FM 4–126

WAR DEPARTMENT

COAST ARTILLERY FIELD MANUAL

ANTIAIRCRAFT ARTILLERY

SERVICE OF THE PIECE

90-MM ANTIAIRCRAFT GUN

October 2, 1942

Vaughan E. Fargo

FM 4-126

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SECTION I

GENERAL

■ 1. SCOPE.—*a.* This manual prescribes a systematic procedure to be followed by gun crews manning 90-mm antiaircraft guns M1 on M1A1 mounts.

b. The matter contained in this manual is intended only as a guide in the assignment of individuals and duties; changes may be made to meet variations in the matériel manned.

■ 2. REFERENCES.—References are listed in the appendix; they are suggested for further study of matériel covered in the manual and allied topics.

SECTION II

ORGANIZATION OF GUN SECTION

■ 3. GUN SECTION.—The gun section is a part of the firing section which consists of four gun sections, a range-detector section, and a machine-gun and executive officer's detail. Two artillery mechanics are assigned to the firing section and are part of the machine-gun and executive officer's detail for purposes of supervision and formation. Each antiaircraft gun is manned by a gun section consisting of a gun squad and an ammunition squad. The gun commander, who is included in the gun squad, serves as chief of section.

■ 4. GUN SQUAD.—The gun squad (10 enlisted men) consists of the gun commander (a sergeant), the gunner (a corporal), the fuze range setter (a technician, fifth grade), one assistant gunner, and six cannoneers. The gun commander and gunner are designated GC and G respectively. Others are numbered 1 to 8, inclusive. Nos. 1, 6, and 8 are ammunition

relayers; No. 2 is the elevation setter; No. 3, the fuze setter operator; No. 4, the loader; No. 5, the fuze range setter; and No. 7, the azimuth setter. The gun squad includes the number of men required to man the 90-mm antiaircraft gun (mobile or fixed) with or without the remote control system or power rammer.

■ 5. AMMUNITION SQUAD.—*a. Mobile units.*—In mobile units the ammunition squad consists of the chief of ammunition (a corporal), four ammunition privates, and one chauffeur. Two basics, assigned to the gun section, work with the squad when their services are not needed elsewhere. The four ammunition men are numbered 9 to 12. The chauffeur is numbered 13.

b. Semimobile units.—In semimobile units the ammunition squad consists of the chief of ammunition (a corporal) and four ammunition privates. The two basics assigned to the

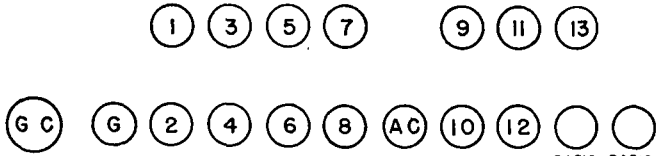


FIGURE 1.—Formation of a mobile 90-mm antiaircraft gun section.

NOTE.—In semimobile units No. 13 (the chauffeur) is eliminated.

gun section work with the squad when their services are not needed elsewhere. Numbering is the same as that in the mobile squad.

■ 6. FORMATION OF GUN SECTION.—The battery is formed as prescribed in FM 4–120. The gun section assembles in two ranks with 4 inches between files and 40 inches between ranks. After forming the section, the gun commander takes post in the front rank 1 pace to the right of his section.

SECTION III

DUTIES OF PERSONNEL

■ 7. BATTERY EXECUTIVE.—*a.* The battery executive commands the firing section and is in general charge of all gun

emplacements. He is responsible to the battery commander for—

(1) Training and efficiency of personnel of the firing section.

(2) Condition of matériel and ammunition under his charge.

(3) Police of the emplacements.

(4) Emplacement and removal of the guns from firing position.

(5) Observance of all safety precautions pertaining to service of the piece.

b. He inspects all matériel and ammunition under his charge. He personally verifies adjustment of all pointing devices as frequently as necessary to insure accuracy. He tests all firing devices before each firing, paying special attention to safety features.

c. At the command PREPARE FOR ACTION, given while the guns are on the road in march order, the battery executive designates the individual positions to be occupied by the guns and supervises the movements into position and the preparation for immediate action.

d. He verifies filling of recoil cylinders and adjustment of recuperator systems, sees that there is no obstruction to the operation of the carriage in recoil or counterrecoil, and so far as possible verifies adjustment of all parts that move in recoil or are affected by it.

e. He is responsible for orienting the guns.

f. He assists the range officer in synchronizing the data transmission system.

g. He receives reports of the assistant battery executive or gun commanders and reports to the battery commander, "Sir, firing section in order," or reports any defects he is unable to remedy without delay.

h. After the firing section has been reported in order, if any circumstances arise which, in his opinion, make it unsafe to fire, he commands: STAND FAST, and reports his action to the battery commander.

i. He is responsible that fire is commenced immediately when ordered by the battery commander, safety precautions permitting.

j. At the conclusion of the drill or firing he commands:

REPLACE EQUIPMENT, inspects the gun positions, and reports to the battery commander.

k. He conducts fire by emergency methods when necessary.

l. Being in position, at the command MARCH ORDER, the battery executive indicates the point of assembly for the guns on the road and supervises the operation.

■ 8. ASSISTANT BATTERY EXECUTIVE.—*a.* The assistant battery executive commands the machine-gun detail, and supervises handling of all ammunition for the battery. He is responsible to the battery executive for—

(1) Training and efficiency of personnel of the machine-gun detail.

(2) Condition of matériel and ammunition under his charge.

(3) Observance of all safety precautions pertaining to service of the piece for machine guns.

(4) Police of the machine-gun positions.

(5) Emplacement and removal from position of machine guns.

b. He is responsible for seeing that the record of ammunition expended is entered accurately in all gun books.

c. He assists the battery executive in the performance of his duties.

■ 9. GUN COMMANDER.—*a.* The gun commander (a sergeant) is in charge of the gun section and is also chief of the gun squad. He is responsible to the battery executive for—

(1) Training and efficiency of personnel of his section.

(2) Condition, care, and preparation for action of all matériel and ammunition under his charge.

(3) Observance of all safety precautions pertaining to service of the piece.

(4) Police of his gun position.

(5) Record of the number of rounds fired from his gun.

(6) Care and correct return of empty ammunition cases to the proper agency.

(7) Enforcement of camouflage and gas discipline.

b. At the command PREPARE FOR ACTION, given while the gun is on the road in march order, he directs the maneuver of the gun into its designated position and the uncoupling of the gun from the truck, and supervises the preparation

of the position. After the gun is emplaced, ready for firing, or the section arrives at the gun position, he commands:

1. DETAILS. 2. POSTS, and supervises the procurement of equipment. After all details have reached their posts, he commands: EXAMINE GUN. He then personally makes an inspection of the gun, carriage, and other matériel, assuring himself that the gun is properly emplaced for firing, that the data transmission system is properly adjusted, that the recoil cylinder is properly filled, and that all moving parts are lubricated. In addition, he makes sure that the oil reserve in rear of the floating piston and the gas pressure in the recuperator are sufficient and that the equilibrator is in proper adjustment. He then commands: REPORT, receives the reports of the members of the gun section as called for in the drill table (sec. XI), and reports to the battery executive, "Sir, No. ——— in order," or reports any defects he is unable to remedy without delay.

c. He supervises the service of the piece and the service of ammunition and personally directs the work of care and preservation of all matériel. He takes his post at any point from which he may conveniently supervise the work of the section.

d. When necessary to verify the section, he commands: COUNT OFF. The cannoneers of the section call off their numbers in succession.

e. At the command TARGET, he repeats the command and target designation and sees that all personnel take post on the run if not already at their posts. When data are being received and set on the gun he verifies roughly the pointing of the gun by sighting along the gun barrel; when the gun is ready for firing he reports or signals, "No. ——— ready," to the battery executive.

f. At the command COMMENCE FIRING, he commands: LOAD, for the first round only, succeeding rounds being fired without further command, and supervises the work of the section. If a limited number of rounds has been prescribed, he cautions the loader, "(So many) rounds only," and commands or signals: SUSPEND FIRING, when that number of rounds has been fired. He then reports to the battery executive, "Sir, No. ——— (so many) rounds fired."

g. At the command SUSPEND FIRING, he repeats the com-

mand, sees that the details remain posted, and that the gun continues to follow the target. He directs the clearing away of empty shell cases and preparation of matériel for further firing.

h. At the command CEASE FIRING, he repeats the command and proceeds as at SUSPEND FIRING, except that the following of the target is discontinued.

i. At the command REST, he repeats the command and allows the members of the section to leave their posts but not the immediate vicinity of the gun.

j. At the command REPLACE EQUIPMENT, he supervises replacing of equipment, sees that the emplacement is policed, and forms his section.

k. In case of misfire he commands: STAND FAST, and sees that the precautions prescribed in paragraph 19 are observed.

l. At the command MARCH ORDER, for mobile guns he supervises withdrawal of the gun from position and placing of the piece on the road at the designated point.

■ 10. CHIEF OF AMMUNITION.—*a.* The chief of ammunition (a corporal) is in charge of the ammunition squad. He is responsible to the gun commander for—

(1) Training and efficiency of the personnel under his charge.

(2) Proper care of ammunition pertaining to the gun.

(3) Observance of all safety precautions in the storage, care, and service of the ammunition.

(4) Correct recording of required ammunition data.

(5) Cleaning and disposition of empty cartridge cases.

(6) Uninterrupted service of ammunition to the gun position during the course of action.

(7) Enforcement of camouflage and gas discipline at ammunition shelters.

b. At the command PREPARE FOR ACTION, he supervises the ammunition squad in the unloading and preparation of ammunition for service and in other duties connected with the preparation of the emplacement as may be directed by the gun commander.

c. At the command 1. DETAILS, 2. POSTS, he posts the members of the ammunition squad and assigns them duties to facilitate ammunition handling.

d. At the command EXAMINE GUN, he inspects the ammunition for possible defects (especially the fuzes for missing lugs, corrosion, and injury), gives the necessary instructions for preparing and arranging the ammunition for firing, and reports to the gun commander, "Ammunition service in order," or reports defects he is unable to remedy without delay.

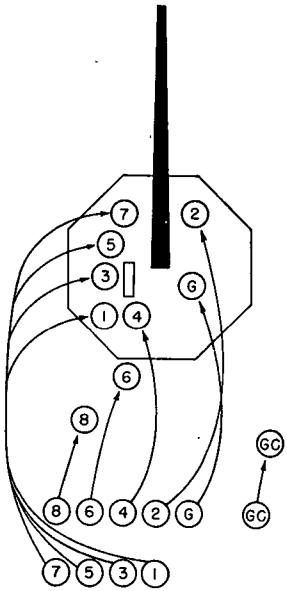


FIGURE 2.—Positions of personnel of gun squad at the command 1. DETAILS, 2. POSTS.

e. During practice or action he supervises the ammunition squad in replenishing the ammunition supply at the gun position, in disposing of empty cases, and in the handling and storing of any additional supply received. He should be prepared at all times to furnish replacements for the gun squad when members of that squad become casualties.

f. He is prepared to furnish information as to powder temperature when called upon by the battery officers to do so.

g. At the command REPLACE EQUIPMENT, he directs the ammunition squad in the securing and covering of all ammunition pertaining to the gun, makes certain that all fuzes which have been cut but not fired have been set back to positions of "safe," helps in the police of the equipment, and forms his squad unless otherwise directed.

h. At the command MARCH ORDER, he supervises the ammunition squad in their normal duties in connection with packing and loading ammunition and in such other duties as may be ordered by the gun commander.

■ 11. ARTILLERY MECHANICS.—The chief artillery mechanic is the custodian of the supplies pertaining to the emplacements to which assigned. He is responsible to the battery executive for the condition and serviceability of the supplies and tools under his charge. He maintains an up-to-date inventory of all tools, equipment, spare parts, and supplies under his charge. He or his assistant issues such equipment, tools, oils, paints, and cleaning materials to the members of the gun sections as may be necessary for the service and care of the guns and accessories. The artillery mechanics, assisted by members of the gun sections, make such minor repairs as can be made with the means at hand.

SECTION IV

NOTES ON SERVICE OF THE PIECE

■ 12. GENERAL.—The service of the piece should be conducted with dispatch and precision and with as few orders as possible. Except for the necessary orders, reports, and instructions, no talking should be permitted. Cannoneers change positions at a run. Loading with dummy ammunition and pointing the piece as for firing is the normal practice at drills. The commands or signals ELEVATE, DEPRESS, RIGHT, and LEFT refer to the direction of motion of the muzzle of the gun. Commands should be given in the prescribed form but should be replaced by signals whenever practicable.

■ 13. OPERATION OF BREECH MECHANISMS.—*a.* The breech mechanisms on all guns discussed herein are semiautomatic. The breech is automatically opened during counterrecoil by the action of the operating crank which strikes against the

operating cam. However, it does not close until the extractors have been tripped; the insertion of a cartridge trips the extractors.

Caution: The extractors should never be tripped with the fingers. If the breech is to be closed without the insertion of a cartridge, the base of a dummy round should be used to trip the extractors.

b. The breech mechanism may be set for hand operation by rotating the breech operating cam lever forward and down to the position marked "Hand." With the breech operating cam lever in this position, the breech operating cam will not come in contact with the breech operating crank during counterrecoil. The breech may be opened by hand by using the breech mechanism operating handle. With the gun in battery, movement of this lever to the rear and down will open the breech. *The breech mechanism operating lever should be returned to its position as soon as the breechblock has been locked open by the extractors.*

■ 14. METHOD OF RAMMING CARTRIDGE.—*a.* On guns not equipped with power rammers, the gunner rams the cartridge into the gun with his left clenched hand. The cartridge is rammed with the side of the gloved fist, wrist vertical, against the base of the cartridge; pressure is applied through the back of the thumb and the side of the index finger. In this way, continuous pressure is applied until the cartridge has been rammed home completely. Furthermore, the hand cannot be caught in the breech, since the rising breechblock knocks it clear.

b. On guns equipped with power rammers, the loader lays the cartridge into the breech recess and moves it into the chamber far enough to allow the gunner to rotate the ramming arm into position behind the cartridge. When the gunner has positioned the rammer arm, the loader trips the rammer with his left hand.

■ 15. METHOD OF HANDLING AMMUNITION AND FUZE SETTER M13.—*a.* The first ammunition relayer takes a round from the stack near the piece or from a member of the ammunition squad, left hand grasping the projectile, right hand near the base. He turns to the left and passes the round to the next ammunition relayer. The second ammunition relayer takes

the round in his upturned palms, turns to the right, and passes it to the ammunition relayer stationed on the mount platform slightly to the rear and left of the fuze setter guide. The ammunition relayer on the mount platform receives the round with his left hand grasping it, and the right hand cupped over the base. He turns to his left, and starts the round into the fuze setter, withdrawing his left hand while pushing the round home with his right. When the round is firmly seated in the fuze setter, he hits the trip lever with his left hand and continues to press against the base of the cartridge with his right until the fuze setter operator has completed one turn of the crank and has called "Cut." He then straightens up, steps back, and repeats the operation upon receiving the next round. After the fuze setter operator calls "Cut," the loader withdraws the round from the fuze setter. He grasps it in his upturned palms, pivots on his right foot, steps forward with his left, and places the round in loading position. As soon as the gunner starts to ram the cartridge, the loader pivots on his right foot, steps back with his left, and stands ready to remove the next round from the fuze setter.

b. An alternate method is for the last two ammunition relayers and the loader to act as a unit; that is, each one in turn performs the duties of all three. Each receives a round, in turn, from the first ammunition relayer, steps onto the platform, inserts the round in the fuze setter, trips the lever; and, when "Cut" has been called, removes the round from the fuze setter and places it in position for the gunner as described in *a* above. As soon as the gunner starts to ram the cartridge, he quickly pivots to his left on his right foot, leaves the platform, and gets another round to start his part in the cycle all over again.

c. The fuze setter operator, standing on the platform alongside the seated fuze range setter, maintains a downward pressure on the handle of the fuze setter crank. When the round is seated in the fuze setter and the setting release has been tripped, the fuze setter operator turns the crank one complete turn counterclockwise until the crank relocks. He calls "Cut." The fuze range setter, seated, keeps pointers matched.

d. The following points are of particular importance in the foregoing procedures:

(1) When the round is in the fuze setter, pressure should be maintained against the base of the cartridge case until the call "Cut" is heard. The use of a heavy glove on the right hand of the ammunition handler who maintains such pressure will greatly reduce the friction against his hand produced by the rotating case.

(2) The release lever on the fuze setter should be tripped with a glancing slap at the release lever so that it will instantly recover and rearm itself before a full revolution of the crank has been completed.

(3) Sufficient downward pressure must be maintained on the crank of the fuze setter so that the rotation will start the instant the release is tripped. Otherwise the release lever would have to be held down and the release would probably fail to rearm when the crank had completed its one revolution.

■ 16. SERVICE OF DRILL AMMUNITION.—When using drill ammunition, the procedure is the same as outlined in paragraph 15, except as follows:

a. (1) A cannoneer takes post to the right of the piece opposite the operating handle and facing the rear. He opens the breech for each round after the firing lever has been tripped and immediately raises the operating handle until it rests against the latch.

(2) Two additional cannoneers are necessary. When the firing of a round has been simulated, the cannoneer next to the operating handle opens the breech immediately. As the round is ejected, it is caught by a cannoneer standing on the ground directly behind the breech. The round is caught with the left hand against the base, and the right hand underneath the case. He clears the breech immediately for the insertion of another round and places the ejected dummy round on the ammunition rack.

b. An alternate method is as follows: a cannoneer takes position on the ground behind and slightly to the right of the breech in such a way that he can catch each round as it is ejected and pass it to another cannoneer. The round is relayed from one cannoneer to another until it reaches the ammunition rack. The gunner operates the operating handle to open the breech after each round has been placed in

the breech and the breechblock returned to firing position. In this method the firing lever is not tripped.

SECTION V

SAFETY PRECAUTIONS

■ 17. GENERAL.—*a.* Safety precautions to be observed in time of peace are prescribed in FM 4–120.

b. The more important safety precautions pertaining to the gun section are described in this section.

c. The precautions referred to in *a* and *b* above should be applied under war conditions where circumstances permit.

■ 18. AMMUNITION.—*a.* All ammunition at the firing point must be so placed that it will be protected against explosion in case of an accident at the gun position. It should be in a dry place and protected from the direct rays of the sun by a tarpaulin or other covering. Erratic shots and dangerously high powder pressures may result from overheated ammunition.

b. Any alteration of loaded ammunition, except in accordance with specific instructions from the chief of the supply service concerned, is hazardous and is therefore prohibited. Specifically, the alteration of time fuzes assembled to ammunition is forbidden.

■ 19. MISFIRES.—*a.* A misfire is said to occur when the piece fails to discharge when an attempt to fire it has been made.

b. In case of a misfire, at least three attempts to fire the primer will be made. The breechblock will not be opened until at least 2 minutes after the last attempt to fire the piece, and the gun will be kept pointed in a safe location in the field of fire.

■ 20. FUZES.—If a round is not fired after the fuze has been set, the fuze must be set back to "safe." The fuze setter is adjusted to read "safe," and the fuze is then reset. The reading on the fuze must then be checked to make sure that it is at "safe."

■ 21. UNLOADING LIVE ROUNDS.—If a round cannot be extracted in the normal manner, it should be fired, safety precautions permitting. If this is impossible, it should be removed under the direct supervision of an officer, a rammer

being used which bears only on the projectile and provides for clearance around the fuze. (See TM 9–370.)

■ 22. DRILL AND FIRING.—*a.* No live ammunition will be allowed near the emplacements except when firing is to take place.

b. The gun will be unloaded except when firing or about to fire.

c. Members of the gun section will be trained always to pass in rear of the gun and well clear of the breech in going from one side to the other.

d. The gunner will keep clear of the firing lever until the piece has been loaded and is ready to be fired. Extra care must be taken to prevent accidental contact with the firing lever during the loading operation. *In addition, the gunner makes sure that he does not fire the piece until he has pivoted on his right foot away from the rear and to the side of the gun.*

SECTION VI

MAINTENANCE OF MATÉRIEL

■ 23. GENERAL.—The proper maintenance of matériel is the direct responsibility of battery personnel. The gun and mount should be thoroughly cleaned and lubricated at intervals as shown on the lubrication check-charts (figs. 18 and 19). Care should be taken to keep all parts free from rust, since malfunctioning often begins with rust. All bearing surfaces, elevating racks and screws, and unpainted parts must be kept clean at all times.

■ 24. PRECAUTIONS.—*a.* Disconnecting the gun from the recoil mechanism will not be attempted by the using personnel.

b. Replace and open cotter pins after replacing nuts.

c. Do not strike any metal parts directly with a hammer; interpose a buffer of wood or copper.

d. Oilholes which have become clogged with oil should be opened with a piece of wire. Wood should never be used for this purpose, as splinters are likely to break off in the hole.

e. As an aid to ready identification, grease and oil fittings are painted red. Oilholes have a red ring painted around them.

f. In case the gun and carriage are to be stored or left unused for any considerable length of time, all bright and unpainted surfaces should be thoroughly cleaned with dry-cleaning solvent so as to be free from rust, water, and lubricating oil, and coated with rust-preventive compound. Dry-cleaning solvent is used in preference to kerosene for cleaning the matériel as it is difficult to remove all traces of kerosene, the presence of which tends to cause the formation of rust underneath the rust-preventive compound.

■ 25 DAILY INSPECTION.—As part of the routine maintenance, a daily inspection of the gun is conducted by the gun section as follows: the gun commander commands: 1. DETAILS, 2. POSTS. The men take their posts. The next command is: 1. EXAMINE, 2. GUN. Each man has a specific job to perform. If circumstances necessitate the absence of some men, others may be assigned to their jobs at the discretion of the gun commander. The gunner, assisted by No. 1, examines, cleans, and oils the breechblock and reach mechanism. He opens and closes the breech to see that it operates freely. The firing mechanism must be inspected. It should work freely and the firing pin should be in serviceable condition. The gunner examines the chamber and bore. Nos. 1, 6, and 8 assist the gunner in sponging and cleaning the chamber and bore. The fuze range setter (No. 5), assisted by No. 3, examines, cleans and oils the fuze setter and the fuze range indicator. No. 3 makes sure that the proper rings are installed in the fuze setter. (Two sets of rings are provided, one for the 30-second mechanical fuze and one for use with dummy cartridges.) Aided by No. 4, the fuze range setter and No. 3 check the setter as follows: the fuze range setter sets a definite value, for example, 12, indicated by the mechanical pointer of the fuze range indicator. No. 3 directs No. 4 to insert a round and the fuze is cut. The reading of the fuze is then checked against the reading indicated by the mechanical pointer on the fuze range indicator. This is repeated with several readings. If a discrepancy is noted, the fuze range indicator must be adjusted. The azimuth setter (No. 7) examines the azimuth indicator and its connections, as well as the traversing mechanism. He traverses the gun a complete 6,400 mils to the left and to the right to see that the

mechanism operates easily. The elevation setter (No. 2) checks the elevation indicator and connections, and elevates the gun to its maximum elevation. He then depresses it, ascertaining that it moves easily and without lost motion. No. 4, assisted by Nos. 1 and 8, inspects the ammunition and arranges it near the gun. No. 9 examines the emplacement. He removes any obstruction and covers any soft spots in the ground that might interfere with the smooth functioning of the ammunition relayers. No. 3 sets the breech operating cam plunger for automatic or hand operation of the breech as directed by the gun commander. Under the direction of the chief of ammunition, the ammunition detail unloads the ammunition and prepares it for use. Each man having performed his duties of EXAMINE GUN, the gun commander gives the command: REPORT. The gunner reports, "Breech in order." No. 5 reports, "Fuze setter in order." No. 7 reports, "Traversing in order." No. 2 reports, "Elevation in order." No. 4 reports, "Ammunition in order."

■ 26. WEEKLY INSPECTION.—Each week, and more often if the amount of firing warrants, the gun and carriage should be thoroughly inspected by the battery commander. The instructions given for daily inspection by the gun section should be carried out and in addition the following directions should be observed:

a. Examine bore with extreme care to see that erosion has not set in. If there are any signs of erosion, that fact should be reported.

b. Operate all moving parts and see that they work freely and correctly.

c. Examine all nuts to see that they are tight and that split pins are in place where required.

d. Examine data transmission system to see that it is in proper operating condition.

e. Examine condition of paint.

f. Examine all small parts such as keys and hinges to see that they are in serviceable condition.

