TM 9-5000-20

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

NIKE I SYSTEMS
TTR ANTENNA
POSITIONING CIRCUITRY (U)

DEPARTMENT OF THE ARMY • MAY 1956

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TM 9–5000–20, Nike I Systems, TTR Antenna Positioning Circuitry (U) is published for the use of all concerned.

The special texts in the TM 9–5000-series are training supplements to those in the TM 9–5001 series which are the basic Army directives for the operation and maintenance of the Nike I Guided Missile System. In the event of conflict, technical manuals in the basic TM 9–5001-series will go[illegible]

[AG 413.44 (26 May 56)]

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NG: None.
USAR: None.
For explanation of abbreviations used, see SR 320–50–1

CONTENTS

PART ONE

MAJOR COMPONENTS

CHAPTER 1

INTRODUCTION

1. PURPOSE AND SCOPE

This special text is a guide for Nike I target-tracking radar maintenance personnel. It presents both a block diagram and a detailed discussion of the antenna positioning system for the target-tracking radar. The block diagram discussion is designed to provide the student maintenance man with an over-all picture of the system so that, with the detailed discussion that follows, he gains a complete understanding of the operation of the system. With this understanding, he is enabled to adjust and to maintain this antenna positioning system for peak performance. (The adjustment checks and procedures are contained in TM 9-5000-23.)

2. REFERENCES

References to material within the body of this publication are of the form "(8a)" or "(fig 9)." References to schematics in AAA and GM School, TM 9-5000-25 or TM 9-5000-26 are referred to by page number. References to other publications are written "(TM 9-5000-15, par 128)" or "(FM 44-80, fig 7)."

3. IMPORTANCE OF MAINTENANCE

The greatest possible accuracy is required in the control of the Nike I missile. This accuracy of control is directly dependent upon the computer's sensing of the location of the target. The azimuth and elevation components of this sensing are derived continuously from the position of the target-tracking radar antenna, which, in turn, is determined by the target-tracking radar antenna positioning system. The principal function of this system is to keep the antenna pointed at the target throughout 6,400 mils in azimuth and from approximately -200 to +3,200 mils in elevation. (When the radar is being tested, the system drives the antenna in elevation from a forward depressed position to a slightly depressed plunged position.) In addition, the antenna positioning system provides for rapid slewing of the antenna to the azimuth and elevation of the designated target. Further, it provides remote indications of the target-tracking radar antenna azimuth and elevation, thus providing the same data for the target. Because of these important functions of the target-tracking radar antenna positioning system, it follows that for the computer's sensing of the target azimuth and elevation to be as accurate as possible, it is necessary that this antenna positioning system be adjusted and be maintained for peak operation. This necessity requires the maintenance personnel to understand completely the target-tracking radar antenna positioning system.

CHAPTER 2

MAJOR COMPONENTS OF THE ANTENNA POSITIONING SYSTEM

Section I. GENERAL

4. SUBSYSTEMS

The target-tracking radar antenna positioning system is divided into two subsystems, one for azimuth and the other for elevation. Each of these subsystems consists of a dither oscillator, an angle modulator, a handwheel drive assembly, two low-power servoamplifiers, an intermediate drive assembly, a coupling unit, a servopreamplifier, high-power servoamplifiers, antenna drive servomotor generators, synchros, switches, relays, lamps, and the connecting circuits. Under certain conditions, the target designate control panel, another coupling unit, another low-power servoamplifier, a fire direction center coordinate converter, and the track antenna control unit become parts of the subsystems.

5. SCOPE

This chapter contains a block diagram discussion and a detailed circuit discussion of each of the major units in the target-tracking antenna positioning system. (Parts Two and Three contain a discussion of the over-all system operation.)

Section II. DITHER OSCILLATOR

6. PURPOSE

Between the time of the computer on-trajectory signal and the time of the end of missile flight (0.4 second after "burst"), the antenna is caused to oscillate slightly in both azimuth and elevation. These movements eliminate the necessity for the antenna positioning circuits to build up error signals strong enough to overcome the static friction of the antenna with the resultant tendency for the antenna to jump. The dither oscillator performs this operation by generating a 7-cps sinusoidal signal which is applied to the antenna positioning systems of both tracking radars.

7. LOCATION (TM 9-5000-25, page 19).

The dither oscillator is the middle unit on the left side of the top bay in the radar power cabinet assembly within the radar control trailer.

8. OPERATION (TM 9-5000-25)

a. Block diagram discussion (page 155). In passing from pin 2 to pin of amplifier V1A, the input wave is amplified and inverted. This inverted wave then passes, in phase, from pin 7 to pin 8 of the cathode follower V1B. From pin 8 of V1B, the output signal goes to the 180° phase-shifting network; to TP1 for monitoring; and either to ground (through the contacts of deenergized relay K1 and terminal 3 of plug P1) or, when relay K1 is energized, to the neon lamp I1 (causing it to flicker) and (through terminal 1 of plug P1) to both tracking-radar angle modulators. In passing through the 180° phase-shifting network, the wave again is inverted, and then it is applied to pin 2 of amplifier V1A, in phase with the original input signal. The 180° phase-shifting network and the amplifier V1A make up an RC-coupled oscillator, having a frequency of seven cycles per second, which is very stable because of the positive feedback. As indicated above, although this oscillator operates whenever power is applied to the circuit, the path for its output is determined by the condition of relay K1. With the DITHER switch S1 in its normal position (the position shown), relay K1 is energized by on-trajectory locking relay K4, on the conditioning relay panel, becoming energized. Relay K4 normally is energized only between the times of the computer on-trajectory signal and of the end of the missile flight; and, therefore, the dither oscillator's 7-cps output normally is applied to the angle modulators only between these times. TM 9-5000-15, paragraph 128, describes the energizing circuitry for this relay K4. The ground to energize relay K1 in this manner is applied (through contacts 4 and 5 of the energized on-trajectory locking relay K4, cable CA6, terminal 7 of plug P1 on the dither oscillator, and the DITHER switch) to the coil of relay K1. For test purposes, relay K1 also can be energized by manually placing the DITHER switch S1 in its DITHER position, which applies ground from terminal 11 of plug P1 through the switch to the coil of relay K1.

b. Detailed circuit discussion (page 156). The signal appearing on the grid (pin 2) of V1A is amplified and inverted by V1A and applied from the plate (pin 1) of V1A through resistor R5 to the grid (pin 7) of V1B. Then it is taken, in phase with the signal on pin 7, from the cathode (pin 8) of V1B and applied through the RC combination of C1, C2, C3, R1, R2, and R3 to the grid of V1A. In passing through this RC network, the signal undergoes sufficient phase shift to reinforce the original signal on the grid of V1A. Thus, enough positive feedback is obtained to cause the oscillator to have very stable operation. The voltage divider (consisting of resistors R4, R5, and R6), between +250 volts and -250 volts, and resistor R7, between -250 volts and the cathode of V1B, provide the proper operating bias voltages for the two-stage circuit. The oscillator operates whenever power is applied to the circuit. The signal on the cathode of V1B passes through resistor R8, is coupled across capacitor C4, and is developed across resistor R9 to become the output of the oscillator. Whenever relay K1 is deenergized, its contacts 1-9 and 10-3 ground the output circuit. When the on-trajectory signal is applied by the computer, a relay ground is connected to terminal 7 of plug P1. This ground energizes relay K1 which opens its contacts 1-9 and 10-3 permitting the 7-cps output to be applied to both tracking-radar angle modulators and to the neon lamp I1 causing it to flicker. For test purposes, the output also may be applied to the angle modulators and lamp by manually placing DITHER switch S1 in its DITHER position, which energizes relay K1.

9. ADJUSTMENTS

Although no adjustments are made on the dither oscillator chassis, its 7-cps output signal is adjustable in amplitude in the input circuit of each angle modulator (par 12b(3)).

CAUTION: If tube V1 is removed for any reason, a transient pulse will be sent from the dither oscillator to the rest of the antenna positioning systems of both radars at the time of on-trajectory. This pulse has sufficient amplitude to drive the missile-tracking radar antenna far enough in both azimuth and elevation to result in a lost missile. Further, if the target-tracking radar is automatically tracking the target in azimuth and/or elevation, this transient pulse will similarly result in lost target. A modification will be installed to prevent this transient pulse.

Section III. ANGLE MODULATOR

10. PURPOSE

The angle modulator in each of the coordinate channels has as its principal inputs the dc error signal from its associated error pulse rectifier (TM 9-5000-18) and the 400-cps servo excitation voltage. As an output it yields a 400-cps error signal whose amplitude is proportional to the magnitude of the error and whose phase angle with respect to the excitation voltage is either zero or 180° depending upon the polarity of the input error signal.

11. LOCATION (TM 9-5000-25, pages 17 and 18).

The azimuth angle modulator is the front unit and the elevation angle modulator the center unit on the slide in the upper right bay of the target-tracking radar control console within the radar control trailer. The same types of units are used in the missile-tracking radar.

