WAR DEPARTMENT FIELD MANUAL

FM 4-138

ANTIAIRCRAFT ARTILLERY

SERVICE OF DIRECTORS M9 AND M10

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WAR DEPARTMENT • SEPTEMBER 1943

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Washington—September 1943

WAR DEPARTMENT,

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FM 4–138, War Department Field Manual, Anti-aircraft Artillery, Service of Directors M9 and M10, 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 • RESTRICTED

SERVICE OF DIRECTORS M9 AND M10 FM4-138

CHAPTER 1

GENERAL

Section I

General

1. SCOPE. a. This manual furnishes a general description of the M9 and M10 directors and provides information relative to the details of operation and employment of personnel. A knowledge of the fundamentals of antiaircraft gunnery, as covered in FM 4–110 and FM 4–121, is helpful in understanding the problem of locating and tracking aerial targets, which is discussed only briefly in this manual.

b. The drill tables are intended only as a guide in the assignment of individuals and duties. Minor

changes in drill procedure may be made to suit local conditions.

2. REFERENCES. This manual should be studied in connection with the various references listed in appendix VI. The glossary of symbols and table of definitions in FM 4–118 should be consulted for terms that are unfamiliar to the reader. Detailed instructions for maintenance of the equipment will be found in Ordnance Technical Manuals.

Section II

Instrument

3. PROBLEM a. The object of antiaircraft artillery defense is to destroy hostile aircraft, to cause them to abandon their mission, or to disturb their bombing operations to such an extent that they miss their target.

b. The necessity for an automatic system of fire control by which the firing data are automatically computed and transmitted instantaneously to the guns is apparent from an analysis of the antiaircraft problem. An airplane is capable of forward movement in any direction in space and at various changes of speed. The small vital area of the target imposes a requirement for great accuracy.

c. Fire control implies the ability to direct the fire accurately and continuously at fixed or moving targets in the air, on land, or sea. A typical antiaircraft artillery battery includes—

(1) A locating device, either optical or radar, or both, which continuously determines the present position of the target.
(2) A director, which calculates from these observations the proper firing data *(Af, QE, F)*.
(3) A battery of guns.
(4) A power plant.
(5) A data transmission system.

Figures 1, 2, and 3 illustrate the general problem of the director. Figure 1 depicts the position of the target at the instant the guns are fired. Figure 2 shows the target position at the point of burst. Figure 3, being a combination of figures 1 and 2, brings out the necessary predicted values computed by the director which allow for the change in position of the target, as shown in figures 1 and 2.

4. DETECTOR. a. The M9 director is an electromechanically operated computing system which calculates the necessary firing data for the 90-mm AA gun with shell M71. The M10 director is identical with the M9 in operation, but calculates firing data for the 4.7-inch AA gun with shell M73. The computer of the M9 director can be distinguished from that of the M10 by the name plate and the MV dial on the correction panel. The M9 MV dial has a maximum setting of 2,800 foot-seconds. The M10 MV dial has a maximum setting of 3,200 foot-seconds. Both directors are fully ballistic, incorporating corrections for drift, muzzle velocity, air density, wind, and dead time. All subsequent remarks in this manual about the M9 director apply with equal force to the M10. Combinations of fire control instruments used with

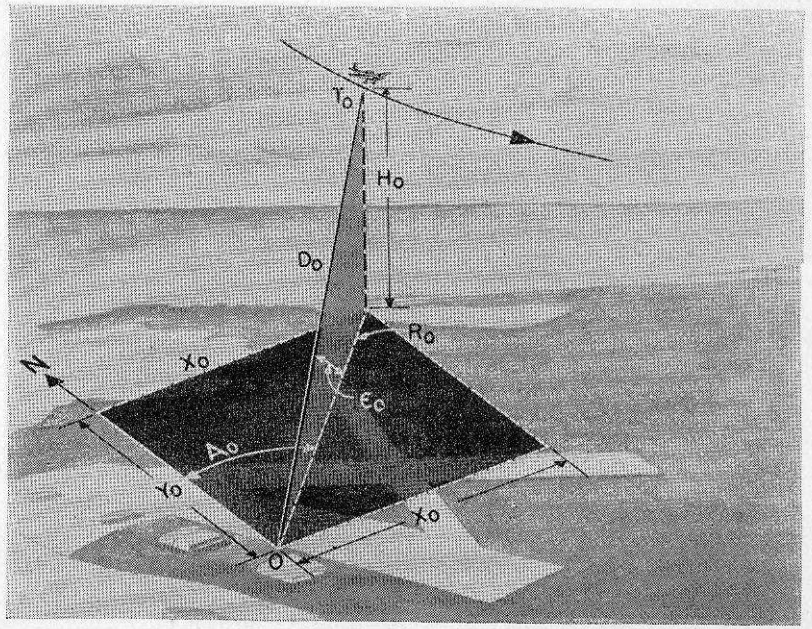


FIGURE 1. Present position of target.

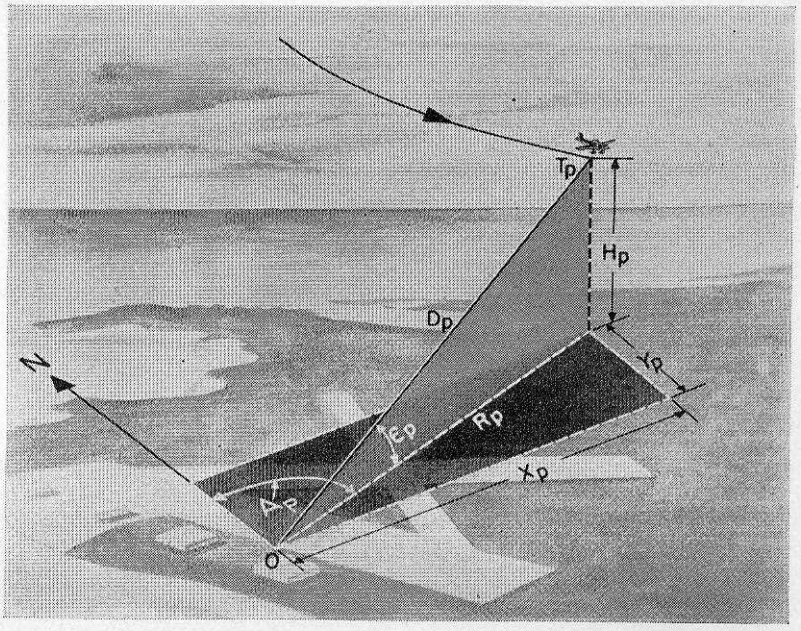


FIGURE 2. Future position of target.

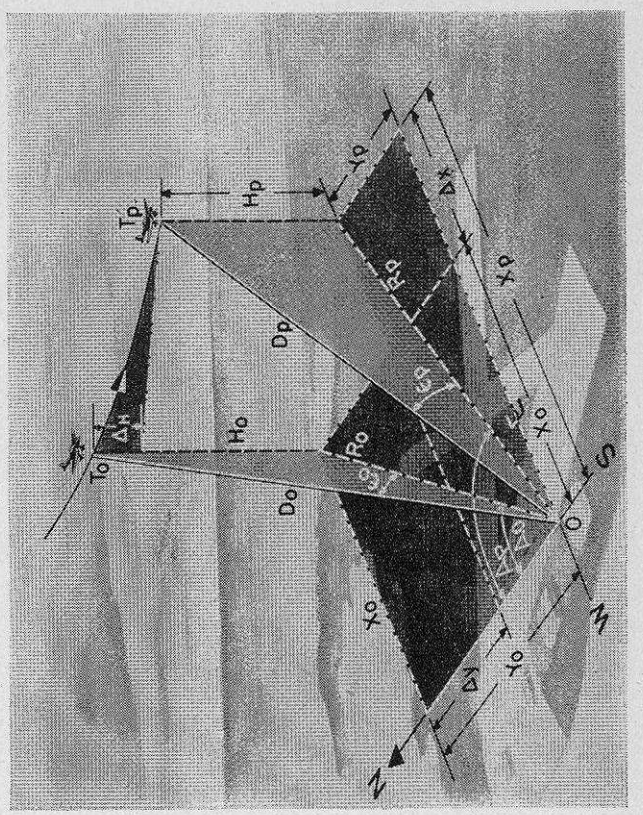


FIGURE 3. Predicted values computed by director.

the M9 director are shown in the schematic diagram in figure 5. The director may also be used for controlling the fire of guns against a land or water target within its limits of operation, as outlined in paragraph 9.

b. Unlike the M7 director, the M9 is divided into four separate units: a tracker, a computer, an altitude converter, and a power rectifier. When the director is used with the height finder M1 or M2, or the SCR–268, all components are used. (When operating with the SCR–547, SCR–545, or SCR–584, some of the components are unnecessary.) The tracking data plus the altitude from the height finder (or SCR–268) are continuously utilized by the director to compute electrically the firing data.

c. A typical grouping of the various units of the M9 director is illustrated in figure 4. This is shown in conjunction with the M1 or M2 height finder. In the trailer are the computer, the power rectifier, and the altitude converter, which is mounted on top of the power rectifier.

5. COMPUTER. The computer of the M9 director receives continuous present position data in the form of rectangular coordinate (X_o, Y_o, and H_o). (Note that the director M9 is a linear speed director.) By utilizing these three values and their rates of change the computer calculates the future position of the target. It then calculates firing data for the future position with respect to the guns. After incorporating ballistic corrections and arbitrary corrections, it positions selsyn transmitters to the corrected firing data (*Af*, *QE*, and *F*) for transmission to the guns.

6. POWER RECTIFIER. This unit furnishes a-c and d-c power required by the M9 director. It operates on 115-volt, 60-cycle, 3-phase power, obtained from the generating unit or from a commercial source. Approximately 3.5 kilovolt-amperes are required.

7. ALTITUDE CONVERTER. This instrument converts the altitude or slant range received from the M1 or M2 height finder, or SCR–268, in the form of selsyn (mechanical) data into an equivalent d-c voltage.

8. TRACKER. This unit is an electro-mechanical device which converts the present position data (obtained by tracking and from the height finder or SCR–268) into a form which can be used by the computer.

9. LIMITS OF OPERATION. The M9 is designed to operate within the following limits:

Present altitude....	300 to 10,000 yards.
Present azimuth ...	No limit.
Present angular height	—175 to +1,600 mils (approximate).
Present slant range.	0 to 28,000 yards.
Target speed	0 to 300 yards per second.
Wind	0 to 60 mph in steps of 4 mph.
Fuze	1 to 32 fuze units.
Battery parallax (each coordinate)	0 to 500 yards in 5-yard increments.
Altitude spot.....	0 to ±150 yards in 15-yard increments.

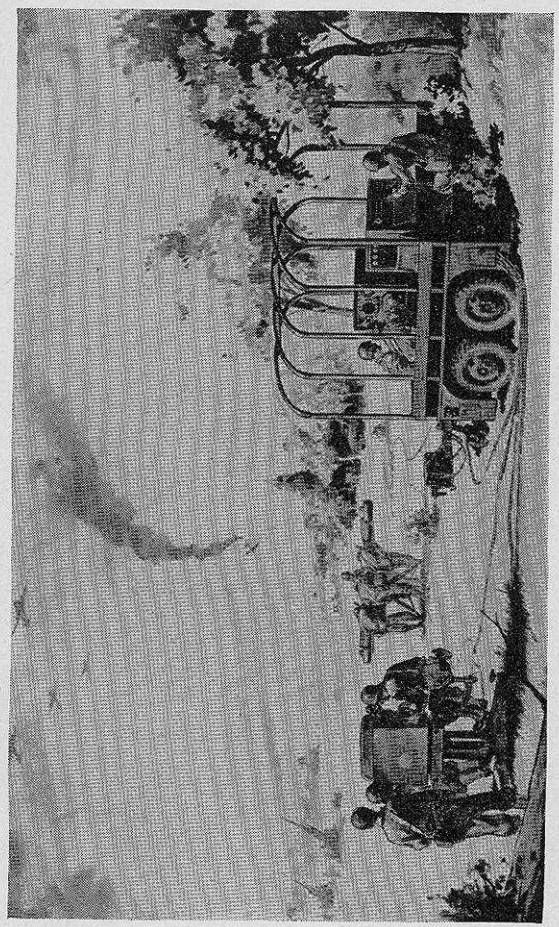


FIGURE 4. Typical set-up of components of the director M9. (This illustration shows the equipment but is not a combat position.)

Azimuth spot.....	±2, 4, 6, 8, 10, 15, 20, 30, 40, and 50 mils.
Elevation spot.....	±2, 4, 6, 8, 10, 15, 20, 30, 40, and 50 mils.
Fuze spot	±10 percent in 1 percent steps.
Present slant range spot	±5 percent in ½ percent steps.
Firing azimuth (angle of train).....	No limit.
Quadrant elevation	—200 to +1,600 mils.
Angular tracking rate, elevation (approximate)...	175 mils per second maximum.
Angular tracking rate, azimuth (approximate)	380 mils per second maximum.
Dead time.....	0 to 4 seconds in 0.2 second per step.
Air density.....	0 to ±20 percent in steps of 2 percent.
Muzzle velocity, M9	2,400 to 2,800 foot-seconds.
Muzzle velocity, M10	2,800 to 3,200 foot-seconds.

Section III
Simplified Explanation

10. PRINCIPLES OF OPERATION. a. Computer. Regardless of the combination of fire control instruments used, the computer always receives X_o, Y_o, and H_o as d-c voltages. In the computer the rates of change of X_o, Y_o, *and* H_o (called $\dot{X}$, $\dot{Y}$, and $\dot{H}$) and are meas-

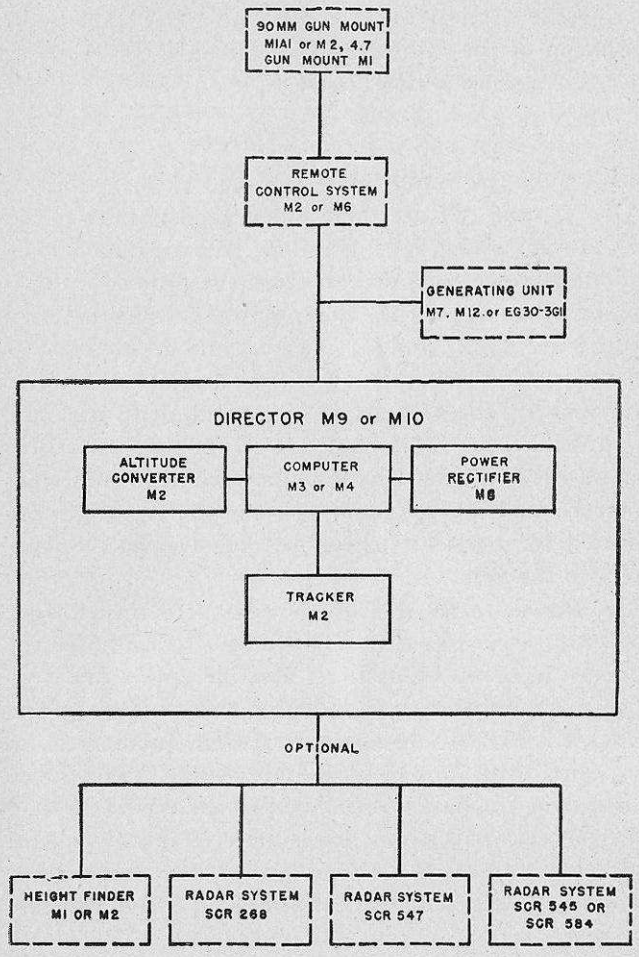


FIGURE 5. Combinations of fire control instruments using director M9 or M10.

ured and then multiplied by the time of flight of the projectile (tp), giving ΔX, ΔY, and ΔH. This is the solution of the following basic formula:

$$\text{Distance} = \text{time} \times \text{rate}$$

$$\Delta X = tp \times X$$

$$\Delta Y = tp \times \dot{Y}$$

$$\Delta H = tp \times H$$

ΔX, ΔY, and ΔH are then added algebraically to X_o, Y_o, and H_o, giving X_p, Y_p, and H_p. Firing data are calculated by the computer to cause the projectile to explode when it reaches the point the coordinates of which are X_p, Y_p, and H_p. Corrections are included in the calculated firing data (Af, QE, and F). These corrections include MV, air density, wind, drift, parallax, and dead time. The final step in the computer is to cause selsyn transmitters to be positioned to the values of corrected Af, QE, and F. These data are transmitted by the self-synchronous data transmission system to the guns.

b. Power rectifier. This unit converts the 115-volt, 60-cycle power to a-c and d-c voltages required for the operation of the computer. Rectifier tubes and copper oxide rectifiers are used for this purpose. The tracker and altitude converter, when used, are also supplied with power from this source. Power for energizing the data transmission system passes through the power rectifier, but this is merely for convenience in the cable system. The power rectifier has no function so far as the data transmission system is concerned.

c. Power. Although not part of the director itself, the power source is mentioned at this time. Usually power is obtained from a gasoline-driven generator.

This may be the generator unit M7, generator unit M12, or engine generator EG 30–3G1. Any one of these three generators provides 115-volt, 60-cycle, 3-phase power. The director uses about 3.5 kilovolt-amperes. It must be 115 volts ±10 percent at 60 cycles ±5. A reliable commercial power source can be used in lieu of the generator if the power furnished is within the above limitations.

d. Tracker. This unit must be used in conjunction with the computer in the following combinations:

(1) Height finder M1 or M2 used.

(2) SCR–268 used.

(3) SCR–545 or SCR–584 used (Method 1). (See **h** below.)

(4) SCR–547–A or SCR–547–B used.

The tracker under the above conditions is actually following the target optically, or by matching the A_o and E_o dials, thus determining A_o and E_o. The tracker can only use D_o as a d-c voltage. The tracker electrically computes H_o and R_o from E_o and D_o by solving the following trigonometric formulas:

$$H_o = D_o \sin E_o \qquad R_o = D_o \cos E_o$$

Also X_o and Y_o are solved by the formulas:

$$X_o = R_o \sin A_o \qquad Y_o = R_o \cos A_o$$

The tracker then sends X_o, Y_o, *and* H_o as d-c voltages to the computer. (See **a** above.)

e. Altitude converter. This unit must be used in conjunction with the tracker in the following combinations:

(1) Height finder M1 or M2.

(2) SCR–268.

None of these instruments can supply the tracker with D_o as a d-c voltage. The altitude converter does the

following: if D_o is furnished by the selsyn, it changes D_o to an equivalent d-c voltage for use by the tracker; if H_o is furnished by the selsyn, it converts H_o into the corresponding D_o (for the E_o at that instant) in the form of a d-c voltage for use by the tracker.

f. The SCR–547A and SCR–547B are designed to supply the tracker with D_o as a d-c voltage. Hence the altitude corrector is unnecessary.

g. The SCR–547C is equipped with a coordinate conversion mechanism (an electro-mechanical device which converts polar coordinates (A and R) into rectangular coordinates (X and Y), or vice versa). It can therefore furnish the computer with d-c voltages corresponding to X_o, Y_o, and H_o. The tracker and altitude converter are unnecessary in this combination.

h. The SCR–545 and SCR–584, when using Method *1*, supply the tracker with A_o and E_o by selsyns and D_o as a d-c voltage. The altitude converter is unnecessary in this combination.

i. The SCR–545 and SCR–584, when using Method *2*, employ the coordinate conversion mechanism (see **g** above). The computer can then be supplied with X_o, Y_o, and H_o as d-c voltages. The tracker and altitude converter are therefore unnecessary in this combination.