■ 27. GUN.—*a.* As soon as possible after firing, the bore must be cleaned to remove all powder fouling and then thoroughly oiled. Using the sponge covered with burlap, wash the bore with a solution made by dissolving ½ pound of soda ash or 1

pound sal soda in 1 gallon of water. Boiling water is most satisfactory. Special attention should be given that section of the bore extending from the origin of the rifling to a point about 24 inches forward, as most of the fouling takes place in that area. After cleaning the bore, wipe it thoroughly dry, using the sponge covered with burlap. Then oil the bore with a heavy lubricating oil.

b. The surfaces of the leveling plates sunk into the top of the breech ring should be protected from injury. Tools or other articles must never be laid upon them.

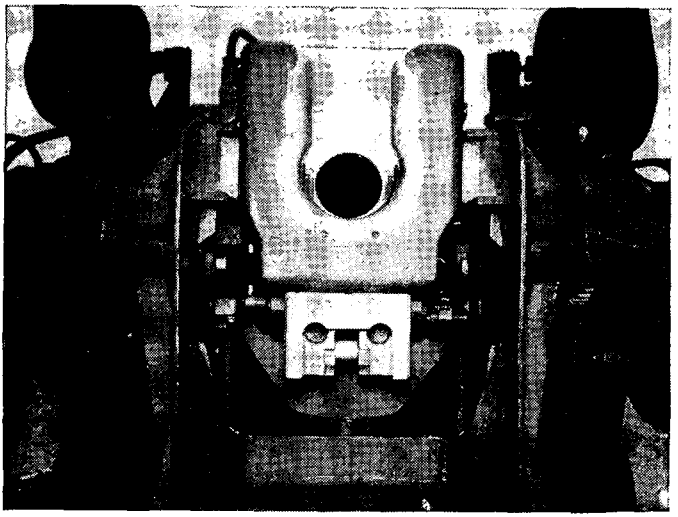


FIGURE 3.—Breech end of gun.

c. When the gun is not in use, the various covers provided for protecting it must be placed in position.

■ 28. BREECH MECHANISM.—*a.* Breech mechanism should be kept clean and the firing mechanism given careful attention. They should be disassembled frequently, and the parts washed with dry-cleaning solvent, wiped dry and lubricated according to chart.

b. It is important that any cutting or abrasions on the bearing surfaces of the breechblock or breech ring be reported to the ordnance maintenance company for correction.

c. If the breechblock does not operate smoothly, or the mechanism requires a greater effort than usual, it will be disassembled and the cause determined.

d. In assembling, do not use a steel hammer directly on any part. A copper plate or drift should be interposed, or a copper hammer used to prevent deforming the part.

■ 29. FIRING MECHANISM.—*a.* The firing mechanism should frequently be disassembled, cleaned, and oiled.

b. The use of an oil that is thicker than authorized will cause the mechanism to absorb the energy of the firing spring and result in misfires. This is especially true in cold weather when unsuitable oil congeals and becomes gummy.

■ 30. RECOIL MECHANISM.—*a.* Under no circumstances will an attempt be made to disassemble the recoil mechanism. Adjustment of the recoil valve may be undertaken only by qualified ordnance personnel.

b. The recoil cylinder and valve passageways should be full of heavy recoil oil, Specification No. 2–96A. In addition to this, two screw fillers full of oil should be forced into the system to move the floating piston away from the rear end of the floating piston cylinder. This is the reserve oil.

c. Every precaution should be taken to prevent the entrance of foreign matter into the recoil mechanism.

d. Recoil oil should never be strained through a cloth as this might result in lint getting into the oil. The receptacles used in handling the oil must be clean and dry. Receptacles that have been used for other oils or materials should not be used for this purpose.

e. The gun commander should constantly verify the complete return of the gun into battery. If the gun does not return to battery, or does so irregularly by jerks or jumps, he should command CEASE FIRING and determine the cause.

■ 31. GUN SLIDES.—The gun slides should be thoroughly cleaned and lubricated as indicated on lubrication chart (fig. 18).

■ 32. MOUNT.—The exposed parts of the elevating rack should be kept clean and covered with a thin coat of oil. Dust and grit will adhere to this oily film; consequently the teeth must frequently be cleaned and fresh oil applied before elevating the gun.

SECTION VII

EMPLACEMENT AND MARCH ORDER

■ 33. GENERAL.—The instructions given in paragraphs 35 and 36 cover the procedure to be followed in changing from traveling position to firing position, and vice versa. Two different sets of instructions for emplacement of the gun are given. The first set presupposes the availability of a prime mover which is used to crush the mount in a minimum of time, and with a minimum of effort on the part of the crew. The second method, used when a prime mover is not available or has been disconnected before it is desired to emplace the gun, is slower but still satisfactory. Only one method of preparing the gun for march order is described, and it does not make use of power supplied by a prime mover.

■ 34. USE OF PERSONNEL.—*a.* The organization of the gun section is covered in section II.

b. In order that the operations may be performed in an efficient manner, all odd-numbered men work on the left side of the gun and the even-numbered men on the right side.

■ 35. EMPLACEMENT OF GUN USING PRIME MOVER.—*a. General.*—Whenever a prime mover is available, it should be used. The prime mover saves time and effort; it does the work of compressing the bogie buffer spring and the work of partially crushing the mount.

b. Procedure.—(1) At the gun commander's command PREPARE FOR ACTION, the gun section dismounts from the truck; the gunner and even numbers from the right side, and the odd numbers from the left side, except No. 3, who walks out on the gun tube. No. 8 tosses out the lifting bar; Nos. 4 and 7 bring out the wheel wrenches; Nos. 1 and 2 bring out the bogie socket wrenches; and Nos. 5 and 6 bring out the bogie ratchet wrenches.

(2) All members of gun squad, except No. 1, assist in untying gun cover, taking it off to the rear and laying it

upon the ground, temporarily unfolded. No. 1 unfastens the break-away chain and pulls the electric cables out of the truck and bogie, and inserts them in the dummy receptacles on the left side of the trail.

(3) Nos. 1 and 2 set the bogie hand brakes and loosen the wing bolts holding the platforms to the trail. The gunner takes his position at the bogie buffer and turns the handwheel so as to retract the plunger a little. No. 3 unfastens the outrigger safety chain. Nos. 5 and 6 remove the canvas covers from the counterpoise cylinders.

(4) Nos. 5, 6, 7, and 8 unlatch, extend, and pin the rear outrigger in its extended position.

(5) All stand clear of the gun except the gunner at the bogie buffer. Directed by the gun commander, the prime mover is driven forward, compressing the spring in the bogie buffer with the axle lug, while the gunner screws down on the bogie buffer plunger retracting handwheel by hand.

(6) When the gun commander judges that the buffer spring has been sufficiently compressed, he orders the prime mover backed up until the gunner can pull out on the latch on the right side of the buffer cylinder and swing the forward end of the buffer cylinder down. (The latch re-engages when the buffer cylinder has moved to lower position.)

(7) The gun commander, after seeing that the bogie buffer cylinder has moved out of the way of the bogie axle lug, orders the prime mover to be driven forward again, partially crushing the gun mount, until the counterpoise cylinder rods have entered into the counterpoise cylinders far enough to allow Nos. 7 and 8 to pull out on the crank handles of the gear boxes, swing the boxes to the front over the ends of the cylinders, and fasten them in place with the swing bolts and wing nuts.

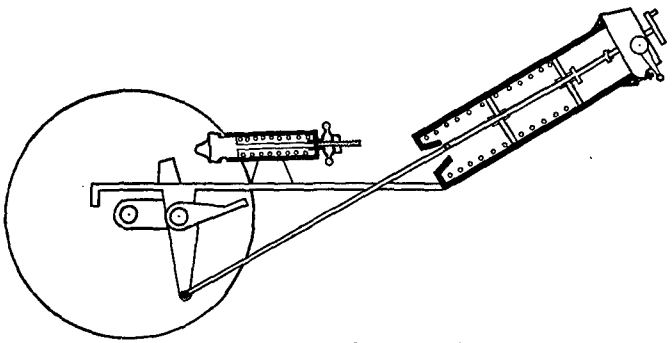
(8) No. 1 inserts lifting bar in the end of the trail. The gunner takes position at and immediately behind the lifting bar, and Nos. 1 and 2 at the lifting bar. The gunner disconnects the gun from the prime mover. (The gunner must not stand between the lifting bar and prime mover, as any sudden movement of the prime mover might crush him.) The gun commander directs the prime mover to move out.

(9) Nos. 1 and 2 press down on the trail, as Nos. 3, 4, 5, 6,

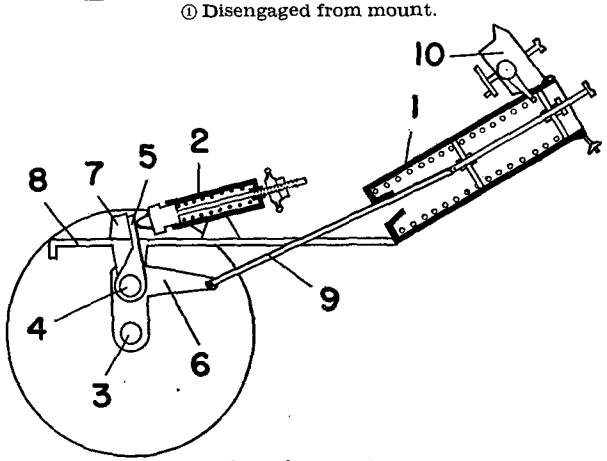
7, and 8 lift the rear outrigger, lowering the trail to the ground.

(10) Nos. 2, 4, 6, and 8 extend and pin the right outrigger, while Nos. 1, 3, 5, and 7 do the same with the left.

(11) Nos. 2, 4, 6, and 8 remove the right platform and lay it aside, while Nos. 1, 3, 5, and 7 do the same with the left.



① Disengaged from mount.



② Traveling position.

1. Counterpoise cylinder.
2. Bogie buffer.
3. Wheel axle.
4. Bogie axle.
5. Axle lug.
6. Axle crank.
7. Bumper.
8. Bogie frame.
9. Connecting rod.
10. Counterpoise gear box.

FIGURE 4.—Bogie mechanism—schematic.

(12) The gunner unfastens the transom cap. No. 5 removes the equilibrator piston stop from the equilibrator and puts it in its holder on top of the equilibrator. No. 2 takes position at the elevation handwheel.

(13) No. 2 elevates the gun slightly to clear the traveling lock. The gunner and No. 1 unpin the traveling lock brace and lower the traveling lock, pinning it to the trail.

(14) The gunner and Nos. 1, 3, 4, 5, and 6 at the trail and Nos. 7 and 8 at the rear outrigger tip the mount gently back on the rear outrigger as No. 2 elevates the gun to maximum.

(15) Nos. 1 and 2 loosen the lock nuts only on the bogie engaging eyebolts and place the socket wrenches on the bogie securing bolts preparatory to loosening them. Nos. 7 and 8, assisted by Nos. 3 and 4, crank "bogie down" until the pedestal rests firmly on the ground and the wheels can be turned. Nos. 5 and 6 place the fuze setter bracket and seat in firing position and place the fuze setter in its bracket.

(16) Nos. 1 and 2 disengage the bogie securing bolts.

(17) Nos. 1 through 8 take position at the trail. The gunner disengages the trail lock rocker arm swing bolt preparatory to lowering the trail.

(18) With Nos. 1 through 8 holding up on the trail to support its weight, the gunner allows the trail lock to swing up to its maximum angle, and then, as Nos. 1 through 8 move the trail down to its lower position, he moves the trail lock down and refastens it by means of the swing bolt.

(19) Nos. 1 and 2 loosen both nuts on each bogie engaging eyebolt while Nos. 3 and 4 push in on bogie engaging eye operating handles.

(20) Nos. 7 and 8 crank "bogie up" until there is enough clearance for the bogie to be rolled out. Nos. 3 and 4 put the bogie hub wrenches on the wheels.

(21) The gunner and Nos. 3, 4, 5, 6, 7, and 8 roll the bogie out as Nos. 1 and 2 ride the bogie, holding up on the eyebolts until they clear the pedestal, then dropping them and manipulating the brakes as directed by the gun commander to guide the bogie. *The gun commander is responsible for checking the clearance between the top of bogie frame and the bottom of the equilibrator cylinder.*

(22) The gunner loosens the auxiliary leveling screw at the front of the mount, using the ½-inch rod, and keeps it

free from binding as the mount is leveled by Nos. 7 and 8 at the left and right leveling jacks, respectively. A leveling vial is mounted on each jack. As soon as the mount has been leveled, the gunner tightens the auxiliary leveling screw by screwing it down. The gun commander verifies the level of the gun. When the level has been verified, Nos. 7 and 8 tighten the jack clamps and place the jack ratchets in the neutral position. No. 7 places his jack handle as close to the rear outrigger as possible in order to prevent breakage of the handle by the platform reinforcing angle.

(23) Nos. 1, 3, 5, and 7 put the left platform in place on the outriggers and fasten it; Nos. 2, 4, 6, and 8 do the same with the right. Platform braces are lowered and adjusted by the nearest member of the gun squad.

(24) Nos. 5 and 6 replace the canvas covers on the counterpoise cylinders. Nos. 2 and 7 lower their seats to the using position. No. 7 connects the cable to the cable receptacle on the left side of the pedestal. The rest of the gun squad fold the canvas cover and place it on the bogie buffer cylinder.

(25) All men assist in placing dirt under those parts of the outriggers which do not touch the ground.

■ 36. EMPLACEMENT WITHOUT USE OF PRIME MOVER.—*a. General.*—Since a prime mover will be used whenever one is available, it is assumed that the gun has already been uncoupled from its prime mover and the rear outrigger is extended and broken at the outer joint.

b. Procedure.—(1) All members of the gun squad, except Nos. 5 and 6, assist in removing the gun cover. Nos. 5 and 6 remove the canvas covers from the counterpoise cylinders. No. 5 removes the equilibrator piston stop from the equilibrator and inserts it in the holder on top of the equilibrator cylinder.

(2) Nos. 1 and 2 check to make certain that the hand brakes are set.

(3) Nos. 2, 4, 6, and 8, at the right, and Nos. 1, 3, 5, and 7, at the left, extend and pin the side outriggers.

(4) Nos. 2, 4, 6, and 8, at the right, and Nos. 1, 3, 5, and 7, at the left, remove the platforms and lay them aside.

(5) The gunner unfastens the transom cap. No. 2 elevates the gun slightly to clear the traveling lock. The gunner,

assisted by No. 1, unpins the traveling lock brace and lowers the traveling lock, pinning it to trail.

(6) Nos. 5, 6, 7, and 8 extend and pin the rear outrigger. The gunner retracts the bogie buffer plunger, using the socket wrench.

(7) With Nos. 1, 3, and 4 at the trail and Nos. 5, 6, 7, and 8 at the rear outrigger, the gun is tipped gently back on the rear outrigger.

Caution: The gun must be prevented from tipping back until the outrigger has been extended.

(8) The gunner pulls out on the latch on the right side of the bogie buffer cylinder and swings the forward end of the buffer cylinder down. (The latch reengages when the cylinder has moved to the lower position.)

(9) With the gunner and Nos. 3 and 4 at the trail and Nos. 5, 6, 7, and 8 at the rear outrigger, the mount is balanced so that all outriggers are parallel to the ground. Nos. 1 and 2 take position at the hand brakes.

(10) At the command of the gun commander, Nos. 1 and 2 release the hand brakes, and the rest of the men apply downward pressure to the mount, partially crushing it. (If the mount does not crush sufficiently, place the rear outrigger on the ground, and apply strong downward pressure to the trail; Nos. 1 and 2 can assist by exerting pressure on the fenders so as to rotate them forward and down.)

(11) As soon as the mount has been crushed enough to retract the counterpoise cylinder rods far enough, Nos. 7 and 8 pull out on the crank handles of the gear boxes and swing the gear boxes to the front over the ends of the cylinders, fastening them in place with the swing bolts and wing nuts. Nos. 1 and 2 loosen the locking nuts only on the bogie engaging eye bolts and place the socket wrenches on the bogie securing bolts preparatory to loosening them. No. 2 elevates the gun to maximum. Nos. 7 and 8, assisted by Nos. 3 and 4, crank "bogie down" until the pedestal rests firmly on the ground and the wheels can be turned. Nos. 5 and 6 place the fuze setter bracket and seat in firing position and place the fuze setter in its bracket.

(12) Nos. 1 and 2 disengage bogie securing bolts.

(13) Nos. 1 through 8 take position at the trail.

(14) The gunner disengages the trail lock rocker arm

swing bolt preparatory to lowering the trail. With Nos. 1 through 8 holding up on the trail to support its weight, the gunner allows the trail lock to swing up to its maximum angle, and then, as Nos. 1 through 8 move the trail down to its lower position, he moves the trail lock down and refastens it by means of the swing bolt.

(15) Nos. 1 and 2 loosen both nuts on each bogie engaging eyebolt while Nos. 3 and 4 push in on bogie engaging eye operating handles.

(16) Nos. 7 and 8 crank "bogie up" until there is enough clearance for the bogie to be rolled out. Nos. 3 and 4 put the bogie hub wrenches on the wheels.

(17) The gunner and Nos. 3, 4, 5, 6, 7, and 8 roll the bogie out as Nos. 1 and 2 ride the bogie, holding up on the bogie engaging eye bolts until they clear the pedestal, then dropping them and manipulating the brakes as directed by the gun commander to guide the bogie. *The gun commander is responsible for checking the clearance between the top of the bogie frame and the bottom of the equilibrator cylinder.*

(18) The gunner loosens the auxiliary leveling screw at the front of the mount, using the ½-inch rod, and *keeps it free from binding* as the mount is leveled by Nos. 7 and 8 at the left and right leveling jacks, respectively. A leveling vial is mounted on each jack. As soon as the mount has been leveled the gunner tightens the auxiliary leveling screw by screwing it down. The gun commander verifies the level of the gun. When the level has been verified, Nos. 7 and 8 tighten the jack clamps and place the jack ratchets in the neutral position. No. 7 places his jack handle as close to the rear outrigger as possible in order to prevent breakage of the handle by the platform reinforcing angle.

(19) Nos. 1, 3, 5, and 7 put the left platform in place on the outriggers and fasten it; Nos. 2, 4, 6, and 8 do the same with the right. Platform braces are lowered and adjusted by the nearest member of the gun squad.

(20) Nos. 5 and 6 replace the canvas covers on the counterpoise cylinders. Nos. 2 and 7 lower their seats to the using position. No. 7 connects the cable to the cable receptacle on the left side of the pedestal. The remainder of the gun squad folds the canvas cover and places it on the bogie buffer cylinder.

FIGURE 5.—Gun emplaced.

(21) All men assist in placing dirt under those parts of the outriggers which do not touch the ground.

■ 37. NOTES ON EMPLACEMENT.—*a. Selecting gun site.*—(1) *General.*—Whenever possible, the gun should be emplaced on firm, well-drained ground. The ground should be examined to make certain that no rocks or other hard substances are concealed under the area where the pedestal or outriggers are to rest. The presence of such obstructions will cause the mount to shift during firing. If it should be necessary to emplace the gun on hard ground, the ground should be loosened first with a pick over an area sufficient to engage the pedestal and outriggers. The location chosen for emplacement should be such that the pedestal, *not the outrigger,* will support the weight of the gun; the mount should never be "bridged" on the outriggers. On uneven ground with a slope greater than 4°, the area under the spade and outriggers should be leveled roughly, since the leveling mechanism of the mount is limited to an adjustment of 4°.

(2) *Precaution.*—In emplacing the gun mount, it is necessary to compress the counterpoise cylinder springs by using the counterpoise gear boxes *before* loosening the nuts of the bogie engaging eyehooks. If this order is not followed, a situation results when the gun and mount are lowered wherein the equilibrator cylinder rests on the frame of the bogie, and thus supports the entire weight of the mount less bogie. The resulting pressure on the under side of the equilibrator cylinder is sufficient to crush the cylinder wall. Unless corrected, this deformation thereafter interferes with the proper operation of the gun in elevation.

b. Field fortification.—In permanent locations, where time permits and drainage is available, the height of the mount above the ground should be reduced by excavating a location for the pedestal and outriggers to a depth of as much as 30 inches. The diameter of the central excavation should be about 5 feet greater than the diameter of the gun platform. Trenches about 30 inches wide should be made for the outriggers and a ramp as wide as the span of the bogie wheels excavated for backing the gun into the hole. Revetment of emplacement sides, as determined by local soil conditions, may require the use of sandbags, timbers, or other expedients to prevent cave-ins and to permit construction of vertical or

near vertical emplacement walls. This method of emplacement in a hole in the ground facilitates concealment and presents a smaller vulnerable gun area; it also reduces danger to personnel resulting from hostile aircraft machine-gun or cannon fire and spray of bursting bombs, and provides a smaller target to hostile tanks or artillery at short range. The time normally required for such an excavation in ordinary soil is about 5 to 10 hours. Guns should habitually be

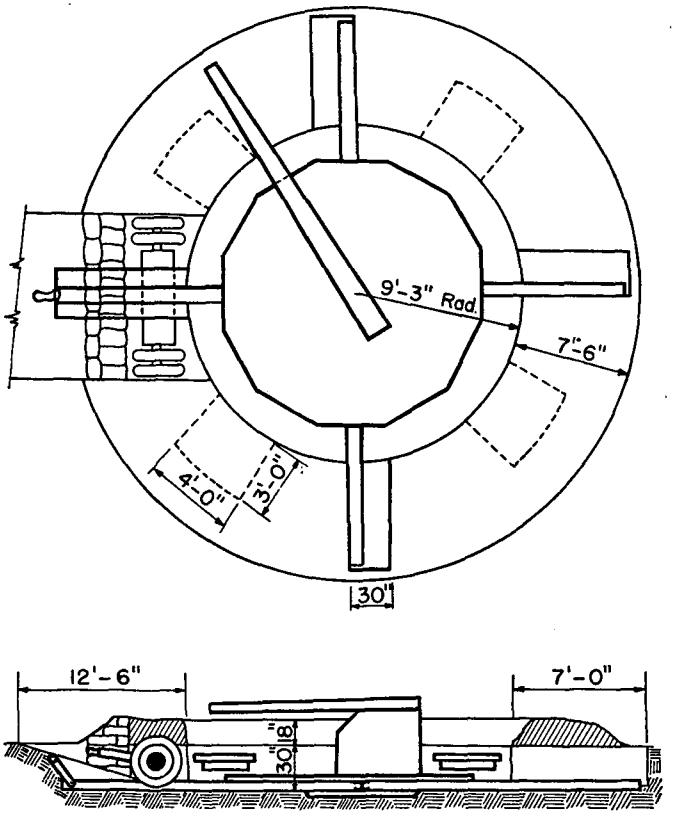


FIGURE 6.—Emplacement for 90-mm gun.

placed in alternate bunker positions during preparation of primary emplacements.

c. Settling shots.—The weight of the gun and mount should be supported mainly by the pedestal, the outriggers being intended to prevent overturning of the mount when firing. When filling in beneath outriggers, loose dirt should be used and it should not be packed. It is usually advantageous to fire one or two settling shots from a newly emplaced gun at about the maximum elevation of the gun in order to seat firmly the pedestal spade; the mount is then releveled.

■ 38. PROCEDURE OF MARCH ORDER.—*a.* The gun commander commands: MARCH ORDER. Nos. 2, 4, 6, and 8 remove, fold, and lay aside the right platform while Nos. 1, 3, 5, and 7 do the same with the left.

b. The gunner loosens the auxiliary leveling screw and *keeps it loose* while Nos. 7 and 8 center the leveling jacks, the center of the jack travel being indicated by marks on the jack body. The gunner then tightens the auxiliary leveling screw by screwing it down and Nos. 7 and 8 tighten the jack clamping screws. Nos. 5 and 6 remove the canvas counterpoise covers. Nos. 3 and 4 put on the bogie hub wrenches preparatory to rolling in the bogie.

c. No. 2 elevates the gun to maximum and folds his seat and footrest in the traveling position. No. 7 sets the gun to zero traverse (the position where the traverse pointer at the lower rear edge of the top carriage is directly in line with a groove in the top of the left jack slide cover) and folds and pins the azimuth setter's seat and footrest in the traveling position. He then disconnects the cable from the cable receptacle on the left side of the pedestal and replaces the cap on the plug and receptacle.

d. No. 5 disconnects the cable from the fuze setter junction box and unpins the fuze setter bracket. Nos. 5 and 6 remove the fuze setter from its firing position and put it in the traveling bracket.

e. Assisted by Nos. 1 and 2, who ride the bogie and hold the eyebolts clear of the pedestal, and Nos. 3 and 4, who manipulate the hub wrenches, the gunner and Nos. 5 and 6

roll in the bogie. Extreme care should be taken to avoid bumping any part of the mount.

