RESTRICTED

FM 4–160

WAR DEPARTMENT

ANTIAIRCRAFT ARTILLERY FIELD MANUAL

SERVICE OF THE PIECE
40-MM FIRE UNIT

5 November 1943

Dissemination of restricted matter.—The information contained in restricted documents and the essential characteristics of restricted material may be given to any person known to be in the service of the United States and to persons of undoubted loyalty and discretion who are cooperating in Government work, but will not be communicated to the public or to the press except by authorized military public relations agencies. (See also par. 18*b*, AR 380–5, 28 Sep 1942.)

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FM 4–160, Antiaircraft Artillery Field Manual, Service of the Piece, 40-mm Fire Unit, is published for the information and guidance of all concerned.

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(For explanation of symbols see FM 21–6.)

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ANTIAIRCRAFT ARTILLERY FIELD MANUAL

SERVICE OF THE PIECE

40-MM FIRE UNIT

(This manual supersedes FM 4–141, 24 June 1942, including C 1, 29 March 1943; and TC No. 74, War Department, 1943.)

CHAPTER 1

GENERAL

■ 1. INTRODUCTION.—The manual prescribes the knowledge and skill required to effectively serve the equipment of the 40-mm fire unit. It is a guide for the selection and assignment of individuals. Fire control is covered in FM 4–151.

■ 2. SCOPE.—The subjects covered include organizations, drill, care and maintenance, and tests and adjustments. Instructions for destroying the equipment in the event of imminent capture are detailed in chapter 6.

■ 3. CHARACTERISTICS AND DATA.—

a. Gun and carriage (40-mm automatic gun M1 and 40-mm AA gun carriage M2).

Weight of gun and carriage	5,549 lbs.
Maximum elevation	90°
Maximum depression:	
Gun level	—6°
With jacks	—11°
Traverse	360°
Maximum recoil	9.45 in.
Normal recoil (7.87 preferred)	7.4 to 8.3 in. limits
Wheel base	126 in.
Minimum turning diameter	38 ft.
Over-all length (traveling)	18 ft. 9½ in.
Over-all width (traveling)	6 ft. 0 in.
Over-all height (traveling)	6 ft. 7½ in.
Maximum extension of jacks	9½ in.

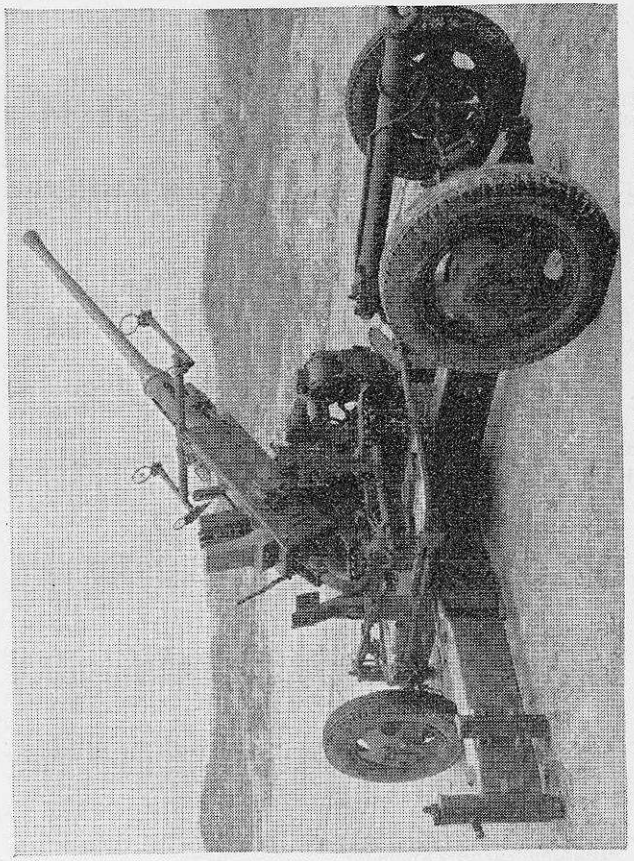


FIGURE 1.—40-mm automatic gun M1 on 40-mm AA gun carriage M2.

Height of gun trunnion (traveling position)	62 in.
Overall width of carriage with outriggers extended and locked	13 ft.
Carriage road clearance	14⅛ in.
Tires	6.00 x 20
Tire pressure	45 lbs./sq. in.

b. Director M5 or M5A1.

Weight of director (without tripod)	500 lbs.
Weight of director in packing chest	665 lbs.
Weight of tripod	120 lbs.
Limits of director:	
Azimuth, no limit.	
Elevation, electrical stops, —5° and 85°	
Elevation, mechanical stops, —10° and 92°	
Maximum angular rates:	
Azimuth	20° per sec.
Elevation	20° per sec.
Range, 40-mm (maximum limited by director)	3,000 yds.

c. Remote control system M5 (see TM 9–1643).—Uses M1 oil gear unit; 60-cycle, 115 volts, 3-conductor, power cable 225 feet long; 15-conductor director cable 30 feet long; generating unit M5; and necessary wiring on carriage.

Weight of power cable	67 lbs.
Weight of director cable	31 lbs.

d. Remote control system M10.—Same as remote control system M5, except the M10 system uses the M3B1 oil gear units; no blackout dial; and variations in wiring (fig. 33).

Weight of M3B1 oil gear (approximate)	250 lbs.

e. Unit generator M5 or M10.

Weight	800 lbs.

f. Machine gun, caliber .50, M2, WC, and mounts M2A1 and M3.—See FM 4–155.

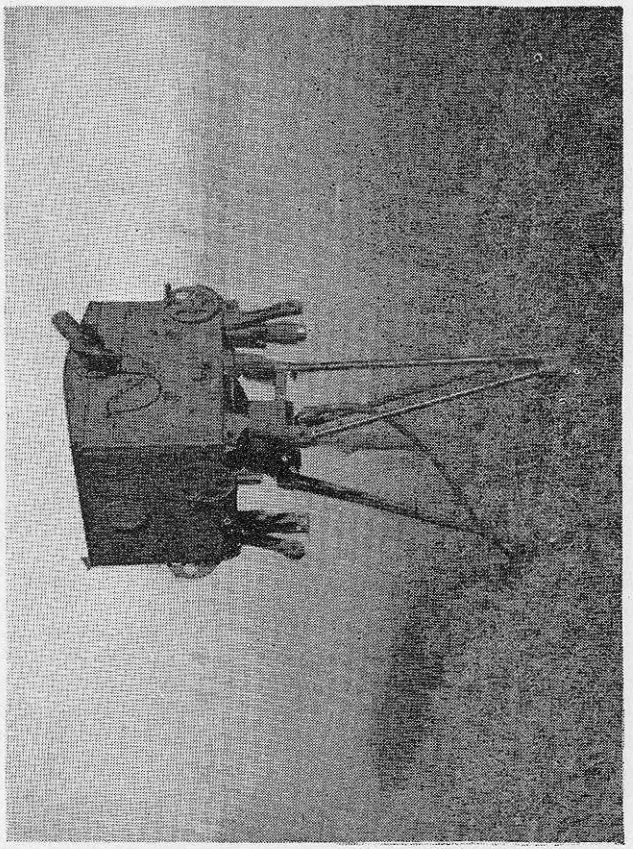


FIGURE 2.—Director M5.

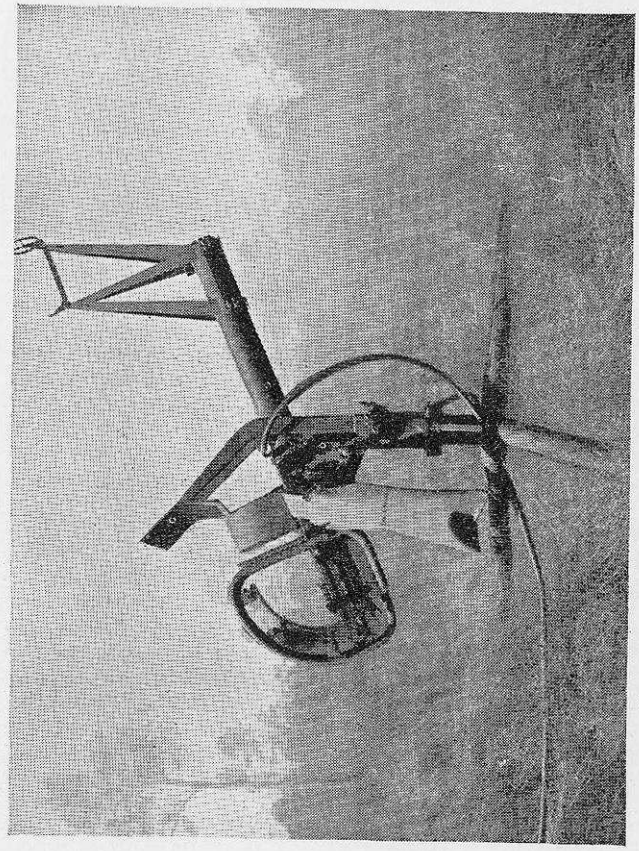


FIGURE 3.—Machine gun, caliber .50 M2, WC, on M3 mount.

g. Multiple caliber .50 machine-gun carriage M51.—M45 turret with four HB caliber .50 M2 machine guns on the M7 generator trailer. (See FM 4–157.)

Road clearance	14¼ in.
Overall length	190 in.
Overall width	96 in.
Height of lower guns from ground	56 in.
Weight of turret, fully equipped, with guns (approximate)	2, 400 lbs.
Weight of trailer (approximate)	4, 500 lbs.
Total weight	6, 900 lbs.
Tires	7.50 x 20
Tire pressure	50 lbs./sq. in.

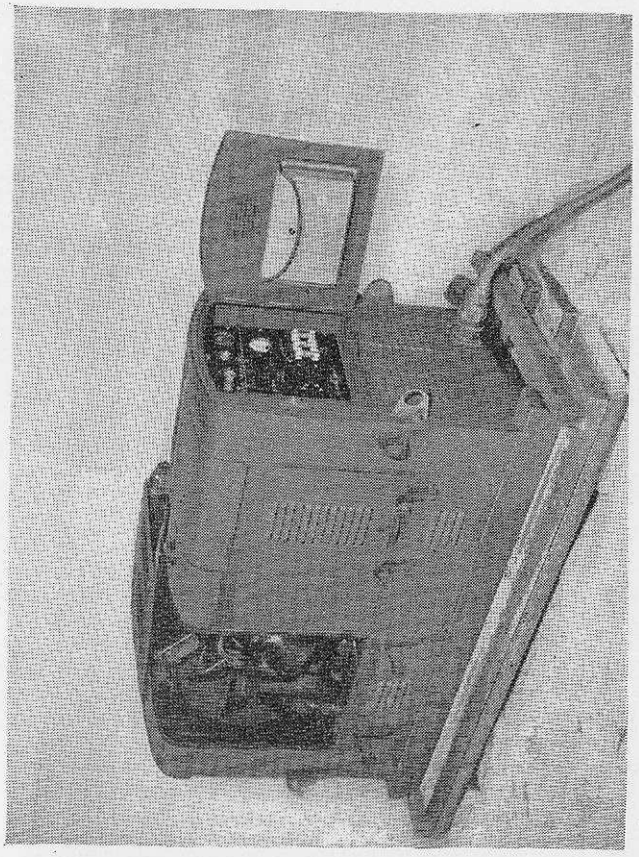


FIGURE 4.—Generating unit M5.

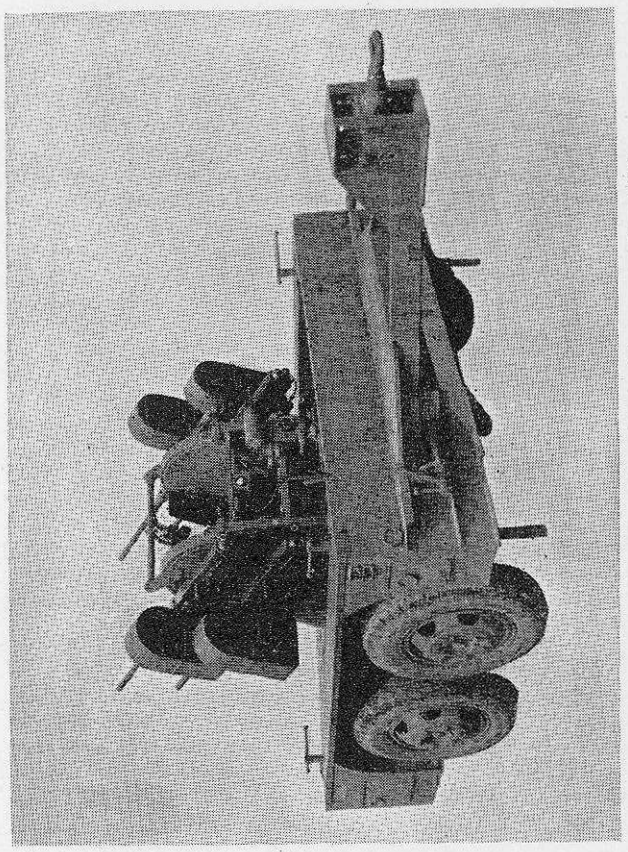


FIGURE 5.—Multiple caliber .50 machine-gun carriage M51.

CHAPTER 2

ORGANIZATION

SECTION I

GENERAL

■ 4. GENERAL.—*a.* The 40-mm fire unit, mobile, consists of a crew of fourteen men, equipped with one 40-mm gun, a director and power plant, and a caliber .50 machine gun, water-cooled, for local protection. Two 2½-ton trucks and one 1-ton trailer provide transportation.

b. The caliber .50 machine gun, water-cooled, is being replaced by the multiple caliber .50 machine gun carriage M51, mounting four caliber .50 machine guns on a power driven turret. In this case, the 1-ton trailer is not issued.

c. The 40-mm gun is towed by a 2½ ton truck referred to as the prime mover. The 1-ton trailer or the multiple caliber .50 machine gun carriage is towed by the fire control truck which also carries the director and power plant.

d. The semimobile 40-mm fire unit consists of a thirteen man crew, equipped as above, except that neither the 2½-ton trucks nor the 1-ton trailer are issued to the fire unit.

■ 5. 40-MM FIRE UNIT.—*a.* Each 40-mm fire unit is under the command of a chief of section and consists of a range section and a gun section. The individual members of the fire unit are listed below, and are referred to by the numbers and abbreviations given at the left margin:

CS Chief of section.
RS Range setter.
1 Elevation tracker.
2 Azimuth tracker.
3 Power plant operator and chauffeur.
4 Telephone operator and alternate tracker.
G Gunner.
5 Machine gunner and lookout.
6 Machine gunner and lookout.
7 Loader and firer.
8 Lookout and lateral gun pointer.

9 Lookout and vertical gun pointer.
10 Ammunition relayer. (10 *is not present in semimobile units but is supplied from basics in battery headquarters.*)
11 Ammunition detail and chauffeur.

b. The range section, composed of **RS, 1, 2, 3,** and **4,** is under the control and direction of **RS.** The gun section, composed of **G, 5, 6, 7, 8, 9, 10,** and **11,** is under the control and direction of **G.**

c. The members of the gun section, with the exception of the machine gunners, ride in the prime mover. The members of the range section and the machine gunners ride in the fire control truck. When on the road, the machine gun is mounted in the fire control truck, manned, and ready for instant action.

d. When the multiple caliber .50 machine gun carriage M51 is used, the two machine gunners and 4 ride in the multiple caliber .50 machine-gun carriage at the alert, ready to open fire on any attacking planes.

■ 6. EQUIPMENT.—*a.* Each mobile 40-mm fire unit is equipped as follows:

(1) Gun, 40-mm automatic M1, on carriage M2; forward area or speed ring sights, or computing sight M7.
(2) Remote control system M5 with oil gear unit M1, or remote control system M10 with oil gear unit M3B1.
(3) Director M5 or M5A1.
(4) Generating unit M5 or M10.
(5) Machine gun, caliber .50, M2, water-cooled, on antiaircraft mount M2A1 or M3, or multiple caliber .50 machine-gun carriage M51.
(6) Two trucks 2½-ton.
(7) One trailer 1-ton (if multiple caliber .50 machine-gun carriage is not issued).

b. Equipment for the semimobile 40-mm fire unit differs from *a* above as follows: no 2-½ ton trucks or 1-ton trailers are issued to the fire units.

SECTION II

DUTIES OF PERSONNEL

■ 7. CHIEF OF SECTION.—*a.* The chief of section is responsible for the administration and training of his fire unit. He is responsible during drill for the prompt correction of errors.

b. In the field, he is responsible, under the general supervision of the platoon commander, for—

(1) Tactical control of the fire unit.
(2) Proper emplacement and fortification of the equipment and preparation for fire.
(3) Camouflage and camouflage discipline.
(4) Local security and antiaircraft observation.
(5) Recognition and selection of targets.
(6) Conduct of fire.
(7) Maintenance and sanitation of the emplacement.
(8) Efficiency of the personnel.

c. The chief of section must insure observance of the following precautions in the conduct of drill:

(1) *DO* be sure axletrees are not unlocked after emplacement if any weight of the gun is carried by the jacks. If this is done, the axletree, acting under the force of counterpoise spring, will snap the wheels down with great violence and (rear axletree) whip the gunstay into the air suddenly, or (front axletree) whip the drawbar forward instantly. Failure to exercise this caution results in severe injury to personnel. This is a major caution for initial training in gun emplacement drill.

(2) *DO* grasp the drawbar forward of the "A" frame in lowering the mount. There is very little clearance at the "A" frame and fingers are likely to be injured.

(3) *DO* see that the front jack handle is locked toward the front of the carriage before lowering the mount.

(4) *DO* keep feet clear of the places on which the jack pads are about to fall when carriage is lowered.

(5) *DO* be sure that the traversing handle at the rear of the top carriage is in the "down" position when lowering mount. It will interfere with the full movement of the drawbar necessary to lower the gun into position if "up."

(6) *DO* be sure that the handbrakes are released before lowering mount.

(7) *DO* be certain that, after the gun has been used for drill, the rammer shoe is forward and that the extractors have been released, allowing the breechblock to close. This relieves tension on the rammer spring, the breech closing spring, and on the firing pin springs.

(8) *DO* be sure to lock the leveling jacks by turning the handles downward and engaging them in the notches after the gun is leveled.

(9) *DO* be sure to test the electric brakes, and the operation of the break-away switch, whenever the gun is connected to a truck for towing.

■ 8. RANGE SETTER.—*a.* The range setter is in charge of the range section and is responsible for the care of the director and other range section equipment. He personally supervises all tests and adjustments of the director, and all handling of the director.

b. In the field, he is responsible for—

(1) Correct emplacement of the director, power plant, and machine gun.

(2) Accurate orientation of gun and director.

(3) Fire control of the fire unit when at director control, or at sight control when using the computing sight M7.

(4) Condition of matériel under his charge.

(5) Efficiency of the range section.

c. The range setter must insure observance of the following precautions in director operation:

(1) *DO* engage the elevation oil gear clutch before closing elevation switch.

(2) *DO* be sure not to force orienting clutch knob. Use only thumb and forefinger and turn only about one-quarter turn to loosen. *Never turn the large knurled knob unless the small knurled knob is tight.*

(3) *DO* reverse the elevation rate as the telescopes approach zero or 85°, to prevent the elevation motion from running against the mechanical stops.

(4) *DO* be sure not to apply rates greater than those used to track actual targets. The director can travel in azimuth at a higher rate than the M1 oil gear can drive the gun, and the gun will jump out of phase. The gun slewing lever must always be lifted before the director is slewed, except when gun is equipped with M3B1 oil gear.

(5) *DO* use slewing clutch or handwheel only to traverse director.

(6) *DO* be sure power is OFF before inserting or removing any cable plugs.

(7) *DO* not lean on the director.

(8) *DO* be sure to reverse rates slowly, otherwise the torque amplifier bands may snap.

(9) *DO* tighten telescope thumbscrews evenly.

■ 9. GUNNER.—*a.* The gunner is in charge of the gun section. He personally directs and assists in the care and maintenance of the gun.

b. In the field he is responsible for—

(1) Correct emplacement and leveling of the gun.

(2) Proper adjustment of all mechanisms of the gun and carriage.

(3) Functioning of the gun during firing.

(4) Fire control of the fire unit at sight control, using forward area sights, or speed ring sights, including use of the speed ring sights on the computing sight M7.

c. The gunner insures observance of the following precautions:

(1) *DO* be sure the extractor releasing lever is not operated when the gun is loaded.

(2) *DO* secure the gun casing with the stay (or by having the vertical crank held or tied down) before removing the tube. If not done, the resulting unbalance would permit the equilibrator to cause the breech casing assembly to run up suddenly to the maximum elevation stop, and probably damage the gun.

(3) *DO* open the breech block before removing the tube.

(4) *DO* not raise or lower the mount with the tube out.

(5) *DO* insert the breech ring retaining pin in the left side of the gun casing before removing tube. It must be inserted in the opening immediately above the hinge of the side cover.

(6) *DO* leave top cover open until the gun barrel is again in position. Failure to observe this precaution may result in displacement of and damage to the breech ring and the autoloader.

(7) *DO* be sure that gun slewing lever is lifted before director is slewed, except when gun is equipped with M3B1 oil gear.

(8) *DO* be certain to remove the muzzle bore sight after orientation. The muzzle bore sight should have a large red tag permanently affixed to make it conspicuous.

■ 10. DUTIES OF RANGE SECTION.—*a.* The range section and machine gunners, as directed by RS, handle the 1-ton trailer or

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multiple caliber .50 machine gun carriage M51 in going in and out of position. They handle and operate the director and power plant.

b. When the multiple caliber .50 machine-gun carriage M51 is provided, the telephone operator sets up the telephone at a convenient place for the chief of section, and assists the machine gunners by serving the right machine guns.

c. When the computing sight M7 is used, the range setter mounts the gun platform and operates the course and speed controls.

■ 11. DUTIES OF GUN SECTION.—*a.* The gun section, except for the machine gunners, serve the 40-mm gun. The machine gunners, as members of the gun section, are responsible to the gunner for administrative purposes. They emplace and march order the machine gun under the direction of the range setter. During action, they supplement the fire of the 40-mm gun and are particularly responsible for covering that portion of the field of fire in the dead area of the 40-mm gun. Riding the fire control truck they are responsible to the range setter during motor marches.

b. When the fire unit is equipped with the water cooled machine gun on the antiaircraft mount M2A1 or M3, 5 and 6 serve the machine gun, and alternate as machine gunner and assistant machine gunner.

c. When the fire unit is equipped with the multiple caliber .50 machine gun carriage M51, the machine gunners assisted by the telephone operator, serve the power turret, 5 as gunner, 6 as left cannoneer and 4 as right cannoneer, 6 assists 5 in engaging targets.

NOTE.—CHIEFS OF SECTION, RANGE SETTERS, AND GUNNERS MUST BE CAPABLE OF PERFORMING THE COMBAT DUTIES OF ALL MEMBERS OF THE FIRE UNIT. ALL MEMBERS OF THE FIRE UNIT MUST BE CAPABLE OF PERFORMING THE COMBAT DUTIES OF NUMBERS 5, 7, 8, AND 9 AS A MINIMUM.

CHAPTER 3

DRILL

SECTION I

PRELIMINARY COMMANDS AND FORMATIONS

■ 12. GENERAL.—*a.* The following drill is an analysis of jobs that must be performed by the members of the fire unit. The drill is organized in a sequence suitable for training. Certain jobs within the fire unit are more complex than others. By close observation during preliminary training in drill, individuals are selected and assigned to the job most suitable to their aptitudes. The fire unit is then drilled as a team to obtain precision. Each member of the fire unit should then be trained in the duties of other members of the crew. Battery officers are personally responsible for the supervision and coaching of chiefs of sections in the conduct of drill.

b. The following general instructions apply to all drills:

(1) The drill prescribed herein will be adhered to strictly.

(2) Drill is conducted in silence, except for commands and reports.

(3) Commands and reports are given in a clear and positive manner.

(4) Errors are corrected instantly and on the spot.

(5) Drill is practiced until all reactions to commands are automatic, instant, and effective.

(6) The ultimate in precision and speed is the goal.

(7) Drill is conducted at the fastest pace at which the fire unit can operate smoothly.

c. The drill is presented in chronological sequence of action, with explanatory notes. Paragraph titles agree with primary commands. Each command is followed by the individual actions performed under that command. Each main operation performed under any primary command is separated from other main operations by a row of dashes. Each group or series of actions performed concurrently or consecutively under a command is separated from other such actions by a space only.

d. The drill contains a number of commands which are shown in bars, for example, [EMPLACE GUN]. These secondary

commands are provided to insure coordination of action during early stages of training, for use when necessary at night, and for continued use when considered helpful. Well trained units must be prepared to anticipate these commands so that no delay in action results from their use. In advanced stages of training and combat, such commands are omitted from the drill, at the option of the unit commander.

e. Throughout this drill the terms **RIGHT, LEFT, FRONT,** and **REAR** are used as follows:

(1) With gun in traveling position, these terms are used to refer to the carriage only. The drawbar end is the **FRONT** and the gun stay end is the **REAR.**

(2) With gun emplaced, these terms are used to refer to the carriage or to the gun. Whenever these terms apply to nontraversing parts, they refer to the carriage, and the drawbar end is **FRONT.** Whenever these terms apply to traversing parts they refer to the gun, and the muzzle is **FRONT.**

(3) With prime mover or instrument truck loaded or unloaded, these terms are used to refer to the vehicle itself and the radiator is **FRONT.**

(4) When these terms are used to refer to the power plant, the radiator of the power plant is **FRONT.**

■ 13. FALL IN.—The fire unit assembles in two ranks with the range section on the right, facing **CS.** The interval is 4 inches

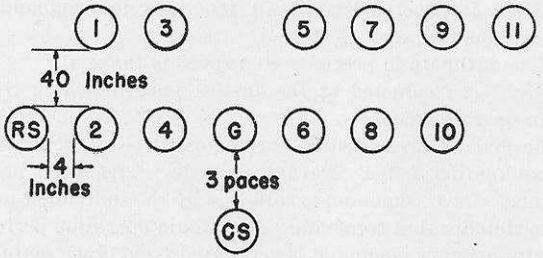


FIGURE 6.—Positions of crew at *FALL IN.* CS takes post 3 paces in front of and facing where the center of the front rank is to form and commands: *FALL IN.*

between files and 40 inches between ranks. **CS** takes his post 3 paces in front of the center of the line on which the front rank

is to form. This command is used when necessary to assemble the fire unit, and is always used prior to dismissing the fire unit from drill.

CS commands: **FALL IN.**

RS takes his post as guide on the right, facing **CS.**
2, 4, G, 6, 8, and **10** form the front rank.
1, 3, 5, 7, 9 and **11** form the rear rank.
(**1** and **3** cover off **2** and **4**; **5, 7** and **9** cover off **6, 8** and **10**; and **11** covers a blank file.)

NOTE.—*CS forms the fire unit in this formation when required, and locates the assembly point so as to best suit the particular situation.*

■ 14. COUNT OFF.—The fire unit being in formation,

CS commands: **COUNT OFF.**
RS reports, ***"Range setter."***
1 to **4** report, their numbers consecutively.
G reports, ***"Gunner."***
5 to **11** report, their numbers consecutively.

■ 15. CALL OFF.—The fire unit being in formation,

CS commands **CALL OFF,** when necessary to verify the fire unit.

Each member of the fire unit reports his assignment as follows:

RS reports, ***"Range setter."***
1 reports, ***"Elevation tracker."***
2 reports, ***"Azimuth tracker."***
3 reports, ***"Power plant operator and chauffeur."***
4 reports, ***"Telephone operator and alternate tracker."***
G reports, ***"Gunner."***
5 reports, ***"Machine gunner and lookout."***
6 reports, ***"Machine gunner and lookout."***
7 reports, ***"Loader and firer."***
8 reports, ***"Lookout and lateral gun pointer."***
9 reports, ***"Lookout and vertical gun pointer."***
10 reports, ***"Ammunition relayer."***
11 reports, ***"Ammunition detail and chauffeur."***
to the fire units.

■ 16. CHANGE ORDER.—The fire unit being in formation,
CS commands: **CHANGE ORDER.**

All members of the firing unit change positions as follows:

RS falls out to rear, takes place of **11.**
1 takes place of **RS.**
2 takes place of **1.**
3 takes place of **2.**
4 takes place of **3.**
G takes place of **4.**
5 takes place of **G.**
6 through 11 move to position of next lower member.

All members move simultaneously to new positions and dress right.

■ 17. MOUNT.—The fire unit being in formation,
CS commands: **MOUNT.**

When equipped with M2A1 or M3 machine gun mount:

4, 2, and 1 mount instrument truck at right rear in that order.
5 and 6 mount instrument truck at left rear and man machine gun.
1 fastens safety strap.
3 and RS take seats in cab.

When equipped with multiple caliber .50 machine-gun carriage M51:

2 and 1 mount instrument truck at right rear in that order.
4, 5, and 6 mount turret trailer in that order.
6 takes post at left of turret.
5 takes post in turret seat.
4 takes post at right of turret.
3 and RS take seats in cab.

Remainder of crew take posts as follows:

10 and G mount prime mover at left rear in that order.
8, 7, and 9 mount prime mover at right rear in that order.
9 fastens safety strap.
11 and CS take seats in cab.

■ 18. DISMOUNT.—The fire unit being in the trucks,
CS dismounts; commands: **DISMOUNT.**

RS and G repeat command when necessary.

RS and 3 dismount from cab.
1 unfastens safety strap.

1, 2, and 4 dismount from right rear of instrument truck.
5 and 6 dismount from left rear unless instructed to remain in truck.

9 unfastens safety strap.
9, 7, and 8 dismount from right rear of prime mover.
G and 10 dismount from left rear of prime mover.
11 dismounts from cab.

NOTE.—*When equipped with multiple caliber .50 machine gun, carriage M51, 4, 5,* and *6 dismount from trailer.*

All form as at the command, ***FALL IN.***

■ 19. LOAD TRUCKS.—This command is used primarily in early stages of training. The fire unit being dismounted, and in formation as prescribed for ***FALL IN*** (par. 13).
CS commands: **LOAD TRUCKS.**

RS and G give supplementary commands as required.
All take posts and load equipment as for ***MARCH ORDER*** (sec. V).

■ 20. UNLOAD TRUCKS.—This command is used primarily in early stages of training. The fire unit being mounted in trucks,
CS dismounts and commands: **UNLOAD TRUCKS.**

RS and G dismount—give supplementary commands as required.
All dismount, take posts and unload equipment as for ***PREPARE FOR ACTION*** (Sec. II).

■ 21. START POWER PLANT.
CS commands and signals to 3: **START POWER PLANT.**
Hand signal: Facing 3, simulates CRANKING with right hand.
3 starts power plant; returns hand signal.

■ 22. CLOSE SWITCH.

CS commands and signals to **3: CLOSE SWITCH.**
Hand signal: Facing **3**, raises and clasps hands together high overhead.

3 closes switch; returns hand signal.

■ 23. OPEN SWITCH.

CS commands and signals to **3: OPEN SWITCH.**
Hand signal: Facing **3**, raises right hand high overhead, palm toward power plant operator.

3 opens switch; returns hand signal.

■ 24. STOP POWER PLANT.

CS commands and signals to **3: STOP POWER PLANT.**
Hand signal: Facing **3**, swings arms across body parallel to ground.

3 stops power plant; returns hand signal.

SECTION II

PREPARE FOR ACTION

■ 25. PREPARE FOR ACTION.—*a. General.*—The procedure for placing the various elements of the fire unit into action from the traveling position is designed so that—

(1) The gun is emplaced in minimum time and is ready to fire, using sight control system, during emplacement of the remainder of the equipment.

(2) The director and power plant are emplaced and prepared for action with the least possible delay, in order that the gun may be fired, using director control, as early as possible.

(3) Local protection is furnished throughout emplacement of all equipment, by either the machine gun or the 40-mm gun.

b. In the following drill, it is assumed that ***CS, RS,*** *and* ***G*** *have made their reconnaissance, and that* ***CS*** *has indicated positions to be occupied by 40-mm gun, director, power plant, machine gun, and trailer. It is also assumed that gun has been traveling with covers in place. If gun is without covers, those portions of drill referring to removal of covers may be omitted.*

CS dismounted and near gun position, commands: **PREPARE FOR ACTION;** Takes post where he can supervise work of the firing unit; exercises general supervision over unloading and emplacement of equipment.

RS [repeats command **PREPARE FOR ACTION**] directs **3** to drive instrument truck to trailer position, and then to machine-gun position.

G [repeats command **PREPARE FOR ACTION**] directs **11** to drive to gun position.

RS supervises movement of instrument truck to trailer position; dismounts [commands: **DISCONNECT TRAILER**] assists 1 and 2 in disconnecting trailer.

3 drives truck to trailer position, as directed by **RS.**

1 unhooks safety belt.

1 and **2** dismount and, assisted by **RS,** disconnect trailer. (**1** at left side, **2** and **RS** at right side.)

RS, 1, and **2** remount truck (if machine-gun position is near, they proceed on foot).

RS supervises movement of instrument truck to machine-gun position; dismounts.

3 drives truck, as directed by **RS**; stops truck at machine-gun position; dismounts.

1, 2, and **4** (if mounted) dismount as soon as truck stops.

1 and **2** unhook tailgate and lower tailgate.

5 on truck, continues to man machine gun.

6 on truck, continues to assist **5** as required; checks ammunition supply and thereafter remains alert for targets.

RS directs preliminary preparation of machine-gun emplacement.

1, 2, 3, and **4** begin preliminary preparation of machine-gun emplacement under the direction of **RS.**

G supervises movement of prime mover to gun position (**CS** may accompany prime mover and supervise its movement to gun position).

11, as directed by **CS** or **G,** drives prime mover to position at which 40-mm gun will be disconnected; stops prime mover.

NOTE.—*When equipped with multiple caliber .50 machine-gun carriage M51, the following drill is applicable:*
At command ***PREPARE FOR ACTION*** (see fig. 7).—

RS dismounts [commands: **DISCONNECT TRAILER**], disconnects break-away chain, light cable and trailer drawbar.

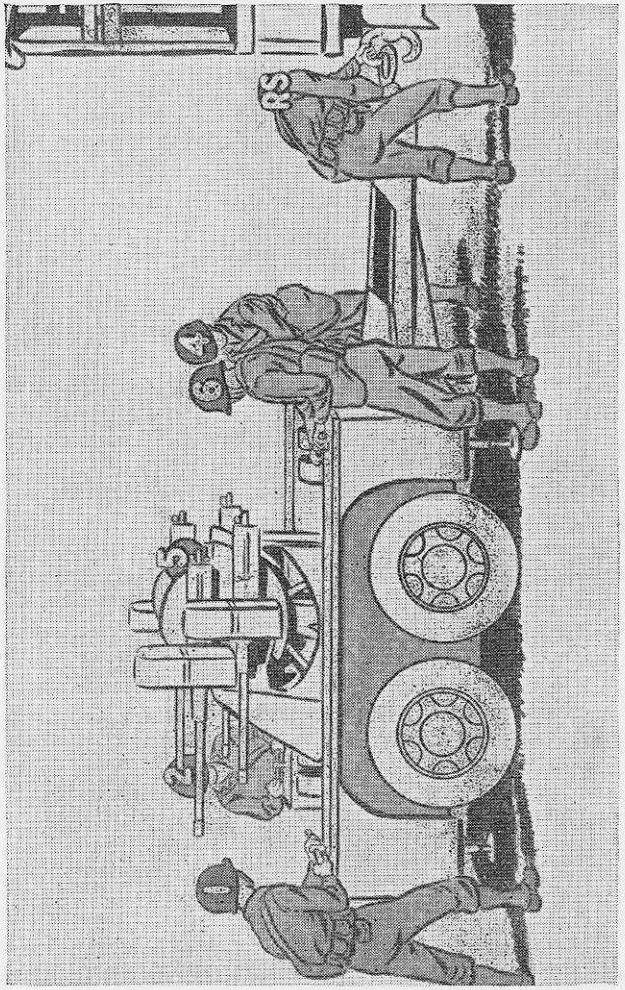


FIGURE 7.—**PREPARE FOR ACTION.** (Multiple caliber .50 machine-gun carriage M51.)

4 and 6 dismount from trailer, ground front jacks (6 on right side of trailer and 4 on left), to lift drawbar off pintle.

1 and 2, dismount from instrument truck, ground rear jacks (1 at right rear trailer jack and 2 at left rear).

1, 2, 4, and 6 adjust jacks at **RS's** direction to stabilize the trailer (the jacks should not carry any of the trailer's weight), and then unload machine-gun ammunition from truck.

5 remains in turret at all times, on the alert.

4 and 6 leave trailer and perform duties required by standard drill to emplace director, power plant, cables and telephone, then return to multiple caliber .50 machine-gun carriage M51 acting as lookouts and cannoneers.

Instrument truck proceeds to director emplacement, and standard drill is continued.

■ 26. EMPLACE GUN.—As soon as prime mover reaches gun position,

G [commands: **EMPLACE GUN**] dismounts; takes post at left of drawbar. (See fig. 8.)

9 unfastens safety belt at rear of truck (tailgate of prime mover is not lowered for dismounting).

10 dismounts from left rear of prime mover; takes post at left rear of carriage to assist in removing gun covers.

9, 7, and 8 dismount in order named, from right rear of truck.

9 takes post at right rear of carriage, to assist in removing gun covers.

7 takes post at right of drawbar, near its center.

8 takes post at right of drawbar, near lunette.

G disconnects break-away chain and brake cable; places brake cable in socket; wraps break-away chain around drawbar, above brake cable retaining tube; signals 11 to back up or pull ahead slightly, as required for disconnecting drawbar.

8, assisted by 7, disconnects drawbar from prime mover; proceeds to left of carriage, to remove lateral sight cover.

7 assists 8 in disconnecting drawbar from prime mover; proceeds to right of carriage, to unlace gun cover from center to front of chassis frame.

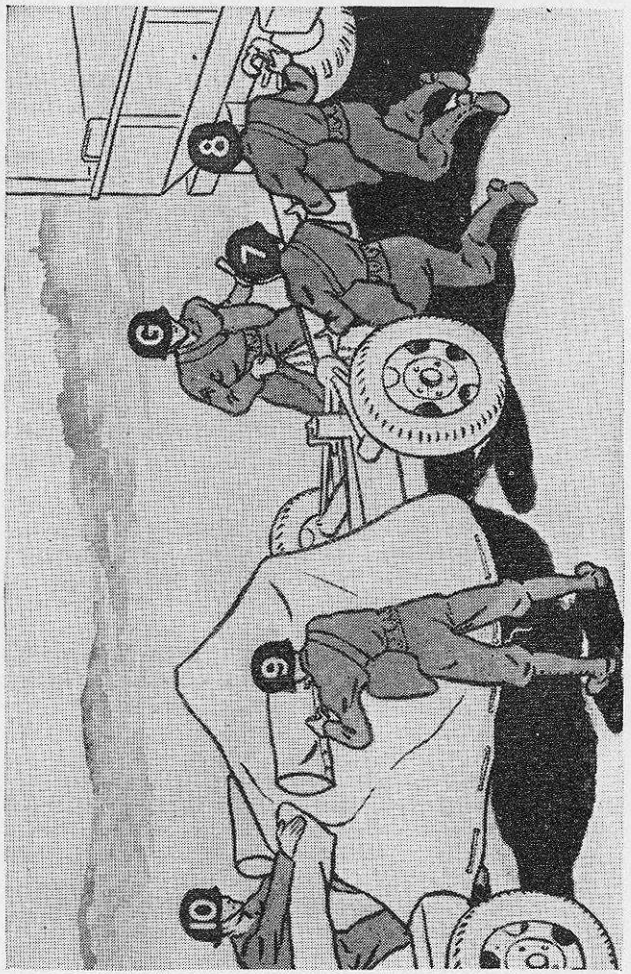


FIGURE 8.—EMPLACE GUN.

9 unfastens gun cover upper strap, barrel cover strap and snap, located at sight bracket; unfastens gun cover lower strap, located at right rear side of chassis frame; unlaces gun cover from center to rear. (Gun cover should be laced from both ends toward the center.)

10 unfastens gun cover lower strap, located at left rear side of chassis frame; unsnaps gun cover along gun stay; unfastens gun cover upper strap and barrel cover strap, located at sight bracket.

G, as soon as gun is disconnected [commands: **PULL AHEAD**] supervises removal of covers; resumes post at left of drawbar.

11 drives prime mover forward about five yards and stops; dismounts; proceeds to right rear of carriage, to assist **10** in removing barrel cover.

7 unlaces gun cover from center to front of chassis frame; unfastens gun cover front strap.

8 removes lateral sight cover and places it aside; receives barrel cover from **10,** and vertical sight cover from **9**; places them aside with lateral sight cover.

9 finishes unlacing gun cover from center to rear; removes vertical sight cover and passes it to **8.**

10, assisted by **11,** removes barrel cover; hands cover to **8.**

11 assists **10** in removing barrel cover.

7, 9, and **11** on right side of carriage, pass top portion of gun cover across gun to **8** and **10.**

8 and **10** receive gun cover and carefully fold it to prevent inside of cover from being exposed to dirt; place with barrel and sight covers, clear of gun.

7 removes autoloader hood and breech cover; lays them aside.

9 and **8,** when time permits, place gun covers at suitable place; return to their posts at carriage.

When gun has to be pushed into a prepared emplacement,

G directs movement of gun into position. (**CS** may direct movement of gun. Such other members of the fire unit as are required may assist in moving gun into position.)

7 takes position at right of drawbar near lunette; lifts drawbar.
8 takes position at left front wheel.

9 takes position at right front wheel.
10 takes position at left rear wheel; operates brake as necessary.
11 takes position at right rear wheel; operates brake as necessary.
7 assisted when necessary by G, guides and helps push gun into position.
8, 9, 10, and 11, assisted by 7, push gun into position. (CS, G, and other members of the fire unit assist when necessary.)

When gun is in position for emplacing,

G takes post at left of drawbar; unlocks steering link securing clamp; assisted by 7, locks drawbar and steering gear with pins, so that they are rigid; takes post at drawbar.
7 assists G in locking drawbar and steering gear; takes post at drawbar end of carriage, in rear of front axletree, and between right front wheel and chassis frame.
8 attaches traversing handle; takes post at drawbar end of carriage, in rear of front axletree, and between left front wheel and chassis frame.
9 attaches elevating handle; removes right outrigger cover and places it aside; swings right outrigger to firing position and locks it; after 11 releases upper plungers of gun stay, elevates gun until it is clear of gun stay and will clear drawbar when gun is slewed (45° is sufficient); takes post at gun stay end of carriage, in rear of rear axletree, and between right rear wheel and rear jack.
10 removes left outrigger cover and places it aside; swings left outrigger to firing position and locks it; sees that slewing lever is down; takes post at gun stay end of carriage, in rear of rear axletree, and between left rear wheel and rear jack; checks that lower plungers of gun stay are locked to rear axletree.
11 releases upper plungers of gun stay; takes post at gun stay to right of carriage.

G commands: **UNLATCH.**
8 sets front locking handle to unlocked position [reports, ***"Unlatched."***]
9 sets rear locking handle to unlocked position [reports, ***"Unlatched."***]

G commands: **READY—LOWER.** (See fig. 9.)
7, 8 and G at front, and 9, 10, and 11 at rear, lower carriage to the ground.
G sets front locking handle to locked position.
11 sets rear locking handle to locked position; disengages gun stay plungers and lowers gun stay.

[G commands: **MAN JACKS.**]
7 takes post at front jack [reports, ***"Ready."***]
9 takes post at right jack [reports, ***"Ready."***]
10 takes post at left jack [reports, ***"Ready."***]
11 takes post at rear jack [reports, ***"Ready."***]
8 removes lever and maul from gun platform, and maul from prime mover; places them in position convenient for use. (He places one maul near each end of chassis frame; if only one is available, he places it near front of chassis frame; takes post at slewing lever.) (See figs. 10 and 11 for positions at jacks.)

G [commands: **GROUND JACKS**] (directs 7, 9, 10, and 11 when uneven ground makes it advisable for certain jacks to be extended farther than others).
7, 9, 10, and 11 lift leveling jack handles; turn handles until footplates rest firmly against ground and handle locks are exactly opposite notches. (All four plates must carry equal loads.)

NOTE.—*Throughout this drill the terms **UP** and **DOWN** refer only to the carriage. Jack handles are to be turned in the direction required to produce movement of the carriage in the direction specified. When command is **UP**, turn handles clockwise.*

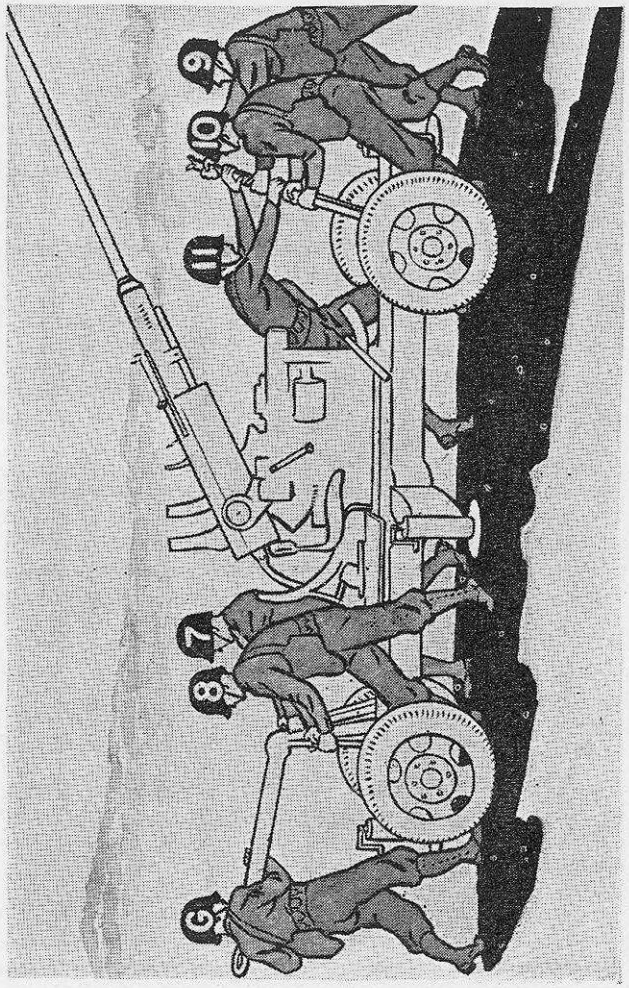


FIGURE 9.—READY—LOWER.

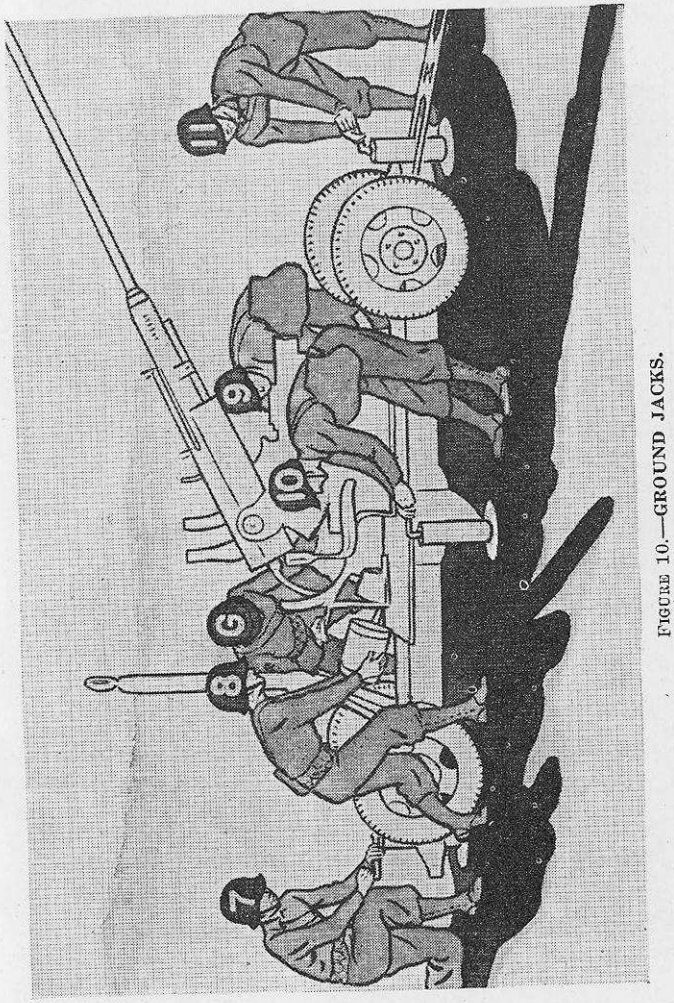


FIGURE 10.—GROUND JACKS.