12. OPERATION (TM 9-5000-25)

a. Block diagram discussion (page 153). The dc error voltage from the associated error pulse rectifier is applied (through terminal 5 of the angle modulator plug P1) to a contact of the coast relay K1. This relay normally is energized by either relay K1 or relay K2 in the automatic tracking control unit becoming energized whenever a target is within fifty yards of the range gate center. It also may be energized for test purposes by positioning the DISABLE switch, on the target-tracking radar control console, to its DISABLE position. In each coordinate channel, an angle error meter, on the target track meter panel of the target-tracking radar control console, is connected through terminal 13 of plug P1 to the wire carrying the input signal from the error pulse rectifier. These ammeters are graduated in mils, positive and negative, from the center (zero) positions; and, therefore, provide a direct reading of the number of mils the antenna is off target in azimuth and in elevation. By positioning, on the target-tracking radar control console, the TEST-OPERATE switch to TEST and the SERVOS TEST switch either to INCrease or to DECrease, the servo test relay is energized and either a positive or negative dc signal is applied through terminal 11 of plug P1 to the wire carrying the error signal from the error pulse rectifier, thereby simulating a constant error. Whenever coast relay K1 is energized, the dc error signal is applied through contacts of that relay to the grids of two tubes of a balanced modulator (pin 3 of V1A and pin 6 of V2B). Between the relay and the grids is a shunting capacitor which attenuates high-frequency signals more than low frequencies, thereby preventing fast fluctuations in the input from affecting the error output as much as slow fluctuations. The dc aid and discharge relay K2 is energized whenever the radar is not automatically tracking a target. When this relay K2 is energized, a ground (instead of the dc error signal) is applied from terminal 8 of plug P1 through contacts of this energized relay to the grids of V1A and V2B. The dither oscillator signal, when present, is applied from terminal 7 of plug P2 through the 7-CYCLE ADJUST (amplitude) potentiometer R27 and a coupling capacitor to the grids of the other two tubes of the balanced modulator (pin 6 of V1B and pin 3 of V2A). Also connected to the grids of these two tubes is the modulator BAL (balance) potentiometer R9, which can apply varying amplitudes of either positive or negative dc signals to these grids to balance the modulator. The 400-cps excitation voltage is applied from terminal 9 of plug P2 (through transformer T1 and a phase-equalizing network) to the cathode of each tube of the balanced modulator. Tubes V1A and V1B are cathode coupled, as are tubes V2A and V2B. The excitation signal applied to the cathodes of V1A and V1B is 180° out of phase with that applied to the cathodes of V2A and V2B. The outputs of the tubes of the balanced modulator are taken from the plates. The plates (pins 1) of V1A and V2A are connected together, as are plates (pins 8) of V1B and V2B. Due to the 400-cps excitation signal being applied 180° out of phase and with no error signal on the grids (the antenna pointed at the target), the outputs of V1A and V2A cancel, and the outputs of V1B and V2B cancel. If the antenna is off target in such a direction (right or above) that a positive error signal is applied to the grids of V1A and V2B, conduction increases in these tubes while conduction of V1B and V2A decreases because of the increased bias (negative grid-to-cathode voltage) on V1B and V2A. Therefore, the combined 400-cps output of V1A-V2A is the output of V1A reduced by the output of V2A; and the combined 400-cps output of V1B-V2B is the output of V2B reduced by the output of V1B. These two combined outputs are 180° out of phase with each other because the excitation signals applied to the cathodes of the controlling tubes are 180° out of phase with each other. The combined output of V1A-V2A is applied to the grid (pin 2) of cathode follower V3A, and the combined output of V1B-V2B is applied to the grid (pin 7) of cathode follower V3B. If a negative error signal is applied to the grids of V1A and V2B, conduction decreases in these tubes and conduction of V1B and V2A increases. Therefore, the combined 400-cps output of V1A-V2A is the output of V2A reduced by the output of V1A; the combined 400-cps output of V1B-V2B is the output of V1B reduced by the output of V2B. Again, these combined signals are 180° out of phase with each other. Further, the signal that is applied to cathode follower V3A from V1A-V2A is 180° out of phase with the signal applied to that cathode follower when the dc error signal from the error pulse rectifier was positive. The same is true of the signals applied to cathode follower V3B. The signals from V1A-V2A and from V1B-V2B are applied to the cathode followers V3A and V3B across a phase equalizing network. This network, together with the phase-equalizing network between transformer T1 and the balanced modulator, makes the phase shift around the entire loop (from error detection to error correction) independent of fluctuations in the frequency of the servo excitations. Cathode follower V3 is a push-pull current amplifier. The outputs of the two sections of this cathode follower, which are 180° out of phase with each other, are applied to the opposite ends of the primary winding of the combining transformer T2; the secondary winding of which has a single 400-cps output signal whose amplitude is proportional to the amount of the error and whose phase depends upon the direction of the error. Two wires lead from the combining transformer secondary winding. One goes to the man-aid relay through terminal 3 of plug P2; and the other to ground through terminal 5 of plug P2. Two monitoring BAL (balance) points, TP1 and TP2, are provided on these wires.

b. Detailed circuit discussion (page 154). The dc error voltage, from the associated error pulse rectifier, is applied to terminal 5 of plug P1, developed across voltage divider R1-R2, and coupled through resistor R4 to contact 4 of coast relay K1. By action of the TEST-OPERATE switch and the SERVOS TEST switch, a constant dc simulated error signal also may be coupled, through resistor R3, to contact 4 of coast relay K1. Otherwise, a ground is applied to resistor R3, making it a developing resistor. The input error signal may be grounded by manually closing the BAL (balance) switch S1. The coast relay K1 is energized by the automatic tracking control unit during automatic tracking. It also may be energized by closing the DISABLE switch (page 272). Either method causes relay ground to be applied through terminal 6 of plug P2 to the coil of the relay. Whenever relay K1 is energized, the dc error signal is applied through its contacts 4-5 to the grids of V1A and V2B. The error signal also is used to charge capacitors C1 and C2 through resistor R6. The function of these capacitors is to maintain an input to the balanced modulator in the event that several target echoes are not received because of the magnetron arcing. Fifty milliseconds after loss of a target, relays K1 and K2 in the automatic tracking control unit deenergize, causing deenergization of the angle modulator coast relay K1 and the automatic tracking control unit relay K3. The deenergization of this relay K3, in turn, causes the dc aid and discharge relay K2 in the angle modulator to energize (page 272). When this relay K2 energizes, ground is applied through its contacts 4-5 to the junction of capacitors C1 and C2 with resistor R6, discharging the capacitors. Capacitor C3, in conjunction with input resistors R1, R2, and R4, forms an equalization network. The impedance of C3, shunting the balanced modulator input, decreases as the frequency increases. High-frequency input signals to the balanced modulator thus are attenuated more than low-frequency signals, with the result that fast fluctuations in the input affect the error output less than do slow fluctuations. This drooping frequency response compensates for the rising frequency response inherent in the azimuth and elevation servos.

(1) The 400-cps servo excitation is applied to the cathodes of V1A and V1B and, 180° out of phase, to the cathodes of V2A and V2B of the balanced modulator through transformer T1 and a phase-equalizing network, consisting of resistors R12, R13, R15, and R16 and capacitor C5. This phase-equalizing network produces a phase lag that varies with frequency. In the case of only the azimuth angle modulator, the servo excitation voltage passes through contacts of the plunge relay K1 prior to entering this unit (page 274). Whenever the antenna is plunged, this relay energizes, reversing the phase relationship of the servo excitation applied to the cathodes of V1A and V1B and to the cathodes of V2A and V2B, thereby reversing the error sensing of the modulator.

(2) With no error input signal (resulting from closing BAL (balance) switch S1) the outputs at the plates of V1A and V2A should be equal and 180° out of phase and, therefore, should cancel. The outputs of V1B and V2B similarly should cancel. BAL (balance) potentiometer R9 can vary the fixed potential on the grids of V1B and V2A between +0.5 and -0.5 volt, enabling the outputs of V1B-V2A to be made equal in amplitude to and thereby cancel the outputs of V1A-V2B when there is no input error signal.

(3) The small 7-cps error voltage from the dither oscillator is applied, between the times of computer on-trajectory signal and of the end of the missile flight, to the grids of V1B and V2A through terminal 12 of plug P2, potentiometer R27, resistor R26, and capacitor C4B. The 7-CYCLE ADJUST potentiometer R27 is used to adjust the amplitude of the input dither oscillator signal to the modulator. Capacitor C4A serves as a developing resistor for this seven-cycles-per-second signal and as a shunting capacitor for higher frequency signals.

(4) The outputs of the balanced modulator are applied to the interstage phase-equalizing network consisting of resistors R19, R20, R22, and R23, of capacitors C6 and C7, and of the screwdriver-controlled PHASE potentiometer R21. This network introduces a phase lead that varies with the frequency of the balanced modulator outputs. With 400-cps signals, the phase lag produced by the R12-R13-R15-R16-C5 phase-equalizing network and the phase lead produced by the R19-R20-R21-R22-R23-C6-C7 phase-equalizing network are equal so that the error output signal is exactly in phase (or exactly in phase opposition, depending upon the sense of the error) with the servo excitation. PHASE adjustment R21 corrects any deviation from this phase quality at 400 cps. When the frequency of servo excitation deviates from 400 cps, the phase shifts produced by the two equalizing circuits are not equal in magnitude. The combined effect causes an over-all lag when the frequency rises above 400 cps and an over-all lead when the frequency falls below 400 cps. The magnitude of phase shift is 0.3° per 1 percent of frequency deviation. This rate of phase change compensates for the phase-frequency characteristic of the azimuth (or elevation) servomotor generators.

(5) The outputs of the interstage equalizing network are applied to the cathode follower output stage V3, which is a push-pull amplifier driving the output transformer T2. Capacitor C8 makes the dynamic load impedance on each tube (which is formed by twice the value of C8 shunting the slightly inductive impedance presented by half the

transformer winding and R24 in series) nearly resistive. Pin 1 of transformer T2 and BAL (balance) TP1 are connected to ground through terminal 5 of plug P2. Pin 3 of transformer T2 and BAL (balance) TP2 are connected to contact 1 of the man-aid relay through terminal 3 of plug P2.

Section IV. HANDWHEEL DRIVE ASSEMBLY

13. PURPOSE

a. Manual operation. In the manual mode of operation of the target-tracking radar antenna positioning system, the handwheel drive generates a 400-cps voltage whose amplitude is proportional to the rate of handwheel rotation and whose phase angle, with respect to the motor excitation, is either plus or minus 90°, depending upon the direction of handwheel rotation.

b. Aided-manual operation. In the aided-manual mode of operation of the positioning system, the handwheel drive produces a 400-cps voltage whose amplitude is proportional to the distance the rotation of the handwheel has moved the rate potentiometer pickoff brush arm from its center position. The phase angle of this voltage with respect to motor excitation is either plus or minus 90° depending upon the side of its center position to which the rate potentiometer pickoff brush arm has been driven by the direction of handwheel rotation. The 400-cps signal of the manual mode continues to be present as a second derivative signal.

c. Automatic operation. In the automatic mode of operation of the antenna positioning system, the handwheel drive produces a 400-cps voltage whose amplitude and whose phase angle, with respect to motor excitation, are determined by the position of its rate potentiometer pickoff brush arm as in the aided-manual mode. Now, however, the position of the pickoff brush arm indirectly is determined by the error signal from the angle modulator.

14. LOCATION (FM 44-80, fig 29 and TM 9-5000-25, page 18).

The elevation handwheel drive assembly consists of the left handwheel and the unit immediately behind it in the control drawer of the target-tracking radar control console. The azimuth handwheel drive assembly consists of the center handwheel and the unit immediately behind it in the same drawer. The same types of units are used in the target-tracking radar range positioning system and in the missile-tracking radar antenna and range positioning systems.