NOTE.—Since the mount settles during firing, it may be necessary to crank "bogie down" or to dig a trench for the wheels to insure clearance between the bottom of the equilibrator cylinder and the top of the bogie frame as the bogie is rolled in. The gun commander is responsible for this clearance and directs Nos. 7 and 8 to crank "bogie down" if necessary.

f. Nos. 3 and 4 pull out on the bogie engaging eye operating handles until they are locked in place by the pawls. Nos. 7 and 8 crank "bogie down" until the bogie engaging eye operating handles may be pulled all the way out as indicated by the bogie engaging eye operating handle pawls dropping into position. Nos. 1 and 2 tighten by hand the lower nuts in the bogie engaging eyebolts, leaving sufficient clearance to permit engaging the bogie securing bolts when the trail is raised.

g. All members of the gun squad take position along the trail preparatory to raising it to the "up" position.

h. The gunner loosens the wing nut and drops the swing bolt, disengaging the trail lock rocker arm. At the command of the gunner, all men lift the forward end of the trail until the trail is locked in the upper position. During this action, the trail lock rocker arm swings to its upper limit and then backs down again to its normal position. The men on the trail hold the trail in upper position while the gunner fastens the trail lock rocker arm again by means of the swing bolt and the wing nuts.

i. With the trail in the "up" position, Nos. 1 and 2 engage the bogie securing bolts and tighten and lock the nuts on the bogie engaging eyebolts. They then set the hand brakes.

j. Nos. 7 and 8, assisted by Nos. 3 and 4, crank "bogie up" until the gear boxes can be disengaged and locked in traveling position (by pushing in on the crank handles).

k. The gunner takes position at the bogie buffer, Nos. 1 and 2 at the hand brakes, and Nos. 3 through 8 at the trail.

l. At the command of the gun commander, Nos. 1 and 2 release the hand brakes and, at the same time, Nos. 3 through 8 give a strong upward push to the trail causing the lug on the bogie axle to swing up against the rubber bumper on top of the bogie directly to the rear of the bogie buffer. The gunner pulls out on the latch shaft handle and swings up

the bogie buffer cylinder at the front after the mount has been raised, until the bogie buffer roller is directly in front of the axle lug. When at the correct angle, the bogie buffer cylinder is latched again by the latch on the side of the buffer cylinder.

m. With Nos. 1, 3, and 4 at the trail and Nos. 5, 6, 7, and 8 at the rear outrigger, No. 2 depresses the gun to 300 mils and the mount is tipped gently forward. As the lug on the bogie axle comes forward against the bogie buffer plunger, the gunner turns the handwheel so as to release the plunger. No. 8 remains at the rear outrigger till the gun has been coupled to prime mover to prevent the mount from tipping backward.

n. The gunner and No. 1 raisé the traveling lock brace. No. 2 depresses the gun into the traveling lock and the gunner swings the transom cap on top of the traveling lock over the gun tube, fastens it, and replaces the muzzle cover.

o. No. 5 removes the equilibrator piston stop from the holder on top of the equilibrator and inserts it in the equilibrator cylinder head. He fastens it with the equilibrator piston stop pin. The gunner plugs the electric brake cable into the socket of the bogie.

p. The gunner and Nos. 2, 4, and 6 put the right platform on the trail and fasten it in position while Nos. 1, 3, 5, and 7 do the same with the left.

q. The gunner and Nos. 2, 4, and 6 fold and latch the right outrigger in traveling position, while Nos. 1, 3, 5, and 7 do the same with the left.

r. The gunner and Nos. 1 and 2 take position at the trail lifting bar and Nos. 3 through 8 at the rear outrigger.

s. The gun commander directs the prime mover in backing to couple the mount. The gunner, assisted by Nos. 1 and 2, couples the mount to the prime mover. Nos. 3 through 8 at the rear outrigger maneuver the mount as directed by the gun commander to assist in coupling the gun to the prime mover.

t. The gun and prime mover having been coupled, Nos. 5 through 8 fold and latch the rear outrigger. No. 3 climbs on top of the mount, secures the outriggers with the outrigger chain, and remains there to help put the canvas cover in place.

u. Nos. 5 and 6 replace the canvas covers on the counterpoise cylinders. No. 1 fastens the break-away chain to the prime mover, plugs the brake cable into the truck, takes the lifting bar out of the trail, and puts it in the truck.

v. Nos. 1 through 8 puts the gun cover on the gun and fasten it in place. No. 3 carries the cover up over the tube from the rear by walking along the tube.

w. The tools are replaced in the truck, Nos. 1 and 2 replacing the bogie socket wrenches, Nos. 4 and 7, the wheel wrenches, and Nos. 5 and 6, the bogie ratchet wrenches.

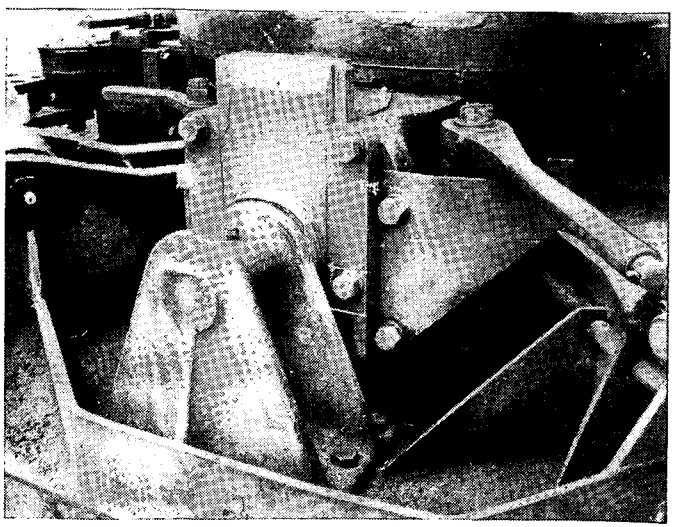


FIGURE 7.—Right leveling jack. (Note centering marks.)

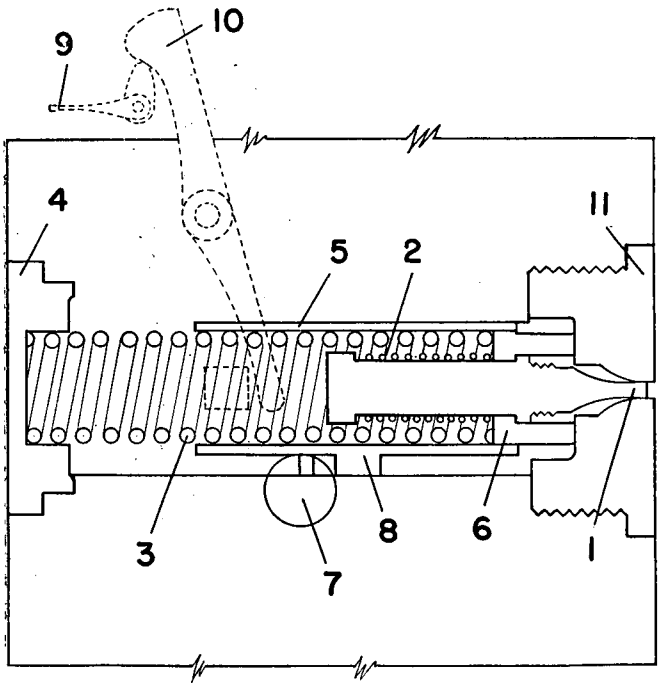
SECTION VIII

ROUTINE DISASSEMBLY AND CHECKS

■ 39. GENERAL.—This section contains special information on the care and handling of 90-mm mobile antiaircraft guns.

■ 40. FIRING MECHANISMS.—*a. Dissassembly.*—With the chamber empty and breech closed, operate the firing mechanism to depress the firing plunger and slide the sear to the

left. Press the firing spring retainer inward against the firing spring and rotate retainer one-quarter turn. The firing spring will force out the retainer. Withdraw the firing spring. The percussion mechanism assembly (composed of the firing pin, firing pin guide, retracting spring, firing spring stop, and $\frac{3}{32}$-inch steel pin) may now be ejected by operating the hand cocking lever handle, or may be withdrawn with the fingers while actuating the firing plunger as above. The percussion mechanism components should not be separated



1. Firing pin.
2. Retracting spring.
3. Firing spring.
4. Firing spring retainer.
5. Firing pin guide.
6. Firing spring stop.
7. Sear (firing plunger bears against sear).
8. Sear lug.
9. Hand cocking lever.
10. Automatic cocking lever.
11. Breechblock bushing.

FIGURE 8.—Firing mechanism—horizontal cross section.

except for replacement of unserviceable parts. When necessary, they may be separated by pressing the stop rearward into the guide and punching out the 3/32-inch steel pin thus exposed. The stop may then be returned to normal position and the firing pin unscrewed from the guide with a screw driver.

b. Removal of sear.—Removal of the sear (fig. 8) requires removal of the breechblock from the breech recess. When clear of the recess, the sear may be removed by pressing it to the left as far as it will go, and removing the U-shaped sear retainer from the left end of the sear. The sear may then be withdrawn to the right. If the sear spring is not withdrawn with the sear, it may be pushed out or withdrawn with a piece of wire.

c. Assembly.—With the breechblock removed from the breech recess, place the sear spring (fig. 10) over the small end of the sear and insert the sear and spring into place through the recess in the right side of the breechblock. Press the arm of the sear into the recess as far as it will go and place the sear retainer in its seat in the small end of the sear as it projects on the left side of the breechblock. Release the pressure to permit the sear spring to move the sear to the right, seating the retainer in the counterbore of the sear hole. If the parts of the percussion mechanism have been separated, insert the firing spring stop into the firing pin guide, pronged end first, and rotate until the prongs project through the openings in the end of the guide. Place the retracting spring in the body of the firing pin and screw the firing pin into the guide from the rear until the shoulder of the pin seats against the end of the guide inside, with the point of the pin projecting from the forward end of the guide. Press the stop in against the retracting spring to expose the traverse pinhole in the guide. If the pinholes in the guide and firing pin are not in alinement, screw the firing pin backward not to exceed one-half turn to aline the holes. Insert the 3/32-inch steel pin through the guide and firing pin, and release the stop to permit the prongs to cover and retain the pin. With the breechblock in the breech recess insert the percussion assembly (fig. 9) into the rear end of the firing pinhole in the breechblock, firing pin point first, with the cocking lug on the right and the sear lug on the bottom

alined with the grooves on the breechblock. Press the firing plunger inward, push the guide assembly forward until it contacts the breechblock bushing, and then release the firing plunger. Place the firing spring (fig. 8) inside the firing

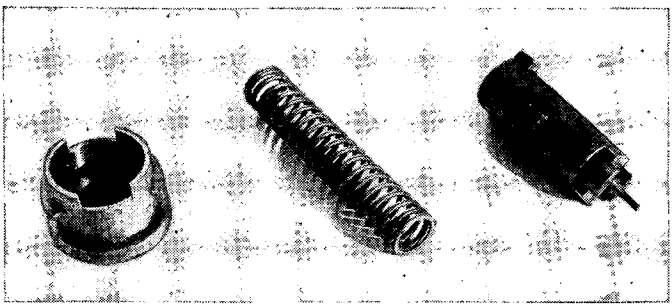


FIGURE 9.—Firing mechanism—disassembled.

pin guide, around the firing pin. Place the cupped end of the firing spring retainer over the rear end of the spring and, with the arrows in the seat of the retainer in a horizontal position, compress the firing spring by pushing the retainer

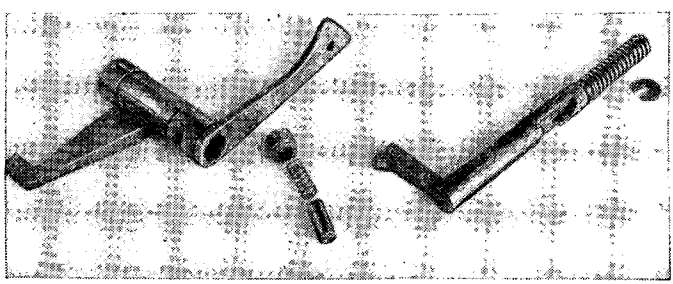


FIGURE 10.—Automatic cocking lever, automatic cocking lever spring retainer cap, automatic cocking lever spring, automatic cocking lever spring retainer, sear, sear spring, and horseshoe washer (retainer).

into the rear of the breechblock until the rear face of the retainer is 3/16 to 1/4 inch below the rear face of the breechblock, and rotate the retainer until one of its arrows is in alinement with the arrow on the breechblock; then release the pressure.

■ 41. BREECHBLOCK.—*a. Removal.*—Any of several methods of breechblock removal may be used. The method used will depend on equipment available.

(1) *Procedure when breechblock support is not available.*—(*a*) Elevate gun to about 400 mils.

(*b*) Remove firing pin spring retainer, firing pin spring and percussion mechanism.

(*c*) Open breech, using operating handle.

(*d*) Remove extractor plunger plugs, springs, and plungers.

(*e*) Close breech almost completely, but allow the operating handle to rest on top of the latch lock.

NOTE.—The operating handle resting on top of the latch lock takes up the pressure of the closing spring. This does away with the necessity of using a special retaining rod.

(*f*) Insert lifting eye in top of the block.

(*g*) Insert smaller end of ½-inch rod into bore at left end of spline shaft to unlock crank detent.

(*h*) Support the weight of the breechblock by means of the lifting eye and at the same time push the spline shaft to the right by means of the ½-inch rod.

Caution: Catch the breechblock crank when it falls out; do not let it drop onto the top carriage.

(*i*) Withdraw spline shaft completely.

(*j*) Lift block out the top of breech ring.

(*k*) Remove extractors.

(2) *Procedure when breechblock support is available.*—(*a*) Elevate gun to about 400 mils.

(*b*) Remove firing pin spring retainer, firing pin spring and percussion mechanism.

(*c*) Open breech, using operating handle.

(*d*) Remove extractor plunger plugs, springs, and plungers.

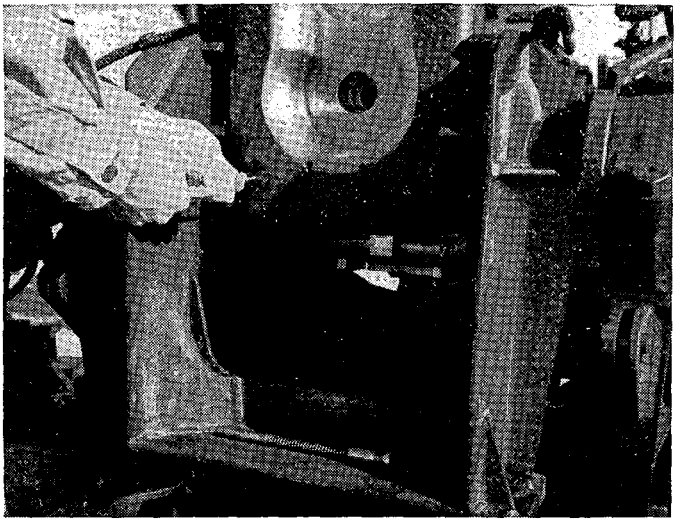
(*e*) Close breech completely. Insert breechblock support in firing mechanism hole, then move operating handle until it rests on latch. (See note in (1) (*e*) above.)

(*f*) Insert lifting eye in top of block.

(*g*) Insert smaller end of ½-inch rod into left end of spline shaft to unlock crank detent.

(*h*) Push spline shaft to the right by means of the ½-inch rod.

Caution: Catch the breechblock crank when it falls out; do not let it drop onto the top carriage.



① Removing extractor plunger plugs, extractor plunger springs, and extractor plungers.

FIGURE 11.—Removal of breechblock.

(*i*) Withdraw spline shaft completely.

(*j*) Lift block out the top of breech ring.

(*k*) Remove extractors.

(3) *Procedure when lifting eye is not available.*—If a lifting eye is not available, elevate gun to maximum elevation before proceeding by either of the above methods.

b. Replacement.—(1) *Procedure when breechblock support is not available.*—(*a*) Leave gun at 400 mils elevation.

(*b*) Slide block down slowly into breech ring until trunnions of extractors are engaged.

(*c*) Place crossheads on breechblock crank crosshead pivots and slide breechblock crank into T-slot.

(*d*) Push breechblock crank forward as far as possible while block is lifted to approximately the closed position.

(*e*) Push spline shaft in from the right while the operating handle is moved slowly back and forth through a small angle.

(*f*) Check to make certain the spline shaft is properly engaged; if it is not, it may slip out during firing and damage the gun. Look into the recess beneath the breechblock. As the beveled end of the spline shaft passes through the hub of the operating crank, it pushes the detent out; as the hole in the spline shaft comes into position, the detent slips back into place. To complete the check, press the *larger* end of the special ½-inch rod against the left end of the spline shaft. The spline shaft should not move.

(2) *Procedure when breechblock support is available.*—(*a*) Leave gun at 400 mils.

(*b*) Slide block down slowly into breech ring until trunnions of extractors are engaged.

(*c*) Block breechblock with breechblock support, flange up.

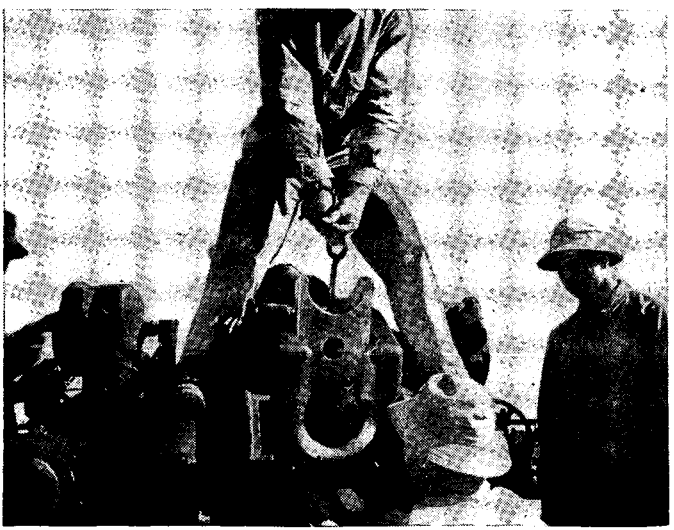
(*d*) Place crossheads on breechblock crank crossheads pivots and slide breechblock crank into T-slot.

(*e*) Push breechblock crank forward as far as possible

② Pushing out spline shaft. (Note position of breechblock support.)

FIGURE 11.—Removal of breechblock—Continued.

③ Catching breechblock crank.



④ Lifting out breechblock and removing extractors.

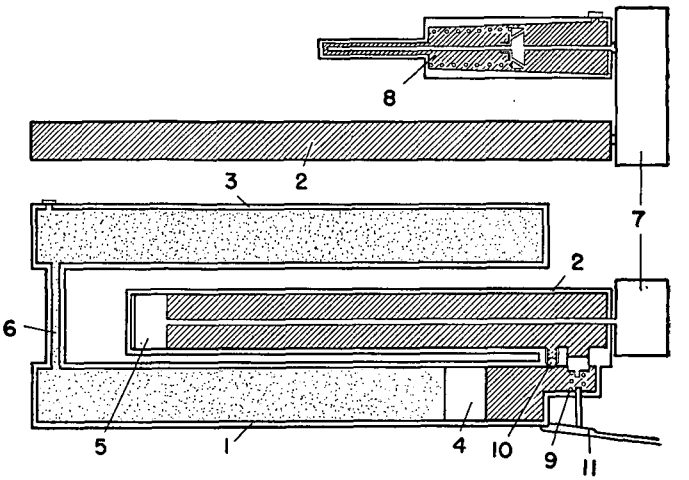
FIGURE 11.—Removal of breechblock—Continued.

while block is lifted until breechblock support can be placed flange down.

(*f*) Push spline shaft in while operating handle is slowly moved back and forth.

(*g*) Check as described in (1) (*f*) above.

(3) *Procedure without lifting eye.*—Either of the above methods may be used without the aid of a lifting eye by having the gun at maximum elevation.



1. Floating piston cylinder.
2. Recoil cylinder.
3. Gas cylinder.
4. Floating piston.
5. Recoil piston.
6. Gas bypass.
7. Breech ring.
8. Counterrecoil buffer.
9. Recoil valve.
10. Counterrecoil valve.
11. Control bar.

FIGURE 12.—Recoil mechanism—schematic.

■ 42. CHECK AND REPLACEMENT OF OIL AND GAS IN RECOIL AND RECUPERATOR SYSTEMS.—*a. General.*—(1) Personnel of the using service will check and reestablish the oil reserve in the recoil system and the gas pressure in the recuperator system.

(2) Oil reserve is additional oil in the recoil system required to move the floating piston (which forms the floating seal in the recoil mechanism separating the nitrogen and the recoil oil) away from the rear end of the floating piston cylinder.

This is necessary to establish a pressure in the recoil cylinder when the piston is in the "in-battery" position, to return the gun into battery at all elevations, and to compensate for changes in temperature. Approximately 6 to 8 ounces of recoil oil is required for the oil reserve. This quantity equals one and one-half to two times the capacity of the oil screw filler, which is slightly less than 4 ounces. Since the recoil mechanism contains no indicator of the oil reserve, *absolute check on the reserve oil necessitates withdrawing the oil reserve and establishing a new reserve of known correct amount. Never add to an existing reserve.*

(3) Gas pressure should be maintained as carefully and should be checked as often as the reserve oil. The using personnel should check, and replenish if necessary.

b. Oil reserve.—(1) *Check.*—With the gun in a horizontal position, remove oil filling plug at lower right rear of cradle. Insert oil release tool and screw it in until the oil filling valve is unseated. If any reserve oil is in the system, it will be forced out through the oil release by the action of the gas on the floating piston. (If the escaping oil has an emulsified

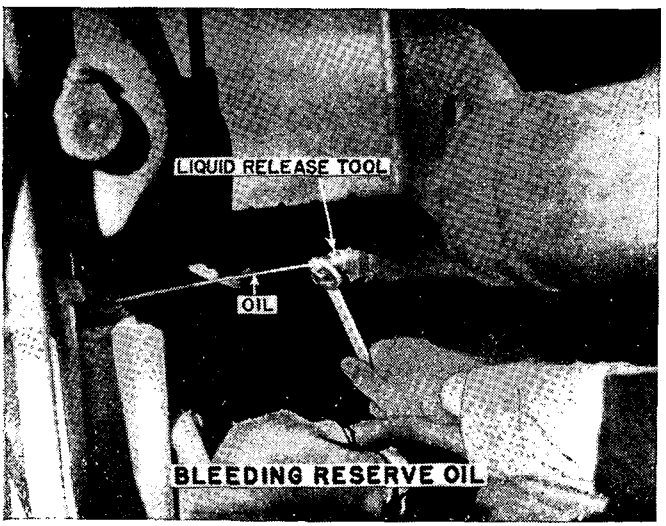


FIGURE 13.

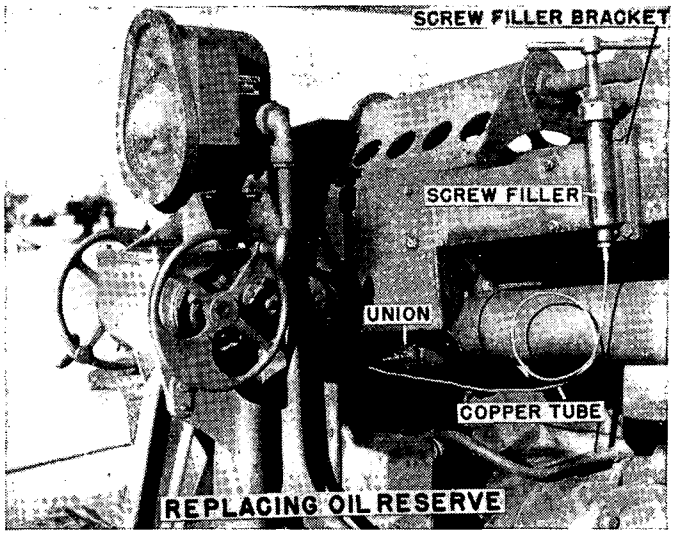


FIGURE 14.

appearance, notify the ordnance maintenance company.) If no oil flows through the oil release, there is insufficient gas pressure in the system, a void in the oil side of the system, or both.

(2) *Establishment when oil flows.*—When a flow of oil is obtained from the test made in (1) above, the oil is allowed to run out through the oil release tool until it ceases to flow or the stream drops at right angles to the flow. This eliminates all of the old reserve, preventing the building up of an excessive reserve. Proper oil reserve is then established as follows: withdraw piston of oil screw filler and fill body of filler with recoil oil, preventing the loss of oil by holding a finger over the end of the tube. If the wind is blowing dust and sand, this should be done in a covered place and all care should be taken to keep the oil in the container and the filler clean. Replace piston and cap. Hold filler with the pipe up and turn screw until a small amount of oil flows from it. This will expel the air from the filler. Place oil screw filler in the bracket provided at the rear left side of the cradle.