554769°—43——3

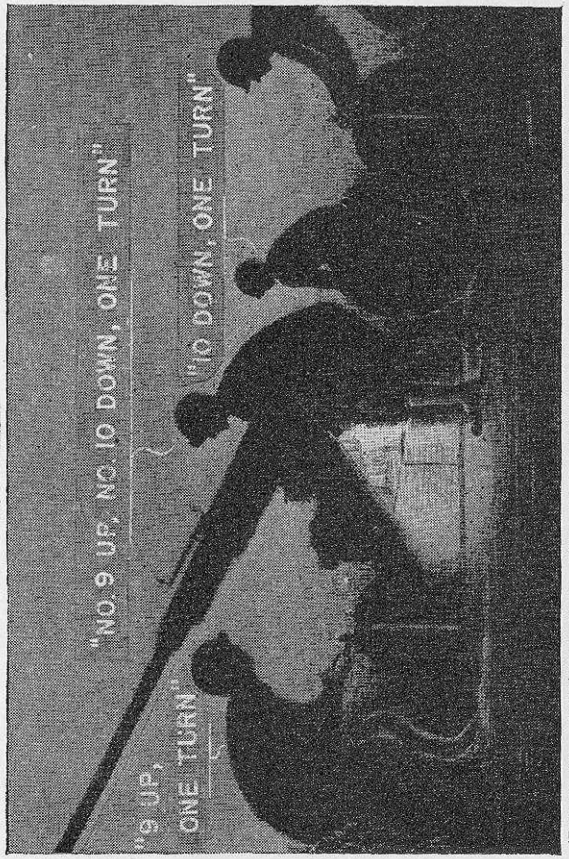


FIGURE 11.—Night leveling. Numerous drill procedures, such as the leveling operation shown here, must be carried out by the crew with the chief of section or gunner unable to see what they are doing, or to see when they finish any part of the operation. Therefore, commands and reports must cover the problems of night operations.

G commands: **UP THREE TURNS** (more if on soft ground).
7, 9, 10, and **11** give jack handles exactly three full turns [report their numbers together with the command, as ***"Seven—Up Three Turns."***]
G, if CS is present [reports ***"Ready to Level."***]
CS commands: **LEVEL,** or if desired, gives command: **SIGHT CONTROL.** If latter command is given, it is executed immediately (see ***SIGHT CONTROL*** below).

G [commands (or repeats): **LEVEL**] assisted by **8,** slews gun so that muzzle is toward gun stay and one leveling tube is parallel to chassis frames.
8 assists **G** in slewing gun during leveling of gun.
7, 9, 10, and **11** grasp leveling jack handles.

G observes position of bubbles in leveling tubes fastened to upper carriage (when gun is out of level, the bubble is always displaced from center of tube in the direction of the higher end); orders that jack at higher end of chassis frame be locked.

Example: Assuming that drawbar end of chassis frame is the higher end, the procedure for leveling is as follows:

G commands: **SEVEN—LOCK.**
7 locks front jack by lowering handle lock into notch [and reports, ***"Seven—Locked."***]
G commands: **ELEVEN—UP TWO TURNS.**
11 gives jack handle exactly two turns in the direction required to raise rear end of chassis frame [reports, ***"Eleven—Up Two Turns."***]
9 and **10,** while **11** is turning his jack handle, give their jack handles exactly one turn (half as many turns and in same direction as **11**) [report, ***"Nine—Up One Turn"—"Ten—Up One Turn."***]
G continues to raise lower end in this manner until gun is level along chassis frame (each outrigger jack raising gun exactly half as much as end jack) or until **11** has raised his end too high.

NOTE.—*Whenever time permits, it is desirable that gun be leveled or releveled, with a minimum extension (run-*

out) of jacks. This entails digging out under wheels and chassis, and lowering gun with jacks.

If 11 has raised his end too high,

G commands: **ELEVEN—DOWN TWO NOTCHES.**

11 moves his jack handle exactly two notches in the direction required to lower rear end of chassis frame [reports, ***"Eleven—Down Two Notches."***]

9 and **10,** while 11 is turning his jack handle, move their jack handles exactly one notch (half as many notches and in the same direction as 11) [report, ***"Nine—Down One Notch," "Ten—Down One Notch."***]

When gun has thus been leveled along chassis frame,

G commands: **ELEVEN LOCK.**

11 locks rear jack by lowering handle lock into notch [reports, ***"Eleven Locked."***]

G observes position of bubble in leveling tube which is parallel to outriggers, commands that jacks at end of outriggers be turned through exactly the same number of turns or notches, but in opposite direction.

Assuming that left outrigger is the higher, the procedure is as follows:

G commands: **NINE UP—TEN DOWN—FOUR NOTCHES.**

9, upon command, moves his jack handle exactly four notches in the direction required to raise outrigger [reports, ***"Nine—Up Four Notches."***]

10, while **9** is turning his jack handle, moves his jack handle exactly four notches in the direction required to lower outrigger—[reports ***"Ten—Down Four Notches."***]

G directs **9** and **10** in this manner until gun is level along outriggers; commands, **LOCK.** [Each man at jack reports, as he complies with any leveling order] assisted by 8, slews gun through 180° and checks that bubbles come to rest in same place. (Bubbles will come to rest at center of bubble tubes if tubes are properly adjusted.)

NOTE.—*In the event* **G,** *or any man at jacks, becomes confused or has reason to believe that jacks are not carrying equal loads, he calls* ***"RELEVEL."***

G commands: **RELEVEL.**

7, 9, 10, and **11** turn their jack handles in the direction required to lower the carriage, and continue to lower carriage until wheels rest upon ground [report, ***"Carriage Down."***]

G commands: **GROUND JACKS.**

The procedure as described above is repeated until the gun is properly leveled.

G when gun is level, removes drawbar pin; folds drawbar to front; places pin in socket.

[G commands: **DRIVE STAKES.**]

8 takes post to right of chassis frame in front of rear axletree, and faces chassis frame, removes upper stake and passes it to **7;** removes lower stake and passes it to **11;** assists in driving stakes when necessary.

7 receives stake from **8;** inserts stake in bracket at front of chassis frame; procures maul; immediately drives stake into ground; passes maul to **9.**

9 removes stake from right outrigger; inserts stake in bracket; receives maul from 7; drives stake into ground; passes maul to **11.**

11 receives stake from **8;** inserts stake in bracket at rear of chassis frame; procures second maul if available or receives maul from **9;** drives stake into ground; passes maul to **10.**

10 removes stake from left outrigger; inserts stake in bracket; receives maul from **11;** drives stake into ground; places maul aside or hands it to **11.**

11 collects mauls; places mauls with gun covers.

G checks level of gun; when found to be out of level, raises drawbar and inserts pin, gives command, **MAN JACKS,** followed by command, **LEVEL.** (These commands, when given, are executed as previously described, and gun is accurately leveled.)

[G reports, to CS: ***"Gun Level."***]

When G reports, ***GUN LEVEL*** *(or, if desired, when he reports,* ***READY TO LEVEL****),*

CS commands: **SIGHT CONTROL** (G gives the command in absence of CS). (See figs. 12, 13, and 14.)

G [repeats (or commands): **SIGHT CONTROL**] removes drawbar pin; folds drawbar to the front; places pin in its socket; supervises preparation for sight control action; insures that elevation switch is "OFF" and slewing lever lifted; takes hold of free end of rope which is attached to firer's foot.

7 takes post on gun platform for sight control action.

8 takes post in lateral gun pointer's seat for sight control action.

9 takes post in vertical gun pointer's seat for sight control action; insures that oil gear clutch lever is to rear; attaches rope to right foot and passes free end to **G**.

10 and **11** proceed to secure and prepare ammunition.

RS (when M7 sight is used) mounts gun platform in rear of **8** and acts as lead setter.

When members of gun section are at posts for sight control action, and time does not permit complete examination of equipment.

CS commands: **EXAMINE FOR ACTION.** (In absence of **CS**, **G** gives the command.)

G [repeats command] insures that recoil buffer is full, secure and properly adjusted; inspects recuperator and equilibrators; examines barrel and loading mechanism; insures recoil recorder set to minimum; insures top and side covers properly closed and locked; verifies deflector tube lowered and secured; insures feed control lever to left; insures safe or fire lever at "SAFE", and loading lever in rear catch; checks condition of sights (assisted by **8** and **9**); inspects ammunition.

7 pulls loading lever fully to rear to set feed control lever to right; moves loading lever to front catch; tests firing mechanism; tests safe or fire lever in three positions; sets to "SAFE"; sets feed control lever to left; inspects loading tray and autoloader; insures top and side covers are closed and locked, loading lever is in rear catch, and breechblock is open; assists **10** and **11** in examining ammunition.

8 and **9** traverse and elevate gun as required to assist **G**; check operation of traversing and elevating mechanism; assist **G** in checking condition of lateral and vertical sights.

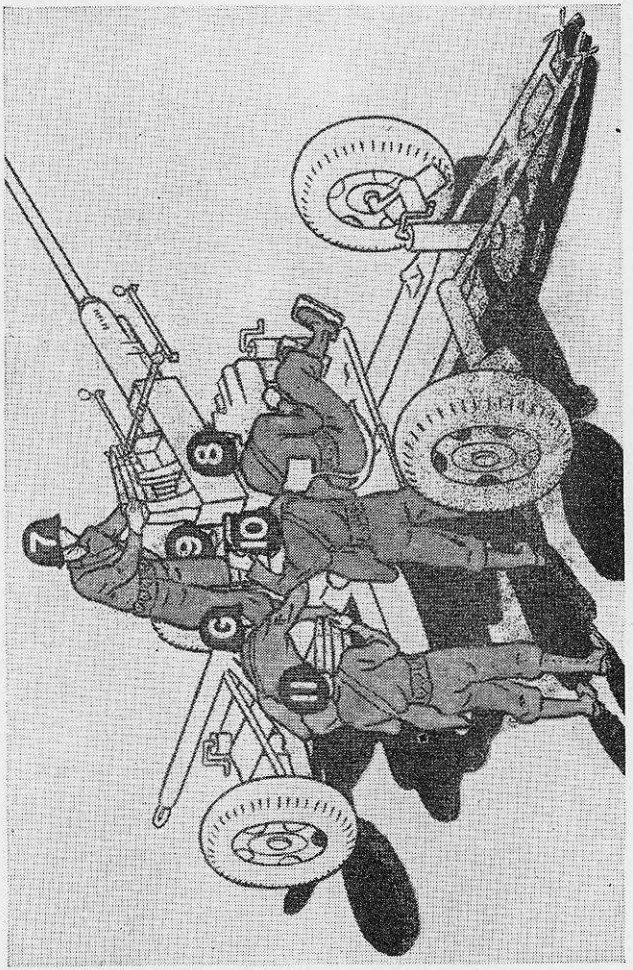


FIGURE 12.—**SIGHT CONTROL.** Forward area sights.

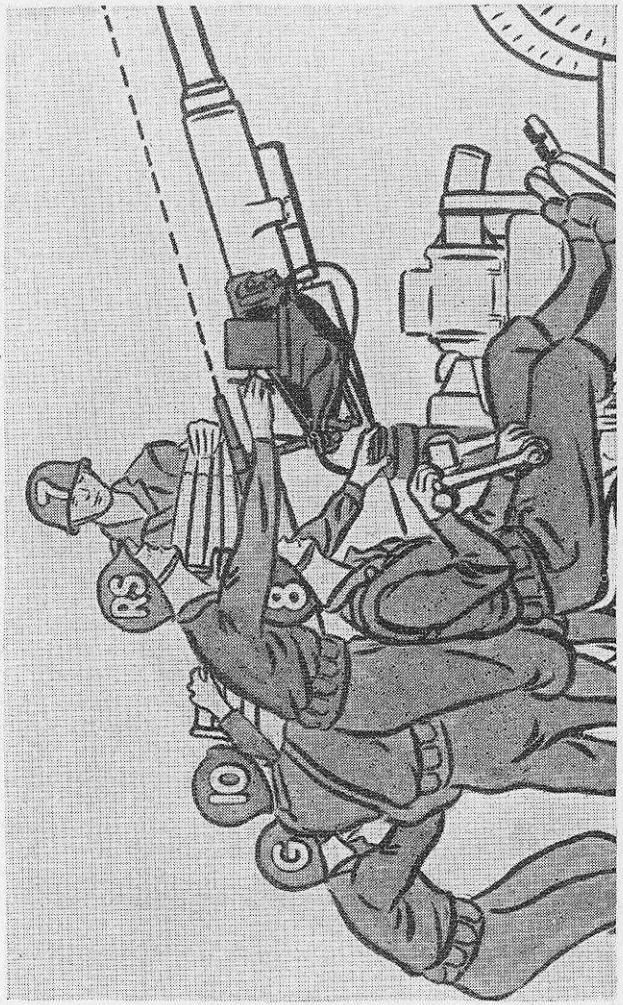


FIGURE 13.—**SIGHT CONTROL.** Computing sight M7.

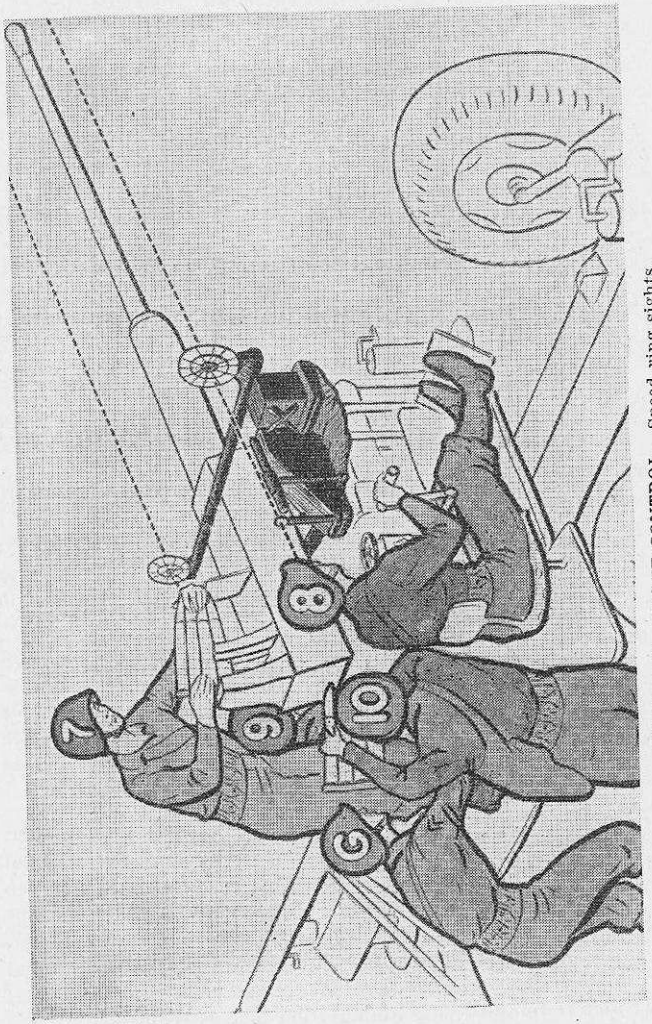


FIGURE 14.—**SIGHT CONTROL.** Speed ring sights.

10 and **11** examine ammunition and clips.

10 assists **7** in tripping the extractor releasing lever as required.

When it is evident that members of the fire unit have completed their duties under command ***EXAMINE FOR ACTION.***

CS commands: **REPORT.** (In absence of **CS**, **G** gives the command.)

[**G** repeats command.]

7, 8, 9, 10, and **11** report any defects to **G.**

G reports to **CS,** ***"Gun in Order,"*** or reports any defects in equipment.

CS commands: **LOAD** (In absence of **CS**, **G** gives the command.)

G [repeats command] makes sure that rope is attached to firer's foot; takes hold of free end of rope.

7 insures safe or fire lever is at "SAFE"; reports, ***"Safe";*** insures feed control lever is at left; pulls loading lever fully to rear; moves it slightly forward, and engages it in rear catch.

10 obtains a loaded clip; keeps himself placed at right of breech casing; passes loaded clips across right side of autoloader to **7.** **10** holds loaded clips with fuzes to his right; closed side of clip vertical and on side away from him. His right hand is placed beneath center of bottom round and his left hand over center of top round.

7 receives loaded clip from **10** by reaching across autoloader, placing palm of right hand against base of bottom round and palm of left hand against next to bottom fuze so as to support bottom fuze also; adjusts position of hands so that lower edges of palms touch front and rear guides; drops loaded clip into autoloader; presses down hard on top round with both hands until bottom round drops to loading tray.

10 and **11** relay or pass ammunition to **7** as required.

When 40-mm gun is ready for sight control action,

[**G.** reports, ***"Ready for Action."***]

G, 10, 11 unload spare barrel, ammunition, tools, and supplies from prime mover and place as directed by **CS.** Spare barrel should be located conveniently near gun position and protected from dirt and weather.

CS orders **11** to park prime mover, indicating parking location; takes post where he can supervise work of the fire unit.

11 parks prime mover returns to gun.

NOTE.—*The above unloading and parking of the prime mover is done when most expedient.*

■ 27. EMPLACE MACHINE GUN.—*When 40-mm gun is ready for sight control action (if* ***RS*** *is engaged on M7 sight,* ***CS*** *performs his duties).*

CS [commands: **EMPLACE MACHINE GUN**] indicates spot for emplacement.

[**RS** repeats command.]

5 and **6** unload feedway and chamber of machine gun.

5 clamps machine gun at horizontal; swings muzzle toward cab of instrument truck.

6 places power cable at rear of power plant; raises right seat of truck to facilitate removal of machine gun.

4, RS, 3, 2, and **1** (dismounted) take post facing tailgate of truck, in order named (**RS** slightly to left of center).

5 dismounts; takes post at left of **4.**

6 removes the ammunition chest and passes it to **4.** (If situation is urgent, chest is not removed.)

4 places ammunition chest near indicated location; returns to this post at rear of truck.

6 pushes water chest to rear of truck.

1 and **2** lift water chest off of truck; place under tailgate.

6, on truck, pushes gun and tripod assembly to rear.

RS and **3** grasp rearmost tripod leg; pull toward rear; lift.

2 and **1** grasp next tripod leg; pull toward rear; lift.

4 and **5** grasp last tripod leg; pull toward rear; lift.

6, on truck steadies machine gun by barrel, as it is lifted down.

5, 4, RS, 3, 2, and **1** lower gun and tripod assembly; place machine gun in position. (See fig. 15.)

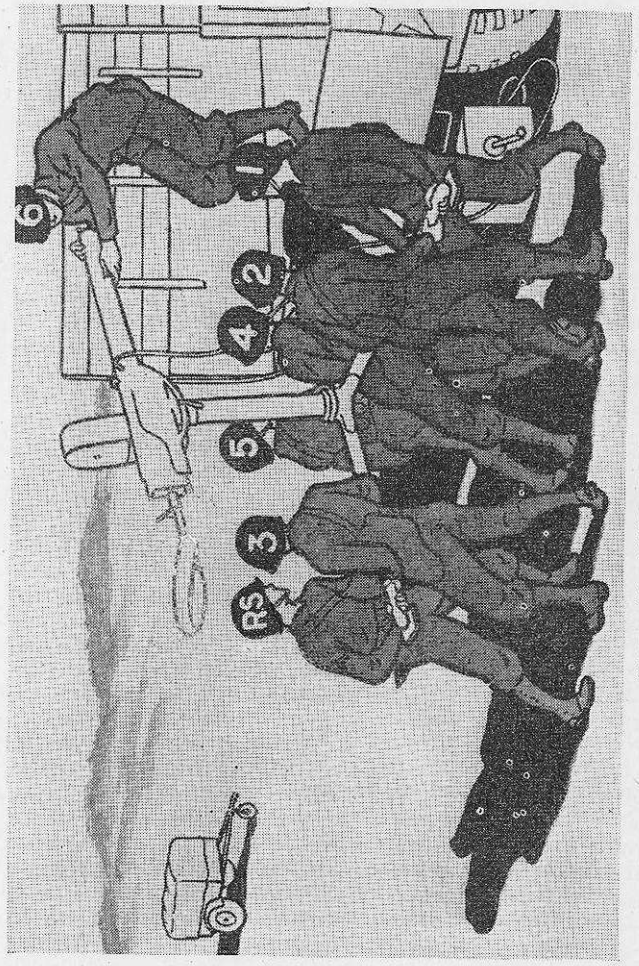


FIGURE 15.—EMPLACE MACHINE GUN.

5 immediately replaces ammunition chest on machine gun; swings machine gun to point into dead area; loads machine gun; unclamps machine gun in elevation; remains ready to fire.
6 passes machine-gun ammunition and tools to 1 and 2; dismounts; assisted by 1 and 2, places water chest to left of machine gun.
1 and 2 assist 6 in placing water chest to left of machine gun.
1, 2, 3 and 4, remount.
3 drives instrument truck to director site as directed by RS.
RS, 6 proceed to director site on foot.

■ 28. EMPLACE DIRECTOR.—When instrument truck has reached the position to which the director is to be emplaced (see note at beginning of par. 27),

RS [commands: **EMPLACE DIRECTOR**] (He marks on ground with his heel the spot on which the director tripod is to be set); takes post facing left rear of instrument truck to supervise and assist in removing director from truck.

3 dismounts; takes post facing center rear of truck.
6 takes post facing right rear of truck.

1 and 2 unlash director tripod from director packing case.
4 insures that power cable is at rear of power plant, so as not to interfere with removal of director; hands director cable, radio, and telephone equipment to 3.
3 receives director cable, radio, and telephone equipment from 4; places them near the place at which director is to be emplaced; returns to rear of truck.
2 and 4 hand director tripod to 3 and 6.
3 and 6 receive director tripod from 2 and 4; place it exactly on spot marked by RS, so that two plungers of tripod will be directly toward direction from which director will be brought to tripod; extend plungers about ½ inch; return to posts at rear of truck.

NOTE.—*When tripod is thus emplaced, the director can be positioned through the gap between the tripod plungers, thus reducing the amount of lifting required.*

1 and 2, assisted by 4, move director packing chest to rear of truck; turn chest one-quarter turn clockwise, so that its long sides are parallel to rear axle of truck, and so that side on which white arrows are painted faces toward the rear.

NOTE.—*When on truck, director chest should be at the front, to right of power plant, and should have its long sides parallel to truck sides. The side on which two white arrows are painted should be to the right. 1 should take hold of left rear corner, 2 should take hold of right front corner, and 4 should take hold of right rear corner. 1 should coordinate the efforts of all three by giving commands suggestive of the direction in which chest should be moved. He should say "Clockwise" when chest should be rotated in that direction, as viewed from above, and "Counterclockwise" when chest should be moved in the opposite direction. By giving these orders alternately and by all three working together, the chest can be moved easily to the rear and rotated one-quarter turn clockwise before allowing it to come to rest at rear of truck.*

1, 2 insert carrying bars in director chest brackets nearest left and right sides of truck, respectively.

4 dismounts; takes post to left of 6.

1 and 2, holding carrying bars and assisted by 3 and 4, move chest until it extends slightly beyond rear end of truck floor.

RS takes hold of left carrying bar at end which extends toward the rear.

6 takes hold of right carrying bar at end which extends toward the rear.

3 takes hold of left carrying bar slightly to rear of center.

4 takes hold of right carrying bar slightly to rear of center.

[RS commands: **READY—LOWER.**]

RS, 3, and 1 (at left) and 6, 4, 2 (at right), lower director chest until only the forward ends (6 to 8 inches) of carrying bars rest upon rear of truck. (See fig. 16.)

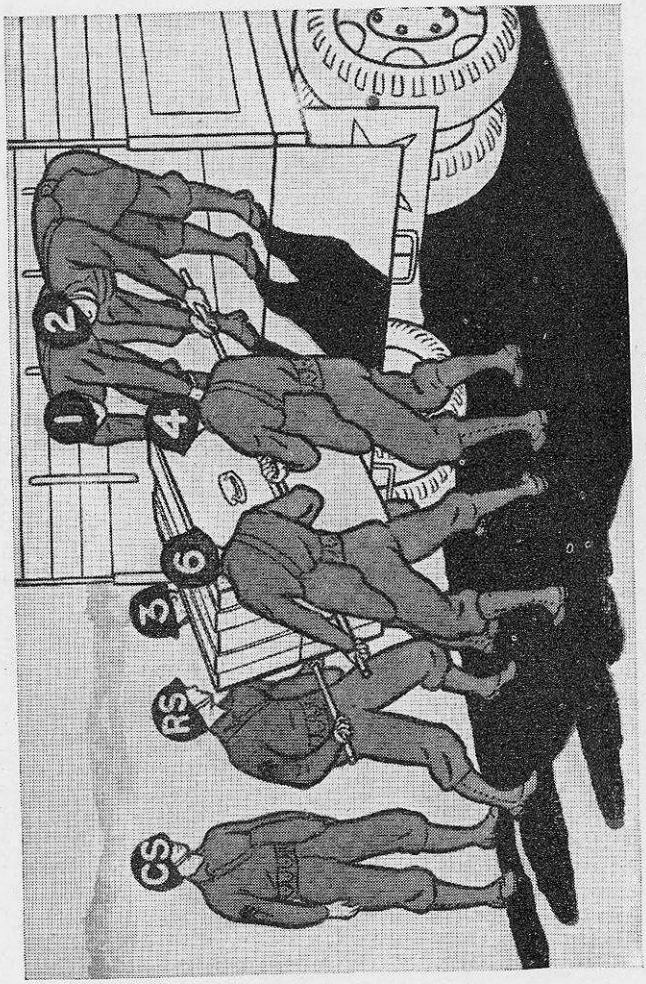


FIGURE 16.—READY—LOWER.

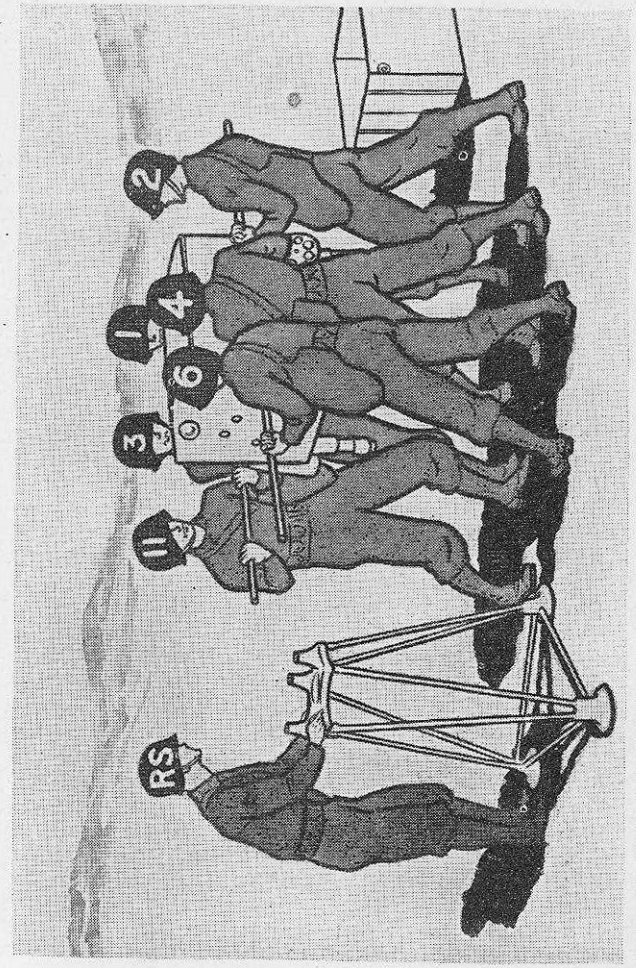


FIGURE 17.—**READY—RAISE.** At the command, the range section assisted by 6 and 11 carry the director to the tripod and emplace it.

1 dismounts to left; takes hold of front end of left carrying bar.

2 dismounts to right; takes hold of front end of right carrying bar.

[RS commands: **READY—CARRY.**]

[RS, **3**, and **1** (at left) and **6**, **4**, and **2** (at right) lower director chest; carry director chest to location indicated by **RS**; lower chest to ground.

NOTE.—***RS** should direct that chest be placed several feet from the place where the tripod is emplaced, and that the side on which white arrows are painted will be facing the direction toward which the director must be carried to mount it upon tripod.*

3 and **4** remove upper section of director chest.

6 removes canvas cover from top of director.

1 and **2** remove carrying bars from director chest and insert them in director carrying brackets.

[RS commands: **READY—RAISE.**]

1, **2**, **3**, and **4**, assisted by **6** and **11** as required, carry director to tripod and prepare to lift and emplace it. (See fig. 17.)

6 and **11** assist as required in carrying and emplacing director.

NOTE.—*Director, when in packing chest, should always have azimuth panel on same side of chest as white arrows (marked on outside of chest). The azimuth panel may be easily identified by the orienting clutch, directly underneath. The director, before it is removed from tripod and placed in packing chest, should be slewed so that orienting clutch (as azimuth panel is faced) appears slightly to right of one of the three plunger receptacles. This facilitates clearing the tripod when director is lifted.*

*Director, when being emplaced, should be brought to tripod with azimuth panel facing the two tripod plungers previously placed in direction of approach. When director is then lifted over tripod, the plungers and receptacles will approximately match. **RS**, facing azimuth panel, should then stoop, grasp slewing handle with left hand, and with right hand, position the receptacles so that rota-*

tion of director is not required. ***RS*** *directs slight movements as required to center director over tripod.*

RS, as director is brought to tripod, takes post at tripod plunger opposite director [and commands: **READY—LIFT**] directs movement of director over tripod; positions receptacles.

1, 2, 3, and **4,** assisted by **6** and **11** if necessary, lift director; remove it over tripod as directed by **RS.**

When director is properly positioned,

RS [commands: **LOWER**] guides receptacles.

1, 2, 3, and **4,** assisted by **6** and **11** if necessary, gently lower director onto tripod.

When director has been placed upon tripod,

RS directs **3** to drive to position at which power plant is to be emplaced, removes carrying bars; hands bars to **6** and **11**; mounts the telescopes; levels director; connects director cables to director and to gun junction box. (**RS** may assist in unloading power plant before leveling director.)

3 drives instrument truck to place indicated by **RS**; starts power plant in truck, if directed by **RS.**

6 and **11** receive carrying bars from **RS**; insert bars into director chest carrying brackets; close director chest and take it to concealment.

11 places canvas cover near director.

NOTE.—*If the tactical situation permits, the power plant may be left in the truck.*

RS, 1, 2, 4, 6, 10 and **11** go to power plant position when it is to be emplaced.

■ 29. EMPLACE POWER PLANT.—*When director has been emplaced (see note at beginning of par. 27),*

RS [commands: **EMPLACE POWER PLANT**] directs and assists in unloading power plant.

3 mounts; places power cable to right of power plant; inserts long carrying bars into power plant side brackets, allowing bars to extend to rear as far as possible, in order to provide maximum leverage.

1 and **2** mount instrument truck; hand power cable to **4** and **6**; each secures a short carrying bar.

4 and **6** receive power cable from **1** and **2**; place it at location selected for power plant emplacement.

3 grasps ends of long carrying bars and lifts rear end of power plant; moves rear end of power plant slightly to right; lowers power plant on short carrying bar which has been placed beneath power plant by **1.**

1, after **3** has lifted rear end of power plant, places short carrying bar beneath rear ends of power plant skids.

3 dismounts; takes post facing left rear of truck.

11, RS, 10, 6, and **4,** in order named, take posts at right of **3** and face rear of truck.

1 at front of power plant, pushes power plant toward rear of truck.

2, when power plant has been pushed toward rear of truck far enough for **1**'s carrying bar to be about midway beneath power plant, places second short carrying bar beneath power plant.

1 continues to push power plant.

2, when necessary, continues to place first one and then the other short carrying bar beneath the power plant, until rear of power plant extends slightly beyond rear end of truck; inserts one short carrying bar into power plant rear brackets; holds power plant while **1** adjusts long carrying bars to center.

1, assisted by **11** (at left) and **6** (at right), adjusts long carrying bars so that bars extend equal amounts to front and rear of power plant.

RS, 10 grasp ends of left and right long carrying bars, respectively.

11, 6 grasp left and right ends of short carrying bar, respectively.

1, 2, 6, 10, 11 and **RS** pull power plant until only about one foot of power plant skids remains upon truck; lower rear end of power plant slightly below truck floor level to assist **2** in removing other short carrying bar from beneath power plant; move rear end of power plant slightly to right.

2 removes short carrying bar from beneath power plant; hands it to **3.**

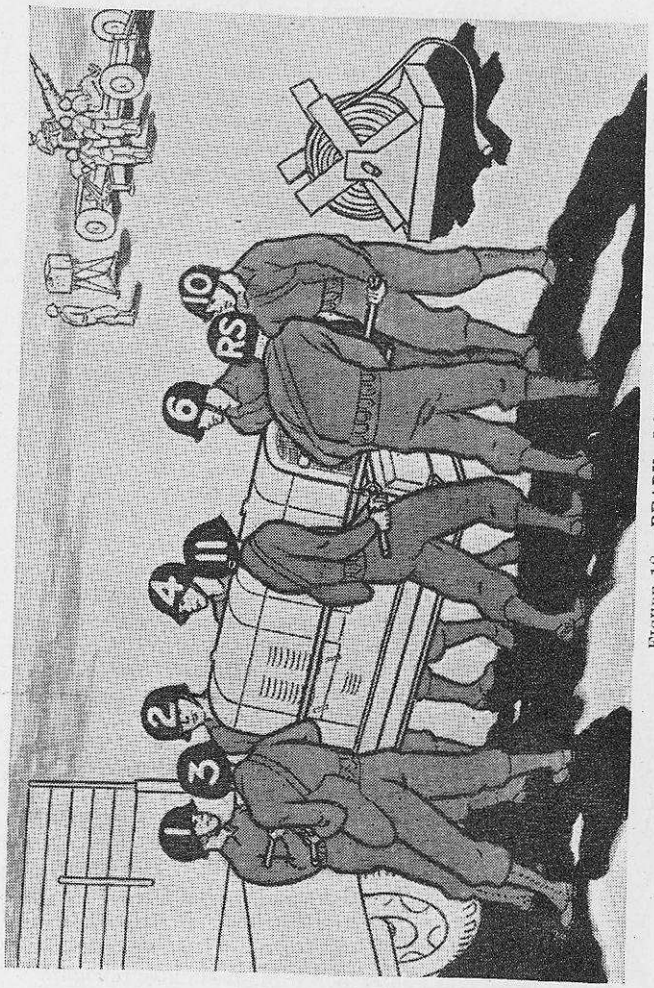


FIGURE 18.—READY—LOWER.

3 receives short carrying bar from 2; places it into power plant front brackets; continues to hold left end of front carrying bar.
4 grasps right end of front carrying bar as power plant is moved slightly farther to rear.

[RS commands: **READY—LOWER.**]
RS, 1, 2, 3, 4, 6, 10, and 11 lower power plant until only 6 to 8 inches of front ends of long carrying bars rest upon truck.
1 and 2 dismount; resume grasp of same carrying bars.

[RS commands: **READY—LOWER**] supervises movement of power plant to position. (See fig. 18.)
RS, 1, 2, 3, 4, 6, 10, and 11 lower power plant to ground; secure more comfortable holds on carrying bars; carry power plant to position as directed by **RS.**

NOTE.—*Power plant should be emplaced with radiator toward gun position so that 3 can see signals while facing control panel.*

NOTE.—*If crew is short, the rear of the power plant may be extended over the end of the truck and lowered to the ground. The front end may then be raised clear of truck bed and the truck driven out from under the power plant.* ***Caution:*** *Truck brakes must be set until front end is raised. Exercise care to prevent dropping either end of power plant and injuring personnel.*

4, assisted when necessary by 1 and 2, strings power cable from power plant to gun; returns to his post at the phone or M51 carriage.
6 returns to his post at machine gun.
10 and 11 return to their posts at the gun.
3 removes carrying bars; starts power plant if directed by CS.
RS directs 3 to park instrument truck at place indicated by CS; returns to director.
3 parks instrument truck as directed; returns to power plant.

■ 30. PREPARE TO ORIENT.

NOTE.—*In the following drill it is assumed that the conditions below prevail when the command,* ***PREPARE TO ORIENT,*** *is given:*

The members of the gun section are at their posts for sight control action.

The gun is loaded, pointed in the direction of anticipated attack, and elevated to 30° or normal standby direction.

The director is in satisfactory operating condition. (It is imperative that the director be checked to determine that it is functioning correctly prior to orientation.)

The remote control oil gear units on the gun are in satisfactory operating condition. (It is imperative that these units be in proper adjustment prior to orientation.)

NOTE.—*See FM 4–157 for duties of 4, 5, 6 in orienting the M51 carriage. The M51 carriage MUST be oriented before or after the 40-mm gun and director are oriented, NOT at the same time.*

CS commands: **PREPARE TO ORIENT** (For exception when orienting with sights, see note at end of par. 31) [commands and signals: **START POWER PLANT**] scans surrounding terrain for suitable aiming (orienting) point. (See note at beginning of par. 31.)

3 starts power plant; adjusts to proper speed and voltage.

[RS repeats the command, **PREPARE TO ORIENT.**

G commands: **MAKE SAFE;** checks level of gun.

7 places safe or fire lever at "SAFE"; reports, ***"Safe";*** throws elevating handle into gear; elevates to 30°.

11 places his hands behind loading tray.

7 pulls loading lever fully to rear, releasing round on loading tray.

11 catches round as it slides off loading tray.

7 places loading lever in front catch.

G connects power cable to gun; insures that elevation switch is "OFF"; when ready for power calls, ***"Power,"*** to CS.

1 and 2 insure that switches are "OFF," deflection marks matched (this gives approximate zero rate and deflection), is "OFF"; when ready for power calls, ***"Power,"*** tn *SC.*

RS checks director cable connections; calls, ***"Power,"*** to CS; checks director level.

CS, when both G and RS have called ***"Power,"*** faces 3, commands and signals: **CLOSE SWITCH.** (CS does not permit any handling of cables or connections after main switch is closed.)

3 connects main cable; closes main switch; adjusts voltage as required.

4, 5, 6, 8, 10, and 11 remain at normal posts.

NOTE.—*Before orienting, it is necessary that deflections (or rates) be brought precisely to zero. The effect of a small deflection left in either side of the director is exactly the same as an error in boresighting the gun. If a deflection does exist in the director it will be in proportion to the range setting; therefore, a change in the range setting will cause a corresponding change in the deflection—visible as a movement of the fine dial (azimuth or elevation). If a deflection does not exist, then a change in range setting can have no effect on the fine dial, and dial will remain stationary.*

RS, 1, and 2 test and accurately set zero deflections as follows:

1 and 2 leave switches "OFF"; push tracking clutches "IN", grasp handwheel handles and bring deflection marks to matched positions; pull clutches "OUT" HARD.

RS runs range pointer from 2,500 yards to 500 yards.

1 and 2, while RS is moving range pointer, watch their fine dials. If dials do not move, deflections are at accurate zero, and the director is ready for orienting; 1 and 2 report, ***"No Change."***

If either does move,

1 or 2 (the tracker concerned) pushes clutch "IN"; calls, ***"Repeat."***

RS again runs range from 2,500 yards to 500 yards; repeats as often as required, until tracker reports, ***"No Change"***; returns range pointer to minimum range.

1 or 2 (the tracker concerned), while RS is moving range pointer, watches his fine dial and adjusts handwheel as necessary, in order to stop movement of dial during movement of range pointer; when change in range setting causes

no movement of dial he reports, ***"No Change"***; pulls tracking clutch half way out LIGHTLY, so that stationary collar (inside director) will not engage clutch and shift the zero deflection setting; leaves clutch in this position during orienting.

1 elevates telescopes to 30°; reports to G, ***"Elevation Thirty Degrees."***

2 removes orienting clutch cover.

9, as soon as round slides off loading tray, depresses gun until upper deflector tube is clear of chute. (For exception, see note at end of par. 31.)

G removes pin and raises deflector tube; replaces pin; places bore sight in muzzle or places cross hairs on muzzle.

7 places bore sight in breech.

9 elevates gun to 30°; reports to G, ***"Elevation Thirty Degrees"***; lifts latch and pushes oil gear clutch lever forward.

G when both 9 and 1 have reported, ***"Elevation Thirty Degrees,"*** turns gun elevation switch to "ON" [reports to CS, ***"Gun Ready."***]

[RS reports to CS, ***"Director Ready."***]

■ 31. ORIENT.

NOTE.—*The aiming (orienting) point should be chosen at an estimated range of at least 1,000 yards for each yard of distance (shortest distance, not necessarily horizontal) separating line of gun bore and line of azimuth telescope in vicinity of gun and director, when both gun and director are pointing approximately at aiming point. For example, with gun and director pointed approximately toward an aiming point, line of azimuth telescope might be observed to clear the gun barrel by an estimated 2 yards; in such case, the aiming point should be at a minimum range of 2,000 yards. As a second example, a proposed aiming point might lie in a direction at right angles to the gun-director line; in this case, the distance between line of bore and line of azimuth telescope is about 4 yards, and the aiming point should be at a minimum range of 4,000 yards. In both examples accuracy within 1 mil is insured.*

The procedure required to orient gun and director in azimuth is distinctly different from that required to orient gun and director in elevation. Throughout both operations, deflection gears are at zero (pointers matched), rate (tracking) clutches are "OUT", rate switches are "OFF", and all changes in direction or elevation of telescopes are accomplished by moving tracking handwheels.

CS commands: **ORIENT** (For exception, see note at end of paragraph); points at and describes aiming point.

RS [repeats command] identifies aiming point (RS will select aiming point in absence of CS).

G grasps gun slewing lever; slews gun until blackout dial is blacked out (or pointers matched); slams gun slewing lever down.

RS places himself at rear of gun; signals (to 1 and 2) directions and amount of movement required in order to point gun toward aiming point; sights through bore; signals 1 and 2 until bore is alined exactly on aiming point. (See fig. 19.)

1 and 2, using hand tracking only (switches "OFF" and deflections exactly at zero as previously set), operate their tracking handwheels as required to move the gun according to signals from RS; stop moving handwheel when RS signals, ***STOP.***

RS, when bore has been exactly alined on aiming point, signals 1 and 2 to stop moving handwheels; commands, **LOCK**; continues to observe aiming point through bore of gun.

8 and 9, at command, ***LOCK,*** from RS, take places standing beside their gun pointer's seats.

9 removes screw and places elevation adjusting lever at **"LINE UP."**

8 and 9 lean over and check alinement of their sights on aiming point; make adjustments if necessary. (See par. 97.)

8 reports to RS, ***"Lateral On"***; resumes post as lookout.

9 reports to RS, ***"Vertical On"***; places adjusting lever to "FAR"; replaced screw; resumes post as lookout.

2, at command, ***LOCK,*** holds handwheel still; wedges handwheel in position with handkerchief or cloth; screws small

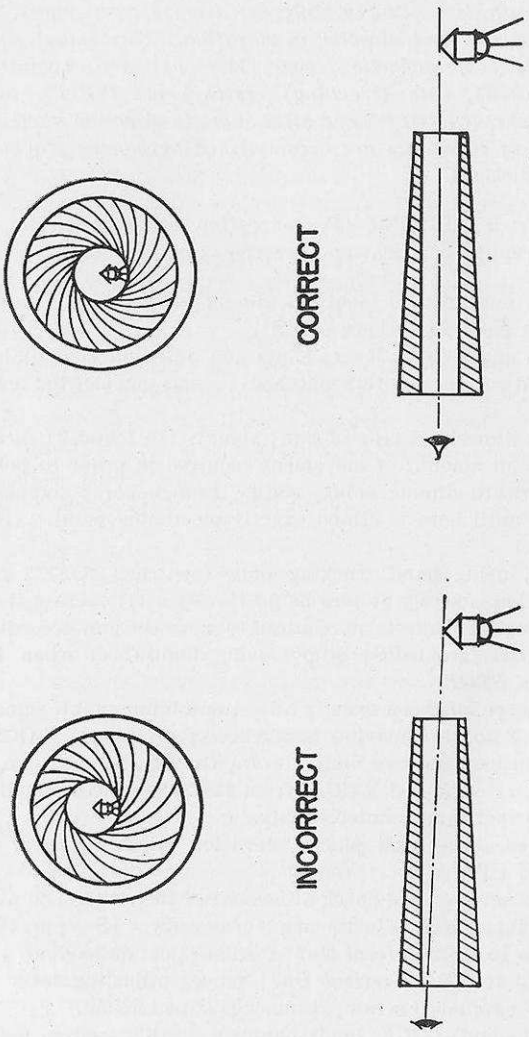


FIGURE 19.—Correct and incorrect boresighting pictures as seen through bore of gun.

knurled nut up tight with thumb and forefinger ONLY (thus locking azimuth transmitter and preventing motion of the gun); unscrews large knurled knob one-quarter turn (thus disconnecting transmitter from director traversing gears); traverses director with handwheel until azimuth telescope is alined accurately in azimuth on aiming point; reports, ***"On."*** (See note at end of paragraph regarding halving backlash.)

NOTE.—*Large knurled knob should be unscrewed just enough to free it; further unscrewing may cause the gun to move. It should never be handled at all (tightened or loosened) unless the small knurled nut is screwed up tightly.*

1, at command, ***LOCK***, holds handwheel still; wedges handwheel with handkerchief or cloth; if same aiming point is to be used when orienting in elevation, looks into telescope to see whether the horizontal cross hair is on the aiming point and calls, ***"Elevation On"*** or ***"Elevation Off."***

RS, observing that gun has not moved from aiming point, when 2 reports ***"On"***, goes to director; looks into azimuth telescope; verifies that vertical cross hair is on aiming point; returns to gun; verifies that gun is still on aiming point; commands, **UNLOCK.** (If at any time during locking, traversing, and unlocking, the gun moves in azimuth, **RS** commands: **REORIENT. 2,** in such a case, tightens large knurled knob, loosens small knurled nut, brings gun to aiming point, and the above operation is repeated.)

2, at the command, ***UNLOCK***, from **RS,** screws large knurled knob up tightly with his fingers; unscrews small knurled nut; traverses director about 20° off aiming point to right and left; each time brings it back on aiming point; reports, ***"On"***; replaces orienting clutch cover when **RS** repeats, ***"On"***; keeps director pointed at aiming point.

RS remains at breech of gun; insures that gun returns to aiming point each time 2 realines director; reports, ***"On"*** to **2.** (In case gun does not return to aiming point he commands: **REORIENT.**) This completes orientation in azimuth.

CS may indicate a new aiming point for elevation. Otherwise same aiming point is used.

1 places the horizontal cross hair of elevation telescope on aiming point by means of his tracking handwheel.

2 places or keeps the vertical cross hair of azimuth telescope on aiming point by means of his tracking handwheel.

RS looks through gun bore to see whether bore is correctly alined on aiming point in elevation; if alinement is in correct, commands: **ADJUST ELEVATION**; remains at rear of breech.

G, at command, ***ADJUST ELEVATION,*** gets necessary tools and goes to elevation oil gear; removes sideplate and adjusts gear so as to move gun vertically in amount and direction indicated by **RS.** (See par. 129.)

1 and 2 retain grasp of handwheel handles; continue to look into telescopes, keeping director pointed exactly at aiming point. (See note at end of paragraph regarding halving backlash.)

