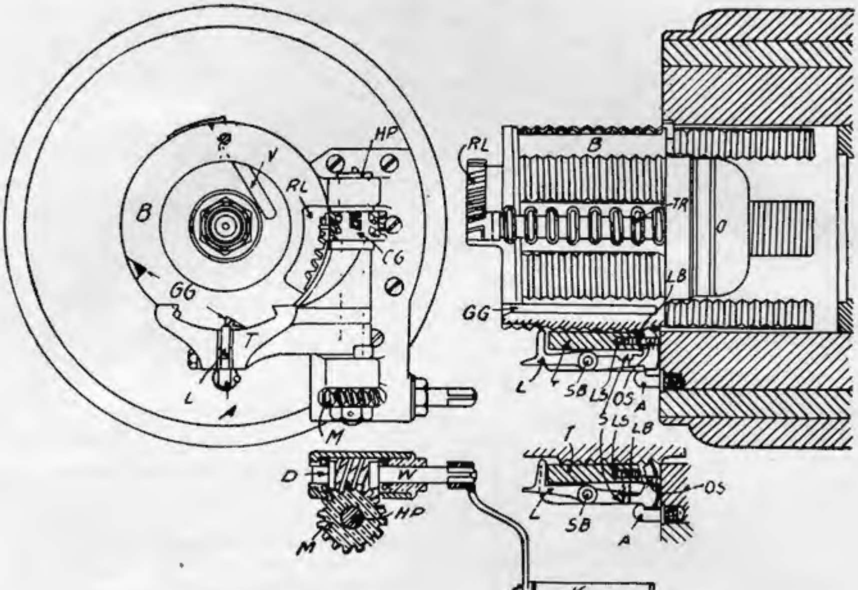


FIGURE 20.—Diagram, Stockett mechanism.

A. Tray latch catch.
B. Breechblock.
CG. Compound gear.
D. Worm.
GG. Grooves.
HP. Hinge pin.
K. Crank handle.
L. Tray latch.
M. Worm wheel.
OS. Tray latch operating stud.
RL. Rotating lug.
S. Latch spring.
T. Tray.
TR. Translating rack.
V. Safety bar.
W. Operating shaft.
LB. Locking bolt.

rotate the breechblock within the breech recess in order to engage or disengage the screw threads, while the other translates the block in or out of the tray recess. Let us follow the block through the operation of opening. With the breech closed, the first operation is to rotate the block to the disengaged position using the upper (revolving) crank. With the block now free from the screw threads, it is brought directly to the rear by means of the lower (translating) crank. When completely out of the breech recess and supported in the tray, the block and tray are swung clear by hand power. To close, the block is swung opposite the breech recess by hand, translated straight ahead from the tray into the recess by the translating crank, and rotated to its final position by the revolving crank.

f. Stockett breech mechanism.—A later development was the Stockett breechblock which is another tray-supported block. In this mechanism all operations, rotating, translating, and swinging, are performed by one crank. Referring to figure 20, the block is opened by turning crank (K). The first motion is transmitted through the worm gear to the rotating lug (RL) which rotates the block the necessary one-twelfth turn. Further movement of crank (K) causes the compound gear (CG) to engage the translating rack (TR), sliding the block to the rear onto the tray (T). The further action of the compound gear on the last teeth of translating rack (TR) causes the tray to swing to the right, carrying the block clear of the breech. In recent mechanisms of this type there has been added a locking device which prevents the rotation of the block by the pressure of the powder gases.

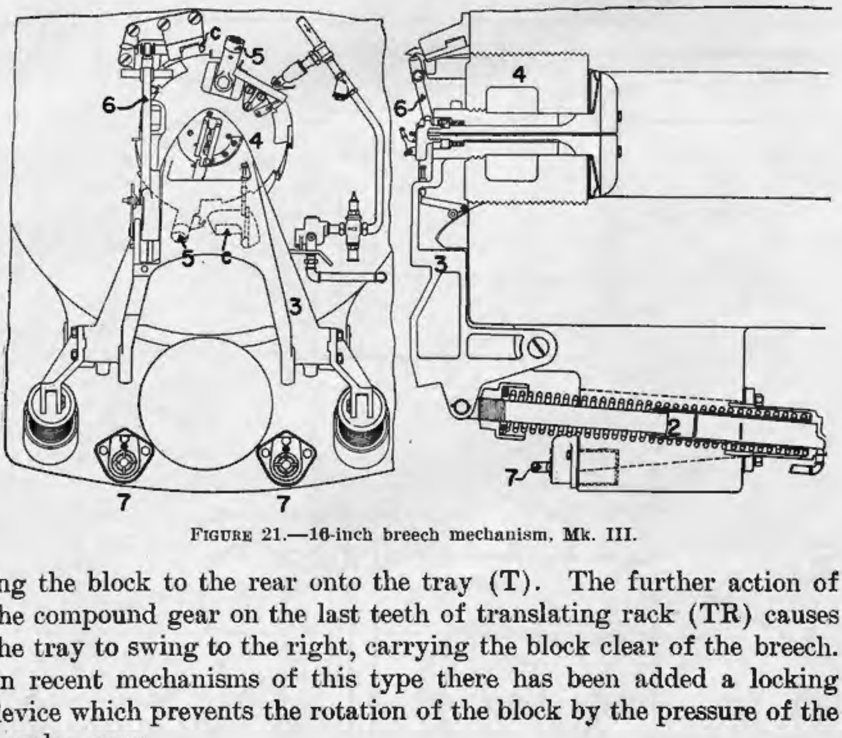


FIGURE 21.—16-inch breech mechanism, Mk. III.

g. Power operated carrier supported block.—(1) This is the latest type of breech mechanism for major-caliber guns and is carrier supported. In this block as in the lever-pull type there is no translation—only rotation and swinging. Referring to figure 21, it is seen that the block is mounted on the upper end of the carrier. The carrier is pivoted at its lower end and swings in the vertical plane

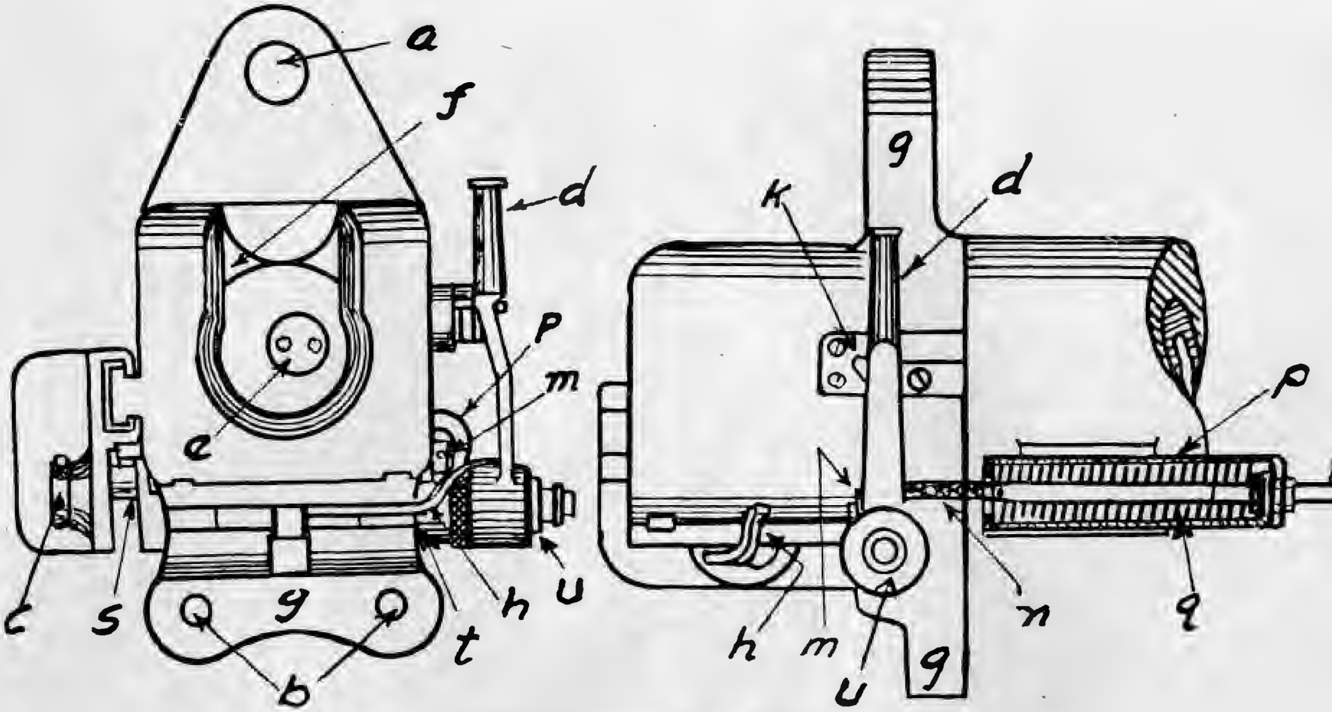


FIGURE 22.—Breech mechanism, 3-inch AA gun, M1917.

a. Recoil piston rod recess.
b. Recuperator piston rods recesses.
c. Operating cam.
d. Operating handle.
e. Face plate.
f. Breechblock.
g. Recoil band.
h. Trigger shaft lever.
k. Handle latch.
m. Chain terminal.
n. Closing chain.
p. Closing spring case.
q. Closing spring.
r. Piston rod.
s. Operating crank.
t. Operating lever.
u. Operating lever clutch.

in contrast to the other blocks which all swing in the horizontal plane. Closing is by power furnished by compressed air acting against a piston. When air is admitted to the cylinder (1) behind the piston (2) it forces the piston outward, pivoting the carrier (3) around its lower end, and carrying the breechblock (4) into the breech recess. As the breechblock enters the recess two cam rollers (5) on the block engage two corresponding cams (c) on the breech, rotating the block the amount necessary to close it completely. The

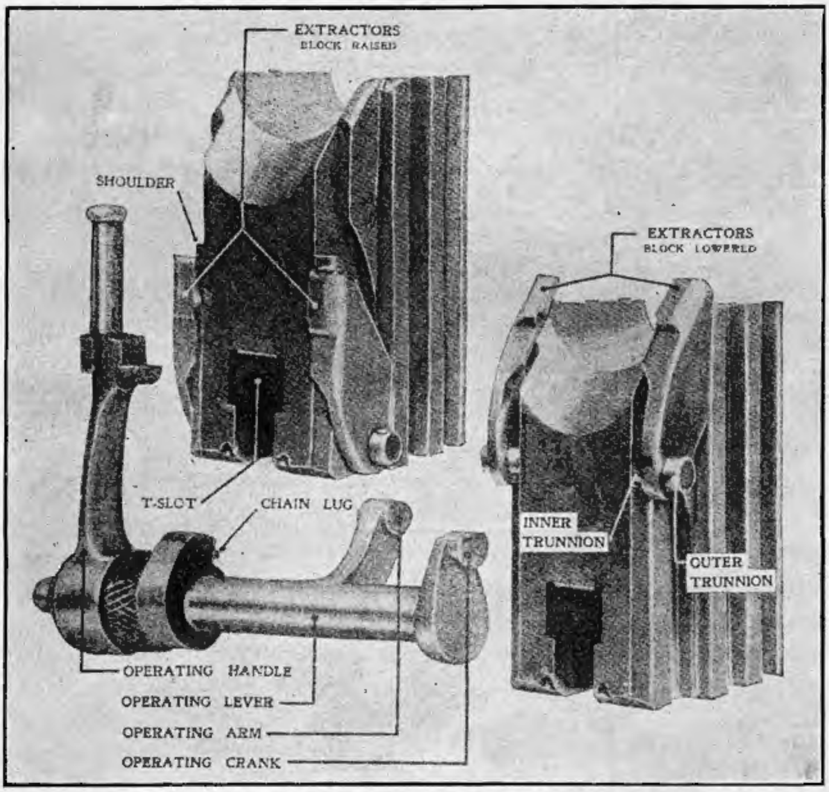


FIGURE 23.—Breechblock and operating lever, 3-inch AA gun, M1917.

block is opened by hand by pulling on the operating lever (6). This rotates the block and frees it from the breech recess, after which it is pulled down against the hydraulic buffers (7). In case of failure of the air supply the block can be operated entirely by hand power.

(2) In the older tray-supported blocks, the pressure on the gas check pad must be adjusted each time the block is assembled by means of a large nut (spindle nut) on the end of the spindle. On the newer carrier-supported blocks there is no adjustment and this

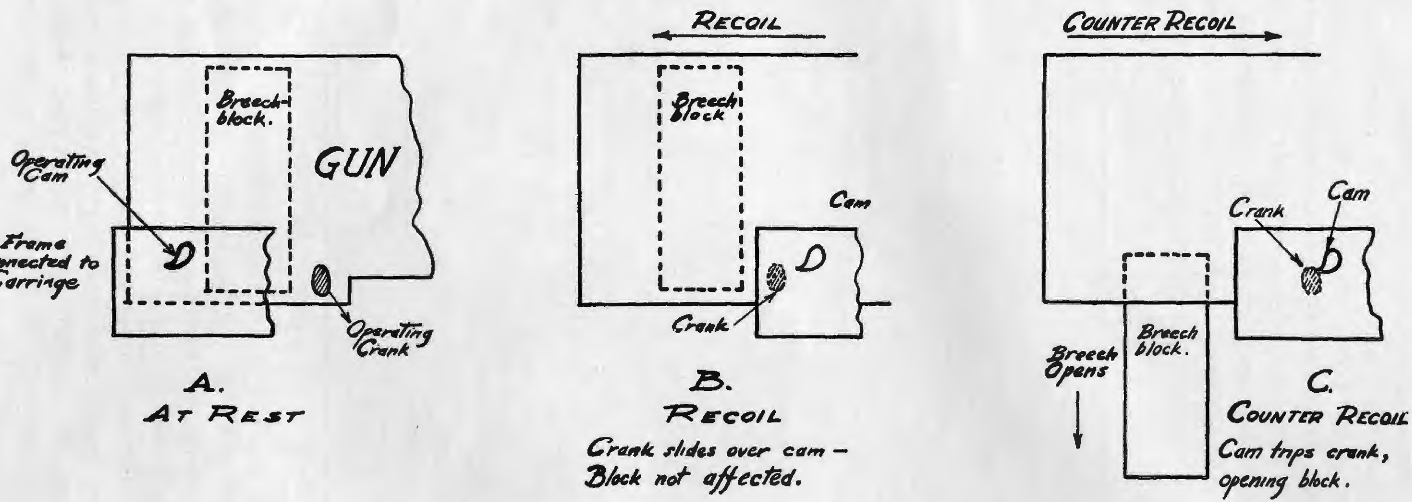


FIGURE 24.—Operation of opening AA gun breechblock.

pressure is supplied by a spring which insures an even uniform pressure at all times. In addition, it is common practice to key the spindles on carrier-supported blocks to the carrier, so that the spindle and mushroom head cannot rotate in reference to the carrier.

14. Drop block for antiaircraft guns.—*a.* The primary requirement for this type of gun is rapid operation, so the block is designed for automatic opening and closing. This type of block is called "semiautomatic" because some of the operations of loading and extracting are performed by hand and some mechanically. A general view of the mechanism is given in figure 22. The block and operating lever are shown in figure 23. The block itself slides up and down under the action of the operating arm in grooves cut in the breech recess of the gun. The front edge of the upper part of the block is beveled so that a cartridge not fully seated by hand is pushed

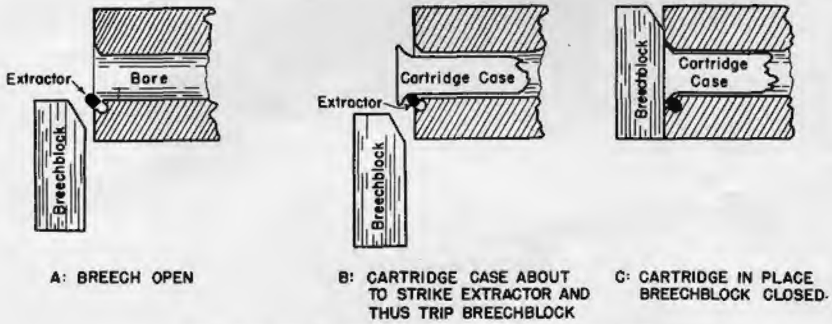


FIGURE 25.—Automatic closing of AA breechblock.

home by the rising block. The block is opened and closed by the operating arm moving up and down in the T-slot cut in the block.

b. The automatic breech opening mechanism is shown in figure 24. In A we see the system at rest, with the operating crank (connected with breechblock) on the gun and the operating cam mounted on a frame which is part of the carriage. As the gun recoils (B) the crank slides under the cam and nothing changes. During counterrecoil (C) the cam strikes the crank, rotates it, and opens the breechblock. In addition, as the crank rotates it stores energy, for closing the block, in a coil spring.

c. The automatic closing mechanism is illustrated in figure 25. As the cartridge is loaded, its rim strikes the extractor, as in B. This trips the closing mechanism and automatically closes the breech, as in C. The power for closing the breechblock is furnished by a spring which stores part of the energy of counterrecoil for this purpose. When desired the clutch may be engaged and the breechblock operated by hand.

d. The breechblock for the 105-mm antiaircraft gun (fig. 26) operates on the same principle as that previously described for the 3-inch gun.

15. Pressure gages.—*a.* Pressure gages for most cannon using separate loading ammunition are mounted in receptacles provided for them on the mushroom head. The two large nuts on the mushroom head are dummy pressure plugs. When the cannon is to be fired these dummies are removed and similar devices containing the real pressure gages are installed.

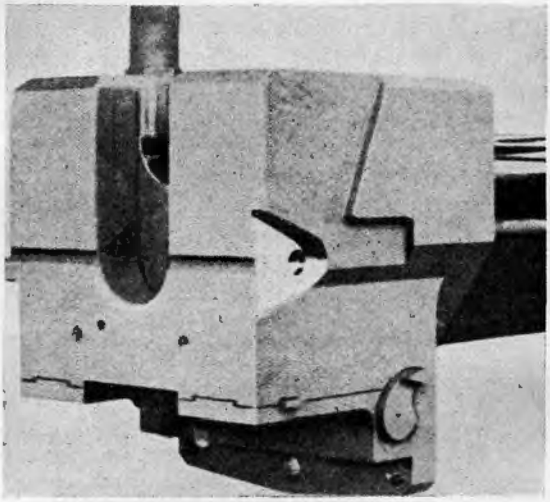


FIGURE 26.—105-mm AA breechblock.

b. The pressure gage consists essentially of a copper cylinder suitably mounted. When this cylinder is subjected to the powder pressure it is deformed in proportion to the pressure exerted. By measuring the cylinder before and after firing it is possible to tell the maximum pressure in the powder chamber.

c. In those cannon not equipped for the use of the gages mentioned above, it is necessary to place gages loosely in the powder chamber and retrieve them after firing.

SECTION IV

FIRING MECHANISMS

16. General.—There are four principal types of firing mechanisms used in the Coast Artillery Corps. Most of our weapons employing separate loading ammunition use the seacoast M1903 mechanism. The latest 14-inch railway gun and the 16-inch guns and howitzers use the firing lock, Mk. I. The 155-mm gun uses the French percussion type mechanism. The fixed ammunition weapons use a continuous pull firing mechanism.

17. Seacoast firing mechanism, M1903.—*a.* This type is used on practically all of our seacoast cannon manufactured prior to the World War. It is designed to fire either by lanyard (using a friction primer) or by magneto (using an electric primer).

(1) As shown in A, figure 27, the primer resembles a blank rifle cartridge with a wire protruding from the rim end. Referring to B, a firing magneto is used in firing electrically, one side of the line being connected by an insulated wire to the wire part of the primer, and the other side grounded to the frame of the gun. When using the friction primer, the lanyard is hooked to the lower end of the firing leaf, and when pulled, draws the wire to the rear, igniting the primer (C, fig. 27).

(2) A seat for this mechanism is provided by two grooves (o) on the rear end of the obturator spindle, figure 28. Referring to that figure, a hinged collar (f) fits the end of the spindle. This collar is threaded on the outside to receive the housing (e) which carries the remainder of the mechanism. In placing the housing it is held stationary while the hinged collar is turned in order to screw on the housing, which is locked to the collar by the spring pin (p). It should be noted that the firing mechanism is free to turn on the spindle as the mechanism rotates with the breechblock. As shown, an ejector (d) is trunnioned in the housing. When the slide (c) is raised, a shoulder strikes the upper end of the ejector and the lower end is thrown to the rear, ejecting the fired primer by means of the lip on the lower end. The housing carries projecting ribs forming guides for the slide, which is moved up and down by the handle (a) after releasing the catch lever (q). Pivoted at (b) in

the slide is the slotted firing leaf (k) which straddles the primer button wire and also carries the electrical contact clips (m) and is provided with an eye into which the lanyard may be hooked. In inserting the primer it is necessary to start the slide downward in order to engage the ejector lip behind the rim of the primer. The

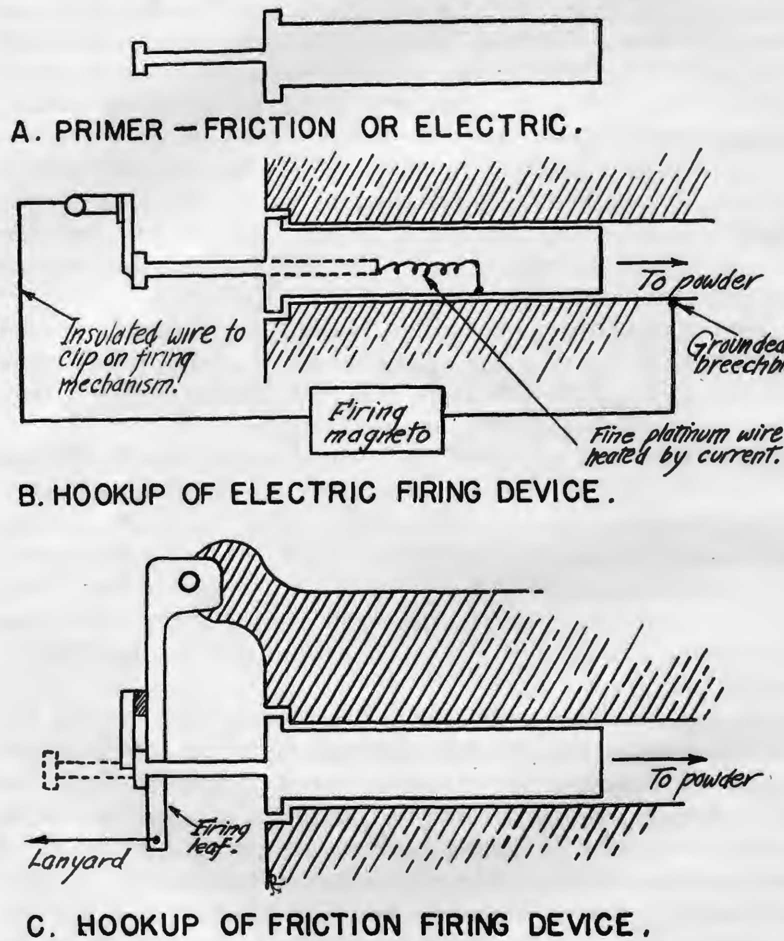


FIGURE 27.—Operation of seacoast firing mechanism, M1903.

firing mechanism is made to rotate with the breechblock by a guide bar (shown in fig. 29 as the horizontal bar extending from the right of the mechanism to the block) which is fixed to the mechanism housing and engages in a longitudinal slot in the block. The bar extending diagonally down from the upper right in figure 29 is the lock bar slide, which prevents the firing leaf from moving to the rear until the breechblock is fully closed.

b. Safety features.—This mechanism has the following safety features:

(1) The firing leaf cannot be drawn back for lanyard firing until the block is completely closed.

(2) The firing circuit is not made at the breech until the block is completely closed.

(3) On mortars the short lanyard cannot be hooked into the firing leaf until the piece has been elevated at least 45°; the plug for firing by electricity cannot be inserted until a similar elevation has been reached.

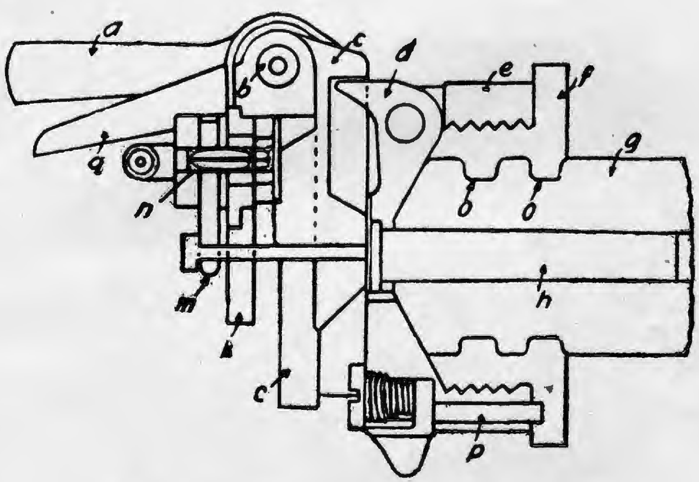


FIGURE 28.—Firing mechanism, seacoast, M1903.

a. Slide handle.
b. Firing leaf pivot.
c. Slide.
d. Ejector.
e. Housing.
f. Hinged collar.
g. Firing mechanism seat.
h. Primer.
k. Firing leaf.
m. Contact clip.
n. Electric terminal.
o. Seat grooves.
p. Spring pin.
q. Catch lever.

(4) On disappearing carriages the short lanyard is not released and the electrical circuit breaker is not closed until the piece is in battery.

18. Firing lock, Mk. I.—*a. General.*—This type resembles the firing lock used on all Navy cannon employing separate loading ammunition. The primer used is a combination electric-percussion type so that firing may be accomplished either by lanyard or by electricity. The primer itself, illustrated in figure 32, resembles a blank revolver cartridge.

b. Operation.—The principal parts of the lock are shown in figure 30. They are the slide, the lock-operating bar, the cocking lever, and the hammer. The operating bar and the slide move up and down as a unit.

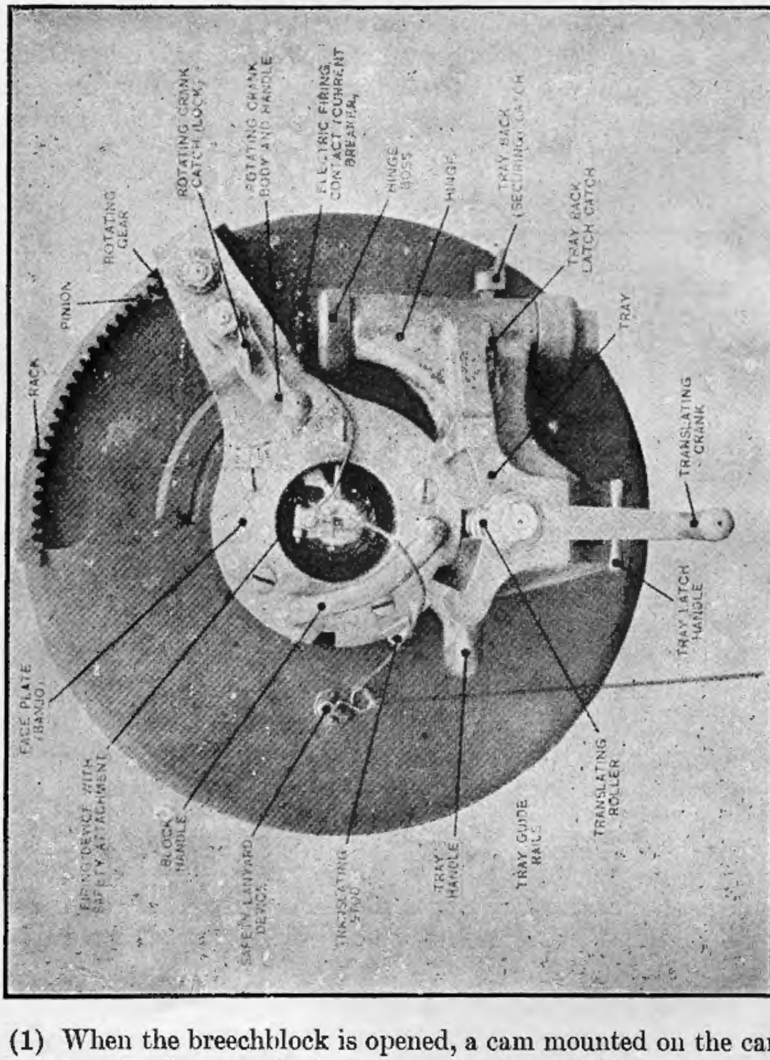


FIGURE 29.—Breech mechanism, 12-inch mortar, M1890, showing firing mechanism.

(1) When the breechblock is opened, a cam mounted on the cannon (fig. 31) pulls down on the lock-operating bar, which lowers the slide until the primer seat is uncovered. As the slide is lowered, it works against the small extractor cam (fig. 30) rotating the extractor to the rear and ejecting the fired primer automatically.

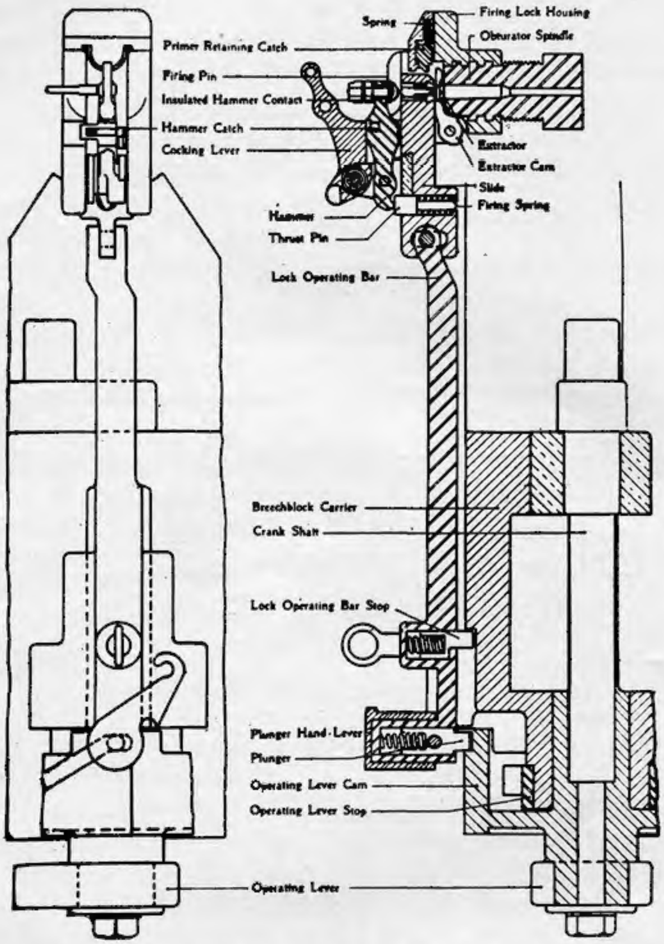


FIGURE 30.—Firing lock, Mk. I, and operating mechanism.

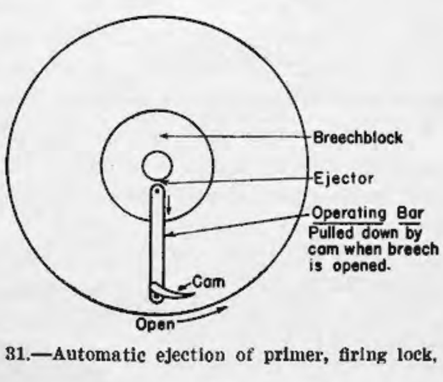


FIGURE 31.—Automatic ejection of primer, firing lock, Mk. I.

(2) When the breechblock is closed the lock-operating bar is automatically raised, which in turn raises the slide until the firing pin is opposite the primer and the lock is ready to fire. For safety reasons

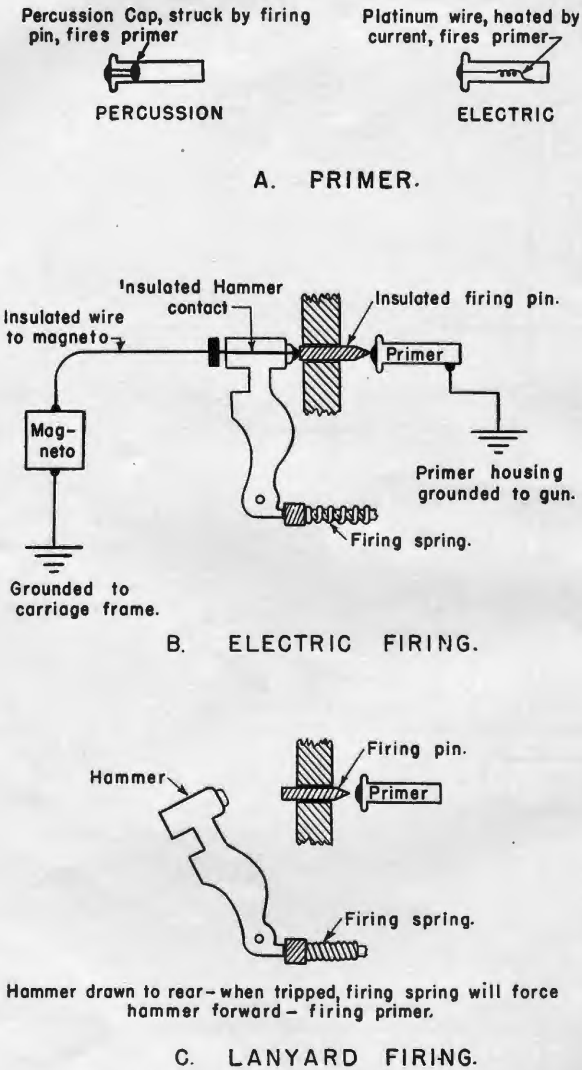


FIGURE 32.—Operation of firing lock, Mk. I.

the primer is not inserted until the block is fully closed. When the block is closed, the operating bar (fig. 30) is pulled down by hand, using the plunger hand lever, the primer inserted, and the operating bar raised to firing position.

(3) For percussion firing, the lanyard is inserted in the hole in the cocking lever. The first part of the lanyard's travel cocks the hammer, while the last part trips the hammer, allowing it to fly forward and strike the firing pin as shown in C, figure 32. The action is identical with that of a double action revolver.

(4) For electric firing, a current of electricity is sent through the insulated hammer and the insulated firing pin to the cap of the primer as shown in B, figure 32.

c. Safety features.—This lock possesses the following safety features:

(1) As shown in figure 31 the slide is held down as long as the breechblock is open, and does not allow the firing pin to move up into firing position opposite the primer until the block is completely closed.

(2) Only when the breechblock is fully closed is the lug on the hammer in line with an opening on the guide block (not shown) permitting the hammer to be operated.

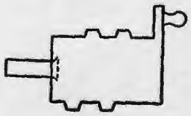


FIGURE 33.—Firing-mechanism block, 155-mm.

d. A more detailed explanation will be found in paragraph 6*d*, TM 9-425 (now published as TR 1315-14B).

19. 155-mm G. P. F. firing mechanism.—*a.* This mechanism, of the percussion type, utilizes primers that resemble blank cartridges for a revolver (fig. 33). Each time the breechblock is closed on a loaded round, a loaded firing-mechanism block is inserted in the housing in the center of the breechblock. (See fig. 34.) The firing-mechanism block is provided with a handle by means of which the block may be screwed into and out of the housing to renew the primer each time the gun is fired. The block is further provided with a flange in which is cut a recess to receive the lug on the front of the percussion hammer and thus prevent the hammer from striking the firing pin except when the lug and recess are lined up. The firing-mechanism block latch is attached to the breechblock carrier at the right and a little above the firing-mechanism housing. Its function is to prevent the firing mechanism from unscrewing during firing. The firing-mechanism block is prevented from being screwed entirely in until the breechblock is fully closed by means of a spring-compressed safety plunger. After the gun is fired and before opening the breech, press back the firing-mechanism block latch in order to free the handle of the firing block. Unscrew the firing-mechanism block, slide the used primer out of the slot in the primer-seat plug, insert a new primer, and after the breech is closed screw the block

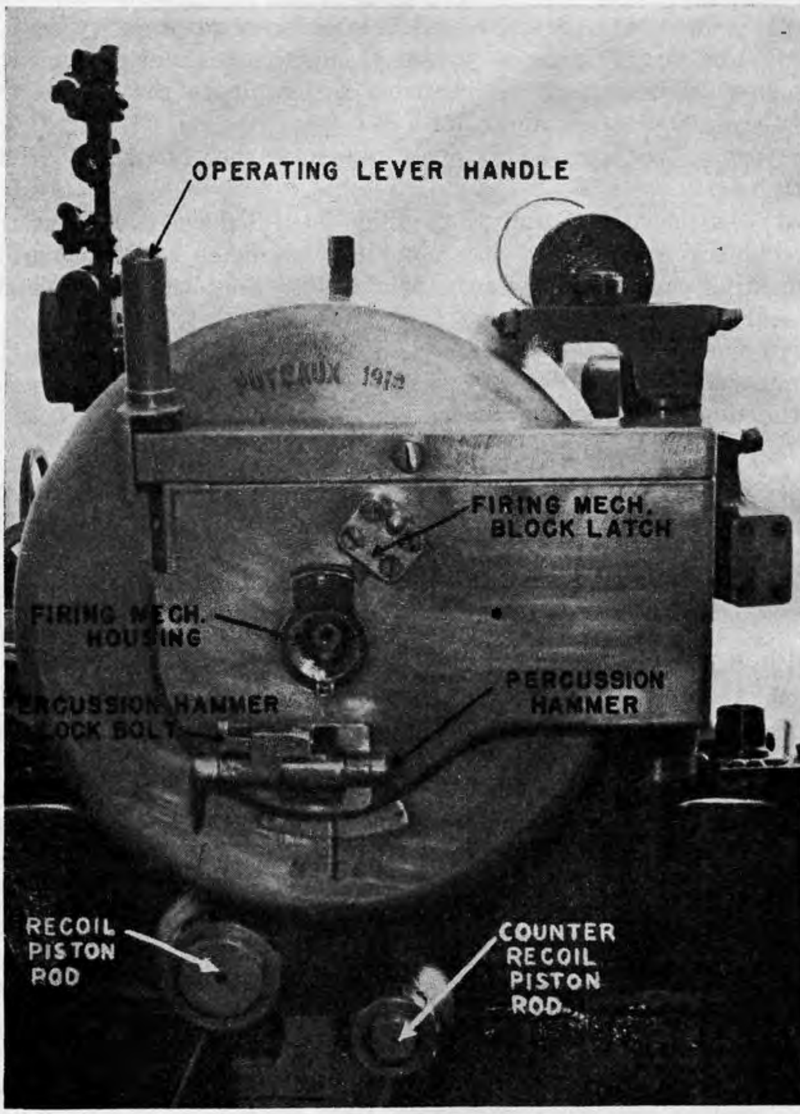


FIGURE 34.—155-mm breechblock showing firing mechanism housing.

into the firing-mechanism housing. The firing-mechanism handle is automatically locked by a safety latch when the handle is rotated to its home position. A percussion-hammer lock bolt with a knurled finger grip is encased in the percussion-hammer operating-shaft housing, its function being to hold the percussion hammer stationary when the gun is in the traveling position. In firing, as a safety precaution, this lock bolt is locked immediately after the breech is opened, and is not unlocked until after the breechblock has been fully rotated and locked in the closed position and the gun is ready to fire.

The force for firing is furnished by pulling a lanyard attached to a steel hammer. When the lanyard is pulled, the percussion hammer strikes the firing pin in the center of the firing-mechanism block, firing the primer, as shown in figure 35.

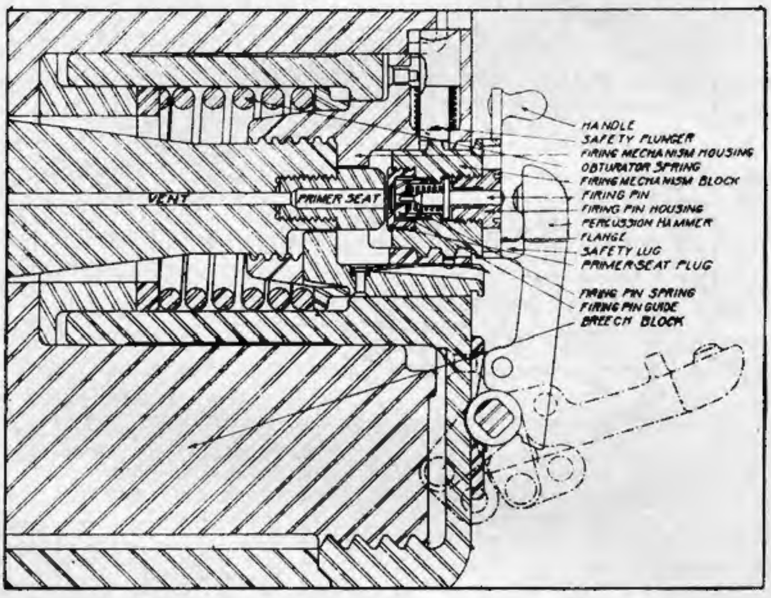


FIGURE 35.—155-mm percussion-type firing mechanism.

b. Safety features.—(1) As a safety feature, there is a safety lug provided on the front of the percussion hammer, designed to prevent the hammer striking the firing pin except when the firing-mechanism block is fully inserted. This is defective in that the primer may be fired when this block is opened one turn. Therefore it is imperative that no attempt be made to insert the firing-mechanism block until the breechblock is fully closed.

(2) The breechblock is provided with a safety plunger mechanically designed to prevent the insertion of the firing-mechanism block until the breechblock is fully closed.

20. Continuous pull firing mechanism.—*a. General.*—This type of firing mechanism is used with fixed ammunition, in which the propelling charge is contained in a metallic case and it is necessary to fire a percussion primer in the base of the case. In our service, this is usually done by means of a firing mechanism of the continuous pull type, in which no cocking of the firing pin is required other than a pull on the lanyard or firing handle of the carriage. Several types of continuous pull firing mechanisms have been supplied to the service which, while similar in general principle, are constructed and operate in different ways. The new type is shown in figure 36.

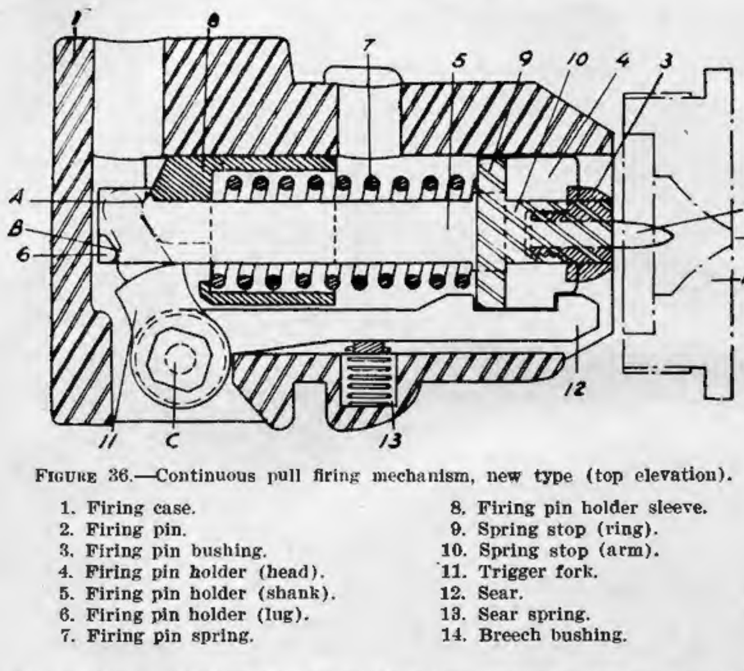


FIGURE 36.—Continuous pull firing mechanism, new type (top elevation).

1. Firing case.
2. Firing pin.
3. Firing pin bushing.
4. Firing pin holder (head).
5. Firing pin holder (shank).
6. Firing pin holder (lug).
7. Firing pin spring.
8. Firing pin holder sleeve.
9. Spring stop (ring).
10. Spring stop (arm).
11. Trigger fork.
12. Sear.
13. Sear spring.
14. Breech bushing.

b. Operation.—Although the mechanism operates on one continuous pull there are really three separate parts to the complete cycle (fig. 37).

(1) Part A, figure 37, might be called the *cocking* phase, for here the first half of the lanyard's pull is used to compress the firing pin spring, much as in a double action revolver, where the first part of trigger pull cocks the pistol. Part B is the *firing* phase, for here the second half of the lanyard's movement releases the sear, allowing the firing spring to expand and force the firing pin against the cartridge cap, firing it. Part C is the *retracting* phase, as here the recoil of the gun allows the lanyard to slack, permitting the trigger fork to rotate

to the rear, bringing firing spring and firing pin with it. This is necessary in order to prevent a protruding firing pin from being broken off by the opening breechblock and to prevent scoring of cartridge bases from the same cause.

(2) Referring to the actual illustration of the new type firing mechanism in figure 36, it is seen that the first movement of the lanyard rotates shaft (C) and the trigger fork (11) forcing the firing pin holder sleeve (8) forward and compressing the firing pin spring (7). This corresponds to the action in A, figure 37. When shaft (C) has been rotated enough to release sear (12), the firing pin holder, bushing, firing pin, and spring stop are driven forward until the spring stop arms, which project about ⅜ inch beyond the front face of the firing pin holder head, strike the walls of the recess in the breech bushing (14). This prevents further forward movement of the spring, but the firing pin holder, bushing, and firing pin continue forward on their own momentum until the pin strikes the primer at (D). This corresponds to B, figure 37. After the primer has been struck, the firing pin spring is still under compression and hence tends to expand. Its forward movement is prevented by the spring stop so it moves to the rear. This movement is transmitted through the sleeve to the trigger fork at point of contact (A). The trigger fork is rotated to the rear, enough slack in the lanyard for this purpose being secured by the recoil of the gun. A torsion spring around the trigger shaft assists in making rotation positive. As the trigger fork bears on the forward faces of the lugs (6) of the firing pin holder, the holder, and hence the firing pin and bushing, move to the rear. This immediate retraction of the firing pin removes the tendency to score the face of the cartridge case. As soon as the gap between the rear face of the firing pin holder head and the spring stop has been closed, the latter also moves to the rear, together with holder, firing pin, and bushing, until the firing spring has regained its extended length. When retraction is complete, the sear spring has forced the sear notch over the edge of the firing pin holder head and the mechanism is again ready to fire as diagramed in C, figure 37.

c. Safety features.—This type mechanism has safety features described as follows:

(1) The mechanism cannot operate by a sudden jar as the firing pin spring cannot be compressed except by a pull on the lanyard.

(2) Mounted in a drop block, the firing pin does not appear opposite the cap on the cartridge until the breechblock is completely closed.

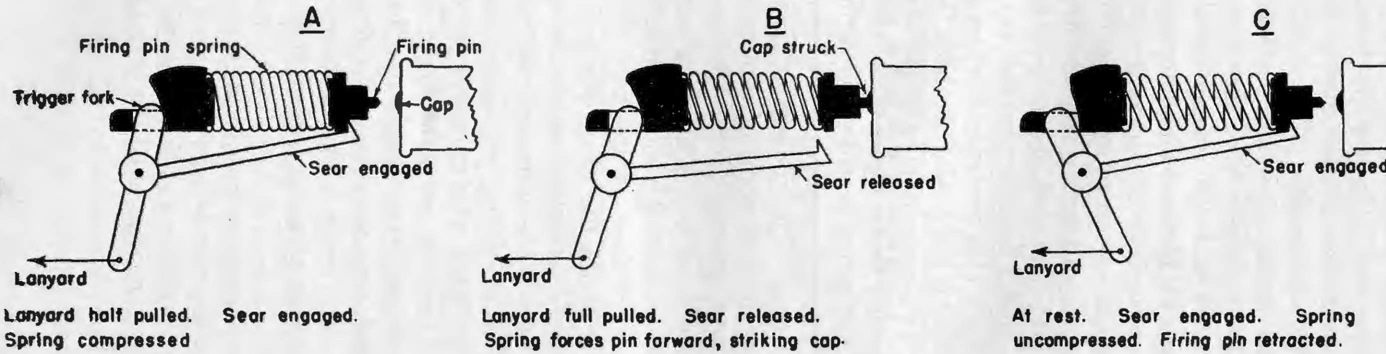


FIGURE 37.—Operation of continuous pull firing mechanism.

SECTION V

RECOIL AND COUNTERRECOIL MECHANISMS

21. General.—On the early muzzle loaders, the full force of recoil was taken by the carriage, which had to be very strong and heavy in consequence. When cannon (both land- and ship-borne) were mounted on wheels they were allowed to roll to the rear on each shot, absorbing some of the recoil by moving. The firing of early ship's cannon plainly illustrated the movements of recoil and counterrecoil. When discharged, the cannon recoiled to the rear of the casemate or gun deck. After loading, the gun crew, with the aid of block and

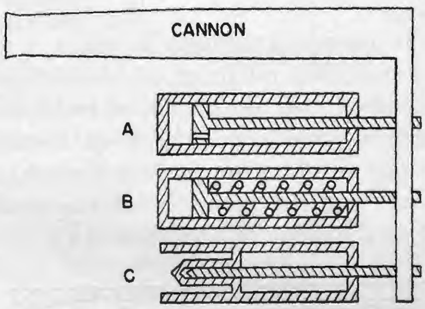


FIGURE 38.—Simplified recoil system.

tackle, counterrecoiled the gun forward into firing position. During the World War, similarly primitive methods were used in railway artillery, the weapon sliding along the track on recoil. As muzzle energy grew larger and larger, it was no longer practical to build carriages heavy enough to stand the shock of recoil, and recoil brakes came into use. In the recoil brake, some form of hydraulic mechanism is used to slow the gun down gradually and finally stop it. To return the gun to firing position, some form of automatic mechanical counterrecoil device is used in connection with the recoil brake.

As illustrated in figure 38, an actual recoil system requires three distinct parts: The recoil brake (A), the counterrecoil mechanism or recuperator (B), and the buffer (C). The brake brings the cannon to a gradual stop in recoil, the counterrecoil mechanism returns the cannon to firing position and holds it there, regardless of elevation, and the buffer brings the cannon to a gradual stop in firing position.

22. Recoil brakes.—*a.* Recoil brakes are all variations of one fundamental type illustrated in figure 39. On recoil, the piston rod which is attached to the gun moves the piston to the rear (right) forcing oil at high pressure through the small holes in the piston,

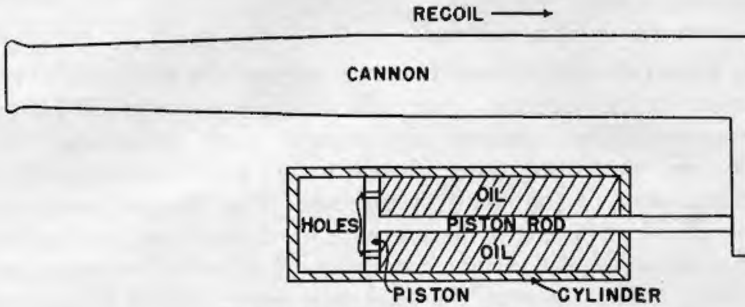


FIGURE 39.—Simple recoil brake.

and the resulting resistance gradually brings the cannon to a stop.

b. It was soon found that oil holes of constant area did not provide uniform braking—recoil velocity was too low at the start and too high at the finish. Some means had to be found to alter the area of the orifices during recoil. One practical method was by the use of throttling grooves cut in the walls of the recoil cylinder. By varying the depth of the grooves, the area of the orifice at any point

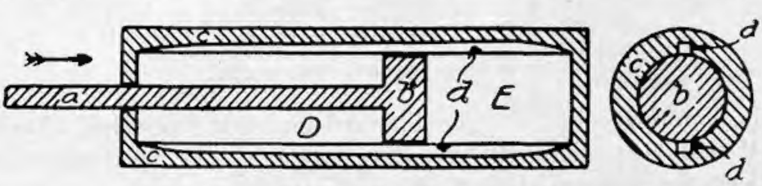


FIGURE 40.—Use of throttling grooves.

a. Piston rod.
b. Piston head.
c. Cylinder.
d. Throttling grooves.

during recoil could be controlled. Another method was devised which provided orifice control through the use of throttling bars (see fig. 41) attached to the cylinder walls and operating in grooves of constant cross-section cut in the piston. Throttling grooves are used in practically all modern recoil mechanisms employing this general type of orifice control.

c. (1) Still another system of orifice control uses a rotating throttling valve (or two-piece piston) as shown in figure 42. One part of the piston is of usual design, having several holes through it; the other part, called the movable valve disk, has holes bored at the same locations as on the main piston. By means of guide grooves cut in the cylinder wall, the movable valve disk may be rotated with reference to the main piston, varying the orifice area as desired. The same design may be employed to secure variable recoil by controlling the rotation of the movable valve disk (f) externally.

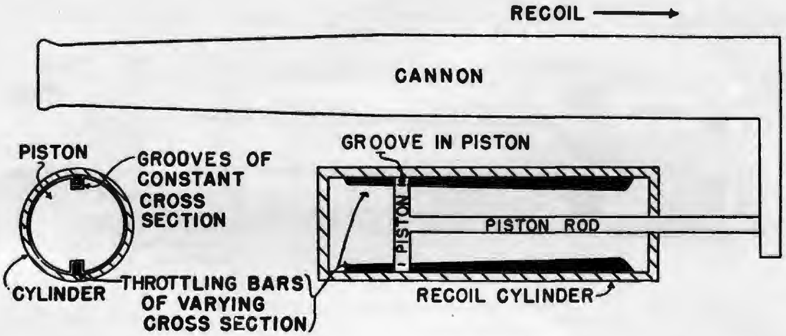


FIGURE 41.—Use of throttling bars.

(2) Variable recoil is employed on mobile weapons to allow long recoil at low angles of elevation to assure stability and short recoil at high elevation to avoid hitting the ground.

d. The 155-mm gun uses a control rod for orifice area control as shown in figure 43. By rotating the control rod the system may be adjusted for long or short recoil as desired.

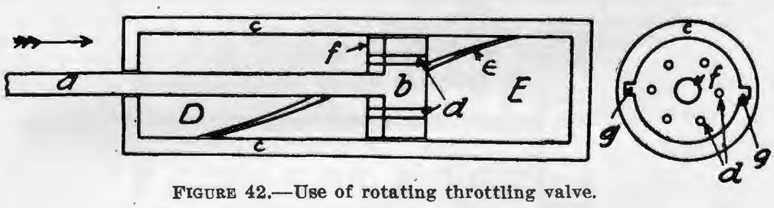


FIGURE 42.—Use of rotating throttling valve.

a. Piston rod.
b. Piston head.
c. Cylinder.
d. Orifices.
e. Guide groove.
f. Movable valve disk.
g. Projections.

23. Counterrecoil mechanisms (or recuperators).—*a. Spring counterrecoil.*—The simplest means of returning a gun from recoiled to firing position is by use of coil springs as illustrated in figure 44. On recoil to the right the springs are compressed, and as they assume their original shape on counterrecoil they return the gun to firing position. The coil springs may be arranged concentrically for greater power or telescopically for greater length of recoil, but the principle of operation does not change.

b. Gravity counterrecoil.—Disappearing carriages use gravity to accomplish counterrecoil. As shown in figure 45, a simple counterweight pulls the gun back into battery. Part of the energy of recoil is used to raise the counterweight. After loading, the gun is tripped and the counterweight falls, raising the gun into firing position.

c. Pneumatic recuperators.—(1) Another method of returning a gun to firing position (counterrecoil) is by means of pneumatic recuperators. A pneumatic recuperator consists of a cylinder filled with gas (or air) under high pressure, and a piston and rod operating within the cylinder. When the gun recoils, the air in the cylinder is still further compressed. This air pressure, acting on the piston, returns the cannon to firing position.

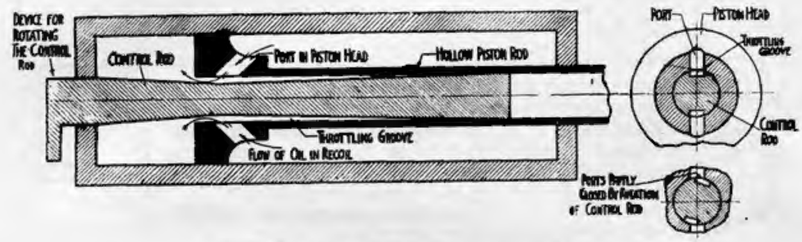


FIGURE 43.—Operation of control rod.

(2) Air under high pressure is difficult to imprison, and several means have been tried to obtain air-tight packing. The most successful means has been the oil seal. This device makes use of the fact that it is comparatively easy to design a packing to confine oil but difficult to design one to confine air. As shown in figure 46 an auxiliary or floating piston may be employed between the main piston and the high pressure gas. The space between the two pistons is filled with oil.

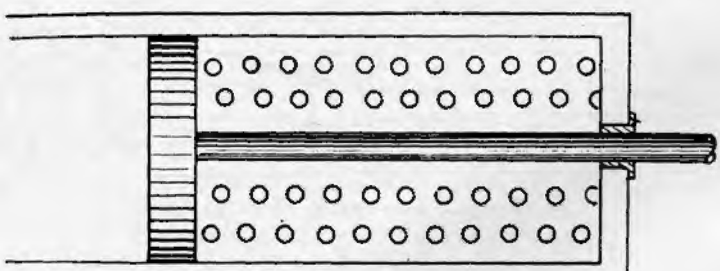


FIGURE 44.—Cross-sectional diagram showing use of two concentric springs.

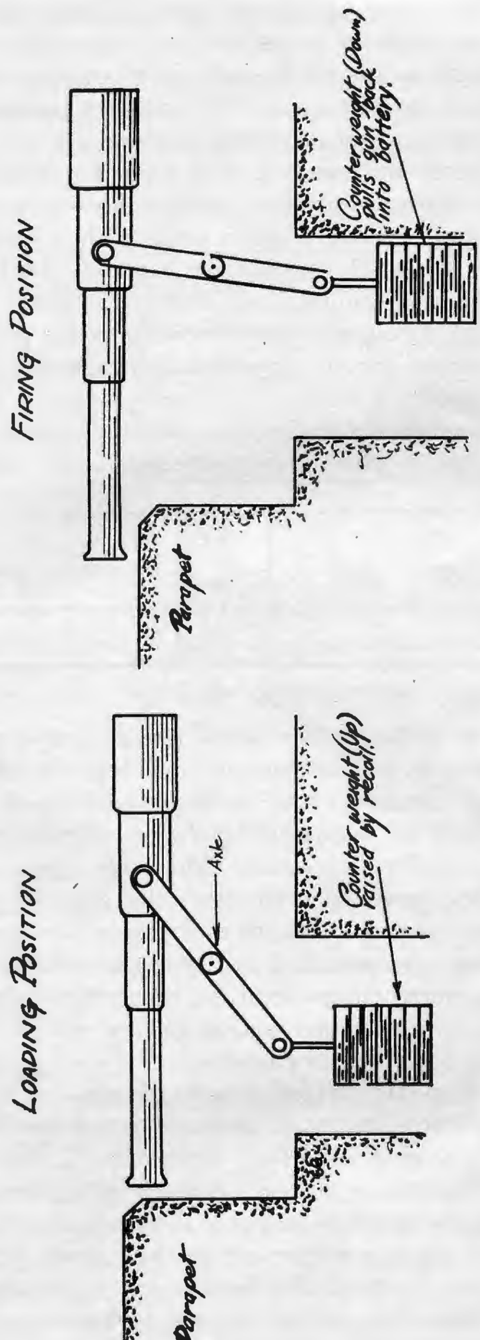


FIGURE 45.—Counterrecoil using counterweight.

An ordinary oil seal keeps the oil confined. Another method has the oil in direct contact with the gas as shown in figure 48. As the oil is at the same pressure as the air there is little tendency for the air to escape. This idea is not only used in the ordinary pneumatic recuperator but also in hydropneumatic recoil devices.

24. Counterrecoil buffers.—*a.* The force required to return a gun from recoil to firing position is considerable—it must be capable of returning the gun to firing position at its highest usable elevation. If the gun is fired at zero elevation, there is merely the friction of the slide to overcome, and counterrecoil velocity is much greater than when firing at high elevation. To absorb the excess energy of counterrecoil and bring the gun to a gradual stop regardless of elevation, the counterrecoil buffer is used.

b. Most buffers are of the dashpot or plug type, as shown in figure 47. During the early part of counterrecoil, oil is trapped in the

FIGURE 46.—Floating piston.

female part of the buffer. During the latter part of counterrecoil, this oil must escape in the narrow opening between the male and the female members. As counterrecoil nears completion, the opening between the male and female members becomes increasingly smaller and finally disappears. The force expended in forcing the oil through the small opening slows the gun down and finally brings it to a gradual stop. On some carriages, notably the 16-inch gun carriage, means are provided in the recoil cylinder for limiting the velocity of counterrecoil by throttling the recoil oil through special orifices, thus applying a buffer action during all of counterrecoil. This mechanism is described in paragraph 31*d* (3).

25. Hydropneumatic recoil mechanisms.—*a.* In some carriages the recoil and counterrecoil mechanisms are combined into one mechanism which accomplishes both functions. In one type (illustrated in fig. 48) the oil is in direct contact with high pressure air. As the gun recoils the piston is pulled to the rear, pressing against the oil, which in turn compresses the air in the upper cylinder. After recoil, conditions are reversed, and the air pressure is exerted (through the oil) against the piston, moving the gun forward into battery. In use, it was found that prolonged firing sometimes caused the air and the oil to form an emulsion (or froth) which lacked desirable qualities as a recoil fluid.

b. A second type of hydropneumatic mechanism was designed which had a floating piston (fig. 49) between the oil and air, separating them. This floating piston separates the air and the oil and re-

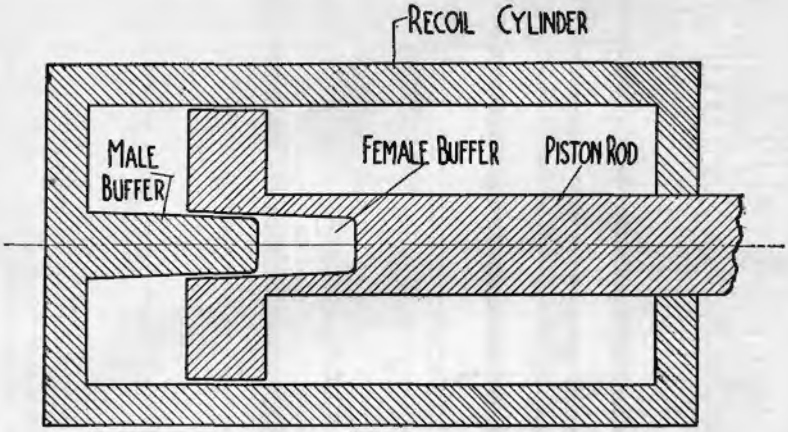


FIGURE 47.—Counterrecoil buffer (simplest type).

moves the difficulties associated with the first type (fig. 49). The actual mechanism, as applied to the 155-mm gun, is illustrated in figure 50. As the gun recoils, the counterrecoil piston (12) is pulled to the rear (right) forcing the oil in the cylinder (13) up into the recuperator cylinder (6). This flow of oil fully opens the regulator valve

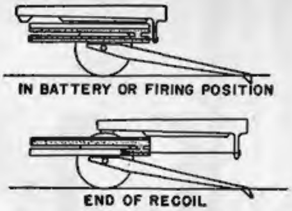


FIGURE 48. — Hydropneumatic recoil system—fluid in contact with gas.

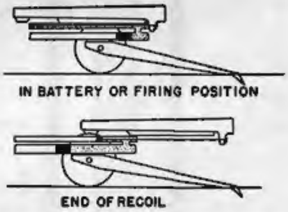


FIGURE 49. — Hydropneumatic recoil system using floating piston.

(8) and allows the oil free passage. When counterrecoil starts, the movement of the oil in the opposite direction closes the regulator valve (8) and forces the oil to go through two small holes in the regulator valve, braking counterrecoil and making it gradual and easy. A counterrecoil buffer (4) of conventional plug type is incorporated in the recoil cylinder.

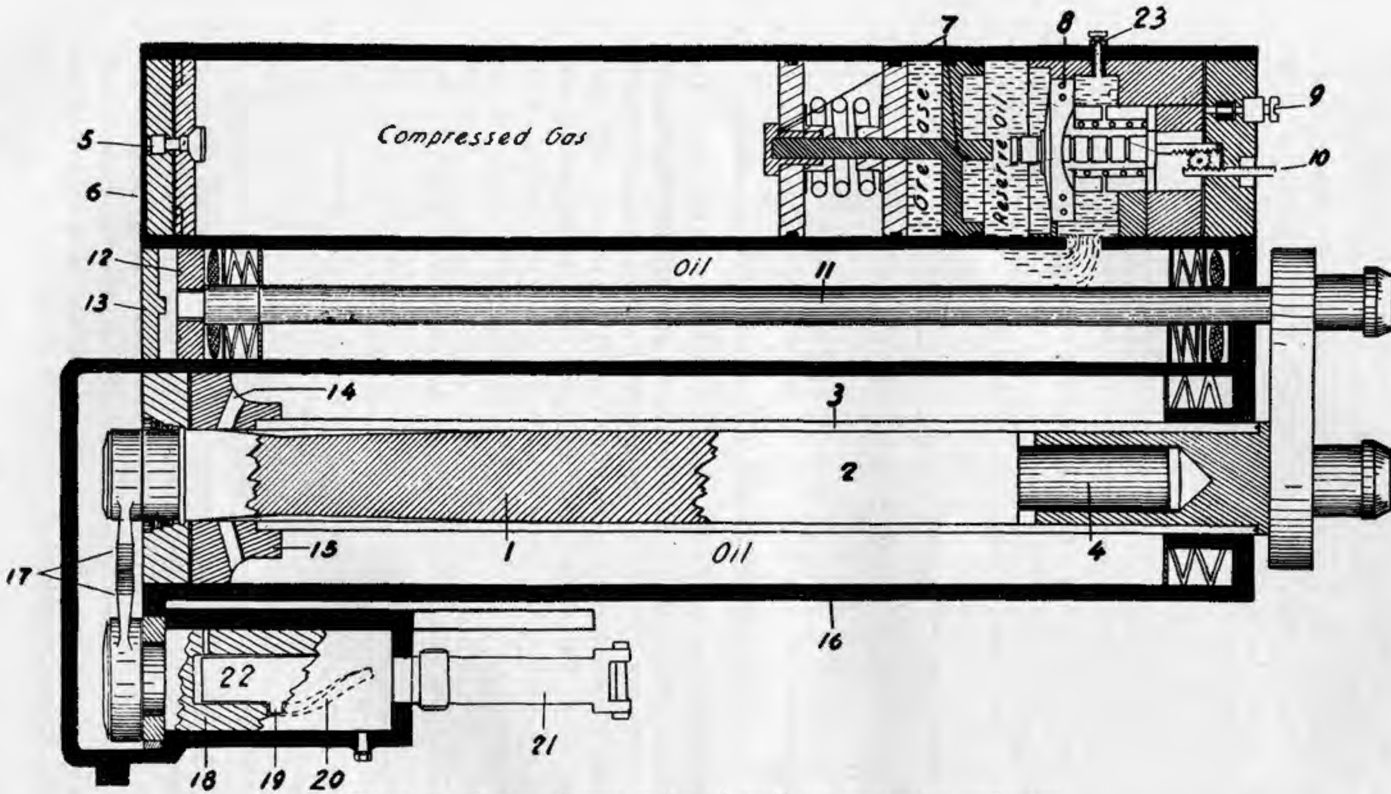


FIGURE 50.—Horizontal cross section of recoil and recuperator mechanism.

1. Control rod.
2. Control rod.
3. Hollow recoil rod.
4. Counterrecoil buffer.
5. Air valve.
6. Recuperator cylinder.
7. Floating piston assembly.
8. Regulator valve.
9. Filling and drain plug.
10. Oil index rod.
11. Counterrecoil rod.
12. Counterrecoil piston.
13. Counterrecoil cylinder.
14. Port in recoil piston.
15. Recoil piston.
16. Recoil cylinder.
17. Gear segments.
18. Sleeve inside cylinder.
19. Cam on valve turning rod.
20. Cam groove inside sleeve.
21. Regulating arm.
22. Valve turning rod.
23. Recuperator filling plug.

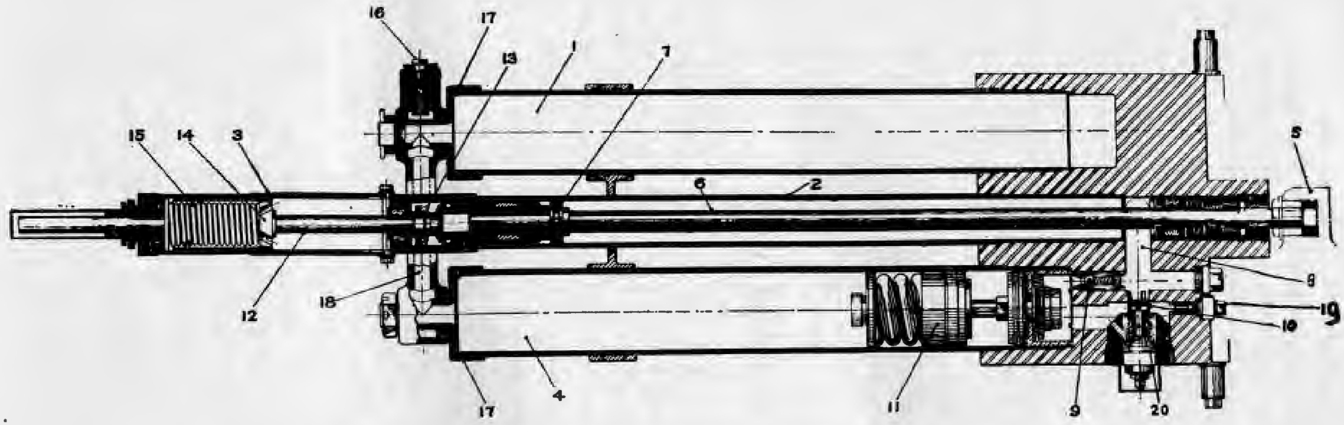


FIGURE 51.—Recoil system, 3-inch antiaircraft mount, M2 (top elevation).

1. Air reservoir cylinder.
2. Recoil cylinder.
3. Counterrecoil buffer cylinder.
4. Floating piston cylinder.
5. Breech ring.
6. Recoil piston rod.
7. Recoil piston.
8. Oil passageway.
9. Counterrecoil valve.
10. Recoil valve.
11. Floating piston.
12. Counterrecoil buffer piston rod.
13. Guide for counterrecoil buffer piston rod.
14. Counterrecoil buffer piston.
15. Counterrecoil buffer spring.
16. Air-filling plug.
17. Cylinder head.
18. Bypass connection.
19. Oil-filling valve and plug.
20. Recoil valve spring.

c. Another application of the hydropneumatic mechanism is used in the present 3-inch antiaircraft (M2) carriage. In this system use is made of two valves to regulate recoil and counterrecoil. Referring to figure 51, on recoil the oil in the recoil cylinder (2) is forced through the recoil valve (10) and moves the floating piston (11) to the front (left) compressing the air in the floating piston cylinder (4). When the force of recoil has spent itself, recoil valve (10) closes and counterrecoil valve (9) opens; air pressure forces the oil through the large orifice opened by valve (9) and returns the gun to firing position. The buffer consists of a dashpot and spring combined, which together ease the gun to a gradual stop. The recoil mechanism is unique in that the valve (10) is constructed so as to make the size of the opening proportional to the oil pressure—the higher the pressure the larger the opening. At the start of recoil the valve opens wide due to high initial pressure, but as the pressure falls, the valve gradually closes, bringing the gun to a smooth stop.

Section VI

FIXED CARRIAGES

26. General.—Carriages may be divided into five general types: disappearing, barbette, tractor-drawn, railway, and antiaircraft. The first two types are fixed, the next two are mobile, and antiaircraft may be either. Though differing somewhat in size, appearance, and method of employment, all these types have many points of comparison. For example, let us see how length of recoil varies in different types of weapons. In a mobile mount of the tractor-drawn type, weight is an important factor. The lighter weapon can negotiate weaker highway bridges, is less likely to get stuck in wet weather, and is in general a handier piece of artillery. To be able to cut down on the weight of the carriage it is necessary to cut down on the stresses that the carriage is expected to bear, and one of the easiest ways to do this is to lengthen the recoil. Therefore our mobile guns which must be pulled along the road are all long recoil weapons. If it is desired to use our guns at high angles of elevation, a compromise must be reached between the advantages of long recoil and the disadvantages of having to dig a deep pit into which the gun may recoil without hitting the ground. This is worked out in the 155-mm gun by having variable recoil—long (6 feet) at low angles of elevation and shorter ($3\frac{1}{2}$ feet) at maximum elevation. At the other extreme are the fixed barbette mounts bolted to concrete blocks. Here stability and weight take care of themselves, and so a short constant length recoil may be adopted. A study of the length of recoil of artillery weapons in the various armies shows that mounts of the same general caliber and function have very similar lengths of recoil. The railway carriage is between the fixed and the tractor-drawn mounts in this respect, generally employing a constant length recoil longer than that of the fixed mount.