Lightly screw the union on the oil screw filler tubing into the oil filling hole, and give the handle of the filler a turn or two to force out any air trapped in the filling hole. Then tighten the union and its follower and force all oil in oil screw filler into recoil mechanism by turning the oil screw filler handle clockwise. Repeat the operations until recoil oil equal to the capacity of one and one-half to two oil screw fillers has been forced into the mechanism. This establishes the reserve oil supply. Disconnect oil screw filler, and replace oil filling valve plug housing plug in filling hole and tighten.

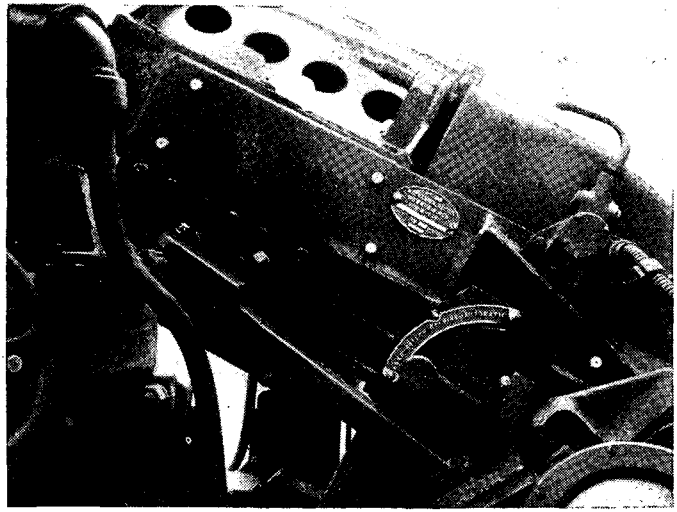


FIGURE 15.—Left side of gun, showing vent plug, recoil cylinder plug, breech operating cam lever, and control bar.

(3) *Establishment when oil does not flow.*—When no flow of oil is obtained when the oil release tool is inserted, the gas pressure should be checked. If there is sufficient gas pressure, the lack of reserve oil must be caused by a void in the system due to leakage. Manipulate elevating and leveling mechanism to obtain a definite depression of the gun muzzle. Make sure there is no dirt around the recoil cylinder plug and the vent plug. Remove recoil cylinder plug. Place it

in a clean place for safekeeping. Completely loosen but do not remove vent plug. The recoil cylinder plug is located just to the rear and the vent plug just forward of the recoil throttling valve mechanism on the left side of the cradle (fig. 15). (Recoil mechanisms of serial number lower than 28 do not have the vent plug.) Using a clean funnel, pour recoil oil of the proper grade into the recoil mechanism, through the recoil cylinder plug hole. Pour very slowly so as not to trap air in the recoil cylinder. On a windy, dusty day use a canvas cover, or do the work indoors. Take every precaution to insure that no foreign substances or materials get into the recoil mechanism, as they may do irreparable damage. When the recoil mechanism is filled to the point where oil can no longer be poured in, reinsert the recoil cylinder plug, but do *not* tighten it in the hole. Prepare and attach a filled oil screw filler as in (2) above, to the system, and slowly force reserve oil into the mechanism. As soon as bubble-free oil starts to emerge from around the recoil cylinder plug, tighten it firmly, but do not force it to the extent of damaging its gasket. Resume injection of oil until it now "cracks out" around the loosened vent plug. Tighten vent plug firmly and resume injecting oil into the recoil mechanism. Almost immediately a sudden increase will be noticed in the force needed on the oil screw filler handle to drive oil into mechanism. This is the point where oil reserve starts to build up. Inject two screw fillers full into the system in the manner described in (2) above. Disconnect oil screw filler from recoil mechanism, and replace oil filling valve plug housing plug and tighten.

c. Gas pressure in recuperator.—After establishing an oil reserve as described above, the gas pressure is checked as follows: With the gun at zero elevation, place ratchet wrench on gun jack, and jack the gun out of battery about 2 inches, or to the limit of the jack. Reverse the motion of the jack screw; the gun should return to battery. Next, elevate the gun to maximum elevation, and jack it out of battery again. Reverse the motion of the jack screw, and note the operation of the gun in returning to battery. When the gun is at maximum elevation and with the proper gas pressure and oil reserve, it may return to battery. If the gun does not return to battery, depress it. There is some angle at which

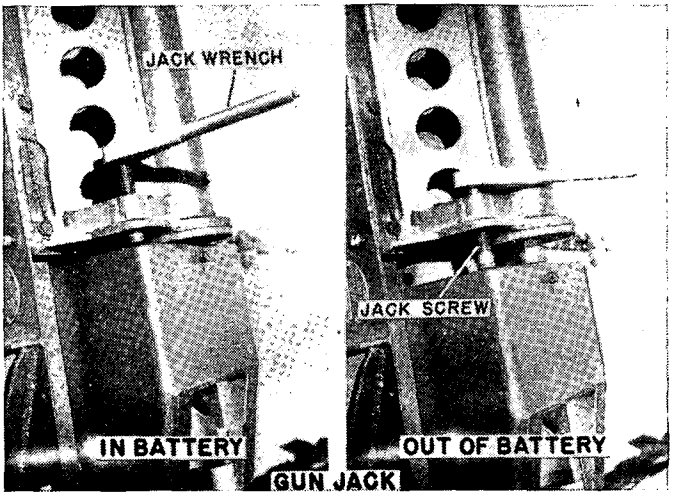


FIGURE 16.

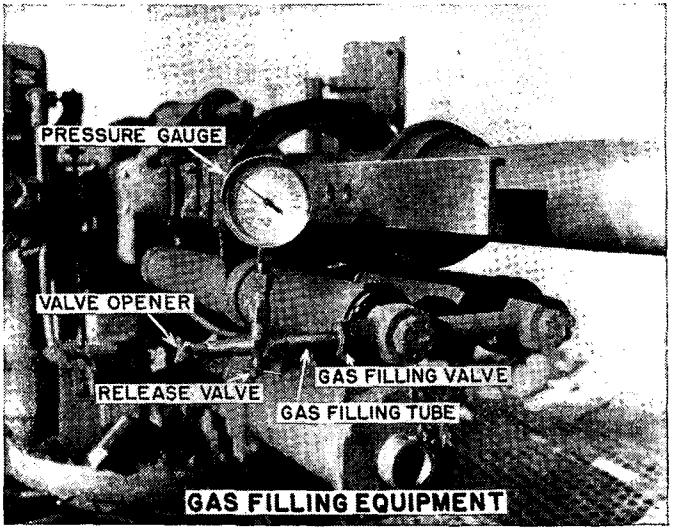


FIGURE 17.

it will return all the way to battery; this angle should be above 710 mils. If this angle is below 710 mils, the gas pressure must be checked with the gage, and replenished, if necessary. However, unless necessary, gas pressure should not be tested by means of the gage, because continual use of the gas filling valve will cause it to leak. The test should be applied before any gage or valve opener is inserted in the filling valve.

d. To charge recuperator with gas.—(1) To check the gas pressure by means of the gage, remove gas filling plug on right side of the forward end of gas cylinder. A filling valve prevents the escape of gas. Screw filling tube into gas filling hole. The tube has a pressure gage mounted on it to indicate the gas pressure. In order to open the filling valve, turn handle on the end of gas filling tube in a clockwise direction. Pressure of the compressed gas in the recuperator system will register on the gage; it should be above 830 pounds per square inch, not to exceed 1,000.

(2) If the pressure should be above 1,000 pounds, allow excess gas to escape by opening release valve on the bottom of gas filling tube. When proper gas pressure is reached, close release valve.

(3) If the pressure is below 830 pounds, connect gas bottle to gas filling tube, and add more nitrogen to the system. To do this, first remove pressure from gas filling tube by turning the handle of valve opener counterclockwise. Open release valve; this allows pressure to escape from the gas filling tube and the gage. Unscrew cap from the front of the tube, and connect flexible copper gas filling tube leading to gas bottle. Tighten all connections. Open filling valve by means of valve opener. Regulate flow of gas into recuperator system by valve on gas bottle. When the proper pressure is indicated on the gage, close valve on gas bottle. Close filling valve. Open release valve and remove gas filling equipment. Close filling hole with the plug.

e. Filling counterrecoil buffer cylinder with oil.—Set gun to zero elevation. Remove oil filling plug on the top of buffer cylinder, and fill cylinder to overflowing. Replace filling plug and tighten. The buffer requires 3½ pints of heavy, low-pour-point recoil oil, but oil *may be added* to oil present in the cylinder.

■ 43. LUBRICATION.—*a.* The life of the gun and mount depends to a great extent on proper lubrication. Particular attention will be given to sliding and bearing surfaces, such as the sliding surfaces of the gun and cradle, roller bearings, ball bearings, elevating rack, traversing rack, and breech mechanism.

b. Industrial type grease fittings and oil plugs are provided

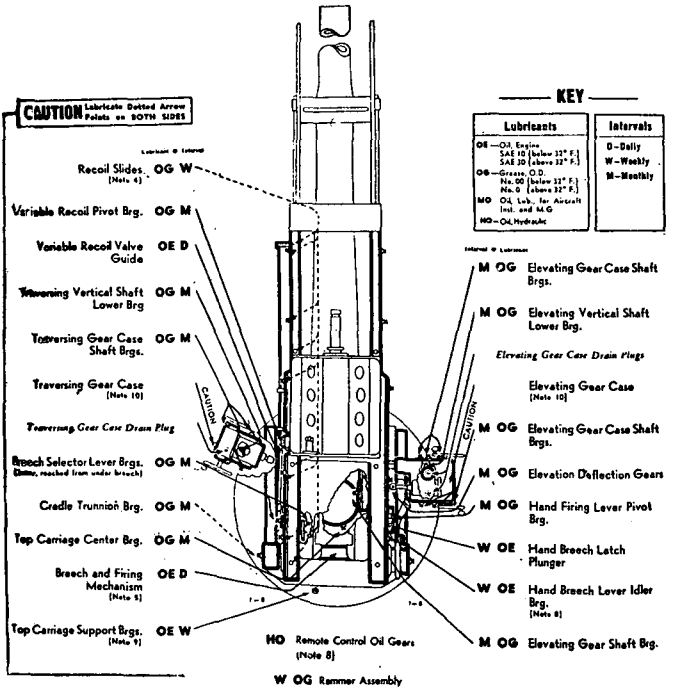


FIGURE 18.—Lubrication chart.

NOTES

Additional lubrication and service instructions on individual units and parts.

1. *Intervals.*—Those indicated are for normal service. For extreme conditions of heat, water, dust, etc., lubricate more frequently.

2. *Fittings.*—Clean before applying lubricant. *Caution:* After washing, lubricate recoil slides, traversing rack, and support bearings.

3. *Elevating rack.*—Clean and apply OE daily.

4. *Recoil slides.*—Keep exposed surfaces coated with OE. Clean and oil before firing.

5. *Breech and firing mechanism.*—Clean and oil all moving parts and exposed metal surfaces with OE daily. Perform operation before and after firing. To avoid misfiring at temperatures below freezing, remove plug to remove firing mechanism. Dip firing mechanism in solvent, dry-cleaning. Operate firing pin in solvent, lubricate with MO, and replace mechanism.

6. *Gun bore.*—Clean and coat with OE after firing. Inspect daily and oil if necessary.

7. *Recoil adjusting cam mechanism and chain.*—Lubricate surface with OG monthly. Located beneath breech and reached from rear.

8. *Hand breech lever idler bearing.*—To reach oiler, pull lever to rear.

9. *Top carriage support bearings.*—Lubricate through three plugs; others located under elevating gear case and opposite point shown.

10. *Points to be lubricated by ordnance maintenance personnel at time of ordnance inspection.*—Elevating and traversing gear cases.

on the gun and mount. The fittings are painted red and the oilholes are marked by a red ring.

c. Care must be taken when cleaning gear cases or sliding surfaces to insure the complete removal of all residue or sediment. Dirt or other foreign matter should not be allowed to drop into any of the gear cases.

d. Lubrication frequencies are based on continuous use of the matériel with frequent firing.

e. No lubricants other than those prescribed will be used without the authority of the Ordnance Department.

f. Oil and grease should be applied while the parts are being maneuvered to insure distribution of the lubricant to all moving parts.

SECTION IX

REMOTE CONTROL SYSTEM M2

■ 44. GENERAL.—*a.* The remote control system M2 automatically and continuously positions 90-mm antiaircraft guns in accordance with data from the director M7 or M4.

b. The gun is automatically positioned with consistent ac-

curacy and speed such as could not be expected of an azimuth setter and an elevation setter manually matching pointers.

c. All parts of the remote control system M2 are located on the 90-mm antiaircraft gun mount. The system consists of three related groups: the signal system, the stroke control system, and the hydraulic system.

d. The signal system receives electrical data from the di-

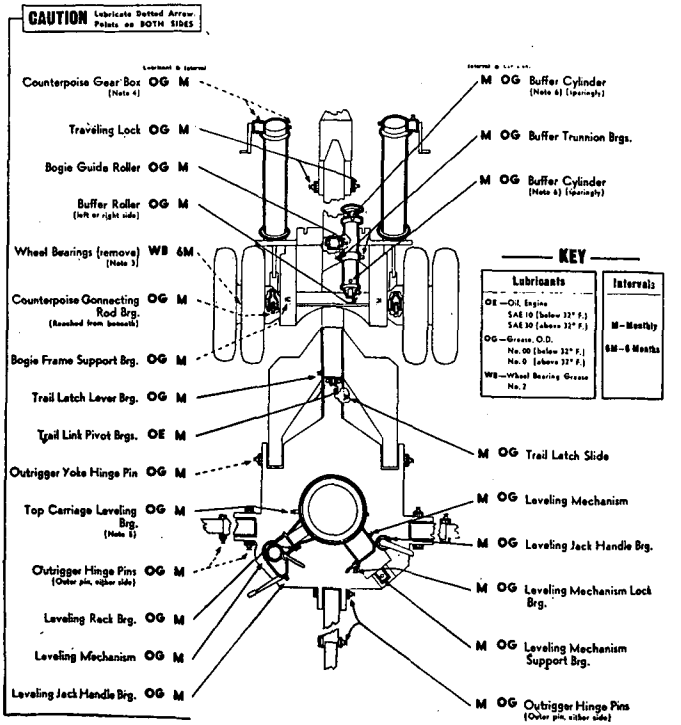


FIGURE 19.—Lubrication chart.

NOTES

Additional lubrication and service instructions on individual units and parts.

1. *Intervals.*—Those indicated are for normal service. For extreme conditions of speed, heat, water, mud, snow, rough roads, dust, etc., lubricate more frequently.
2. *Fittings.*—Clean before applying lubricant. *Caution:* After washing, lubricate counterpoise connecting rods, trail lock, leveling bearing, hinge pins, and rollers.
3. *Wheel bearings.*—Remove wheel, clean and repack bearings only.
4. *Counterpoise gear box.*—Remove top of cylinders and lubricate side walls with CG monthly and after moving carriage.
5. *Top carriage leveling bearing.*—Lubricate until grease extrudes from vent at opposite side of carriage.
6. *Buffer cylinder.*—*Caution:* Excessive grease in units will cause malfunction. If overfilled, remove grease fitting and operate parts to force out excessive grease.
7. *Oil can points.*—Lubricate hand brake levers, pedestal carriage bolts, clevises and hinges, etc., with OE weekly.
8. *Remote control oil gears.*—Completely fill with HO. Expel all air. Check frequently and add HO when necessary.
9. *Rammer assembly.*—Lubricate exposed surfaces with OE.

rector and produces an "error signal" when the gun is not in the synchronous position. The stroke control system amplifies this electrical signal and converts it into directional, mechanical movement. This movement controls the hydraulic system which, in turn, positions the gun.

■ 45. THEORY OF OPERATION.—The signal system consists of coarse repeater, synchronizer, synchrotransformer, lag meter, and demodulator. These are all parts of the indicator regulator M1. The indicator regulator is classified as part of the cable system, but is actually such an essential part of the remote control system that it will be considered as such in this section. The signal system produces a voltage when the gun is not in the synchronous position. The stroke control system is both electrical and mechanical, and has been called the nerve center of the remote control system. It amplifies the signal produced by the signal system and converts it into directional, mechanical movement. Actually the stroke control system determines how much the gun is going to move and stops the gun with a minimum of "hunting" when the synchronous position has been reached. The hydraulic system amplifies the movement of the stroke control system and moves the gun to synchronism.

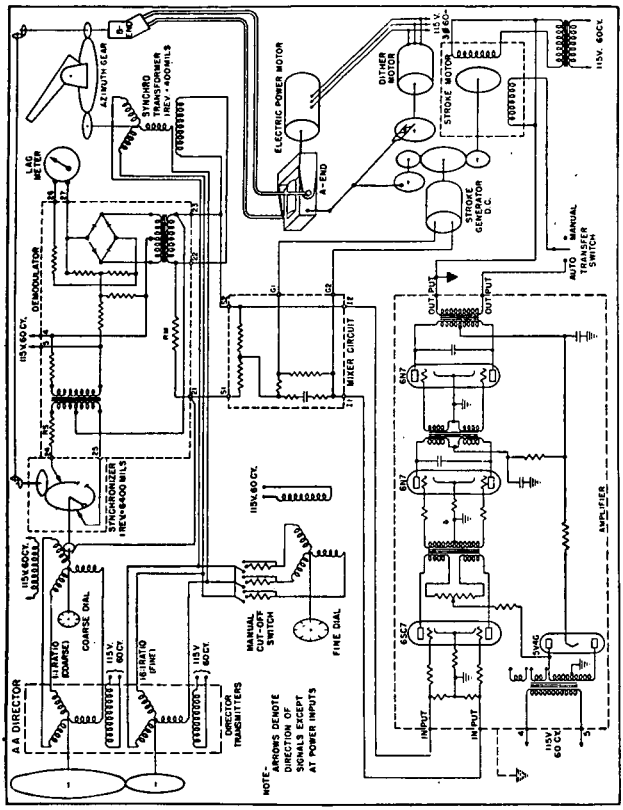


FIGURE 20.—Wiring system—schematic.

a. Signal system (figs. 20 and 21).—(1) Two electrical inputs and one mechanical input determine the output of the signal system. These inputs are the coarse and fine data from the director and the mechanical indication of the present position of the gun. If the electrical and mechanical inputs agree, synchronism exists, and no signal is produced. If they do not agree, a signal consisting of voltage of the proper phase and intensity is transmitted to the stroke control system. In addition, by means of the lag meter, the signal system shows whether or not the remote control sys-

tem is functioning accurately at any given moment. There is a signal system for elevation and one for azimuth, and so there are two indicator regulators, identical and interchangeable.

(2) Coarse data are considered independently of fine data. Coarse data are received by a coarse repeater in the indicator regulator. Since 115-volt, 60-cycle, a-c is applied to the field of the coarse repeater, the Y-coil rotor of the repeater will be forced electrically to assume an angular position the same as that of the Y-coil rotor of the transmitter. This is a simple Selsyn arrangement. One revolution of the transmitter rotor or the receiver rotor corresponds to one revolution of the gun through 6,400 mils.

(3) The synchronizer must select a 60-cycle a-c voltage which is either in phase with the power supply or 180 electrical degrees out of phase. The shaft of the coarse receiver rotor carries a silver roller which rotates inside silver slip rings. One half set of rings is separated from the other half by

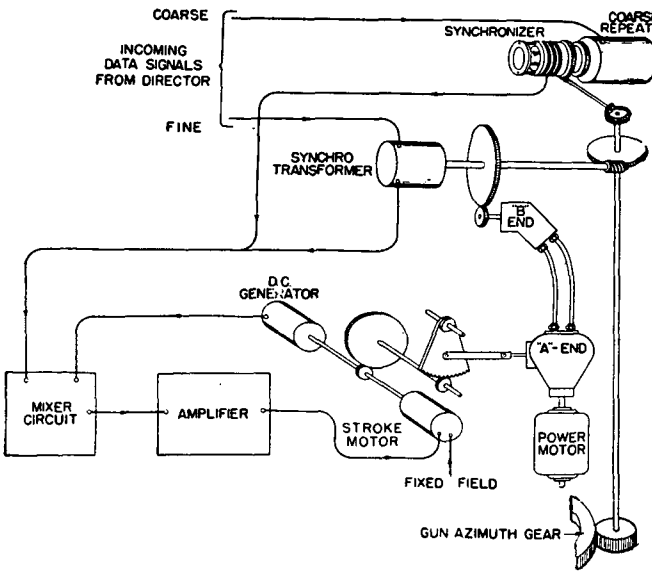


FIGURE 21.—Wiring system—simplified.

insulated sections called "islands." The phase of the voltage selected by the synchronizer depends upon the half set of silver rings with which the roller is in contact. When the roller is in contact with one of the insulated islands, the gun is within 150 mils of synchronism; and, since there is no contact between roller and slip ring, the circuit is broken. At this point the synchrotransformer will dominate and move the gun the rest of the way to synchronism as described below. The synchronizer is a separate assembly and acts as a single-pole, double-throw switch; the position of the coarse receiver determines the direction in which the switch will throw.

(4) In response to the impulse produced by the synchronizer, the gun moves; the unit containing the slip rings moves with the gun in a 1:1 ratio, through mechanical gearing. If the data output of the director is not changing, the silver roller contact will remain stationary, being connected to the shaft of the coarse receiver rotor. Since the slip ring unit is moving and the roller contact is not, the roller contact will eventually move out of contact with the slip ring. This will occur when the gun is within 150 mils of synchronism. At this point, the synchronizer no longer has an output, and the synchrotransformer takes control.

(5) The synchrotransformer consists of a Y-connected winding and a field winding. The fine transmitter in the director is electrically connected to the Y-coil of the synchrotransformer. The fine transmitter rotor is mechanically geared to the rotor of the coarse transmitter in a 16:1 ratio; thus for every change of 400 angular mils of the transmitted data, the rotor of the fine transmitter will turn through 360 electrical and mechanical degrees. If the field winding of the synchrotransformer were energized with 115-volt a-c, and if the rotor were free to rotate, it would follow the movement of the transmitter rotor, acting according to the usual Selsyn principle. *However, the field winding is not energized with 115-volt a-c and the rotor is not free to rotate.* Data from the director positions the rotor of the transmitter and a triplet of voltages is induced in the Y-coil of the transmitter and sent through the cable system to the Y-coil of the synchrotransformer. Each of these three voltages causes a magnetic flux and the resultant flux may in-

duce a voltage in the field winding of the synchrotransformer, depending upon the relative positions of rotor and stator.

(6) There are two relative positions of the rotor and stator of the synchrotransformer for which the resultant magnetic flux is perpendicular to the field winding and the induced voltage consequently is zero. One of these points represents the synchronous position of the gun (or any multiple of 400 mils from that position), and the other zero voltage position represents a gun position 200 mils from synchronism (or any multiple of 400 mils from that position).

(7) The rotor of the synchrotransformer is geared to the movement of the gun. When the gun is out of synchronism, a voltage is induced in the stationary field winding of the synchrotransformer. The phase of this induced voltage will be either in phase with the reference voltage or 180° out of phase, depending upon which side of the zero point the gun is positioned in relation to the incoming signal. Since every 400-mil movement of the gun causes a complete rotation of the synchrotransformer, the signal output of the synchrotransformer will change phase every 200 mils as the gun approaches synchronism. This is indicated by the movement of the lag meter pointer.

(8) The signal output of the synchrotransformer is fed into a pair of terminals. The output of the synchronizer is fed into another pair of terminals. These two pairs of terminals are connected, and thus the outputs of the synchrotransformer and the synchronizer are in parallel. This creates the following situation: The synchronizer is of a fixed phase (the phase producing the desired output to the stroke control system). At the same time the voltage output of the synchrotransformer is being fed to the stroke control system through the same channel. Since the phase of the synchrotransformer signal changes every 200 mils, the output of the synchrotransformer alternately aids and opposes the output of the synchronizer every 200 mils.

(9) The effective voltage output of the synchrotransformer is limited to a fraction of the synchronizer output by means of a resistor, thus minimizing the effect of the synchrotransformer output. However, when the gun comes within 150 mils of synchronism, the synchronizer ceases to produce an output, and the output of the synchrotransformer

takes control. At the point where the synchronizer relinquishes control to the synchrotransformer, the phase of the synchrotransformer output is the same as that of the disconnected synchronizer. Thus, the stroke control system continues to do its job and the gun continues to move to the synchronous position.

(10) The secondary function of the signal system is to provide a visual indication of the proper functioning of the entire system. Depending upon the position of the gun in relation to the incoming signal from the fine transmitter at the director, the pointer of the lag meter will deflect to the left or right. The pointer of the lag meter is at zero when the gun is in the synchronous position (or any multiple of 200 mils away from synchronism).

b. Stroke control system (figs. 20, 21, and 25).—(1) Before considering the stroke control system it is necessary to understand the fundamentals of the hydraulic system (*c* below). The gun is positioned in azimuth and elevation by hydraulic motors called B-ends. These motors rotate in either direction depending upon the direction of the flow of oil and at a speed proportional to the amount of oil flowing. The direction and amount of flow are determined by the stroke of hydraulic pumps called A-ends. This stroke is varied by displacing a yoke. It is the stroke control system that positions the yoke. In addition, the stroke control system is responsible for returning the system to an inoperative condition when the gun has reached synchronism.