RS looks through bore; commands and signals: **UP** or **DOWN,** as required; when bore is exactly alined on aiming point in elevation, he reports, ***"Elevation On."***

G, at report, ***"Elevation On,"*** from **RS,** tightens oil gear screws; checks with **RS** that gun has not moved; replaces sideplate (if elevation adjustment has been necessary); *removes bore sight (or cross hairs) from muzzle* and passes it to **11**; lifts slewing lever and slews gun to point in normal standby direction; holds elevation switch at "ON" while **1** depresses gun.

7 removes bore sight from breech and passes it to **11**; places loading lever in rear catch; presses down hard on top round in autoloader until bottom round drops onto loading tray; receives loaded clips from **10** and refills autoloader if required.

1, using elevating handwheel on the director, depresses gun until deflector tube can be replaced.

7 replaces deflector tube as soon as it will clear chute.

11 receives bore sights from **G** and **7**; places bore sights with tool box,

10 passes loaded clip to **7** (if required).

1, after deflector tube is replaced, elevates gun and director to 30° or normal standby elevation.

G, when gun is elevated above horizontal, removes his hand from elevation switch.

All members of the fire unit take (or remain at) their posts.

[RS reports to **CS,** ***"Ready."***]

CS [repeats, ***READY***] if desired, he commands and signals to **3: OPEN SWITCH** and **STOP POWER PLANT.**

NOTE.—*The director should be checked for backlash in the gear trains of both azimuth and elevation motions as prescribed in paragraphs 111 and 112, and the deviations from aiming point determined. Backlash should then be taken into account during orientation. After gun has been alined in the aiming point in azimuth and the director orienting clutch has been locked, the director should be traversed in one direction until the vertical cross hair has passed the aiming point by an amount equal to half the measured backlash angle, thus halving the backlash error. The elevation backlash should be halved similarly.*

NOTE.—*It may be desirable, when time is limited, to check orientation with gun sights, instead of by bore sighting. Such a method requires positive knowledge that gun sights are already correctly alined. The procedure is identical with that above, with the following exceptions:*

CS adds the words, **"WITH SIGHTS",** to the two commands, **PREPARE TO ORIENT,** and **ORIENT.**

G, 7, 9, 11, and 1 omit all procedure relating to handling of the bore sights and deflector tube.

9 removes screw and places elevation adjusting lever at "LINE UP," immediately after he pushes oil gear clutch handle forward.

RS, instead of looking through bore, looks through and alines gun until sights are on aiming point (lateral sight for azimuth and vertical sight for elevation).

■ 32. DETAILS, POSTS.

CS commands: **DIRECTOR CONTROL (or SIGHT CONTROL)—DETAILS, POSTS.**

The individual members of the fire unit take their posts as follows, for director control:

RS facing range panel of director.
1 facing elevation panel of director.
2 facing azimuth panel of director.
3 at power plant.
4 at telephone and radio.
5 at machine gun, as firer.
6 at left side of machine gun, as loader.

NOTE.—*When equipped with multiple caliber .50 machine-gun carriage M51, 4, 5, and 6 take posts on trailer. (See fig. 23.)*

G near breech, where he can supervise gun section.
7 on gun platform, at left of and facing breech casing.
8 in dead area, behind director, on right of line from director to gun, as AA lookout.
9 in dead area, behind director, on left of line from director to gun, as AA lookout.
10 on ground at right of breech casing, near enough to pass ammunition to 7.
11 near ammunition supply.

For positions at director control, see figure 20.
For positions at sight control, see figure 21.

■ 33. EXAMINE EQUIPMENT.

CS commands: **EXAMINE EQUIPMENT.**

[RS repeats command.]
[G commands: **EXAMINE GUN.**]

RS and G check cable connections.
3 checks fuel, oil, and water of power plant; verifies that trouble light and dash light are in order; starts power plant; adjusts voltage and speed (frequency).

RS and G report, ***"Power"*** to CS.

CS commands, and signals 3: **CLOSE SWITCH.**
3 insures that main power cable is connected, and closes main switch, on command of CS; checks voltage and speed (frequency); makes necessary adjustments for proper operation.
RS checks level of director; tests operation of slewing clutch and operating limits of range scale; checks alinement of open sight; supervises director tests made by 1 and 2.

Positions of Personnel and Equipment at Director Control

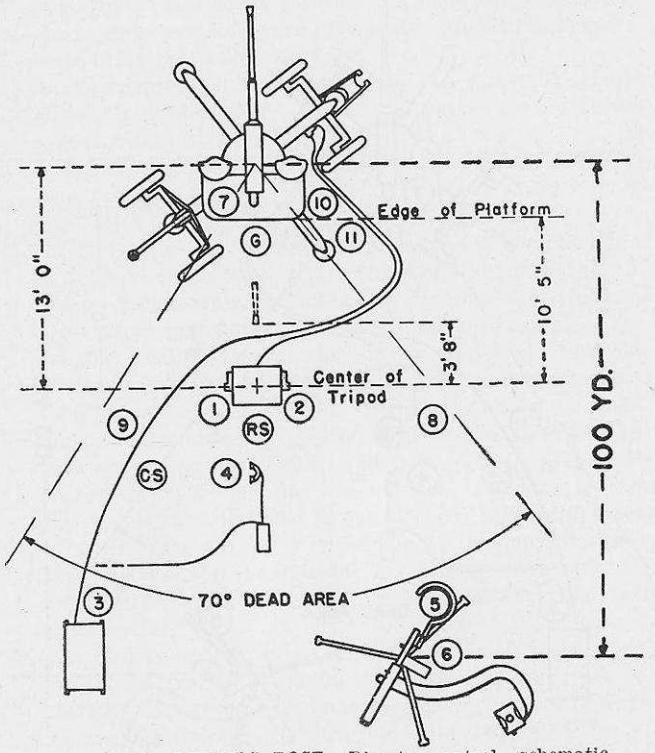


FIGURE 20.—**DETAILS, POST.** Director control—schematic.

1, 2, and RS, with clutches "OUT" and switches "OFF," check zero deflection. (See par. 105.)
1 and 2 set handwheel handles at twelve o'clock; turn switches "ON"; push clutches "IN"; note that direction of

Positions of Personnel and Equipment at Sight Control

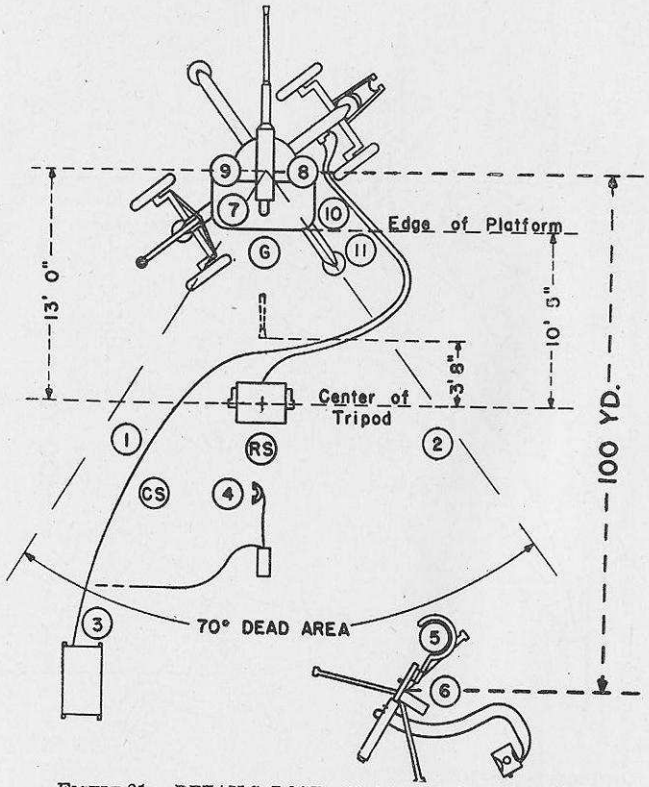


FIGURE 21.—DETAILS, POST. Sight control—schematic.

rotation of constant speed gears is counterclockwise on M5 (clockwise on M5A1) directors; time the rate of rotation to insure that speed is 20 revolutions in 60 seconds, plus or minus ½ second; introduce rates in both directions, noting

smoothness of operation; return handwheel handles to 12 o'clock position; pull clutches "OUT" hard (1 notes slight movement of elevation dials and 2 notes no movement of azimuth dials); turn switches "OFF"; check uniform tightness of telescope thumbscrews; check alinement of telescopes.
2 snaps "ON" illumination switch.
1 and 2 cover telescopes with hands; look in eyepieces and check that cross hairs are illuminated; focus telescopes.
2 snaps illumination switch "OFF."
1 checks superelevation run-down time (see par. 115); checks elevation prediction by running elevation test problems (see par. 121).
2 checks azimuth prediction by running azimuth test problems (see par. 122).
4 tests telephone and radio communication.
G checks level of gun through 180°; insures that recoil buffer is full, secure, and properly adjusted (see par. 74); inspects recuperator spring and equilibrators; removes breechblock and gages protrusion of striker; examines barrel and loading mechanism; insures top cover and side cover are properly closed and locked; verifies that deflector tube is lowered and secured; checks oil motors for leaks; adds oil, if necessary; checks (and adjusts if necessary) backlash, dither, and creep (see pars. 128 to 134); tests traversing and elevating mechanism, including slewing clutch, blackout dial, and limit switches; checks alinement of sights (assisted by 8 and 9); examines steering gear, drawbar assembly, brake cable, break-away switch springs, axles, tires, and wheels; checks ammunition, tools, and spare barrel.
7 sets feed control lever to right; tests firing mechanism; tests safe or fire lever in its three positions; sets at "SAFE"; sets feed control lever to left; assists G in removing, examining, lubricating, and replacing breech mechanism; assists G in examining loading tray and autoloader; closes and locks top and side covers; leaves breech closed and rammer forward; examines and lubricates front jack and front locking handle; assists 10 and 11 in examining ammunition.

8 traverses gun as required to assist G; checks operation and lubrication of traversing mechanism; adjusts seat; examines and lubricates rear locking handle; inspects stake lifting lever and mauls; assists G in checking lateral sight; makes certain traversing handle is out of gear.

9 elevates gun as required to assist G; checks operation and lubrication of elevating mechanisms; adjusts seat; examines and lubricates right jack and outrigger eccentric pivot; assists G in testing vertical sight; makes certain elevating handle is out of gear and oil gear clutch lever is forward; tests the firing mechanism with safe or fire lever in each of its three positions.

10 examines ammunition and clips, assisted by 7 and 11; assists 7 by tripping extractor releasing lever as required; examines and lubricates left jack and outrigger eccentric pivot; lubricates springs, axletrees, wheels, and remainder of carriage; examines steel stakes.

11 assists 10 in examining ammunition and clips; examines and lubricates gun stay and rear jack.

NOTE.—*Machine gun is not stripped or disassembled. If action is likely, the machine MUST not be examined at same time as other equipment, but LATER. Either the 40-mm or the machine gun must be ready to fire at all times.*

5 pulls machine-gun operation handle to rear, unloads, releases and presses trigger to insure that gun will fire; examines firing pin striker for possible break or improper protrusion; checks oil buffer adjustment and insures that backplate is completely closed and latched; insures that latch on mount (lower right rear for M2A1) is released; again pulls handle to rear and releases; checks head space adjustment; checks timing adjustment; insures that backplate buffer adjusting screw is tight; loads gun and, with operating handle, works several rounds through gun to insure proper feeding and loading; where situation permits, obtains permission of CS and fires short burst at high angle, in safe field of fire, in order to test gun; unloads; makes adjustments if necessary; checks condition and alinement of antiaircraft sight (if furnished); places first

round behind holding pawl, closes cover, and pulls operating handle once; points gun into dead area away from 40-mm gun. (One additional operation of handle will be required before gun can be fired.)

6 checks ammunition supply, insuring that ammunition belt is folded correctly in chest, with double link ahead (if metal links are used); insures that belt feeds freely through feed opening in chest; tests feed pawl spring and holding pawl spring by pressing with fingers; examines feed lever pivot for excessive play; examines feed lever stud and bolt cam grooves for burs and excessive wear; sees that bolt switch is set for left-hand feed; examines extractor and extractor switch for flaws, burs, and faulty or missing springs; insures that automatic cartridge aliner is securely in place, and spring working freely; lubricates breech mechanism if required; insures that water chest is filled, and pumps water through gun; observes muzzle and for leaks and tightens muzzle gland (very slightly) if required; looks into muzzle (with bolt retracted by 5) to see that bore is clean and free of obstruction; aids 5 as required.

NOTE.—*When equipped with the multiple machine-gun carriage M51, the duties of 4, 5, and 6 at EXAMINE EQUIPMENT are as follows. If action is likely, the M51 carriage MUST not be examined at the same time as other equipment, but LATER. Either the 40-mm or the M51 carriage must be ready to fire at all times.*

5 turns on turret drive switch.

4 starts power charger.

5 elevates to 90° limit stop, then depresses to zero limit stop noticing any sluggishness or slipping of the elevation drive. Returns guns to horizontal; elevates to 10°.

4 and 6 unload guns, examine chamber, pull operating handles of all guns to rear and release.

5 turns on firing circuit switch, observes whether indicator light goes on.

5, assisted by 4 and 6, checks the operation of the solenoids, one at a time. As firing mechanisms of each gun operate, 4 and 6 report, ***"Check."*** 4 and 6 pull back on operating handles as necessary to verify operation of firing mechanisms.

5 traverses 360°, noting any sluggishness or slipping of turret drive mechanisms; selects orienting point, indicating it to 4 and 6. Holds sight on orienting point with central dot one-fourth of radius of inner circle below orienting point to compensate for superelevation setting; 5 turns off turret drive switch. Thereafter uses sight interlock switch as needed to check that sight has not moved off orienting point.

4 and 6 remove solenoid cables, remove backplates, driving springs, bolt studs, and bolts of all guns. Close top covers and verify the alinement of guns on orienting point. If barrel reflectors are provided, the backplates and bolts need not be removed.

4 reports, ***"Right guns on"*** as soon as he has verified the alinement.

6 reports, ***"Left guns on"*** as soon as he has verified the alinement. If any gun is not correctly alined, either 4 or 6 reports, ***"Gun out of line."*** Immediate action is taken by 4 or 6 to correct alinement.

4, 6 lift covers, replace bolts, bolt studs, driving springs, backplates of guns, and reconnect all solenoid cables; retract bolts fully and lifting ejectors slightly, lock bolts to rear; check the ammunition chests for proper loading; verify that front gun joint pins are latched in place.

5 slews gun to cover dead area (or primary zone assigned); turns off sight light and turret drive switch.

4, 6 clean bores of gun.

5 checks contents of left and right spare bulb containers; leaves seat; turns on turret drive switch; checks voltmeter reading for condition of batteries; turns off turret drive switch; checks gasoline supply; examines water level in batteries (⅜" above top of plates); examines connection of battery cables, power cables, power charger leads and grounds, trunnion cables, solenoid plugs; turns off power charger; unscrews oil filler plug of power charger and checks oil level; takes place in seat again.

4, 6 check stowage on the trailer; check ammunition in chests in corners of trailer for proper markings and left and right feed.

4, 6 release bolts on guns, inspect machine gun mechanism as follows: Examine firing pin strikers for possible break or

improper protrusion; check head space adjustment; insure that backplate buffer adjusting screws are tight; test belt feed lever springs, feed pawl springs, holding pawl springs, and extractor switch springs by working parts with fingers; examine feed lever pivots for excessive play; examine feed levers, studs, and bolt cam grooves for burs or excessive wear; verify that bolt switches are set for correct direction of feed; examine extractors for worn edges, flaws, burs, or missing springs; insure that automatic cartridge aliners are securely in place and springs working freely. Set hand firing mechanisms to operating positions and operate firing mechanisms; set hand firing mechanism out of operating position; close covers; half load all guns; stand by at attention behind receivers of respective guns ready to report.

When the members of the range section have completed their inspection,

RS commands: **REPORT.**

1 reports, ***"Elevation In Order,"*** or reports any defects.

2 reports, ***"Azimuth In Order,"*** or reports any defects.

3 reports, ***"Power Plant In Order,"*** or reports any defects.

4 reports, ***"Communications In Order,"*** or reports any defects.

When the members of the gun section have completed their inspection,

G commands: **REPORT.**

5 reports, ***"Machine Gun In Order,"*** or reports any defects.

6 reports, ***"Machine Gun Ammunition In Order,"*** or reports any defects.

NOTE.—*When equipped with multiple caliber .50 machine-gun carriage M51, 6 reports,* ***"Machine Guns And Ammunition In Order."*** *4 and 5 do not report.*

7 reports, ***"Breech and Loading Mechanism In Order,"*** or reports any defects.

8 reports, ***"Traversing Mechanism In Order,"*** or reports any defects.

9 reports, ***"Elevating Mechanism In Order,"*** or reports any defects.

10 reports, ***"Ammunition In Order,"*** or reports any defects.

*When **RS** and **G** have received their reports,*

CS commands: **REPORT.**

RS reports, ***"Range Section In Order,"*** or reports any defects.
G reports, ***"Gun and Machine Gun In Order,"*** or reports any defects.

■ 34. TRIAL SHOT.—*Trial shots should be fired immediately following orientation, whenever the tactical situation permits. Authority for firing trial shots must be specifically obtained by the chief of section from a higher commander. At least two trial shots should be fired, one with left traverse and one with right traverse. (See FM 4–151.)*

The gun being loaded and the fire units at posts,

CS commands: **TRIAL SHOT.** If necessary, signals and commands **3: START POWER PLANT.**

3 starts power plant; adjusts voltage and speed.
1 and **2** insure that switches are "OFF", deflection marks matched, and tracking clutches "OUT"; report, ***"Power,"*** to **RS.**
RS reports, ***"Power,"*** to **CS**; sets range pointer to 1,500 yards (or other range as desired for firing trial shot) and wedges range handwheel with handkerchief or cloth.

CS faces **3**; commands and signals: **CLOSE SWITCH.**
3 closes main switch; adjusts voltage as necessary.
7 insures that gun is elevated to 30° reports to **G**, ***"Elevation Thirty Degrees."***
1 insures that director is elevated to 30°; reports to **G**, ***"Elevation Thirty Degrees."***
G insures that oil gear lever is forward; then turns elevation switch to "ON" and sets recoil recorder to minimum reading.
1 and **2**, as soon as power is furnished, turn switches "ON."
RS commands: **THIRTY DEGREES** (or other elevation as desired for firing trial shot).

1 pushes clutch "IN"; elevates to specified elevation, and carefully adjusts handwheel until fine dial does not move; wedges handwheel with handkerchief or cloth; removes hands from director.
1 and **2** report, ***"Ready,"*** to **RS.**
RS reports, ***"Ready for Trial Shot,"*** to **CS.**
CS commands: **FIRE ONE TRIAL SHOT, LEFT TO RIGHT (*or Right to Left* if desired).**
1 keeps hands off director; takes paper and pencil in his hands.
RS grasps slewing handle; slews director to point at least 30° left of gun (for left to right trial shot); releases slewing handle; keeps hand off wedged range handwheel; raises left arm and holds it aloft.
G, as soon as director is slewed by **RS**, grasps slewing lever and slews gun until dial is blacked out (or pointers matched); slams slewing lever down.
7 insures that gun is loaded; places loading lever in front catch; places safe or fire lever at "SINGLE FIRE."

2, as soon as director is slewed and arm of **RS** is raised, moves handwheel handle to 12 o'clock position; pushes clutch "IN"; moves handwheel handle smoothly to 6 o'clock position (clockwise for left to right trial shot, or counterclockwise for right to left trial shot); wedges handwheel with handkerchief or cloth; removes hands from director; takes paper and pencil in his hands.
1 and **2** look into telescopes.
RS, when gun has traversed to position where it points directly away from director, commands: **FIRE,** and drops his arm to his side.
7 presses firing pedal one time; places safe or fire lever at "SAFE"; places loading lever in rear catch.
1 and **2** observe the tracer in their telescopes; look down quickly and draw path of tracer on prepared sketch of reticle.

2 removes cloth wedge; matches deflection marks; pulls clutch "OUT."
1 turns switch "OFF"; leaves handwheel wedged and clutch "IN" if another trial shot is to be fired.

RS examines sketches made by 1 and 2; reports to CS, ***"One Trial Shot Fired."***

G reads length of recoil (if unsatisfactory adjusts recoil buffer); resets recoil recorder.

4, 5, 6, 8, 10, and **11** remain at normal posts during the trial shot procedure.

NOTE.—*For each additional trial shot, the above procedure is repeated. The point of intersection of each pair of tracer trajectory curves as seen by 1 and 2 and superimposed on each other's drawings should coincide with the point of intersection of the telescope cross hairs. If they do not coincide, a complete check of gun and director adjustments and orientation is made and another pair of trial shots are fired. Correct orientation and adjustments should eliminate lateral deviation of the trial shot and should insure intersection in elevation as well, however, if intersection in elevation does not result after accurate orientation and adjustment of gun and director are accomplished, an adjustment is made in the elevation oil gear to produce intersection.* (*See par. 129.*)

■ 35. RELIEVE SPRINGS.—*Upon completion of the day's drill, or when the gun is to be left for a long period of time, it is desirable that tension of breech closing, breechblock, and rammer springs be relieved.*

CS commands: **RELIEVE SPRINGS.**

10 takes post at right side of breech casing near extractor releasing lever, and exerts a moderate pressure on lever toward rear of gun.

7, after determining that gun is unloaded, pulls loading lever fully to rear, thereby taking weight of rammer off check levers; places feed control lever to the right.

10, pushing on extractor releasing lever, allows breech to close.

7 closes breech slowly by moving loading lever into front catch, thereby relieving the breech closing and breechblock springs; places safe or fire lever to "SINGLE FIRE"; releases rammer by operating fire mechanism; places safe or fire lever at "SAFE" and returns feed control lever to the left.

SECTION III

ACTION, DIRECTOR CONTROL

■ 36. GENERAL.—Upon the appearance of a target, CS or any member of the fire unit who sights or hears the target calls out, ***TARGET,*** and points out the approximate location.

Immediately upon hearing the report, CS commands: **TARGET,** if action is to be with director control. He commands: **TARGET, SIGHT CONTROL,** if action is to be with sight control.

Immediately upon hearing the report, each member of the fire unit goes to his post, if not already at his post, and upon hearing the command, ***TARGET,*** prepares for action as indicated by the command.

After giving the command, ***TARGET,*** CS recognizes the target and, if it is hostile, commands: **ENGAGE.**

The fire unit prepares for action at the command, ***TARGET,*** but does not open fire until after CS has commanded, ***ENGAGE.***

The primary responsibility of the machine-gun or M51 carriage is the dead area of the 40-mm gun. In case the director is not being used, the primary zone of the machine-gun or M51 carriage is designated by CS. Surveillance of the primary zone must be continuous regardless of whether the machine-gun or M51 carriage is engaged therein or not. Especially in case of multiple targets, particularly when approaching from different directions, the crew of the machine-gun or M51 carriage must take immediate and appropriate action without command from CS.

NOTE.—*See FM 4–155 for detailed duties of* ***5*** *and* ***6*** *at the following commands* (***TARGET, FIRE, CEASE FIRING,*** *and* ***CEASE TRACKING***) *at the machine gun.*

NOTE.—*See FM 4–157 for detailed duties of* ***4, 5, 6*** *at the following commands* (***TARGET, ENGAGE, FIRE, CEASE FIRING,*** *and* ***CEASE TRACKING***) *at the M51 carriage. The duties of* ***1, 2, 3,*** *as prescribed in FM 4–157, become the duties of* ***5, 4, 6,*** *respectively in the 40-mm fire unit. Those portions of the drill in FM 4–157 which relate to the half-track vehicles do not apply when manning the M51 carriage.*

■ 37. TARGET, DIRECTOR CONTROL.

NOTE.—*In the following drill it is assumed that the conditions below prevail when the command,* ***TARGET,*** *is given:*

All members of the fire unit are at their posts for director controlled action as in figure 22.

The power plant is operating properly, and the main switch is closed.

The gun is loaded, pointed in the direction of anticipated attack, and elevated to 30° or other normal standby direction.

The director telescopes are pointed in the direction of anticipated attack and elevated to 30° or other normal standby direction.

The director is set with range dial indicating minimum range with deflection gears at zero (pointers matched), with rate (tracking) clutches "OUT" and with rate switches "OFF."

The machine gun is manned, ready for instant action, and may engage, without command, any target entering its sector and which is recognized as hostile.

NOTE.—*If the multiple caliber .50 machine-gun carriage M51 is used, figure 22 is modified to the extent shown in figure 23.*

CS commands: **TARGET**; points at target; if more than one target is visible in direction indicated, he describes desired target, as necessary; continues to look at target.

3 checks to see that main switch is closed and that power plant is operating at proper frequency and voltage.

G repeats command; checks that oil gear lever is forward and elevation switch is "ON"; grasps gun slewing lever; slews gun to point slightly ahead of target; looks down at blackout dial; slews gun so that dial is blacked out (or pointers matched); continues to slew gun, keeping dial blacked out (or pointers matched); takes hold of rope which is attached to firer's foot.

NOTE.—*Periodically* ***G*** *sets recoil recorder to minimum, reads length of recoil after gun is fired, makes any neces-*

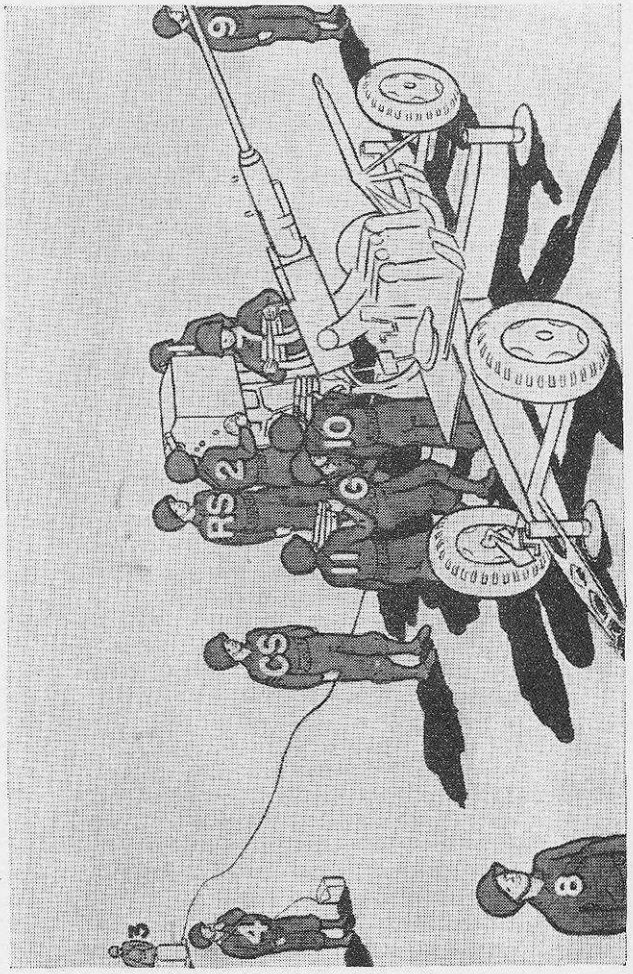


FIGURE 22.—DETAILS POST. Director control.

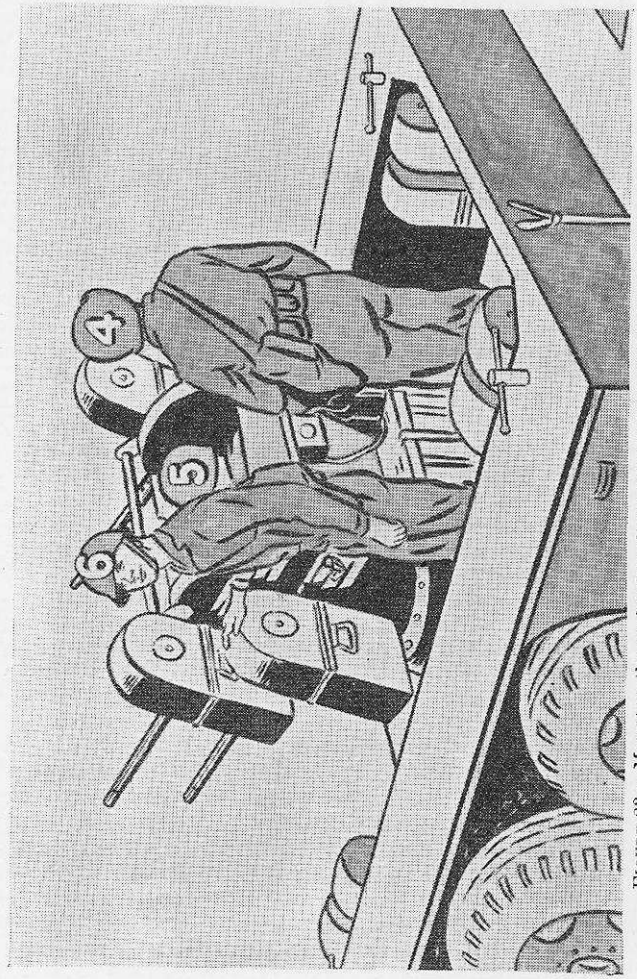


FIGURE 23.—Manning the multiple caliber .50 machine-gun carriage M51 for action. (Duties of telephone operator, 4, are transferred to CS or RS.)

sary adjustments to recoil buffer, and resets recoil recorder, checking again if adjustment was necessary.

7 places loading lever in front catch; insures that feed control lever is turned left; keeps autoloader full.

8 and **9** aid **CS** in recognizing target; act as **AA** lookouts.

10 and **11** each obtain a loaded clip pass to **7**, as required.

4 acts as **AA** lookout.

5 and **6** as firer and loader, respectively; prepare to fire on any hostile target within range.

NOTE.—*When equipped with multiple caliber .50 machine gun carriage M51, **6** indicates target to **5** and assists him in getting on target.* (See fig. 24.)

1 and **2** at command, ***TARGET,*** turn rate switches "ON"; look into telescopes; each grasps his tracking handle lightly with thumb and fingers of right hand (*handles should be held in this manner at all times*); moves handle to 12 o'clock position; pushes rate clutch "IN"; (movement of handles to 12 o'clock position prior to pushing clutches "IN" introduces no tracking rate).

RS at command, ***TARGET,*** grasps slewing handle with right hand and places left hand over 1's right hand; looking over open sight, slews in azimuth and sets in vertical rate so that telescopes point toward target. (RS must remove excessive elevation rate before releasing 1's hand.)

1, allowing his right hand to be guided by **RS,** reports, ***"On"*** as soon as he sees target in telescope.

2, continuing to hold his handle at 12 o'clock, reports, ***"On"*** as soon as he sees target in telescope.

RS when **1** and **2** have reported, ***"On,"*** commands: **TRACK;** at same time, smartly removes both hands from director; quickly raises left arm and holds it aloft. (The command ***TRACK*** is given loudly and is used to insure perfect coordination of action by **RS, 1, 2, G,** and **7.**)

G repeats command, ***TRACK*** (heard from **RS** or **7,** or when he sees **RS**'s arm raised); slams gun slewing lever down; retains hold of rope attached to 7's ankle.

7 repeats command, ***TRACK*** (heard from **RS** or **G,** or when he sees **RS**'s arm raised).

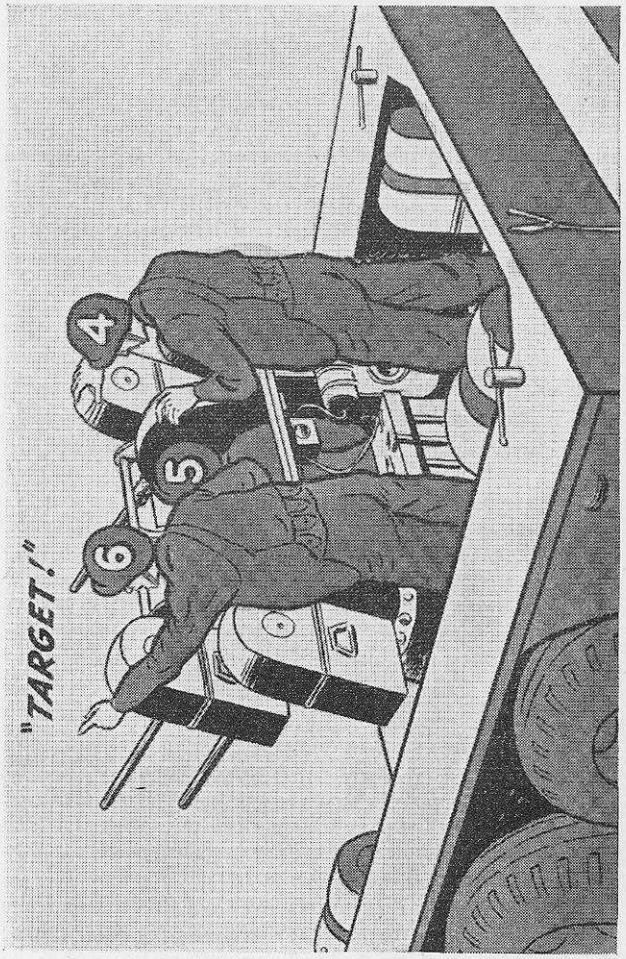


FIGURE 24.—**TARGET.** 4 and 6 act as lookouts in the dead area, 6 indicates target to 5 and assists him in getting on target.

1, at command, ***TRACK,*** adjusts tracking rate, as necessary.
2, at command, ***TRACK,*** immediately applies a rate by a smooth movement of his handwheel (this initial movement must be in proper direction, clockwise for traverse right).
1 and 2, when tracking is smooth, report, ***"Steady,"*** continue to track. (If they lose sight of target they report, ***"Lost"*** (see TARGET LOST Drill).)

CS commands: **ENGAGE,** as soon as he (with aid of other section members) has recognized target as hostile. (He may also command **ENGAGE, AUTO-FIRE.)**
RS observes target; estimates and sets ranges.
1 and 2 continue to track target.
3 maintains proper operation of power plant.
4, 5, 6, same as at ***TARGET.***
7 places safe or fire lever to "SINGLE FIRE." (If command is ***ENGAGE AUTO-FIRE*** he places safe or fire lever to "AUTO.") Stands ready to fire and receive additional loaded clips from **10.**
8 and 9 acts as lookouts for new targets; follow gun around as traversed, or take other positions as directed by **CS.**
10 keeps himself placed in position to pass additional clips; receives loaded clip from **11.**
11 passes loaded clip to **10**; prepares to pass additional clips; loads clips, as necessary. (**10** and **11** may alternate in passing loaded clips directly to **7.**)

RS commands: **FIRE,** when target is within range, tracking is steady, and proper range is set in director; at same time, drops left arm smartly to his side; continues to set ranges.
7 presses firing pedal; releases it and presses it again for each shot, at rate of about one shot per second (if command by **CS** was ***ENGAGE, AUTO-FIRE,*** he presses firing pedal and holds it down for duration of firing); when possible deflects empty clips from gun platform.
1 and 2 continue to track.
CS exercises general supervision; may command **CEASE FIRING, CHANGE TARGETS,** or **SIGHT CONTROL.** (See par. 38, 40, and 42.)

3, same as at ***ENGAGE.***
4, 5, 6, same as at ***TARGET.***
G watches functioning and pointing of gun. (If gun points near director or other unsafe condition develops, he pulls 7's foot from firing pedal and, at same time, commands: **CEASE FIRING.** As soon as firing is again safe he commands **FIRE.** (See par. 45.)
8 and 9 same as at ***ENGAGE;*** act as AA lookouts; remain alert for command ***SIGHT CONTROL*** or other commands.
10, 11, relay or alternate passing loaded clips to 7, as required; insure that empty clips are cleared from gun platform. 11 loads additional clips, as required.

■ 38. CEASE FIRING, DIRECTOR CONTROL.

RS commands: **CEASE FIRING,** when target is out of range. (CS may give the command at any time.)

G [repeats command] and pulls rope attached to 7's foot, removing foot from firing pedal.
7 places safe or fire lever at "SAFE" and reports, ***"Safe";*** fills autoloader, as necessary.
10 and 11 stand ready to relay ammunition to 7.
1 and 2 continue to track target.
RS continues to set ranges.
3, 4, 5, 6, 8 and 9 continue normal duties.

■ 39. CEASE TRACKING, DIRECTOR CONTROL.

CS commands: **CEASE TRACKING.**

[RS repeats command.]
G lifts gun slewing lever; swings gun to direction of anticipated attack. (In order to protect the selsyn units, G insures that the gun is always so positioned that the azimuth indicator is blacked out or pointers matched as long as power is being delivered to the gun and director.)
7 sets safe or fire lever to "SAFE"; secures loading lever in rear catch.
1 and 2 immediately move handwheels to 12 o'clock, making certain that all rates are zeroed; pull out clutches; turn switches to "OFF."

1 sets telescope at 30° or normal standby direction.
G checks that safe or fire lever is at "SAFE" and that loading lever is in rear catch; leaves elevation limit switch at "ON"; checks gun level.
RS slews director to direction of anticipated attack; sets range to minimum; verifies position of switches, deflection marks, and clutches; checks level of director.
3 keeps power plant running properly.
4 continues as telephone operator and lookout.
8 continues as lookout.
9 gathers empty cartridge cases and clips; places them near 11; returns to post as lookout.
10 and 11 replenish ammunition at gun; load empty clips, as necessary.
5 and 6 continue normal duties.

■ 40. CHANGE TARGETS, DIRECTOR CONTROL.

CS commands: **CHANGE TARGETS**: points at new target. (If more than one target is available in new direction, he indicates desired target, as necessary.)

[RS repeats command.]
G [commands: **CEASE FIRING**] pulls 7's from firing pedal; lifts gun slewing lever; slews gun to point slightly ahead of new target; looks down at blackout dial and slews gun so as to keep dial blacked out (or pointers matched).
7 removes foot from firing pedal; places safe or fire lever at "SAFE"; refills autoloader as necessary.
1 and 2 quickly move tracking handwheel handles to 12 o'clock position, leaving tracking clutches "IN"; insure that deflection marks are matched; report, ***"Zero"*** to **RS**; hold handwheel handles at 12 o'clock as director is slewed.

RS, after 1 and 2 report, ***"Zero"*** and gun slewing lever is lifted, grasps slewing handle with right hand; slews director to point approximately at new target; retains grasp on slewing handle; looks over open sight; uses left hand to aid 1 in getting on target.

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1 and 2, as soon as they see target in telescopes, report ***"On"***; 2 does not apply tracking rate.
1 allows his right hand to be controlled by RS's hand.
RS, when 1 and 2 have reported ***"On"*** smartly removes both hands from director; at same time commands: **TRACK** (loudly enough to be heard at gun); quickly raises left arm and holds it aloft; sets range into director.
G repeats command, ***TRACK*** (heard from RS or 7, or when he sees RS's arm raised); slams gun slewing lever down; takes hold of rope attached to 7's ankle.
7 repeats command, ***TRACK*** (heard from RS or G, or when he sees RS's arm raised); places safe or fire lever to previous firing position.
1, at command, ***TRACK,*** adjusts tracking rate, as necessary.
2, at command, ***TRACK,*** immediately applies tracking rate.
1 and 2 when tracking is smooth report, ***"Steady"***—continue to track target. If they lose sight of target, they call, ***"Lost."*** (See par. 41.)
3, 4, 5, 6, 8, 9, 10, and 11 continue normal duties.

RS commands: **FIRE** when target is within range, tracking steady, and proper range is set into director, at same time dropping left arm smartly to his side; continues to set ranges.
7 resumes firing.

41. TARGET LOST, DIRECTOR CONTROL.

NOTE.—*Whenever target disappears from telescopes, 1 and 2 call* ***"Lost."***

When ***RS*** *believes that target is only temporarily obscured and that it will reappear in the telescopes or he believes that he can aid and coach 1 and 2 back on target, he merely repeats,* ***"Lost."***

When ***RS*** *believes that a new pick-up is required he repeats,* ***"Lost"*** *and commands:* ***ZERO.***

The drill procedures are as follows:

When target is lost and ***RS*** *can aid and coach trackers back on target,*

1 and 2, call, ***"Lost";*** do not change tracking rates; leave clutches "IN"; continue to look into telescopes.

RS repeats, ***"Lost,"*** loud enough to be heard at gun.
G pull's 7's foot from firing pedal, [and at the same time, commands: **CEASE FIRING**] does not lift gun slewing lever.
7 removes foot from firing pedal; places safe or fire lever at "SAFE"; refills autoloader, as necessary.
RS looks over open sight, searching for target; gives no command as long as he thinks target will reappear near his line of sight; grasps 1's hand on handwheel handle.
CS, 3, 4, 5, 6, 8, 9, 10, and 11 continue normal duties.

RS, when he again sees target, looks over open sight, guides 1's hand on handwheel handle; coaches 2 by commanding **RIGHT** or **LEFT.**
1 and 2, when they see target in telescopes, report, ***"On"***; adjust rates as necessary to track target.
RS, when 1 and 2 report ***"On,"*** commands: **TRACK**; raises left arm and holds it aloft; sets range into director.

1 and 2, when tracking smoothly, report, ***"Steady"***; continue to track target.

RS commands: **FIRE,** when tracking is steady and proper range is set into director; at same time, drops left arm smartly to his side; continues to set ranges.
7 resumes firing.

When target is lost and new pick-up is necessary,

1 and 2 call, ***"Lost";*** do not change tracking rates until RS commands ***ZERO.***

RS repeats, ***"Lost,"*** loud enough to be heard at gun; commands: **ZERO,** loud enough to be heard at gun.
G pulls 7's foot from firing pedal, [and at same time commands: **CEASE FIRING**].
7 removes foot from firing pedal; places safe or fire lever at "SAFE"; refills autoloader, as necessary.

1 and **2** quickly set tracking handwheel handles to 12 o'clock; leave clutches "IN": report, ***"Zero"*** to **RS**; hold handwheel handles at 12 o'clock, as director is slewed.

G, at command ***ZERO,*** lifts gun slewing lever; slews gun to point slightly ahead of target; looks down at blackout dial; slews gun so as to keep dial blacked out (or pointers matched).

RS, immediately after **1** and **2** report ***"Zero"*** and gun slewing lever is lifted, grasps slewing handle with right hand; slews director to point approximately at target; retains grasp on slewing handle; looks over open sight; uses left hand to aid **1** in getting on target.

1, allowing his right hand to be guided by **RS,** reports, ***"On"*** as soon as he sees target in telescope.

2, continuing to hold his handle at 12 o'clock, reports, ***"On"*** as soon as he sees target in telescope.

RS, when **1** and **2** have reported, ***"On,"*** commands: **TRACK**; at same time, smartly removes both hands from director; quickly raises left arm and holds it aloft; sets range into director.

G repeats command, ***TRACK*** (heard from **RS** or **7**, or when he sees **RS**'s arm raised): slams gun slewing lever down; takes hold of rope attached to **7**'s ankle.

7 repeats command, ***TRACK*** (heard from **RS** or **G**, or when he sees **RS**'s arm raised); places safe or fire lever to previous firing position.

1, at command, ***TRACK,*** adjust tracking rate, as necessary.

2, at command, ***TRACK,*** immediately applies tracking rate.

1 and **2** when tracking is smooth, report, ***"Steady,"*** continue to track target.

CS, **3, 4, 5, 6, 8, 9, 10,** and **11** continue normal duties.

RS commands: **FIRE,** when tracking is steady and proper range set into director; at same time, drops left arm smartly to his side; continues to set ranges.

7 resumes firing.

■ 42. SIGHT CONTROL, FROM DIRECTOR CONTROL.

CS commands: **SIGHT CONTROL;** when desirable, commands and signals; **OPEN SWITCH** to **3.**

G [repeats command, **SIGHT CONTROL**] lifts gun slewing lever; throws elevation switch to "OFF."

RS [commands: **ZERO**] sets range to minimum—(when **M7** sight is used, mounts gun platform in rear of **8** ready to set in leads).

1 and **2** insure that tracking rates are at zero, tracking clutches "OUT," and switches "OFF"; they report, ***"Zero"*** to **RS.**

8, takes lateral gun pointer's seat; leaves traversing handle out of gear, as long as command ***TARGET*** is not given.

7, if **9** is to fire, removes rope from his ankle and passes rope end to **9.**

9, takes vertical gun pointer's seat; raises latch and pulls oil gear clutch lever to rear; throws elevating handle into gear; attaches rope end to right foot (if he is to fire).

3, at command or signal, ***OPEN SWITCH,*** opens main switch; keeps power plant running, unless **CS** orders otherwise.

4, 5, 6, 10, and **11** continue normal duties.

■ 43. GROUND TARGET OR WATER TARGET, DIRECTOR CONTROL.

CS commands: **GROUND TARGET, DIRECTOR CONTROL** or **WATER TARGET, DIRECTOR CONTROL;** indicates target by pointing and describing.

[**G** repeats command.]

The command is executed in manner similar to execution of ***TARGET*** (see par. 37). Exceptions are as follows:

CS, same as for sight control (par. 60).

7, same as for sight control (par. 60).

1 will normally leave switch "OFF" and clutch pulled out hard, with deflection marks matched; will track target manually, tracking high or low as required, in terms of target heights. (On command, ***ONE-CLUTCH IN*** from **RS** at any time, he will turn switch "ON," move handwheel handle to 12 o'clock, push clutch "IN," and track center of target with aided tracking.)

2 will normally leave switch "OFF" and clutch pulled out hard, with deflection marks matched; will track target manually, taking leads in terms of target lengths. (On command, ***TWO-CLUTCH IN*** from **RS** at any time, he will turn switch "ON," move handwheel handle to 12

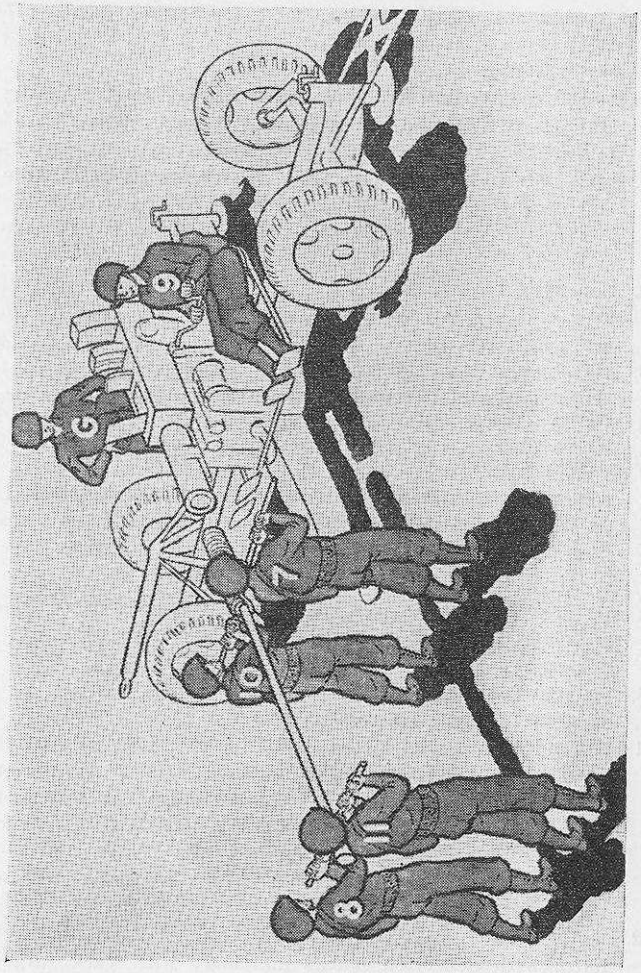


FIGURE 25.—CHANGE BARRELS.

o'clock, push clutch "IN," and track target with aided tracking. In this case he will track on the center of the target.)

RS normally does not set ranges (unless he has ordered one or both trackers to clutch in). He coaches **1** in terms of target heights, as ***"Up One-half,"*** and **2** in terms of target lengths, as ***"Left Two."*** (If at any time aided tracking in elevation or azimuth is desired, he commands: **ONE-CLUTCH IN** or **TWO-CLUTCH IN,** as desired; in this case he sets ranges into the director instead of coaching **1** or **2.**) All coaching orders represent the desired total lead.