27. Types.—*a*. In fixed seacoast artillery there are two general types of mounts—barbette and disappearing. The barbette was first used in our coast artillery and was of the general type illustrated in figure 52. In this carriage the angle of elevation was limited to 15° so that the mount had neither the advantage of long range nor of good protection for mount and crew.

b. As an attempt better to protect the installation from naval gun fire, the disappearing carriage was developed. In the days of flat trajectory naval weapons and before the advent of the airplane, it fulfilled its mission effectively, though it was a complicated carriage and had a limited traverse. For several years the disappearing carriage was all supreme in our service although little use was made of the idea abroad. Naval designers continued to increase the caliber and range of weapons afloat, and it became necessary to do the same thing for weapons ashore. In this situation the disappearing weapon proved unsuitable because its basic design did not lend itself to high-angle fire. The barbette carriage again became the accepted type, and the disappearing carriage finally disappeared entirely from new designs.

c. There were three possible solutions to the problem of protecting barbette mounted cannon. The first was dispersion of the elements of the battery. In this scheme, guns, powder magazines, power plants, and plotting rooms were widely separated. Ammunition was served by railroads using gasoline locomotives. Plotting rooms and power plants were bombproofed.

d. The second solution was to use one- or two-gun turrets as the Navy does at sea. (Fig. 53.) In this mount, power plant, plotting room, and ammunition storage and service are all underground. A maximum use is made of labor saving devices cutting down on the

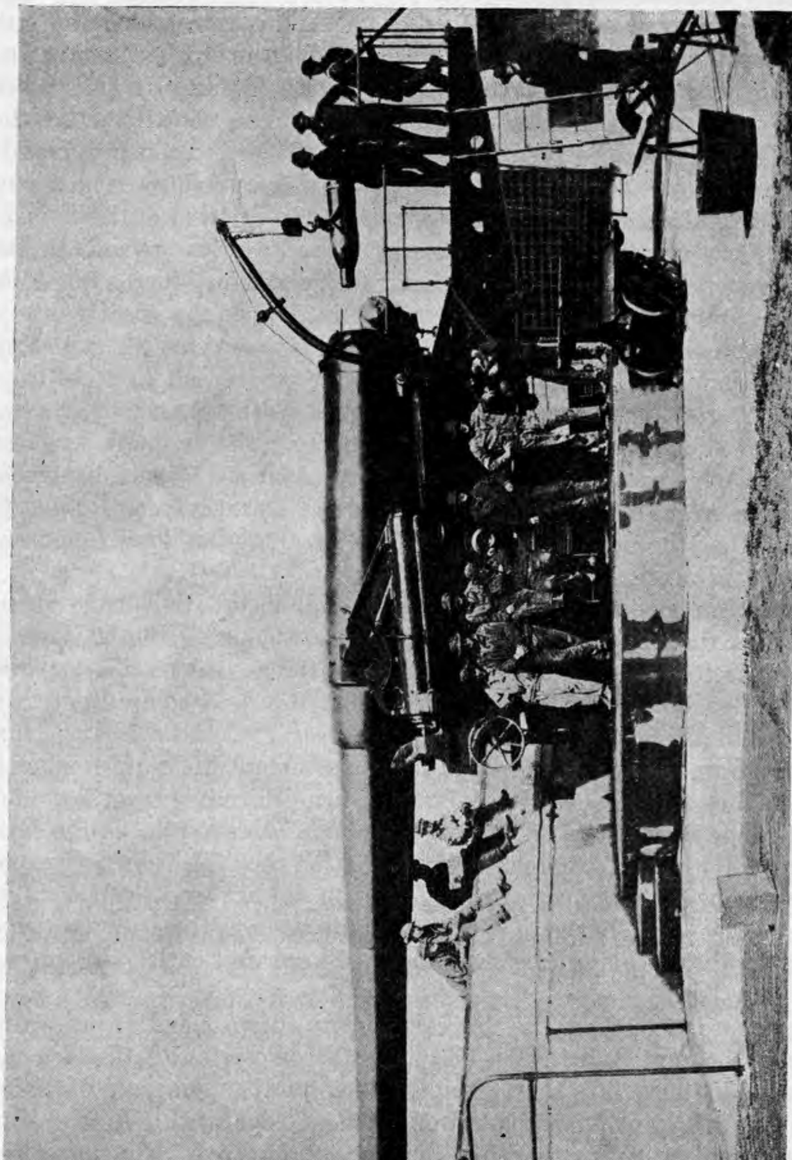


FIGURE 52.—12-inch barbette carriage, M1892.

number of men needed. The installation is easily gasproofed. The crew members are all behind armor plate and cannot be driven away from their posts by attack aviation.

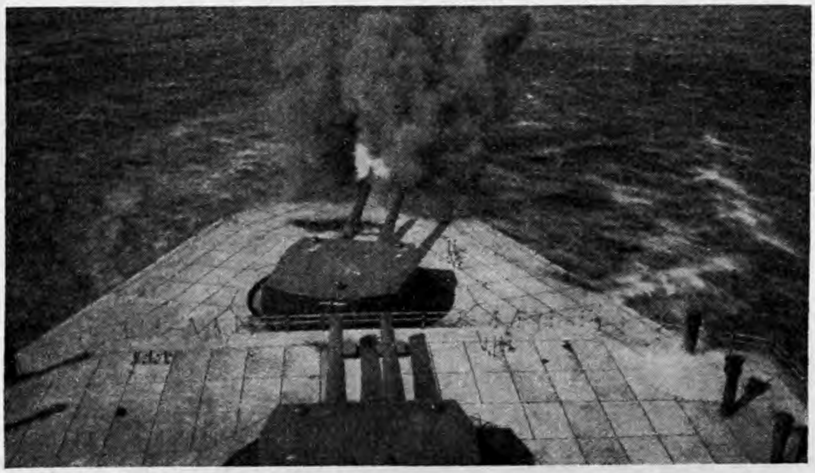


FIGURE 53.—Turrets used in coast defense.

e. The third solution combines the characteristics of the first two. For the want of a better name it is called the casemate type. In this design the gun is placed on a barbette mount. Over the mount is constructed an open-fronted house of steel and concrete so placed

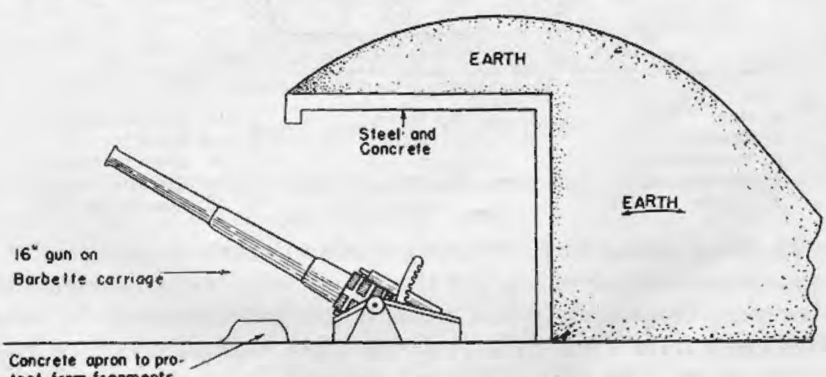


FIGURE 54.—Casemate emplacement.

that the gun and crew are protected except from the immediate front. This structure of course limits the field of fire to something less than 180°, although permitting the maximum angle of elevation. Power plant, ammunition storage and service, and plotting room are all bombproofed. The battery is almost as difficult to gasproof as the open barbette type. Unfortunately the open front of the casemate is pointed in the direction of the expected enemy, so that a direct hit would be as damaging as with the barbette type. For protection against heavy bombs the casemate is much superior to the open type, as a bomb must land immediately in front of the open door to do any damage. The casemate renders the battery almost immune to damage by attack aviation.

f. In the past our service has built barbette mounts in the open rather than in casemated or turret mounts because of the greatly increased cost of the latter.

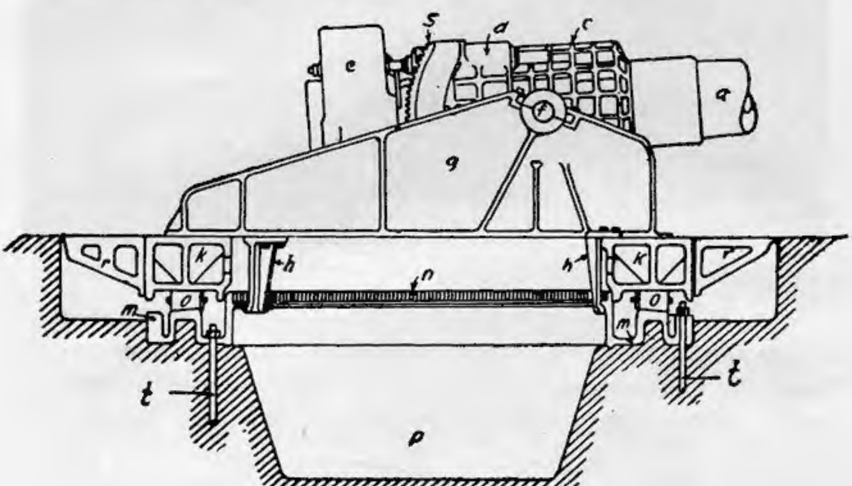


FIGURE 55.—Mounting of barbette carriage, M1919.

a. Gun.
c. Cradle.
d. Recoil cylinder.
e. Recoil band.
f. Cradle trunnion.
g. Side frame.
h. Recoil clips.
k. Racer.
m. Base ring.
n. Traversing rack.
o. Conical rollers.
p. Recoil pit.
r. Racer brackets.
s. Elevating rack.
t. Foundation bolts.

28. Traversing and elevating mechanisms.—*a. General.*—All carriages employ elevating and traversing mechanisms in order that they may be accurately laid in elevation and direction. In most carriages of the same general design these mechanisms have been standardized. For this reason only traversing and elevating mechanisms of standard type will be described here.

b. Traversing mechanisms.—(1) Traversing mechanisms for major caliber weapons have in most cases become standardized on the type shown in figure 55. The mechanism is, in effect, a gigantic roller bearing, with conical rollers (o) operating between two bearing surfaces—a lower called the base ring (m) and an upper called the racer (k). The main frame of the carriage is bolted to the racer and rotates with it. To prevent the top carriage from tipping when the gun is fired, recoil clips (h) engage a lip on the base ring. Inside and concentric with the base ring is mounted the circular traversing rack (n). A spur pinion, meshing with this rack, traverses the cannon. Some idea of the efficiency of this system is obtained when it is realized that on a 16-inch gun mount a force of 27 pounds at the traversing handwheel traverses a mass of 660,000 pounds. An azimuth circle, also mounted concentric with the racer, is provided for setting azimuth in firing at a target that cannot be seen from the gun position. For the larger caliber carriages, traversing is accomplished by electric power operating through Waterbury speed gears.

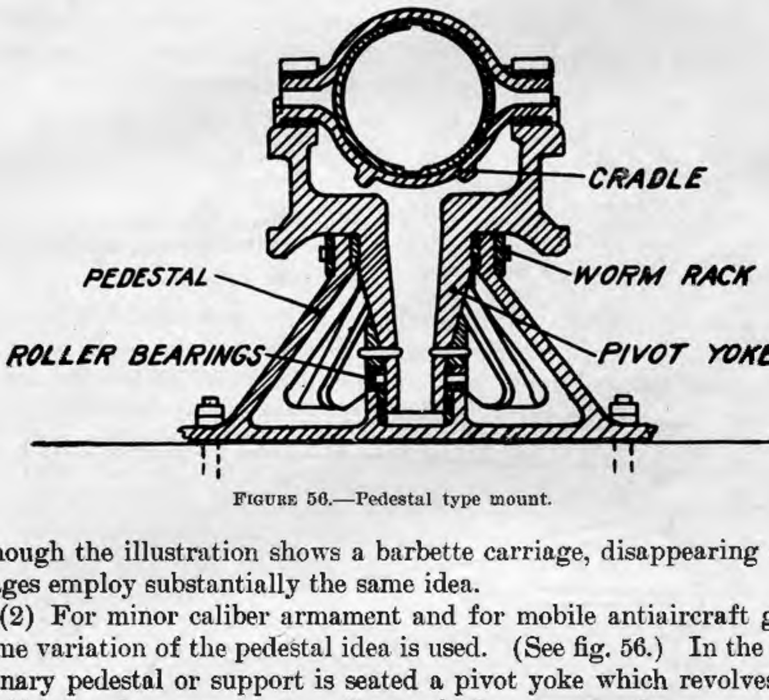


FIGURE 56.—Pedestal type mount.

Though the illustration shows a barbette carriage, disappearing carriages employ substantially the same idea.

(2) For minor caliber armament and for mobile antiaircraft guns some variation of the pedestal idea is used. (See fig. 56.) In the stationary pedestal or support is seated a pivot yoke which revolves on antifriction bearings of the roller or ball type. To the upper part of the pedestal is bolted the traversing (or worm) rack, and a pinion engaging this rack traverses the gun.

c. Elevating mechanisms.—There are two general types of elevating mechanisms—the screw type (fig. 57) and the elevating rack type (fig. 58).

(1) The screw type elevating mechanisms can best be visualized by imagining an ordinary screw automobile jack which transforms rotary

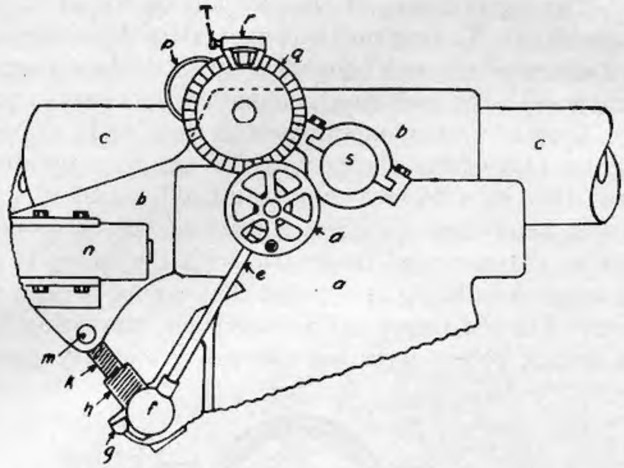


FIGURE 57.—Screw elevating mechanism.

a. Pivot yoke.
b. Sleeve cradle.
c. Gun.
d. Elevating handwheel.
e. Handwheel shaft.
f. Gear case.
g. Elevating nut gear case.
h. Outer elevating screw.
k. Inner elevating screw.
m. Screw holding pin.
n. Recoil cylinder.
p. Large intermediate gear
q. Range disk.
r. Elevation pointer.
s. Cradle trunnion.

motion at the handle to upward motion at the jack head. Attach the jack base to the main carriage and the jack head to the cradle and you have visualized the screw mechanism. Though illustrated in figure 57 as applied to a barbette carriage, this mechanism is also used with

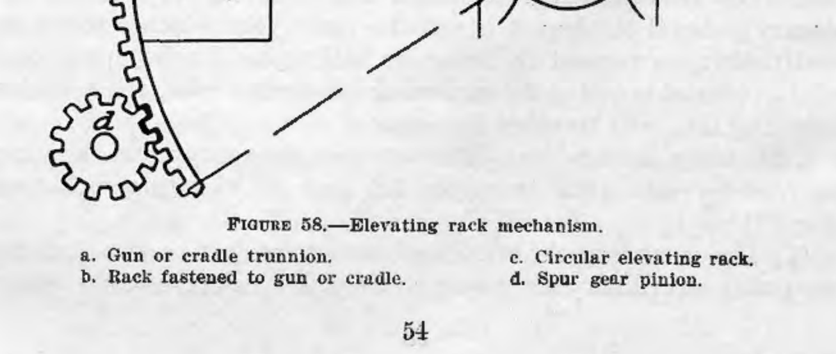


FIGURE 58.—Elevating rack mechanism.

a. Gun or cradle trunnion.
b. Rack fastened to gun or cradle.
c. Circular elevating rack.
d. Spur gear pinion.

disappearing carriages, changing the elevation through raising or lowering the elevating arm (fig. 64).

(2) The elevating rack mechanism of latest design (fig. 58) consists of a circular rack (c) fastened to the cradle and a set of plain spur gears starting with (d) connected to the elevating handwheel on the main carriage. With a well-designed mechanism it is possible to get a 1° change in elevation for each turn of the elevating handwheel, and to elevate or depress a 16-inch gun with a force of 30 pounds at the wheel's rim. This mechanism is also used on our antiaircraft and mortar carriages.

(3) When the rack and pinion idea is applied to disappearing carriages a straight rack fastened to the elevating arm is used. The gun, pivoted about the trunnions, is raised or lowered in elevation by the action of the elevating arm in lowering or raising its breech end. Note in figure 64 that the elevating arm is trunnioned to the gun near the breech.

(4) Some form of protective device is provided on all elevating mechanisms to prevent injury from the shock of discharge.

(*a*) On the barbette or mortar carriage this takes the form of a friction clutch which slips before the load on the gears becomes too great.

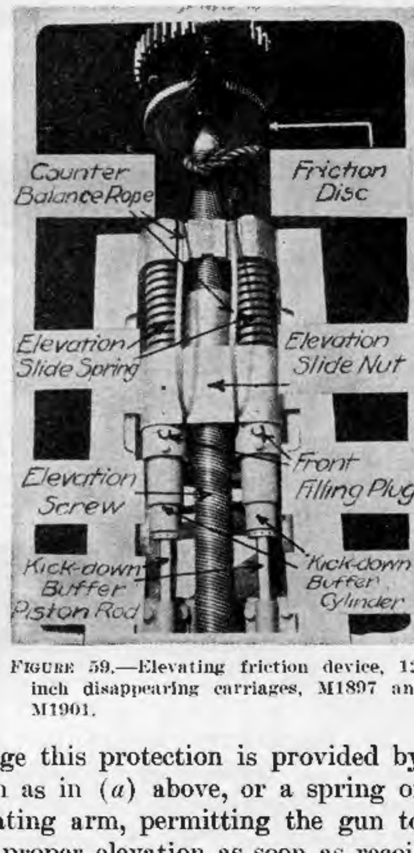


FIGURE 59.—Elevating friction device, 12-inch disappearing carriages, M1897 and M1901.

(*b*) On the disappearing carriage this protection is provided by a friction clutch in the gear train as in (*a*) above, or a spring or hydraulic mechanism on the elevating arm, permitting the gun to kick down but returning it to its proper elevation as soon as recoil is over. (See fig. 59.)

(5) Our major caliber barbette cannon are provided with electrical elevating mechanisms operating through Waterbury speed gears. This greatly decreases the time consumed in going from loading to firing position and vice versa.

d. Antifriction elevating device.—To enable major caliber guns to be elevated and depressed quickly and easily an antifriction elevating device (fig. 60) is employed. This is really a two-piece bearing—one a roller bearing for easy operation (d); the other, a larger diameter main trunnion bearing (a) to take the shock of discharge. During normal operation the main trunnion does not touch its plain main trunnion bearing at all, as the weight of the gun is floated on the crutch (e) and the roller bearing carries the load. When the gun is fired, the force of recoil depresses the Belleville springs (k) so that the main trunnion rests on the main trunnion bearing, transmitting the force of recoil directly to the side frames of the carriage. When the gun has returned to firing position the Belleville springs again float the gun's weight clear of the main bearing, and the roller bearing allows the gun to be depressed or elevated easily.

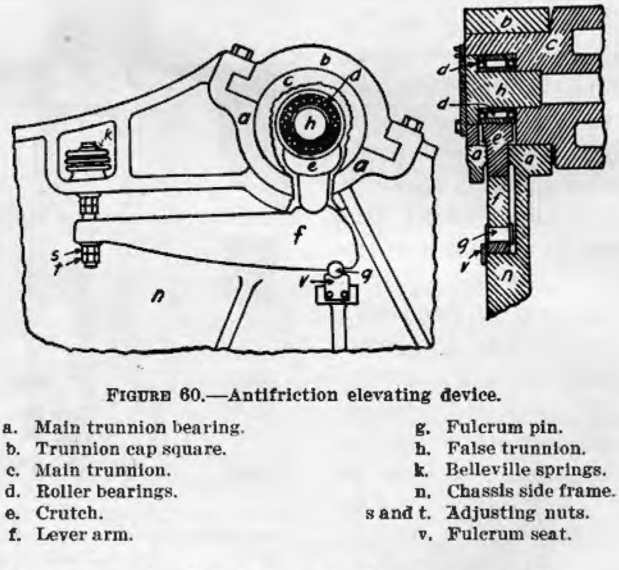


FIGURE 60.—Antifriction elevating device.

a. Main trunnion bearing.
b. Trunnion cap square.
c. Main trunnion.
d. Roller bearings.
e. Crutch.
f. Lever arm.
g. Fulcrum pin.
h. False trunnion.
k. Belleville springs.
n. Chassis side frame.
s and t. Adjusting nuts.
v. Fulcrum seat.

29. Waterbury hydraulic speed gear.—*a.* Because electric motors for traversing, for elevating, and for ramming encounter maximum torque on starting, and because very fine variations in speed are necessary, conventional speed control is not satisfactory. Instead, the electric motor is allowed to run at its most efficient speed and is connected to the mechanism it is to operate through a Waterbury hydraulic speed gear. With this gear any desired speed—either forward or backward—may be achieved while the driving motor runs continually at its designed speed in one direction. A sketch of a Waterbury gear appears in figure 61, and a simplified drawing in figure 62. All space within the case, not occupied by metal, is filled with oil. The small cylinders with their plungers are small pumps. The right side (A end) of the case is the driving side; the left, the

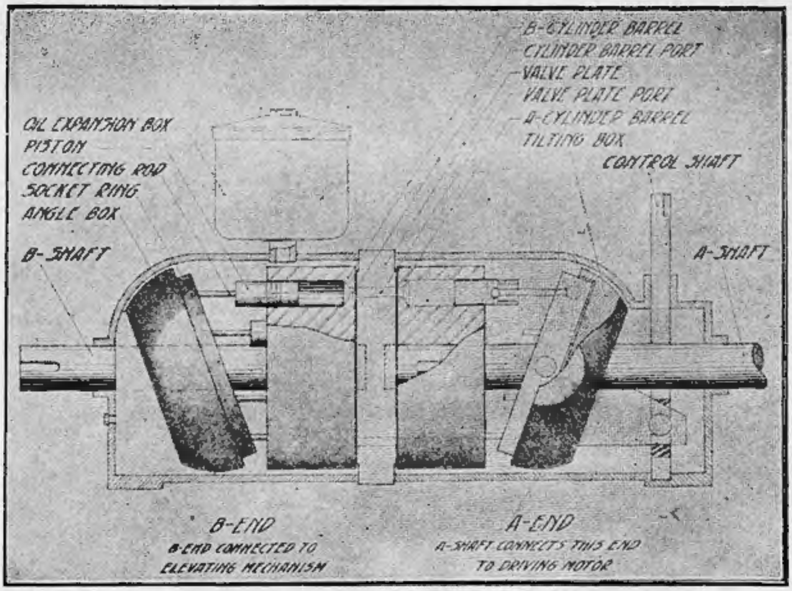


FIGURE 61.—Diagrammatic sketch of Waterbury hydraulic speed gear.

driven side. As the right side shaft rotates, more or less oil is pumped by the four small pumps illustrated, depending on the angle at which the tilting box is set by the worm gear shown. The greater

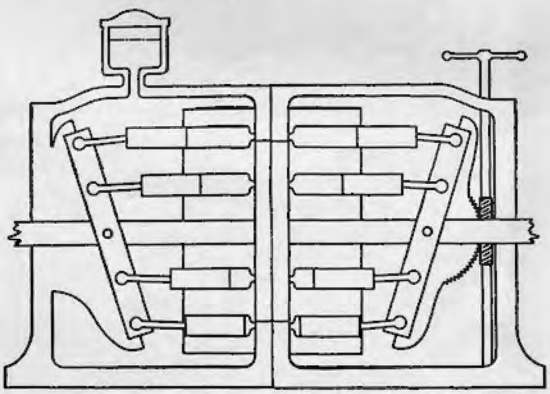


FIGURE 62.—Simplified sketch of Waterbury speed gear.

the tilt, the greater the amount of oil pumped through to the driven side, and the faster the driven side shaft will rotate. As can be seen from the drawing, if the tilting box is tilted in the opposite direction, the driven shaft will rotate in the opposite direction.

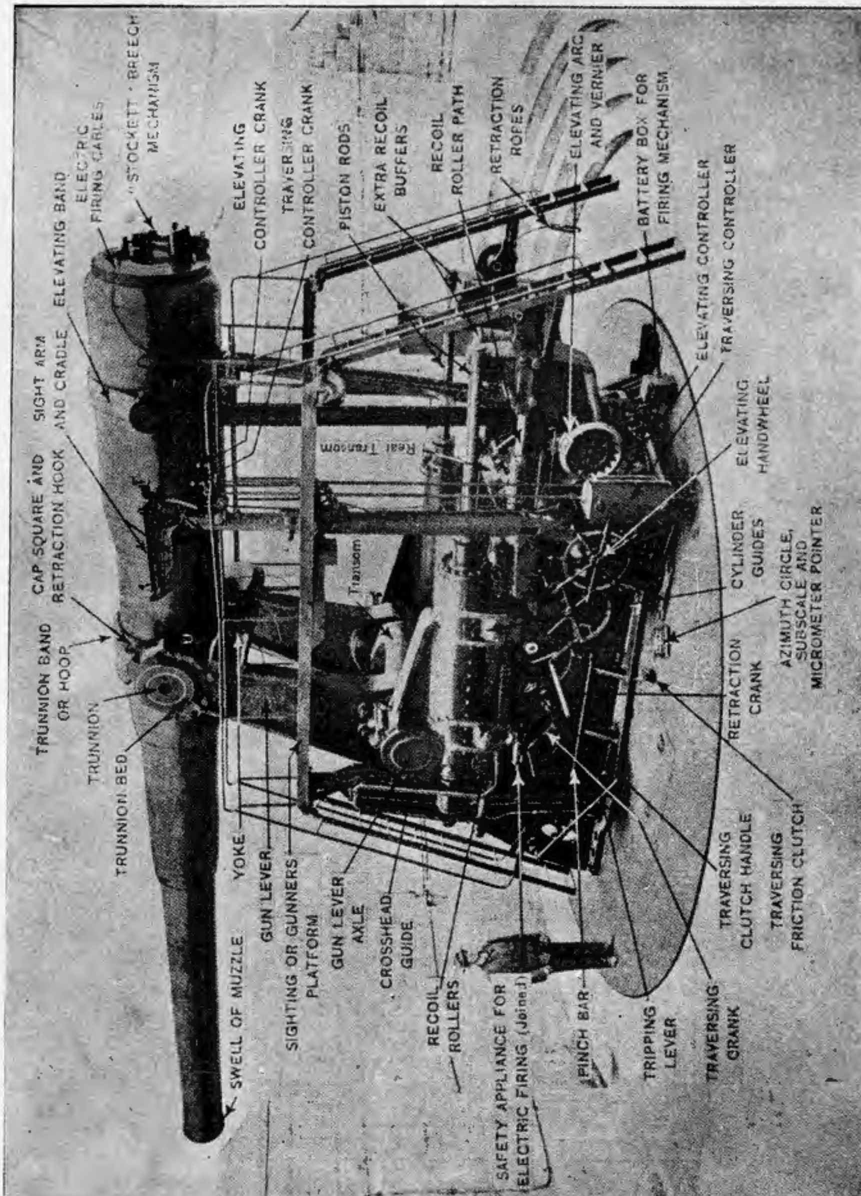


FIGURE 63.—Disappearing carriage in battery.

b. By means of these gears a gun may be elevated rapidly to its approximate elevation and then gently eased into its exact firing position; it may be depressed rapidly almost to horizontal and easily brought up against its stop for loading. An automatic stop is provided to prevent injury to the gun due to careless depressing. Similarly the mount may be traversed at will and the rammer operated with differing speeds for projectile and powder.

30. Disappearing carriages.—*a.* The majority of our seacoast artillery is mounted on disappearing carriages. Their great disadvantage is the lack of range obtainable with guns mounted on them, but within range they are efficient carriers for the guns they mount. Besides being limited in range disappearing carriages are limited in traverse. In most disappearing weapons the usable field of fire is limited to a sector of 170° or less.

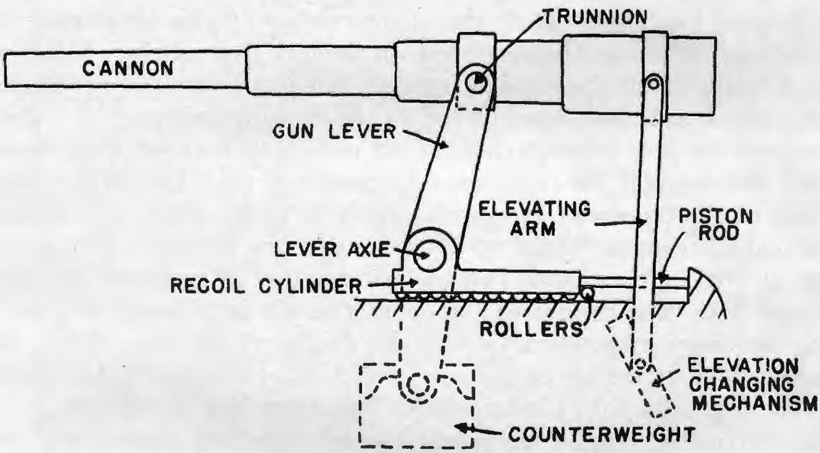


FIGURE 64.—Simplified disappearing carriage.

b. As illustrated in figure 63, the disappearing carriage appears to be covered with confusing gadgets. It becomes relatively simple in principle, however, when it is realized that the carriage utilizes the hydraulic recoil brake to control recoil, gravity (lead counterweight) to accomplish counterrecoil, and dashpot buffers to control counterrecoil. The need for most of the extra equipment comes from the fact that the gun and the operating parts of its carriage are so widely separated when in battery.

c. Reduced to its simplest terms, the disappearing carriage is as shown in figure 64. When fired, the gun recoils to the rear and down, pivoting about the lever axle and forcing the recoil cylinder (the piston rod is fixed) to the rear. When fully recoiled the gun lever is approximately horizontal and the counterweight raised. (See fig. 65.) At this point the whole recoiling system is caught and held by a trigger arrangement, as otherwise the counterweight would fall, raising the gun to firing position. After loading, the carriage is tripped (trigger released), the counterweight functions, and the gun is returned to firing position.

d. Detailed description.—(1) As shown in figure 65, the gun is in firing position. The broken outline shows the gun in loading position. A base ring (fig. 55) surrounds a well, constructed in the concrete of the emplacement. A racer rests on live rollers on the base ring and is pintled on a cylinder formed by a wall of the base ring. The racer (fig. 65) supports the superstructure of the carriage and carries a working platform of steel plates (D). The forward ends of the side frames (V) are designed to form vertical guideways for the crosshead (r) from which the counterweight (t) is suspended by rods (s). The top carriage rests on flanged live rollers which roll on the rails of the chassis side frames. The gun levers (h) have axles (K) which are trunnioned on top of the recoil cylinders (m). They support the gun between their upper ends, and between their lower ends they support the counterweight crosshead (r). Cut on the front faces of the crosshead are ratchet teeth in which pawls (p) engage to hold the counterweight up after the gun has recoiled. The pawls are pivoted on the chassis (V) and are released by means of tripping levers (q). The weight of the counterweight is adjusted to give it the necessary preponderance over the weight of the gun. When the gun is fired it recoils to the rear and down. The gun levers recoil to the rear with the cylinders (m). The lower end of the gun levers rise vertically, being constrained by the crosshead guides, and the upper ends therefore move in an elliptical curve coming to rest as shown in the outlined position (c). The gun being loaded and ready to fire, the pawls are tripped and the counterweight drops, carrying the gun back to the firing position. Figure 63 is another illustration of a typical disappearing gun and mount.

(2) The emplacement consists of a massive block of concrete having a parapet built on the arc of a circle whose center is the center of the gun position. The sides of the emplacement are termed traverses. It is open to the rear. The powder and projectile magazines are usually under the gun emplacements.

e. Horizontal recoil mechanism.—In figure 66 can be seen a detailed drawing of the recoil cylinders.

(1) As the gun recoils, the cylinders are pulled to the right. Part of the oil is forced through orifices in the piston in the conventional manner, braking the recoil in the process. Part of the oil goes through pipes (a) and (b), valves (v_1) and (v_2), and pipe (d),

assisting in the braking action. Pipe (a) equalizes the pressure between the two recoil cylinders.

(2) The action of the counterrecoil buffer is controlled by valve (v_2). As the buffer lug (n) enters the right end of the recoil cylin-

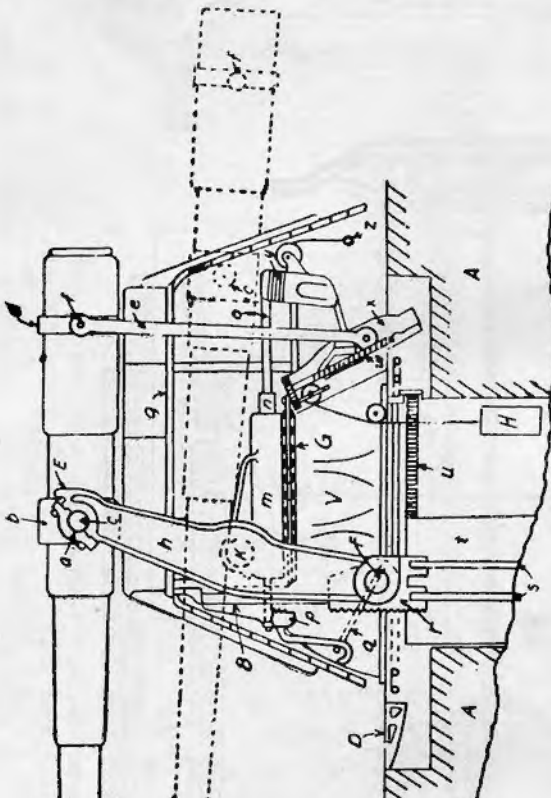


FIGURE 65.—Disappearing carriage.

a. Cap square.
b. Trunnion band.
c. Gun trunnion.
d. Elevating band.
e. Elevating arm.
f. Elevating arm trunnion.
g. Gunners platform.
h. Gun lever.
m. Recoil cylinder.
n. Stuffing box.
o. Piston rod.
p. Tripping pawl.
q. Tripping lever.
r. Crosshead.
s. Counterweight rods.
t. Counterweight.
u. Traversing rack.
w. Elevating screw.
x. Elevating slide.
y. Buffer (Balata plates).
z. Retracting cable.
A. Concrete emplacement.
B. Crosshead guide.
D. Floor plates.
E. Retracting lug (hook).
F. Crosshead pin.
G. Recoil rollers.
H. Counterbalance weight.
K. Gun lever axle.
V. Side frame (chassis).

der at the completion of counterrecoil, oil is forced through pipe **(f)** and valve (v_2) to the left end of the cylinder, acting as an adjustable buffer.

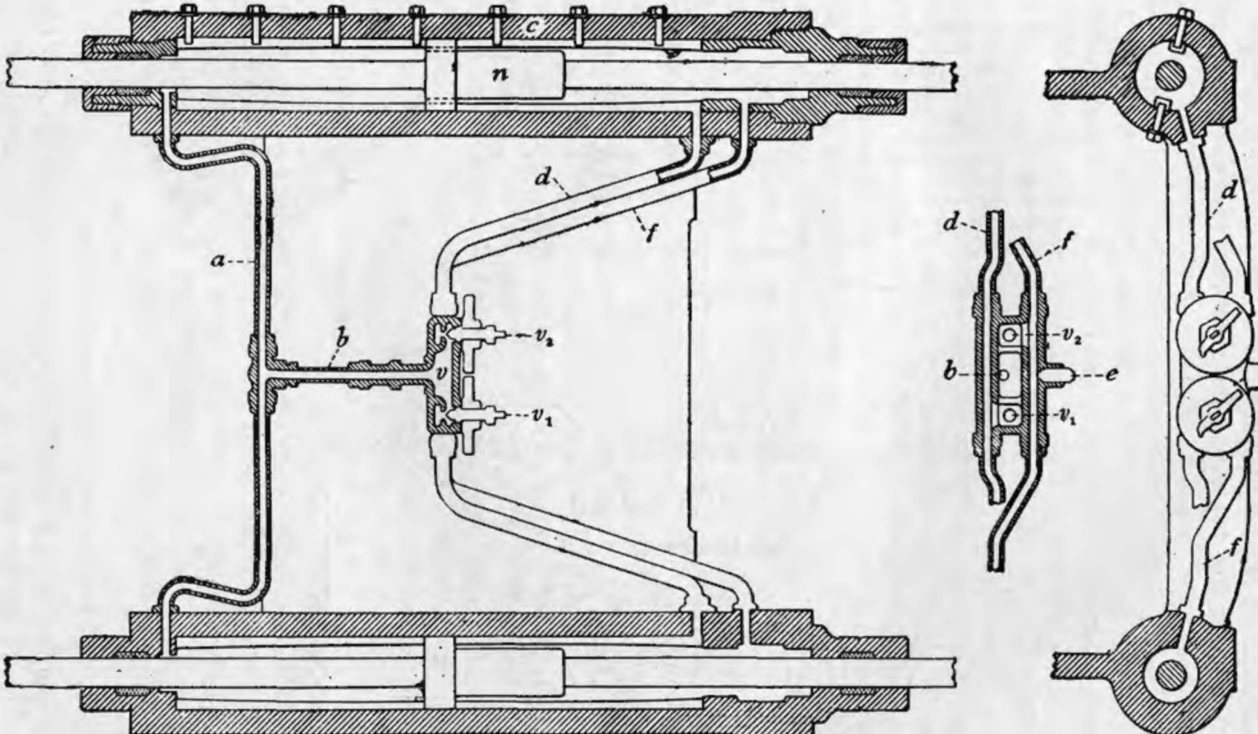


FIGURE 66.—Horizontal recoil cylinders showing valve systems.

a. Equalizer pipe.
b. Intermediate pipe.
c. Cylinder walls.
d. Recoil pipe.
f. Counterrecoil pipe.
n. Buffer lug.
v. Valve.
v_1. Recoil valve.
v_2. Counterrecoil (buffer) valve.

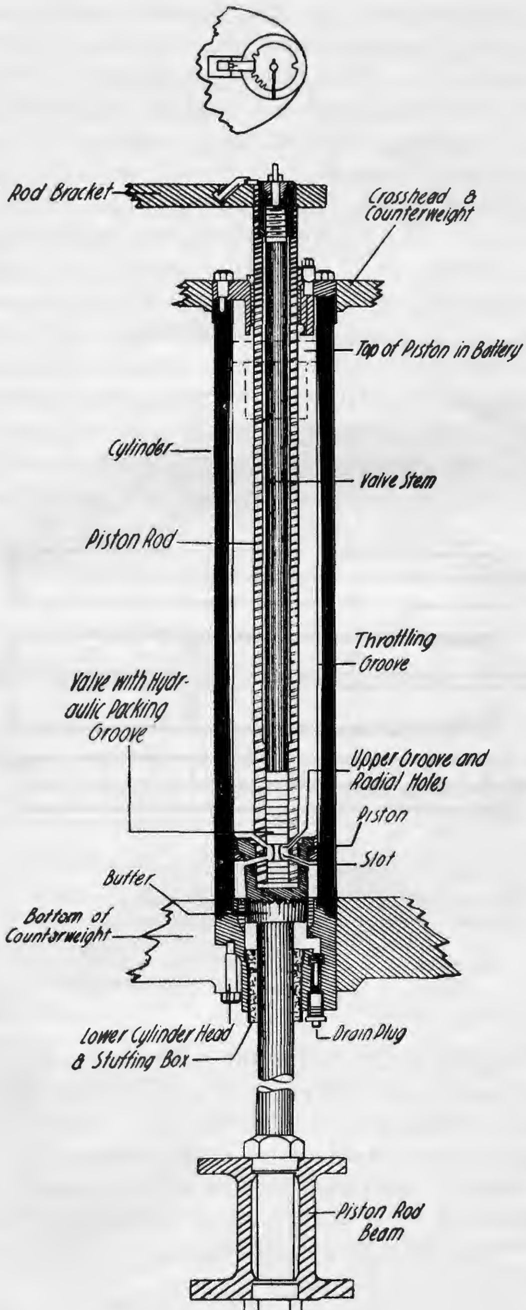


FIGURE 67.—Vertical recoil cylinder.

(3) It is necessary for the disappearing carriage to recoil to the same height (for loading) regardless of powder or air temperature, powder pressure, etc. It is also imperative that the gun go fully into battery on counterrecoil. A method of controlling recoil and counterrecoil has been incorporated to achieve these desired ends. Referring again to figure 66, valves (v_1) and (v_2) both pass oil on recoil, and therefore recoil can be controlled by adjusting them. Valve (v_2) passes oil on counterrecoil, so counterrecoil may be controlled by adjusting (v_2). In actual practice, (v_2) is adjusted for proper counterrecoil, and then valve (v_1) for the desired recoil.

f. Vertical recoil mechanism.—(1) Some of the later carriages employ one vertical recoil cylinder mounted in the center of the counterweight instead of the conventional two horizontal cylinders. The cylinder is constructed as shown in figure 67 and is fastened to the crosshead and counterweight at its upper end. The piston rod

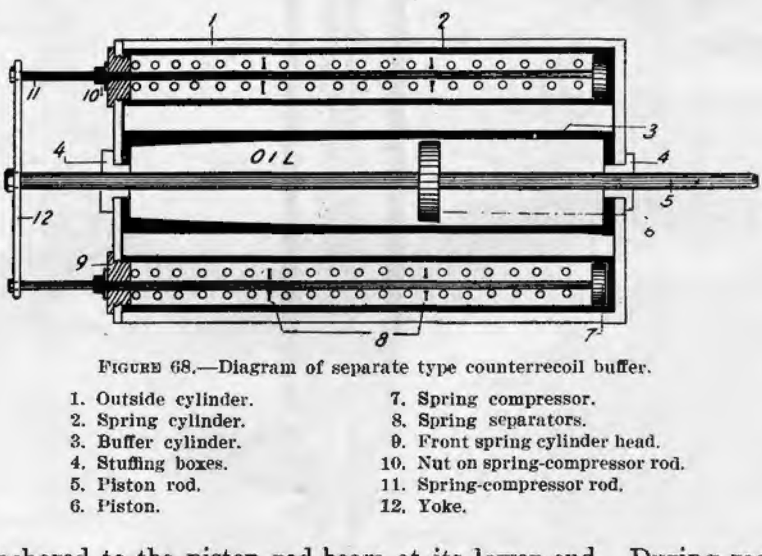


FIGURE 68.—Diagram of separate type counterrecoil buffer.

1. Outside cylinder.
2. Spring cylinder.
3. Buffer cylinder.
4. Stuffing boxes.
5. Piston rod.
6. Piston.
7. Spring compressor.
8. Spring separators.
9. Front spring cylinder head.
10. Nut on spring-compressor rod.
11. Spring-compressor rod.
12. Yoke.

is anchored to the piston rod beam at its lower end. During recoil the cylinder moves and the rod and piston stand fast. Part of the oil is forced through conventional orifices in the piston. The rest flows through one adjustable valve at the lower end of the piston rod. Length of recoil is controlled by this valve located in the piston rod which is operated by a shaft extending down through the hollow upper rod. By adjusting a handle on the upper end of the rod, it is possible to control the length of recoil.

(2) Two specially designed counterrecoil buffers (fig. 68) mounted at the forward end of the side frames are furnished. As the gun

goes into battery, the gun levers strike the piston rods (5). The oil in the cylinder (3) brakes the motion of the rod in the usual manner—brings the gun to a gradual stop in battery. At the same time the springs in the spring cylinders are compressed. When the gun recoils on the succeeding shot these springs force the piston rod out into position for another action. These buffers are miniature recoil-counterrecoil mechanisms with a hydraulic brake and spring return and an adjustable valve.

(3) There is a definite relation between the settings of the recoil valve and the buffer valves. With a higher setting of the recoil valve, counterrecoil will be more free, and consequently the buffer valve setting should be lower.

g. Control mechanisms.—(1) The elevating mechanism is controlled by a system of gears which raises or lowers the breech of the cannon through the elevating arm, as shown in figures 63 and 64. Mounted on one of the side frames are the elevating handwheel and the range disk. Range is set on the cannon by moving the elevating handwheel until the disk indicates the desired range. See paragraph 28*c* for a more detailed description.

A protective device such as has been described in paragraph 28*c* (4) prevents the shock of recoil injuring the gears of the elevating system.

(2) Pointing in direction on a disappearing carriage may be accomplished in two ways. In case II firing, a gun pointer, standing on the gunner's platform (fig. 63), keeps the gun pointed in the proper direction by sighting on the target through a telescopic sight (fig. 69). The proper angle between the sight and the axis of the bore (deflection) is set off on a scale on the sight. For case III firing the gun is set at a predetermined azimuth by means of a graduated azimuth circle and index.

(3) The traversing system is of the usual type described in paragraph 28*b*. However, it may be controlled either from the traversing handwheel mounted on the side frame of the carriage or from the gunners' platform. A train of gears and shafts leads from these two control positions to a spur gear meshing with a circular rack mounted on the base ring.

h. Azimuth circles.—Disappearing carriages are provided with azimuth circles for case III pointing. The circles are graduated in whole degrees and are attached to the stationary base ring.

i. Loading mechanisms.—The loading mechanisms for those major caliber weapons employing hand loading, are very similar.

(1) The projectile is handled on an ammunition loading truck (fig. 70). The shell (a) has been rolled onto the truck from a loading

table built into the emplacement. In loading the gun, the truck is run up against the face of the breech (s) where it is brought to a gradual stop by the buffer ram (h). It is held against the breech by

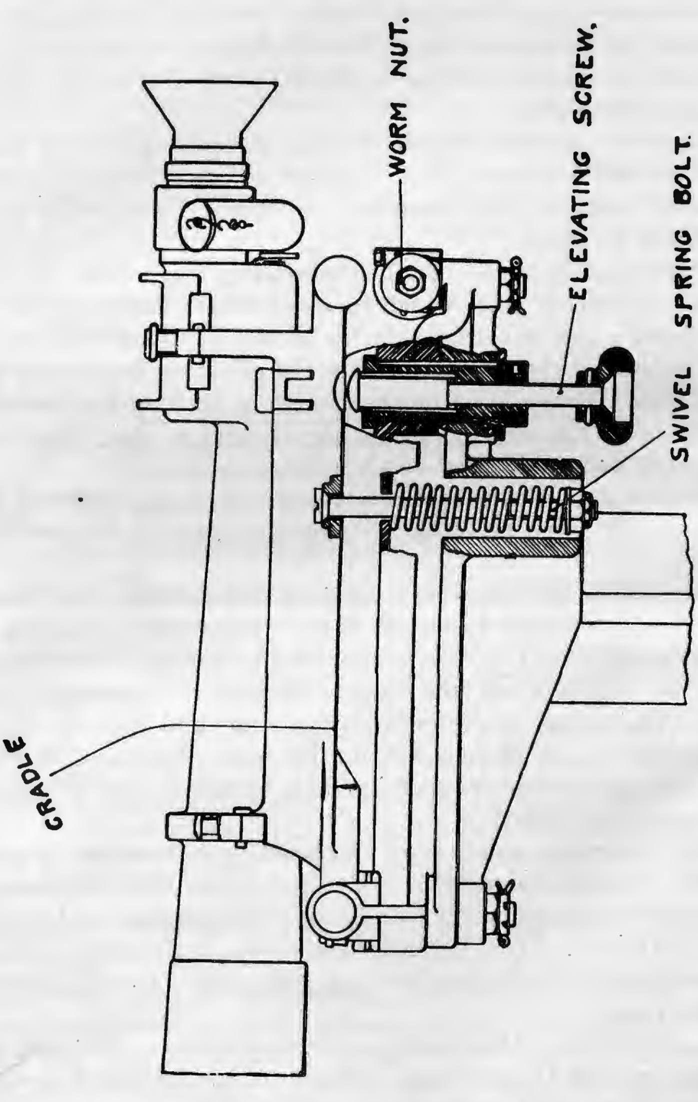


FIGURE 69.—Telescopic sight, M1912, and cradle.

brakes actuated by the brake lever (n). A rammer is placed against the base of the projectile, and the shell rammed by members of the crew.

(2) Powder is brought out of the magazine by hand (mortars) or on a tray (guns). The powder is either pushed directly off the tray into the powder chamber, rolled from the tray to the ammunition truck and pushed home from the truck, or placed on the truck by hand and pushed into the chamber from the truck.

This method of loading is used on all disappearing carriages, all fixed mortar carriages, and on the 12-inch barbette carriage, M1917.

31. Barbette carriages.—*a. General.*—Barbette carriages are used for all fixed seacoast guns of recent design. Their advantages are—

(1) All-round fire.
(2) Elevations up to 65°.
(3) High speed of operation.
(4) Simplicity and ruggedness of carriage.

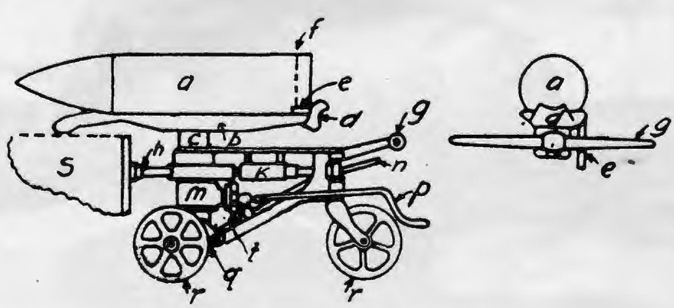


FIGURE 70.—Ammunition loading truck.

a. Projectile.
b. Shot tray.
c. Column.
d. Shot back stop.
e. Shell back stop.
f. Base of shell projectile.
g. Truck handles.
h. Buffer ram.
k. Ram cylinder.
m. Worm gearing.
n. Brake lever.
p. Elevating crank.
q. Brake.
r. Wheels.
s. Breech of gun.
t. Gearing.

In all modern barbette installations the gun is mounted in a cradle (see fig. 11). Recoil and counterrecoil (recuperator) systems are mounted parallel to the gun, so that recoil takes place parallel to the axis of the bore regardless of the firing elevation. The base ring, rollers, racer, and azimuth circle resemble closely those described under traversing mechanisms (par. 28*b*) so that no further discussion of these features is deemed necessary.

b. Pedestal types.—One particular type of barbette carriage used with 3-inch and 6-inch guns is called the pedestal type. The general characteristics of this type of mount are shown in figure 56. A conical pedestal is bolted to the concrete platform. A pivot yoke, free to revolve, is seated in the pedestal. Upward extending arms of the pivot yoke form seats for the trunnions of the cradle. The gun is supported and slides in recoil in the cradle. The weight of all the revolving parts is supported by roller bearings on a central base within the pedestal. The recoil and recuperator cylinder is located in the lower rear portion of the cradle. A conventional recoil brake, spring recuperators, and dashpot counterrecoil buffers are used on this carriage. Bolted to arms of the pivot yoke on each side are brackets to which are attached gunners' platforms which move with the gun in azimuth. These mounts are furnished with a telescopic sight. (See fig. 69.) An illustration of a 6-inch seacoast gun on this mount is shown in figure 71.

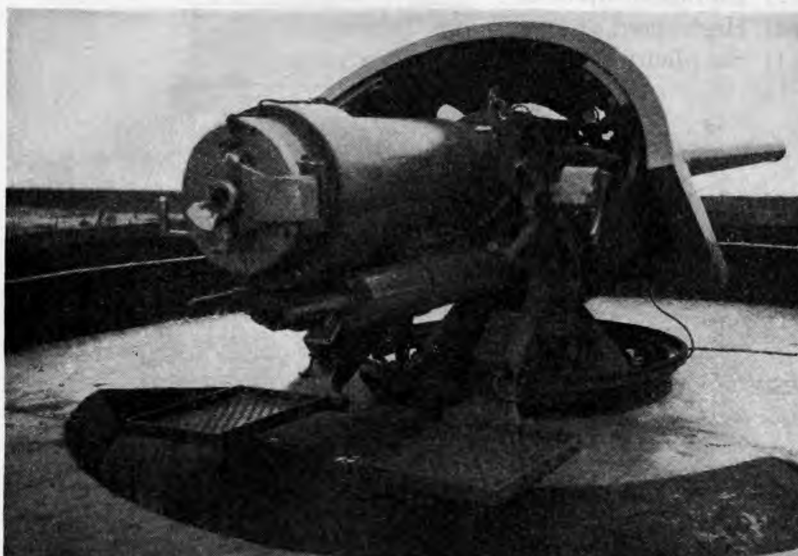


FIGURE 71.—6-inch barbette carriage, pedestal type.

c. M1917.—This carriage (fig. 72) was designed as a long-range mount for 12-inch guns, M1895MI, already in existence.

(1) The recoil system (fig. 73) employs a single conventional recoil cylinder with a plug type buffer allowing a recoil of 30 inches. The flow of oil past the piston is regulated by throttling grooves of constant width and varying depth.

(2) The counterrecoil system incorporates four of the spring cylinders shown in figure 74. These furnish the force necessary to return the gun to firing position regardless of elevation. The movement of the gun into battery is eased by the action of the plug type buffer mentioned above.

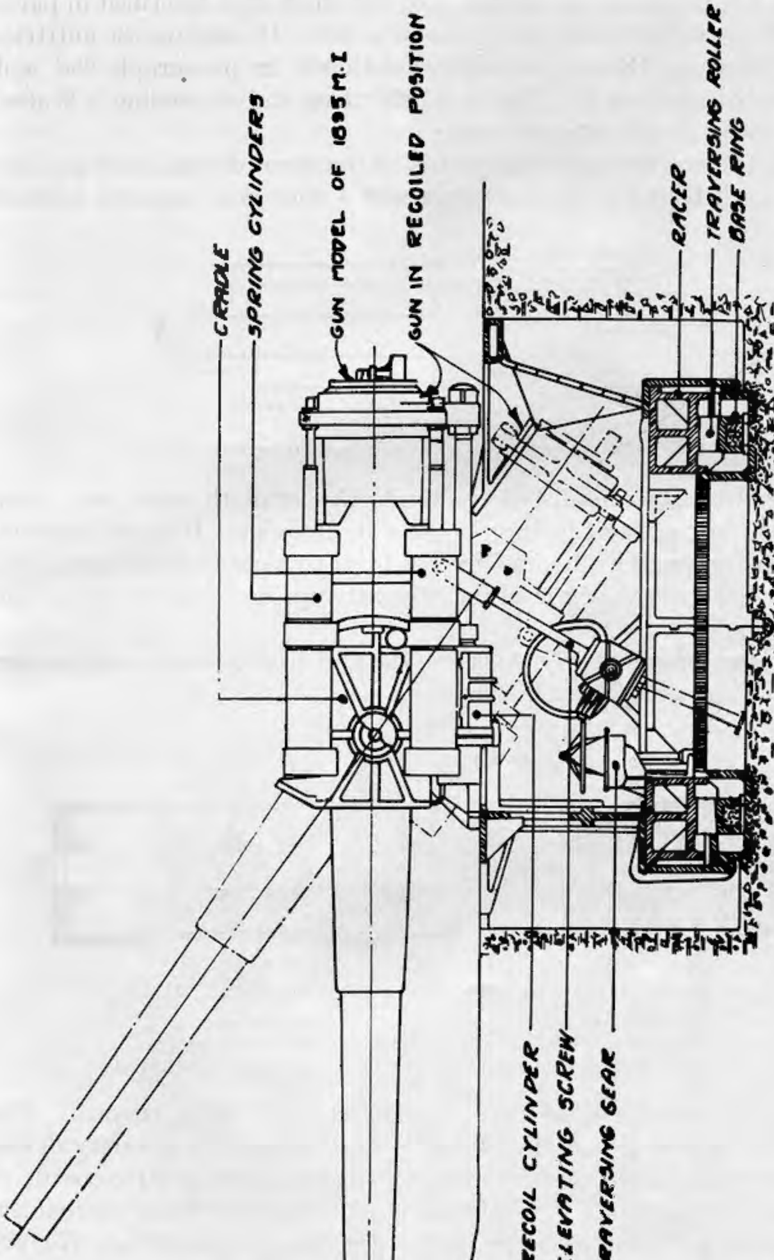


FIGURE 72.—12-inch barbette carriage, M1917.

(3) The elevating mechanism is of the screw type described in paragraph 28*c* and permits elevations up to 35°. It employs the antifriction elevating device previously mentioned in paragraph 28*d* and illustrated in figure 60. For rapid elevating and depressing a Waterbury speed gear is incorporated.

(4) The traversing mechanism is of the usual design, having a circular rack bolted to the base ring and a spur gear meshing with it.

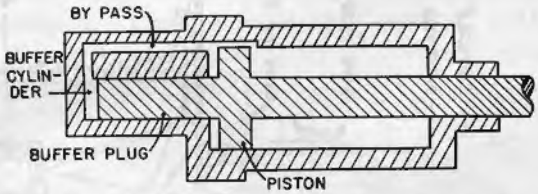


FIGURE 73.—Recoil cylinder, 12-inch barbette carriage M1917.

Traversing is accomplished by hand. An azimuth circle and index furnish the means of laying the piece in direction. It is not expected that the gun will be fired using case II so no sight is furnished.

(5) The breechblock is of the Stockett type described in paragraph 13*f*.

(6) The ammunition is served to the gun on shot trucks and powder trays in the usual manner.

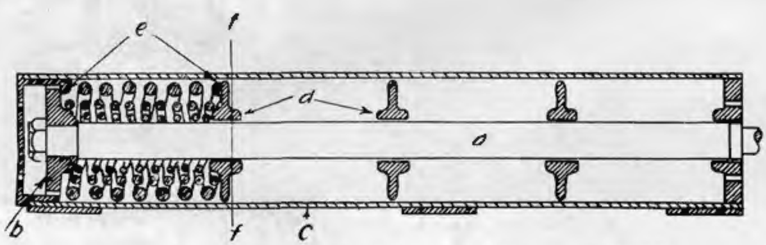


FIGURE 74.—Spring cylinder, 12-inch barbette mount, M1917.

a. Recuperator piston rod.
b. Recuperator piston.
c. Recuperator cylinder.
d. Spring seats.
e. Set of springs.
f–f. Piston at end of recoil.

(7) The piece may be fired either electrically or by lanyard. The electric method is normal. There is only one electrical safety device incorporated in the design—that which breaks the electric circuit at the breech until the breechblock is closed. The firing mechanism M1903 is equipped with the device described in paragraph 17*a* (2) which prevents the lanyard functioning until the block is fully closed.

(8) Note particularly that the mount is designed to be employed without parapet protection, that the elevation and azimuth setters

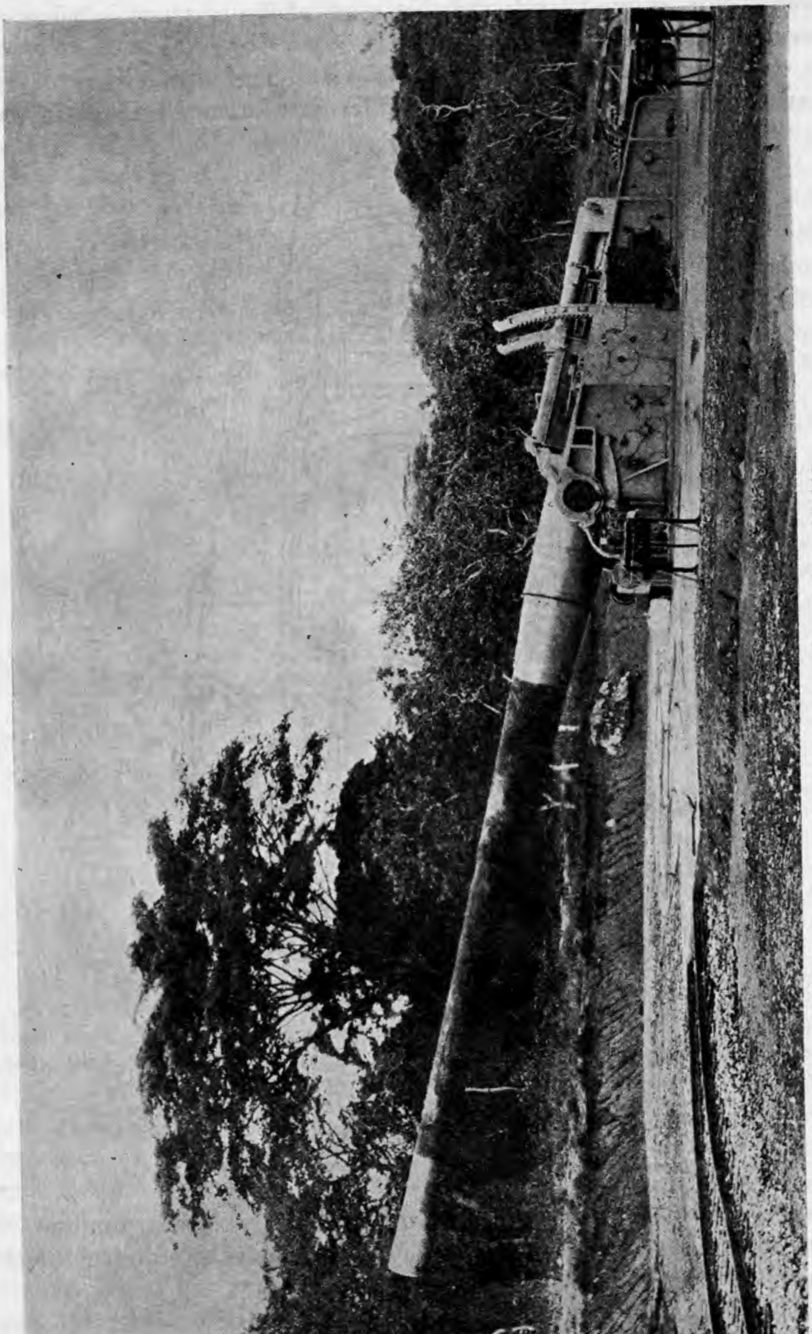


FIGURE 75.—16-inch barbette carriage, M1919.

work below ground level, and that most of the carriage is below the level of the floor plate.

d. 16-inch, M1919 and M1919M1.—(1) The two models of this carriage are almost identical and differ only in small details in their

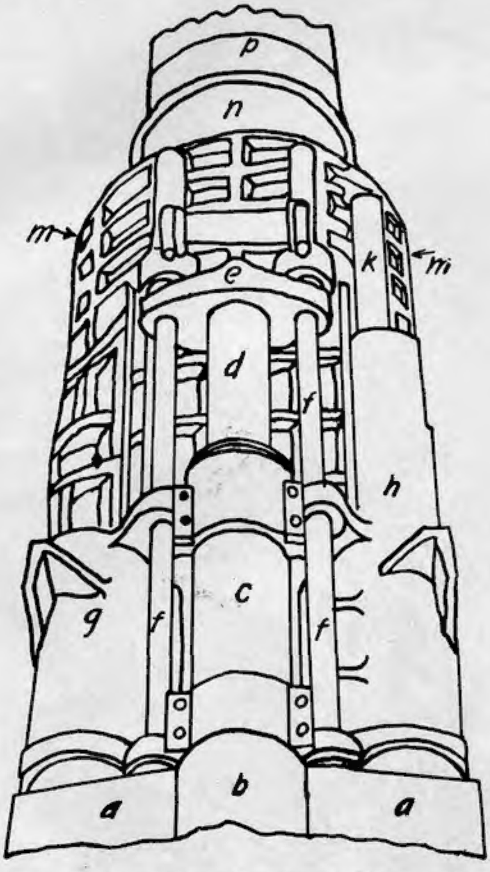


FIGURE 76.—Top view of recoil and recuperator systems, 16-inch barbette carriage, M1919.

a. Recoil band.
b. Recuperator air chamber.
c. Recuperator oil cylinder.
d. Recuperator hollow piston.
e. Yoke.
f. Connecting rods.
g. Plain recoil cylinder.
h. Buffer recoil cylinder.
k. Recoil piston extension.
m. Cradle.
n. Dust guard.
p. Gun.

design. As may be seen from figure 75 the cradle is trunnioned in two side frames which are in turn bolted to the top surface of the racer.

(2) The cradle (fig. 76) is a ribbed casting of considerable complexity. On the top (and bottom) of the cradle are mounted the

recoil cylinders, both the long type (h) and the short (g). The recuperator is of the two-cylinder pneumatic type and is mounted with one cylinder over and one under the gun.

(3) A schematic diagram of the recoil and counterrecoil system showing the working relation of each of the parts is shown in figure 77.

(*a*) The short cylinder is the conventional hydraulic brake. The long cylinder combines both the recoil and buffer functions, the left half of the cylinder being the recoil section and the right half the counterrecoil. In effect, the long cylinder limits the velocity of counterrecoil by the same means that the ordinary recoil cylinder employs to limit the velocity of recoil. Small counterrecoil throttling grooves are cut in the walls of the cylinder—grooves too small to

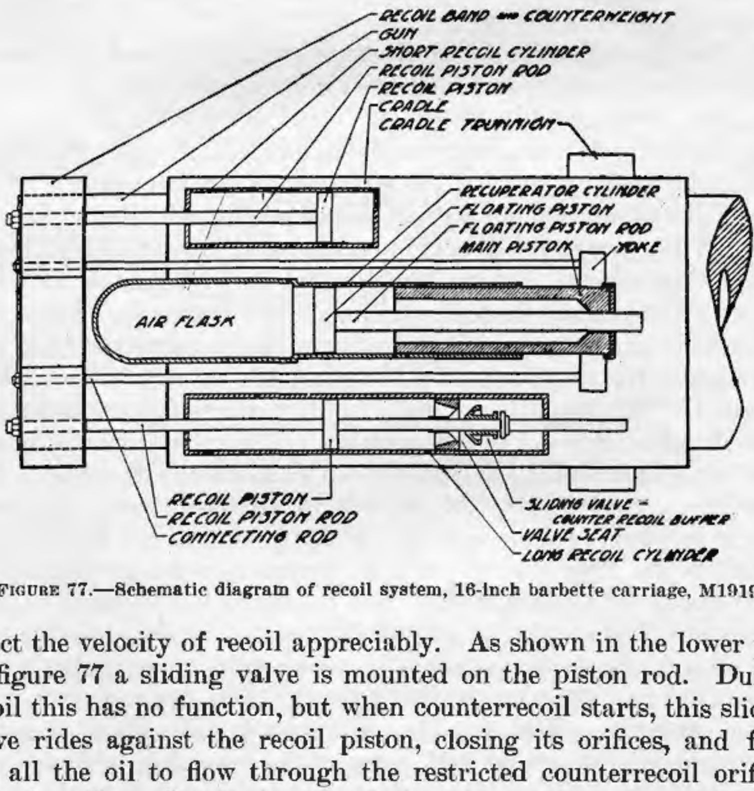


FIGURE 77.—Schematic diagram of recoil system, 16-inch barbette carriage, M1919.

affect the velocity of recoil appreciably. As shown in the lower part of figure 77 a sliding valve is mounted on the piston rod. During recoil this has no function, but when counterrecoil starts, this sliding valve rides against the recoil piston, closing its orifices, and forcing all the oil to flow through the restricted counterrecoil orifices. This throttling effect limits the velocity of counterrecoil regardless of the angle of elevation and insures an even, smooth return to firing position.

(*b*) Power to return the heavy gun to firing position regardless of elevation is furnished by the two pneumatic recuperator cylinders mounted on the cradle. These cylinders are of conventional design (c and d, fig. 76) and have been previously described in paragraph 23*c*.

(4) The elevating mechanism is that previously described in paragraph 28*c*. A hand brake of automotive type is employed to hold the cannon at the exact elevation desired. The mechanism employs an antifriction elevating device (see par. 28*d*) to decrease elevating friction, and an electric elevating system operating through a Waterbury speed gear.

(5) The traversing mechanism is the one illustrated in figure 55 and described in paragraph 28*b*. Electric traversing through a Waterbury gear is employed. An azimuth circle and index furnish means of setting predetermined azimuths for case III firing. No sight is supplied as case II is not used.

(6) The breechblock is the carrier supported drop block illustrated in figure 21 and is of the type described in paragraph 13*g*. It is hand opened and pneumatically closed.

(7) The firing device used is the firing lock, Mk. I, (par. 18). The gun may be fired by lanyard (percussion) or by electricity.

(8) The ammunition supply is handled almost entirely by power. Figure 78 illustrates the general arrangement. A circular railroad track is built around the gun emplacement and by suitable switches connects with the main track line leading to the magazines. Projectile and powder cars are provided to transport the ammunition from the magazines to the emplacement. The projectile car (p) is secured to the mount by dropping its side rails (n) into recesses in the revolving projectile table (m) and in this position will revolve with the mount while being unloaded. The powder car (not shown) coupled to the projectile car may be kept in position to deliver powder, but ordinarily it is taken away as soon as a complete charge has been placed on the powder tray (f). This is to obviate the danger of having several charges of powder in such close proximity to the breech in case of accident. The projectiles are rolled from the car over the side rail bars (n) onto the revolving table (m) which holds three projectiles at a time. The car is then uncoupled from the table, the table revolved, and the projectiles rolled onto the parking table (e). Hand-operated lock stops are provided on both sides of the revolving table to hold the projectiles in place and also to lock the revolving table to the parking table during transfer of projectiles. Table (e) is slightly inclined, and the projectiles roll until stopped in position by the hand-operated feed stops indicated by the small squares, the first projectile lying between these stops. In this manner, one projectile at a time is fed

onto the rammer tray as shown at (d); the spanner tray (b) is then lowered into position in the open breech of the gun. The rammer operator at (h) maneuvers the rammer (k) by electrical power and pushes the projectile into the gun (a). The two forward sections of powder (g) are rolled over onto the loading tray, as soon as the rammer has been withdrawn, and rammed, followed in the same manner by the remaining two powder sections. The spanner tray (b) is then raised and thrown back clear and the breech is closed ready for firing. It is readily seen that it is possible to have ten projectiles at the gun at one time, and by coupling three powder charge cars to the projectile car the ten complete rounds could be kept at hand. The power rammer

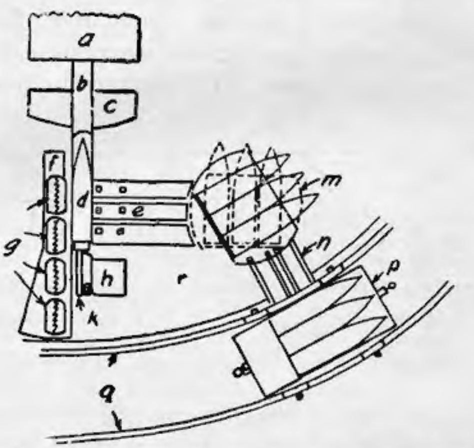


FIGURE 78.—Loading mechanism, 16-inch barbette carriage.

a. Breech of gun.
b. Spanner tray (folds back).
c. Breech operating platform.
d. Projectile on rammer tray.
e. Parking table, projectiles.
f. Powder tray.
g. Powder charge on receiving table.
h. Operator platform.
k. Power rammer.
m. Revolving projectile table.
n. Lock bars (side rails of car).
p. Projectile car.
q. Circular track about gun platform.
r. Platform on carriage racer.

comprises essentially a cast steel frame or housing and a flexible forged steel chain, the chain being driven through sprockets and gearing by a speed gear and motor. In event of power failure, hand cranks can be used. In considering this loading arrangement, it is well to remember that the projectiles weigh approximately 2,400 pounds and each of the four sections of a powder charge, approximately 215 pounds. Handling such weights by hand truck and rammer would be cumbersome and slow at the best. The gun in question has a loading angle of plus 4°, which means that the projectile in loading must slide up a 4° slope.

(9) The bore is cleared after each round by compressed air which blows all unburned gases, powder bags, and smoke out through the muzzle.

(10) Power for all these accessories is furnished by a gas-electric or Diesel-electric generating set located some distance from the guns. Electric power is used to compress the air for bore clearing and breechblock closing.

(11) With all these power aids the ability of the weapon to fire for long periods is limited only by the ruggedness of the matériel.

32. Mortar carriages.—*a. General.*—(1) Modern warships are protected to a certain degree against the fire of high-powered seacoast weapons using direct fire. The deck armor of warships, however, is thin as compared to the side armor and offers an extremely vulnerable target. Specially designed weapons called mortars are used to attack the deck armor. All mortars in our service are of

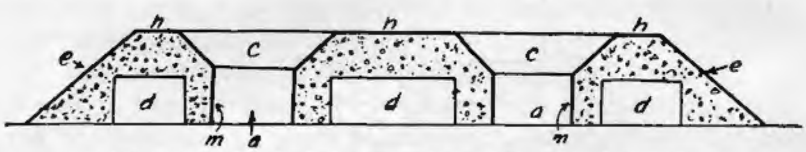


FIGURE 79.—Horizontal cross-section of mortar emplacement.

a. Mortar pits.
c. Apron.
d. Magazines.
e. Exterior slope.
h. Traverse.
m. Interior wall.

12-inch caliber and due to the low muzzle velocities used have a greater accuracy life than guns. They will be found emplaced in pits with two or four mortars in each pit as shown in figure 79. From the nature of the emplacement, fixed mortars are better protected from gunfire, bombing, or aerial machine gunning than any other type of artillery mounted in the open. The emplacement for the individual mortar does not differ from gun emplacements already discussed except in dimensions. It is simply a pit in the concrete with a shoulder on the pit edge to receive the base ring.

(2) The mortars themselves differ in appearance and construction. The oldest, the M1890, is of built-up construction and is 10 calibers long. The newest, the M1912, is of wire-wrapped construction and is 15 calibers long. The M1908 is a compromise between the two, being wire-wrapped in construction but 10 calibers long. The greater length of the M1912 is reflected in an increase of muzzle velocity to 1,800 feet per second, as compared with the 1,500 feet per second of the 10 caliber mortars. This higher muzzle velocity in-

creases the maximum range of the M1912 mortar by some 4,000 yards.