11. MECHANISMS. **a.** It is not the purpose of this manual to provide a detailed explanation of the various electrical and mechanical devices employed to perform the various operations and calculations stated in paragraph 10. The basic calculations made by the director are:

(1) Multiplication.

(2) Algebraic addition.

(3) Rate determination.

(4) Rate smoothing.

(5) Determination of firing data.

b. Rate smoothing has optional control. On the adjustment panel of the computer is a switch (see fig. 17) with three positions labeled "10 sec," "20 sec," and "Automatic." When thrown to "10 sec," the computer averages the rates ($\dot{X}$, $\dot{Y}$, and $\dot{H}$) over the preceding 10 seconds. At the "20 sec" position the average is over the previous 20 seconds. At the "Automatic" position, the rates are averaged by the "10 sec" circuit for the first 20 seconds of operation and thereafter the "20 sec" circuit is used. This cycle will occur every time tracking is commenced, or whenever the slewing handles on the tracker are used.

c. The azimuth and elevation handwheels on the tracker are provided with aided-tracking mechanisms to smooth out the actual track of the target. The D_o and H_o handwheels on the altitude converter are provided with aided-tracking mechanisms to insure a smooth D_o and H_o rate (if target is changing altitude). The proper use of the aided-tracking mechanisms is given in paragraphs 59 to 61, inclusive.

d. Maintenance of the director is a most important and necessary function. The devices used in the director are sensitive and require accurate adjustment. Any failure in battery maintenance will be reflected immediately in inaccuracies of the firing data. It is imperative that the tests be performed exactly in the sequence stated. The prescribed routine of tests gives assurance that the essential parts are functioning satisfactorily.

CHAPTER 2

INSTALLATION

Section I

Location of Director

12. SITE. **a.** In setting the director in position consideration should be given to the utilization of its fullest capabilities. Figures 9 to 12 show possible combinations of fire control instruments. The separation of fire control instruments is limited by the lengths of the interconnecting cables, as shown in the diagrams. (See par. 18.)

b. The maximum distances between the tracker and the directing point (or base piece) is limited to the adjustments provided in the computer for parallax. These distances are 500 yards north or south and 500 yards east or west. The vertical distance is 500 yards above or below the directing point.

c. The maximum vertical distance between the tracker and the height finder is limited to 150 yards by the parallax adjustment on the altitude converter.

d. The tracker, when used optically, must be set up so that there is a full sweep of the telescopes over the field of fire to be covered. It may be fitted into any plan of field fortification and camouflage which still

permits this field of vision. The other units of the director may be concealed or protected as conditions permit.

e. The side covers of the computer must be opened for inspection, test, or change of vacuum tubes. Protection from the weather is desirable though not essential, as the design permits normal operation under any weather conditions. If it should be necessary to open the computer, other than the outside panel doors, a tarpaulin should be used in inclement weather.

Section II

Assembly

13. GENERAL. Assuming that the positions for the various components have been selected in accordance with limitations previously discussed, the method of assembly will now be considered.

14. TRACKER. **a.** The three legs of the tripod M12 are removed from the truck and placed near the selected position. The coupling pins are withdrawn from their clips under the legs.

b. The pedestal is then removed from the rear of the truck. Do not allow hard objects to strike the top of the pedestal, as this is the seat for the tracker head and damage may result.

c. Lift the pedestal, set each leg in position in turn, and insert the coupling pins securely in place. (See fig. 6.)

d. The ground plates of the tripod must be firmly

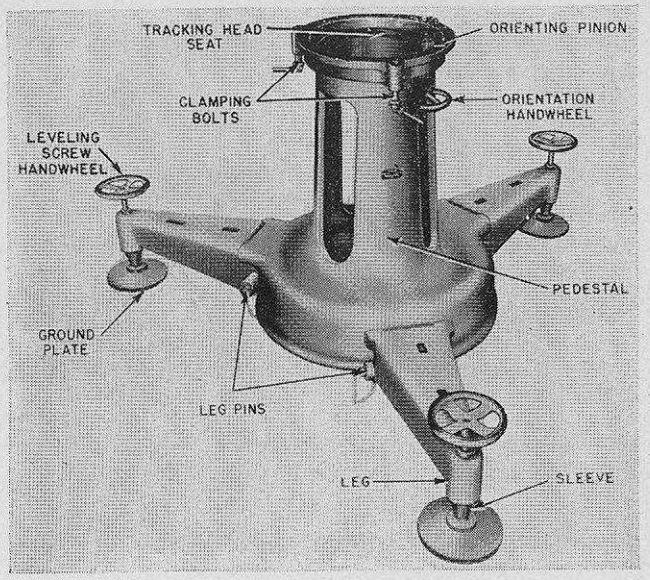


FIGURE 6. Tripod M12.

seated on solid ground, so that the tripod will not shift when the tracker head is placed on it. The trackers ride the tracking head on seats. The tracker must not shift under any operating condition. In soft ground it may be necessary to provide a foundation under the ground plates. The tripod should also be approximately level. *The seating surface on the top of the pedestal should be wiped clean.*

e. The tracking head is then removed from the trailer. Insert the eight porter bars in the holes provided in the lifting frame at the bottom of the head. Make certain that each bar is secure by turning the bar to insure that it is locked by the locking lug. Do

not set the tracking head on the ground or on any rough object. There is a machined surface exposed on the bottom of the tracking head, and serious damage to this surface may result.

f. Using eight men (one per bar), lift the head from the trailer and place it centrally in its proper position on the pedestal. Remove the porter bars.

g. Reach under the lifting frame and rotate the clamping ring until one of the extending pins is in line with a clamping bolt. Screw in the clamping bolt loosely. The three clamping bolts should then enter their holes and are tightened with the attached hand levers.

h. Mount the two brackets for the observers' seats and clamp the seats in position in the bracket. (See fig. 7.)

i. Mount the two telescopes and plug in the telescope light cords.

15. OTHER COMPONENTS. The computer, altitude converter and power rectifier will ordinarily be operated in the trailer in which they are transported. They may be removed from the trailer for operation if the tactical situation permits and adequate weather protection is provided. If the situation warrants the removal of this equipment from the trailer, the following procedure is used:

a. Computer. Sixteen men are ordinarily required to carry the computer. The carrying equipment for the computer, shown in figure 8, consists of four brackets and four porter bars.

b. Rectifier. Six men are ordinarily required to carry the power rectifier. The unit is carried by means

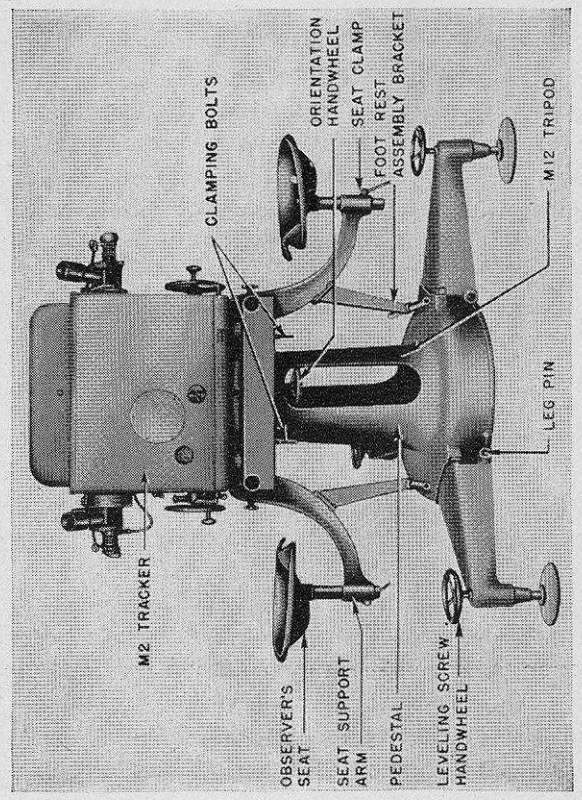


FIGURE 7. Tracker M2.

of two porter bars, which are passed through the two handles at the sides of the unit and held in place by pins through the handles and bars.

c. Altitude converter. The altitude converter may be unbolted from the power rectifier. Two men can carry the altitude converter by means of the handles provided at the sides of the case.

Section III
Leveling

16. LEVELING. a. Operate the azimuth slewing clutch and turn the tracker head by hand until one of the levels visible through the windows in the tracker head (see fig. 23) is parallel to a line through two of the leveling screws on the tripod. Adjust these leveling screws until the bubble in this level is centered.

b. Adjust the third level screw on the tripod until the bubble in the other level is centered.

c. Turn the tracker 3,200 mils and notice whether the level bubbles remain at the center; if not, the level vials are probably out of adjustment. It is not necessary for the bubble to be exactly centered so long as it remains in the same position at all azimuth settings.

d. The other units of the director have no level bubbles. UNDER NO CIRCUMSTANCES SHOULD THESE UNITS BE TIPPED OVER ON THEIR SIDES.

Section IV

Connections

17. ELECTRICAL CONNECTIONS. a. The cable for all electrical connections is weatherproof. Each is of the multiple-conductor type and must be handled with care. Do not make sharp bends. Straighten out all kinks. *Mishandling breaks down the insulation.* It must be protected from rough usage and from vehicles rolling over it. If necessary to cross a road, the cable should be buried a sufficient depth in the ground to offer complete protection. In most situations the cables are entirely buried for their protection.

b. The M9 director is designed for use with various combinations of height finding and range computing equipment. Thus the availability of units, or substitution due to failure or loss in the field, determines the cable connections. Figures 9 to 12 show the units and the cables furnished.

18. DESCRIPTION OF M7 CABLE SYSTEM. a. The M7 cable system provides the necessary cables for connecting the various units of the director. These cables are shown on the cabling diagram. The receptacles are color-coded.

b. The cable system provides the following cables:

3 3-conductor, 300-foot power cable (yellow), for use between primary 3-phase power supply and power rectifier.

1 21-conductor, 15-foot cable, 21-prong plug (yellow), for use between power rectifier and

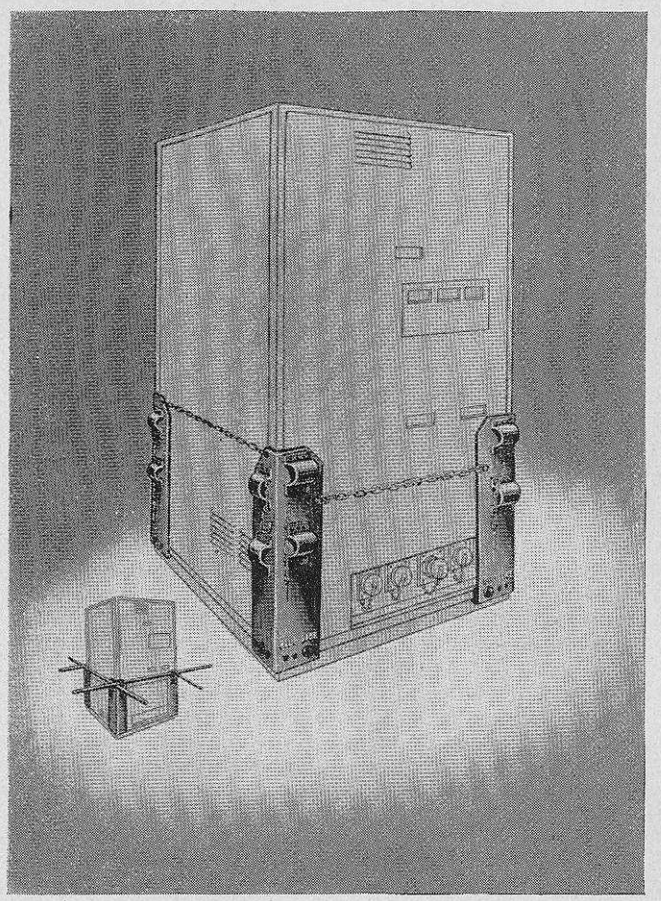


FIGURE 8. Computer with carrying brackets attached.

computer. (An extra cable is provided in the battery accessories.)

1 20-conductor, 15-foot cable, 19-prong plug

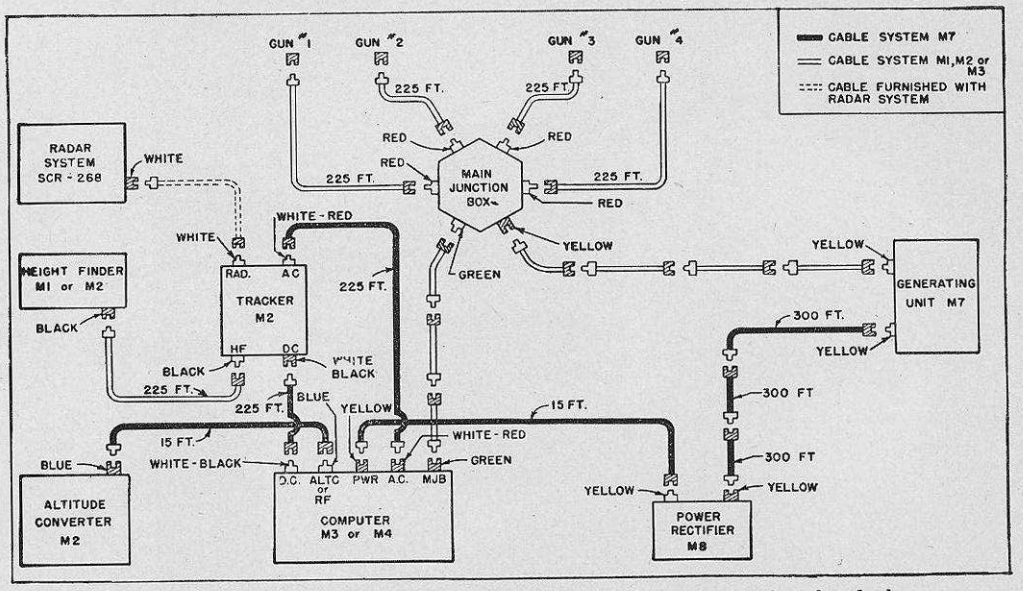


FIGURE 9. Cable diagram with SCR–268 and M1 or M2 height finder.

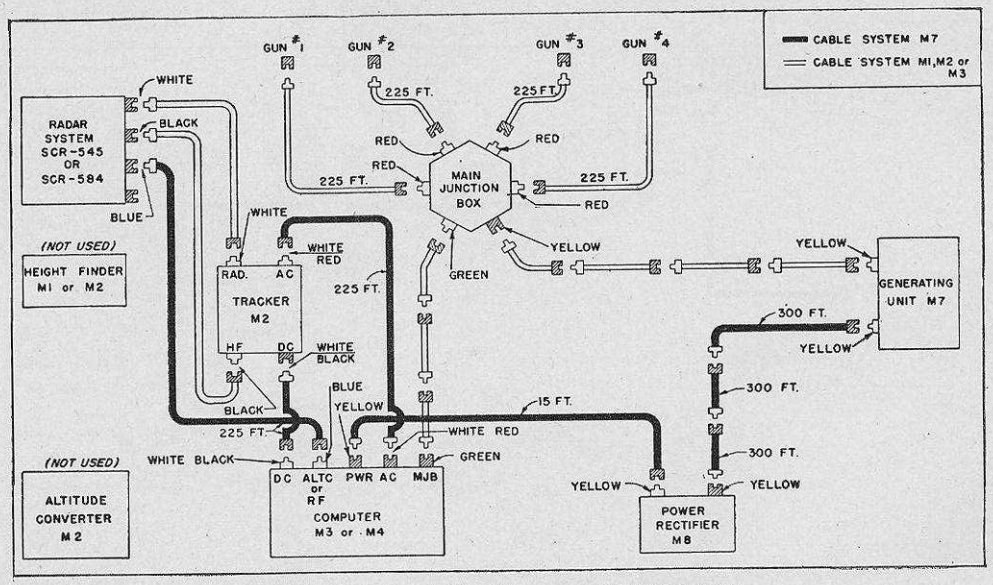


FIGURE 10. Cable diagram with SCR–547.

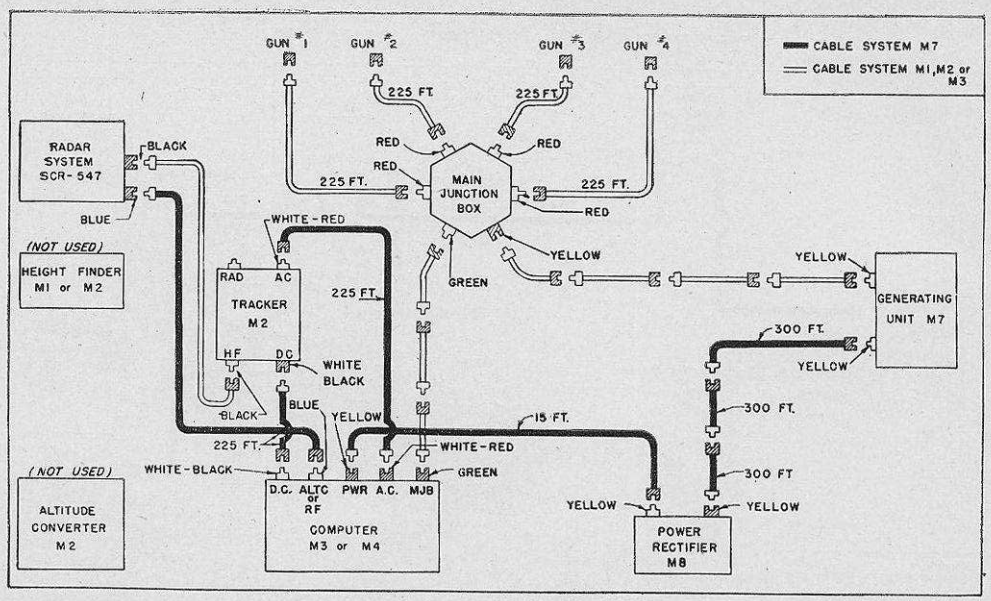


FIGURE 11. Cable diagram with SCR–545 or SCR–584 (Method 1).

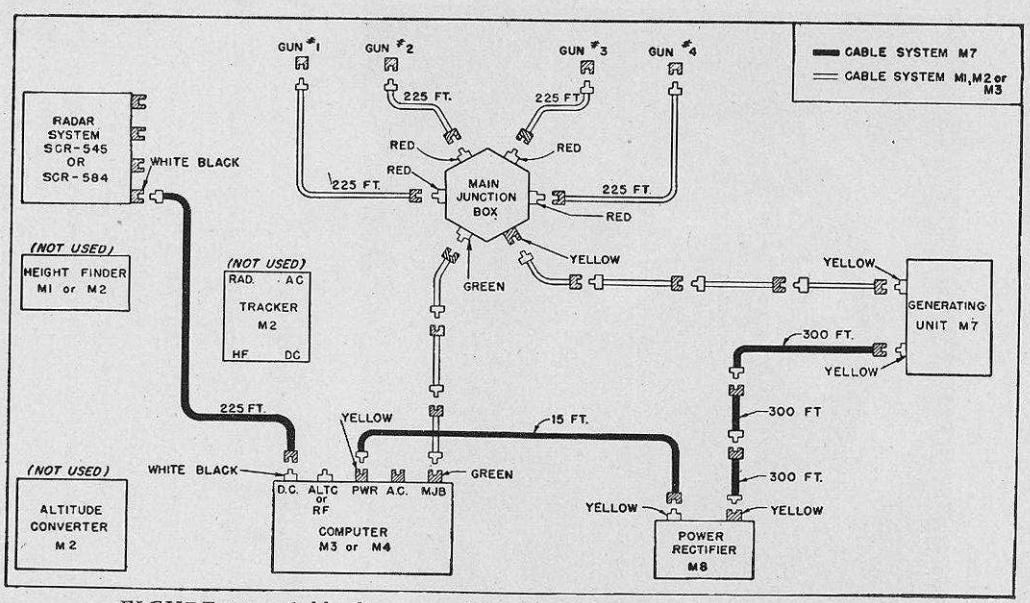


FIGURE 12. Cable diagram with SCR–545 or SCR–584 (Method 2).