NOTE.—*In order to provide maximum security of position and cover for personnel, **7** may kneel on the gun platform and fire with his hand. In this case **10** keeps autoloader full and **11** passes ammunition to **10.***

■ 44. CHANGE BARRELS, DIRECTOR CONTROL.

CS commands: **CHANGE BARRELS.** (**G** may give the command whenever necessary.) (See fig. 25.)

G slews gun to safe field of fire, pointing muzzle over outrigger whenever possible; throws elevation switch to "OFF" [commands: **MAKE SAFE.**]

7 and **11** execute command ***MAKE SAFE,*** as prescribed in paragraph 30.

[**G** commands: **RELEASE.**]

7 places safe or fire lever at "AUTO-FIRE"; presses firing pedal to release rammer; returns safe or fire lever to "SAFE"; reports, ***"Safe".***

G inserts breech ring retaining pin in left side of gun casing.

Caution: *Retaining pin should be inserted without fail every time the barrel is removed.*

9 takes seat; depresses gun to horizontal; grips elevating handle to prevent breech casing from elevating while barrel is removed; continues to hold breech casing down until spare barrel has been installed.

8 arranges convenient supports upon which to place barrel.

Caution: *The breech casing must be held horizontally*

through the entire procedure. The breech casing may be clamped in the gun stay, or the elevation handle thrown into gear, and tied securely.

G turns top cover latch, raises cover and opens until automatic catch holds cover open.

***Caution:** Never close top cover with barrel removed. Serious damage may result.*

7 and **10** place rear tube wrench on top of barrel, making certain that lug engages recess.
8 and **11** place front tube wrench on barrel (with catch down) and lock wrench.

[G commands: **TURN.**]
7, **10, 8,** and **11,** facing breech casing, turn wrenches one-half turn counterclockwise.

[G commands: **LIFT.**]
7, **10, 8,** and **11** take up weight of barrel on wrenches; continuing to face breech casing, withdraw barrel to front; place on convenient supports.

7 and **10** remove rear tube wrench; place wrench under spare barrel, engaging lug in recess.
8 and **11** remove front tube wrench; fasten on spare barrel (with catch up), and lock.

[G commands: **READY-UP.**]
7, **10, 8,** and **11,** facing breech casing, lift spare barrel; insert carefully in gun; slide barrel into place; turn wrenches one-half turn clockwise; remove wrenches.

G closes top cover and secures latch; removes breech ring retaining pin.
11 replaces wrenches with tools; returns to this post.
7 returns to gun platform.
8 and **9** return to their posts.

■ 45. Elevation (When Out of Phase), Director Control.—*Any member of the firing unit who observes that gun is out of phase in elevation calls, **ELEVATION.***

G pulls **7**'s foot from firing pedal; throws elevation switch to "OFF."
RS reports to **7** approximate elevation of telescope (to nearest degree);
1 continues to track target.
2 continues to track target.
RS continues to set ranges.
7 throws elevating handle into gear; elevates or depresses to elevation reported by RS; reports, ***"Set."***
G turns elevation switch to "ON"; reports, ***"Gun Ready."***
7 resumes firing (unless other command has been given).

Note.—*G is responsible for the pointing of the gun. If gun jumps out of phase in azimuth, he pulls **7**'s foot from firing pedal; commands: **CEASE FIRING;** lifts slewing lever; slews gun to point slightly ahead of target; glances down at blackout dial and slews gun so that dial is blacked out (or pointers matched); slams lever down and **7** resumes firing unless other command has been given.*

■ 46. Stoppage, Director Control.—The term stoppage denotes a failure of gun to fire. It may be the result of personnel, ammunition, or mechanical failure.

If gun fails to fire,

7 releases firing pedal; presses pedal again, holding it down.

If gun still fails to fire,

7 checks to see if failure to fire is due to lack of ammunition; if not due to lack of ammunition, calls, ***"Stoppage";*** removes foot from pedal; sets safe or fire lever at "SAFE"; reports, ***"Safe."***
G, when 7 calls, ***"Stoppage,"*** lifts slewing lever; assists 7 as necessary.
7, assisted by G as necessary, checks extractor releasing lever to see if breechblock is open or closed (if lever moves through about 90°, the breechblock is closed; if about 40°, the breechblock is open).

If breechblock is open,

G calls, ***"Stoppage";*** assists 7 in remedying stoppage.
7, assisted by G, remedies stoppage.

If breechblock is closed,

NOTE.—*The following portion of* ***STOPPAGE*** *Drill is applicable to target practice conditions only:*

G calls, ***"Misfire";*** slews gun to point in safe direction.
7, when G calls, ***"Misfire,"*** immediately recocks gun and attempts to fire.

NOTE.—*To recock the firing pin, the loading lever is pulled to the rear until the loading lever handle is in line with both upper stop pawls of autoloader. A slight relief in pressure is noticeable at this point and the lever should not be moved farther to the rear as additional movement would cause lowering of breechblock. The firing pin having thus been cocked, it is necessary only to return loading lever to front catch. The forward movement of loading lever will release the firing pin; therefore, it is not necessary to step on firing pedal.*

If second attempt to fire fails, and at least 30 seconds but not more than 40 seconds has elapsed since original misfire,

CS commands: **MAKE SAFE.**
7 and 11 execute command, ***MAKE SAFE,*** as prescribed in paragraph 30.
11 passes round to G.
G examines round; passes it to 11, with instructions as to disposal of the round.

If primer has been struck,

11 places round in a safe place at least 20 yards from the gun, as directed by G.

If primer has not been struck,

G removes breechblock, tests firing mechanism and firing pin.
7 assists G.

If round has not been fired or removed within 45 seconds and barrel is HOT,

CS directs further action as required.

If water is available, it should be played on barrel until barrel is cool, after which additional effort should be made to remove the round.

If water is not available, all personnel should stand clear of gun until it is cool, after which additional efforts should be made to remove the round.

NOTE.—*When a stoppage occurs during combat, the gun must be cleared at once. Tracking is continued and G, assisted by 7, clears the stoppage as quickly as possible.*

If the breechblock is closed, 7 recocks gun and attempts to fire. If second attempt to fire fails, the round is immediately removed from the breech and placed to one side. Firing is resumed.

When stoppage has been remedied,

CS commands: **LOAD;** gives further instructions as required.

■ 47. CHECK LEVEL, DIRECTOR CONTROL.—*The gun and director must be level if director control fire is to be effective. Therefore, the gun and director must be checked for level frequently (after each firing engagement when practicable, or whenever considered necessary by* ***CS****).*

CS commands: **CHECK LEVEL.**

G slews gun so that one leveling tube is parallel to an outrigger and the other leveling tube is parallel to the chassis frame; if gun is not level, directs leveling of gun as prescribed in paragraph 26.
RS slews director so that a leveling tube is parallel to two leveling plungers; when found to be out of level, proceeds to level the director as described in paragraph 103.

NOTE.—*If either gun or director is greatly out of level* ***CS*** *commands:* ***ORIENT.***

■ 48. UNLOAD, DIRECTOR CONTROL.

CS commands: **UNLOAD.**

[G repeats command.]
7 sets safe or fire lever to "SAFE"; reports, ***"Safe,"*** insures that gun is elevated to about 30°.
11 places his hands behind loading tray.
7 pulls loading lever fully to rear, releasing round on loading tray; while loading lever is fully to rear, sets feed control lever to right.
11 catches round as it slides off loading tray.
7 engages loading lever in forward catch; inserts unloading tool, removes rounds from top of autoloader; insures that round in feed rollers is removed; passes rounds to 10; sets feed control lever to left.
10 receives ammunition from 7.

■ 49. STANDBY, DIRECTION ———, ELEVATION ———, DIRECTOR CONTROL.

NOTE.—*It has been provided that following the command* ***CEASE TRACKING,*** *both gun and director are made to point in the direction of anticipated attack and elevated to 30° or other normal standby direction. Therefore, the gun and director will normally be pointed toward the center field of fire and be elevated to 30° or other normal standby direction. To prevent the gun from jumping out of synchronization in elevation at a point below the limit switch, and so necessitate resynchronizing in elevation, 30° are usually taken as the normal standby elevation. In tactical set-ups this may prove unsatisfactory and another elevation may be designated as SOP for that situation. In this event or when, for any reason, it is desired to point the gun and director in a direction or at an elevation other than normal,*

CS commands: **STANDBY, DIRECTION ———, ELEVATION ———** (CS specifies the direction toward which the gun is to be pointed in azimuth, and the angle at which the gun is to be pointed in elevation.)

RS slews director to indicated direction.
1 sets telescopes to elevation ordered and reports, ***"Set."***
G slews gun to direction ordered.

■ 50. STAND FAST, DIRECTOR CONTROL.—*When* ***CS*** *desires to prevent or check execution of a command already given, or to insure that all members of the fire unit remain vigilant at post,*

CS commands: **STAND FAST.**

[G and RS repeat command.]

G pulls 7's foot from firing pedal (if necessary); lifts gun slewing lever.
7 removes foot from firing pedal; places safe or fire lever at "SAFE"; reports, ***"Safe."***
RS sets range to minimum (if no target is visible).
1 and 2 immediately move handwheels to 12 o'clock, making certain that deflection marks are matched—pull clutches "OUT" and turn switches "OFF" (if no target is visible).

All members of the fire unit remain vigilant at posts and await further commands.

■ 51. REST, DIRECTOR CONTROL.—*The command,* ***REST,*** *is given when firing has been temporarily suspended and it is considered undesirable to withdraw the fire unit from the gun position, or when it is necessary to keep the unit in action for long periods, ready to open fire on short notice.*

CS *first gives orders for such work to be carried out as may be necessary. When this work has been completed,*

CS commands: **REST.**

7 checks safe or fire lever at "SAFE"; reports, ***"Safe."***
4 (or other member designated by CS) remains at telephone.
8 and 9 (or other members designated by CS) remain alert as lookouts.

All other members of the firing unit remain near their posts.

■ 52. CASUALTY DRILL.—In the event of casualties to personnel, replacements to the fire unit will be detailed by CS. If CS becomes a casualty, RS or G will perform the duties of CS, in addition to his own.

The minimum required for director control is five: RS, 1, and 2, at the director; 3 at the power plant; and 7 as loader and firer.

The minimum required for sight control is three: 8 and 9 as lateral and vertical gun pointers, and 7 as loader.

A suggested alternate list is as follows:

Assignment	Alternates	Assignment	Alternates
CS	RS and G.	5	6 and 3.
RS	CS and 4.	6	5 and 3.
G	CS and RS.	7	G and 10.
1	9 and 4.	8	1 and 2.
2	8 and 4.	9	1 and 2.
3	6 and 11.	10	11 and 8.
4	RS.	11	10 and 9.

Each member of the fire unit, in addition to his assigned duties, must learn the duties of other members of the fire unit. A suggested list (consistent with the alternate list) is as follows:

Regular assignment	To learn	Regular assignment	To learn
CS	RS and G.	5	6.
RS	CS, G, and 4.	6	5 and 3.
1	8 and 9.	7	No other duties.
2	8 and 9.	8	2 and 10.
3	5 and 6.	9	1 and 11.
4	RS, 1, and 2.	10	7 and 11.
G	CS and 7.	11	3 and 10.

SECTION IV

ACTION, SIGHT CONTROL

■ 53. GENERAL.

NOTE.—*Sight control is employed when director control is impossible due to shortage of, maladjustment of, or accident to director and associated equipment. Sight control is also used in situations requiring extreme mobility and when the field of fire is exceedingly limited by terrain features or enemy tactics which result in angular rates beyond the capacity of the director.*

Upon the appearance of a target, CS or any member of the fire unit who sights or hears the target calls out, ***"Target,"*** and points out the approximate location.

Immediately upon hearing the report, CS commands: **TARGET, SIGHT CONTROL,** if action is to be with sight control.

Immediately upon hearing the report, each member of the fire unit goes to his post, if not already at his post; and upon hearing the command, ***TARGET,*** prepares for action as indicated by the command.

After giving the command, ***TARGET, SIGHT CONTROL,*** CS recognizes the target, and if it is hostile, commands: **ENGAGE.**

The fire unit prepares for action at the command, ***TARGET,*** but does not open fire until after CS has commanded, ***ENGAGE.***

■ 54. TARGET, SIGHT CONTROL.

NOTE.—*In the following drill it is assumed that the conditions below prevail when the command,* ***TARGET, SIGHT CONTROL*** *is given:*

All members of the fire unit are at their posts for sight controlled action, as in figure 26.

The gun is loaded, pointed in the direction of anticipated attack, and elevated to 30° or other normal standby direction.

NOTE.—*The machine gun is manned, ready for instant action, and may engage, without command, any target entering its sector and which is recognized as hostile. See notes under paragraph 36 regarding detailed duties of 4, 5, 6 at the machine-gun or M51 carriage.*

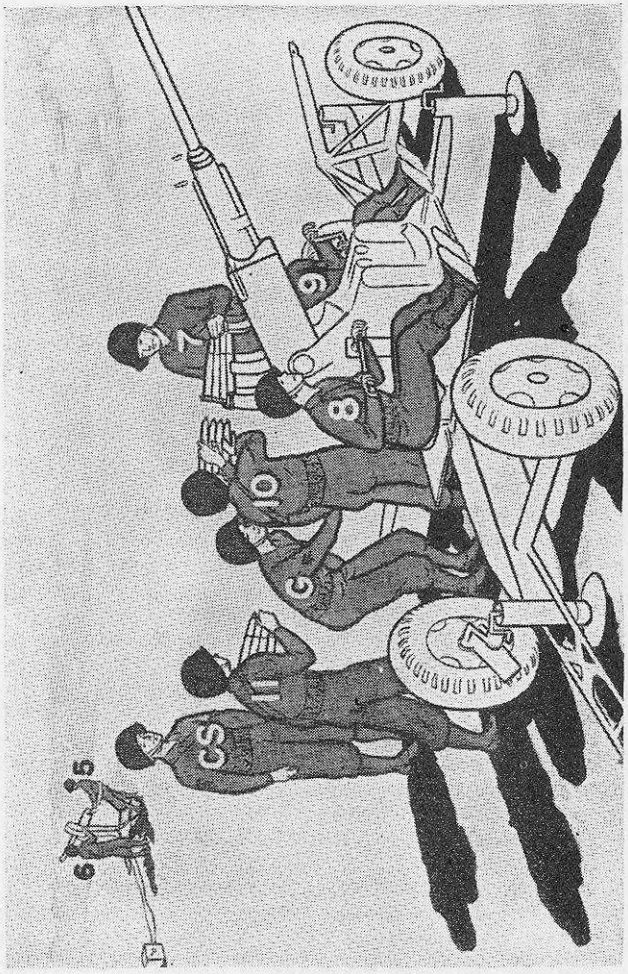


FIGURE 26.—Positions of crew for action at sight control, without M7 sight.

CS commands: **TARGET, SIGHT CONTROL.** (G gives command in absence of CS.)

G grasps gun slewing lever; slews gun to point toward target; removes hand from slewing lever; picks up free end of rope, attached to 9's (or 7's) foot; studies target in order to recognize it; coaches 8 and 9 in taking initial leads.

9 takes vertical gun pointer's seat; raises latch and pulls oil gear clutch lever to rear; throws elevating handle into gear; attaches rope to right foot (if he is to fire); elevates or depresses to target; takes lead, as directed by G; reports, ***"On"***; tracks target.

8 takes lateral gun pointer's seat; throws traversing handle into gear, after gun is slewed to point toward target; traverses to target; takes lead as directed by G; reports, ***"On"***; tracks target.

7 places loading lever in front catch; insures that feed control lever is turned left; attaches rope to right foot (if he is to fire); keeps autoloader full.

10 passes loaded clips to 7 as required.

11 passes loaded clips to **10**; loads additional clips if needed. (10 and 11 may alternate in passing to 7.)

1, 2 replace 8, 9 as lookouts.

3 remains at power plant, ready for action.

4 remains at telephone and radio (if equipped with multiple machine-gun carriage M51, acts as right cannoneer)

5, 6 remain as machine gunners, ready for instant action.

NOTE.—*When M7 sight is used, **RS** mounts gun platform in rear of 8 and acts as lead setter.*

RS sets target's course and speed.

8 tracks target through telescope.

9 tracks target through telescope.

CS commands: **ENGAGE**, when target is recognized as hostile. (G gives command in absence of CS.) Command may also be ***ENGAGE, AUTO-FIRE.***

7 sets safe or fire lever to "SINGLE-FIRE." (May set "AUTO-FIRE" if command is such); stands ready to receive additional loaded clips.

554769°—43——7

G observes target to determine when within range; coaches gun pointers in taking leads.

8, 9, 10, 11 (and RS when using M7 sight) same as at *TARGET, SIGHT CONTROL.*

G commands: **FIRE,** when target is within range and gun pointers are tracking properly; observes tracers and coaches gun pointers in correcting leads (except when using M7 sight). He observes pointing of gun; remains alert to command, ***STOP-TRAVERSE***, if necessary.

9 (if he is to fire) depresses and releases firing pedal as rapidly as individually aimed rounds can be fired; fires only while target is visible to him. (If command was ***ENGAGE, AUTO-FIRE,*** pedal is depressed.) Continues tracking; corrects lead as directed by G (except when using M7 sight).

8 continues tracking; corrects lead as directed by G (except when using M7 sight).

7 watches functioning of autoloader; receives additional loaded clips from 10 (or 11) as required; keeps autoloader properly filled; remains ready to fire with his foot pedal in case 9's pedal becomes inoperative, or in case G directs that 7, rather than 9, fire; when possible, deflects empty clips from gun platform.

10, 11 relay or alternate passing loaded clips to 7 as required; insure that empty clips are cleared from gun platform. 11 loads additional clips as required.

NOTE.—*Periodically, G sets recoil recorder to minimum, reads length of recoil after gun is fired, makes any necessary adjustment to recoil buffer, and resets recoil recorder, checking again if adjustment was necessary.*

NOTE.—*If high speed, close range target makes tracking impossible, if gun points dangerously near friendly personnel and equipment, or if gun points dangerously near any obstruction close by,*

G commands: **STOP—TRAVERSE;** pulls firer's foot from firing pedal.

9 removes foot from firing pedal, if he is firing; leaves elevating handle in gear.

8 throws traversing handle out of gear.

7 removes foot from firing pedal, if he is firing (Sets safe or fire lever to "SAFE" in target practice only.)

10 and 11 remain ready to pass ammunition.

G slews gun to direction where firing may be resumed; coaches gun pointers in taking leads (except when using M7 sight).

8 throws traversing handle into gear; traverses to target; takes lead, as directed by G (except when using M7 sight); reports, ***"On"***; tracks target.

9 elevates or depresses to target; takes lead, as directed by G (except when using M7 sight); reports, ***"On"***; tracks target.

7 at report, ***"On,"*** insures that safe or fire lever is set to previous firing position.

RS continues to set leads when using M7 sight.

G commands: **FIRE.**
Firing is resumed.

■ 55. CEASE FIRING, SIGHT CONTROL.

G commands: **CEASE FIRING** and pulls firer's (9 or 7, as case may be) foot from firing pedal when target is out of range. (CS may give the command at any time.)

7 places safe or fire lever to "SAFE" and reports, ***"Safe"***; fills autoloader as necessary.

G watches for target; coaches 8 and 9.

10 and 11 stand by ready to relay ammunition to 7.

8 and 9 continue to track target; when target reappears, establish leads and report ***"On"***.

RS continues to set leads when using M7 sight.

G commands **FIRE** and firing is resumed.

■ 56. CEASE TRACKING, SIGHT CONTROL.

CS commands: **CEASE TRACKING.**

[G repeats command.]

7 insures that safe or fire lever is at "SAFE"; secures loading lever in rear catch.

8 throws handle out of gear; takes post as lookout if director control is to be used.

9 sets gun at 30° (or other normal standby direction); gathers empty cartridge cases and clips, placing them near **11**; if fire unit is to revert to the normal director control, throws handle out of gear; raises latch and pushes oil gear clutch lever forward; returns to post as lookout.

G checks that safe or fire lever is at "SAFE," loading lever is secured in rear catch, gun is level; slews gun to direction of anticipated attack; if fire unit is to revert to the normal director control, checks that elevation limit switch is at "OFF" position, and that elevation oil gear clutch lever is forward.

10 and 11 replenish ammunition at gun; load empty clips as necessary.

RS sets speed indicator to speed of expected attack when using M7 sight.

■ 57. CHANGE TARGETS, SIGHT CONTROL.

CS commands: **CHANGE TARGETS,** when new and more important target appears.

G [repeats the command] (gives command in absence of **CS**); pulls firer's foot from firing pedal.

9 removes foot from firing pedal, if he is firing; leaves elevating handle in gear.

8 throws traversing handle out of gear.

7 (removes foot from firing pedal, if he is firing); sets safe or fire lever to "SAFE."

10 and 11 remain ready to pass ammunition.

G slews gun to point toward new target; coaches gun pointers in taking leads (except when using M7 sight).

RS estimates speed and course of new target and applies leads when using M7 sight.

8 throws traversing handle into gear; traverses to target; takes lead, as directed by **G** (except when using M7 sight); reports, ***"On"***; tracks target.

9 elevates or depresses to target; takes lead, as directed by **G** (except when using M7 sight); reports, ***"On"***; tracks target.

7 at report, ***"On,"*** sets safe or fire lever to previous firing position.

G commands: **FIRE.**
Firing is resumed.

■ 58. TARGET LOST, SIGHT CONTROL.—*When target is obscured by a cloud or some feature of the terrain.*

8 and **9** report, ***"Lost,"*** do not change tracking rates.

G commands: **CEASE FIRING;** pulls firer's foot from firing pedal.

9 removes foot from firing pedal, if he is firing.

7 (removes foot from firing pedal, if he is firing); refills autoloader, as necessary.

G watches for target; coaches **8** and **9.**

8 and **9,** when target reappears; quickly establish correct leads, as directed by **G** (except when using M7 sight); report, ***"On"***—track target.

RS quickly sets correct leads when using M7 sight.

G commands: **FIRE.**
Firing is resumed.

■ 59. DIRECTOR CONTROL, FROM SIGHT CONTROL.

CS commands: **DIRECTOR CONTROL;** commands and signals: **START POWER PLANT,** if plant is not running.

[G and RS repeat the command, ***DIRECTOR CONTROL.***]

9 raises latch and pushes oil gear clutch lever forward; removes rope from his ankle; passes rope end to **7**; calls, ***"Elevation."***

RS, **1,** and **2,** take posts at director.

1 and 2 insure that rates are at ZERO, clutches "OUT" and switches "OFF."

RS observes elevation scale; when **9** calls, ***"Elevation,"*** he reports, ***"Elevation"*** ——— (to nearest degree).

RS calls; ***"Power"*** to **CS;** checks director level.

CS faces **3**—commands and signals: **CLOSE SWITCH.**

3 closes main switch; adjusts voltage as required.

9, at report, ***"Elevation ———"*** from RS, brings gun to the reported elevation; reports, ***"Set"***; throws elevating handle out of gear; takes post as lookout.

8, at command, ***DIRECTOR CONTROL,*** traverses gun to normal standby direction; throws traversing handle out of gear; at report ***"Set,"*** from 9, throws elevation switch to "ON" position; takes post as lookout.

G checks gun level; checks that elevation switch is "ON."

7 receives rope end from 9 and attaches it to his own ankle.

4, 5, 6, 10, and 11 continue normal duties.

■ 60. GROUND TARGET OR WATER TARGET (SIGHT CONTROL).

CS commands: **GROUND TARGET, SIGHT CONTROL, or WATER TARGET, SIGHT CONTROL**; indicates target by pointing and describing. (G gives command in absence of CS.)

NOTE.—*For fire control, see FM 4–151. The M7 sight is not used for ground or water target sight control.*

[G repeats (or gives) the command.]

The command is executed in manner similar to execution of ***TARGET, SIGHT CONTROL.*** *(See par. 54.) Exceptions are as follows:*

CS (or G), if target is a tank, immediately commands: **A. P.**, following the above command. Thereafter only armor-piercing rounds (in clips) are passed to 7.

7 normally sets safe or fire lever to "SINGLE FIRE." If target is a tank and ***A. P.*** is ordered, he sets safe or fire lever to "AUTO FIRE" and returns to "SINGLE FIRE" as soon as HE rounds in autoloader have been fired, unless ***"AUTO-FIRE"*** has been ordered.

9, unless ordered otherwise, turns elevation adjusting lever to "NEAR."

7 or 9 in firing at "SINGLE FIRE," fires each shot only after 8 has reported, ***"On."***

G pulls 7 or 9's foot from firing pedal and orders: **SINGLE FIRE,** whenever necessary. He coaches 8 and 9 in terms of target lengths and target heights, as **LEFT TWO,** and **UP ONE-HALF**. These orders always represent the desired total lead.

8, each time he judges that his lead and tracking is correct, reports, ***"On."***

NOTE.—*In order to provide maximum security of position and cover for personnel, 7 may kneel on the gun platform ready to fire with his hand if ordered to fire by* ***G.*** *In this case* ***10*** *keeps autoloader full and* ***11*** *passes ammunition to* ***10.***

SECTION V

MARCH ORDER

■ 61. GENERAL.—The procedure for placing the various elements of the fire unit into traveling position is designed so that—

a. The gun remains in firing position as long as possible.

b. Fire control equipment is loaded with least possible delay.

c. Local protection is provided by either the 40-mm gun or .50 caliber machine gun during all operations of placing the equipment into traveling position.

■ 62. MARCH ORDER.—*When the fire unit is to be moved out of position or from one position to another,*

CS commands: **MARCH ORDER** [if necessary, commands and signals: **STOP POWER PLANT** to 3] supervises the work of the fire unit.

[G commands: **SIGHT CONTROL.**] (For execution see par. 63, SIGHT CONTROL—At March Order.)

[RS commands: **MARCH ORDER POWER PLANT.**] (For execution see par. 64, MARCH ORDER POWER PLANT.)

3, opens main switch; disconnects power cable; prepares power plant for loading; inserts carrying bars; goes for instrument truck; drives truck to power plant position.

6, 10, and 11 go to power plant position.

■ 63. SIGHT CONTROL (AT MARCH ORDER).

NOTE.—*If already at sight control, the gun section (except* ***10*** *and* ***11****) stands fast at the command,* ***SIGHT CONTROL.*** *If the fire unit is at director control,*

G [commands: **SIGHT CONTROL**] lifts gun slewing lever; throws elevation switch to "OFF" position.

8 takes lateral gun pointer's seat; throws traversing handle into gear; continues, in his seat, to act as lookout.

7 removes rope from his ankle; passes rope end to 9 (if 9 is to fire); fills autoloader, if required.

9 takes vertical gun pointer's seat; raises latch and pulls oil gear clutch lever to rear; throws elevating handle into gear; if he is to fire, attaches rope to his right foot, passing free end to G; continues, in his seat, to act as lookout.

G remains near slewing lever, ready to slew gun to target if necessary; prepares to pass loaded clips to 7 when needed.

RS (when using M7 sight) mounts gun platform in rear of 8 prepared to set in leads.

■ 64. MARCH ORDER POWER PLANT.

NOTE.—*In case RS is engaged with the M7 sight while the remainder of the fire unit is being prepared for movement, it will be impossible for RS to perform any of the duties shown in this paragraph. In this case CS performs the duties.*

RS [commands: **MARCH ORDER POWER PLANT**] verifies main switch open; disconnects director cable from director and gun; goes to power plant position.

1 and 2 at director, insure that deflection marks are matched, clutches are pulled "OUT," switches are "OFF"; place switch covers on. After power cable is disconnected, assist 4 in rolling up power cable from gun to power plant.

4 disconnects phone or hands phone to CS, as CS may direct; verifies main switch is open; disconnects power cable from gun junction box; assisted by 1 and 2, rolls up power cable from gun to power plant.

CS receives phone from 4; stays near telephone; continues to supervise work of the firing unit.

3, after he has driven instrument truck to power plant position, dismounts.

RS, 1, 2, 3, 4, 6, 10, and 11 take same position at carrying bars as during emplacement of power plant (See par. 29, EMPLACE POWER PLANT).

RS [Commands: **READY—LIFT**] directs movement of power plant to instrument truck so that front (radiator) end

of power plant is carried toward truck; directs that power plant be stopped when slightly to rear of truck.

RS, 1, 2, 3, 4, 6, 10, and 11 carry power plant to truck.

[RS commands: **READY—LIFT.**]

RS, 1, 2, 3, 4, 6, 10, and 11 lift power plant until carrying bars are slightly higher than truck floor; move power plant forward until front ends of carrying bars extend 6 to 8 inches within truck; lower power plant so that front ends of carrying bars rest upon truck and rear ends of carrying bars are slightly lower than front ends.

1 and 2 mount truck; face to the rear; grasp front ends of carrying bars.

[RS commands: **READY—LIFT.**]

RS, 1, 2, 3, 4, 6, 10, and 11 lift power plant until its skids are slightly higher than truck floor; move power plant forward until front ends of skids extend 6 to 8 inches within truck; lower power plant so that front ends of skids rest upon truck and rear ends of skids are slightly lower than front ends; move rear end of power plant slightly to the right to assist removal of front short carrying bar by 3.

3 removes front short carrying bar; places it beneath front ends of power plant skids, keeping carrying bar as far to right of truck as possible and at an angle which will facilitate movement of power plant toward left front corner of truck; mounts truck to left of power plant.

RS, 3, 4, 6, 10, and 11 push power plant forward until rear end of power plant extends only slightly beyond rear of truck.

11 removes rear short carrying bar; hands it to 2.

2 receives carrying bar; places it beneath front ends of power plant skids in same manner as other bar (when necessary, continues to place first one and then the other short carrying bar beneath power plant until front of power plant is within about one foot of front of truck).

1, 2, and 3 push power plant toward left front corner of truck.

3 withdraws long carrying bars rearward until front ends are about flush with front end of power plant.

3, when power plant is against front of truck, takes hold of rear ends of long carrying bars and, using leverage thus provided, places power plant in left front corner of truck; lifts rear end of power plant to permit 1 to withdraw short

carrying bars from beneath skids; lowers rear end of power plant to truck floor; withdraws long carrying bars and places them between power plant and left side of truck.

1 places short carrying bars with long bars.

2 dismounts.

4 assisted by 2 lifts power cable onto truck.

1 and 3 place power cable on truck floor at rear of power plant; dismount.

NOTE.—*If crew is short, power plant may be loaded by reversing the process outlined in the note in paragraph 29.*

■ 65. MARCH ORDER DIRECTOR.—*When power plant has been properly placed upon instrument truck (see note at beginning of par. 64),*

RS [commands: **MARCH ORDER DIRECTOR**] goes to director position.

3 mounts truck and drives to director position; dismounts.

1, 2, and 4 go to director position.

6 and 11 go for director packing chest; place chest; place chest near director position so that side of chest, on which white arrows are painted, faces the direction toward which the director will be carried to chest; open chest.

10 returns to gun position; prepares to hand ammunition to 7 as required during sight control action.

RS lowers open sight; dismounts telescopes; secures them in director chest; slews director so that orienting clutch (as azimuth panel is faced) appears slightly to right of tripod plunger opposite the direction toward which director will be carried when removed from tripod (See par. 28, EMPLACE DIRECTOR); releases slewing handle when director is in this position.

1 and 2 remove carrying bars from director chest brackets; hand-carrying bars to RS.

RS receives carrying bars from 1 and 2; places carrying bars into director carrying brackets; directs 1, 2, 3, 4, 6, and 11 to their places at carrying bars; takes post at azimuth panel.

1, 2, 3, 4, 6, and 11 take same positions at carrying bars as during emplacement of director; raise brackets.

RS, when director carrying brackets have been raised, inserts pins [commands, **READY—LIFT**] directs movement of director from tripod to packing chest; insures that director is placed in chest so that azimuth panel is on same side of chest as white arrows (marked on outside of chest).

1, 2, 3, 4, 6, and 11 lift director from tripod; carry it to chest; place it in chest, as directed by **RS.**

1 and 2 remove carrying bars from director, and insert bars into packing chest carrying brackets, inserting bars first into the two brackets farthest removed from side marked with arrow.

6 procures canvas cover.

RS and 6 place cover over director.

3 and 4 close chest, being certain that white arrows (painted on outside of upper and lower sections of chest) are matched.

11 returns to gun.

RS, 1, 2, 3, 4, and 6 take same positions at carrying bars as during removal of director chest from truck.

RS [commands: **READY—LIFT**] directs movement of chest to truck so that, when chest is carried to truck, the side bearing the white arrows will be away from truck.

RS, 1, 2, 3, 4, and 6 carry director chest to truck; adjust their holds upon carrying bars.

RS [commands: **READY—LIFT.**]

RS, 1, 2, 3, 4, and 6 lift chest until front ends of carrying bars are slightly higher than truck floor; move chest forward until front ends of carrying bars extend 6 to 8 inches within truck; lower chest until front ends of carrying bars rest upon truck and rear ends are slightly lower than front ends.

1 and 2 mount truck; face to rear; grasp front ends of carrying bars.

RS [commands: **READY—LIFT.**]

RS, 1, 2, 3, 4, and 6 lift chest until bottom of chest is slightly higher than truck floor; move chest forward until chest is more than halfway within truck; lower chest onto truck.

1 and 2 pull while RS, 3, 4, and 6 push chest into truck.
1 and 2 remove carrying bars.
4 mounts.
1, 2, and 4 move chest toward front of truck in same manner used to move it to rear of truck during unloading of director; turn chest one-quarter turn counterclockwise, so that long sides are parallel to truck sides, and so that the side on which white arrows are painted faces to right; move chest against front of truck and close to right side of power plant.
1 places carrying bars between chest and power plant.
3 and 6 get director tripod and hand it to 2 and 4.
2 and 4 receive tripod; place it across top of director chest with leveling plungers to the left.
1 and 2 lash tripod to director packing chest.
4 dismounts; gets director cable and phone; loads director cable and phone into truck; mounts truck; places director cable upon power plant and power cable at rear of director.
1 and 2 assist 4 in loading director cable and telephone.
1, 2, 3, 4, and 6 load radio and any remaining equipment into instrument truck.
3 mounts.
6 returns to machine-gun position to assist 5.
RS reports to CS, ***"DIRECTOR LOADED."***

■ 66. MARCH ORDER MACHINE GUN.—*When the director has been loaded onto instrument truck (when equipped with caliber .50 machine gun on M2A1 or M3 mount) (see note at beginning par. 64),*

[CS commands: **MARCH ORDER MACHINE GUN.]**

[RS repeats command.]
3 drives instrument truck as directed by RS.
RS, 1, 2, 3, and 4, proceed to machine-gun position.
[RS commands: **MACHINE GUN ON TRUCK.]**
5 and 6 unload chamber and remove ammunition from feedway of machine gun.
5 clamps machine-gun mount at horizontal; swings muzzle toward truck.
6 removes ammunition chest and passes it to 4. (If situation is urgent, chest is not removed.)

4 places ammunition chest on truck, and returns to his post at machine gun.
1 and 2, assisted by 6, place water chest under tailgate.
6 mounts truck; places ammunition chest so that it will not interfere with the process of placing machine gun on truck.
5, 4, RS, 3, 2, and 1 take hold of machine-gun tripod in same manner as during emplacement of machine gun; lift machine gun on truck, executing in reverse order the procedure followed when removing machine gun from truck.
6, on truck, steadies machine gun by barrel as it is placed on truck; pulls gun into position; replaces ammunition chest on machine gun; raises top cover, places first round behind holding pawl, and closes top cover.
5 mounts truck; immediately loads machine gun; unclamps machine gun in elevation; remains ready to fire; reports, ***"Machine Gun Ready"*** to RS.
1 and 2 lift water chest on truck; place ammunition and tool box on truck.

RS reports, ***"Machine Gun Ready,"*** to CS.
3 mounts truck.
4 mounts truck, lowers right seat of truck; places power cable on right seat, near front of truck.
1 and 2 raise and hook tailgate.
1 hooks safety belt.
3 drives instrument truck to trailer, as directed by RS.
RS, 1, and 2 proceed to trailer position; connect trailer to instrument truck (1 at left side, 2 and RS at right side); mount.

■ 67. MARCH ORDER GUN.

NOTE.—*If gun is without covers, those portions of drill referring to replacement of covers may be omitted.*

When machine gun is on truck and ready to fire.

[CS commands: **MARCH ORDER GUN.]**

[G commands: **UNLOAD.]**
7, 10, andn 11 unload the gun (See par. 48).
11, after receiving round from loading tray, places round with ammunition; goes to rear stake.

9 dismounts from seat; obtains stake lever; loosens right stake; hands lever to 11; replaces stake in right outrigger bracket.
8 dismounts from seat; procures gun covers; places them near left outrigger; procures outrigger covers; places one outrigger cover and one sight cover near each outrigger; places autoloader hood and rear (breech) cover on gun platform.

G as soon as unloading is completed [commands: **RELIEVE SPRINGS**] slews gun to point over rear of carriage; presses slewing lever down.
10 and 7 relieve springs (see par. 35).
10 goes to left outrigger stake.
7 insures that safe or fire lever is at "SAFE," loading lever in front catch, and gun elevated to about 30°; places hood on autoloader and rear cover in breech; goes to front stake.
11 receives stake lever from 9; loosens rear stake; hands lever to 10; replaces stake in lower rear chassis bracket; assist 7 in replacing stake in top rear chassis bracket.
10 receives lever from 11; loosens left stake; hands lever to 7; replaces stake in left outrigger bracket.
7 receives lever from 10; loosens front stake; hands lever to 8; hands stake to 11; returns to front jack.
8 places lever and maul on gun platform, strapping them in place.

G [commands: **MAN JACKS**] takes post at drawbar; raises drawbar and inserts pin.
7, 9, 10, and 11 take regular places at jacks; grasp jack handles and unlock jacks.

[G, as soon as jacks are manned, commands: **READY—CARRIAGE DOWN.**]
7, 9, 10, and 11 rapidly lower the carriage until wheels rest upon ground; retract jacks fully and lock handles (all must lock handles in notch away from gun).
7, 8, and G take posts at drawbar, as during emplacement.
9, 10, and 11 take posts at gun stay, as during emplacement.
11 engages gun-stay plungers.

Caution: *To prevent injury to personnel, it is essential that weight of carriage rest upon wheels before locking handles are unlocked; otherwise, drawbar may move forward with great force or gun stay may move upward with great force.*

G commands: **UNLATCH.**
G and 11 set locking handle to unlocked position; report, ***"Unlatched."***

G commands: **READY—RAISE.**
7, 8, and G at front and 9, 10, and 11 at rear, raise carriage to travel position.
8 guides securing clamp so that it will clear bracket during last portion of movement.
8 and 9 set locking handles to the locked position (without order from G).
G, assisted by 7, fastens steering link securing clamp; removes pins from drawbar and steering gear; places pins in brackets.
7 assists G in fastening steering link securing clamp, in removing pins from drawbar and steering gear, and in placing pins in brackets.
9 depresses gun into gun stay.
11 clamps gun securely in gun stay with upper plungers.
9 and 10 unlock outriggers and swing them to travel position; attach outrigger covers.
8 and 9 remove their traversing and elevating handles; strap securely to platform.
8 passes barrel cover to 10.
10 and 11 replace barrel cover.
11 goes for prime mover.
8 and 9 replace sight covers.
8 and 10 lift gun cover and throw top portion across gun to 7 and 9.
7 and 9 receive top portion of gun cover from 8 and 10.
7 and 9 complete fastening and lacing of gun cover.

NOTE.—*Procedure for replacing and fastening all covers should be as nearly as possible the reverse of procedure for removing them.*

10, 11, and 7 load ammunition into prime mover.
G, 8, and 9 load tools and other equipment as required.
11 backs prime mover up to drawbar as directed by G.
G directs 11 in backing up.
8 and 7 connect drawbar to prime mover.
G connects break-away chain; places brake cable plug into receptacle of prime mover; signals 11 to pull ahead very slightly and checks break-away switch.
11 tests operation of electric brakes from cab.
[G commands: **MOUNT.]**

All members of the gun section take the same positions which they originally occupied in truck. (See fig. 27.)

CS takes place in cab of prime mover; directs movement of firing unit to new location.

■ 68. MARCH ORDER TRAILER.—The following drill applies when the unit is equipped with multiple caliber .50 machine gun carriage M51. At command ***MARCH ORDER POWER PLANT*** and ***MARCH ORDER DIRECTOR***—

4 and 6 leave multiple caliber .50 machine gun carriage M51 to perform duties under the standard drill in loading the power plant, cables, and director; return to multiple caliber .50 machine gun carriage M51.

When the fire unit is loaded and prepared to travel except for hooking on the multiple caliber .50 machine-gun carriage M51.

[CS commands **MARCH ORDER TRAILER.]**

3, backs instrument truck to trailer.
1, 2, 4, and 6 load ammunition on instrument truck.
1 and 2 run rear trailer jacks up (1 right, 2 left). [Each reports, ***"Jack up."***]
4 and 6 man front trailer jacks to position drawbar so that it can be engaged in the pintle, then run jacks up.
RS guides instrument truck to trailer; hooks lunette on pintle, and locks it; connects light cable and break-away chain; supervises testing of electric brakes.
4 and 6 mount trailer, as AA lookouts and cannoneers, 6 standing in front right corner, and 4 in front left corner

of trailer. (6 serves left guns on turret, 4 serves right guns.)
5 continues on the alert in the turret, which is faced to the rear of the trailer.
RS, 1, and 2 mount instrument truck.
RS awaits or proceeds with instructions from CS.

SECTION VI

ACTION FROM WHEELS

■ 69. GENERAL.—*a.* No member of the 40-mm fire unit will ride the gun carriage while the gun is being towed.

b. When the 40-mm fire unit is on the march in the combat zone and action against either aerial or ground targets is imminent and highly probable, the fire unit is prepared for emergency action and the following conditions prevail:

(1) The gun is without all covers, except the breech and barrel covers and the autoloader hood, which are in place.

(2) Seven rounds of ammunition are in autoloader, loading tray is empty, springs are relieved, loading lever is in front catch, and safe or fire lever is a "SAFE."

(3) All personnel are in their proper places in the trucks as shown in figure 27.

NOTE.—*For duties of machine gunners when on the march, see FM 4–155. For detailed duties of* ***4, 5, 6*** *at command* ***TARGET (BEING ON THE MARCH)*** *when manning the M51 carriage, see FM 4–157 (also see note in par. 36).*

■ 70. ACTION FROM WHEELS.

CS or any member of the fire unit who sights or hears the target, calls out, ***"TARGET,"*** and points out the approximate direction.

CS commands: **ACTION FROM WHEELS.**

11 heads prime mover out of traffic lane; halts as quickly as possible without throwing the men in the truck about unduly. He chooses *any near spot*, out of all traffic lanes with a good field of fire and on level ground if possible. Speed is essential; therefore, action is immediate and field of fire is sacrificed if necessary.

G [commands: **ACTION FROM WHEELS**] dismounts from prime mover as soon as it stops.

7, 8, 9, and 10 dismount from prime mover as soon as it stops.

Position of Personnel and Equipment in Trucks

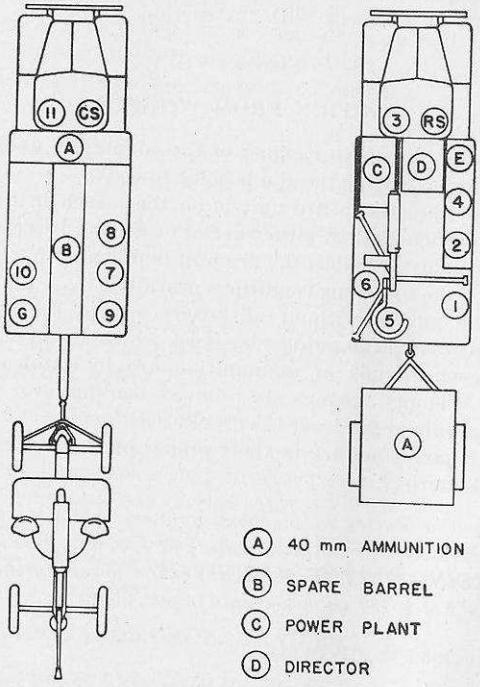


FIGURE 27.—Loading arrangement, 40-mm fire unit, mobile. (The trailer "A" shown is the 1-ton trailer. When the multiple caliber .50 machine-gun carriage M51 is issued, it replaces this trailer, and 4, 5, and 6 ride the multiple caliber .50 machine-gun carriage M51 at the alert. 5 rides in the gunner's seat with the guns to the rear and horizontal, acting as antiaircraft lookout to the rear. 4 and 6 act as antiaircraft lookouts to the sides.)

7 removes autoloader hood and breech cover.

8 and 9 swing left and right outriggers respectively to firing position and lock them; take their respective seats.

10 releases upper plungers of gun stay; lowers gun stay; removes barrel cover.

G grasps gun slewing lever; slews gun to point toward target; removes hand from slewing lever; picks up free end of rope attached to 9's foot; studies target in order to recognize it; coaches 8 and 9 in taking leads.

7 pulls loading lever fully to rear; moves it slightly forward and engages it in rear catch; presses down hard on top round with both hands until bottom round drops to loading tray; places loading lever in front catch; insures that feed control lever is turned left; keeps autoloader full.

8 throws traversing handle into gear after gun is slewed to point toward target; traverses to target; takes lead as directed by G; reports ***"On"***; tracks target.

9 insures that oil gear lever is toward rear; throws elevating handle into gear; attaches rope to right foot; elevates or depresses to target; takes lead as directed by G; reports ***"On"***; tracks target.

10 disconnects break-away chain and brake cable; signals 11 to back up or pull ahead slightly, as required to disconnect drawbar; opens pintle; signals 11 to pull ahead about 5 feet; lowers drawbar to ground; unfastens tailgate; unloads a box of ammunition; signals 11 to pull truck ahead; passes loaded clips to 7, as required.

11 moves truck about 50 feet from gun, under cover if available; dismounts; assists 10 in supplying ammunition to 7.

Remainder of action is the same as under the command, ***TARGET, SIGHT CONTROL*** (see par. 54).

NOTE.—*If the 40-mm AA gun is fitted with the M7 computing sight, and it is to be used, the above drill is modified accordingly:*

8 and 9 track target through telescopes.

G sets the direction and estimated speed on the sight; makes necessary adjustments on sight based on observation of tracers.

When ready to resume march—

CS commands: **MARCH ORDER.** (Command given by G in absence of CS.)

G commands: **MAKE SAFE** followed immediately by **RELIEVE SPRINGS** (see pars. 30 and 35).
7 and 11 make safe.
7 and 10 relieve springs.
7 fills autoloader as required; insures safe or fire lever is at "SAFE," and loading lever is in front catch; replaces autoloader hood and breech cover.
8 traverses gun to point over rear of carriage.
9 depresses gun as required to engage the gun stay.
10 raises gun stay and engages upper plungers; replaces barrel cover.
8 and 9 unlock left and right outriggers respectively; swing them to traveling position.
11 backs prime mover up to drawbar as directed by **G.**
10 and 11 load ammunition onto prime mover.
G and 10 connect drawbar to prime mover as 11 moves vehicle in accordance with signals from **G;** connect brake cable and break-away chain; check break-away switch.
11 tests operation of electric brakes from cab.
CS, G, 7, 8, 9 and 10 mount prime mover.

NOTE.—*When time permits or terrain requires lower center of gravity,*

CS commands: **DROP CARRIAGE** when gun has been prepared for sight control action as prescribed under command ***ACTION FROM WHEELS*** above. All members of the gun section take the same posts and follow the same procedure in lowering the carriage as is prescribed in paragraph 26 of the regular drill; however, they immediately return to their posts for sight control without extending the jacks.