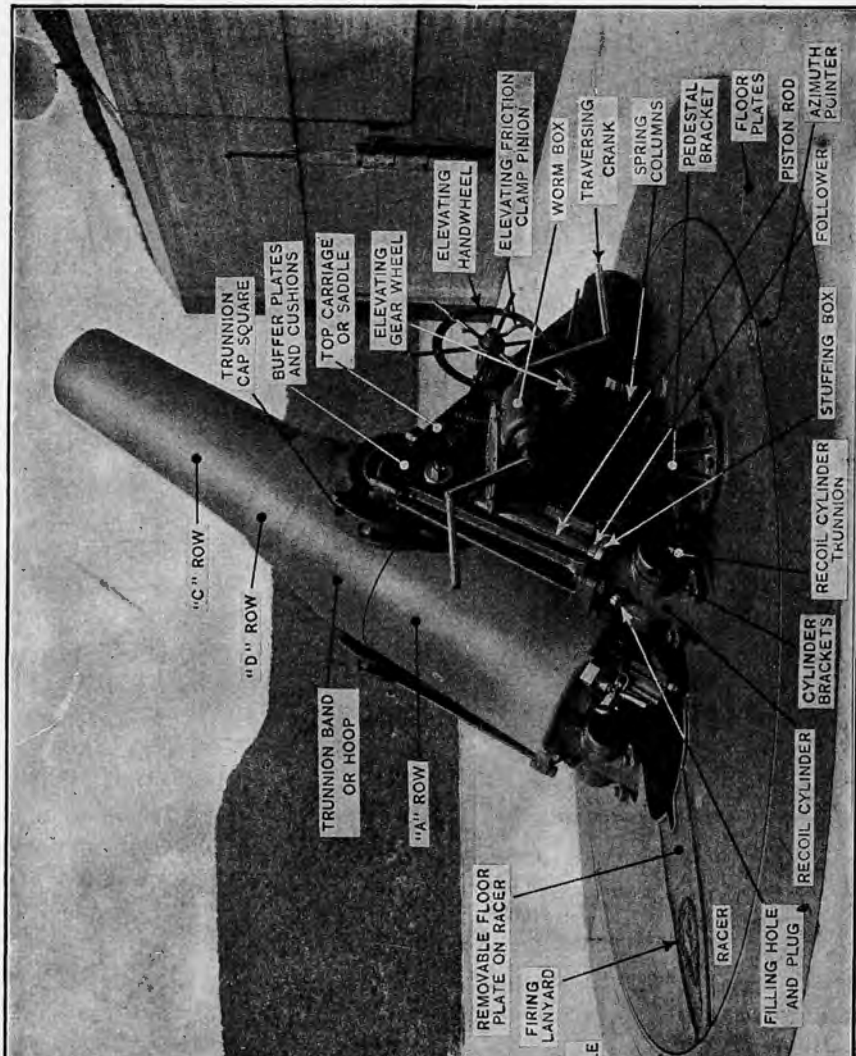


FIGURE 80.—12-inch mortar, M1890MI, mounted on carriage M1896.

(3) There are two general types of carriages used with fixed mortars at the present time—the M1896MI, MII, and MIII, and the

M1908. The M1896MIII and the M1908 will be discussed as type carriages.

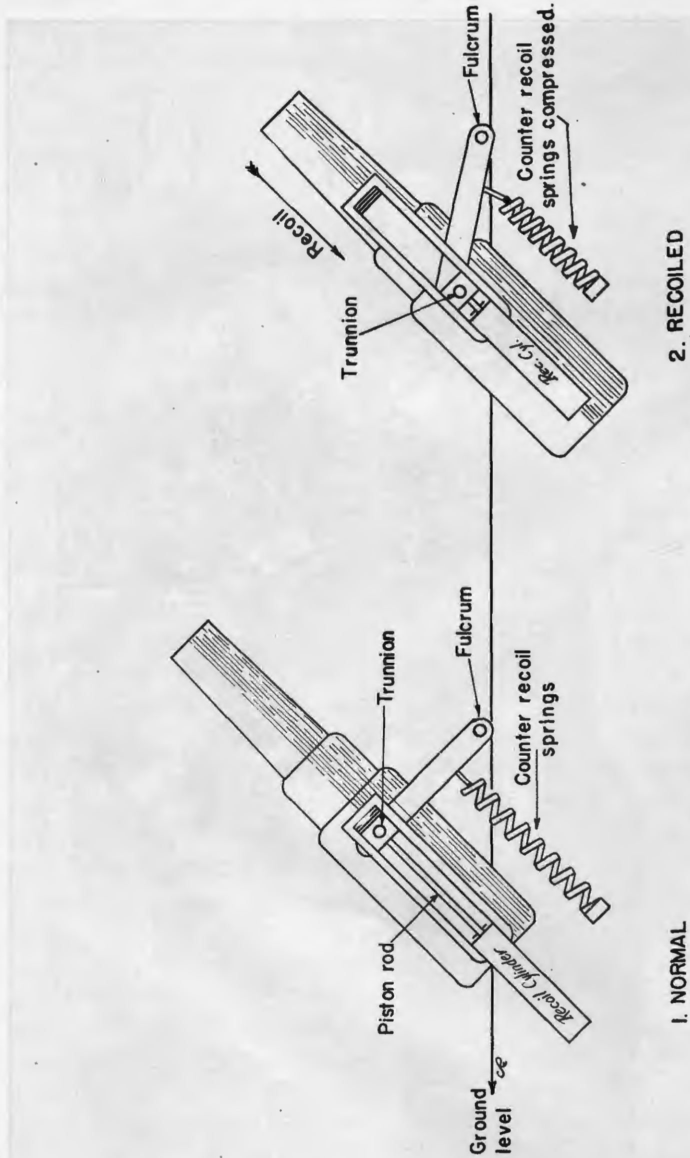


FIGURE 81.—Mortar recoil system, M1896 carriage.

b. M1896MIII.—Because a mortar operates only at elevations between 45° and 65° it has not been necessary to have the recoil cylinders always parallel to the axis of recoil. The carriage has therefore been simplified, no cradle is used, and the splines necessary with cradle recoil have been eliminated.

(1) A simplified sketch of the recoil system is shown in figure 81. As the mortar recoils, the whole system pivots about the fulcrum. The recoil is absorbed mostly by the recoil cylinders and to a lesser extent by the counterrecoil springs. When recoil has been completed the compressed counterrecoil springs bring the trunnions back to their original position. Dashpot type buffers located in the upper end of the recoil cylinders bring the mortar to an easy stop at the end of counterrecoil.

The recoil system consists of two identical recoil cylinders of conventional design pivoted about trunnions mounted on the chassis. At the upper end of these cylinders, guides are mounted. These guides insure that recoil will take place parallel to the piston rods as the guides on a locomotive keep the piston rod lined up with the cylinder. Note that in this system the piston and rod move and the cylinder is anchored.

The counterrecoil system comprises several spring columns to supply the force necessary to return the cannon to firing position, and two dashpot counterrecoil buffers to cushion the last movement of counterrecoil.

(2) The elevating mechanism consists of two elevating handwheels operating through a train of spur gears and an elevation rack to elevate and depress the piece. No antifriction elevating device is provided. Elevation (rather than range) is set in degrees and minutes on a quadrant fixed to the left trunnion. A friction clutch prevents injury to the elevating gears when the piece is fired.

(3) The traversing mechanism is of conventional design employing the usual base ring—conical rollers—racer assembly. A circular rack is bolted to the base ring, and a spur gear meshing with this rack traverses the carriage.

An azimuth circle and index enable the mortar to be laid at a predetermined azimuth as all firing must be by case III.

(4) The ammunition is served to the mortar on a shot truck in the manner described in paragraph 30*i*. Mortar powder charges are made up in several different weights corresponding to the different zones of fire. A communication system is necessary between the magazine and plotting room to inform the magazine personnel of the zone in which it is intended to fire.

(5) The piece may be fired by lanyard or electrically, the latter being the preferred method. The firing mechanism, M1903, is em-
devices.
ployed. Each firing system (lanyard or electrical) has two safety

(*a*) The short lanyard is made so short that it cannot be hooked in the firing mechanism until the mortar is elevated 45°, and the firing mechanism has the usual device which prevents the mechanism operating until the breech is fully closed.

(*b*) The electric firing system has a plug and socket arrangement on the left of the mortar, so arranged that the plug cannot be inserted in the socket until the mortar is elevated to 45° or more. On

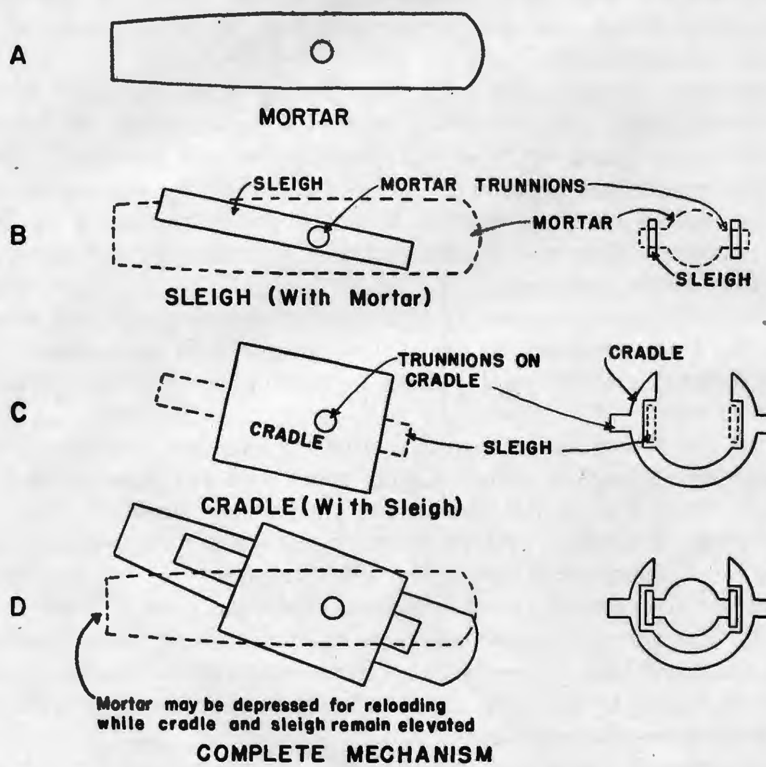


FIGURE 82.—Mortar recoil system, M1908 carriage.

the breech itself an electric contact is provided that is only closed when the breechblock is fully closed.

c. 12-inch mortar carriage, M1908.—(1) *General.*—This carriage departs radically from the design of the M1896 carriage. The basic difference lies in the means of depressing and elevating the mortar after each shot. The carriage is so arranged that the cradle and attached parts may be kept continuously laid in elevation, although the mortar itself is depressed for loading.

(2) The cradle used with this mount is of the same general type as described for barbette cannon in paragraph 10, except that it is open at the top. However, instead of a cannon equipped with splines sliding in the cradle, a sleigh slides in notches in the cradle, as shown in C, figure 82. The mortar itself is trunnioned in the sleigh, as shown in B. Recoil and counterrecoil cylinders act between cradle and sleigh in the conventional manner. By this mounting it is possible to keep sleigh and cradle at the exact firing elevation at all times, allowing the mortar to be depressed on its own trunnions for reloading as shown in D. During recoil the mortar is locked to the sleigh and recoils with it as a unit.

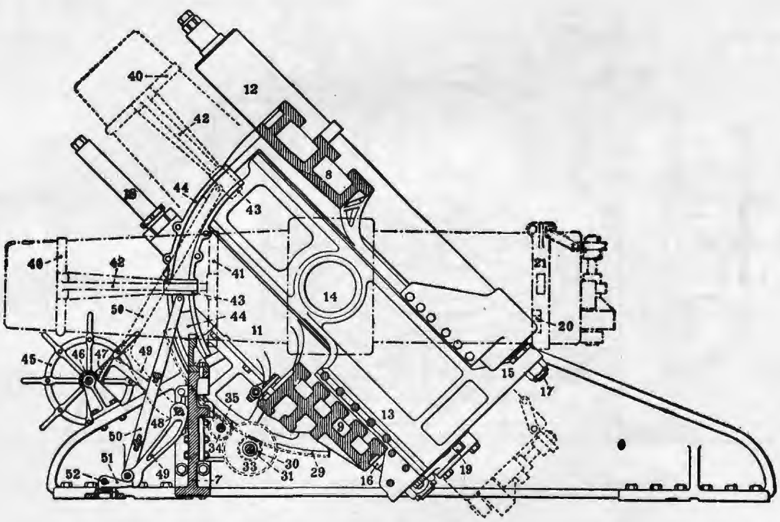


FIGURE 83.—12-inch mortar carriage, M1908 (longitudinal section).

(3) The recoil system consists of two hydraulic recoil cylinders (18, fig. 83) of conventional design mounted below the mortar. The cylinders themselves are mounted on the cradle; the piston rods are connected to lugs (16, fig. 83) at the rear of the sleigh. The length of recoil is 24 inches. When the mortar recoils, the stress is transmitted—

(*a*) Through the mortar trunnions to the sleigh.

(*b*) Through the lugs (16) from the sleigh to the recoil piston rods to the recoil cylinders on the cradle.

(*c*) Through the cradle trunnions from the cradle to the side frames.

(4) The counterrecoil system is composed of two spring cylinders (12, figs. 83 and 84), each containing two columns of spiral springs. These spring cylinders furnish the force necessary to move the mortar back into firing position. Plug type buffers on the forward end of the two recoil cylinders prevent the mortar charging into firing position.

(5) The elevating mechanism is of conventional circular rack and pinion design except that two racks bolted to the cradle underneath the recoil cylinders are used.

(6) The traversing mechanism is of usual design consisting of a circular rack bolted to the base ring and a spur gear meshing with it.

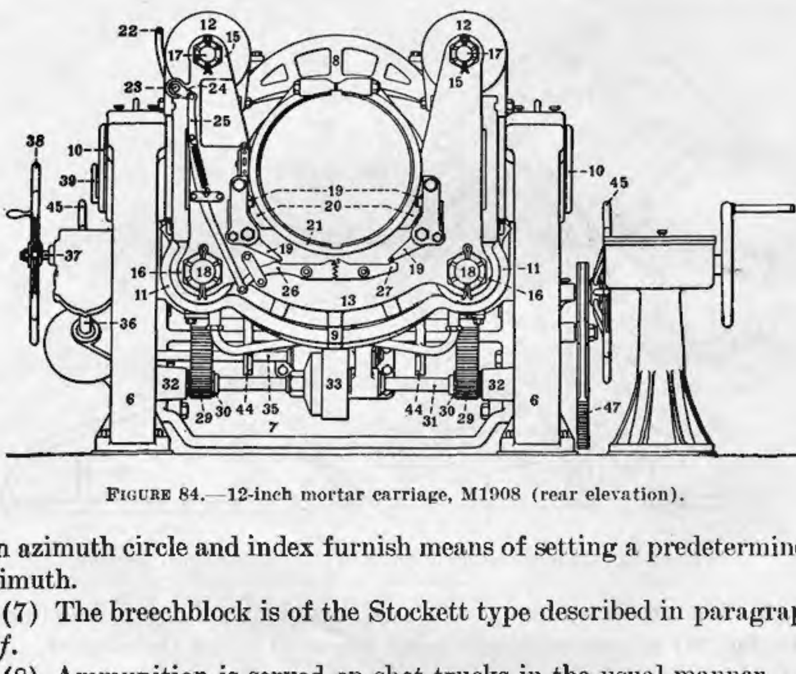


FIGURE 84.—12-inch mortar carriage, M1908 (rear elevation).

An azimuth circle and index furnish means of setting a predetermined azimuth.

(7) The breechblock is of the Stockett type described in paragraph 13*f*.

(8) Ammunition is served on shot trucks in the usual manner.

(9) Firing is by electricity or by lanyard as previously described for the M1896MIII carriage in paragraph 32*b* (5).

33. Turret mounts.—At the mouth of Manila Bay is located the "concrete battleship" mounting major caliber guns in naval turrets (fig. 53). Since this was built there have been no other major caliber turret installations in our service. These turrets are designed according to naval practice, use electric power and compressed air for all operations, and require a minimum crew.

SECTION VII

TRACTOR-DRAWN MOUNTS

34. General.—The 155-mm gun of French design is the only tractor-drawn weapon used by the Coast Artillery Corps. Some of the guns now in use were manufactured in France (M1917) and some in the United States (M1918MI). They differ only in minor particulars. Firing a 95-pound shell to a maximum range of 17,400 yards these guns are a valuable addition to our mobile secondary armament.

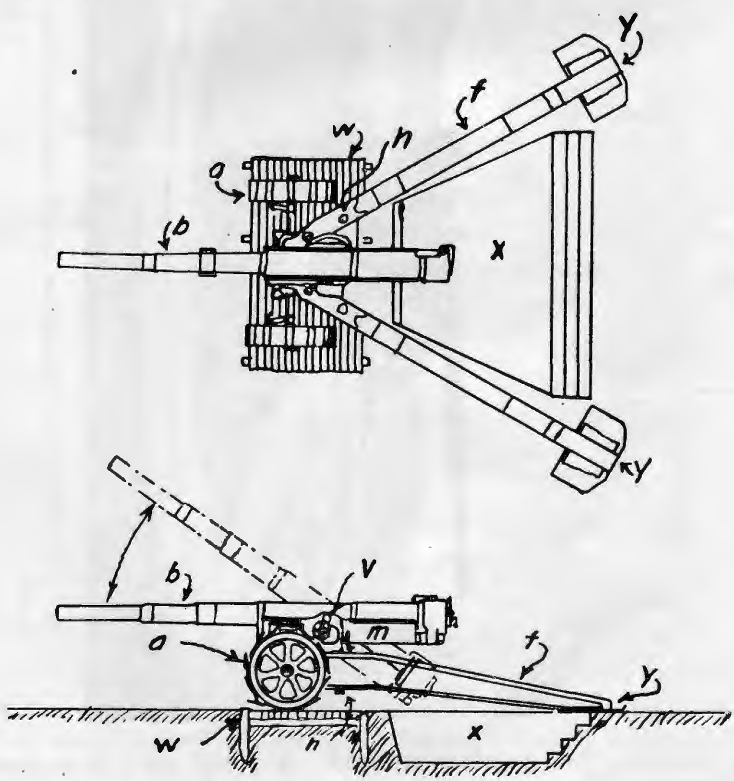


FIGURE 85.—Mount in firing position (top and side elevations).

a. Wheels (shoes attached).
b. Gun (dotted at maximum elevation).
f. Trails.
h. Trail hinge pins.
m. Cradle.
v. Sight mounting.
w. Firing platform.
x. Recoil pit.
y. Spades.

The carriage (fig. 85) is of the split trail type and permits a maximum elevation of 35°. The recoil-recuperator mechanism is of the hydropneumatic variable recoil type described in paragraph 25*b*.

35. Firing and traveling positions.—*a.* In the firing position the trails are spread and the outer ends attached to buried spades (y, fig. 85). Shoes are generally attached to the wheels (a); the

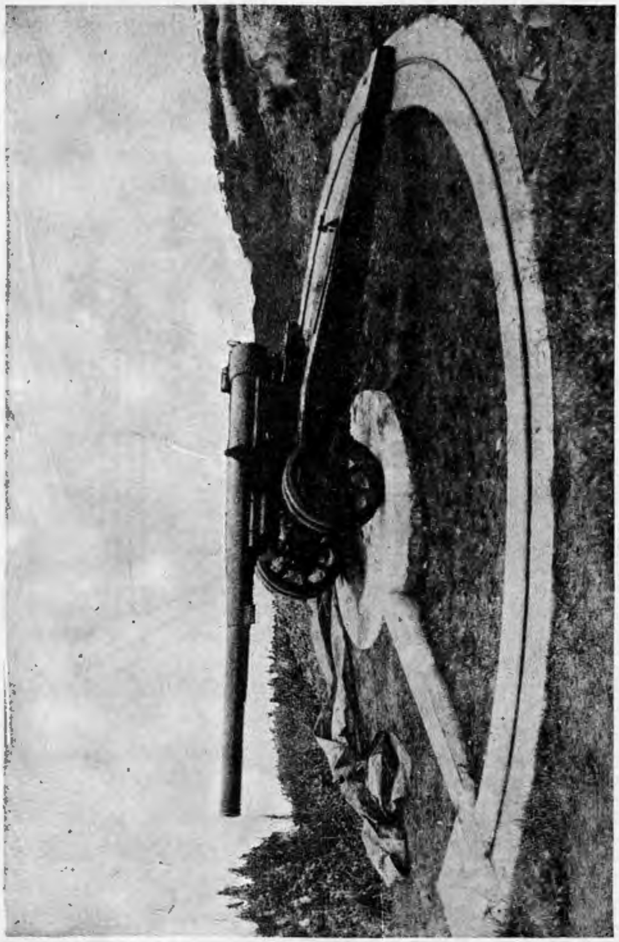


FIGURE 86.—155-mm gun on permanent emplacement.

firing platform (w) is often omitted. A recoil pit (x) is needed for high-angle fire as the carriage is designed for a relatively long recoil. As in most mobile guns the recoil is variable, changing from a maximum of 6 feet at zero elevation to a minimum of 3½ feet at the extreme elevation of 35°. As normally emplaced the gun has a maximum traverse of 60°. This may be increased any desired amount up to all-round fire by the use of the so-called "Panama mount" (fig. 86).

b. When it is desired to take up the traveling position, the trails (f) are released from the spades, brought together, and supported on a two-wheeled bogie or limber (g) (fig. 87). In order to equalize the weight between front and rear wheels, the recuperator and recoil piston rods are disconnected from the cannon proper and the cannon is drawn to the rear by the retracting rack (c, fig. 87). It is also

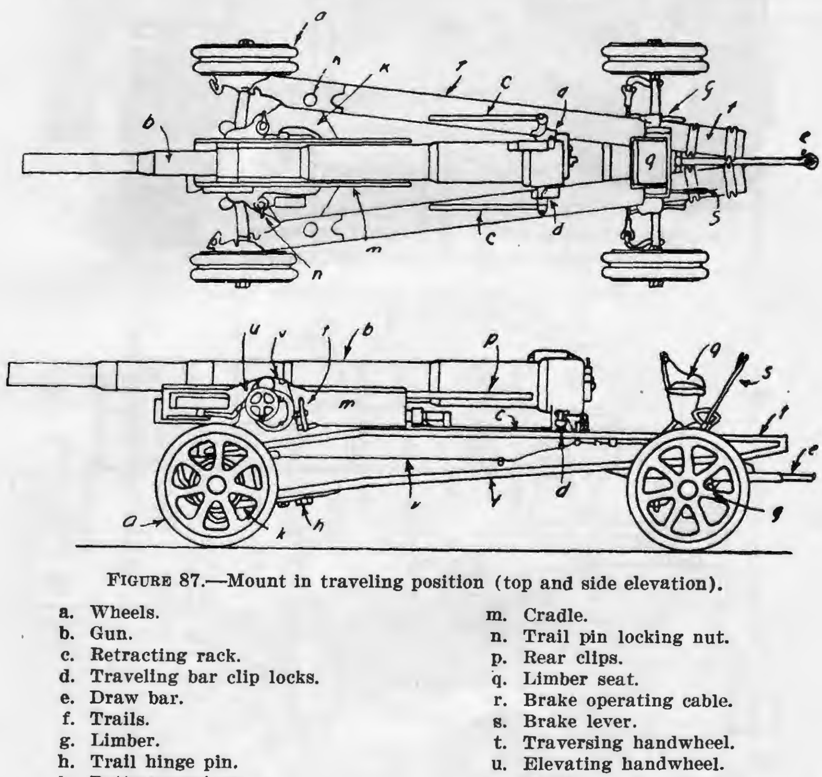


FIGURE 87.—Mount in traveling position (top and side elevation).

a. Wheels.
b. Gun.
c. Retracting rack.
d. Traveling bar clip locks.
e. Draw bar.
f. Trails.
g. Limber.
h. Trail hinge pin.
k. Bottom carriage.
m. Cradle.
n. Trail pin locking nut.
p. Rear clips.
q. Limber seat.
r. Brake operating cable.
s. Brake lever.
t. Traversing handwheel.
u. Elevating handwheel.
v. Sight mounting.

necessary to transfer the weight of the gun from the axle to the traveling spring in order to cushion the chassis while in motion. This is accomplished by jacking up the mount until its weight is off the axle (fig. 88), connecting the shackle bolts, and removing the pivot pin from the pivot pin recess.

36. Accessories.—*a.* Most of the parts that must be moved in going from firing to traveling position and vice versa are too heavy for handling by manpower alone. For this reason certain accessories

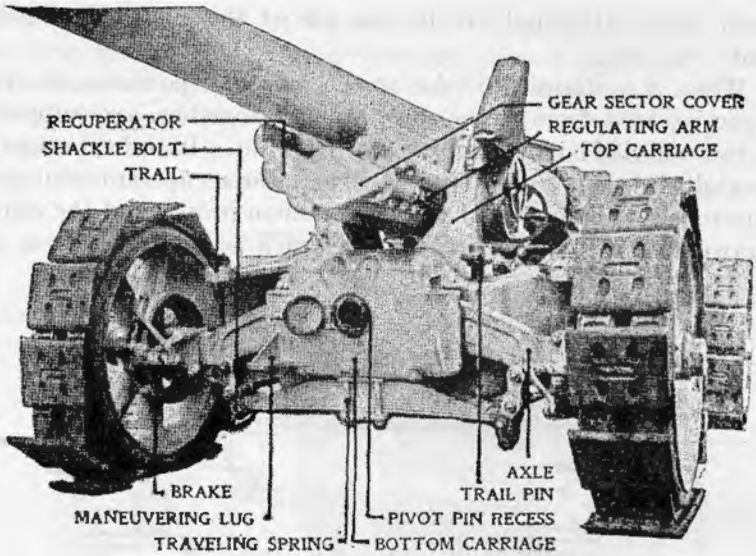


FIGURE 88.—Traveling position (front view).

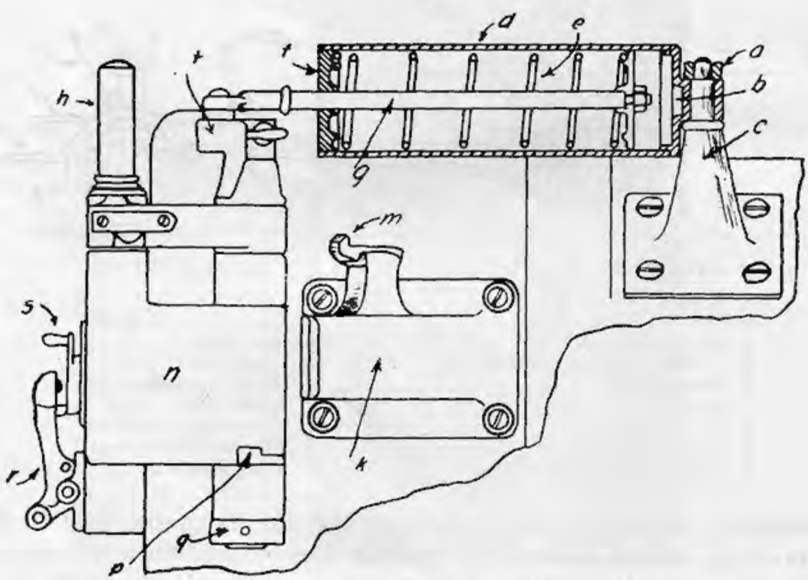


FIGURE 89.—Counterbalance cylinder.

a. Bracket collar.
b. Pivoted cylinder head.
c. Counterbalance bracket.
d. Counterbalance cylinder.
e. Counterbalance spring.
f. Cylinder head.
g. Tension rod.
h. Operating lever handle.
k. Lever catch bracket.
m. Lever catch.
n. Block carrier.
p. Hinge pin driving washer.
q. Hinge pin collar.
r. Firing hammer.
s. Firing mechanism.
t. Hinge pin lug.

are provided, that is, a jack beam and jacks to raise and lower the trails and for replacing the shackle bolts and the axle pivot pin, and a retracting rack to slide the gun forward or back in its cradle.

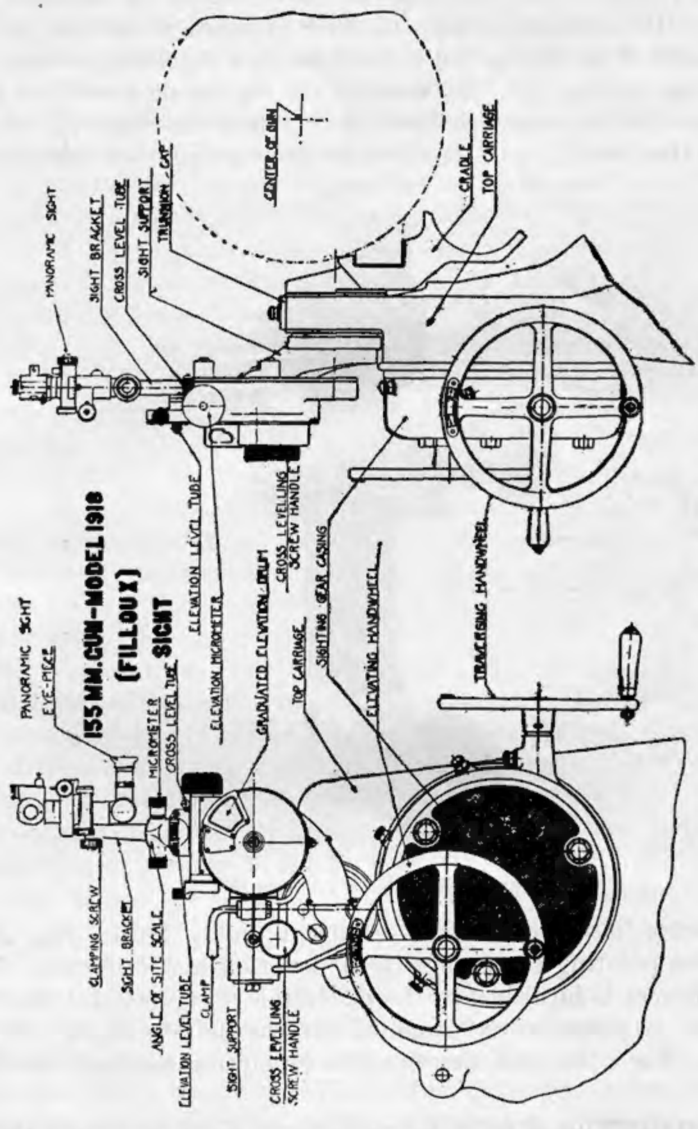


FIGURE 90.—Quadrant sight, M1918 (Schneider).

b. (1) This gun is not depressed to horizontal for reloading so a counterbalance cylinder is provided to make the breechblock easier to operate at all elevations. The cylinder is fixed so that the amount of turning movement supplied to the breechblock may be adjusted to suit the average firing elevation.

(2) The cylinder itself (fig. 89) is a plain spring cylinder (d) enclosing a counterbalance spring (e). Working in the center of the cylinder is the tension rod (g), which is attached at one end to the forward end of the spring and at the other to a regulating nut on top of the hinge pin lug (t). By rotating the regulating screw and nut, the tension of the counterbalance spring may be adjusted to the desired value according to the expected average angle of elevation.

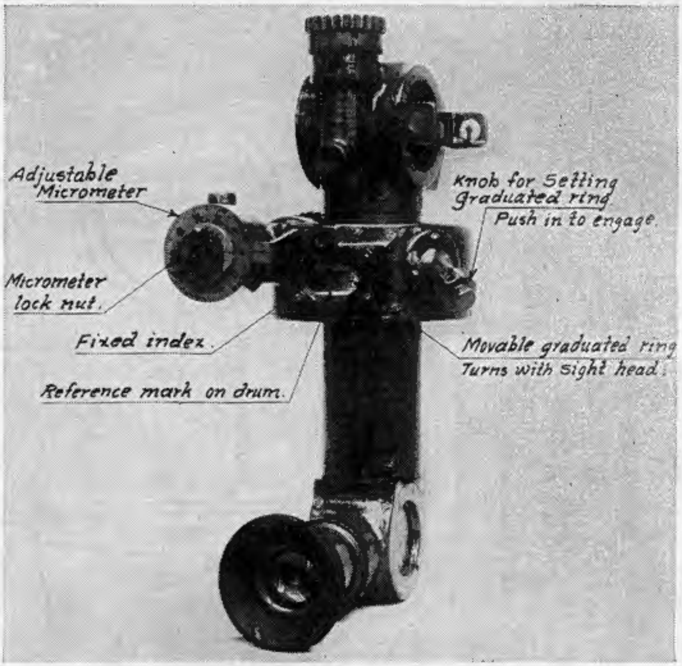


FIGURE 91.—Panoramic telescope, M2.

c. Sighting mechanism.—The quadrant sight, M1918 (fig. 90), is used for pointing the gun both in direction and elevation. The optical element is furnished by the panoramic telescope, M2 (fig. 91). The sight is permanently mounted on the left trunnion of the carriage. For a detailed description of pointing methods, see FM 4-15.

37. Constructional details.—*a. General.*—The carriage is shown in figures 85, 86, and 87. The gun proper is mounted in a cradle, on which are the recoil and recuperator mechanisms. The recoil and recuperator rods move with the gun, the cylinders remaining stationary.

(1) When fired, the gun recoils in the cradle and its movement is guided by the longitudinal clips or splines on the gun which slide through slots in the cradle as shown in figure 11. The movement of the piece is controlled during recoil by the operation of the parts within the recoil and recuperator cylinders, which, during recoil, store up sufficient energy within the recuperator cylinder to return the piece to the firing position.

(2) The cradle is supported by the top carriage which is mounted upon and traverses on the bottom carriage.

(3) The bottom carriage is mounted upon the axle by interchangeable connections therewith for the traveling and firing positions. It is braced to the rear by two trail members, which are connected to it by hinge joints permitting movement of the trails from the firing to the traveling positions.

b. Principal parts.—The principal parts are the cradle (including the recoil and recuperator mechanism), top carriage, bottom carriage, elevating mechanism, traversing mechanism, trails, spades, axle, traveling spring, wheels, wheel shoes, and road brake.

(1) *Cradle.*—The cradle is of conventional design, having the recoil and recuperator cylinders mounted underneath the gun. It is trunnioned in the top carriage, and the gun slides forward and rearward on the usual arrangement of splines (or clips) working in slots in the cradle. The hydropneumatic recoil mechanism is shown in figure 49 and is described in paragraph 25*b*.

(2) *Top carriage.*—The top carriage is a large steel casting mounted on and secured to the bottom carriage upon which it traverses. On it are mounted the traversing and elevating handwheels together with the driving gears and shafting of these mechanisms. The tipping parts (gun and cradle) of the mount are supported and pivoted in two trunnion bearings. Figure 92 shows a front view sketch of the appearance of the top of the carriage. The bottom face of the top carriage is a large elliptical bearing surface (h) which, when the gun is fired, bears upon a corresponding surface of the bottom carriage, thus transmitting the firing stresses and the shock of recoil through the bottom carriage to the wheels and trails.

(3) *Bottom carriage.*—Supporting the top carriage, the bottom carriage rests upon the gun axle and the trails and does not turn when the gun is traversed. The bottom carriage consists essentially of a large, rather flat steel casting. On the flat upper surface of this casting rests the top carriage. To permit easy traversing, a device is used which greatly resembles the antifriction elevating device described in paragraph 28*d*. When traversing, the top carriage is

supported on a small antifriction bearing (s, fig. 93). When the gun fires, the additional downward thrust compresses the Belleville springs at p, allowing the full lower surface of the top carriage to bear on the full upper surface of the bottom carriage.

(4) *Traversing mechanism.*—The traversing mechanism consists of a shaft and gear train assembled in bearings in the top carriage

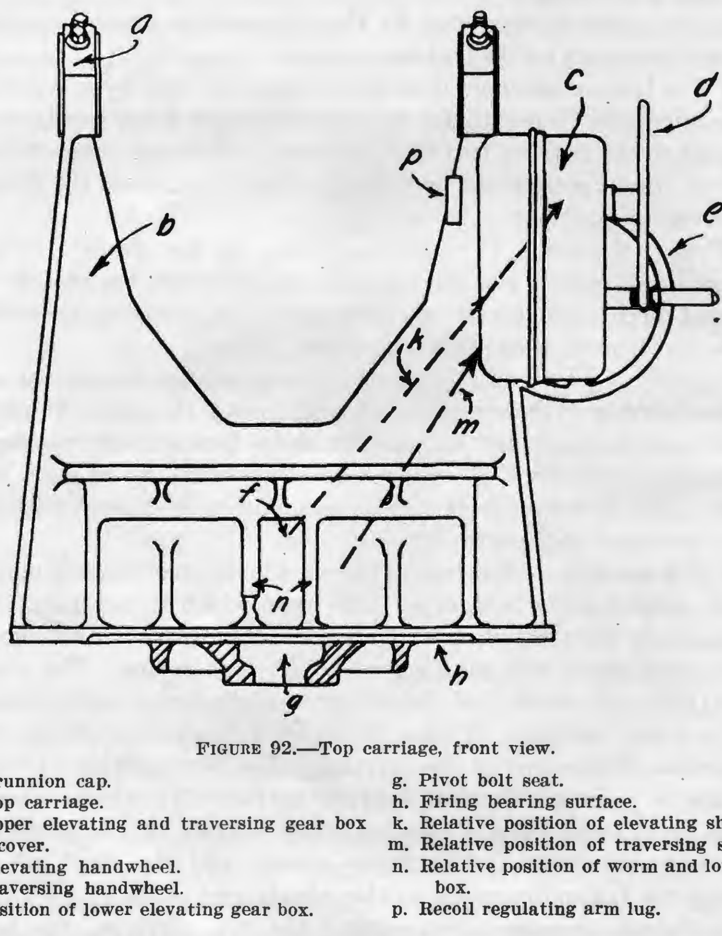


FIGURE 92.—Top carriage, front view.

a. Trunnion cap.
b. Top carriage.
c. Upper elevating and traversing gear box cover.
d. Elevating handwheel.
e. Traversing handwheel.
f. Position of lower elevating gear box.
g. Pivot bolt seat.
h. Firing bearing surface.
k. Relative position of elevating shaft.
m. Relative position of traversing shaft.
n. Relative position of worm and lower gear box.
p. Recoil regulating arm lug.

and actuating a worm (also supported in the top carriage) enmeshed with a rack bolted to the bottom carriage. Two circular bronze castings, the elevating and traversing gear box and gear-box cover, assemble one within the other on the left top side of the top carriage (c, fig. 92). The traversing handwheel (e) is connected through suitable shafting (m) to a gear box and worm (n). This worm meshes with the large worm rack on the bottom carriage, traversing the top carriage.

(5) *Elevating mechanism.*—The parts of the elevating mechanism are similar and their method of operation is identical with that of the traversing assemblage. The elevating handwheel (d, fig. 92) is mounted on a shaft in the gear-box cover and, through a helical driving pinion, drives a gear on an inclined shafting (k). The lower end of the shafting is suported in a gear box (f) secured in the front

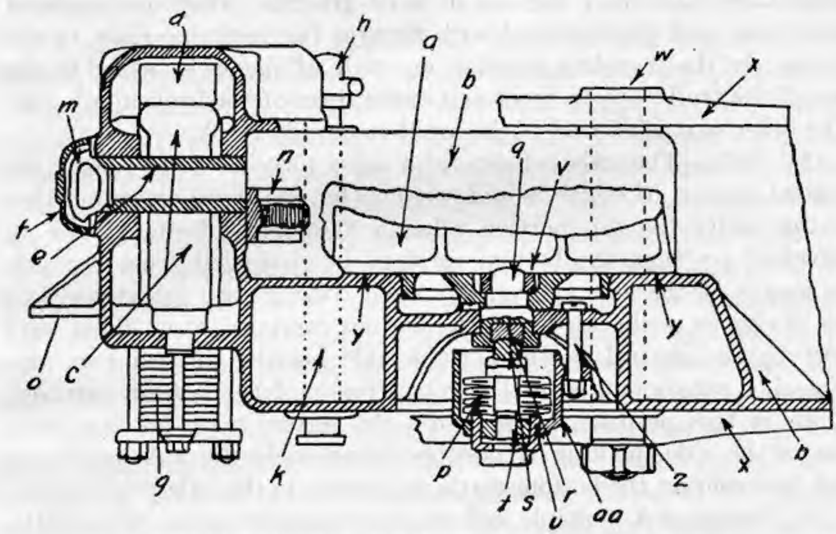


FIGURE 93.—Bottom carriage, assembled view, firing position.

a. Top carriage.
b. Bottom carriage.
c. Axle space.
d. Centering pin.
e. Axle pivot pin.
f. Cover.
g. Traveling springs.
h. Trail pin locking nut.
m. Axle pivot pin handle.
n. Traversing rack segment.
o. Maneuvering lug.
p. Belleville springs.
q. Pivot bolt.
r. Socket, upper.
s. Socket, bearing.
t. Socket, lower.
u. Spring box nut.
v. Pivot bolt nut.
w. Trail hinge pin.
x. Trail.
y. Firing bearing surface.
z. Spring box bolt.
aa. Spring box.

lower part of the top carriage. Two meshed pinions in the gear box continue the drive to the elevating worm shaft and worm which is enmeshed with a circular worm rack attached to the bottom of the cradle.

(6) *Trails.*—Two trails of box girder type are provided to prevent the carriage from moving to the rear when the gun is fired. They are made of steel plate suitably reinforced and are attached by pivot pins to the sides of the bottom carriage. In the traveling position

the trails are coupled together and are fastened to the limber. In the firing position they are opened out, each trail being moved about 30° from the coupled position. The rear ends are provided with fittings for attaching the spades. The trails are fitted also with racks for retracting the gun to its traveling position and with clips and screws for holding the traveling lock which holds the gun in the traveling position.

(7) *Spades.*—Two pairs of spades are provided, one for use in soft ground and the other for use in hard ground. They are made of steel plate and are provided with fixtures for fastening them to the trails. In the traveling position one pair of spades is lashed to the top of the trails, one in front and one in rear of the brakeman's seat. The other pair is carried in the artillery supply truck.

(8) *Axle.*—The axle consists of a solid piece of forged steel, the central portion of which is of I section (fig. 88), with exception that at the center the top portion takes a cylindrical form. When in traveling position, the bottom carriage is suspended from the axle by means of the axle spring, but upon coming into firing position, the spring is unshackled and the bottom carriage given direct support by the central portion of the axle bearing against two axle centering pins mounted at the top (front) of the bottom carriage. While in this position, holes within the bottom carriage aline with one in the axle, making it possible to assemble the axle pivot pin and thus connect the bottom carriage directly to the axle.

(9) *Spring.*—A multiple leaf spring is fastened to the front of the bottom carriage at its center and extends laterally beneath the axle to which it is shackled. It supports the bottom carriage and the parts assembled to it and relieves the carriage from road shocks during transport. Each end is bushed and fitted with a pin for unshackling the spring when changing from the traveling to the firing position.

(10) *Wheels, wheel shoes, and brakes.*—The wheels are an assemblage of a cast steel body, called the wheel center, with two solid rubber tires between which is a tire separator of forged steel. The wheel bearings are *not* designed for high speed towing behind truck or prime mover (fig. 88). The wheel shoes are issued as part of the regular equipment for use in moving the carriage over poor ground, and while in firing position. The brakes are of the conventional external contracting type mounted on the rear wheels only, and operated by a handbrake lever.

(11) *Breechblock.*—The breechblock is of the lever pull carrier supported type, described in paragraph 13*d*.

Section VIII

RAILWAY ARTILLERY MOUNTS

38. General.—*a*. The demands for heavy mobile artillery in the World War greatly exceeded all estimates, even those of the Germans. Accordingly, all of the belligerents were forced to improvise wherever possible, and railway artillery came into its own. Guns from seacoast forts, land forts, and old battleships were mounted on improvised railway cars and sent to the front. These rough mounts had no recoil mechanisms and no traversing mechanisms. The recoil was absorbed by allowing the mount to roll along the track with all brakes set, and after each round a winch was used to bring the car back to its original position. Traverse was secured by building an epi, or curved spur track, and moving the mount along the curve until the desired azimuth was secured, as shown in the top drawing of figure 94. Later developments in design included a means of pointing in direction in which the whole car was traversed on a previously prepared bed or emplacement as shown in the middle drawing, figure 94. This is the means generally used in major caliber railway seacoast artillery today. A third type of design used for minor caliber guns and 12-inch mortars has top carriage traverse, shown in the lower drawing of figure 94.

b. There are several advantages possessed by railway artillery as seacoast defense weapons. The most important is its great strategic mobility. For instance, it would be a great advantage if in the event of a Pacific war, we could concentrate on our western coast all the seacoast armament now emplaced on the Atlantic. Railway seacoast artillery can also be used with the field army, if not required for coast defense. If information is secured far enough in advance, railway artillery can be concentrated on almost any part of our coasts to oppose an attempted enemy landing on the beach. Deception using dummy guns and concealment can be practiced, so that the enemy will never be sure just where all of our seacoast armament is located or how much we really have.

c. An examination of the figures discloses that the primitive type of railway artillery carriage using an epi for traverse is unsuited for seacoast defense work. For this work, major caliber guns equipped for car traverse are used on specially prepared emplacements to which the carriages are readily shifted. Minor caliber guns and 12-inch mortars equipped for top carriage traverse are suitable for seacoast use, as their design permits preparing the gun to fire in some 3 hours, and allows the all-round fire of the fixed emplacement.

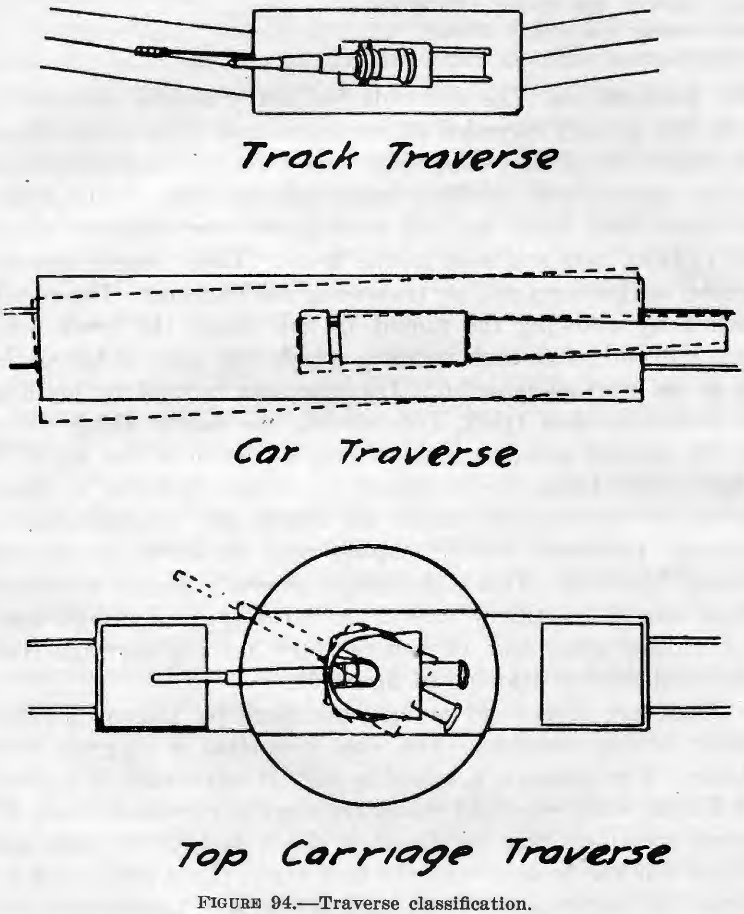


FIGURE 94.—Traverse classification.

d. Of the several types of recoil control (fig. 95), only cradle recoil control is used in seacoast artillery. In top carriage recoil control the maximum range of the weapon is severely limited, while in sliding and rolling recoil control there is too much time lost in bringing the carriage back to firing position after each shot.

e. Carriages are further classified as to method of anchorage.

(1) Cars using rolling recoil have the brakes set before firing and are returned to the original position by means of a winch, as shown in the top drawing in figure 96.

(2) Those mounts using top carriage traverse use a track platform braced with outriggers as shown in the middle drawing and are valuable as light seacoast weapons. They are, in effect, a barbette mount on a railway car.

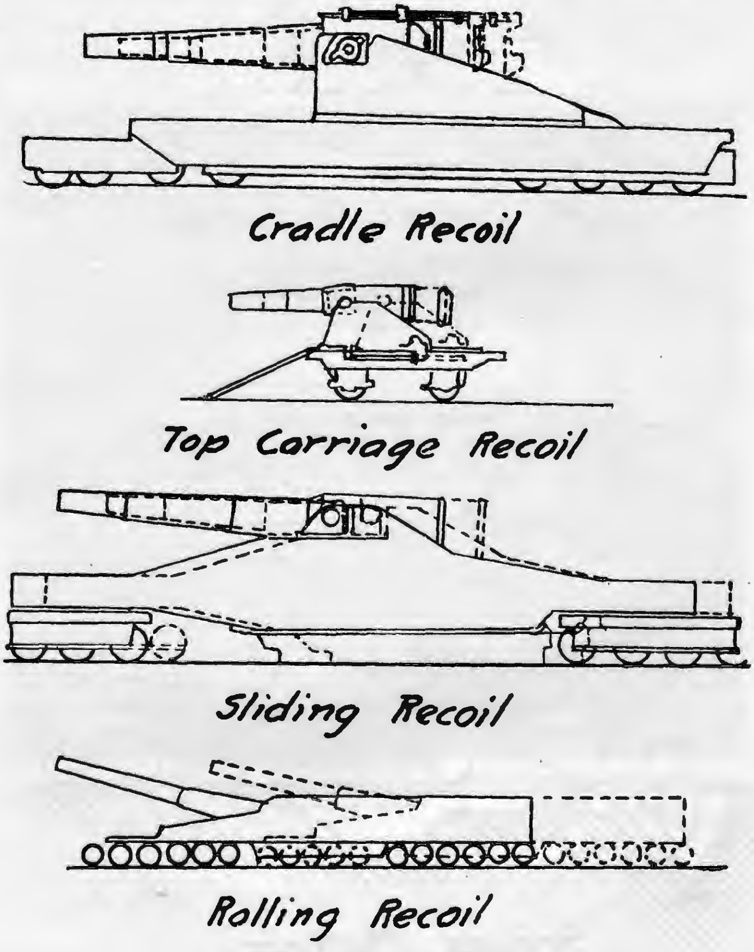


FIGURE 95.—Recoil classification.

(3) For the major caliber guns, some rather elaborate emplacement either of timber (lower fig. 96) or of concrete must be built. Building one of these emplacements is a matter of days rather than hours. A prepared emplacement of concrete is shown in figure 110.

f. Pointing equipment.—All railway guns used in seacoast defense are laid for range by means of the elevation quadrant, M1917. This quadrant is mounted on the right trunnion by means of a tapered shank which permits of easy removal of the quadrant to prevent its being injured by the shock of firing. The quadrant may be seen in

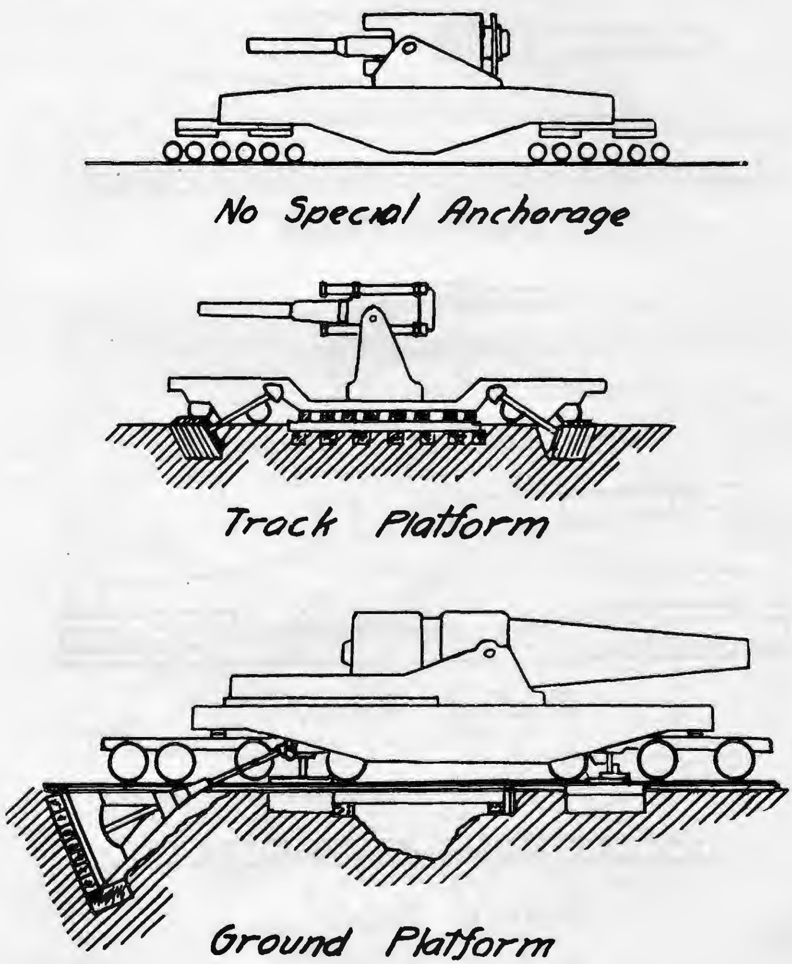


FIGURE 96.—Anchorage classification.

place on the 8-inch railway gun in figure 98 and on the 12-inch mortar in figure 102.

39. 8-inch railway gun mount, M1918.—The 8-inch railway gun appears in two separate models. The earlier model, developed during the World War, is shown in figure 98. The mount is practically a barbette carriage of conventional design mounted on a railway car.

a. Recoil system.—(1) The recoil system of this gun employs one conventional recoil cylinder (fig. 99) and four spring-operated recuperator cylinders. In order to minimize the stresses sustained in recoil, the length of recoil has been made long (48 inches). A plug type counterrecoil buffer at the forward end of the piston rod prevents the mount charging into battery.

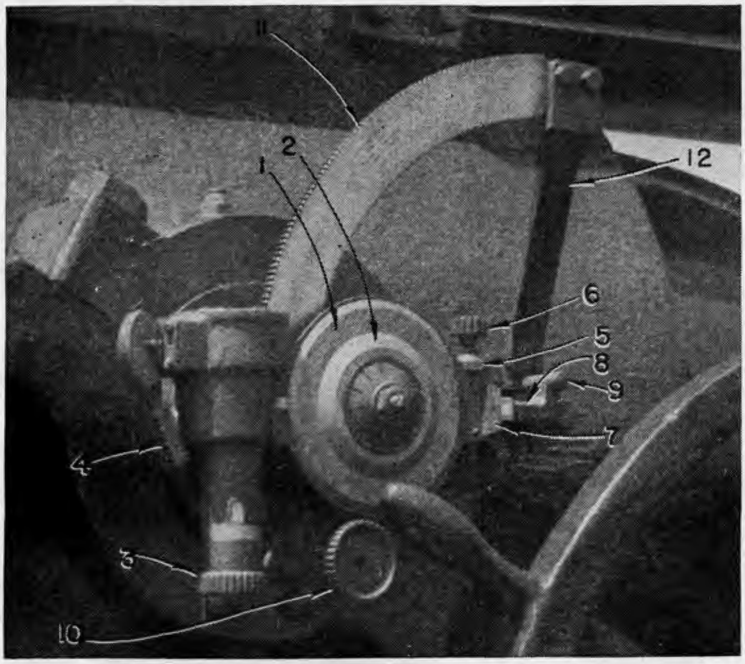


FIGURE 97.—Elevation quadrant, M1917.

1. Elevation disk.
2. Outer friction disk.
3. Elevation micrometer.
4. Throw-out lever.
5. Angle of site micrometer scale.
6. Micrometer screw handle.
7. Angle of site scale.
8. Elevation level.
9. Cross level.
10. Cross level screw handle.
11. Rocker arm (elevation quadrant).
12. Rocker arm support.

(2) The gun was designed for operation as a fixed barbette weapon, firing a heavy seacoast projectile. Tests on the railway carriage have disclosed that sustained operation with a heavy projectile is only possible when firing parallel to the tracks, as at other azimuths the mount moves around as the gun is fired. At present the guns are fired with the lighter 200- and 260-pound projectiles, and the mount is stable in all positions.

b. Elevating mechanism.—This mount employs a conventional elevating mechanism as described in paragraph 28 *c* (2), except that

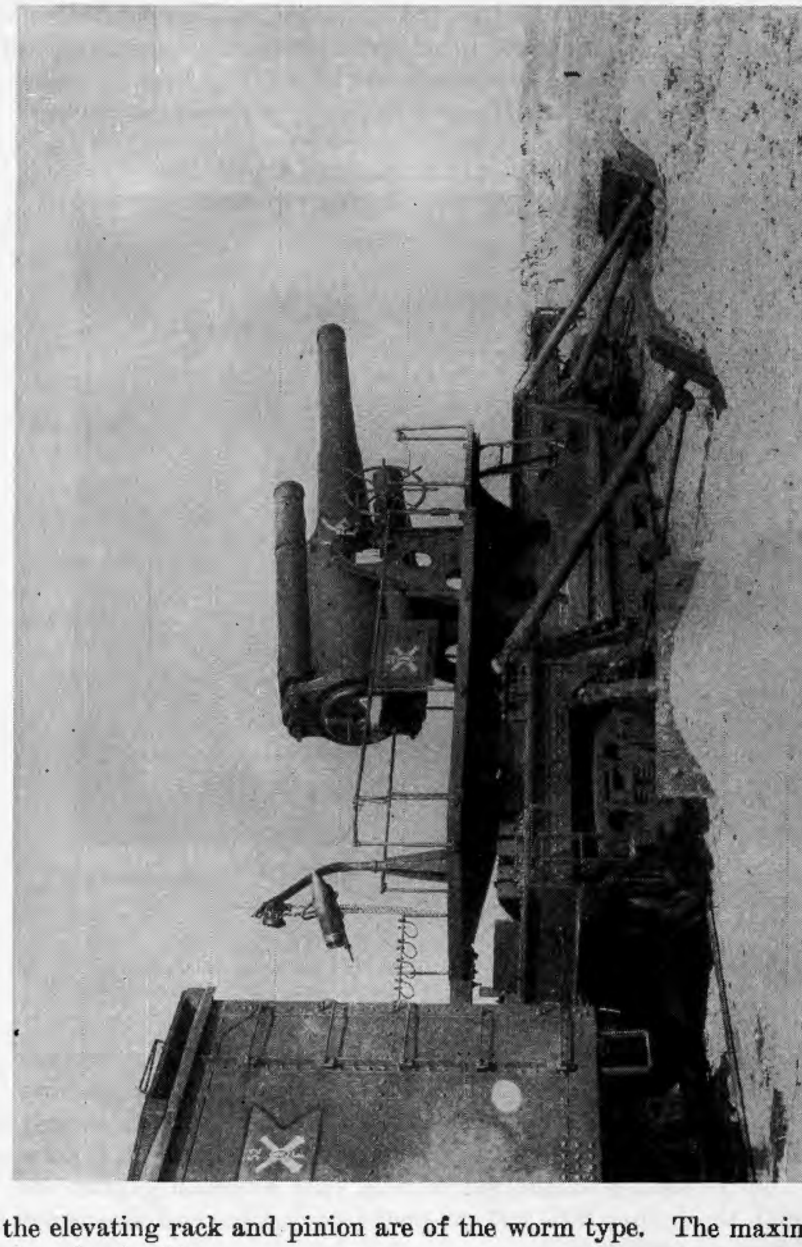


FIGURE 98.—8-inch gun on railway mount, M1918, emplaced.

the elevating rack and pinion are of the worm type. The maximum elevation is 42°.

c. Traversing mechanism.—The type described in paragraph 28*b* is employed, using the conventional rack and pinion. The mount may be traversed through a full 360°.

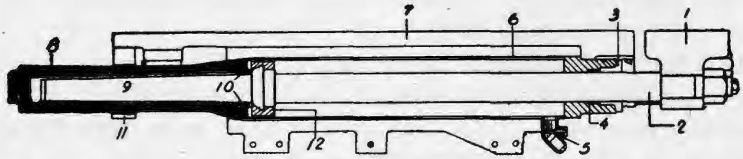


FIGURE 99.—8-inch recoil cylinder showing plug type counterrecoil buffer.

1. Recoil band.
2. Piston rod.
3. Follower.
4. Packing.
5. Filling valve.
6. Recoil cylinder.
7. Cradle.
8. Cylinder head.
9. Piston rod buffer.
10. Cylinder head bushing.
11. Cylinder head support.
12. Piston.

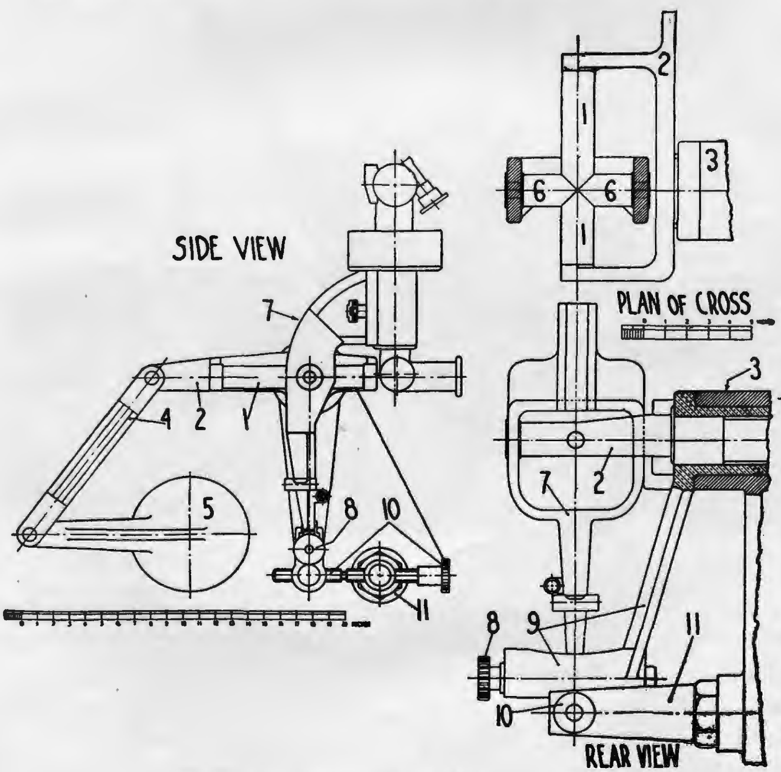


FIGURE 100.—Diagrams of sight mount, type C.

d. Ammunition.—Ammunition is handled by means of a davit (fig. 98) and chain hoist. Operating conservatively, a round may be fired every 40 seconds.

e. Breechblock.—The breechblock is of the old two-handled type (fig. 19) and employs the standard seacoast firing mechanism, M1903, with friction primers.

f. Sight mount, type C.—This is the standard equipment for the 8-inch railway carriage, M1918. (See fig. 100.)

40. 8-inch railway gun mount, M1.—*a.* This weapon, the most modern railway gun we possess, resembles the wartime 8-inch gun previously described. Like that gun, it may be emplaced for all-round fire in a few hours without tearing up the tracks.

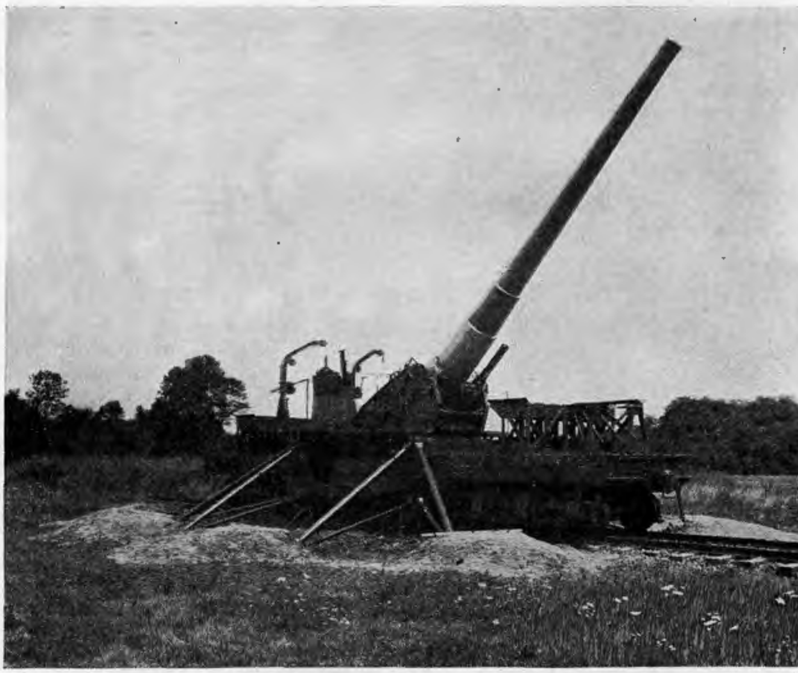


FIGURE 101.—8-inch railway gun mount, M1.

b. As may be seen from figure 101, it is practically a barbette carriage mounted upon a railway car. The elevating and traversing mechanisms are of standard "barbette type" design, employing spur gears. The elevating system has a brake to hold the gun at the desired elevation. A heavy counterweight at the breech end of the gun enables the trunnions to be mounted well toward the rear, without the use of equilibrators. Like the 14-inch railway gun, it is loaded by allowing the shell to slide down a tray set at an angle of $-5°$.

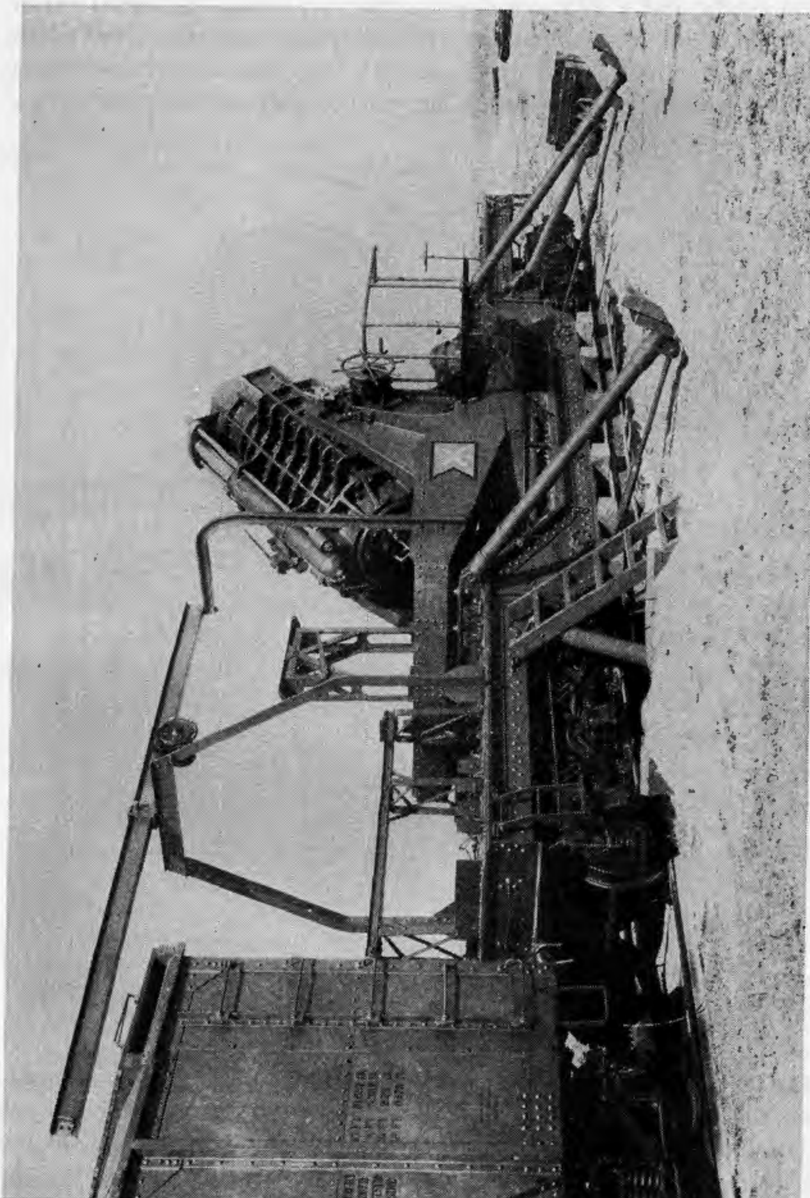


FIGURE 102.—12-inch mortar on railway mount, M1918, emplaced.

c. The gun itself is a modern weapon, 45 calibers long, and of the built-up type. It fires a 260-pound projectile to a range of 27,550 yards, and a 200-pound projectile to a range of 33,850 yards.

d. The recoil system employs two conventional recoil cylinders, giving the mount a recoil of 27 inches. One pneumatic recuperator cylinder of conventional design moves the gun forward into firing position after each round.

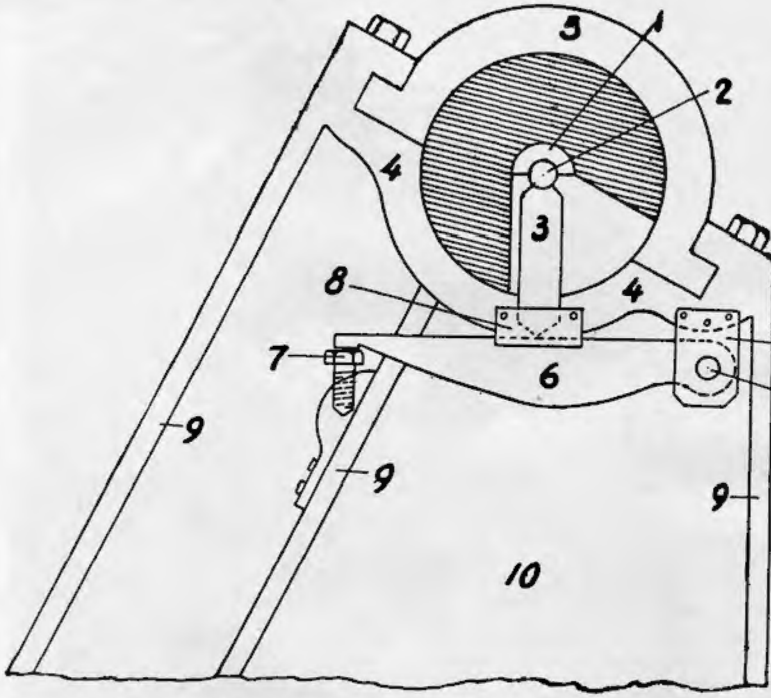


FIGURE 103.—Antifriction device, 12-inch railway mortars.

1. Bronze bushing.
2. Rolling pin (steel).
3. Crutch (steel).
4. Main trunnion bearing.
5. Trunnion cap square.
6. Beam.
7. Adjusting screw.
8. Crutch guide.
9. Side-frame ribs.
10. Side frame.
11. Stirrup.
12. Beam pivot pin.

41. 12-inch railway mortar mount, M1918.—*a*. Mounted upon the same type of car as the 8-inch railway gun is the 12-inch railway mortar, M1918. Built to utilize 12-inch mortars, M1890 and M1890MII, dismounted from fixed mounts in the various harbor defenses during the World War and designed primarily for service with the field army overseas, the weapon proved itself well adapted to seacoast defense. It is the only piece of primary armament manned by the Coast Artillery Corps capable of being rushed to a threatened location, emplaced, and fired within a matter of hours.

b. (1) The recoil mechanism resembles that of the M1908 fixed mortar, employing a sleigh sliding in a cradle. Two recoil cylinders

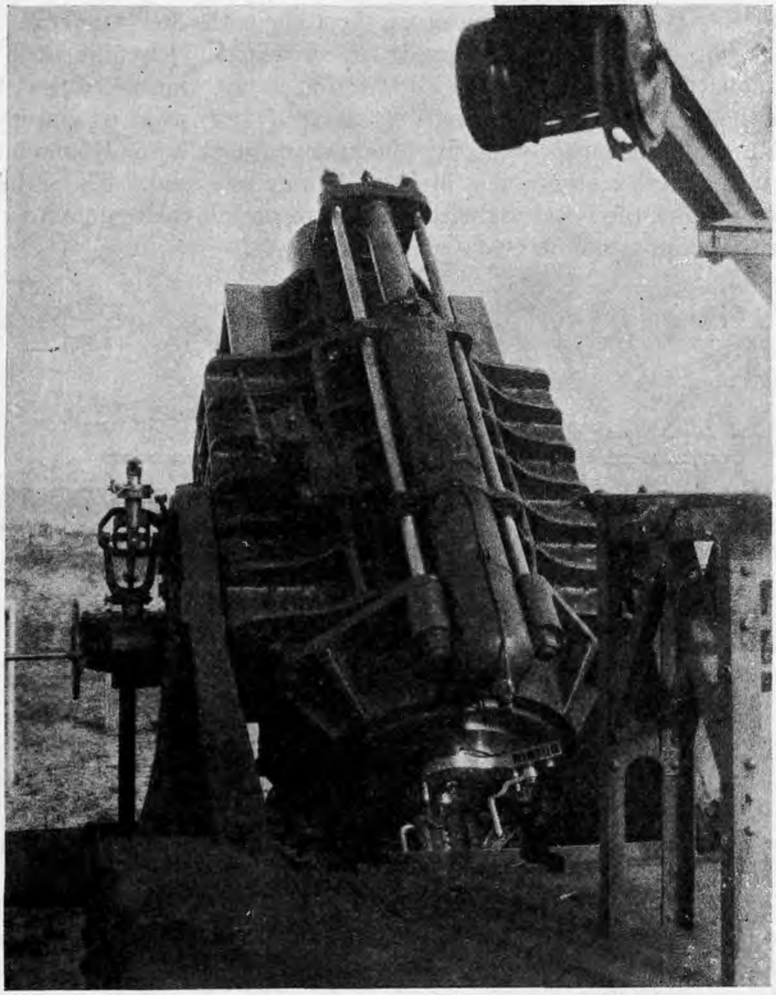


FIGURE 104.—Sight mount, type D, on 12-inch railway mortar carriage, M1918.

of conventional design are built into the underside of the cradle. Recoil length is 32 inches. One pneumatic recuperator cylinder mounted above the cradle returns the mortar to firing position after recoil.