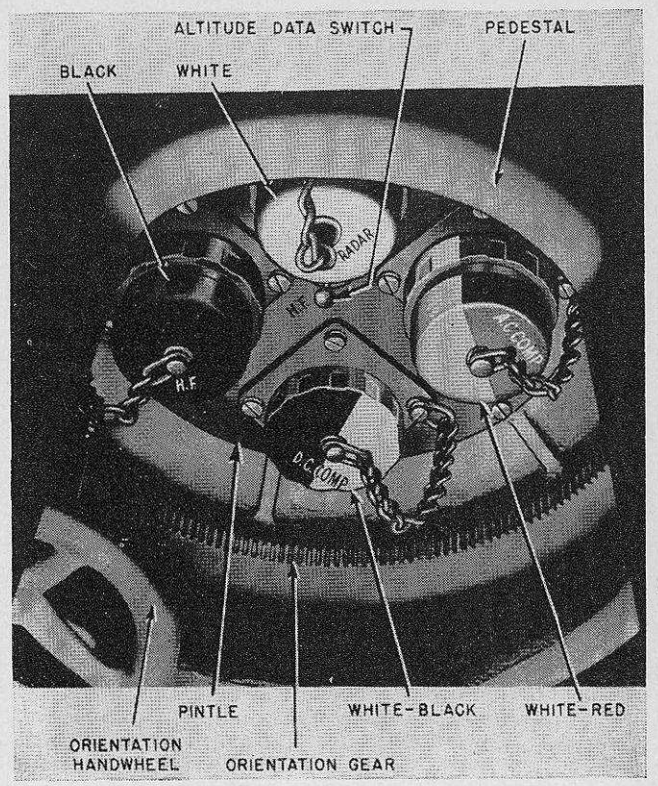


FIGURE 13. Cable connections of tracker.

(blue), for use between computer and altitude converter. (An extra cable is provided in the battery accessories.)

2 20-conductor, 225-foot cables, 19-prong plug (*a-c* white-red, *d-c* white-black), for use between computer and tracker (*a-c* and *d-c*) and between computer and radar units when required. (An extra cable is provided in battery accessories.)

c. The following cables connect to the M9 director, but are not a part of the M7 cable system:

1 20-conductor, 225-foot cable, 19-prong plug (green) between computer and main junction box (MJB).

1 20-conductor, 225-foot cable, 19-prong plug (black) between tracker and height finder (optical or radar).

1 20-conductor, 225-foot cable, 19-prong plug (white) between tracker and radar units when required.

d. Cables are also provided to connect generator and guns to the main junction box. They are not part of the M7 system.

e. In an emergency *cables of the same type,* regardless of the system to which they belong, can be interchanged.

19. CONNECTING CABLES. a. Remove the cap on the cable fitting and the cap of the matching colored receptacle of the unit. Following the cable diagram for the type of units used, insert the cable fittings in the correct receptacles. The alining pin must be fitted into the alining groove before force is applied to the receptacle. Screw the caps together to prevent dirt and moisture from entering.

b. Care must be taken, when the three-conductor power cable is connected, to make sure that the plug (yellow) is correctly inserted. One of the three pins is larger than the other two, and the plug should be turned so that the larger pin fits into the larger hole.

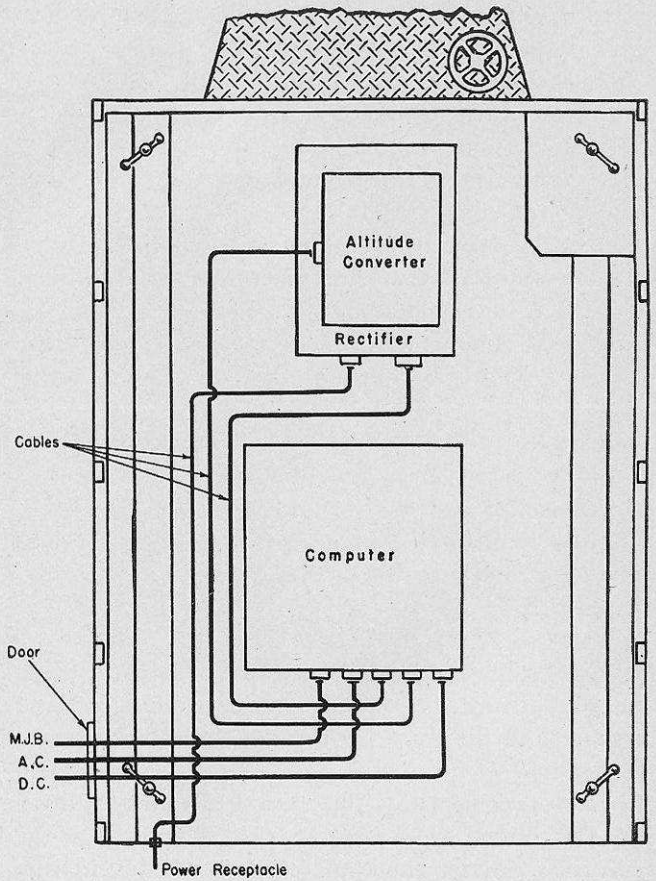


FIGURE 14. Lay-out of trailer.

There is no alining pin on the side of the plug and it is possible to force the larger pin into the smaller hole. This spreads the contact so that thereafter a poor connection results even when the plug is correctly inserted. The other cables have alining pins on the plugs and receptacles, making it impossible to connect them incorrectly.

c. The plugs must be pushed *in all the way* to insure a good contact. Screw ring tight *by hand.* Burning and pitting of the contacts result if this is not done.

d. *Never connect or remove the plugs if the power is on.* If connections are made with the power on, damage to the director may result.

e. Extra lengths of cable should not be used when the distance does not require their use.

CHAPTER 3

ORIENTATION AND SYNCHRONIZATION

Section I

General

20. GENERAL. a. After the tracker has been emplaced and accurately leveled it must be oriented. The transmitters and receivers of the director must be synchronized with those of the various other fire control instruments and with the guns.

b. Orientation insures that the line of sight of the tracker and the axes of the bores of the guns are parallel when the same readings are indicated on the mechanical pointers of the tracker and the guns. Radar, when used, must also be oriented so that its electrical axis is parallel to the line of sight of the tracker when the mechanical pointers indicate the same values.

c. Synchronization is accomplished by adjusting the received data to agree with the transmitted data. For example, the data transmitted from the computer must be identical with that received at the gun clocks.

Section II

Orientation

21. ORIENTATION. a. Azimuth. To orient the tracker in azimuth the following procedure is used:

(1) Determine the azimuth of some distant point from the tracker. It must be visible from all guns and fire control instruments requiring orientation.

(2) Set this azimuth on the A_o dial by the azimuth handwheel.

(3) Loosen the three clamping bolts located on the tracker pedestal underneath the head. (See fig. 7.)

(4) Rotate the tracking head by means of the orientation handwheel (fig. 7) until the vertical cross hair in the azimuth scope intersects the selected point.

(5) Finally, with the correct reading on the dials and the vertical cross hair on the orienting point, tighten the three clamping bolts firmly *by hand.*

Caution: Swing the clamping bolt handles down (vertical position) when finished. The tracker will "jam" on the handles if left horizontal.

b. Elevation. The telescopes are firmly clamped to the tracking head and should be oriented in angular height; however, a check should be made and the procedure as outlined below should be followed:

(1) Set the elevation scope to read "Zero" and rotate the director until the horizontal cross hair alines with some easily recognized distant object.

(2) Rotate the tracker through 3,200 mils.

(3) Remove the telescope and replace on the friction plate 180° from its normal position. The scope must

be held securely in place by hand, as there is no provision for clamping it in place.

(4) By sighting through the scopes the horizontal cross hair should coincide with the reference point within an allowable error of ½ mil.

(5) If an error of ½ mil is exceeded, take up one-half the error with the elevation handwheel.

(6) Loosen the six screws on the friction plate and, by gently tapping the scope, bring the horizontal hair back on the reference point. Keep the elevation handwheel from moving during this step.

(7) Repeat the above procedure until the error lies within the allowable limits.

(8) Tighten the six screws on the friction plate. Replace the telescope.

Section III

Synchronization

22. SYNCHRONIZATION. a. With all the cables connected and the generating unit in operation, the data transmission systems are ready for synchronization. The systems between the computer and guns, between the height finder and altitude converter, and between the radar unit and the tracker must be checked for complete synchronization.

b. The azimuth receivers at the guns are made to read the same as the azimuth transmitter at the computer. Any adjustment that may be necessary is made by turning the adjustment screw at the guns. In like manner the elevation and fuze receivers at the guns

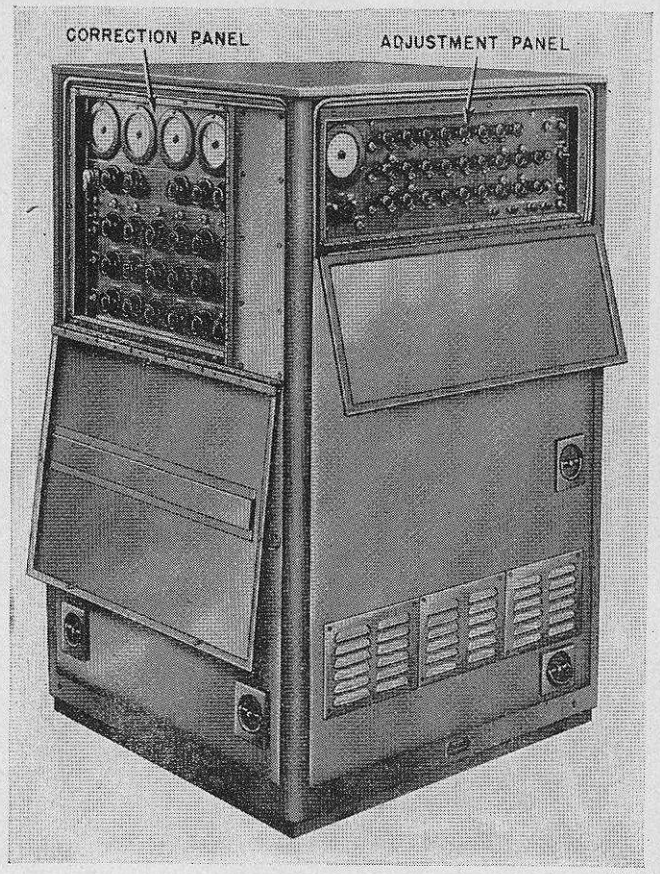


FIGURE 15. Computer.

are synchronized with the quadrant elevation and fuze transmitters at the computer. Each transmitter and receiver should be checked at two or more widely separated points to verify the correctness of readings

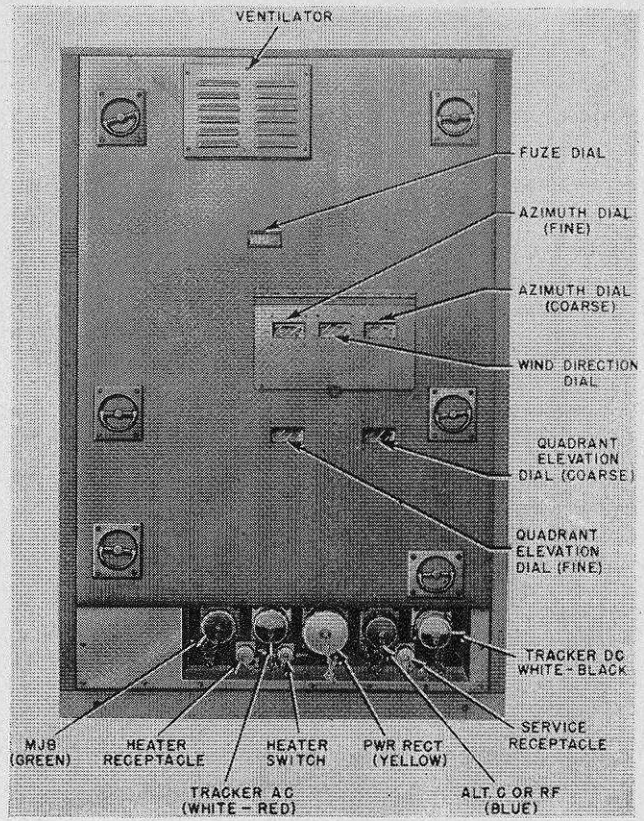


FIGURE 16. Back of computer.

and to insure that directions of rotation are identical.

c. When the height finder M1 or M2 is used, the altitude and range transmitter must be synchronized with the altitude and slant range receiver on the altitude converter. Similarly the E_o and A_o transmitters in the tracker are checked against the respective receivers at the height finder. The adjustments, if necessary, are made at the height finder. (See FM 4–142.)

d. When radar equipment is used with the director the respective transmitters and receivers must also be synchronized. The procedure is similar to that mentioned above and is completely covered in Field Manuals on the particular radar equipment.

e. As previously stated, any necessary adjustment is made at the equipment used with the director as there is no provision for accessible adjustments to be made within the M9 or M10.

CHAPTER 4

OPERATION

Section I
General

23. GENERAL. **a.** This chapter deals with the operation of the M9 director when used with various combinations of fire control instruments. Present position data may be obtained entirely by optical observations, partly by optical and partly by radar, or entirely by radar.

b. In each case, however, the operating procedure will consist of the following steps:

(1) Picking up target.
(2) Insuring that all instruments are on the same target.
(3) Tracking.
(4) Determining slant range (or altitude).
(5) Determining time to fire.

Section II
Parallax

24. GENERAL. After the director is set up, allowance must be made in computing the firing data for the dis-

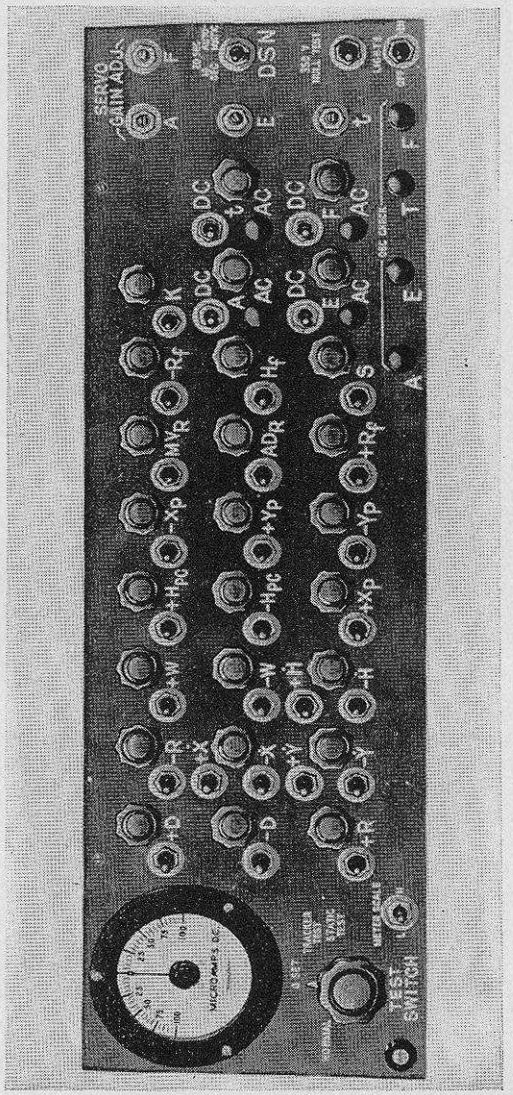


FIGURE 17. Adjustment panel of computer.

placement of the tracker from the directing point. The directing point is the center of the geometrical pattern formed by the guns on the ground.

25. BATTERY PARALLAX. a. Measure the ground distance between the tracker (or radar, if used as a tracker) and the directing point of the battery.

b. If the tracker is used, sight the telescope on the directing point and note the reading on the azimuth and elevation dials. If radar is used, these readings are obtained from the radar personnel.

c. Resolve the ground distance into north-south and east-west components and into a vertical component by use of the M1 slide rule or other method of comparable accuracy. Parallax is always considered direct or from the guns (directing point) (DFG).

d. Set the three BATTERY PARALLAX switches on the correction panel of the computer for the direction of the tracking unit from the directing point (*E* if the tracking unit is east of the directing point). Then set the corresponding dials to the amount of parallax in each coordinate to the nearest 5 yards. In each case the correction is determined by the setting of the TENS (coarse) dial *plus* that of the UNITS (fine) dial. (See fig. 18.)

26. DIFFERENCE IN HEIGHT BETWEEN TRACKER AND HEIGHT FINDER. To allow for the difference in height between the tracker and the height finder, the altitude spot controls on the altitude converter are used. Throw the ALTITUDE SPOT switch to + if the height finder is above the tracker, and to − if the height finder is below the tracking unit. The ALTI-

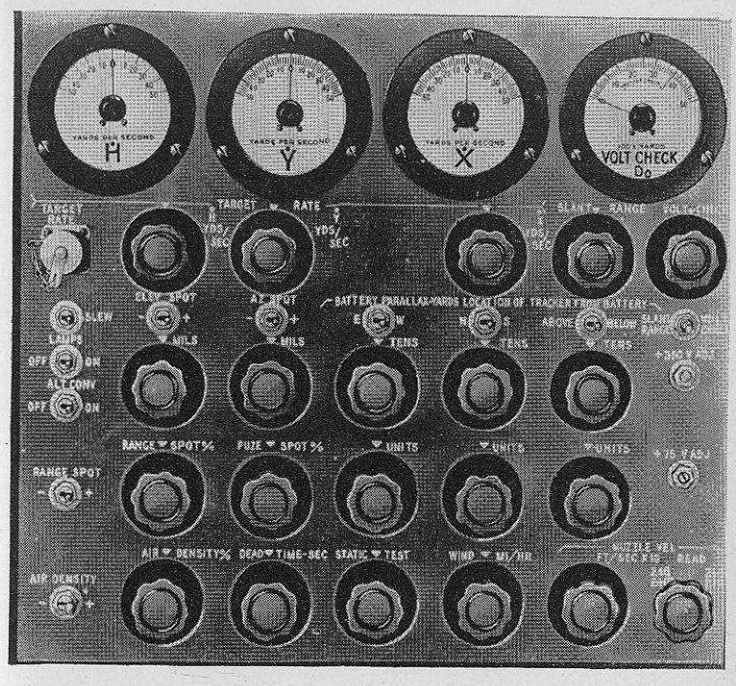


FIGURE 18. Correction panel of computer.

TUDE SPOT dial is set to read the difference in height to the nearest 15 yards. (See fig. 21.)

Section III

Ballistic Settings

27. GENERAL. a. Due to various nonstandard conditions always present in antiaircraft fire, ballistic data must be set in the director. These data vary from

time to time and day to day, and consequently must be frequently checked. To take full advantage of the M9, which is a ballistic director, every effort should be made to obtain correct ballistic data, rather than rely on spots to correct errors. (See par. 62.) PREPARATION OF FIRE MUST BE STRESSED AS THE MEANS OF GAINING ACCURACY IN FIRE.

b. Ballistic corrections are not applied in the same manner as in the M7 director. It is not necessary to convert nonstandard conditions to corrections in H and ϕ and apply these corrections on the spot dials as in the M7 director.

