FM 4-121

WAR DEPARTMENT FIELD MANUAL

ANTIAIRCRAFT ARTILLERY FIELD MANUAL FIRE CONTROL, GUNS

RESTRICTED. *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. 23b, AR 380-5, 15 Mar 1944.)

WAR DEPARTMENT • 22 DECEMBER 1943

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FM 4–121, Antiaircraft Artillery Field Manual, Fire Control, Guns, 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

FIRE CONTROL, GUNS

(This manual rescinds Training Circular No. 89, War Department, 1942.

CHAPTER 1

GENERAL

Paragraphs
SECTION I. General 1–2
II. Problems of AAA fire control 3–6

SECTION I

GENERAL

■ 1. PURPOSE.—This manual prescribes that knowledge of fire control which will enable the antiaircraft artillery gun officer to perform his normal duties relative thereto. This manual is intended to supplement FM 4–110 on gunnery.

■ 2. SCOPE.—This manual deals with the practical aspects of fire control for AAA guns with all combinations of equipment. Instruments and accessories for guns are described briefly. For additional details on any one piece of equipment, refer to the particular Field Manual and Technical Manual covering that equipment. Orientation and synchronization of AA guns and associated fire control equipment are covered herein. Methods of fire control against all types of targets using various combinations of fire control instruments are treated.

SECTION II

PROBLEMS OF AAA FIRE CONTROL

■ 3. BASIC CONSIDERATIONS.—*a.* Fire control in its most complete sense implies ability to direct accurate and continuous fire at moving or fixed targets located in the air or on land or sea. The necessity for an automatic system of fire control by which firing data are computed and transmitted instanta-

neously to the guns is apparent from an analysis of the antiaircraft problem (see FM 4–110). The time available for effective antiaircraft firing is very short, only a matter of a few seconds.

b. The effectiveness of fire control depends primarily on preparation for fire. The AA gun battery is a team whose success is largely measured by the thoroughness of its preparation. (See ch. 3.)

■ 4. METHODS OF FIRE CONTROL.—*a.* The method of fire control to be employed on a particular occasion depends on the type of target engaged and the types of instruments with which the battery is equipped.

b. Types of targets encountered may be broadly classified as follows:

(1) Seen aerial targets:
(*a*) High flying targets.
(*b*) Low flying targets.
(*c*) Targets executing shallow dive or climb.
(*d*) Diving targets.
(2) Unseen aerial targets.
(3) Ground and naval targets:
(*a*) Moving targets (tanks, armored cars, and boats).
(*b*) Stationary targets.

c. The various types of fire control instruments, accessories, and guns which may be used by an AA gun battery are shown in figure 1. Two gun laying radars, the SCR–545 and the SCR–584, are currently in use. The latter is the more mobile of the two. Both are able to furnish present position data to any type of gun director in the service. Two types of height finders are in use, the stereoscopic height finder M1 or M2, and the radio-optical height finder SCR–547. Both may supply the director with present altitude or slant range as desired. Batteries equipped with the gun laying radar will not have the SCR–547, but will have a stereoscopic height finder in addition to the radar. Normally altitude (H_o) or slant range (D_o) is furnished by the radar when operative, the height finder being reserved for an emergency role. There are two types of directors, the mechanical director, for example, the M7, and the electrical director, for example, the M9. They compute firing data for the guns (A_f, ϕ, and F).

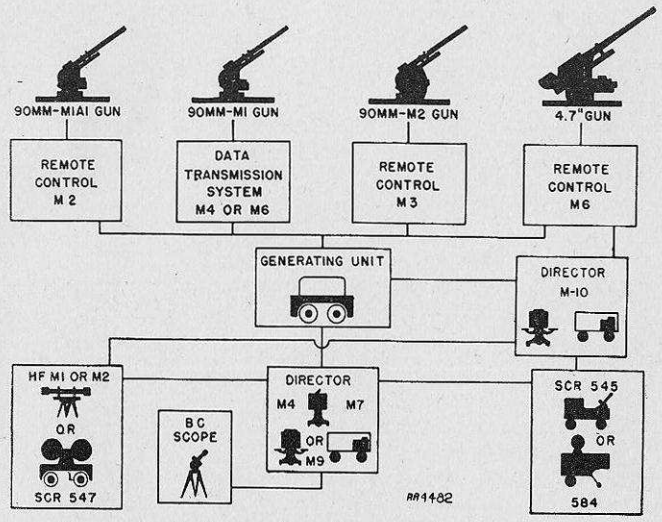


FIGURE 1.—Instruments and accessories for AA guns.

■ 5. BATTERY EMPLACEMENT.—*a.* The problem arises as to what the relative distances and patterns of guns and instruments should be for effective fire control. As a practical matter, distances and patterns are limited by three factors: terrain conditions, limits of parallax displacement, and the length of cable available. Normally, the director should be located as far away from the guns as terrain features permit. This is recommended to eliminate jerky tracking due to smoke, flash, and concussion of firing, and to provide dispersal for local protection. For recommended hook-ups of cables see paragraph 56.

b. The limits imposed on dispersion of the director from the guns by battery parallax are 500 yards north–south and 500 yards east–west. This is true of both the M7 and M9 directors. However, parallax limits of the directors are never exceeded as the cable allowance authorized by the Tables of Equipment falls short of 500 yards, director from guns, in all cases.

c. The fire control instruments themselves should be as close to one another as is commensurate with a 360° field of fire. This consideration is especially applicable with respect to radar and the tracking head of the M9 director; these two instruments should not be farther apart than 30 yards. A typical lay-out for the fire control instruments of a battery equipped with a stereoscopic height finder SCR–584 and M7 director with command post in the center is shown in figure 20.

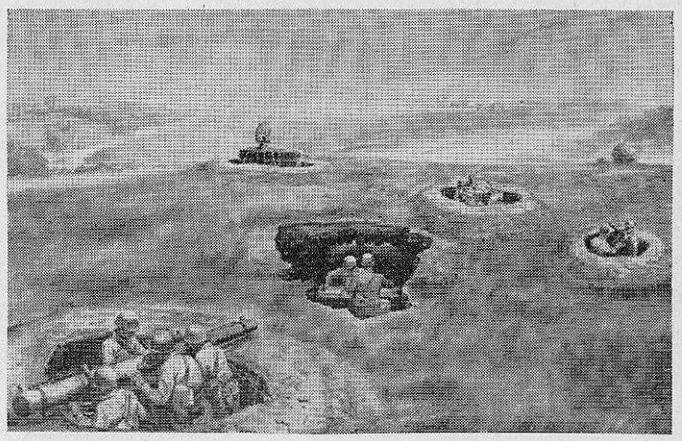
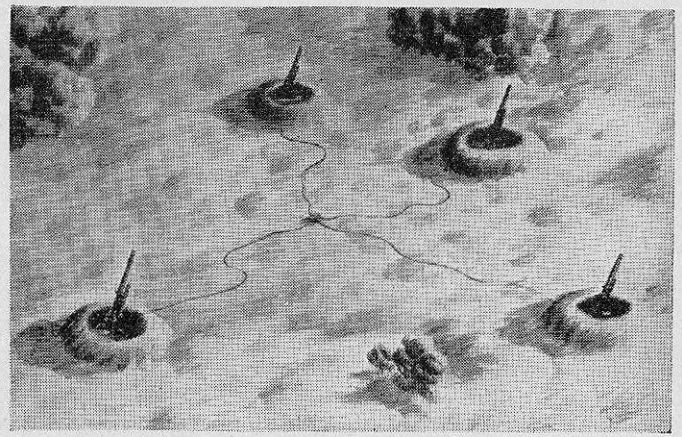


FIGURE 2.—Typical lay-out of fire control instruments.

d. Siting of the four guns of the battery depends on terrain and the fact that only one 225-foot cable runs from the main junction box to each gun. Furthermore, in many cases, the guns must be sited with a view to effective fire against ground and naval targets. No one particular pattern is recommended. A boxlike formation has been adhered to by many units and found to be satisfactory. It is advisable, however, to make the box somewhat irregular in shape in the interests of camouflage (see fig. 3①). Another lay-out which has produced good results in firing is shown in figure 3②. The feature of this lay-out is the gun in the center. If the guns are to be emplaced near the edge of a road which

offers a likely approach for tanks, the diamond-shaped lay-out shown in figure 3③ is effective. Other emplacements depend on the conditions of the moment and the battery commander's ingenuity.



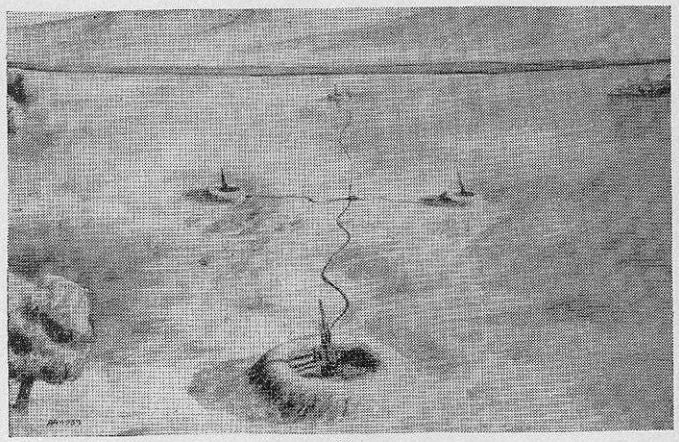
①



②

FIGURE 3.—Typical gun lay-outs.

560538°—43——2



③

FIGURE 3.—Typical gun layouts—Continued.

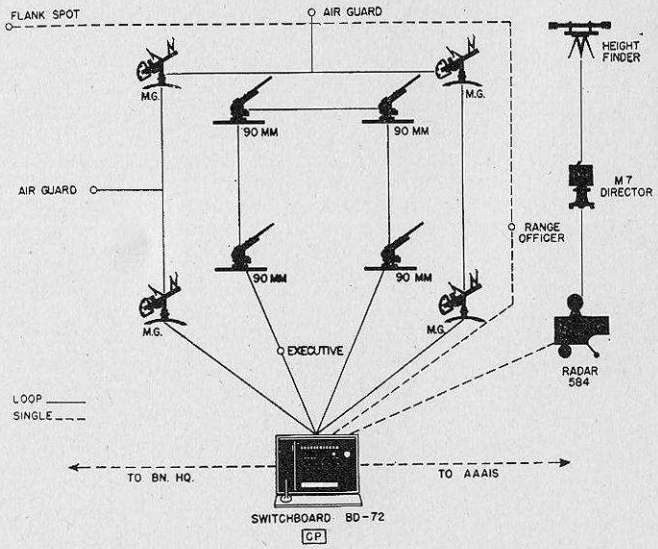


FIGURE 4.—Internal communications for AA gun battery.

■ 6. COMMUNICATIONS.—*a.* The internal wire communications set up for an AA gun battery is a most important consideration in the exercise of tactical control of fire.

b. Communication must be established between the elements as indicated in figure 4. These communications do not include the necessary set-up for emergency fire control systems.

CHAPTER 2

INSTRUMENTS AND ACCESSORIES FOR AA GUNS

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SECTION I.	Height finder	7–8
II.	Radar	9–11
III.	Directors	12–14
IV.	Observation instrument AA BC, M1	15–17
V.	Power and data transmission systems	18–22

SECTION I

HEIGHT FINDER

■ 7. STEREOSCOPIC HEIGHT FINDER M1 OR M2.—*a. Description.*—These instruments are designed to measure the altitude (or range) of a target by optical means. For detailed description see FM 4–142.

b. Manning detail.—The height finder squad consists of 6 men. See FM 4–142 for specific duties.

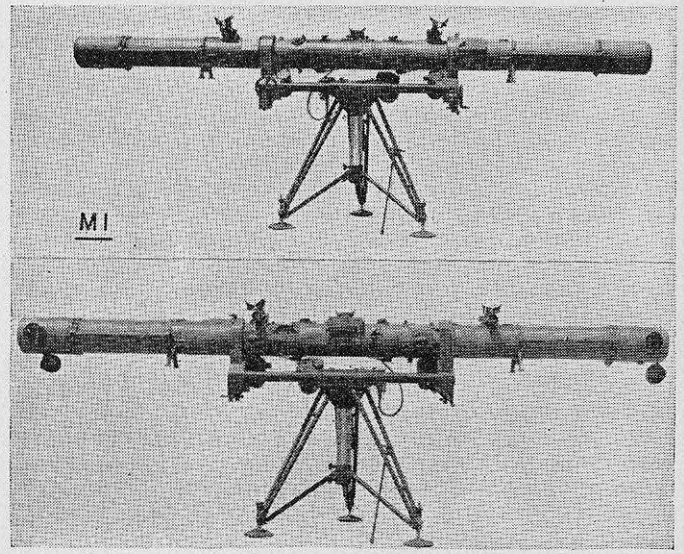


FIGURE 5.—Stereoscopic height finder—front and rear views.

c. Operation.—When in action, the telescope is pointed at the target by two trackers, the altitude (or range) to the target is determined by an observer, and the data are transmitted to the director by the altitude or range setter. See FM 4–142 for details of drill and operation.

■ 8. RADIO-OPTICAL HEIGHT FINDER SCR–547.—*a. Description.*—This instrument is designed to measure the altitude (or range) of a target by electrical means. It must be pointed optically at the target. The unit is powered either by the battery generator unit through a special plug adapter or by a generator unit mounted in a 2½-ton truck. For detailed description see FM 4–143.

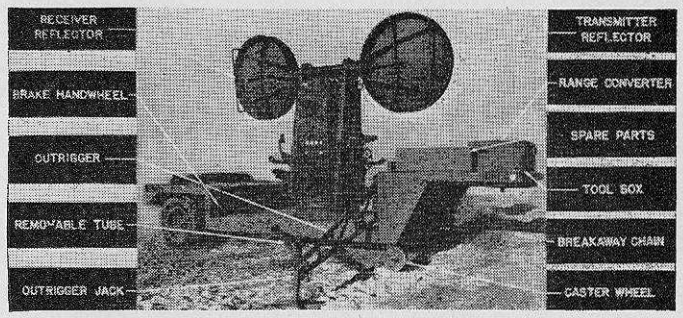


FIGURE 6.—SCR–547 in operating position.

b. Manning detail.—The SCR–547 squad consists of eight men which is sufficient to provide the necessary men for supervision, maintenance work, and relief operators. See FM 4–143 for specific duties.

c. Operation.—When in action, the antenna must be optically pointed at the target by two trackers. The range (or altitude) is determined by the range operator. The data are transmitted automatically to the director. See FM 4–143 for details of drill and operation.

SECTION II

RADAR

■ 9. GENERAL.—Two types of gun laying radar, the SCR–584 and the SCR–545, have been developed to overcome the visi-

bility limitations on AAA fire. Both radars are mobile, medium range units and may be used for medium range searching to provide advance warning of the approach of planes. Both sets determine and supply present position data in a form immediately usable to all types of AA gun directors.

■ 10. SCR–584.—*a. Description.*—This instrument can be placed in operation normally within 30 minutes. It will automatically track targets up to short radar ranges (greater than effective gun ranges). It will detect the presence of aircraft up to medium radar ranges. Present position data are transmitted to the director. The unit is powered by the battery power plant through a special plug adapter. For detailed description see FM 4–144.

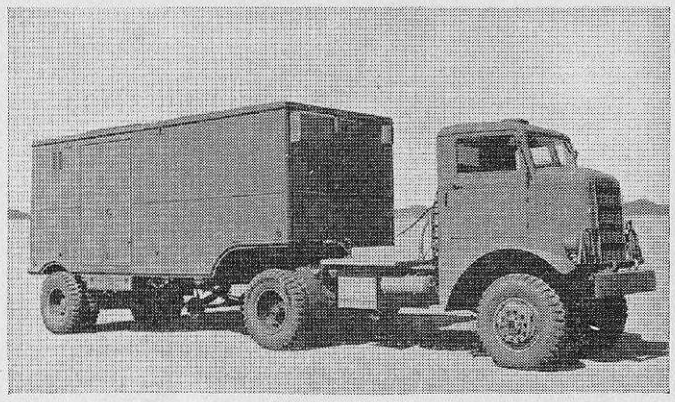


FIGURE 7.—SCR 584 in traveling position.

b. Manning detail.—The SCR–584 squad consists of nine men which provides the necessary men for supervision, maintenance work, and relief operators. See FM 4–144 for specific duties.

c. Operation.—The unit scans the area for indications of targets on the PPI (plan position indicator) scope. When the target is within automatic tracking range, the antenna is pointed at the target manually and control is switched to automatic. Four methods of operation can be used.

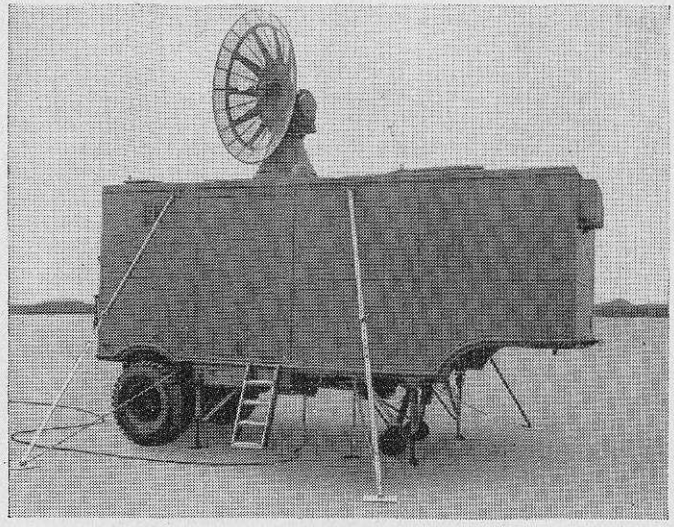


FIGURE 8.—SCR–584 in operating position.

(1) *PPI scan.*—The unit automatically scans the sky within certain definite limits.

(2) *Manual.*—Searching is by manual control of the operators.

(3) *Automatic.*—Tracking in elevation and azimuth is automatic. Range tracking is manual.

(4) *Remote.*—The unit follows data transmitted by the target designating system of the director. For further details on operation and drill see FM 4–144.