(2) The carriage has been designed to permit fire at elevations between 20° and 65°, though only those elevations between 45° and 65° are of use in seacoast artillery work. To emplace, the car is raised on four hydraulic jacks and lowered onto oversized railway ties as shown in figure 102. It is held in position by the outriggers and may be fired at extreme range throughout the 360° traverse.

c. The elevating mechanism is of conventional circular rack and pinion type and employs an antifriction device similar to that used on the latest barbette carriages (par. 28 *d*). Instead of employing Belleville springs to allow the trunnions to drop a small amount on firing, a steel crutch and a long steel beam are used. The stress of recoil causes the beam to deflect enough to permit the trunnion to rest on the main trunnion bearing (fig. 103).

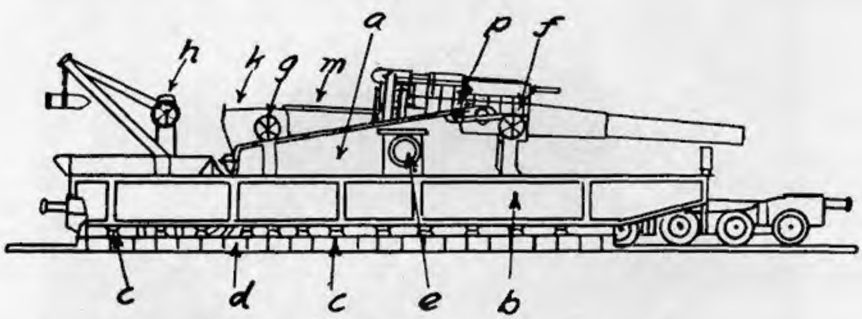


FIGURE 105.—12-inch (Batignolles) on field platform.

a. Top carriage.
b. Body girder.
c. Emplacing wedges.
d. Structural steel platform.
e. Elevation slip device.
f. Elevation handwheel.
g. Traversing handwheel.
h. Loading hoist (crane).
k. Projectile table.
m. Loading tray.
p. Antifriction device.

d. Sight mount, type D.—This mount is standard equipment for the 12-inch railway mortar carriage, M1918. Figure 104 is a photograph of the mortar showing the sight mount.

42. 12-inch railway gun mount (Batignolles).—*a.* This mount was originally designed by the French for use as a fixed nonsliding mount with a limited traverse of 5° each side of the center line. The ground platform (fig. 105) requires that the tracks be torn up to emplace the weapon.

b. The recoil mechanism of conventional design consists of two hydraulic recoil cylinders mounted under the cannon, and one pneumatic recuperator mounted over the cannon. They closely resemble those shown in figures 46 and 99.

c. As this gun is capable of throwing a 900-pound projectile to a range of some 30,000 yards and can be moved wherever there is a

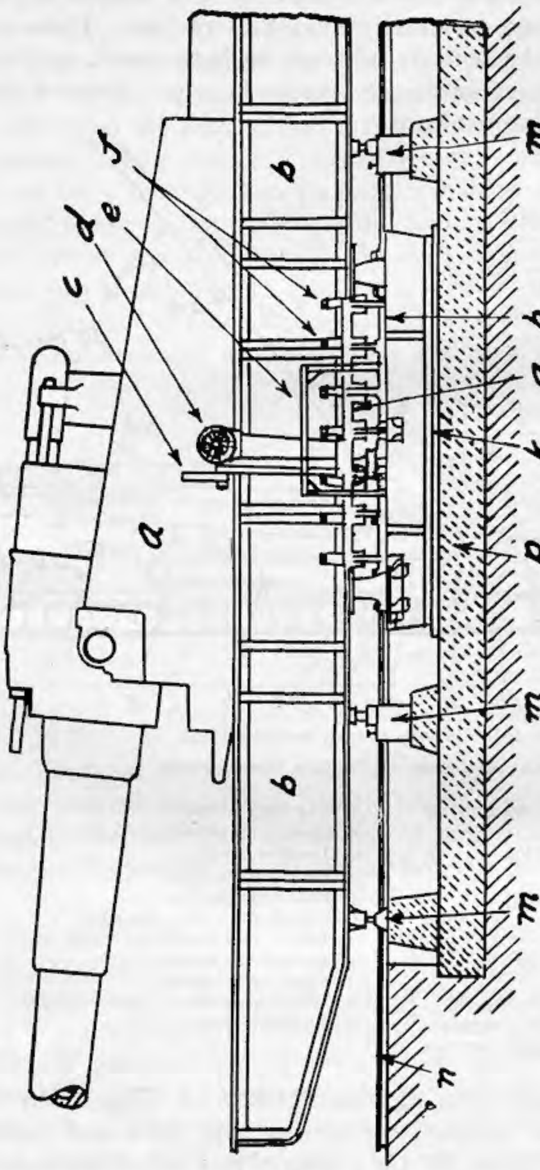


FIGURE 106.—12-inch (Batignolles) on fixed emplacement.

a. Top carriage.
b. Girder.
c. Sight standard.
d. Traversing handwheel.
e. Gunner's platform.
f. Car body holding bolts.
g. Cross beam on racer.
h. 10-inch (M1896) racer.
k. 10-inch (M1896) base ring.
m. Jacks.
n. Track rails.
p. Concrete emplacement.

railroad, its possibilities as a seacoast defense weapon were immediately realized. In its original form its maximum traverse was 10°—for seacoast artillery work it should be 360°. The scheme shown in figure 106 was finally worked out, in which the base ring, traversing rollers, and racer of the obsolete 10-inch disappearing carriage were mounted on a concrete platform and used to convert the Batignolles carriage to an all-round fire weapon. These concrete platforms could be built in advance on both coasts, and only occupied when the dangerous areas became known. None of these platforms have actually been built.

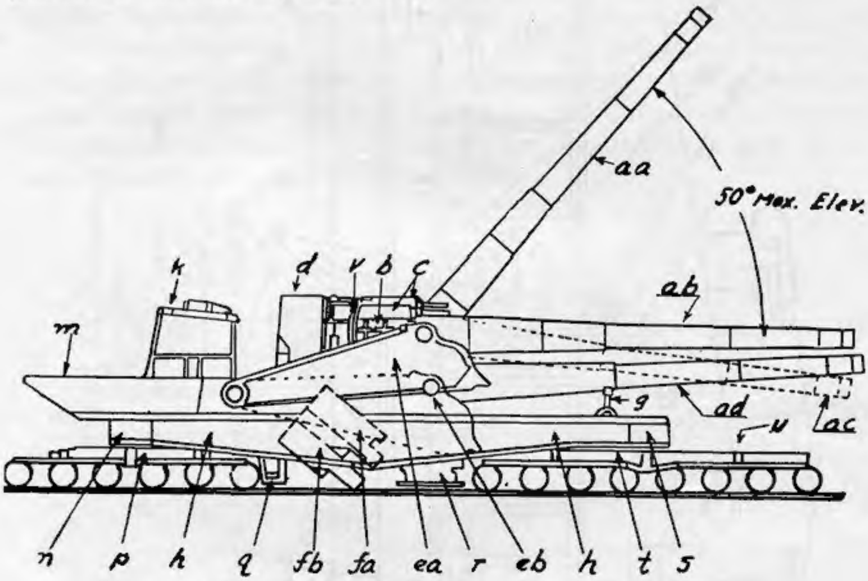


FIGURE 107.—14-inch railway mount, M1920.

aa. Gun in firing position at maximum elevation.
ab. Gun infiring position at zero elevation.
ac. Gun in loading position at −7° elevation.
ad. Gun in travel position at 3.5° elevation.
b. Cradle.
c. Recoil cylinder.
d. Recoil band.
ea. Top carriage in firing position.
eb. Top carriage in travel position.
fa. Gun breech at maximum elevation.
fb. Gun breech, recoil.
g. Travel rest.
h. Car body girder.
k. Loading stand tray.
m. Loading trunk.
n. Rear body bolster.
p. Rear span bolster.
q. Traversing roller assembly.
r. Lower pintle assembly and plate.
s. Front body bolster.
t. Front span bolster.
u. Space occupied by power plant.
v. Elevating rack.

43. 14-inch railway gun mount, M1920.—*a.* This is our outstanding railway gun designed for fire at both fixed and moving targets. As shown in figure 107 the principal member of the carriage is the car body girder (h) which is supported at each end by a large railway truck (p and t). The top carriage mounts the cradle, recoil mechanisms, and gun.

b. (1) Several problems have been ingeniously worked out in the design of this gun. For instance, there was the requirement for two differing heights of trunnions. To lower the center of gravity for traveling and to decrease the over-all height of the mount so that it may pass through tunnels, a low height of trunnions is desirable. On the other hand the trunnions should be high for firing in order that the cannon may have ample space for recoil at high elevations. These mutually exclusive requirements have been met by the use of a movable top carriage which is raised for firing and lowered for traveling. The general idea is illustrated in figure 108, which shows the top carriage in both upper (firing) and lower (traveling) positions.

(2) For land warfare it was desired to be able to fire the gun from a field emplacement on the track. For this purpose a previously

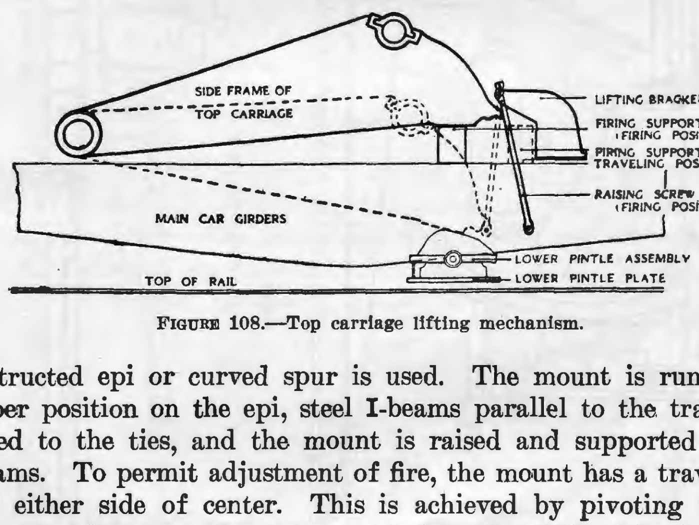


FIGURE 108.—Top carriage lifting mechanism.

constructed epi or curved spur is used. The mount is run to the proper position on the epi, steel I-beams parallel to the tracks are spiked to the ties, and the mount is raised and supported on the I-beams. To permit adjustment of fire, the mount has a traverse of 3½° either side of center. This is achieved by pivoting the top carriage at its rear end (or upper pintle) (fig. 109). The front end of the top carriage may be moved to the right or left to secure the 3½° traverse desired. By the use of the epi and the field emplacement it is possible to go into firing position in less than 1 hour.

(3) For seacoast defense work which requires all-round fire it is necessary to have a previously prepared platform or permanent emplacement. This consists of a concrete block about 42 feet in diameter. To this block are bolted two steel parts—one, the circular base plate about 9 feet in diameter; and the other the base ring, some 32 feet in diameter (fig. 110). To go into position on this emplacement, the mount is moved over the bridge rails and hinge rails (fig.

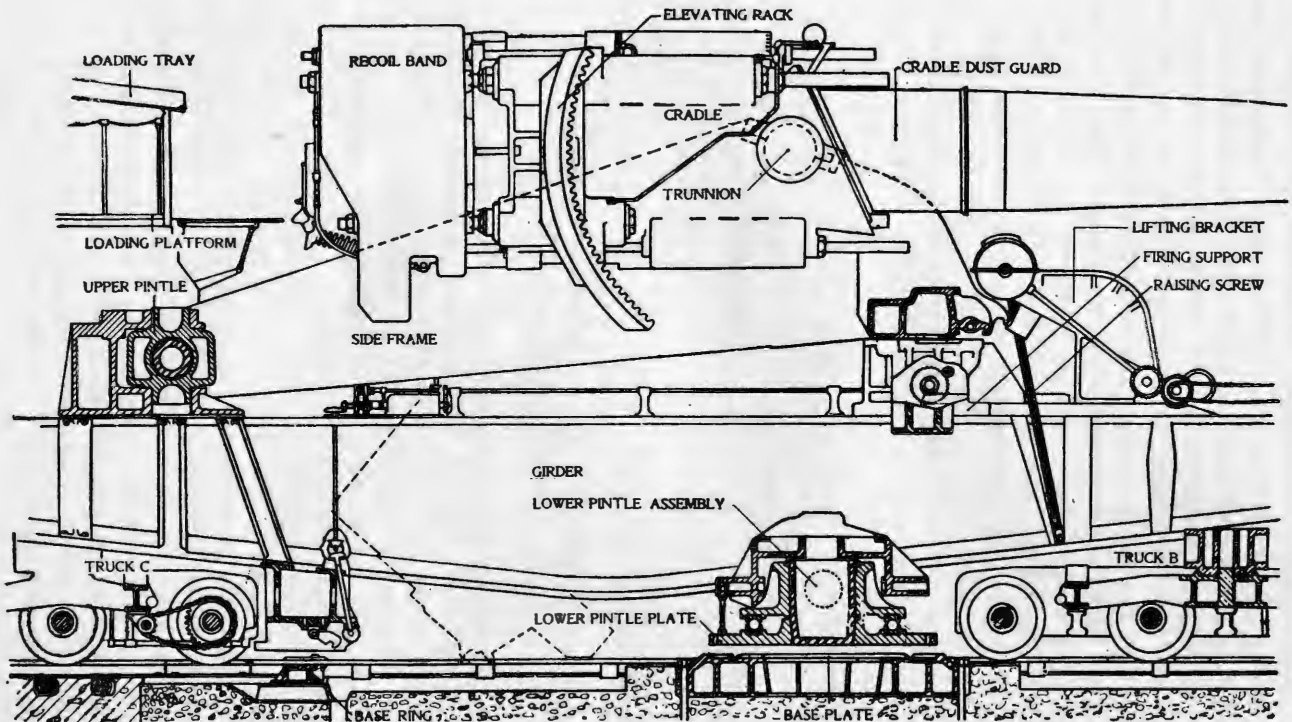


FIGURE 109.—Top carriage assembly.

110) until the lower pintle center coincides with the center of the concrete block. The whole mount is then lowered by a mechanical lowering device until its weight rests on the base plate. The base plate is then bolted down solidly. The two traversing rollers on the mount traversing beam rest on the base ring, being held against

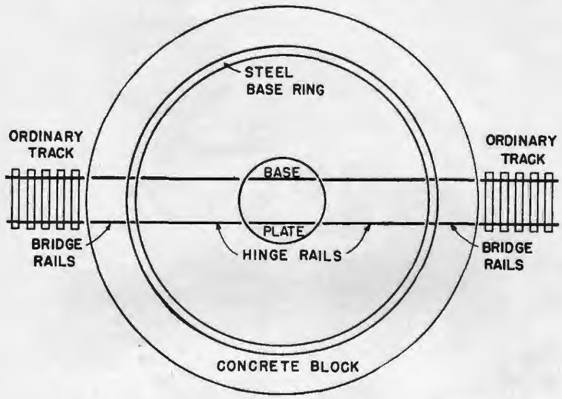


FIGURE 110.—Permanent emplacement for 14-inch railway mount.

tipping by clips which engage a lip on the edge of the base ring (fig. 111). The top carriage is then raised to firing position, and the trucks are run from under the mount. As the electric power plant is carried on the forward truck, this may only be moved the length of the cable furnished, about 100 yards. The total time

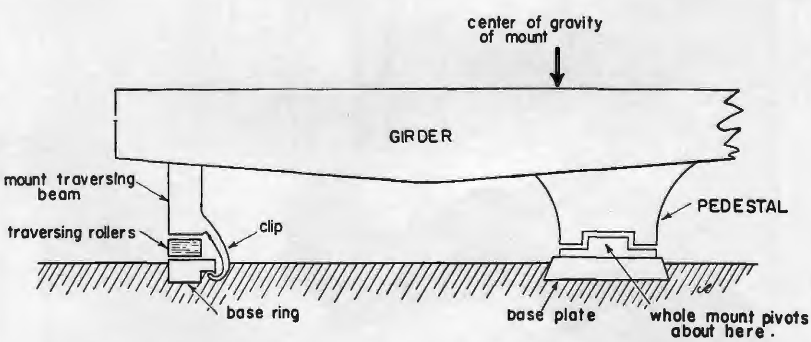


FIGURE 111.—Mount traversing mechanism, 14-inch railway gun.

required for emplacing the mount (after the concrete block is completed) is about 2½ hours.

c. The mount traversing mechanism is employed when the mount is on the permanent emplacement. As shown in figure 111 the mechanism consists of a pedestal (or pivot) around which the mount revolves, and a traversing beam-traversing roller assembly. When the pedestal is in position on the base plate, the traversing rollers rest on

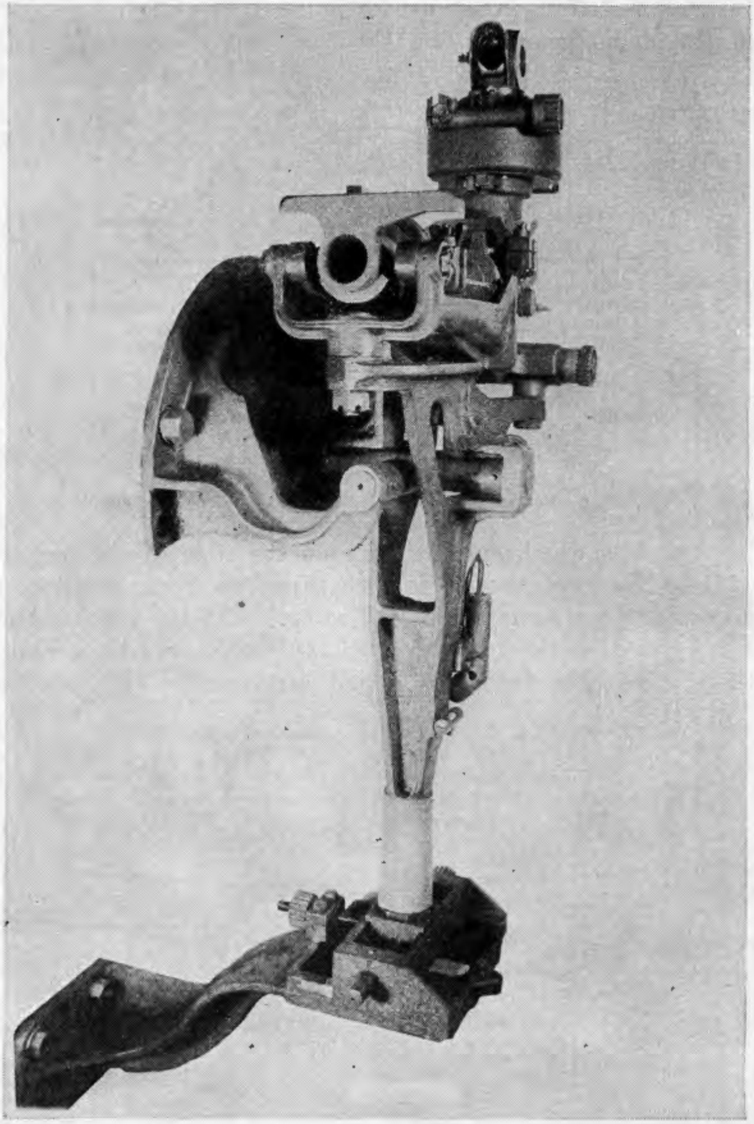


FIGURE 112.—Sight mount, M1920 (front).

the base ring. As the center of gravity of the mount is between the pedestal and the traversing beam (fig. 111) part of the weight is borne by each of these members. Actual traverse is accomplished by turning

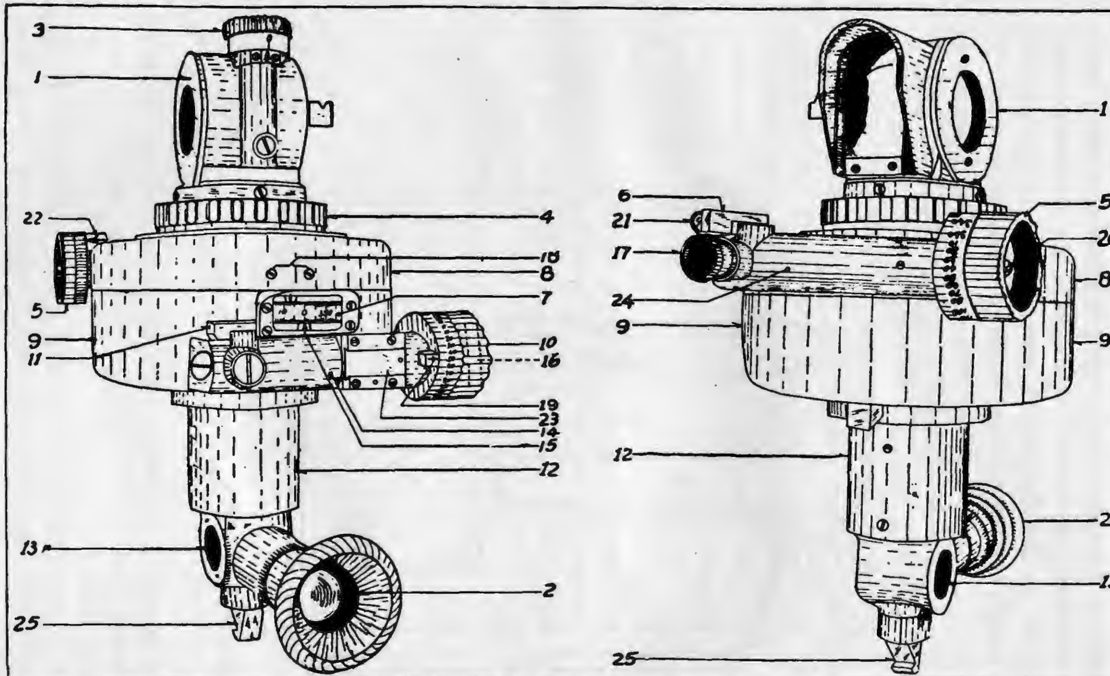


FIGURE 113.—Panoramic telescope, M1922.

1. Rotating head.
2. Eyepiece.
3. Elevation worm knob.
4. Azimuth circle adjusting collar.
5. Azimuth circle adjusting worm micrometer.
6. Azimuth circle adjusting worm throw-out lever.
7. Azimuth circle.
8 and 9. Azimuth circle housing.
10. Azimuth micrometer.
11. Azimuth worm throw-out lever.
12. Telescope housing.
13. Eyepiece elbow.
14. Azimuth worm housing.
15. Azimuth index.
16. Winged micrometer clamp screw.
17. Azimuth circle adjusting worm lock screw.
18. Screws holding auxiliary index.
19. Azimuth micrometer index.
20. Micrometer clamp screw.
21. Winged clamp screw for azimuth circle adjusting worm.
22. Azimuth circle adjusting worm micrometer index.
23. Socket for lamp bracket.
24. Azimuth circle adjusting worm housing.
25. Lug for locking sight to adapter.

the traversing rollers through suitable gearing. To assure stability, a clip on the traversing beam engages a lip on the edge of the base ring. During recoil the stresses imposed on the mount-traversing beam are very large. To take these stresses, and still permit easy traversing, a device is used which functions much as does the antifriction elevating mechanism described in paragraph 28*d*. The traversing rollers are attached to the traversing beam by means of Belleville springs heavy enough to support the weight ordinarily carried. The

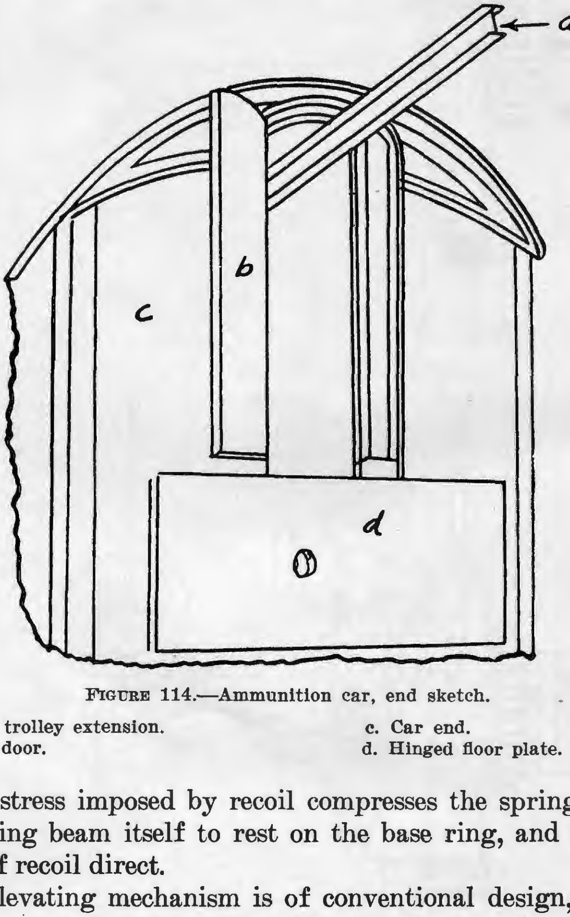


FIGURE 114.—Ammunition car, end sketch.

a. Rail trolley extension.
b. End door.
c. Car end.
d. Hinged floor plate.

additional stress imposed by recoil compresses the springs, allowing the traversing beam itself to rest on the base ring, and to transmit the stress of recoil direct.

d. The elevating mechanism is of conventional design, employing a circular rack and spur gearing. The recoil mechanism is the same as that employed on the 16-inch howitzer barbette carriage, consisting of four conventional recoil cylinders and one pneumatic recuperator cylinder. The mount has a recoil of 35 inches. For reloading, the gun is depressed to $-7°$ and the projectile loaded by sliding down a tray set on a −7° slope. For elevating and depressing by power, the mount is furnished with a self-contained power plant mounted on the front truck.

e. Sight mount, M1920.—The sight mount, M1920 (fig. 112), is standard equipment for the 14-inch railway gun, M1920.

f. Panoramic telescope, M1922.—This sight is standard equipment for the 14-inch railway gun mount, M1920.

44. Ammunition and auxiliary cars.—It is intended to supply the railway batteries with three types of standard cars—ammunition, supply, and fire-control. The ammunition and fire-control cars are steel boxcars while the supply car is a flatcar. These cars differ very slightly from the commercial cars of the same type. The fire-control car is arranged with windows and heating arrangements. The ammunition car has special ends as shown in figure 114. This consists of a folding-back floor plate and an end swing door that permits the service of projectiles and powder from the ammunition car to the mount car. This is accomplished by means of an overhead rail trolley that can be slid forward and projected over the end of the mount car. On this trolley are mounted ordinary rolling triplex blocks of sufficient capacity. In the loading of the cars a limit is placed upon the amount of ammunition per car. In the case of certain guns complete rounds (powder and projectile) are carried in the same car while in others the projectile and powder are carried in separate cars.

SECTION IX

SEARCHLIGHTS

45. General.—*a.* The range of a searchlight is the maximum distance at which an object in its beam is visible. The visibility of the object does not depend on its actual illumination but upon the contrast between its illumination and the illumination of the surrounding field. The most obvious way of improving the contrast between the illuminated target and the searchlight beam is to move the controlling observer away from the searchlight and thus decrease the depth of illuminated atmospheric particles through which he sees the target. This has the effect of decreasing the luminosity of the field, thereby improving the contrast and increasing the range.

It has been found from experience that the distance between the controller and searchlight should be at least 50 feet. Each increase in distance up to that point brings about a substantial increase in range. Most of the possible advantage to be gained by movement to one side is obtained at 50 feet.

b. All the searchlights used in our service depend upon the electric arc as their source of light. The ordinary arc light employed in street lighting and the older searchlights used two plain carbons, a positive and a negative. In the modern high intensity arc the negative carbon is a carbon pencil, with a very small core, but the positive carbon has been radically changed. It has been found that the actual light source in the arc is a globule of incandescent gas held in a crater in the positive carbon. In the old type arc this globule was of incandescent carbon gas. In the new high intensity positive carbon a core of rare earths, cerium and lanthium, has been provided. When these rare earths are fused in the arc they provide a globule of incandescent gas which is at a much higher temperature, and therefore a more intense source of light than was provided by the old style plain carbon arc.

c. When the arc is struck carbon is fused into an incandescent gas which conducts electricity. (See fig. 115.) Carbon particles flow from the negative to the positive carbon. This forms the incandescent globule of gas (which is the actual light source) by fusing the positive carbon. It is this globule of gas which must be kept at the exact focus of the parabolic mirror, as tests show that a 40 percent

FIGURE 115.—Normal appearance of arc.

loss of efficiency occurs if the light is ¼ inch out of focus. The constant bombardment of the positive carbon by carbon particles from the negative wears it away, and as this wear is concentrated at the upper edge of the positive carbon it is necessary to gradually rotate it so that the wear is uniform. In addition, means must be provided for gradually feeding both positive and negative carbons to compensate for their burning away and to maintain the globule of gas at the exact focus of the mirror. In early searchlights this rotating of the positive carbon and feeding of both carbons were done by hand. Experience showed that it was difficult for an operator to accomplish

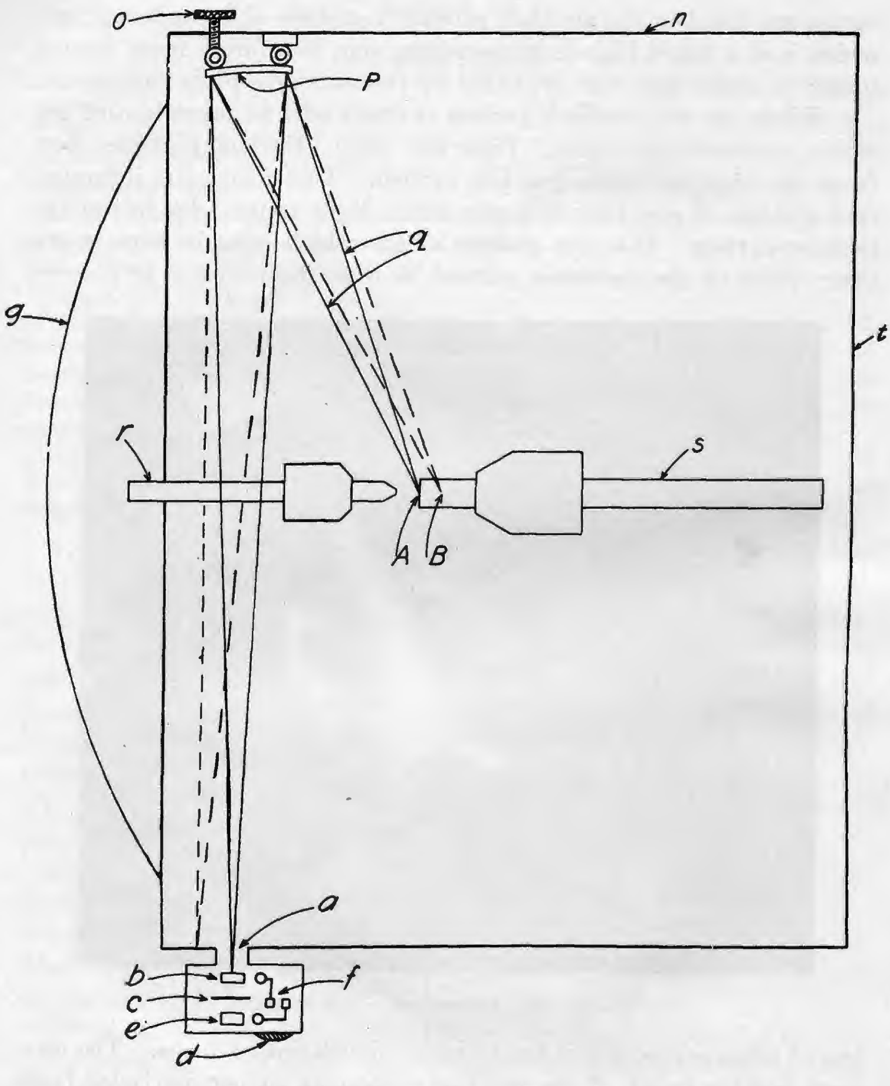


FIGURE 116.—Diagram thermostat operation.

a. Direct ray shield light slot.
b. Exposed zinc strip. } Thermostat
c. Shadow plate. } Thermostat
d. Contact viewing window. } Thermostat
e. Compensating strip. } Thermostat
f. Contacts.
g. Mirror.
n. Drum.
o. Mirror adjusting screw.
p. Thermostat mirror.
q. Light rays.
r. Negative carbon.
s. Positive carbon.
t. Front door of drum.
A. Arc crater of positive carbon in proper focal point—contacts are separated.
B. Arc crater position when zinc strip cools enough to allow contacts to touch and positive carbon is fed up to A.

NOTE: b, c, d, e, and f are enclosed in the thermostat housing.

this efficiently and so automatic mechanical means have been provided to do this work.

d. The rotation of the positive carbon is a simple motion accomplished by an electric motor. The feeding of the positive carbon is a much more complicated problem as it must be fed at a variable rate, depending on how fast it is burning away. In our modern harbor defense searchlights, use is made of a beam of light playing upon a thermostat to control this motion as shown in figure 116. The thermostat is located inside a small window. A focusing lens or mirror is employed to focus the rays of the arc on or near this window. When the light source is in exact focus, this beam of light is directed just inside the window. As the carbon burns away (and the light source therefore leaves the focal point) this beam of light leaves the window, and the thermostat cools, causing it to close an electrical contact and feed the positive carbon forward. This movement of the positive carbon brings the light source back into focus and causes the beam of light from the lens (or mirror) to enter the window, the thermostat heats, the electrical circuit is made, and the feeding of the positive carbon stops. When the positive carbon again burns away, the light again leaves the thermostat and the feeding operation is repeated. The AA searchlight employs a similar method, as shown in figure 128.

e. In addition to maintaining the light source at the focal point of the mirror it is necessary to maintain the arc at proper length. This is accomplished by regulating the feeding of the negative carbon. This feeding device is designed to maintain a constant voltage across the arc. To accomplish this, the coil of a solenoid is connected across the arc as shown in figure 117. The reciprocating shaft and the U-shaped frame attached to it is moved right and left by the rotary motion of the feed motor shaft. When the arc becomes too long and the voltage across the coil too high, it attracts an iron core which raises the U-shaped frame, engages the lower pawl, and feeds the negative carbon forward by rotating the negative feed roller shaft. If the arc becomes too short, the attraction of the solenoid for the iron core is lessened and a coil spring pulls the iron core out of the solenoid lowering the U-shaped frame, engaging the upper pawl, and causing the negative carbon to be retracted. Both feeding operations go on constantly and automatically and result in maintaining the light source at the focal point of the mirror and in keeping the arc length constant. The negative feed mechanism also serves to strike the arc when the main switch is closed.

46. Harbor defense searchlight unit.—Though all searchlights are the same in principle, there are certain definite differences in the way the original idea has been applied. Harbor defense fixed

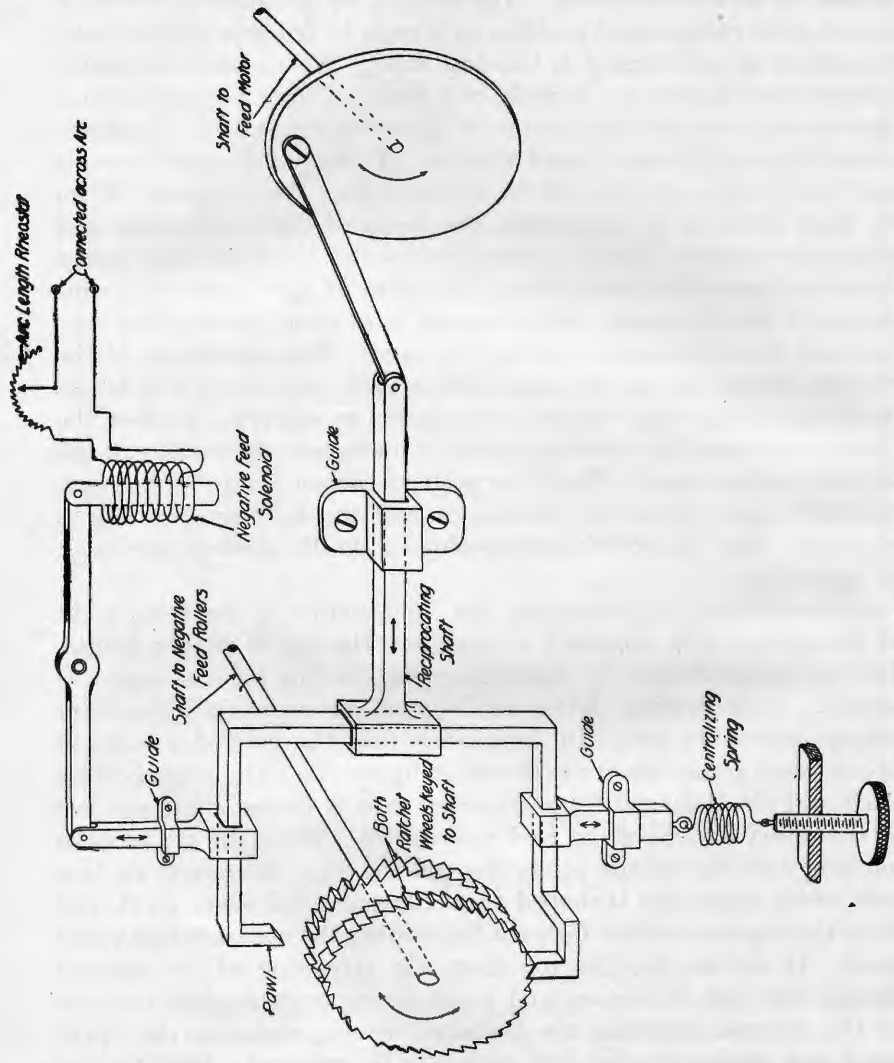


FIGURE 117.—Schematic diagram of the negative feeding mechanism.

lights may be subdivided into four general parts, and will be described as such. These parts are—

Searchlight proper (or projector).
Lamp mechanism.
Distant electric control.
Power supply unit.

In contrast to the mobile antiaircraft light, harbor defense lights are considered fixed although they may be mounted on elevators, towers, or short railroads for movement between protected daytime positions and exposed night positions.

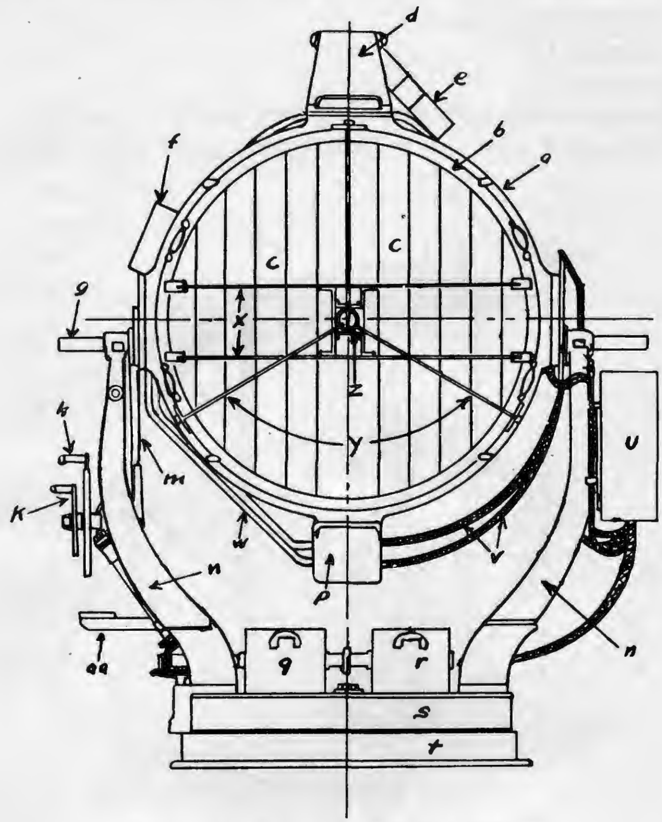


FIGURE 118.—Front view, 60-inch fixed light.

a. Drum.
b. Door.
c. Glass strips.
d. Ventilating hood and motor.
e. Muffler.
f. Thermostat instrument box.
g. Drum trunnions.
h. Traversing handwheel.
k. Elevating handwheel.
m. Elevating rack.
n. Right and left arms.
p. Lamp trough.
q and r. Training mechanism boxes.
s. Turntable.
t. Base.
u. Contactor panel box
v. Power leads.
w. Conduits.
x. Reinforcing strips.
y. Braces.
z. Carbon tube.
aa. Operator's platform.

47. Searchlight proper (or projector).—This comprises all that we generally think of as a searchlight as we look at it in figure 118.

It consists principally of—

Drum (or barrel) (a).
Parabolic mirror (60 inches in diameter).
Glass front (b and c).
Ventilating hood and motor (d).
Trunnion arms (n).
Turntable (s).
Base (t).
Hand elevating and traversing handwheels (h and k).
Lamp mechanism and various unseen parts inside the drum.

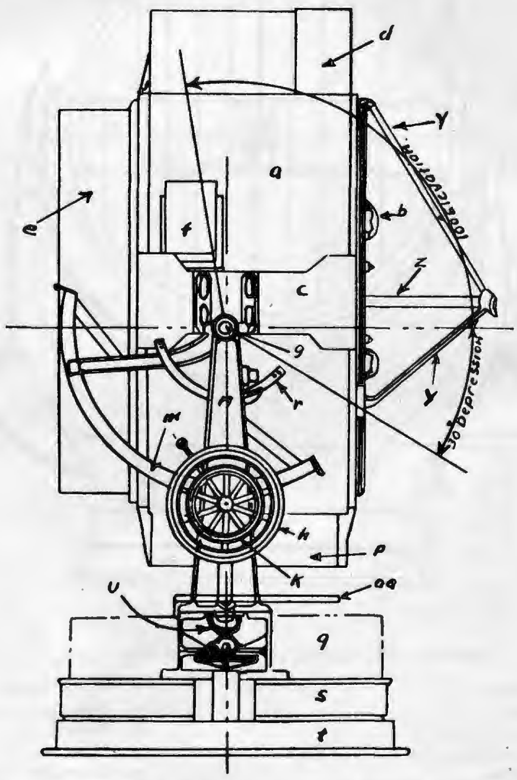


FIGURE 119.—Side view, 60-inch harbor defense searchlight.

a. Drum.
b. Door handles.
c. Side plate.
d. Ventilating hood.
e. Mirror frame and dome.
f. Thermostat instrument box.
g. Drum trunnion.
h. Traversing handwheel.
k. Elevating handwheel.
m. Elevating rack.
n. Right arm.
p. Lamp trough.
q. Training mechanism box.
r. Elevating scale arm.
s. Turntable.
t. Base.
u. Training gears.
y. Braces.
z. Carbon tube.
aa. Operator's platform.

Figure 119 shows a side view of the same searchlight.

The drum is the barrel of the searchlight and is a short cylinder about 60 inches in diameter connecting the mirror with the glass front. If the searchlight is compared to a gun and carriage we find the following corresponding parts:

Searchlight	*Gun and carriage*
Drum	Gun barrel
Mirror	Breechblock
Glass front	Muzzle cover
Trunnions	Trunnions
Trunnion arms	Side frames
Turntable	Racer
Base	Base ring

Hand elevating and traversing are accomplished much as for a fixed gun.

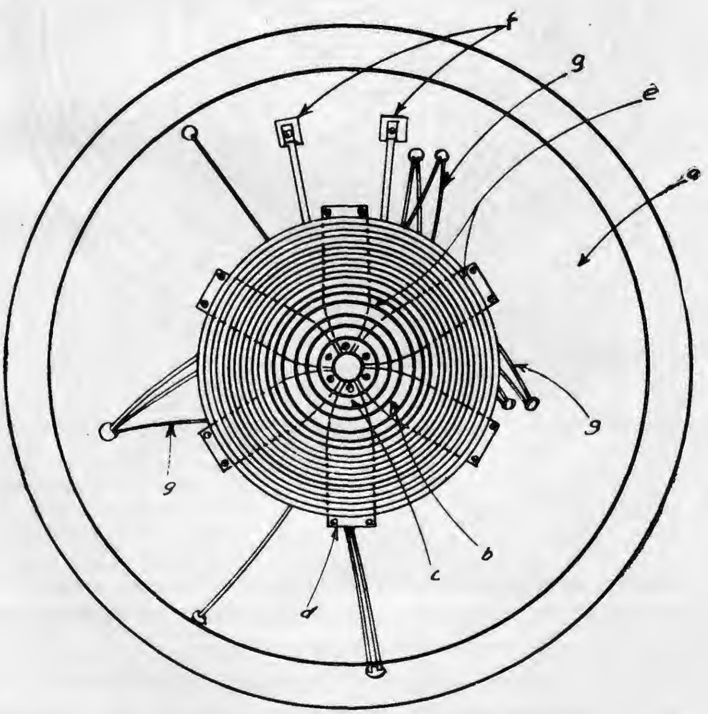


FIGURE 120.—Turntable, underside.

a. Turntable.
b. Positive contact ring.
c. Negative contact ring.
d. Contact ring insulation.
e. Training contact rings (10).
f. Main power leads.
g. Training circuit leads.

In the turntable (fig. 120) are located the contact rings for the transmission of operating power and distant electric control power from the base to the proper motors on the light. These rings permit free rotation without danger of twisting off any cable connections between turntable and base. In the base (fig. 121) are the contact plungers (or brushes) which bear on the contact rings in the turntable.

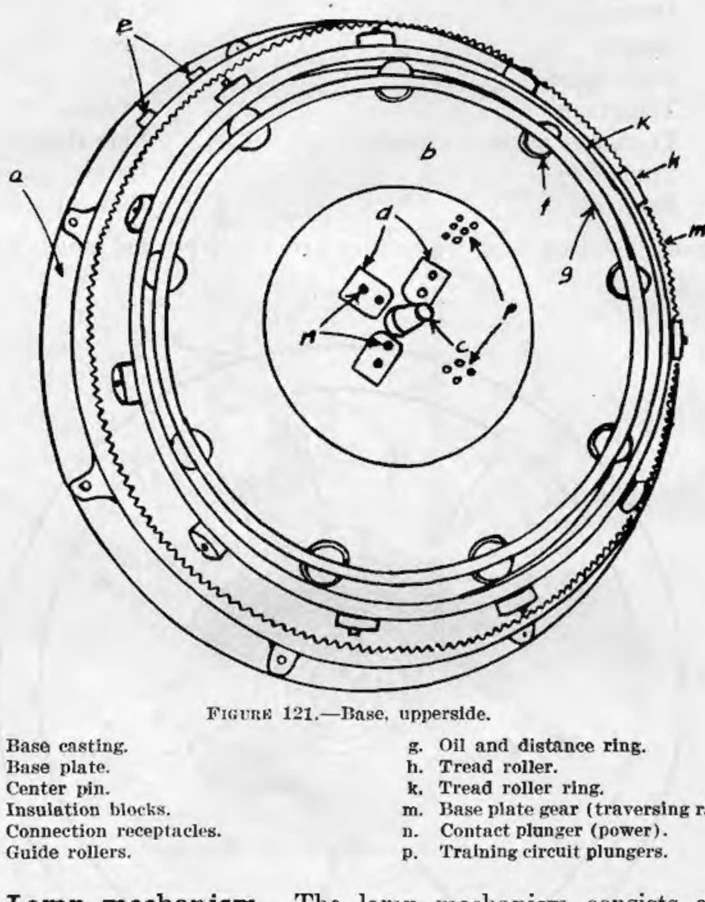


FIGURE 121.—Base, upperside.

a. Base casting.
b. Base plate.
c. Center pin.
d. Insulation blocks.
e. Connection receptacles.
f. Guide rollers.
g. Oil and distance ring.
h. Tread roller.
k. Tread roller ring.
m. Base plate gear (traversing rack).
n. Contact plunger (power).
p. Training circuit plungers.

48. Lamp mechanism.—The lamp mechanism consists of the lamp control mechanism, the positive and negative (carbon holding) heads, and the relay controlled circuit breakers.

a. Lamp control mechanism.—The lamp control mechanism contains all the mechanism for feeding the carbons so as to maintain the light source at the focal point of the mirror. The motor that furnishes the power for these operations also drives a small fan that cools the positive and negative heads. The positive feed is controlled

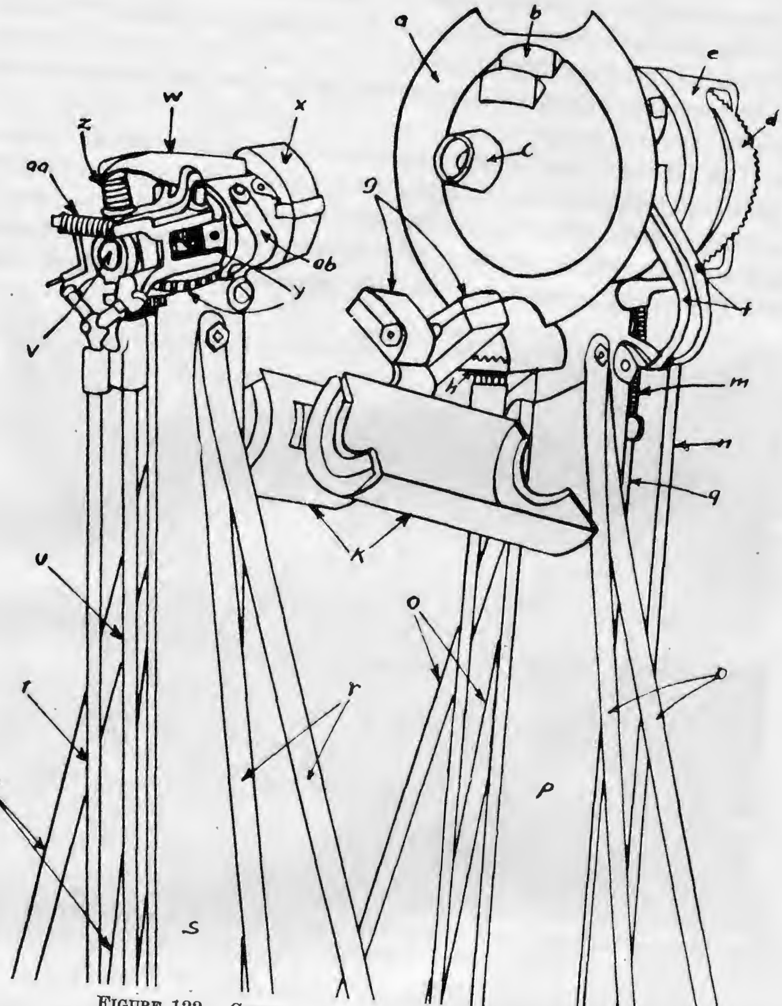


FIGURE 122.—General view, columns, heads, and occulter.

a. Front cap and stray light shield.
b. Ventilating vents.
c. Positive carbon.
d. Positive head bevel gear.
e. Bearing cage casting.
f. Contact strip brush leads.
g. Occulter counterbalance weights.
h. Occulter gear.
k. Occulter caps.
m. Star wheel feed rod spring.
n. Positive head driving shaft.
o. Airtube braces (positive).
p. Positive column airtube.
q. Star wheel feed rod.
r. Airtube braces (negative).
s. Negative column airtube.
t. Negative carbon release shaft.
u. Negative feed shaft.
v. Negative carbon.
w. Compression spring lever.
x. Negative head.
y. Negative feed gear.
z. Compression spring.
aa. Feed roller bracket spring.
ab. Negative contact strip leads.

NOTE.—The above columns and shafts extend down into the control box.

by a thermostat as shown in figure 116 and described in paragraph 45*d*. The negative feed mechanism which governs the arc length has been described in paragraph 45*e*.

b. The carbons themselves are carried in the positive and negative heads (fig. 122).

(1) The positive head is on the right of the figure. As the positive head receives most of the heat, its operating parts are protected by a large bronze shield (a). In addition, a quartz bushing supports a portion of the carbon which projects beyond the shield. Behind the shield is mounted the feed mechanism, which feeds the

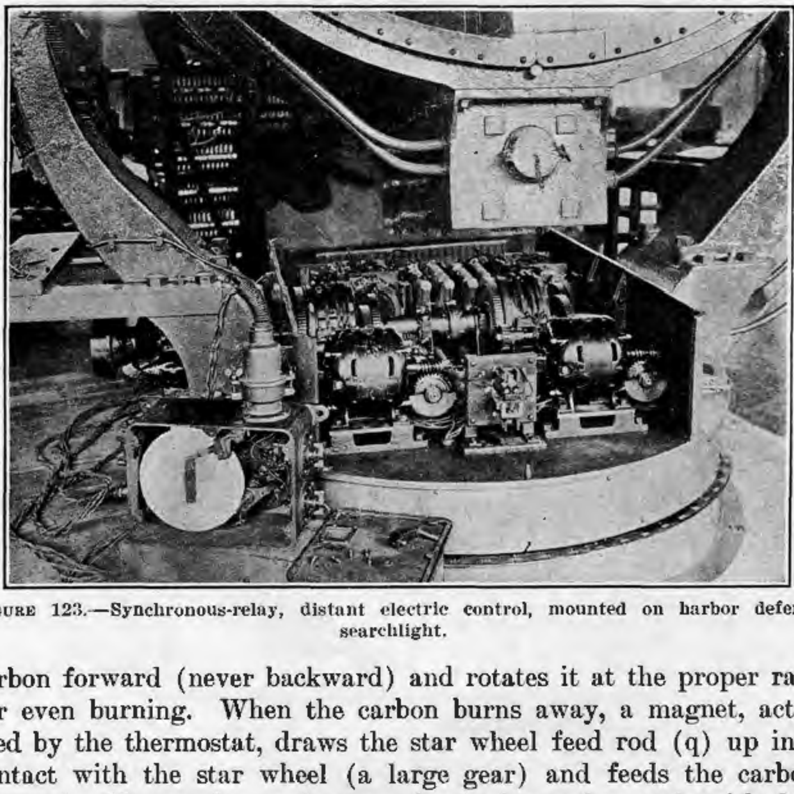


FIGURE 123.—Synchronous-relay, distant electric control, mounted on harbor defense searchlight.

carbon forward (never backward) and rotates it at the proper rate for even burning. When the carbon burns away, a magnet, actuated by the thermostat, draws the star wheel feed rod (q) up into contact with the star wheel (a large gear) and feeds the carbon forward. The occulter and accessories (g, h, and k) are furnished to secure instant darkening of the light. However, since a high-intensity carbon has little afterglow, the occulter is little used. The positive carbon is inserted from the front through a carbon tube (z, fig. 119) extending through the center of the glass front. Although the positive carbon is consumed more rapidly than the negative, it is good practice to recarbon both heads at the same time. To enable the operator to keep the light source (the incandescent globule) at the focal point of the mirror and the arc at the proper length, a ground-glass view finder is furnished, which shows the arc at ¾ size. By marking the proper positions of the positive and negative carbons on this finder, it is possible to have efficient operation without frequent refocusing.

(2) The negative head (x) (on the left in fig. 122) holds the negative carbon (v) and feeds it forward or back as actuated by the negative control rod (u). The negative carbon is inserted from the rear (left) by separating the feed rollers which support the carbon. After insertion, these rollers grip the negative carbon, support it, and feed it backward and forward.

49. Distant electric control (D. E. C.).—Distant electric control is desirable for two reasons. It enables the searchlight to be controlled from a point at a distance from the light itself, thus greatly increasing the efficiency of the operator-light team, and it enables the light

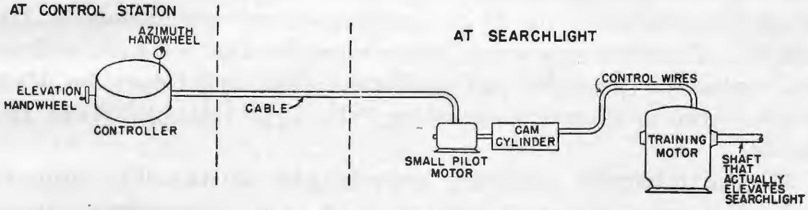


FIGURE 124.—Distant electric control showing general functioning of parts.

to be controlled directly from the observation post of the commander of the particular tactical unit using the light.

a. Controls.—The control in general use is of the synchronous-relay type. At the control station is located the device called the controller for traversing and elevating the light, and for turning it on and off. The necessary distant electrical control motors and their controls (fig. 123) are mounted on the light itself. The technical details of the operation of the distant electrical control are beyond the scope of this manual. The general idea is illustrated in figure 124. When the operator in the control station turns the elevation handwheel, electrical impulses are sent over wires to the armature of a small pilot motor. As this motor is too small to elevate the light directly, it is used to control a cam cylinder. This cam cylinder, operating through suitable contactors and resistances, controls the power to the large training motor which elevates or depresses the light.

A similar hook-up controls the azimuth.

The controller has two electric switches, one to throw the current on or off at the lamp of the projector, the other to give two speeds of operation to the projector. This change in speed is accomplished by a magnetic clutch located between the training motor and the traversing or elevating pinion. When the switch is turned in the direction marked "fast" the speed is 7½ times greater than when the switch is at the position marked "slow." The whole system requires ten conductors in the cable connecting controller and light and is reliable up to distances of 2 miles.

A hand elevating, traversing, and main switch mechanism is provided at the searchlight for emergency use.

b. Synchronous type controller.—This controller is the old standard type which is employed by some searchlights now installed in the various harbor defenses. Although no longer standard, these units will be continued in service during the life of the searchlights on which they are installed.

This controller operates on the same general principle as the synchronous-relay type.

50. Power supply unit.—The standard power unit for the harbor defense searchlight is the 25 kw. gasoline-electric generating set, type GM 12. Complete operating instructions for this set will be found in "Instruction Book No. 1, Installation, Care, and Operation of the 25 kw. Gasoline-Electric Generating Sets, Type GM–12," W. D. Doc. No. 497.

51. Antiaircraft artillery searchlight units.—The illumination of aircraft for night defense is of prime importance. Aerial bombardment of rear areas will, as a rule, be carried on at night.

Since 1917 the antiaircraft searchlight and its auxiliary equipment has been in a continuous state of development, keeping pace with other antiaircraft matériel. As a result several types of searchlights, power units, distant electric controllers and comparators will be met with in the service. Any major emergency will undoubtedly require the use of superseded models now in storage. The 60-inch mobile searchlight unit, M1939, is the latest type in service. The following earlier types will be found in the service:

36-inch barrel type.
60-inch open type.
MI.
MII.
MIV.
MVI.
M1934.
M1937.

52. MVI searchlight unit.—The MVI searchlight unit was the first unit, embodying all the modern features, to be issued in quantity. For convenience a detailed description of this unit will be given below and other models will be described later by showing their points of difference.

a. Characteristics.—Experiments have shown that the optimum efficiency consistent with desired mobility and limit of size is obtained in a searchlight having the following characteristics:

60-inch parabolic mirror (glass or metal).
150- to 200-ampere, high-intensity arc.
High-intensity soft-core positive carbon.
Cored negative carbon.
Full automatic regulation of arc length and focal position of positive carbon.

With few exceptions all antiaircraft searchlights have these features, and therefore a thorough understanding of the principles and operation of the MVI searchlight will be applicable with little change to the operation of other models.

b. Components of searchlight unit.—Each of the modern models of the 60-inch mobile searchlight unit has the following components:

Searchlight.
Power unit.
Sound locator.
Control station.
Cables.

c. Detailed description.—Figure 125 shows the arrangement of these components in the normal set-up of the complete unit. On the right, the power unit B is shown. Through cables (1) it supplies D. C. power for the arc and distant electric controller. Cable (2) carries the 120-volt single phase alternating current required for the comparator data transmission. Cables (1) and (2) are 600 feet in length. The searchlight A, actually 600 feet away from the power unit, is shown in the upper center. Cable (4) connects the distant electric controller to the searchlight A while the right section of cable (3) transmits the azimuth and elevation of the searchlight back to the comparator. Cables (3) and (4) are 200 feet long. 120-volt alternating current power for operating the data transmission system is furnished by a rotary converter mounted on the truck chassis. The rotary converter changes the direct current developed by the searchlight generator to alternating current. The comparator E and distant electric controller F together constitute the control station and are shown in the lower center. The sound locator C is connected to

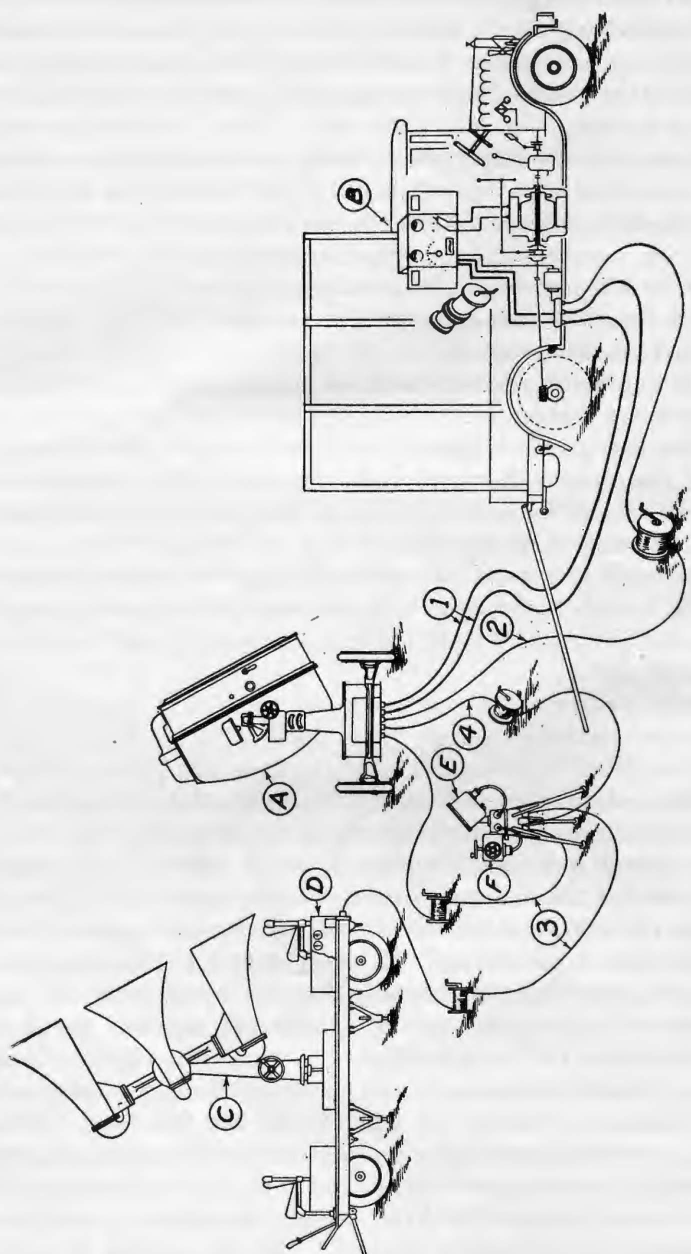


FIGURE 125.—Arrangement of searchlight equipment.

the comparator by the left section of cable (3), also 200 feet in length. This cable transmits the azimuth and elevation of the sound locator, corrected by the acoustic corrector D, to the comparator.

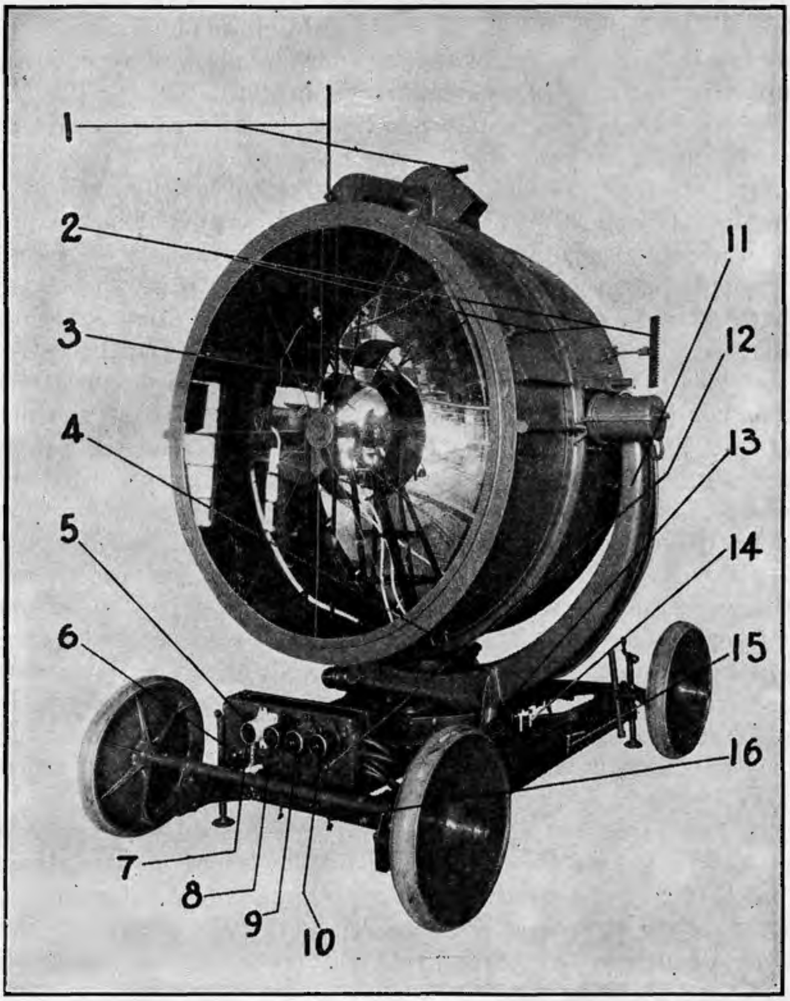


FIGURE 126.—60-inch mobile search light, MVI.

1. Daylight training sights (azimuth).
2. Daylight training sights (elevation).
3. Stray-light shield.
4. Sliding door into drum.
5. A. C. supply receptacle.
6. A. C. supply switch.
7. Comparator cable receptacle (white).
8. Controller cable receptacle (red).
9. Positive power cable receptacle (yellow).
10. Negative power cable receptacle (yellow).
11. Pocket for recarboning wrench.
12. Azimuth training motor switch.
13. Azimuth lock arm.
14. Azimuth lock bracket.
15. Azimuth lock pin.
16. Eye for winch cable.

Careful orientation of the sound locator and searchlight is necessary, in order that the matching of azimuths and elevations of the sound locator and searchlight will train the searchlight in the direction determined by the sound locator.

53. Searchlight, MVI.—*a.* The searchlight is of aluminum alloy construction, the rear half being cast in one piece to form a rigid support for the parabolic glass mirror (fig. 126).

The lamp mechanism is of the fully automatic type with provision for semiautomatic and manual control.

Training of the searchlight may be accomplished by hand at the searchlight; by extended hand control which permits of its operation in elevation and azimuth mechanically at a distance of 12 feet; or by remote electric control. The last method is normal.

b. Drum and chassis.—(1) The front half of the drum is provided with two sliding doors so that access to the lamp is available from either side of the searchlight drum. A tubular guard for the positive carbon is provided at the center of the glass front. Bayonet type locking studs permit this tube to be held in either its housed position, inserted within the drum, or in its outer position. A ventilating motor is mounted on top of the drum. Its purpose is to scavenge burnt gases and soot from the drum and at the same time to cool the interior. A set of daylight sights is mounted on the searchlight for the purpose of training, and determining the accuracy and efficiency of the personnel and comparator systems during daylight drills against a moving target.

Mounted on the right-hand side of the drum is the lamp-control box (figs. 127 and 129) containing the feed motor and the various control knobs. Below the lamp-control box are the focusing knob; ammeter and voltmeter; ground glass finder; elevation training motor; and main switch for the arc.

(2) The searchlight chassis (fig. 126) is equipped with four leveling screws and two sets of level vials. One set of vials is accurate to one-half degree and the other to one minute. Also mounted on the chassis are the receptacles for the cable plugs; the azimuth training motor; a switch to energize the A. C. transmission system; an azimuth clutch; and a locking pin.

On the trunnion yoke and base are mounted a movable azimuth circle; the azimuth A. C. transmitter; resistors (for reducing the 100-volt direct current to 35 volts required in the distant electric control); and switches for meter and scale lights as well as for the azimuth part of the distant electric control.

c. Operating principles of the lamp mechanism.—The high-intensity arc is kept at the focal point of the mirror by means of a thermostat

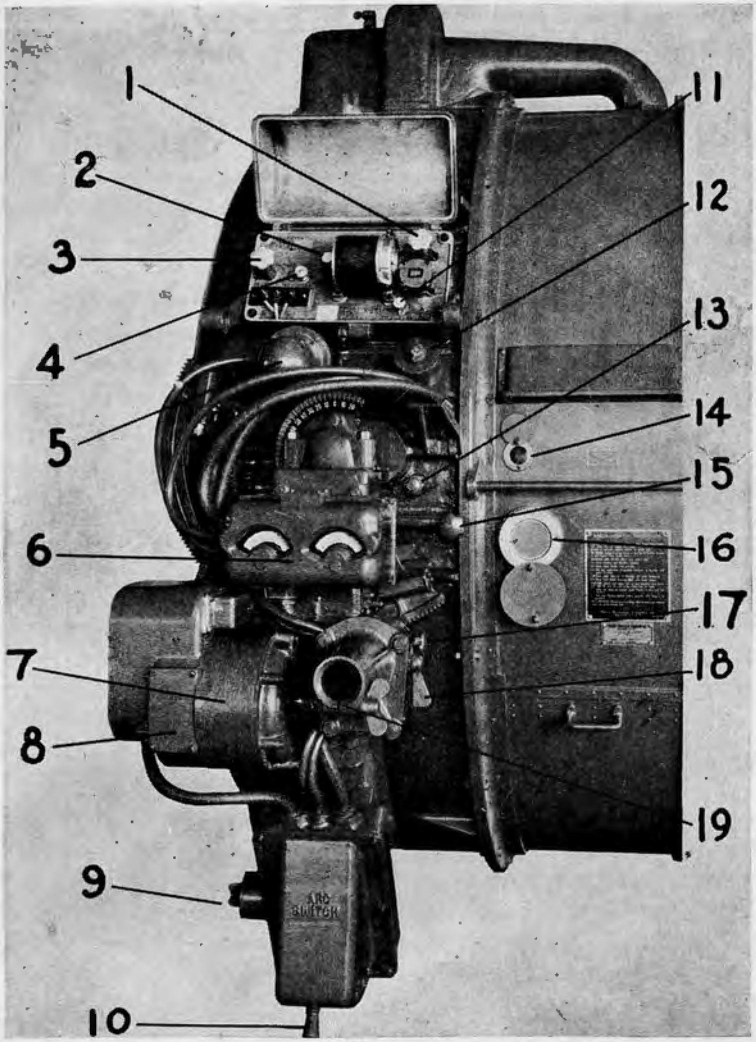


FIGURE 127.—Right-hand side of searchlight.

1. Hand-feed knob (positive).
2. Positive feed adjusting knob.
3. Hand-feed knob (negative).
4. Centralizing knob.
5. Scale illuminating lamp.
6. Voltmeter and ammeter.
7. Elevation training motor.
8. Oil hole.
9. Lamp switch for meters and scales.
10. Arc switch.
11. Arc-length adjustment knob.
12. Recarboning-lamp switch.
13. Thermostat adjusting screw.
14. Arc peephole.
15. Focusing knob.
16. Ground glass finder.
17. Elevation clamping lock.
18. Elevation clutch lever.
19. Socket for extended hand control.