15. OPERATION OF PRINCIPAL COMPONENTS (TM 9-5000-25, pages 269 and 270).

a. Servomotor B1 (M). This Kollsman servomotor is a two-phase induction-type motor containing a squirrel cage rotor and two stator windings spaced 90° electrically from each other. Except during automatic slewing to the coordinates of the designated target or when positioning the antenna by means of the track antenna control unit, a 400-cps motor excitation voltage of fixed amplitude is applied to one of the stator windings (page 252). A 400-cps control voltage, 90° out of phase with the excitation voltage, is applied in the automatic mode of operation to the other stator winding. The torque developed by the motor is roughly proportional to the applied control voltage. During either manual or aided-manual operation, the shaft of this motor is turned by the handwheel instead of by the motor.

b. Generator B1 (T). This generator is a two-phase induction generator, quite similar to the servomotor. It also has two stator windings in electrical quadrature and a squirrel cage rotor. A 400-cps tachometer excitation voltage of fixed amplitude is applied to one of the stator windings. The generator and servomotor B1 share a common shaft which is geared to the handwheel to give a speed ratio of 47:1. Therefore, whenever the shaft is rotated, a 400-cps signal is generated. This signal is 180° out of phase with the servomotor control signal.

c. Magnetic clutch. The magnetic clutch, when engaged, couples the rate potentiometer to the handwheel shaft through reduction gearing, giving a speed ratio of 1:13 1/3. Coil L1 operates this magnetic clutch. One end of this coil is connected to -28 volts; and the other to ground, provided the associated MAN-AID-AUTO switch on the target-tracking radar control console is in the AUTO position during acquisition of the target or any time it is in the MAN position (page 272). While this ground is applied to the coil, the coil is energized and the clutch is disengaged. When the coil is deenergized, the clutch is engaged. The coil is shunted by a varistor 7B1 (a nonlinear resistance which decreases in value as the voltage impressed across it increases). When the coil circuit suddenly is interrupted, either by repositioning the MAN-AID-AUTO switch off the MAN position or by ceasing to acquire with the MAN-AID-AUTO switch in the AUTO position, the high voltage generated in the coil by the collapse of the field causes a lowering of the resistance of the varistor, thereby rapidly dissipating the energy stored in the coil. This circuit action prevents excessive arcing at the contact points. Whenever the rate potentiometer has been driven to either of its extreme positions, the potentiometer pickoff arm hits a mechanical stop, and the clutch slips, allowing continued rotation of the handwheel shaft. (With the clutch properly adjusted, $5\frac{1}{2}$+1/8 revolutions of the handwheel will move the potentiometer pickoff arm from its center position to the stop.)

d. Rate potentiometer R3. The rate potentiometer is connected across the secondary winding of rate excitation transformer T1. The voltage on the potentiometer pickoff arm is zero in the center position and increases linearly with the distance of the pickoff arm from its center position to a value of 6.3 volts at either extreme position. The signals tapped at opposite sides from the center position of the pickoff arm are in phase opposition with each other. The potentiometer pickoff arm is suspended on springs which keep it centered whenever the magnetic clutch is disengaged.

16. ADJUSTMENTS (TM 9-5000-25, pages 269 and 270).

a. PHASE potentiometer R2. An inherent phase shift exists between the tachometer excitation voltage applied to and the voltage generated by the servomotor generator B1. Since the impedance of the generator excitation winding is inductive, the excitation current lags the excitation voltage. Introduction of the PHASE potentiometer R2 in series with this winding reduces the angle of lag between the excitation current and the excitation voltage and thus advances the phase of the generated voltage When the potentiometer is adjusted so that its value approaches zero ohms, the generated voltage lags the excitation voltage by about 1°. By adjusting the potentiometer toward its maximum value of 100 ohms, it is possible to zero the phase angle between the generated and the excitation voltages. This zero phase angle is necessary because part of the generator output is used, in the automatic mode of operation of the antenna positioning system, as a negative (velocity) feedback for the servomotor B1.

b. BAL (balance) potentiometer R4. A phenomenon known as creep is caused by a small voltage induced in the stator output winding of the generator B1. This small induced signal is sufficient to cause movement of the antenna even though the shaft of the servomotor generator B1 is held stationary. Creep is eliminated by applying a 400-cps voltage in series with the generator output winding so that it cancels the stationary generator induced voltage by returning the normally grounded end of the output winding to ground through resistor R1 and to a maximum of 6.3 volts through resistor R5 and BAL (balance) potentiometer R4. Potentiometer R4 is connected across the same secondary winding of transformer T1 as is the rate potentiometer. Since an amplitude of 12.6 volts is measured across this winding and since the centertap of this winding is grounded, the center position of the potentiometer is zero volts, the extreme positions of the potentiometer are 6.3 volts, and the signal on one side of the center position is in phase opposition with that on the other side. Therefore, a compensating voltage up to 6.3 volts of either phase can be tapped off by means of R4. Resistors R5 and R1 (R5 being much greater than R1) act as a voltage divider to reduce this compensating voltage to the range of values required for zeroing the generator output when the shaft of the servomotor generator B1 is stationary.

Section V. LOW-POWER SERVOAMPLIFIER

17. PURPOSE

This unit accepts 400-cps control signals and delivers corresponding driving power for the appropriate servomotor.

18. LOCATION TM 9-5000-25, page 18).

Seven low-power servoamplifiers are located in the target-tracking radar console control drawer. From left to right, the low-power servoamplifiers are the first, second, sixth, eighth, ninth, tenth, and thirteenth units in the rear of the drawer and for purposes of this text are numbered 1 through 7, respectively. Low-power servoamplifiers 1 and 2 are used in the antenna elevation positioning system, 3 and 4 are used in the antenna azimuth positioning system; 5 is used in the antenna azimuth positioning system only when operating with a remote FDC system; and 6 and 7 are used in the range positioning system. The same types of units are used in the missile-tracking radar range and antenna positioning systems.

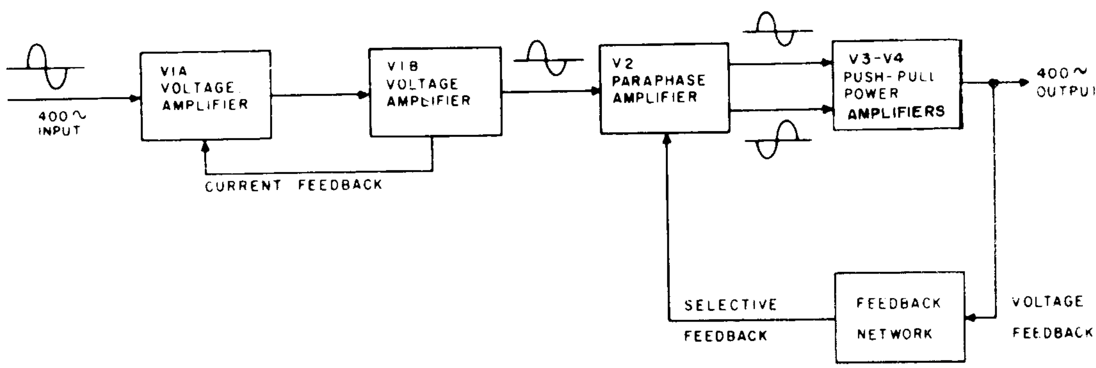

Figure 1. Block diagram of the low-power servoamplifier.

19. OPERATION

a. Block diagram discussion (fig 1). The 400-cps input signal is applied through the two-stage, RC-coupled voltage amplifier V1. Negative (current) feedback is employed between the two stages of V1, which in effect makes V1 a constant current generator. The amplified voltage then is applied from V1 to the paraphase amplifier V2, which yields two equal amplitude output signals, one in phase with and the other in phase opposition with the input signal. These two output voltages of opposite phase drive push-pull power amplifiers V3 and V4. These tubes provide the current amplification required to obtain sufficient output power to operate the servomotor. A

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negative (selective) feedback returns part of the output voltage through a frequency-selective network to the input of the paraphase amplifier V2. The principal function of this feedback is to make the low-power servoamplifier frequency selective.

b. Detailed circuit discussion (TM 9-5000-25, page 143).

(1) The 400-cps servo control input voltage is applied to terminal 3 of plug P1, which is connected directly to the grid (pin 7) of the voltage amplifier V1. This tube is a twin triode, each section of which forms one stage of the two-stage, RC-coupled voltage amplifier.

(2) The bias applied to the grid of V1A, the first amplifier stage, is established by voltage divider R2-R3-R8 connected between -250 volts and ground. R8 also serves as the cathode resistor for V1B, the second amplifier stage. The bias applied to the grid of V1B is established by voltage divider R5-R4-R1 connected between +250 volts and -250 volts. R1 also serves as the plate-load resistor of V1A. Plate-load resistor R6 of V1B operates as part of a bridged-T network. Capacitor C1 couples the signals from the plate (pin 6) of V1A to the grid (pin 2) of V1B. Negative feedback is taken from the cathode (pin 3) of V1B and applied to the grid (pin 7) of V1A. The approximate static operating values of the circuit are:

(a) The current flow through V1B is approximately 1 ma, developing a static drop of 3.3 volts across resistor R8.

(b) The resulting 253.3 volts across resistors R2 and R3 are divided so that a bias of -1.3 volts is applied to the grid of V1A.

(c) This bias yields a static current slightly greater than 0.5 ma through V1A and resistor R1, which develops a drop of 122 volts across plate-load resistor R1.

(d) The resulting static voltage of 378 volts is divided so that a static potential of +2 volts is applied to the grid of V1B.

(e) Since the cathode of V1B is at a d-c potential of 3.3 volts, the bias on V1B is -1.3 volts.

(f) With this bias, there results a quiescent current of 1 ma through resistor R8, V1B, and resistor R6, as was stated in (a) above.

(3) The biasing arrangement is such that in dynamic operation of the amplifier, inverse current feedback takes place from V1B to V1A.

If the current through V1B increases:

(a) The cathode of V1B becomes more positive.

(b) The voltage rise at the cathode of V1B is applied back to the grid of V1A through resistor R3, causing a drop at the plate of V1A.

(c) Capacitor C1 couples this drop to the grid of V1B.

(4) Thus, the current feedback counteracts any changes in the space current. Consequently, the effective output impedance is very high, so that the voltage amplifier may be regarded as a constant current generator. The output of the voltage amplifier V1 is coupled through capacitor C3 to the grid (pin 2) of V2A of the paraphase amplifier.

(5) Tube V2A of the paraphase amplifier is used to increase the amplitude of the applied signal to the desired level. Tube V2B of the paraphase amplifier is used as an inverter and amplifier to produce a signal of the same amplitude as the output of V2A but of opposite polarity. Since common cathode resistor R10 is not bypassed, the voltage which appears across it is the resultant of the two plate currents, and has the same shape and polarity as the voltage applied to the grid of V2A. This action differs from that of a cathode follower in that:

(a) The output from the stage is taken from the plate so that, although the voltage developed across resistor R10 is degenerative, the gain of the stage is not limited to less then unity.

(b) The plate current of both tubes flows through resistor R10.

(6) The value of resistor R10 causes the amplitude of the degenerative voltage developed across it to be one-half that of the voltage applied to the grid of V2A, which also is equal to the effective signal voltage between the grid and the cathode of V2A and to the signal that is applied to the cathode of V2B. Since the grid of V2B is connected to ground, application of this voltage to the cathode of V2B has the same effect as would be obtained by applying a voltage of opposite polarity to the grid. As a result, signals opposite in polarity but equal in amplitude are obtained from the plates of V2.