28. AIR DENSITY. The air density is obtained from the proper zone of meteorological message and is given as "percent of normal." Throw the AIR DENSITY switch to + if the air density is above normal, and to − if below normal. The AIR DENSITY knob is set to the nearest *even* percent difference from normal. The range is 20 percent in steps of 2 percent.

29. WIND CORRECTION. a. The velocities of the ballistic wind and of its azimuth are also obtained from the proper zone of the meteorological message. The velocity of the wind in miles per hour is set in by means of the WIND knob on the correction panel. The range is 0–60 miles per hour. As the smallest setting is in multiples of 4 miles per hour, wind velocities set in are taken to the nearest 4 miles per hour. For example, if the wind velocity is 13 miles per hour, the WIND knob is set at 12.

b. The wind azimuth is not set on the correction panel, but on a dial in the back of the computer (see

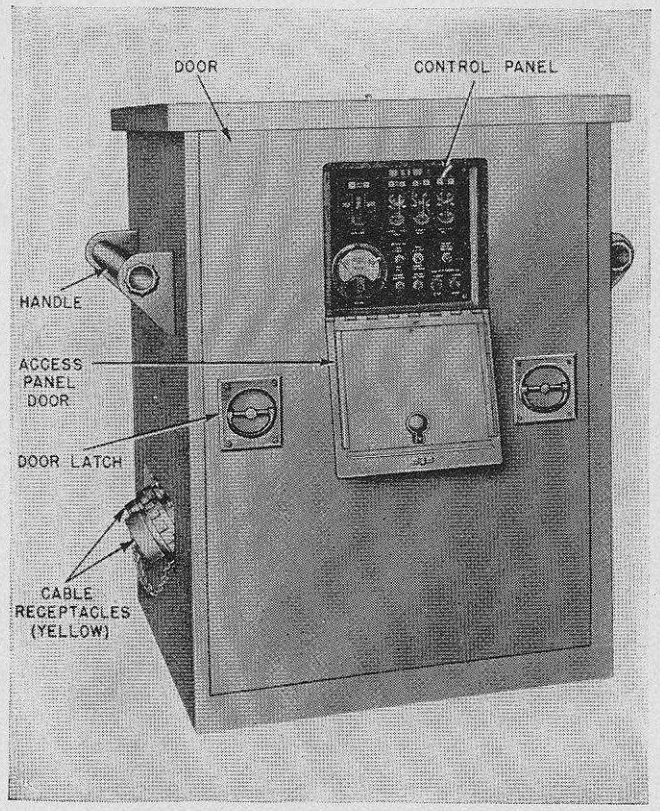


FIGURE 19. Power rectifier.

fig. 16). This is set by means of a knob reached through the hinged cover. The wind azimuth is set in mils directly on the dial.

30. MUZZLE VELOCITY. a. The muzzle velocity is obtained from the range officer. It is set in the director

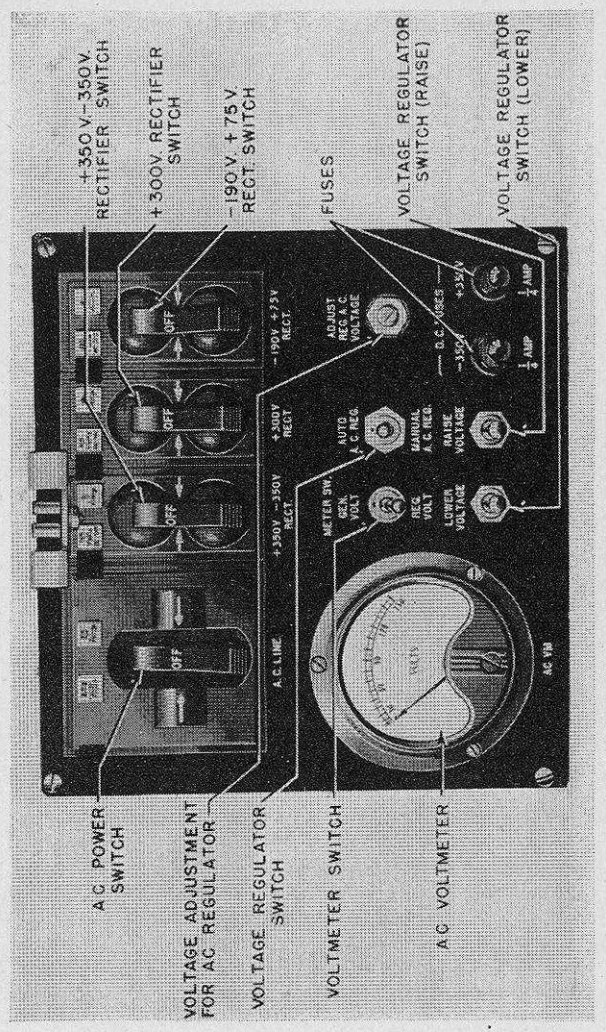


FIGURE 20. Panel of power rectifier.

by means of the MV knobs on the correction panel (see fig. 18). The right-hand knob is set to high or low range, as indicated on the dial. The left-hand knob is set to the average muzzle velocity of the *battery corrected for temperature of the powder and for air temperature (elasticity).* The right-hand knob has two positions. The two numbers, with one zero added to each, represent the limits of the range of the muzzle velocity obtainable with the knob in that position. The left-hand knob has eleven positions, each with two numbers. Thus, with the right-hand knob in the lower position, the low number (with one zero added) on the dial of the left-hand knob is the muzzle velocity setting. On the higher setting of the right-hand knob, read the higher figures (plus one zero) on the left-hand knob.

b. The position of the left-hand knob in which the two numbers are the same is unaffected by the position of the right-hand knob, and is the position of muzzle velocity when setting the dial at zero, as directed in section II, chapter 6.

31. DEAD TIME CORRECTION. Dead time, corresponding to the average speed of the gun crews, is set into the computer by means of the DEAD TIME control knob. Dead time is measured from the instant the projectile is removed from the fuze setter to the instant that round is fired. The range is from 0 to 4 seconds, in steps of 0.2 second.

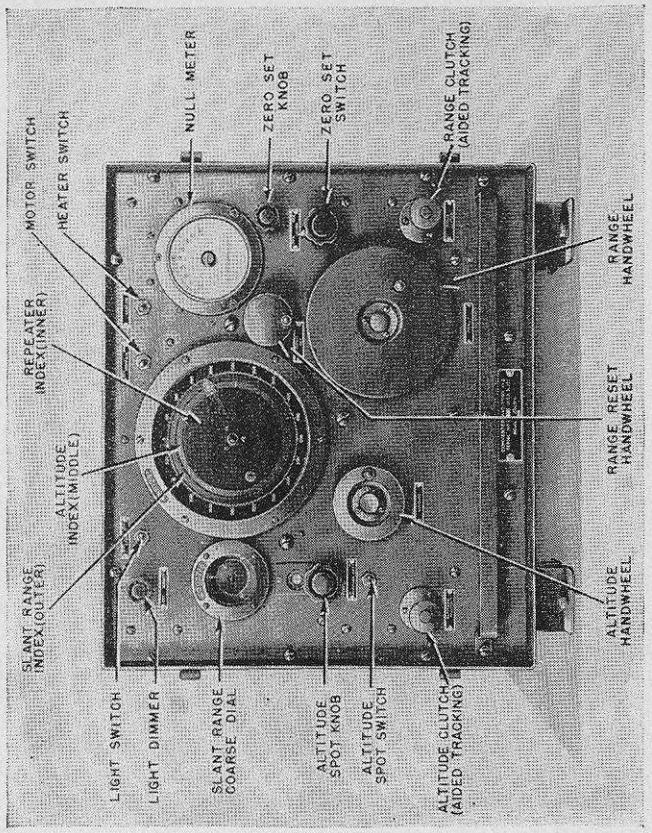


FIGURE 21. Altitude converter.

Section IV

Adjustments

32. GENERAL. a. The director requires adjustments before operation. Provision is also made for checking certain parts of the operation after the adjustments are made, as covered in section II, chapter 6. The adjustments and checks are made when the director is moved to a new position and at definite intervals of about every 2 hours during operation. When the director has been set up in a tactical position, field tests are made at least once a day and at a time when action is least likely. Field tests are made just before firing a trial shot problem.

b. During the checks and adjustments at the computer none of the settings on the dials of the tracker and altitude converter (or radar) should be moved.

c. To insure correct results, the checks and adjustments should be made in the order in which they are described.

33. TO ENERGIZE SYSTEM. a. Throw the AC POWER switch on the panel of the rectifier (see fig. 20).

b. Throw the other three switches on the panel marked RECT. Except in an emergency, wait 5 minutes for the temperatures to stabilize before making checks and adjustments.

34. CHECK OF A-C POWER. a. This test is performed at the rectifier panel. Throw the VOLTMETER switch to "Gen volt." The voltmeter will indicate the voltage of the power supply. This must not be less

than 100 volts nor over 130 volts. If the reading is outside these limits, the power supply should be adjusted or changed. If a number of lengths of power cable are used to connect the generator to the rectifier (yellow plug), the voltage drop may be sufficient to bring the voltage below these limits. (Do not use more lengths of cable than necessary.)

b. Throw the VOLTMETER switch to "Reg volt" and the VOLTAGE REGULATOR switch beside it to "Auto ac reg." The meter indicates the automatically regulated voltage. This should not be less than 112 volts and not more than 118 volts at all times.

35. CHECK OF A-C VOLTAGE REGULATOR. a. This test is performed at the rectifier panel. With the VOLTMETER switch at "Reg volt," throw the VOLTAGE REGULATOR switch to "Manual ac reg."

b. Raise the voltage above 118 volts by pressing the button marked RAISE VOLTAGE.

c. Throw the VOLTAGE REGULATOR switch to "Auto ac reg." The meter should return to not greater than 118 volts or less than 115 volts.

d. Throw the VOLTAGE REGULATOR switch to "Manual ac reg."

e. Lower the voltage below 112 volts by pressing the button marked LOWER VOLTAGE.

f. Throw the VOLTAGE REGULATOR switch to "Auto ac reg." The meter should return to not less than 112 volts or greater than 115 volts.

36. ADJUSTMENT OF A-C VOLTAGE REGULATOR. If the above values (par. 35) are exceeded, turn the adjustment screw on the rectifier panel marked ADJUST REG. AC VOLTAGE to the right if the readings were low, and to the left if the readings were high, until the test is performed within the prescribed limits. Return the VOLTAGE REGULATOR switch to "Auto ac reg."

37. MANUAL A-C VOLTAGE REGULATOR. If the automatic regulator fails so that the voltage will not remain within the above limits, manual regulation should be used. Throw the regulator switch to "Manual ac reg" position and adjust the voltage by pressing momentarily one of the buttons marked RAISE VOLTAGE and LOWER VOLTAGE. This adjustment must be repeated as required to maintain the voltage within the above limits. This is an emergency method and should be used only until the fault can be corrected.

38. CHECK OF D-C VOLTAGES. a. Turn the SLANT RANGE—VOLT CHECK switch on the correction panel of the computer to "Volt check." (See fig. 18.)

b. Turn the VOLT CHECK knob to each of the marked voltages successively. At each position the VOLT CHECK meter needle should stand within one-half division of the red line on the scale, except the +75-V test which must be exact. Return VOLT CHECK knob to "off."

c. Failure to obtain an indication at *any one* position of the VOLT CHECK knob indicates trouble which must be cleared before the director can be operated.

39. CHECK AND ADJUSTMENT OF 350-VOLT POWER. **a.** This check and adjustment is performed at the computer. Throw the METER SCALE switch on the adjustment panel to "L." (See fig. 17.) TEST SWITCH on adjustment panel is set to NORMAL.

b. Throw the 350V NULL TEST switch on the adjustment panel to the right. The meter on the adjustment panel should read zero. If it does not, bring it to zero by turning the adjustment screw marked +350V ADJ on the correction panel. The STATIC TEST switch must be OFF to make this adjustment.

40. ADJUSTMENT OF 75-VOLT POWER. **a.** This adjustment is performed at the correction panel of the computer. Turn the SLANT RANGE–VOLT CHECK switch to VOLT CHECK. Turn the VOLT CHECK knob to "75v." Turn the adjustment screw marked 75V ADJ to bring the needle of the VOLT CHECK voltmeter *exactly* to the red line. *This is a very critical adjustment.*

b. Return VOLT CHECK knob to "Off."

41. OSCILLATOR CHECK. This check is performed at the adjustment panel of the computer. Press successively the four buttons marked OSC CHECK and note indications on meter. The meter should read not less than 35 as each button is pressed. If a reading of less than 35 is obtained, trouble is indicated which must be cleared before director can operate properly. The buttons are spring-loaded and will return to "Off" position when pressure is released.

42. CHECK AND ADJUSTMENT OF TRANSMITTERS (SERVO GAIN). **a.** Set the azimuth index of the tracker

(or radar if the tracker is not used) to approximately 2,900 mils and the elevation index to approximately 900 mils.

b. Set the range index of the altitude converter (or radar if the altitude converter is not used) to approximately 10,000 yards.

c. Throw each switch, in turn, marked DC (*A, E, t,* and *F*) on the adjustment panel of the computer.

d. As each switch is thrown, turn the associated knob *very slowly* to the limit on the right and left and observe the indications of the meter on the adjustment panel.

e. The difference in the readings on the meter should be two divisions when the knob is turned slowly from the right limit to the left limit. If greater or less than two divisions, adjustment must be made. If less than two divisions, turn the screw adjustment marked SERVO GAIN ADJ (*A, E, t,* or *F*) counterclockwise. If greater than two divisions, turn screw clockwise. After each adjustment of the screw, the above test must be repeated until the difference of the readings on the meter scale is two divisions.

f. If the servo gain is out of adjustment, the selsyn data to the guns will be uneven; a jerky motion will result if adjusted too tightly (clockwise), and a sluggish motion if adjusted too loosely (counterclockwise).

g. Operator should check at the completion of this test to insure that the switches marked DC (*A, E, t,* and *F*) are in left position.

43. ZERO SET OF AMPLIFIERS. **a.** Turn the TEST SWITCH on the adjustment panel of the computer to "0 set." Throw the METER SCALE switch to

"*L*." The d-c cable (black-white) from computer to tracker or radar must be connected, or the STATIC TEST switch on the correction panel of the computer must be turned to one of positions 1 to 8.

b. *The following order must be followed whenever this test is performed.*

(1) Switches $+D$, $-D$, $+R$, $-R$, $+W$, $-W$, $+H_{PC}$, $-H_{PC}$, $+X_p$, $-X_p$, $+Y_p$, $-Y_p$, MVR, AD_R, $+Rf$, $-Rf$, Hf, S, K. Throw each of the lettered switches on the adjustment panel to the right, in turn. Observe the meter on the adjustment panel. There should be a small movement of the needle; if there is no movement, turn the associated knob slightly. If the amplifier is functioning, turning the knob will cause the meter needle to move. If the needle remains stationary, trouble is indicated which must be cleared before the director can operate. If there is a movement of the meter needle, turn the associated knob slowly until the meter reads zero or not more than one-half scale division from zero. Proceed to the next switch and repeat the operation. The panel is designed so that the operator starts with the switch at the upper left corner ($+D$), goes down vertically, moves to the next column to the right, goes down vertically, and so on until all switches have been operated. It should be noted that certain switches are skipped at this time.

(2) Buttons A–AC, E–AC, t–AC, and F-AC are now tested in that order. As each button is pressed, turn the associated knob until the meter reads a *minimum* value.

(3) Switches $-\dot{X}$, $-\dot{Y}$, and $-\dot{H}$ are now tested in that order. The procedure is the same as given in *(1)* above. Note that these three switches are left until the end of the test. It takes about 1 minute for the director to clear the rates set up in the computer by operating these switches.

(4) Switches $+\dot{X}$, $+\dot{Y}$, and $+\dot{H}$ are not used at all in this test. They are dummy switches.

(5) After completing the test at any switch, the operator should be sure that the switch is in the left position before proceeding to the next switch. Switches are spring-loaded, but they sometimes stick.

c. Return TEST SWITCH to "Normal," METER SCALE switch to "*H*," and STATIC TEST switch to "Off."

44. CHECK AND ADJUSTMENT OF ALTITUDE CONVERTER AMPLIFIER. a. Throw the ZERO SET switch on the altitude converter panel to "Adj." (See fig. 21.)

b. Turn the TEST SWITCH on the adjustment panel of the computer to "Normal."

c. On the altitude converter panel turn the ZERO SET knob until the NULL METER reads "Zero."

d. Return the ZERO SET switch on the altitude converter panel to "Opr."

Section V

Operations Prior to Firing

45. GENERAL. a. Prior to firing, check all connections, switches, and settings of ballistic data. Use the check list in paragraph 70. If the temperature is very

low, or if condensation causes clouding of the glass windows, the heaters in the tracker and altitude converter may be turned on to warm up the equipment.

b. The director should be habitually kept with certain settings, so that a target can be engaged in a minimum time. Also, since these settings are made when the operators are not under strain of working against time, there is much less chance of erroneous settings. These settings include—

(1) Tracker at midazimuth of primary zone of fire.

(2) Altitude of expected targets is set in. If the tactics of enemy targets are not known, an average altitude should be set in.

(3) In case slant range is used instead of altitude, the slant range to the expected point of pick-up is set in. If the tactics of enemy targets are not known, the slant range for maximum fuze is set in.

(4) Null meter on altitude converter is zeroed after altitude, *(2)* above (or slant range, *(3)* above) is set in.

(5) Telescope on tracker are elevated to the angular height at which targets are normally picked up. If no data on angular height are available, telescopes are set at about 300 mils; unless the presence of a mask indicates that a greater angular height should be used.

(6) Any rates on the tracker aided tracking mechanisms are run down to zero and the aided tracking levers returned to vertical position.

(7) Aided tracking mechanisms on the altitude converter are disengaged (pulled out).

(8) Parallax is set in for the most likely type of fire. For example, at night, unseen fire may be the general rule, hence parallax set in on the director should be *radar from guns.* During daylight, visible targets are

more likely in most cases, hence parallax set in should be *tracker from guns.*

(9) Developed MV of the battery *corrected for powder temperature and elasticity* is set in at all times on the director and kept up to the minute.

(10) Wind velocity, direction, and density for the zone in which it is anticipated targets will be engaged are set in on the director. The data are obtained from the latest meteorological message. If no data are available on enemy targets, the zone covering the altitude selected in *(2)* above should be used.

(11) Value of dead time for the battery at the quadrant elevation anticipated for COMMENCE FIRING should be set in.

46. ENERGIZING THE SYSTEM. a. The system is energized by throwing the four power switches on the panel of the power rectifier (see fig. 20). The director will be ready for operation in about 60 seconds after the switches are closed.

b. Since the director will require less frequent adjustment after operating temperatures are stabilized, the director should be kept energized during periods when it may be required to operate.