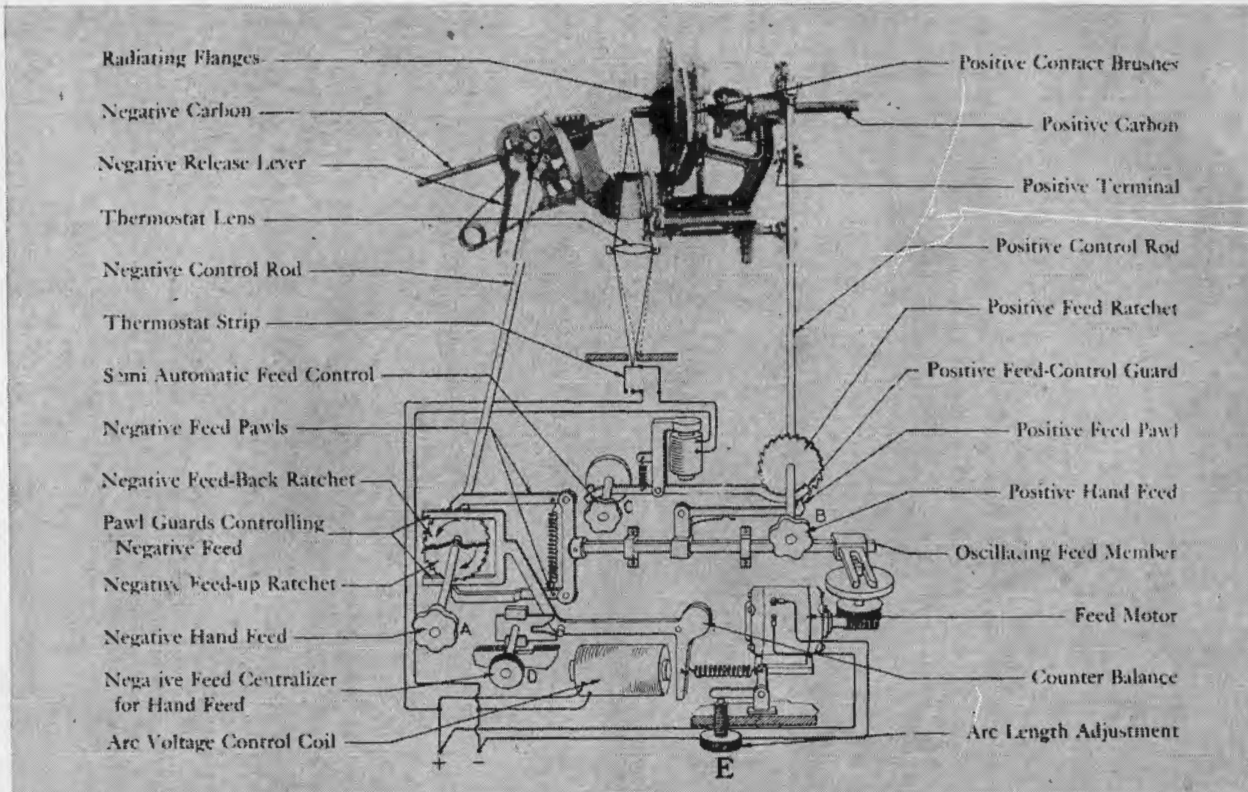


Figure 128.—Schematic diagram of the lamp mechanism and control box.

controlled feed mechanism. The feed mechanism is actuated by a small shunt motor designed to operate normally at 78 volts direct current (arc voltage). This feed motor drives an eccentric which causes the oscillating feed member to reciprocate, thereby actuating the positive and negative feed.

(1) *Positive feed.*—The positive carbon is fed forward either by hand or automatically. It cannot be fed backward. The automatic thermostat control operates as described in paragraph 45*d*, using a lens instead of a mirror (fig. 128) for focusing the rays of the arc.

The oscillating feed member carries the positive feed pawl which slides over the positive feed-control guard. Each reciprocation of the oscillating feed member causes the positive feed pawl to engage normally one tooth of the positive feed ratchet, thus rotating slightly the positive control rod which is fastened to the positive feed ratchet. Rotation of the positive feed rod feeds the positive carbon forward and at the same time rotates the positive carbon. As soon as the positive carbon burns back $\frac{1}{64}$ inch, the light from the crater (concentrated by the thermostat lens) is thrown onto the bimetallic thermostat strip. The resulting intense heat causes warping of this strip and closes an electric contact. The thermostat magnet coil becomes energized, attracts the positive feed-control guard, and allows the positive feed pawl to engage a greater number of teeth, thereby increasing the rate of feed of the positive carbon until the crater again reaches the focal position. The concentrated light rays then cease to fall in the thermostat slot and the thermostat contacts open. The normal rate of feeding is again resumed until the conditions just described are repeated. In case the thermostat should fail, the normal rate of feed can be increased by means of the semiautomatic feed-control knob. The positive carbon may be fed and rotated manually by means of the positive hand feed knob. Figure 129 shows the exterior of the lamp control box where all controls of the positive and negative carbons are located.

NOTE: It is important that this normal rate of feeding be less than the rate of burning, as otherwise the positive carbon will chase the negative back into the negative head and melt the head.

(2) *Negative feed.*—The negative carbon can be fed forward or backward at a rapid rate, either by hand or automatically. The voltage across the arc varies with the distance between the positive and negative carbons. This variation is used to control the relative position and feeding of the negative carbon as described in paragraph 45*e*. The negative carbon can be fed forward or backward by hand

when the fork carrying the feed pawls is centralized, which is accomplished by moving the negative feed centralizer knob to the left. The negative control rod can then be turned freely in either direction by means of the negative hand feed knob.

54. Power unit.—The essential features of the power unit follow:

a. Chassis.—A duplex truck transports the searchlight and furnishes power for its operation. The same motor that operates the truck drives a D. C. generator for furnishing power for the searchlight. The D. C. generator is mounted in rear of the transmission. A hand clutch is provided so that the engine of the truck may engage and

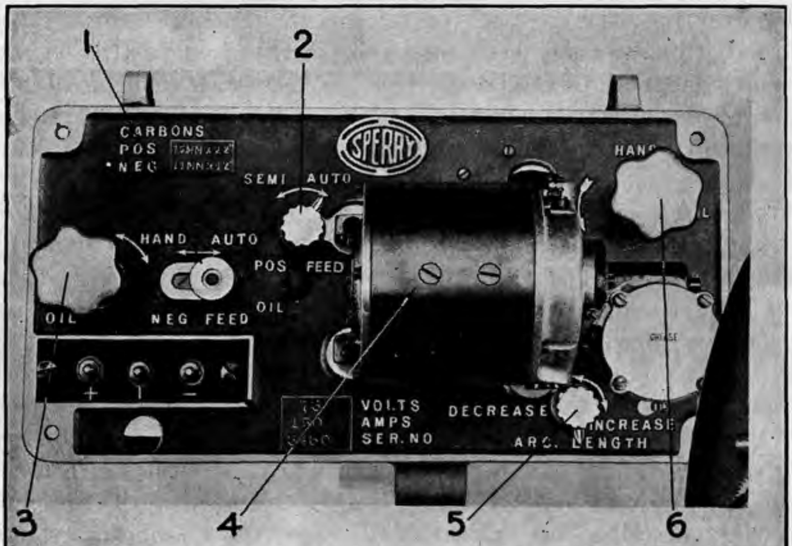


FIGURE 129.—Exterior of lamp control box.

1. Negative feed centralizer knob.
2. Semiautomatic feed control knob.
3. Negative hand feed.
4. Feed motor.
5. Arc length adjustment knob.
6. Positive hand feed.

operate the D. C. generator or drive the truck as desired. The lever controlling this clutch is on the left of the driver's seat.

b. Engine.—The engine is a 6-cylinder, 55 hp., Buda, type DW-6. A fly-ball type governor is provided for maintaining an engine speed of 1,800 r. p. m. when driving the generator. The governor is cut into operation by pressing the governor cut-out button on the dash. A speedometer reading of from 23 to 27 miles per hour indicates proper adjustment of the governor.

c. Body.—A specially designed body provides for convenient carrying of the searchlight, its auxiliaries, and four members of the crew, as well as the permanent mounting of the main cable reel, control panel, and loading winch.

Figure 130 shows a rear view of the power unit with the ramps in position for loading, cable in place, comparator in box, and the tripod in traveling position.

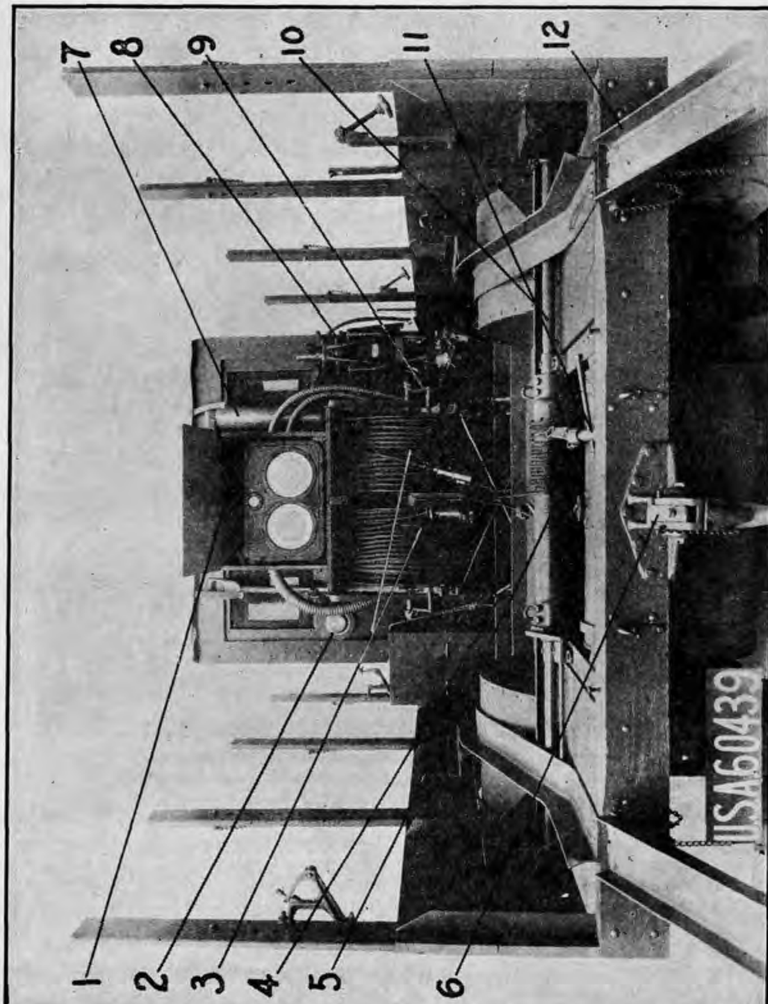


FIGURE 130.—Duplex truck, rear view.

1. Comparator box.
2. Loading light.
3. Main power cables.
4. Locking pins for searchlight.
5. Loading winch.
6. Coupler.
7. Carbon container.
8. Control station tripod.
9. Cable reel cranks.
10. Pins for locking seat.
11. Turnbuckle for locking searchlight.
12. Ramps in loading position.

d. Searchlight generator.—The 15-kw. flat compounded generator mounted on the chassis is designed to deliver 150 amperes at 100 volts at 1,800 r. p. m. The armature is carried on a hollow shaft, concentric with the main drive shaft, so that the armature does not revolve when the car is being driven over the road. Two ventilating covers are provided on the generator; the one located on the top near the front end is hinged, and the other located on the right side near the end is pivoted. Both ventilating covers must be open when the generator is operating and closed when the unit is on the road.

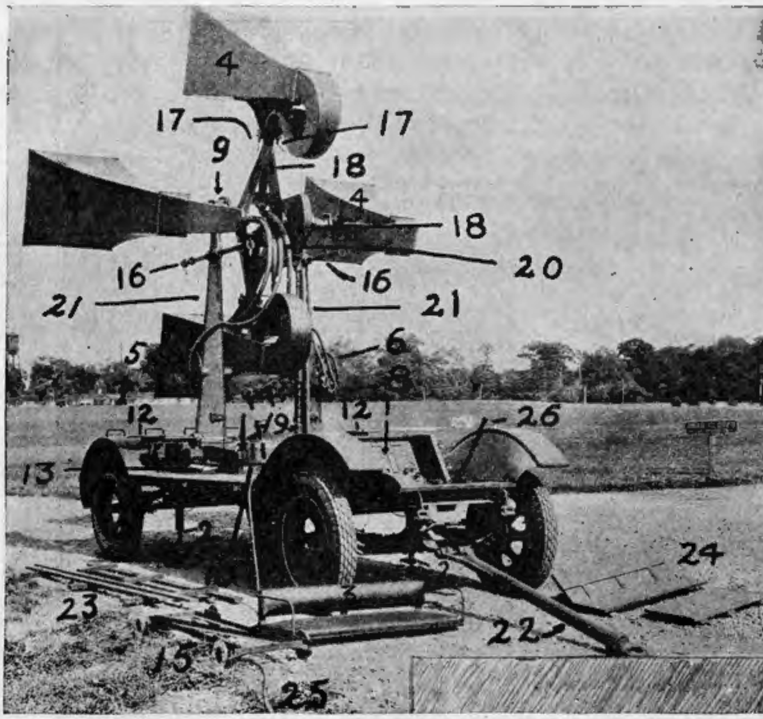


FIGURE 131.—Sound locator, M1A1, in listening position.

1. Acoustic corrector.
2. Jacks.
3. Front seat (removed).
4. Horns.
5. Traversing handwheel.
6. Elevating handwheel.
7. Headset (azimuth).
8. Headset (elevation).
9. Horn bearings.
10. Azimuth circle.
11. Turntable.
12. Seats for operators.
13. Footrest.
14. Adjustable locking screws.
15. Horn locking frame (removed).
16. Traveling horn supports.
17. Hand clamp screws.
18. Horn support sections.
19. Elevation control shaft.
20. Rubber tubes.
21. Vertical columns.
22. Towing bar.
23. Side frames.
24. Covers for acoustic corrector.
25. Cable leading to comparator.
26. Brake handle.

e. Power panel.—The operation of the searchlight generator and the rotary converter is controlled by a power panel mounted directly behind the driver's seat. The equipment on the power panel includes circuit breakers for the 150-ampere searchlight load; a field rheostat for the searchlight generator; a D. C. voltmeter and D. C. ammeter for the searchlight generator; a switch for starting the rotary converter; and an A. C. voltmeter for indicating the A. C. voltage delivered by the rotary converter.

55. Sound locators.—Sound locators are used to furnish approximate target location data to the searchlights. A description of the theory and practice of their operation will be found in FM 4-110.

a. M1A1 sound locator.—(1) Many of the locators in use in our service at present are some modification of the M1 model (fig. 131). These locators employ four metal exponential horns, two for azimuth and two for elevation. Data as to the target's location are transmitted mechanically to an acoustic corrector (1). The upper and

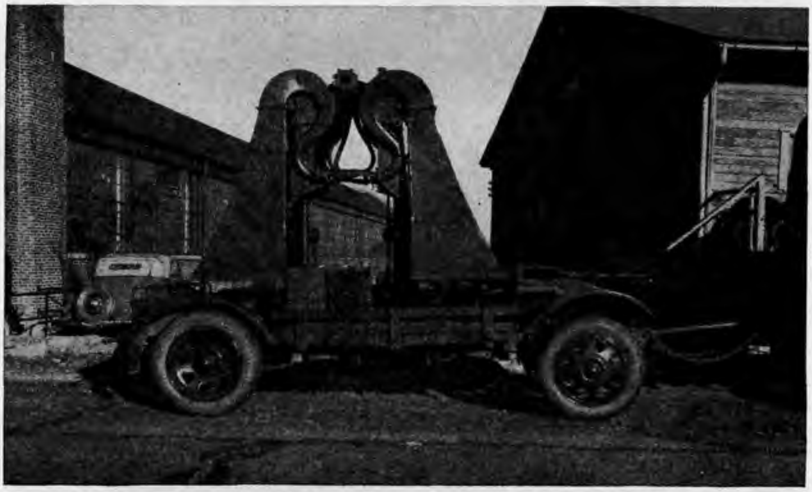


FIGURE 132.—M1A1 sound locator in traveling position.

lower horns are the elevation horns; the right and left horns, the azimuth. Each pair is connected by rubber tubing to a listener who centers the sound heard, moving the horns by turning a handwheel (5 and 6). It is extremely important that each horn be hooked to the proper earpiece, as otherwise confusion and inefficient operation will result. The locator is mounted on a 4-wheeled trailer weighing some 5,000 pounds. In traveling, the horns are removed and shifted to a more compact traveling position (fig. 132).

(2) *Acoustic corrector.*—Using as arguments the angular travel and the estimated altitude of the airplane, the acoustic corrector corrects the azimuth and elevation, indicated by the horns, for the travel of the target during the time required for the sound to reach the locator. This corrected direction of the airplane (elevation and azimuth) is

then transmitted automatically by two A. C. data transmitters to the comparator. (See fig. 138.) This instrument and its operation are fully described in FM 4-110.

b. Sound locator M2.—(1) As may be seen from figure 133, the M2 sound locator differs radically in appearance from the M1. It has only three horns instead of four, as one horn has a split sound track so that one of its tubes goes to the azimuth listener and one to the elevation listener. The horns are of a combined conical and exponential type, with thick side walls of balsa wood to cut down parasitic noise. The edges of the horns have been carefully rounded to prevent the wind whistling as it passes over them. Figure 133 also shows the three-man crew required—one elevation listener, one azimuth listener, and one acoustic corrector operator.

FIGURE 133.—Sound locator, M2, in listening position.

(2) The acoustic corrector is also of radically different design. This corrector uses the estimated target speed as an argument in calculating the sound lag correction. Provision is also made for corrections for parallax between locator and searchlight.

(3) The complete unit weighs 450 pounds. No trailer is furnished, and the unit is divisible into five loads varying from 30 to 295 pounds each in weight. As may be seen (fig. 134), the locator may be carried

in the body of the same cargo truck that carries a portable power plant.

56. Control station.—A control station must meet two requirements—it must train the searchlight from a distance, and it must afford a means of pointing the light at the point in the sky indicated by the sound locator. The control station for the MVI unit (fig. 135) has two distinct parts, each designed to fulfill one of the above requirements.

a. Distant electric controller.—The distant electric controller (2, fig. 135) enables the operator to control the searchlight through

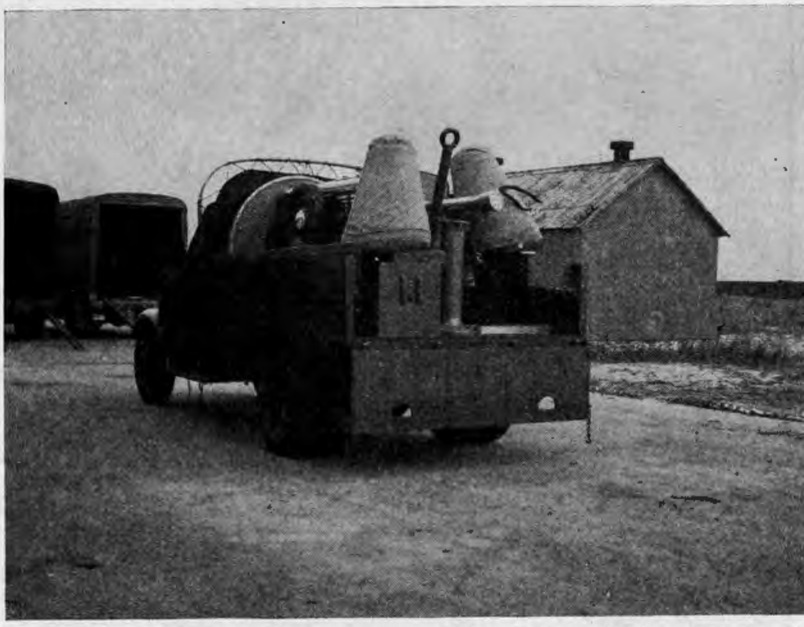


FIGURE 134.—M2 sound locator in traveling position (parts loaded into cargo truck).

azimuth and elevation handwheels mounted on the controller box. It is of the brush-shifting type, sending electrical impulses to a small brush-shifting motor mounted on the light. This small, relatively weak motor shifts the brushes of the training motor and causes it to traverse or elevate the light the desired amount. The technical details are too involved to explain here but the general idea is shown in figure 136.

b. Comparator.—The comparator indicates the relative position of locator and light on two large dials (fig. 137). Only the azimuth section of the comparator will be described as the elevation section operates in a like manner. The azimuth of the target is transmitted

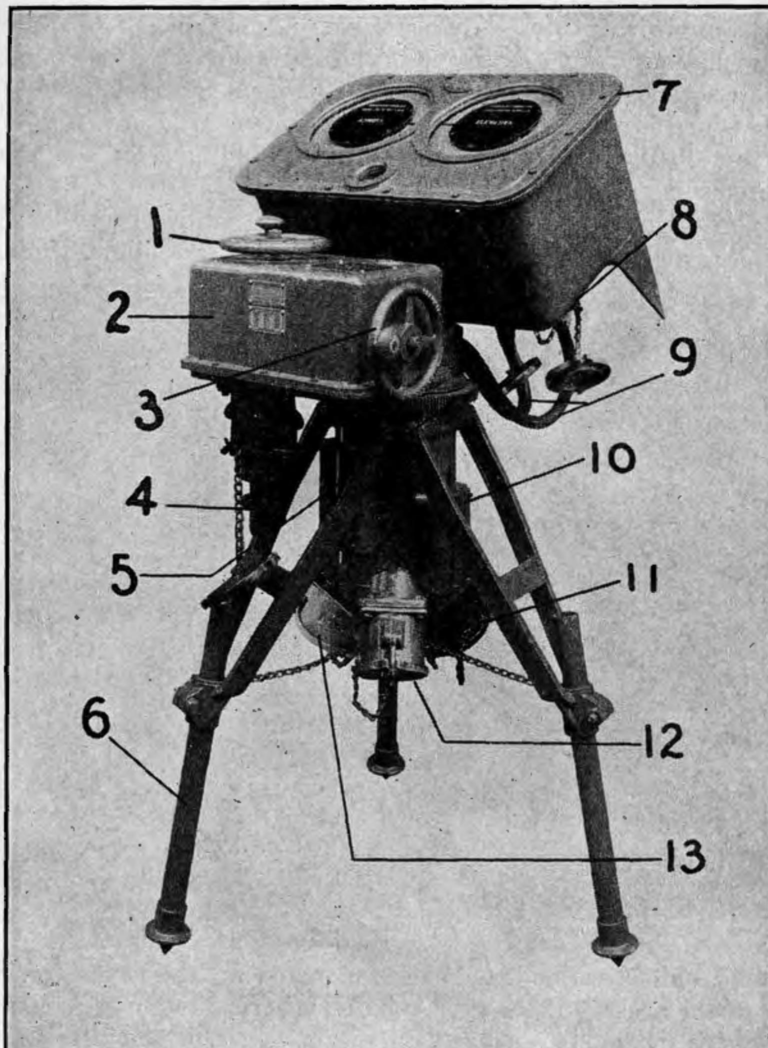


FIGURE 135.—Control station.

1. Azimuth handwheel.
2. Searchlight controller.
3. Elevation handwheel.
4. Cable from tripod to controller.
5. Azimuth training gear.
6. Tripod.
7. A. C. comparator.
8. Synchronizing knobs.
9. Cables from tripod to comparator.
10. Slip ring cover.
11. Receptacle for controller cable (red).
12. Receptacle for sound locator cable (blue).
13. Receptacle for searchlight cable (white).

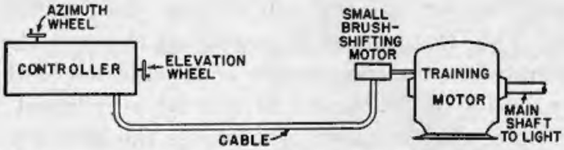


FIGURE 136.—Distant electric control MVI searchlight unit, showing general functioning of parts.

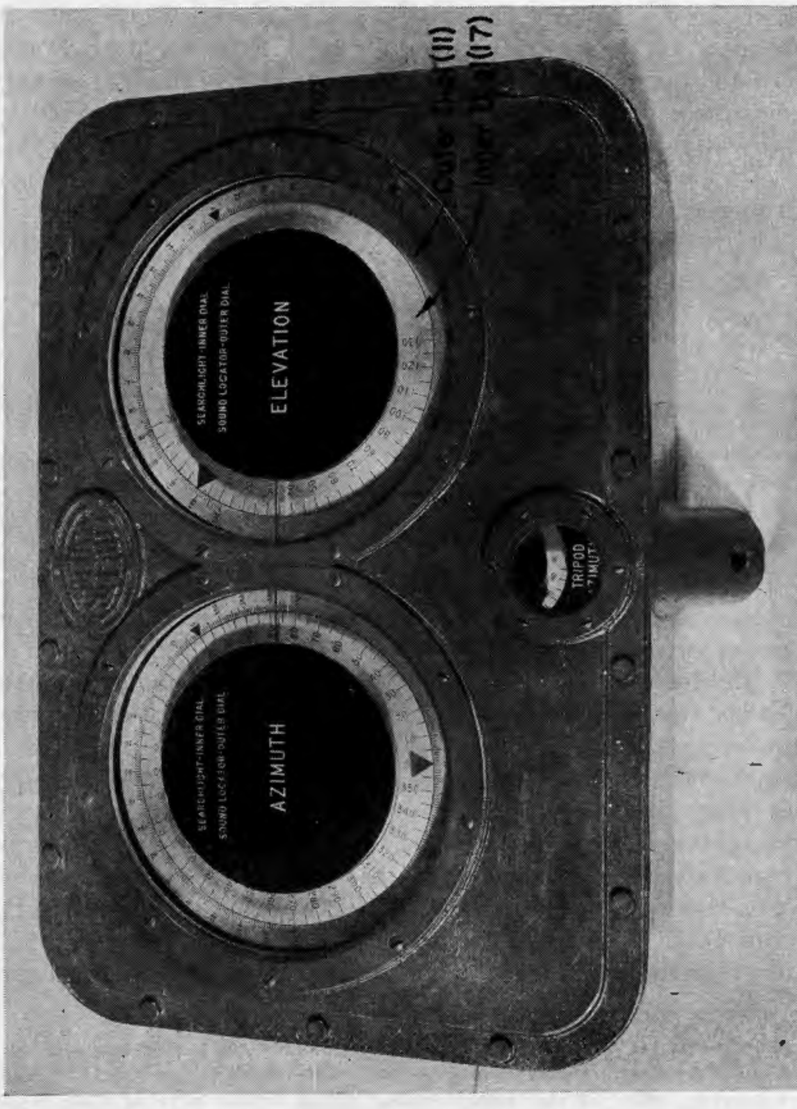


FIGURE 137.—Face of AA searchlight comparator, MIII.

from the sound locator by a self-synchronous data transmitter of the normal type. This transmitter is connected through the cable with a receiver mounted in the comparator and connected to the outer dial (11). Every motion of the locator in azimuth is reflected in the movement of this outer dial—it always indicates the azimuth sent out by the locator. Similarly the searchlight sends its azimuth to the inner dial, which always indicates the light's azimuth. By matching the indexes on the two dials, the light is brought to point in the direction indicated by the locator. The general idea is shown in figure 138. In actual practice the controller operator searches a few degrees each side of the point indicated by the sound locator. This is necessary because the error of the locator is larger than the area covered by the searchlight beam.

c. Slip rings.—Mounted on the tripod supporting comparator and controller are the slip rings. These rings, which handle 21 electrical

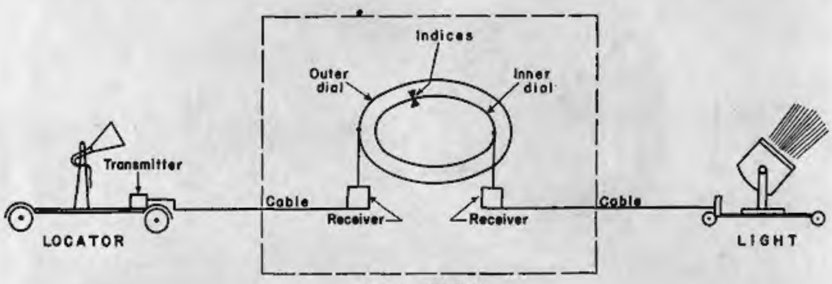


FIGURE 138.—Diagram showing connections of light and locator to comparator.

conductors, enable the controller to be rotated many times without danger of twisting off a cable (fig. 139).

57. Cables.—*a. Main power cables.*—Two heavy single conductor cables, 600 feet long, with yellow plugs at each end carry D. C. power to the searchlight arc and the distant electric control. The plugs on one cable have a + sign and those of the other cable have a − sign. These plugs fit into receptacles of the same color and sign on the searchlight and power unit. Both main power cables are carried on reels permanently mounted in the body of the power unit but must be removed for use. Their resistance is sufficient to reduce the 100-volt D. C. power output of the power unit to the 78- to 80-volt power required by the searchlight, and thus act as a ballasting resistance.

NOTE.—When the arc heats up, its resistance decreases and it tends to pass more and more current. To counterbalance this effect we use the ballasting (or balancing) effect of the copper cables. These cables increase their resistance as they heat, cutting down on the current they will pass. As they cool, their resistance decreases and they will pass more current. This balances the tendency of the arc to run away and results in smooth operation.

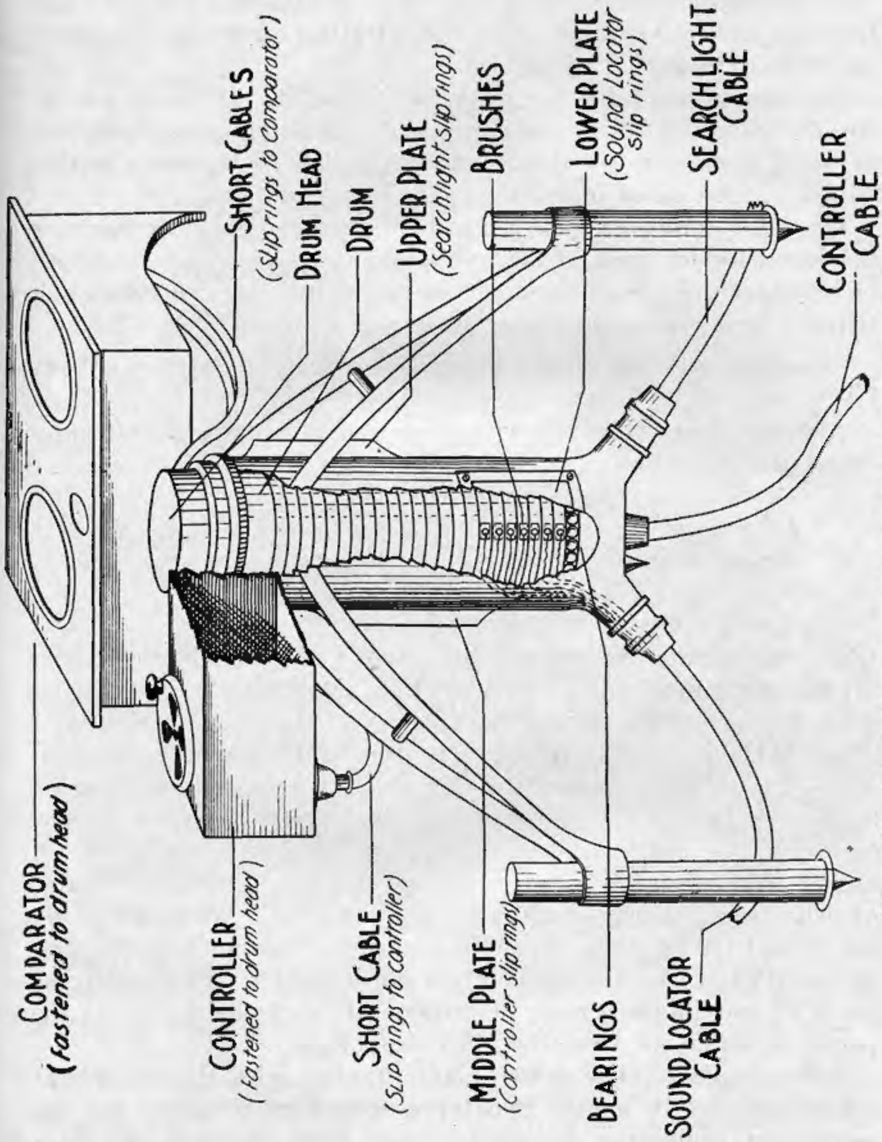


FIGURE 139.—Schematic sketch of control station for MVI AA searchlight.

b. Distant electric control cable.—A nine-conductor cable 200 feet long with a red plug on each end carries the phase and D. C. power leads for training the searchlight in azimuth and elevation from the distant electric controller. These red plugs fit in receptacles of like color on the control station tripod and the searchlight.

c. Comparator cables.—There are two comparator cables, each 200 feet long and each of nine conductors, identical except for the painting of their plugs.

One comparator cable has plugs painted white. This cable operates the searchlight dials in the comparator. Its plugs are connected to white receptacles on the searchlight and on the control station tripod. It is carried in its box on the power unit.

The other comparator cable has blue plugs. This cable operates the sound locator dials in the comparator. Its plugs are connected to receptacles of like color on the sound locator and control station tripod. It is carried on the sound locator trailer.

NOTE.—Blue and white cables are interchangeable if the plugs are properly wired.

d. Precautions.—The following precautions are imperative to prevent failure of cables:

Do not drag cables by means of plugs.
Do not run over cables with vehicles.
Do not kink the cable.
Keep cables in boxes when not in use.
Handle cables with utmost care.

Cable failures are the most frequent source of matériel trouble, and are usually caused by rough handling. Most breaks in the conductors occur within a foot of the plugs.

58. M1934 searchlight unit (mobile and portable).—*a. General.*—The separate elements of this unit are arranged as shown in figure 125 for the MVI except that the rotary converter is now located at the control station. The sound locator is the same. A higher powered truck is furnished, coupled to a generator capable of delivering 150, 200, or 250 amperes as desired. When delivering the normal 150 amperes, the motor is turning over much slower than in the MVI trucks and is therefore much quieter. Prior study of the MVI searchlight permits description of this model by listing the points of difference from the MVI searchlight.

b. Power plant.—The power plant supplied with the searchlight equipment may be one of two types, mobile or portable, and the searchlight equipment derives its name from the type of power unit with which it is supplied. Thus there is the mobile searchlight equipment and the portable searchlight equipment. The mobile equipment has the combined truck-power plant. The portable equip-

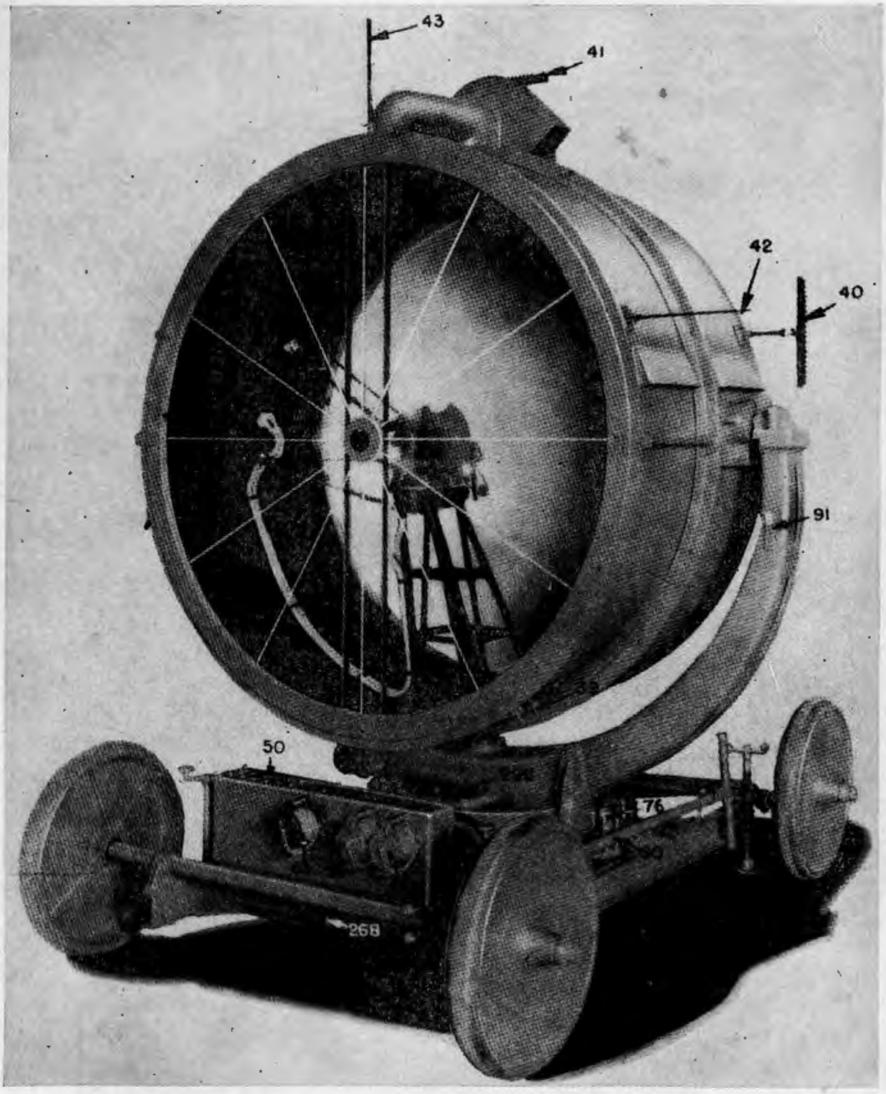


FIGURE 140.—60-inch high-intensity searchlight (front and left side of drum—rear of chassis).

39. Panel to permit access to inside of drum.
40.} Daylight sights,
42.} elevation.
41.} Daylight sights,
43.} azimuth.
50. Junction box.
60. Steering tongue.
61. Power cable receptacle, positive.
62. Power cable receptacle, negative.
63. Control cable receptacle.
76. Azimuth lock pin.
91. Pocket for carboning wrench.
266. Handhole plate.
268. Loading eye for winch cable.

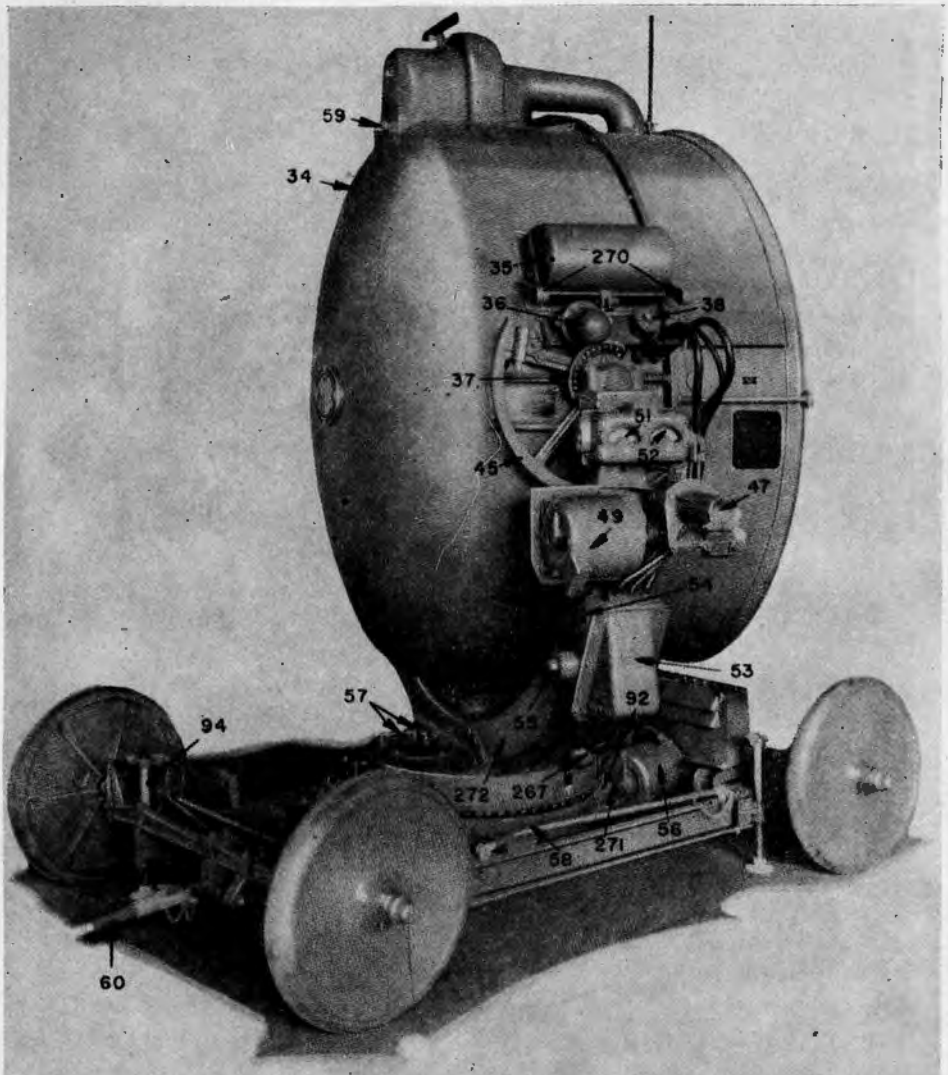
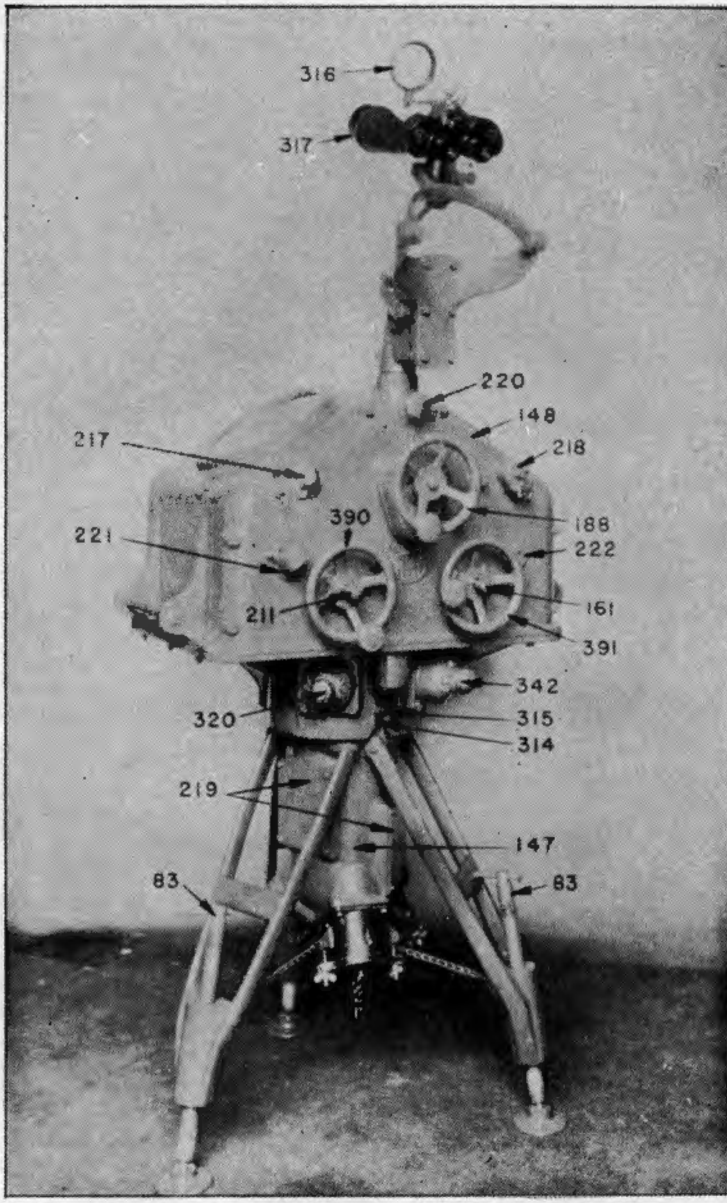


FIGURE 141.—Right side and rear of drum—front of chassis.

34. Drum casting.
35 Control mechanism box.
36. Elevation scale lamp.
37. Elevation scale.
38. Recarboning lamp switch.
45. Elevation gear sector.
47. Controller socket.
49. Elevation control motor.
51. Voltmeter.
52. Ammeter.
53. Arc switch.
54. Extension lamp socket.
55. Scale and meter lights.
56. Azimuth control motor.
57. Levels.
58. Transportation lock.
59. Lug.
60. Steering tongue.
92. Azimuth worm housing.
94. Leveling jacks.
267. Azimuth scale lamp.
270. Orienting sights.
271. Azimuth clutch (under housing at this location).
272. Trunnion arms.



83	LEVELLING JACKS	218	SOUND LOCATOR ELEV. DIAL SYN. KNOB	314	ALIGNMENT SLOT
147	TRIPOD	219	HAND HOLE COVER PLATES	315	ALIGNMENT LUG
148	CONTROL UNIT	220	BINOCULAR HEIGHT ADJUSTING KNOB	316	OPEN SIGHT
161	ELEV. HANDWHEEL CLUTCH KNOB	221	AZ. DRIVE FRICTION CLUTCH ADJ. SCREW	317	BINOCULAR
188	SEARCHING H'DWHEEL	222	ELEV. DRIVE FRICTION CLUTCH ADJ. SCREW	320	A-C. SWITCH
211	AZ. HANDWHEEL CLUTCH KNOB			342	D-C. SWITCH
217	SOUND LOCATOR AZ. DIAL SYN. KNOB			390	OBSERVER'S AZ. HANDWHEEL
				391	OBSERVER'S ELEV. HANDWHEEL

FIGURE 142.—Control station, searchlight unit, M1934.

ment has no truck for transportation and is equipped with a power plant mounted on a 4-wheeled trailer.

c. Searchlight.—(1) The searchlight itself (figs. 140 and 141) has been little changed. Provision has been made for the use of 150-ampere, 200-ampere, or 250-ampere carbons. The elevating and traversing motors are directly controlled from the control station, without any intermediary brush-shifting motors. Metal mirrors are used.

(2) *To change from 150-ampere operation to 200-ampere operation.*—The searchlight when shipped is adjusted to operate at 150 amperes. To change from this type of operation to 200-ampere operation, certain adjustments must be made to power plant voltage and the positive feed mechanism in addition to recarboning with 200-ampere carbons.

d. Control station.—The control station has been radically altered (fig. 142).

(1) Binoculars, automatically trained to follow the searchlight beam, are provided.

(2) An automatic spiral searching device is incorporated.

(3) The distant electric controller directly actuates the elevating and training motors on the light. The rotary converter is now located near the control station on a short cable.

(4) The electric feed back of the searchlight's azimuth and elevation to the comparator has been eliminated. Instead the handwheels of the distant electric controller are directly geared to turn the searchlight dials in the comparator.

59. M1937 searchlight unit.—*a. General.*—The latest design in search light equipment is embodied in the M1937 searchlight unit which provides for subunits to be hauled in cargo trucks. In these units, the light and accessories go in one truck, and the power plant (the motor-generator set) in another. In this case, it is not necessary to discard the whole system if something happens to a specialized vehicle, such as the combined truck-power plant of the MVI and M1934 lights. With the exception of the power plant the unit remains substantially the same as before.

If an M2 sound locator is used it may be packed in the truck carrying the power plant (fig. 134). The complete unit (set up) is shown in figure 143.

b. Power plant.—The power plant (fig. 144) furnishes the 125 volts D. C. required for the unit. It comprises a 6-cylinder gasoline motor directly connected to a direct current generator and the necessary control devices for controlling the generator output. It may be towed or carried in the truck body.

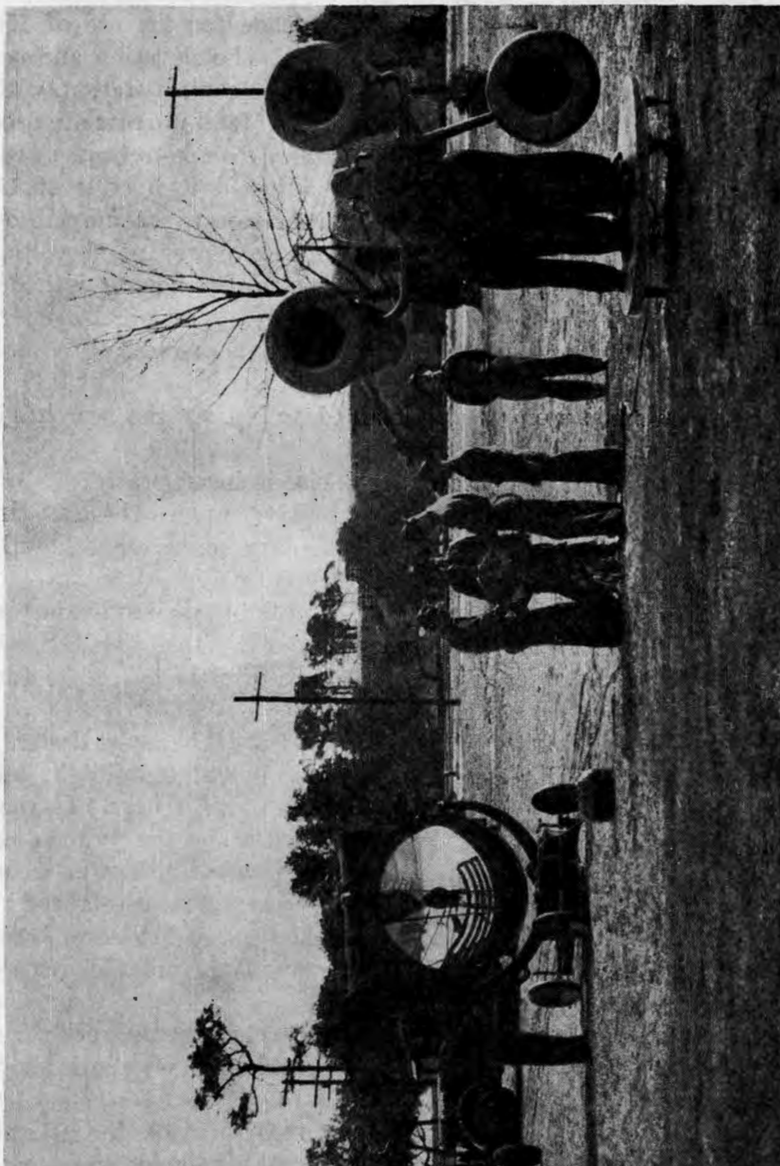


FIGURE 143.—AA searchlight unit, M1937.

c. Control station.—Incorporated in the light unit's control station is a new apparatus, called the "zero reader." In all previous light units, it has been necessary to match two pointers (an inner and an outer) in order to point the light at the same point in the sky as the

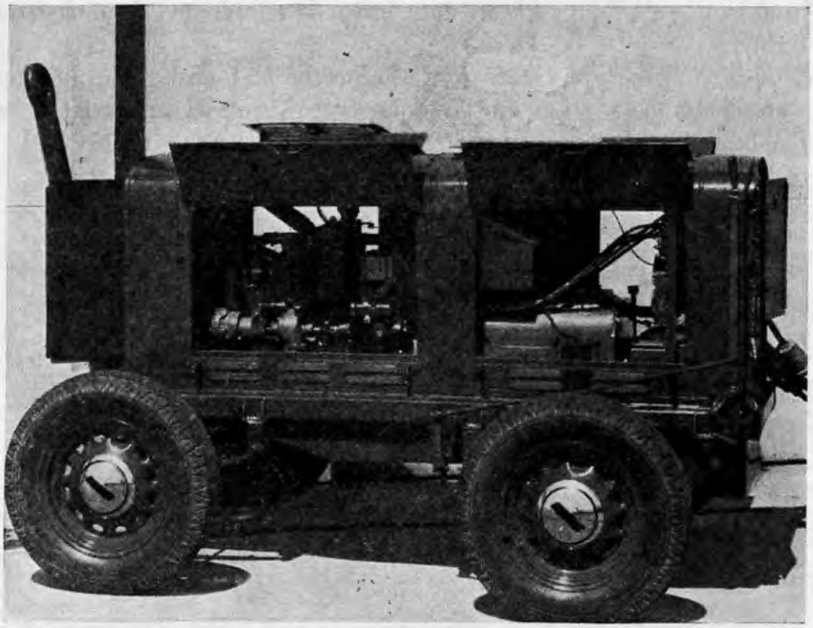


FIGURE 144.—Power plant, AA searchlight unit, M1937.

locator. With the zero reader this condition is indicated on the face of a two-way voltmeter (fig. 145). If light and locator are pointed at the same point in space, the needle points straight up. If they are not, the needle indicates the direction to move the light in order to bring them to the same point. This makes it much easier for the controller operator as he can notice the position of one large needle better than the relative positions of two small indexes.

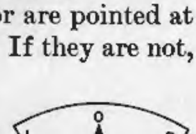


FIGURE 145.—Voltmeter face on zero reader.

60. Older searchlight units.—*a. General.*—As a heritage of the World War we have a number of 36-inch barrel-type lights mounted on trucks and a supply of 60-inch open-type lights mounted on passenger car chasses. Since the war and prior to the MVI light we had the MI, MII, and MIV lights. Only a brief description will be given of these types.

b. 36-inch barrel-type searchlight.—This light (fig. 146) has no sound locator and no distant electric control. In design it resembles the 60-inch harbor defense light described in paragraph 47. The power unit and carrying vehicle is a $5\frac{1}{2}$-ton chain drive, solid tired, Mack truck, which is slow, heavy, and easily mired. In case it is desired to use a sound locator, data must be telephoned from locator to light.

c. 60-inch open-type searchlight.—Like the 36-inch light, this light has no sound locator and no distant electric control. Data must be phoned from locator to light if a locator is to be used.

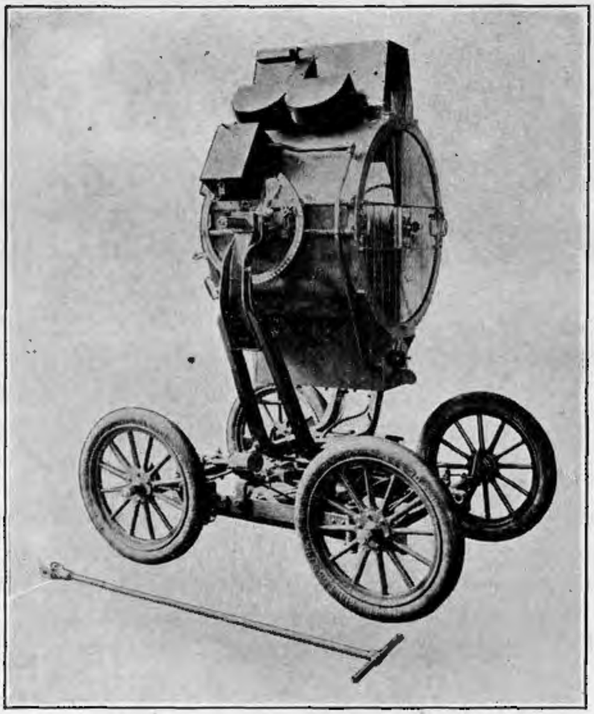


FIGURE 146.—36-inch barrel-type searchlight.

(1) As shown in figures 147 and 148, the light has a 60-inch glass mirror (a). A hole 13 inches in diameter is cut in the center of the mirror for the insertion of the lamp mechanism (e). The light is elevated on trunnions carried on trunnion supports (q) and traversed on a turntable (h) much as is the MVI light.

(2) The lamp mechanism is operated entirely by hand—both positive and negative feed and arc strike being accomplished by hand. Carbons are good for about one-half hour of continuous service.

(3) The power unit is a standard eight-cylinder motor of war vintage. The motor is governed to turn the 15 kw. direct-current generator at 1,400 r. p. m.

(4) Wind and rain interfere with the efficient operation of this open light.

d. MI mobile searchlight unit.—This unit closely resembles the MVI. It has D. C. data transmitters and receivers for the comparator system instead of A. C., and impulse type training motors

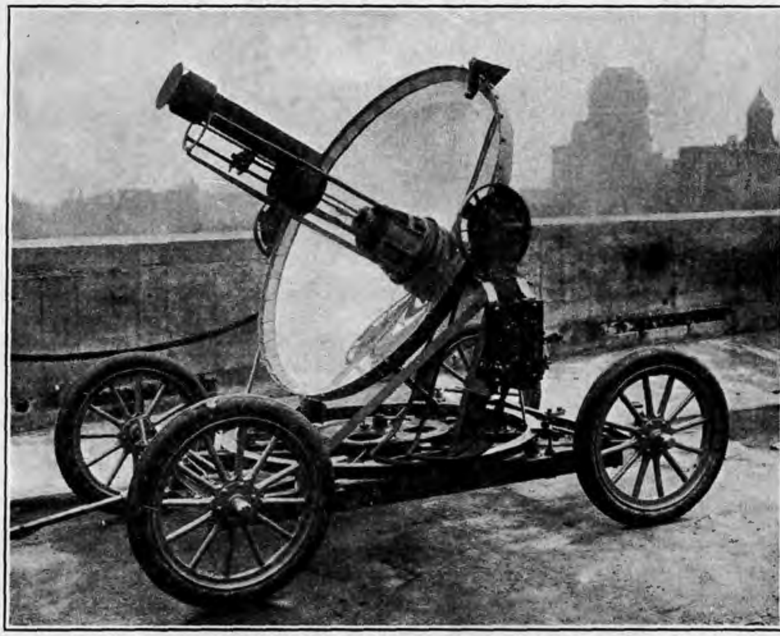


FIGURE 147.—60-inch open-type AA searchlight.

for the distant electric control. The vehicle is a passenger car chassis modified to mount the 15 kw. generator and to carry the light.

e. MII mobile searchlight unit.—Only 5 units were manufactured so that no description will be given.

f. MIV mobile searchlight unit.—This unit may be described as a halfway design between the MI and MVI types. Its distant electric control is of the impulse (MI) type, while its comparator system is of the MVI (A. C.) design. The vehicle is a passenger car chassis of later model.

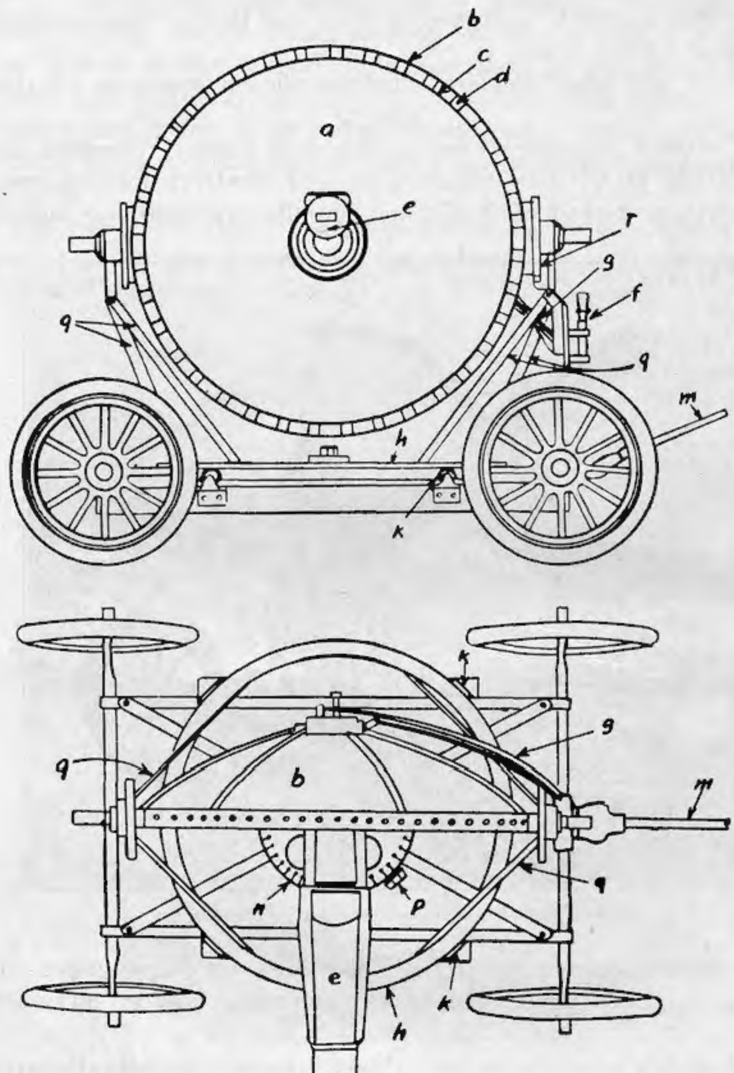


FIGURE 148.—60-inch open-type searchlight with high-intensity lamp.

a. Reflecting mirror.
b. Mirror frame.
c. Mirror retaining ring.
d. Mirror retaining lugs.
e. Lamp mechanism.
f. Power switch.
g. Power leads.
h. Turntable.
k. Traversing rollers.
m. Maneuvering handle for hand towing.
n. Azimuth circle plate.
p. Azimuth pointer.
q. Trunnion supports.
r. Elevation clamp.

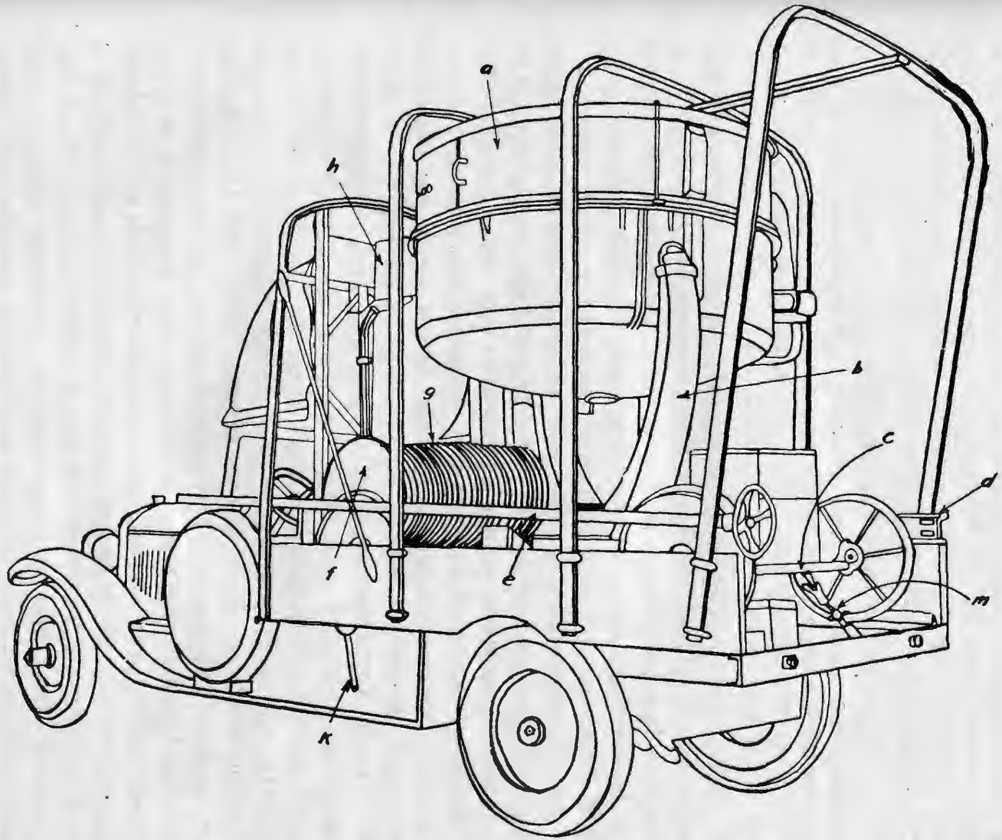


FIGURE 149.—MI searchlight in traveling position on its power unit.

a. Projector drum.
b. Drum supporting yoke.
c. Projector carriage.
d. Runways.
e. Extended hand controller.
f. Cable drum.
g. Power cable.
h. Control panel box.
k. Generator gear shift lever.
m. Rear tie rod.

Section X

ANTIAIRCRAFT GUNS AND MOUNTS

61. General.—*a. Models.*—Antiaircraft weapons were first introduced during the World War and many improvements in both guns and mounts have been made since that time. Further improvements are under development. Due to these constant improvements, antiaircraft guns and mounts of various characteristics are in service.

b. General requirements.—The essential requirements for a good antiaircraft gun are high-muzzle velocity and high rate of fire. The first is secured by using a long-barreled cannon and a large charge of powder. The second is secured by designing the gun, the ammunition, the breech mechanism, and the mount so as to allow the weapon to be served with a minimum of effort on the part of the crew.

62. 3-inch antiaircraft gun, M1917A2 and modifications (fixed).—*a. M1917A2 and M1917A3.*—(1) The gun is normally mounted on the 3-inch antiaircraft pedestal mount, M1917 or M1917MII, and is in general use as a fixed antiaircraft weapon in our harbor defenses. It is built up of alloy steel, consisting of tube, jacket, and locking hoop. The jacket envelopes the rear portion of the tube and projects beyond it to form the breech recess or seat for the breech mechanism. A lug, known as the recoil lug, projects from the upper surface of the jacket near its extreme end and affords a point of attachment for the piston rod of the recoil cylinder. A lug also projects from the under surface to which are attached the counterrecoil spring rods. The locking hoop is threaded and forced on the tube and forward end of the jacket and secures the latter against any rearward movement of the tube under firing stresses. The key on the gun engages in the keyway of the cradle and prevents the gun from rotating when fired. (See fig. 152.)

(2) The gun has a length of bore of 55 calibers and has been retubed to provide a uniform twist of 1 turn in 40 calibers (M1917A2). This rifling is now standard for antiaircraft weapons.

(3) The gun is chambered to use M1917 fixed ammunition, and either shrapnel or high-explosive shell may be fired. A muzzle velocity of 2,600 foot-seconds is obtained with the former and 2,800 foot-seconds with the latter.

(4) *Breech mechanism.*—The breech mechanism for this gun is the drop block type described and illustrated in paragraph 14.

(5) *Firing mechanism.*—The firing mechanism is of the continuous pull type (old type) very similar to that described in paragraph 20.

(6) The 3-inch antiaircraft gun, M1917A3, has a special removable liner. Otherwise it is identical with the M1917A2.

b. M1917MIA2 and M1917MIA3 (fixed).—(1) *General.*—These guns have the same ballistic features as the M1917A2 gun, differences being confined to relatively unimportant improvements in design.

(2) *M1917MIA2 gun.*—This gun is similar in general construction to the M1917A2 gun, except that instead of the breech ring being integral with jacket it is a separate piece. The breech end of jacket is threaded to receive the breech ring, which is screwed and shrunk on the jacket and held by a lock screw. The locking hoop is omitted. This gun was originally built with a rifling increasing in twist from 1 turn in 50 calibers to 1 turn in 25 calibers but like the M1917 gun has been retubed to provide a uniform twist of 1 turn in 40 calibers.

(3) The 3-inch antiaircraft gun, M1917MIA3, is identical with the M1917MIA2 except that it has a special removable liner.

c. M1917MI1 gun.—This gun is similar in general construction to the M1917MIA2 gun except in the method of securing the latch plate to the gun. It was built with a uniform twist of rifling of 1 turn in 40 calibers.

63. 3-inch antiaircraft gun, M1918 and M1918MI (mobile).—*a. M1918.*—(1) *General.*—(*a*) This gun is mounted on the M1918 trailer mount. The gun and mount, of World War manufacture, are no longer considered standard mobile antiaircraft equipment although many are still in existence. The gun is built up of nickel steel forgings consisting of a tube, jacket, and breech ring. The tube carries a shoulder at its rear end which prevents forward motion in the jacket. The jacket carries two flanges on its lower side which form a slide for the gun. It also has a lug on the top near the forward end which contains a T-slot that holds the recoil cylinder in place. The rear end is threaded on the outside to receive the breech ring. The breech ring is threaded at its forward end and screws on to the rear end of the jacket. The breech ring carries a recoil lug at the top for the attachment of the recoil piston rod and another lug at the bottom that extends nearly the full width of the ring. This lug is used for the attachment of the counterrecoil spring rods.

(*b*) The gun has a length of bore of only 40 calibers and is rifled with an increasing right-hand twist of from 1 turn in 50 calibers to 1 turn in 25 calibers. Some of these guns have been retubed to provide a uniform twist of 1 turn in 25 calibers (M1918A1).

(*c*) The gun is chambered to use M1918 fixed ammunition, and either shrapnel or high-explosive shell may be fired. A muzzle velocity of 2,400 foot-seconds is obtained with the former and 2,600 foot-seconds with the latter. (See fig. 157.)

(2) *Breech mechanism.*—The breech mechanism for this gun is similar to that for the M1917 gun (par. 14) except that the breechblock must be opened by hand. The operating cam feature of the M1917 gun, by which automatic opening is provided, is omitted.

(3) *Firing mechanism.*—The firing mechanism for this gun like that for the M1917 gun is of the continuous pull type (old type). (See fig. 37 for operation.)

b. M1918MI.—This gun differs from the M1918 gun in that the section of the breech ring which encircles the jacket and tube is 1.6 inches longer than the same part on the M1918 gun. This permits a longer thread on the jacket and a greater thickness of metal in the rear of the jacket. Also, the latch plate of this gun is attached to the breech ring by the use of a key and split pin, instead of bolts and screws used for this purpose on the M1918 gun. Otherwise the two guns are identical. As in the case of the M1918 gun, some of these guns have been retubed to provide a uniform twist of rifling of 1 turn in 25 calibers.

64. 3-inch antiaircraft guns, M2 and M4 (fixed).—*a. M2 gun.*—The M2 gun is of two-piece construction embodying a tube and a removable liner as described in paragraph 9. A breech ring is screwed on the breech end of the tube and supports the breech mechanism. Both tube and removable liner are cold-worked. The bore is 55 calibers long and is rifled with a uniform twist of 1 turn in 40 calibers.

M1917 fixed ammunition is employed giving a muzzle velocity of 2,600 foot-seconds for the shrapnel and 2,800 foot-seconds for the high-explosive shell.

The continuous pull firing mechanism of the new type described in paragraph 20 is employed. The breech mechanism is of the drop block type described in paragraph 14.

b. M4 gun.—The M4 gun is identical with the M2 except that the removable liner has been made heavier in order to permit greater tolerance in manufacture. This change increases the weight of the gun by 440 pounds.

65. 3-inch antiaircraft guns, M1 and M3 (mobile).—*a. General.*—These guns are mounted on the 3-inch antiaircraft mobile mounts, M1 and M2, respectively. The M1 and M3 guns are practically identical except that the liner of the latter has been made heavier in order to allow greater tolerance in manufacture. Inasmuch as the M3 gun is now standard and only a few M1 guns are in service, the description which follows will relate to the M3 gun. The gun is constructed by the process of cold-working, or auto-frettage, and consists of three principal forgings—the tube, the liner, and the breech ring. It has a length of bore of 50 calibers and is rifled with a uniform right-hand twist of 1 turn in 40 calibers. The gun is chambered to use M1918 fixed ammunition, and either shrapnel or high-explosive shell may be fired. A muzzle velocity of 2,600

FIGURE 150.—Cold-worked gun with removable liner, 3-inch 50-caliber AA gun.

foot-seconds is obtained with the former and 2,800 foot-seconds with the latter.

b. Tube.—The exterior of the tube is threaded at the breech end and screws into the breech ring (fig. 150). Forward of the breech ring threads, the exterior portion of the tube has a cylindrical sliding surface. The remainder of the exterior is tapered to the muzzle. The interior of the tube is taper-bored to receive a removable liner as described in paragraph 9. The bore contains two keyways to prevent the rotation of the liner. These keyways are located at the top and bottom near the breech end of the tube. Two shoulders in the bore, 5½ inches apart, located at the front and rear ends of the rear keyways, prevent the liner from moving forward when the gun is fired. To prevent the liner from slipping to the rear when the gun is elevated, a retaining ring, screwed into the breech end of the tube, is provided.

c. Liner.—The liner (fig. 151) is of the removable type. The exterior fits the bore of the tube with a slight clearance between the two, and is divided into three different diametrical zones to form two shoulders. The zone between the shoulders contains two integral keys, one upper and one lower, which fit corresponding keyways in the bore of the tube. The liner when assembled in the tube is prevented from moving forward by the shoulders in the tube and from moving to the rear by the retaining ring which screws into the breech recess. The bore of the breech end of the liner forms the powder chamber. This chamber is designed for use with M1918 fixed ammunition.

d. Breech ring.—The breech ring (fig. 150) has an interior thread at the front end to screw on to the breech end of the tube and is secured by a lock screw. A lug projects from the bottom face to which is attached the recoil piston rod. The rear of the ring, which

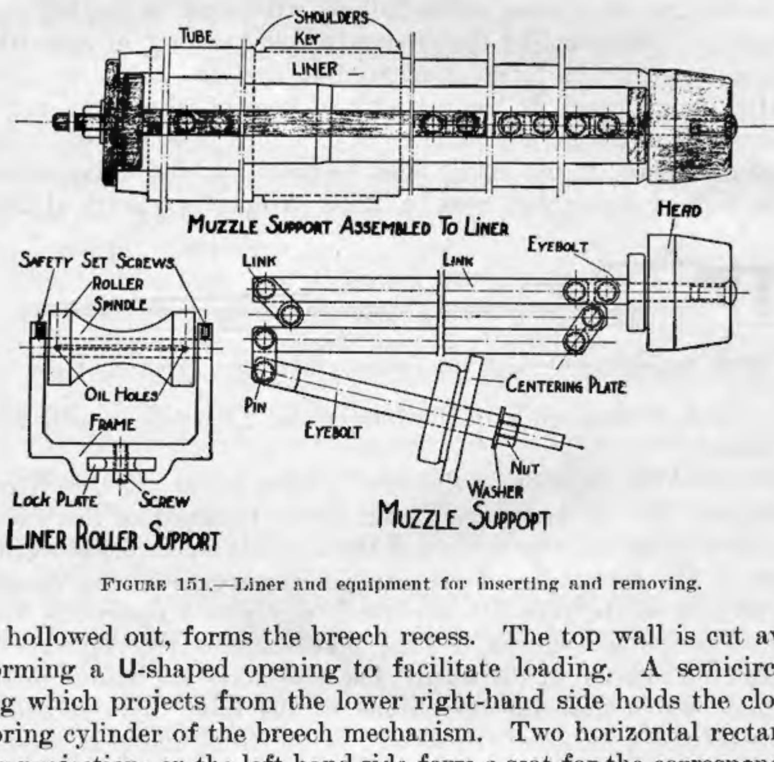


FIGURE 151.—Liner and equipment for inserting and removing.

is hollowed out, forms the breech recess. The top wall is cut away, forming a U-shaped opening to facilitate loading. A semicircular lug which projects from the lower right-hand side holds the closing spring cylinder of the breech mechanism. Two horizontal rectangular projections on the left-hand side form a seat for the corresponding guide in the cradle. Two dovetailed seats in the bottom face are provided for the lock plate which is retained in position by the lock-plate key. The lock plate holds the operating shaft in place and forms a part of the operating shaft bearings.

e. Breech mechanism.—The breech mechanism for this gun is of the drop block or vertical sliding type. In all essential respects it is similar to the mechanism for the M1917 gun, described and illustrated in paragraph 14.

f. Firing mechanism.—The new type of continuous pull firing mechanism, described in paragraph 20 and illustrated in figure 36, is provided for this gun.

g. Equipment for removal of liner.—(1) Special equipment has been provided for removing and inserting the liner for this gun. The equipment consists of a muzzle support, a roller support, and a retaining ring wrench. This equipment, with the exception of the wrench, is shown in figure 151. The unit is not a traction or power device but merely a support and clamping arrangement. The supports are designed to hold the liner out of contact with the tube, while it is being inserted or extracted, thereby preventing or greatly reducing the tendency to score either member.