(7) The 400-cps push-pull output of the paraphase amplifier V2 is applied (through coupling capacitors C4 and C5 and parasitic suppressors R12 and R15) to the grids of push-pull amplifier tubes V3 and V4. Resistor R18 is used to drop the supply voltage required on the screen

grids. Common cathode resistor R14 provides the proper bias for class AB operation of the tubes. The plates of V3 and V4 are connected through parasitic suppressors R19 and R17 to the primary of output transformer T1. The output, therefore, is developed across the transformer by currents flowing alternately through each tube and through each half of the transformer primary winding. The control winding of the associated Kollsman servomotor is the load connected to the secondary of the transformer T1. This inductive load is resonated by capacitors C6 and C7, so the impedance reflected into the primary of the transformer is almost a pure resistance. Each of the two tubes (V3 and V4) sees half of this reflected resistance as plate-load resistance.

(8) In the antenna positioning circuits, the control voltage input to the low-power servoamplifier usually is the sum of a 400-cps error voltage and a 400-cps velocity feedback voltage that is 180° out of phase with the error voltage. The velocity feedback voltage is generated by a servomotor generator and is not a pure sine wave. Instead, it contains a pronounced third-harmonic distortion—an undesired 1, 200-cps voltage. This voltage would add to the current flowing through the power amplifier tubes, thus causing unnecessary and injurious loading of the pentode plates. To avoid this, a selective feedback circuit is used to discriminate against the third harmonic and to keep the response at the sideband frequencies to both sides of 400 cps fairly flat. This circuit, called a bridged-T network, consists of resistors R6 and R7 and of capacitors C2 and C3. Voltage divider R6-R7, connected across the secondary of transformer T1 supplies a portion of the output signal to the junction of C2 and R7. From this junction, the feedback signal has a choice of three possible paths:

(a) Through resistor R7 to the grid of the paraphase amplifier section V2A.

(b) Through capacitor C2, resistor R6, and the power supply to ground.

(c) Through capacitors C2 and C3 to the grid of V2A.

(9) A feedback signal with a frequency of considerably less than 400 cps at the junction of C2 and R7 sees a lower impedance through the resistor R7 and therefore, it is applied to the grid of V2A by path (a). A feedback signal with a frequency near 400 cps sees a lower impedance through capacitor C2 than through resistor R7 and through resistor R6 than through capacitor C3, so it is shunted to ground through the

power supply by path (b) rather than being applied to the grid of V2A. In effect then, there is no feedback of signals having frequencies near 400 cps. A feedback signal with a frequency considerably greater than 400 cps sees a lower impedance through capacitor C2 than through resistor R7 and through capacitor C3 than through resistor R6, so it is applied to the grid of V2A by path (c). Since the feedback is degenerative, the gain of the low-power servoamplifier is inversely proportional to the attenuation of the feedback signal---the more feedback applied to the grid of V2A, the smaller the gain.

(10) At higher frequencies, the condition that the degenerative velocity feedback from the servomotor generator be in phase opposition with the error signal cannot be met, so regeneration instead of degeneration might result. To prevent regeneration, the low-power servoamplifier is made insensitive to rapid fluctuations of the input signal by the bridged-T network described above and by the series network C8 and R20 across the inputs to the power amplifiers V3 and V4. At 400 cps, the reactance of C8 is so large that the inputs to the power amplifiers are attenuated only very slightly. However, at frequencies above 1,000 cps, the admittance of the network becomes appreciable, and the gain of the low-power servoamplifier decreases sharply.

Section VI. INTERMEDIATE DRIVE ASSEMBLY

20. PURPOSE

The intermediate drive assembly accepts as inputs the 400-cps error signal output of a low-power servoamplifier and a synchro position signal. As outputs, it generates a 400-cps signal and it delivers a 400-cps synchro control transformer rotor position signal.

21. LOCATION (TM 9-5000-25, page 18).

The elevation intermediate drive assembly is located to the left and slightly to the rear of the elevation handwheel drive assembly, and the azimuth intermediate drive assembly is located to the right and slightly to the rear of the elevation handwheel drive assembly in the target-tracking radar console control drawer. The same types of units are used in the missile-tracking radar antenna positioning system.

22. OPERATION OF PRINCIPAL COMPONENTS (TM 9-5000-25, pages 269 and 270).

a. Servomotor generator. The servomotor generator in the azimuth intermediate drive assembly is numbered B6, and the one in the elevation intermediate drive assembly is numbered B2. This unit is similar in construction and operation to handwheel drive servomotor generator B1, described in paragraphs 15a and 15b except that there is no handwheel and the shaft always is turned by the motor.

b. Synchro control transformer. The 25-speed synchro control transformer in the azimuth intermediate drive assembly is numbered B5, and the one in the elevation intermediate drive assembly is numbered B1. The shaft of this synchro (the intermediate shaft) is geared to the shaft of the servomotor generator. The stator windings (S1, S2, and S3) of this synchro are connected to the stator windings of a 25-speed synchro control transmitter, external to this assembly, and accept as inputs, 400-cps signals which indicate the position of the synchro control transmitter rotor. One end (R2) of the synchro control transformer rotor winding is connected to ground; and the other end (R1) delivers, as an output, a 400-cps signal indicating the difference in the positions of the rotor windings of the synchro control transformer and of the synchro control transmitter with respect to their associated stator windings.

23. ADJUSTMENT

A PHASE potentiometer is connected in series with the generator excitation winding. This potentiometer is numbered R3 in the azimuth intermediate drive assembly and R1 in the elevation intermediate drive assembly. Its operation and purpose are the same as that of PHASE potentiometer R2 in the handwheel drive assembly, described in paragraph 16a---that is, to zero the phase angle between the servomotor generator output voltage and the excitation voltage.

Section VII. TARGET DESIGNATE CONTROL PANEL

24. PURPOSE

Insofar as this text is concerned, the purposes of this unit (FM 44-80, fig 9) are:

a. To generate a signal representing the target azimuth for use of the target-tracking radar antenna azimuth positioning system.

b. To control the azimuth of the PPI steerable azimuth line.

c. To display the azimuth of the steerable azimuth line.

d. To accept and utilize remote FDC-generated target azimuth data.

e. To accept and display remote FDC-generated target elevation data.

Other purposes of this unit are discussed in TM 9-5000-9.

25. LOCATION (2y, page 192)

The target designate control panel is the front unit located to the left of the PPI on the battery control console.

26. OPERATION (TM 9-5000-25)

a. Azimuth synchro control transformer B5 (page 270).

(1) When using the battery acquisition radar as the origin of the designated target's azimuth ("local" operation), the stator windings (S1, S2, and S3) of this synchro are connected to the stator windings of the target acquisition synchro control transmitter B1 in the azimuth data unit of the target-tracking radar antenna. Geared to the shaft of this synchro control transformer is a handwheel which permits manual positioning of the shaft and the steerable azimuth line. The position of the rotor of the target acquisition synchro control transmitter is determined by the azimuth position of the antenna. Since one end (R1) of the synchro control transformer rotor winding is connected to ground, its other end (R2) carries as an output, a 400-cps signal which represents the difference in the positions of the rotor windings of the synchro control transformer and of the synchro control transmitter with respect to their associated stator windings. Thus, when the steerable azimuth line has been positioned over the target PPI pip, this signal represents the difference in the target azimuth and the antenna azimuth. The azimuth dial on the target designate control panel is connected to the shaft of the synchro control transformer B5 and therefore, provides a direct reading, in mils, of the azimuth of the steerable azimuth line (the azimuth of the target).

(2) When using a remote fire direction center (FDC) as the source of the target's azimuth ("remote" operation), the stator windings (S1, S2, and S3) of the synchro control transformer B5 are connected, during "remote examine", to the stator windings of the azimuth synchro control transmitter in the FDC coordinate converter. Geared to the synchro control transformer shaft is the servomotor generator B6.

This unit is similar in construction and operation to the handwheel drive servomotor generator B1, described in paragraphs 15a and 15b, except that there is no handwheel control and that excitation signals are provided only during the "remote examine" operation. Therefore, unless connected to a remote FDC and unless employing the "remote examine" operation, the synchro control transformer operates as described in (1) above. When both these conditions exist, however, the positions of the synchro control transformer rotor winding, the steerable azimuth line, and the azimuth dial are determined by the servomotor. Since the rotor of the FDC coordinate converter azimuth synchro control transmitter is positioned by the FDC-supplied target azimuth signal, the output of the rotor of the synchro control transformer represents the difference in the FDC-supplied azimuth and that of the steerable azimuth line; and since this signal is the control signal for the servomotor generator B6, the synchro control transformer rotor winding, the steerable azimuth line, and the azimuth dial are positioned by the FDC-supplied target azimuth. The 400-cps signal generated by the servomotor generator B6 is applied as a velocity feedback signal to the servomotor control circuit. PHASE potentiometer R2 is connected in series with the generator excitation winding and is used to zero the phase angle between the servomotor generator output voltage and the excitation voltage (par 16a).

b. Elevation synchro data repeater B1 (page 269). The target designate control panel contains the elevation synchro data repeater B1. The stator windings of this repeater will be connected to the stator windings of the elevation synchro data transmitter in the AN/GSG-2 FDC coordinate converter. When using the AN/GSG-2 system as the source of the target elevation ("remote" operation), one end (R2) of the synchro data repeater rotor is connected to ground and the other end (R1), to motor excitation. This rotor winding, therefore, assumes the same electrical position with respect to its stator windings as the rotor winding of the synchro data transmitter has with respect to its stator windings. Connected to the shaft of this rotor is the FDC ELEVATION dial on the target designate control panel. Since the rotor winding of the synchro data transmitter is positioned by the FDC-supplied target elevation signal, this dial provides a direct reading in mils of the elevation angle being transmitted from the FDC. During "local" operation, the connections of the synchro data repeater rotor are reversed, thereby causing the dial to turn 180° and show only a blank face.

Section VIII. FDC COORDINATE CONVERTER

27. PURPOSE

Insofar as this text is concerned, the FDC coordinate converts a mechan-
ical motion representing the target azimuth (and elevation if connected to the AN/GSG-2 system), received from the remote FDC and parallax-corrected, [illegible] 400-cps signal.

[illegible] LOCATION

Although the FDC coordinate converter has not yet been installed in most Nike systems, space and cabling have been provided in the upper left bay of the target-tracking radar control console for installation of the FDC coordinate converter used with the AN/GSG-2 system. The FDC coordinate converter used with the AN/FSG-1 and the AN/MSG-4 systems probably will be installed in a separate trailer containing other elements of the battery termination of these systems.