47. ADJUSTMENTS. a. Adjustments should not be made during the firing period, but when an opportunity occurs, the TEST SWITCH on the *adjustment panel* should be turned to 0 SET position and the $+R_f$, $-R_f$, H_f, S and K amplifiers checked by throwing the switches with these designations. If these amplifiers show departures from zero of less than 2 divisions of the meter scale, adjustment is not required. If *any*

one of these amplifiers shows a greater departure, the +350 v power +75 v power and all amplifiers should be checked and readjusted as necessary as described in Section IV on "Adjustments."

b. In any case, the transmitter (servo gain) adjustments should be checked by throwing the switches marked *DC* and the *A, E, t* and *F* amplifiers readjusted as described in par. 42.

c. The TEST SWITCH on the *adjustment panel* of the Computer must be returned to NORMAL position before firing is again commenced.

Section VI

Operation with Height Finder M1 or M2

48. PICKING UP TARGET. a. Throw switch at base of tracker to "H.F." ALT. CONV. switch on the correction panel of the computer must be "On." (See fig. 13.)

b. The slewing operator grasps the slewing handles and turns tracker in direction of indicated target. He uses the open sight on the azimuth telescope.

c. The elevation tracker operates the elevation slewing clutch and elevates or depresses the telescope to bring the target into the field of view, using the slewing handle.

d. The trackers at the height finder match pointers on the elevation and azimuth indicators. When the observer locates the target in his field of view, he throws a switch which lights the "On target" signal

at the tracker, or notifies the tracker by other means. (This switch is not found on all models.) As soon as the observer indicates that his data are OK, the range setter starts to transmit the data to the altitude converter. If the height finder should get on target first, he assists the tracker in getting on target. This can be done by furnishing A_o and E_o or by noting the relative positions of the indices on the A_o and E_o receivers at the height finder. The tracker is then told to traverse right (or left) and elevate (or depress) so as to match pointers at the height finder.

e. The operators at the altitude converter are advised whether altitude or slant range is being transmitted.

49. TRACKING TARGET. As soon as the trackers pick up the target in their telescopes, they quickly place the vertical and horizontal cross hairs on the target by using the handwheels. They engage the aided tracking mechanisms and establish as quickly as possible a tracking rate (both A and E) which follows the average movement of target. *The time required to produce the data necessary for firing will depend on how quickly a steady rate is obtained and the accuracy of the predictions will be affected by the steadiness of this rate.* It is important, therefore, that the trackers be well trained in setting in steady rates and in setting in these rates quickly. (See pars. 59 to 61, inclusive.)

50. DETERMINING SLANT RANGE OR ALTITUDE. a. Slant range. The operator is advised as to whether

range is between 0–10,000, 10,000–20,000 or 20,000–30,000 yards. The slant range setter sets his dials to the approximate range by pushing in and turning the RANGE RESET knob, and turning his hand-wheel until the index on the outer dial of the slant range dial matches the inner dial which is receiving the data from the height finder. Data from the height finder are intermittent. As quickly as possible, the slant range setter establishes a rate of movement of his index so as to correspond to the average rate of movement of the index controlled by the height finder. He uses the aided tracking mechanism for this purpose. *The time required to obtain firing data depends upon how quickly a steady rate is established and the accuracy of the data is affected by the steadiness of the rate.* In this situation, the altitude setter at the altitude converter should keep the NULL METER at "Zero" by using his handwheel. Unless the target is changing altitude, he should not use his aided tracking mechanism. The operation of the altitude setter is not necessary, but if change over from slant range to altitude is made the transition is expedited.

b. Altitude. The altitude setter matches his index (middle) to the inner dial which is receiving data from the height finder. He should not use aided tracking unless the target is changing altitude. If the altitude is changing he establishes a steady rate using the aided tracking mechanism. The slant range setter concentrates on the NULL METER and keeps it as close to zero as possible, using his handwheel and aided tracking.

c. Reference. More details on the operation of

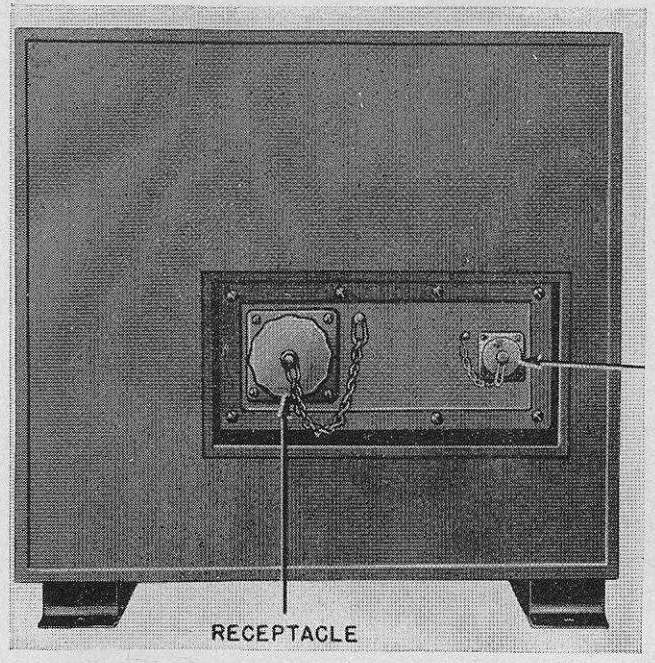


FIGURE 22. Back of altitude converter.

aided tracking are given in paragraphs 59 to 61, inclusive.

51. CHECK ON TRACKER AND HEIGHT FINDER ON SAME TARGET. The elevation and aximuth of the telescopes of the tracker are continuously transmitted to the receivers at the height finder. The match of the indices at the height finder will indicate whether the tracker and the height finder are following the same target.

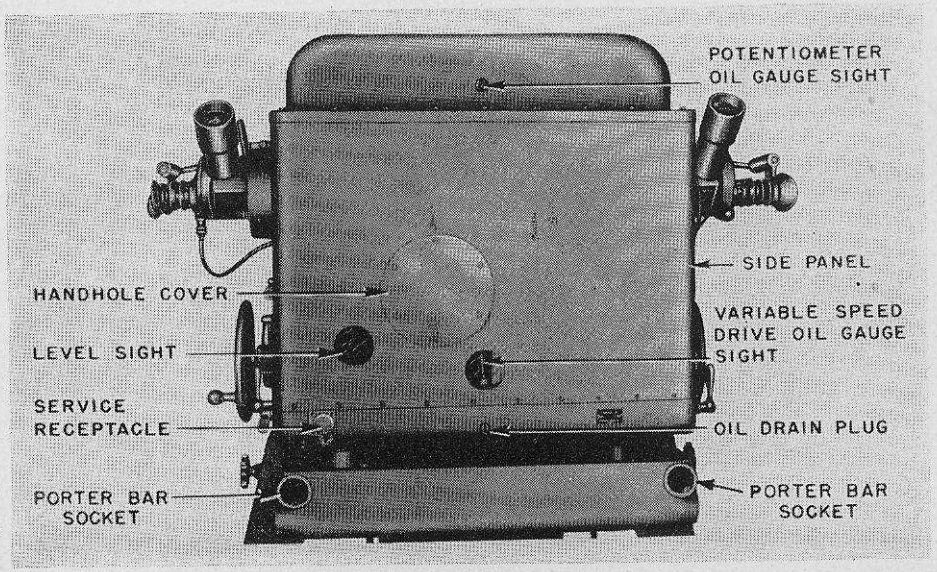


FIGURE 23. Rear of tracker.

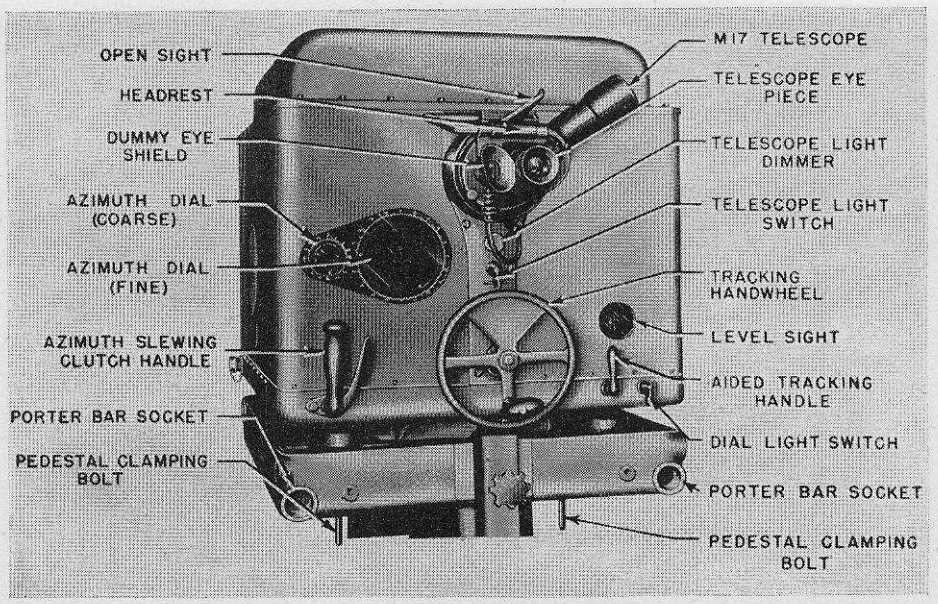


FIGURE 24. Right side of tracker.

Section VII
Operation with SCR–268

52. TARGET VISIBLE. a. Throw the switch at the base of the tracking head to "Radar" position. (See fig. 13.)

b. The operation using the SCR–268 is the same as with the height finder except that the altitude indications are continuous rather than intermittent.

53. CHECK ON TRACKER AND SCR–268 ON SAME TARGET. The angular height and azimuth of the target are continuously transmitted from the radar system to the central disks of the dials of the tracker. The match of the tracker A_o and E_o dials indicates whether the tracker and the SCR–268 are following the same target.

54. TARGET INVISIBLE. When the target becomes invisible, the operators at the tracker can continue to track the target by matching their pointers to the indices actuated by the SCR–268. The accuracy of tracking is not as great as with optical observations. The target can be followed and should be in the field of the tracker telescopes when it again becomes visible.

Section VIII
Operation with SCR–547

55. GENERAL. The SCR–547A, 547B, and 547C all provide a d-c voltage equivalent to slant range. There-

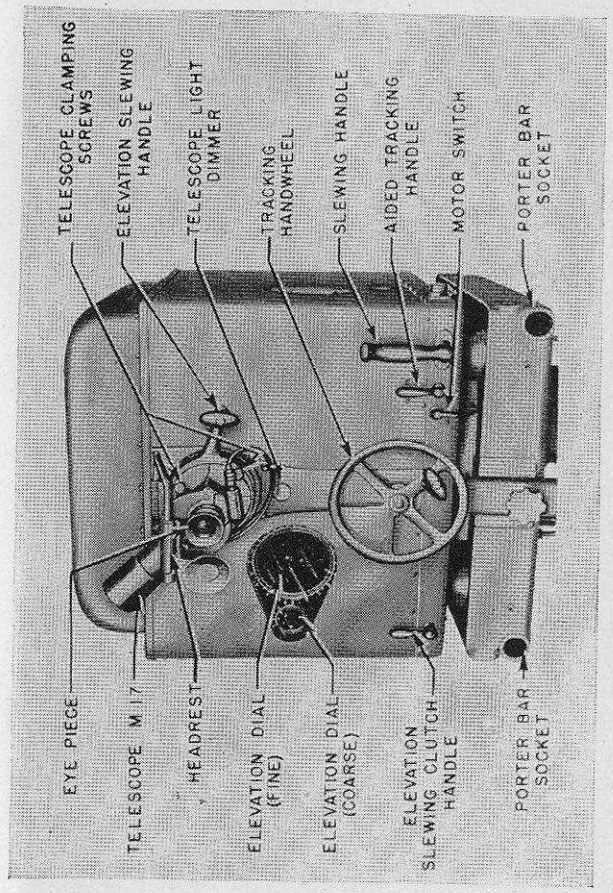


FIGURE 25. Left side of tracker.

fore, the altitude converter is not required. Throw the ALT. CONV. switch on the correction panel of the computer to "Off."

a. SCR–547–A, 547–B. Switch at base of tracker is at "H.F." Operations at tracker are exactly as in paragraphs 48 to 51, inclusive. This system is inoperative when target is invisible.

b. SCR–547–C. Neither altitude converter nor tracker is used. The SCR–547–C is connected directly to the computer. This system can be used for either visible or invisible targets.

Section IX
Operation with SCR–545 and SCR–584

56. GENERAL. The SCR–545 and SCR–584 are similar as far as operation is concerned and may be operated in two ways. The altitude converter is not used in either method.

a. Method 1. The radar unit transmits to the tracker the azimuth and angular height of the target as selsyn data and the slant range as a d-c voltage. Target designation may take place either at the tracker or the radar. Throw the ALTITUDE DATA switch under the tracker to "H.F." for target designation at the radar, and to "Radar" for target designation at the tracker.

NOTE: When the altitude data switch is in the "H.F." position, selsyn data are *sent* from the tracker. When the switch is in the "Radar" position, selsyn data are *received* at the tracker.

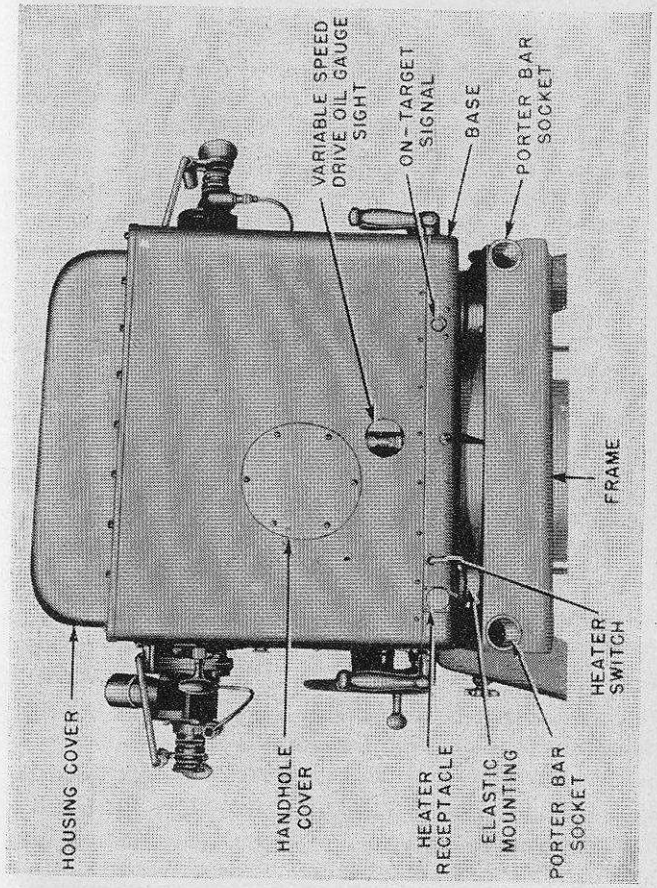


FIGURE 26. Front of tracker.

b. Method 2. The radar unit transmits d-c voltages equivalent to the rectangular coordinates (X_o, Y_o, and H_o) directly to the computer. This eliminates the use of the tracker. No target designation is made in this method.

Section X
Determining Time to Fire

57. TARGET RATE a. The director predicts the future position of the target upon the assumption that the target will fly in a straight line at a constant speed. The *rate of change* of each of the three coordinates of its position ($\dot{X}$, $\dot{Y}$, $\dot{H}$) is constant. When a target is being tracked, these rates can be read directly on the three target rate meters marked "Yards per second" on the correction panel of the computer. From left to right, they read rates of change in altitude ($\dot{H}$), in north-south distance ($\dot{Y}$), and east-west distance ($\dot{X}$). In each case the rate of change (or component of target speed) in yards per second is given by the indication of the dial of the control knob, *plus or minus* the reading of the meter. Before readings can be obtained, each knob must be set to the nearest even 50 yards per second so that the needle of the corresponding meter is "On scale." Positive readings (left of zero) in the three components mean that the target is climbing, it is moving from west to east, and from south to north. Negative readings mean the reverse.

b. When tracking is started, the target rate needles will start to move. If any needle reaches the end of its

scale, the associated knob is turned until the needle is again on the scale. Normally, the needles do not have the same relative position on all three dials. When the needles cease to move, it is an indication that the data are smooth and tracking is steady.

58. TIME TO FIRE. a. Firing should not begin until steady tracking has been obtained for at least 7 seconds. *The deciding factor, however, is the establishment of a steady rate and not the elapsed time.*

b. The data smoothing network (D.S.N.) reduces tracking inaccuracies as explained in paragraph 11**b.** Experience will show which of the three positions of the D.S.N. switch on the adjustment panel of the computer gives the best firing data. The 20-second network gives maximum smoothing, but increases the time interval before firing. The "Automatic" position will give the speed of the 10-second D.S.N. initially and the accuracy of the 20-second D.S.N. later.

Section XI
Aided Tracking

59. GENERAL. Two types of aided tracking mechanisms are employed in the M9 director. They are slightly different in construction and in operation. The purpose is the same—to provide a smooth rate whenever needed.

60. AIDED TRACKING ON TRACKER. a. Description. Aided tracking mechanisms are provided for assisting the elevation and azimuth tracker on the tracker. Ad-

jacent to each tracking handwheel on the right is the aided tracking lever which has two positions, AID or POS. In the AID position, the motion of the tracker's handwheel establishes a rate and positions the tracking handwheel as well. As the handwheel is turned, the rate changes, increasing it in one direction, and decreasing it in the opposite direction. If the aided tracking handle is turned to POS after tracking with the handle on AID, the rate set in is removed, but not instantaneously. With the handle at the POS position at the inception of tracking, the only motion affecting the tracker is the actual rotation of the handwheel. Thus for manual operation, the handle should be at POS.

b. Operation. *For aided tracking, the handle is turned to "Aid."* Every motion of the handwheel does two things, first, it actually moves the tracker, and second, it changes the rate. The direction and amount of the rate are dependent on the direction of rotation and amount of rotation of the handwheel. If the direction of rotation of the handwheel is reversed, the rate is reduced. When a rate has been set in, the tracker continues to move at an even rate even though the handwheel is stationary. In normal tracking the operator first gets on the target using unaided tracking POS. Continuing to track with his handwheel he moves his handle to "Aid." The motion of his handwheel sets up a rate which begins to move the tracker. As the rate builds up he turns his handwheel slower and slower. In a few seconds he builds up the rate so that he no longer needs to turn his handwheel. The angular rates are not constant, hence it is necessary to vary the rates as

tracking progresses. This is done by putting in small increments on the tracker's handwheel. Each time the handwheel is turned the tracker is moved slightly and the rates are changed slightly.

c. The aided tracking mechanism is the same for both elevation and azimuth. At the conclusion of tracking the trackers throw the levers to "Pos" and the rates in the trackers run down to zero.