(2) The muzzle support consists of a linked rod with a bronze head on one (muzzle) end. The other (breech) end of the rod is threaded and receives the centering plate, washer, and nut. Just forward of the threaded portion of the rod is a rectangular portion to receive the rectangular hole of the centering plate. The rear end of the bronze head and the forward end of the centering plate fit into the bore of the liner. The rest of the bronze head has a diameter slightly greater than the muzzle end of the liner but smaller than the inside diameter of the bore of the tube. The front end of the bronze head is tapered.

(3) The roller support consists of a bronze roller mounted on a spindle which rests in a frame. The frame is designed to slide into the breech recess from the under side and is locked in position by a lock plate secured to the frame by a screw.

(4) The retaining ring wrench is designed to fit the slots in the retaining ring.

NOTE.—Under no circumstances should a liner be removed or replaced against time.

66. 105-mm antiaircraft gun, M3 (fixed).—This gun is of one-piece cold-worked construction and is 60 calibers long. A screwed-on breech ring supports the breech mechanism. It is rifled with a uniform twist of 1 turn in 30 calibers.

The gun was designed for mounting on a fixed mount, where weight is not an important factor. Power ramming is employed to load fixed ammunition. The projectile weighs 33 pounds and is fired at a muzzle velocity of 2,800 foot-seconds. An accuracy life of 1,500 rounds is expected.

67. Mounts.—Due to the fact that an airplane target is under fire for a period measured in seconds, the mount must be constructed with special characteristics peculiar to the antiaircraft weapon.

a. As it is desired to have a high rate of fire, the mount must have a recoil mechanism that is quick, that is, that returns the gun to firing position rapidly.

b. As it is desired to combine a cannon having a highmuzzle velocity with a mount possessing stability, recoil must be long and recoil and counterrecoil smooth.

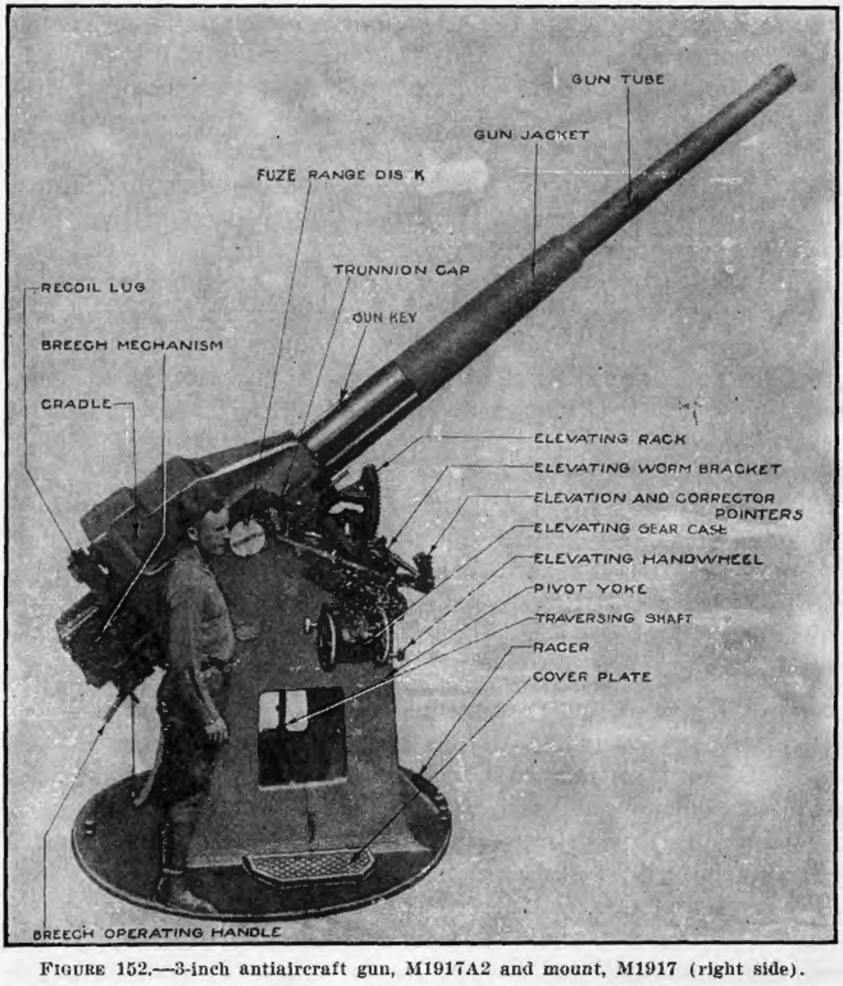


FIGURE 152.—3-inch antiaircraft gun, M1917A2 and mount, M1917 (right side).

c. As targets of high angular velocity may have to be engaged, elevating and traversing mechanisms must operate smoothly and rapidly.

d. As the area above the muzzle is clouded with smoke and heated air during firing, it is desirable to dispense with any form of sight and use case III firing throughout.

68. 3-inch antiaircraft mount, M1917 (fixed).—This mount is of the barbette type and is designed to mount a 3-inch antiaircraft gun, M1917A2, M1917A3, M1917MIA2, or M1917MIA3. The mount permits a traverse of 360° and elevations of 0° to 90°. Removable stops are provided, however, which limit the elevation for safety reasons to 85°. The mount consists of the following principal parts: base plate, racer, pivot yoke, and cradle. That portion of the mount above the base plate is shown in figure 152. Figure 153 shows the base plate and racer assembly.

a. Base plate, racer, yoke, and cradle.—(1) The base plate (fig. 153) is a circular steel casting anchored to a solid concrete platform with sixteen foundation bolts. The upper surface of the plate is machined to form the lower roller path. At the center of the casting is a cylindrical projection the interior of which forms the housing for the 360° electrical contact (d) and the exterior holds the traversing rack (o).

(2) The racer (fig. 153) is a circular steel plate which rests and revolves on rollers placed on the roller path of the base plate. The under surface is machined to form the upper roller path and the upper surface to fit the yoke to which it is bolted. Clips (f), front and rear, which are bolted to the under side of the racer, engage with a flange on the base plate and prevent the mount from overturning when the gun is fired.

(3) The pivot yoke (fig. 152) is a single steel casting, bolted to the racer, and consisting of two vertical side frames joined in front by a transom. At the top of each side frame is a trunnion bearing for receiving the trunnions of the cradle.

(4) The cradle (fig. 152) is a steel casting suspended by trunnions resting in bearings at the top of the side frames of the pivot yoke. The cradle is bored and bushed with front and rear liners through which the gun slides in recoil. It also carries the housing for the various parts of the recoil system. A keyway cut in the front liner receives the key located on top of the gun and prevents the gun from rotating when fired.

b. Traversing mechanism.—(1) Power for movement of the mount in azimuth is normally transmitted from the traversing handwheel to the mount through a set of gears and a clutch mounted in the traversing gear case on the left side of the mount. A vertical pinion shaft (fig. 152) from this case meshes with the teeth of the traversing rack on the cylindrical projection of the base plate. Figure 153 shows the base plate and racer assembly. The traversing rack (o) is free to rotate about the base plate. A friction band (n) passes around and clamps the traversing rack cylinder (c) and rack (o) beneath the rack teeth (q). This band is made fast to the base plate by the friction band set screw (m). An adjustable clamp spring (p) is provided on the opposite side to vary the grip between the friction band and traversing rack cylinder. In this way for all normal loads the traversing rack is fixed with respect to the base ring, but when an abnormal load is applied, the friction band slips and the rack and rack cylinder move.

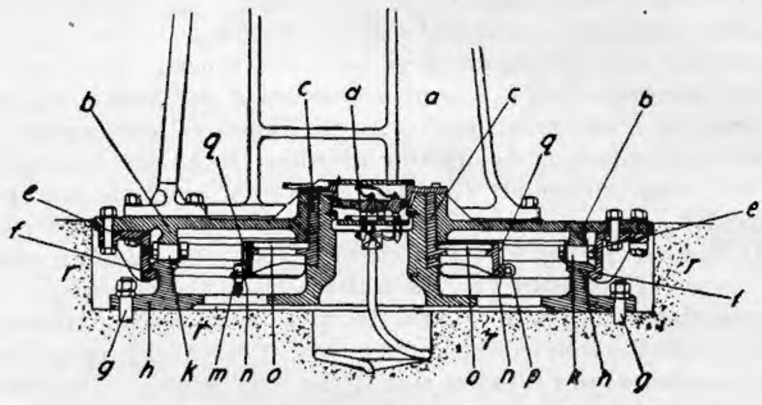


FIGURE 153.—Base plate and racer assembly.

a. Yoke side frame.
b. Racer.
c. Traversing rack cylinder.
d. 360° contact.
e. Distance ring.
f. Recoil clips.
g. Foundation bolts.
h. Base plate.
k. Traversing rollers.
m. Friction band set screw.
n. Friction band.
o. Traversing rack.
p. Adjustable clamp spring.
q. Traversing rack teeth.
r. Concrete emplacement.

(2) The distance ring (e) is a circular bronze ring provided with spaces and bearings for the traversing rollers (k). The traversing rollers, 30 in number, are interposed between the roller paths of the base plate and racer, bearing the weight of the mount. The rollers are held in their proper position by the distance ring.

(3) Speed is desirable in putting the gun on the target, and for this reason a foot-operated clutch is provided that disconnects the traversing mechanism from the vertical traversing pinion shaft, and the entire mount above the base ring can be turned around by pushing on the carriage or gun. In addition, two speeds of traversing are obtained by a speed gear shift on the handwheel shaft. This shift is

operated by a handle within reach of the traversing operator. The speed gear shift arrangement is shown in figure 154. A shift collar (h) operated by shift lever (k) is keyed to the handwheel shaft (n).

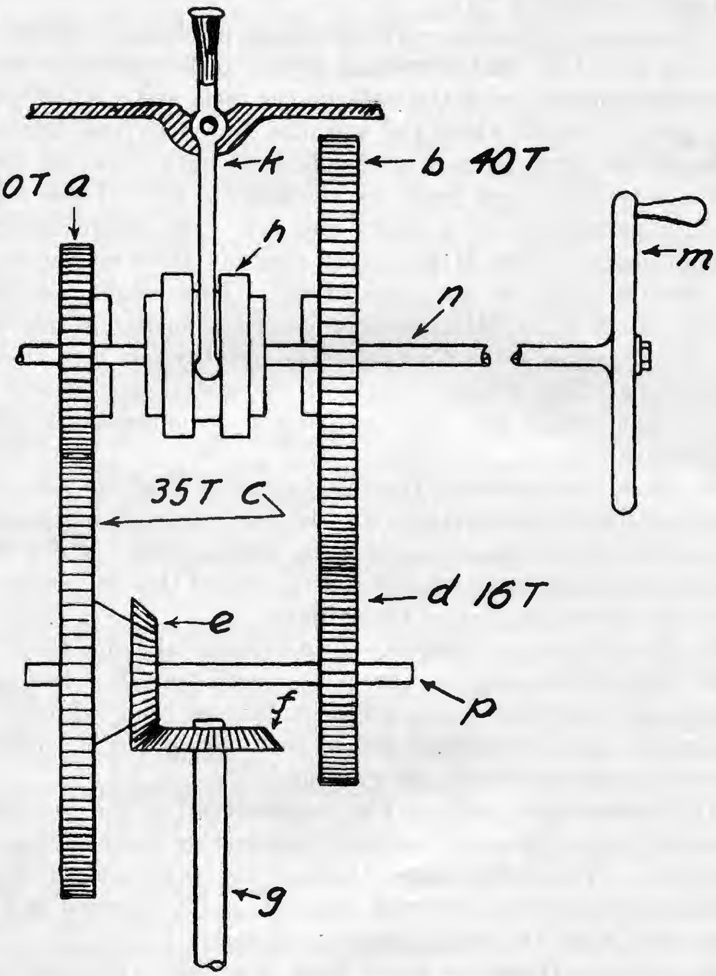


FIGURE 154.—Speed gear shift assembly.

a. Slow motion pinion.
b. Speed pinion.
c. Slow motion gear wheel.
d. Speed gear wheel.
e. Speed bevel gear.
f. Traversing bevel gear.
g. Traversing shaft.
h. Shift clutch.
k. Shift clutch lever.
m. Handwheel.
n. Handwheel shaft.
p. Speed gear shaft.

The pinions (a) and (b) are mounted free to revolve on the handwheel shaft. Mounted fast to the speed gear shaft (p) are speed gear wheel (d) and a combined spur wheel (c) and bevel pinion (e).

The traversing shaft (g) is driven by bevel gear (f) from pinion (e). It is seen that all gears are in continual motion while the handwheel (m) is turning, but the speed transmitted to shaft (g) depends upon the position of clutch (h).

c. Elevating mechanism.—The elevating mechanism consists of an elevating rack (fig. 152) keyed and bolted to the cradle, an elevating worm which meshes with the teeth on the rack, and a set of spur and bevel gears through which the worm is driven by two handwheels. Although the elevating rack is of sufficient length to permit elevation to 90°, removable stops limit the elevation to 85°. These stops are provided principally as a safety measure. The comparatively low trunnion height of the M1917 mount does not allow convenient loading above a quadrant elevation of 65°. This height has been increased on the M1917MII mount as described in paragraph 69*c*.

d. Recoil system.—(1) *General.*—The recoil system is of the hydrospring type. The different parts of the system are housed in the cradle. One recoil and two recuperator (counterrecoil) cylinders are provided.

(2) *Recoil mechanism.*—The recoil cylinder is of the conventional type described in paragraph 22*b*. In this mount it is screwed into the cradle and does not move with the gun in recoil. Three longitudinal throttling grooves equally spaced around the circumference are cut in the interior surface of the cylinder.

(3) *Recuperator mechanism.*—Two cylindrical holes bored in the cradle form the housing for the counterrecoil springs. Two columns of springs, inner and outer, are assembled in each cylinder over a spring rod. At the forward end of each spring rod is a piston, the rear end being attached to the gun lug.

(4) *Counterrecoil buffer.*—The counterrecoil buffer (or plunger) is tapered and is designed to check the recoiling parts as they return to battery. The buffer passes through the front end of the recoil cylinder and enters a recess or dashpot in the forward end of the piston rod, when the latter returns to battery.

(5) *Action.*—When the gun is fired, it recoils to the rear about 12 inches, carrying with it the recoil piston and spring rods, thereby compressing the counterrecoil springs. The energy of recoil is taken up by the resistance offered to the flow of oil through the apertures and by the resistance of the counterrecoil springs. The gun is returned to battery by these springs. The recoil piston is carried forward by the gun and engages the counterrecoil buffer, thus easing the gun into battery.

e. Pointing equipment.—Practically all M1917 mounts are equipped with sights and case I½ pointing equipment, transmission of firing data by telephone being employed. The antiaircraft sight, M1917, described in FM 4-110, and the bracket fuze setter, M1916, described in paragraph 82*f* (1), are used. A few of the modified antiaircraft fixed mounts (par. 69) have been equipped with electrical data transmission systems (sec. XI).

69. 3-inch antiaircraft mounts, M1917MI, M1917MII and M3.—*a. General.*—The M1917 mount described above has been redesigned to facilitate loading at the higher elevations, to facilitate elevating and depressing the gun, and to effect other desirable improvements not incorporated in the original mount. These improvements are embodied in the M1917MI, M1917MII, and M3 pedestal mounts.

b. M1917MI.—(1) This mount is shown in figure 155. The pivot yoke instead of being a single casting is made in two parts, a right-side frame and a left-side frame. These frames are bolted together at the center of the front transom. To provide a higher loading angle, the height of the trunnions above the racer has been increased from 60 to 67½ inches. Each side frame is also cut away at the lower rear to afford more room for loading operations.

(2) To facilitate elevating and depressing the gun, a roller bearing, antifriction device, has been incorporated in the trunnion bearings of the new mount. This device operates on the same principle as the one mounted on the 16-inch barbette carriage (par. 28*d*).

It will be noted from figure 156, however, that the device for the M1917MI mount is of somewhat different design. The main trunnions have extensions (c) of smaller diameter, which are held up in nests of roller bearings (b), similar to those on the 16-inch mount. The roller bearing racer is supported directly by the crutch (d) and the Belleville springs (e). The gun is thus held up by the trunnion extensions and the crutches, the main trunnions not bearing on their surfaces. Hence friction is low and the heavy gun is elevated or depressed with comparatively little effort. When the gun is fired, however, the Belleville springs are compressed and the main trunnions settle into the main bearing surfaces which take the greater portion of the shock. Immediately after the gun is fired, the springs lift the gun off the main bearing surfaces by means of the crutch and trunnion extensions, and the trunnions again rest only in the nest of roller bearings.

(3) New elevating and traversing gear case assemblies, ball-bearing equipped, have also been provided for this mount. Elevations of from −5° to 85° are permitted with the new mount.

(4) The traversing rack has been made in the form of an internal gear which is bolted to the base plate. This allows a greater gear ratio between the traversing pinion and the rack. The process of traversing the gun is facilitated and the foot-operated clutch, allowing free move-

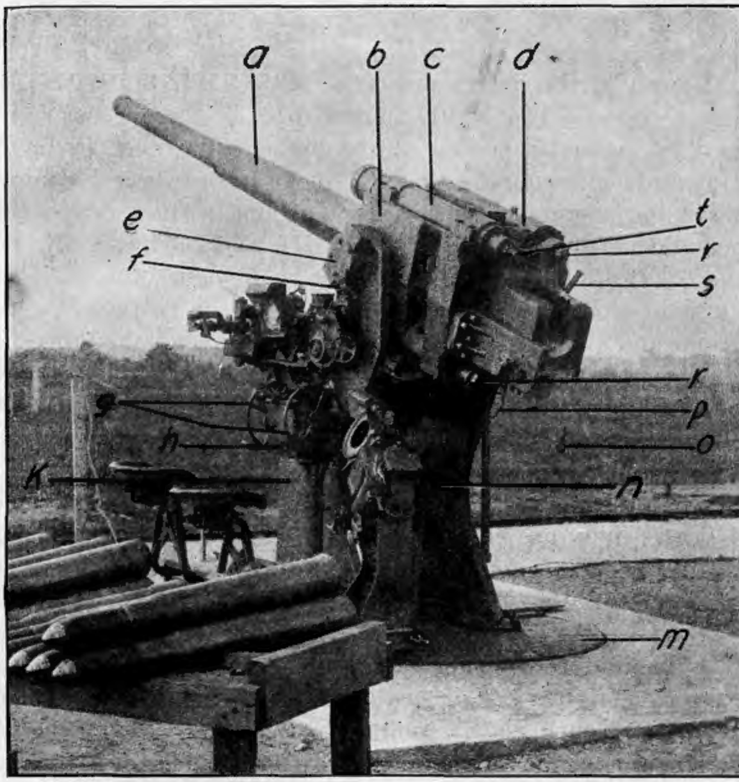


FIGURE 155.—3-inch AA mount, M1917MI (left side) (with M1917MII gun and experimental pointing equipment).

a. Gun.
b. Cradle.
c. Counterrecoil cylinder.
d. Recoil cylinder.
e. Antifriction device.
f. Belleville springs.
g. Traversing handwheels.
h. Traversing gear case.
k. Traversing shaft.
m. Racer.
n. Pivot yoke.
o. Lanyard.
p. Elevating handwheel.
r. Recoil piston rod.
s. Operating handle.
t. Counterrecoil piston rod.

ment of the gun, has been removed. The two-speed feature of the M1917 mount has been retained. The friction band is no longer used.

(5) The cradle has also been redesigned to permit the modifications in the trunnions indicated in (2) above and to effect a change in the recoil system. The new cradle carries 2 recoil and 2 counterrecoil

cylinders, 2 cylinders above and 2 below the gun. The upper right and lower left cylinders are recoil cylinders; the upper left and lower right, counterrecoil cylinders. With this arrangement of cylinders, the resultant of forces in recoil lies in the axis of the bore. The length of recoil has been increased from 12 inches to 16 inches. The increased trunnion height permits this increase in length of recoil without causing interference when the gun is fired at high elevations.

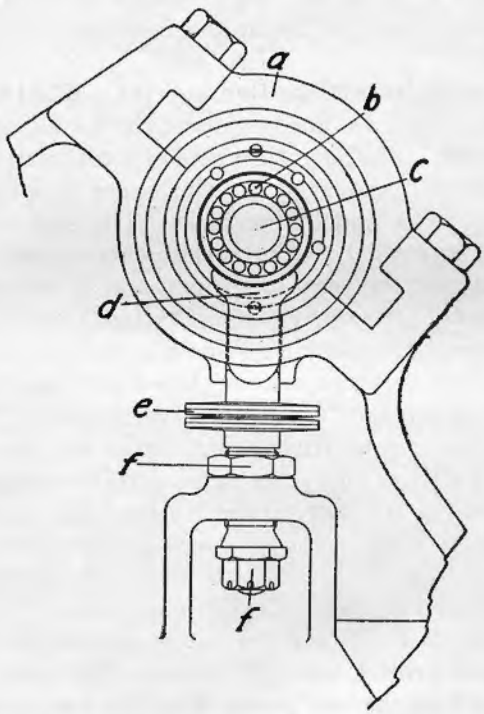


FIGURE 156.—Antifriction device assembly.

a. Cap square.
b. Roller bearings.
c. Trunnion extension.
d. Crutch.
e. Belleville springs.
f. Adjusting nuts.

c. M1917MII.—The M1917MI mount, described in *b* above, has been manufactured in limited quantities. The great majority of fixed antiaircraft mounts still on hand are M1917 mounts. A project has been instituted whereby a few of these original mounts will be modified annually to conform as nearly as practicable to the new M1917MI mount. The modifications are to be made locally, the necessary parts to be shipped from the arsenals. When modified these mounts will be designated M1917MII. The modifications include raising the trunnions (by the installation of filler pieces), installation of the roller bearing, antifriction device, and improvement of the elevating and traversing mechanisms to conform to those of the M1917MI mount. No material change is to be made in the cradle, the number and arrangement of recoil and counterrecoil cylinders in the M1917 mount to be retained.

d. M3.—This mount was designed to accommodate the 3-inch antiaircraft gun, M4. It is similar in all respects to the M1917MI mount except for larger and heavier cradle and bearings to accommodate the heavier M4 gun.

70. 3-inch antiaircraft trailer mount, M1918 (mobile).—This mount (fig. 157) is designed to mount the 3-inch antiaircraft gun, M1918 or M1918MI. The mount consists of a top carriage and cradle, mounted on a 4-wheel trailer truck. The trailer is equipped with outriggers, stability jacks, and lifting jacks. The gun and carriage remain fixed to the trailer in both the traveling and firing positions. The mount permits of 360° traverse of the gun and of elevations from 10° to 85°. A variable, hydrospring, recoil system is provided.

a. Top carriage.—(1) *General.*—The top carriage consists of side frames bolted to the carriage bottom plate and joined transversely in front by the transom and elevating worm bracket. The cradle is pivoted in the trunnion bearings at the top of the side frames. The top carriage as a unit swings on traversing rollers around a pintle on the base plate which is bolted to the trailer. The traversing rollers have an upper roller path on the top carriage bottom plate and a lower roller path on the base plate. A bronze bushing is provided as a pintle bearing, a circular cover protecting it from dirt.

(2) *Firing clips.*—Front and rear clips are bolted to the carriage bottom plate and project through holes in the plate, engaging an annular flange cast on the base plate. The clips barely clear the flange and keep the top carriage from tipping on the rollers when the gun is fired.

(3) *Traveling locks.*—When traveling, the gun is locked at about 20° elevation, lengthwise of the trailer, by upper and lower traveling locks, which protect the elevating and traversing mechanisms.

(4) *Azimuth circle.*—A bronze azimuth circle, graduated in mils and bolted to brackets secured to the base plate, is provided for use in preparatory firings. The circle is graduated counterclockwise.

b. Elevating mechanism.—The gun is elevated and depressed by means of a worm mounted in a bracket to the side frames, which is meshed with the elevating arc bolted to the cradle. The worm is driven by a handwheel through bevel and spur gears. Elevations of from 10° to 85° are permitted.

c. Traversing mechanism.—The traversing mechanism is attached to the left side of the top carriage. (See fig. 157.) Movement of the traversing handwheel is transmitted through a pinion and gear to the traversing shaft on which is keyed a worm which meshes with the traversing rack. The traversing shaft is in upper and lower sections separated by a friction clutch. This clutch is of the multiple disk type, the disks being pressed together by a spring. By pressing down on the hand lever (above the clutch), the spring load

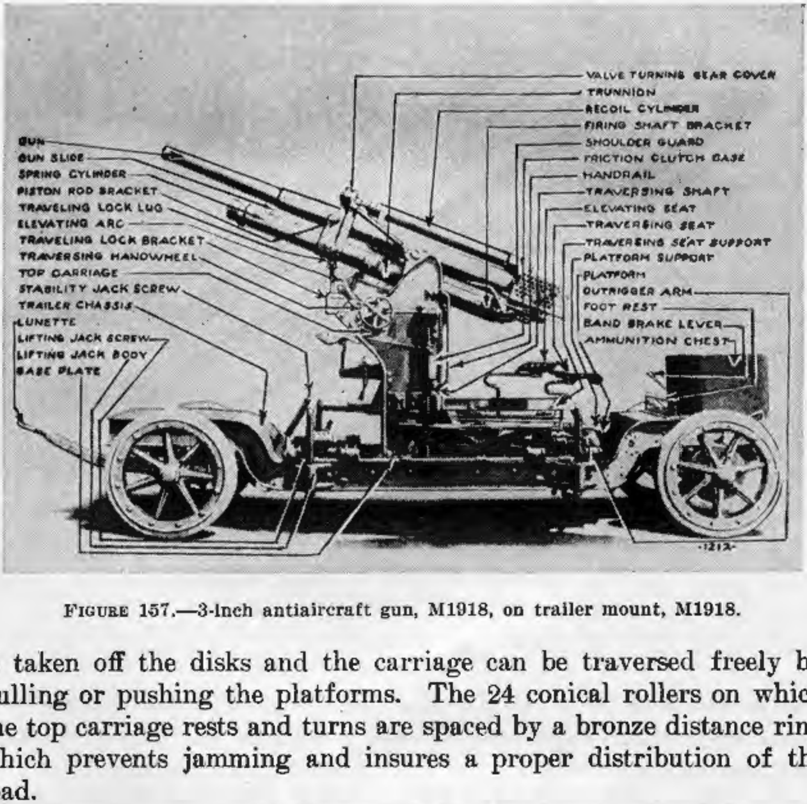


FIGURE 157.—3-inch antiaircraft gun, M1918, on trailer mount, M1918.

is taken off the disks and the carriage can be traversed freely by pulling or pushing the platforms. The 24 conical rollers on which the top carriage rests and turns are spaced by a bronze distance ring which prevents jamming and insures a proper distribution of the load.

d. Recoil system.—(1) *General.*—The recoil system is of the variable hydrospring type. A variable recoil was adopted for this mount to increase stability and provide a high loading angle. A comparatively long recoil at low elevations is necessary for this mount to prevent it from overturning. At high angles of elevation, where the force of recoil is exerted downward, the mount is obviously more stable and a long recoil is unnecessary. In fact, a long recoil is impracticable because the breech would strike the platform in recoil. Hence, a recoil system was provided which gives long recoil at low elevations and short recoil at high elevations. The gun recoils about 40 inches at the minimum elevation of 10° and about 16 inches at the maximum elevation of 85°.

(2) *Recoil mechanism.*—(*a*) The recoil mechanism is shown in figure 158. Section AA is a cross section through the longitudinal section at AA. The recoil cylinder is securely fastened to the gun

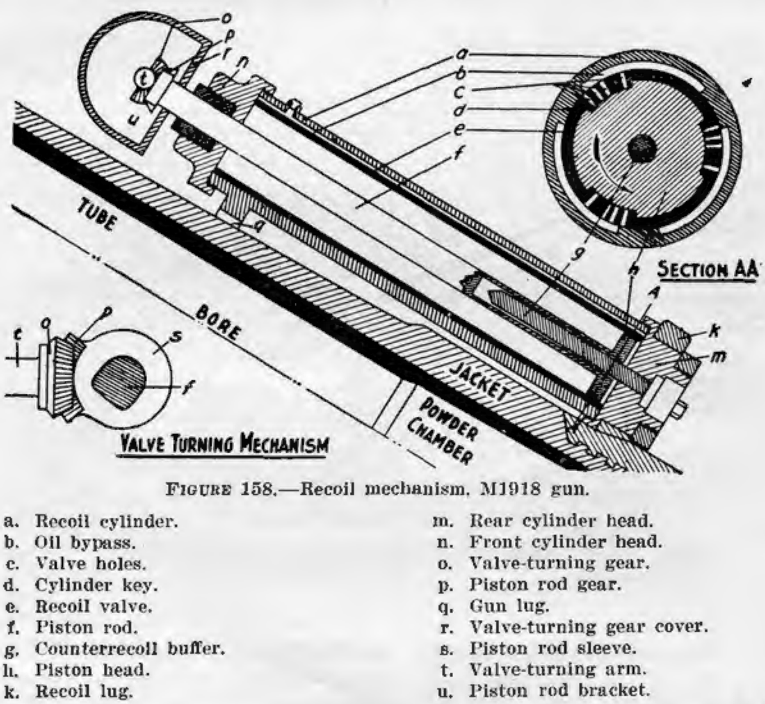


FIGURE 158.—Recoil mechanism, M1918 gun.

a. Recoil cylinder.
b. Oil bypass.
c. Valve holes.
d. Cylinder key.
e. Recoil valve.
f. Piston rod.
g. Counterrecoil buffer.
h. Piston head.
k. Recoil lug.
m. Rear cylinder head.
n. Front cylinder head.
o. Valve-turning gear.
p. Piston rod gear.
q. Gun lug.
r. Valve-turning gear cover.
s. Piston rod sleeve.
t. Valve-turning arm.
u. Piston rod bracket.

and moves with it in recoil. The interior wall of the cylinder has three longitudinal bypasses (b), separated by a like number of keys (d), 120° apart.

(*b*) The recoil valve (e) is a hollow cylinder which extends throughout the length of the recoil cylinder and moves with it in recoil. A small diametrical clearance between the two cylinders permits the recoil valve to rotate within the recoil cylinder. Twelve longitudinal rows of holes (c) are drilled in the valve. Four rows are located symmetrically together in three groups, 120° apart.

(*c*) The piston rod (f) is attached to the mount and does not move in recoil. It is reamed at its rear end to receive the counterrecoil buffer (g). The piston head (h) is firmly locked on rear end of the piston rod and is fitted to the recoil valve (e) with a small diametrical clearance. At its forward end, the piston rod is squared to take the piston rod sleeve (s) and piston rod gear (p). The piston rod gear is meshed with the valve-turning gear (o), which is connected by means of an arm (t) to an adjustable coupling rod pivoted to the right trunnion cap. When the gun is moved in elevation, the piston rod, head, and recoil valve are rotated by means of these gears and connecting parts. The valve-turning gear is journaled in the piston rod bracket (u, fig. 158), which is riveted to and forms a part of the cradle. This bracket keeps the piston rod from moving endwise when the gun is fired. It is braced against this pull by two steel tubes (fig. 157) attached to the trunnions.

(3) *Recuperator mechanism.*—The gun is returned to battery by counterrecoil springs assembled in the two counterrecoil cylinders which are housed in the cradle beneath the gun (see fig. 157). Two columns of springs, inner and outer, are assembled in each cylinder over spring rods which are attached at the rear end to the gun lug. The spring rods move in recoil with the gun and compress the springs.

(4) *Counterrecoil buffer.*—The buffer (g, fig. 158) is a tapered bronze plunger which is threaded into the rear cylinder head (m) and enters the rear end of the piston rod (f). During recoil, the hole in the piston rod fills with oil. During counterrecoil it is trapped by the plunger and forced out through the small diametrical clearance around the plunger, checking the forward motion of the gun into battery.

(5) *Action.*—(*a*) When the gun is moved in elevation, the piston rod (f, fig. 158) and recoil valve (e) are rotated, so that twelve or less rows of holes (c) are exposed to the bypasses (b) as the cylinder and valve move over the piston head in recoil. Each row of holes produces a certain nominal length of recoil, spoken of as 40-inch, 33-inch, 22-inch, and 16-inch recoil. The actual length of recoil will vary slightly from these nominal lengths, depending on the clearance around the piston, friction on the guides, variations in the counterrecoil springs, and differences in powder pressure. Thus, at 10° elevation all holes in the valve are exposed to the bypasses and a recoil of approximately 40 inches is obtained. As the gun is elevated, a less number of holes are exposed and the recoil is shortened.

(*b*) When the gun is fired, the recoil cylinder and valve move to the rear over the piston head, and oil is forced through such holes as are exposed to the bypasses. Most of the energy of recoil is absorbed by the resistance offered to the flow of oil through the small holes in the recoil valve, the bypasses in the recoil cylinder, and the slight clearance around the piston. The remainder of the recoil energy is taken up by the counterrecoil springs. The gun is returned to battery by the counterrecoil springs, which have been compressed during recoil. The energy of counterrecoil is absorbed by the resistance offered to the flow of oil out of the end of the piston rod past the counterrecoil buffer (plunger).

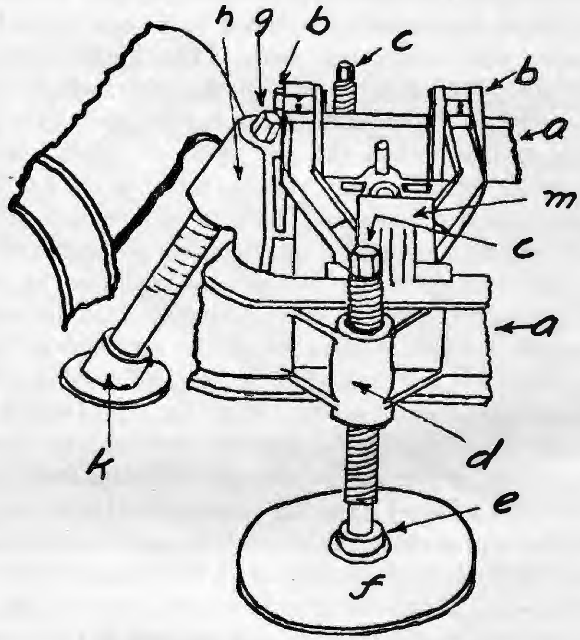


FIGURE 159.—Stability and lifting jacks.

a. Chassis channel.
b. Outrigger lugs.
c. Lifting jackscrew.
d. Lifting jack body.
e. Screw bearing.
f. Lifting jack float.
g. Stability jackscrew.
h. Stability jack body.
k. Stability jack float.
m. Outrigger folded in travel position.

e. Trailer.—The trailer (fig. 157) is a four-wheeled vehicle equipped with springs and solid rubber tires. A base plate is rigidly bolted to the trailer chassis and supports the traversing rollers and top carriage. To stabilize the unit in action, 4 lateral outriggers and 2 inclined stability jacks, front and rear, are provided. Four vertical lifting jacks are also provided with which to level the unit during emplacement, the weight being taken on detachable floats. A level is mounted on the trailer near each lifting jack. During action, the lifting jacks are raised until clear of their floats and the outriggers are adjusted to support the entire weight of the gun, top carriage, and trailer. In traveling position, the outriggers are folded up and the jackscrews raised. The stability and lifting jack and the outrigger details are shown in figures 159 and 160, respectively.

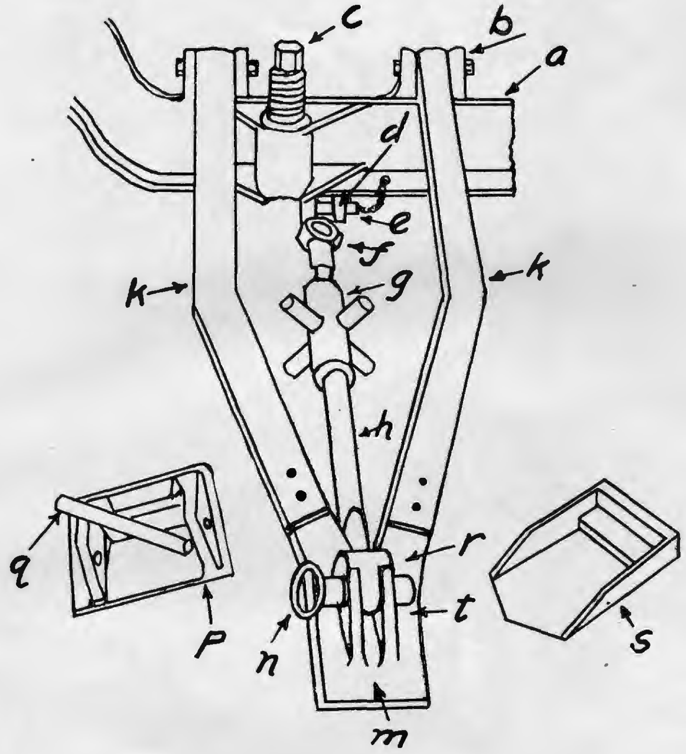


FIGURE 160.—Outriggers.

a. Chassis channel.
b. Outrigger lugs.
c. Lifting jack.
d. Brace lug.
e. Brace lug lock pin.
f. Inner brace.
g. Turnbuckle.
h. Outer brace.
k. Outrigger arms.
m. Outrigger connection.
n. Plunger pin.
p. Float.
q. Float pin.
r. Channel section (outrigger end).
s. Spade.
t. Hinge joint.

f. Pointing equipment.—Most of the M1918 mounts are equipped with sights and case I½ pointing equipment. The antiaircraft sight, M1918, and the bracket fuze setter, M1916, are used. The former is described in FM 4-110, the latter in section XI hereof. A few of the M1918 mounts have been equipped with electrical data transmission systems also described in section XI.

71. 3-inch antiaircraft mounts, M1, M2, M2A1, and M2A2 (mobile).—*a. General.*—(1) These mounts, familiarly known as

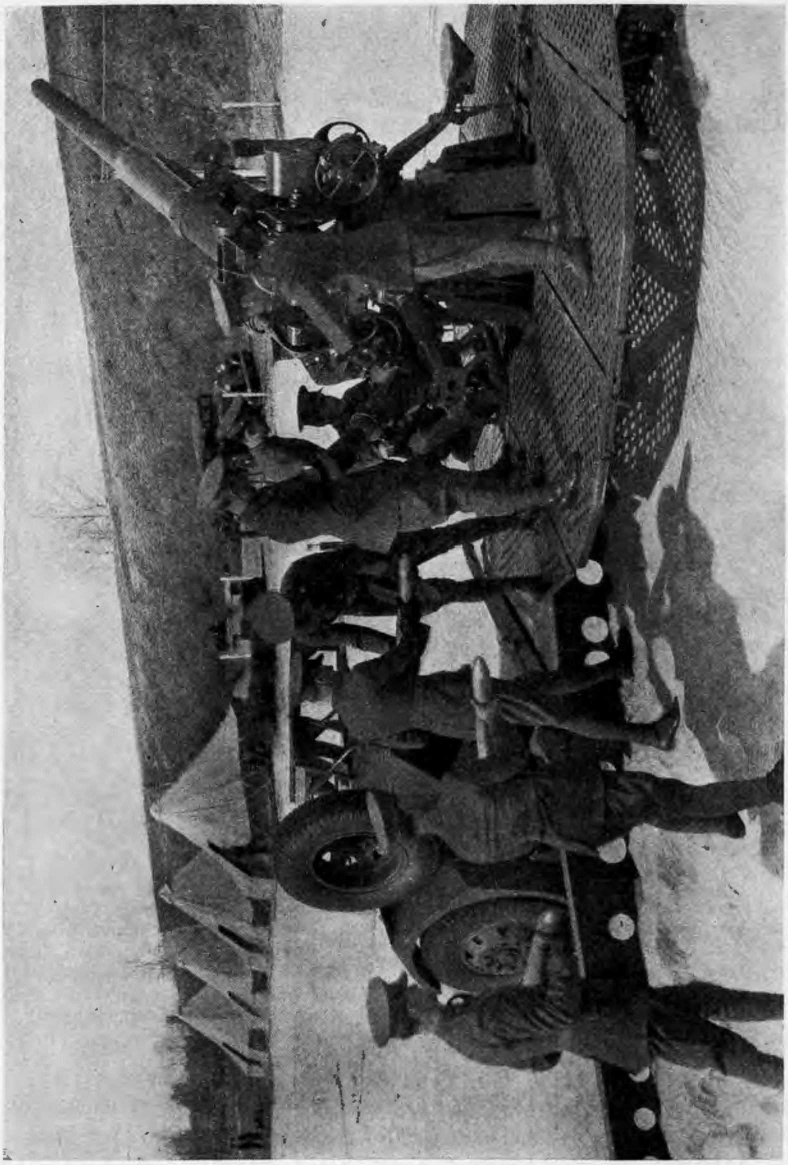


FIGURE 161.—M2 mount.

spider mounts, are provided for the 3-inch antiaircraft guns M1 and M3, respectively. The M1 mount is the earlier type and only a comparatively few are in service. The two mounts are quite similar in appearance but several improvements have been incorporated in the design of the M2 mount. The most important of these is a great reduction in weight due to the use of aluminum or welded steel parts. The description which follows pertains to the M2 mount unless otherwise stated.

(2) The mount, which is shown in various positions in figures 161, 162, 164, 165, and 166, is of the mobile trailer type. It consists principally of a top carriage and cradle mounted on a four-wheel trailer. The trailer is provided with pneumatic tires, is capable of high motor-drawn speeds in transit over good roads, and owing to

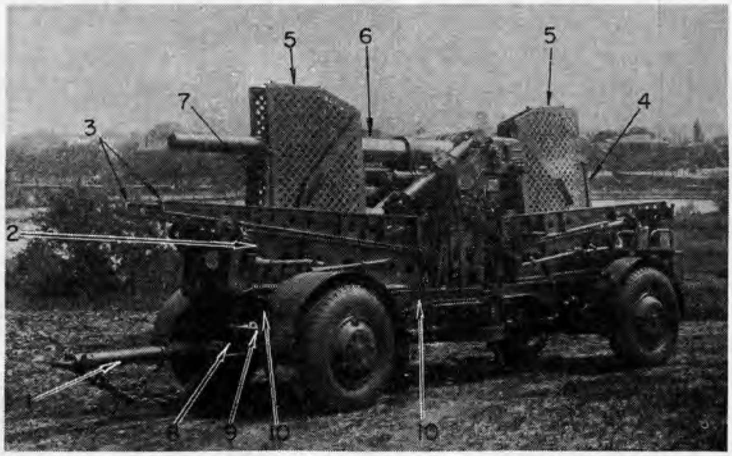


FIGURE 162.—3-inch AA mount, M2 (in traveling position).

1. Lunette.
2. Outrigger, intermediate section.
3. Outrigger, outer section.
4. Platform traveling support.
5. Platform.
6. Gun (M3).
7. Platform traveling support and gun lock.
8. Front bogie.
9. Bogie clamp screws.
10. Outrigger, main section.

the large tires can maneuver at slower speeds over irregular terrain. Outriggers are provided to secure stability in firing. A leveling mechanism is provided which permits of leveling the gun 5° in all directions. The traversing mechanism permits of 360° traverse. Elevations of from −1° to +80° are permitted. The mount is equipped with data receivers of the follow-the-pointer type and a continuous type fuze setter, for use with an electrical data transmission system, which are described in section XI.

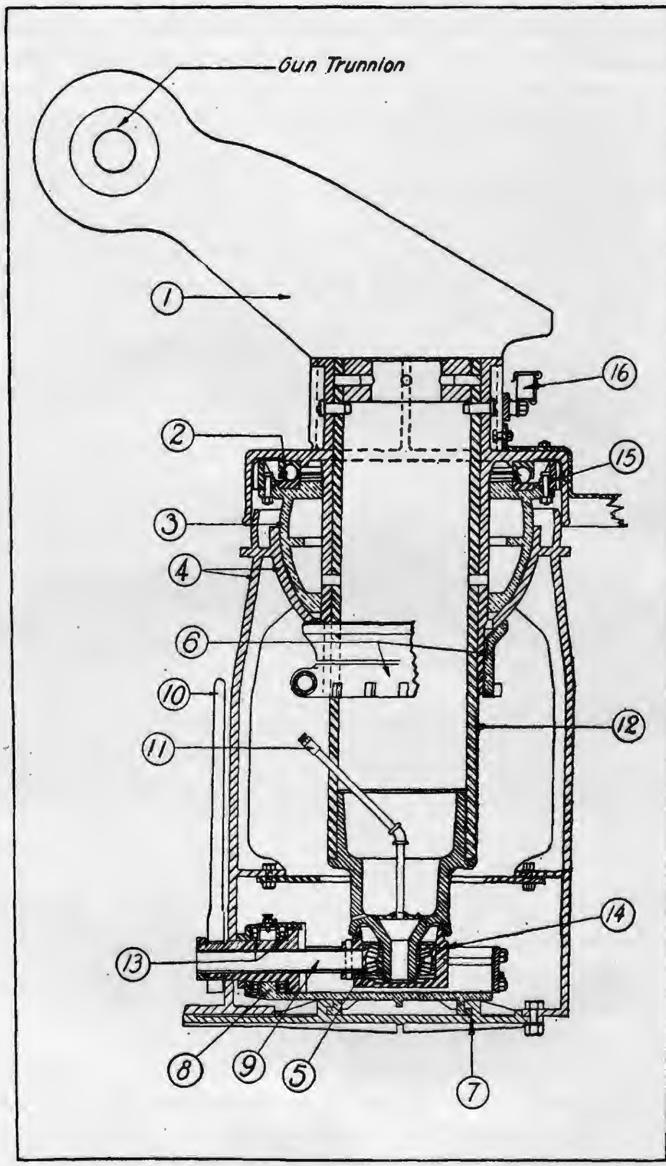


FIGURE 163.—Top carriage pedestal and leveling mechanism.

1. Top carriage.
2. Ball thrust bearing.
3. Spherical bearing.
4. Pedestal.
5. Spherical roller bearing.
6. Counterrecoil nut.
7. Base plate.
8. Guide.
9. Screw.
10. Ratchet wrench.
11. Grease pipe.
12. Spindle.
13. Ball bearings.
14. Housing.
15. Traversing rack.
16. Level vial assembly.

(3) The gun is mounted in a cradle which forms the housing for the recoil system. The recoil system is of the hydropneumatic, constant recoil type described in paragraph 25.

Equilibrators of the pneumatic type are provided to overcome the effect of trunnioning the gun so near the breech.

b. Top carriage.—Figure 163 shows an assembly view of the top carriage pedestal and leveling mechanism. The top carriage (1), which is of welded steel plate, is of the spindle type. It is supported by ball thrust bearings (2) resting on the spherical bearing (3) to which the traversing rack (15) is bolted. The spherical bearing is held in a support in the pedestal (4). The lower end of the spindle (12) is held by a spherical roller bearing (5) which forms a part of the leveling mechanism. The nut (6) prevents the top carriage lifting during counterrecoil. Oil pipes and plugs are provided in the top carriage to permit the lubrication of the traversing thrust bearing. Attached to the carriage are the elevating and traversing mechanisms, the elevation and azimuth receivers, fuze setter, fuze range receiver, gun junction box, and the seats for the operators. (See figs. 164 and 165.) In the firing position the carriage is lowered to the ground by means of jacks attached to the pedestal (see *n* below). To the four corners of the pedestal are attached the main outriggers (*j* below) and lengthwise of the mount are secured the permanent portions of the platform (*n* below).

c. Leveling mechanism.—The leveling mechanism (fig. 163) provides a means of accurately leveling the mount when emplaced. Attached to the base of the pedestal (4) is plate (7) on which guide (8) is supported. This guide is operated by means of a screw (9) with a ratchet wrench (10). Held in the guide at right angles is a housing (14) which is similarly operated by another screw and ratchet wrench. These wrenches remain attached at all times. The movement of the two screws results in a movement of the top carriage about the center of the spherical bearing (3). A lever on each wrench shifts the ratchet and reverses the action of the wrench. Sufficient movement is provided to permit of 5° leveling in all directions. Two level vials (16) at right angles to each other are attached to the top carriage for the guidance of the operators leveling the mount. An alemite lubricator (11) is mounted with a pipe to provide lubrication of the bearing (5). Alemite fittings are also provided for the lubrication of thrust bearings for each of the leveling screws (9).

d. Traversing mechanism.—The traversing mechanism is manually operated by one cannoneer by turning handwheel (7, fig. 164). The traversing rack (15, fig. 163) is bolted to the spherical bearing

(3) which is prevented from tilting in the pedestal (4). Meshing with this rack is a pinion and integral shaft, keyed to which is a worm wheel. This worm wheel meshes with another worm, which in turn is connected to the handwheel (7, fig. 164). Mounted on the pinion shaft is a split spur gear which drives the receiver through a bevel pinion and shaft and the flexible adjustable coupling. The

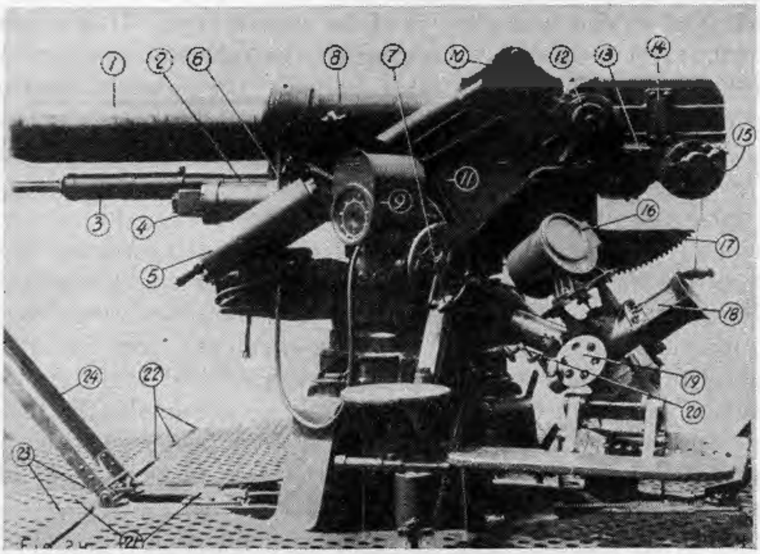


FIGURE 164.—3-inch antiaircraft mount, M2 (left side).

1. Tube.
2. Recoil cylinder.
3. Counterrecoil buffer cylinder.
4. Floating piston cylinder.
5. Equilibrator.
6. Cradle bracket.
7. Traversing handwheel.
8. Cradle.
9. Azimuth receiver.
10. Cradle equilibrator trunnions.
11. Top carriage.
12. Trunnions.
13. Cradle extension.
14. Oil screw filler bracket.
15. Breech operating mechanism.
16. Fuze range receiver.
17. Elevating rack.
18. Fuze setter.
19. Adjusting handwheel.
20. Setting crank.
21. Platform (permanent portion).
22. Platform hinges (center).
23. Platform hinges (outer).
24. Platform traveling support and gun lock (partially unfolded).

purpose of this coupling is to set the mechanical pointers on the azimuth receiver (9) to agree with the oriented azimuth of the gun as indicated by the electrical pointers. During drill or firing, the operator keeps the mechanical pointers of the receiver in coincidence with the electrical pointers by turning the traversing handwheel (7). Each turn of the traversing handwheel equals 33.3 mils movement of the gun in azimuth. The traversing mechanism is ball-bearing mounted throughout and is lubricated by oil contained in the case. Filling, drain, and overflow plugs are provided.

e. Elevating mechanism.—The elevating mechanism is manually operated by one gunner by turning handwheels (18, fig. 165). The elevating rack (20) is bolted to the cradle and meshes with the elevating pinion. To the end of the pinion shaft is keyed a worm wheel which meshes with a worm, on whose shaft are keyed the two hand-

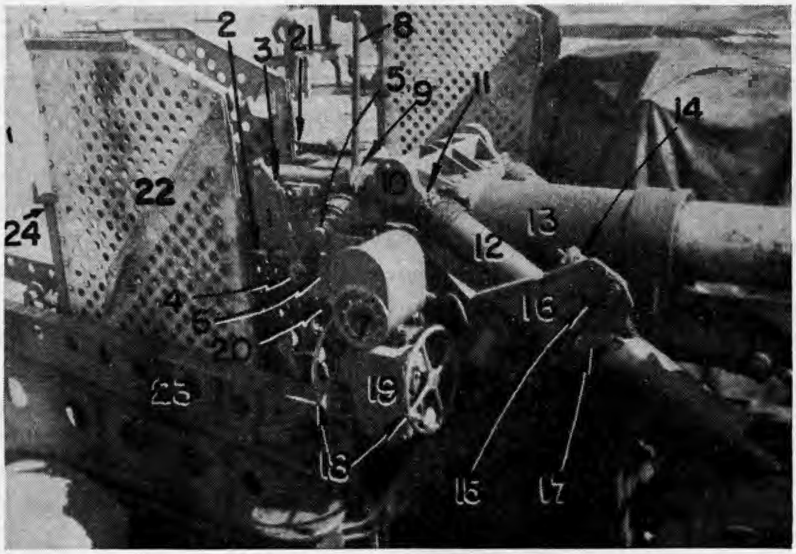


FIGURE 165.—3-inch antiaircraft mount, M2 (traveling position, right side).

1. Breech ring.
2. Lock plate key.
3. Operating handle.
4. Clutch operating shaft.
5. Gun trunnions.
6. Elevation gear segment.
7. Elevation receiver.
8. Wrench, jacking device.
9. Jacking device.
10. Cradle equilibrator trunnions.
11. Equilibrator piston rod.
12. Equilibrator cylinder.
13. Cradle.
14. Temperature scale shaft.
15. Temperature scale window.
16. Top carriage.
17. Main equilibrator trunnions.
18. Elevating handwheels.
19. Elevating gear box.
20. Elevating rack.
21. Cradle extension.
22. Platform.
23. Outrigger.
24. Platform traveling support.

wheels (18). The pinion, pinion shaft, worm wheel, and worm are contained in the gear box (19). Mounted on an extension of the right trunnion (5) is a segment (6) which meshes with a ball-bearing mounted pinion and shaft in rear of the elevation receiver (7). A gear on this shaft meshes with the receiver pinion, driving the receiver pointers. An adjustable flexible coupling is provided on this shaft for the purpose of setting the mechanical pointers of the receiver to agree with the quadrant elevation of the gun. During drill or firing, the operator keeps the mechanical pointers of the receiver in coincidence with the electrical pointers by turning the elevating handwheels (18). Stops are provided to limit the depression at −1° and the elevation at +80°. Each turn of the elevating handwheel equals 33.3 mils movement of the gun. The elevating mechanism is ball-bearing mounted throughout and lubricated by oil in the housing which contains the elevating shaft. The housing is filled with oil through a hole in the top of gear box (19) to a height determined by the overflow hole in its side. The housing can be drained by removing the drain plug in the bottom of the gear box. All parts not lubricated by oil are provided with alemite grease fittings.

f. Equilibrators.—(1) *General.*—In a mobile mount it is necessary to keep the trunnions as low as practicable in order to secure stability. A high loading position is also necessary for all antiaircraft mounts. These requirements are met in the M2 mount by placing the trunnions at a height of only 69 inches above the ground and very near the breach. The latter, however, results in an unbalanced condition of the gun and cradle. The resultant muzzle preponderance is overcome by the use of especially designed equilibrators of the pneumatic type.

(2) *Description.*—Two equilibrators, one on each side of the gun, are provided. The equilibrator cylinder (12, fig. 165) is trunnioned to the top carriage at (17) and contains an air chamber, piston rod (11), a piston head, and springs. The piston rod passes out of the upper end of the cylinder and is attached to the cradle at (10). The chambers at the lower ends of the cylinders are charged with air. The pressure of this air (about 500 pounds per square inch) through the pistons supplies the force required to balance the gun and cradle at all elevations a column of springs is mounted between the piston force is required. When the gun is elevated the cradle pulls the piston rods out, thus increasing the volume of each air chamber and reducing the effective pressure. To assist in maintaining a balance at all elevations a column of springs is mounted between the piston head and the upper end of each cylinder. These springs are compressed by the pistons with increasing counteraction to the pressure of air as the gun is elevated.

(3) *Tests and adjustments.*—(*a*) The gun should elevate and depress with approximately equal effort. If this is not the case the pressure should be checked and the air supply replenished if necessary.

(*b*) Adjustments to compensate for changes in atmospheric temperature are made by turning the squared shaft (14, fig. 165) with a wrench until the pointer indicates the proper temperature on the temperature scale which may be observed through the window (15).

g. Cradle assembly.—The cradle (8, fig. 164) supports the gun and houses the recoil system. The gun trunnions (12) which are placed near the rear end of the cradle are supported on roller bearings mounted on the top carriage trunnion seats. At the left rear of the cradle casting is provided an extension (13, figs. 164 and 165), which supports the breech operating mechanism (15, fig. 164) and a bracket (14) for the oil screw filler device. Lugs are placed on the upper rear surface of the face, to which the equilibrator piston rods are attached at (10). At the front end there is provided a bracket (6) which supports the forward end of the recoil and recuperator cylinders. The bore of the cradle is provided with bronze liners in which the gun slides in recoil. To facilitate the manual retraction of the gun, a jacking device (9, fig. 165) and wrench (8) are provided. The device consists of a screw and head, the head bearing against the breech ring (1) of the gun. (See *h* (4) below.)

h. Recoil system.—(1) *General.*—The recoil system for the M2 mount is of the constant hydro-pneumatic type. A variable recoil system is unnecessary as the increased stability of this mount permits a medium length of recoil (32 inches) at low elevations, and the rearward position of the trunnions permits the same length of recoil to be employed at high elevations without interference from the platform. Due to the weight of the gun, the length of recoil increases slightly at high elevations, but the recoil system is essentially of the constant type.

(2) *Recoil and recuperator mechanisms.*—These mechanisms are contained in one unit. The system, in general, consists of three monel metal cylinders, cylinder heads, the bypass connection, recoil piston and rod, floating piston, recoil and counterrecoil valves, air and oil filling valves, and the liquid and air with which the system is filled. A detailed description of the system and its action is given in paragraph 25.

(3) *Test of oil reserve.*—The purpose of the oil reserve is to move the floating piston (11, fig. 51), from its seat and suspend it between the air and oil in the cylinder (4). An oil reserve must be maintained at all times, otherwise damage to the system will occur when the gun is fired. To check the oil reserve the gun is depressed to the horizontal position and the oil-filling plug (19) is removed. An oil release tool (bleeder) is inserted and screwed in until the oil-filling valve is unseated. If any reserve oil is in the system it will be forced out through the bleeder by action of the air on the floating

piston. If no oil is released an oil reserve must be established. The oil-filling plug at the top rear of cylinder (4) is removed (plug not shown) and oil is poured in through a funnel until the cylinder is full. The plug is then replaced and the proper oil reserve is established by the injection of oil through the filling valve (19). A special oil screw filler device is mounted in the bracket (14, fig. 164) and used for this purpose. Only one screw filler full of oil is inserted. If an oil reserve cannot be established in this manner, it is apparent that the air pressure is low, and must be reestablished. The counterrecoil buffer cylinder has a separate oil supply. It is filled through a plug at the top of the cylinder.

(4) *Test of air pressure.*—The air pressure in the recuperator cylinders is tested by manually retracting the gun. The jacking device (9, fig. 165) and wrench (8), described in *g* above, are used for this purpose. With the gun in the horizontal position, the screw is turned until the gun is forced to the rear about 1 inch. The gun is then released by turning the screw to its original position. The gun should follow back into battery. If it does not the air supply is very low and should be reestablished by ordnance personnel. If the gun returns to battery in the horizontal position the pressure should be tested with the gun elevated. The gun is elevated to 1,450 mils and the jacking operation repeated. If the gun does not follow into battery when the jack is released, depress slowly and note the angle at which the gun returns to battery. If this angle is below 900 mils the air supply must be replenished. The air-filling valve (16, fig. 51) is in the bypass connection (18).

i. Platform.—The platform is made of strong aluminum plate stiffened by metal angles. Holes are drilled in the platform to prevent the operating personnel from slipping and to reduce the sounding board effect when the gun is fired. The front and rear sections of the permanent portion of the platform (21, fig. 164) are fastened to the pedestal. The folding portions of the platform are hinged in the center at (22) on each side of the mount. The inside edge of the end sections of the platform are also hinged to the permanent portion of the platform at (23). This arrangement permits the middle sections to be folded over onto the end sections and both sections on either side folded toward the center and locked, as shown in figures 162, 165, and 166. In the firing position the folding portions of the platform are supported on the top surface of the main outriggers and on brackets. These brackets are attached to the main outriggers and are extended when the outriggers are spread apart.

j. Outriggers.—Four outriggers are provided and carried on each mount to provide stability of the mount at all angles of the gun during firing. The outriggers on the M2 mount are either of cast aluminum or welded steel construction, the latter being the newer type. (Those of the M1 mount are steel castings and much heavier.) Each outrigger (fig. 161) is composed of three sections—main (9), intermediate (3), and outer (2). The main section is hinged to the pedestal, the intermediate to the main section, and the outer to the intermediate section. In the firing position these sections are swung out, fully extended and locked. In the traveling position (fig. 162) the main outriggers form the chassis, carrying the mount in the center and supported on each end by the bogies (8) and (16).

k. Bogies.—Front and rear bogies (fig. 162) are provided to support the mount in the traveling position. Each bogie consists of a frame seat, springs, axle, wheels, and tires. In addition, the front bogie is provided with a drawbar and steering mechanism and the rear bogie with brakes and brake mechanism. The bogie frames are of either bolted or welded construction, the latter being the newer type. (Bogie frames on the M1 mount are of bolted construction.) In the traveling position the bogie frames are located under the engaging seats provided on the main outriggers and securely fastened in place by clamp screws (9). The frames are supported on semi-elliptical springs secured to the axles. The wheel hubs are carried on conical roller bearings. The rear wheel hubs are provided with brake drums. Two spare wheels are provided for the mount. Both bogies are removed when the mount is placed in firing position. (See *n* below.)

l. Jacks.—The jacks (fig. 162) provide a means of raising and lowering the mount from traveling to firing position. Two jacks of the compound screw type, operated through gears, and a ratchet wrench are attached to the pedestal. The jacks and floats are screwed up against the mount in the traveling position. The ratchet wrenches (15) remain attached. Each jack is provided with a float (12) to obtain sufficient bearing when resting on the channel placed on the ground. The jack floats are connected by a chain tie (13). This tie prevents the inner screws of the jacks from rotating independently of the outer screw, thus maintaining the proper relation between the screws of each jack. The maximum lift of the jacks is 26 inches.

m. Pointing equipment.—The M2 mount is equipped with data receivers of the follow-the-pointer type for case III pointing and electrical data transmission. No gun sights are provided. The continuous type fuze setter (18, fig. 164) described in section XI is used. The electrical data transmission system is also described in section XI.

n. Emplacement of mount (fig. 166).—On uneven ground with greater than about 5° slope the areas under spade and outriggers should be roughly leveled, as the leveling mechanism of the mount is limited to an adjustment of 5°. The procedure given below is a general guide for emplacing the unit:

(1) The spare wheels are first removed. The jack supporting channel is placed on the ground under the mount so that the jacks, when run down, will rest thereon. The jacks (10) are then run down by means of the ratchet wrenches until the floats are in contact with the channel.

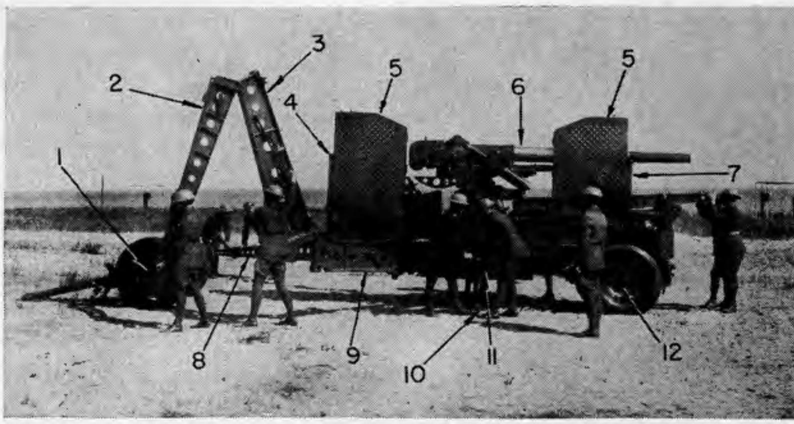


FIGURE 166.—Emplacing 3-inch AA mount, M2 (front bogie removed, front outriggers being placed and jacks manned).

1. Front bogie.
2. Outrigger, outer section.
3. Outrigger, intermediate section.
4. Platform traveling support.
5. Platform.
6. Gun (M3).
7. Platform traveling support and gun lock.
8. Outrigger (extended).
9. Outrigger, main section.
10. Jack.
11. Pedestal spade.
12. Rear bogie.

(2) The screws (9, fig. 162) fastening the front and rear bogie frames to the mount are released just prior to the load being taken by the jacks. The jacks are now further run down, lifting the mount sufficiently to permit the withdrawal of one of the bogies as shown in Figure 166. After removing one bogie, the outriggers on that end are swung outward at an angle of 45° and the intermediate and outer sections unfolded and locked by means of the keys provided.

(3) The mount is then tipped from the ends of the extended outriggers and the other bogie removed. The remaining outriggers

are now released and swung outward. The intermediate and outer sections are unfolded and locked.

(4) The mount is then lowered to the ground, the jacks being operated until the stop is reached. Care should be taken in lowering the jacks to keep the mount approximately level. *Before firing begins, the jacks must be raised again.*

(5) If the under surface of the outriggers does not engage the ground for the full length of the outriggers, loose earth should be shoveled under them so as to provide continuous contact with the ground.

(6) The four sections of the folding platform are then released, lowered into position, and locked. The platform traveling support

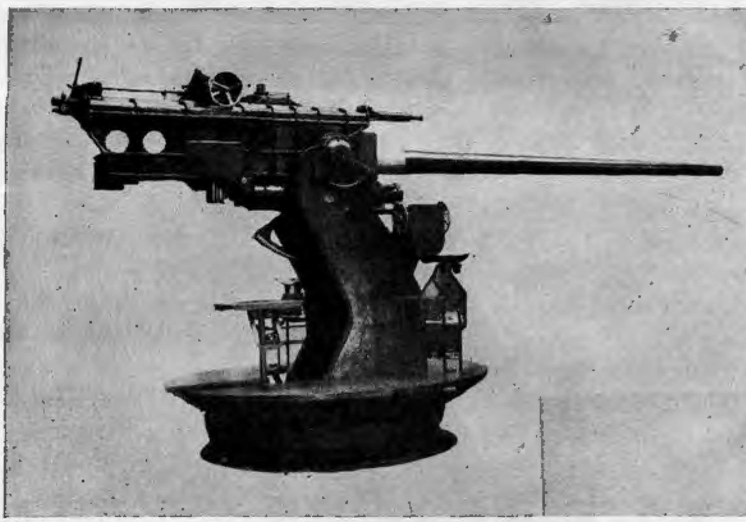


FIGURE 167.—105-mm antiaircraft gun mount, M1.

and gun traveling lock units are unlocked and unfolded (4 and 7, fig. 166).

(7) The fuze setter bracket is removed from its traveling position and attached to the top carriage and the seat unfolded. The fuze setter is removed from its traveling position and placed in the fuze setter bracket. The transmission cable from the main junction box is then connected to the gun junction box on the mount.

(8) The pointing tests and adjustments are now made as prescribed in FM 4-110.

o. The M2A1 mount is the same as the M2 but carries the two spare wheels on the bogies, and handwheels with bevel gears have been added to the jacking mechanism.

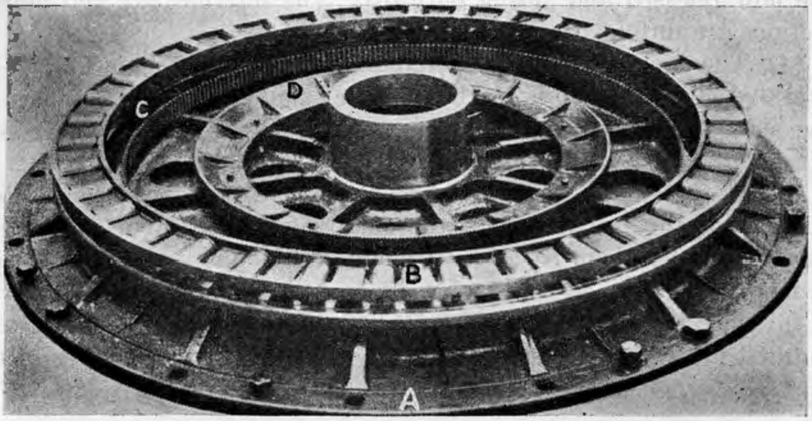


FIGURE 168.—Base plate—roller assembly.

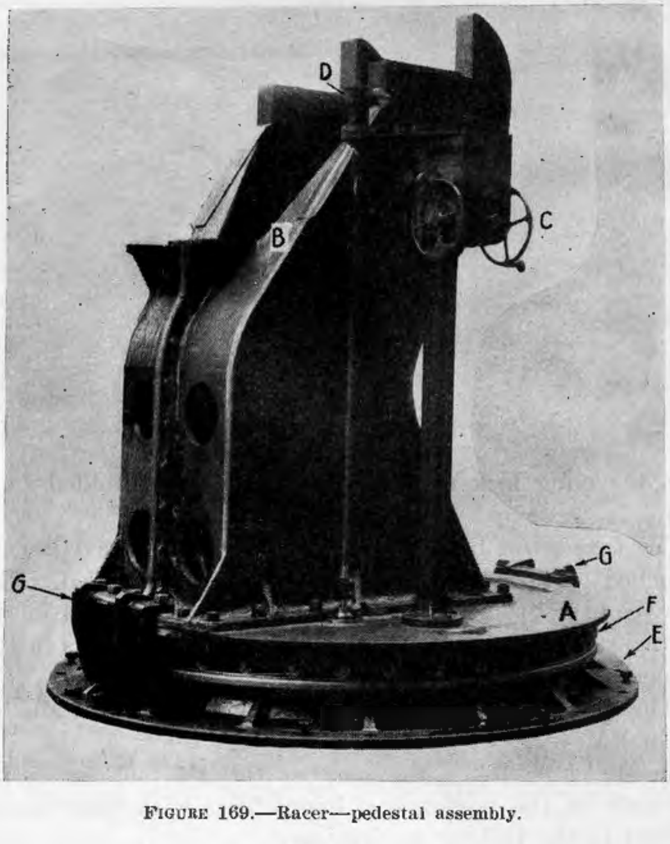


FIGURE 169.—Racer—pedestal assembly.

p. The M2A2 mount has the modifications mentioned in *o* above and in addition has 4-wheel electric brakes.

72. 105-mm antiaircraft mount, M1 (fixed).—The 105-mm antiaircraft gun M3 (par. 66) is used with this mount. A power rammer is furnished to handle the heavy fixed ammunition, allowing a sustained rate of fire of 15 to 20 rounds per minute. The mount is shown in figure 167.

a. The part of the mount which is bolted to the concrete is shown in figure 168. Note the base plate (A), the roller assembly (B), and the traversing rack (C). The gear (D) transmits (through a pinion and shaft) the present azimuth of the mount to the azimuth data receiver. The raised center portion of the base plate (E) acts as a pintle for the racer and takes the horizontal component of the recoil stresses.

b. Figure 169 illustrates the movable part of the mount. It shows the racer (A) which traverses on the roller assembly shown in figure 168. The pedestal (B) consists of two yokes bolted together. The trunnion bearings fit into the right-angled notches at the upper end of the pedestal. The traversing handwheels are shown at C and the azimuth receivers' mechanical drive at D.

The mount proper (fig. 167) is quite different in appearance from the M1917 fixed mount already considered. The large structure to the rear of the trunnions is the power ramming device. Trunnion bearings are of the antifriction type. The elevating rack of conventional design is shown underneath the cradle.

The recoil mechanism is of the hydrospring type giving a constant recoil of 16 inches. It consists of a single hydraulic recoil cylinder with a dashpot counterrecoil buffer mounted at the front end and two counterrecoil spring cylinders. As may be seen from the illustration the gun is trunnioned at its center of gravity and no equilibrators are provided.