NOTE.—*CS may give the command,* ***ACTION FROM WHEELS—DROP CARRIAGE,*** *initially. In this event, the gun section first prepares the gun for immediate sight control action from wheels with carriage up, and then lowers the carriage unless the command* ***ENGAGE*** *by* ***CS*** *precludes the lowering of the carriage until a break in action. When the carriage has been dropped, the gun is placed in traveling position according to standard drill.*

CHAPTER 4

CARE AND MAINTENANCE

SECTION I

GENERAL

■ 71. INTRODUCTION.—It is necessary that all antiaircraft personnel understand the problems of everyday maintenance of antiaircraft artillery equipment. All members of the fire unit are trained in first echelon maintenance and to assist in second echelon maintenance. Selected personnel are trained in second echelon maintenance. Detailed maintenance procedures will be found in TM 9–252, 9–616, 9–659, and 9–1643.

a. First echelon.—First echelon maintenance is performed by battery enlisted personnel trained in the operation of the equipment.

b. Second echelon.—Second echelon maintenance is performed by battery personnel trained in the operation of the equipment and augmented by a noncommissioned officer (battery specialist) specially trained in the maintenance of the battery matériel.

■ 72. QUALIFIED BATTERY SPECIALIST.—*a.* A qualified battery specialist is a man who has completed a recognized course of instruction in maintenance, such as offered by the Ordnance Schools, Antiaircraft Artillery School, officially authorized manufacturer schools, centralized training camp schools, or schools conducted by qualified maintenance company personnel.

b. The chief of section, range setter, and gunner must be able to perform all authorized first and second echelon tests and adjustments on the equipment and to intelligently supervise and be responsible for maintenance and repair. (See app. I.)

SECTION II

40-MM AUTOMATIC GUN M1

■ 73. LUBRICATION.—The following instructions supplement the lubrication chart figure 28.

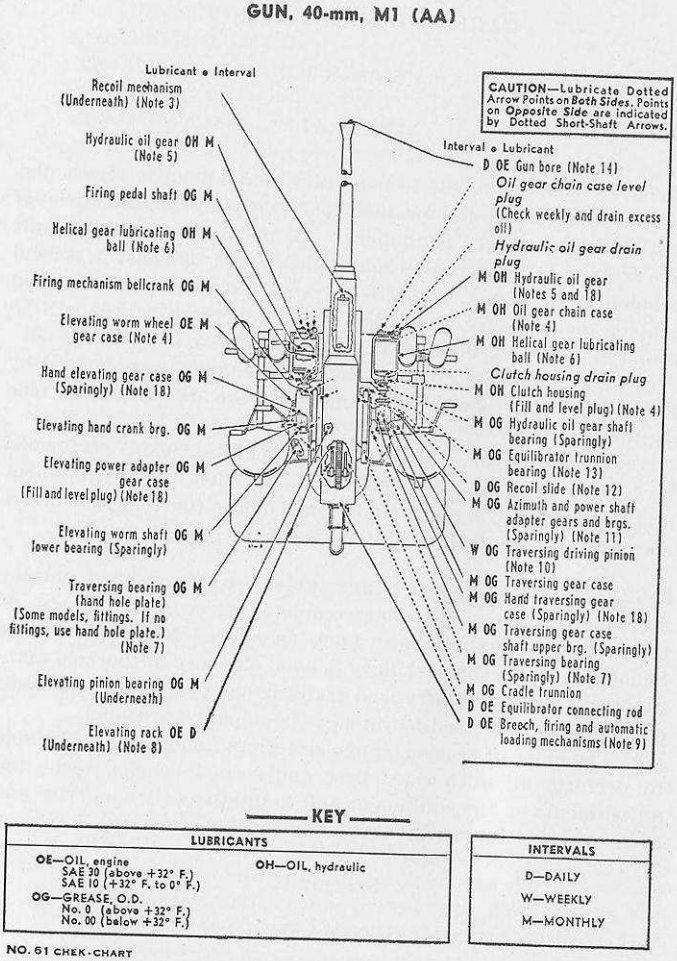


FIGURE 28.—Lubrication chart, 40-mm gun M1.

a. Note 1, Fittings.—Clean before applying lubricant. Where bearings can be seen, lubricate until new lubricant is forced from the bearing.

Caution: Lubricate after washing gun and carriage. Do not use high pressure washing system for cleaning artillery matériel.

b. Note 2, Intervals.—Intervals indicated are for normal service. For extreme conditions of speed, heat, water, sand, mud, snow, rough roads, dust, etc., lubricate more frequently.

c. Note 3, Recoil fluid.—See paragraph 74.

d. Note 4, Gear cases.—Monthly, check level; if necessary, add lubricant to correct level. Every 6 months, drain, flush, and refill. Gear cases will be flushed when changing grades of oil to clean them of sediment and moisture. In localities where atmospheric temperatures permit the use of the same grade the year round, they will be drained and flushed every 6 months. Follow the procedure below:

(1) Drain used oil and replace drain plug.

(2) Fill case approximately half full with oil, engine, SAE 10, and manipulate the gears rapidly for 5 minutes.

(3) Drain flushing oil, replace plug and fill case to correct level with lubricant specified on Lubrication Guide.

e. Note 5, Hydraulic oil gears.—Remove cap from filter, fill through center hole, using gun provided, until oil escapes from vent at side of filter.

f. Note 6, Helical gear lubricating balls.—Remove cover held on by six stud nuts and fill recess around ball. ***Caution:*** Do not allow moisture, dirt, or grit to enter open mechanism. Add only enough oil to fill ball recess.

g. Note 7, Traversing bearing.—If no fittings are present, remove handhole plate and hand-fill with grease, O. D. (seasonal grade). If traverse action becomes difficult due to extreme cold, apply oil, lubricating, preservative, light or oil, hydraulic, through handhole plate. In all cases, traverse 360° while lubricating.

h. Note 8, Elevating rack.—Daily, clean and apply oil, engine (seasonal grade).

i. Note 9, Breech, firing, and automatic loading mechanisms.—Daily and before and after firing, clean and oil all moving parts and exposed metal surfaces with oil, engine (seasonal grade). ***Caution:*** To insure easy breech operation and to avoid misfiring in cold weather, clean with solvent, dry-cleaning, dry and lubri-

cate with oil, lubricating, preservative, light. To clean firing mechanism, remove and operate pin in solvent, dry-cleaning.

j. Note 10, Traversing driving pinion.—Traverse while lubricating to spread lubricant.

k. Note 11, Azimuth and power shaft adapter gears and bearings.—Some models have ¼-inch plug. Remove plug, insert fitting, lubricate with grease, O. D. (seasonal grade), sparingly and replace plug. ***Caution:*** Do not use upper plug.

l. Note 12, Recoil slides.—Daily and before firing, clean and oil exposed metal surfaces. Keep exposed surfaces covered with thin film of oil, engine (seasonal grade).

m. Note 13, Equilibrator case.—Every 3 months, remove end piece and spring; coat inside with grease, O. D. (seasonal grade).

n. Note 14, Gun bore.—Daily and after firing, clean and coat with oil, engine (seasonal grade).

o. Note 17, Oil can points.—Weekly, lubricate clevises and linkage with oil, engine (seasonal grade).

p. Note 18, Points to be serviced and/or lubricated by ordnance maintenance personnel at time of ordnance inspection.—Hydraulic oil gears, traversing rack and bearing race, hand elevating and traversing gear cases, elevating power adapter gear case, and universal joints on azimuth indicator drive shaft.

■ 74. MAINTENANCE.—*a. Barrel assembly.*—(1) Wear in bore of barrel depends on number of rounds fired, speed of fire, and care given in cleaning and cooling between periods of firing. Accuracy life of a barrel is greatly decreased by rapid firing and the resulting quick heating up.

(2) Change barrel as often as practicable during firing, to cut down overheating, to produce uniform performance, and to increase barrel life.

(3) When possible, barrel should be washed in clean hot water immediately upon removal from gun. For several days after use, barrels should be cleaned and oiled daily until "sweating" ceases. No abrasives of any kind should ever be used in cleaning gun.

(4) When barrel is not to be used for some time, all surfaces should be thoroughly oiled. Surplus oil must be removed before firing.

b. Breech mechanism.—(1) Breech mechanisms should be frequently taken apart and examined to find out if they are in

good working order. Treat parts with care. Rough handling and jerking must be avoided and no unnecessary force employed in removing or installing breechblock.

(2) Upon installation, if breech mechanism fails to operate smoothly or requires greater than usual effort to operate with hand operating lever, it should be disassembled immediately, and cause of malfunction determined and corrected.

(3) Before assembly, special care must be taken to insure that all sand, grit, and other foreign matter is removed from threads of breech ring and from threads at breech end of tube. Failure to observe this precaution may produce badly burred or torn threads.

(4) Breech casing top cover is opened when disassembling barrel assembly. It must not, under any circumstances, be closed until tube is again in position.

(5) Immediately after firing, breechblock and cartridge extractors should be removed, cleaned thoroughly with dry-cleaning solvent, washed, oiled, and reassembled in gun. In very low temperatures, use a low cold-test oil on breech mechanism. Before installing breech mechanism in gun, inspect for scores or deformations on bearing surfaces, and make sure that breechblock bushing screw is secure and flush with front face of breechblock.

c. Automatic feed mechanism.—Keep parts in automatic feed mechanism free from dirt and foreign substance. Keep a thin film of oil on the bearing surfaces. Do not oil feed rollers and feed tray excessively. Oil will accumulate sand and dirt which will result in malfunctions.

d. Recoil mechanism.—(1) Smooth and efficient working of gun in action depends largely on proper adjustment and maintenance of recoil mechanism. It is important that recoil cylinder be correctly filled in accordance with instructions below. If recoil cylinder is not properly filled and if, due to worn or improper packing, there is a loss of liquid, recoil and counter-recoil will not be satisfactory, and gun may be put out of action.

(2) Energy of recoil is absorbed largely by recoil cylinder, a certain amount is taken up by recuperator spring in overcoming friction in slides and in inertia of barrel.

(3) Extreme length of recoil is fixed by distance between recoil cylinder piston and metal at rear end of cylinder, which

forms a seat for packing. This distance is 9.45 inches. Recoil should never reach this limit, however, as this would result in damage to recoil cylinder. If recoil is too short, automatic loader will not function efficiently. Therefore, a length of recoil has been fixed at which gun functions most smoothly and with minimum shock. Length of recoil is from 7.4 to 8.3 inches, the most desirable measurement being 7.87 inches.

(4) Procedure for filling recoil cylinder. A little more than 1 pint of liquid is required to fill recoil cylinder. Steps are performed in the following order:

(*a*) Elevate gun barrel to 25°.

(*b*) Remove filling plug.

(*c*) Unscrew counterrecoil adjusting valve.

(*d*) Using filling funnel, pour in liquid slowly until it overflows from filling hole.

(*e*) Remove funnel and replace filling plug.

(*f*) Elevate and depress slowly a few times, finally bringing gun barrel back to 25° elevation.

(*g*) Again remove filling plug and, using funnel, pour in more liquid until cylinder is again full.

(*h*) Reset counterrecoil adjusting valve by closing it completely and then unscrewing it one-third of a turn.

(*i*) Replace filling plug, being sure that it is tightly secured.

(5) *Recoil fluid.*—(*a*) For all operating temperatures above —20° F., a blend of 60 parts by volume of oil, hydraulic, and 40 parts by volume of oil, recoil, light, will be used. The blend is to be mixed thoroughly before being placed in the recoil cylinders. If in combat proper liquid cannot be secured, light lubricating oil can be used in recoil cylinder or, in extreme emergency, water can be used. Any emergency liquid used must be carefully strained, and all impurities and foreign substances removed. Any substitute liquid should be removed as soon as possible, the recoil mechanism thoroughly cleaned with dry-cleaning solvent and dried, and proper liquid put in cylinder.

(*b*) For all operating temperatures below —20° F., a blend of 50 parts by volume of oil, recoil, special, and 50 parts by volume of oil, recoil, light, will be used. The blend is to be mixed thoroughly before being placed in the recoil cylinders.

(6) Certain examinations of recoil system must be made before firing.

(*a*) Examine cylinder to be sure it is correctly filled and that there is no leakage. If there is leakage, packing glands must be tightened. This tightening must be done carefully. If leakage is serious call ordnance personnel or qualified battery specialists to make necessary repairs.

(*b*) Check to be sure piston rod is properly connected and collar, which bears against sleeve to keep recuperator spring under compression, is screwed home and secured by two setscrews.

(7) Faulty recoil or counterrecoil:

Cause	*Corrective action*
(*a*) Recoil violent or excessive.	
1. Air in recoil cylinder.	*1.* Elevate gun and refill.
2. Insufficient liquid in recoil cylinder.	*2.* Check and fill recoil cylinder.
3. Weak recoil cylinder piston rod.	*3.* Have new recoil cylinder piston rod installed.
4. Incorrect setting of recoil cylinder control spindle valve.	*4.* Close valve a fraction.
5. Weak or broken recuperator spring.	*5.* Have recuperator spring replaced.
(*b*) Recoil short.	
1. Guides or guideways within breech casing dry or burred.	*1.* Remove burs, clean, and lubricate.
2. Recoil cylinder packings too tight.	*2.* Repack.
3. Use of heavy lubricants at low temperatures.	*3.* Use proper lubricants.
4. Incorrect setting of recoil cylinder control spindle valve.	*4.* Open valve a fraction.
(*c*) Counterrecoil slow.	
1. Incorrect setting of recoil cylinder control spindle valve.	*1.* Open valve approximately one-third turn.
2. Burs or grit on guides or guideways within breech casing.	*2.* Remove burs, clean, and lubricate.

Cause	*Corrective action*
3. Use of heavy lubricants at low temperatures.	3. Use proper lubricants.
4. Recoil cylinder packings too tight.	4. Repack.
5. Weak or broken recuperator spring.	5. Have a recuperator spring replaced.
(*d*) Counterrecoil violent.	
1. Insufficient liquid in recoil cylinder.	1. Check and fill recoil cylinder.
2. Air in recoil cylinder.	2. Elevate gun and refill recoil cylinder.
3. Incorrect setting of control rod spindle valve.	3. Close valve a fraction.
(*e*) Failure to counterrecoil.	
1. Recoil cylinder rod spindle valve closed.	1. Open valve approximately one-third turn.
2. Burs or grit on guides or guideways within breech casing.	2. Remove burs, clean, and lubricate.
3. Recoil cylinder packings too tight.	3. Repack.
4. Weak or broken recuperator spring.	4. Have recuperator spring replaced.

■ 75. CARTRIDGE OBSTRUCTION IN AUTOMATIC LOADER.—*a.* Feed rods in automatic loader contain a safety device which prevents breakage of feed pawls in case any obstruction prevents cartridges from moving down onto loading tray.

b. To remove an obstruction, stop and feed pawls should be depressed with pawl depressing tool into recesses in rods to allow removal of cartridges in automatic loader. When obstruction has been removed, another cartridge placed on loading tray by hand, and additional cartridges placed in automatic loader, firing can be resumed. On first recoil, feed holders are automatically coupled with rods as plungers return to normal position.

■ 76. REMOVING CARTRIDGE EXTRACTORS WITH BREECH RING IN GUN.—*a.* Remove breechblock assembly. Insert threaded end of puller in hole in right side of breech casing. Screw it into end

of extractor spindle. Then with extractors in rear position and spindle arm on breech ring in forward position, pull out extractor spindle. When spindle is removed, extractors will fall out. (Extractor spindle arm cannot be removed without taking breech ring out of breech casing.)

b. Assemble extractors into position in breech ring with hook sides down. Put extractors in rearward position and extractor spindle arm forward. Insert spindle by pushing it all the way into position with puller. Remove puller.

SECTION III

40-MM CARRIAGE M2

■ 77. LUBRICATION.—*a. Cleaning.*—Bearing surfaces, revolving parts, springs, screw threads, gear teeth, and exterior parts must be cleaned and free from dirt at all times. Special attention should be given to exposed teeth and bearing surfaces. All lubricating fittings should be kept clean and oil and grease passages free from dirt and accumulated hardened grease. A piece of wire may be used to clean out these passages.

b. Lubricants.—Additional lubrication and service instructions applicable to individual units and parts shown in figure 29 are as follows:

(1) *Note 1, Fittings.*—Clean before applying lubricant. Where bearings can be seen, lubricate until new lubricant is forced from the bearing. ***Caution:*** Lubricate after washing gun and carriage. Do not use high pressure washing system for cleaning artillery matériel.

(2) *Note 2, Intervals.*—Intervals indicated are for normal service. For extreme conditions of speed, heat, water, sand, mud, snow, rough roads, dust, etc., lubricate more frequently.

(3) *Note 15, Wheel bearings.*—To clean and pack wheel bearings properly, they must be removed from the hub. Follow the procedure below:

(*a*) Remove bearings from hub and wash in solvent, dry-cleaning, until all the old lubricant is removed from both inside and outside of cage.

(*b*) Lay bearings aside to dry and wash inside of hub and spindle with solvent, dry-cleaning.

(*c*) When bearings are thoroughly dry, coat lightly with oil, engine (seasonal grade), and pack races with grease, general

CARRIAGE, GUN, 40-mm, M1 and M2 (AA)

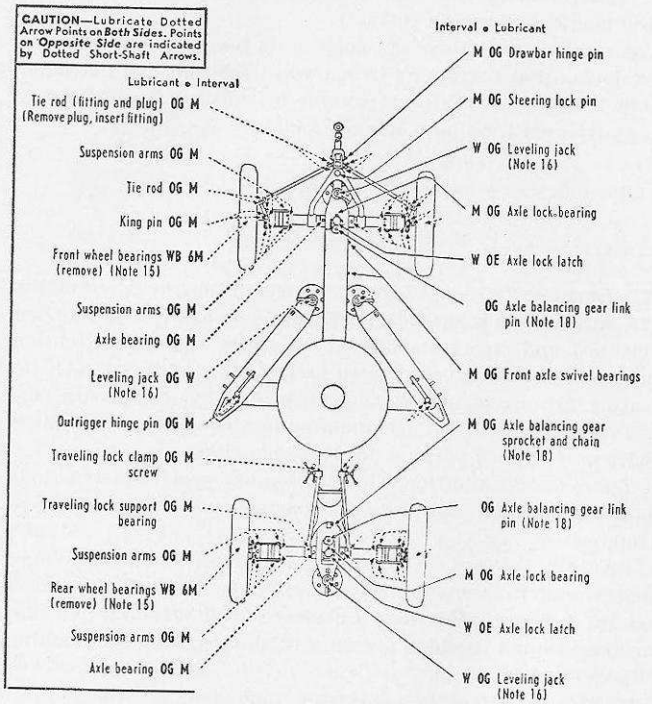


FIGURE 29.—Lubrication chart, 40-mm gun carriage M2.

purpose, No. 2, and reassemble in hub. To pack a bearing satisfactorily, it is necessary to knead lubricant by hand into space

between the cage and inner race. Coat inside of hub and spindle with a thin coat of grease to prevent rusting. The lubricant packed in bearing races is sufficient to provide lubrication until the next service period. An excess may result in leakage of lubricant into the brake drum.

(*d*) Replace wheel and adjust bearings according to instructions in TM 9–252.

(4) *Note 16, Leveling jacks.*—Weekly, coat cylinders with oil, engine (seasonal grade).

(5) *Note 17, Oilcan points.*—Weekly, lubricate drawbar traveling lock, brake levers, inner tie rod ends with oil, engine (seasonal grade).

(6) *Note 18, Points to be lubricated by ordnance maintenance personnel at time of ordnance inspection.*—Front and rear axle balancing gear spring rod thrust bearings front and rear axle balancing gear link pins, and rear axle balancing gear sprocket bearings and chain.

SECTION IV

DIRECTOR M5

78. INSTRUCTIONS FOR CARE IN HANDLING.—*a*. Never lift director without using carrying bars provided.

b. Set tripod legs firmly in ground to insure that once director is placed on tripod and level it will remain in a level position.

c. When placing director on tripod, lower it carefully into position. Do not drop it, because to do so might damage director mechanisms or threads on leveling screws.

d. Turn off all electrical switches when inserting or removing cable plug from receptacle in bottom of director.

e. Do not slew director by pushing on case; use azimuth throw-out lever and slewing handle. Grip lever tightly so as to fully disengage clutch teeth. Use moderate slewing speeds. Slewing director too fast will cause director to get out of synchronization with gun which necessitates reorientation.

f. Never attempt to tighten or loosen the orienting nut (large knurled knob) unless locking nut (small knurled nut) is tight, and never attempt to traverse or slew director while both locking nut and orienting nut are tight. Failure to observe this precaution will result in serious damage to future azimuth mechanism.

g. Never reverse rates with a quick turn of the handwheel. Such procedure may result in breaking the torque amplifier bands.

■ 79. CLEANING.—*a. External surfaces.*—(1) Remove dust from metal surfaces of director with a soft, dry cloth.

(2) Wipe metal surfaces with a soft, dry cloth as soon as possible after being exposed to rain.

(3) When cleaning windows of director, care must be exercised to eliminate possibility of scratching them.

(4) Remove rubber eyeshields occasionally and wash them in warm water.

b. Telescope lenses.—(1) Special care must be exercised to keep exposed sides of lenses clean and dry. Dust and moisture will pit and discolor surfaces if permitted to remain on them.

(2) Remove dust from lenses by brushing lightly with a camel's-hair brush. Use of cleaning cloth is prohibited.

(3) Remove grease or oil by applying liquid lens-cleaning soap or alcohol sparingly and wiping dry with lens tissue paper. If liquid lens-cleaning soap or alcohol is not available, breathe heavily on lens and wipe dry as directed above. Repeat the procedure until lens is clean.

(4) Do not wipe lenses with fingers.

c. External lubrication.—Apply a few drops of oil to handwheel knob pins to keep knobs working freely. Occasionally oil leveling screws in tripod head to insure smooth and easy movement of screws.

d. Internal lubrication.—(To be done only by ordnance or qualified battery personnel.) Internal lubrication of M5 director will only be done periodically or when deemed necessary. (See fig. 30.)

(1) Rate motor governor ball bearing. Maintain a light film.

(2) Torque amplifier input drum spindle bearings and input shaft bearing. Maintain a light film.

(3) Differentials. Several drops.

(4) Multiplying and variable speed mechanism rails. Several drops.

(5) Variable speed mechanism slide. Several drops.

(6) Use only grease, lubricating special at the following points:

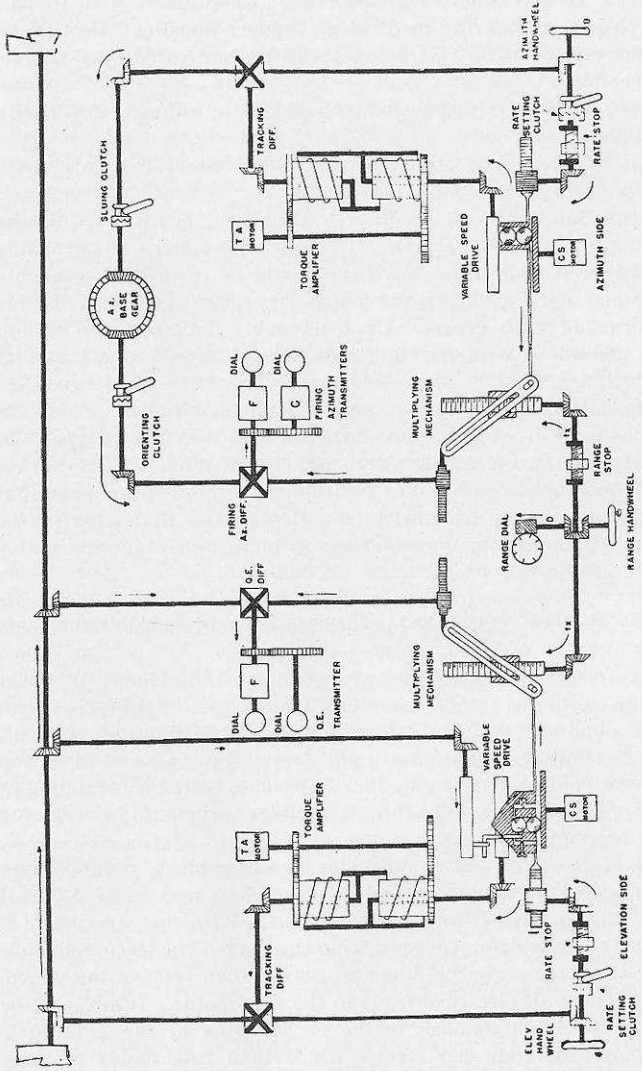


FIGURE 30.—M5 director—schematic diagram.

(*a*) Torque amplifier grease cups. Keep full.

(*b*) Large bearing in director support housing. Use grease gun periodically. This bearing can be lubricated only on disassembly.

(*c*) Variable speed mechanism disks and rollers. Cover with a light film.

(*d*) Multiplying mechanism time screw and nut. Cover with a light film.

(*e*) Ball bearings. Ordinarily these bearings will require no attention while in service. If grease shows signs of hardening or other deterioration, bearings should be removed, thoroughly cleaned with a dry-cleaning solvent, dried, and immediately lubricated with grease. Upon assembly, ball bearings should be lubricated with a thin film of grease unless otherwise instructed, primarily to prevent corrosion of the metal surfaces. Application of too much grease should be avoided. Excessive greasing will clog the ball bearings and may retard speed of shafts and cause complete stoppage in cold climates. Note that ball bearings in rate motor governor and torque amplifier input shaft and spindle are lubricated with oil rather than with grease.

(*f*) Upon assembly, seal the top plate and four side plates with grease.

■ 80. PARTS REPLACEMENT.—Disassembly and assembly for parts contained in accessory chest.

a. Torque amplifier.—Remove top cover. Disconnect electrical leads to torque amplifier motor. Loosen small set screw on input coupling. Slide back, breaking contact with output cylinder. Rotate output coupling until slot is vertical. Loosen three cap screws holding torque amplifier to base and lift torque amplifier out of the director. The torque amplifier is replaced by reversing the procedure.

b. Rate motor.—If the director has fuse block, remove three cap screws holding same and the fuse block may be held out of the way by tying it to the front tie bar. With the governor at a two o'clock position (as seen from the rear of the motor) remove the two cap screws holding the guard; then remove the guard. Disconnect all electrical leads to the rate motor. (Care must be taken to avoid damage to the carbon ring of the governor.) Remove the four cap screws which hold rate motor to base.

Remove rate motor. To reassemble, reverse procedure. (See fig. 31.)

c. Range scales.—Remove three screws holding the range scale. Remove range scale, and replace.

d. Selsyn motors.—One transmitter can be removed without removing the entire holding bracket by first removing necessary parts of gear train in the individual case under consideration; then disconnect electrical connections and shift out of holding bracket.

SECTION V

REMOTE CONTROL SYSTEM M5

■ 81. CARE IN HANDLING CABLES AND COMPONENT PARTS.—*a.* No cable of the size used with this system will withstand repeated kinking or twisting. Avoid bending cables on a short radius or allowing them to chafe against a moving object.

b. Do not allow vehicles to run over unprotected cables.

c. Keep plugs and receptacles clean; accumulated dirt will cause faulty connections.

d. When the cables are not connected, all plugs must be kept closed with covers provided to exclude dirt and moisture. D-shaped plugs of director cable are furnished with leather covers that should be pulled over plugs when plugs are not connected.

e. When disconnecting a cable, pull on body of plug, never on cable or spring. D-shaped plugs have to be turned to unlock them before they can be disconnected.

f. If it becomes necessary to tape ends of any flexible cables, use rubber tape only.

g. Oil and grease are detrimental to rubber; keep cables free of these materials. If oil or grease does get on cable, wipe off oil or grease, and wash with soapy water the place which has been exposed.

h. When cables are not plugged in, protect cable receptacles in gun junction box by means of covers provided for that purpose.

■ 82. LUBRICATION.—*a. Oil gears.*—(1) Cleanliness is important in handling oil for oil gears. When replenishing oil supply of oil gears, oil must be taken from a container whose seal is not broken. Dust or moisture must not be allowed to get into oil

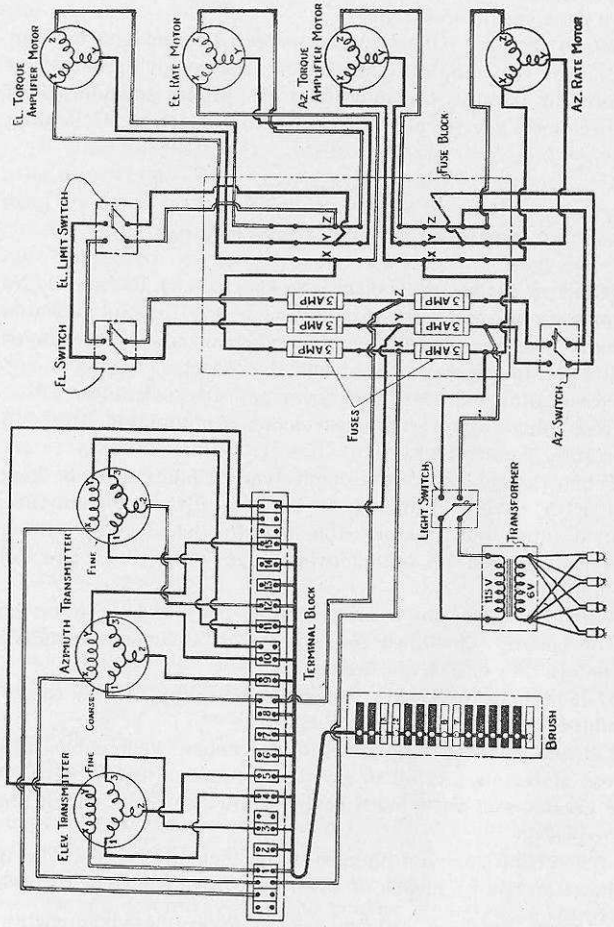


FIGURE 31.—M5 director—wiring diagram.

while refilling, and remaining oil in container should be used for some other purpose or thrown away. Oil gun must be kept clean and should be used only for hydraulic oil. ***Caution:*** Oil gear units, when filled with oil, must always be kept upright; otherwise oil will get into electrical control elements and cause damage. If, through accident, oil does get into electrical control compartment, remove covers from compartment, and wipe up any excess oil.

(2) If system is in frequent use, oil should be changed every 6 months. To change oil, drain used oil through drain plug under filter assembly; replace drain plug, tighten plug securely, and then add new oil through filter until oil flows from overflow hole in side of filter. Use only oil, hydraulic (U. S. Army Specification 2–79A). If dirt is suspected to be in oil system, unit should be removed and cleaned thoroughly.

(3) The filter contains a filter bobbin assembly which may require replacement after several oil changes. To replace filter bobbin assembly, unscrew retainer at top of filter opening, using spanner provided; lift out old filter, and install a new one.

(4) Drain oil from chain case daily and from clutch housing weekly. The chain requires lubrication with grease, graphite, medium, at 6-month intervals.

(5) Transmitter spiral gear is lubricated by a cork lubricating ball located in a recess under driving pinion. This recess should be filled with oil hydraulic, at frequent intervals. The cover over the spiral gear must be removed to permit lubrication. Left-over oil may be used. When lubricating spiral gear, note condition of cork ball. Ball must be replaced as soon as it shows signs of becoming soft and oil-soaked.

b. Azimuth indicator.—(1) The azimuth indicator (blackout dial) has an oil cup, fitted with a felt pad, located in top of housing.

(2) Several drops of oil, lubricating (U. S. Army Specification 2–27E) should be applied yearly to these oil cups. Oil very sparingly, as excess oil will damage the repeater.

■ 83. REPAIR AND REPLACEMENT.—*a. Wiring diagram.*—When checking wiring connections after repair and replacement or when searching for bad or wrong connections use the wiring diagram (figure 32).

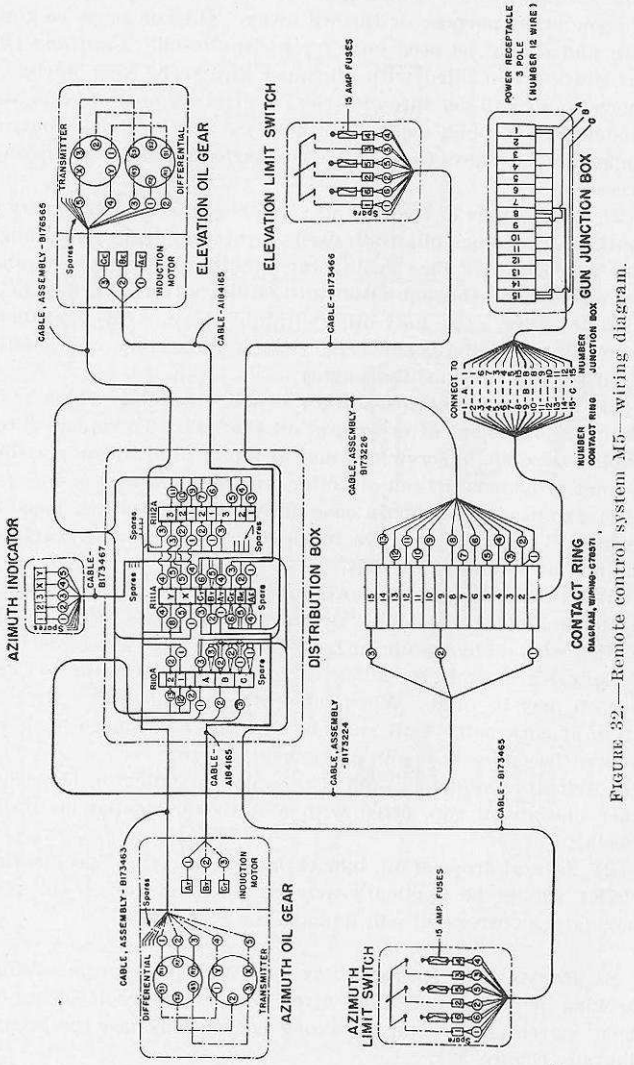


FIGURE 32.—Remote control system M5—wiring diagram.

b. Malfunctions.—(1) If induction motor in either oil gear does not run when power is applied, the trouble may be due to blown fuses in elevation limit switch or azimuth switch. (The fuse used is rated 15 amperes and 250 volts.) Shut off power before attempting to replace fuses. Close cover tightly after fuses have been replaced.

(2) If gun tracks irregularly, it is probable that the supply of hydraulic oil is getting low. Remedy this malfunction by replenishing oil supply. Fill unit through oil filter and from new cans of approved oil. (U. S. Army Specification 2–79A). Fill until oil flows out through small pilot hole in filter body. Screw filter cover on tightly after filling.

(3) If system still fails to operate properly, the cause may be either a fault in electrical connections or a malfunction of mechanical parts of oil gear. Qualified personnel must be called to remedy this condition.

c. Replacing oil gears.—To perform unit replacement of oil gears in case of failure of a unit, proper facilities must be available to prevent entrance of dust into the interior when cover plates are removed. Proceed as follows:

(1) Disconnect three leads to electric motor by removing terminal well cover plate on top of motor and loosening the three terminal screws. Note the lead markings, black for 60 cycles and red for 50 cycles (mark the leads if there are no lead markings) to insure that leads can be reconnected to their corresponding terminals. Remove four screws securing cable adapter to motor housing and withdraw wires from terminal well.

(2) Remove terminal side cover over transmitter and electrical differential assembly, exposing terminal screws. This cover is on the same side as the clutch lever. Disconnect three leads (R_1, R_2, R_3) from differential and two leads (X, Y) from resetter transmitter by loosening the terminal screws. Do not disconnect interconnecting leads (S_1, S_2, S_3, and 1, 2, 3). Note lead markings (mark leads if there are no lead markings) to insure that leads can be reconnected to their corresponding terminals. Remove three screws securing cable adapter to housing and withdraw wires.

NOTE.—Interchanging two wires will result in gun moving in opposite direction from that of director.

(3) Remove four bolts securing oil gear to carriage, and single bolt at the rear of electric motor. Remove oil gear by pulling it

forward from front of carriage, being careful not to damage drive shaft or coupling mechanism.

(4) Note that in replacing a unit, a distinction must be made between azimuth oil gear and elevation oil gear. Although both units are similar in outward appearance, they cannot be interchanged, except by performing process as outlined below, as their gearing ratios are different. The azimuth unit has a 64-tooth spiral gear, on the resetter transmitter, while elevation unit has a 108-tooth spiral gear. Also, the pinion which meshes with these gears is differently positioned in the two units. In absence of accurate name plate data, unit can be positively identified by removing adjusting side cover (this cover is on same side as filter cap) and counting teeth on resetter transmitter spiral gear.

(5) To mount replacement oil gear, reverse foregoing process.

(6) After replacing elevation oil gear, it will be necessary to reorient gun in elevation.

d. Changing elevation oil gear to azimuth oil gear. (1) Data:

Type of unit	Spiral pinion	Spiral gear	Gear ratio
Elevation	21 teeth	108 teeth	5.14 to 1.
Azimuth	16 teeth	64 teeth	4 to 1.

(2) One spare elevation oil gear is furnished with every two gun carriages. A package of spare parts consisting of a spiral gear, a taper pin, and a sleeve, to be used on converting elevation unit to an azimuth unit is also furnished.

(3) In order to convert an elevation oil gear to an azimuth unit, remove right-hand side cover plate. The three screws clamping the spiral gear between toothed disk and adapter on gear assembly must be withdrawn and disk and gear removed.

(4) The taper pin securing double pinion (left pinion for elevation and right pinion for azimuth) on transmitter shaft assembly must be driven out, pinion slid over to left side of shaft, and pinion secured in place by inserting taper pin into hole provided.

(5) Mount spare spiral gear (64 teeth), replace disk, and sesure gear and disk to adapter by means of three screws that

were withdrawn. Take care to mesh gear with right-hand pinion.

(6) Check backlash between gear and pinion. Excessive backlash will result in erratic orientation of gun and director. For adjustment see paragraph 130. Replace cover plate, taking care to insert gasket.

(7) Remove the four nuts and studs holding the rear bell housing. In order to remove the studs with the nuts, mutilate threads on ends of studs so that nuts will not screw completely off. The studs will come out upon exerting pressure on nuts. After removing nuts with studs, rotate bell housing 180° and secure in place. Do not under any circumstances pull bell housing off motor. If this is done the rear motor bearings will fall out and replacement of bearing necessitates use of a special tool which is not issued to the using arm. The bell housing is rotated to enable fastening the upper portion of the oil gear unit to carriage. (Bell housings which are equipped with two brackets need not be rotated.)

(8) Interchange pipe plug and grease fitting in clutch housing cover and secure each in place.

(9) Remove cotter pin on shaft pin which supports clutch lever locking lever, drive out shaft pin and remove locking lever. Insert spare sleeve, drive shaft pin back in place and secure it by means of cotton pin.

(10) An azimuth unit can be converted to an elevation by reversing above replacements and assemblies.

(11) When spare elevation oil gear is changed over into an azimuth oil gear and replaces the azimuth unit on gun, be sure to switch name plates. After having done this, then change azimuth unit, which has just been removed from gun into an elevation oil gear. Name plates will then be correct.

SECTION VI

REMOTE CONTROL SYSTEM M10

■ 84. GENERAL.—Field operation and maintenance requires the removal of no cover that exposes any part of the hydraulic system. No dither adjustment, pilot valve adjustment, creep test, or adjustments of elevation resetter transmitter (for ele-

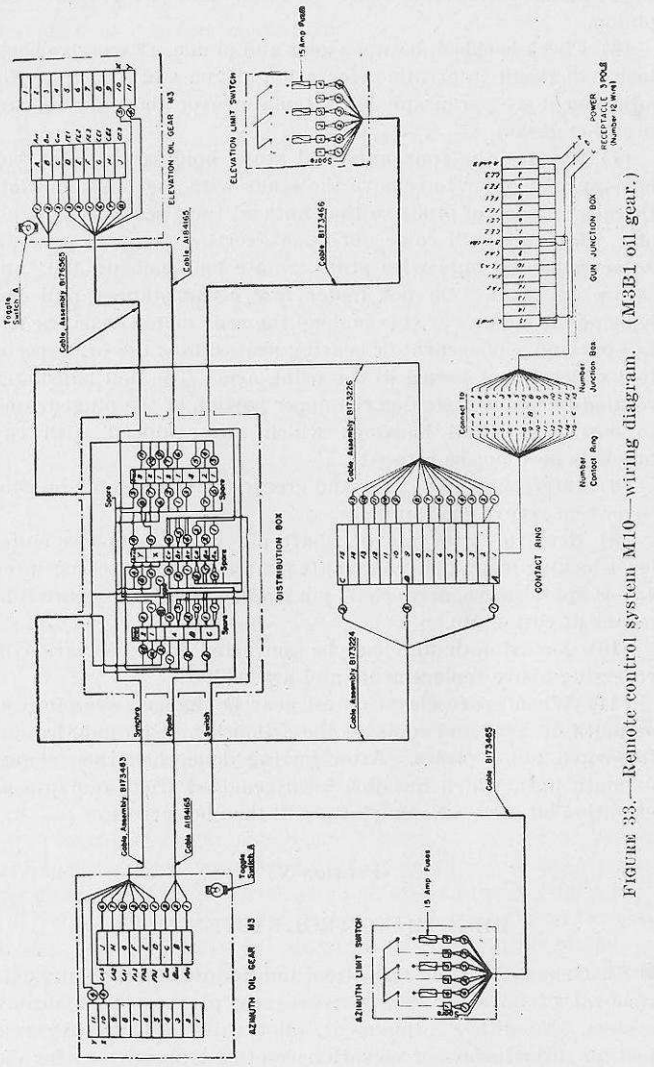


FIGURE 33.—Remote control system M10—wiring diagram. (M3B1 oil gear.)

vation orientation as required in M1 oil gear units) can be made by using personnel. Dither is set at the optimum value, and together with the pilot valve is preset by the manufacturer and

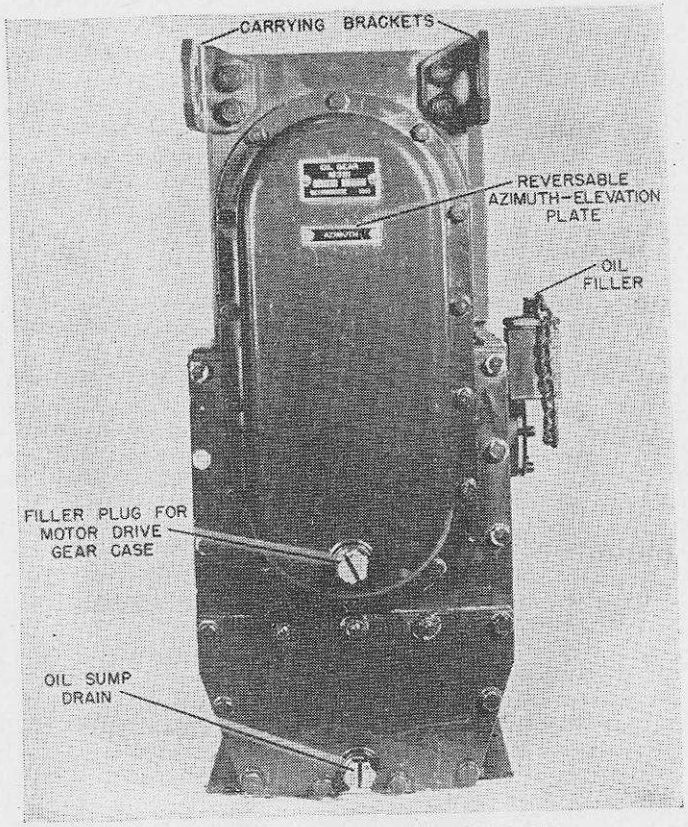


FIGURE 34.—Oil gear unit M3B1—front view.

neither permits of field adjustment. Figure 33 shows the wiring diagram for the remote control system M10.

a. Lubrication.—(1) *Hydraulic transmission.*—Lubrication of the hydraulic portion of the oil gear is unnecessary if the sump case is kept filled with clean Univis 48 oil or equivalent (fig. 34).

(Univis 40, 47, 54 in temperate climates, and SAE 10 and kerosene mixed for extremely cold temperatures.) The oil gears comprise precision apparatus. It is important that the oil gear

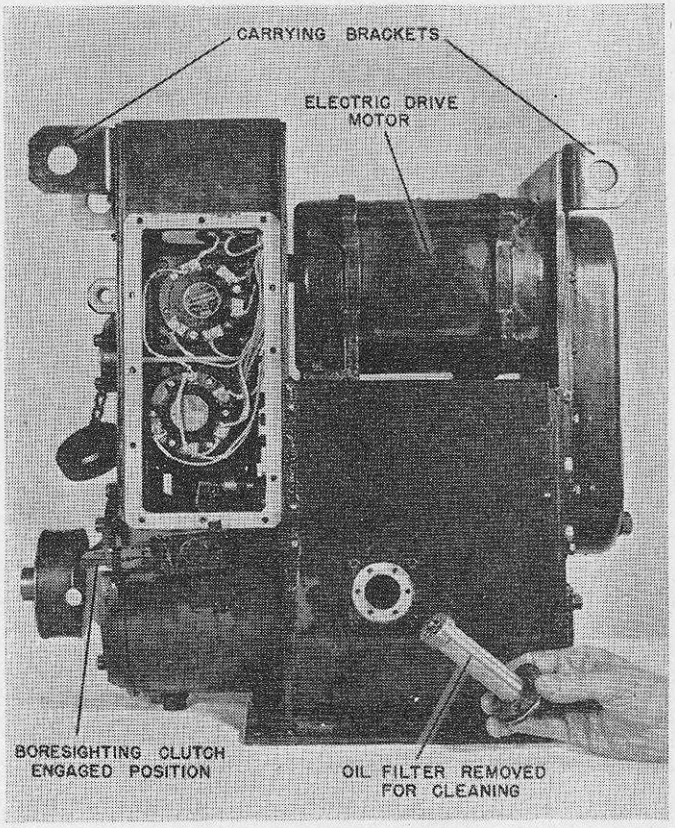


FIGURE 35.—Oil gear unit M3B1—right side view.

be operated only after the oil level has been checked. The level should be approximately midway between the limits of the window on the sight gage (fig. 44). The hydraulic transmission system is completely sealed and requires no adjustment or

maintenance by using personnel other than filling the oil sump. (No oil gun is required to fill or replenish oil.) Sump capacity, 2½ gallons.

(2) *Gear train and clutches* (see fig. 35).—Remove side plate covers and grease the gear train and clutch mechanism in the synchro and output gear housing with a Norma Hoffman #51 or #66 grease, or equivalent every month. Any oil leakage from the hydraulic portion of the control into the selsyn housing should be drained monthly by removing the drain plug (fig. 35).

(3) *Output bearing.*—Grease the output bearing with Norma Hoffman #51 or #66 grease or equivalent every few months (fig. 44).

(4) *Input gearing.*—Lubricate the gear train between the electric motor and the hydraulic pump by keeping the electric motor gear case full to the drain plug level with SAE 50 motor oil (fig. 35).

b. Cleaning the filter (see fig. 36).—(1) The filter inserted in the oil line to the stroke control should periodically be removed and cleaned. This cleaning can be accomplished without draining the oil merely by removing the six screws at the end of the filter housing and withdrawing the filter cartridge, being careful not to injure the gasket. The filter cartridge is accessible from the right side of the unit. A small quantity of oil may be lost from the filter housing, but it will be replaced by the gear pump when the control is again started.

(2) The filter cartridge is metallic and should be washed free of dirt, lint, and other foreign particles, using solvent dry-cleaning or gasoline and allowed to dry before inserting. The screws should be kept tight and the gasket free from damage to prevent leakage of oil at the replenishing pressure. Any time that a large amount of oil is added to the sump, the filter cartridge must be cleaned after 5 minutes of operation to remove the lint inherent in new oil.

(3) *The symptoms of a clogged filter are absence of snappiness in the action of the control, sluggishness during synchronization and low oil pressure.* The oil pressure should be approximately 150 lbs./sq. in. and can be checked by inserting a pressure gage in place of the pipe plug in the filter cap.

SECTION VII

UNIT, GENERATING, M5

■ 85. CARE AND PRECAUTIONS.—*a.* The M5 power plant should be kept clean and adequately supplied with water, lubricating oil, and gasoline at all times.

b. Be sure that antifreeze is added to water supply when operating in cold climates and that proper grade of oil is used for the temperature under which the unit is operating.

c. Always keep main switch in "off" position when connecting or disconnecting power cable, and before starting engine.

d. If unit is used in any inclosure, be sure that exhaust is piped to outside. Exhaust contains carbon monoxide which is odorless and very deadly.

e. Periodically check to see that all electrical connections and leads are in good order and that electrical indicators and controls are functioning properly. When not in use, keep the receptacle cover screwed to outlet receptacle.

f. Do not pour gasoline into fuel tank while engine is running or while ignition switch is turned on.

g. Operate unit at 130 volts and 60 cycles. Never let the voltage get below 115.