(2) The stroke control system consists of mixer, amplifier, and stroke control assembly (stroke control motor, stroke generator, and spring coupling). There are two stroke control systems, one for azimuth and one for elevation, identical in function but *not* interchangeable.

(3) The signal produced by the signal system when the gun is out of synchronism is called the "error signal." This signal is used to produce a mechanical motion which will actuate the hydraulic system. However, the error signal is not powerful enough to accomplish this and must be magnified. This is done by the amplifier. It is important to note that the amplifier is so constructed that the phase of the amplified a-c output is the same as any a-c input.

(4) The output of the amplifier, that is, the amplified sig-

nal, is connected across one field of the two-phase stroke motor. The other phase is connected across a fixed a-c power supply. The phase of this fixed supply is constant in magnitude. The low inertia stroke motor will rotate in one direction or the other, depending upon the phase of the output to the variable field from the amplifier. The phase of the output amplifier signal will determine in which direction the gun will move to go into a position of synchronism. The rotary motion of the motor is transmitted to the hydraulic

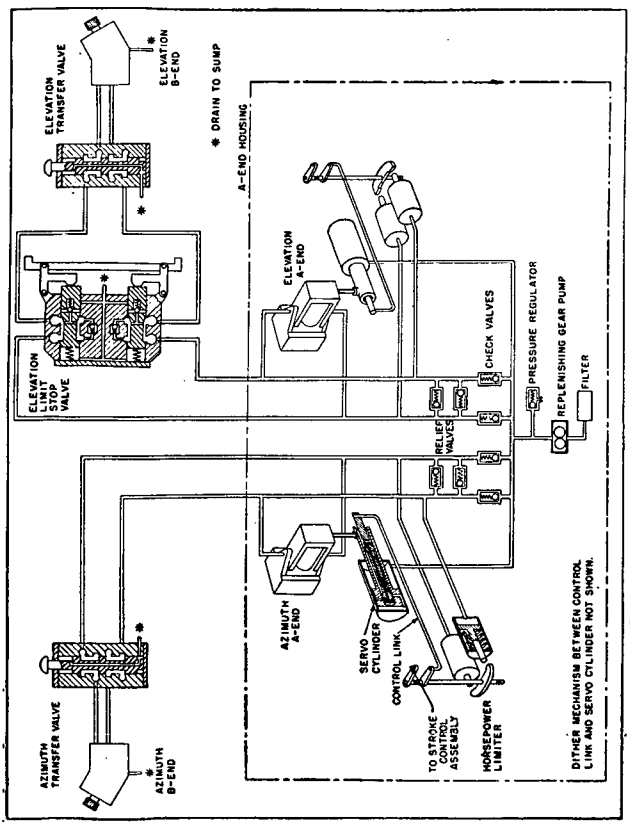


FIGURE 22.—Hydraulic system—schematic.

system through the spring coupling, and the hydraulic system acts to move the gun in either direction according to the phase of the original error signal.

(5) A vital part of the stroke control system is the d-c generator. Consider how the remote control system would work without it. The error signal is amplified and converted to mechanical power which is used to displace the yoke of the A-end hydraulic pump, and the gun moves toward synchronism. At the instant the gun reaches synchronism, the error signal becomes zero but the hydraulic system is driving the gun at maximum rate. As the gun passes the synchronous position, an error signal of opposite phase builds up, is amplified and converted to mechanical power, and motion of the gun is reversed. This will be repeated over and over again, the gun never quite settling at the synchronous point; the swinging back and forth is known as "hunting."

(6) The above situation is avoided through the action of the d-c generator. As the stroke motor rotates, displacing the A-end yoke, it also rotates a d-c generator through mechanical gearing. The generator produces d-c voltage proportional to the speed of rotation. The voltage goes through a circuit where it ultimately opposes the error signal voltage; this circuit is called the mixer. The d-c voltage, during a time interval, is "stored up" in a condenser in the mixer.

(7) Time is required for the opposing d-c voltage to charge up the condenser, and the error signal causes the stroke motor to displace the A-end yoke through a maximum angle, producing a maximum gun speed toward the synchronous position. As the gun approaches synchronism, the error signal decreases in magnitude. However, the d-c generator has already dropped its charge, due to the fact that the condenser discharges its accumulated voltage in a very short time. As the gun goes past synchronism and the stroke motor reverses due to the reversal in signal, the d-c generator also rotates and once more builds up a charge on the condenser. The gun is now under the influence of the synchrotransformer signal, which is zero at synchronism. At some point between the time when the gun reverses after its first swing past synchronism and the time when it again goes by synchronism in opposite direction, the voltage stored up on the condenser overcomes the input signal. It has not had time to dis-

charge its signal, and thus after the gun has passed synchronism once, the condenser charge overcomes the synchro-transformer signal, which is decreasing, and runs the stroke motor to position the yoke to neutral, causing the gun to stop moving and settle into synchronism with only one, possibly two, "overswings."

c. Hydraulic system.—The hydraulic system accomplishes the actual moving of the gun. It works as a variable speed rotary drive. (See figs. 22 and 25.)

(1) *Principal parts.*—The principal parts of the hydraulic system are—

(*a*) Variable delivery pump, called the A-end pump.

(*b*) Fixed stroke hydraulic motor, called the B-end motor.

(*c*) Hydraulic piping connecting pump and motor.

(2) *Auxiliary equipment.*—The auxiliary equipment consists of—

(*a*) Replenisher pump.

(*b*) Relief and check valves (in one assembly).

(*c*) Servo cylinder.

(*d*) Horsepower limiters.

(*e*) Dither mechanism.

(*f*) Transfer valves.

(*g*) Elevation stop valve.

(3) *A-end pump* (figs. 20, 21, 23, and 25).—The A-end pump consists of a flange and shaft, a cylinder block connected to the flange by a universal link, and pistons and connecting rods. The pistons are retained in cylinders in the cylinder block and are connected to the flange by connecting rods. The flange and shaft are rotated at constant speed. Through the universal link connection (not shown in fig. 23), the cylinder block rotates with the flange. The angle between the axis of rotation of the cylinder block and that of the flange can be varied. If there is no angle between the two, then, in the course of rotation, the pistons will not move either inward or outward in their cylinders. If there is an angle, then each piston in its cylinder will move inward during one-half revolution, and outward during the next. Each piston in its cylinder, during the course of rotation, comes opposite two ports. Depending upon whether the piston is moving inward or outward in its cylinder as it

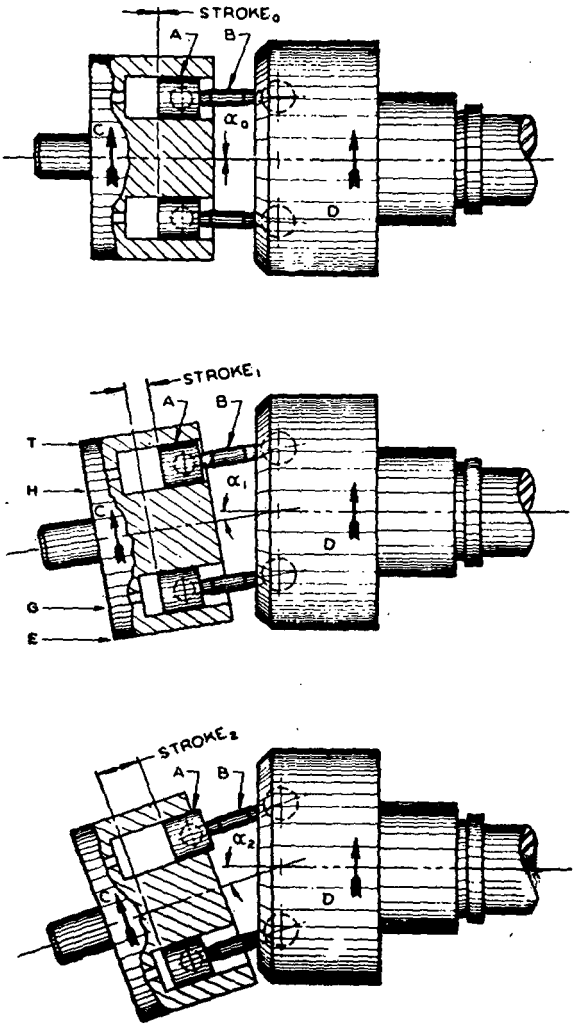


FIGURE 23.—A-end pump.

comes opposite a port, it draws oil through the port, or delivers it. Thus, depending upon the angle between the axis of rotation of the cylinder block and that of the flange, a certain amount of oil is pumped by the action of the cylinders.

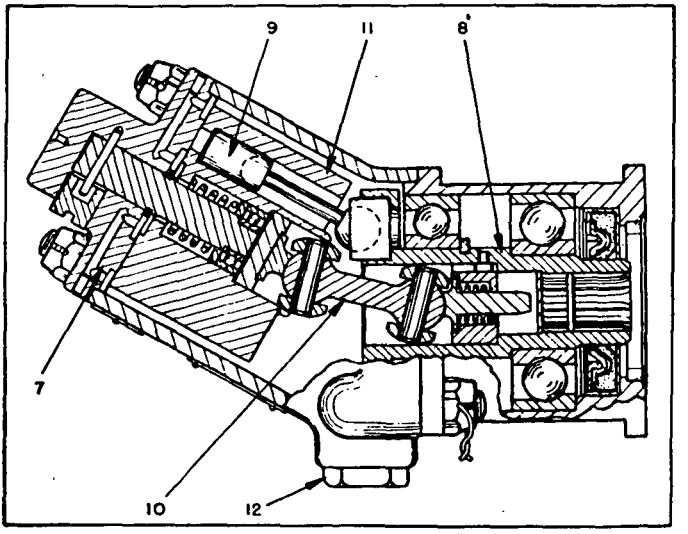
Since the speed of rotation is constant, the rate of delivery of oil will also vary with the angle. If the angle is reversed at the A-end pump, the flow of oil will reverse, the high pressure line (outlet) becoming the low pressure line (inlet) and vice versa.

(4) *B-end motor* (fig. 24).—Except for the fact that the angle between the axis of rotation of the flange and that of the cylinder block is fixed, the B-end motor is constructed exactly the same as is the A-end pump. Just as a simple electric generator can be made to run as an electric motor, so the hydraulic pump arrangement described above can be run as a hydraulic motor. It involves a simple reversal of procedure. As the oil enters a given port under pressure, it exerts force on the piston head; this force is transmitted through the piston and connecting rod to the flange, whose construction prevents any movement except rotation. Through the universal link connection, the cylinder block is also made to rotate. If the flow of oil reverses, inlet ports become outlet ports and vice versa, and the direction of rotation of the B-end motor reverses.

(5) *Replenisher pump.*—Theoretically, the oil should travel from the A-end pump to the B-end motor, do its work, and return, without leakage. However, leakage cannot be prevented. The replenisher pump, which is a gear-type pump, is driven by the same motor which provides power for the system. It acts as its name implies, supplying oil to the low-pressure side to replace oil lost through leakage.

(6) *Relief and check valves assembly.*—The check valves admit oil from the replenisher pump to the low pressure side at a minimum pressure of 75 pounds. The relief valves are just that; if too much pressure (more than 1,400 pounds per square inch) should be built up, they allow the oil to pass from the high to the low pressure side without going through the B-end motor, that is, the oil is detoured.

(7) *Servo cylinder* (fig. 26).—Just as the error signal must be magnified to run the stroke control motor, so the force exerted by the stroke control motor must be amplified before it can move the A-end yoke. The servo cylinder is the "force amplifier." The stroke control motor moves the follow valve in one direction or the opposite. As the follow valve moves,



7. Valve plate carrying inlet and outlet ports (not shown).
8. Drive shaft.
9. Piston.
10. Universal joint.
11. Cylinder block.
12. Drain hole.

FIGURE 24.—Operation of B-end motor—schematic.

it opens one of two ports, allowing oil to enter and push against either the front of the face of the piston or the rear of the face, depending upon which port has been opened. The oil pressure moves the piston. As the piston moves, the open port is closed, motion ceases, and oil pressure holds the piston where it is positioned. If the stroke motor continues to move the follow valve, the piston continues to follow. The

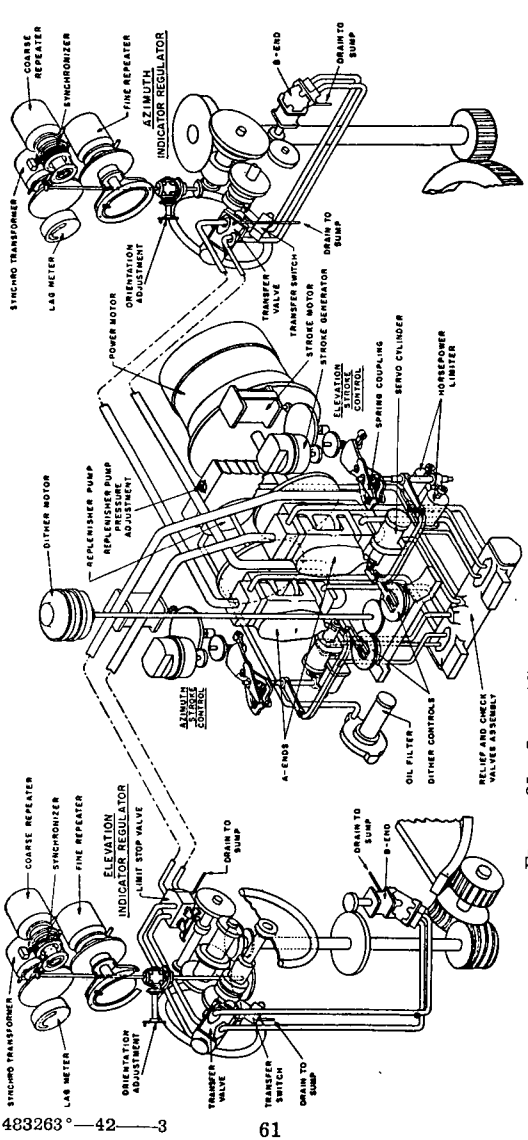
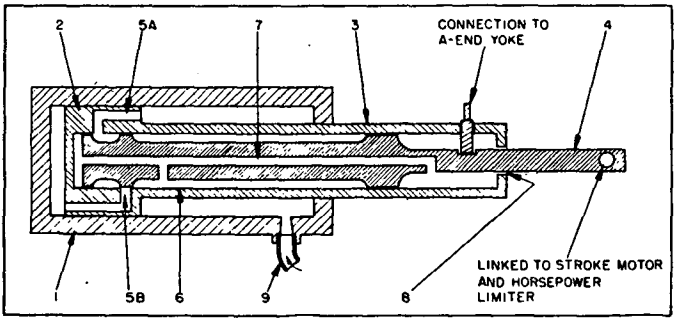


FIGURE 25.—Isometric diagram of remote control system M2.

piston, in moving, positions the A-end yoke, creating an angle between the flange and cylinder block of the A-end pump. The oil which operates the servo cylinder is supplied by the replenisher pump and enters at 75 pounds per square inch pressure.

(8) *Horsepower limiters* (fig. 22).—If there is too much pressure, the relief valves detour the flow of oil, so that it flows back to the A-end pump without going through the B-end motor. However, it may be necessary to reduce the rate of delivery of oil to the A-end pumps when the B-end motor is



1. Cylinder.
2. Power piston.
3. Piston rod.
4. Follow valve.
5. Ports.
6. Drainage canal.
7. Drain opening.
8. Drainage to sump.
9. Oil input from replenisher pump.

FIGURE 26.—Servo cylinder.

overloaded. (This also overloads the three-phase drive motor.) Two horsepower limiters (one for elevation and one for azimuth) take care of this. Each cylinder (each horsepower limiter has two cylinders) contains a piston and a spring under tension against the oil pressure from the main lines. If there is too much pressure, the piston moves against the spring. The piston protrudes from the cylinder, and in turn is responsible for moving the control link to the follow valve of the servo cylinder. This acts to move the A-end yoke toward the neutral position. The horsepower limiter acts to move the A-end yoke only part way to the neutral position,

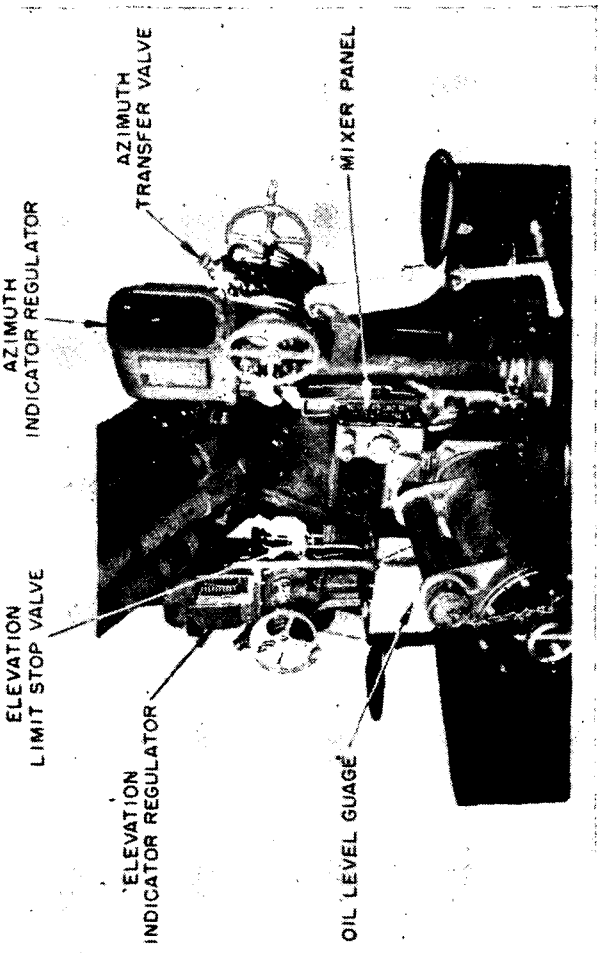


FIGURE 27.—90-mm gun M1A1 with remote control system M2 (azimuth side).

thus limiting the angle and the amount of oil pumped. The spring coupling on the stroke control allows the horsepower limiters to limit the amount of oil pumped even when the stroke control motor is calling for increased oil pumping, if that increased pumping would overload the motor.

(9) *Dither motor.*—This arrangement is a motor with gears and adjustable eccentric pins. It acts through the servo cylinder to shake the A-end. The eccentric pins make possible the shaking motion. The purpose is simply to eliminate the effect of sticking or backlash in the linkages or the effect of hydraulic dead spots. (A hydraulic dead spot occurs because of slight leakage past the pistons of the pumps and motors. The dither motor prevents this by imparting a slight motion to the mechanical links and to the oil at all times.)

(10) *Transfer valves.*—It may be desired to change from automatic to manual operation. For this purpose there is a hydraulic switch to disconnect the B-end motor from the A-end pump, bypassing the oil. As the knob is pushed in to change from manual to automatic operation, it connects the B-end motor and the A-end pump, and at the same time throws a switch closing the electrical circuit between output of the amplifier and the stroke control mechanism.

(11) *Elevation limit stop valves.*—There are mechanical stops limiting the motion in elevation. However, it would not be desirable to have the mechanism hit the stop at full speed, and so a throttling device is needed. A pair of valves perform this function. They are each actuated by an elevation stop nut; the valve is closed as the nut approaches its limit. The throttling is not complete. It merely retards the rate of flow of oil, and thus slows the movement of the gun so that it moves slowly into the mechanical stops.

■ 46. OPERATION.—*a. Preliminary tests and adjustments.*—The preliminary tests and adjustments, step by step, are as follows:

(1) With the main load switch at the power plant "off"—

(*a*) Level the gun.

(*b*) Orient the gun.

(*c*) Check level of oil in the A-end housing. Add oil, if necessary, and notify ordnance in case of leakage.

(*d*) Check lag meters at both indicator regulators. If either pointer is not directly over the center mark, unscrew the small plug under the left sliding cover of the indicator regulator; set the pointer to the proper position by turning the slotted shaft with a screw driver. *This is a simple mechanical adjustment. Caution:* Turning this slotted shaft too much may weaken the spring in the adjusting mechanism.

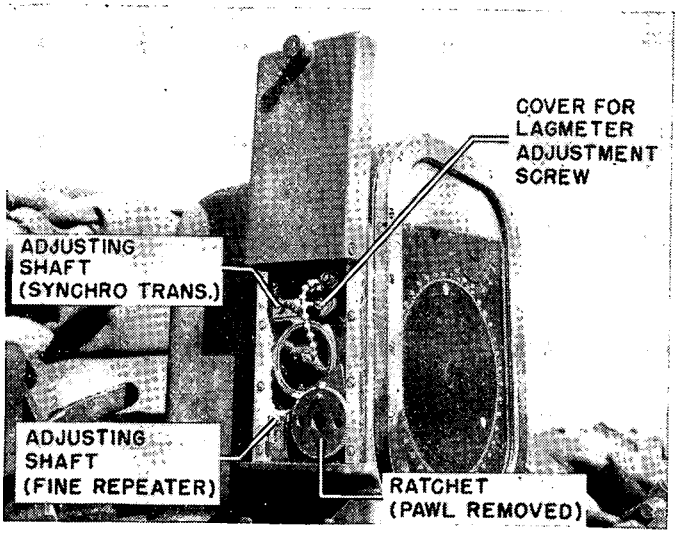


FIGURE 28.—Indicator regulator M1—left side.

(*e*) Make certain that the gun is set for "manual" operation. The transfer valves should be out. The handwheels should be engaged. The indicator regulator switches should be set at "manual." The motor switch at the gun junction box should be "off."

(*f*) Have the power plant voltmeter reading about 75 volts.

(2) With the main load switch at the power plant "on."—

(*a*) Set voltage at the director voltmeter to 115 volts by adjusting the position of rheostat knob at generator control panel. *The voltage must be built up gradually.*

(*b*) Synchronize the cable system. (This is the same as synchronizing the M4 or M6 data transmission systems.)

(*c*) Apply calibration corrections required by the gun.

(*d*) Operate the gun manually in both azimuth and elevation, checking mechanical operation to make certain that no undue strain will be put on the system when it starts functioning. In each case, note action of lag meter pointer.

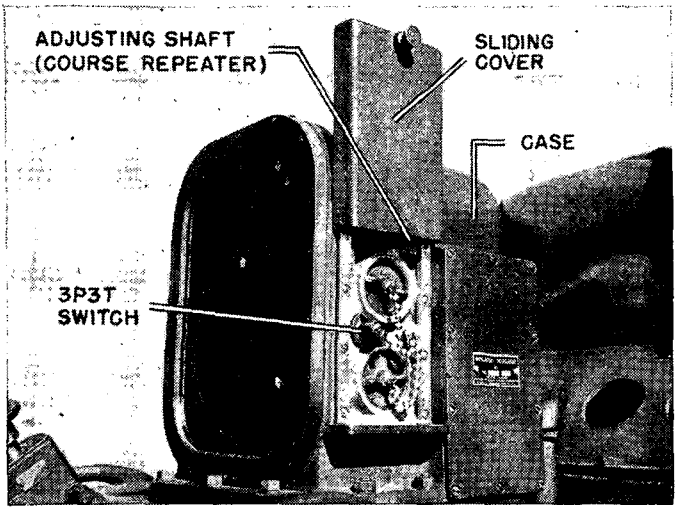


FIGURE 29.—Indicator regulator M1—right side.

When the transmitter data is less than 200 mils ahead of the gun position, the lag meter pointer should swing to the right, and vice versa.

(*e*) Turn motor switch at the gun junction box to "on." Listen for any abnormal noise or other evidence of malfunctioning of the mechanisms in the A-end housing.

(*f*) If the temperature is below 0° F., allow the motor to run for at least 3 minutes to warm up. Above that temperature no warming up period at all is required if the cable has

been plugged into the gun mount and the power plant is running.

NOTE.—The motor switch does not control the amplifier. The amplifier is on whenever the cable is furnishing power.

(*g*) Clear platform of unnecessary personnel. *Reason:* While the steps below are being performed, the gun may swing around or depress, and cause injuries.

(*h*) Set the gun manually to the synchronous position and zero the lag meter by adjusting the synchrotransformer screw under the left-hand cover plate of the azimuth indicator. Set the gun no more than 50 mils out of synchronism in azimuth. Set the indicator-regulator switch at "Automatic."

(*i*) *1.* Disengage handwheels, pushing them toward the muzzle of the gun.