■ 11. SCR–545.—*a. Description.*—A power plant for operation of the unit is carried in the prime mover. The unit contains two complete radio systems, one for searching and one for tracking. The unit provides present position data to the director. The search system will detect targets up to medium radar ranges. The track system will track targets up to short radar ranges (greater than effective gun ranges). Tracking targets may be by manual or automatic control. For detailed description see FM 4–146.

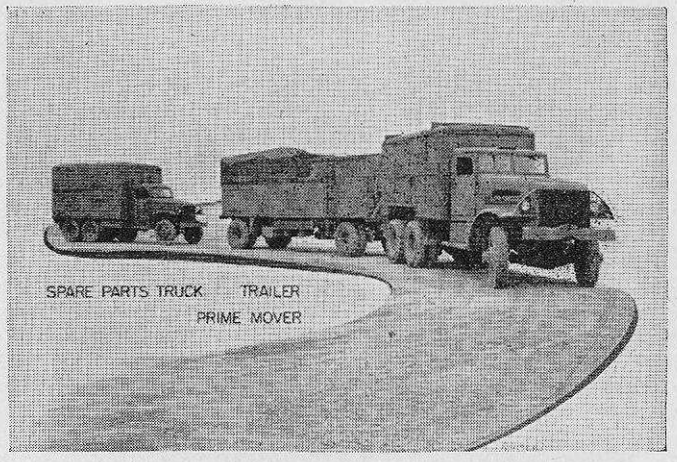


FIGURE 9.—SCR–545–A in traveling position.

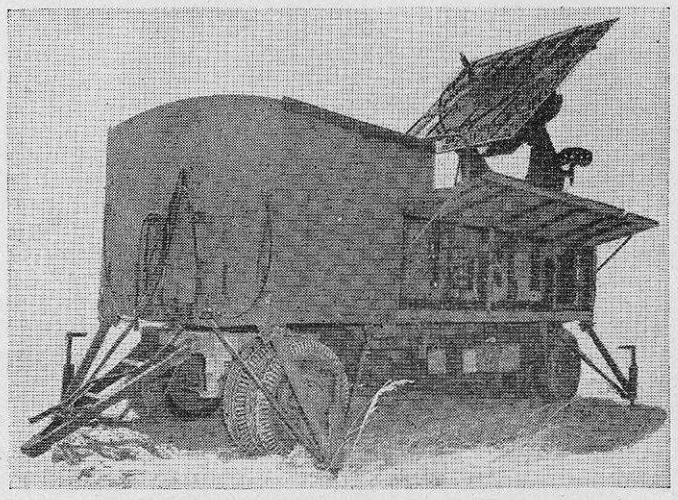


FIGURE 10.—SCR–545–A in operating position.

b. Manning detail.—The SCR–545 squad consists of nine men which provides the necessary men for supervision, maintenance work, and relief operators. See **FM 4–146** for specific duties.

c. Operation.—The unit searches the area for indications of targets. When a target is picked up it is tracked manually until it is in close enough for automatic control. For further details on operation and drill see **FM 4–146.**

SECTION III

DIRECTORS

■ **12. DIRECTORS M4 AND M7.**—*a. Description.*—The director is a computing instrument which determines firing data. (*A*, *QE*, and *F*) for the guns. It may obtain present position data (exclusive of altitude or range) by tracking or from a radar. Altitude (or range) is obtained from a height finder or radar. Power is furnished by the battery power plant. For detailed description see **FM 4–136.**

b. Manning details.—The M4 crew consists of five men. The M7 crew consists of six men. This crew does not provide for all types of maintenance work or for relief operators. See FM 4–136 for specific duties.

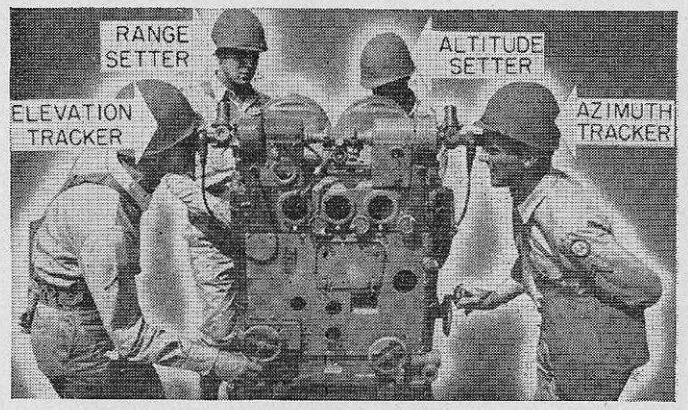


FIGURE 11.—M4 (M4A1B1) director manning detail (director corporal not shown).

c. Operation.—The target is tracked by the director either through the telescopes or by matching pointers when present position data are furnished by a radar. Altitude is received from a height finder or radar. The director calculates firing data and transmits them by selsyns to the guns. For further details on operation and drill see FM 4–136.



FIGURE 12.—M7 (M7A1B1) director manning detail (director corporal not shown).

■ 13. DIRECTORS M4A1B1, M4A1B2, M7A1B1, M7A1B2.—*a. Description.*—These directors are modifications of the M4 and M7 directors described in paragraph 12. The modification consists of incorporating rate smoother mechanisms. See FM 4–136 for further details.

b. Manning detail.—(1) M4A1B1 and M7A1B1 use the same detail as the M4 and M7, respectively.

(2) M4A1B2 and M7A1B2 require two additional men. See FM 4–136 for duties of additional men.

c. Operation.—See FM 4–136 for details of operations of these modified directors.

■ 14. DIRECTORS M9 AND M10.—*a. Description.*—(1) The M9 director performs the same functions as the M4 and M7 directors and modifications, but by electrical means. It consists of four components.

(2) The M10 is identical in appearance to the M9 except for the name plate and the MV dial on the computer. The M10 is used exclusively for the 4.7-inch (120-mm) gun. The computer, rectifier, and altitude converter are carried in a trailer and generally operated from the trailer. Power is furnished by the battery generator unit. For detailed description see FM 4–138.

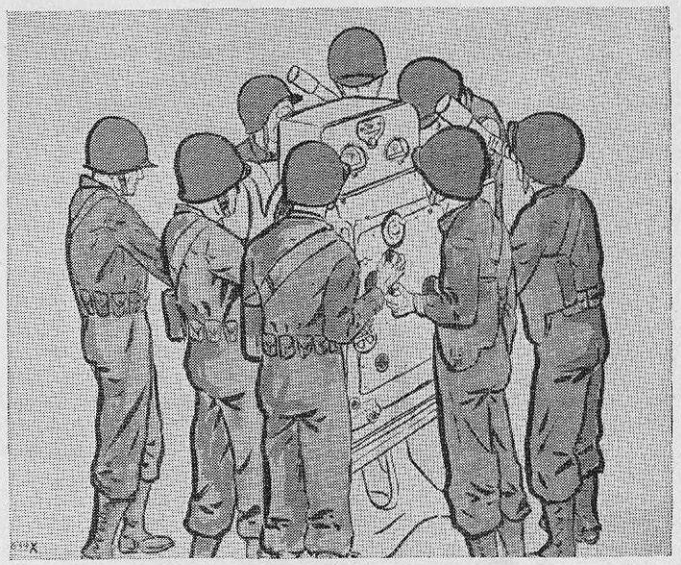


FIGURE 13.—M7A1B2 director manning detail.

b. Manning detail.—The M9 (or M10) crew consists of six men. This does not provide for all types of maintenance work or relief operators. See FM 4–138 for specific duties.

c. Operation.—The director calculates firing data and transmits them to the guns by selsyns. Two basic methods are possible.

(1) *Tracker used.*—The target is tracked by the tracker either through the telescopes or by matching pointers when present position data are received from a radar.

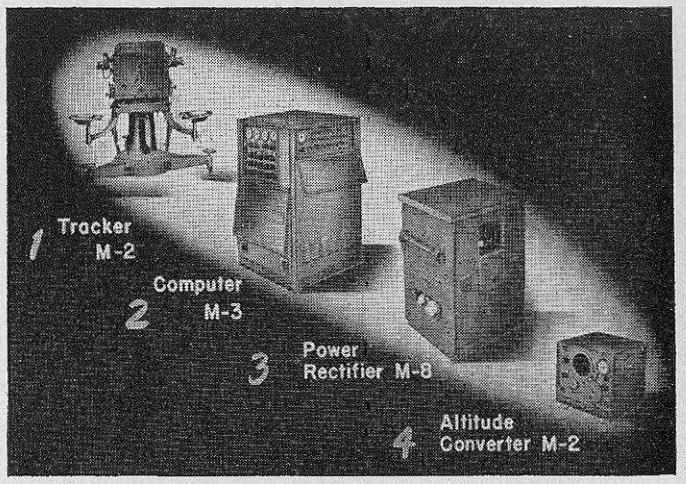


FIGURE 14.—Components of the director M9.

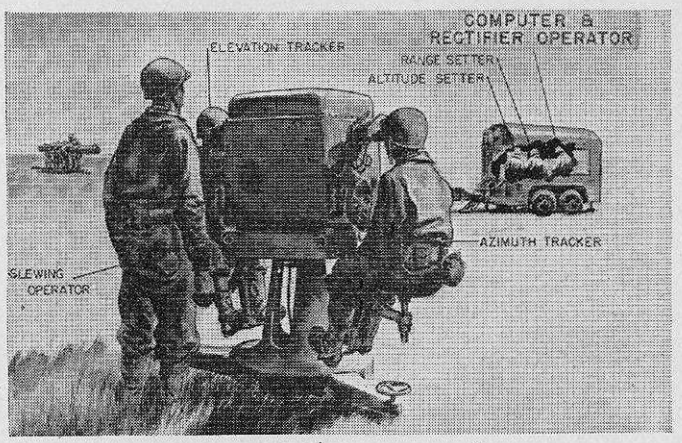


FIGURE 15.—M9 director in action.

(2) *Tracker not used.*—The target is tracked by the radar and present position data furnished direct to the computer. For further details on operation and drill see FM 4–138.

SECTION IV

OBSERVATION INSTRUMENT AA BC, M1

■ 15. GENERAL.—This instrument is primarily used by the battery commander to observe and recognize targets and study effect of fire during the period of engagement. It can be used to measure deviations during trial fire or calibration fire and also can be substituted for a transit in the orientation of the battery.

■ 16. DESCRIPTION.—The instrument consists of a telescope unit, mount, and tripod.

a. Telescope.—The telescope unit consists of two separate optical systems, the observer's telescope and the battery commander's telescope. The observer's telescope is used solely for tracking purposes and is of the standard M2 elbow type telescope with eyepiece set along the horizontal axis of rotation. It is an 8-power telescope with a field of 8°45′ and is provided with an amber light filter. The battery commander's telescope is also of the elbow type. By means of a revolving nut the power may be shifted from 10 to 20 with field visions of 6°9′ and 3°5′ respectively. This scope can be focused by means of a knurled ring near the eyepiece. It is also provided with amber and blue filters operated by an exterior lever. The reticle is graduated with a horizontal and vertical mil scale with a least reading of 5 mils.

b. Mount.—The telescope mount is carried on the base of the azimuth instrument M1918 with a special trunnion support rigidly attached. The telescope is held firmly in place by cap squares on the trunnion support. These caps are hinged on one side and are held by screws on the other which when loosened permit removal of the scope. This mount screws on the tripod in the usual manner and is leveled by use of two spirit levels and four leveling screws. The mount has two sets of scales, one set for azimuth and one for elevation. The azimuth set consists of a main scale with divisions to 20 mils and a subscale which rotates on the shaft of the traversing handwheel. This scale is divided into 200 graduations of 1/10 mil which equals 20 mils per handwheel revolution. The elevation set consists of a main scale attached to the elevation rack with 10 mils divisions and a sub-

scale rotating on the elevating shaft reading to 1 mil. An azimuth release clamp is provided for orienting purposes. Fine adjustment can be made by use of the tangent screw and tangent clamp screw.

c. Tripod.—The tripod is the common wooden type provided with threaded head on which the mount is screwed. A tripod cap protects the threads when the instrument is disassembled. A spirit level in the head provides a means for setting up so that the head is approximately level.

d. Lighting circuit.—A 4-volt circuit is provided with sockets for illuminating the azimuth scale, the elevation scale, the cross hairs of the observer's and battery commander's scopes, and the mil graduations. The intensity of illumination can be controlled by a cartridge rheostat.

■ 17. OPERATION.—*a.* The instrument is manned by a tracker who is responsible for setting up, orienting, and preparing the instrument for use.

b. The tracker stands at the left side of the instrument and tracks targets as designated, by turning the elevating handwheel with his left hand and the traversing handwheel with his right. Meanwhile, the target may be observed by the battery commander or his representative through the BC telescope on the right-hand side of the instrument.

c. When one of these instruments is used to observe the deviation of trial shots, it is carefully set at the azimuth and angular height of the trial shot point. As each shot is fired, the observer, looking through the BC telescope, observes the position of the burst with respect to the mil graduations on the cross hairs. He calls out the lateral and vertical deviation of each burst from the center of the cross hairs. The same procedure for observing bursts in fire for effect is employed.

SECTION V

POWER AND DATA TRANSMISSION SYSTEMS

■ 18. GENERAL.—*a.* A data transmission system provides for the immediate and continuous transmission of data from the external tracking instruments to the director and from the director to the guns. Multi-conductor cables connect the director to the guns and the power plant through the main junction box, and connect the director to the height finder or radar directly. There are four data transmission systems currently in use, the M6 system, the M7 cable system, the M1 and M2 cable systems, and the M3 cable system. The M6 is the oldest system, designed for use with the pointer matching 90-mm gun battery. The M1 and M2 cable systems are designed to be used with the remote control system M2 and the remote control 90-mm gun battery in conjunction with the M7 director. These two systems are similar, the only difference between them being that the M1 will accommodate a four-gun battery, while the M2 is for a two-gun battery. Hereafter, only the M1 system will be referred to. The M7 cable system is peculiar to the M9 and M10 directors. When the battery is equipped with an M9 or M10 director, both the M1 or M3 and M7 cable systems are utilized.

b. Caution in handling cables.—(1) The plugs and receptacles of the cable systems have aligning keys and keyways to assure proper connections. When the various cables are plugged into the corresponding receptacles, the threaded collar provided for the purpose should be screwed down tightly over each connection to insure a watertight and dustproof union.

(2) Cables must be handled with care. Most cable failures take place within a foot of the plugs, which indicates that rough handling of the cable at the plug is the major source of difficulty. It has been found by actual experience that the observance of the following rules greatly reduces cable failures.

(*a*) Plugs should be removed from receptacles by pulling on the *plug,* not on the cable. Pulling on the cable will bend and break the soldered electrical connections at the plug.

(*b*) When moving the cables, pull on the *cable,* not on the plug. Pulling on the plug will rupture the electrical conductors.

(*c*) When moving the cables, do not allow the plugs to drag along the ground, catching on rocks, bushes, and other obstructions. Carry the cable so the plug is clear of the ground.

(*d*) Do not lay the cable where it may be run over by vehicles.

(*e*) Do not kink the cables.

(*f*) Do not be in too much of a hurry to reel in the cables when MARCH ORDER is given. A few minutes spent the night before may save hours of repair work the next day.

(*g*) In hot climates deterioration of cables can be greatly reduced by burying them 1 foot underground in order to protect them from rain and from the sun's rays.

(*h*) When a shallow channel or ditch is prepared for a cable, one sidewall of the ditch may be constructed in the form of a ledge or step 4 inches from the surface. The cable is laid on this step. The lower part of the ditch provides drainage for the cable which helps to preserve it.

(*i*) In cold climates it is best to leave cables above ground unless sufficient time is available to build padded troughs in which to place the cables underground. Many cables have been rendered unserviceable while they were being removed from frozen ground.

(*j*) Do not oil or grease cables.

(*k*) Store cables in a cool, dark place.

(*l*) Do not use friction tape on cable conductors; use rubber tape only.

(*m*) Keep plugs and receptacles covered when not in use.

■ 19. M6 DATA TRANSMISSION SYSTEM.—The M6 system consists of the following: 12 interchangeable, 225-foot cables, each containing 20 conductors with 19 poles at each end; 2 M4, 1,200-rpm, four-cylinder gas-electric power plants; a ten-sided, cast aluminum junction box with 6 designated cable receptacles; 12 cable reels; 5 trouble lamps; and 3 electrical testing meters. The power plants are not operated simultaneously; one unit is used at a time, the other being available for emergency. The receptacles on the junction box are die stamped, four with the word GUN, one with the word DIRECTOR, and one with POWER PLANT. In addition, they may be painted with distinctive colors to match the corresponding receptacle on the piece of equipment to which each is connected. *Red* is for guns. *Yellow* is for the power plant-junction box connection. *Black* is for the director-junction box connection. *Olive drab* or *white*

is for the director-radar connection. The system may be operated correctly only when it is properly connected. Improper connections must be avoided so that synchronous units are not burned out or incorrect data transmitted to the director.

■ 20. M1 AND M2 CABLE SYSTEMS.—The M1 cable system consists of the following: ten 225-foot cables, four of which contain 21 conductors (junction box to guns) and six 20 conductors and 19 poles; four 150-foot, 3-conductor cables; 2 gas-electric power plants, each generating 35 kva, 125 volts, three-phase, 60-cycle a-c power; a square, cast aluminum junction box with 6 designated cable receptacles, 13 cable reels, a set of trouble lamps, and electrical testing equipment. The M2 cable system is exactly the same as the M1 except that it has only two 225-foot, 21-conductor cables. As in the M6 data transmission system, the extra power plant is for alternate, not simultaneous use. The main junction box of the M1 system is also die stamped to identify proper receptacles, and its receptacles should be painted with the same distinctive color code as those of the M6 system. While the M1 cable system is designed primarily for use with the remote control system, the gun mounts can be operated manually at the guns by means of the data transmitted to the pointer matching indicators at the guns. There is no possibility of making wrong connections at the main junction box with the M1 cable system. The cables and receptacles for the three divisions of the system are all different. The 21-conductor cables fit only the cable receptacles on the guns and the receptacles on the main junction box marked GUN. The 3-conductor cables fit only the power plant receptacles, and the 20-conductor cables fit only the proper receptacles on the main junction box, the director and height finder.