TABLE II.—CHARACTERISTICS OF ANTIAIRCRAFT ARTILLERY GUNS

ITEM	TYPE OF MOUNT	RIFLING ONE TURN IN CALIBERS	WEIGHT ON ROAD (LBS.)	WEIGHT OF GUN (LBS.)	WEIGHT OF GUN AND MOUNT (LBS.)	ELEVATION DEGREES MIN	ELEVATION DEGREES MAX.	TOTAL TRAVERSE DEGREES	EQUILIBRATOR TYPE	RECOIL MECHANISM TYPE	LENGTH OF RECOIL	REMOVABLE LINER TYPE	BREECH ACTION AUTOMATIC OPENING	BREECH ACTION AUTOMATIC CLOSING	LENGTH OF BORE CALS.	AMMUNITION PROJECTILE	AMMUNITION FUZE	AMMUNITION WT. PROJ. FUZED	AMMUNITION CARTRIDGE CASE	NORMAL MUZZLE VELOCITY	MAXIMUM HORIZONTAL RANGE FOR SAFETY PURPOSES	MAXIMUM HORIZONTAL RANGE AS LIMITED BY FUZE	MAXIMUM VERTICAL RANGE	FIRING TABLES	TRAJECTORY CHARTS
FIXED MOUNTS GUN, 105-mm, AAM3	M1	50	FIXED	6,575	33,330	-5	+80	360	NONE	HYDRO-SPRING	CONSTANT 16"	NONE	YES	YES	60	M38, HE M38, PRACTICE	M2 M2	32.90 33.54	M6 M6	2800	19,220	13,160	12,520	105 A A-E-1	105 A A-E-1a, 1b, 1c
GUNS 3-INCH M1917 A2 & M1917 M1A2 M1917 A3 & M1917 M1A3	M1917 & M1917MII	40	FIXED	3,105	15,280	-3	+85	360	NONE	HYDRO-SPRING	CONSTANT 12"	NONE SPECIAL	YES	YES	55										
M1917MII & M1925 M1 M2	M1917 M1	40	FIXED	3,105	15,280	-5	+85	360	NONE	HYDRO-SPRING	CONSTANT 16"	NONE M2 LIGHT	YES	YES	55	MK. IX, HE M42, HE M42, HE MK. I, SHRAP	MK. III A2 MK. III A2 M43 MK III A1	12.74 12.78 12.97 15.30	MK I M2 MK I M2 MK I M2 MK I A1	2800 2600 2800 2600	11,600 14,200 12,600	7,400 10,550 7,550	8,200 9,500 8,600	3AA-K-2 3AA-N-1 3AA-J-2	3AA-K-2a, 2b, 2c, 2d, 2e 3AA-N-1a, 1b, 1c, 1d, 1e, 1f 3AA-J-2a, 2b, 2c, 2d, 2e
M4	M3 & M3A1	40	FIXED	3,445	15,700	-5	+85	360	NONE	HYDRO-SPRING	CONSTANT 16"	M4 HEAVY	YES	YES	55										
MOBILE MOUNTS GUNS 3-INCH M1918 & M1918M1 M1918A1 & M1918M1A1	M1918 WITH TRAILER M1918	50 - 25 25	14,085	1,966	9,175	+10	+85	360	NONE	HYDRO-SPRING	MAX 40" MIN 16	NONE	NO	YES	40	MK I, HE MK IX, HE M42, HE MK I, SHRAP	MK III A2 MK III A2 MK III A2 MK III A1	15.64 12.74 12.78 15.30	MK II A1 MK II M2 MK II M2 MK II A1	2400 2600 2600 2400	11,800 11,000 11,800	7,800 7,700 7,800	7,900 7,000 7,900	3AA-I-2 3AA-L-1 3AA-I-2	3AA-I-2a, 2b, 2c, 2d, 2e 3AA-L-1a, 1b, 1c, 1d, 1e 3AA-I-2a, 2b, 2c, 2d, 2e
M1 M3	M1A1 M2A1	40	16,500 15,900	1,918 2,310	12,700 12,100	-1	+80	360	PNEUMATIC	HYDRO-PNEUMATIC	CONSTANT 32"	M1 LIGHT M3 HEAVY	YES	YES	50	MK IX, HE M42, HE M42, HE MK I, SHRAP	MK III A2 MK III A2 M43 MK III A1	12.74 12.78 12.97 15.30	MK II M2 MK II M2 MK II M2 MK II A1	2800 2800 2800 2600	11,600 14,200 12,600	7,400 10,550 7,550	8,200 9,500 8,600	3AA-K-2 3AA-N-1 3AA-J-2	3AA-K-2a, 2b, 2c, 2d, 2e 3AA-N-1a, 1b, 1c, 1d, 1e, 1f 3AA-J-2a, 2b, 2c, 2d, 2e

NOTES

1. While the same types of projectiles may be used for both mobile and fixed 3-inch antiaircraft guns, the size of the cartridge case is different.

2. When the supply of M2 fuzes is exhausted, the M43 fuze will be used in 105-mm ammunition.

3. Except with the HE shell M42 the Mk. III fuze may be used in place of the Mk. III A1 or the Mk. III A2 until exhausted.

SECTION XI

ACCESSORIES FOR ANTIAIRCRAFT GUN MOUNTS

73. General.—*a.* In addition to the guns and mounts proper, the following principal accessories are required to complete the equipment of an antiaircraft artillery gun battery in the field:

(1) Fire control instruments.
(2) Data transmission system.
(3) Instrument trailer (certain units only).
(4) Power unit.
(5) Fuze setters.
(6) Sights (certain units only).
(7) Prime movers.

b. (1) The various antiaircraft fire control instruments, including altimeters, height finders, data computors, etc., are described in FM 4-110.

(2) Data transmission systems may be divided into two general classes, telephonic and electrical. The former is used with mounts equipped for case I½ pointing (see FM 4-110); the latter, which is now the standard system, employs case III pointing and electrical and automatic transmission of data. Follow-the-pointer devices are used, no gun sights being required. Electrical data transmission systems are described in paragraphs 74 to 79.

(3) Instrument trailers are provided for some types of data computors (directors). The trailers also carry fire control equipment and the power unit for the electrical data transmission system. Trailers and power units are discussed in paragraphs 80 and 81.

(4) Continuous type fuze setters with fuze receivers mounted thereon are employed on mounts equipped with electrical data transmission systems. The bracket type fuze setter is normally used on mounts not so provided. (See par. 82.)

(5) Sights are now employed only on those antiaircraft mounts not provided with electrical data transmission systems. The antiaircraft

gun sights now in use are discussed in FM 4-110. Present sights are not particularly satisfactory due principally to backlash and play and because smoke obscures the target when the gun is fired.

(6) Prime movers (trucks) are furnished each mobile antiaircraft gun battery for the primary purpose of towing the mounts. They are also used for transporting personnel, ammunition, and equipment. Descriptions and operating instructions are furnished with each unit.

74. Electrical data transmission systems.—*a. General description.*—(1) The rapidity and accuracy of fire required of an antiaircraft gun have led to the development of electrical data transmission systems. Such a system may be defined as the necessary apparatus for transmitting automatically over a distance the data derived from a computing or plotting device.

(2) The apparatus includes a source of power, the transmitters, the receivers, and the necessary connecting wires and junction boxes. Three transmitter units are located in the data computor, one each for the three elements of firing data required for case III pointing—azimuth, quadrant elevation, and fuze range. There are likewise three receiver units at each gun, each being connected to the corresponding transmitter unit in the data computor. An altitude transmitter at the height finder and a corresponding receiver in the data computor are also a part of the system. The source of power is connected to all units.

(3) A follow-the-pointer system of applying data is employed. The data transmitted automatically and continuously from the data computor are indicated by electrical pointers on the receivers. The receivers likewise contain mechanical pointers which are connected by gearing to the fuze setter or to the traversing or elevating mechanism of the gun. It only remains necessary, therefore, for the operators at the receivers to match the mechanical pointers to the electrical pointers by operating the fuze setter, traversing the gun or elevating the gun, as the case may be. The gun is thus laid at the proper data determined by the data computor. The altitude transmitter and receiver units operate in a similar manner.

b. Advantages.—An electrical data transmission system has the following specific advantages:

(1) Makes the transmission of firing data instantaneous and permits the pointing of the gun simultaneously with the determination of data. Practically all dead time is eliminated.

(2) Eliminates the constant interruptions that obtain in transmission of data by telephone.

(3) Eliminates the possibility of error in the transmission of data and due to the use of follow-the-pointer methods makes the application of data at the guns more rapid, simple, and less liable to error.

(4) Eliminates several operations at the instruments and guns and eliminates the subsequent possibility of personnel errors. One of the most likely sources of error eliminated is the gun pointers' operation.

(5) Eliminates the inherent inaccuracies existing in any sighting system so far provided.

All of the above advantages contribute directly to the accuracy and rate of fire.

c. General classes.—Our present electrical data transmission systems employ alternating current as their source of power. They are of the self-synchronous type, that is, once in synchronism they stay that way unless disturbed by some outside source.

d. Standard types.—The following electrical data transmission systems are in use:

(1) M2 system, for the M1A1 director (Vickers).
(2) M2A1 system, for the M2 director (Sperry).
(3) T8E3 system, for the T8E3 director (Sperry).
(4) M3 system, for the M3 director (Sperry).
(5) M4 system, for the M3 and M4 directors (Sperry).

The M4, the latest system, will be described in detail and the others briefly.

75. Data transmission system, M4.—*a. Fuze range transmission.*—A single transmitter in the computor furnishes the fuze range data for the four guns of the battery. The phase (transmitter to receiver) leads are routed, as are all other leads from the director to the guns, through the main junction box, where each of the three leads is distributed to the four guns through the four (20-conductor) gun cables to the four gun junction boxes, thence through 20-conductor cables to the fuze range receivers. The remaining leads in the 20-conductor cable to the fuze range receiver carry the 60-cycle, 110-volt A. C. power (leads Nos. 4 and 5), the 60-cycle, 6-volt A. C. for the indicator and fuze setter lamps, and 3 spares. The assembled receiver is mounted on the fuze setter. The repeater has a dial bearing a pointer on its shaft. Concentrically with this dial a rotatable annular ring is mounted, bearing an index. This annular ring is geared to the fuze setting ring in the fuze setter. Concentric with the rotatable annular ring is a fixed scale on which the actual transmitted or set fuze ranges may be read. (See fig. 173 for diagram of M4 system.)

b. Fuze indicator, M4.—(1) The fuze indicator, M4 (fig. 170), consists of an A. C. synchronous receiver which positions a dial pointer with respect to a fixed circular scale graduated in fuze range. An index pointer mechanically geared to the fuze setter mechanism rotates concentrically with the dial pointer and the fixed scale. Two types of fuze indicator scale are used: one, graduated with a non-uniform scale from 0–21, is used with the powder train fuze, Mk.III; the other, graduated with a uniform scale from 0–30, is used with the mechanical fuze. The graduations and numbers on the fixed scale and the indexes on the repeater dial and the mechanical pointer are cut through to permit indirect illumination and are filled in with

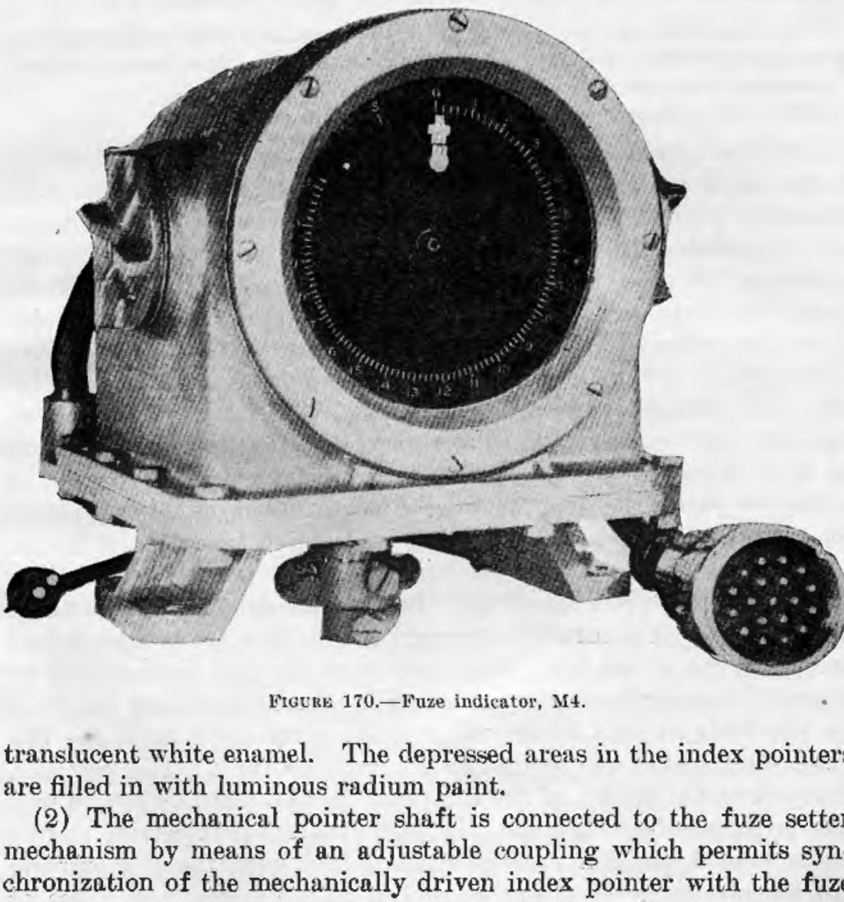


FIGURE 170.—Fuze indicator, M4.

translucent white enamel. The depressed areas in the index pointers are filled in with luminous radium paint.

(2) The mechanical pointer shaft is connected to the fuze setter mechanism by means of an adjustable coupling which permits synchronization of the mechanically driven index pointer with the fuze setter.

(3) The entire mechanism is enclosed in a water-tight case provided with a shatter-proof glass window through which the dial and indexes may be seen. Two cable connectors are provided, one for the 20-conductor junction box cable and the other for the

2-conductor fuze setter lamp cable. The case may be removed from its base to gain access to the mechanism. The indicator is mounted directly on the fuze setter.

(4) The repeater case may be rotated to synchronize the indicator with the data transmitter in the director by unscrewing the cover on the right side of the indicator and adjusting the slotted shaft end which protrudes into the upper part of the cavity. This motion is limited to about 30° on either side of the zero position. The rotation is accomplished through the use of a worm and worm wheel so the repeater case will not rotate after having been adjusted.

NOTE.—Indicator, receiver, and repeater are oftentimes used indiscriminately in antiaircraft literature. The generally accepted definitions are as follows:

Indicator—The complete indicating device as shown in fig. 170.

Receiver (or repeater)—The electric motor within the indicator.

c. Altitude transmitter.—The altitude transmitter is built into the height-finder cradle. Its principal elements include a transmitter unit, concentric coarse and fine dials for indicating the altitude or range, and a handwheel drive for setting readings. The inner dial (coarse) is attached directly to the rotor shaft and has an equicrescent (uniformly divided) scale representing 10,000 yards for a complete revolution. The other dial (fine) ring is geared to the shaft of the inner dial and has an equicrescent scale indicating 1,000 yards per revolution. The smallest division on the fine dial is 20 yards. An auxiliary dial and spot corrector knob are provided for setting calibration or other corrections. The dial indicates corrections up to plus or minus 500 yards, the smallest division being 100 yards. Illumination for the dials is provided by 6–8-volt automotive type electric lamps.

d. Azimuth transmission.—Each transmitter is capable of controlling its repeater to a precision of $\frac{1}{2}$°. In the transmission of azimuth or elevation, greater accuracy is necessary and the data are broken up into two parts, coarse and fine. Each part is transmitted and received by separate transmitters and repeaters. The coarse transmitter handling the hundreds of mils makes one revolution for 6,400 mils; the fine transmitter makes one revolution for each 400 mils. The precision of transmission is that of the fine; that is, $\frac{1}{2} \times 1/360 \times 400 = .56$ mil. The device is self-synchronous; that is, the dials of the receiving instruments take a position exactly synchronized with the transmitting instruments whenever power is applied to the system regardless of synchronism or lack of synchronism before the application of power. The azimuth transmitter consists of two transmitter units geared together in 16 to 1 ratio, both driven by the firing azimuth shaft in the director. The slower (coarse) transmitter makes one revolution for a change in azimuth of 6,400 mils. The faster (fine) transmitter makes one revolution for each 400 mils change in azimuth. These two related transmitters are connected to their receivers by six conductors (plus No. 4 and No. 5, the power leads). The tagging of these six phase leads are fine transmitter to fine receiver 1, 2, and 3; coarse transmitter to coarse receiver 6, 7, and 8. Leads Nos. 4 and 5 are at all times 110-volt, 60-cycle A. C. power leads. The operation of the double-unit receiver may best be understood by a study of the schematic diagram of figure 171. Two repeater (receiver) motors are mounted on the gun in a watertight case. The coarse reading receiver motor has a pointer mounted on its rotor shaft which by action of its transmitter (coarse) makes one revolution for 6,400 mils change in transmitted

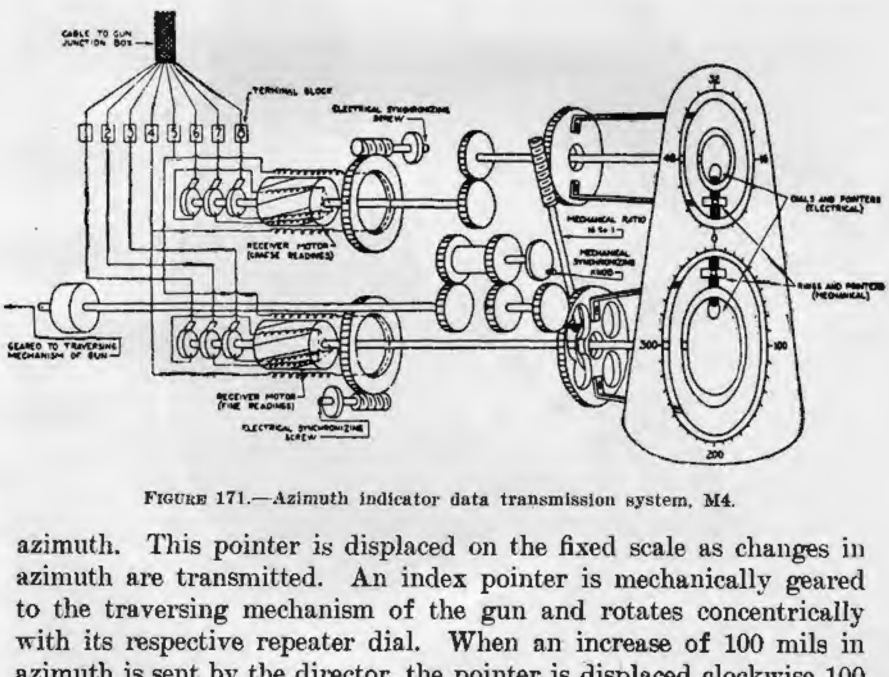


FIGURE 171.—Azimuth indicator data transmission system, M4.

azimuth. This pointer is displaced on the fixed scale as changes in azimuth are transmitted. An index pointer is mechanically geared to the traversing mechanism of the gun and rotates concentrically with its respective repeater dial. When an increase of 100 mils in azimuth is sent by the director, the pointer is displaced clockwise 100 mils from the fixed scale. If the gun is now traversed so as to increase its azimuth 100 mils, the concentric pointer will rotate 100 mils and match with the pointer rotated by the coarse receiver motor. The fine receiver carries a pointer which makes one revolution for each 400 mils of transmitted azimuth. A concentric dial is geared to the traversing mechanism of gun. Its motion is entirely independent of the pointer. This dial has a pointer which makes one complete revolution for each 400 mils traverse of the gun. A study of the schematic diagram will show that when the pointers of the coarse receiver are first matched and the pointers of the fine receiver then matched the gun is laid to the transmitted azimuth.

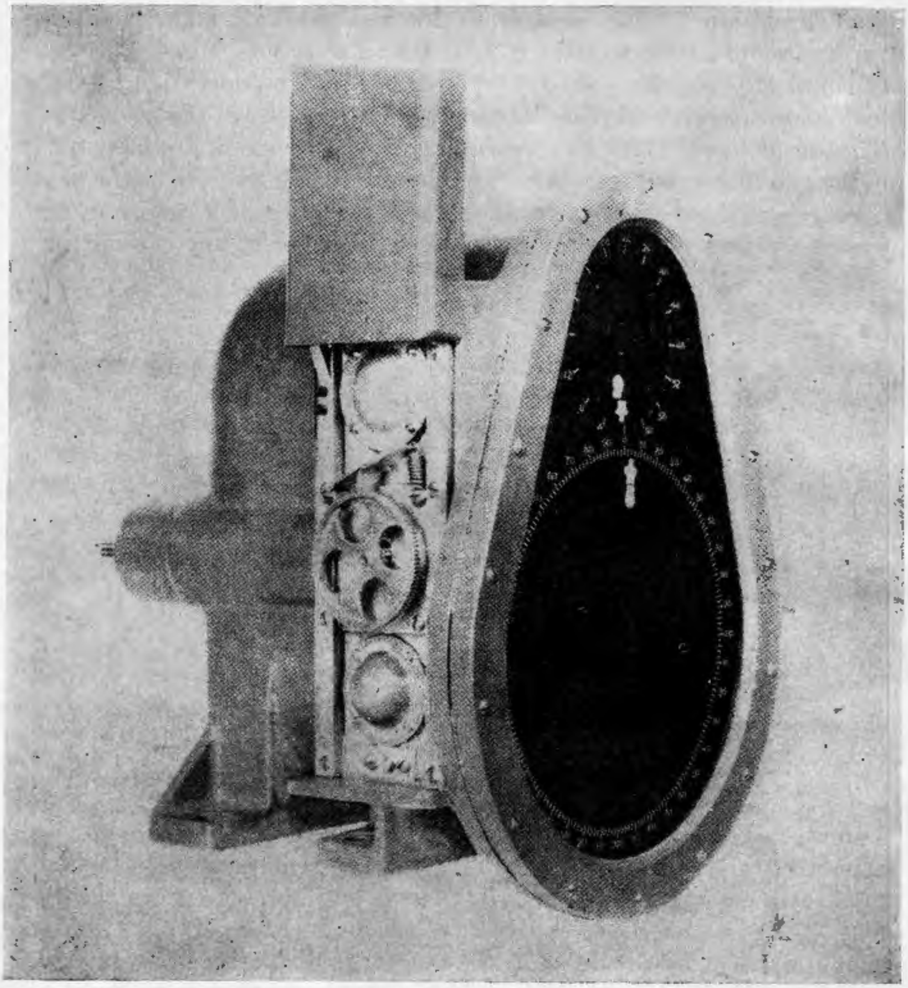


FIGURE 172.—Azimuth or elevation indicator, M4.

e. Elevation transmission.—The elevation transmitter, located in the director, and its four double-unit receivers, one on each gun, are identical in every way with the azimuth units described above.

f. Azimuth or elevation indicator, M4.—(1) The azimuth or elevation indicator, M4 (fig. 172), contains two A. C. synchronous repeaters, one for positioning a fine dial indicating 400 mils per revolution and one for positioning a coarse dial indicating 6,400 mils per revolution. Two index pointers, one for the fine dial and one for the coarse dial, are mechanically geared to the traversing or elevating mechanism of the gun mount and rotate concentrically with their respective repeater dials. These pointers are read against a fine fixed scale graduated from 0 to 400 mils in two mil steps, and a coarse fixed scale graduated from 0 to 6,400 mils in 400 mil steps. The graduations and numbers on the fixed scales and the indexes on the electrical dials and mechanical pointers are cut through to permit indirect illumination and are filled in with translucent white enamel. The depressed areas in the index pointers are filled in with luminous radium paint.

(2) The entire mechanism is enclosed in a watertight case provided with a shatter-proof glass window through which the scales and index pointers may be seen. Two cable connectors are provided, the one not used being closed with a plug. The front plate of this case is removable, giving access to the mechanism.

(3) The repeater units can be rotated to synchronize the indicator dials with the data transmitters in the director. The fine or lower dial is synchronized by raising the sliding cover on the left side and adjusting with a screw driver the slotted shaft end which protrudes into the lower part of the cavity. The coarse or upper dial is synchronized by lowering the cover plate on the right side of the indicator and turning a similar shaft which protrudes into the upper part of the cavity enclosing the terminal board. (Care must be exercised when lowering this cover to avoid damaging the gasket and conductors.) This adjusting motion is limited to about 30° on either side of the zero position. The rotation is accomplished through the use of a worm and worm wheel, and the repeater cases will not rotate after having been adjusted. *At no time should the gun be traversed or elevated while this sliding cover is up, as it would change the adjustment.*

(4) When laying the gun in azimuth or elevation, the operator first roughly matches the received indication on the coarse repeater dial and thereafter keeps the index on the fine mechanical pointer in coincidence with the index on the fine electrically driven dial.

(5) A knob protruding into the cavity on the left side and accessible by the sliding cover, through the medium of a differential, allows the mechanically driven indexes to be set to read correctly for the gun position. The sliding cover must be pushed down to its normal position after having made this adjustment. The cover, through the medium of a detent fastened to it and teeth on the outer rim of

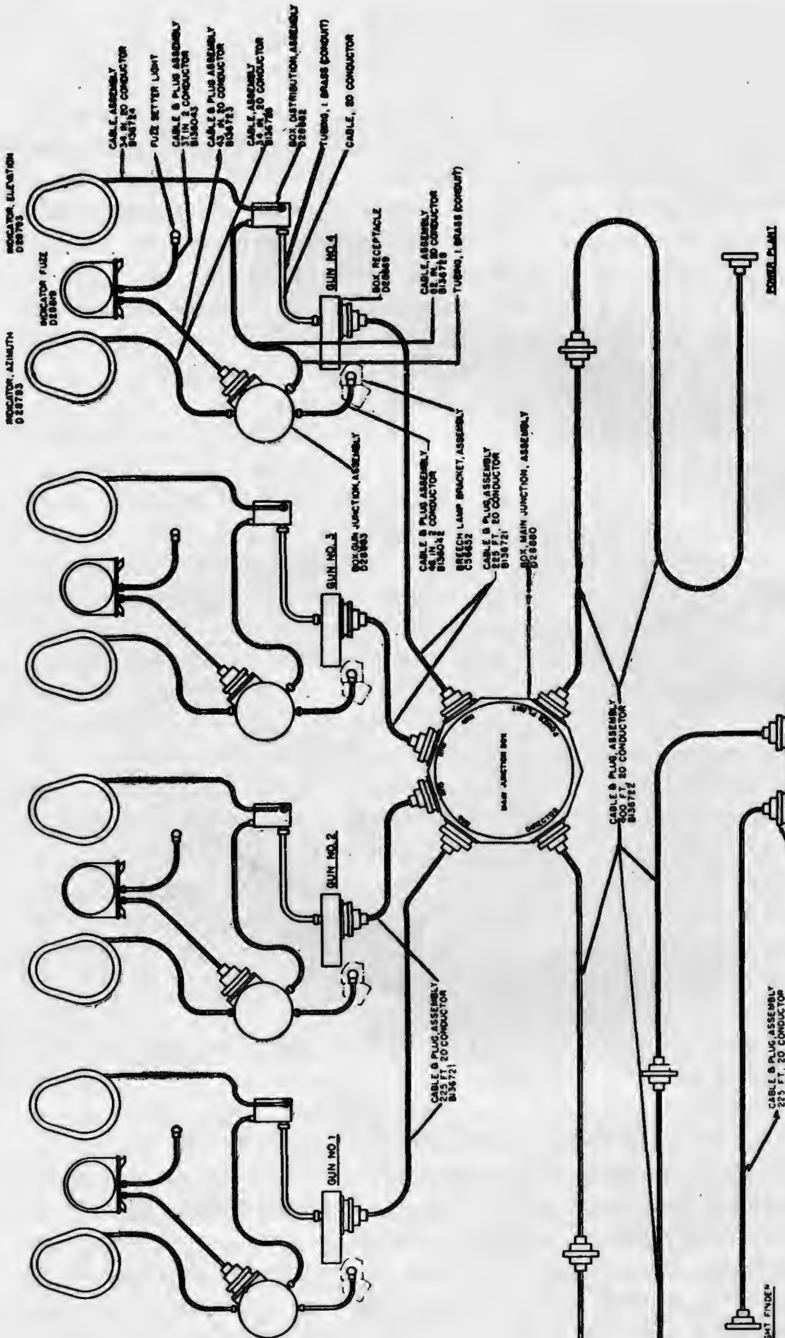


FIGURE 173.—Data transmission system, M4, assembly.

the adjusting knob, automatically locks and prevents rotation after the adjustment has been made.

(6) The scales and indexes are indirectly illuminated by three lamps which are an integral part of the unit.

g. Layout of equipment.—Figure 173 shows the layout of the entire AA battery equipment. Data are fed from the director to the main junction box through a 20-conductor cable with both cable connections made through a 19-pole receptacle and plug.

There are six plug receptacles on the main junction box, one for each gun cable, one for the director cable, and one for the cable from the source of power. The main junction box serves to distribute incoming data to the various required destinations. The 20-conductor cable from the height finder routes the altitude to the director. The 20-conductor cable from the power source routes power to the main junction box, thence to the director, height finder, and each gun. The firing data received by the main junction box

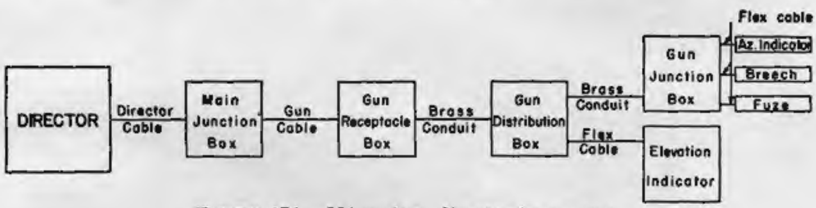


FIGURE 174.—M4 system, director to one gun.

through the 20-conductor cable are routed through the four 20-conductor gun cables to the four gun receptacle boxes. The gun receptacle box has but one receptacle which receives the incoming 20-conductor gun cable. The 20-conductor cable between the receptacle box and the gun distribution box is enclosed in a brass conduit which is fastened rigidly to the top carriage by clips. A sketch of the data transmission system showing the connections from the director to one gun is given in figure 174.

From the gun distribution box one 20-conductor cable enclosed in brass conduit connects with the gun junction box and one 20-conductor flexible cable is connected with the elevation indicator. The gun junction box distributes the incoming circuits using a 20-conductor cable to the azimuth indicator, a 2-conductor cable to power the breech lamp, and a 19-pole receptacle and 20-conductor cable to connect the fuze indicator. With the exception of the short lengths secured to the top carriages of the gun mounts, the flexible cables are provided with receptacles and plugs to facilitate handling and permit flexibility in the tactical arrangement of the components employed in the fire control system. The portable cable assemblies are made in 225- and 400-foot lengths. The 225-foot lengths are normally used for connecting the receptacle boxes on the gun mounts and the main junction box and also the director to the height finder. The 400-foot lengths are normally used for connecting the main junction box to the director and to the generating unit. Since all cables are interchangeable, they should be employed in the manner which best suits the locations of all components of the battery.

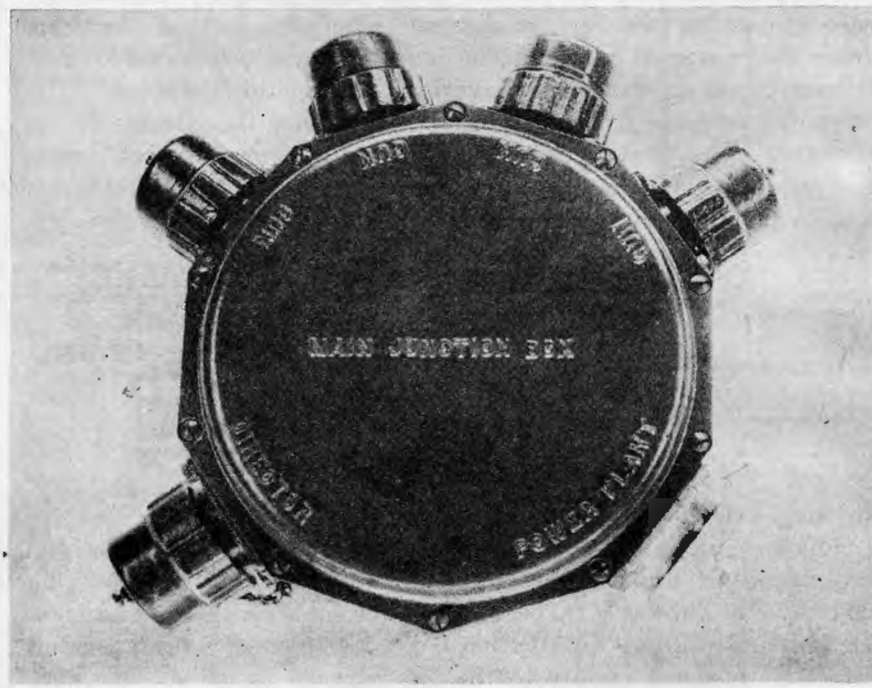


FIGURE 175.—Main junction box.

h. Main junction box M3.—The main junction box (fig. 175) consists of a decagonal cast aluminum body for supporting the component assemblies and lid. The box is entirely portable and may be placed in any convenient position to accommodate the desired arrangement of guns and director. It is provided with five 19-pole receptacles, four of which are painted red for the gun cables and one painted green for the director cable; and one 19-hole receptacle painted yellow for the power cable from the generating unit. The box is made watertight by gaskets under the lid and the 19-pole receptacles.

i. Cables.—(1) The 20-conductor flexible cable is composed of seven No. 15 and thirteen No. 18 stranded conductors. The conductors are insulated with Latox (95 percent) rubber, twisted together, filled and covered with a tough rubber sheath. Each conductor is composed of a number of soft annealed copper strands and several chromium steel strands, thus providing maximum flexibility consistent with mechanical strength and electrical conductivity. The conductors are color coded to facilitate circuit identification.

(*a*) The seven larger conductors (size No. 15) are in the center of the cable. Four are employed as power lines and the remaining three for data circuits.

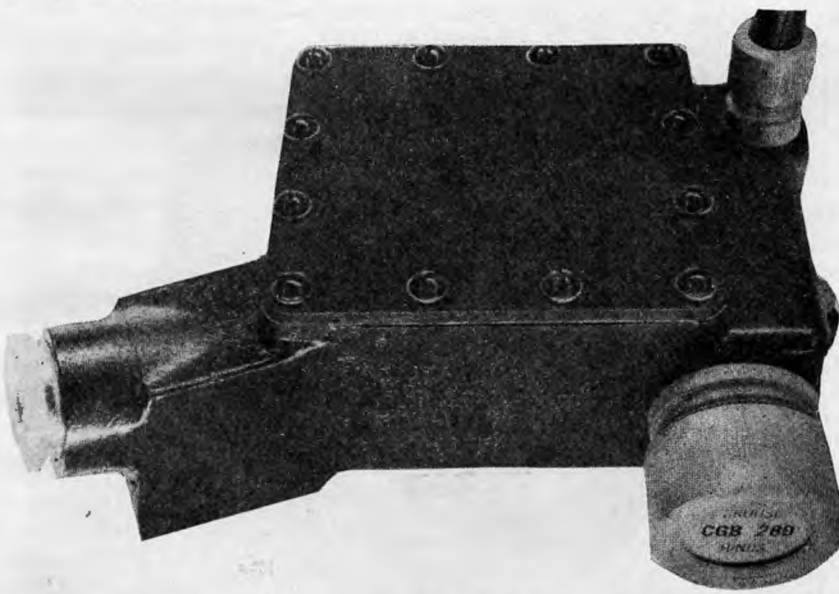


FIGURE 176.—Distribution box for data transmission system, M4.

(*b*) The thirteen smaller conductors (size No. 18) are cabled around the seven heavy conductors. Twelve of these conductors are employed to interconnect the secondary circuits of the transmitters and the repeaters.

(2) In wiring the units, care should be taken to use similar size wires in each circuit to equalize line resistance. This procedure should be carried out where possible in all circuits. *The heavier lines on the wiring diagrams represent heavy conductors in the cables and should be connected accordingly.*

j. Gun junction box.—(1) The gun junction box consists of a circular cast aluminum body to support the component parts employed for circuit distribution. The component assemblies include a stuffing box to accommodate the cross-carriage conduit and cables from the distribution box; two connectors for the separate cables to the azimuth indicator and the breech light; a socket for connecting the portable trouble lamp; a switch to control all low-voltage lamps; a 19-pole receptacle for the fuze indicator cable plug; a transformer and terminal boards. The lid is fastened securely to the body, and the unit is made watertight by means of gaskets under the lid and receptacle. The stuffing box, connectors, switch, trouble light sockets, and covers are also provided with suitable gaskets. The assembly is mounted on the left side of the top carriage.

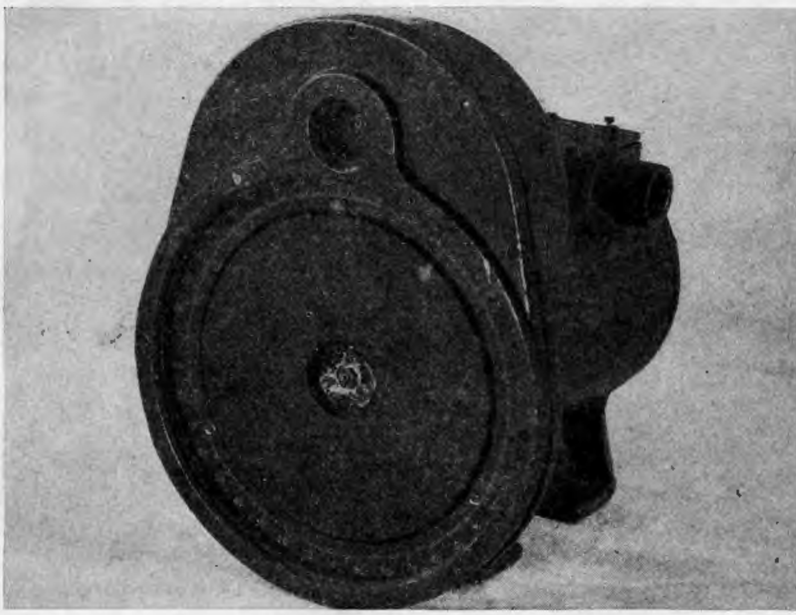


FIGURE 177.—Indicator, T8E3.

(2) A 19-pole receptacle is bolted to the front of the box to provide a connection for the 19-pole plug on the fuze indicator cable.

(3) The trouble lamp is a commercial article. It is provided with a standard automotive type double contact plug for connection to the socket located on the rear of the gun junction box.

(4) A 20-conductor flexible cable required for connecting the azimuth indicator is furnished with the gun junction box. This cable is supplied with marked terminals to facilitate circuit identification in the indicator. A 2-conductor cable equipped with a double con-

tact plug for connection to the socket in the breech lamp assembly is also furnished with this box. The 20-conductor cable for connecting the gun junction box and the distribution box is enclosed in a brass conduit which is fastened rigidly to the top carriage by clips.

76. Data transmission system, M3.—The data transmission system, M3, was designed for use with either director M3 or director M4. This system can be used with either of these directors without making changes in electrical connections or plug receptacle assemblies. The various components of this system are essentially the same as the components of the M4 data transmission system and will not be described in detail.

77. T8E3 system—general description.—*a.* All repeaters (receivers) employed in the system are of the single motor type and all transmitters are of the single generator type, operating on 110–120 volt, single phase, 60-cycle, alternating current, supplied by the A. C. gasoline electric generating unit, T8E3.

b. The system is not completely self-synchronous. For the transmission of azimuth and elevation from the director to the guns, and data from the tracker to the director the system is self-synchronous only within 200 mils either side of the synchronous position, one revolution of the transmitter and repeater representing 400 mils of arc. The transmission of fuze range, altitude or target range, and target identification angles to the height finder is completely self-synchronous.

c. The cable system, main junction box, and extension junction box are so designed as to allow the director, tracker, and height finder to be placed to operate in any of the following arrangements:

Case 1—director and height finder at the guns. Director used to track target.

Case 2—director, height finder, and tracker at the guns. Director masked, azimuth and angular height transmitted to director by tracker.

Case 3—director and height finder at the guns. Director masked, azimuth and angular height transmitted to director by tracker located at a distant O. P.

Case 4—director at the guns, height finder and tracker at O. P. Director masked, azimuth and angular height transmitted by tracker.

Case 5—director and height finder at O. P. Director used to track target.

Case 6—director, height finder, and tracker at O. P. Director masked, azimuth and angular height transmitted to director by tracker.

d. The gun cable system allows the four gun mounts of the battery to be arranged in the form of a 100-yard square with the director or main junction box located in the center.

78. Data transmission system, M2.—*a. General.*—(1) This system, a schematic diagram of which is shown in figure 178, is used with the AA director, M1A1. In this type of unit the transmitters and receivers are identical in appearance and construction, except that the transmitter is of greater size and load capacity than the receiver, in order that one transmitter may control a number of receivers. Each instrument consists of a stationary bipolar field structure (stator) surrounding a rotatable armature (rotor). The field circuit is excited directly from the 110-volt A. C. supply. The rotor is wound with a three-phase winding connected to three slip rings. Suitable means are provided for damping the oscillations of receiver rotors. The connecting lines to each instrument, whether transmitter or receiver, consists of five conductors, two of which supply the stator field and three the rotor. The former two leads are referred to as power leads, the latter three as phase or data leads. (See *f* below.)

(2) The azimuth and elevation transmitters and receivers are double units, the data being broken up into two parts, coarse and fine, as a means of securing greater accuracy. The fuze range and altitude transmitters and receivers are single units.

(3) The system is self-synchronous; that is, the dials of the receiving instruments take a position exactly synchronized with the transmitting instruments whenever power is applied to the system, regardless of synchronism or lack of synchronism before the application of power. Initial adjustments must be made, however, when the system is first assembled or when units are replaced. (See *i* below.)

b. Fuze range unit.—A single transmitter in the computor furnishes the fuze range data for the four guns of the battery.

The receiver unit (1, fig. 187) is mounted on the fuze setter. Like the transmitter unit it contains only one motor. The transmitted data are indicated by the electrical pointer (2) on the inner dial which is connected to the motor shaft. The setting of the fuze setter is indicated by the mechanical pointer (3) on a ring mounted concentric with the inner dial, the ring being geared to the fuze setting ring in the fuze setter (see par. 82*b*). Concentric with this ring is a fixed scale on which the fuze setter or transmitted data may be read. The proper fuze range is set continuously by keeping the mechanical pointer matched with the electrical pointer.

c. Azimuth unit.—(1) In the transmission of azimuth and elevation greater accuracy is necessary, and the data are broken up into two parts, coarse and fine. Each part is transmitted and received by separate transmitters and receivers, respectively. The two transmitter units of the azimuth transmitter are geared together in 64 to 1 ratio, both driven by the firing azimuth shaft of the data computor. (See

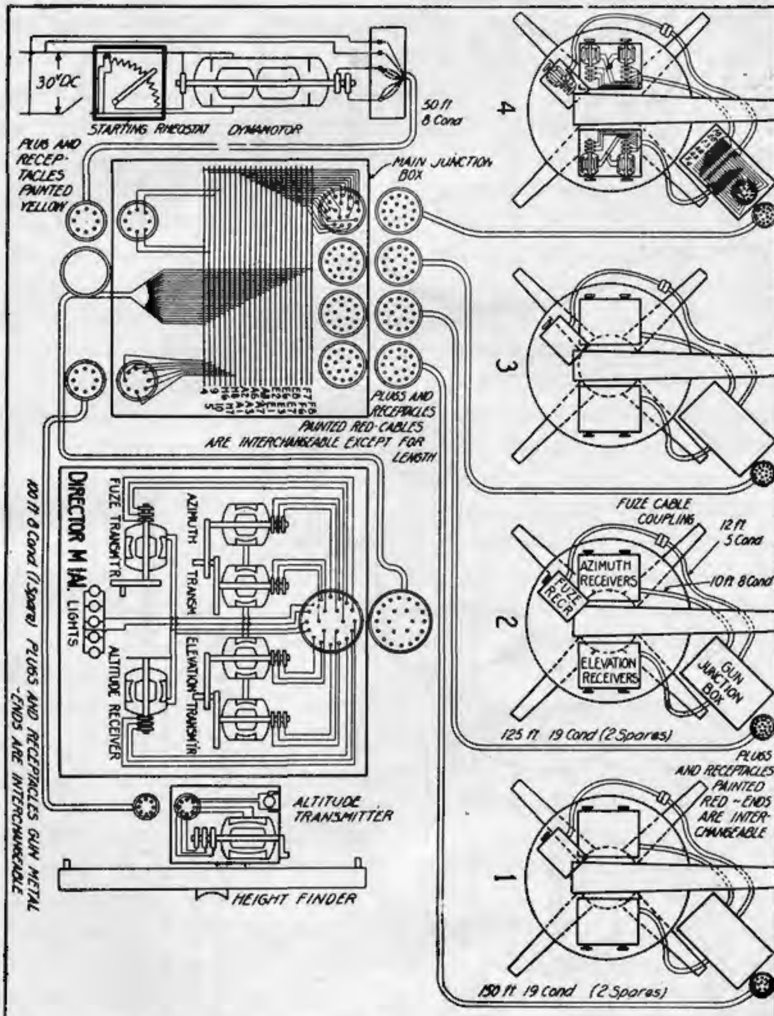


FIGURE 178.—Schematic diagram self-synchronous transmission system, M2.

fig. 179.) The coarse transmitter makes one revolution for a change in azimuth of 6,400 mils; the fine transmitter one revolution for each 100 mils change in azimuth. These two related transmitters are connected to their receivers by six conductors.

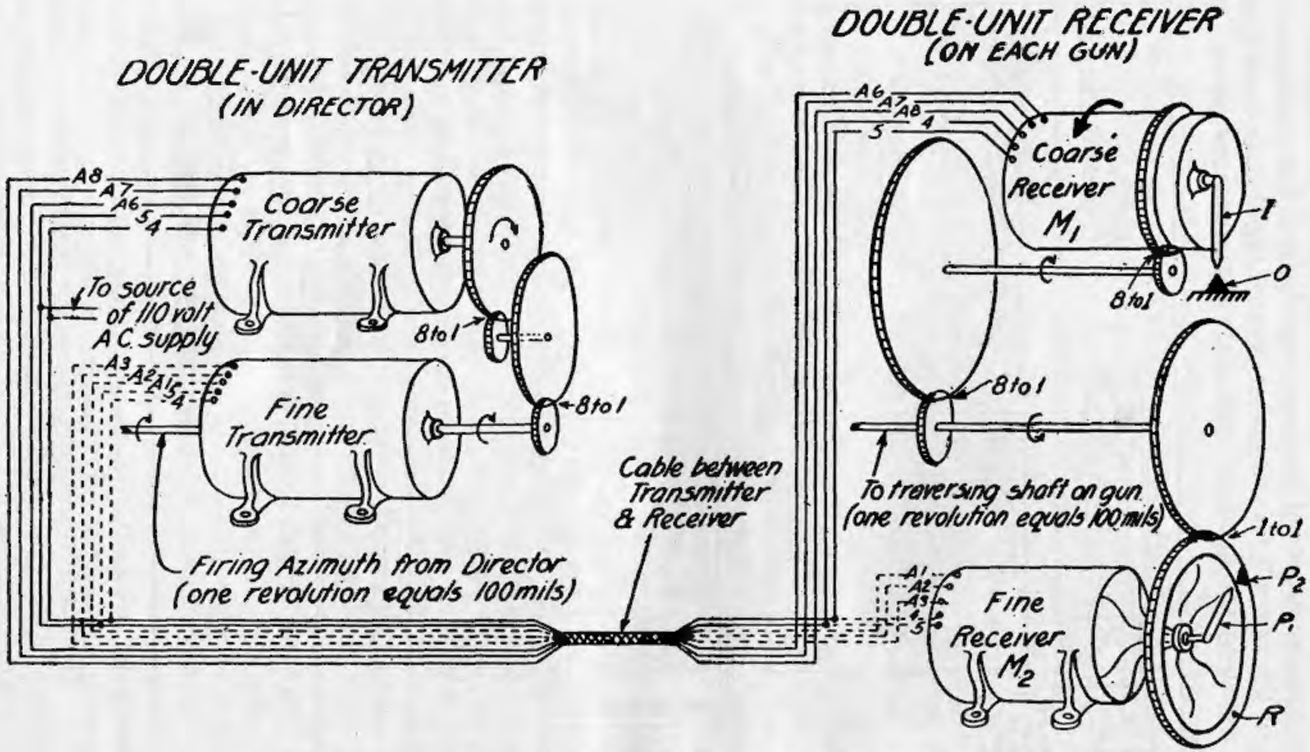


FIGURE 179.—Schematic diagram of double-unit azimuth transmitter-receiver, data transmission system M2 and M2A1.

(2) The azimuth receiver unit also contains two motors. The two motors (fig. 179) are mounted on the gun in a brass case. The coarse motor (M_1) has a zero pointer (I) mounted on its rotor shaft, which by action of its transmitter (coarse) makes one revolution for 6,400 mils change in transmitted azimuth. This pointer (I) is displaced from the fixed index (O) as changes in azimuth are transmitted. The zero pointer and index are also shown as (2) and (3), respectively, in figure 180, this elevation receiver being similar to the azimuth receiver except for graduation of the coarse scale (1). The coarse azimuth scale, which is mounted on and rotates with the motor housing, is graduated in divisions of 100 mils from 0 to 6,400 mils, a reading window and fixed index (4) being provided. The housing of the coarse receiver (M_1, fig. 179) is also rotatable and geared to the traversing mechanism of the gun. Therefore, when the gun is traversed the entire coarse receiver—that is, housing, scale, rotor, and pointer (I)—is rotated. When an increase of 100 mils in azimuth is sent by the data computor, the pointer (I) is displaced clockwise 100 mils from index (O). The pointer will disappear and indicating arrows will appear in the pointer window, the arrows indicating the direction in which they must move in order for the pointer and index to be rematched. If the gun is now traversed until the pointer (I) is opposite its index (O), the entire coarse receiver will have been rotated counterclockwise and the azimuth of the gun increased by 100 mils. Therefore, for approximate setting of azimuth, it is but necessary to keep the pointer (I) and index (O) matched by traversing the gun.

(3) The fine receiver motor (M_2) carries on its shaft a dial and pointer (P_1) which make one revolution for each 100 mils of transmitted azimuth. A concentric ring (R) is geared to the traversing mechanism of the gun and carries a mechanical pointer (P_2). The dial and pointer make one complete revolution for each 100 mils traverse of the gun, their motion being entirely independent of the dial and pointer (P_1). Figure 180 shows an exterior view of the fine pointer dial (5), the fine electrical pointer (6), the fine pointer ring (7), and the mechanical pointer (8). It also shows the fine mil scale (9) which may be used to indicate the reading of either pointer.

(4) The coarse zero pointer (2, fig. 180) and its index (3) are first matched. The mechanical pointer (8) is then brought into coincidence with the fine pointer (6) by traversing the gun. Having once been matched, the coarse pointer and index will remain matched by the operation of matching the fine pointers, so that the attention of the operator need not, except for occasional check, be directed from the latter.

d. Elevation unit.—(1) The elevation transmitter located in the data computor and its four double-unit receivers, one on each gun, are identical in every respect with the azimuth unit described above except for the graduation of the receivers. The elevation receiver

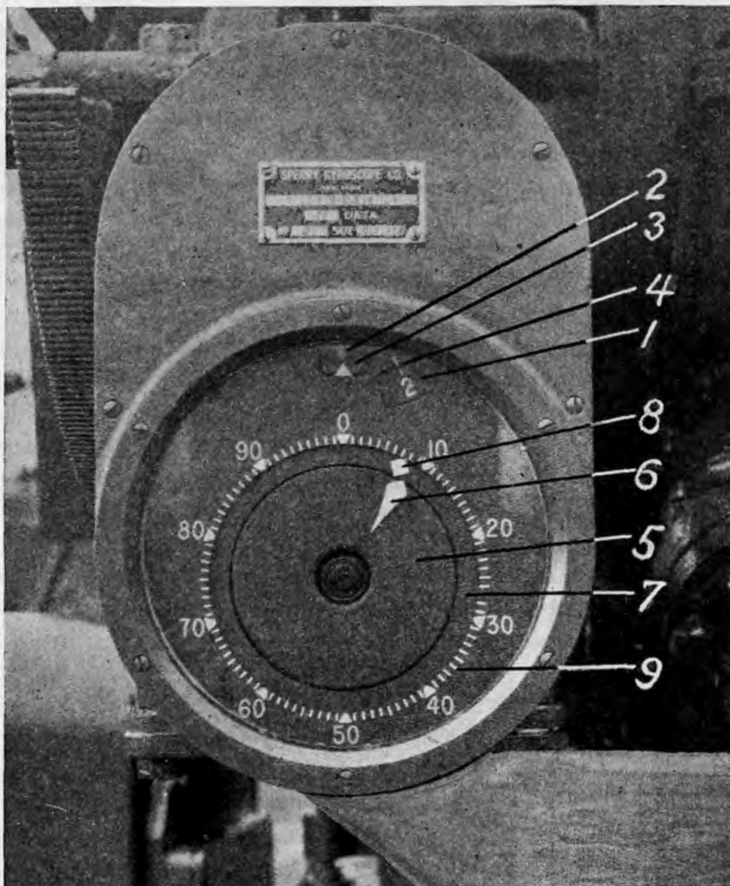


FIGURE 180.—Elevation receiver.

1. Coarse motor scale.
2. Coarse motor (zero) pointer.
3. Zero pointer index.
4. Coarse scale index.
5. Electrical pointer dial.
6. Fine electrical pointer.
7. Mechanical pointer ring.
8. Mechanical pointer.
9. Fine motor scale.

coarse motor is graduated from zero to 1,600 mils, only one-fourth of its complete revolution being used. The fine motor is graduated similar to that of the azimuth unit, one revolution causing a change of 100 mils in elevation.

(2) Figure 180 shows an exterior view of the elevation receiver unit. The actual elevation at which the gun is laid is indicated by the index (4) and mechanical pointer (8) opposite coarse scale (1) and fine scale (9), respectively. The elevation transmitted from the data computor is also indicated in hundreds of mils on scale (1), but the fine reading is indicated by the electrical pointer (6) opposite scale (9). Figure 180 indicates that the gun is laid at a quadrant elevation of between 207 and 208 mils, while the elevation transmitted from the data computor is between 208 and 209 mils. The gun must be elevated until the mechanical pointer (8) matches the electrical pointer (6), assuming that the index (2) and pointer (3) have been matched. The gun will then be laid at the transmitted elevation.

e. Altitude unit.—For the transmission of altitude a single transmitter is required at the height finder and a single receiver at the data computor as for the fuze unit.

The dials of both transmitter and receiver are graduated in 20-yard divisions of altitude from zero to 10,000 yards. Each 200-yard graduation is numbered. The altitude is read from the height finder and set manually into the transmitter, from whence it is transmitted electrically to the receiver in the data computor.

f. Cables, cable plugs, cable receptacles, and junction boxes.—(1) Figure 178 shows a layout of the entire system. The azimuth and elevation double-unit transmitters are connected to their receivers by six phase leads, the single unit fuze range transmitter by three. All units are connected to the power source by two additional power leads (4 and 5). Thus a total of 17 conductors, 15 phase leads and 2 power leads, are required between the data computor and the guns. These conductors are contained in a 22-conductor flexible cable, which has a special slip-ring plug on one end to fit in a receptacle at the data computor and is wired at the other end directly to the terminal strips in the main junction box.

(2) The main junction box serves to distribute incoming data to the various required destinations. The 8-conductor cable from the height finder routes the altitude to the main junction box, thence through the 22-conductor cable to the data computor. The 8-conductor cable from the power source routes power to the main junction box, thence to the computor, height finder, and each gun. The firing data received by the main junction box through the 22-conductor cable are routed through four 19-conductor gun cables to the four gun junction boxes. There are six plug receptacles on the main junction box, one for each gun cable, one for the height finder cable and one for the cable from the source of power.

(3) Each gun junction box receives one of the four 19-conductor gun cables and distributes the data, through smaller cables, to the three receivers on the gun. The 19-conductor cable plug, the pattern of which is shown in figure 181, fits into a receptacle in the junction box. The 8-conductor cables to the azimuth and elevation receivers and the 5-conductor cable to the fuze range receiver are connected directly to their terminal strips in the gun junction box, that is, no plugs and receptacles are used.

(4) Each conductor in each cable has an identification letter and number stamped on each end. Throughout the system the letter A,

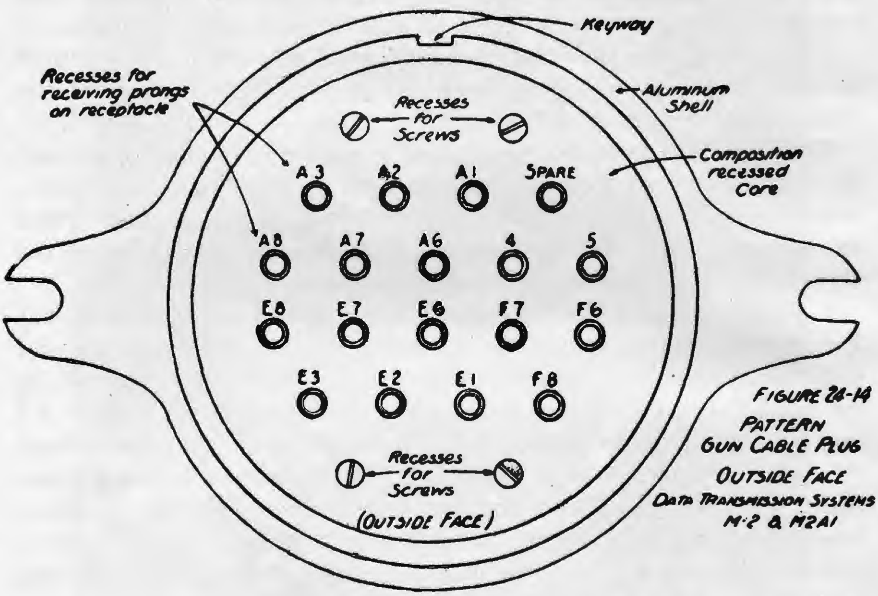


FIGURE 181.—Pattern of gun cable plug.

in the tagging scheme, indicates azimuth, E indicates elevation, F indicates fuze range, and H indicates height (altitude). The numbers 1, 2, and 3 coupled with one of the foregoing letters indicate phase leads for fine receivers, while 6, 7, and 8 pertain to phase leads for coarse receivers. Leads No. 4 and No. 5 are at all times 110-volt, 60-cycle A. C. power leads. The terminal strips on all junction boxes are stamped with identifying letters and numbers. Plugs and receptacles have identifying letters and numbers engraved on their rear faces. (See fig. 181.)

g. Power source.—The system can use any source of power supplying 100–120 volt, 50–60 cycle single phase alternating current.

h. Care and maintenance.—The system requires ordinary care and attention to prevent damage. When the cables are not connected, all plugs and receptacles should be kept covered with the covers provided so as to exclude moisture from the system. Heavy vehicles should be prevented from running over any cable. Cable should be stored on the reels on the instrument trailer when not in use. Receiver motors on the guns should be lubricated at 6-month intervals by placing a small quantity of heavy oil at the point where the shaft enters the rear of the housing.

i. Adjustment of system.—(1) *Electrical adjustments.*—(*a*) Although the system is inherently self-synchronous, certain adjustments must be made when the system is first assembled, when cables must be cut back or spliced, or when individual transmitter or receiver units are replaced.

(*b*) The first step is to insure that all receivers are connected to the proper transmitters and that receiver motors rotate in the proper direction for any change in transmitter data. The direction of rotation of a receiver may be reversed by exchanging any two of its phase (rotor) leads.

(*c*) Having completed this step, it is necessary to make the receiver dials indicate the same value of azimuth, elevation, or fuze range as their transmitter dials. To perform this operation, turn on the A. C. power, remove the glass cover of the receiver (fig. 138), loosen the clamp nut which holds the pointer dial (5) to the rotor shaft, turn the pointer (6) on the dial to the correct value opposite the scale (9), and reclamp. The unclamping and clamping of the pointer dial should be done with extreme care to avoid bending the dial which must rotate absolutely free of any friction.

(*d*) Synchronism is now complete and should be checked at several random positions of the transmitter. The system should remain in synchronism indefinitely unless the changes indicated in (*a*) above are necessary. It is advisable, however, to verify the synchronism before each daily drill and target practice. No change in synchronization is necessary as a result of change of battery position.

(2) *Mechanical adjustments.*—(*a*) Certain mechanical adjustments must be made in addition to and independently of the electrical adjustments indicated above. It is not only necessary that the electrical pointers of the receivers indicate the data transmitted from the data computor but that the mechanical pointers indicate the data at which the gun is actually laid. The mechanical pointer of the elevation receiver, for example, should indicate the same quadrant elevation as determined by a clinometer or quadrant.

(*b*) Pointing tests and adjustments are covered fully in FM 4-110. In general, the mechanical adjustment of a receiver is made by releasing the adjustable coupling and turning the shaft leading to the receiver until the mechanical pointer indicates the correct value. The coupling is then reclamped without disturbing the setting.

(*c*) In addition to the mechanical tests of each gun receiver unit, the battery as a whole must be bore-sighted and oriented as provided in FM 4-110.

79. Data transmission system, M2A1.—*a.* This system is an adaptation of the M2 system (par. 78) for use with the AA director, M2 (Sperry).

b. The important modifications are listed below:

(1) The cable from the director to the main junction box has 19 conductors (22 in the M2 system). The plug on the director end of this cable is interchangeable with any gun-cable plug. (The M2 system has a special slip ring type plug on the director end of the 22-conductor cable.)

(2) The cable from the director to the height finder has 10 conductors (8 in the M2 system). This cable may be routed through the main junction box or directly to the director, depending on the relative location of the director and height finder. In addition to the transmission of altitude to the director, the director furnishes present azimuth and present angular height to the height finder through this 10-conductor cable. By follow-the-pointer indication the height finder operator is assured of being on the same target as the director.

(3) Leads Nos. 9 and 10 are unused. Illumination of reticules and scales is effected by transforming the 120-volt A. C. carried by leads Nos. 4 and 5 to 6 volts A. C. Small transformers for this purpose will be found in the height finder and director. Leads Nos. 4 and 5 also supply the 120-volt A. C. power required for follow-up motors in the M2 director.

(4) Telephone communications between the director and battery position (at the main junction box) is provided by telephone terminals connected to two of the transmission leads.

(5) Illumination at the gun junction boxes and at the main junction box is provided for by 110-volt lighting sockets, tapped off of power leads Nos. 4 and 5.

80. Instrument trailers.—*a. General.*—(1) The older mobile antiaircraft artillery battery equipment includes a trailer for the purpose of transporting the director, height finder, power-supply unit, and other fire-control equipment. The type issued to mobile batteries is drawn by a truck similar to the prime movers provided for towing the guns. It is designated instrument trailer, M1. Three varieties of power units and electrical systems have been supplied with this trailer. The general features of one unit only will be described.

(2) Some antiaircraft artillery batteries are equipped with two smaller trailers, one to carry the M2 director and the other to carry the power unit. While these trailers are essentially hand-drawn vehicles they may be towed at speeds up to 20 m. p. h. They were designed to fill the need for limited mobility of the director and power unit, especially over poor roads, trails, or open country not traversable by the instrument trailer, M1, and its prime mover.

b. Instrument trailer, M1, equipped with power unit.—(1) *Chassis.*—(*a*) Figure 182 shows the trailer with the M2 director and cables connected. In traveling position all fire-control units are carried in canvas covered chests. These chests are secured to the trailer by means of toggle clamps. With the exception of the tool and accessories chest, all chests are removable. When transporting the M1A1 director, the tripod is secured to the tool and accessories chest while the director itself is carried in a chest. When the M2 director is used, the director and its base are permanently bolted to the floor of the chassis. The following units comprise the fire-control equipment and power supply system carried on the trailer:

1 director with chest of accessories.
1 height finder and mounting.
1 B. C. observation telescope with mounting and tripod.
Telephone and plotting equipment.
2 gasoline generator units.
1 rotary converter.
1 power panel.
1 storage battery, 32-volt.
1 gasoline tank.

(*b*) In addition, the mount is provided with 2 spare wheels, the necessary tools and spare parts, and 2 cable reels attached to the front of the platforms. The larger reel contains 4 compartments for the 4-gun cables. The smaller reel contains 4 compartments for the following cables:

Cable from panel plug to main junction box.
Telephone cables.
Height finder cables.
Spare compartment.

Each reel is provided with handles for winding the cable and a ratchet and pawl to prevent unwinding.

(*c*) The jacks are provided for the purpose of leveling the platform and partially removing the load from the springs when the

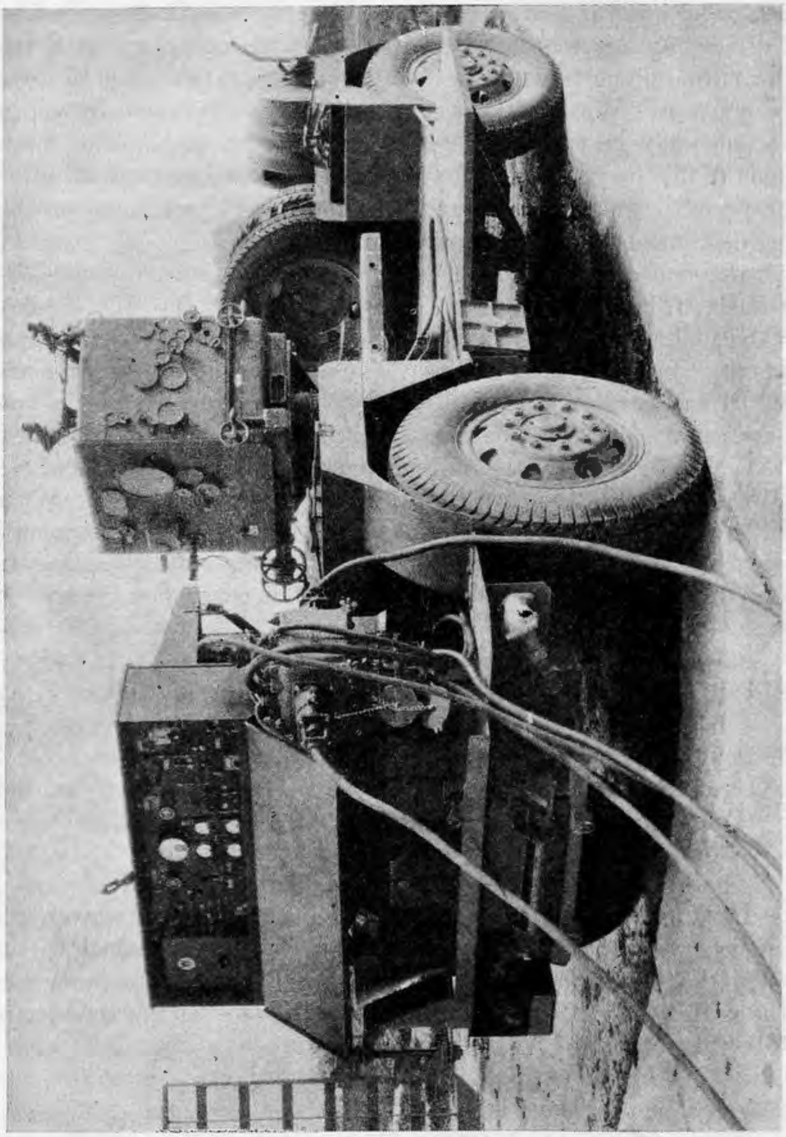


FIGURE 182.—Instrument trailer, M1, mounting M2 (Sperry) director and power unit.

director is operated on the trailer. The jacks are held in traveling position by means of a spring latch. To place the jacks in the leveling position, push the spring latch clear of the handle and lift the jack slightly by means of the float to remove the handle from its carrying seat. Withdraw the jack horizontally until the stop is reached; swing the jack downward and lower the screw until the float is in contact with the ground.

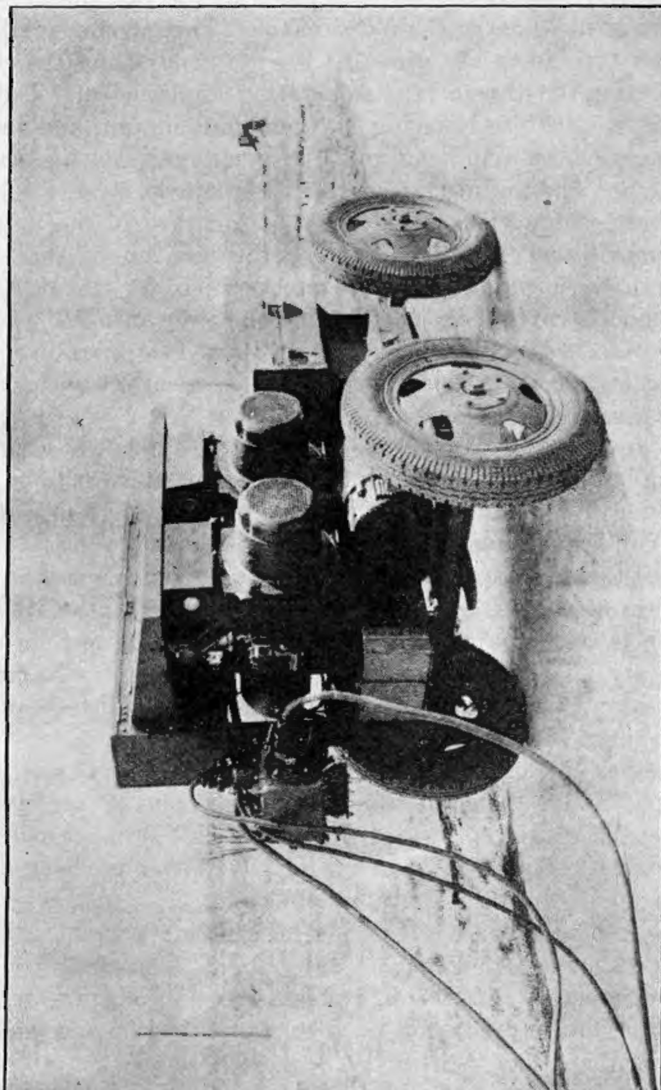


FIGURE 183.—Instrument trailer. M2A1, mounting power unit.

(2) *Power plant.*—The trailer is equipped for furnishing 120-volt A. C. power for operation of the data transmission system, either directly by one of the two gas engine driven alternators or by a rotary

converter operated from a 32-volt battery. The unit is operated from the switchboard mounted across the rear of the trailer.

c. Instrument trailers, M2 and M2A1.—(1) *Chassis.*—Figure 183 shows the instrument trailer, M2A1, carrying its normal load, the power unit. A similar chassis designated as the instrument trailer, M2, is furnished to carry the M2 director. Three commercial automatic screw-type jacks are provided for use in lowering the chassis, when mounting the director, to its operating emplacement. The front axle is removed before lowering by removing the pin, and the rear axle is removed by removing the two wing nuts, raising the two hinged latches, and pulling the axle unit to the rear.

(2) *Power plant.*—The power plant is identical to the unit with the instrument trailer, M1, except for the location of the storage battery and the bolting of the main junction box for the M2A1 data transmission system to the rear frame of the power unit.

(3) *To place trailers in operating position.*—The procedure is similar to that for the M1 trailer. Figure 184 shows the set-up for a fixed antiaircraft artillery battery.

81. Power supply units.—*a. General.*—In the latest designs the power supply units and the directors are constructed so as to be transportable in ordinary cargo trucks. They are low enough in weight so that they can be man-handled into and out of the truck bodies. Trailers for directors and power supply units are no longer manufactured.

b. Power unit, M4.—The latest power supply unit is the M4. This unit which is very similar to the T8E3 and M3 units has no battery power supply. To secure power the gasoline motor must be running. For this reason two complete M4 power units are supplied to each gun battery to make certain that one will be always available.

(1) The gasoline engine is a commercial 4-cylinder, 4-cycle, water-cooled type. It is capable of standing a continuous 25 percent overload above the rated capacity of the generator. It is started by an electric starter. The 6-volt battery for the starter is charged by a small separate generator of the automobile type.

(2) The generator is a self-excited alternating current generator delivering 2 kv.-a. at 115 volts.

(3) The mounting consists of two main frame members which form the chassis. On this is a metal hood to protect engine and generator from the weather.

(4) A panel board is provided which includes the necessary ammeters, voltmeters, rheostats, switches, etc., for the operation of the unit.

(5) The unit weighs approximately 700 pounds and is designed to be transported in the body of any truck.