61. AIDED TRACKING ON ALTITUDE CONVERTER.

a. Description. Aided tracking mechanisms are provided for assisting the slant range and altitude setters on the altitude converter. On the altitude converter panel are two buttons marked RANGE CLUTCH and ALTITUDE CLUTCH. The operation of the mechanism is the same. The buttons have two positions, pushed in (engaged), and pulled out (disengaged). In the engaged position the range (or altitude) setter's handwheel increases the rate when turned in one direction and decreases it when turned in the opposite direction. In the disengaged position the rate is reduced to zero almost instantly. In the disengaged position the range (or altitude) setter's handwheel changes range or altitude without setting in or changing the rate.

b. Operation by range setter. Since slant range will always be a variable in courses encountered, the slant range operator will habitually use his aided tracking mechanism. With the aided tracking disengaged, when the range handwheel is turned slant range will be changed, but the moment the handwheel stops turning the range becomes stationary. With aided tracking engaged, when the range handwheel is turned

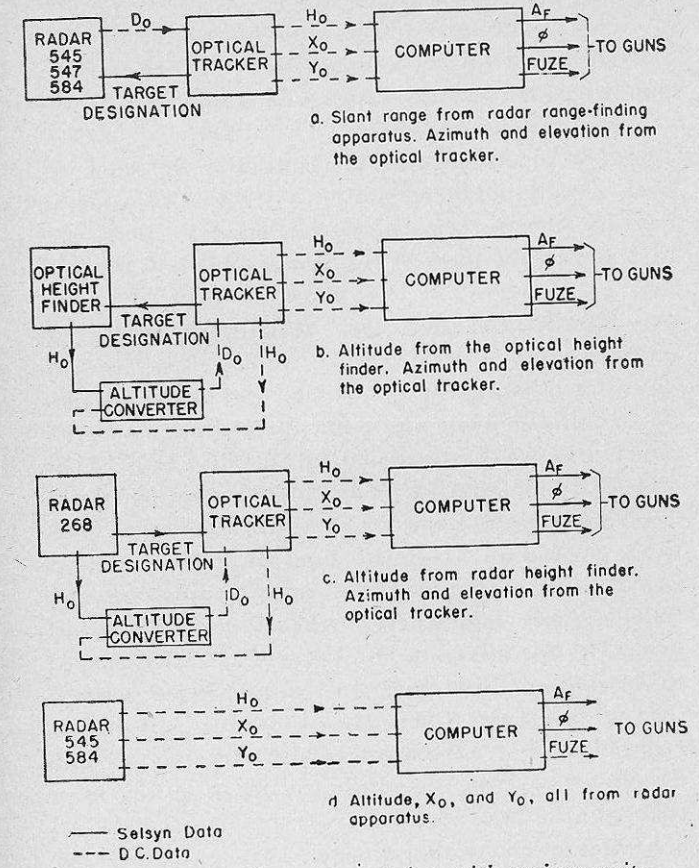


FIGURE 27. Data transmission with various units.

two things are done: first, the handwheel actually sets in an increment in slant range, and second, it sets up a rate. The direction and amount of the rate are dependent on the direction and amount of rotation of the handwheel. If the direction of rotation of the handwheel is reversed, the rate is reduced. When a rate has been set in, it changes range at that rate even though the range handwheel is stationary. In normal operation the range setter zeros the NULL METER by using unaided tracking (range clutch pulled out). He continues to keep the NULL METER at zero with his handwheel and at the same time pushes in the range clutch. The handwheel motion is now setting in a rate which is helping to keep the NULL METER at zero. As the rate builds up, the operator turns his handwheel slower and slower. In a few seconds a rate is built up which makes it unnecessary to turn the range handwheel in order to zero the NULL METER. Slant range does not vary constantly. Hence it is necessary to vary the rate as tracking progresses. This is done by putting in small increments on the range handwheel. Each time the handwheel is turned a small increment in slant range is added and the rate is changed slightly. The range clutch is disengaged at the end of each course. If slant range is being received by the altitude converter the slant range setter does the same as outlined above except that he matches his index (outer) to the index on the inner dial instead of keeping the NULL METER at zero.

c. Operation by altitude setter. If the target is flying at constant altitude, the altitude setter on the altitude converter leaves his altitude clutch disengaged. If H_o is being transmitted from the height finder (or radar) he matches his index (middle) to the index on the inner dial. If D_o is being transmitted, he keeps the NULL METER at zero. If the target is

changing altitude he uses his altitude clutch in exactly the same manner as explained in **b** above to keep either the indices on the dial matched or the NULL METER zero, depending on whether H_0 or D_0 is being transmitted to the altitude converter. At the end of the course the altitude clutch is disengaged, removing the H rate.

Section XII
Spot Corrections

62. GENERAL. a. The term "spot" is defined as "an adjustment correction based upon observation of fire." The spot control knobs on the M9 director accomplish a somewhat different function from the implied definition above. Actually, the spot correction is used to compensate for known errors such as matériel, fuze, and data transmission errors.

b. Due to present day high speed, high altitude targets, and the necessary elapsed time between firing and the observation of the bursts, it is rarely that an opportunity will exist to spot or adjust the fire on any given course. This is further complicated in the M9 director by the "smoothing networks" which average out any sudden change in applied data which would occur with certain spots. Therefore, spotting normally will not be done while firing.

c. If all data set into the director are correct, there is theoretically no reason for any adjustment to bring the burst on the target as the M9 and M10 directors are fully ballistic. However, in addition to the known errors, there are unknown and unpredictable errors.

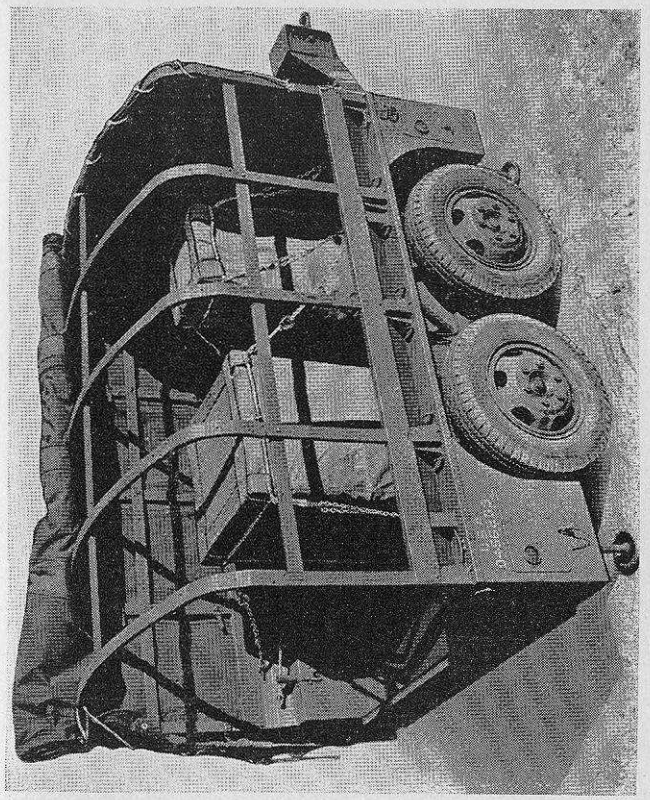


FIGURE 28. Computer, rectifier, and altitude converter in trailer.

These may be due to errors in the meteorological message, inability to calculate the exact muzzle velocity, and other unknown variables. Little can be done to correct these except to set in the ballistic data as accurately as possible. If a *consistent* error persists through more than one course, or in a trial shot problem, a spot correction can be set in.

63. APPLYING SPOT CORRECTIONS. Spot corrections are applied by setting the various knobs to the desired values. Each type of spot has its own knob on the correction panel. (See fig. 18.) Each knob is equipped with detents. The knob should engage the detent. Values of spots in between the values shown cannot be set, so do not try it.

64. ELEVATION SPOT. An elevation spot is introduced by throwing the ELEV SPOT switch to + for an increase of elevation, or to — for a decrease of elevation. The amount of the spot is controlled by the position of the associated knob and indicated on the dial. Only spots of 0, 2, 4, 6, 8, 10, 15, 20, 30, 40, or 50 mils can be set in.

65. AZIMUTH SPOT. The azimuth spot is set in the same manner as the elevation spot, except the AZ SPOT switch is used.

66. FUZE SPOT. A fuze spot is introduced by means of the FUZE SPOT knob. The amount of the spot is indicated on the dial in "percent of fuze time." Spots of ±10 percent in steps of 1 percent may be set in.

67. RANGE SPOT. a. A range spot is set in by throwing the RANGE SPOT switch to + for an increase of

slant range or to — for a decrease of slant range. The amount of spot is controlled by the associated knob, and is indicated on the dial in "Percent of slant range." Spots of ±5 percent in steps of 0.5 percent may be set in.

b. The range spot does not function when the altitude converter is used to receive altitude.

68. ALTITUDE SPOT. a. When altitude is being transmitted, an altitude spot is set in by throwing the ALTITUDE SPOT switch on the altitude converter to + for increase and — for decrease altitude. The amount is set on the dial by the ALTITUDE SPOT knob. Spots of ±150 yards in steps of 15 yards may be set in. (See fig. 21.)

b. The altitude spot does not function when the altitude converter is used to receive slant range.

Section XIII
Precautions

69. GENERAL. Before firing, precautions must be taken to see that the various switches are in the correct position for the type of operation used. There are also a number of steps which, if done inadvertently or omitted, can interfere with the operation of the director. They are listed here to use as a check list before going into operation.

70. PRECAUTIONS. a. The cabinet doors of power rectifier must not be open. (The doors are provided with switches which automatically cut off high voltage power when opened.)

b. The cabinet doors of the computer must not be open.

c. The test switch on the adjusting panel of the computer must be in "Normal" position.

d. The amplifier adjusting knobs on the adjusting panel of the computer must not be moved. The adjustment panel door must be closed to prevent accidental movement of the knobs.

e. The ALT. CONV. switch on the correction panel of the computer must be in "Off" position if the altitude converter is not connected, and in "On" position if altitude converter is used.

f. The STATIC TEST switch on the correction panel of the computer must be in "Off" position.

g. The ZERO SET switch in the altitude converter must be in "Operate" position.

h. The toggle switch on the under side of the tracker must be in "HF" position when the height finder (optical or radar) is used. When receiving data from SCR–268, SCR–545, or SCR–584 it must be in "Radar" position.

i. The voltage of the 115-volt regulated power must be within the limits of 112 to 118 volts, either by automatic regulation or by necessary readjustment by the manual regulation.

j. The amplifiers must be in zero adjustment for accurate results. Check and adjust if necessary during intervals between firing periods as described in paragraph 47.

k. In general, remember that accurate results cannot be obtained unless the tracker, radar system, and guns are correctly leveled and oriented, and the data transmission systems are accurately synchronized.

CHAPTER 5

PREPARATION FOR MOVEMENT

Section I

Packing

71. GENERAL. As previously stated, the average tactical situation will not require the removal of the rectifier, altitude converter, or computer from the trailer. This greatly simplifies the problem of packing for movement, and the duties involved.

72. TRACKER. a. Remove telescopes and pack them in carrying box.

b. Disconnect and pick up cables.

c. Remove tracking head from pedestal by reversing order described in setting up tracker.

d. Place tracking head in rear of trailer. Jacks on trailer must be down or trailer will tip. Bolt the tracking head to floor with bolts and clamps provided.

e. Prepare units in trailer for movement by replacing covers over panels.

f. Cover the units in trailer with canvas covers.

g. Place web harnesses over equipment.

h. Connect harnesses to eyebolts built into trailer with lashings provided. Adjust lashings to keep them tight at all times.

i. Remove legs from pedestal. Grease pins for preservation. This will also help in reassembling tripod at next position. Put a light film of grease or oil on top of pedestal and orienting pinon. The tripod is carried in the truck. Care must be taken to prevent damage to pedestal top by striking it with hard objects, as it may be injured sufficiently to prevent proper orientation of tracker.

j. Spare parts boxes, oilcans, porter bars, and cables are carried in the truck. In some cases it may be desirable to stow some of these items on the trailer. Pack loose parts securely so that they will not shift during transit.

k. Couple trailer to truck. Raise trailer jacks all the way up and lock the jack screw handles with the clips provided on side of trailer. Tie down the canvas cover. Connect break-away chains, light cables, and electric brake jumper cord. The chief of section inspects unit before moving for the security of the load and operation of the brakes.

Section II

Destruction of Matériel

73. GENERAL. a. When surrender or abandonment of matériel is inevitable, the M9 director and its component parts must be destroyed to prevent its use by the enemy. *The destruction of matériel is a command decision to be implemented only on authority delegated by the division or higher commander.*

Plans for destruction should be flexible, as the procedure is governed by the tactical situation and the time and matériel available. *Above all, keep in mind the possibility of the enemy reconstructing a unit from various complete parts captured in different sectors.* Thus, if one organization leaves the right side of the tracker, another the left side, a complete unit could be put together.

b. All fire control equipment, including optical sights and binoculars, is difficult to replace. It should be the last equipment destroyed. If evacuation of personnel is made, all possible items of fire control equipment should be carried. If evacuation of personnel is not possible, fire control equipment must be thoroughly destroyed as indicated below.

(1) Method 1. Demolition with TNT is the most satisfactory method. Remove the telescopic sights from the tracker and smash. Smash in the azimuth and elevation dials. Place 2-pound TNT charges in each side of the tracker, connected together with detonating cord. Insert a tetryl nonelectric cap with at least 5 feet of safety fuze in one charge. Ignite fuze and take cover. Repeat procedure for every other component of the director, including power plants.

(2) Method 2. Remove telescopic sights and smash. Remove side, front, and rear covers. Completely smash all units of the director, including power plants, using an ax or sledge. Pour gasoline into the units and ignite.

c. Smash all cable receptacles and plugs. All cables from the director to the guns, height finder, or radar should be heaped up in a pile, doused with gasoline,

and burned. If time is available, cut the cables into short lengths with an ax before burning.

d. Destroy, by burning with gasoline, all firing tables, trajectory charts, instruction books, circuit diagrams, and any other written material on the director.

e. Smash all meters and radio tubes.

f. Destroy all replacement units, spare tubes, and parts with gasoline or explosive.

g. For destruction of vehicles see FM 4–126, FM 4–127, or FM 4–128.

h. Destruction projects to suit expected conditions should be planned thoroughly in advance and incorporated in Standing Operating Procedure so they may be executed efficiently. Information as to the correct destruction procedure should be understood by all personnel in the range section. Partial destruction is very rarely justified.

CHAPTER 6

SERVICE OF INSTRUMENT

Section I

Duties of Personnel

74. CHIEF OF SECTION. The chief of section is in charge of the range-detector section under the range officer and is responsible for its instruction and efficiency.

a. He carries out the orders of the range officer in regards to siting of equipment, field fortifications, camouflage, gas discipline, security, maintenance, and manning details for various conditions of readiness.

b. He supervises the operation and drill of the section. He repeats all commands.

c. He directs the orientation and synchronization of the fire control instruments and assists in the synchronizing of the section and the guns.

75. MAINTENANCE SERGEANT. The maintenance sergeant is responsible for the condition of matériel under his charge. He personally directs the care and preservation of, and supervises all repairs to, the equipment which he is qualified to make and which are within the echelon of battery maintenance.

He assists the chief of section in the supervision of operation and installation. He gives such aid as may be required to ordnance personnel engaged in correction of troubles.

76. SLEWING OPERATOR (INSTRUMENT CORPORAL). The slewing operator is in charge of the director. He supervises the setting up of the tracker. He is responsible for putting the tracker on the indicated target. He assists in target recognition. He slews the tracker when a new target is engaged. In addition, he checks the operation of the tracker. He assists the chief of section in training the director crew and in supervising the operation of the director.

77. ELEVATION TRACKER. The elevation tracker assists in setting up the tracker. He removes the telescopes from the packing box and mounts them on the tracker. He connects the electric cords for lighting of the reticles. He assists the azimuth tracker in laying cables from tracker to computer. He assists the instrument corporal in orienting and synchronizing the tracker. He tracks the target in elevation.

78. AZIMUTH TRACKER. The azimuth tracker assists in setting up the tracker. Assisted by the elevation tracker, he lays the cables from computer to tracker. He makes *all* cable connections at the tracker. He tracks target in azimuth.

79. RANGE SETTER. The range setter assists in setting up the tracker. He lays cable from computer to altitude converter and connects same. He also connects *all* cables at the computer. He matches the range dial at the altitude converter when slant range is being transmitted. When altitude is being transmitted, he keeps the NULL METER on the altitude converter at zero.

80. ALTITUDE SETTER. The altitude setter assists in setting up the tracker. He matches the altitude dial at the altitude converter when altitude is being transmitted. When slant range is being transmitted, he keeps the NULL METER on the altitude converter at zero.

81. COMPUTER AND RECTIFIER OPERATOR. The computer and rectifier operator parks the trailer as directed by the chief of section. He supervises the uncoupling of the trailer, disconnecting of light and brake cables, and lowering of the jacks. He supervises and assists in the removal of the lashings, harnesses, and covers on the equipment in the trailer. He removes the bolts and clamps holding tracking head to floor. When cables are all connected and checks and adjustments given in paragraphs 34 to 44, inclusive, have been completed satisfactorily, he reports to the instrument corporal "Computer and rectifier in order."

82. DRILL TABLES. The following drill tables give the details of what each man in the director crew does at each command. Figure 29 shows the relative positions of the men and equipment in the performance of the drill.

a. Prepare for action. *(1) Chief of section.* Repeats the command of the range officer. Supervises

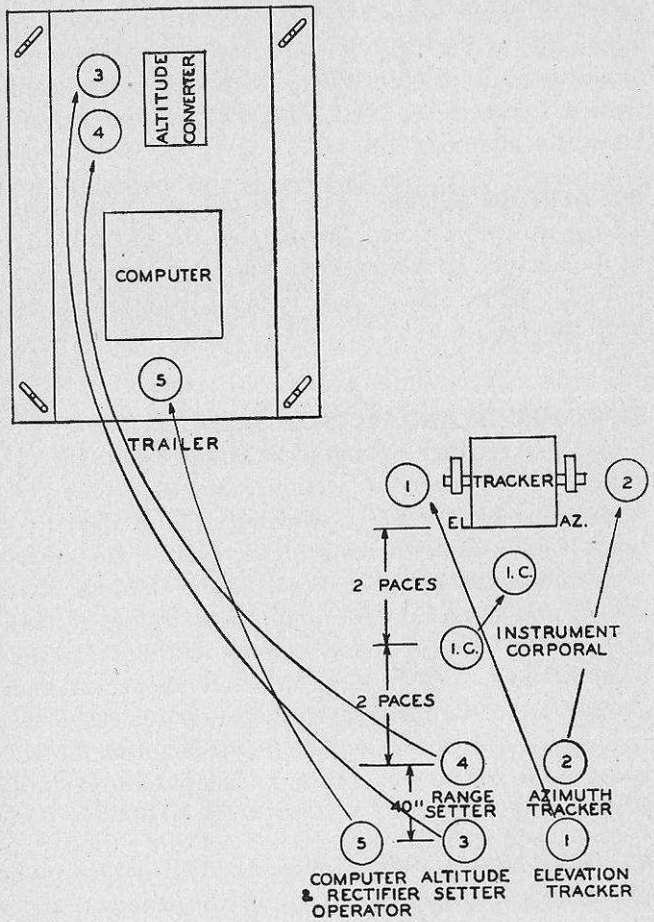


FIGURE 29. Formation for director crew.

the work of entire section. Indicates the positions of the various fire control instruments. Gives command to turn on power. When section is in order, reports to range officer, "Sir, range-detector section in order."

(2) Instrument corporal (slewing operator). Supervises the setting up of the tracker. Levels the tracker. Using data furnished, orients the tracker. Assisted by height finder sergeant (or radar sergeant) and gun commander, checks the synchronization of the entire data transmission system. Reports to chief of section, "Director in order."

(3) No. 1 (elevation tracker). Assisted by No. 2, removes light and brake cables, break-away chains, and uncouples trailer. Signals truck driver to pull truck away. Assisted by other members of director crew, manhandles trailer into designated position. Turns down jack on left front corner of trailer. Assisted by Nos. 2, 3, 4, 5, and three other men from range section, sets up tracker at designated spot. Attaches his seat bracket and seat. Removes both telescopes from packing box and mounts them on tracker. Connects cords for reticle lighting. Assists No. 2 in laying cables from computer to tracker. Assists the instrument corporal in orienting and synchronizing tracker.