■ 21. M3 CABLE SYSTEM.—The M3 cable system consists of the following: eleven 225-foot cables (20 conductors and 19-pole); ten 150-foot, 3-conductor cables; one adapter cable (3-pole–19-pole); two gas-electric power plants each generating 35 kva, 125 volts, three-phase, 60-cycle a-c power; a 10-sided junction box with six designated cable receptacles,

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cable reels, a set of trouble lamps, and electrical testing equipment. The two power plants must be used simultaneously. The main junction box is die stamped to identify receptacles.

■ 22. M7 CABLE SYSTEM.—The M7 cable system provides the necessary cables for connecting together the various units of the M9 or M10 director and associated fire-control equipment. Whenever the battery is equipped with an M9 or M10 director, it will have not only the M7 but also the M1 or M3 cable system. The 225-foot, 20-conductor, 19-pole cables which are part of all systems are interchangeable. When these systems are combined, 9 such cables are available. If the battery operates with an SCR–547, an additional cable of this type is available. The M7 cable system consists of the following cables:

a. Three 3-conductor, 300-foot power cables (yellow) for use between the power generator and the power of the M9.

b. One 21-conductor, 15-foot cable (21-prong plug) (yellow) for use between power and computer of M9. An extra cable of this type is provided in the battery accessories.

c. One 20-conductor, 15-foot cable (19-prong plug) (blue) for use between computer and altitude converter of M9. An extra cable is provided.

d. Three 20-conductor, 225-foot cables (19-prong plug; a-c and d-c) for use between the computer and tracker or radar and computer or tracker.

CHAPTER 3

PREPARATION FOR FIRE

■ 23. GENERAL.—*a.* Preparation *for* fire includes—

(1) Selection and training of personnel.

(2) Checks of matériel, including maintenance and orientation.

(3) Preparation of fire.

b. Preparation *of* fire is the process of determining corrections to firing data which will place the center of burst of the opening rounds on or near the target. *Preparation of fire is the most important and vital phase of AA gunnery and fire control.* The most rigorous attention must be paid to it. See FM 4–110 for a discussion of preparation of fire, which includes—

(1) Corrections for matériel errors.

(2) Corrections for nonstandard conditions (ballistic corrections).

(3) Corrections determined by preparatory fire.

(*a*) Calibration fire.

(*b*) Trial fire.

■ 24. TRAINING OF PERSONNEL.—*a. General.*—In preparing a battery for fire, the next step after having made a proper selection of personnel is training. Battery commanders, battery officers, and those of higher authority must exercise all their knowledge, experience, energy, and initiative in order to produce an organization capable of effective fire. Intelligent supervision, careful planning, and frequent inspections are the main factors involved. Training is a function of command, and serves, better than any other single function, to test the ability of the commander.

(1) Training is a continuous process and though it may be divided into different types and phases, is carried on throughout the existence of an organization. All military training has for its ultimate object victory in battle.

(2) The training objective of AA gun batteries is, naturally, destructive fire against enemy targets.

(3) Attention must be given to training of alternates or replacements. At least three well-trained stereoscopic ob-

servers must be available; members of the gun crew and range section must be able to fill any position in their particular section. Privates must be instructed in the duties of noncommissioned officers; noncommissioned officers must be prepared to take over duties of higher grades. All personnel, officers and men, must be generally familiar with all positions in their unit, including those filled by personnel of higher rank, so that vacancies can be filled quickly and with a minimum of additional training. Each man must be ready to move up to the next higher grade at a moment's notice.

(4) The state of training must be checked periodically by inspections, drills, alerts, and examinations. Those conducting inspections and examinations must be familiar with the material, methods, and training objectives involved, so that an intelligent check can be made.

b. Training of director trackers.—In order to give suitable results, the tracking errors of the director, both human and matériel, must be reduced to an absolute minimum.

(1) Mechanical errors can be largely eliminated by proper supervision, test, and adjustment.

(2) The most common cause of sloppy tracking is the untrained or improperly trained tracker. In training director trackers it is well to emphasize the following:

(*a*) The director, in order to predict accurate data, must have a smooth, even rate fed in by the trackers. The trackers must therefore track with the cross hairs on the nose or other definite feature of the plane. The same point must be tracked throughout the engagement. Once the trackers are on target and the rate has been established, the plane should appear as a superimposed figure on the reticle of the telescope.

(*b*) It is essential that trackers be given daily supervised drill. This drill should be on a plane. If no plane is available to track, some mechanical moving object should be rigged up by the battery mechanic. It is detrimental to the training of trackers to have them track in space with no target.

(*c*) The standard of accuracy must be set high and kept high. The tracker must take his job seriously and, above all, must be supervised.

■ 25. CHECKS OF MATÉRIEL.—*a.* A good portion of the battery officer's time must be devoted to checking matériel. Fire control instruments and guns must be in perfect mechanical and electrical condition.

b. A thorough knowledge of all equipment and matériel used by a firing battery is essential for those concerned with making tests and adjustments. The director or data computer is checked by means of check problems; the height or range finder is checked to determine whether adjustments have been made for temperature and visual peculiarities of the observer; the guns, fuze setters, and data transmission systems require certain tests and adjustments. Radars must be tested and adjusted. Both officers and men must be able to perform personally all the necessary tests and adjustments. Even though battery commanders do not normally adjust their equipment personally, the intimate knowledge required to do so enables them to do a better job of training and supervision. Pertinent manuals describe in detail the method of making the tests and adjustments required.

CHAPTER 4

ORIENTATION

		Paragraphs
SECTION I.	General	26–28
II.	Directors M7 and M9	29–32
III.	Height finder	33–35
IV.	Guns	36–41

SECTION I

GENERAL

■ 26. ORIENTATION.—*a.* Orientation of a gun battery is the mechanical adjustment of guns and fire control instruments so that when all are pointed in parallel directions, the mechanical pointers on their azimuth and elevation receivers indicate the azimuth and elevation of that direction. Complete orientation of a gun includes the adjustment of the fuze setter and the zeroing of the lagmeters of the remote control system.

b. Because orientation and synchronization of radar equipment SCR–545 and SCR–584 is so closely allied, a discussion of both *orientation* and *synchronization* of this equipment is included under section IV, chapter 5.

■ 27. ORIENTATION REQUIREMENTS.—Orientation of a battery is accomplished when the following requirements are met:

a. Instruments and guns are leveled.

b. Guns and instruments, being set at the same indicated azimuth, point in parallel directions.

c. Guns being set at a given elevation as indicated on the elevation indicator, the axis of each bore is at that elevation.

d. Fire control instruments being set at a given elevation, the line of sight is at the indicated elevation.

e. Fuze setter actually sets the fuze on a projectile to the fuze range indicated on the mechanical (outer) dial of the fuze indicator at the gun.

■ 28. AZIMUTH DETERMINATION.—*a.* An orienting line must be established for each battery position and for the directors if they are located at a distance from the guns. The precision with which the azimuth of the orienting line is

determined is dependent upon the time permitted for determining the azimuth, the equipment available, and the degree of coordination of the battery with other units.

b. Methods of determining direction are fully described in TM 4–226 (when published). The following methods are listed in order of increasing precision and approximately the order of increasing expenditure of time.

(1) Watch and sun.
(2) Compass.
(3) Map.
(4) Observation on the sun.
(5) Observation on a star.

c. The azimuth of an orienting line is usually determined very roughly when the battery is first installed, so that meteorological messages may be used immediately. Then, as time permits, the azimuth is determined by a more precise method. Batteries that are an integral part of a coordinated defense should obtain the precise azimuth of an orienting line, determined by an observation on a star.

SECTION II

DIRECTORS M7 AND M9

■ 29. SETTING UP AND LEVELING.—*a. Director M7.*—Before the director can be oriented it must be set up and leveled as prescribed in FM 4–136.

b. Director M9.—The tracker must be set up and leveled following procedure given in FM 4–138. The units of the director other than the tracker do not require precise adjustment of position.

■ 30. ORIENTATION IN AZIMUTH.—*a. Director M7.*—(1) Turn orienting clutch to IN.

(2) Turn power ON at motor switch.

(3) With red button pushed in, set azimuth of known reference point on present azimuth dial.

(4) Release red button and turn motor switch OFF.

(5) Turn orienting clutch to OUT.

(6) Traverse director with slewing handwheel until vertical cross hair in azimuth telescope intersects reference point.

(7) Turn orienting clutch IN and replace cover.

(8) Check setting on present azimuth dial and alignment of cross hair on reference point.

b. Director M9.—(1) Set azimuth of known reference point on present azimuth dial.

(2) Loosen three clamping bolts in the base of the tracker.

(3) Traverse tracker with orienting handwheel (or wrench) until vertical cross hair in azimuth telescope intersects reference point.

(4) Tighten the three clamping bolts *by hand.*

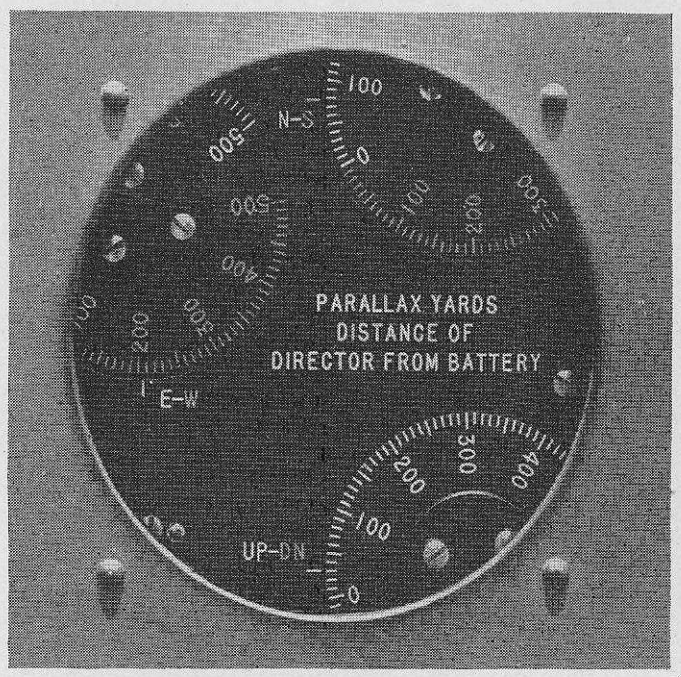
(5) Check setting on present azimuth dial and alignment of cross hair on reference point.

■ 31. CHECK OF ALIGNMENT OF ELEVATION TELESCOPE.—This check is made periodically and also after any move of the director or tracker. The purpose is to verify that the angular height dials actually read 0 mils when the line of sight through the elevation telescope is exactly horizontal. The procedures are given in FM 4–136 and FM 4–138.

■ 32. PARALLAX (OFFSET).—*a. Director M7.*—Means are provided in the director to correct for the offset of the director or radar from the battery directing point. This correction is set into the instrument by three screws located on the front side to the right of the altitude dial. The amount of parallax correction set in is indicated by the parallax dials located on the right side of the instrument. (See fig. 16.) Parallax corrections can be readily computed on the wind component solver by the method described in FM 4–136.

b. Director M9.—Means are provided on the computer to correct for the offset of the tracker or radar from the battery directing point. These corrections are set in on knobs and associated switches on the correction panel of the computer. Corrections can be computed by trigonometric functions or graphical solution.

c. Radar.—Parallax corrections are computed radar from battery directing point. These corrections are always used when all present position data are *furnished by the radar.*



If director is—

Above / East of / North of } guns—use white figures. Below / West of / South of } guns—use red figures.

FIGURE 16.—M7 director parallax dials with settings of: W—205, N—79, UP—30.

SECTION III

HEIGHT FINDER

■ 33. GENERAL.—Because the M1 and M2 height finders are identical in principle and have only slight differences in construction, the M1 and SCR–547 height finders are considered primarily in this discussion.

■ 34. ORIENTATION.—*a. Height finder.*—(1) *Setting up and leveling.*—The height finder is set up and leveled as prescribed in FM 4–142.

(2) *Orientation in azimuth.*—(*a*) Traverse the height finder until center mark on left reticle of telescope intersects the reference point.

(*b*) Turn the orienting clutch until mechanical pointer indicates the correct azimuth.

(*c*) Release orienting clutch and replace cap.

(*d*) Check setting on azimuth dial and alignment of reticle mark on reference point.

(*e*) If reference point is more than 5,000 yards distant, check alignment of tracking telescopes. (For adjustment, see FM 4–142.)

(3) *Orientation in elevation.*—The height finder M1 is so adjusted at the factory that it is oriented in elevation if properly assembled and leveled in the field. To check this orientation, proceed as follows:

(*a*) Depress the height finder tube by the elevation handwheel until the level on the telescope is accurately centered. The mechanical pointer on the elevation dial should now indicate zero elevation, and the index on the telescope should match the zero line on the elevation bearing housing.

(*b*) If the index line and the zero mark do not match, elevate the instrument until they do.

(*c*) Loosen the locking knobs and lift the telescope from the cradle.

(*d*) Turn the mechanical pointer back to zero. Lower the telescope on its cradle and tighten the locking knobs.

(*e*) Again a check is made to see that the lines match and at the same time a check is made to see that the elevation dials read "zero."

b. Radio optical height finder SCR–547.—(1) The SCR–547 is set up and leveled as prescribed in FM 4–143.

(2) *Orientation in azimuth.*—(*a*) Traverse the pedestal until the cross hair of the azimuth telescope intersects the reference point.

(*b*) Turn the orientation adjustment until the mechanical pointer indicates the correct azimuth.

(*c*) Release the orientation adjustment and replace cap.

(*d*) Check the setting on the dial and the alignment of the cross hairs on the reference point.

(3) *Orientation in elevation.*—The instrument is oriented in angular height when the mount is properly leveled.

(4) *Orientation in slant range.*—The instrument is oriented in slant range by starting the SCR–547 and positioning the main pulse in the step. (See FM 4–143.)

(5) *Orientation in altitude.*—(*a*) Set slant range to 18,000 yards.

(*b*) Set angular height to 533 mils.

(*c*) Adjust the altitude dial to read 9,000 yards by means of the HEIGHT CALIBRATE adjustment on range converter.

(*d*) Check by reducing slant range and verifying that altitude remains one-half of the slant range.

(6) For complete discussion on orientation, see FM 4–143.

c. Both the height finder M1 and SCR–547 may also be oriented by the backsight method. (See par. 37.)

■ 35. PARALLAX DISPLACEMENT.—*a. Height finder.*—(1) In order that the director receives the altitude of the target above the director (or tracker), it is necessary to correct altitudes for any vertical displacement between the two instruments.

(2) The correction for vertical displacement is made on the vertical parallax dial at the height finder after synchronizing in altitude.

(3) Corrections are plus if height finder is above director (or tracker) and minus if below.

(4) The correction is computed by trigonometric or graphical means after the distance and the angle of depression or elevation are measured.

b. Radio optical height finder SCR–547.—When using the SCR–547 in transmitting selsyn altitude, the parallax displacement is compensated for by missynchronizing the altitude transmitter by the amount of yardage required for adjustment.

SECTION IV

GUNS

■ 36. GENERAL.—There are various methods of orienting a battery in azimuth, as—

a. Known datum point method.

b. Backsight method.
c. Infinite point method.

■ 37. ORIENTATION IN AZIMUTH.—*a. Directing point.*—The directing point is defined as the center of mass of the guns when in position.

b. Azimuth.—The azimuth of the reference point from the directing point must be obtained by the most accurate means available considering the time element. These data should be improved at the first opportunity.

c. Known datum point method.—(1) Level gun.

(2) Boresight gun on datum point by means of boresight in breech and cross hairs on muzzle. Remove firing mechanism and sight through hole in breechblock bushing if boresight for breech is not available.

(3) Raise sliding cover on left side of azimuth indicator-regulator. Raise detent and turn toothed adjusting knob until the mechanical (outer) dial indicates azimuth of the line gun-datum point (par. 40).

(4) Release detent.

(5) Check lagmeter (par. 41).

(6) Close cover.

(7) Check setting on the azimuth indicator and alignment of bore on datum point.

d. Backsight method.—An alternate method of orienting the guns in azimuth is the backsight method. In using this method, all guns and fire control instruments should preferably be visible from the director.

(1) Orient director.

(2) Level guns. (See service of piece manuals.)

(3) Boresight each gun on the azimuth tracking telescope of the director using a boresight in the breech and cross hairs centered on the muzzle of the gun as a line of sight.

(4) Traverse the director until the azimuth tracking telescope is sighted down the axis of the bore of the gun.

(5) Adjust the mechanical pointers of the azimuth indicator-regulator at the guns to read the same number of mils, plus or minus 3,200 mils, as is showing on the present azimuth dial of the director. (See par. 37*c*(3) through (7) above for adjustment.)

e. Infinite point method.—Another method of orienting a battery is by celestial tracking. In using this method, be sure that all elements are sighting on the identical point. The operation is as follows:

(1) Level all guns and fire control equipment.

(2) Select a celestial body, such as the sun, moon, a planet, or a well-defined star, as a datum point at infinite range.

(3) If the azimuth of the celestial body is known, then the director can be set with that azimuth on the dials, otherwise the azimuth dials of the director are set to read the approximate azimuth, as determined by compass or other means.

(4) A breech boresight is placed in the breech and vertical and horizontal cross hairs are centered across the muzzle of each gun.

(5) The fire control instruments and guns are pointed at and track simultaneously the same celestial body. The best method of doing this is to use the director and one gun (or one piece of fire control equipment) at a time. Preset the gun and let the sun or celestial body come tangent to the vertical cross hair on the muzzle of the gun. At this instant the director stops tracking and the director present azimuth dial is read. This same reading is set on the gun. The same procedure is followed until all equipment is oriented.