■ 86. LUBRICATION.—The M5 power plant should not be lubricated excessively and frequency of oiling should be based on the number of hours of operation. Use only specified oils and lubricants.

Part	Frequency	Lubricant	Quantity and application
A-c generator	200 hours operation	Grease, lubricating special (Grease special low-temperature).	One turn of grease cup cap each bearing. Keep grease cup filled.
Water pump	200 hours operation	Grease, water pump, hard.	One turn of grease cup cap. Keep grease cup filled.

Part	Frequency	Lubricant	Quantity and application
Crankcase	50 hours operation	Oil, engine	Drain and refill through breather tube as required to maintain level at least three-fourths full on bayonet gage; capacity 4 quarts.
Fan	50 hours operation	Oil, engine	Remove plug in hub. Fill until oil drips from shaft.
Starter	50 hours operation	Oil, engine	Few drops in oil hole.
Battery charging generator.	50 hours operation	Oil, engine	8 to 10 drops in oil cup at each end.
Oil filter	150 hours operation if oil becomes dirty.	Oil, engine	Renew refill cartridge.
Distributor	150 hours operation; oftener if necessary.	Oil, engine	Few drops in oiler.
Breaker	50 hours	Grease, water pump, hard.	Wipe breaker cam lightly with grease.
	50 hours	Oil, engine	One drop on breaker cam pivot pin.
Air filter	Once a day in dusty conditions to once a week where little dust is encountered.	Oil, engine	Remove oil cup; empty and refill with fresh oil.
Governor linkage.	Occasionally	Oil, engine	Few drops on joints
Commutators and slip rings.	Do not lubricate under any circumstances.		

■ 87. CRANKCASE.—*a.* SAE 30 engine oil should be used for temperatures of 32° F. and over.

b. Use SAE 10 engine oil for temperatures between 32° F. (freezing point) above zero and 0° F.

c. When temperature is below 0° F., the following procedure should be followed using SAE 10 engine oil:

(1) With oil level at full mark, add 1 quart of solvent, dry-cleaning, or gasoline.

(2) Run engine 5 to 10 minutes to mix oil and dilute thoroughly and stop engine.

(3) After stopping, notice level of crankcase oil on oil gage stick. Level will be above normal "full" mark. Mark this increased level on gage for future reference.

■ 88. PROCEDURE FOR SUBZERO TEMPERATURES.—The following procedure should be used when operating power plant at subzero temperatures:

a. At end of each operating period, check oil level.

b. If oil level is below normal "full" mark, add necessary quantity of SAE 10 engine oil to bring level to full mark. Then add the necessary quantity of dry-cleaning solvent or gasoline to raise the level to the mark recorded in paragraph 87 *c*(3).

c. Oil pressure should be noted immediately after each start. If none is indicated, engine must be shut down immediately to determine the cause.

d. The generator must be run at least 30 minutes every time it is operated. The radiator should be covered to give rapid warm-up and the cover removed as soon as operating temperature is reached. After engine is stopped, the cover should be replaced to keep engine temperature as high as possible during shut-down period.

e. If engine is hard to start due to cold weather, then the spark plug gap could be reduced from 0.025 inch to 0.015 inch, or any intermediate point between the two limits.

f. If difficulty is experienced with water in the gasoline, causing freezing in tank or in lines, add ¼ pint of pure wood alcohol (not Prestone) to each 5 gallons of gasoline. This will absorb the water and allow the engine to run smoothly.

g. At temperatures below +32° F., add Ethylene Glycol to the cooling system to prevent freezing.

■ 89. TROUBLE SHOOTING, GENERATOR.

Malfunctions	*Causes*
a. Arcing at brushes of exciter generator.	(1) Dirty commutator. (2) Worn-out brushes. (3) Brushes stuck in holders.
b. Fails to generate rated current.	(1) Unbalanced load in lines. (2) Defective wiring.

Malfunctions	*Causes*
	(3) Links in subpanel connected incorrectly. (4) Rheostat incorrectly adjusted. (5) Worn brushes or dirty commutator in exciter.
c. Fails to operate at proper frequency.	(1) Links in subpanel connected incorrectly. (2) Defective wiring. (3) Engine not set at correct speed.
d. Fails to deliver rated output.	(1) Links in subpanel connected incorrectly. (2) Defective wiring. (3) Fuses out. (4) Rheostat incorrectly adjusted. (5) Engine not up to speed. (6) Dirty commutator and worn brushes in exciter.

■ 90. TROUBLE SHOOTING, ENGINE.

Malfunctions	*Causes*
a. Starter will not turn over the engine.	(1) Low battery. (2) Defective starter motor. (3) Loose or defective wiring. (4) Broken Bendix spring.
b. Engine fails to start or is hard to start, runs and stops.	
(1) Fuel system.	(*a*) No gasoline or clogged gas line. (*b*) Improper fuel mixture. (*c*) Throttle valve stuck, loose or out of adjustment.

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Malfunctions	*Causes*
(2) Ignition system.	(*a*) Loose or defective wiring.
	(*b*) Breaker points out of adjustment, worn, or pitted.
Very rare	(*c*) Defective coil or condenser.
Very rare	(*d*) Magnet weak.
	(*e*) Spark plug cracked or dirty.
(3) Mechanical failure.	(*a*) Intake manifold leaking.
	(*b*) Valve seats bad.
	(*c*) Valve sticking.
c. Engine misses.	
(1) Ignition system.	(*a*) Spark plug dirty or cracked.
	(*b*) Spark plug gap wrong.
	(*c*) Loose or defective wiring.
	(*d*) Breaker points sticking, pitted, or worn.
(2) Mechanical failure.	(*a*) Head or manifold gaskets leaking.
	(*b*) Valves warped or broken.
	(*c*) Valves or tappets sticking.
	(*d*) Valve tappets improperly adjusted.
d. Runs but lacks power.	
(1) Fuel system.	(*a*) Improper gas mixture.
	(*b*) Governor or throttle loose.
	(*c*) Air cleaner needs cleaning.
	(*d*) Oil too thin.

Malfunctions	*Causes*
(2) Mechanical failure.	(*a*) Valve seats worn.
	(*b*) Piston rings weak, worn, or sticking.
	(*c*) Improper timing.
	(*d*) Muffler clogged.
e. Overheats.	
(1) Fuel system.	(*a*) Carburetor choke valve partly closed.
	(*b*) Improper gas mixture.
(2) Ignition system.	(*a*) Spark retarded too far.
	(*b*) Improper timing.
(3) Lubrication system.	Lack of oil or oil too thin.
(4) Valves leaking.	
(5) Overload on generator.	
(6) Cooling system.	(*a*) Radiator clogged, leaks.
	(*b*) Water low.
	(*c*) Water pump clogged or broken.
f. Faulty carburetion.	
(1) Fuel system.	(*a*) Carburetor improperly adjusted.
	(*b*) Using too much fuel.
	(*c*) Water in fuel.
	(*d*) Sediment in fuel tank.
	(*e*) Shut-off valve closed.
(2) Mechanical failure.	(*a*) Valve leaking.
	(*b*) Intake manifold leaking.
	(*c*) Gaskets leaking.
g. Poor compression.	
(1) Ignition system.	Loose or cracked spark plug.
(2) Lubrication system.	Oil too thin to seal piston.
(3) Mechanical failure.	(*a*) Valves sticking or not seating.
	(*b*) Valve tappets sticking or set too close.
	(*c*) Piston rings worn, weak, broken, or sticking.

Malfunctions	*Causes*
	(*d*) Cylinder head loose.
	(*e*) Head gasket leaking.
	(*f*) Scored cylinder.
	(*g*) Worn piston and cylinder.
h. Explosion in carburetor or intake manifold.	
(1) Fuel system.	Gas mixture too lean.
(2) Mechanical failure.	(*a*) Intake valve sticking, warped, or broken.
	(*b*) Intake tappet sticking or set too close.
	(*c*) Intake valve spring weak.
	(*d*) Intake manifold leaking.
	(*e*) Incorrect timing.
	(*f*) Cylinder head gasket leaking.
i. Explosion in muffler.	
(1) Ignition system.	Ignition too late or weak spark.
(2) Mechanical failure.	Exhaust valve holding open or warped.
j. Excessive smoke from exhaust.	
(1) Lubrication system.	(*a*) Too much oil in crankcase.
	(*b*) Oil too thin.
(2) Fuel system.	(*a*) Carburetor needle valve open too far.
	(*b*) Carburtor float sticking or leaking.
(3) Worn bearings.	
k. Low or high oil pressure.	(1) Oil too heavy or too light for climatic conditions.
	(2) Clogged oil lines or bad oil pump.

Malfunctions	*Causes*
	(3) Worn bearing and piston ring.
l. Operating knocks.	
(1) Motor overheated.	(*a*) Radiator clogged.
	(*b*) Water pump not operating satisfactorily.
	(*c*) Loose or broken fan belt.
	(*d*) Lack of oil.
(2) Mechanical failure.	(*a*) Carbon in cylinder.
	(*b*) Loose main bearing or rod bearing.
	(*c*) Worn piston or cylinder (piston slap).
	(*d*) Loose valve tappets.
	(*e*) Tight piston.
	(*f*) Loose flywheel.
m. Overheating.	
(1) Cooling system.	(*a*) Leak or low in water.
	(*b*) Clogged radiator.
	(*c*) Broken water pump.
	(*d*) Slipping or broken fan belt.
	(*e*) Bent fan blades.

SECTION VIII

AMMUNITION

■ 91. GENERAL.—Moisture and extremes of temperature are detrimental to ammunition. Therefore, ammunition must be kept dry and under cover from direct rays of the sun at all times.

■ 92. 40–MM AMMUNITION.—*a. Identification by marking.*—When ammunition is manufactured, an ammunition lot number is stamped on each round. Therefore to obtain the greatest accuracy in any firing, use rounds from the same ammunition lot, whenever practicable.

b. Painting and marking.—Projectiles are painted to prevent rust. Various colored paints are used for the purpose of identi-

fication as to type. The projectiles of the types of ammunition listed below are painted as follows:

(1) High explosive—yellow, the markings in black.

(2) Armor-piercing (not explosive)—black, the markings in white.

(3) Drill or dummy (inert)—black, the markings in white.

c. High explosive shell.—A complete round (HE) is designed for use against lightly protected targets, such as aircraft. It consists of a primer and a propelling charge contained in the brass cartridge case, which is crimped tightly to projectile. Tracer and igniter which is fitted to base of projectile, is known as a shell-destroying or self-destroying tracer, because it is so arranged that should projectile fail to hit target and explode, tracer, upon burning through, will destroy shell by causing its explosion. Tracer burns for approximately 7 seconds or for about 3,500 yards. The round is 17.65 inches long and weighs 4.67 pounds.

d. Armor-piercing shell.—Projectile does not contain a fuze or high explosive. It has a tracer in base.

e. Fuzes.—The fuze is of inertia type designed to explode upon impact with a target of very light weight. It is boresafe. ***Caution:*** Fuzes will not be tampered with or disassembled. They are very sensitive.

f. Ammunition checks.—(1) *40-mm ammunition.*—(*a*) Check to see that all rounds are properly loaded in clips, and that they are clean, free from nicks and burs, and not corroded.

(*b*) Inspect nose of fuze to insure that it is not damaged or perforated.

(*c*) Inspect primer to insure that it is flush with the base of the cartridge. It must not protrude.

(2) *Caliber .50 ammunition.*—(*a*) Inspect belts for short rounds, corroded or split cases, or thin rims.

(*b*) See that belt feeds into gun with double end of links feeding first.

Section IX

COMPUTING SIGHT M7

■ 93. General Precautions.—Disassembly and assembly is permitted only to the extent specifically authorized herein. The turning of screws or other parts not incident to boresighting,

alinement of telescopes, or to the use of the system is expressly forbidden except for qualified personnel.

■ 94. Lubrication.—*a.* Ball bearings, gear drives, covered joints, and the flexible shaft are lubricated at assembly. Further lubrication of these will be required only at long intervals, and is performed by ordnance personnel.

b. Telescope yoke surfaces, the telescoping rod to the azimuth telescope yoke and link clevis pins should be frequently oiled with oil, lubricating, for aircraft instruments and machine guns.

c. Keep the outside of the flexible shaft casing free of oil.

d. Lighting devices.—Remove the flashlight battery cells whenever the lighting devices are not in use for several days. Chemical reaction set up in the cells as they become exhausted will cause the cells to swell, thereby making removal difficult and damaging the battery tube.

■ 95. Maintenance.—*a.* To replace the dry cells, grasp the cap at the forward end of the lighting device and pull it forward, removing the tube containing the dry cells from the cylindrical sleeve on the arm. Unscrew the tube and replace the dry cells, placing both cells with their central terminals toward the cap. Use two standard flashlight battery cells. Screw the tube into the cap and replace it in the sleeve on the arm.

b. To replace a lamp, remove the plug on the flexible cord from the lamp socket, then unscrew the socket, rendering the lamp accessible. Replace the lamp, using a standard screw-base flashlight lamp, and return the socket and plug to their original positions.

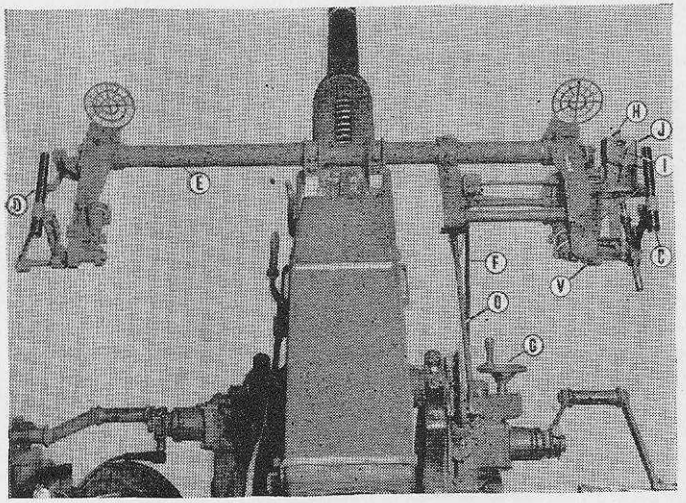
Section X

COLD WEATHER OPERATION

■ 96. Exercising Equipment.—When temperature is below 32° F., in order to keep the weapon in readiness for immediate operation, generator, oil gear, director, and gun must be periodically exercised. Schedule for exercise should be as follows:

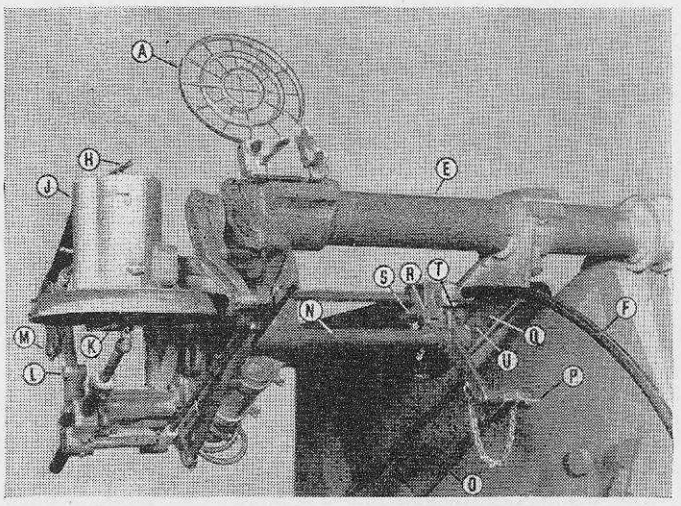
a. Procedure.—(1) Start and run generator as specified in paragraph 88.

(2) While generator is warming up, elevate and traverse gun manually in order to work out excessive stiffness. Operate breechblock by cocking and releasing firing pin.



C. Telescope M7, azimuth.
D. Telescope M74, elevation.
E. Main support bar.
F. Flexible shaft.
G. Azimuth gear box handwheel.
H. "Direction of flight" arrow.
I. Speed adjustment wheel.
J. Deflection mechanism control case.
O. Link (superelevation cam shaft arm to trunnion frame).
V. Telescope light switch.

FIGURE 36.—Computing sight M7 ready for use with telescopes M7 (Azimuth—right) and M74 (elevation—left) in their holders.



A. Front sight, direct fire.
E. Main support bar.
F. Flexible shaft.
H. "Direction of flight" arrow.
J. Deflection mechanism control case.
K. Lead screw housing.
L. Telescope lateral adjustment.
M. Telescope vertical adjustment.
N. Superelevation cam shaft arm.
O. Link.
P. Link wing screw.
Q. Superelevation cam link.
R. Boresighting plug (shown in its clip (S)).
S. Boresighting plug clip.
T. Boresighting plug boss.
U. Boresighting hole.

FIGURE 37.—Azimuth side of computing sight M7 with direct fire sight mounted.

(3) After generator motor has reached stable conditions, close main switch.

(4) Turn switches on the director, balance out superelevation creep and allow motors of director to run.

(5) With clutch disengaged, close switch to elevation oil gear and allow this to warm up. Wedge azimuth clutch in "off" position and after elevation gear has operated for 5 minutes, engage azimuth slewing clutch to operate azimuth gear.

(6) After azimuth gear has operated 5 minutes, engage both clutches and operate gun with director for approximately 5 minutes.

(7) Turn off director switches and allow oil gears and generator to run approximately 10 minutes.

(8) This exercising operation should be performed from 4 to 12 times per day when temperatures are below 32°, depending on temperatures and requirements of individual units.

b. When unit is at proper operating temperature.—(1) The oil gear unit has just been in use and is at the proper operating temperature. It is desired to run the unit a certain period every half hour in order to maintain the oil at a sufficiently high temperature to allow satisfactory operation at a moment's notice.

(2) The normal operating speed of the output shaft of the unit at maximum deflection of the sensitive valve is 210 rpm, corresponding to a tracking rate of approximately 20° per second. If the minimum satisfactory speed at maximum deflection of the sensitive valve is 160 rpm, corresponding to a tracking rate of approximately 15° per second, then the operating time per half hour listed in column 1 below will be sufficient at the temperatures between the limits listed in column 2. However, if the minimum satisfactory speed under the same conditions is 180 rpm, corresponding to a tracking rate of approximately 17° per second, then the same operating time will be sufficient only for the temperature ranges listed in column 3.

Column 1	*Column 2*	*Column 3*
Length of time each unit must be operated each half hour.	Maximum starting speed not less than 160 rpm when temperature is—	Maximum starting speed not less than 180 rpm when temperature is—
0 minute.	Above +30° F.	Above +40° F.
5 minutes.	+30° F. to −10° F.	+40° F. to 0° F.
10 minutes.	−10° F. to −40° F.	0° F. to −30° F.
15 minutes.	Below −40° F.	−30° F. to −40° F.

(3) Correspondingly longer periods, up to continuous operation, will be required as the temperature of the surroundings falls below −40° F.

CHAPTER 5

TESTS AND ADJUSTMENTS

SECTION I

40-MM AUTOMATIC GUN M1

■ 97. CHECKS TO BE MADE BEFORE EVERY FIRING.—*a.* Failure to observe the following points during assembly of gun may cause stoppages:

(1) See that striker cover is flush with breech and properly locked with slot vertical. (Arrows must be matched.)

(2) See that loading tray bolt is flush with breech ring and properly locked with slot vertical. (Arrows must be matched.)

(3) See that tapered pins in cylinder catches are fully home in correct position.

(4) See that rollers on ends of feed pawl rod are in position.

(5) See that all springs are working correctly, especially springs operating three check levers in base of automatic loader.

(6) See that no obstruction is preventing check levers from working.

(7) See that split pin and bolt are replaced in upper part of cartridge deflector tube.

b. Gun level (false zero).—Check to see that gun is properly leveled. (See fig. 38.) If gun leveling tubes prove to be out of adjustment proceed in following manner:

(1) Use one leveling tube to level gun if one or both level tubes are out of adjustment.

(2) Place leveling tube parallel to line between two jacks and bring bubble to center.

(3) Rotate gun through 180°. If bubble moves off center return it halfway to center using leveling jacks.

(4) Place leveling tube in line with alternate sets of leveling jacks in turn and continue successive half-corrections toward center until error in bubble position from center of vial remains unchanged. This false center of bubble is called the "false zero", and gun is level at this point.

(5) At first opportunity refer gun to ordnance or qualified battery specialist for adjustment of leveling tubes.

c. Forward area sight check.—Put bore of gun on a point 1,500 yards or more from gun position. If forward area sights are not on same point, adjust in following manner:

(1) Remove screw and place elevation adjusting lever of rear element of elevation sight at "line up" position.

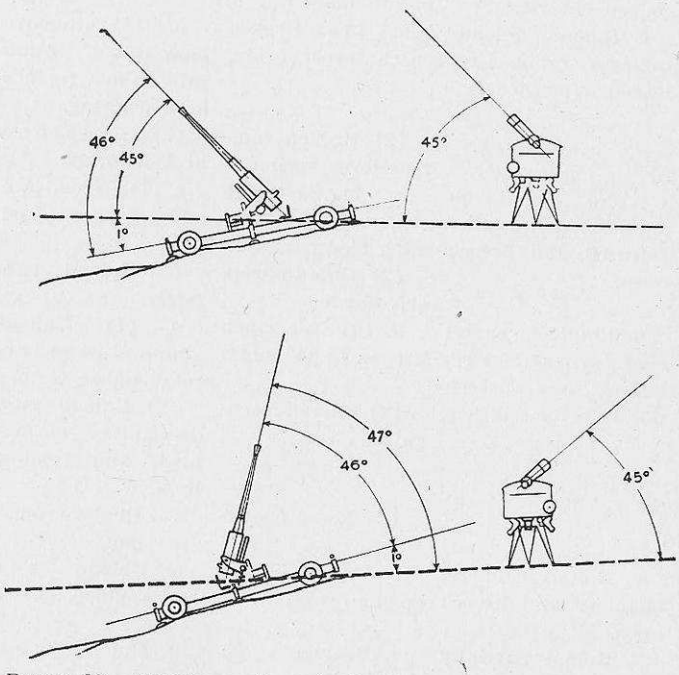


FIGURE 38.—Importance of precise leveling. (Note how an error in leveling of 1° may cause an error twice as great in orientation in elevation.)

(2) Adjust in azimuth by loosening the two setscrews holding rear element. Slide element right or left as required and tighten screws.

(3) Adjust in elevation by loosening the two screws (not the wing nuts) holding front element. Slide element up or down as required and tighten screws.

■ 98. TABLE OF MALFUNCTIONS AND CORRECTIVE ACTION.—Stoppages during firing and corrective action:

Stoppages	*Cause*	*Corrective action*
a. Round on loading tray, rammer cocked (at rear).	*a.* Slow loading (only two rounds in autoloader).	*a.* Insert new clip of cartridges.
b. Round on loading tray, rammer released (forward).	*b.* (1) Broken catch lever spring.	*b.* (1) Remove loose round. If gun fails to fire, replace broken spring.
	(2) Broken rammer lever spring.	(2) Replace broken spring.
c. No round on loading tray, rammer released and breech open.	*c.* (1) Cartridge obstruction jamming feed pawls.	*c.* (1) Unload gun and release feed pawls.
	(2) Gun improperly loaded.	(2) Reload correctly.
d. Round in barrel chamber, rammer released, and breech not fully closed.	*d.* (1) Too much grease in chamber.	*d.* (1) Unload gun, and clean barrel chamber.
	(2) Burred mechanism.	(2) Unload gun, dismantle mechanism and remove burs.
	(3) Loose projectile.	(3) Remove round from gun.
e. Round in barrel chamber and breech open.	*e.* Breech closing spring broken.	*e.* Unload gun and replace spring.
f. Round partially loaded.	*f.* Broken rammer spring.	*f.* Unload gun, remove automatic loader, and replace broken spring.
g. No round in barrel chamber.	*g.* Broken cylinder catch, broken cylinder catch arm, or broken catch torsional spring.	*g.* Remove automatic loader and replace broken parts.

Stoppages	*Cause*	*Corrective action*
h. No round on loading tray, rammer released, breech open, and one round on feed rollers.	*h.* (1) Feed control lever to the right.	*h.* (1) Place feed control lever to the left and reload.
	(2) Insufficient rounds in loader.	(2) Reload if firing is to continue.
i. Misfeed and no rounds on loading tray.	*i.* Bottom cartridge in clip not parallel to top of loader.	*i.* Push down on cartridges. If they do not move, remove and reload.
j. Feed roller fails to rotate.	*j.* Taper pin out of position.	*j.* Remove automatic loader and replace taper pin.
k. Premature firing of shell (muzzle or tube burst).	*k.* Obstruction in bore, perforated fuze of worn barrel.	*k.* Replace barrel.
l. Round in barrel chamber, rammer released, breech closed, and round fails to fire.	*l.* (1) Defective round.	*l.* (1) Recock and fire again.
	(2) Round still doesn't fire.	(2) Wait 30 seconds and extract round.
	(3) Primer has been struck.	(3) Remove round from gun area and put in safe place.
	(4) Primer has not struck.	(4) Remove breechblock.
	(*a*) Broken striker (firing pin) or faulty striker spring.	(*a*) Replace striker or striker spring.
	(*b*) Insufficient protrusion of firing pin.	(*b*) Remove breechblock and replace as above.
	(*c*) Striker spring cover incorrectly installed.	(*c*) Remove breechblock and install striker spring cover in correct position.

Stoppages	*Cause*	*Corrective action*
	(*d*) Striker sticking in striker bushing.	(*d*) Remove breechblock and install striker spring cover in correct position.
	(*e*) Firing mechanism failing to function properly.	(*e*) Examine firing mechanism and find fault.

SECTION II

40-MM GUN CARRIAGE M2

■ 99. BRAKES.—*a*. Keep electric brakes in good adjustment and braking of all wheels equalized. Check that "hotshot" battery is properly charged.

b. Before moving the gun any distance get in the habit of making sure that the following is done:

(1) Electric brake plug is plugged into prime mover and break-away chain is hooked up.

(2) Test emergency brake by putting break-away switch on the "on" position and driving prime mover forward slowly.

(3) Test electric brakes by having the driver of prime mover drive very slowly ahead and slowly apply electric brakes.

c. Trouble shooting chart.

Malfunction	*Cause*	*Corrective action*
(1) No braking or intermittent braking.	(1) (*a*) Broken wire in circuit.	(1) (*a*) Check entire wiring for broken wires. Repair or replace.
	(*b*) Broken wire in magnet.	(*b*) If broken wire is on outside of magnet, repair if possible. If no current flows through magnet, notify qualified battery or ordnance personnel.

Malfunction	*Cause*	*Corrective action*
	(*c*) Controller defective.	(*c*) Short out controller by connecting both wires to one terminal and see whether brakes are effective. If they are, replace controller.
	(*d*) Poor connection at brake, controller, or plug and socket.	(*d*) Clean and tighten all connections.
	(*e*) Defective plug or socket.	(*e*) Check plug and socket for loose connections, dirty or corroded blades, or broken socket. Repair or replace with new socket.
(2) Very weak brakes.	(2) (*a*) Worn out.	(2) (*a*) Report to ordnance or qualified battery personnel.
	(*b*) Glazed magnet facing.	(*b*) Roughen face of magnet with coarse emery cloth.
	(*c*) Foot control out of adjustment on prime mover.	(*c*) When carriage brakes are adjusted pedal travel is shortened. This throws controller out of adjustment. Reset controller with new pedal travel to cover, full range of controller.
	(*d*) Insulation of wire broken.	(*d*) Check wiring for defective part.

Malfunction	*Cause*	*Corrective action*
	(*e*) Loose connection.	(*e*) Repair or replace.
	(*f*) Insufficient current.	(*f*) Clean and tighten all connections, and check plug and socket for corroded or dirty blades or broken socket. Replace broken parts.
	(*g*) Poor ground connections at brakes.	(*g*) Clean and make good connections at brake and frame.
	(*h*) Worn wheel bearings.	(*h*) Replace bearings.

■ 100. EQUILIBRATORS.—*a.* On end of compressing rod in equilibrator is a large adjusting nut. This nut on each equilibrator can be tightened and loosened to maintain correct balance of gun and to insure easy rapid elevation and depression.

b. Equilibrators require little lubrication. Every 3 months, springs should be removed from case, and the inside of case, springs, and spring guides should be lubricated with grease.

■ 101. FRONT AND REAR AXLE COUNTERPOISE MECHANISMS.—*a.* Counterpoise mechanisms are designed to aid in raising and lowering gun and carriage. Keep them in constant adjustment. Adjusting is done by means of a large nut threaded upon the long rod holding the compression springs. By removing cotter key this nut can be either tightened to place the spring in more compression or loosened to slack up the compression.

b. Lubrication of the axle balancing mechanism should be done by ordnance personnel at the time of ordnance inspection. However, the threaded portion of the compression rod on which the adjusting nut travels should be kept greased.

■ 102. TIRES.—*a.* Tires and tubes used on the gun carriage are size 6.00 x 20. Tires are 6-ply heavy duty truck transport type, with heavy, bullet-resisting tubes. Pressure to be maintained

in the tires is 45 pounds per square inch. Check tires daily for proper air pressure.

b. Rubber deteriorates rapidly in tropical climates. Special care must be taken to store spare tires and tubes in the dark and, if possible, in an even temperature. When possible protect tires from direct rays of the sun.

SECTION III

DIRECTOR M5

■ 103. DIRECTOR LEVEL.—*a. Level.*—Place one of the level tubes in line with two leveling knobs. Level the tube by adjusting the two leveling knobs. Level the other tube by raising or lowering the third leveling knob. Traverse director through 360° stopping every 90° to check both bubbles. If bubbles deviate from center of tubes by more than one division, relevel and recheck. If bubbles are still off then adjust as in *b* below.

b. Adjustment of level bubbles.—Level one of the leveling tubes when parallel to two knobs. Swing director around 180° and bring that bubble half-way back to center of tube by means of same two knobs. Then with a pin wrench raise or lower the tube until bubble is centered. Repeat this process until bubble stays level at these two positions. Then turn director 90° and with third leveling knob move bubble to center of tube. This particular tube should now be level at all points. Other bubble tube can then be raised or lowered by the pin wrench to show level.

■ 104. RANGE STOP AND RANGE DIAL (to be done by ordnance and qualified battery personnel).—*a. Range stop.*—Check that 10 full turns of range handwheel can be made. If they cannot, proceed in following manner: check that small pins in range shaft which engage range stop are driven in shaft so that threaded sleeve is in its proper position. If threaded sleeve is not properly located, pull pins, adjust sleeve, and reinsert pins.

b. Range dial.—At minimum range setting of handwheel against its stop, the scribed lines on each multiplying mechanism should be lined up, and range dial should indicate minimum (datum line) range. If these conditions do not exist, proceed in following manner:

(1) If dial is all that is off, loosen screws holding it and reset.

(2) If scribed lines on lateral multiplier are off but range stop is correctly set, disengage bevel gears at bottom of time screw, realine these marks, and remesh gears. Reset dial if necessary.

(3) If range stop is not set correctly, move range mechanism enough so that stop nut can be rotated up against the innermost stop pin, when scribed lines on lateral multiplier are correctly matched. Reset dial if necessary.

(4) If scribed lines on vertical multiplier are not matched at minimum range position, remove screws holding range mechanism to base of director. Slide whole mechanism back until beveled gear (immediate left-front) can be unmeshed from shaft leading to multiplier. Then turn this shaft until scribed lines are matched and remesh beveled gear. Reset dial if necessary.

■ 105. ZERO DEFLECTION.—With range dial at minimum push in rate setting, clutch and turn handwheel until white lines on deflection gear are as nearly matched as is possible by eye. Then pull out smartly on rate setting clutch. Rotate range handwheel from minimum to maximum and back again, watching for movement of fine dial. If it moves, proceed in following manner: loosen nut on clamp that holds fixed dog (stationary collar) on rate setting clutch and loosen guide screw on this casting. Find position of zero deflection (link of multiplier in vertical position) by turning deflection gear by handwheel (clutch in), until no movement of fine dial is noticed when range is run from minimum to maximum and back. Block handwheel. Rotate fixed dog in its casting until teeth of sliding dog will mesh exactly with fixed dog when clutch is pulled out. Tighten nut on clamp and then tighten guide screw. ***Caution:*** *Above procedure must be followed exactly and care must be taken on tightening clamping screw to avoid breaking casting. Recheck zero deflection after tightening.* (To be done by ordnance or qualified battery personnel.)

■ 106. OPEN SIGHT.—Place horizontal cross hair of the elevation scope on a distant point. If line of sight over open sight does not intersect this point, loosen thumbscrew of open sight,

adjust open sight until it is on the point, and tighten thumbscrew.

■ 107. SPRING TENSION OF VARIABLE SPEED DRIVE (to be done by ordnance and qualified battery specialists only).—With a spring balance scale reading from 0 to about 10 pounds, measure tension on spring between disk and cylinder of variable speed drive in following manner:

a. Place one end of a rod which is 2 feet long against center of rocker assembly, and place hook of scale against other end of rod. Pull toward director until cylinder is forced away from ball bearings of variable speed drive.

b. Reading on the scale should be between 7 and 8 pounds. If it is not, tighten or loosen nut on spring until the proper reading of scale is obtained.

■ 108. SPEED CHECK OF DISK IN VARIABLE SPEED DRIVE (CONSTANT SPEED MOTOR) (to be done by ordnance and qualified battery personnel).—Turn power on and with a stop watch, record the time required for 20 revolutions of the bronze gear which drives the disk of variable speed drive. The gear should rotate in a counterclockwise direction on M5 (clockwise on M5A1) directors, and should make 20 complete turns in 60 seconds ± ½ second. This check should be under load and without load (use load of 2° deflection and 1,200-yard range). If deviation is greater than tolerance provided above, adjust constant speed motor governor in following manner:

a. Remove two screws holding governor guard to base, remove guard by turning governor itself to a 2 o'clock position and then lift guard up and out with a twisting motion.

b. Turn each of four adjusting nuts on governor same amount (hold screw with pliers to prevent its slipping); one-quarter turn on each nut equals approximately 1 second change in time for 20 revolutions of disk. Tighten if too slow and loosen if too fast.

■ 109. ALINING TELESCOPES.—*a.* Level the director. Zero vertical deflection and pull out the elevation rate setting clutch.

b. Turn the elevation handwheel until the quadrant elevation dials read zero. Insert the lining up pin in the quadrant elevation transmitter.

c. Place both telescopes on the director in their respective positions.

d. The elevation telescope should be pointed at zero angle of sight. Check this by means of a testing target or on the horizon. If it is not so pointed, loosen the two clamping bolts which clamp the segment gear to the telescope shaft and shift the telescope to the proper position. Tighten the clamp. Recheck.

e. The lines of sight of the azimuth and elevation telescopes must be parallel within 1 mil in azimuth, and elevation.

f. To make an accurate check of this condition, construct a testing target on which is painted a set of cross hairs whose centers are 29⅝ inches apart. The lines of the cross hairs should be about 12 inches long and about 1 inch in width. This testing target should be placed between 100 and 200 yards from the director at the same height as the telescopes.

g. Using the elevation handwheel, elevate the telescope about 10° then reverse direction and bring the horizontal reticle line of the elevation telescope to bear accurately on the horizontal crossline on the left side of the testing target. Lightly block the handwheel to prevent further movement.

h. The horizontal reticle line of the azimuth telescope should now intersect the horizontal crossline on the right side of the testing target. If it does not, remove the telescope, loosen the four screws which hold the clamping ring, retaining enough friction to hold the telescope in any position. Replace the telescope and shift it manually until the alinement is correct. Remove the telescope, tighten the four screws, then replace the telescope and recheck the alinement.

i. Pull out the azimuth rate setting clutch. Turn the azimuth handwheel until the vertical reticle line of the azimuth telescope accurately intersects the vertical crossline of the right side of the testing target. Block the handwheel to prevent further movement. Never force the block; drop it in lightly. A slight pressure against the director will tend to slew it in azimuth and render this adjustment inaccurate.

j. The vertical recticle line of the elevation telescope should now intersect the vertical crossline on the left side of the testing target. If it does not, remove the telescope and check that no foreign substance lies between the telescope and the flange. Also check the azimuth telescope in this respect. Check also

that the four screws which hold the clamping ring on the azimuth side are properly and evenly tightened.

k. If no testing target is available, the telescopes may be checked in elevation on any point which lies in the same plane as the telescopes on the director. For the check in azimuth, both vertical reticle lines should intersect on some target which is between 1,500 and 3,000 yards range. The tolerance must still be observed.

■ 110. VERTICAL PLUMB TRAVEL.—*a.* Level the director. Establish a plumb line of sufficient length to remain in the field of view of the telescope for 45° movement.

b. The vertical reticle line of the azimuth telescope should follow the plumb line from 0° to 45° within 1 mil. If an adjustment is necessary, it probably means that the four clamping screws which provide the telescope adjustment are improperly tightened. Tighten the four screws necessary in order to correct any condition outside the tolerance. In the event adjustment cannot be obtained, try a substitute telescope or place a shim under the pads of the azimuth or elevation telescope shaft flange.

■ 111. CHECKING AZIMUTH BACKLASH.—*a.* Set range dial to datum line. Aline zero deflection marks and pull out the azimuth rate setting clutch.

b. Locate several objects in the field of view which are approximately 90° apart in azimuth. These objects should include angles throughout 360°. Turn the azimuth handwheel to increase azimuth and stop when the vertical reticle line of the azimuth telescope intersects the first reference point. Do not overrun. Record the reading of the firing azimuth dials.

c. Continue to turn the handwheel in the same direction for approximately 20° then reverse direction. Observe through the telescope and stop when the vertical reticle line again intersects the first reference point. Do not overrun. Record the reading of the azimuth dial. The difference between these readings must not be more than 6 minutes. The width of each line graduation is approximately 3 minutes.

d. Any adjustment necessary will require a complete check of the gear train in azimuth. Note particularly the differential mechanisms, and if necessary, replace them with serviceable

parts. *Check that the orienting clutch is tight* and that the dials will record any handwheel or slewing motion of the director as this will have considerable bearing on the results of the check for backlash in azimuth.

■ 112. CHECKING BACKLASH IN ELEVATION.—*a.* Set range dial to datum line. Aline zero deflection marks and pull out the elevation rate setting clutch.

b. Locate several objects in the field of view which are approximately 30° apart in elevation. These objects should include angles from zero to 90°. Turn the elevation handwheel to increase elevation and note when the horizontal reticle line of the elevation telescopes intersects the first reference point. Do not overrun. Record the reading of the quadrant elevation dials.

c. Continue to turn handwheel in the same direction for approximately 20° then reverse direction. Observe through the telescope and note when the horizontal reticle line again intersects the first reference point. Do not overrun. Record the reading of the quadrant elevation dials. The difference between the two readings must not be more than 6 minutes. The width of each line graduation is approximately 3 minutes.

d. Any adjustment necessary will require complete check of the gear train in elevation. Note particularly the differential mechanisms and if necessary replace them with serviceable parts. Check that the pinion of the quadrant elevation mechanism is meshed properly with the segment gear. If it appears to be loose, check the tension of the antibacklash gear spring. If the gears appear to be too far apart, loosen the four screws clamping the bearing of the pinion and shift it up as necessary until the mesh is proper.

e. This is a comparatively rough check, but is satisfactory for field use where a transit or similar instrument is not available for making an accurate check. If a transit is available, it may be used by making a special adapter to fit it on the telescope flange to compare dial reading against transit reading for any angular movement, and for check of backlash.

■ 113. DYNAMIC OPERATION OF TORQUE AMPLIFIER.—This is merely a check to determine whether or not torque amplifier is delivering a smooth rate without chatter or jerk. Any jerk

can be noticed by watching movement of fine dial when a rate has been applied. Other causes of jerk besides the torque amplifier may be orienting clutch, worm drive assembly, rate motors, and tension of flat spring supporting ball carriage.

■ 114. ZERO RATE IN AZIMUTH.—With azimuth deflection gear set at zero deflection (pointers matched), fine dial should creep no more than 1°/min. with motor on. If creep is excessive, loosen locking screw on bracket of bar assembly and turn adjusting screw in direction of rotation of output cylinder until motion ceases. (To be done by ordnance or battery personnel.)

■ 115. SUPERELEVATION AND ZERO RATE ELEVATION (to be done by ordnance or qualified battery personnel).—Set deflection gears at zero elevation (pointers matched). Check superelevation run-down times; that is, with a stop watch, time run-down of telescope from 5° to 0° on fine dial. After running up to about 67°, time the run-down from 65° to 60°. For 0.058″ K setting (40-mm gun) times are 12.9 seconds ± 0.5 second for run-down from 5° to 0°, and 29.1 seconds ± 2.5 seconds for run-down from 65° to 60°.

a. If a stop watch is not available, the test can be made by using the second hand of an ordinary watch. In this case the test will be run as follows: set the telescopes at 25° (as read on the elevation transmitter dials), and time the run-down from 20° to 0°. For 0.058″ K setting (40-mm gun) times are 58 seconds ± 5 seconds for run-down from 20° to 0°, and 63 seconds ± 5 seconds for run-down from 65° to 55°.

b. If actual time exceeds the limits mentioned above, proceed in following manner:

(1) Remove top cover and front panel.

(2) Observe to see that maximum eccentricity of superelevation cam is downward at 90°. On most directors there are scribed lines on end of cam which will match when this condition is realized. On other directors, it is necessary to determine proper setting by eye alone. If this setting is off, it can be corrected by first loosening the nut holding superelevation cam lever bracket to telescope shaft. Rotate cam to proper position by tapping lightly on lever bracket in direction desired. Tighten nut.

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c. (1) Push rate clutch in and move ball cage out to near edge of constant speed disk. Loosen the two screws holding K setting scale to ball carriage. With special wrench loosen lock nut on adjustable arm, being sure to hold micrometer head firmly with finger. Tighten screws holding scale and with a screw driver run micrometer head out until scribed line on head matches 0.05 setting on the scale (zero division point on head should be opposite bottom edge of scale). Make proper number of turns and divisions on micrometer head to set in desired **K** factor. For a 40-mm gun (muzzle velocity 2750 f/s—0.0580″ K setting), set in 6 turns and 13 divisions. Loosen screws holding scale; tighten lock nut; retighten scale screws and run ball cage back to center of disk, by setting deflection gear to zero (fig. 39).

(2) Place electric wire jumpers across elevation limit switch by connecting one end of wires to **Y** and **Z** phases of rate motor at fuse block (normally pink and orange) and other ends to connections on top of elevation rate motor switch, being careful that pink wire at block is connected to pink wire at switch. Check for zero rate at 90° (motors on) as indicated by fine dial. If creep in excess of 1°/min. is observed, loosen lock screw on bracket of bar assembly, and turn adjusting screw in direction of rotation of output cylinder until minimum creep is observed. (Keep scopes at 90° at all times during this check.)

(3) Test run-down times as indicated above. After checking run-down from 5° to 0°, if time is not within tolerance, move ball cage as in adjusting for zero rate, until time is within tolerance. Run telescope to 90° and check for zero rate; if off, move cam, as in initial setting, until zero rate is obtained. If any adjustment of this cam is necessary, recheck time from 5° and 0°, and continue adjustments until it is within tolerance. Recheck run-down from 65° to 60°. If time is not within limits, turn adjusting screw on ball cage until it is correct. If any adjustment is necessary at this point, a complete recheck of run-down from 5° to 0° and 65° to 60° as well as zero rate at 90° must be run. When the requirements for all three tests have been satisfied, remove jumper wires from elevation limit switch and fuse block.

■ 116. REMESHING OF ELEVATION SEGMENT GEAR (to be done by ordnance and qualified battery personnel).—Elevation segment

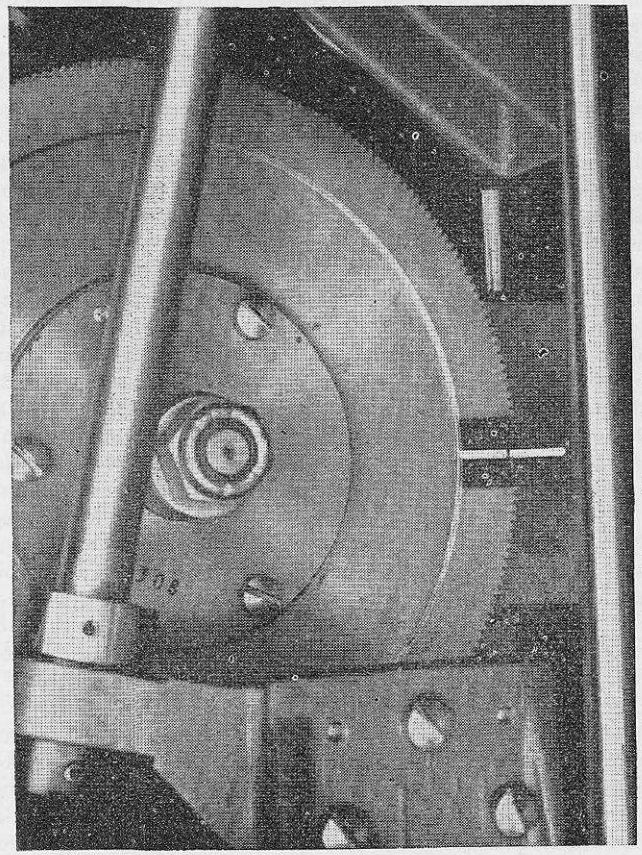


FIGURE 39.—Deflection zeroed.

gear is purposely disengaged from quadrant elevation mechanism during the process of effecting certain repairs and it may become disengaged during operation of director, due to neglect or abuse. Segment gear may be engaged with antibacklash gear of quadrant elevation mechanism from either side, therefore both procedures are given below.

a. When segment gear is engaged from the right (move in a clockwise direction until contact is made with antibacklash gear), proceed as follows: set elevation deflection gears to zero and pull clutch out. Swing the mechanical stop, which is toward rear of director, out of path of segment gear. While holding segment gear out of mesh, turn elevation handwheel until lining up pin can be inserted into elevation transmitter, and insert lining up pin. Lower segment gear until it touches antibacklash gear on quadrant elevation mechanism. From point of contact, count 21 teeth in a counterclockwise direction on antibacklash gear and mark tooth for identification. Remove lining up pin, lift segment gear slightly, and turn antibacklash gear clockwise, by means of elevation handwheel, until marked tooth will engage with first tooth of segment gear. Wind antibacklash gear four or five teeth in proper direction to tighten, and then engage segment gear. Turn antibacklash gear counterclockwise by means of elevation handwheel, until lining up pin can again be inserted, and insert lining up pin. Loosen screw holding coarse dial and set it to read zero. In same manner, set fine dial to read zero. (Approximately the seventeenth tooth of segment gear should be engaged at this time when dials are indicating zero.) Remove lining up pin, swing stop back into path of the segment gear, and tighten stop slightly. Turn elevation handwheel until telescopes are depressed to $-10° \pm 1°$, adjust stop against segment gear, and tighten stop.

b. When segment gear is engaged from the left (moved in a counterclockwise direction until contact is made with antibacklash gear), proceed as follows: set elevation deflection gears to zero and pull clutch out. Swing the mechanical stop, which is toward front of director, out of path of segment gear. While holding segment gear out of mesh, turn elevation handwheel until lining up pin can be inserted into elevation transmitter and insert lining up pin. Lower segment gear until it touches antibacklash gear on quadrant elevation mechanism. From

point of contact count 25 teeth in a clockwise direction on antibacklash gear and mark tooth for identification. Remove lining up pin, lift segment gear slightly, and turn antibacklash gear counterclockwise, by means of elevation handwheel, until marked tooth will engage with first tooth of segment gear. Wind antibacklash gear four or five teeth in proper direction to tighten and then engage segment gear. Turn antibacklash gear clockwise by means of elevation handwheel, until lining up pin can again be inserted, and insert lining up pin. Loosen screw holding coarse dial and set it to read 80°. In same manner, set fine dial to read zero. (Approximately the twenty-first tooth of the segment gear should be engaged at this reading.) Remove lining up pin, swing stop back into path of the segment gear and tighten stop slightly. Turn elevation handwheel to increase elevation until sixth or seventh tooth of segment gear is engaged. Stop should now be against segment gear. Dial reading should be $92° \pm 1°$. Decrease elevation and set other stop to engage at $-10° \pm 1°$. Note that stops can be swung in a slight arc, thus increasing or decreasing travel of segment gear. A small adjustment may also be made by bending stop; however, do not weaken stops by excessive bending. A spring action must always be present in stops, in order to absorb shock of engagement. Purpose of stops is to prevent disengagement of segment gear under normal manual operating conditions. Allowing motor to coast into stop under high deflection rates will soon cause gear to become disengaged.