(4) No. 2 (azimuth tracker). Assisted by No. 1, removes light and brake cables, disconnects break-away chains, and uncouples trailer. Assisted by other members of director crew, manhandles trailer into designated position. Turns down jack on right front of trailer. Assisted by Nos. 1, 3, 4, 5, and three men from range section, sets up the tracker at designated spot. Attaches his seat bracket and seat. Assisted by No. 1, lays cables between tracker and computer.

Makes *all* cable connections at the tracker. Assists instrument corporal in orienting and synchronizing the tracker.

(5) No. 3 (altitude setter). Assisted by other members of director crew, manhandles trailer into designated position. Turns down jack on left rear of trailer. Assisted by Nos. 1, 2, 4, 5, and three men from range section, sets up tracker at designated spot. Removes panel cover over altitude converter. Makes check and adjustments on altitude converter. Reports to instrument corporal "Altitude converter in order."

(6) No. 4 (range setter). Assisted by other members of director crew, manhandles trailer into designated position. Turns down jack on right rear of trailer. Assisted by Nos. 1, 2, 3, 5, and three men from range section, sets up tracker at designated spot. Assists No. 5 in removing lashings, harnesses, and covers on equipment in trailer. Lays and connects cable between computer and altitude converter. Connects all cables at the computer.

(7) No. 5 (computer and rectifier operator). Directs the spotting of the trailer as directed by chief of section. Removes rear cover. Assisted by No. 4, removes lashings, harnesses, and covers from equipment in trailer. Unfastens the bolts and clamps holding the tracking head to the floor. Assisted by Nos. 1, 2, 3, 4, and three men from the range section, sets up the tracker at designated spot. Makes the checks and adjustments required for the rectifier and computer. Reports to the instrument corporal, "Computer and rectifier in order."

b. In rear of tracker, fall in. *(1) Chief of section.* Gives command to all concerned.

(2) Instrument corporal (slewing operator). Takes post 2 paces in rear of tracker directly in rear of elevation telescope facing away from tracker. Repeats command.

(3) No. 1 (elevation tracker). Takes post 40 inches in rear of No. 2, facing tracker.

(4) No. 2 (azimuth tracker). Takes post at close interval on right of No. 4, facing tracker.

(5) No. 3 (altitude setter). Takes post 40 inches in rear of No. 4, facing tracker.

(6) No. 4 (range setter). Takes post as guide, 4 paces in rear of elevation telescope and facing tracker.

(7) No. 5 (computer and rectifier operator). Takes post at close interval on left of No. 3, facing tracker.

c. Count off. *(1) Chief of section.* Gives command to all concerned.

(2) Instrument corporal (slewing operator). Repeats command.

(3) No. 1 (elevation tracker). Counts off "One."

(4) No. 2 (azimuth tracker). Counts off "Two" immediately after No. 1.

(5) No. 3 (altitude setter). Counts off "Three" immediately after No. 2.

(6) No. 4 (range setter). Counts off "Four" immediately after No. 3.

(7) No. 5 (computer and rectifier operator). Counts off "Five" immediately after No. 4.

d. Call off. *(1) Chief of section.* Gives command to all concerned.

(2) Instrument corporal (slewing operator). Repeats command.

(3) No. 1 (elevation tracker). Calls out "Elevation tracker."

(4) No. 2 (azimuth tracker). Calls out "Azimuth tracker" immediately after elevation tracker.
(5) No. 3 (altitude setter). Calls out "Altitude setter" immediately after azimuth tracker.
(6) No. 4 (range setter). Calls out "Range setter" immediately after altitude setter.
(7) No. 5 (computer and rectifier operator). Calls out "Computer and rectifier operator" immediately after range setter.

e. Details, post. *(1) Chief of section.* Gives command to all concerned.
(2) Instrument corporal (slewing operator). Repeats command. Takes post directly in rear of tracker facing toward the front of tracker.
(3) No. 1 (elevation tracker). Takes post in seat at the elevation telescope.
(4) No. 2 (azimuth tracker). Takes post in seat at azimuth telescope.
(5) No. 3 (altitude setter). Takes post in trailer opposite dial on altitude converter.
(6) No. 4 (range setter). Take post in trailer opposite NULL METER on altitude converter.
(7) No. 5 (computer and rectifier operator). Takes post in trailer opposite rear of the computer.

f. Examine equipment. *(1) Chief of section.* Gives command to all concerned.
(2) Instrument corporal (slewing operator). Repeats command. Grasps slewing handles and slews tracker approximately 1,600 mils in both directions, returning to original position.
(3) No. 1 (elevation tracker). Tests light in telescope. Tests operation of elevation slewing clutch. Elevates and depresses telescopes manually. Tests operation of

aided tracking lever. Removes any rate and returns lever to vertical position.
(4) No. 2 (azimuth tracker). Tests light in telescope. Traverses tracker manually in both directions. Tests operation of aided tracking lever. Removes any rate and returns lever to vertical position.
(5) No. 3 (altitude setter). Checks operation of aided tracking button. Pulls button "Out."
(6) No. 4 (range setter). Checks operation of aided tracking button. Pulls button "Out."
(7) No. 5 (computer and rectifier operator). Conducts tests prescribed. Makes adjustments as are necessary.

g. Report. *(1) Chief of section.* Receives report from all concerned.
(2) Instrument corporal (slewing operator) Receives reports from Nos. 1, 2, 4, and 5 in that order. Reports to chief of section "Director in order."
(3) No. 1 (elevation tracker). Reports "Elevation in order."
(4) No. 2 (azimuth tracker). Reports "Azimuth in order."
(5) No. 3 (altitude setter). Reports "Altitude converter in order."
(6) No. 4 (range setter). Does not report.
(7) No. 5 (computer and rectifier operator). Reports "Computer and rectifier in order."

h. Target. *(1) Chief of section.* Repeats command and designation of target to instrument corporal. As soon as fire control instruments are on target, reports to range officer, "Sir, range section on target." In addition, he may be required to assist in fire adjustment.
(2) Instrument corporal (slewing operator). Repeats

the command. Using slewing handles, slews tracker until on target in open sight. Reports to chief of section, "Director on target" as soon as trackers commence to track target. Relays report of No. 5 ("Target rates smooth") to range officer if necessary. Stands by, ready to slew in the event of reassignment of target.

(3) No. 1 (elevation tracker). Using the elevation slewing clutch, lines up telescopes on target. Looks through telescope and when he sees target, calls "On target." Using unaided tracking, bisects target with horizontal cross hair. Immediately engages aided tracking and tracks target in elevation.

(4) No. 2 (azimuth tracker). Looks through his telescope and when he sees target calls "On target." Using unaided tracking, bisects target with vertical cross hair. Immediately engages aided tracking and tracks target in azimuth.

(5) No. 3 (altitude setter). Matches altitude dial when altitude is being transmitted to altitude converter. Keeps NULL METER zeroed when slant range is being transmitted.

(6) No. 4 (range setter). Keeps NULL METER zeroed when altitude is being transmitted to altitude converter. Keeps indices on slant range (and altitude) dial matched when slant range is being transmitted.

(7) No. 5 (computer and rectifier operator). Keeps regulated voltage at rectifier within limits. By turning knobs under rate meter on correction panel, keeps needles on scale. Reports to range officer, "Target rates smooth" when needles stop moving. Applies spots as directed on the correction panel of the computer.

i. Cease tracking. *(1) Chief of section.* Gives command to all concerned.

(2) Instrument corporal (slewing operator). Repeats the command. Slews tracker so that it points at the midazimuth of the primary zone of fire. Remains at post.

(3) No. 1 (elevation tracker). Ceases tracking. Removes any rate in the aided tracking mechanism. Returns lever to vertical position. Elevates telescopes to an average angular height where targets are usually picked up initially. Remains at post.

(4) No. 2 (azimuth tracker). Ceases tracking. Removes any rate in aided tracking mechanism. Returns lever to vertical position. Remains at post.

(5) No. 3 (altitude setter). Ceases tracking. Pulls "Out" aided tracking button. Remains at post.

(6) No. 4 (range setter). Ceases zeroing NULL METER. Pulls "Out" aided tracking button. Remains at post.

(7) No. 5 (computer and rectifier operator). Returns target rate meters to zero by means of knobs on correction panel of computer. Turns off power switches on rectifier if so directed. Turns on heater switches if conditions require, or so directed.

j. March order. *(1) Chief of section.* Gives command to all concerned. Supervises the packing and replacing of all equipment. Checks security of load and operation of brakes on trailer.

(2) Instrument corporal (slewing operator). Repeats the command. Supervises the replacing of the tracker.

(3) No. 1 (elevation tracker). Removes telescopes from tracker and replaces them in packing box. Removes his seat and bracket from the tracker. Assists

No. 2 in picking up cables between computer and tracker. Assisted by Nos. 2, 3, 4, 5, and three men from range section, replaces the tracker in the trailer and tripod in the truck. Runs up jack on left front of trailer. Assisted by No. 2, couples trailer to truck. No. 1 directs truck driver in this operation. Assisted by No. 2, connects the light and brake cables and break-away chains. Assists in stowing equipment as directed.

(4) No. 2 (azimuth tracker). Removes his seat and bracket from tracker. Disconnects all cables at tracker. Assisted by No. 1, picks up cables between computer and tracker. Assisted by Nos. 1, 3, 4, 5, and three men from range section, replaces tracker in trailer and tripod in truck. Runs up jack on right front of trailer. Assisted by No. 1, couples trailer to truck, connects light and brake cables, and break-away chains. Assists in stowing equipment as directed.

(5) No. 3 (altitude setter). Replaces panel cover over altitude converter. Assisted by Nos. 1, 2, 4, 5, and three men from range section, replaces tracker in trailer and tripod on truck. Runs up jack on left rear of trailer. Assists in stowing equipment as directed.

(6) No. 4 (range setter). Disconnects all cables at the computer. Picks up the cable between computer and altitude converter. Assisted by Nos. 1, 2, 3, 5, and three men from range section, replaces tracker in trailer and tripod in truck. Runs up jack on right rear of trailer. Assists No. 5 in placing covers, harnesses, and lashings on equipment in trailer. Assists in stowing equipment as directed.

(7) No. 5 (computer and rectifier operator). Prepares

computer and rectifier for travel. Assisted by Nos. 1, 2, 3, 4, and three men from range section, replaces tracker in trailer and tripod in trucks. Fastens bolts and clamps holding tracking head to floor of trailer. Assisted by No. 4, covers all equipment, places harnesses in position, and tightens lashings. Supervises the running up of the jacks so that it is not done until the trailer is ready to be coupled to the truck. Ties down the rear cover.

Section II
Field Tests

83. GENERAL. The director should be tested periodically. These tests are made by the battery personnel. No special equipment is required. The tests are always made immediately after setting up at a new position. Thereafter the test should be made daily at a time when firing is not anticipated. The results are entered on the log sheets (figs. 1 and 2, app. II) provided. These tests are in addition to those given in paragraphs 34 to 44, inclusive, which should always be conducted prior to the field tests.

Caution: Remove the cable to the main junction box (green plug on the computer) before making any field tests.

84. TRACKER TEST. Reference is made to this test on the log sheet and in TM 9–671. This test is no longer required and need not be conducted. Spaces on log sheet should be left blank.

85. TARGET RATE TEST. a. With the system energized, set the azimuth index of the tracker at zero and the elevation index of the tracker at 1,600 mils. If the SCR–545 or SCR–584 is used, these values are set on the radar. Set the range index of the altitude converter (or of radar system, SCR–547, SCR–545, or SCR–584 if the altitude converter is not used) at zero.

b. Push in the range clutch of the altitude converter and turn the range handwheel of the altitude converter about one turn to the right. The range index will then run at a rate of about 150 yards per second which, after 10 seconds, should be indicated on the $\dot{H}$ meter of the target rate indicator on the computer. Adjust the knob associated with the $\dot{H}$ meter as required to bring the needle on scale. (Produce a similar rate with radar system SCR–547, SCR–545, or SCR–584 if the altitude converter is not used.)

(1) When the needle settles down, note the reading of the range dial of the altitude converter and the reading of the $\dot{H}$ meter. Note the reading of the $\dot{H}$ meter 60 seconds later. The two readings of the $\dot{H}$ meter should agree within 10 yards per second.

(2) The difference between the readings of the range dial at the start and at the end of the 60-second period, divided by 60, is the indicated rate in yards per second of the range index. This should not differ from the rate indicated by the $\dot{H}$ meter by more than the limit shown on the log sheet.

c. Leaving the azimuth index of the tracker (or radar) at zero, set the elevation index at zero and repeat the above test, observing the $\dot{Y}$ meter of the target rate indicator. The indicated rate of the range dial should not differ from the rate indicated by the

$\dot{Y}$ meter by more than the limit shown on the log sheet.

d. With the elevation index of the tracker (or radar) at zero, set the azimuth index at 1,600 mils and repeat the above test, observing the $\dot{X}$ meter of the target rate indicator. The indicated rate of the range dial should not differ from the rate indicated by the $\dot{X}$ meter by more than the limit shown on the log sheet.

e. Remove range rate after each test by pulling out on the range clutch on the altitude converter.

86. FUZE PREDICTION TEST. a. With the system energized, set the DEAD TIME knob at 4 seconds. Set the range index of the altitude converter (or radar if altitude converter is not used) at zero. Push in the range clutch of the altitude converter and turn the range handwheel about one turn to the right so that the range index moves in the direction of increasing range at about 150 yards per second. (Produce a similar effect with radar SCR–547, 545, or 584 if the altitude converter is not used.)

b. Observe the dial of the fuze transmitter in the computer. When this dial indicates any convenient fuze number, suddenly turn the DEAD TIME knob to zero. Measure with a stop watch the time required for the dial of the fuze transmitter to return to the same fuze number. This time should not differ from 4 seconds by more than the limit shown on the log sheet.

c. Repeat the test with the DEAD TIME knob set at 3 seconds. The measured time should not differ

from 3 seconds by more than the limit shown on the log sheet.

87. DIRECTOR STATIC CHECK. This test is designed to indicate the functioning of the *complete* director with fixed target positions.

a. D-c cable (white-black) must be connected.

b. Energize the system.

c. Set the TEST SWITCH on the adjustment panel of computer at "Static test" and the STATIC TEST switch on the correction panel in "Off" position.

d. Set all correction dials on the correction panel of computer to zero.

e. Set the azimuth and elevation index of the tracker (or radar) and the range index of the altitude converter (or radar) to each of the three sets of value as given on log sheet (see fig. 2, app. II).

f. For each of the three settings of the above indices, record the transmitter dial readings of the computer. These readings should agree with the values given for them in the log sheet within the allowable variation indicated.

g. Return TEST SWITCH on adjustment panel to "Normal."

88. COMPUTER STATIC CHECK. This test is designed to indicate any malfunctioning of the computing circuit when proper electrical voltages are imposed on it. Further, it checks the performance of the computer alone. The director static test checks functioning of the complete director.

a. Disconnect the d-c (white-black) cable at the

computer. This eliminates effect of tracker on the system.

b. Energize the system.

c. Set all corrections and spots on the correction panel of the computer to zero.

d. Set TEST SWITCH on adjustment panel of computer at "Static test."

e. Operate the STATIC TEST switch on the correction panel of the computer to each of its positions, 1 to 8, successively.

f. In each of the eight positions of the switch, readings on the transmitters of the computer are recorded.

g. Return STATIC TEST switch on correction panel to "Off." Return TEST SWITCH on adjustment panel to "Normal." Reconnect the d-c (white-black) cable at the computer.

89. CORRECTIONS TEST. The purpose of the corrections test is to indicate the correct functioning of the corrections for parallax, air density, muzzle velocity, and wind.

a. Remove the d-c (white-black) cable at the computer.

b. Energize the system and set the TEST SWITCH on the adjustment panel of the computer to "Static test."

c. Set the STATIC TEST switch on the correction panel of the computer to positions 1, 3, and 8 as called for on log sheet.

d. All correction dials on the correction panel are set at zero.

e. On the correction panel, successively set the values given in log sheet for parallax, air density, muzzle

velocity, and wind, on the switches and dials for these corrections.

NOTE: As only one correction is to be tested at a time, at each setting all other correction dials should be at zero. Wind azimuth must be set in on wind direction dial on rear of computer.

f. Record the transmitter dial readings after each setting.

g. Zero all correction dials. Return STATIC TEST switch on correction panel to "Off." Return TEST SWITCH on adjustment panel to "Normal." Reconnect d-c (white-black) cable at computer.

90. ANALYSIS OF FIELD TESTS AND ACTION. a. Target rate test. If limits are exceeded the test should be repeated with a view of establishing definitely that personnel errors were not involved. If the error consistently exceeds the limit, qualified personnel should be called in.

b. Fuze prediction test. Theoretically the accuracy of the director exceeds the accuracy with which the test can be conducted. The limit is approximate only. If the limit is exceeded, any possibility of personnel errors should be eliminated by repeating test. If the time is practically instantaneous or extremely prolonged, for example, 10 to 15 seconds or more, a serious fault is indicated. Otherwise the exceeding of limit should be disregarded. Qualified personnel should be called in case of trouble.

c. Director static test. One-third of the errors can exceed the limits but no error must exceed twice the limit. The possibility of personnel errors should be eliminated by repeating test. If the test still exceeds

the tolerances, power supply and amplifier zeroing should be rechecked. (See pars. 34 to 44, inclusive.) If this does not eliminate the excessive errors, call on qualified personnel.

d. Computer static check. Twenty-five percent of the errors can exceed the limits but no error must exceed twice the limit. The possibility of personnel errors should be eliminated by repeating test. If the test still exceeds the tolerances, power supply and amplifier zeroing should be rechecked. (See pars. 34 to 44, inclusive.) If this does not eliminate the excessive errors, call on qualified personnel.

e. Corrections test. *(1)* The results should agree within the limits indicated on the log sheet except when the computer static test for the same position of the STATIC TEST switch does not give 0 difference. In this case the limits for the correction test are liberalized by the amount of the computer static test errors. For example, in column (3), line 14 (fig. 2, app. II), the error is 3, which exceeds the limit given in column (4) of ±2. However, the error for position 1 (column (3), line 4) was 2 mils. Adding 2 (the error) to ±2 the limit, the liberalizing limit is 4 mils. Hence, the error in column (3), line 14, is not in excess of the limit.
(2) Twenty-five percent of the errors can exceed the limits but no error must exceed twice the limit. The possibility of personnel errors should be eliminated by repeating the test. If the test still exceeds the tolerances, power supply and amplifier zeroing should be rechecked. (See pars. 34 to 44, inclusive.) If this does not eliminate the excessive errors, call on qualified personnel.