■ 38. ORIENTATION IN ELEVATION.—To orient the gun in elevation, proceed as follows:

a. With a gunner's quadrant, lay the gun at an elevation of 800 mils. Last motion of gun must be in direction of increasing elevation.

b. Hold gun stationary; raise sliding cover on left side of elevation indicator.

c. Raise detent engaged in the toothed adjusting knob and turn knob until the mechanical (outer) dial reads 800 mils.

d. Release detent.

e. Check lagmeter (par. 41).

f. Lower cover.

g. Check setting on elevation indicator and elevation of gun bore.

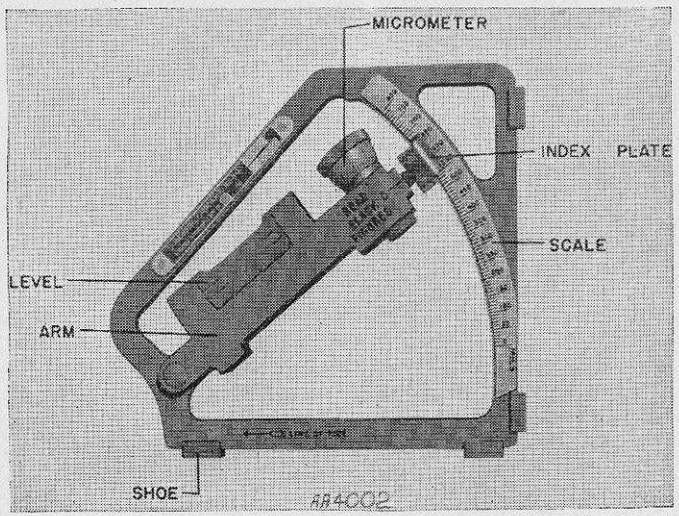


FIGURE 17.—Gunner's quadrant M1.

■ 39. ORIENTATION IN FUZE.—*a. M13 fuze setter.*—(1) A fuze setter is properly oriented when the fuze setter actually sets the fuze on a projectile to the value shown on the fuze indicator at the gun.

(2) To orient the fuze setter proceed as follows:

(*a*) Set fuze setter at some convenient setting, such as 15.

(*b*) Insert a round of ammunition in fuze setter and set fuze.

(*c*) Take the round out of fuze setter and read setting on fuze.

(*d*) Repeat process at least twice more. If the average of all settings agrees with the mechanical index on the fuze range scale, no further adjustment is necessary.

(*e*) If, however, it does not agree, it will be necessary to adjust the fuze range scale as follows: (See fig. 25.)

1. Remove window frame from indicator face.
2. Loosen six screws in clamping ring to allow scale to be moved.

3. Insert blunt point in hole over the zero and slide scale around under clamping ring until the average value set on the rounds in (*d*) above is opposite the mechanical index.
4. Tighten the clamping ring screws evenly and firmly.
5. Check by setting several more rounds at a different fuze range.
6. Replace window.

b. M20 fuze setter.—Orientation of the M20 fuze setter is a factory adjustment. Necessary adjustments by using arm are given in paragraph 45.

■ 40. GUN PARALLAX.—*a.* It is apparent from figure 18 that in a battery emplacement the guns and fire control instruments do not lie along the line of sight from the director to the datum point. Therefore, the ranges and azimuths from each element of the battery to the datum point will differ. In order to have all elements oriented, it is necessary to compute the azimuth from each element to the datum point. Then, when each element of the battery is laid on the datum point and its proper azimuth is set on the azimuth indicators, the battery will be oriented in azimuth. As an illustration, take a simple case of a battery consisting of a director and one gun.

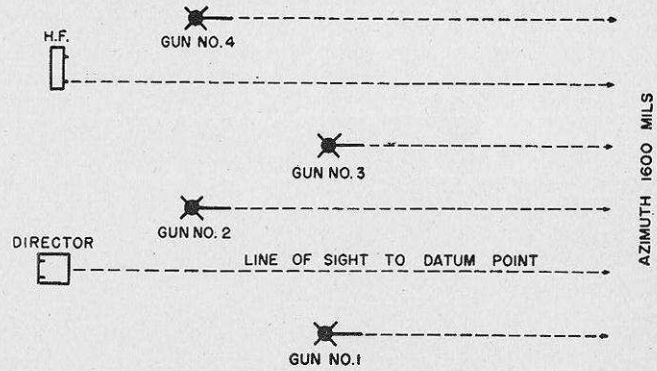


FIGURE 18.—Battery parallax.

b. It can be seen from figure 19 that the battery must be oriented in azimuth. A lookout tower on the summit of a hill has been selected as a datum point; its range from the director has been computed at 5,030 yards. Its azimuth from the director is 1,200 mils. The gun has been emplaced 30 yards nearer the datum point than the director and 30 yards to the right of the director line of sight to the datum point. Therefore, the gun's horizontal range to the datum point is 5,000 yards, approximately.

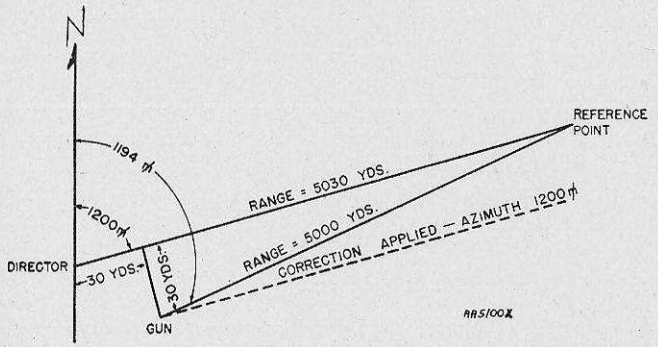


FIGURE 19.—Gun parallax.

The angle which is subtended by this 30 yards at 5,000 yards horizontal range can be determined by means of the following formula:

$$\text{Number of mils} = \frac{\text{Lateral displacement in yards}}{.001 \text{ range}}$$

Substituting for known values:

$$\text{Number of mils} = \frac{30}{.001 \times 5{,}000}$$
$$= 30 \div 5$$
$$= 6$$

Therefore, 6 mils is the angle of offset between the line of sight from the director to the datum point and that from the gun to the datum point. The gun being on the right of the director datum point line of sight, the 6 mils is subtracted from the azimuth of the director datum point line of sight.

The resultant gives the azimuth of the lookout tower from the gun as 1,194 mils. If the gun were traversed to the right through 6 mils, the azimuth indicator would read 1,200 mils, its line of sight would be parallel to the director line of sight, and the gun would be oriented in azimuth. However, antiaircraft gun batteries ordinarily consist of not one but four guns. The process of orienting a four-gun battery in azimuth is merely the application of the principle illustrated above to each element of the battery to be oriented. (See fig. 20.)

Horizontal range from director to datum point = 5,030 yards
Azimuth from director to datum point = 1,200 mils

	Gun No. 1	Gun No. 2	Gun No. 3	Gun No. 4
Range displacement in yards	−30	−90	−120	−60
Range to datum point in yards	5,000	4,940	4,910	4,970
Lateral parallax (offset) in yards	R–30	R–60	R–90	R–90
Substitute in formula				
Number of mils = $\frac{\text{Lateral displacement in yards}}{.001 \times \text{range to DP}}$	6	12	18	18
Lateral parallax in mils	−6	−12	−18	−18
Azimuth datum point from guns in mils	1,194	1,188	1,182	1,182

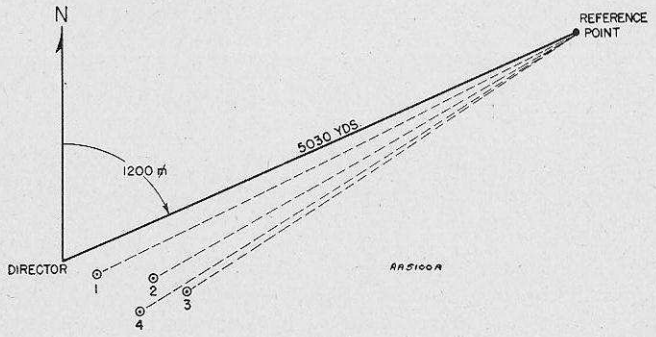


FIGURE 20.—Illustration of gun parallax.

■ 41. LAGMETER ADJUSTMENT.—Check the lagmeters on both azimuth and elevation indicators and if the needle is not at zero, carefully adjust the mechanical adjustment screws on the left side of the indicator-regulators. (See fig. 21.)

NOTE.—Do not force lagmeter adjusting screw farther than necessary as damage to the mechanism may result. Do not zero lagmeter mechanically while data transmission system is energized.

CHAPTER 5

SYNCHRONIZATION

	Paragraphs
SECTION I. General	42
II. Synchronization of guns (with M2 remote-control system) with director M7 or M9	43
III. Synchronization of height finder with director	44–45
IV. Orientation and synchronization of radar with director	46–48
V. Application of calibration corrections	49–52

SECTION I

GENERAL

■ 42. SYNCHRONIZATION.—*a.* Synchronization is the process of making certain that all elements of data are being transmitted correctly between the various components of the battery.

b. Synchronization is entirely separate from orientation and is usually performed after orientation. It will seldom be necessary to synchronize after the initial adjustment has been made. Lack of synchronization usually indicates some fault in the data transmission system. Primarily as a precaution against faults, the synchronization must be checked each time the data transmission system is used.

c. Synchronization of the battery resolves itself into synchronization of the following matériel with the director.

(1) Guns.
(2) Height finder.
(3) Radar.

SECTION II

SYNCHRONIZATION OF GUNS (WITH M2 REMOTE-CONTROL SYSTEM) WITH DIRECTOR M7 OR M9

■ 43. SYNCHRONIZATION.—*a.* (1) The indicator regulators at the guns are said to be synchronized with the dials at the director when the comparable dials at both guns and director indicate identical readings in all positions.

(2) During orientation of the guns with power OFF, the lagmeters of both indicators were zeroed. (See par. 41.)

b. (1) To synchronize, set controls as follows:

(*a*) On director M7, turn the power switch on the left side of the director to the OFF position. On director M9, set the switch on the adjustment panel to STATIC TEST.

(*b*) Motor switch to OFF at gun junction box.

(*c*) Transfer valve plungers OUT in both elevation and azimuth.

(*d*) Selector switches on both indicators in AUTOMATIC position.

(*e*) Power switch on generator in OFF position.

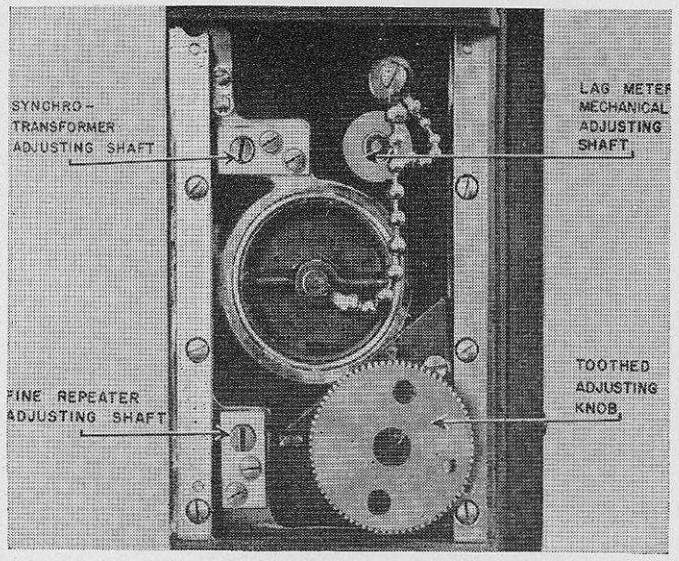


FIGURE 21.—Left side of M1 indicator regulator.

(2) Start generator and idle until warm. Be sure selector switches are in AUTOMATIC position. Then close power plant switch to energize the system while generator is still at idling speed. Bring generator speed up to 1,200 rpm and adjust field rheostat on generator until voltage at director is 115 volts approximately.

(3) Set angle of train, quadrant elevation, and fuze on the director to any convenient value. Note exact readings of the dials. ***Caution:*** *Thereafter do not change the director readings until synchronization is completed.*

(4) Operate the gun manually until the values of quadrant elevation and angle of train selected in (3) above are set on the mechanical pointers of their respective indicators.

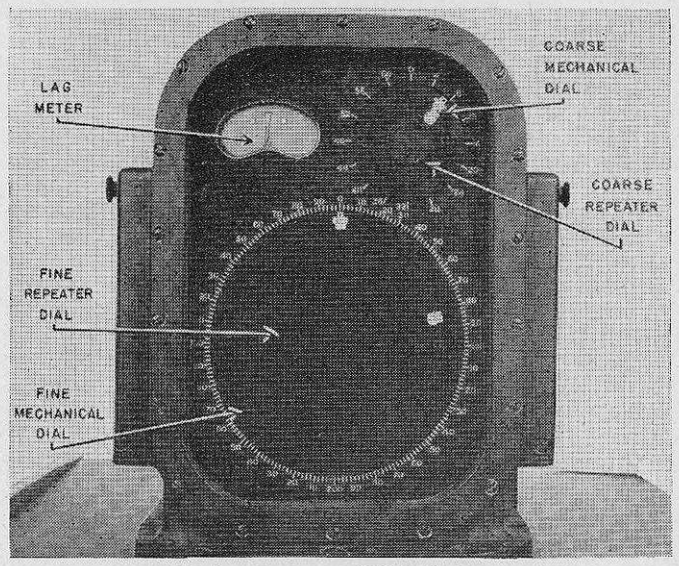


FIGURE 22.—Front view of M1 indicator regulator.

(5) Set the selector switches on the azimuth and elevation indicators to the MANUAL position. ***Caution:*** *When turning the selector switch from AUTOMATIC to MANUAL, it must be turned slowly.*

(6) Observe position of electrical fine dial pointers (inner) on azimuth and elevation indicators. If inner pointers do not match outer pointers, adjust the fine repeater shaft under the left-hand cover plate to match inner pointers to outer pointers.

(7) If the course pointers do not match, adjust the coarse repeater shaft under the right-hand cover at the top.

NOTE.—Coarse dials do not need to match exactly for proper operation, and therefore would seldom require adjusting. If coarse dials fail to match by more than 100 mils, do not adjust; call ordnance personnel.

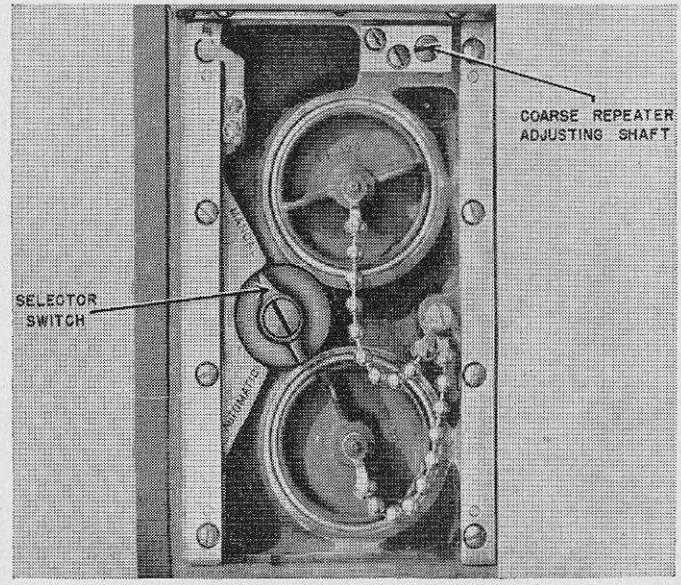


FIGURE 23.—Right side of M1 indicator regulator.

(8) Set the selector switch at AUTOMATIC on both indicators. This electrically disconnects the fine receiver from the system.

(9) Check the level of oil in A end housing. Add oil only if the oil level cannot be seen through the oil level gauge; notify qualified personnel in case leaks are observed.

(10) Turn on the motor switch at the gun junction box and watch oil level; if oil level rises, turn off motor switch immediately and call qualified personnel.

(11) Turn synchro-transformer adjusting screw (fig. 21) until the lagmeter reads zero on both the azimuth and elevation indicators.

NOTE.—Do not touch this adjusting screw after this operation.

(12) Disengage the azimuth handwheel by pushing the handwheel toward the muzzle and depress the transfer valve plunger.

NOTE.—If, after the transfer plunger is pushed in, the gun does not come to a synchronous position, or the gun oscillates, notify qualified personnel.

(13) If the lagmeter pointer moves from its zero position, it indicates that the amplifier is not balanced. The amplifier is balanced and the gun returned to position by adjusting the balancing screw *AZ* (fig. 24) until the lagmeter needle returns to its zero position. ***Caution:*** *Care must be taken not to force adjusting screws beyond the stops; only small adjustments should be necessary.*

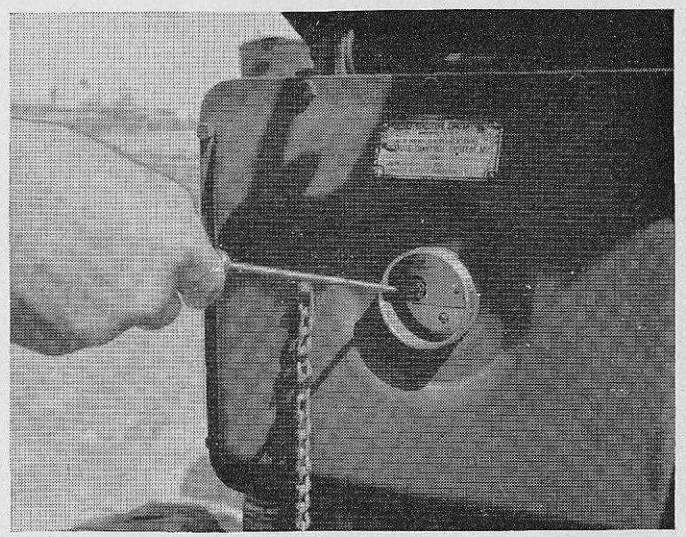


FIGURE 24.—Amplifier.

(14) Repeat steps (12) and (13) for elevation.

NOTE.—Adjusting screw on amplifier is marked EL for elevation.

(15) *Fuze synchronization.*—Operate the fuze setter manually until the value in (3) above is set on the mechanical pointer. If the inner pointer does not match the outer pointer, remove cover *X* on fuze setter and adjust by use of the slotted screw *T* (fig. 25).