■ 117. ELECTRICAL ZERO.—*a.* All M5 directors are electrically zeroed by the manufacturer. Due to road shock, occasionally transmitter housings will slip in their brackets in the director disturbing electrical zero. Ordinarily this will not greatly affect operation of equipment with the M1 type oil gear units. However, with the M3B1 oil gears all selsyns in the data transmission system must be in exact electrical zero. If the gun barrel "chatters" or waves it may be that one of the director transmitters is out of electrical zero (applicable only to the M3B1 oil gear unit). Repair must be made by Ordnance or authorized battery personnel by electrically zeroing transmitters which have slipped.

b. Electrically zeroing the director (must be followed in sequence as it appears below).

(1) *Elevation zero check.*—(*a*) Turn power off leaving director and power cables connected.

(*b*) Remove director panel and disconnect on the director power terminal strip leads on the lower bank, Nos. 2, 3, 4, 5, 8, 9, 10, 11, and 12. It is not necessary to tape these leads but they must be kept separated. By disconnecting lower 8 lead, single-phase power is obtained (fig. 32).

(*c*) Turn director dials to zero.

(*d*) Connect a jumper between terminals 1 and 5 and measure the voltage between terminals 4 and 15, and rotate the stator housing of the elevation transmitter until voltage reads 20 to 30 volts (approximate check to determine close electrical zero or 180° from zero).

(*e*) *Exact check.*—Measure voltage between 3 and 4 and rotate the stator housing of the elevation transmitter until the voltage reads less than 1 volt. Elevation transmitter is now electrically zeroed.

NOTE.—Turn power on at generator only when measuring the voltages.

(2) *Azimuth zero check.*—To be made in sequence after elevation zero check.

(*a*) Zero dials.

(*b*) Disconnect both leads at upper 8 on director terminal strip.

(*c*) Connect a jumper between terminals 1 and 9.

(*d*) Measure voltage between terminals 10 and 15 and rotate stator of azimuth *coarse* transmitter until it reads 20 to 30 volts.

(*e*) Measure voltage from 10 to the lead formerly going to 8 (try both former leads and obtain correct one, but measure voltage using each, and the one that jumps in voltage when the azimuth dial is hand-cranked away from zero but returns to less than one volt when the dial is returned to zero is the correct lead to use). Rotate stator of azimuth *coarse* transmitter until the voltage is less than one volt.

NOTE.—Probably the left lead at terminal 8 is the correct one of the two and in order to make the check, move the azimuth dial as described.

(*f*) Connect jumper from 1 to 12.

(*g*) Measure voltage between 10 and 15 and rotate stator housing of the azimuth *fine* transmitter until the voltage reads 20–30 volts. If the voltage reads about 200 volts the housing has slipped 180° from electrical zero.

(*h*) Measure voltage between 10 and 11 and rotate stator of *fine* azimuth transmitter until it reads less than one volt.

(*i*) Remove jumpers, reconnect all wires, replace cover. Electrical zero is complete.

■ 118. TEST PROBLEMS.—The purpose of running these problems is to collect data on operation of director that will enable a definite and orderly procedure for trouble shooting to be followed, which will uncover the root of any improper behavior quickly and effectively.

■ 119. ELEVATION TEST PROBLEM.—*a.* Aline zero deflection marks on elevation side and pull out rate setting clutch. First set in proper range for problem. To check increasing elevation, set telescopes at about 0° (use telescope scale), push in rate setting clutch and turn in deflection wanted (as registered on fine dial). Turn on motor and time, with stop watch, travel of telescope from 15° to 75° (watch telescope scale).

b. In checking decreasing elevation follow same procedure, except start telescope at about 84° to enable a correct rate to be set in, and to get a good start before commencing to time it at 75°. Time from 75° down to 15°. This is repeated for various ranges and deflections as indicated in tables in paragraph 121. Readings should correspond to those of tables in paragraph 121, within listed tolerances. If they do not, then follow trouble-shooting chart (par. 123). (To be done by ordnance or qualified battery personnel.)

■ 120. AZIMUTH TEST PROBLEMS.—Tighten small knurled nut on orienting clutch and loosen large knurled knob approximately one-quarter turn. Switch motor on and set in desired range and then deflection. The time required for one complete revolution of director is recorded. Tests are made with director turning in a clockwise direction and again with director turning in a counterclockwise direction. To facilitate this test, reference marks may be provided by taping a wire to base of director and putting a chalk mark on support assembly. The tests are re-

peated for various ranges and deflections as indicated in table in paragraph 122. The readings should correspond to those of the table in paragraph 122, within the listed tolerances. If they do not, then follow the trouble-shooting chart in paragraph 124. (To be done by ordnance or qualified battery personnel.)

■ 121. ELEVATION PROBLEMS.—(Problems must be run with increasing and decreasing elevation.)

Range scale (F) MV. 2750 FS SE setting .058

ELEVATION INCREASING

Deflection in degrees +	Range in yards			
	500	1,000	1,500	2,000
5	10.2±0.8	19.9±1.3	32.0±1.9	47.6±2.7
10	4.9±0.5	9.4±0.8	14.7±1.0	21.3±1.4
15		6.0±0.6	9.4±0.8	13.6±1.0
20			6.8±0.6	9.7±0.8
	Time, in seconds, for telescopes to elevate from 15° to 75°.			

ELEVATION DECREASING

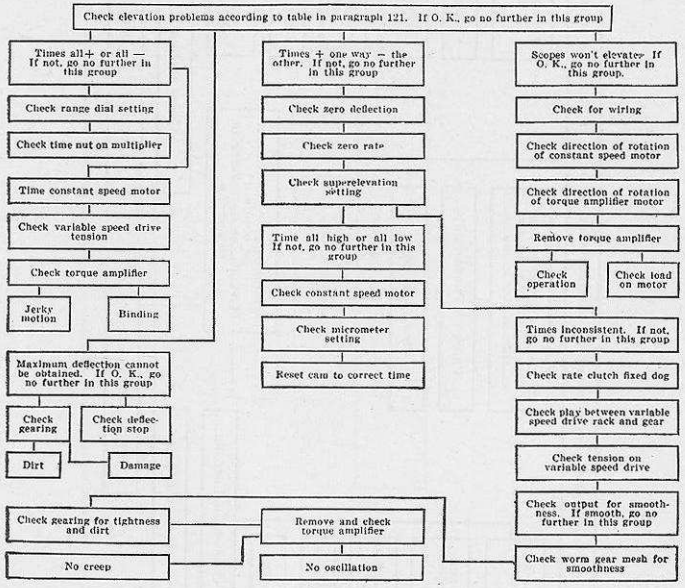
Deflection in degrees−	Range in yards			
	500	1,000	1,500	2,000
5	9.4±0.8	16.9±1.1	25.1±1.6	33.8±2.0
10	4.7±0.5	8.7±0.7	13.1±1.0	18.0±1.2
15		5.7±0.6	8.7±0.7	12.2±0.9
20			6.5±0.6	8.9±0.7
	Time, in seconds, for telescopes to depress from 75° to 15°.			

■ 122. AZIMUTH PROBLEMS.—(Problems must be run clockwise and counterclockwise.)

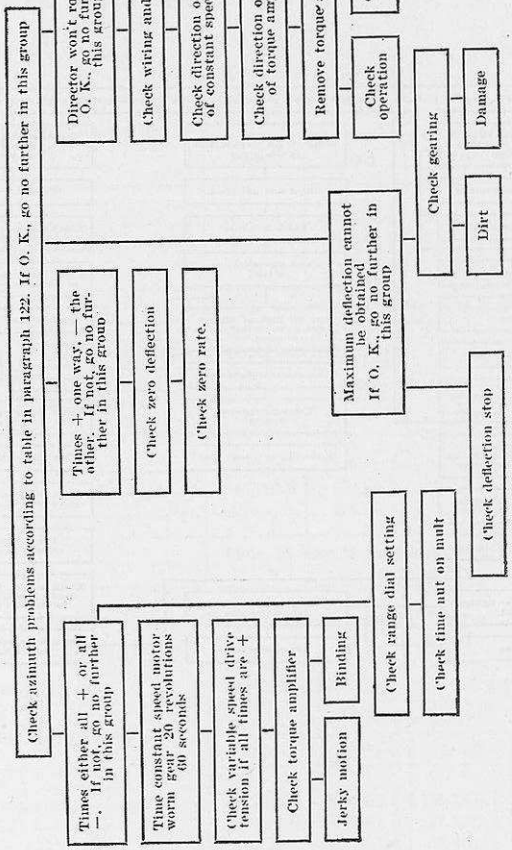
Range scale (F) MV. 2750 FS SE setting 0.58

Deflection in degrees + and −	Range in yards			
	500	1,000	1,500	2,000
5	48.9±1.8	99.2±3.3	158.1±5.0	226.1±7.1
10	23.6±1.0	48.6±1.8	77.8±2.7	111.5±3.6
15		31.2±1.2	50.4±1.8	72.1±2.5
20			36.1±1.4	52.6±1.9
	Time, in seconds, required for director to turn through one revolution in azimuth.			

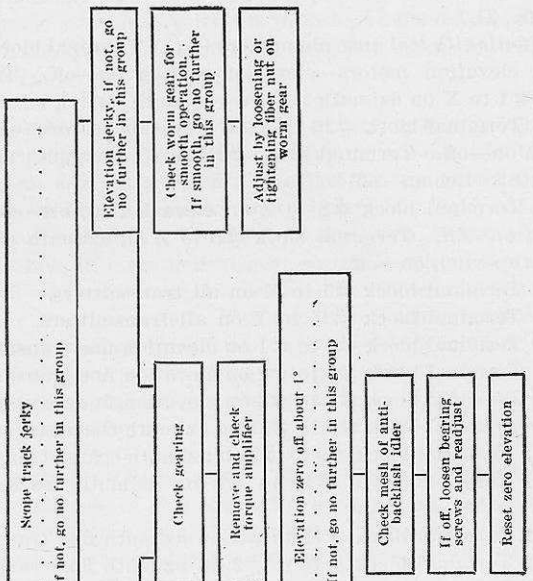
■ 123. ELEVATION TROUBLE CHART.



124. Azimuth Trouble Chart.



125. Tracking Error.



■ 126. ELECTRICAL TEST.—Disconnect power from director. Set present angular height to 45° by means of elevating handwheel. This will prevent elevation limit switch from breaking circuit. (To be done by ordnance or qualified battery specialists only.) (See fig. 31.)

a. Continuity test (use ohmmeter).—(1) Terminal block #1 to X on elevation motors—elevation switch on—off. Terminal block #1 to X on azimuth motors—azimuth switch on—off.

(2) Terminal block #15 to Y on elevation motors—elevation switch on—off. Terminal block #15 to Y on azimuth motors—azimuth switch on—off.

(3) Terminal block #8 to Z on elevation motors—elevation switch on—off. Terminal block #8 to Z on azimuth motors—azimuth switch on—off.

(4) Terminal block #1 to X on all transmitters.

(5) Terminal block #15 to Y on all transmitters.

(6) Terminal block #4 to #1 on elevation fine transmitter.

(7) Terminal block #5 to #2 on elevation fine transmitter.

(8) Terminal block #3 to #3 on elevation fine transmitter.

(9) Terminal block #8 to #11 on azimuth coarse transmitter.

(10) Terminal block #9 to #2 on azimuth coarse transmitter.

(11) Terminal block #10 to #3 on azimuth coarse transmitter.

(12) Terminal block #11 to #1 on azimuth fine transmitter.

(13) Terminal block #12 to #2 an azimuth fine transmitter.

(14) Terminal block #10 to #3 on azimuth fine transmitter.

b. Insulation test.—(1) Terminal block #1–15, inclusive, will be "meggered" to director frame. Minimum acceptable resistance value is on (1) megohm.

(2) The 6-volt terminals on the illumination step-down transformer will be "meggered" to director frame. Minimum acceptable resistance value is 1 megohm.

■ 127. SET ELEVATION LIMIT SWITCH.—The Y and Z phases between elevation limit switch and elevation motor switch should be opened at 85° and 0°, within ±1° error. Verify limit switch setting by means of an ohmmeter. If adjustment is necessary, loosen screws which clamp limit switch to side frame, and shift switch slightly to right or left as required. Repeat checking and adjusting until desired result is obtained. (To be done by ordnance or qualified battery specialist only.)

SECTION IV

REMOTE CONTROL SYSTEM M5

■ 128. GENERAL.—The tests and adjustments described below must be made at regular intervals in order to insure proper operation of the system. All of these tests and corrective adjustments are made "On carriage."

■ 129. ADJUSTING SETTING OF GUN TRANSMITTER ROTOR (ELEVATION ADJUSTMENT).—If the gun and director are not oriented in elevation, an adjustment is made to position the rotor of gun position transmitter. Remove cover plate on right side of elevation oil gear unit. With power turned on, insert adjusting key in hole in large helical gear so that teeth on key mesh with teeth on smaller gear. Loosen the three setscrews in small gear and turn key. Turning key rotates transmitter rotor, energizes oil gear unit, and moves gun. When gun is in proper orientation in elevation, the gun position transmitter and director transmitter are aligned. Tighten three setscrews firmly and remove key.

■ 130. ACCURACY (BACKLASH) TEST AND ADJUSTMENT.—*a. Test.*—The purpose of this test is to check over-all operation of system. A reference mark or indicator is put on the clutch housing and a corresponding mark made on circumference of output coupling. The director is traversed 6° (14° for checking elevation unit) making sure that director does not overrun reading. The output coupling should make one complete revolution ±1/16 inch (three revolutions ±3/32 inch for elevation). Test should be run in both directions. If the unit still cannot meet this requirement, make adjustment for backlash. (To be done by ordnance or qualified battery specialists only.)

b. Adjustment.—Remove right-hand side cover plate, and test freedom of movement between gear and pinion for backlash (play). If backlash is present, loosen the three screws in bracket which supports right end of pinion shaft. Press the two gears together by lifting horizontal shaft and then tighten screws. If the backlash is still excessive, ream out screw holes in bearing bracket to a slightly larger diameter, and again push the two gears together while tightening screws. Be sure that gears run together smoothly and freely after adjustment.

■ 131. DITHER ADJUSTMENT.—With unit in operation, correct dither adjustment is checked by placing a hand on output coupling. A perceptible tremble or vibration indicates proper dither adjustment. If no tremble is felt, or coupling vibrates excessively, an adjustment must be made as follows: Remove protective cap nut, marked dither, on left side of main case, turn adjusting screw until proper intensity of vibration exists. Replace nut covering adjusting screw.

NOTE.—AN ADJUSTMENT OF DITHER INCREASES SENSITIVITY; THEREFORE, CREEP OF OUTPUT COUPLING MAY RESULT. FOR THIS REASON IT IS ADVISABLE TO ADJUST FOR DITHER BEFORE ADJUSTING FOR CREEP. (See fig. 40.)

■ 132. NEUTRAL SETTING OF PILOT VALVE (CREEP TEST).—*a. Test.*—When there is no torque in electrical differential, pilot valve must also be in neutral position so there is no turning of output shaft. Switch power off at generating unit and remove director cable from gun junction box. It is imperative that director be disconnected from gun while making creep adjustment. This will make the electrical differential electrically "dead" and allow springs to hold torque arm in neutral position. Restore power and close limit switch putting oil gear in operation. Check output coupling of oil gear unit for rotation (creep). Maximum allowable creep is 1 revolution in 3 minutes. If creep is more than 1 revolution in 3 minutes adjustment must be made.

b. Adjustment.—To take out creep, remove right-side cover plate and adjust by turning knurled screw of pilot valve rod in proper direction.

Caution: Oil motor will operate and move gun rapidly when the slightest pressure is applied to torque arm or knurled screw. Adjustment must be made by turning screw slightly, then removing hand and observing effect of adjustment. Adjustment should always be made until no creep exists at output coupling. Check final adjustment by moving torque arm a small amount clockwise and counterclockwise. Upon release, unit should come to rest without creep of output coupling. (See figs. 41 and 42.)

■ 133. TORQUE TEST.—This test is to check power developed by oil gear. A low rate is set in director. The gun should follow

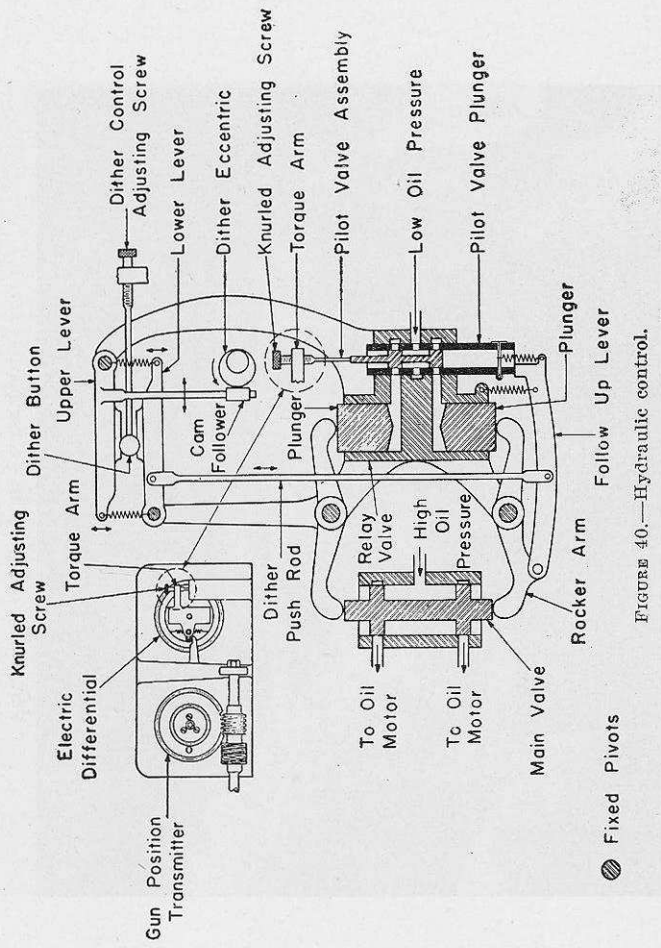


FIGURE 40.—Hydraulic control.

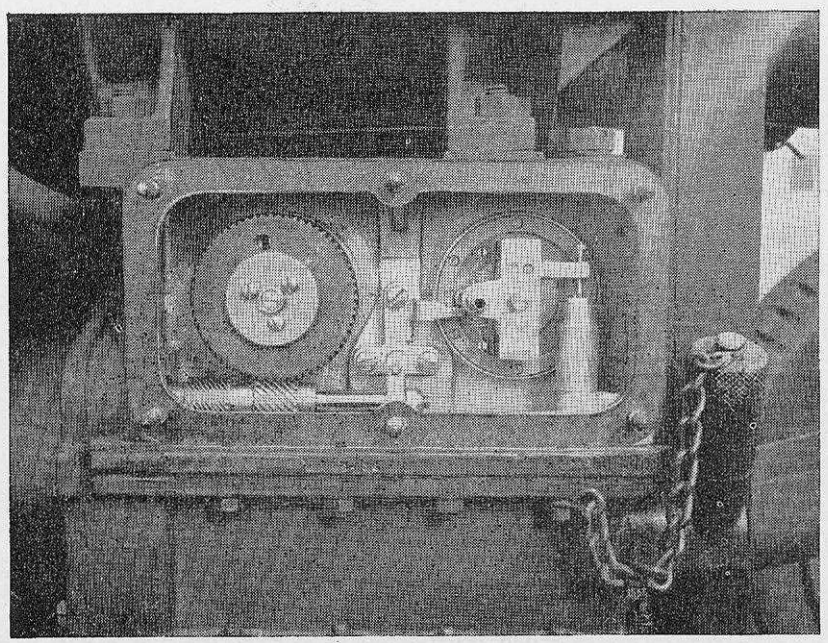


FIGURE 41.—Oil gear unit—cover plate removed.

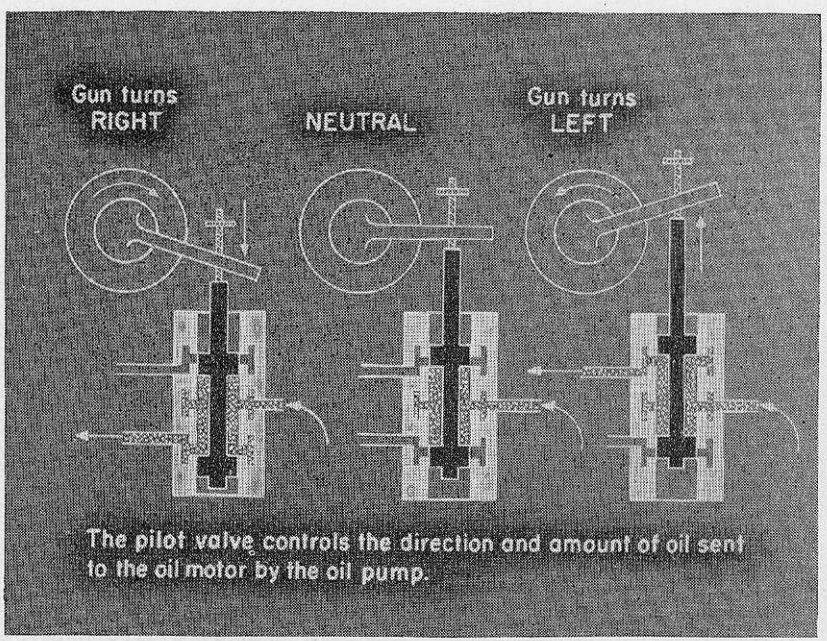


FIGURE 42.—Relation of pilot valve movement to direction of gun turning.

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smoothly without lag. If this condition is not met, check oil level and voltage and frequency at power plant. If oil level and power are satisfactory, increase dither slightly. If unit still cannot meet the test remove it and turn it over to ordnance or qualified battery specialist.

■ 134. ADJUSTMENT OF LIMIT SWITCHES.—*a. Elevation limit switch.*—This switch must cut off power to oil gear units at 85° ± 1° and at 0° ± 1°. With system energized, elevate by means of director until unit shuts off. Take elevation reading at director dials. Repeat procedure while depressing gun and adjust, if necessary, by changing position of blocks on rotating disk on gun trunnion until above limits are reached.

b. Azimuth limit switch.—This switch is not a true limit switch and may require adjustment. The switch should snap on just *after* oil gear clutch is engaged by throwing gun slewing lever. Adjustment is made by changing spring tension on azimuth oil gear clutch lever.

SECTION V

REMOTE CONTROL SYSTEM M10

■ 135. OIL GEAR SLEWING CLUTCH.—The azimuth oil gear slewing clutch must fully engage *before* power reaches the unit. Adjustment is maintained by adjusting tension on the springs of the azimuth oil gear slewing clutch rod connected to the azimuth slewing handle.

■ 136. ELEVATION LIMIT CAM (BY ORIENTATION).—*Units fully self-synchronous.*—After cables are connected and unit is ready for orientation, disengage oil gear boresighting clutches (fig. 43). Hand crank the gun onto the aiming point and reengage the oil gear boresighting clutches. Orientation is now complete. Do not use the azimuth orienting clutch on the director. The elevation limit switch must remain open while the azimuth controls are being started to prevent generator overload. Power one, and then the other. To stop the remote control system, disengage gun slewing lever and electrical limit switch. Power switch at generator should be opened if both oil gears are off.

■ 137. UNITS SELF-SYNCHRONOUS IN AZIMUTH BUT NOT IN ELEVATION.—Boresight in azimuth as described in paragraph 136. In elevation use the following procedure:

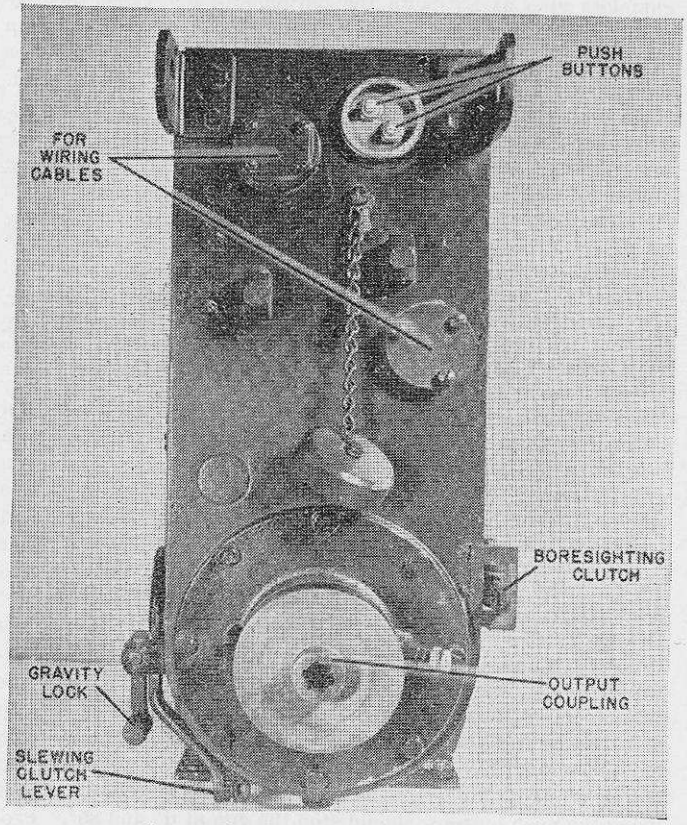


FIGURE 43.—Oil gear unit M3—rear view.

a. Procedure when limit cam is in proper position.—Slew the gun in elevation with power on by pushing the upper power slewing push button on the elevation oil gear and thus slewing the gun in elevation. With the push button depressed the gun should stop, because of the hydraulic limit cam, at 85°. If the

gun does not stop at about 87° immediately release the push button to prevent moving the gun against the mechanical limit stop on the gun elevating rack and thereby damaging it. If the gun *does stop* at 85° with the button still depressed then by pushing the lower push button the gun should depress and *stop* hydraulically at 0°. Leaving the gun at 0°, run the director telescopes to 0° by hand and then power the elevation unit. Then move the director telescopes on to the aiming point. This should move the gun barrel to within a few mils of the aiming point in elevation. Disengage the oil gear boresighting clutch. Crank gun manually onto aiming point, making certain that director telescopes remain on aiming point. Re-engage oil gear boresighting clutch. Run director telescopes above 85° and below 0°. Gun should stop at 85° and 0° without disconnecting the elevation electrical limit switch. Using director, move gun back on to aiming point. Orientation should check within one quarter of a mil.

b. Procedure where limit cam is not properly positioned.— When the test mentioned in *a* above has been made, and the gun has not stopped by the time it has reached 87°, release push button as described above. Then depress lower push button and slew gun down until the limit cam stops it, which in this case will be something greater than 0°. Since the mechanical limit stop has stopped the gun's depression and since this limit cam was designed to stop the gun at 0°, it will be necessary to disengage the boresighting clutch and run the gun by hand to 0° and reengage the boresighting clutch. A retest should allow the gun to stop at 0° and 85° by use of the push buttons. Orientation will then proceed as described in *a* above. If, when the test described in *a* above is made and the gun when slewed in elevation stops at something less than 85°, then, leaving the gun barrel as stopped, release push button, disengage boresighting clutch, crank gun to 85°, reengage boresighting clutch. A retest, using the push buttons, should stop the gun at 0° and 85°. Proceed with orientation as described in *a* above where gun did stop at 0° and 85°. Once the limit cam has been properly positioned in order to orient a unit (gun stops at 0° and 85° at push button slewing)—

(1) Run the gun by hand to 0°.

(2) Run director to 0° and power the unit.

(3) Move director on to aiming point.

This should bring gun within a few mils of the aiming point. Disengage the boresighting clutch, crank gun exactly on to aiming point. Reengage boresighting clutch. Using personnel should be restricted to the use of the elevation boresighting clutch only for orienting. If this precaution is followed, the elevation hydraulic limit cam cannot get out of position and thus require the adjustment described above.

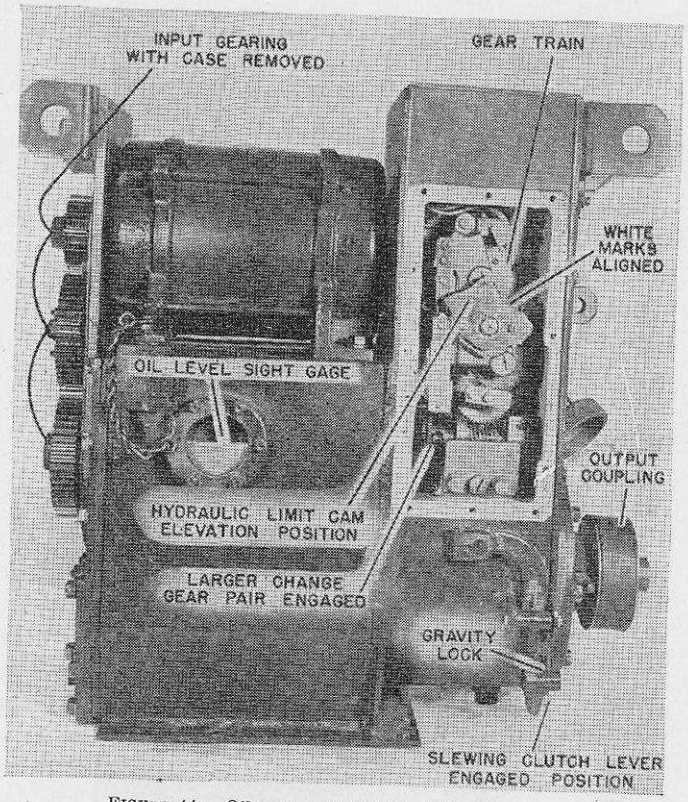


FIGURE 44.—Oil gear unit M3B1—left side view.

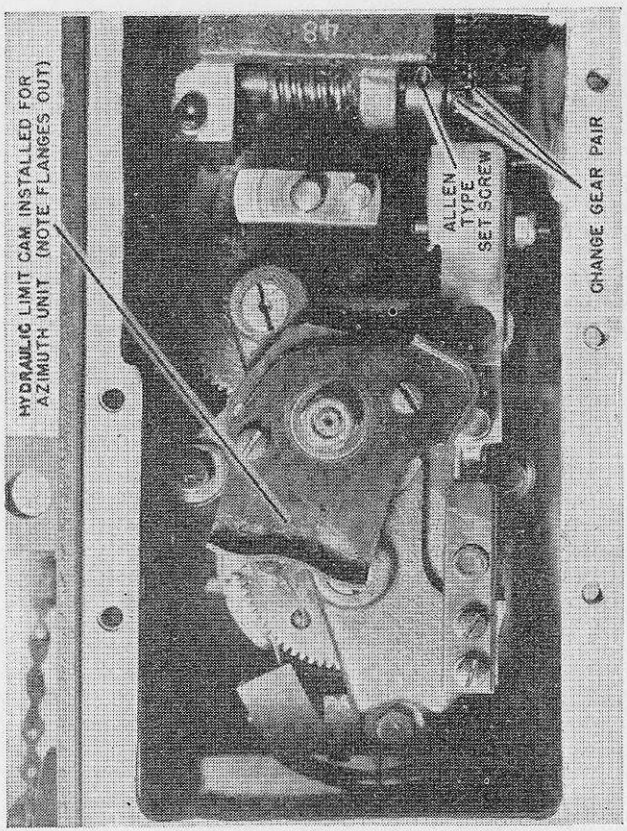


FIGURE 45.—Hydraulic limit cam installed for azimuth unit.

■ 138. CHANGING AN AZIMUTH TO ELEVATION UNIT OR VICE VERSA.—*a.* All M3B1 oil gear units are adaptable to azimuth drive or elevation drive. As they leave the factory, they are assembled one way or another as indicated by the small name plate (fig. 34) on the motor drive gear case. Any unit can be reversed in the field by performing the following operations:

(1) Remove the left-hand side cover looking at the coupling end of the unit (fig. 44).

(2) Loosen the Allen type setscrew in the collar of the change gear pair (fig. 45).

(3) To make an azimuth unit slide the change gear pair to the right hand position so that the smaller gear of the sliding pair will then mesh with the right-hand gear on the hydraulic motor shaft. To make an elevation unit, slide the change gear pair to the left, so that the larger gear of the pair meshes with the middle gear on the hydraulic motor shaft (fig. 45).

(4) Check to be sure the proper mesh is obtained and tighten the lock screw securely.

(5) To make an elevation unit, turn the hydraulic limit cam (fig. 44) so that the flanges face inward and will then contact the roller of the limit mechanism. There is a point marked on the cam and on the shaft showing its proper location, by matching the white lines. It may be necessary to slip the limit cam in either direction away from line up position of white marks (fig. 44) in order to get the limit cam to stop the gun at 0° when oriented with director. Thus final adjustments of limit cam, using the two screw heads holding it to the shaft, should be made with gun and director operating. This limit cam will commence to stop the gun 5° before it reaches the limit as set. To make an azimuth unit, turn the limit cam so that the flanges on the cam are toward the outside of case (fig. 45). This prevents it from acting on the limit mechanism.

(6) Replace the side cover.

(7) Remove the top cover over wiring compartment and put switch "on", for all self-synchronous units. If the unit is not self-synchronous (no elevation coarse transmitter in the director) turn switch to "off" position. Replace cover.

(8) To make an azimuth unit, remove the pin through the slewing clutch lever gravity lock (fig. 43) and insert the lock so that in the down position it does not lock the slewing lever.

In elevation units, the gravity lock must operate to lock the slewing lever in the down position.

(9) Change the small name plate on the motor gear by reversal so that it reads "Azimuth" or "Elevation", as required (fig. 34).

SECTION VI

UNIT, GENERATING, M5

■ 139. BATTERY.—The battery should be checked weekly for water supply. Level of liquid should be ¼ to ½ inch above top of plates. Terminals should be kept clean and tight and covered with a light coat of petrolatum to help prevent corrosion.

■ 140. AIR CLEANER.—The air cleaner is of the oil type and is normally self-cleaning except that oil in its reservoir should be changed at intervals, according to amount of dust in air. Air cleaner should be inspected daily and oil should be changed at the end of every day's operations if air is very dusty, otherwise once a week. Use same oil as specified for crankcase. At temperatures below 0° F., operate air cleaner without oil. The oil reservoir is in outside cup and, to be refilled, thumbscrew on bottom should be unfastened, cup dropped down, old oil emptied, and reservoir refilled to the bead with specified oil.

■ 141. GASOLINE FILTER.—Dirt or water in gasoline line will be trapped in glass bowl of gasoline filter and will be plainly visible. Gasoline should be turned off before removing bowl and care exercised not to damage gasket. If metallic filter element should clog, it should be blown out by means of a tire pump.

■ 142. BATTERY CHARGING GENERATOR.—The strap on battery charging generator that bears the name plate should be removed and commutator and brushes cleaned as often as necessary.

■ 143. OIL FILTER.—The oil filter has a replaceable element. Inspect after every 50 hours of operation and replace if element is plugged with sludge.

■ 144. FAN BELT.—The V-type fan belt should be kept in proper adjustment. It does not need to be extremely tight. It is tight

enough if it can be deflected about 1 inch when grasped midway between its pulleys.

■ 145. OIL PRESSURE.—Oil pressure should be approximately 15 pounds per square inch when engine is warm and running at 1,200 rpm. At lower speeds the pressure will be less.

■ 146. STARTER.—If starter pinion fails to engage engine flywheel properly, entire starter motor should be removed. The drive on end of armature should be cleaned and lubricated or spring replaced if found to be broken.

■ 147. DISTRIBUTOR.—Distributor cap should be removed occasionally and breaker points inspected. They should be kept smooth and bright and if pitted they should be replaced. The maximum spark gap should be 0.025 inch.

■ 148. CARBURETOR.—The carburetor has no adjustments for gas mixture; this was determined and fixed at factory. The only adjustment is for setting idling speed at approximately 900 rpm. To make this adjustment, throttle lever should be held against idling speed stop with engine at full operating temperature and idling screw adjusted until frequency meter reads 48 cycles or slightly less.

■ 149. SPARK PLUGS.—Spark plugs are 14-mm in size. The points of spark plugs should be spaced 0.025 inch apart.

■ 150. ADJUSTMENT FROM 50- TO 60-CYCLE CURRENT.—*a. General.*—For 50-cycle current, power unit should operate at 1,000 rpm for 60-cycle current it should operate at 1,200 rpm. M5 director requires 60-cycle, 130-volt current while Director M6 (British) requires 50-cycle, 145-volt current. (The voltages specified are those to which power plant should be adjusted when main switch is open and frequency is correct. When adjusted to these values the voltages should not drop below 115 and 130, respectively, even under adverse load conditions.)

b. Procedure.—(1) Pivot the links on subpanel from side numbered 50 to that numbered 60. Subpanel is mounted on right side of tool box.

(2) Start power unit and turn on power to director and gun. Adjust the adjusting screw on carburetor until frequency meter indicates 60 cycles.

SECTION VII

COMPUTING SIGHT M7

■ 151. GENERAL.—The alinement of the sighting system should be verified frequently and adjusted if necessary.

■ 152. ALINEMENT OF TELESCOPES.—The optical axes of the telescopes are alined parallel with each other and with the bore of the gun when superelevation and all deflections are removed from the sight.

a. Prepare gun for boresighting.

b. Remove the wing screw which connects the link from the trunnion to the superelevation cam shaft arm.

c. Remove the superelevation boresighting plug from its clip.

d. Tip the deflection mechanism control case forward, thereby rotating the superelevation cam shaft arm, so that the boresighting plug will aline its boss in the superelevation cam arm with the hole in the superelevation cam link. See figure 46 of sight in boresighting position.

e. Set speed to zero.

f. Boresight on a celestial body or other aiming point.

g. Adjust the telescope holders laterally and vertically as necessary to bring the telescopes onto the aiming point.

h. Remove the boresighting plug, tip the deflection mechanism control case into its normally vertical position, and connect the link from the trunnion to the superelevation cam arm with its wing screw.

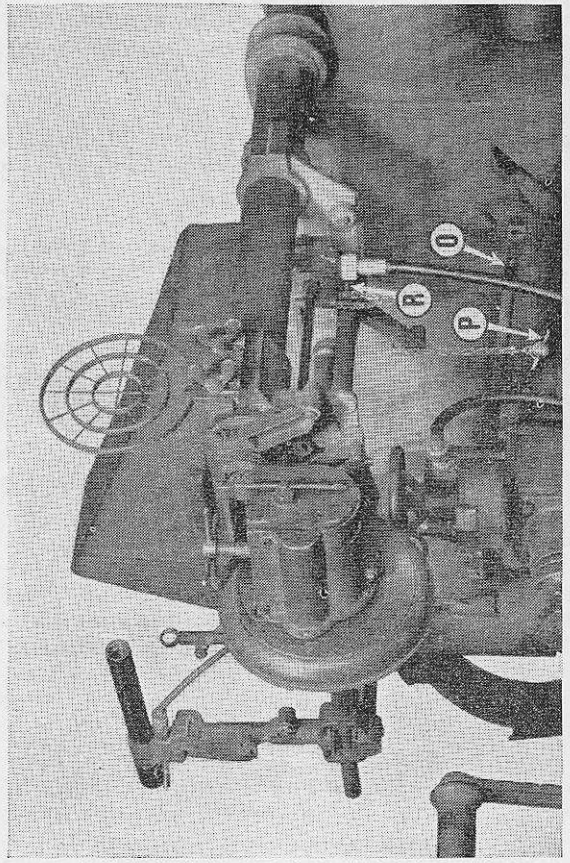
i. Insert the boresighting plug in its clip.

■ 153. VERIFICATION OF VERTICAL AXIS OF DEFLECTION MECHANISM CONTROL CASE.—The vertical axis of this case should remain vertical at all elevations of the gun.

a. Level the gun carriage.

b. Elevate the gun to 45° and place a gunner's quadrant (set at "0") or bench level across the bosses on the top of the control case.

c. If the bubble does not center, loosen the lock nuts at the two ends of the link from the superelevation cam shaft arm to the trunnion, and shorten or lengthen the link by turning the rod in the manner of a turnbuckle.



O. Link.
P. Link wing screw.
R. Boresighting plug (shown in boss (T) projecting into hole (U) in link (Q).

FIGURE 46.—Azimuth side of computing sight M7 in boresighting position.

d. Check the setting by using the gunner's quadrant at 0° and at 85° elevation. If there is a deviation of over 10 mils at either position, report to qualified personnel.

■ 154. VERIFICATION OF ALINEMENT OF MAIN ASSEMBLY WITH BORE.—*a.* Level the gun carriage.

b. Level the gun to zero elevation, using a gunner's quadrant set at "0."

c. Test level of the main bracket on the azimuth side by putting the gunner's quadrant across its two bosses. If there is a deviation of over 5 mils above or below zero elevation, report to qualified personnel.

■ 155. VERIFICATION OF AZIMUTH DRIVE TO ARROW.—*a.* Level the gun carriage.

b. Level gun to approximately zero elevation and aline bore and axis of arrow shaft with a distant object.

c. Set speed to 500 miles/hour.

d. Traverse gun through 360°. If axis of arrow does not remain directed at the same object, report to qualified personnel.

CHAPTER 6

DESTRUCTION OF EQUIPMENT

■ 156. GENERAL PRINCIPLES.—*a.* Tactical situations arise when, due to limitations of time or transportation, it becomes impossible to evacuate all equipment. In such situations it is imperative that all matériel which cannot be evacuated be destroyed to prevent—

(1) Its capture intact by the enemy.

(2) Its use by the enemy, if captured, against our own or allied troops.

b. The working principles to be followed are:

(1) Methods for the destruction of matériel subject to capture or abandonment in the combat zone must be adequate, uniform, and easily followed in the field.

(2) Destruction must be as complete as the available time, equipment, and personnel permit. If thorough destruction of all parts cannot be completed, the most important features of the matériel must be destroyed, and parts essential to the operation or use of the matériel and which cannot be easily duplicated, ruined or removed. *THE SAME ESSENTIAL PARTS MUST BE DESTROYED ON ALL LIKE UNITS TO PREVENT THE ENEMY'S CONSTRUCTING ONE COMPLETE UNIT FROM SEVERAL DAMAGED ONES BY "CANNIBALIZATION."*

(3) THE DESTRUCTION OF MATÉRIEL IS A COMMAND DECISION TO BE IMPLEMENTED ONLY ON AUTHORITY DELEGATED BY THE DIVISION OR HIGHER COMMANDER.

■ 157. METHODS.—*a.* The destruction procedure outlined is arranged *in order of effectiveness.* Destruction is accomplished by method No. 1, if possible. If method No. 1 cannot be used, destruction is accomplished by one of the other methods outlined, in the priority shown.

b. Whichever method is used, the sequence outlined must be adhered to. Uniformity of destruction is then obtained, whether or not the method is carried to completion.

c. Certain of the methods outlined require special tools and materials, such as TNT and incendiary grenades, which may not be normal items of issue. The issue of such special tools and

materials, the vehicles for which issued, and the conditions under which destruction are effected *are command decisions* in each case, according to the tactical situation.

■ 158. 40-MM GUN.—*a. Sights.*—Detach all optical sights, when used. *If evacuation is possible, carry the sights;* if evacuation is not possible, thoroughly smash the sights.

b. Method No. 1.—(1) Open drain plug on recoil mechanism, allowing recoil fluid to drain. *It is not necessary to wait for the recoil fluid to drain completely before igniting the fuze* (*(5) below*).

(2) Remove an HE shell from a complete round, and seat the shell in the chamber.

(3) Plug the bore, for approximately two-thirds of its length, using a ramrod wrapped with cloth or waste to make it fit tightly in the bore. Mud, stones, clay, etc., may be used to plug the bore in lieu of the ramrod.

(4) Cut down a ½-pound TNT block to fit snugly in the chamber behind the HE shell. Insert a tetryl nonelectric cap, with approximately 3 to 4 feet of safety fuze, into the TNT block. Close the breech as far as possible without damaging the safety fuze.

(5) Ignite the safety fuze and take cover at least 100 yards from the gun. Elapsed time is 2 to 3 minutes if ramrod is used to plug the bore and cut-down TNT block is carried with gun; longer if other bore obstructions are used.

c. Method No. 2.—(1) See *b*(1) above.

(2) See *b*(3) above.

(3) Insert one complete HE round into gun.

(4) Take cover and fire the gun using a lanyard 100 feet long. Elapsed time: 1 to 2 minutes using ramrod to plug the bore; longer if bore is plugged with mud.

d. Method No. 3.—(1) See *b*(1) above.

(2) Jam an HE round in the muzzle.

(3) Same as *c*(3) above.

(4) Same as *c*(4) above. Elapsed time: 2 to 3 minutes.

NOTE.—Spare barrels must be destroyed first by steps *d*(2), (3), (4).

■ 159. GUN CARRIAGE.—*a.* Whenever possible, artillery carriage destruction must be accomplished in conjunction with the demolition of the tube, breech, and recoil mechanism. *When this*

cannot be done, destruction of the tube, breech, and recoil mechanism has priority.

b. Method No. 1.—(1) Place ½-pound TNT block as indicated in table I. Detonate TNT charges simultaneously, using detonating cord, tetryl nonelectric caps, and at least 5 feet of safety fuze. Electric detonating methods may be used if available.

(2) This method of demolition may be combined with destruction of the tube, breech, and recoil mechanism (par. 158) by simultaneous detonation.

TABLE I.—*TNT charges for destruction of towed artillery carriages*

Carriage for—	Number of ½-pound TNT blocks	Placed—	Estimated time (required minimum)	Minimum danger zone (yards)
40-mm AA gun	4	One in breech casing through top cover; one elevation pinion housing; two front axle balancing spring.	6 to 7	200

c. Method No. 2.—(1) Fire adjacent guns at each other at point-blank range, using HE or AP shells. Several direct hits will be necessary to destroy 40-mm cannon by fire from guns of the same caliber. Fire from cover. Danger space is from 200 to 500 yards.

(2) Destroy the last gun and carriage by the best means available.

(3) *Danger from cannibalization is inherent in this method.*

■ 160. VEHICLES.—*a. Method No. 1.*—(1) Remove and empty portable fire extinguishers. Puncture the fuel tanks if readily accessible. Place TNT charges as indicated in table II. Insert tetryl nonelectric caps with at least 5 feet of safety fuze in each charge. Ignite the fuze and take cover. Elapsed time: 1 to 2 minutes *if* charges are prepared beforehand and carried to the vehicle.

TABLE II.—*Charges for destruction of vehicles*

Vehicle	TNT charge (pounds)	Placed—
Trucks	2	On top of clutch housing. It is necessary to open hood properly to place charge.
	2	On left side of engine as low as possible. (Use only if time is available.)
Trailers	2	Over axle inside each wheel.

(2) If charges are prepared beforehand and carried in the vehicle, *keep the caps and fuzes separated from the charges until used.*

(3) For the destruction of pneumatic tires, see paragraph 161.

b. Method No. 2 (for trucks).—Remove and empty the portable fire extinguishers. Puncture the fuel tanks if readily accessible. Smash all vital elements (such as distributor, carburetor, radiator, engine block, air and oil cleaners, generator, control levers, crankcase, and transmission) with a heavy ax, pick, or sledge. Pour spare gasoline, oil, or distillate over entire unit and ignite.