Section III
Maintenance

91. CARE AND MAINTENANCE. a. There are five echelons of maintenance: First and second are by the battery; third and fourth by ordnance personnel; and fifth, which is factory repair. (See app. V.) Batteries make the tests and adjustments outlined in this manual. In addition, the battery is responsible for lubrication.

b. Exposed and accessible parts are lubricated on periodic inspections. Potentiometers and gear boxes are drained only when they are received from the factory or depot or shipped there. Bare metal surfaces are protected by a film of grease or oil.

c. In handling the various components, rough treatment must be avoided. The tracker head is provided with a shock mounting frame for transportation. *Under no circumstances should any of the components be tipped over on their sides or upside down.*

d. Whenever practicable, the tracker telescopes should be removed and stored in their case. The exposed glass surfaces of the telescopes should be kept clean and dry. Only lens paper or a camel's-hair brush should be used in cleaning the lenses. Ethyl alcohol is excellent for cleaning, if available. Exercise particular care to keep the lenses free from oil and grease. Do not wipe the lenses with the fingers. Occasionally remove the rubber shields and wash in lukewarm water.

e. When the equipment is not in operation the access doors on the computer and power rectifier should

be kept closed and the tracker should be kept covered if exposed to the weather.

f. The motors in the tracker and the altitude converter should be operated only when director is actually in use. All illuminating lamps should be turned off when not needed.

g. Cable receptacles must be kept clean. When not in use, the cables must be stored on their reels and the plugs and receptacles protected by their caps.

h. Dirt and dust must be cleaned from the ventilator screens of the computer.

i. If the director is not in frequent use, the handwheels on the tracker and the altitude converter should be turned throughout their range at least once every 2 weeks to operate the mechanisms and to prevent gumming or sticking. When the director is stored in a damp place the heaters in all of the units should be connected to a source of 115-volt power, and the heater switches on the units thrown to "Comm." or "On" position.

j. The correct functioning of the whole director system depends on two dry batteries in the base of the computer. If these are damaged, or in any way fail to deliver their rated voltage, they must be replaced. Under usual conditions these batteries will require replacement at intervals of 6 months to a year. (See TM 9–671.) If director is stored, these batteries should be removed.

k. Windows should be kept free from grease and oil which collect dust and reduce visibility. In cleaning windows, wipe only lightly to avoid scratching the glass.

APPENDIX I

WEIGHTS OF COMPONENTS

Unit			*Pounds*
Director M9 or M10, complete			4,800
Computer M3 or M4			1,500
Power rectifier M8			600
Tracker M2 on tripod M12			1,500
Tracker M2	1,000		
Pedestal, tripod M12	290		
3 legs for tripod M12	50	each	
Altitude converter M2			200
Cable system M7, approximately			1,000

APPENDIX II

INSTRUCTIONS FOR USE OF LOG SHEETS

a. The results of tests are entered on log sheets. Use one sheet for each series of tests made at one time. If no log sheets are received with the equipment, they should be reproduced locally. (See figs. 1 and 2 below.)

b. If any test is not made because it does not apply to the equipment in use, write "Not required" in the space provided for the record of that test. If any test applying to the equipment in use is not made, write "Not made" in the space provided for the record of that test and state under "Notes" the reasons for not making the test.

c. Enter in the spaces provided on the face of the sheet, figure 1:

(1) The date.

(2) The time of day when the tests are completed.

(3) The battery designation.

(4) The location of the battery.

(5) The name and rank of the person in charge (computer operator).

(6) The serial numbers of the units of equipment used in the tests. The serial numbers will be found on the name plates of the units. If any piece of equipment

LOG SHEET

DIRECTOR M9

1 DATE 8-19-43 TIME 7.25 AM PM
2 BATTERY
3 LOCATION CAMP DAVIS, N.C.
4 DIRECTOR CHIEF T/5 JONES

SERIAL NUMBERS
TRACKER 250 HGHT FDR
ALT. CONV. 6 RADAR 221
POWER RECT. 4
COMPUTER 4 GEN. UNIT 1461

WEATHER
CLEAR ☐ CLOUDY ☐ RAIN ☑ SNOW ☐
AVERAGE TEMPERATURE 45° F.
HUMIDITY HIGH ☑ LOW ☐ AVE ☐

TRACKER TEST

	TRACKER DIALS	CENTER DIAL (MILS)		TARGET RATE TEST: RATE METER	RANGE DIAL (YD/SEC)	RATE METER (YD/SEC)	DIFFERENCE (YD/SEC)		LIMIT YD/SEC.	FUZE PREDICTION TEST: DEAD TIME SEC.	OBSER'D TIME SEC.	DIFF. SEC.	LIMIT SEC.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
6	AZIMUTH FINE	LAGS LEADS		$\dot{H}$	182	180	2		2	4	3.6	0.4	1.0
7	ELEVAT'N FINE	LAGS LEADS		$\dot{V}$	174	180	6		2	3	3.2	0.2	1.0
8				$\dot{X}$	198	198	0		2				

NOT REQUIRED

9 NOTES: NOTES: NONE NOTES: NONE

SUMMARY OF CONDITIONS SINCE LAST REPORT

10 TIME POWER ON 2 HRS.
11 POWER CIRCUITS REQUIRING EXCESSIVE ADJUSTMENT 115V ☐ 350V ☐ 75V ☑
12 DESIGNATION OF AMPLIFIERS REQUIRING EXCESSIVE ZERO-SET ADJUSTMENT + Hpc
13 OTHER OPERATING TROUBLES ENCOUNTERED CHATTERING NOTICED ON CURRENT RELAY WHEN POWER
14 WAS TURNED ON. CLEARED UP IN ABOUT 10 MINUTES. REPLACED BURNED OUT BULB IN
15 CORRECTION PANEL
16 DATES OF ORDNANCE SERVICE VISITS 1-4-43 : 3-15-43
17
18 TIME OUT OF SERVICE DUE TO TROUBLE CONDITION ___ HOURS ___ MINUTES
19
20 REMARKS NONE
21
22
23 (ATTACH SHEET FOR ADDITIONAL DATA IF NECESSARY)

FIGURE 1. *Sample log sheet (front).*

STATIC TESTS (TEST SWITCH, ADJ. PAN. AT STATIC TEST POS.)

TEST	CORRECTION	STATIC TEST SW. POS.	TRANSMITTER DIAL READINGS: AZIMUTH - MILS STD.	OBS.	DIFF. OBS	DIFF. LIMIT	ELEVATION - MILS STD.	OBS.	DIFF. OBS	DIFF. LIMIT	FUZE - FUZE NOS. STD.	OBS.	DIFF. OBS	DIFF. LIMIT	DATA TO BE SET IN TRACKER AND ALT. CONVERTER: AZIMUTH (MILS)	ELEVATION (MILS)	SL. RANGE (YDS)	
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	
DIRECTOR STATIC TEST	NIL	0	800	803	3	±25	655	655	0	± 3	5.24	5.26	.02	±.07	800	627	3565	1
	NIL	0	2401	2403	2	±2.5	1251	1248	3	± 3	14.76	14.77	.01	±.07	2408	1208	7758	2
	NIL	0	6103	6105	2	±2.5	919	916	3	± 3	22.80	22.79	.01	±.07	6111	779	10260	3
															DATA FOR USE OF BTRY COMMANDER: SLANT RANGE (16)	HORIZ. RANGE (17)	YDS. PER 0.1 FUZE NO. (18)	PROB ERROR FIRE (19)	
COMPUTOR STATIC TEST	NIL	1	800	802	2	±3.5	655	655	0	± 4	5.24	5.28	.04	±.04	3565	2911	57.7	20.1	4
	NIL	2	1313	1314	1	±2.5	380	382	2	±2.5	14.60	14.60	.00	±.06	7740	7468	36.2	14.5	5
	NIL	3	2401	2401	0	±3.5	1251	1250	1	±2.5	14.76	14.74	.02	±.06	7758	2915	35.0	8.8	6
	NIL	4	2909	2911	2	±2.5	923	923	0	±2	23.24	23.18	.06	±.07	10377	7483	28.7	19.3	7
	NIL	5	4000	4002	2	±3.5	657	662	5	± 4	5.28	5.18	.10	±.04	3564	2923	57.5	51.0	8
	NIL	6	4512	4514	2	±2.5	385	387	2	±2.5	14.66	14.61	.05	±.06	7758	7476	36.2	23.8	9
	NIL	7	5588	5591	3	±3.5	1251	1250	1	±2.5	14.76	14.74	.02	±.06	7758	2915	35.0	11.5	10
	NIL	8	6103	6105	2	±2.5	919	919	0	±2	22.80	22.74	.06	±.07	10260	7402	28.8	19.2	11
															PARALLAX TO BE SET IN: EAST-WEST (20)	NORTH-SOUTH (21)	ABOVE-BELOW (22)	
CORRECTION TEST	PAR	1	910	910	0	± 2	603	606	3	±2.5	5.78	5.81	.03	±.05	500 YDS. EAST	0	0	12
	PAR	1	660	662	2	± 2	711	713	2	±2.5	4.80	4.84	.04	±.05	500 YDS. WEST	0	0	13
	PAR	1	690	693	3	± 2	603	607	4	±2.5	5.78	5.81	.03	±.05	0	500 YDS. NORTH	0	14
	PAR	1	940	942	2	± 2	711	712	1	±2.5	4.80	4.86	.06	±.05	0	500 YDS. SOUTH	0	15
	PAR	1	800	803	3	± 2	764	763	1	±2.5	5.80	5.84	.04	±.05	0	0	500 YDS. ABOVE	16
	PAR	1	800	803	3	± 2	528	531	3	±2.5	4.78	4.84	.06	±.05	0	0	500 YDS. BELOW	17
	A.D.	3	2402	2400	2	± 2	1247	1247	0	±2.5	14.02	14.00	.02	±.05	AIR DENS. = -10%			18
	A.D.	3	2401	2400	1	± 2	1255	1254	1	±2.5	15.82	15.60	.02	±.05	AIR DENS. = +10%			19
	M.V.	3	2401	2400	1	± 2	1255	1254	1	±2.5	15.54	15.54	.00	±.05	MV = 2500 FT./SEC.			20
	M.V.	3	2402	2400	2	± 2	1247	1247	0	±2.5	14.08	14.08	.00	±.05	MV = 2700 FT/SEC.			21
	W	3	2369	2367	2	± 2	1260	1260	0	±2.5	14.60	14.60	.00	±.05	WIND 60 M/P/H			22
		8	6112	6114	2	± 2	912	912	0	±2.5	23.88	23.80	.08	±.05	DIRECTION N. (0 MILS)			23

NOTES: STATIC TESTS # 6 — COL # 19 ∴ PROBABLE ERROR = $\sqrt{(14.9)^2+(15.5)^2+(18.1)^2} \times .845$
2 X 7476 = 14.9 YD. P.E = 23.8
2 X 7758 = 15.5 YD.
.75/.78 X 36.2 = 18.1 YD.

FIGURE 2. *Sample log sheet (back).*

named on the sheet is not used in the tests, write "Not used" in the space provided for the serial number of that piece.

(7) Check one of the types of weather indicated which was most prevalent during the tests.

(8) The approximate temperature during the tests.

(9) Check one of the degrees of humidity indicated which was most prevalent during the tests.

d. Under "Fuze prediction test," record the observed time for each of the tests. Enter the differences between the observed times and the dead times in the column headed "Difference." Describe any observed peculiarities or difficulties in space headed "Notes."

e. Under "Summary of conditions since last report," enter in the spaces provided:

(1) The total time during which power has been maintained on the director. Check any power supply which has required excessive adjustment.

(2) The designations (for example, +D, −D, +R, −R) of amplifiers which have required excessive adjustment.

(3) Any other operating troubles encountered. Describe fully.

(4) The dates of visits by ordnance service personnel.

(5) The total time during which the director could not be operated due to trouble conditions.

(6) Remarks in regard to the operation of the director —difficulties experienced, conditions of equipment, results obtained.

f. On the back of the sheet, in the columns indicated under the several tests, enter the observed readings of the azimuth and elevation transmitter dials to the nearest mil and the observed readings of the

fuze transmitter dial to the nearest two hundredths of a fuze number (by means of the vernier). Enter the differences between the observed readings and the standard readings in the columns headed "Diff.—Obs."

g. The column at the right headed "Prob. error of fire" is for the use of the battery commander, to be filled out at his discretion. Method of computing probable error is shown under notes, figure 2.

APPENDIX III

SPARES AND ACCESSORIES

Spares and accessories for the director include—

a. Two telescopes, spare eyeshields, and carrying chest.

b. Porter bars for tracker and power rectifier and carrying bracket for the computer and altitude converter.

c. Canvas covers for the four main components of the system, harness, and lashings for securing equipment in trailer.

d. Three cables (spares):

One 21-conductor cable 15 feet long.
One 20-conductor cable 15 feet long.
One 20-conductor cable 225 feet long.

e. Tools and accessories as required for draining refilling potentiometer housing.

f. Two 5-gallon cans containing potentiometer oil.

g. Two extension lights and four extension cords.

h. Spare vacuum tubes and carrying chest.

i. Spare lamp bulbs.

j. Five Operator's Manual, TM 9–671.

k. Miscellaneous items such as a screw driver, 3-inch ball peen hammer, tube extractor tool, wrench, lens cleaning paper, cloth and brush, gasket cement, log sheets, fuzes, and air filter cells.

l. Equipment chest for the spares and accessories.

APPENDIX IV

DATA FLOW DIAGRAM

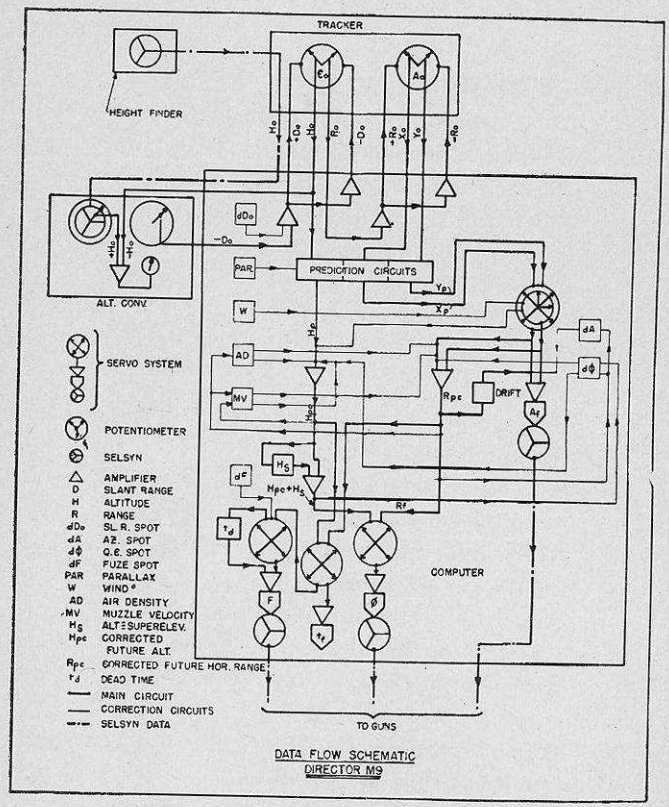


FIGURE 1. Data flow diagram.

APPENDIX V

MAINTENANCE DIRECTORS M9 AND M10

1. FIRST ECHELON.

Clean lenses (external surfaces only).
Replace telescope lamps.
Replace and clean eyeguards.
Clean and repaint exposed surfaces.
Clean plugs and receptacles.
Clean windows.

2. SECOND ECHELON.

Set up director.
Replace any blown fuses with proper types.
Aline telescopes on tracker.
Run director static tests (par. 87) and record results on log sheet.
Run target rate tests (par. 85) and record results on log sheet.
Run fuze prediction tests (par. 86) and record results on log sheet.
Run computer static test (par. 88) and record results on log sheet.
Run corrections test (par. 89) and record results on log sheets.
Replace dial lights, except in tracker.

[1] Replace defective vacuum tubes in rectifiers, regulators, amplifiers, or oscillators. (When vacuum tube in first stage of amplifier is changed, it is necessary to make cathode stabilization test and adjustment.)
[1] Remove oil from servo potentiometers and tracker potentiometers; replace oil.

3. THIRD ECHELON.

Make periodic tests on all vacuum tubes in tube test set.
Check any vacuum tubes rejected by second echelon.
Check cathode stabilization of any amplifier in which any vacuum tubes may have been changed.
Investigate any corrosion which may be present at any point in equipment and correct it.
Check wearing of shafts in bearings at any point in equipment, making necessary replacements.
Clean air filter units.
Check servos for excessive contact resistance in potentiometers, making necessary replacements.
Remove and replace any defective servo units.
Test and replace any defective data smoothing networks.
Check and replace any defective parts of correction circuits.

[1] Emergency duties in case third echelon maintenance is not available. Can be performed only by a man who has successfully completed a recognized course in the director M9 at any authorized school (see TM 9–671).

Check and replace any defective parts of adjustment circuits.
Check and replace defective blower unit.
Check and replace any defective amplifier units.
Check and replace any defective modulator amplifier units.
Check and replace any defective d-c regulator units.
Check and replace any defective cables.
Check and replace any defective resistance assemblies.
Check and replace any defective amplifier input networks.
Check and replace any defective filament transformers.
Check and replace any defective copper oxide rectifier units.
Check, replace, and reset defective selsyn units.
Check and replace defective rectifier units.
Check and replace defective a-c line regulators.
Check and replace defective tracker head.
Check and replace defective altitude converter.
Check, replace, and readjust voltage adjustments on voltage regulator panels if necessary.
Check all operating adjustments to see that they can be made properly

4. FOURTH ECHELON.

Repair defective cables.
Overhaul defective tracker head.
Overhaul defective altitude converter.
Check and repair defective rectifier units.

Check and repair defective a-c line regulators.
Check and repair defective d-c regulators.
Check and repair defective modulator amplifier units.
Check and repair defective amplifier units.
Overhaul defective blower unit.
Repair defective portions of correction circuits.
Repair servo units.
Replace defective cards.

5. FIFTH ECHELON.

Repair defective data smoothing networks.
Repair defective amplifier input networks.

APPENDIX VI

LIST OF REFERENCES

1. MANUALS.

Camouflage and protective measures FM 4–104, FM 5–20
Chemical attack, defense against.... FM 21–40
Cleaning and preserving..... TM 9–850
Commands ..... FM 4–104
Communications FM 4–104, FM 24–5, FM 24–6, FM 24–10
Data transmission—Notes on matériel, cable system, M1 and M2.
Explosives and demolitions..... FM 5–25
Field fortifications ..... FM 4–104, FM 5–15
Fire control, AA guns..... FM 4–121
Formations ..... FM 4–120
Gunnery for AAA..... FM 4–110
Height finder M1 and M2 FM 4–142, TM 9–1623, TM 9–2623
Recognition of Aircraft..... FM 30–30
Recognition of armored vehicles... FM 30–40
Inspections ..... FM 4–120
Director M9 and M10.. TM 9–671, TM 9–1671
Remote control system, M2 TM 9–1642, TM 9–2642
90-mm AA gun matériel, M1 and M1A1 ..... TM 9–370, TM 9–1370

90-mm AA gun matériel, M2..... TM 9–373
4.7-inch AA gun matériel..... TM 9–380
Organization ..... FM 4–104
Reference data ..... FM 4–118
SCR–268 ..... FM 4–176
SCR–545 ..... FM 4–146
SCR–547 ..... FM-4–143
SCR–584 ..... FM 4–144
Service of the piece, 90-mm AA gun on M1A1 mount..... FM 4–126
Service of the piece, 90-mm AA gun on M2 mount..... FM 4–127
Service of the piece, 4.7-inch AA gun FM 4–128
Tactics and technique..... FM 4–104
Training publications, list of..... FM 21–6

2. FIRING TABLES AND TRAJECTORY CHARTS.

Gun, 90-mm, M1..... FT–90AA–B–2
TC–90AA–B–2
Gun, 4.7-inch FT–4.7AA–C–1
TC–4.7AA–C–1

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