29. OPERATION (TM 9-5000-25)

a. Elevation synchros (page 269). The AN/GSG-2 FDC coordinate converter contains an elevation synchro data transmitter and an elevation synchro control transformer with their rotors on a single shaft and positioned by the parallax-corrected FDC-supplied target elevation signal. The operation of the synchro data transmitter is discussed in paragraph 26b. The stator windings (S1, S2, and S3) of the elevation synchro control transformer will be connected to those of the elevation synchro control transmitter in the elevation data unit of the target-tracking radar antenna. One end (R1) of the control transformer rotor winding is connected to ground. Therefore, the other rotor winding end (R2) will carry a 400-cps signal representing the difference in the positions of the synchro control transformer rotor winding and of the elevation data unit synchro control transmitter rotor winding with respect to their associated stator windings---the difference in the FDC-supplied target elevation and the antenna elevation.

b. Azimuth synchros (page 270). The FDC coordinate converter contains an azimuth synchro control transmitter and an azimuth synchro control transformer with their rotors on a single shaft and positioned by the parallax-corrected FDC-supplied target azimuth signal. The operation of the the synchro control transmitter is discussed in paragraph 26a(2). The stator windings (S1, S2, and S3) of the FDC coordinate converter azimuth synchro control transformer will be connected to those of the target acquisition synchro control transmitter in the azimuth data unit of the target-tracking radar antenna. One end (R1) of the control transformer rotor winding is connected to ground.

Therefore, the other rotor winding end (R2) will carry a 400-cps signal representing the difference in the positions of the synchro control transformer rotor winding and of the target acquisition synchro control transmitter rotor winding with respect to their associated stator windings---the difference in the FDC-supplied target azimuth and the antenna azimuth.

Section IX. COUPLING UNITS

30. PURPOSE

All the inputs and outputs of the coupling units are 400-cps signals. Within the coupling units, the input signals are developed, amplitude-controlled, routed, and combined by means of the coupling unit circuits and resistors, both variable and fixed. In addition, a switch on the azimuth coupling unit and on the elevation coupling unit can, for test purposes, ground one of the output channels on each of these coupling units.

31. LOCATION (TM 9-5000-25, page 18).

The elevation coupling unit is the fourth; the azimuth coupling unit, the seventh; and the range coupling unit, the eleventh unit from the left in the rear of the target-tracking radar console control drawer.

32. OPERATION (TM 9-5000-25)

a. Terminal connections. Table I lists the connections that are made to the terminals of plugs P1 on the azimuth coupling unit (pages 159 and 270), on the elevation coupling unit (pages 160 and 269), and on the range coupling unit (pages 142 and 270) by switch and relay action when the antenna positioning system is placed in the various modes of operation.

b. 400-cps signal data flow. The following subparagraphs describe the paths the 400-cps signals follow through the coupling units with the antenna positioning system in the various modes of operation. Although all resistances in each circuit affect the signal amplitude, only the major ones are mentioned.

c. Azimuth coupling unit (pages 159 and 270) in automatic mode of operation.

(1) The 400-cps signal from the azimuth angle modulator enters the coupling unit on terminal 4 of plug P1; passes through potentiometer R17, across developing resistor R18, through resistor R2, across developing resistors R4, R3, R21, and R1; and leaves the unit at terminal 14 of plug P1.

(2) The 400-cps signal from antenna drive servomotor generators B3, B5, B7, and B9 enters the coupling unit on terminal 15 of plug P1, is developed across resistor R6, and then takes two separate courses. One course is through resistor R5; across developing resistors R4, R3, R21, and R1; and out from the unit at terminal 14 of plug P1. The other course is through resistor R7 and out from the unit at terminal 11 of plug P1.

(3) The 400-cps signal from the azimuth intermediate drive synchro control transformer B5 enters the coupling unit on terminal 3 of plug P1, is developed across resistor R8, passes through resistor R9, and leaves the unit at terminal 11 of plug P1.

(4) The 400-cps signal from the azimuth intermediate drive servomotor generator B6 enters the coupling unit on terminal 8 of plug P1, is developed across resistor R11, and then takes two separate courses. One course is through resistor R10 and out from the unit at terminal 11 of plug P1. The other course is through resistor R12 and out from the unit at terminal 9 of plug P1.

(5) The 400-cps signal from the azimuth rate potentiometer R3 enters the coupling unit on terminal 1 of plug P1; passes through potentiometer R14, across developing resistor R22, and through resistor R13; and leaves the unit at terminal 9 of plug P1.

(6) The 400-cps signal from the azimuth handwheel drive servomotor generator B1 enters the coupling unit on terminal 5 of plug P1, is developed across resistor R16, passes through resistor R15, and leaves the unit at terminal 9 of plug P1.

d. Azimuth coupling unit in manual mode of operation.

(1) The 400-cps signal from the azimuth handwheel drive servomotor generator B1 enters the coupling unit on terminal 5 of plug P1, is developed across resistor R16, passes through resistor R15 and across developing resistors R13 and R14, and leaves the unit at terminal 9 of plug P1.

(2) The 400-cps signal from azimuth intermediate drive servomotor generator B6 enters the coupling unit at terminals 6 and 8 of plug P1. The signal entering at terminal 8 is developed across resistor R11, passes through resistor R12 and across developing resistors R13 and R14, and leaves the unit at terminal 9 of plug P1. The signal entering at terminal 6 passes through resistor R4; is developed by resistors R1, R2, and R17; and leaves the unit at terminal 14 of plug P1.

(3) The 400-cps signal from azimuth intermediate drive synchro control transformer B5 enters the coupling unit on terminal 2 of plug P1; passes through resistor R20, across developing resistor R21, through resistor R3, and across developing resistors R1, R2, and R17; and leaves the unit at terminal 14 of plug P1.

(4) The 400-cps signal from antenna drive servomotor generators B3, B5 B7, and B9 enters the coupling unit on terminal 15 of plug P1, is developed across resistor R6, passes through resistor R5, and leaves the unit at terminal 14 of plug P1.

e. Azimuth coupling unit in aided-manual mode of operation. In the aided-manual mode of operation, the signal paths described in d above, continue to exist except that resistors R13 and R14 no longer are used to develop the 400-cps signals from azimuth handwheel drive servomotor generator B1 and from azimuth intermediate drive servomotor generator B6; and that the 400-cps signal from the azimuth rate potentiometer R3 enters the unit on terminal 1 of plug P1; passes through potentiometer R14, across developing resistor R22, through resistor R13; and leaves the unit at terminal 9 of plug P1.

f. Automatic slewing azimuth coupling unit.

(1) The 400-cps signal from either target designate control panel synchro control transformer B5 or the FDC coordinate converter azimuth synchro control transformer enters the coupling unit on terminal 7 of plug P1; is developed across resistor R19; passes through resistor R1 and across developing resistors R2 and R17, R3 and R21, and R4; and leaves the unit at terminal 14 of plug P1.

(2) The 400-cps signal from antenna drive servomotor generators B3, B5, B7, and B9 enters the unit on terminal 15 of plug P1, is developed across resistor R6 and then takes two separate routes. One is through resistor R5; across developing resistors R4, R3 and R21, and R2 and R17; and out at terminal 14 of plug P1. The other route is through resistor R7 and out at terminal 11 of plug P1.

(3) The 400-cps signal from azimuth intermediate drive synchro control transformer B5 enters the unit on terminal 3 of plug P1, is developed across resistor R8, passes through resistor R9, and leaves the unit at terminal 11 of plug P1.

Table 1. Coupling unit connections.

PLUG P1 TERMINAL NO.	UNIT	MODE OF OPERATION				
		AUTOMATIC	MANUAL	AID-MAN	AUTO SLEW	REM CONTROL
1	Az	RATE	Ground	RATE	Gnd or 0 RATE	Gnd or 0 RATE
	El	RATE	Ground	RATE	Gnd or 0 RATE	Gnd or 0 RATE
2	Az	Open	INT CT B5	INT CT B5	Open	Ant Cnt Unit
	El	Open	INT CT B1	INT CT B1	Open	Ant Cnt Unit
3	Az	INT CT B5	Open	Open	INT CT B5	INT CT B5
	El	INT CT B1	Open	Open	INT CT B1	INT CT B1
4	Az	AUTO	Ground	Ground	Ground	Ground
	El	AUTO	Ground	Ground	Ground	Ground
5	Az	HW FB	HW FB	HW FB	0 HW FB	HW FB
	El	HW FB	HW FB	HW FB	0 HW FB	HW FB
6	Az	Ground	INT FB B6	INT FB B6	Ground	Ground
	El	Ground	INT FB B2	INT FB B2	Ground	Ground
7	Az	Ground	Ground	Ground	Q CT (A)	Ground
	El	Gnd or E LIM	Gnd or E LIM	Gnd or E LIM	Gnd or E LIM	Gnd or E LIM
8	Az	INT FB B6	INT FB B6	INT FB B6	INT FB B6	INT FB B6
	El	Ground	Ground	Ground	Q CT (E)	Ground

Table I. Coupling unit connections. (cont)

PLUG P1 TERMINAL NO.	UNIT	MODE OF OPERATION				
		AUTOMATIC	MANUAL	AID-MAN	AUTO SLEW	REM CONTROL
9	Az	HW IN LP 4	INT IN LP 4	INT IN LP 4	0 HW IN LP 4	0 HW IN LP 4
	El	HW IN LP 2	INT IN LP 2	INT IN LP 2	0 HW IN LP 2	0 HW IN LP 2
	Rg	Ground	Ground	Ground	Q A CT	Ground
10	El	Ground	Open - SLEW	Open - SLEW	Ground	Ground
	Rg	O Q A FB	O Q A F.B	O Q A FB	Q A FB	O Q A FB
11	Az	INT IN LP 3	O LP 3	O LP 3	INT IN LP 3	INT IN LP 3
	El	INT IN LP 1	O LP 1	O LP 1	INT IN LP 1	INT IN LP 1
	Rg	O Q A IN LP 5	O Q A IN LP 5	O Q A IN LP 5	Q A IN LP 5	O Q A IN LP 5
12	El	INT FB B2	INT FB B2	INT FB B2	INT FB B2	INT FB B2
13	Az	Ground	Ground	Ground	Ground	Ground
	El	Ground	Ground	Ground	Ground	Ground
14	Az	A IN Preamp	A IN Preamp	A IN Preamp	A IN Preamp	A IN Preamp
	El	E IN Preamp	E IN Preamp	E IN Preamp	E IN Preamp	E IN Preamp
15	Az	A FB	A FB	A FB	A FB	A FB
	El	E FB	E FB	E FB	E FB	E FB

Table I. Coupling unit connections (cont).

LEGEND

Abbreviation	Definition
A FB	The 400-cps signal from the antenna drive servomotor generators B3, B5, B7, and B9.
A IN Preamp	The 400-cps signal applied from the coupling unit to the azimuth servopreamplifier.
Ant Cnt Unit	The 400-cps error signal from the track antenna control unit.
AUTO	The 400-cps error signal from the associated angle modulator.
Auto Slew	The automatic slewing of the antenna to the designated target azimuth or to the designated target elevation as determined by the AN/GSG-2 system.
Az	The azimuth coupling unit.
E FB	The 400-cps signal from the antenna drive servomotor generators B4 and B5.
E IN Preamp	The 400-cps signal applied from the coupling unit to the elevation servopreamplifier.
El	The elevation coupling unit.
Gnd or E LIM	The terminal normally is connected to ground. However, if the antenna reaches either its minimum or its maximum elevation limit, the terminal has the 400-cps signal from the appropriate elevation limit switch on it.
Gnd or 0 RATE	The connection may be either to ground or to the centered pickoff arm of the rate potentiometer R3---no signal.
HW FB	The 400-cps signal from the handwheel drive servomotor generator B1.