■ 161. PNEUMATIC TIRES.—*a. General.*—(1) Rubber is such a critical item that, whenever matériel is subject to capture or abandonment, an attempt to destroy pneumatic tires must always be made, *even if time will not permit destruction of the remainder of the vehicle.*

(2) With adequate planning and training, however, the destruction of tires may be accomplished in conjunction with destruction of the vehicle without increasing the time necessary.

b. Method No. 1.—(1) Ignite an M14 incendiary grenade under each tire.

(2) To insure the best results when this method is combined with the destruction by TNT of trucks or towed artillery carriages, be certain that the incendiary fires are well started before detonating the TNT.

c. Method No. 2.—(1) Damage the tires with an ax, pick, or heavy machine-gun fire (deflate them before doing this, if possible). Pour spare gasoline on tires, dousing each one, and ignite.

(2) When used in conjunction with wheeled vehicle destruction, the ensuing fire will adequately destroy the vehicle.

■ 162. MACHINE GUN, CALIBER .50 M2.—*a. Method No. 1.*—Field Strip. Use barrel as a sledge. Raise cover; lay bolt in feedway; lower cover on bolt, smash cover down over bolt. Deform backplate. Wedge buffer into rear of casing allowing depressors to protrude; break off depressors by striking with the barrel. Lay barrel extension on its side. Hold down with one foot, break off the shank. Deform casing by striking side plates just back of the feedway.

b. Method No. 2.—Insert bullet point of complete round into muzzle and bend slightly, distending mouth of case to permit pulling of bullet. Spill powder from case, retaining sufficient powder to cover the bottom of the case to approximately ⅛ inch. Reinsert bullet, *point first* back into case mouth. Chamber and fire this round with the reduced charge; the bullet will stick in the bore. Chamber one complete round, lay weapon on ground, and fire with a 30-foot lanyard. Use the best available cover as this means of destruction may be dangerous to the person destroying the weapon.

■ 163. MOUNT, MACHINE GUN, CALIBER .50, AA, M2A1, M3.—Use machine-gun barrel or tripod leg as a sledge. Deform or break traversing and elevating mechanisms. Deform or break recoil and counterrecoil system and trigger mechanism.

■ 164. AMMUNITION.—*a. General.*—(1) Time will not usually permit the destruction of all ammunition in forward combat zones.

(2) When sufficient time and materials are available, ammunition may be destroyed as indicated below. At least 30 to 60 minutes will be required to destroy adequately the ammunition carried by combat units.

(3) In general, the methods and safety precautions outlined in TM 9–1900 should be followed whenever possible.

b. Unpacked complete round ammunition.—(1) Stack ammunition in small piles. (Small arms ammunition may be heaped.) Stack or pile most of the available gasoline in cans and drums around the ammunition. Throw onto the pile all available inflammable material such as rags, scrap wood, and brush. Pour the remaining available gasoline over the pile. Sufficient in-

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flammable material must be used to insure a very hot fire. Ignite the gasoline and take cover.

(2) 40-mm ammunition can be destroyed by sympathetic detonation, using TNT. Stack the ammunition in two stacks, about 3 inches apart, with the fuzes in each stack toward each other. Place TNT charges between the stacks. Use a minimum of 1 pound of TNT per 10 rounds of 40-mm ammunition. Detonate all TNT charges simultaneously from cover.

c. Packed complete round ammunition.—(1) Stack the boxed or bundled ammunition in small piles. Cover with all available inflammable materials, such as rags, scrap wood, brush, and gasoline in drums or cans. Pour gasoline over the pile. Ignite the gasoline and take cover. (Small arms ammunition must be broken out of the boxes or cartons before burning.)

(2) (*a*) The destruction of packed complete round ammunition by sympathetic detonation with TNT is not advocated for use in forward combat zones. To insure satisfactory destruction involves putting TNT in alternate cases or bundles of ammunition—a time-consuming job.

(*b*) In rear areas or fixed installations, sympathetic detonation may be used to destroy large ammunition supplies if destruction by burning is not feasible. Stack the boxes, placing in alternate boxes in each row sufficient TNT blocks to insure the use of 1 pound of TNT per 10 rounds of 40-mm ammunition. Place the TNT blocks at the fuze end of the rounds. Detonate all TNT charges simultaneously. (See FM 5–25 for details of demolition planning and procedure.)

■ 165. FIRE-CONTROL EQUIPMENT.—*a. General.*—(1) All fire-control equipment, including optical sights and binoculars, is difficult to replace. It should be the last equipment to be destroyed, if there is any chance of personnel being able to evacuate. If evacuation of personnel is made, all possible items of fire-control equipment should be carried. If evacuation of personnel is not possible, fire-control equipment must be thoroughly destroyed as indicated below.

(2) Firing tables, trajectory charts, and similar items should be thoroughly burned.

(3) All optical equipment will be thoroughly smashed.

b. M5 director.—(1) *Method No. 1.*—Demolition with TNT is the most satisfactory. Remove telescopic sights and smash.

Remove side, front, and rear covers. Place ½-pound TNT charges in each side, connected together with detonating cord. Insert tetryl nonelectric cap with at least 5 feet of safety fuze in one charge. Replace covers as tightly as possible without damaging the fuze. Ignite the fuze and take cover.

(2) *Method No. 2.*—Remove telescopic sights and smash. Remove side, front, and rear covers. Completely smash the director mechanisms using an ax or sledge. Pour gasoline into the director and ignite.

(3) Smash all cable receptacles and plugs. All cables from the director to the guns should be heaped up in a pile, doused with gasoline, and burned. If time is available, cut the cables into short lengths with an ax before burning.

c. Power plant.—In general, follow the methods outlined in paragraph 160*b* for the destruction of trucks. Destruction of the generator and generator panel must be assured.

d. Power turrets.—(1) *Method No. 1.*—Use spare barrel as sledge and smash solenoids, Mk. 9 reflector sight, junction box batteries, and power charger. Remove guns and deform hangers with spare barrel. Cut spare V-belts for variable speed drive unit. Detonate 1-pound TNT charge under gunner's seat.

(2) *Method No. 2.*—Cut spare V-belts for variable speed drive unit. Remove hatch doors, and cut all V-belts on variable speed drive units. Remove and smah open cells of batteries. Remove and smash power charger. Remove and destroy all guns. Place ½-pound TNT charge against inner face of each trunnion and on top of variable speed drive unit and detonate. As an alternate method pile on wood or debris and ignite.

■ 166. DECONTAMINATION.—See FM 21–40, TM 9–850, and TM 3–series.

CHAPTER 7

ORIENTATION

SECTION I

GENERAL

■ 167. PURPOSE.—The purpose of orientation of the 40-mm automatic gun with the director M5 is to make the axis of the bore of the gun parallel to the axis of the director telescopes when no deflections exist in the director.

■ 168. ACCURACY LIMIT.—The limit of accuracy in orientation required to effect satisfactory fire control is 1 mil. This requirement means that the center line through the bore of the gun and the lines of sight through the director telescopes must not be out of parallelism in either the horizontal or the vertical plane by more than 1 yard in every 1,000 yards.

■ 169. ESSENTIAL REQUIREMENT.—The following requirements are essential to accurate orientation:

a. The gun and director must be level.

b. The gun remote control oil gear must be in proper adjustment with regard to backlash, dither, and creep explained in paragraphs 130, 131, and 132.

c. The director must be in proper operating condition as determined by the results of the following tests or checks explained in chapter 5.

(1) Alinement of telescopes (seldom out).
(2) Vertical plumb travel (seldom out).
(3) Backlash in azimuth (seldom out).
(4) Backlash in elevation (seldom out).
(5) Dynamic check of torque amplifiers for smooth operation.
(6) Constant speed motors for direction and speed of rotation.
(7) Superelevation run-down time to verify adjustment.
(8) Azimuth test problem to verify predictions.
(9) Elevation test problem to verify predictions.

d. The director must be prepared so that the following conditions prevail:

(1) The range index indicates the lowest value on the range dial.

(2) Each deflection gear is in that position at which, with no power being delivered to the director, no movement of the fine transmitter takes place when the range handwheel is moved from maximum to minimum. The deflection marks should be matched when the deflection gears are in this position.

(3) The tracking clutches should be out.

(4) The rate motor switches should be off.

e. The power and director cable connections must be in order and power must be supplied to the gun and director at correct voltage and frequency.

f. The orienting point or points must be selected with proper care as prescribed in paragraph 31.

g. The orienting procedure outlined in this manual must be thoroughly understood and correctly followed.

■ 170. PROCEDURE.—*a.* The procedure for accomplishing orientation in azimuth is distinctly different from that required for accomplishing orientation in elevation when guns equipped with the remote control systems M5 and oil gears M1 are concerned.

b. Azimuth orientation involves four main steps:

(1) The axis of the bore of the gun is pointed exactly at the orienting point by means of the oil gear units controlled remotely by the director which is moved as necessary by direct tracking (movement of tracking handwheels with clutches disengaged).

(2) The director electrical transmission system is locked and its azimuth mechanical motion is interrupted so that the director can be moved without disturbing its electrical transmission system or causing movement of the gun.

(3) The vertical reticle of the azimuth telescope is pointed exactly at the orienting point by means of the tracking handwheel.

(4) The director electrical transmission system is unlocked and its mechanical motion is reengaged so that any movement of the director will cause equal motion of the gun.

c. Elevation orientation involves four main steps:

(1) The horizontal reticle of the elevation telescope is pointed exactly at the orienting point by means of the tracking handwheels.

(2) The gun elevation oil gear resetter transmitter is disconnected from its drive gear by means of loosening the three screws of its friction connection.

(3) The axis of the bore of the gun is pointed exactly at the orienting point by means of the elevation oil gear resetter transmitter. (See par. 129.)

(4) The gun elevation oil gear resetter transmitter is reconnected to its drive gear by means of tightening the three screws of its friction connection.

d. The detailed procedures which fire unit personnel must follow to accomplish correct orientation in azimuth and in elevation are outlined in the drill contained in paragraph 31. For orienting procedure for guns equipped with remote control systems M10 and oil gears M3B1, see paragraph 136.

e. When the tactical situation permits, orientation should be checked by firing trial shots. (See par. 34.)

■ 171. PRACTICE.—It is essential that orientation be practiced often. Personnel must be encouraged to devise many means for effecting accurate orientation in the face of a variety of conditions and full advantage must be taken of this constructive thinking by requiring that orientation be accomplished under many difficult assumed or imposed conditions such as adverse terrain and blackout.

SECTION II

METHODS

■ 172. GENERAL.—The methods of orientation are divisible into two main classes: parallelism, where the axis of the bore and the line of sight are made absolutely parallel; and convergence, where the axis of the bore and the line of sight are made to converge upon a common point selected so that the converging angle does not exceed 1 mil. Under certain circumstances, orientation in azimuth and in elevation are accomplished by the same process. Under other circumstances, orientation in azimuth is accomplished by one method and orientation in elevation is accomplished by another method. The choice of methods often depends upon whether orientation is to be undertaken during the day or at night.

■ 173. PARALLELISM.—The axis of the bore of the gun and the lines of sight of the telescopes are made parallel by the following methods:

a. A celestial body is selected as the orienting point. Care must be taken to select one that is bright, easily identified, and conveniently located. The North Star or a star which does not appear to move rapidly is well suited; however, the moon can be used successfully. The axis of the bore of the gun is placed on the orienting point by means of the director, the director transmitter is locked, the director orienting clutch figure is disengaged, the vertical reticle of the azimuth telescope is placed

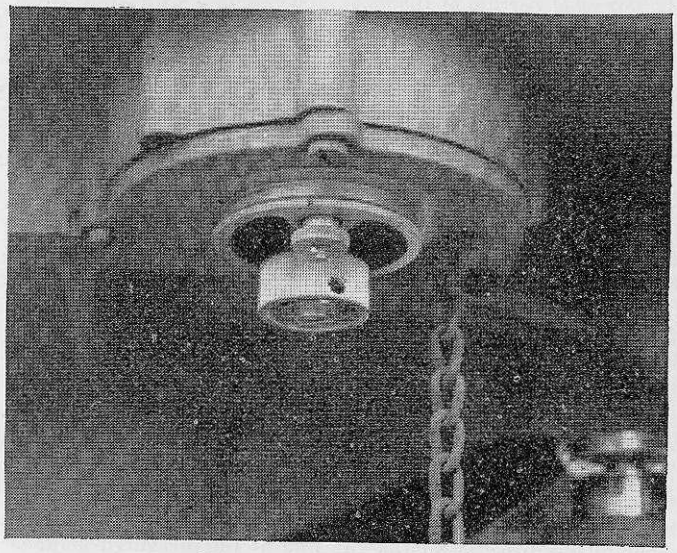


FIGURE 47.—Orienting clutch.

on the orienting point, the orienting clutch is reengaged, and the transmitter is unlocked. If out in elevation, the horizontal reticle of the elevation telescope is placed on the orienting point and the resetter transmitter of the gun elevation oil gear is adjusted as required. (See par. 129.) If the moon is used as the orienting point allowance must be made for its size and motion. A satisfactory method is as follows: The gun and director are oriented approximately. By means of the director, the bore of the gun is placed toward the moon so that the right most portion of the moon appears just to the left of the vertical

reticle of the gun bore sight. The director transmitter is locked and the orienting clutch is disengaged. The moon is now tracked in such a manner that the left most portion of the moon appears just to the right of the vertical reticle of the azimuth telescope. Tracking with the director is stopped at that instant when the left most portion of the moon appears even with the vertical reticle of the gun bore sight. The orienting clutch is then reengaged, the transmitter is unlocked, the director is traversed until the left most portion of the moon appears even with the vertical reticle of the director and tracking is continued in this manner until it is verified that the moon appears in exactly the same place with respect to the vertical reticle of the gun bore sight. Orientation in azimuth and in elevation are accomplished similarly by this method which can be employed during evening, night, and early morning when the weather permits.

b. Two stakes are correctly placed, and the axis of the bore of the gun is placed upon one and the line of sight of the appropriate director telescope is then placed upon the other. The steps involved are as follows:

(1) When orienting in azimuth, the power is turned off and the gun and director are placed manually at 90° with and pointing to the same side of the gun-director line. The distance from the center of the azimuth telescope to the center of the gun is then measured. The center of the 40-mm gun is located approximately halfway between the pawls and front guide on the autoloader. When this distance is established, one stake is emplaced at some point along the line of sight of the azimuth telescope and another stake is emplaced at 90° from the telescope line of sight in the direction of the gun and at the measured distance from the first stake. Now with power on, the gun is placed on the second stake, the director transmitter is locked, the orienting clutch is disengaged, the director is placed on the first stake, the orienting clutch is reengaged, the director transmitter is unlocked and the correctness of orientation is checked carefully.

(2) When orienting in elevation, the procedure in (1) above is carried out with the following additions: just prior to manually placing the gun and director at 90°, the director is slewed so that the line of sight of the elevation telescope is pointed toward the pintle center of the gun, the telescopes are placed at zero elevation as indicated by elevation fine transmitter dial,

and the difference in height between the center of the telescope shaft and the center of the gun trunnion is measured by using the director as a transit. In order to permit satisfactory use of the telescope for clear registration at short distances, it is necessary to cover the front of the telescope with a peep sight made from a piece of cardboard or other opaque material in the center of which a round hole of approximately $\frac{3}{16}$-inch diameter has been cut. This small hole must be centrally located with respect to the objective (front) lens. After the difference in height between shaft and trunnion has been measured, the procedure in (1) above is followed; however, the director telescopes are kept level at all times and the gun is set at zero elevation also. The fact that the director and gun are so placed limits the use of this method to terrain which will permit the emplacement of the stakes into ground which is approximately at the same level as the gun. Following the emplacement of the stakes, a mark is placed on each stake at the exact level of the center of the telescope shaft, and another mark is placed upon the stake on which the gun is to be bore sighted. This second mark is located at a distance from the first mark which is equal to the difference in height between the center of the telescope shaft and the center of the gun trunnion. When the marks have been made, the gun and director are oriented in elevation by holding the director telescope on its mark and adjusting the gun elevation oil gear as required to bring the axis of the bore of the gun exactly on its mark.

NOTE.—Carefully selected terrain features or structures suitably marked can be used in lieu of stakes and in situations which permit the use of lights this method can be used at night.

c. The azimuth telescope is sighted through the bore of the gun in order to place its line of sight in coincidence with the axis of the bore of the gun. When this method is employed, it is necessary to focus the azimuth telescope so that the bore of the gun and the reticles of the telescope are clearly defined, and the peep sight described in paragraph 173*b* (2) is recommended. Orientation is accomplished in the following manner: The gun is slewed until it points away from the director. The gun and director are then manually operated until the line of sight of the azimuth telescope is made to coincide with the axis of the bore of the gun. This condition is obtained through successive move-

ments of the gun and director in azimuth and elevation. The height of the gun also is adjusted as required by means of the jacks and care is taken to insure that the gun remains level. When the gun and director have been properly positioned manually, the gun elevation switch is left off, the main power switch between the power plant and the gun is closed, and the gun slewing clutch is engaged. The director transmitter is locked, the director orienting clutch is disengaged and the director transmitter is unlocked (both small knurled nut and large knurled knob of orienting clutch must be loose). After the completion of the above steps, the gun and director are moved into line for azimuth. The gun is moved under power by turning the transmitter drive shaft inside the large knurled knob with a coin or screw driver and such movement of the director as may be required is done by means of the tracking handwheel. With the gun and director now oriented in azimuth, the director transmitter is locked, the director orienting clutch is engaged, the director transmitter is unlocked, and the azimuth indicator on gun is adjusted until the dial is blacked out (or pointers matched). Upon the completion of orientation in azimuth, the elevation switch is turned on and if the gun and director are out of elevation, the gun elevation oil gear is adjusted. (See par. 129.) After the gun is fully oriented, it is lowered by its jacks and checked for level. This method can be used during daylight and at night by directing the beam of a flashlight down the bore from the muzzle.

d. The axis of the bore of the gun is made to point in the same direction in azimuth as the line of sight of the azimuth telescope by sighting along the center line of gun barrel. This method requires an orienting point which is located along the line of sight of the azimuth telescope when the telescope is pointed at the pintle center of the gun. Orientation in azimuth is accomplished in the following manner: The center of the front guide of the autoloader is located and a mark is placed thereat upon the upper rear edge. With power off, the gun and director are pointed approximately in the same direction. The gun is then elevated so that the mark, when seen through the azimuth telescope, will appear just above the rear guide of the autoloader (fig. 48). With the gun elevated to this position, the mark on the front guide will be almost directly above the azimuth pintle center of the gun. When the gun and director have been posi-

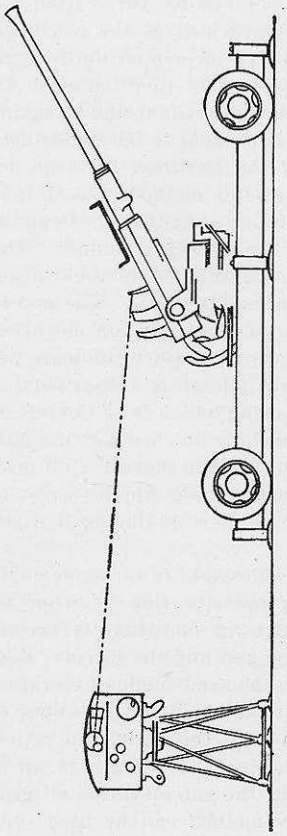


FIGURE 48.—Azimuth telescope alined on pintle center of gun. (Line of sight should just clear rear guide; side frames are not involved.)

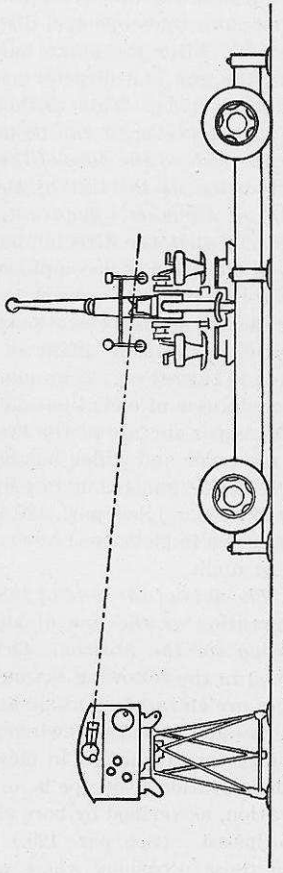


FIGURE 49.—Gun traversed 90° to permit placing stake on line of sight of azimuth telescope.

tioned in this manner and the vertical reticle of the azimuth telescope is on the mark, the azimuth handwheel is wedged lightly and the gun is traversed out of the way so that it will not interfere with the line of sight of the azimuth telescope (fig. 49). A stake is now set up in line with the vertical reticle of the azimuth telescope at a distance of 50 to 100 yards from the director. After the stake has been provided as the orienting point, the gun and director are oriented in manner outlined in paragraph 173*a*. This method applies only to orientation in azimuth; however, it can be used during daylight and at night.

e. The axis of the bore of the gun is brought to the same angle of elevation as the line of sight of the elevation telescope by means of a gunner's quadrant. When this method is used, it is necessary that the director be in proper adjustment. Orientation in elevation is accomplished in the following manner. The director telescopes are brought to the selected angle of elevation as indicated by the elevation fine transmitter dial. The gun is brought to the same angle of elevation and the gun elevation switch is turned on. A gunner's quadrant is set to indicate the selected angle of elevation and is then placed upon that portion of the upper surface of the breech casing which is to the left of the top cover and which has been machine finished for this purpose. If the gun is out in elevation, the gun elevation oil gear is adjusted. (See par. 129.) This method applies only to orientation in elevation; however, it can be used during daylight and at night.

f. The axis of the bore of the gun is brought to the same angle of elevation as the line of sight of the elevation telescope by sighting on the horizon. Orientation in elevation is accomplished in the following manner: The gun and the director telescopes are elevated approximately to the same angle of elevation and the gun elevation switch is turned on. The telescopes of the director are moved in elevation until the horizontal reticle of the elevation telescope is on the horizon. If the gun is out in elevation, as verified by bore sighting, the gun elevation oil gear is adjusted. (See par. 129.) This method can be used only upon those occasions where an unobstructed view is afforded and when orientation can be accomplished during daylight or moonlight.

■ 174. CONVERGENCE.—The axis of the bore of the gun and the lines of sight of the telescopes are made to converge upon a common point by the following methods:

a. A distant point is selected as the orienting point. Care must be taken to select one that will permit convergence within the limit of accuracy of one mil. (See par. 31 and 168.) A practical method for testing the suitability of any orienting point is to move the gun and director manually until the line of sight of the azimuth telescope and the axis of the bore of the gun are on the point; stand in line with and facing the azimuth telescope, and estimate the distance from the line of sight to the axis of the bore of the gun in terms of yards. The point is satisfactory when it is located as many thousand yards away from the gun position as there are yards separating the line of sight of the azimuth telescope from the axis of the bore of the gun. A point which has been approved in this manner must be regarded as being located at the minimum distance away from the gun position; therefore, the point which produces the smallest angle of convergence should be used when more than one suitable point is available. After the proper orienting point has been selected, orientation is accomplished as outlined in the drill contained in paragraph 31. This method can be used for orienting in azimuth and in elevation during daylight. It can also be used at night, when it is safe and practical to use a light for the orienting point.

b. The axis of the bore of the gun and the line of sight of the elevation telescope are sighted on a horizontal line. This method requires a well-defined horizontal line such as is provided by a building or bridge. The line selected must be approximately perpendicular to a line from it to the gun position. Orientation in elevation is accomplished as provided in paragraph 173*f*.

APPENDIX I

ECHELONS OF MAINTENANCE

■ 1. 40-MM AUTOMATIC GUN M1.—First and second echelons.

a. Adjust counterrecoil adjusting nut.
b. Exercise recoil.
c. Clean and lubricate gun.
d. Boresight gun.
e. Replace following.
(1) Barrel assembly.
(2) Breech ring and components.
(3) Breechblock and components.
(4) Breechblock inner cocking lever.
(5) Breechblock outer cocking lever.
(6) Breechblock closing spring and components.
(7) Extractor and components.
(8) Loading tray rammer pad.
(9) Feed pawls on automatic loader.
(10) Recoil cylinder complete assembly.

■ 2. 40-MM CARRIAGE M2.

a. First echelon.
(1) Replace complete wheel assembly.
(2) Clean and lubricate carriage.
(3) Inflate tires.
(4) Change tires.
b. Second echelon.—Check voltage in electric brakes and lighting system.

■ 3. DIRECTOR M5.

a. First echelon.
(1) Open sight—adjust.
(2) All external surfaces including telescope flanges and seats—clean.
(3) Telescope lenses (external surfaces only)—clean.
(4) Telescope lamps—replace.
(5) Socket assemblies—replace.
(6) All handwheels and external parts of the director and tripod requiring lubrication—lubricate.
(7) All exposed or scratched surfaces—retouch with paint.
(8) Telescopes—aline.

(9) All possible tests without removing the cover plates on the director—run.
(10) Rubber eyeshields—replace.
b. Second echelon.
(1) Range dial—replace and make corresponding micrometer adjustment.
(2) Range stop pins—replace.
(3) Reticle light cables—repair and replace.
(4) Levels—replace and adjust.
(5) Rate motor—replace.
(6) Rate motor governor—adjust.
(7) Torque amplifier (Directors M5 and M6)—replace.
(8) Range dial lamp—replace.
(9) Fuses (Directors M5 and M6)—replace.
(10) Transmitters—replace.
(11) Elevation mechanical stops—adjust.
(12) Gear segment—reengage.
(13) Brush support assembly—clean.
(14) Solenoid brake (Director M5A1)—adjust.
(15) Packing chest—repair.
(16) Tripod M7—repair.
(17) Over-all inspection—repair.

■ 4. REMOTE CONTROL SYSTEM M5.

a. First echelon.
(1) Oil gear.
(*a*) Adjust dither.
(*b*) Adjust pilot valve.
(*c*) Maintain hydraulic oil level.
(*d*) Drain and refill gear case.
(*e*) Maintain oil level in chain case.
(*f*) Maintain oil level in clutch housing.
(*g*) Grease clutch housing fitting.
(*h*) Oil ball-float reservoir.
(*i*) Replace oil gear unit.
(*j*) Reverse motor leads.
(*k*) Remove and replace sensitive valve to flush out unit.
(2) Azimuth indicator—adjust mechanically.
(3) Azimuth switch and elevation limit switch.
(*a*) Replace fuses.

(*b*) Tighten switch.

b. Second echelon.

(1) Oil gear.

(*a*) Change azimuth unit to elevation and vice versa.

(*b*) Replace bad connections to gun transmitter and electrical differential.

(*c*) Clean oil filter bobbin.

(*d*) Replace oil filter bobbin.

(*e*) Replace chain case gaskets.

(2) Azimuth indicator.

(*a*) Tighten electrical shutter wedge.

(*b*) Replace indicator.

(3) Azimuth switch and elevation limit switch.

(*a*) Replace blown fuses.

(*b*) Tighten switch contacts.

(4) Gun junction box.

(*a*) Tighten electrical connection.

(*b*) Check continuity of wiring system. (See fig. 31.)

(5) Cables.

(*a*) Minor repairs to cables.

(*b*) Replace cables.

■ 5. UNIT, GENERATING, M5 OR M10.

a. First echelon.

(1) Maintain oil level in crankcase.

(2) Maintain gas in tank.

(3) Maintain battery water level.

(4) Maintain radiator water level.

(5) Renew fuze links.

(6) Clean gasoline sediment bowl.

(7) Paint all exposed surfaces.

(8) Replace lamps.

(9) Drain crankcase oil and refill.

b. Second echelon.

(1) Grease, oil, and lubricate.

(2) Clean or replace air and oil filters.

(3) Adjust engine governor.

(4) Clean and flush radiator and cooling system.

(5) Adjust or replace fan or generator belts.

(6) Replace battery.

(7) Replace generator.

(8) Replace starting motor.

(9) Check and tighten all electrical terminals.

(10) Replace small sections of wiring between terminals.

(11) Adjust "zero" settings on voltmeters and ammeters.

(12) Adjust oil pump pressure.

(13) Adjust rate of charge of battery charging generator.

(14) Adjust spring tension or replace brushes on starter motor, battery charging generator, exciter, and/or alternator.

(15) Sandpaper commutators on starter motor, battery charging generator and exciter.

(16) Change operation from 50 to 60 cycles, or vice versa.

(17) Replace the following engine and generator accessories:

(*a*) Spark plugs and ignition wiring.

(*b*) Spark coil.

(*c*) Cylinder head and gasket.

(*d*) Intake and exhaust manifolds.

(*e*) Valve tappet covers.

(*f*) Fan assembly.

(*g*) Starter.

(*h*) Starter Bendix spring.

(*i*) Generator, battery charging.

(*j*) Generator, battery charging voltage regulator.

(*k*) Water cooling system hose.

(*l*) External oil lines.

(*m*) Oil pan.

(*n*) Water cooling system thermostat.

(*o*) Carburetor.

(*p*) Battery cables.

(*q*) Voltage regulator.

(*r*) Water pump packing.

(*s*) Oil filter.

(*t*) Oil gauge.

(*u*) Oil lines and fittings.

(*v*) Oil strainer.

(*w*) Fuel gauge.

(*x*) Battery cables.

(*y*) Starting switch.

(*z*) Frequency meter.

(*aa*) Muffler.

(*ab*) Exhaust pipe.

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(*ac*) Small electrical components on the panel.
(*ad*) Ammeter.

■ 6. CALIBER .50 MACHINE GUN, M2, W. C.—See FM 4–155.

■ 7. MULTIPLE CALIBER .50 MACHINE-GUN CARRIAGE, M–51.—See FM 4–157.

■ 8. COMPUTING SIGHT M7.
a. Aline telescopes.
b. Clean telescopes.
c. Clean all external surfaces.

APPENDIX II

USE AND EMPLOYMENT OF DIRECTOR TRAINER M8

SECTION I

GENERAL

■ 1. PURPOSE OF TRAINER.—*a.* The director trainer M8 was developed as an aid in training range setters for M5 directors. The device consists of an artificial M5 director target and tracer stream. It is intended for indoor use. All shots produced by the device are "line" shots.

b. The director trainer M8 permits the range setter to develop skill by giving him practice and experience in interpreting artificial line shots, and reacting by manual operation of the range handwheel. However, use of the trainer is not a substitute for actual practice firing.

■ 2. REFERENCES.—*a.* TM 9–657 contains a complete description of the trainer and instructions for its unpacking, installation, mechanical operation, care, and maintenance.

b. FM 4–151 contains a detailed discussion of the principles of fire control and of range adjustment for the M5 director.

SECTION II

PRELIMINARY INSTRUCTIONS

■ 3. OBJECTIVE.—The training objective for range setters on M5 directors is to develop to a high degree and maintain their ability to watch tracers, interpret them accurately, make instant decisions, and react by automatic and correct adjustment of the range handwheel.

■ 4. TRAINING PLAN.—*a.* Instruction in the following must be given immediately before training on the M8 trainer:

(1) *Method of prediction.*—Director characteristics and the angular travel method of prediction.

(2) *Method of fire adjustment.*—*First*, causing the tracers to intersect the line of sight to the present position of the target; that is, obtaining line shots. The trainer provides this. In actual firing, this is the result of proper tracking. *Second*, causing this intersection to take place at a future position of the

target, by applying a range setting that corresponds with this future position. Hits are obtained as the target flies through that future slant range.

b. A brief preliminary explanation of the trainer, its purpose, and its method of operation, must be given the students. The instructor emphasizes just what decisions regarding range adjustments the range setter must make, and how these decisions are made on the basis of tracer observation. The charts of various trainer target courses are shown, and the section grouped around the front of the trainer to observe the movement of the conductor-wiper contact on the chart as several courses are run through the trainer.

c. Director trackers also are included for a proportion of the training on the director trainer M8, when director crews are established. In this phase of training the range setter adjusts range, but only on reports of "Over," "Short" or "Hit" made by the trackers, and does not watch the tracers himself. The trackers stand at their normal posts for director control and, observing the tracers, call out sensings.

d. Training on the Hunt miniature range (see par. 13) may proceed at the same time as training on the M8 director trainer. The more proficient men, or those already assigned as range setters, may be given more advanced training on a combination of the Hunt range and the director trainer. (See par. 14.)

■ 5. PRECAUTIONS.—*a.* The instructor must insist that range setters make bold adjustments of range, hold the setting until the target has flown through this range, then make bold corrections to keep well "ahead" of the target. The practice of a creeping adjustment will not be permitted.

b. The range setter must be careful to make "jumps" in range in the right direction. He must never reverse the direction of turning the handwheel during any one leg of a course.

c. After the first range setting is made, the range setter must not look at the range dial. He must learn by practice to know all the time what range setting he has in the director. Once range is initially set, concentration of mind alone must be relied on.

d. Some men may attempt to memorize courses for the trainer in order to get an impressive number of hits. The instructor must impress upon the men that such efforts are worse than

useless, as the trainer is only a means to an end. The aim is to produce hand-eye coordination, not artificially high scores.

e. As the value of training to the range setter depends on practice in making adjustments based on what he actually sees, no coaching is permitted by anyone. However, it may be found desirable to permit an observer to call out "Midpoint" of the course from the chart if there is difficulty in determining from the aspect of the target the time at which midpoint is reached.

SECTION III

TRAINING

■ 6. ORGANIZATION OF GROUPS FOR INSTRUCTION.—In the absence of a routine operating and recording crew for the equipment, groups for instruction should be organized in groups of five men; one man as range setter, two as first and second range recorders, and two as first and second shot recorders. However, where several organizations can cooperate, it will be found profitable to employ a single operating crew and record section to "process" the large number of trainees more efficiently.

■ 7. OPERATION OF RECORD SECTION.—*a.* Two record sheets, "A" and "B," are used for each range setter's record course.

b. Record sheet "A" (fig. 50) is used by the first range recorder to indicate changes made in the range dial setting. The first range recorder stands near the target assembly, and in rhythm with the calling off of the sensing of each shot by the first shot recorder (see *c* below) touches his pencil lightly opposite each respective shot number on record sheet "A." When he hears "Range" called out by the second range recorder (see *d* below) he marks an "X" opposite the shot number on which his pencil falls at the instant.

c. The first shot recorder is stationed at the target assembly and, in a low voice, calls sensings of "Short," "Over," or "Hit," which are recorded on the record sheet "B" (fig. 51) by the second shot recorder. The sensings are called out only for the benefit of the recorder, and must not be loud enough to be heard by the range setter. The first shot recorder will not use signals to indicate sensings.

d. The second range recorder stands behind the range setter and records the initial range and each new range setting. Each

time the range setter turns the handwheel to set in a new range, he calls out "Range," for the first range recorder to hear, and records the new ranges in a column on plain paper. When the course is over, the appropriate range settings are recorded from this column, on record sheet "A."

■ 8. INTERPRETATION OF RECORD SHEET "A" AND "B."—Record sheet "B" indicates the number of hits obtained, and record sheet "A" generally indicates why any poor scores are obtained. Record sheet "A" also indicates immediately whether or not a man is making range adjustments in the proper manner, regardless of the score of hits.

■ 9. ROUTINE OF INSTRUCTION.—*a.* During the first training period, a slow target course chart is used (60 yards per second). Each range setter is given a minimum of five courses on this

RECORD SHEET "A"

(Sample copy)

Shot No.	Range dial setting	Shot No.	Range dial setting	Shot No.	Range dial setting
1	1540	19		37	
2		20		38	
3		21x	985	39	
4		22		40x	985
5		23		41	
6		24		42	
7		25x	822	43x	1175
8x	1410	26		44	
9		27		45	
10		28		46	
11		29		47x	1280
12		30		48	
13x	1280	31		49	
14		32		50	
15		33		51x	1540
16		34		52	
17x	1070	35		53	
18		36		54	

DIRECTIONS.—Record the range dial setting at start, and each time change is made. Enter each new dial setting opposite observed shot number.

FIGURE 50.—Illustration of use of record sheet "A" for director trainer M8.

chart. The members of the five-man groups should rotate, so that each man acts as range setter for five courses at a time.

b. The above courses may be run in 10 minutes for each man with an ample allowance of time for the interpretation of the record sheets for each range setter as he finishes a course.

RECORD SHEET "B"

(Sample copy)

Shot No.	Short	Hit	Over	Shot No.	Short	Hit	Over	Shot No.	Short	Hit	Over
1	x			19			x	37		0	
2	x			20			x	38			x
3	x			21			x	39			x
4	x			22			x	40			x
5		0		23			x	41			x
6		0		24			x	42			x
7		0		25		0		43			x
8			x	26		0		44			x
9			x	27		0		45		0	
10		0		28			x	46			x
11			x	29			x	47			x
12			x	30			x	48			x
13			x	31		0		49			x
14			x	32		0		50			x
15			x	33		0		51			x
16			x	34		0		52			x
17			x	35		0		53			x
18		0		36		0		54			x

Record "shorts" and "overs" by making x in proper column.
Indicate hits by placing circle in proper column.

FIGURE 51.—Illustration of use of record sheet "B" for director trainer M8.

■ 10. RANGE ADJUSTMENT TABLE.—Figure 52 is a tabulation of the basic rules used as guidance in adjustment of fire by range setting. The fourth column is used when no sensings are obtained, and its application must be used and stressed in advance training, where the sensings are reported by the trackers.

■ 11. ANALYSIS OF CORRECT FIRE ADJUSTMENT FOR A SPECIFIC COURSE.—*a.* Figure 53 illustrates graphically, application of the principles of fire adjustment embodied in the table in figure 52,

for a particular course. The data used in preparation of figure 53 duplicate the data assumed for the corresponding chart for the trainer, and illustrate correct range adjustment. The symbols in the legend must be studied before attempting to interpret the chart.

b. The timing of rounds *as fired*, is shown across the top of the chart. The range settings, the timing of rounds *as observed*,

RANGE ADJUSTMENT TABLE

Speed and position of target	Range change in handwheel turns			
	Short	Hit	Over	No sensing[1]
High speed (300 mph or over):				
Approaching leg	No change	−1½	−3	−3
Midpoint	+2	No change	No change	No change
Receding leg	+3	+1½	No change	+3
Moderate service speed (under 300 mph):				
Approaching leg	No change	−1	−2	−2
Midpoint	+1	No change	No change	No change
Receding leg	+2	+1	No change	+2
Target practice speed (under 150 mph):				
Approaching leg	No change	−½	−1	−1
Midpoint	+½	No change	No change	No change
Receding leg	+1	+½	No change	+1

[1] When no sensings are made, range adjustment is made when the estimated present range is equal to the actual range setting.

FIGURE 52.—Table for use as guide in technique of range setting.

together with sensings, show in the irregular stepped graph across the chart. Every tenth round is numbered for convenience in matching rounds as fired with the same rounds as observed. Time of flight, t_p, is also shown, by the curve at the bottom of the chart.

c. Assume that fire is opened on this course for a present range of 2,000 yards or more; an initial range setting of 1,540 yards (seven turns of the handwheel) is used.

(1) Fire commences and continues at the rate of one round per second throughout the course. By the time the first round is observed, rounds number two and three have already been

fired. The range setter sees the first round as "short" just after the third round is fired. The reaction time for observation, decision, and range adjustment is about 2 seconds; this means that two more rounds have been fired by the time he senses the first round as "short" and decides "no change."

(2) The fifth round registers a hit, and in 2 more seconds, the range setter has sensed this shot, made his second decision, and reduced the range setting by one half turn of the handwheel. Note that observation of the sixth and seventh rounds, also hits, does not affect the decision made from sensing round number five as a "hit."

(3) The next round to reach the target after this second decision on range is shot number ten. Accordingly, range is again reduced one-half turn of the handwheel. The round fired immediately thereafter, number fourteen, is sensed as an "over" and the range setting is reduced by a full turn of the handwheel. Note that this round (the fourth on which a decision is made) is the fourth "over" in a series of seven "overs," but that the adjustment made on observing it yields a hit.

Two things are paramount: first, the range setter must make bold changes in range. Second, he must allow the first projectile fired on the basis of each new range setting enough time to reach the target, before reacting again to tracer observation; he must ignore intervening rounds.

(4) The process continues similarly until round twenty-five is observed as a hit near midpoint. Accordingly (see fig. 52) the range setting is not changed. Rounds twenty-six and twenty-seven are also hits. Round twenty-eight is an "over," but being observed near midpoint, range setting is not altered. Rounds twenty-nine and thirty are also "over." However, rounds thirty-one to thirty-seven are observed as hits.

(5) Round thirty-eight is observed "short" and a full turn increase of range setting is made. However, this does not produce a hit for a subsequent round (number forty-one) and again range is increased by a full turn in accordance with the principles contained in figure 52.

Record sheets "A" and "B" are based on the graph of the course illustrated in figure 53.

■ 12. ADVANCED TRAINING ON HIGH SPEED COURSES.—*a.* Training is continued by the use of higher speed courses. Charts based on

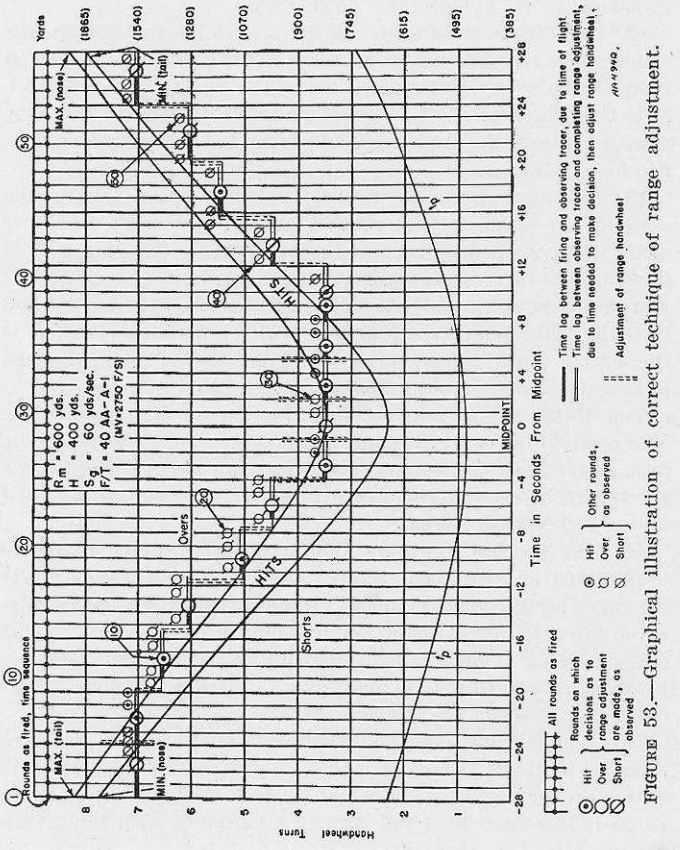


FIGURE 53.—Graphical illustration of correct technique of range adjustment.

a variation of R_m and H for the various high-speed courses are run in an orderly sequence. In high-speed courses a series of shorts may occur, then overs with no intervening hits, or vice versa. However, the table for range adjustment indicates the proper number of handwheel turns which must be applied in order to get the maximum probability of hits.

b. During advanced training, the range setter is subjected to the distracting effect of battle noises and muzzle blast, produced by the equipment. He is required to wear a gas mask for a number of the courses.

c. The degree of ability which the range setter demonstrates in making adjustments in range on the various courses, target practice speed and high speed, is a measure of his efficiency on the trainer. In making an estimate of a man's ability, record sheets "A" and "B" are useful. In the analysis of the record sheets special emphasis is placed on the reaction time (the time required to make the correct range adjustment) of the range setter and upon the number of hits he obtains.

d. When the relative positions of the target and the tracer can be quickly and correctly interpreted by the range setter, his reaction to overs and shorts becomes automatic. Such hand-eye coordination, if thoroughly developed in training practice, is easily brought into effective use in actual combat.

e. The preliminary training outlined above will indicate those men who show the most ability on the director trainer. Meanwhile initial practices on the Hunt miniature range will demonstrate the respective abilities of the members of the group in range estimation. The men who show most aptitude and quickest reaction as range setters during this preliminary work are given advanced training. The program of advanced training consists of further practice on the two devices above, and particularly, on a combination of the Hunt range and the director trainer as explained below.

■ 13. HUNT MINIATURE RANGE.—*a.* The purpose of the Hunt miniature range (fig. 53) is to provide instruction for the range setter, and other operators, in range estimation by means of a three-dimensional model of an aerial target moving in space. The range consists of a movable mirror which reflects the image of a scale model of a medium bomber, or some other typical automatic weapons target. This target is rotated about its cen-

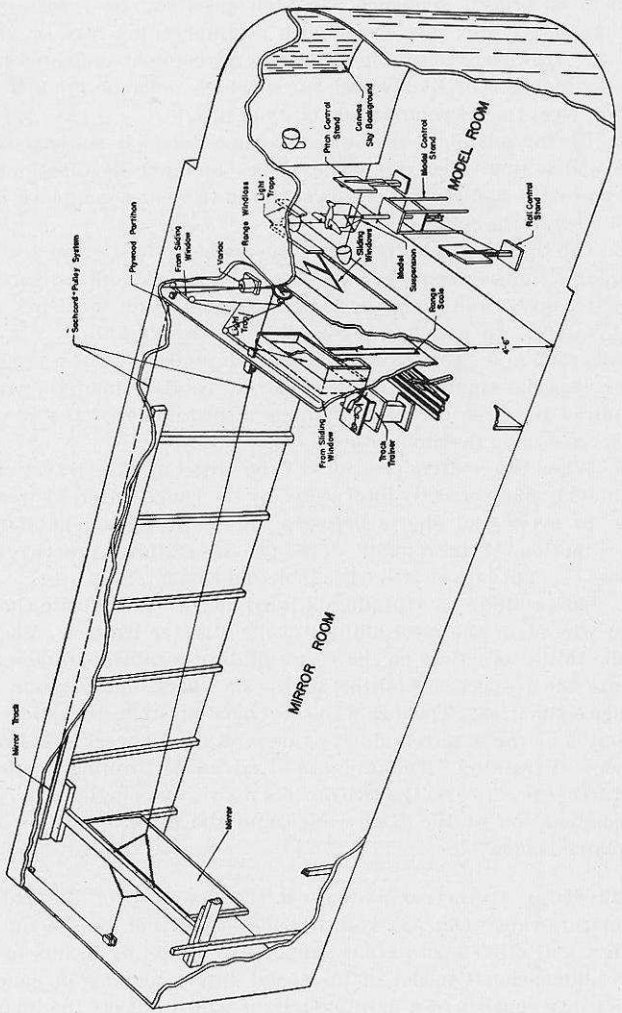


FIGURE 54.—Schematic drawing of the Hunt miniature range.

ter so that it assumes any desired angle as the mirror is moved and thus simulates an approaching and receding plane. The target is located above and behind the observer in a small, floodlit room. Light from a small source above the observer illuminates the target and background, which are seen by the observer in the mirror located in front of him. The mirror is moved forward and backward in a range tunnel to vary the apparent distance to the target. The instructor, observing the range scale which is part of the mirror control system, may check the range estimate of the observer against the actual range which is simulated.

b. The observers must wear an eye-flap, or glasses so constructed that the vision of either eye may be blocked out. By this means the factor of stereoscopic vision is eliminated.

■ 14. COMBINED TRAINING ON THE DIRECTOR TRAINER AND HUNT RANGE.—Combined training may be provided by two methods:

a. By one method, the director assembly and the target assembly are placed beside each other in the range, the target assembly on the right. The range setter adjusts the range in accordance with tracer observation. At the same time, by careful practice and timing on the part of the windlass operator, the mirror is moved forward and backward in close correlation with the turning of the target so that mirror and target reach the midpoint at the same time. If this method is to be used, the range scale of the Hunt miniature range (1 to 72) must be replotted to conform to the 1 to 135 scale of the trainer.

b. A second arrangement is to place only the director assembly facing the mirror, leaving the target assembly to one side for observation and calling out of sensings by the trackers of the director crew. The light slot from the control room is opened and the standard target is used. The range setter estimates range and sets in an initial range adjustment. The trackers, observing the tracers on the target assembly, call out sensings, providing realistic fire adjustment training for a complete director crew.

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