NOTE.—Apply fuze calibration if required by turning screw *T*.

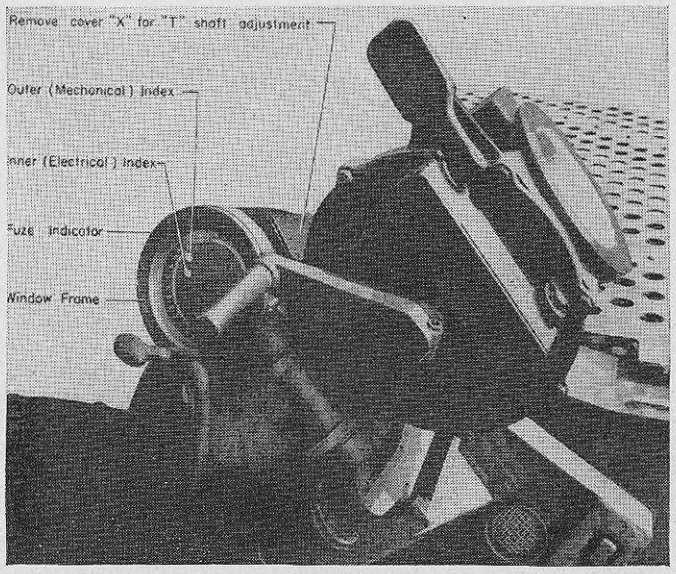


FIGURE 25.—Fuze setter M13.

c. Operating tests.—The fire control system is now ready for operation. However, the following operational tests of the mechanism are made. Pull out the transfer valve plungers, engage the handwheels, and set the gun manually to approximately 50 mils out of synchronism, in azimuth and elevation, with the data transmitted by the director.

With the indicator regulator switches on AUTOMATIC and the handwheels disengaged, depress the transfer valve plungers and allow the gun to come to rest; note at the same time whether excessive hunting occurs. This test checks the operation of the synchro-transformer, the amplifier, and the hydraulic system. Repeat the test with the gun at least 400 mils out of synchronism. This test checks the operation of the synchronizer, in addition to the components mentioned above.

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

(1) When power is off, lagmeter pointers should be at zero.

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

(3) The balance of the amplifier must be checked in azimuth and elevation, as described in *b*(13) and (14) above. Temperature change and other conditions may cause slight variations.

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

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

e. Removal from operation.—The following steps are necessary to remove the system from operation:

(1) Pull out proper transfer valve plunger.

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

(3) Return proper indicator-regulator switch to MANUAL position.

(4) Engage the handwheels.

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

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

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(2) Turn indicator regulator switches to AUTOMATIC.
(3) Disengage handwheels.
(4) Push in transfer valve plungers.

g. Guns with other than M2 remote control system.—Synchronization of the M2 90-mm and the 4.7-inch (120-mm) guns is very similar. For details, see respective service of the piece manuals.

SECTION III

SYNCHRONIZATION OF HEIGHT FINDER WITH DIRECTOR

■ 44. GENERAL.—Synchronization of the height finder with the director involves the following.

a. The altitude indicator of the M7 director or the altitude converter of the M9 director is synchronized with the altitude transmitter of the height finder when their electrical indices indicate identical readings at all settings.

b. Synchronization of the target designating system is accomplished when the electrical indices on the azimuth and elevation dials of the height finder and the present azimuth and present angular height dials on the M7 director, or on the tracker of the M9 director, indicate identical readings at all azimuths and elevations.

■ 45. SYNCHRONIZATION.—*a. Height finder M1.*—To synchronize the height finder with the director, proceed as follows:

(1) *Synchronization in azimuth and angular height.*—(*a*) Energize data transmission system.

(*b*) Set present azimuth and present angular height at the director to convenient readings.

(*c*) Check the readings of the transmitter dials at the director with the readings of the electrical indices on the height finder azimuth and elevation indicators. Increase readings of the transmitters at the director and again verify the new readings. If either of the height finder indices does not agree with those at the director, adjustment is made at the height finder. (See FM 4–142.)

(2) *Synchronization in altitude.*—The transmitter on the height finder is checked for synchronization with the electrical index of the altitude and range dial on the director M7 or on the altitude converter of the M9 director as follows:

(*a*) Energize data transmission system and set the vertical parallax dial to zero.

(*b*) Set the transmitter scale on the height finder to any convenient round number and check against the reading of the electrical index on the director's altitude and range dial. If the readings do not agree, a plus or minus correction is applied on the vertical parallax dial. After this adjustment, the height finder's transmitter and the director's receiver are checked in at least two other positions to verify the correctness of readings. (This adjustment is temporary only; for a permanent adjustment, qualified personnel must adjust director.)

b. Radio optical height finder (SCR–547).—(1) *Azimuth.*—There is no adjustment provided for the electrical pointer at the SCR–547 to make it agree exactly with the transmitter at the director. The synchronous repeater system is set up at the factory to position itself properly and performs in the field without adjustment unless trouble develops, in which case qualified personnel should be called.

(2) *Angular height.*—Synchronization in angular height is also factory adjusted and requires no adjustment unless trouble develops, in which case qualified personnel should be called.

(3) *Altitude.*—This adjustment is made to make the altitude reading at the director agree with the reading on the range converter. This is done in the following manner:

(*a*) Pull out range converter drawer halfway and remove the cover exposing the housing of the altitude selsyn.

(*b*) Loosen the six screws which hold the selsyn housing and turn the slotted shaft until the altitude received at the director agrees with the dial on the range converter.

(*c*) Retighten the selsyn housing screws. Replace cover and close drawer.

(4) *Slant range.*—In the case of the M9 director where potentiometer slant range is transmitted, the synchronizing adjustment is made at the factory. In case of trouble, call qualified personnel.

SECTION IV

ORIENTATION AND SYNCHRONIZATION OF RADAR WITH DIRECTOR

■ 46. GENERAL.—The operations of orienting and synchronizing radar equipment are so interwoven that for purpose of clarity both orienting and synchronizing procedures will be discussed together. Although there are various methods of orienting only the backsighting method will be discussed. For other methods of orienting, see respective service of the radar manuals.

■ 47. SCR–584 WITH DIRECTOR.—It is assumed that the director is properly oriented and necessary tests and adjustments made, that cables are hooked up as shown in figure 26 or 27, and that the optical axis of the radar has been aligned with the electrical axis by methods directed in FM 4–144. Proceed to orient and synchronize the SCR–584 as follows:

a. With M7 director.—(1) Place the SCR–584 in full operation. Then proceed as follows:

(*a*) With control switch in AUTOMATIC, turn ON the azimuth and elevation motor generators by means of the azimuth and elevation switches in the switch box. Turn the safety switch to RUN and the control switch to MANUAL.

(*b*) By means of the handwheels on the antenna position control unit, point the parabola accurately in azimuth and elevation at the center of the azimuth telescope of the director as observed through the telescopic sight on the parabola on the SCR–584.

(*c*) *At the same time* direct the azimuth telescope of the director at the center of the telescope on the parabola of the SCR–584.

(*d*) Turn OFF the azimuth and elevation motor generators. Wait until the motor generators stop, then throw the safety switch to STOP. Check the position of the parabola by looking through the telescope. If the parabola has moved, repeat the above steps to reposition it.

(*e*) Remove the azimuth selsyn cover plate from the pedestal. Loosen the azimuth orientation locking handle and push down and turn the azimuth orientation handle

until the inner and outer coarse azimuth pointers of the director differ by approximately 3,200 mils. Continue to rotate slowly until the director fine azimuth pointers are accurately matched. Tighten the azimuth orientation locking handle, keeping the fine azimuth pointers matched at the director. The coarse azimuth pointers at the director may be accurately positioned by loosening the clamps on the coarse azimuth transmitting selsyn at the SCR–584 and rotating its

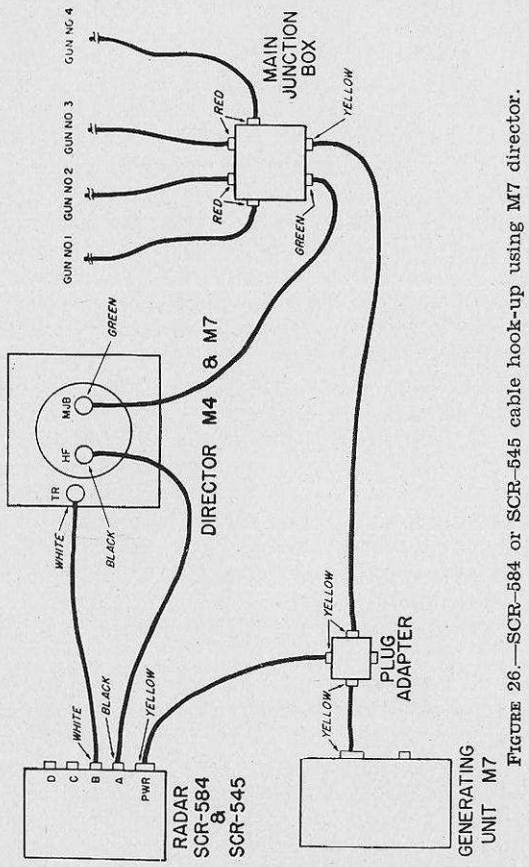


FIGURE 26.—SCR–584 or SCR–545 cable hook-up using M7 director.

stator to obtain a difference of 3,200 mils between the inner and outer dials at the director. Tighten the clamps in this position.

(*f*) Remove the elevation selsyn cover plate on the rear of the pedestal yoke.

(*g*) Note that when the two sights are pointed at each other one is depressed and the other elevated. If the SCR–584 is depressed, the angle of depression as indicated by the innermost dial at the M7 must be exactly the same reading as the angle of elevation indicated by the outermost dial. If not, loosen the clamps on the fine elevation transmitting selsyn and rotate the stator to obtain the desired reading.

(*h*) The coarse elevation pointers are adjusted in the same manner.

(*i*) Personnel on the roof must stand clear of the parabola. Start the azimuth and elevation motor generators. Turn the safety switch to RUN and rotate the parabola approximately 3,200 mils with the azimuth handwheel. Turn the control switch to REMOTE.

(*j*) Look at both the fine and coarse azimuth indicators of the director. If the inner and outer pointers of each are not matched, then match them by loosening the clamps on the azimuth selsyn transformer in the base of the pedestal of the SCR–584 and rotate its stator until both the fine and coarse azimuth pointers are matched. When the pointers are matched the parabola will be pointing in the same direction as the director instead of at the director. Tighten the clamps in this position.

(*k*) Look at both the fine and coarse elevation indicators of the director. If the innermost and outermost pointers of each are not matched, then match them by loosening the clamps on the elevation selsyn transformer located in the pedestal of the SCR–584 and rotate its stator until both the fine and coarse pointers are matched, and the parabola is pointing in the same elevation as the director. Replace the elevation selsyn cover plate.

(*l*) Traverse the director to 0 mils in azimuth and 0 mils in elevation. The parabola of the SCR–584 must follow and the azimuth and elevation pointers at the director must stay matched.

(*m*) Turn OFF the azimuth and elevation motor generators. Wait until the motor generators stop, then throw the safety switch to STOP.

(*n*) Loosen the clamp on the PPI selsyn located in the base of the pedestal and rotate its stator to cause the sweep direction on the PPI to agree with the azimuth read on the inner pointers of the director, which is 0 mils. Replace the azimuth selsyn cover plate.

(*o*) Place the control switch in AUTOMATIC and look at the pointers of the azimuth and elevation indicators on the antenna position indicator. If all of the pointers do not read zero, they will require adjusting as indicated below.

(*p*) If any adjustments are necessary, pull the antenna position indicator halfway out of the control rack. (On some units it is more feasible to work from the rear of the antenna position indicator.)

(*q*) If the inner pointer of the azimuth dial does not read zero, loosen the clamp on the *local* azimuth receiving selsyn in the antenna position indicator, then rotate the stator until the *inner* pointer *does* read zero. Tighten the clamp in this position.

(*r*) If the outer pointer of the azimuth dial does not read zero, loosen the clamp on the *remote* azimuth receiving selsyn in the antenna position indicator, then rotate the stator until the *outer* pointer *does* read zero. Tighten the clamp in this position.

(*s*) If the inner pointer of the elevation dial does not read zero, loosen the clamp on the *local* elevation receiving selsyn in the antenna position indicator, then rotate the stator until the *inner* pointer *does* read zero. Tighten the clamp in this position.

(*t*) If the outer pointer of the elevation dial does not read zero, loosen the clamp on the *remote* elevation receiving selsyn in the antenna position indicator, then rotate the stator until the *outer* pointer *does* read zero. Tighten the clamp in this position.

(2) Orient and synchronize in altitude as follows:

(*a*) Before the SCR–584 can be oriented and synchronized for transmitting either altitude or slant range selsyn data, the slant range potentiometer must be accurately calibrated as prescribed in TM 11–1324.

(*b*) Turn ON the elevation motor generator. Turn the control switch on the SCR–584 control panel to the MANUAL position and the safety switch to RUN.

(*c*) Set the hair line on the range indicator unit to 8,000 yards. Throw the altitude slant range switch on the altitude converter control unit to the ALTITUDE position. Throw the altitude-slant range switch on the data panel to the ALTITUDE position. Elevate the parabola of the SCR–584 and the director until the pointers of the elevation dials at the director read 533 mils.

(*d*) With the pointers on the range dials of the SCR–584 set at 8,000 yards, the altitude read at the altitude converter data unit should be 4,000 yards.

(*e*) If the dial on the data unit does not indicate 4,000 yards the height calibrate adjustment on the front of the altitude converted data unit must be turned until the indicated altitude is correct.

(*f*) Elevate the parabola to 1,067 mils as indicated at the director. Set the slant range hair lines to 10,000 yards. The altitude converter data dial should now indicate 8,660 yards altitude. If not, refer to TM 11–1324 for altitude converter adjustments. If it is necessary to move the elevation potentiometer located in the pedestal, recheck the elevation orientation and synchronization.

(*g*) The altitude at the director is set to 8,660 yards and the AA pointers made to match by turning the selsyn adjustment rod on the altitude data unit.

NOTE.—The above procedure is necessary when orienting the SCR–584 for the first time with a specific director. As long as the same equipment (director and SCR–584) is used together, the selsyns in the antenna position indicator should not need adjusting, although they must be checked and adjusted if necessary. Orientation and synchronization in azimuth may be accomplished by loosening the azimuth orientation locking handle, and turning the azimuth orientation handle until the inner and outer azimuth dials of the director show a difference of eactly 3,200 mils. Elevation orientation and synchronization are correct when the SCR–584 and M7 have been leveled, providing the adjustment of the telescope on the parobola has not been changed since the

last orientation and synchronization. A check must always be made.

(3) The SCR–584 is now oriented and synchronized with the M7 director.

b. With M9 director.—(1) Present position information is transmitted to the computer of the M9 or M10 director by means of data transmitting potentiometers. Present position azimuth and elevation data may also be transmitted to the tracker of these directors by means of the coarse and fine selsyns transmitters in the pedestal of the SCR–584. Perform the following checks:

(*a*) Refer to *a*(1)(*a*) through (*d*) above, inclusive.

(*b*) All dials on the correction panel of the computer must be set to their normal position (that is, no correction set into the computer). Set the test switch on the adjustment panel of the computer to TRACKER TEST. Set the altitude slant range switch to SLANT RANGE.

(*c*) Remove the azimuth selsyn cover plate from the pedestal. Loosen the azimuth orientation locking handle by turning counterclockwise. Push down the azimuth orientation handle, and rotate it until the reading on the firing azimuth dials at the computer differ by 3,200 mils from the readings of the outer pointers on the azimuth dials of the tracker. At the same time, the inner (electrical) pointers on the azimuth dials of the tracker must differ by 3,200 mils from the outer (mechanical) pointers. Tighten the azimuth orientation locking handle while holding the azimuth orientation handle to keep proper azimuth indication at the computer. If the inner (electrical) pointers at the tracker do not indicate correctly when the firing azimuth dials at the computer have been set, the difference must be compensated for by adjusting the individual selsyns at the SCR–584.

(*d*) Note that when the two sights are pointed at each other, one is depressed and the other elevated. If the SCR–584 is depressed, the angle of depressions as indicated by the inner elevation dials at the tracker must be exactly the same reading as the angle of elevation indicated by the outer dials. The angle of *depression* as read at the *computer* must be the same as the angle of *elevation* as read at the *tracker*.

(*e*) Loosen lock nut on the elevation selsyn drive shaft. Loosen setscrew lock nuts on elevation selsyn adjusting arm; adjust setscrews until the angle of *depression* read at the

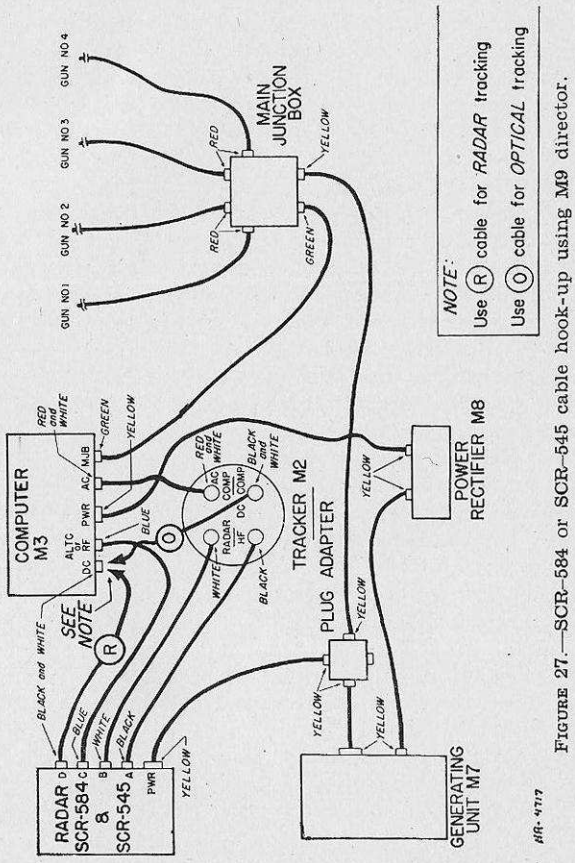


FIGURE 27.—SCR–584 or SCR–545 cable hook-up using M9 director.

quadrant elevation dial of the computer is the same as the angle of *elevation* as read at the tracker. Tighten setscrew lock nuts and the lock nut on the elevation selsyn drive shaft.