Table I. Coupling unit connections (cont).

LEGEND (cont)

Abbreviation	Definition
0 HW FB	The connection is to the handwheel drive servomotor generator however, since its shaft is stationary, no signal is present.
HW IN LP 2	The 400-cps signal applied from the elevation coupling unit, through low-power servoamplifier number 2, to the control winding of the elevation handwheel drive servomotor B1.
0 HW IN LP 2	The connection is the same as described immediately above, but the elevation handwheel drive servomotor B1 is not excited.
HW IN LP 4	The 400-cps signal applied from the azimuth coupling unit, through low-power servoamplifier number 4, to the control winding of the azimuth handwheel drive servomotor B1.
0 HW IN LP 4	The connection is the same as described immediately above, but the azimuth handwheel drive servomotor B1 is not excited.
INT CT B1	The 400-cps signal from the rotor of the elevation intermediate drive synchro control transformer B1.
INT CT B5	The 400-cps signal from the rotor of the azimuth intermediate drive synchro control transformer B5.
INT FB B2	The 400-cps signal from the elevation intermediate drive servomotor generator B2.
INT FB B6	The 400-cps signal from the azimuth intermediate drive servomotor generator B6.
INT IN LP 1	The 400-cps signal applied from the elevation coupling unit, through low-power servoamplifier number 1, to the control winding of the elevation intermediate drive servomotor B2.

Table I. Coupling unit connections (cont).

LEGEND (cont)

Abbreviation	Definition
INT IN LP 2	The 400-cps signal applied from the elevation coupling unit, through low-power servoamplifier number 2, to the control winding of the elevation intermediate drive servomotor B2.
INT IN LP 3	The 400-cps signal applied from the azimuth coupling unit, through low-power servoamplifier number 3, to the control winding of the azimuth intermediate drive servomotor B6.
INT IN LP 4	The 400-cps signal applied from the azimuth coupling unit, through low-power servoamplifier number 4, to the control winding of the azimuth intermediate drive servomotor B6.
0 LP 1	The connection is made to low-power servoamplifier number 1 which has no output connection.
0 LP 3	The connection is made to low-power servoamplifier number 3 which has no output connection
Open - SLEW	The connection is to the elevation SLEW switch S6, which in its center position presents an open, and in either of its operated positions provides a 400-cps signal.
Q A CT	During "remote examine" only, the 400-cps signal from the rotor of the target designate control panel synchro control transformer B5.
Q A FB	During "remote examine" only, the 400-cps signal from the target designate control panel servomotor generator B6.
0 Q A FB	During all operations except "remote examine", either the shaft of the target designate control panel servomotor generator B6 is not turning or the generator is not excited, therefore, although the connection is as stated immediately above, no signal is present.

Table I. Coupling unit connections (cont)

LEGEND (cont)

Abbreviation	Definition
Q A IN LP 5	During "remote examine" only, the 400-cps signal applied from the range coupling unit, through low-power servoamplifier number 5, to the control winding of the target designate control panel servomotor B6.
0 Q A IN LP 5	During all operations except "remote examine", the connections remain as described immediately above, but no signal is present.
Q CT (A)	The 400-cps signal from either the target designate control panel synchro control transformer B5 or the FDC coordinate converter azimuth synchro control transformer.
Q CT (E)	When operating with the AN/GSG-2 system only, the 400-cps signal from the AN/GSG-2 coordinate converter elevation synchro control transformer.
Rem Control	Control of the antenna position by means of the track antenna control unit.
Rg	The range coupling unit.

(4) The 400-cps signal from azimuth intermediate drive servomotor generator B6 enters the unit on terminal 8 of plug P1, is developed across resistor R11, passes through resistor R10, and leaves the unit at terminal 11 of plug P1.

g. Operation with the track antenna control unit (azimuth coupling unit).

(1) The 400-cps azimuth signal from the track antenna control unit enters the coupling unit on terminal 2 of plug P1; passes through resistor R20, across developing resistor R21, through resistor R3, and across developing resistors R4, R2 and R17, and R1; and leaves the unit at terminal 14 of plug P1.

(2) The 400-cps signal from antenna drive servomotor generators B3, B5, B7, and B9 enters the unit on terminal 15, is developed across resistor R6, and then takes two separate paths. One is through resistor R5, across developing resistor R4, and out at terminal 14 of plug P1. The other is through resistor R7 and out at terminal 11 of plug P1.

(3) The 400-cps signal from the azimuth intermediate drive synchro control transformer B5 enters the unit at terminal 3 of plug P1, is developed across resistor R8, passes through resistor R9, and leaves the unit at terminal 11 of plug P1.

(4) The 400-cps signal from azimuth intermediate drive servomotor generator B6 enters the unit on terminal 8 of plug P1, is developed across resistor R11, passes through resistor R10, and leaves the unit at terminal 11 of plug P1.

h. Elevation coupling unit (pages 160 and 269) in automatic mode of operation.

(1) The 400-cps signal from the elevation angle modulator enters the coupling unit on terminal 4 of plug P1; passes through potentiometer R22, across developing resistor R23, through resistor R2, across developing resistors R1, R3, R6, R4 and R5; and leaves the unit at terminal 14 of plug P1.

(2) When present, the 400-cps elevation limit signal enters the coupling unit on terminal 7 of plug P1; passes through resistor R1, across developing resistors R3, R6, R4 and R5; and leaves the unit at terminal 14 of plug P1.

(3) The 400-cps signal from the antenna drive servomotor generators B4 and B5 enters the coupling unit on terminal 15 of plug P1, is developed across resistor R9, and then takes two separate courses. One course is through resistor R8, across developing resistors R6, R4 and R5, R3, and R1, and out at terminal 14 of plug P1. The other course is through resistor R10 and out at terminal 11 of plug P1.

(4) The 400-cps signal from the elevation intermediate drive synchro control transformer B1 enters the unit on terminal 3 of plug P1, is developed across resistor R12, passes through resistor R11, and leaves the unit at terminal 11 of plug P1.

(5) The 400-cps signal from elevation intermediate drive servomotor generator B2 enters the unit on terminal 12 of plug P1, is developed across resistor R14, and then takes two separate courses. One is through resistor R13 and out at terminal 11 of plug P1, and the other is through resistor R15 and out at terminal 9 of plug P1.

(6) The 400-cps signal from the elevation rate potentiometer R3 enters the coupling unit on terminal 1 of plug P1; passes through potentiometer R19, across developing resistor R25, through resistor R18, and across developing resistor R16; and leaves the unit at terminal 9 of plug P1.

(7) The 400-cps signal from the elevation handwheel drive servomotor generator B1 enters the coupling unit on terminal 5 of plug P1, is developed across resistor R21, passes through resistor R20, and leaves the unit at terminal 9 of plug P1.

i. Elevation coupling unit in manual mode of operation.

(1) The 400-cps signal from elevation handwheel drive servomotor generator B1 enters the coupling unit on terminal 5 of plug P1; passes across developing resistor R21, through resistor R20, across developing resistors R18 and R19 and developing resistors R16 and R17; and leaves the unit at terminal 9 of plug P1.

(2) When present, the 400-cps elevation slewing signal enters the coupling unit on terminal 10 of plug P1; passes across developing resistor R17, through resistor R16, across developing resistors R18 and R19, and leaves the unit at terminal 9 of plug P1.

(3) The 400-cps signal from elevation intermediate drive servomotor generator B2 enters the coupling unit at terminals 6 and 12 of plug P1. The signal entering at terminal 12 passes across developing resistor R14, through resistor R15, across developing resistors R16 and R17 and developing resistors R18 and R19; and leaves the unit at terminal 9 of plug P1. The signal entering at terminal 6 passes through resistor R3, across developing resistor R1 and developing resistors R2 and R22, and leaves the unit at terminal 14 of plug P1.

(4) The 400-cps signal from the elevation intermediate drive synchro control transformer B1 enters the coupling unit on terminal 2; passes through resistor R24, across developing resistor R5, through resistor R4, across developing resistor R8 and developing resistors R2 and R22; and leaves the unit at terminal 14 of plug P1.

(5) The 400-cps signal from antenna drive servomotor generators B4 and B5 enters the coupling unit on terminal 15 of plug P1, is developed across resistor R9, passes through resistor R8, across developing resistors R6 and R7, and leaves the unit at terminal 14 of plug P1.

(6) When present, the 400-cps elevation limit signal enters the coupling unit on terminal 7 of plug P1, passes through resistor R1, across developing resistors R2 and R22, and leaves the unit at terminal 14 of plug P1.

j. Elevation coupling unit in aided-manual mode of operation. In the aided-manual mode of operation, the signal paths, described in i above, continue to exist except that resistors R18 and R19 no longer are used to develop the 400-cps signals from the elevation handwheel drive servomotor generator B1, from the elevation SLEW switch S6, and from the elevation intermediate drive servomotor generator B2 and that the 400-cps signal from the elevation rate potentiometer R3 enters the unit on terminal 1 of plug P1; passes through potentiometer R19, across developing resistor R25, through resistor R18; and leaves the unit at terminal 9 of plug P1.

k. Automatic slewing (acquiring with the AN/GSG-2 system only) (elevation coupling unit).

(1) The 400-cps signal from the AN/GSG-2 coordinate converter elevation synchro control transformer enters the coupling unit on terminal 8 of plug P1; is developed across resistor R7; passes through resistor R6, across developing resistors R4 and R5, R3, R2 and R22, and R1; and leaves the unit at terminal 14 of plug P1.

(2) When present, the 400-cps elevation limit signal enters the coupling unit on terminal 7 of plug P1; passes through resistor R1; across developing resistors R2 and R22, R3, and R4 and R5; and leaves the unit at terminal 14 of plug P1.

(3) The 400-cps signal from antenna drive servomotor generators B4 and B5 enters the unit on terminal 15 of plug P1, is developed across resistor R9, and then takes two separate routes. One is through resistor R8, across developing resistors R4 and R5, R3, R2 and R22, and R1; and out at terminal 14 of plug P1. The other is through resistor R10 and out at terminal 11 of plug P1.

(4) The 400-cps signal from the elevation intermediate drive synchro control transformer B1 enters on terminal 3 of plug P1, passes across developing resistor R12 and through resistor R11, and leaves the unit at terminal 11 of plug P1.

(5) The 400-cps signal from the elevation intermediate drive servomotor generator B2 enters on terminal 12 of plug P1, is developed across resistor R14, passes through resistor R13, and leaves the unit at terminal 11 of plug P1.

l. Operation with the track antenna control unit (elevation coupling unit).

(1) The 400-cps signal from the track antenna control unit enters the coupling unit on terminal 2 of plug P1; passes through resistor R24, across developing resistor R5, through resistor R4, and across developing resistors R6, R3, R2 and R22, and R1; and leaves the unit at terminal 14 of plug P1.