2. Depress transfer valve. The gun will move in synchronism. Make sure that it does so without excessive hunting.

3. Check lag meter pointer. If it is not at zero, remove the amplifier cover cap and turn the slotted shaft marked AZ until the pointer is directly over the center mark. *Reason:* If the lag meter pointer is off when the system is set in operation and the gun returns to a stationary position after seeking synchronism, it indicates that a signal is being sent out. This should not be the case in synchronism. The only reason it could be so is that the amplifier is not correctly adjusted and is producing a voltage, causing a false signal output which will move the gun until it is neutralized by an error signal produced by the signal system. This error signal will be false but will be indicated by the lag meter and, although the gun is stationary, the position is one of false synchronism.

4. Check fine mechanical pointer. It will usually be in synchronism and the following procedure will not be necessary. If it is not in synchronism with the data transmitted from the director, turn the slotted shaft of the synchrotransformer under

the left sliding cover of the indicator regulator until the fine mechanical pointer is at the same setting as the fine transmitter dial. *Reason:* When this operation is performed, the stator of the synchrotransformer is turned and a signal is sent out which causes the gun to turn. Through the mechanical gearing, the Y-coil of the synchrotransformer will also turn until it induces no voltage in the stator and no error signal is sent out. If necessary, readjust balance of amplifier which may have been moved too far in one direction.

(*j*) Repeat (*h*) and (*i*) for elevation.

(*k*) Repeat (*h*), (*i*), and (*j*), setting the gun about 400 mils out of synchronism. Observe the operation of the system. (Note that steps (*h*) and (*i*) check synchrotransformer operation, and step (*j*) checks synchronizer operation.)

(*l*) Turn indicator regulator switches to "automatic."

(*m*) With transfer valves depressed, operate the gun from the director, observing the manner in which the gun responds to various rates.

(*n*) Check operation of elevation limit stop at both extremes.

b. Operation.—If the preliminary tests and adjustments are carefully and accurately performed, the remote control system will function perfectly unless some part of the system should break down. The following checks should be made frequently:

(1) When power is off, lag meter pointer should be at zero.

(2) Voltage at the director should be checked; it should be kept as near 115 volts as possible in no case being allowed to fall below 109 or rise above 121 when guns are not being speeded up or slowed down. Large fluctuations mean trouble at either generator or guns.

(3) The balance of the amplifier should be checked in azimuth and elevation, as described in *a*(2)(*i*)3 above. Temperature change and other conditions may cause slight variations.

(4) Operating personnel should be on lookout at all times for any indication that the system is not functioning properly.

(5) A gun should not be left at either elevation limit with the hydraulic system in operation.

c. Removal from operation.—These are the steps to remove the system from operation:

(1) Pull out proper transfer valve.

(2) Turn off motor switch. (Replace motor switch cover cap if system is not to be operated for any length of time.)

(3) Return proper indicator regulator switch to "manual" position, adding the fine repeater to the system.

NOTE.—*Whenever moving the indicator regulator switch from "automatic" to "manual", hold it at the half-way point for 5 seconds. Reason:* When the indicator regulator switch is thrown to the "manual" position, the fine repeater is added to the circuit. The pause in the intermediate position of the switch gives the fine repeater rotor time to synchronize with the fine transmitter at the director at reduced voltage, thus placing no strain on the electrical circuit.

(4) Engage the handwheels.

d. Return to operation.—Once the system has been synchronized and balanced properly, it may be put back in operation as follows:

(1) Turn motor switch at the gun junction box to "on."

(2) Turn indicator regulator switches to "automatic."

(3) Disengage handwheels.

(4) Push in transfer valves.

e. Warning.—The foregoing constitutes a basic discussion of the theory of operation of the remote control system M2. It covers the essentials and is complete enough to serve its purpose, but it will not furnish the reader with sufficient technical knowledge to attempt trouble shooting or any operation requiring removal of cover plates of the system.

■ 47. MAINTENANCE.—*a. General.*—(1) *Cleanliness* should be the watchword of using personnel. Its importance cannot be overestimated. Dirt and dust must not be allowed to enter any part of the remote control system. The purolator should be cleaned at least once every 6 months. Only new oil should be added to the system, and oil should be strained through a strainer of fine wire mesh when being added to the system; it must *never* be strained through any type of cloth strainer, or it will carry lint into the system.

(2) Voltages must be checked frequently, and kept up to the required strength. Any unwarranted drop in voltage will

cause the pointers and various parts of the system to lag. This lag will be cumulative, and cause the system to function improperly.

b. Care and preservation.—(1) All operations relating to trouble shooting and to care and preservation of the remote control system M2 should be performed only by authorized personnel. Ordnance personnel or using personnel who have successfully completed a course on the remote control system M2 at the Antiaircraft Artillery School are authorized to do this work.

(2) Parts of the signal and stroke control systems, such as condensers or vacuum tubes, should be replaced when necessary.

(3) When the oil is to be replenished or replaced in the hydraulic system, the following precautions must be observed:

(*a*) Oil in the reservoir must be kept at the proper level; this level is checked at the window of the A-end housing front cover.

(*b*) When adding oil, allow no foreign matter to enter the system. Do not use any type of cloth strainer; strain through fine wire mesh. Use new oil.

(*c*) Keep spare containers of oil sealed, if possible, or at least covered, until used. The purpose of this is to prevent the absorption of moisture by the oil.

(*d*) Use no oil other than that specifically issued for use in this system. The sealed cans in which the oil is received should bear the imprint "U. S. (Army) Spec. No. 3580", in addition to any trade-mark name or other designation.

(*e*) The oil in the system should be changed frequently enough to insure proper operation.

(*f*) When the oil is changed, the system should be flushed with fresh oil. *Use no oil or liquid except fresh oil conforming to the specification of* (*d*) *above for this purpose.*

(*g*) After the oil has been changed, the power motor should be turned on for a few minutes in order to allow the system to clear itself of air. The system may be very noisy until all air is removed, but no damage will result. After this has been done, the oil level should be rechecked.

c. Trouble shooting.—Trouble shooting is divided into three separate parts. Preliminary tests ((1) below) cover those

tests which should always be made when any fault appears. They are checks to determine that the usual precautions have been taken. These tests are mostly visual checks. General tests ((2) and (3) below) include those tests which are not specific, but which check a number of the units or circuits

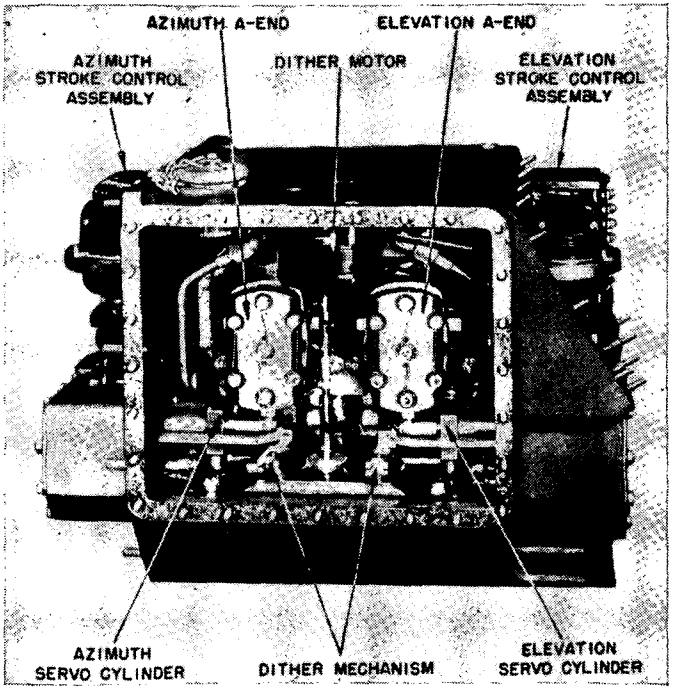


FIGURE 30.—A-end housing—interior view.

making up the system. They constitute something of a general diagnosis performed when the system ceases to function properly. Miscellaneous troubles ((4) below) list possible symtoms cross-referenced to a list of specific causes.

(1) *Preliminary tests.*—These checks should be made immediately when the system fails to operate properly.

(*a*) Check the oil level in the A-end housing. This is done by noting visually whether or not the oil in the housing comes up to the line on the oil level gage mounted on the front cover of the A-end housing.

(*b*) Check the voltage applied to the system. This should be no less than 109 and no more than 121 volts.

(*c*) Check the mechanical operation of the elevating and traversing drives. Manually elevate and traverse the gun to make sure that the gearing is free, and that the equilibrator is functioning properly.

(*d*) With power "on" and the system set for "manual" operation, check at several points to make sure that the fine and coarse dials on the indicator regulator are accurately indicating the data transmitted by the director.

(*e*) Check to make sure that the transfer valve plunger is pushed "in" all the way to the "automatic" position.

(2) *General test No. 1.*—General test No. 1 is performed as follows:

(*a*) The lag meter pointer should register zero under these conditions: Data system connected to director and gun; transfer valve plunger "in"; power switch "off"; gun and director synchronized. If the lag meter does not read zero, adjust the synchrotransformer to cause it to do so, as described in paragraph 46*a*(1)(*d*).

NOTE.—In case the demodulator fails to work, synchronization of the gun and director must be checked by determining that there is zero voltage between terminals S1 and S2 in the indicator regulator. *Reason:* If any voltage exists between S1 and S2, an error signal is being sent out by the signal system, and synchronism does not exist. If there is no voltage between those two terminals, no error signal is being sent out, indicating synchronism has been achieved. Demodulator failure may result in a false lag meter reading.

(*b*) Under the conditions given in (1) above, the following five tests should be performed after removing the covers over the stroke control mechanism:

1. The large gear of the stroke control assembly should not rotate. Slow rotation of this gear indicates a slight amplifier unbalance or lack of synchronism between gun and director if the system is functioning properly. *Reason:* When the power switch is "off", the power motor does not run.

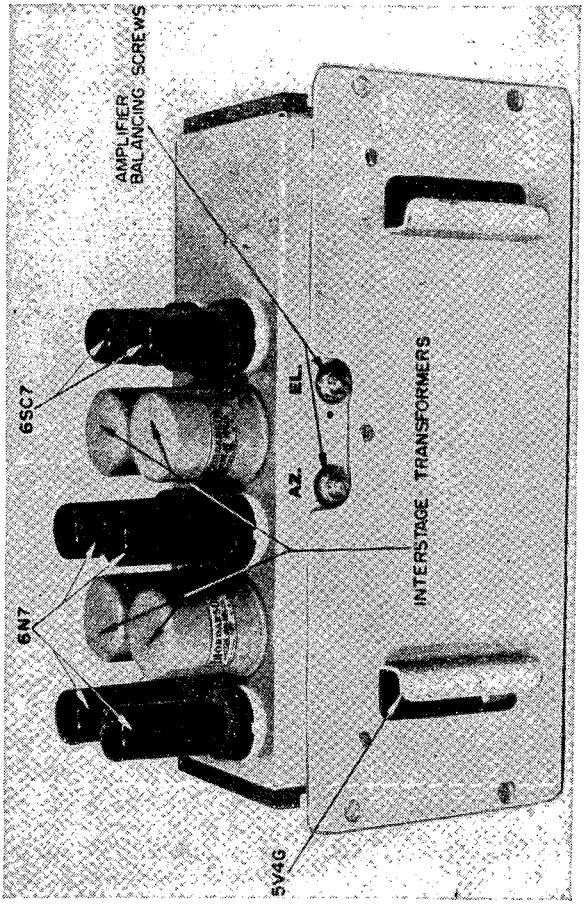


FIGURE 31.—Amplifier.

Therefore, the hydraulic system does not work, and the gun does not move. Therefore, any signal, either an error signal caused by lack of synchronism between gun and director or a false error signal caused by amplifier unbalance, can be detected only through motion of the large gear of the stroke control assembly, since the stroke control assembly is activated by the output of the amplifier.

2. With the index finger, flip the large gear of the stroke control unit. The gear should return approximately to its original position. *Reason:* As the gear is turned, direct current will be generated proportionately by the d-c generator. This will act through the mixer and the amplifier to return the gear to its original position, since the condenser has not had time to discharge.
3. With the index finger, turn the large gear of the stroke control unit to one side, and hold for about 5 seconds. Release; the gear should hold this new position. *Reason:* The power motor is not running, and the gun is not turning. The 5 seconds gives the condenser time to discharge. Note that this will work only if the amplifier is balanced, and not sending out a false signal.
4. With the index finger pull the large gear slowly to one side. There should be a uniform resistance to this pull. *Reason:* The condenser is both charging and discharging at a constant rate and, acting through the amplifier, causes the stroke motor to resist rotation of the gears. Uniform resistance indicates that there is no mechanical impediment in the system and that the electrical circuits are functioning properly.
5. With the index finger pull the large gear swiftly to one limit, and note the momentary voltage output from the amplifier on terminals Nos. 1 and 3 of the stroke motor. For both directions of motion of the large gear, this voltage should be 12 to 15 volts.

(*c*) Successful results on the above test indicate that the amplifier, mixer circuit, transfer switch, stroke motor, and stroke generator are all functioning properly, and that the phase rotation of the power supply is correct. Conversely, improper operation indicates malfunctioning of one or more of the above units or faulty system wiring.

(3) *General test No. 2.*—Test No. 2 is performed as follows:

(*a*) *1.* Disconnect wires from terminals Nos. 24 and 25 of the demodulator.

2. Move the gun manually into approximate synchronism with the director.

3. Set the system for "automatic" operation.

(*b*) Under conditions set forth in (1) above, perform the following operations:

1. With a constant speed input signal, make sure that the gun follows smoothly in the proper direction.

2. Make certain the gun synchronizes from 150 mils off the synchronous position without hesitation. (If the gun is moved more than 200 mils from synchronism with the director, it will proceed to "synchronize" at some other point.)

(*c*) Proper performance of this test indicates correct functioning of the entire system with the exceptions of the synchronizer, coarse Selsyn data system, or synchronizer voltage supply circuit (located in the demodulator). *Reason:* When leads 24 and 25 were disconnected, the synchronizer and the coarse Selsyn data system were cut out of the system. With the gun 150 mils from synchronism, these would send no signal and the synchrotransformer would carry the gun to synchronism. The proper performance of the above test indicates that the synchrotransformer is correctly sending out its signal, and the stroke control and hydraulic systems functioning properly. If any system does not function correctly until one section is removed from it, obviously the fault lies in that section.

(4) *Miscellaneous troubles.*—A list of troubles which may affect the system, gun mount, or data transmission system, and thus cause the remote control system M2 to operate improperly is given below. Symptoms are cross-referenced to causes and remedies, and causes are referred to by number in the order of probability of their occurrence.

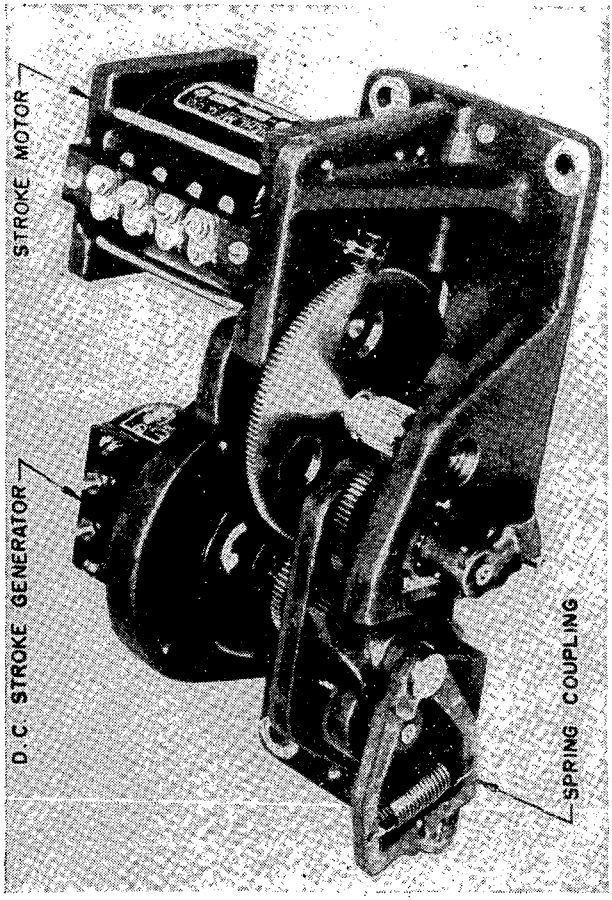


FIGURE 32.—Stroke control assembly.

Symptoms

1. Power motor running, but no gun motion in either axis. (1, 2, 3.)
2. Intermittent noise from A-end (due to air in hydraulic system). (3, 4, 2.)
3. Low top speed. (5, 6, 7.)
4. Sluggish operation. (8, 5, 7.)
5. Rough operation in elevation. (6, 9.)
6. Gun operates continuously in one direction. (8, 10, 11, 13, 14, 15, 16.)
7. Hunting uniform, but will track if set in synchronism. (8, 15, 16.)
8. Hunting continuous and uniform, and cannot be made to settle out. (8, 17, 18, 19, 15, 16, 12.)
9. Erratic hunting. (20, 10, 21, 22, 16, 15.)
10. Tracks and synchronizes smoothly, but lag meter shows large error. (24.)
11. Works only one way in elevation, that is, either elevates only or depresses only. (25.)
12. Gun will synchronize at any one of several points. (23.)
13. Motor stalls easily. (26.)
14. Gun wanders one or two mils while tracking or at standstill. (27, 15, 16.)
15. No gun motion in one axis, normal operation in other axis. (13, 14, 8, 10, 11, 15, 16.)

Causes and remedies

1. Three phase motor power supply reversed. Check with a phase indicator, and reverse leads, if necessary (general test No. 1).
2. No oil replenisher pressure. Replenisher pump may require priming if the power motor has been operated from power supply with wrong phase rotation, or if the pump has been operated with low oil level. Check the oil level. Pull out transfer valves, and let system run for a while, with oil being by-passed, until pump is primed.
3. Oil level low. Check, using sight gage on front of A-end housing. If too low, replenish. Do *not* strain oil through any kind of cloth.
4. Leak in hydraulic high pressure lines or blown gasket.
5. Handwheel torques high. Check, measuring handwheel torques by applying known weights to handwheels. Less than 41 pounds should be required at handwheel handles in elevation, and less than 15 pounds in azimuth.
6. Equilibrator not properly adjusted. If equilibrator is too weak, movement of the gun may be rough during depression; if too strong, the movement of the gun may be rough during elevation.
7. Sticky horsepower limiter plunger. Check with power switch "on." Operate the control manually toward one side. Horsepower limiter plunger should operate, because of gun acceleration, tending to stop control arm from being pulled all the way to one side. As gun picks up speed, horsepower limiter action should cease, permitting control arm to move all the way to one side. This condition may be revealed by shuddering as the gun is either elevated or depressed, or as it is traversed to the left or to the right.
8. Faulty amplifier or tubes (general test No. 1). Check, and insert new amplifier or new tube if necessary.

9. Backlash in gun mount gearing. Dither may show on mechanical dials of the indicator regulator without appreciably vibrating gun mount.

10. Open circuit in data to indicator regulator. Check operation of fine and coarse dials.

11. Open circuit in leads S1 and S2. This will be the case only if the circuit opens after the A-end yoke has been displaced. Check continuity.

12. Open circuit or short circuit in mixer. Check continuity and resistance values.

13. Transfer switch failure. Check continuity. Resistance between O1 and M1 in indicator regulator should be zero ohms when transfer plunger is pushed "in," and approximately 13 ohms when transfer plunger is pulled "out."

NOTE.—As applied to 6, that is, gun operating continuously in one direction, this situation can come about only if the A-end yoke has been moved by the system prior to transfer switch failure. *Reason:* The A-end yoke has then been displaced, and, with the failure of the transfer switch, no signal can get through to bring it back, and the gun will continue to operate in one direction.

14. Fixed field of stroke motor not energized. Symptom 6 will be evident, only if A-end yoke has been displaced before trouble occurs. *Check:* Read voltage at terminals Nos. 3 and 4 of stroke motor or terminals M and OA 2 or OE 2 in the gun junction box. They should read about 20 volts a-c (general test No. 1).

15. Mechanical sticking of stroke control. *Check:* With transfer plunger "out", stroke control should rotate freely and evenly by hand (general test No. 1).

16. Sticky stroke linkage or servo cylinder. *Check:* Observe spring coupling on stroke control assembly. The jaws should not open during normal constant speed tracking. They may open slightly during sudden oscillation or while synchronizing. *Reason:* The purpose of the spring coupling is simply to allow momentary motion of the follow valve and associated parts in one direction after the stroke motor has reversed direction. It imparts a braking action, since inertia would make a sudden mechanical reversal of direction inadvisable. The jaws should not be open unless direction is being reversed, or during oscillation or synchronization.

17. Faulty stroke generator. *Check* (general test No. 1): Reason for observed hunting is covered by the explanation in paragraph 45*b*(5) concerning the operation of the system without the d-c generator.

18. Condenser open-circuited. *Check:* Measure resistance from C1 to C2 on high resistance scale of analyzer. Pointer should deflect toward zero momentarily.

19. Condenser short-circuited (general test No. 1). *Check:* Measure resistance from C1 to C2. If short-circuited, the resistance will read less than 1,000 ohms.

20. Intermittent short circuit or open circuit in any of the electrical components or wiring system (including loose ground strap on amplifier box).

21. Coarse synchronizer or coarse repeater sticking. *Check:* Observe operation of coarse dial (general test No. 2). *Reason:* This situation will cause improper reception of data from director and the result will be erratic error signaling and erratic hunting.

NOTE.—If all guns of a battery are connected to the cable system, but only *one* gun is being operated, slight sticking of coarse repeaters

in the other guns may cause the operating gun to hunt erratically. Cables should be disconnected from guns not in use.

22. Electrical rotation of coarse repeater or fine synchrotransformer reversed. Check coarse repeater by observation of coarse dials on gun and director. Check fine synchrotransformer by removing leads 24 and 25 (disconnecting synchronizer), and note the direction of travel of the gun with respect to director in "automatic" operation (general test No. 2). *Reason:* If the electrical rotation of the synchrotransformer is reversed, every time the synchronizer brings the gun to within 150 mils of synchronism, the synchrotransformer, instead of carrying the gun the rest of the way, will throw it back away from synchronism. At this point, the synchronizer will take over, bring the gun to within 150 mils of synchronism, and the process will be repeated over and over again. On the other hand, if the synchronizer's electrical rotation is reversed, then it will turn the gun *away* from synchronism, and, every time the synchrotransformer takes over it will "synchronize" the gun at some point off synchronism. (If, in this latter case, the gun is originally within 150 mils of synchronism, the synchrotransformer will carry it to true synchronism.)

23. Open circuit in synchronizer or no voltage applied to synchronizer. Check continuity and voltage between terminals 23 and 24, and 23 and 25. This voltage should be over 14 volts (general test No. 2).

NOTE.—This will be true only if gun is at least 150 mils out of synchronism. *Reason:* If gun is within 150 mils of synchronism, the synchronizer has no effect upon it, and any fault in the synchronizer will not be apparent.

24. Demodulator failure. *Check:* Operate gun manually to bring voltage between S1 and S2 to zero. The lag meter should then read zero. *Reason:* When synchronism exists, there should be no error signal sent out (as evidenced by zero voltage between S1 and S2); and when there is no error signal, the lag meter should read zero.

25. Elevation limit stop value sticking. If, after the gun has hit a stop, it can be made to pull out of that stop when in "automatic" operation but will not then run toward it, a sticky valve plunger is indicated.

26. Three-phase power switch making poor contact or no contact on one or more poles. Check continuity. *Reason:* Motor will run on one phase or two, but due to low torque, will stall easily.

27. Dither too small. *Check:* Dither should be just perceptible in sound of hydraulics and just detectable by touching the gun when the gun is traversing, elevating, or depressing. Dither should not shake dials.

d. Summary.—(1) If the remote control system M2 is properly cared for and operated correctly, it will function properly. In this respect, especially, the importance of *cleanliness* cannot be overestimated.

(2) If trouble should become apparent, check all guns in the battery, making sure that the trouble is not general; if all guns are affected similarly, then the trouble is general, and the cable system is probably at fault.