(*f*) Throw the radar-height finder switch at the tracker to the RADAR position. Loosen the clamps on the SCR–584

coarse azimuth transmitting selsyn and rotate its stator until the outer and inner pointers of the coarse azimuth dial at the tracker differ by 3,200 mils. Tighten the clamp in this position. Loosen the clamps on the SCR–584 fine azimuth transmitting selsyn and rotate its stator until the outer and inner pointers of the fine azimuth dial at the tracker are exactly matched.

(*g*) If the inner elevation pointers at the tracker do not read as indicated in (*d*) above, it is necessary to remove the cover plate on the rear of the pedestal yoke. Loosen the clamps on the SCR–584 coarse elevation transmitting selsyn and rotate the stator until the angle of depression as indicated on the inner dial of the coarse selsyn of the tractor is the same as the angle of elevation as indicated on the outer dial of the same selsyn. Tighten the clamps in this position.

(*h*) The fine elevation pointers are adjusted in the same manner.

(*i*) Refer to *a*(1)(*i*) through (*t*) above, inclusive.

(2) *Slant range.*—Set the hair line pointers on the range indicator to 6,000 yards. Throw the altitude-slant range switch on the data panel to the SLANT RANGE position. If the range meter at the computer does not read exactly 6,000 yards the potentiometer in the range indicator must be set according to procedure outlined in TM 11–1324 and 11–1424.

NOTE.—The above procedure is necessary when orienting the SCR–584 for the first time with a specific director. As long as the same equipment (director and SCR–584) is used together, the selsyns in the antenna position indicator should not need adjusting, although they must be checked and adjusted if necessary. Orientation and synchronization in azimuth may be accomplished by loosening the azimuth orientation locking handle, turning the azimuth orientation handle, and rotating it until the reading on the azimuth dial at the computer differs by 3,200 mils from the readings of the outer pointers on the azimuth dials of the tracker. Elevation orientation and synchronization are correct when the SCR–584 and the M9 have been leveled, providing the adjustment of the telescope on the parabola has not been changed since the

last orientation and synchronization. A check must always be made.

(3) The SCR–584 is now oriented and synchronized with the M9 director.

■ 48. SCR–545–A WITH DIRECTOR.—It is assumed that the director is properly oriented and necessary tests and adjustments made, that cables are hooked up as shown in figure 26 or 27, and that the optical axis of the radar has been aligned with the electrical axis by methods directed in FM 4–146. Proceed to orient and synchronize the SCR–545–A as follows:

a. With M7 director.—(1) Close all switches on the main power panel, with the exception of the HIGH VOLTAGE-START. Proceed as follows:

(*a*) Set the MANUAL-AUTOMATIC SWITCHES on all operator control units at MANUAL.

(*b*) By means of the AZIMUTH and ELEVATION HANDWHEELS, direct the antenna at the azimuth telescope of the director as observed through the telescope on the antenna of the SCR–545–A.

(*c*) At the same time, direct the azimuth telescope of the director at the telescope on the antenna of the SCR–545–A.

(*d*) Remove the cover from the rear hatch of the SCR–545 to expose the coarse and fine azimuth synchronous transmitters. Loosen the clamping ring on the coarse transmitter and turn it by hand until the inner and outer coarse azimuth pointers of the director differ by 3,200 mils. Tighten the clamping ring.

(*e*) Loosen the clamping ring on the fine azimuth transmitter and turn it by hand until the inner and outer fine azimuth pointers of the director are accurately matched. Tighten the clamping ring.

(*f*) Note that when the two sights are pointed at each other, one is depressed and the other elevated. If the SCR–545–A is depressed, the negative angular height as indicated by the innermost dial at the director must be exactly the same as the positive angular height indicated by the outermost dial. If the coarse and fine indicators are not correct, remove the cover from the angular height synchronous transmitters at the SCR–545 and adjust the proper transmitter to obtain the desired reading.

(*g*) Remove the cover from the azimuth dials on the azimuth control unit in the cab and loosen the coarse and fine dials. Set these dials to read exactly the same as the inner azimuth pointers at the director.

(*h*) Remove the cover from the elevation dials on the elevation control unit in the cab and loosen the coarse and fine dials. Set these dials to read exactly the same as the inner elevation pointers at the director.

(*i*) Traverse the antenna by means of the AZIMUTH and ELEVATION HANDWHEELS until the innermost and outermost pointers at the director are matched.

(*j*) Turn the upper and lower adjusting screws on the azimuth TARGET DESIGNATION UNIT in the cab until the upper and lower dials each read the azimuth indicated by the coarse azimuth dial on the AZIMUTH CONTROL UNIT.

(*k*) Turn the upper and lower adjusting screws on the elevation TARGET DESIGNATION UNIT in the cab until the upper and lower dials each read the elevation indicated by the coarse elevation dial on the ELEVATION CONTROL UNIT.

(2) Orient and synchronize in altitude as follows:

(*a*) Before the SCR–545 can be oriented and synchronized for transmitting either altitude or slant range selsyn data, the slant range potentiometer must be accurately calibrated as prescribed in TM 11–1127.

(*b*) Operate the range handwheel on the range control unit to set a reading of 8,000 yards on the range dial of the range control unit in the cab.

(*c*) Set the data flow switch on the range control unit at the altitude position. Elevate the antenna of the SCR–545 to 533 mils. Set an angular height of 533 mils in the director.

(*d*) The altitude dial at the SCR–545 should now read 4,000 yards. If the dial does not indicate 4,000 yards, operate the HEIGHT CALIBRATE ADJUSTMENT on the front of the altitude converter until the dial indicates 4,000 yards.

(*e*) Set the altitude at the director to 4,000 yards. Match the AA pointers on the altitude dial at the M7 director by turning the ALTITUDE SYNCHRONOUS TRANSMITTER ADJUSTMENT at the SCR–545.

(*f*) As a check, operate the range handwheel on the range control unit to set a reading of 10,000 yards on the range dial of the range control unit in the cab. Elevate the antenna to 1,067 mils. The altitude dial should now indicate 8,660 yards. If this reading does not check within 10 yards, refer to TM 11–1127 for adjustment procedure. When the AA pointers at director are matched, the altitude dial should read 8,660 yards.

b. With M9 director.—In orienting and synchronizing the SCR–545 with the M9 director, proceed as follows:

(1) Refer to *a*(1) above.

(2) Set the data flow switch on the range control unit at M9 ON.

(3) Set computer at TRACKER TEST.

(4) Loosen the azimuth potentiometer locking nut and operate the azimuth potentiometer crank until the firing azimuth dial at the computer reads the same azimuth as the azimuth dial on the azimuth operator's control unit which is located in the cab of the SCR–545.

(5) Check the reading of the quadrant elevation dial at the computer. Its reading should agree with the angular height on the elevation dials of the elevation operator's control unit which is also in the cab of the SCR–545. If the reading does not agree, refer to TM 11–1127 for adjustment of the elevation potentiometer.

(6) Set a reading of 6,000 yards on the range dials of the range control unit which is in the cab of the SCR–545. The range meter at the computer should read exactly 6,000 yards. If the reading does not agree, refer to TM 11–1127 for adjustment of the range potentiometer.

Section V

APPLICATION OF CALIBRATION CORRECTIONS

■ 49. General.—*a.* The purpose of calibration fire is to determine from the relative location of the centers of burst of the guns of a battery the corrections to be applied to the individual guns in order that the battery may shoot a predetermined pattern.

b. Calibration fire is undertaken upon receipt of one or more different guns and when analysis of the results of fire

indicates that former calibration corrections are no longer effective.

c. Calibration corrections are gun corrections only. Therefore, since the corrections are applied to the individual guns, the corrections must be in terms of azimuth, quadrant elevation, and fuze.

d. It is never a good policy to correct a correction if it can be avoided. Consequently, all corrections are removed from the guns before conducting calibration fire.

■ 50. Azimuth.—To apply calibration corrections in azimuth, proceed as follows:

a. Set gun at some even azimuth such as 800 mils.

b. Raise sliding cover on left side of azimuth indicator.

c. Raise detent engaged in the toothed adjusting knob, and by turning knob, move mechanical (outer) fine pointer to the value in the opposite sense to that of the correction. For example, if indicator is set at 800 miles and a plus 5 mils correction is to be applied, make pointer read 795 mils; if a minus 5 mils correction is to be applied, make the pointer read 805 mils. Close cover.

d. Record amount of correction in gun book, and remember that if gun is checked in orientation, it should be in error by the amount of the calibration correction; for example, if a calibration correction of plus 5 mils has been applied and the gun is pointed at a datum point the azimuth of which is 1,500 mils, the azimuth indicator should read 1,495 mils.

■ 51. Quadrant Elevation.—To apply calibration corrections in elevation, proceed as follows:

a. Set gun elevation indicator-regulator to 800 mils.

b. If calibration correction is plus 5 mils, raise sliding cover on left side of elevation indicator and turn toothed adjusting knob until mechanical (outer) dial reads 795 mils. If a minus 5 mils correction is to be made, the indicator dial is made to read 805 mils. Lower cover. Record amount of calibration correction. Remember that when orientation of the gun in elevation is checked subsequently the guns will be in error by the amount of the calibration correction.

■ 52. FUZE RANGE.—*a. M13 fuze setter.*—In applying a calibration correction to the M13 fuze setter, proceed as follows:

(1) Energize data transmission system.

(2) Set director so that fuze dial reads any fuze range, such as 12.0.

(3) By means of the electrical synchronizing screw (which is in lamp well on right side of fuze indicator, as you face the dial), make electrical (inner) dial read fuze range plus or minus the correction. For example, make the dial read 12.2 to apply a correction of plus 0.2 fuze numbers.

(4) Record amount and sense of calibration correction, remembering that when synchronization is checked, the fuze setter will be out of *synchronization* by amount of correction applied. For example, if the fuze dial on the director reads 10 and a correction of plus 0.2 fuze numbers has been applied, the fuze indicator dial on the fuze setter at the gun will read 10.2.

b. M20 fuze setter.—(1) To apply calibration corrections in fuze range, proceed as follows:

(*a*) With power connected, turn torque amplifier switch ON.

(*b*) Set director at any convenient fuze range.

(*c*) Remove cover cap and turn vernier adjusting shaft to the desired correction.

(2) After the calibration correction has been set into the fuze setter, a check must be made to see that the correction has been applied properly. To check this, proceed as follows:

(*a*) Remove firing mechanism from breechblock.

(*b*) Open breech.

(*c*) Turn rammer fuze setter power switch ON.

(*d*) Place fuze control lever in fuze position and present round to ramming rolls.

(*e*) When round has been rammed home, turn OFF rammer-fuze setter, open ramming rolls, open breech, and remove round.

(*f*) Compare set fuze with reading on director. The set fuze should have the same reading as the director reading plus or minus the correction.

CHAPTER 6

METHODS OF FIRE CONTROL AGAINST SEEN AERIAL TARGETS

		Paragraphs
SECTION I.	General	53–54
II.	Cable hook-ups	55–56
III.	High-flying targets	57–59
IV.	Low-flying targets	60–62

SECTION I

GENERAL

■ 53. DEFINITIONS.—*a.* Aerial targets must necessarily be classified with relation to the methods of fire control employed by the guns and instruments with which the AA battery is equipped. This chapter deals with seen targets. Such targets are classified in three categories: high flying targets (high angle fire), low-flying targets (low angle fire), and diving targets (either high or low angle fire).

b. When using the M1 or M2 height finder, targets flying at angular heights greater than 180 mils and altitude greater than 550 yards may be defined as high-flying targets. Planes that are either flying at altitudes less than 550 yards or at angular heights less than 180 mils are low flying targets. When radar instead of the stereoscopic height finder, is transmitting selsyn data, the altitude limitation is 300 yards.

■ 54. BASIC CONSIDERATIONS.—*a. Limitations of equipment.*—When the battery employs an M4 or M7 director or modifications, it is impossible to predict data for targets at slant ranges of less than about 3,500 yards due to the constructional limitations of the quadrant elevation cam. It follows that some method of fire control other than director control must be adopted for close-in targets when the battery is equipped with an M4 or M7 director. The M9 director, on the other hand, is limited chiefly by the angular tracking rates possible on the tracker.

b. Present position data.—(1) Both the SCR–545 and the SCR–584 are gun laying radars and when properly adjusted will give reliable present position data to the director. These radars supply more accurate present altitude (H_o) or present slant range (D_o) data than the stereoscopic height finder.

Therefore, when the battery is equipped with both radar and stereoscopic height finder, radar data in H_o or D_o are preferable.

(2) Radar does not give present azimuth (A_o) and present angular height (ϵ_o) as accurately as optical tracking. However, the difference in accuracy between radar data in A_o and ϵ_o and the same data obtained by visual tracking is comparatively slight. In the case of the M9 director, the source of present positon data (A_o and ϵ_o) must be determined by existing conditions of visibility. On a day when the ceiling is high and visibility good, A_o and ϵ_o should be obtained by visual tracking. If, on the other hand, visibility is poor, radar present position data (X_o, Y_o and H_o) should be fed directly to the computer. Where the M7 director is used, A_o and ϵ_o are obtained by visual tracking as long as the target can be seen. When the target cannot be seen, radar data are used with the M7 director.

c. Tactical control of fire by battery officers.—(1) The battery commander is free to go where needed, but normally remains either at the radar, the BC telescope, or the command post during an alert. He keeps posted on all matters of intelligence which will aid him in deciding when to alert the battery to fire on an enemy target. If there is more than one target which may be engaged, he designates the target to be fired upon.

(2) The executive officer remains centrally located with respect to the guns and supervises the gun position.

(3) The range officer supervises the range detector section. He is stationed wherever needed in the range-detector section. He is responsible for the calculation and application of ballistic corrections to the director. He is responsible that necessary adjustments as a result of observation of fire are made.

SECTION II

CABLE HOOK-UPS

■ 55. DIRECTORS M4 AND M7.—*a. With height finder M1 or M2 or SCR–547.*—When the M4 or M7 director is used in conjunction with either type of height finder, only one cable runs between the two instruments, as indicated in figure 28.

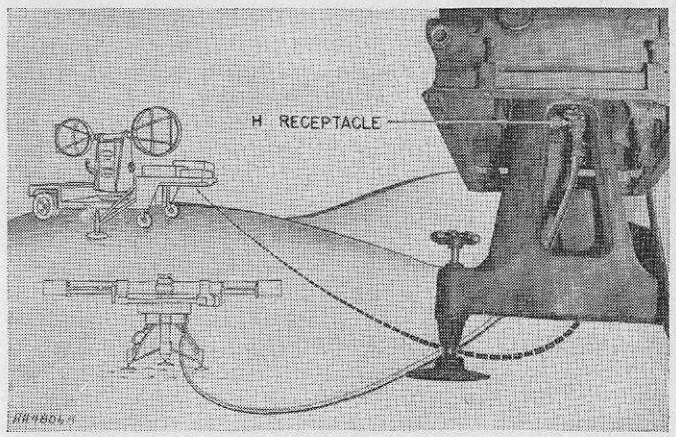


FIGURE 28.—Cable hook-up with height finder M1 or M2 or SCR–547 with M7 director.

b. With radar SCR–584 or SCR–545.—If radar SCR–584 or SCR–545 is employed with the M7 director, two cables are run between the radar and the director (see fig. 29).

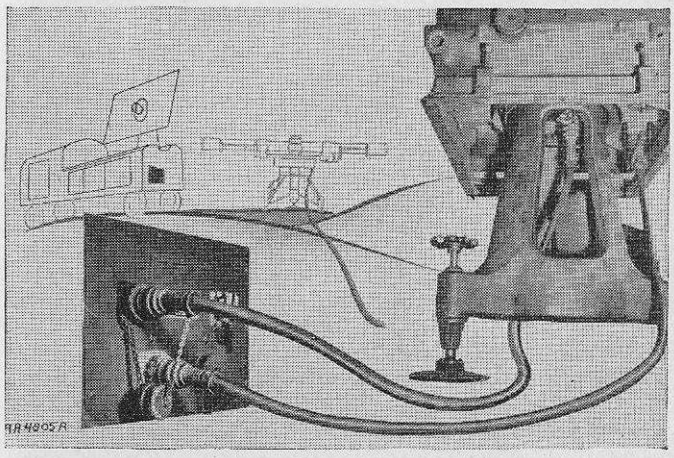


FIGURE 29.—Cable hook-up SCR–545 with M7 director.

c. Although the normal cable hook-up in a battery equipped with radar is that indicated above, it is feasible to vary this hook-up by inserting the HF cable in the director in lieu of the radar A cable. This hook-up permits *search* by radar while director and HF are engaging the target at hand. In this event, the switch at the base of the director is thrown to H. However, two basic objections to this type of hook-up must be considered. In the first place, altitudes received from the height finder are not so consistently accurate as those transmitted by radar. Second, it is not possible for the director automatically to position the SCR–584 in A_o and ϵ_o.

■ 56. DIRECTORS M9 AND M10.—When operating with the stereoscopic height finder, the tracker of M9 director is hooked up in a similar manner to that for the M7 director shown in figure 28.

a. With SCR–547.—When the SCR–547 is hooked up to the M9 director, the SCR–547 sends potentiometer D_o direct to the computer. Target designation data are sent from tracker to SCR–547 direct.

b. With radar SCR–584 or SCR–545.—The cable connections for use between the SCR–584 or SCR–545 and the M9 director are shown in figure 30. This figure must be studied carefully as it shows the recommended hook-up along with the elements of data transmitted through each cable. With such a hook-up, any combination of equipment may be employed. The height finder is not used to transmit H_o as long as the radar is operative for reasons that radar data are more accurate, extra operators are needed, and it is impossible for the director to send present position data to the radar.