(2) When present, the 400-cps elevation limit signal enters the coupling unit on terminal 7 of plug P1; passes through resistor R1 and across developing resistors R6, R3, and R2 and R22; and leaves the unit at terminal 14 of plug P1.

(3) The 400-cps signal from the antenna drive servomotor generators B4 and B5 enters the unit on terminal 15, is developed across resistor R9, and then takes two separate paths. One is through resistor R8; across developing resistors R6, R3, R2 and R22, and R1; and out at terminal 14 of plug P1. The other is across developing resistor R9, through resistor R10, and out at terminal 11 of plug P1.

(4) The 400-cps signal from the elevation intermediate drive synchro control transformer B1 enters on terminal 3 of plug P1, is developed across resistor R12, passes through resistor R11, and leaves the unit on terminal 11 of plug P1.

(5) The 400-cps signal from the elevation intermediate drive servomotor generator B2 enters the unit on terminal 12 of plug P1, is developed across resistor R14, passes through resistor R13, and leaves the unit at terminal 11 of plug P1.

m. Range coupling unit (pages 142 and 270). When connected to a remote FDC system and with the battery target designate system in the "remote examine" condition, the following signals follow the indicated routes in the range coupling unit (all other circuits in this coupling unit are used for range positioning):

(1) The 400-cps signal from the synchro control transformer B5 in the target designate control panel enters the coupling unit on terminal 9 of plug P1, is developed across resistor R12, passes through resistor R13, and leaves the unit at terminal 11 of plug P1.

(2) The 400-cps signal from the servomotor generator B6 in the target designate control panel enters the coupling unit on terminal 10 of plug P1, is developed across resistor R14, passes through resistor R15, and leaves the unit at terminal 11 of plug P1.

n. Outputs.

(1) Azimuth coupling unit (pages 159 and 270).

(a) Automatic mode of operation.

1. The combined 400-cps signals from the azimuth angle modulator and from the antenna drive servomotor generators B3, B5, B7, and B9 are sent to the azimuth servopreamplifier from terminal 14 of plug P1.

2. The combined 400-cps signals from the antenna drive servomotor generators B3, B5, B7, and B9, from the azimuth intermediate drive synchro control transformer B5, and from the azimuth intermediate drive servomotor generator B6 are sent to low-power servoamplifier 3 from terminal 11 of plug P1.

3. The combined 400-cps signals from the azimuth intermediate drive servomotor generator B6, from the azimuth rate potentiometer R3, and from the azimuth handwheel drive servomotor generator B1 are sent to low-power servoamplifier 4 from terminal 9 of plug P1.

(b) Manual mode of operation.

1. The combined 400-cps signals from the azimuth handwheel drive servomotor generator B1 and from the azimuth intermediate drive servomotor generator B6 are sent to low-power servoamplifier 4 through terminal 9 of plug P1.

2. The combined 400-cps signals from the azimuth intermediate drive servomotor generator B6, from the azimuth intermediate drive synchro control transformer B5, and from the antenna drive servomotor generators B3, B5, B7, and B9 are sent to the azimuth servopreamplifier through terminal 14 of plug P1.

(c) Aided-manual mode of operation. The output signals are as described in subparagraph (b) above, except that the 400-cps signal from the azimuth rate potentiometer R3 also is combined with the signals from the azimuth handwheel drive servomotor generator B1 and from the azimuth intermediate drive servomotor B6 and is sent to low-power servoamplifier 4 from terminal 9 of plug P1.

(d) Automatic slewing.

1. The combined 400-cps signals from either the target designate control panel synchro control transformer B5 or the FDC coordinate converter azimuth synchro control transformer and from the antenna drive servomotor generators B3, B5, B7, and B9 are sent to the azimuth servopreamplifier through terminal 14 of plug P1.

2. The combined 400-cps signals from the antenna drive servomotor generators B3, B5, B7, and B9, from the azimuth intermediate drive synchro control transformer B5, and from the azimuth intermediate drive servomotor generator B6 are sent to low-power servoamplifier 3 from terminal 11 of plug P1.

(e) Operation with the track antenna control unit.

1. The combined 400-cps signals from the track antenna control unit and from the antenna drive servomotor generators B3, B5, B7, and B9 are sent to the azimuth servopreamplifier from terminal 14 of plug P1.

2. The combined 400-cps signals from the antenna drive servomotor generators B3, B5, B7, and B9, from the azimuth intermediate drive synchro control transformer B5, and from the azimuth intermediate drive servomotor generator B6 are sent to low-power servoamplifier 3 from terminal 11 of plug P1.

3. Any output of the combined 400-cps signals entering on terminals 1 and 5 of plug P1 need not be considered since it leaves the coupling unit on terminal 9, passes through low-power servoamplifier number 4, and then is applied to the nonexcited azimuth handwheel drive servomotor B1.

(2) Elevation coupling unit (pages 160 and 269).

(a) Automatic mode of operation.

1. The combined 400-cps signals from the elevation angle modulator, from the antenna drive servomotor generators B4 and B5, and, when

present, from the elevation limit switch, are sent to the elevation servopreamplifier from terminal 14 of plug P1.

2. The combined 400-cps signals from the antenna drive servomotor generators B4 and B5, from the elevation intermediate drive synchro control transformer B1, and from the elevation intermediate drive servomotor generator B2 are sent to low-power servoamplifier 1 from terminal 11 of plug P1.

3. The combined 400-cps signals from the elevation intermediate drive servomotor generator B2, from the elevation rate potentiometer R3, and from the elevation handwheel drive servomotor generator B1 are sent to low-power servoamplifier 2 through terminal 9 of plug P1.

(b) Manual mode of operation.

1. The combined 400-cps signals from the elevation handwheel drive servomotor generator B1, from the elevation intermediate drive servomotor generator B2, and, when present, from the elevation SLEW switch S6, are sent to low-power servoamplifier 2 through terminal 9 of plug P1.

2. The combined 400-cps signals from the elevation intermediate drive servomotor generator B2, from the elevation intermediate drive synchro control transformer B1, from the antenna drive servomotor generators B4 and B5, and, when present, from the elevation limit switch, are sent to the elevation servopreamplifier through terminal 14 of plug P1.

(c) Aided-manual mode of operation. The output signals are as described in subparagraph (b) above except that the 400-cps signal from the elevation rate potentiometer R3 also is combined with the signals from the elevation handwheel drive servomotor generator B1, from the elevation intermediate drive servomotor generator B2, and, when present, from the elevation SLEW switch S6, and is sent to low-power servoamplifier 2 from terminal 9 of plug P1.

(d) Automatic slewing (with the AN/GSG-2 system only).

1. The combined 400-cps signals from the AN/GSG-2 coordinate converter elevation synchro control transformer, from the antenna drive servomotor generators B4 and B5, and, when present, from the elevation limit switch, are sent to the elevation servopreamplifier through terminal 14 of plug P1.

2. The combined 400-cps signals from the antenna drive servomotor generators B4 and B5, from the elevation intermediate drive synchro control transformer B1, and from the elevation intermediate drive servomotor generator B2 are sent to low-power servoamplifier 1 through terminal 11 of plug P1.

(e) Operation with the track antenna control unit.

1. The combined 400-cps signals from the track antenna control unit, from the antenna drive servomotor generators B4 and B5, and, when present, from the elevation limit switch, are sent to the elevation servopreamplifier from terminal 14 of plug P1.

2. The combined 400-cps signals from the antenna drive servomotor generators B4 and B5, from the elevation intermediate drive synchro control transformer B1, and from the elevation intermediate drive servomotor generator B2 are sent to low-power servoamplifier 1 from terminal 11 of plug P1.

3. Any output of the combined 400-cps signals entering on terminals 1 and 5 of plug P1 need not be considered since it leaves the coupling unit on terminal 9 of plug P1, passes through low-power servoamplifier 2, and then is sent to the nonexcited elevation handwheel drive servomotor B1.

(3) Range coupling unit (pages 142 and 270). When connected to a remote FDC system and with the battery target designate system in the "remote examine" condition, the combined 400-cps signals from the target designate control panel synchro control transformer B5 and servomotor generator B6 are sent to low-power servoamplifier 5 through terminal 11 of plug P1.

o. Switches and adjustments.

(1) Regardless of the mode of operation, pressing the BAL (balance) switch S1 on either the elevation coupling unit or the azimuth coupling unit grounds the output from that coupling unit (terminal 14 of plug P1) to the associated servopreamplifier.

(2) Increasing the resistance of the azimuth coupling unit potentiometer R14 decreases the amplitude of the 400-cps azimuth rate potentiometer R3 signal, and, as will be shown later, thereby decreases the rate of antenna azimuth rotation resulting from the rate potentiometer signal.

(3) Increasing the resistance of the azimuth coupling unit potentiometer R17 decreases the amplitude of the 400-cps azimuth angle modulator signal, and, as will be shown later, thereby decreases the rate of antenna azimuth rotation resulting from a particular output of the angle modulator.

(4) Increasing the resistance of the elevation coupling unit potentiometer R19 decreases the amplitude of the 400-cps elevation rate potentiometer R3 signal, and, as will be shown later, thereby decreases the rate of antenna elevation rotation resulting from the rate potentiometer signal.

(5) Increasing the resistance of elevation coupling unit potentiometer R22 decreases the amplitude of the 400-cps elevation angle modulator signal, and, as will be shown later, thereby decreases the rate of antenna elevation rotation resulting from a particular output of the angle modulator.

Section X. SERVOPREAMPLIFIER

33. PURPOSE

The azimuth and elevation servopreamplifiers each accept, as an input from the associated coupling unit, a 400-cps error signal whose amplitude is proportional to the pointing error and whose phase angle, with respect to servo excitation, is either zero or 180°, depending upon the direction of the error. Since this signal is not powerful enough to supply the antenna drive servomotors, it is used only to control the high-power servo system. The servopreamplifiers are the first units in the azimuth and in the elevation high-power servo systems; their function in these high-power systems is similar to that of the low-power servoamplifiers in the servomotor systems. Each of these units converts the 400-cps input signal to a push-pull dc voltage whose magnitude and polarity are controlled by the amplitude and phase, respectively, of the 400-cps input signal.

34. LOCATION (TM 9-5000-25, page 18).

The elevation servopreamplifier is the third and the azimuth servopreamplifier is the fifth unit from the left in the rear of the target-tracking radar console control drawer. The same type units are used in the missile-tracking radar antenna positioning system.

35. OPERATION

a. Block diagram discussion (TM 9-5000-25, page 147).