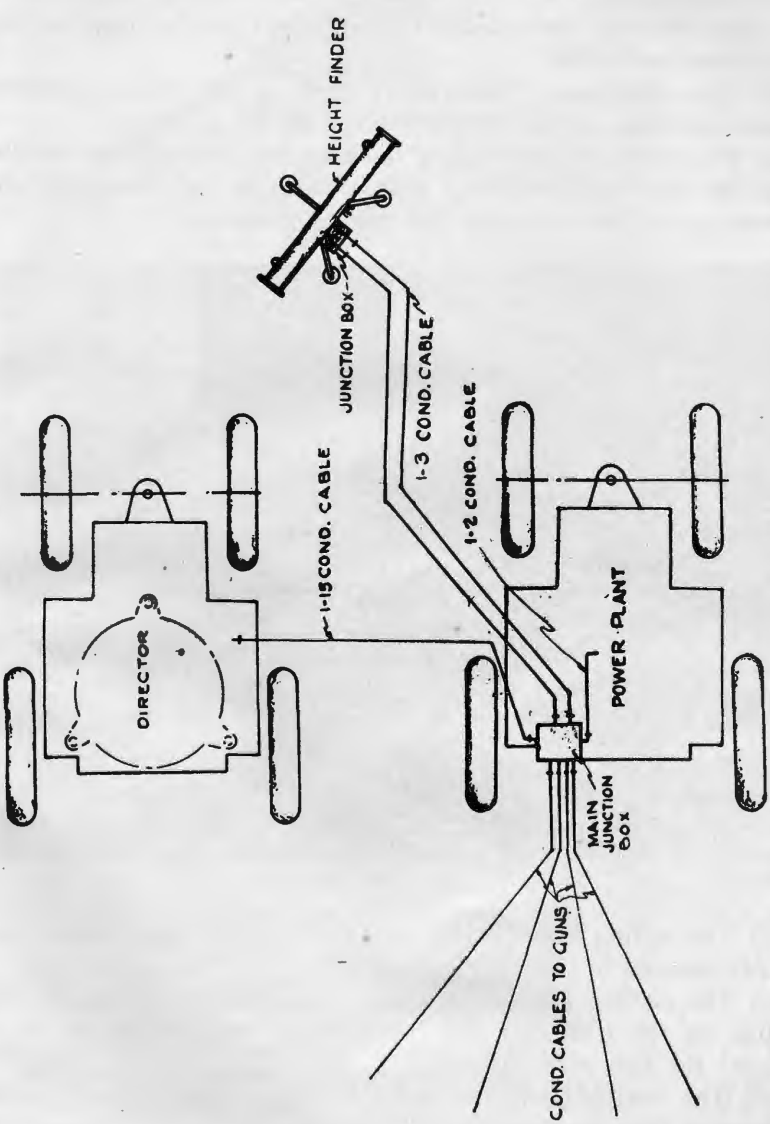


FIGURE 184.—Arrangement of instrument trailers, M2 and M2A1, cables and height finder.

c. Director transportation.—The latest directors (the T8E3, the M3, and the M4) are designed to be transported, without boxing, in the body of a cargo truck.

82. Fuze setters.—*a. General.*—(1) All modern antiaircraft guns use continuous fuze setters—fuze setters that keep the fuze set in accordance with the latest data from the director, regardless of how much the data have changed during the time the projectile has been in the fuze setter.

(2) The continuous fuze setters used in our service perform certain operations in the cutting of the fuze.

(*a*) The round of ammunition must be held down in its receptacle in the fuze setter so that it cannot jump up out of contact with the setting mechanism during the cutting operation.

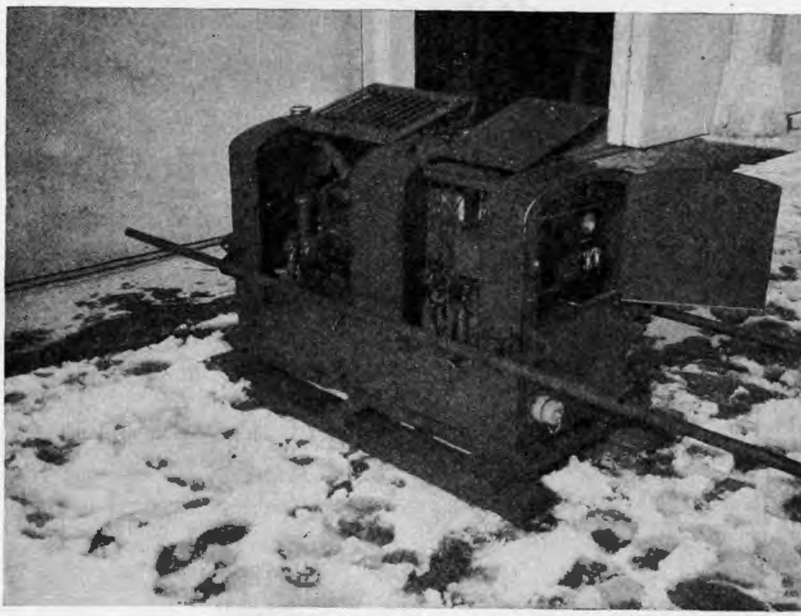


FIGURE 185.—M4 power unit.

(*b*) The setting handwheel must be released as soon as the round is fully inserted in the setter but not before.

(*c*) The cutting mechanism must make two revolutions, the first to line up the fuze with the cutting parts and the second to cut (or set) the fuze actually.

(*d*) The setting handwheel must be locked as soon as the round is removed from the fuze setter.

These operations may be performed in differing ways—some manually, some automatically—and the descriptions following will show how each model accomplishes these four necessary operations.

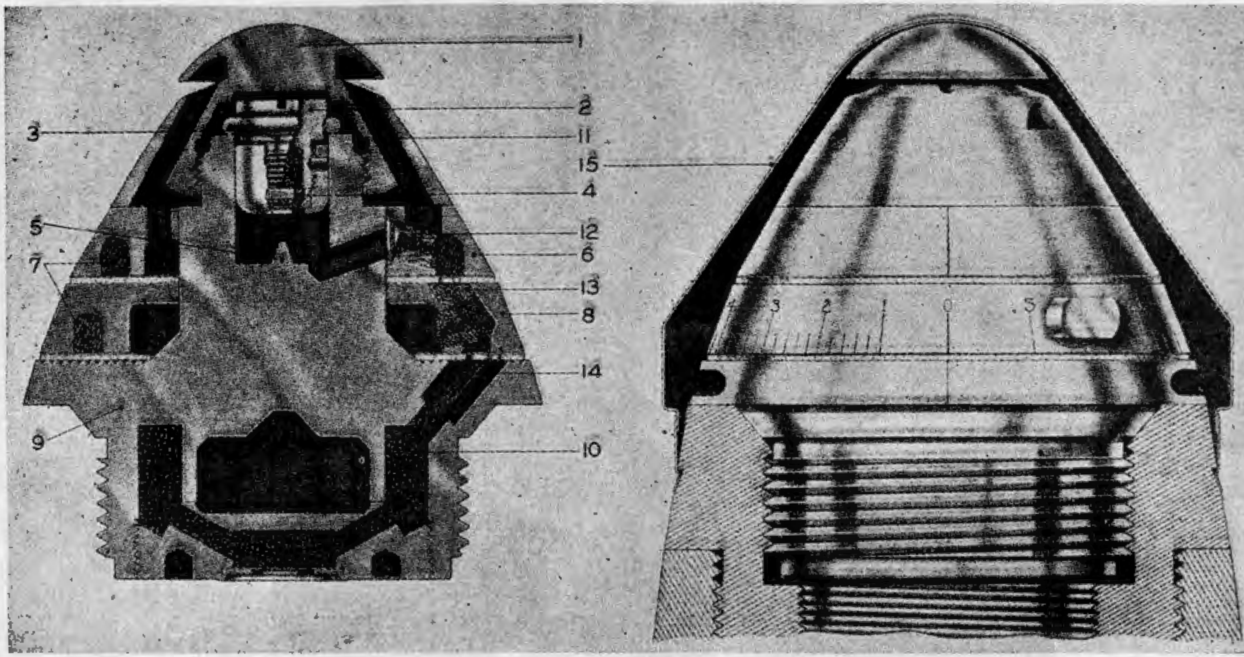


FIGURE 186.—Antiaircraft time fuze, Mk. III.

1. Closing cap.
2. Concussion plunger.
3. Resistance ring.
4. Concussion primer.
5. Concussion firing pin.
6. Upper time train ring.
7. Powder train.
8. Lower or graduated time train ring.
9. Body.
10. Magazine charge (black powder).
11. Vents.
12. Powder pellet.
13. Powder pellet.
14. Powder pellet.
15. Waterproof cover.

(3) Figure 186 shows an antiaircraft time fuze of the powder-train variety. The parts to note are the time train ring (8) with its lug (shown in the right-hand illustration) and the body (9) which has a lug which does not show. It is the relative position of these two lugs which determines the time set on the fuze.

b. Fuze setters, M2 and M3.—(1) *Description.*—The fuze setter (fig. 187) is mounted on a bracket on the left side of the gun. The

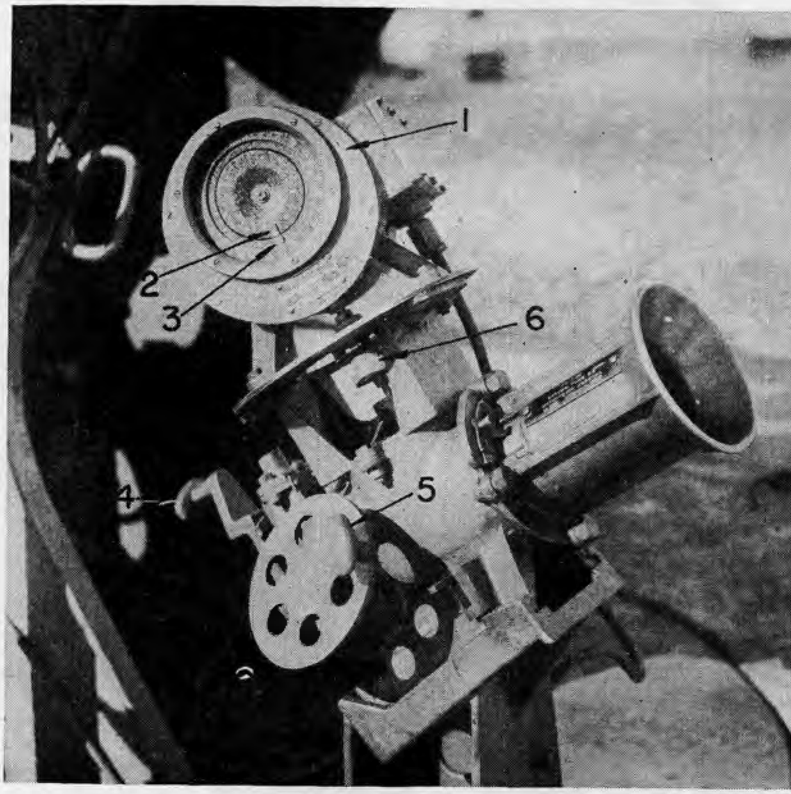


FIGURE 187.—Continuous fuze setter, M3, and fuze range receiver.

1. Fuze range receiver.
2. Electrical pointer.
3. Mechanical pointer.
4. Setting handwheel.
5. Adjusting handwheel.
6. Adjustable coupling.

fuze range receiver unit (1) is mounted on and connected by shafting to the fuze setter. The fuze setter proper has two principal elements, the fuze-setting mechanism and the adjusting mechanism. The function of the setting mechanism is to set the fuze on the projectile in accordance with the setting of the adjusting mechanism, as indicated by the mechanical pointer (3) on the receiver. The function of the adjusting mechanism is to adjust the setting to agree with the fuze range transmitted from the data computor, as indicated by the electrical pointer (2) on the receiver. Both mechanisms require manual operation.

(2) *Operation.*—The round of ammunition is placed in the mouth of the fuze setter. The nose of the projectile strikes a plunger, releasing a locking latch which engages the shoulder on the fuze, thus preventing withdrawal of the round from the setter. When the plunger referred to above is depressed, a second plunger is lifted which releases the setting crank (4) and the setting ring which it controls. The crank is now rotated twice in a clockwise direction. At the completion of the second turn, the crank and setting ring automatically lock. Somewhere in the first turn of the crank and setting ring the pawls on the latter will engage the time ring lug of the fuze. When thus engaged, the entire round of ammunition will be turned until the body lug of the fuze engages with the pawls in the adjusting ring. (Rotation of the round is made possible by proper tensioning of the time ring of the fuze.) After engaging the body lug of the fuze, rotation of the round is stopped and the time ring of the fuze turns with the setting ring of the fuze setter, until stopped by the crank at the end of the second turn. Near the end of the second turn of the crank, the locking latch is forced out, releasing the round. The crank, however, remains locked until the round is removed from the setter and another round is inserted. As long as the round remains in the setter, any rotation of the adjusting handwheel (5), which controls both the mechanical pointer on the receiver and the adjusting ring of the setter, will cause the fuze to be set at the fuze range indicated by the former. It remains only, therefore, for the operator to keep the mechanical and electrical pointers of the receiver in coincidence, for the fuze range to be set continuously in accordance with the data transmitted from the data computor.

(3) With this type of fuze setter the round of ammunition is turned by the time ring lug on the fuze, and the turning is made possible by proper tensioning of the time ring of the fuze. If the round is grasped or held during the setting operation or if the time ring is improperly tensioned, erratic settings will likely occur. Care should therefore be taken to release the round as soon as it grips the locking mechanism. All fuzes should be tested for proper tension of the time ring before using.

c. Fuze setters, M5 and M6.—(1) *Description.*—(*a*) These fuze setters were designed to reduce the number of erratic bursts which occur with the M2 and M3 types, due to improper tensioning of the time ring of the fuze or to the round being held or grasped during the setting operation. The fuze range receiver unit and the fuze setter proper are mounted in the same manner as the M2 and M3 types, and except for the arrangement of handwheels the outward appearances of the types are quite similar. The operating design of the M5 and M6 types, however, is exactly the reverse of that of the M2 and M3 types. Instead of the round being turned initially by the time ring lug of the fuze, as in the M2 and M3 types, it is turned by the body lug, the body lug of the fuze engaging the pawl in the setting ring of the fuze setter and the time ring lug of the fuze engaging the pawl in the adjusting ring of the fuze setter.

(*b*) The setting crank has been placed on the side of the fuze setter, rather than at the rear as in the M2 and M3 types. This position is more convenient for the operator. The setting head of the fuze setter is hinged to the body, making the parts accessible for inspection or cleaning.

(2) *Operation.*—The round is inserted and locked, the setting handwheel released, and two complete turns of the setting crank made as for the M2 and M3 types. During the first turn of the setting handwheel the body lug on the fuze is engaged by the pawls in the setting ring of the fuze setter, thus turning the round. The lug on the time ring of the fuze is engaged by the pawl in the adjusting ring of the setter as the round turns, after the body lug has been engaged. Final setting of the fuze by means of rotating the adjusting handwheel and ring takes place after both lugs have been engaged.

(3) As indicated above, the round of ammunition in this fuze setter is rotated by means of the body lug of the fuze instead of the time ring lug as in the M2 and M3 types. Consequently, rotation of the round does not depend upon proper tensioning of the time ring of the fuze. Also, holding or grasping the round during the setting operation will not interfere with the displacement of the time ring and the final setting of the fuze. Due to the fact that the rotation of the setting handwheel is transmitted directly to the projectile through the setting ring pawl and the body lug, it is difficult to grasp or hold the round while the setting handwheel is being rotated. If sufficient pressure were exerted, however, the probable effect would be to stop rotation of the handwheel, although it is possible that the lug would be stripped or the fuze unscrewed from

the projectile. The latter results are not likely to occur unless several settings have been made on the same fuze.

d. Fuze setter, M8.—(1) *Description*.—The latest type of fuze setter is the M8 (fig. 188). This setter has several advantages over its predecessors.

(*a*) It is greatly simplified which lessens repairs and reduces the cost of manufacture.

(*b*) It is about 35 percent lighter in weight.

(*c*) It handles dummy, powder train, or mechanical fuzes by the interchange of two simple mechanisms.

This setter incorporates several novel features of design. No mechanical means are provided for holding the round down in the

FIGURE 188.—Comparison of the M5 and the M8 fuze setters.

cutter during the setting of the fuze, so that the ammunition handler must maintain pressure on the base of the round during the cutting operation. A manual release for the setting handwheel has been substituted for the mechanical release heretofore provided.

The fuze setter is hinged so that the socket and the adapter may be separated. This makes the operations of cleaning, oiling, and changing the pawl rings easy to accomplish. As may be seen from the illustration the bell of the cutter is much shorter than on the M5, and the fuze indicator is built right into the mechanism instead of being attached to it.

(2) *Operation*.—A round is placed in the fuze cutter by the ammunition handler who maintains a constant downward pressure on

the base of the shell during the cutting operation. As soon as the round is fully inserted, the setting handwheel mechanism is released by a quick slap on the release lever (fig. 188). When the release lever has been struck, the setting handwheel is given one full turn, cutting the fuze. (This motion is geared up so that one turn of the setting handwheel causes two turns of the pawl rings.) The removal of the round automatically locks the setting handwheel. In changing from one type fuze to another, two operations are necessary—the two pawl rings must be changed and a different indicator dial installed. The substituted indicator dial must be set by the cut-and-try method. After the fuze setter is assembled a live round is inserted and cut. Without changing the position of the mechanical pointer the outer scale is moved so that the mechanical pointer indicates the setting obtained on the fuze. The scale is clamped in this position and two or three additional rounds are cut for verification. (In changing from one fuze to another it is necessary to change both pawl rings and indicator dial.)

e. Adjustment of continuous fuze setters.—(1) In order to insure that the operation of the continuous fuze setter will result in the accurate setting of fuzes it is necessary that the fuze setter be tested for mechanical accuracy. This operation is separate and distinct from the process of synchronizing the electrical fuze range receiver and the corresponding transmitter in the data computor, as discussed in paragraph 78*i*.

(2) The mechanical adjustment of the fuze setter is verified by setting the fuzes on a few projectiles and then comparing the setting with the reading of the mechanical pointer (3, fig. 187) on the receiver. If the setting on the fuzes does not agree with the position of the mechanical pointer, the pointer should be moved by means of the adjustable coupling (6), immediately below the receiver, and the test and adjustment continued until the fuze setting actually cut on the projectile agrees with the reading of the mechanical pointer. Fuzes should always be set back to safe before the test rounds are returned to the ammunition rack.

f. Bracket fuze setter, M1916.—(1) This fuze setter (fig. 189) has no electrical receiver unit and must be employed with telephonic data transmission systems. The fuze ranges telephoned from the data computor are applied by turning a crank (214) until the proper values are set on the range ring (212). The fuze range setting applied to the range ring is set on the fuze of the projectile by inserting the round in the fuze setter and rotating it clockwise until the body lug on the fuze strikes the ring stop (213) of the fuze setter. The latter stop is positioned by the operation of setting the fuze range on the range ring.

(2) The fuze setter contains an independent corrector device consisting of a corrector ring (215), a corrector knob (218), and a corrector scale (217). The normal of the scale is 30. Changing the

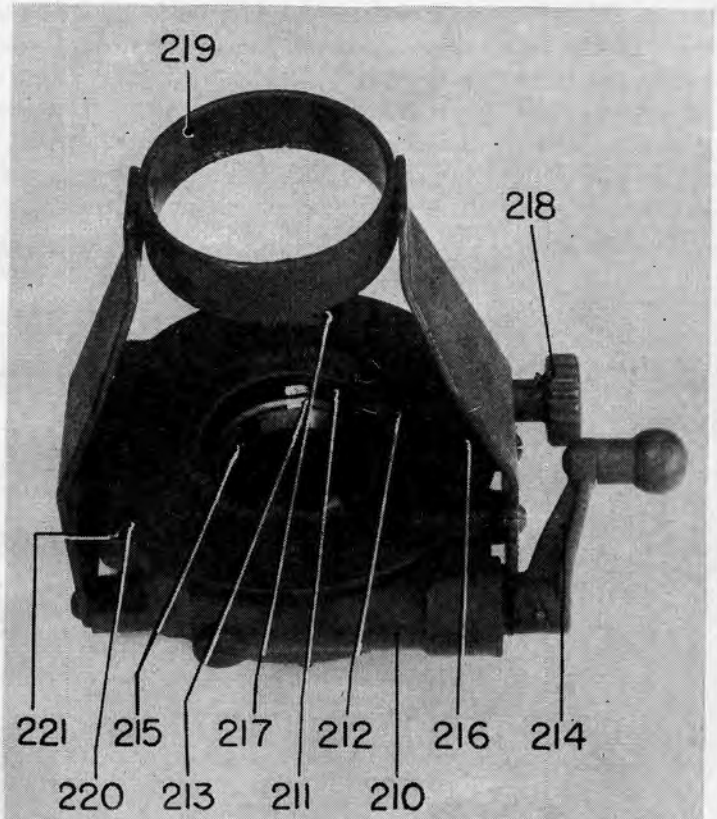


FIGURE 189.—Bracket fuze setter, M1916.

210. Housing.
211. Range ring worm wheel.
212. Range ring.
213. Range ring stop.
214. Range worm crank.
215. Corrector ring.
216. Housing cover.
217. Corrector scale.
218. Corrector worm knob.
219. Guide.
220. Locking screw.
221. Housing cover screw.

setting of this scale operates to increase or decrease the time of burning of the fuze without disturbing the principal setting on the range ring (212). Decreasing the corrector setting increases the time of burning of the fuze; conversely, increasing the setting decreases the time of burning. One division of the corrector equals one-tenth of an average fuze range unit. Consequently, if the corrector scale were set at 28 and the principal scale at 8.0, the resultant setting on the fuze would be 8.2 or a fuze range of 8⅕. The corrector device permits fuze range corrections to be made to the individual fuze setters without disturbing the fuze ranges transmitted from the data computor to the battery as a whole. It also permits adjustment of the fuze setter to correct for an erroneous setting as indicated in (3) below.

(3) *Adjustment.*—The accuracy of the fuze setter is tested by cutting a few fuzes to determine if the setting agrees with that indicated by the range ring scale (212) as changed by any setting on the corrector scale (217). With a setting of 30 applied to the latter, which is normal, the setting on the fuze should agree exactly with that on the range ring scale (212). If it does not, the corrector scale (217) should be moved and additional rounds tested until the proper setting is secured. Fuzes should always be set back to safe before the test rounds are returned to the ammunition rack (S, fig. 186).

g. Fuze setters in use.—The following fuze setters are in use:

Model	Ammunition	Fixed or mobile gun	Fuze used
M2	M1918	Mobile	MkIIIA1 (powder train).
M3	M1917	Fixed	MkIIIA1.
M5	M1918	Mobile	MkIIIA1.
M6	M1917	Fixed	MkIIIA1.
M8	Any	Either	MkIIIA1 (powder train). M43 (mechanical). Dummy.
M1916 (bracket)	M1918	Mobile, M1918	MkIIIA1.

SECTION XII

ANTIAIRCRAFT ARTILLERY AUTOMATIC WEAPONS

83. General.—*a.* During the latter part of the World War both sides commenced to use hedge-hopping tactics on a large scale. Earlier these attacks had been limited to isolated cases of aviators attacking a troop train or an infantry column on their way home from their main mission. The year 1918 saw the use of organized attack (low-flying) aviation with missions assigned in advance and large numbers of aircraft participating.

b. As long as these attacks were isolated and made by single planes, unorganized defense missions sufficed, but the organized attack called for organized defense. Definite antiaircraft machine gun organizations came into being, whose sole mission was the shooting down of low-flying aircraft. Since the war an antiaircraft machine gun battalion has been made a part of every antiaircraft regiment,

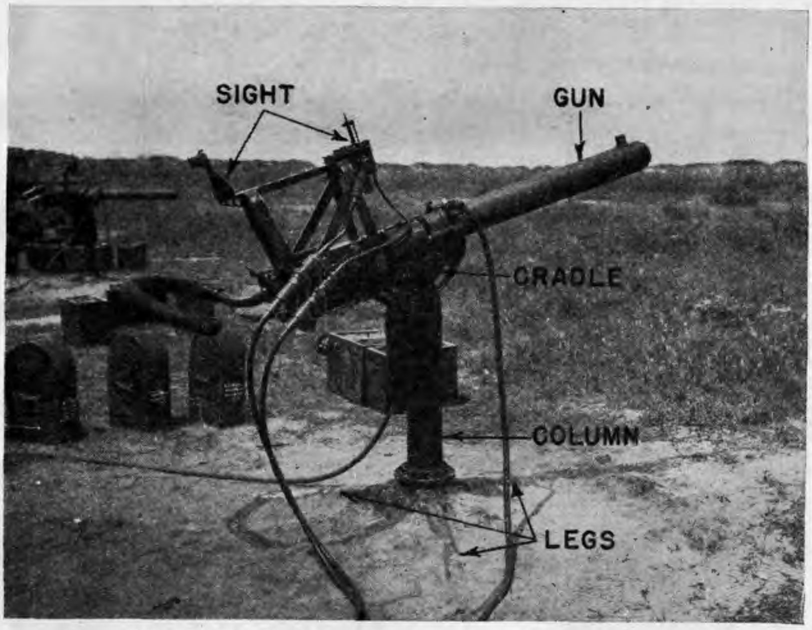


FIGURE 190.—Caliber .50 machine gun, M2, on mount, M2.

and all troops make provision for their own defense from low-flying aircraft.

c. At the present time there are two automatic weapons standardized for use by the antiaircraft artillery, the caliber .50 machine gun, M2, and the 37-mm automatic cannon, M1. The machine gun is mounted on the mount M2, while the 37-mm is mounted on a 4-wheeled trailer.

84. Browning machine gun, caliber .50, M2.—*a. General.*—The gun is water cooled, recoil operated, and belt fed. Its general appearance, mounted on the mount M2, is shown in figure 190. The gun, empty, weighs about 100 pounds. The rate of fire averages

600 rounds per minute, the rate being adjustable within limits by means of the oil buffer described in *b* (5) below.

The maximum vertical range of the caliber .50 gun is approximately 5,000 yards and the maximum horizontal range 7,500 yards. The maximum burn-out range (during which the tracer is visible) is about 2,000 yards. The maximum vertical and horizontal ranges on the caliber .30 machine gun are limited to 2,700 and 3,300 yards, respectively, and the tracer ammunition is visible for about 1,100 yards.

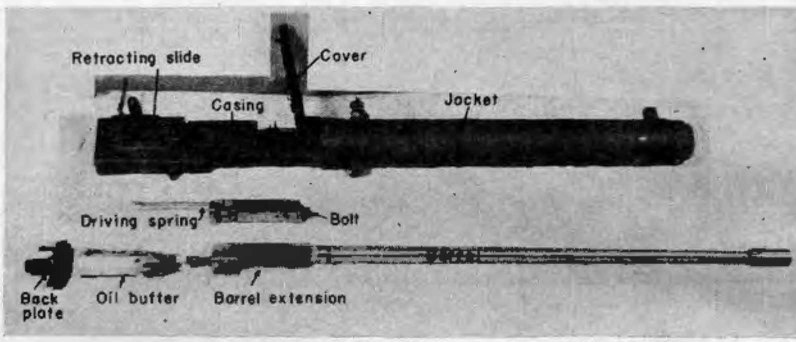


FIGURE 191.—Principal parts of caliber .50 machine gun, M2.

b. Parts of the gun.—(1) The M2 gun may be divided for study into seven principal groups as follows:

(*a*) Casing.
(*b*) Jacket.
(*c*) Barrel.
(*d*) Oil buffer.
(*e*) Bolt.
(*f*) Back plate.
(*g*) Cover.

(2) The various groups and their general relation to each other are shown in figure 191.

(*a*) The casing forms a rectangular box comprising the rear third of the gun and contains most of the operating parts.

(*b*) The jacket is fastened to the casing and forms the forward two-thirds of the gun's length. It supports the removable barrel and holds the cooling water.

(*c*) The barrel group comprises the barrel and the barrel extension. The breech end of the barrel and the barrel extension are shown in figure 192.

The 45-inch barrel screws into the extension with a coarse thread. Head space is adjusted by screwing the barrel farther into or out of the barrel extension. In order to maintain the head-space adjustment at the desired value a locking system is provided. This consists of the many notches at the extreme rear of the barrel and of a barrel locking spring fitting into them. The deep groove in the barrel is normally filled with a water packing to prevent the water from the jacket leaking out.

FIGURE 192.—Barrel group, caliber .50 machine gun, M2.

(*d*) The oil buffer affords a means of bringing the bolt to a gradual stop and of adjusting the rate of fire (fig. 193).

(*e*) The bolt is shown disassembled in figure 194. In operation, the bolt slides in grooves in the upper part of the barrel extension as shown in figure 195.

(*f*) The back plate (fig. 191) forms the rear wall of the casing. It is the first piece taken out in disassembling the gun, and its removal permits the rest of the operating parts to be withdrawn. It

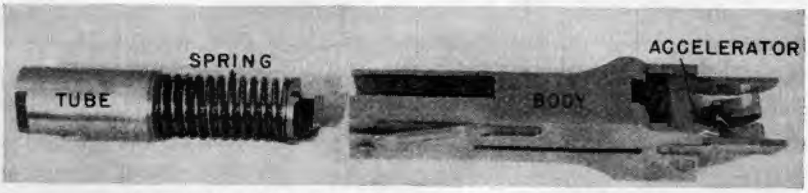


FIGURE 193.—Oil buffer group, caliber .50 machine gun, M2.

has a cylinder filled with fiber buffer disks to absorb excess recoil energy not cushioned by the oil buffer.

(*g*) When the cover is in the raised position, the gun cannot be loaded or fired. When not firing, guns are habitually left with covers raised as a safety precaution.

c. Operation.—(1) Ammunition is loaded into metallic link belts of 200 rounds each and carried in the ammunition chest illustrated in figure 197. This chest is hung on the left side of the gun. To load, the cover is raised, the belt placed so that the first cartridge is in proper position, the cover lowered, and the bolt handle is pulled twice. The gun is now loaded and ready to fire. As the trigger is actuated, the gun fires automatically, the empty cartridges going out through the bottom of the gun and the metallic links of the belt out the right-hand size.

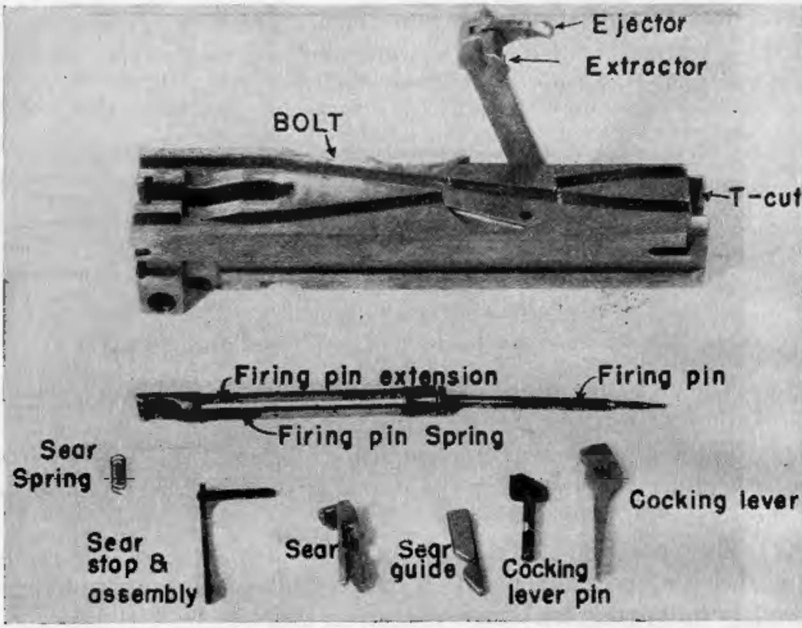


FIGURE 194.—Bolt group, caliber .50 machine gun, M2.

(2) It is not practical to give a detailed functioning of the individual parts but the general function of the mechanism will be described. The gun has been loaded as described in (1) above.

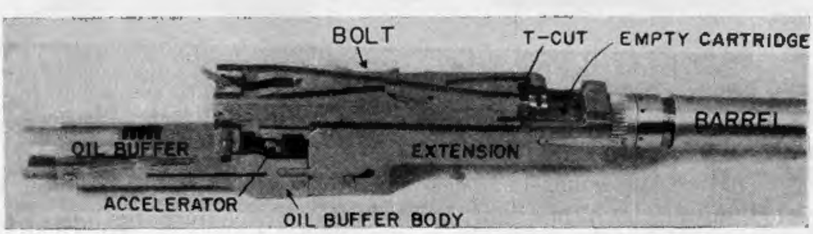


FIGURE 195.—Recoil, showing bolt freed from barrel extension.

When the gun is fired the mechanism moves to the rear under the force of recoil (fig. 195). It carries with it the empty cartridge case and one loaded cartridge. It is slowed up and stopped by the oil buffer and the fiber buffer disks in the back plate. In the forward movement (under the action of the driving spring) the empty case is ejected downward, and the loaded cartridge enters the chamber (fig. 196). When the bolt reaches its fully forward position the cartridge fires and the cycle is repeated.

(3) When the gun is fired, the barrel, barrel extension, and bolt are carried to the rear as a unit, held together by the breechlock. (See fig. 192.) When they have moved together about an inch the breechlock unlocks and the bolt is freed from the barrel extension and continues to the rear, extracting the empty cartridge from the chamber. (See fig. 195.) On its way backward the barrel extension strikes the accelerator which gives the bolt an additional kick to the rear. The barrel extension comes to rest against the front end of the oil buffer body as shown in the illustration. When fully to the rear the bolt is stopped by the oil buffer group (fig. 193). At this time one loaded cartridge and one empty case are within the barrel extension. The empty case is held in the T-cut in the bolt; the loaded

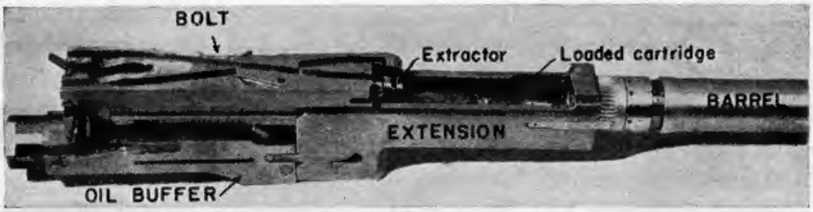


FIGURE 196.—Recoil, showing bolt starting forward.

cartridge, held by the extractor, is vertically above the empty case ready to drop into the T-cut as soon as the case is ejected downward.

As the bolt starts forward the loaded cartridge is brought into line for loading into the chamber (fig. 196). At the same time the ejector pushes the empty case down out of the T-cut and out of the gun. As the bolt completes its forward motion the cartridge now held firmly by the T-cut enters the chamber. The extractor resumes the starting position ready to extract the new cartridge from the belt.

When the bolt reaches its fully forward position the sear is tripped, the firing pin strikes the cap of the loaded cartridge, the cartridge fires, and the cycle is repeated.

d. Stoppages.—(1) *General.*—The automatic functioning of the gun as explained above is dependent upon the operating condition of the parts, the proper assembly and adjustment of the parts, and the condition of the cartridge belt and ammunition. If a failure or defect occurs in any of these features, a stoppage will occur and the gun will cease to function until the cause of the stoppage is removed.

(2) *Causes and classes.*—Provided the gun and parts are properly maintained and assembled, very few stoppages will occur due to mechanical deficiencies. Occasionally, however, parts will break or become weak or worn. The most frequent causes of stoppages are defective ammunition and improper head-space adjustment.

(3) *Prevention.*—It is particularly important, due to the short available firing time on the normal machine gun aerial target, that every effort be made to eliminate possible causes of stoppages before the target is engaged. *Prevention is always the best remedy for stoppages.* It is essential that the gun and parts be maintained in proper operating condition at all times. The head-space adjustment must be carefully made and each round of ammunition must be carefully examined for defects before firing begins. Particular defects to look for are split cases, battered or damaged cases, and loose rounds (bullet loose in case).

e. Head-space adjustment.—(1) *General.*—By head-space adjustment is meant the adjustment of the space between the rear end of the barrel and the front face of the bolt so that the bolt will press closely against the base of the cartridge when the gun is loaded. The extreme importance of head-space adjustment is frequently overlooked. It is probably the most important adjustment of the machine gun, and unless properly made a stoppage will certainly occur and serious injury to the gun or operating personnel may result. If the head space is excessive a stoppage will often occur in which the case will be pulled in two, leaving the front portion of the case in the chamber. This will not only prevent entrance of the next cartridge, and thus interrupt the firing, but may result in serious damage to the gun. If the adjustment is too tight the recoiling parts will either not go home, to permit the gun to be fired, or excessive strain on the breech lock and pin will break the barrel extension in firing.

(2) *Method of making adjustment.*—The head-space adjustment should first be made in the following manner, *with the recoiling parts removed from the gun:*

(*a*) Screw the barrel (fig. 192) into the barrel extension and stop at the beginning of the clicking sound when the barrel locking spring engages the notches of the barrel.

(*b*) Place the bolt in its guides in the barrel extension and push it *all* the way home being careful that the extractor is raised or removed.

(*c*) Lock the bolt to the barrel extension by pushing the breech lock up into the recess of the bolt. Hold it firmly in that position.

(*d*) Screw in the barrel until a resistance, other than that caused by the barrel locking spring engaging the notches in the barrel, is felt. *Be sure that the breech lock is still held firmly up in the cut of the bolt.*

(*e*) Release the breech lock, pull back the bolt and screw in the barrel one notch or one and a fraction notches, depending on whether the tooth of the barrel locking spring rests in a notch or between two notches of the barrel.

(3) *Test and readjustment.*—A positive rule for adjustment that will fit all guns cannot be given. The exact adjustment can only be determined by experience and test. After the adjustment indicated in (2) above has been made, the parts should be assembled in the gun and the following tests applied:

(*a*) Pull back and release the bolt handle several times. In case the recoiling parts do not go fully forward smoothly the adjustment is too tight. Unscrew the barrel one notch.

(*b*) Raise the cover and extractor. Move the bolt slightly to the rear by means of the bolt handle. If the bolt moves independently of the barrel the adjustment is too loose. Readjust by screwing the barrel in one notch and test again.

The above tests of head-space adjustment must always be made prior to firing the gun even though it is supposed to be in adjustment.

(4) *Quick head-space adjustment.*—After the correctness of head-space adjustment for a particular gun and barrel has been established as indicated above and by actual firing, the proper notch for head-space adjustment should be marked, and the number of clicks required to screw the barrel up tight in the barrel extension from this point, with the bolt removed, should be counted and noted in the gun record. Then, to adjust head space quickly, screw the barrel in until the proper number of full turns has been made and stop with the barrel locking spring in the marked notch, or screw the barrel tight into the barrel extension and then unscrew the required number of clicks.

f. Accessories.—The principal accessories are the ammunition chest and the water circulating unit.

(1) The ammunition chest, caliber .50, M2, is made of steel and holds a belt of 200 rounds. For firing, it is mounted on the left of the gun. It is illustrated in figure 197.

(2) The water circulating unit, M3, is composed of the water chest and the necessary hose and connections as shown in figure 197. The chest has a pump resembling those used in a gasoline filling station. During firing, one member of the crew turns the handle, forcing cool water up through the hose to the jacket of the gun, and returning the

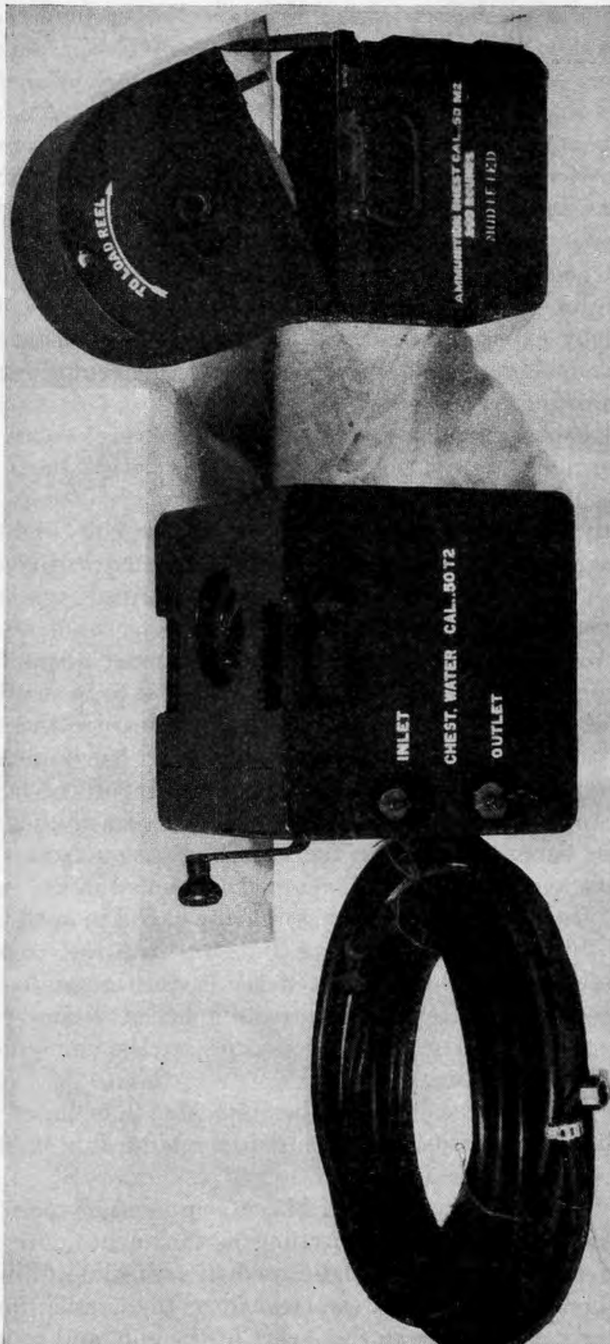


FIGURE 197.—Water circulating unit (left) and ammunition chest for caliber .50 machine gun, M2.

heated water for cooling. The hose arrangements are shown in figure 190, the two forward hoses being for water.

g. Mount, M2, for caliber .50 machine gun, M2.—(1) The mount, M2, has a large vertical column supported at the bottom on three wide-spreading legs. It weighs approximately 400 pounds, of which the largest single part, the cradle, weighs 150 pounds. The mount permits a maximum elevation of 69°, a depression of 15°, and a traverse of 360°. (See fig. 190.)

(2) In order to eliminate vibration the gun is allowed to recoil about an inch by a spring operated system. This recoil system floats the gun between the recoil spring and the counterrecoil spring. The recoil is variable, a maximum recoil at 0° elevation and a minimum recoil at the maximum elevation of 69°.

(3) To prevent the gun from firing when in the recoiled position the trigger arrangement has been altered. As now designed the last motion of counterrecoil trips the trigger for each separate shot. The new system has no appreciable effect on the rate of fire.

(4) The mount is a free mount pointed by the gunner without the use of handwheels. A backrest affords the gunner a means of steadying and pointing the gun, leaving the hands free.

85. Browning machine gun, caliber .50, M1921 and M1921A1.—*a. General.*—Many units are equipped with the older model caliber .50 machine guns and will use them until the M2 is available for issue.

b. Practically all the description of the M2 gun applies to the M1921 except that the older gun has a 36-inch barrel instead of a 45-inch one.

c. As shown in figure 198, it is mounted on the tripod mount, M1. This mount has no recoil system and is equipped with a different type of shoulder rest for the gunner. The same ammunition box and water circulating unit may be employed as is used for the M2 gun and mount.

86. Browning machine gun, caliber .30, M1917.—*a. General.*—This gun was the predecessor of the caliber .50 machine gun and employs the same general operating mechanism. It was manufactured during the World War in large quantities and is a reliable, efficient machine gun.

b. Description.—(1) Note in figure 199 how the regular jacket-casing arrangement is employed. The rear sight is mounted on top of the cover. A flash hider is used to hide flash and smoke. A pistol grip containing shock absorbing fiber washers takes the place of the two handles on the caliber .50, M1921.

(2) On the interior the parts are very similar to those of the caliber .50. No oil buffer is employed, the buffer disks giving enough cushion-

ing effect for the smaller energy to be handled. The functioning is almost identical with that of the caliber .50 gun.

(3) The antiaircraft machine gun tripod mount, M1, described in paragraph 85*c*, is used to mount this gun.

FIGURE 198.—Browning machine gun, caliber .50, M1921, and AA machine gun tripod mount, M1.

1. Yoke.
2. Center support.
3. Adjusting bracket.
4. Tripod legs.
5. Leg braces.
6. Shoulder stock, M3.
7. Stock adjusting joint.
8. Stock adjusting slide lock.

87. 37-mm automatic cannon.—*a. General.*—There is a twilight zone between the portion of the sky covered efficiently by the machine gun and that covered by the 3-inch or 105-mm gun. The 37-mm automatic cannon, M1, was developed to cover this space.

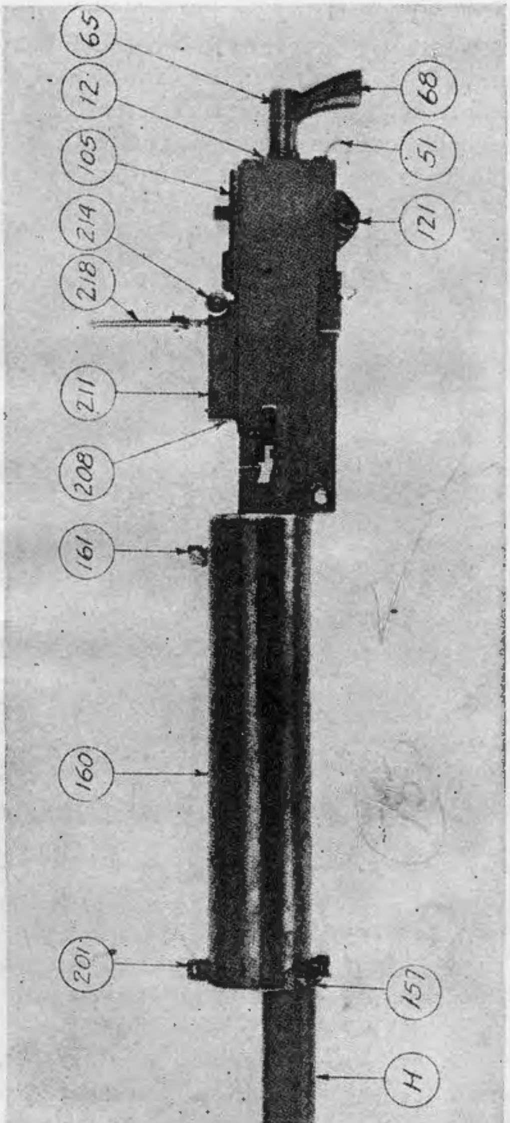


FIGURE 199.—Browning machine gun, caliber .30, M1917 (left side).

H. Flash hider.
12. Driving spring rod.
51. Trigger.
65. Grip.
68. Stock, left.
105. Latch.
208. Rear sight base.
211. Rear sight movable base.
214. Windage screw knob.
121. Elevating bracket and bracket pin hole.
157. Cork stem.
160. Water jacket.
161. Water plug (upper).
201. Front sight base.
218. Rear sight leaf.

Firing an explosive bullet, with a fabric-sensitive fuze, this weapon needs comparatively few hits to disable or destroy the average airplane. Actual war service in Spain demonstrated the value of a German cannon of similar characteristics and led to the adoption of this weapon for our antiaircraft service.

b. Description.—The cannon (fig. 200) is a clip loaded, air cooled, recoil operated automatic cannon firing at the rate of about 120 rounds per minute. It is trunnioned in rear of the breech and balanced by a suitable spring equilibrator. The recoil mechanism is of the hydraulic recoil, spring-counterrecoil type, having a recoil of 10¾ inches. The gun barrels are detachable and one extra is carried with each gun. The operation of the automatic mechanism is somewhat like that of

FIGURE 200.—37-mm automatic cannon on trailer mount in firing position.

the caliber .50 machine gun. However, the breechblock operates vertically instead of horizontally, resembling the 3-inch AA gun block.

c. Mount.—Shown in traveling position (fig. 201) the mobile mount weighs some 5,000 pounds. Going from traveling to firing position (fig. 200) is a matter of seconds, as it requires only the tripping of the front and rear axle assemblies to allow the main frame to rest on the earth. To go from firing to traveling position is almost as easy, as use is made of leverage to raise the frame up into its road position, a four-man crew furnishing adequate manpower. Spring action to cushion the chassis is provided by four coil-spring and shock-absorber cylinders, much as on some modern automobiles.

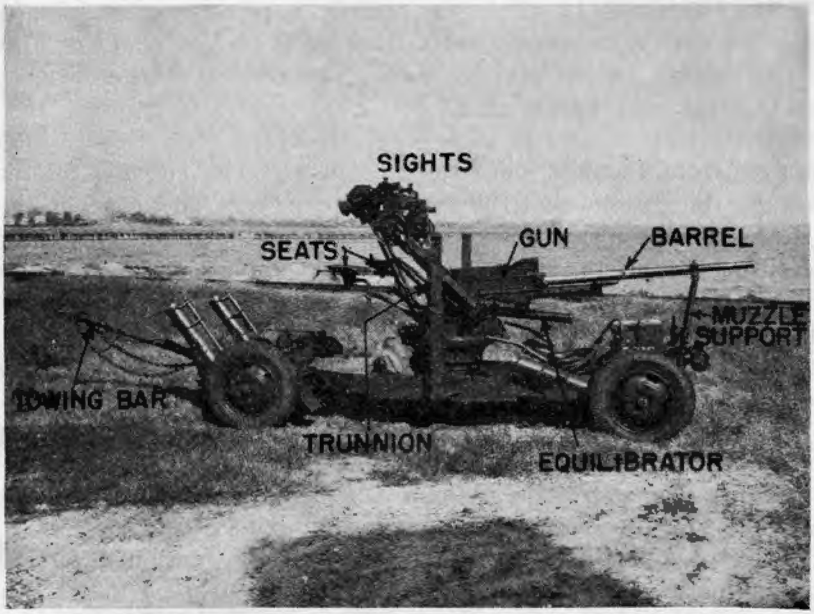


FIGURE 201.—37-mm automatic cannon in traveling position.

FIGURE 202.—Control station, control equipment set, M1.

d. Accessories.—(1) The two operators pointing the gun are equipped with a one-power collimating sight each so that any form of fire control desired may be used. The vertical tracker fires the gun by means of a foot trigger.

(2) Shell are loaded in 5- or 10-shell clips fed in without interruption from the left side of the cannon. The empties fall out through the bottom, and the empty clips emerge on the right side. All of the ammunition is tracer, the projectile weighing 1¼ pounds. After firing a burst of 80–100 rounds, the barrel is cooled by pumping water through it from a caliber .50 machine gun water circulating unit equipped with breech and muzzle plugs. This unit is shown under the gun barrel in figure 201. About 3 minutes are required to cool the barrel to air temperature.

(3) The mount is towed by any vehicle capable of pulling its weight satisfactorily.

(4) For fire control the platoon is provided with a control equipment set, M1, for automatic gun as described in paragraph 88.

88. Fire-control equipment.—The control equipment set, M1, for automatic gun is the standard fire-control system for the machine guns and the automatic cannon. The control station (fig. 202) affords a means of directing and correcting the fire of all the guns simultaneously. It is not a computing device and depends on the observation of tracers for correcting the estimated opening leads.

Each pair of the eight shafts projecting from the box goes to one machine gun, operating a front sight in azimuth and elevation, as shown in figure 190. These flexible shafts resemble speedometer cables in appearance and construction and permit the transmission of rotary motion over short distances with small error. By proper adjustment of the sights the four guns are made to fire together, and then the fire of the platoon is controlled as one gun.

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[A.G. 352.6 (9-15-39).]

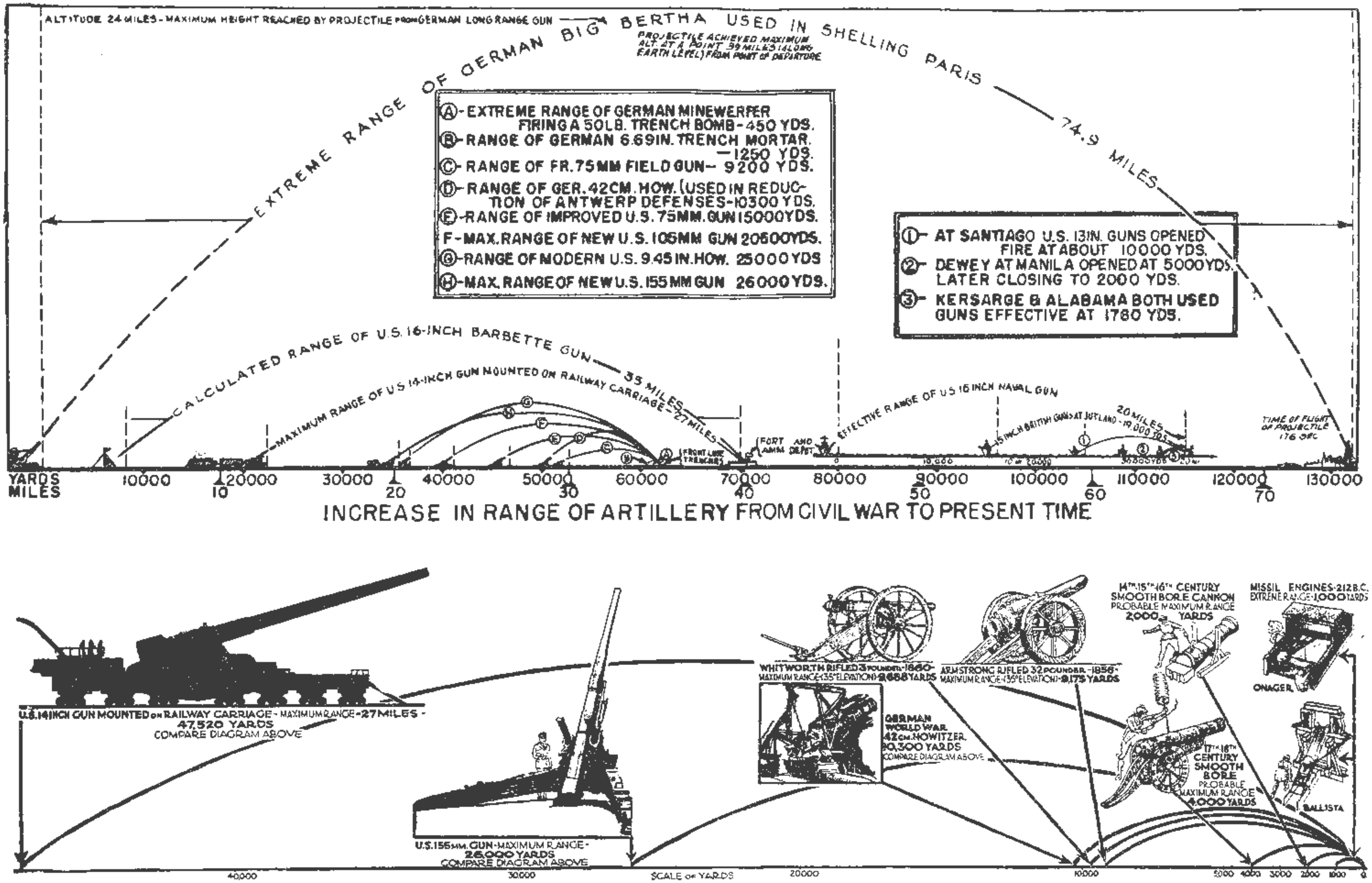
BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

E. S. ADAMS,
Major General,
The Adjutant General.

U. S. GOVERNMENT PRINTING OFFICE: 1940



Examples of artillery typical of their times, and their respective ranges, from the ancient missil engines of 212 B. C. to the 42-centimeter German howitzers used at Antwerp in the World war, as compared with examples of America's most modern guns, maximum ranges of which are in excess of comparative weapons employed in the World war.

FIGURE 1.—Development of artillery.

Table I.—CHARACTERISTICS OF SEACOAST ARTILLERY

	Gun								Carriage															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
															Recoil			Counterrecoil						
	Caliber	Model	Length (calibers)	Weight (pounds)	Type construction	Rifling	MV	Life (full charge)	Mounts gun in line	Model	Type	Weight (pounds)	Elevation—Min.—Max.	Total traverse	Length	Mechanism type	Number of cylinders	Mechanism type	Number of cylinders	Buffer type	Sight	Type	Single or step-cut	Number of handles to operate
A B	3"	1902MI and 1903	50 55	1,950 2,500	Built-up	1-50 to 1-25	2,600	2,500	A B	M1902 M1903	Barbette	6,600	−10° to +15° −10° to +16°	360°	9"	Hydraulic (grooves)	1	Spring	1	Tapered dash-pot.	Bar. Car. 1902	Lever-pull	Single	1
C	6"	M1897MI	45	15,600	Built-up	1-50 to 1-25	2,600	1,000	D	M1900	Barbette	24,808	−5° to +20°	360°	15"	Hydraulic (grooves)	1	Spring	2	Dashpot	3" Tel. 1904	Lever-pull	Single	1
D E	6"	M1900 M1903	50	20,000	Built-up	1-50 to 1-25 1-50 to 1-25	2,600	1,250	C E-D-F	M1898 M1903	Disappearing	64,800 97,500	−5° to +15°	170°	36" 40"	Hydraulic (grooves)	2	Counterweight	2	Tapered dash-pot.	3" Tel. 1904	Lever-pull	Single Cone	1
F G	6"	M1905	50	21,100	Built-up	Uniform 1-25	2,600	1,250	F E-F-H-I	M1905 1905MI 1905MII	Disappearing	113,100	−5° to +15°	170°	40" 47"	Hydraulic (grooves)	1 (on ctr. wt.)	Counterweight	1	Dashpot	3" Tel. 1904	Lever-pull	Cone	1
H I	6"	M1908 M1908MI M1908MII	45	12,300	Wire-wound.	1-50 to 1-25	2,600	1,000	H	M1910	Casemate Barbette	57,607	−3° to +12°	120° 360°	15"	Hydraulic (grooves)	1	Spring	2	Tapered dash-pot.	3" Tel. 1904	Lever-pull	Single	1
K	155 mm	M1917 M1917AI M1918MI	37	8,795	Built-up	Uniform 1-30	2,410	3,000	K	M1917 M1918	Mobile	11,065	0° to 35°	60°	Variable, 71" max.; 43" min.	Hydropneumatic	1	Hydropneumatic	2	Dashpot	Quadrant M1918	Lever-pull	Single	1
L	240-mm how. (9.45").	1918	21.1	10,700	Built-up	1-40 to 1-20	1,700	3,000	L	M1918	Mobile platform (4 loads).	41,300	−1° to 60°	Mobile 20° Fixed 360°	45"	Hydropneumatic	2	Pneumatic	1	Dashpot	Quad. sight M1918	Lever-pull	Single	1
M	8"	M1888 M1888MI M1888MII	32	33,200	Built-up	1-50 to 1-25	2,600 1,950	900	M	M1918	Railway	174,000	0° to 42°	360°	48"	Hydraulic (grooves)	2	Spring	4	Tapered dash-pot.	Pan. Type C	1888 Rotating tray	Step	2
N O	10"	1888MI, MII	34	67,200	Built-up	1-50 to 1-25	2,250	500	N N	1893 1919	Barbette Sldg. Ry.	144,600 387,200	−7° to +15° +10° to +54°	320°	50"	Hydraulic (bars)	2	Gravity	2	Dashpot	Tel. 1898 Pan. Type K.	1888 Rotating tray	Single	2
P Q	10"	1895MI	35	66,700	Built-up	1-50 to 1-25	2,250	500	N P	1894MI 1896LF	Disappearing	270,000	−5° to +12° −5° to +12°	140°	54"	Hydraulic (bars)	2	Counterweight	2	Dashpot		Stockett 95	Single	1
R S	10"	1900	40	76,500	Built-up	1-50 to 1-25	2,250	700	P R	1896ARF 1901LF	Disappearing	268,000 398,000	−5° to +12° −5° to +12°	360° 170°	67"	Hydraulic	2	Counterweight	2	Dashpot	Tel. 1898 3" Tel. 1904	Stockett 95	Single	1
T U	12"	M1888 MI MII	34	116,200	Built-up	1-50 to 1-25	2,235	350	V W	M1897 M1901	Disappearing	487,000 542,000	−5° to +10°	Limited by emplcmnt.	67"	Hydraulic (bars)	2	Counterweight	2	Tapered dash-pot.	3" Tel. 1904	Stockett 1895	Single	1
V W	12"	M1895 M1900	35 40	114,700 131,400	Built-up Built-up	1-50 to 1-25	2,600 2,250	350 400	T V	M1892 M1917	Barbette	229,000 302,000	−7° to +15° 0° to +35°	360°	48" 30"	Hydraulic (bars) (Grooves)	2 1	Gravity Spring	0 4	Dashpot Plug	Tel. 1910 3" Tel. 1904	1888 Rotating tray	Single	2
X									V	Batignolles 1918	Railway	322,000	15° to 38°	±5°	35"	Hydropneumatic (Grooves).	2	Pneumatic	1	Plug	Pan. type E	Stockett 1895	Single	1
Y									V	Sliding	Railway	550,000	15° to 40°	Curved track		Slides along track	None	Hand and power	None	None	Pan. type D	Stockett 1895	Single	1
I	12" M	M1890	10	29,000	Built-up	1-40 to 1-20	1,500	1,500	I I	1918 1896MI, MII	Railway Fixed	176,000 128,000	−5° to +65° 0° to 70°	360° 360°	30" 23"	Hydraulic (grooves) Hydraulic (grooves)	2 2	Pneumatic Spring	1 5	Plug Dashpot	Mounting type D	Stockett 1908 Rotating tray 1890	Single	1 2
II III	12" M	M1908 M1912	10 15	18,200 33,300	Wire Wire	1-20 1-40 to 1-20	1,500 1,800	1,500 1,000	II III	1908 1896MI, MIII	Fixed	126,000 132,000	0° to 65° 0° to +70°	360° 360°	24" 23"	Hydraulic (grooves)	2 2	Spring Spring	2 5	Plug Dashpot	1908	Stockett 1908	Single	1
IV	14"	1907 MI	34	110,600 118,800	Wire	1-25	2,150	300	IV	1907 1907MI	Disappearing	619,100 636,000	−5° to +20°	Various 120°–220°	73"	Vertical hydraulic (grooves).	1	Weight	None	Dashpot	3" Tel. 1914	1909 Stockett	Step	1
V	14"	1909	40	137,700	Wire	1-50 to 1-25	2,370	250	V	1909	Turret	2,316,000	0° to 15°	360°	48"	Hydraulic (grooves)	1	Spring	4	Plug	3" Tel	1907 Stockett	Step	1
VI	14"	1910 MI	40	138,000	Wire	1-50 to 1-25	2,350	250	VI	1907 1907MI	Disappearing	682,000	−5° to +20°	120°–280°	73"	Vertical hydraulic (grooves).	1	Weight	None	Dashpot	3" Tel. 1912	1907 Stockett	Step	1
VII	14"	1919	40	138,000	Wire	1-50 to 1-25	2,350	250	VII	E	Railway	437,000	0° to 30°	360°	60"	Hydraulic (grooves)	1	Spring	6	Dashpot		1907 Stockett	Step	1
VIII	14"	M1920MI M1920MII	50	192,500 233,800	Wire	1-32	3,000	200	VIII	M1920	Railway	681,300	−7° to +50°	Top carriage 7° Car body 360°	35"	Hydraulic	4	Pneumatic	1	Plug	3" Tel. 1920	Drop MII	Step	1
IX	16" how	1920	25	195,300	Built-up	Uniform 1-25	1,950	800	IX	1920	Barbette	705,000	−7° to +65°	360°	38.5"	Hydraulic	4	Pneumatic	1	Plug	Mount 1920	Drop	Step	1
X	16"	1919MII, MIII	50	385,600	Wire	1-30	2,700	175	X	1919	Barbette	1,000,000	−7° to +65°	360°	40"	Hydraulic (grooves)	4	Pneumatic	2	Valve	3" Tel. 1918	Drop	Step	1
XI	16"	1919	50	340,600	Wire	1-30	2,750	175	XI	1917	Disappearing	1,670,000	−5° to +30°	360°	89"	Hydraulic (bars)	2	Counterweight	None	Plug	3" Perios 1917	Side	Step	1
XII	16"	1895	35	284,000	Built-up	1-50 to 1-25	2,190	200	XII	1912	Disappearing	1,274,000	−5° to +20°	170°	89"	Hydraulic (bars)	2	Counterweight	None	Plug	3" Tel. 1912	Side	Single	1
XIII	16"	Mk. II Modif. 1 Navy.	50		Built-up	1-32	2,750	175	XIII	1919MI	Barbette	1,000,000	−7° to +65°	360°	40"	Hydraulic (grooves)	4	Pneumatic	2	Valve	3" Tel. 1918	Drop	Step	1

*For aliquot powder charges.

TABLE I.—CHARACTERISTICS OF SEACOAST ARTILLERY

Gun						Carriage													Breechblock					
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
												Recoil			Counterrecoil									
Length (calibers)	Weight (pounds)	Type construction	Rifling	MV	Life (full charge)	Mounts gun in line	Model	Type	Weight (pounds)	Elevation—Min.—Max.	Total traverse	Length	Mechanism type	Number of cylinders	Mechanism type	Number of cylinders	Buffer type	Sight	Type	Single or step-cut	Number of handles to operate	Power	Firing mechanism	Firing table
50 55	1,950 2,500	Built-up	1-50 to 1-25	2,600	2,500	A B	M1902 M1903	Barbette	6,600	−10° to +15° −10° to +16°	360°	9″	Hydraulic (grooves)	1	Spring	1	Tapered dash-pot.	Bar. Car. 1902	Lever-pull	Single	1	Hand	Percussion continuous 1903 (110 gr.).	3-M-2
45	15,600	Built-up	1-50 to 1-25	2,600	1,000	D	M1900	Barbette	24,808	−5° to +20°	360°	15″	Hydraulic (grooves)	1	Spring	2	Dashpot	3″ Tel. 1904	Lever-pull	Single	1	Hand	Combined 1903	90# 6-B-1 108# 6-C-1
50	20,000	Built-up	1-50 to 1-25 1-50 to 1-25	2,600	1,250	C E-D-F	M1898 M1903	Disappearing	64,800 97,500	−5° to +15°	170°	36″ 40″	Hydraulic (grooves)	2	Counterweight	2	Tapered dash-pot.	3″ Tel. 1904	Lever-pull	Single Cone	1	Hand	Combined 1903	90# 6-D-1 108# 6-C-1
50	21,100	Built-up	Uniform 1-25	2,600	1,250	F E-F-H-I	M1905 1905MI 1905MII	Disappearing	113,100	−5° to +15°	170°	40″ 47″	Hydraulic (grooves)	1 (on ctr. wt.)	Counterweight	1	Dashpot	3″ Tel. 1904	Lever-pull	Cone	1	Hand	Combined 1903	90# 6-D-1 108# 6-C-1
45	12,300	Wire-wound.	1-50 to 1-25	2,600	1,000	H	M1910	Casemate Barbette	57,607	−3° to +12°	120° 360°	15″	Hydraulic (grooves)	1	Spring	2	Tapered dash-pot.	3″ Tel. 1904	Lever-pull	Single	1	Hand	Combined 1903	90# 6-B-1 108# 6-C-1
37	8,795	Built-up	Uniform 1-30	2,410	3,000	K	M1917 M1918	Mobile	11,065	0° to 35°	60°	Variable, 71″ max.; 43″ min.	Hydropneumatic	1	Hydropneumatic	2	Dashpot	Quadrant M1918	Lever-pull	Single	1	Hand	French percussion (same as 240-mm).	155-B-3 155-C-2
21.1	10,700	Built-up	1-40 to 1-20	1,700	3,000	L	M1918	Mobile platform (4 loads).	41,300	−1° to 60°	Mobile 20° Fixed 360°	45″	Hydropneumatic	2	Pneumatic	1	Dashpot	Quad. sight M1918	Lever-pull	Single	1	Hand	Percussion 21-gr. (same as 155).	240-B-2
32	33,200	Built-up	1-50 to 1-25	2,600 1,950	900	M	M1918	Railway	174,000	0° to 42°	360°	48″	Hydraulic (grooves)	2	Spring	4	Tapered dash-pot.	Pan. Type C	1888 Rotating tray	Step	2	Hand	Combined 1903	8-A-2 8-D-1 8-E-1 8-G-1
34	67,200	Built-up	1-50 to 1-25	2,250	500	N N	1893 1919	Barbette Sldg. Ry.	144,600 387,200	−7° to +15° +10° to +54°	320°	50″	Hydraulic (bars)	2	Gravity	2	Dashpot	Tel. 1898 Pan. Type K.	1888 Rotating tray	Single	2	Hand	Combined 1903	10-A-1 10-B-1
35	66,700	Built-up	1-50 to 1-25	2,250	500	N P	1894MI 1896LF	Disappearing	270,000	−5° to +12° −5° to +12°	140°	54″	Hydraulic (bars)	2	Counterweight	2	Dashpot		Stockett 95	Single	1	Hand	Combined 1903	10-A-1 10-B-1
40	76,500	Built-up	1-50 to 1-25	2,250	700	P R	1896ARF 1901LF	Disappearing	268,000 398,000	−5° to +12° −5° to +12°	360° 170°	67″	Hydraulic	2	Counterweight	2	Dashpot	Tel. 1898 3″ Tel. 1904	Stockett 95	Single	1	Hand	Combined 1903	10-A-1 10-B-1
34	116,200	Built-up	1-50 to 1-25	2,235	350	V W	M1897 M1901	Disappearing	487,000 542,000	−5° to +10°	Limited by emplcmnt.	67″	Hydraulic (bars)	2	Counterweight	2	Tapered dash-pot.	3″ Tel. 1904	Stockett 1895	Single	1	Hand	Combined 1903	12-E-2 12-F-3 12-K-1 12-L-4 12-N-1
35 40	114,700 131,400	Built-up Built-up	1-50 to 1-25	2,600 2,250	350 400	T V	M1892 M1917	Barbette	229,000 302,000	−7° to +15° 0° to +35°	360°	48″ 30″	Hydraulic (bars) (Grooves)	2 1	Gravity Spring	0 4	Dashpot Plug	Tel. 1910 3″ Tel. 1904	1888 Rotating tray	Single	2	Hand	Combined 1903	12-E-2 12-F-3 12-K-1 12-L-4 12-N-1
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10	29,000	Built-up	1-40 to 1-20	1,500	1,500	I I	1918 1896MI, MII	Railway Fixed	176,000 128,000	−5° to +65° 0° to 70°	360° 360°	30″ 23″	Hydraulic (grooves) Hydraulic (grooves)	2 2	Pneumatic Spring	1 5	Plug Dashpot	Mounting type D	Stockett 1908 Rotating tray 1890	Single	1 2	Hand	Combined 1903	12-I-1 12-G-1 12-A-3*
10 15	18,200 33,300	Wire Wire	1-20 1-40 to 1-20	1,500 1,800	1,500 1,000	II III	1908 1896MI, MIII	Fixed	126,000 132,000	0° to 65° 0° to +70°	360° 360°	24″ 23″	Hydraulic (grooves)	2 2	Spring Spring	3 5	Plug Dashpot	1908	Stockett 1908	Single	1	Hand	Combined 1903	12-G-1 12-A-3*
34	110,600 118,800	Wire	1-25	2,150	300	IV	1907 1907MI	Disappearing	619,100 636,000	−5° to +20°	Various 120°-220°	73″	Vertical hydraulic (grooves).	1	Weight	None	Dashpot	3″ Tel. 1914	1909 Stockett	Step	1	Hand	Combined 1903	14-C-1 14-D-1 14-I-1
40	137,700	Wire	1-50 to 1-25	2,370	250	V	1909	Turret	2,316,000	0° to 15°	360°	48″	Hydraulic (grooves)	1	Spring	4	Plug	3″ Tel	1907 Stockett	Step	1	Hand	Combined 1903	14-A-2 14-B-2 14-H-1
40	138,000	Wire	1-50 to 1-25	2,350	250	VI	1907 1907MI	Disappearing	682,000	−5° to +20°	120°-280°	73″	Vertical hydraulic (grooves).	1	Weight	None	Dashpot	3″ Tel. 1912	1907 Stockett	Step	1	Hand	Combined 1903	14-A-2 14-B-2 14-H-1
40	138,000	Wire	1-50 to 1-25	2,350	250	VII	E	Railway	437,000	0° to 30°	360°	60″	Hydraulic (grooves)	1	Spring	6	Dashpot	------	1907 Stockett	Step	1	Hand	Combined 1903	14-A-2 14-B-2 14-H-1
50	192,500 233,800	Wire	1-32	3,000	200	VIII	M1920	Railway	681,300	−7° to +50°	Top carriage 7° Car body 360°	35″	Hydraulic	4	Pneumatic	1	Plug	3″ Tel. 1920	Drop MII	Step	1	Air	Firing lock Mk. 2 (percussion electric).	14-E-2 14-E-3 14-M-1
25	195,300	Built-up	Uniform 1-25	1,950	800	IX	1920	Barbette	705,000	−7° to +65°	360°	38.5″	Hydraulic	4	Pneumatic	1	Plug	Mount 1920	Drop	Step	1	Air	Firing lock Mk. 1 (percussion electric).	16-A-1 (C2)
50	385,600	Wire	1-30	2,700	175	X	1919	Barbette	1,000,000	−7° to +65°	360°	40″	Hydraulic (grooves)	4	Pneumatic	2	Valve	3″ Tel. 1918	Drop	Step	1	Air	Firing lock Mk. 1	16-C-1 (2,340 £)
50 35	340,600 284,000	Wire Built-up	1-30 1-50 to 1-25	2,750 2,190	175 200	XI XII	1917 1912	Disappearing Disappearing	1,670,000 1,274,000	−5° to +30° −5° to +20°	360° 170°	89″ 80″	Hydraulic (bars) Hydraulic (bars)	2 2	Counterweight Counterweight	None None	Plug Plug	3″ Perios 1917 3″ Tel. 1912	Side Side	Step Single	1 1	Hand Hand	Combined 1903 Combined 1903	------ 16-C-1 (2,340 £)
50	------	Built-up	1-32	2,750	175	XIII	1919MI	Barbette	1,000,000	−7° to +65°	360°	40″	Hydraulic (grooves)	4	Pneumatic	2	Valve	3″ Tel. 1918	Drop	Step	1	Air	Firing lock Mk. 1	16-B-1