SECTION III

HIGH FLYING TARGETS

■ 57. PICKING UP TARGETS.—*a. General.*—The following procedures outline the sequence of action of the battery:

(1) Warning of approach of targets is received.

(2) Personnel take battle stations.

(3) Equipment is prepared for action.

(4) Power plants are started.

(5) Equipment is energized.

(6) The various fire control instruments are habitually kept with certain desired settings so that the target can be

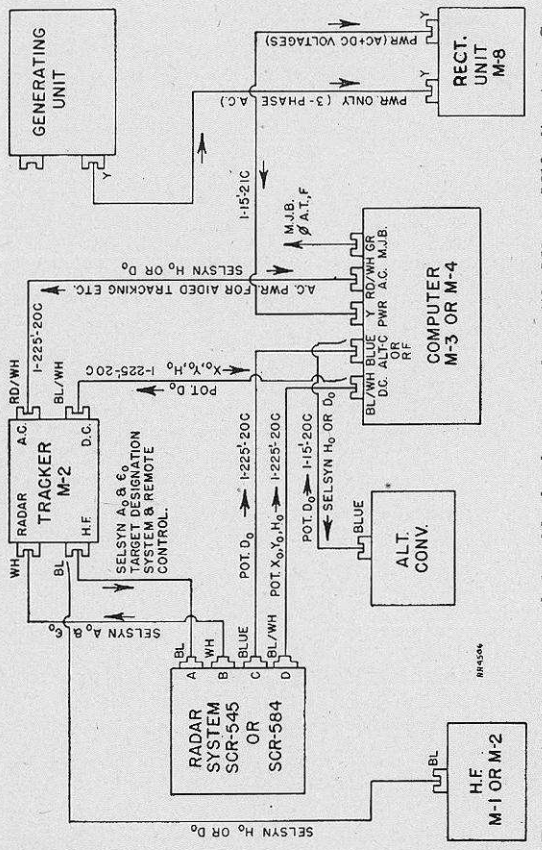


FIGURE 30.—Recommended cable hook-up—radar with M9 or M10 director. See figure 27 for power connections between generating unit, radar, and main junction box.

engaged in a minimum time. See appropriate service of the piece manuals.

b. Pick-up with aid of radar.—(1) *Directors M9 and M10.*—The elevation and azimuth trackers match pointers by means

of their respective handwheels. Once the target is sighted, the elevation and azimuth trackers cease matching pointers and track the target visually.

(2) *Directors M4 and M7 and modifications.*—(*a*) Altitude setter throws altitude receiver switch to T.

(*b*) Elevation tracker matches outer pointers to inner pointers or E_o dial using auxiliary handwheel.

(*c*) Azimuth tracker matches pointers on present azimuth dial.

(*d*) Altitude setter matches AA pointers when radar indicates data correct.

(*e*) Range setter allows middle pointer to catch up with inner pointer before he commences to match pointers using range handwheel.

(*f*) When target is sighted in telescope of director, azimuth and elevation trackers cease matching pointers and commence tracking.

(3) *Height finder M1 or M2.*—When radar sets SCR–584 or SCR–545 are operative, the stereoscopic height finder is not normally cabled into the director. The height finder, however, should be manned and ready for action. In the case where the height finder is connected to the M7 director to enable the radar to be used solely for searching, the procedure in picking up targets is as follows:

(*a*) Azimuth and elevation trackers match pointers.

(*b*) The observer watches for target in telescope reporting, "Target," when seen.

(*c*) The azimuth and elevation trackers cease matching pointers and commence tracking.

c. Unaided visual pick-up.—(1) *Directors M9 and M10.*—(*a*) The slewing operator grasps the slewing handles, operating the azimuth slewing clutch, and turns the tracker to direct the telescopes toward the target with the aid of the open sight on azimuth telescope.

(*b*) The elevation tracker operates the elevation slewing clutch and moves the telescopes in elevation by the slewing handle as ordered by the slewing operator.

(*c*) If the target is picked up by the height finder first, the operators at the tracker are advised of the angular height

and azimuth by telephone. The target is located by setting these values on the dials of the tracker.

(2) *Directors M4 and M7.*—The altitude receiver switch is always in the H position when radar is unavailable or inoperative. In picking up a target for tracking, the open collimator sight is used to direct the azimuth and elevation telescopes to the target. The director corporal stands behind the director with his eye about 8 inches from the sight. He operates the elevation and slewing handwheels until the trackers can see the target through their telescopes and take over the tracking.

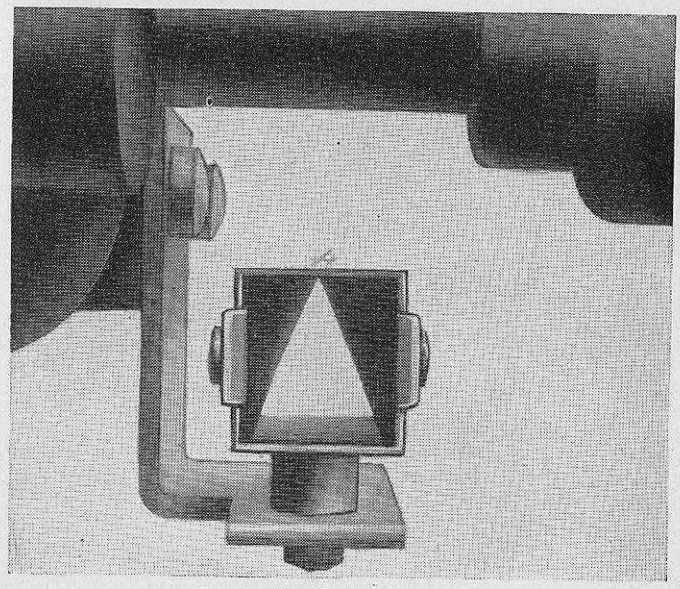


FIGURE 31.—Collimator sight.

(3) *Height finder M1 or M2.*—The precise drill employed by the height finder squad in picking up targets visually is described in FM 4–142.

■ 58. CONDUCT OF FIRE USING M9 OR M10 DIRECTOR.—*a. With height finder M1 or M2.*—(1) *Procedure at height finder.*—(*a*) When trackers are on target at the height finder, the

height finder sergeant or altitude setter checks match of pointers on elevation and azimuth dials and calls, "Target check."

(*b*) Observer calls, "Read," each time stereoscopic contact is made.

(*c*) Altitude setter reads value, sets it on the transmitter, and answers, "Check." Reports to director, "Altitude correct," or signals when data are consistent.

(2) *Procedure at director M9.*—(*a*) Altitude data switch on base of tracker at HF.

(*b*) Aided tracking handles at POS.

(*c*) Trackers place cross hairs on target using manual tracking.

(*d*) As soon as tracking is smooth, handles are moved to AID and trackers continue to track, using handwheels.

(*e*) Adjustments are made by small increments on trackers' handwheels.

(*f*) To engage a new target, handle is turned to POS and left for 5 to 7 seconds to remove rates. The procedure above is repeated on new target.

(*g*) *The time required to obtain firing data depends on how quickly a smooth rate of tracking is established.*

(*h*) Altitude setter matches middle index to inner dial. Aided tracking is used only for targets changing altitude.

(*i*) Range setter keeps the needle of null meter as close to zero as possible, using the range handwheel and aided tracking.

(*j*) The computer and rectifier operator maintains needles of target rate meters on scale, using the associated knobs. Reports, "Data smooth," when needles become relatively stationary.

(*k*) Range officer reports to battery commander, "Data in order."

(3) Fire is conducted by the guns in accordance with appropriate service of the piece manuals.

b. With radio height finder SCR–547.—(1) *Procedure at SCR–547.*—(*a*) Trackers follow target through telescopes.

(*b*) Range operator measures slant range as described in FM 4–143.

(*c*) HEIGHT-RANGE transfer switch is at HEIGHT.

(*d*) Range operator signals director by ON TARGET BUTTON.

(2) *Procedure at director M9.*—Same as in *a*(2) above except that (*h*) and (*i*) are excluded.

(3) Fire is conducted at guns in accordance with appropriate service of the piece manuals.

c. With SCR–545 or 584.—(1) *Procedure at radar.*—See FM 4–144 and 4–146.

(2) *Procedure at director.*—Same as in *a*(2) above except that (*h*) and (*i*) are excluded.

(3) Fire is coordinated at guns in accordance with appropriate service of the piece manuals.

■ 59. CONDUCT OF FIRE USING DIRECTOR M4 OR M7.—*a. With height finder M1 or M2.*—(1) Operation at the height finder during fire is the same as that described in paragraph 58*a*(1).

(2) *Procedure at director M4 or M7.*—(*a*) H–T switch on base of director at H.

(*b*) Trackers follow target through telescopes.

(*c*) Range setter matches pointers on E_o dial using range rate smoother.

(*d*) Altitude setter matches AA pointers on altitude dial, holding rate smoother knob at zero.

(*e*) Fuze dead time setter matches the speed of rotation of fuze rate drums.

b. With radio height finder SCR–547.—Operation is similar to that described in paragraph 58*b*. At the director the procedure is identical to that set forth in *a*(2) above.

c. With SCR–545 or 584.—H–T switch at base of director is at T. Procedure at the director is the same as described in *b* above.

SECTION IV

LOW-FLYING TARGETS

■ 60. GENERAL.—Two types of low-flying targets are considered in this section: constant altitude targets and diving targets.

■ 61. CONSTANT ALTITUDE TARGETS.—*a. Using M9 director.*—(1) When the M9 is used with the SCR–584, SCR–545, or SCR–547, the conduct of fire is the same as that outlined for high-flying targets. (See par. 58.)

(2) When the M9 is used with the height finder M1 or M2, slant range must be transmitted to the altitude converter. The range setter matches the indices on the slant range dial using aided tracking. The altitude setter keeps the needle of null meter at zero with his handwheel.

b. Using M7 director.—(1) When slant range is transmitted by the radar, the H–T switch on the director must be at T. When slant range is transmitted by a height finder, the switch is at H.

(2) The trackers follow the target through their telescopes or match pointers if radar data are furnished.

(3) The range setter matches the HOR pointers on altitude dial by turning the range handwheel using aided tracking.

(4) The altitude setter matches the E_o dials using the altitude handwheel.

(5) Fuze dead time setter matches the fuze rate drums.

c. Emergency measures against low level targets.—(1) Against low level coming attacks, a series of barrages fired in the path of the plane may be an effective defense. A condensed table or trajectory chart showing the fuze to be used when the range of the plane is estimated may be made up for the use of the gun commander. The vertical lead can be assumed to be a constant of 25 mils since the trajectory is practically flat up to 4,000 yards. No lateral lead is necessary.

(2) As soon as the attacking planes are sighted, the responsible gun commander indicates their location by yelling or signaling. The gun pointers concerned immediately point their piece in that general direction and, by watching the gun commander as he sights along the gun barrel, elevate, depress, or traverse to get on the target. As soon as he sights the planes, the gun commander estimates (considering time lag involved) what fuze to use, notifying the ammunition detail. The ammunition detail immediately begins to pass ammunition with preset fuzes to the gunner who loads and waits for the command to commence firing. As soon as the gun commander has the gun aligned on the target, he yells, "Fire". Both azimuth and elevation operators continue to watch the gun commander to make any

corrections he may indicate. Two rounds are fired at the initial fuze range followed by two rounds at each of the lower fuze settings. Maximum rate of fire is maintained. As many rounds as possible are fired at the minimum fuze setting.

(3) A table of fuzes to successive barrage points using the initial estimated range as the argument is given below.

Initial range of plane (yards)	Fuze to first barrage point (seconds)	Fuze to second barrage point (seconds)	Fuze to third barrage point (seconds)	Fuze to fourth barrage point (seconds)	Fuze to fifth barrage point (seconds)
6,000	7	5	3	1.67	0.6
5,000	5	3	1.67	1.67	.6
4,000	3	1.67	.6	.6	
3,000	3	1.67	.6		
2,000	1.67	.6			
1,000	.6				

NOTE.—M43A3 fuzes have lower limit of 1.67 seconds.

■ 62. DIVING TARGETS.—*a.* Both the M7 and M9 directors are designed to predict data for diving or climbing targets.

(1) When the M9 director is used for fire against diving targets, the procedure is the same as for other targets.

(2) When the M7 director is employed, the procedure is as follows:

(*a*) Altitude setter carefully adjusts the altitude handwheel, using rate smoother to the estimated rate "up" or "down." Further adjustment is made to the altitude handwheel to match the AA pointers.

(*b*) The trackers follow the target in their telescopes.

(*c*) The range setter keeps the E_o dials matched by means of the range handwheel and rate smoother.

(*d*) The fuze dead time setter matches the fuze rate drums.

b. (1) Experience has shown that director control against steep angle diving targets is ineffective. The gun defense against dive bombers is a curtain of fire in the path of the target near the midpoint of its dive. Since speed is essential, the fuze setting and leads must be determined in advance.

Normally, when a plane is diving on the gun, a fuze of 2 seconds, vertical lead of 15 mils, and no lateral lead are effective for any angle of dive. Point the gun at the plane, set in the 15-mil vertical lead, and shoot as many rounds preset at 2 seconds as possible.

(2) As soon as a dive bomber is sighted beginning its attack, the responsible gun commander points and yells, "Dive Bomber," the azimuth and elevation trackers immediately traverse their piece in that general direction and, *watching the gun commander* as he sights at the plane along the barrel, elevate or depress and traverse as he signals. As soon as the gun commander is on target, he yells, "Fire." At the signal, "Dive Bomber," the ammunition handlers immediately pass ammunition with fuzes preset at 2 seconds to the gun. Fire is begun and continued as rapidly as possible until the gun commander gives the order to cease firing.

CHAPTER 7

FIRE CONTROL AGAINST UNSEEN TARGETS

Paragraphs
SECTION I. Radar control 63–64
II. Barrage fire 65–68

SECTION I

RADAR CONTROL

■ 63. USING SCR–584.—*a.* The operation of the SCR–584 is described in detail in FM 4–144.

b. When on search mission, the PPI operator determines the course of targets indicated to assist the battery commander in selection of targets.

c. When so directed, the operators track the designated target and go into automatic control whenever feasible.

d. The director signal switch is operated to notify the director when data from the radar are correct.

e. The PPI operator watches for any indicated change in course of target and immediately notifies the director.

f. The director is notified immediately if the radar should lose the target.

■ 64. USING SCR–545–A.—*a.* The operation of the SCR–545 is described in detail in FM 4–146.

b. When on search mission, the operators determine the course of targets indicated to assist the battery commander in selection of targets.

c. When so directed, the operators track the designated target and go into automatic control as soon as feasible.

d. The radar crew notify the director when data from the radar are correct.

e. The operators watch their scopes for any indicated change of course and immediately notify the director.

f. The director is notified when target is lost.

SECTION II

BARRAGE FIRE

■ 65. GENERAL.—*The only justification for barrage fire is the failure of all better fire control methods. It must be considered solely as an emergency expedient. Generally speaking, it is an extravagant and usually ineffective method of fire.*

■ 66. BARRAGE.—*a.* To employ barrage fire, the location of the probable objective and the possible paths of the enemy aircraft must be known. The altitude, angular height, and azimuth of a point on the probable path are determined, so that a volume of fire may be placed about that point. Definite aerial *points* should be selected. Dispersing fire by one battery over a volume should not be attempted. Where more than one battery is available to fire simultaneously, each battery can cover a specific zone by firing at different points in the sky. The concentration and zone coverage possible will depend on the number of guns available for the mission.

b. When barrages are to be fired by numerous batteries, the points at which the various batteries will fire are determined in advance by higher commanders. In general, a series of barrage points will be chosen as soon as the units are in position. The points having been selected and identified, higher authority can then call upon various batteries or battalions to fire barrages on the point or points desired.

■ 67. TECHNIQUE.—*a.* Data for desired barrage point (azimuth, angular height, and altitude) are placed on the director. Pointers on guns are matched, the desired number of fuzes preset, and the designated number of rounds fired, at a specified time.

b. Data for each battery (A_f, QE, and F) are computed for the barrage points using a trajectory chart or firing table. (*The director will also solve for the data.*) These data, for all barrage points, are furnished the gun commanders. When a barrage is directed, he causes the values to be set on the indicator dials, presets the desired number of fuzes, and fires the designated number of rounds at the specified time.

■ 68. RULES OF THUMB FOR BARRAGES.—*a.* Barrage fire should not be resorted to except to defend small, important, and vital areas.

b. Ordinarily a barrage is of no avail unless a large concentration of guns can be used to bear on this small area.

c. When as a last resort AA artillery is required to fire barrages at unseen targets, it is better to choose a point or area and fire all guns at that point or specific area.

CHAPTER 8

FIRE CONTROL FOR GROUND AND NAVAL TARGETS

Paragraphs
SECTION I. Antimechanized firing 69–71
II. Observation of terrestrial indirect fire 72–74

SECTION I

ANTIMECHANIZED FIRING

■ 69. GENERAL.—*a.* All 90-mm AA guns are equipped with optical sights for direct fire missions. These sights are used by the azimuth and elevation trackers of the gun crew independently of any other fire control equipment.

b. The theory of leads as well as the gunnery employed when using direct fire sights may be found in FM 4–110.

■ 70. DIRECT FIRE SIGHTS.—This section treats with the M24 and M26 elbow telescopes as used on the M1 and M1A1 90-mm mounts and with the M60 periscopic telescope as used in the M7 sighting system on the M2 90-mm mount.

a. Description.—(1) *M24 and M26 elbow telescopes.*—The M24 and M26 sights are mounted on the M1 and M1A1 gun mounts. Telescope mount M28 is used with elbow telescope M24 (azimuth). Telescope mount T65 supports elbow telescope M26 (elevation). For further description see FM 4–126. The reticle patterns of the M24 and M26 telescopes are shown in figures 32 and 33.

(2) *M60 periscopic telescope.*—The reticle pattern of this telescope for both azimuth and range is identical. (See fig. 34.) For further description see FM 4–127.

b. Operation.—In laying the gun for azimuth and range the trackers track simultaneously in the following manner:

(1) The gun commander calls off the estimated range and estimated lateral lead, for example, "Range 500 yards, lead 15 mils."