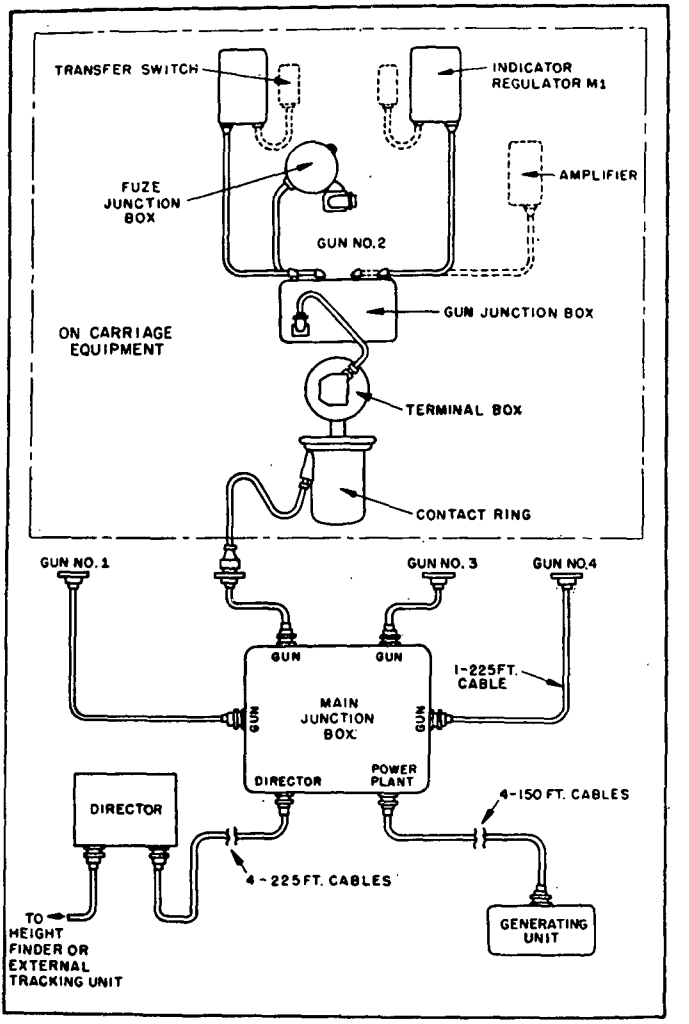


FIGURE 33.—Data transmission system.

(3) Before seeking the source of trouble on a gun, first check the source of power supply, the cable system, and the data receivers.

(4) Take all the time necessary to determine where the trouble is most likely to exist before taking anything apart. In other words, *diagnose before disassembling.*

SECTION X

FUZE SETTER M13

■ 48. DESCRIPTION.—*a.* The fuze setter consists principally of the fuze indicator, the adjusting mechanism, and the setting mechanism. The indicator and adjusting mechanism are inclosed within the case (lower part below hinge, fig. 35) while the setting mechanism is housed within the body (upper part above hinge).

b. (1) The fuze indicator includes a fuze range scale, a mechanical index (outer pointer), an electrical index inner pointer), and a standard a-c synchronous electrical receiving unit (fig. 34).

(2) The electrical receiving unit positions the electrical index at the position on the fuze range scale corresponding to the fuze setting transmitted from the director.

c. The adjusting mechanism is that mechanism which causes the fuze to be set at the particular fuze setting desired. A handwheel (fig. 34) is geared both to the mechanical index and to the adjusting ring (fig. 35). The function of the adjusting ring is to engage and hold fast the slot in the time setting cap of the fuze on the projectile. By turning the handwheel, the mechanical index is made to indicate a particular fuze setting and the adjusting ring is revolved to such a position that its pawl will stop the time setting cap on the fuze at the same fuze setting indicated by the mechanical index.

d. The setting mechanism, driven by the setting handle (fig. 34), contains a setting ring (fig. 35) and the setting ring pawl engages the slot on the body of the fuze and turns the projectile until the fuze body is properly positioned with respect to the time setting cap of the fuze.

■ 49. OPERATION DURING SETTING OF FUZE.—*a.* One turn of the setting handle causes the setting ring to make two revolutions. During the first revolution the setting ring pawl arrives at and engages the slot in the body of the fuze and rotates the entire round thereafter.

b. The adjusting ring, meanwhile, has been positioned according to the fuze setting indicated by the director (pointers matched). During either the first or second revolution

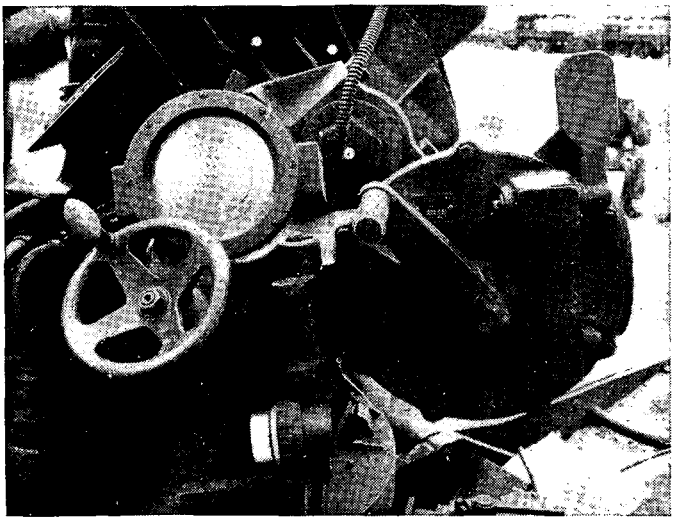


FIGURE 34.—Fuze setter M13—front view.

of the setting ring (depending on the position of the adjusting ring pawl with respect to the slot in the time setting cap of the fuze at the instant the projectile is inserted in the fuze setter) the slot in the time setting cap of the fuze arrives at and is engaged by the adjusting ring pawl, thus holding the time setting cap still thereafter.

c. The setting ring continues to turn the projectile until the second revolution is completed, when a stop pawl terminates the movement. In this position the body of the fuze

has been stopped at what might be called a "zero" position, while the time setting cap of the fuze has been stopped at a point the proper number of graduations away from the zero position, and the fuze is said to be "set."

■ 50. ADJUSTING AND SETTING RINGS.—The case and the body are hinged, and by loosening the wing nut holding the two together, it is possible to swing the body away from the case, giving access to the adjusting and setting rings. Two sets of rings are provided, one for the 30-second mechanical fuze,

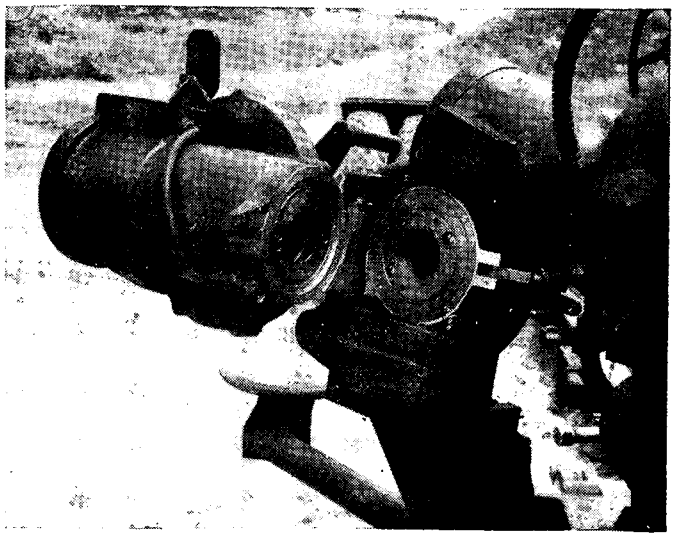


FIGURE 35.—Fuze setter M13—open.

and one for use with dummy cartridges. The rings are easily changed, and the rings of a particular set cannot be assembled improperly because the screw holes in the rings are spaced differently.

■ 51. ADJUSTMENTS.—*a. To change rings in fuze setter.*— Open the fuze setter as shown in figure 35, remove screws and lock washers in each ring already assembled in the fuze setter, and remove this set of rings. If the rings stick in place in the

fuze setter after the fastening screws have been removed, insert the screws into the tapped holes in the rings and pull the rings loose. Obtain the other set of rings from the accessory chest and assemble adjusting ring to adapter in the case or lower part of the fuze setter, and the setting ring to the socket in the body or upper part.

b. To orient mechanical index with fuze range scale on face of indicator.—If the outer or mechanical index does not indicate on the fuze range scale the fuze setting to which the fuze setter actually sets the fuze, it will be necessary to adjust the fuze range scale as follows: Carefully remove window frame from indicator face so as not to injure the gasket. Next sufficiently loosen the six screws in the ring which clamps the scale in place, to allow the scale to be moved. Place a round in the fuze setter, set the fuze, and read the setting on the fuze as closely as possible. Insert a blunt point in the hole in the scale over the zero and slide the scale around under the ring until the value set on the fuze is opposite the indicating marks on the outer or mechanical index. Recheck at another fuze setting, then tighten clamping ring screws evenly and firmly. Replace window and its fastening screws.

c. To synchronize electrical index with director.—Energize the data transmission system, set director so that the fuze dial reads any even fuze range, such as 14, and check the reading of the electrical index (inner pointer) with that transmitted by the director. If readings do not agree, take off cover plate of lamp well on right side (facing it) of fuze range indicator, and the electrical synchronizing screw will be found in the cavity. Turn it with a screw driver until the electrical index (inner pointer) reads the transmitted fuze range. Replace cover plate. Check fuze range indicator at several other settings both greater and less than the original. In this connection, before any changes are made, any calibration corrections which are to be or have been made in fuze range must be taken into consideration. See FM 4–110 for application of calibration corrections.

■ 52. CARE AND PRESERVATION.—The following instructions should be carefully observed in the care and preservation of the fuze setter:

a. The adjusting and setting rings should be removed frequently from the fuze setter, cleaned thoroughly, lubricated, and then replaced. These rings should be handled carefully to prevent the bending of the thin metal sides adjacent to the pawls, because any interference with the action of these pawls may cause erroneous fuze settings. In lubricating the rings, the surfaces except the pawls and their guides should be greased with petrolatum (U. S. A. Spec. 2–67) to prevent rust. The pawls and their guides should be oiled with lubricating oil for aircraft instruments and machine guns (U. S. A. Spec. 2–27).

b. The screws which fasten the adjusting and setting rings in place should be kept tight, with the lock washers under the screw heads to prevent the screws from loosening.

c. Rings which are not being used should be kept in the accessory chest.

d. Great care should be exercised in handling the rings and scale, especially when changing the rings or adjusting the scale, as they are easily deformed or damaged.

e. No provision has been made for lubricating in the field any of the internal moving parts, as the entire device should be torn down and serviced at regular intervals by ordnance maintenance personnel.

f. Care should be exercised, when handling the fuze setter, not to bump any part of the device. The wing nut on the eyebolt should be tight at all times, especially when the fuze setter is to be picked up. Always grasp the large main castings when handling. The fuze setter should not be laid down; it should be placed in its support on the gun mount or in the traveling bracket.

g. The fuze setter should be kept covered with the canvas cover when it is not in use.

h. Whenever the cable receptacle (fig. 34) is not connected to the gun junction box, it should be stowed on the dummy receptacle with the cable wrapped around the front of the fuze indicator.

SECTION XI

DRILL TABLES

TABLE I.—*Emplacement using prime mover*

GUN COMMANDER

Operation

A Commands: PREPARE FOR ACTION.
B Supervises.
C Supervises.
D Supervises.
E Directs as prime mover is moved forward.
F Judges when buffer spring has been sufficiently compressed, and orders prime mover backed up until gunner can perform his job.
G After bogie cylinder has moved out of way of axle lug, orders prime mover to be driven forward again, partially crushing mount, until counterpoise cylinder rods have entered into counterpoise cylinders far enough for Nos. 7 and 8 to perform their job.
H As soon as gunner has disconnected gun from prime mover, directs prime mover to move out.
I Supervises lowering trial.
J Supervises.
K Supervises.
L Supervises.
M Supervises.
N Supervises.
O Supervises.
P Supervises.
Q Supervises.
R Supervises.
S Supervises.
T Supervises.
U Supervises; is responsible for checking clearance between top of bogie frame and bottom of equilibrator cylinder.
V Verifies level of gun.
W Supervises.

Operation

X Supervises.
Y Supervises.

GUNNER

Operation

A Dismounts from right side of truck.
B Assists in untying gun cover, taking off to rear, and laying it on ground temporarily unfolded.
C Takes position at bogie buffer and turns handwheel so as to retract plunger a little.
D
E Screws down on bogie buffer retracting handwheel by hand.
F Pulls out on latch and swings forward end of cylinder down to lower position, when latch reengages.
G
H Takes position at and immediately behind lifting bar; leans across lifting bar and disconnects gun from prime mover.
I
J
K
L Unfastens transom cap.
M Unpins traveling lock brace and, as No. 2 elevates, lowers traveling lock, pinning it to trail.
N At trail, helps tip mount gently back on rear outrigger.
O
P
Q Disengages trail lock rocker arm swing bolt.
R With Nos. 1 through 8 supporting weight of trail, allows trail lock to swing up to maximum position; as Nos. 1 through 8 move trail to lower position, moves trail lock down, and refastens by means of swing bolt.
S
T
U Helps roll out bogie.
V Loosens auxiliary leveling screw, using ½-inch rod, and keeps it free from binding as mount is leveled. Tightens auxiliary leveling screw by screwing down.
W

Operation

X Helps fold canvas cover and place it on bogie buffer cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 1

Operation

A Dismounts from left side of truck, bringing bogie socket wrench.

B Unfastens break-away chain, pulls electric cables out of truck and bogie and inserts them in dummy receptacles on left side of trail.

C At left, sets bogie handbrake, and loosens wing bolts, holding platform to trail.

D

E

F

G

H Inserts lifting bar in end of trail and takes position at lifting bar.

I Presses down on trail.

J Helps extend and pin left outrigger.

K Helps remove and lay aside left platform.

L

M Assists gunner.

N At trail, helps tip mount gently back on rear outrigger.

O At left, loosens lock nut only on bogie engaging eyebolt. Places socket wrench on bogie securing bolt, preparatory to loosening.

P At left, disengages bogie securing bolt.

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S At left, loosens both nuts on bogie engaging eyebolt while No. 3 pushes in on bogie engaging eye operating handle.

T

U At left, rides bogie, holding up on bogie engaging eyebolt until it clears pedestal, then dropping it and

Operation

manipulating hand brake as directed by gun commander to guide bogie.

V

W Helps put left platform in place on outriggers and fasten it.

X Helps fold canvas cover and place it on bogie buffer cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 2

Operation

A Dismounts from right side of truck, bringing bogie socket wrench.

B Assists in untying gun cover, taking off to rear, and laying it on ground, temporarily unfolded.

C At right, sets bogie handbrake, and loosens wing bolts, holding platform to trail.

D

E

F

G

H Takes position at lifting bar.

I Presses down on trail.

J Helps extend and pin right outrigger.

K Helps remove and lay aside right platform.

L Takes position at elevation handwheel.

M Elevates gun slightly to clear traveling lock.

N Elevates gun to maximum.

O At right, loosens lock nut only on bogie engaging eyebolt. Places socket wrench on bogie securing bolt, preparatory to loosening.

P At right, disengages bogie securing bolt.

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S At right, loosens both nuts on bogie engaging eyebolt while No. 3 pushes in on bogie engaging eye operating handle.

Operation

T

U At right, rides bogie, holding up on bogie engaging eyebolt until it clears pedestal, then dropping it and manipulating hand brake as directed by gun commander to guide bogie.

V

W Helps put right platform in place on outriggers and fasten it.

X Lowers seat to using position.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 3

Operation

A Walks out on gun tube.

B Assists in untying gun cover, taking off to rear and laying it on ground, temporarily unfolded.

C Unfastens outrigger safety chain.

D

E

F

G

H Takes position at rear outrigger.

I Lifts rear outrigger.

J Helps extend and pin left outrigger.

K Helps remove and lay aside left platform.

L

M

N At trial, helps tip mount gently back on rear outrigger.

O Assists No. 7.

P

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S At left, pushes in on bogie engaging eye operating handle.

T At left, puts bogie hub wrench on wheel.

U At left, manipulates hub wrench.

V

Operation

W Helps put left platform in place on outriggers and fasten it.

X Helps fold canvas cover and place it on bogie buffer cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 4

Operation

A Dismounts from right side of truck, bringing wheel wrench.

B Assists in untying gun cover, taking off to rear and laying it on ground, temporarily unfolded.

C

D

E

F

G

H Takes position at rear outrigger.

I Lifts rear outrigger.

J Helps extend and pin right outrigger.

K Helps remove and lay aside right platform.

L

M

N At trail, helps tip mount gently back on rear outrigger.

O Assists No. 8.

P

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S At right, pushes in on bogie engaging eye operating handle.

T At right, puts bogie hub wrench on wheel.

U At right, manipulates hub wrench.

V

W Helps put right platform in place on outriggers and fasten it.

Operation

X Helps fold canvas cover and place it on bogie buffer cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 5

Operation

A Dismounts from left side of truck, bringing bogie ratchet wrench.

B Assists in untying gun cover, taking off to rear and laying it on ground, temporarily unfolded.

C At left, removes counterpoise cover.

D Helps unlatch, extend, and pin rear outrigger.

E

F

G

H Takes position at rear outrigger.

I Lifts rear outrigger.

J Helps extend and pin left outrigger.

K Helps remove and lay aside left platform.

L Removes equilibrator piston stop rod from equilibrator and puts it in holder on top of equilibrator.

M

N At trail, helps tip mount gently back on rear outrigger.

O Places fuze setter bracket and seat in firing position and places fuze setter in bracket.

P

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S

T

U Helps roll out bogie.

V

W Helps put left platform in place on outriggers and fasten it.

X At left, replaces canvas cover on counterpoise cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 6

Operation

A Dismounts from right side of truck, bringing bogie ratchet wrench.

B Assists in untying gun cover, taking off to rear and laying it on ground, temporarily unfolded.

C At right, removes counterpoise cover.

D Helps unlatch, extend, and pin rear outrigger.

E

F

G

H Takes position at rear outrigger.

I Lifts rear outrigger.

J Helps extend and pin right outrigger.

K Helps remove and lay aside right platform.

L

M

N At trail, helps tip mount gently back on rear outrigger.

O Places fuze setter bracket and seat in firing position and places fuze setter in bracket.

P

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S

T

U Helps roll out bogie.

V

W Helps put right platform in place on outriggers and fasten it.

X At right, replaces canvas cover on counterpoise cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 7

Operation

A Dismounts from left side of truck, bringing wheel wrench.

Operation

B Assists in untying gun cover, taking it off to rear, and laying it on ground, temporarily unfolded.

C

D Helps unlatch, extend, and pin rear outrigger.

E

F

G At left, pulls out on crank handle of gear box, swings box to front over end of cylinder, and fastens it in place with swing bolt and wing nut.

H Takes position at rear outrigger.

I Lifts rear outrigger.

J Helps extend and pin left outrigger.

K Helps remove and lay aside left platform.

L

M

N At rear outrigger, helps tip mount gently back on rear outrigger.

O At left, cranks down bogie until pedestal rests firmly on ground and wheels can be turned.

P

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S

T At left, cranks up bogie until there is enough clearance for bogie to be rolled out.

U Helps roll out bogie.

V Levels mount at left leveling jack. When level has been verified, tightens jack clamp, and places jack ratchet in neutral position. Places jack handle as close to rear outrigger as possible to prevent breakage of handle by platform reinforcing angle.

W Helps put left platform in place on outriggers and fasten it.

X Lowers seat to using position and connects cable to cable receptacle.

Y Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 8

Operation

A Dismounts from right side of truck, tossing out lifting bar.

B Assists in untying gun cover, taking off to rear and laying it on ground, temporarily unfolded.

C

D Helps unlatch, extend, and pin rear outrigger.

E

F

G At right, pulls out on crank handle of gear box, swings box to front over end of cylinder, and fastens it in place with swing bolt and wing nut.

H Takes position at rear outrigger.

I Lifts rear outrigger.

J Helps extend and pin right outrigger.

K Helps remove and lay aside right platform.

L

M

N At rear outrigger, helps tip mount gently back on rear outrigger.

O At right, cranks down bogie until pedestal rests firmly on ground and wheels can be turned.

P

Q Takes position at trail.

R Helps support weight of trail while gunner swings trail lock up to maximum position; helps move trail down to lower position.

S

T At right, cranks up bogie until there is enough clearance for bogie to be rolled out.

U Helps roll out bogie.

V Levels mount at right leveling jack. When level has been verified, tightens jack clamp and places jack ratchet in neutral position.

W Helps put right platform in place on outriggers and fasten it.

X Helps fold canvas cover and place it on bogie buffer cylinder.

Y Helps place dirt under those parts of outriggers which do not touch ground.

TABLE II.—*Emplacement without use of prime mover*

GUN COMMANDER

Operation	
A	Supervises.
B	Supervises.
C	Supervises.
D	Supervises.
E	Supervises.
F	Supervises.
G	Supervises.
H	Supervises.
I	Supervises.
J	Gives command to release brakes and crush mount.
K	Supervises.
L	Supervises.
M	Supervises.
N	Supervises.
O	Supervises.
P	Supervises.
Q	Supervises. *Is responsible for checking clearance between top of bogie frame and bottom of equilibrator cylinder.*
R	Verifies the level of the gun.
S	Supervises.
T	Supervises.
U	Supervises.

GUNNER

Operation	
A	Helps remove gun cover.
B	
C	
D	
E	Unfastens transom cap. As No. 2 elevates gun slightly, unpins traveling lock brace and lowers traveling lock, pinning it to trail.
F	Retracts bogie buffer plunger, using socket wrench.
G	
H	Pulls out on latch on right side of bogie buffer cylinder and swings down forward end of buffer cylinder. (The latch reengages when the cylinder has moved to the lower position.)

Operation

I At trail, helps balance mount so that all outriggers are parallel to ground.

J Helps apply downward pressure to mount, partially crushing it.

K

L

M

N Disengages trail lock rocker arm swing bolt. With Nos. 1 through 8 supporting weight of trail, allows trail lock to swing up to maximum angle. As Nos. 1 through 8 move trail down to lower position, moves trail lock down and refastens it by means of swing bolt.

O

P

Q Helps roll out bogie.

R Loosens auxiliary leveling screw, using ½-inch rod, and keeps it free from binding as mount is leveled. Then, tightens auxiliary leveling screw by screwing it down.

S

T Helps fold canvas cover and place it on bogie buffer cylinder.

U Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 1

Operation

A Helps remove gun cover.

B At left, checks to make certain hand brake is set.

C Helps extend and pin left outrigger.

D Helps remove and lay aside left platform.

E Assists gunner.

F

G At trail, helps tip mount gently back on rear outrigger.

H

I At left, takes position at hand brake.

J At left, releases hand brake.

K At left, loosens lock nut only on bogie engaging eyebolt. Places socket wrench on bogie securing bolt.

L At left, disengages bogie securing bolt.

Operation

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O At left, loosens both nuts on bogie engaging eyebolt.

P

Q At left, rides bogie, holding up on bogie engaging eyebolt until it clears pedestal, then dropping it and manipulating hand brake as directed by gun commander.

R

S Helps put left platform in place on outriggers and fasten it.

T Helps fold canvas cover and place it on bogie buffer cylinder.

U Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 2

Operation

A Helps remove gun cover.

B At right, checks to make certain hand brake is set.

C Helps extend and pin right outrigger.

D Helps remove and lay aside right platform.

E Elevates gun to 300 mils.

F

G

H

I At right, takes position at hand brake.

J At right, releases hand brake.

K At right, loosens lock nut only on bogie engaging eyebolt. Places socket wrench on bogie securing bolt and elevates gun to maximum.

L At right, disengages bogie securing bolt.

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O At right, loosens both nuts on bogie engaging eyebolt.

P

Operation

Q At right, rides bogie, holding up on bogie engaging eyebolt until it clears pedestal, then dropping it and manipulating hand brake as directed by gun commander.

R

S Helps put right platform in place on outriggers and fasten it.

T Lowers seat to using position.

U Helps place dirt under those parts of outrigger which do not touch ground.

NUMBER 3

Operation

A Helps remove gun cover.

B

C Helps extend and pin left outrigger.

D Helps remove and lay aside left platform.

E

F

G At trail, helps tip mount gently back on rear outrigger.

H

I At trail, helps balance mount so that all outriggers are parallel to ground.

J Helps apply downward pressure to mount, partially crushing it.

K Assists No. 7.

L

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O At left, pushes in on bogie engaging eye operating handle.

P At left, puts bogie hub wrench on wheel.

Q At left, manipulates hub wrench.

R

S Helps put left platform in place on outriggers and fasten it.

Operation

T Helps fold canvas cover and place it on bogie buffer cylinder.

U Helps place dirt under these parts of outriggers which do not touch ground.

NUMBER 4

Operation

A Helps remove gun cover.

B

C Helps extend and pin right outrigger.

D Helps remove and lay aside right platform.

E

F

G At trail, helps tip mount gently back on rear outrigger.

H

I At trail, helps balance mount so that all outriggers are parallel to ground.

J Helps apply downward presure to mount, partially crushing it.

K Assists No. 8.

L

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O At right, pushes in on bogie engaging eye operating handle.

P At right, puts bogie hub wrench on wheel.

Q At right, manipulates hub wrench.

R

S Helps put right platform in place on outriggers and fasten it.

T Helps fold canvas cover and place it on bogie buffer cylinder.

U Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 5

Operation

A Removes left canvas counterpoise cover. Removes equilibrator piston stop rod from equilibrator and inserts it in the holder on top of equilibrator.

B

C Helps extend and pin left outrigger.

D Helps remove and lay aside left platform.

E

F Helps extend and pin rear outrigger.

G At rear outrigger, helps tip mount gently back on rear outrigger.

H

I At rear outrigger, helps balance mount so that all outriggers are parallel to ground.

J Helps apply downward pressure to mount, partially crushing it.

K Places fuze setter bracket and seat in firing position and places fuze setter in its bracket.

L

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O

P

Q Helps roll out bogie.

R

S Helps put left platform in place on outriggers and fasten it.

T At left, replaces canvas cover on counterpoise cylinder.

U Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 6

Operation

A Removes right canvas counterpoise cover.

B

C Helps extend and pin right outrigger.

Operation

D Helps remove and lay aside right platform.
E
F Helps extend and pin rear outrigger.
G At rear outrigger, helps tip mount gently back on rear outrigger.
H
I At rear outrigger, helps balance mount so that all outriggers are parallel to ground.
J Helps apply downward pressure to mount, partially crushing it.
K Assists No. 5.
L
M Takes position at trail.
N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.
O
P
Q Helps roll out bogie.
R
S Helps put right platform in place on outriggers and fasten it.
T At right, replaces canvas cover on counterpoise cylinder.
U Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 7

Operation

A Helps remove gun cover.
B
C Helps extend and pin left outrigger.
D Helps remove and lay aside left platform.
E
F Helps extend and pin rear outrigger.
G At rear outrigger, helps tip mount gently back on rear outrigger.
H
I At rear outrigger, helps balance mount so that all outriggers are parallel to ground.
J Helps apply downward pressure to mount, partially crushing it.

Operation

K At left counterpoise cylinder, pulls out on crank handle of gear box and swings gear box to front over end of cylinder, fastening it in place with swing bolt and wing nuts. Cranks down bogie until pedestal rests firmly on the ground and wheels can be turned.

L

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O

P At left counterpoise cylinder, cranks up bogie until there is enough clearance for bogie to be rolled out.

Q Helps roll out bogie.

R Levels mount at left leveling jack. When level has been verified, tightens jack clamp and places jack ratchet in neutral position. Places jack handle as close to rear outrigger as possible to prevent breakage of handle by platform reinforcing angle.

S Helps put left platform in place on outriggers and fasten it.

T Lowers seat to using position. Connects cable to cable receptacle.

U Helps place dirt under those parts of outriggers which do not touch ground.

NUMBER 8

Operation

A Helps remove gun cover.

B

C Helps extend and pin right outrigger.

D Helps remove and lay aside right platform.

E

F Helps extend and pin rear outrigger.

G At rear outrigger, helps tip mount gently back on rear outrigger.

H

I At rear outrigger, helps balance mount so that all outriggers are parallel to ground.

Operation

J Helps apply downward pressure to mount, partially crushing it.

K At right counterpoise cylinder, pulls out on crank handle of gear box and swings gear box to front over end of cylinder, fastening it in place with swing bolt and wing nuts. Cranks down bogie until pedestal rests firmly on the ground and wheels can be turned.

L

M Takes position at trail.

N Holds up on trail, helping support its weight while gunner allows trail lock to swing up to maximum angle; helps move trail down to lower position.

O

P At right counterpoise cylinder, cranks up bogie until there is enough clearance for bogie to be rolled out.

Q Helps roll out bogie.

R Levels mount at right leveling jack. When level has been verified, tightens jack clamp, and places jack ratchet in neutral position.

S Helps put right platform in place on outriggers and fasten it.

T Helps fold canvas cover and place it on bogie buffer cylinder.

U Helps place dirt under those parts of outriggers which do not touch ground.

TABLE III.—*March order*

GUN COMMANDER

Operation

A Commands: MARCH ORDER.

B Supervises.

C Supervises.

D Supervises.

E Supervises. *Is responsible for clearance between top of bogie frame and bottom of equilibrator cylinder.* Directs Nos. 7 and 8 to crank down bogie, if necessary.

F Supervises.

G Supervises.

Operation

H Supervises.
I Supervises.
J Supervises.
K Supervises.
L Supervises; gives command for releasing hand brakes and pushing up on trail.
M Supervises.
N Supervises.
O Supervises.
P Supervises.
Q Supervises.
R Supervises.
S Directs prime mover in backing to couple mount. Directs maneuvering of mount to facilitate coupling.
T Supervises.
U Supervises.
V Supervises.
W

GUNNER

Operation

A
B Loosens auxiliary leveling screw and keeps it loose while Nos. 7 and 8 center the leveling jacks. Tightens auxiliary leveling screw by screwing it down.
C
D
E Helps roll in bogie.
F
G Takes position along trail.
H Loosens wing nut and drops swing bolt, disengaging trail lock rocker arm. Gives command for Nos. 1 through 8 to lift trail. Trail lock rocker arm swings to upper limit and back to normal position. While Nos. 1 through 8 hold trail in upper position, refasten trail lock rocker arm by means of swing bolt and wing nuts.
I
J
K Takes position at bogie buffer.

Operation

L Pulls out on latch shaft handle and swings up bogie buffer cylinder at front after mount has been raised until bogie buffer roller is directly in front of axle lug. (When at correct angle, bogie buffer cylinder is relatched by latch in side of cylinder.)

M As lug on bogie axle comes forward against bogie buffer plunger, turns handwheel so as to release plunger.

N Raises traveling lock brace. When No. 2 depresses gun into traveling lock, swings transom cap on top of traveling lock over gun tube and fastens it. Replaces muzzle cover.

O Plugs electric brake cable into socket of bogie.

P Helps put right platform in place on trail and fasten it.

Q Helps fold and latch right outrigger in traveling position.

R Takes position at trail lifting bar.

S Couples mount to prime mover.

NUMBER 1

Operation

A Helps remove and lay aside left platform.

B

C

D

E At left, rides bogie holding bogie engaging eyebolt clear of pedestal.

F At left, hand tightens lower nuts on the bogie engaging eyebolts leaving sufficient clearance to permit engaging the bogie securing bolts when the trail is raised.

G Takes position along trail.

H At command of gunner, helps lift forward end of trail until trail is locked in upper position.

I At left, with trail in upper position, engages bogie securing bolt and tightens and locks bogie engaging eyebolt nuts. Sets hand brake.

J

K At left, takes position at hand brake.

L At left, at command of gun commander, releases hand brake.

Operation

M At trail, helps tip mount gently forward.
N Assists gunner.
O
P Helps put left platform in place on trail and fasten it.
Q Helps fold and latch left outrigger in traveling position.
R Takes position at trail lifting bar.
S Assists gunner.
T
U Fastens break-away chain to prime mover, plugs brake cable into truck and takes lifting bar out of trail, and puts it in truck.
V Helps put gun cover on gun and fasten it in place.
W Puts bogie socket wrench in truck.

NUMBER 2

Operation

A Helps remove, fold, and lay aside right platform.
B
C Elevates gun to maximum. Folds seat and footrest in traveling position.
D
E At right, rides bogie holding bogie engaging eyebolt clear of pedestal.
F At right, hand tightens lower nuts on the bogie engaging eyebolts leaving sufficient clearance to permit engaging bogie securing bolts when the trail is raised.
G Takes position along trail.
H At command of gunner, helps lift forward end of trail until trail is locked in upper position.
I At right, with trail in upper position, engages bogie securing bolt and tightens and locks bogie engaging eyebolt nuts. Sets hand brake.
J
K At right, takes position at hand brake.
L At right, at command of gun commander, releases hand brake.
M Depresses gun to 300 mils.
N Depresses gun into traveling lock.
O

Operation

P Helps put right platform in place on trail and fasten it.
Q Helps fold and latch right outrigger in traveling position.
R Takes position at trail lifting bar.
S Assists gunner.
T
U
V Helps put gun cover on gun and fasten it in place.
W Puts bogie socket in truck.

NUMBER 3

Operation

A Helps remove and lay aside left platform.
B At left, puts bogie hub wrench on wheel.
C
D
E At left, manipulates hub wrench.
F At left, pulls out on bogie engaging eye operating handle until it is locked in place by pawl.
G Takes position along trail.
H At command of gunner, helps left forward end of trail until trail is locked in upper position.
I
J Assists No. 7.
K Takes position at trail.
L At command of gun commander, gives strong upward push to trail.
M At trail, helps tip mount gently forward.
N
O
P Helps put left platform in place on trail and fasten it.
Q Helps fold and latch left outrigger in traveling position.
R Takes position at rear outrigger.
S At rear outrigger, helps maneuver mount as directed by gun commander to assist in coupling.
T Climbs on top of mount, secures outriggers with outrigger safety chain, and remains to help put canvas cover in place.
U

Operation

V Carries gun cover up over tube from rear by walking along tube.

W

NUMBER 4

Operation

A Helps remove, fold, and lay aside right platform.

B At right, puts bogie hub wrench on wheel.

C

D

E At right, manipulates hub wrench.

F At right, pulls out on bogie engaging eye operating handle until it is locked in place by pawl.

G Takes position along trail.

H At command of gunner, helps lift forward end of trail until trail is locked in upper position.

I

J Assists No. 8.

K Takes position at trail.

L At command of gun commander, gives strong upward push to trail.

M At trail, helps tip mount gently forward.

N

O

P Helps put right platform in place on trail and fasten it.

Q Helps fold and latch right outrigger in traveling position.

R Takes position at rear outrigger.

S At rear outrigger, helps maneuver mount as directed by gun commander to assist in coupling.

T

U

V Helps put gun cover on gun and fasten it in place.

W Puts wheel wrench in truck.

NUMBER 5

Operation

A Helps remove and lay aside left platform.

B At left, removes canvas counterpoise cover.

C

Operation

D Disconnects cable from fuze setter junction box and unpins fuze setter bracket. Helps remove fuze setter from firing position and puts it in traveling bracket.

E Helps roll in bogie.

F

G Takes position along trail.

H At command of gunner, helps lift forward end of trail until trail is locked in upper position.

I

J

K Takes position at trail.

L At command of gun commander, gives strong upward push to trail.

M At rear outrigger, helps tip mount gently forward.

N

O Removes equilibrator piston stop from holder and inserts in equilibrator cylinder head; fastens it with equilibrator piston stop pin.

P Helps put left platform in place on trail and fasten it.

Q Helps fold and latch left outrigger in traveling position.

R Takes position at rear outrigger.

S At rear outrigger, helps maneuver mount, as directed by gun commander, to assist in coupling.

T Helps fold and latch rear outrigger.

U Replaces canvas cover on left counterpoise cylinder.

V Helps put gun cover on gun and fasten it in place.

W Puts bogie ratchet wrench back in truck.

NUMBER 6

Operation

A Helps remove, fold, and lay aside right platform.

B At right, removes canvas counterpoise cover.

C

D Helps remove fuze setter from firing position and put it in traveling bracket.

E Helps roll in bogie.

F

G Takes position along trail.

Operation

H At command of gunner, helps lift forward end of trail until trail is locked in upper position.

I

J

K Takes position at trail.

L At command of gun commander, gives strong upward push to trail.

M At rear outrigger, helps tip mount gently forward.

N

O

P Helps put right platform in place on trail and fasten it.

Q Helps fold and latch right outrigger in traveling position.

R Takes position at rear outrigger.

S At rear outrigger, helps maneuver mount as directed by gun commander to assist in coupling.

T Helps fold and latch rear outrigger.

U Replaces canvas cover on right counterpoise cylinder.

V Helps put gun cover on gun and fasten it in place.

W Puts bogie ratchet wrench back in truck.

NUMBER 7

Operation

A Helps remove and lay aside left platform.

B At left, centers leveling jack, center of jack travel being indicated by marks on jack body.

C Sets gun to zero traverse (position where traverse pointer at lower rear edge of top carriage is directly in line with a groove in top of left jack slide cover) and folds and pins azimuth setter's seat and footrest in position. Disconnects cable from cable receptacle and replaces cap on plug and receptacle.

D

E Cranks down bogie, if necessary, as directed by gun commander.

F At left, cranks down bogie until bogie engaging eye operating handles may be pulled all the way out.

G Takes position along trail.

Operation

H At command of gunner, helps lift forward end of trail until trail is locked in upper position.

I

J At left, cranks up bogie until gear box can be disengaged and locked in traveling position.

K Takes position at trail.

L At command of gun commander, gives strong upward push to trail.

M At rear outrigger, helps tip mount gently forward.

N

O

P Helps put left platform in place on trail and fasten it.

Q Helps fold and latch left outrigger in traveling position.

R Takes position at rear outrigger.

S At rear outrigger, helps maneuver mount as directed by gun commander to assist in coupling.

T Helps fold and latch rear outrigger.

U

V Helps put gun cover on gun and fasten it in place.

W Puts wheel wrench in truck.

NUMBER 8

Operation

A Helps remove, fold, and lay aside right platform.

B At right, centers leveling jack, center of jack travel being indicated by marks on jack body.

C

D

E Cranks down bogie, if necessary, as directed by gun commander.

F At right, cranks down bogie until bogie engaging eye operating handles may be pulled all the way out.

G Takes position along trail.

H At command of gunner, helps lift forward end of trail until trail is locked in upper position.

I

J At right, cranks up bogie until gear box can be disengaged and locked in traveling position.

K Takes position at trail.

Operation

L At command of gun commander, gives strong upward push to trail.

M At rear outrigger, helps tip mount gently forward. Remains at rear outrigger until gun has been coupled to prime mover to prevent mount from tipping back.

N At rear outrigger.

O At rear outrigger.

P At rear outrigger.

Q At rear outrigger.

R Takes position at rear outrigger.

S At rear outrigger, helps maneuver mount as directed by gun commander to assist in coupling.

T Helps fold and latch rear outrigger.

U

V Helps put gun cover on gun and fasten it in place.

W

TABLE IV.—*Drill*

GUNNER

Command	
DETAILS POSTS	Places a wiper of cotton waste and can of oil in convenient place. Assisted by No. 4, removes breech cover and deposits at designated place. Takes post at right rear of gun, opposite and facing breech.
EXAMINE GUN	Assisted by No. 4, examines, cleans, and oils breech mechanism; tests firing mechanism; examines chamber and bore. If necessary, has Nos. 1, 4, 6, and 8 assist in sponging and cleaning bore.
REPORT	Reports to gun commander, "Breech in order," or reports any defects he cannot remedy without delay.
TARGET	Opens breech by bearing down on breech operating handle until breechblock is locked open; immediately latches operating handle. Assumes position, feet well braced, clear of recoil but convenient for loading.

Command	
COMMENCE FIRING	*a. Without power rammer.*—When No. 4 places a round in the loading position, gunner rams it with his clenched left fist. When his fist is knocked clear by the rising breechblock, he pivots back on his right foot and fires the gun. *b. With power rammer.*—When No. 4 places a round into the breech recess, the gunner rotates the ramming arm into position behind the cartridge. After No. 4 has tripped the rammer and the breechblock has closed, he pivots back on his right foot and fires the gun.
SUSPEND FIRING CEASE FIRING	*c.* Continues ramming and firing until SUSPEND FIRING or CEASE FIRING is ordered. In case of misfire calls, "Misfire," to the gun commander, and keeps all cannoneers clear while the prescribed safety precautions are taken.

NUMBER 2 (ELEVATION SETTER)

Command	
DETAILS POSTS	Assists No. 1 in removing and folding gun cover. Takes post at elevation station, seated on elevation setter's seat, facing elevation indicator regulator.
EXAMINE GUN	Examines elevating mechanism, elevating gun to maximum and then depressing. Examines elevation indicator and connections. With No. 7, examines gun junction box.
REPORT	Reports to gun commander, "Elevation in order," or reports any defects he cannot remedy without delay.
TARGET	Turns indicator regulator switch to "Automatic." Disengages handwheels by sliding them toward muzzle of gun. Pushes in transfer valve. Watches lag meter pointer which indicates whether or not remote control system is operating properly. If neces-

Command	
	sary, raises transfer valve, turns indicator regulator switch to "manual" stopping at intermediate position for 5 seconds, engages handwheels, and matches pointers, keeping them matched.
COMMENCE FIRING	Continues to watch lag meter pointer or, if operating gun manually, continues matching pointers.
SUSPEND FIRING	Same as at COMMENCE FIRING.
CEASE FIRING	Turns indicator regulator switch to "manual," holding switch for 5 seconds in intermediate position. Raises transfer valve. Engages handwheels. Remains at post.

NUMBER 3 (FUZE SETTER OPERATOR)

Command	
DETAILS POSTS	Assists No. 1 in removing and folding gun cover. Removes muzzle and deposits at designated place. Takes post at right rear of fuze range setter, facing fuze setter.
EXAMINE GUN	Assists No. 5 in examining, cleaning, and oiling fuze setter. Checks to see that proper rings are in setter.
REPORT TARGET	No duties.
	Places hand on handle so that as soon as the release lever is struck by No. 1, the crank will start. Turns handle until it comes in contact with stop. Calls "Cut," to signify that the fuze is set and round can be withdrawn.
COMMENCE FIRING	Continues setting fuzes as quickly as projectiles are inserted in fuze setter and trip lever tripped, calling "Cut," as each fuze is set.
SUSPEND FIRING	Sets fuze on unset round, if one is in fuze setter, or on round inserted after command has been given.
CEASE FIRING	Remains at post prepared to set to "safe" fuzes which have been cut.

NUMBER 4 (LOADER)

Commands	
DETAILS POSTS	Procures chamber and bore sponge and wiper of cotton waste. Places sponge in designated place. Assists gunner in removing breech cover, and takes post about 2 feet to left and rear of breech facing gunner.
EXAMINE GUN	Assists gunner in examining, cleaning, and oiling breech mechanism, chamber, and bore of gun. Sees that breech operating cam lever is set for "automatic" or "hand operation" of breech as directed by gun commander.
REPORT TARGET	No duties.
	As soon as a round has been cut by No. 1, moves to No. 1 position and stands ready to remove round.
COMMENCE FIRING	*a. Without power rammer.*—Removes round from fuze setter and holds in loading position at the breech.
	b. With power rammer.—Removes round from fuze setter and lays it into the breech recess, moving it into the chamber far enough to allow the gunner to rotate the rammer arm. After the gunner has positioned the rammer arm, the loader trips the rammer with his left hand, loading the round.
	c. As soon as round has been loaded, pivots on right foot, steps back with left, and stands ready to remove next round from fuze setter.
SUSPEND FIRING	If an unfired round is in gun, places right palm, finger down, behind breechblock and, at signal of gunner, catches ejected round and passes it to No. 6. Remains at post.
CEASE FIRING	Same as at SUSPEND FIRING.

NUMBER 5 (FUZE RANGE SETTER)

Command	
DETAILS POSTS	Takes post at fuze range setter's station, seated on fuze range setter's seat facing fuze setter.
EXAMINE GUN	Assisted by No. 3, examines, cleans, and oils (when necessary), fuze setter, fuze range indicator, and connections. With added assistance of No. 1, checks fuze setter and indicator by setting several values and cutting fuzes, checking reading on fuze against values on indicator.
REPORT	Reports to gun commander, "Fuze setter in order," or reports any defects he cannot remedy without delay.
TARGET	Matches pointers and keeps them matched.
COMMENCE FIRING	Continues to keep pointers matched.
SUSPEND FIRING	Same as at COMMENCE FIRING.
CEASE FIRING	Turns mechanical pointer to "safe" position and directs No. 1 to remove round from setter. Supervises setting to "safe" of other rounds which have been cut, checking each fuze as it is removed from setter. Remains at post.

NUMBER 7 (AZIMUTH SETTER)

Command	
DETAILS POSTS	Assists No. 1 in removing and folding gun cover. Takes post at azimuth station, seated on azimuth setter's seat facing azimuth indicator regulator.
EXAMINE GUN	Examines traversing mechanism, traversing 360° and back. Examines azimuth indicator and connections. With No. 2, examines gun junction box.
REPORT	Reports to gun commander, "Traversing in order," or reports any defects he cannot remedy without delay.

Command	
TARGET	Turns motor switch at gun junction box to "on." Turns indicator regulator switch to "automatic." Disengages handwheels by sliding them toward muzzle of gun. Pushes in transfer valve. Watches lag meter pointer which indicates whether or not remote control system is operating properly. If necessary, pushes in transfer valve, engages handwheels, turns indicator regulator switch to "manual" stopping at intermediate position for 5 seconds, matches pointers, and keeps them matched.
COMMENCE FIRING	Continues to watch lag meter pointer or, if operating gun manually, continues matching pointers.
SUSPEND FIRING	Same as at COMMENCE FIRING.
CEASE FIRING	Turns indicator regulator switch to "manual", stopping at intermediate position for 5 seconds. Raises transfer valve. Engages handwheels. Turns off motor switch. Remains at post.

NUMBERS 1, 6, 8 (AMMUNITION RELAYERS)

Command	
DETAILS POSTS	No. 1, assisted by Nos. 2, 3, and 7, removes and folds gun cover and places it at designated place. No. 1 takes position immediately in the rear of fuze setter, facing it, standing on the gunner's platform. No. 6 takes post directly in rear of the fuze setter, standing on the ground and facing No. 1. No. 8 takes post on the ground about 3 or 4 feet from the gunner's platform and facing No. 6.
EXAMINE GUN	No. 1 inserts round in fuze setter when called for by No. 3 for purpose of testing; examines ammunition. Assisted by Nos. 6 and 8, No. 1 arranges and inspects ammuni-

tion near gun. If necessary, assists in cleaning and sponging bore.

REPORT — No. 1 reports to gun commander, "Ammunition in order," or reports any defects he is unable to remedy without delay.

TARGET — No. 1 takes round from No. 6, who has received it from No. 8, and inserts it in fuze setter; presses down on base end of case with palm of right hand, brings left over, and strikes trip lever on top side of fuze setter. After No. 3 calls, "Cut," No. 1 relieves pressure on case and steps back so as to make room for No. 4 to remove the round from fuze setter. (No. 4 maintains pressure on base of round before removing it, if necessary.) No. 1 stands ready to receive another round from No. 6 and repeat procedure. Nos. 6 and 8, aided by members of the ammunition squad, keep No. 1 supplied with ammunition. (No. 6 hands round to No. 1 with left hand under rear of round and right hand on the fuze. No. 6 faces No. 1.)

COMMENCE FIRING — No. 1 continues loading fuze setter and, stepping back for additional rounds as fast as No. 4, removes each round from fuze setter. Nos. 6 and 8, aided by members of the ammunition squad, continue serving ammunition to No. 1.

SUSPEND FIRING — If there is no round in fuze setter, Nos. 1 and 3 load and cut one round to have it ready for immediate use. No. 8 and the ammunition squad stand ready to serve ammunition to No. 1. If an unfired round remains in chamber, No. 6 receives it from No. 4 and turns round over to ammunition corporal or assistant.

CEASE FIRING — Nos. 1, 3, and 4 set at "safe" any rounds which have been cut and return them to stacks. Return to and remain at posts.

NUMBERS 9 TO 13 (AMMUNITION SQUAD)

Command	
DETAILS POSTS	Stationed by chief of ammunition in such manner as to expedite supply of ammunition and performance of such other duties as may be called for.
EXAMINE GUN	Under direction of chief of ammunition, removes necessary ammunition from boxes or crates and prepares it for complete practice or action. If practice or action is imminent, place ammunition supply in stack at gun emplacement. No. 9 disposes of any obstructions and covers soft spots on ground which might interfere with smooth functioning of ammunition relayers.
REPORT TARGET	No duties.
	Stand ready to replenish ammunition supply at gun position.
COMMENCE FIRING	Continue to supply ammunition to gun position. No. 9 clears empty shell cases from emplacement, being careful to avoid getting behind gun while it is in action.
SUSPEND FIRING	After collecting all empty shell cases and replenishing supply at gun, remain at posts unless otherwise directed. No. 9 continues clearing empty shell cases from emplacement.
CEASE FIRING	Same as at SUSPEND FIRING.

APPENDIX

LIST OF REFERENCES

Ammunition, general	TM 9–1900
Antiaircraft ammunition	TM 9–370
Antiaircraft artillery, examination for gunners	FM 4–150
Antiaircraft artillery, formations, inspections service, and care of matériel	FM 4–120
Antiaircraft artillery, gunnery, fire control, and position finding, antiaircraft guns	FM 4–110
Antiaircraft artillery, organization and tactics	FM 4–105
Antiaircraft artillery, reference data	FM 4–155
Care and maintenance of matériel	TM 9–370
Coast artillery weapons and matériel	TM 4–210
Data transmission system, M4	TM 9–1656
Drill ammunition	TM 9–370
Fuze setter	TM 9–2641
90-mm Antiaircraft gun matériel	TM 9–370
Safety precautions in firing	AR 750–10 TM 4–235