(2) The azimuth tracker picks up and tracks and target with the proper lead mark of the reticle on the center of the target. In this case the target is centered on the 15-mil azimuth reticle mark.

NOTE.—The center mark of the azimuth reticle should always point *ahead* of a moving target and *at* a stationary target.

(3) The range tracker, when the target is in the telescope's field of view, places the proper range line of the reticle on the top of the track housing in the case of a tank or on the water line in case of a boat.

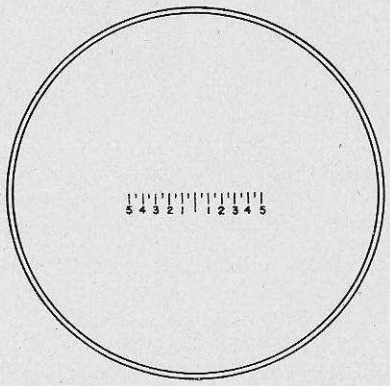


FIGURE 32.—Azimuth reticle of M24 elbow telescope

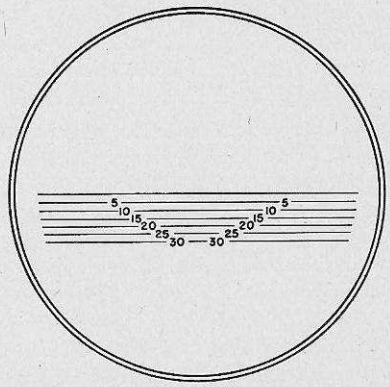


FIGURE 33.—Range reticle of M26 elbow telescope. Figures express ranges in hundreds of yards.

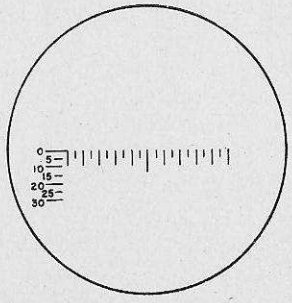


FIGURE 34.—Reticle M60 periscopic telescope. Figures express ranges in hundreds of yards. Vertical lines are 5-mil graduation.

■ 71. ADJUSTMENT OF FIRE USING DIRECT FIRE SIGHTS.—*a. Azimuth.*—After a round has been fired, the azimuth tracker notes the position of the burst or impact on the reticle. He adjusts for any lateral deviation by moving the reticle mark on which the impact occurred to the horizontal center of the target by traversing the gun.

b. Range.—The range tracker notes the position of the burst or impact on the elevation reticle and adjusts for any range or vertical deviation by moving the reticle mark on which the impact occurred to the vertical center of the target by elevating or depressing the gun.

SECTION II

OBSERVATION OF TERRESTRIAL INDIRECT FIRE

■ 72. GENERAL.—This section deals with the control and correction of fire on terrestrial targets by an observer at the OP. It is not possible to lay down definite procedures, as observation depends largely on terrain features as well as conditions of the moment. However, certain guiding principles can be laid down, and by intelligent use of these principles, effective fire can be brought to bear on a target with the least possible delay and with a minimum expenditure of ammunition.

■ 73. SELECTION OF OP.—There is no set rule governing the distance the OP is from the target or gun position. The relative positions of the OP, target, and gun must be known to both the observer and the personnel at the gun position.

Other relevant factors involved in the selection of the OP are—

a. A comprehensive view of the surrounding terrain, especially a clear view of the target.

b. Concealment of observers as well as concealment of approaches.

c. A position as close to the gun-target line as possible and one on as high ground as possible.

■ 74. CONTROL OF FIRE.—Observation is possible with the minimum instrumental equipment. Normally, only field glasses will be available.

a. Observing from position on or near gun-target line.—This is the simplest method and consequently observers should be sited as close to the gun-target line as possible. In correcting bursts from this position, the following procedure is followed:

(1) First, correct all bursts for line (azimuth). This can be accomplished by direct measurement of the burst from the gun-target line. The observed angle must be corrected by the ratio of $\frac{OP\text{-}Target\ distance}{Gun\text{-}Target\ distance}$

(2) After adjustment for line has been accomplished, the bracketing method is used to adjust in range. (For bracketing method, see FM 4–110.)

b. Observing from flank.—See FM 6–40 for a discussion of flank spotting methods.

CHAPTER 9

SPOTTING AND ADJUSTMENT OF AA FIRE

Paragraphs
SECTION I. Spotting 75–77
II. Adjustment of fire 78–83

SECTION I

SPOTTING

■ 75. GENERAL.—*a.* Spotting is the process of visually determining the deviation of bursts from the target. A deviation is the angular or linear displacement of burst or center of burst of a series of shots, from the target.

b. Spotting may be on a single burst or on the center of burst of a series of shots. The location of a burst or center of burst of a group of shots with reference to a moving aerial target must be determined in three dimensions.

(1) Above or below the target (vertical deflection).

(2) Right or left of the target (lateral deflection).

(3) Over or short of the target (deviation in slant range).

■ 76. METHODS OF SPOTTING.—*a. General.*—There are two methods of spotting which experience has shown to be practicable; the unilateral method in which all deviations are determined at the battery position, and the bilateral method in which lateral and vertical deviations are determined at the battery position and range deviations at a flank station (O_2). The location of an antiaircraft artillery gun battery generally determines the arrangements for spotting. A battery should take advantage of all possible means for observation of fire, including the use of flank stations. Only one flank station can be used for a particular target, but stations at various azimuths from the battery position are established if practicable. Spotting must be continuous and the facilities for spotting must be as complete as conditions permit. Deviations must be determined at the instant the burst occurs to prevent errors due to the relative movement of the target and the burst.

b. Unilateral method.—(1) Lateral and vertical deviations are determined at the battery position, by the use of spotting telescopes or equivalents. When spotting scopes are not available, lateral and vertical deviations must be determined

by eye. During fire for effect, the same officers or assistants who determine lateral and vertical deviations must also make the necessary adjustment corrections and in each case adjustment must immediately follow the determination of deviations.

(2) It is possible to determine range deviations by spotting with the stereoscopic height finder. However, it necessitates having an accomplished observer. *Sensings* are obtained, the magnitude where possible being given in such general terms as "way over," "over," "hit," "doubtful," "short," and "way short." For method of spotting by magnitude see TM 4–250. The spotter is connected by telephone with the range officer at the director and calls out the sensings continuously over the telephone. The following two important conditions must be insisted on:

(*a*) The observer must sense only when he is certain. Never guess, call the shot doubtful.

(*b*) The burst must be on line, or very close to line to get sensings.

(3) It is also possible to determine range deviations by spotting with the SCR–584 or SCR–545. Overs and shorts may be observed on the oscilloscope in yards of slant range. (See FM 4–110.)

c. Bilateral method.—(1) Lateral and vertical deviations are obtained as in the unilateral method explained in *b* above.

(2) Range deviations are observed from a flank station. If suitable instruments (such as a BC scope) are available, deviations can be read in angular units (mils). However, if field glasses or eyes are used, deviations in terms of *sensings* only are determined.

■ 77. Location of Observing Stations.—*a.* The location of the flank spotting station is an important consideration in the preparation for spotting or adjusting fire. A study of baseline lengths in relation to accuracy of observation reveals that a baseline should not be less than 3,000 yards in length for reasonably accurate results. A baseline of any considerably greater length will usually introduce communication maintenance difficulties that will more than offset the increased accuracy.

b. Effect of lateral and vertical deviations.—An unavoidable weakness of any system of flank spotting is the loss of spotting accuracy which results when the bursts occur far off the line of position. The effect of such deviations is particularly noticeable when a spotting baseline as short as 1,000 yards is employed. For example, in figure 35, which represents the firing situation, in the inclined plane, it will be noted that with a 1,000-yard spotting baseline and a slant range of 5,000 yards, a burst which is correct for range, but

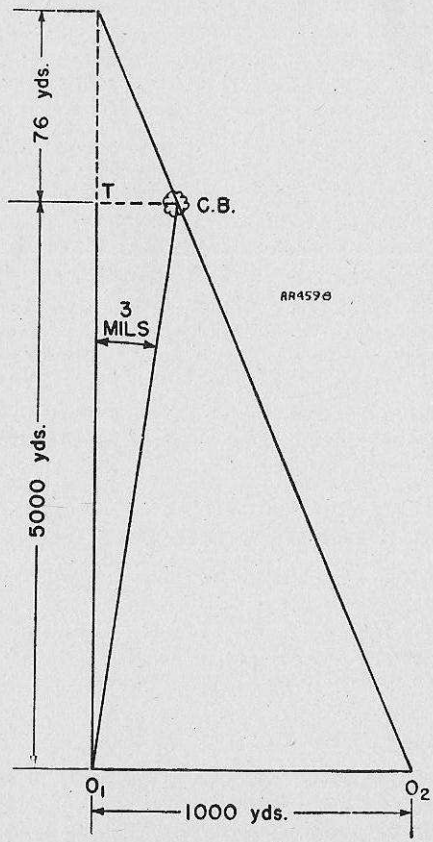


FIGURE 35.—Effect of lateral and vertical deviations.

is 3 mils right (observed from the battery) appears from the flank as being 76 yards over in slant range. At an angular height of 800 mils, such an observation thus calls for an erroneous altitude correction of down 54 yards. Using a 3,000-yard baseline under similar conditions, the burst appears as being 25 yards over in slant range. At an angular height of 800 mils, such an observation requires an erroneous altitude correction of down 18 yards. This consideration indicates the necessity for a spotting baseline of at least 3,000 yards in length. Lateral and vertical deviations from the line of position will each result in spotting errors in range of varying amounts, depending on the target angle, slant range, and inclination of the slant plane. When the inclination of the slant plane is less than 800 mils, the effect of lateral deviations is more serious. When the inclination of the slant plane is greater than 800 mils, the vertical deviation is more serious. In any case, it should be accepted as a definite doctrine of antiaircraft gunnery that only when the center of impact of a group of bursts is within 5 mils of the target both laterally and vertically (with a spotting baseline of 3,000 yards or more) can full reliance be placed on flank observations.

SECTION II

ADJUSTMENT OF FIRE

■ 78. DEFINITION.—Adjustment of fire is the process of determining and applying corrections to firing data in such a manner as to move the center of burst to the adjusting point and keep it there. Adjustment of fire and spotting are very closely allied. Without spotting there can be no adjustment. The effectiveness of the adjustment will increase or decrease with the accuracy of the spotting.

■ 79. GENERAL.—*a.* Thorough preparation for fire normally reduces the necessity for adjustment of fire. However there are instances where complete preparation for fire cannot be conducted. In this case it seems reasonable that a fire adjustment technique be developed by battery commanders and used when and where needed.

b. (1) *Opportunities for fire adjustment will be extremely limited under stress of enemy action because of the time*

factor. In most cases, adjustment of fire is a course-to-course proposition.

(2) Adjustment corrections must be made boldly. Each correction applied must be of such magnitude as to bring the center of burst onto the adjusting point. *Time does not permit of piecemeal adjustment.* If deviations are abnormally large, a thorough check on equipment is generally indicated.

■ 80. APPLICATION OF CORRECTIONS TO FIRING DATA.—*a.* Before attempting to apply adjustment corrections to firing data, the artilleryman must be thoroughly familiar with the effect of such corrections on the position of bursts. Summarizing briefly, facilities may be provided for applying corrections during fire for effect, depending upon the type of fire control instruments, as follows:

(1) Vertical adjustment correction is normally applied in terms of mils "up" or "down," and to the full value of the vertical deviation observed, "below" or "above." Irrespective of the manner in which it is applied, the net result is to change the quadrant elevation at which the gun is laid which moves the burst along the ϕ line.

(2) Lateral adjustment correction is normally applied in terms of mils, "right" or "left," and to the value of the lateral deviation observed, "left" or "right," converted into the horizontal plane. The net result is to change the lateral pointing (azimuth) of the gun and move the burst laterally by the amount indicated.

(3) Present altitude correction is normally applied in yards, "up" or "down," and to the full value of the range deviation observed, converted into terms of altitude. The net result is to change one of the basic elements used in calculating firing data and thus move the burst along the line of position.

(4) Fuze range correction is never used for fire adjustment based on observations.

b. Effects on position of the burst, resulting from corrections to firing data, are illustrated in figure 36.

■ 81. LATERAL AND VERTICAL CORRECTIONS.—*a.* With an understanding of the effect upon the position of bursts of corrections to firing data, the ground work is laid for a discussion of methods of adjusting fire during fire for effect.

The first step in adjusting fire, that is, determination of deviations of bursts from the target, has been presented in section I. Influence of the time factor requires that spotting and adjusting be combined as far as practicable into a single operation; that is, the observer of the deviations should also apply the adjustment corrections. The M4 and

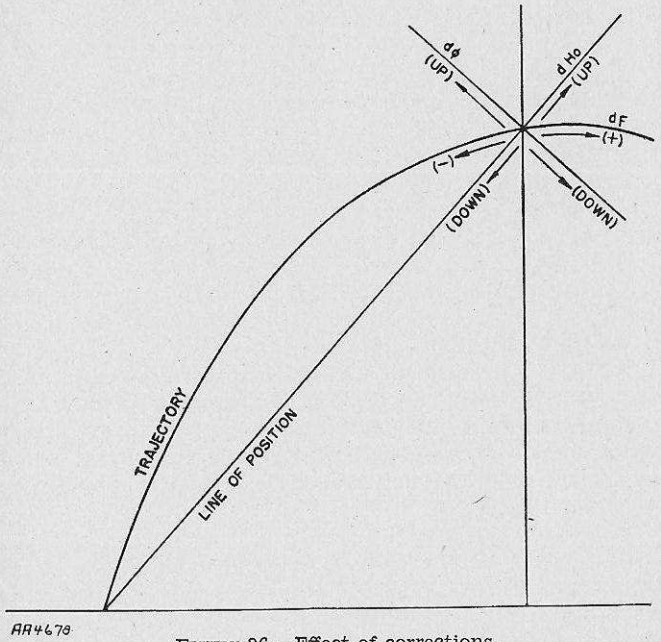


FIGURE 36.—Effect of corrections.

M7 directors are provided with facilities for spotting and correcting vertical and lateral deviations. Range deviations must be relayed to the range officer or qualified assistant by telephone or some other method. If adjustment of fire could be accomplished slowly and deliberately, corrections would be applied laterally and vertically to bring bursts on to the line of position before observing range deviations.

b. The second step in adjusting fire is to place the center of burst as close to the line of position as possible. This is accomplished by the application of vertical and lateral corrections. The spotting telescope on the M4 or M7 directors measures the lateral deviations in an inclined plane; that is, along a horizontal line through the target and perpendicular to the line of position. Lateral corrections, however, are applied to the director in the horizontal plane. Therefore, the observed *lateral* deviations in the inclined plane must be converted into equivalent lateral deviations in the horizontal plane. This conversion is done by the following factors.

Angular height:	*Factor*
0–600 mils	1.0
600–1,000 mils	1.5
1,000–1,200 mils	2.0
1,200–1,400 mils	4.0

See FM 4–136 for a convenient method of placing these factors on the director telescopes.

■ 82. MODIFIED BRACKETING METHOD OF FIRE ADJUSTMENT.—*a.* In the modified bracketing method of adjustment, the range corrections are applied in terms of forks. It is impossible for the observer to obtain reliable sensings of the bursts until the bursts are on or very close to the line of position. Therefore, range adjustments must be delayed until the vertical and lateral corrections take effect.

b. Since the observer determines only the sense of burst (over or short) with reference to the target, and cannot give measured deviations, the adjusting officer must apply corrections in terms of a "fork" (approximately 4 percent of the altitude), which is the unit of adjustment in this method. (See fig. 37.) Corrections should be made according to the following:

Way over	Down 3 forks.
Over	Down 2 forks.
Hit	No change.
Doubtful	No change.
Short	Up 1 fork.
Way short	Up 2 forks.

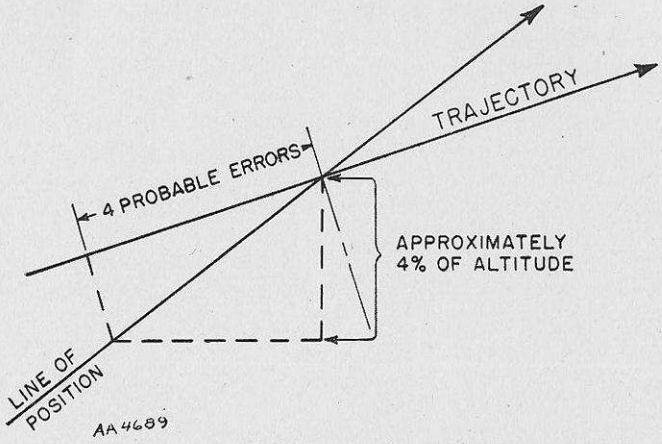


FIGURE 37.—Determination of fork.

c. When the sense is reversed, apply a correction of one-half of the adjusting unit in the opposite direction. When the center of burst has been sensed short, however, the correction should not be such as to place it beyond the target. When the center of burst is over, the correction should be of such magnitude as to surely reverse the sense.

■ 83. GENERAL RULES FOR ADJUSTMENT OF FIRE.—*a.* Adjustment will not compensate for accidental personnel errors. Therefore, before any adjustment takes place be sure that the fault is a matériel one and not a personnel one.

b. If there is more than one battery firing on the same target, it is impossible under battle conditions to adjust fire. Officers must be able to distinguish the bursts of their guns from the bursts of other guns in order to adjust fire.

c. Adjustments cannot be made until bursts from previous rounds have been observed. The moral is not to set in a correction unless you have observed that a correction is needed.

d. An adjustment in altitude is not justified unless the center of the burst is on or near the line of position in azimuth. Therefore, the bursts must be on the line of position in order to adjust in range.

e. When the angular height of the target is less than 500 mils, make no spot correction in altitude less than 50 yards; when angular height is greater, make no spot altitude correction less than 100 yards.

f. If the magnitude of the range deviation is spotted, the range correction is equal in value but opposite in sign subject to the limitations in *e* above.

g. In all adjustments, be bold. Time is wasted by making small adjustments.

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