(1) The 400-cps error signal from terminal 14 of the coupling unit plug P1 is applied to the 2-stage voltage amplifier V1 through terminal 3 of the servopreamplifier plug P1. Negative (current) feedback is employed between the two stages of V1; this, in effect, makes V1 a constant-current generator. The amplified voltage is then applied from V1 to the 2-stage voltage amplifier V2. A negative feedback is employed, through a bridged-T network, between the two stages of V2. This bridged-T network is used to make the feedback (and therefore the servoamplifier) frequency selective. Tubes V1 and V2 with their feedback circuits make up a frequency-selective, 4-stage voltage amplifier.

(2) The output of the 4-stage voltage amplifier is applied to the phase-sensitive demodulator V3 and V4. In addition, 400-cps servo excitation is applied as a reference voltage to V3 and V4. The 400-cps control voltage from V2 is either in phase or in phase opposition with the reference voltage, depending upon the direction of the pointing error of the target-tracking radar antenna. The demodulator compares its two inputs with each other and produces, as outputs, two pulsating dc

voltages of equal amplitude but of opposite polarity. The polarity of the push-pull output voltage is determined by the phase relationship of the control voltage and the reference voltage; and the average amplitude is proportional to the amplitude of the control voltage that is in phase or in phase opposition with the reference voltage. The two outputs are then applied through cathode followers V5A and V5B to terminals 9 and 11 of plug P1. These cathode followers reduce the output impedance of the servopreamplifier to a low value.

(3) With no error signal applied to the servopreamplifier (by closing the BAL (balance) switch S1 on the associated coupling unit), the voltage between the cathodes (pins 3 and 8) of V5A and V5B is set (by means of the BAL (balance) potentiometer R27) to zero as monitored at the test points on the output circuits.

b. Detailed circuit discussion (TM 9-5000-25, page 148).

(1) The 400-cps input control voltage is applied to terminal 3 of plug P1, which is connected directly to the grid (pin 2) of the voltage amplifier tube V1A. Each section of twin triode V1 forms one section of the 2-stage, RC-coupled voltage amplifier.

(2) The bias applied to the grid of V1A, the first amplifier stage, is established by the voltage divider R2-R1-R6 connected between -250 volts and ground. R6 also serves as the cathode resistor for V1B, the second amplifier stage. The bias applied to the grid of V1B is established by the voltage divider R3-R4-R5 connected between +250 volts and -250 volts. R3 also serves as the plate-load resistor of V1A. R7 is the plate-load resistor of V1B. Capacitor C1 couples the signals from the plate (pin 1) of V1A to the grid (pin 7) of V1B. Negative feedback is taken from the cathode (pin 8) of V1B and applied to the grid (pin 2) of V1A. (Note that this is almost identical to the 2-stage voltage amplifier of the low-power servoamplifier described in paragraph 19b(2).) The approximate static operating values of the circuit are:

(a) The current flow through V1B is approximately 0.43 ma, developing a static drop of 3.5 volts across R6.

(b) The resulting 253.5 volts across R1 and R2 are divided so that a bias of -1.1 volts is applied to the grid of V1A.

(c) This bias yields a static current of 0.55 ma through V1A and R3, which develops a drop of 133 volts across plate-load resistor R3.

(d) The resulting static voltage of 367 volts is divided so that a static potential of +2.3 volts is applied to the grid of V1B.

(e) Since the cathode of V1B is at a dc potential of 3.5 volts, the bias on V1B is -1.2 volts.

(f) With this bias, a quiescent current of 0.43 ma through R6, V1B, and R7, results as was stated in (a) above. The biasing arrangement is such that in dynamic operation of the amplifier, inverse current feedback takes place from V1B to V1A. If the current through V1B increases, the cathode of V1B becomes more positive. The voltage rise at the cathode of V1B is applied back to the grid of V1A through resistor R1, causing a drop at the plate of V1A. Capacitor C1 couples this drop to the grid of V1B. Thus, the current feedback counteracts any changes in the space current. Consequently, the effective output impedance is very high, so that voltage amplifier V1 may be regarded as a constant-current generator. The output of voltage amplifier V1 is coupled through capacitor C3 to the grid (pin 2) of voltage amplifier V2.

(3) The bias applied to the grid of V2A is determined by the quiescent cathode potential of V2B, which in turn depends upon the quiescent current through cathode resistor R13. This current is equal to the current (approximately 0.62 ma) flowing through resistor R12 (as a result of the -250 volts applied across resistors R12 and R13), minus the tube current (approximately 0.56 ma). Therefore, the net current flow through resistor R12 from cathode to ground is about 0.06 ma. The voltage thus developed across resistor R13 places the cathode of V2B at a quiescent potential of -1 volt. This dc potential also is applied to the grid of V2A through resistor R8. Tube V2A draws a quiescent current of 0.58 ma, which causes a static voltage of 140 volts to be developed across plate-load resistor R9. Therefore, the plate of V2A operates at a quiescent voltage of 110 volts. The 360 volts appearing across voltage divider R10-R11 is divided so that the dc potential at the grid of V2B is -2.1 volts, resulting in a bias of -1.1 volts for tube V2B, as required to produce the quiescent current of 0.56 ma.

(4) The voltage amplifier V2 has a frequency-selective feedback circuit to discriminate against the third harmonic of the servomotor generator signal. This feedback arrangement is identical in principle to the one used in the low-power servoamplifier (par 19b(8), (9), and (10)). This circuit, a bridged-T network, consists of resistors R7 and R8 and capacitors C2 and C3. This network causes the feedback voltage to be very small at 400 cps but to increase rapidly both above and below that frequency. Therefore, the gain of the amplifier is maximum at 400 cps but decreases rapidly at all other frequencies.

(5) The output of V2B is an amplified 400-cps voltage which is applied through capacitor C5 and resistors R15 and R16 to the phase-sensitive demodulator V3 and V4. Capacitor C6 is connected between ground and the output side of capacitor C5 to bypass any remaining high-frequency components of the 400-cps signal.

(6) Servo excitation voltage is applied to the primary of transformer T1. The secondary of this transformer applies this voltage, as a reference or carrier voltage, to the cathode (pin 1) of V3B and to the plate (pin 2) of V4B; and, in phase opposition, to the plate (pin 2) of V3A and to the cathode (pin 1) of V4A. Since the carrier voltage applied through transformer T1 has an amplitude much greater than that of the control signal applied through capacitor C5, the carrier voltage determines which pair of the four diodes is conducting and which pair is not conducting. Therefore, during one half-cycle of the servo excitation wave, V3A and V3B are nonconductive and V4A and V4B are conducting; and during the other half-cycle, V4A and V4B are nonconducting and V3A and V3B are conducting. The voltage applied by the secondary of transformer T1 is divided evenly by the voltage dividers formed by each pair of diodes with the associated resistors, i.e., during one half-cycle of the servo excitation wave, half the carrier voltage appears across V4B and resistor R20 and half appears across V4A and resistor R18; and during the other half-cycle, one-half the carrier voltage appears across V3B and resistor R19 and the other half, across V3A and resistor R17. The following subparagraphs further explain the operation of the phase-sensitive demodulator V3 and V4.

(a) Phase-sensitive demodulator, inphase operation (fig 2(1)).

1. During inphase operation, the reference voltage at terminal 1 of transformer T1 is in phase with the control voltage from V2B; and during the first half-cycle of operation, terminal 1 of transformer T1 is positive and terminal 3 is negative. Therefore, diodes V3A and V3B conduct and diodes V4A and V4B do not conduct. The voltage applied from transformer T1 to V3A and V3B is developed across voltage divider R17-V3A-V3B-R19. Since the resistance of R19 and V3B equals that of R17 and V3A, one-half the applied voltage is developed across R17 and V3A and the other half across R19 and V3B. In the absence of any control voltage applied through resistor R15, the voltage at the cathode (pin 5) of V3A and the plate (pin 7) of V3B (the midpoint of the voltage divider) remains constant and equal to the -2.25-volt potential present at the centertap of transformer T1. This voltage acts as a bias voltage for the following stage, V5A. The control voltage is applied through resistor R15 to the cathode (pin 5) of V3A and to the plate

(pin 7) of V3B; and through resistor R16 to the plate (pin 7) of V4A and to the cathode (pin 5) of V4B. Because V3B is conducting, the low-impedance path through it and resistor R19 effectively eliminates the positive alternation of the control voltage that is applied to its plate. The positive wave of the control voltage that is applied to V4A and V4B, however, is not affected by these nonconducting tubes, and therefore is applied to the RC filter circuit consisting of resistor R22 and capacitor C8. This filter causes a positive dc potential to appear across capacitor C8 and on the grid (pin 7) of V5B.

2. During the second half-cycle of operation, terminal 1 of transformer T1 continues to be in phase with the control voltage from V2B but is now negative, and terminal 3 is positive. During this period, diodes V4A and V4B conduct, diodes V3A and V3B do not conduct. The voltage applied from transformer T1 to V4A and V4B is developed across voltage divider R18-V4A-V4B-R20. Since the resistance of R20 and V4B is equal to that of R18 and V4A, one-half of the applied voltage is developed across R18 and V4A and the other half across R20 and V4B. In the absence of any control voltage applied through resistor R16, the voltage at the cathode (pin 5) of V4B and the plate (pin 7) of V4A (the midpoint of the voltage divider) remains constant and equal to the -2.25-volt potential present at the centertap of transformer T1. This voltage acts as a bias voltage for the following stage, V5B. The control voltage is applied through resistor R16 to the plate (pin 7) of V4A and to the cathode (pin 5) of V4B; and through resistor R15 to the cathode (pin 5) of V3A and to the plate (pin 7) of V3B. Because V4B now is conducting, the low-impedance path through it and resistor R20 almost completely eliminates the negative alternation of the control voltage that is applied to its cathode. However, negative wave of the control voltage that is applied to V3A and V3B is not affected by these nonconducting tubes; therefore, it is applied to the RC filter circuit consisting of resistor R21 and capacitor C7. This filter causes a negative dc potential to appear across capacitor C7 and on the grid (pin 2) of V5A.

(b) Phase sensitive demodulator, out-of phase (fig 2(2)).

1. During out-of-phase operation, the reference voltage at terminal 1 of transformer T1 is 180° out of phase with the control voltage from V2B; and during the first half-cycle of operation, terminal 1 of transformer T1 is positive, and terminal 3 is negative. Therefore, diodes V3A and V3B conduct, and diodes V4A and V4B do not conduct. Because V3A is conducting, the low-impedance path through it and resistor R17 effectively eliminates the negative alternation of the control voltage that is applied to its plate. However, the negative

wave of the control voltage that is applied to V4A and V4B is not affected by these nonconducting tubes; therefore, it is applied to the R22-C8 filter. This filter causes a negative dc potential to appear across capacitor C8 and on the grid (pin 7) of V5B.

2. During the second half-cycle of operation, terminal 1 of transformer T1 continues to be 180° out of phase with the control voltage from V2B but now is negative, and terminal 3 is positive. During this period, diodes V4A and V4B conduct and diodes V3A and V3B do not conduct. Because V4A now is conducting, the low-impedance path through it and resistor R18 almost completely eliminates the positive alternation of the control voltage that is applied to its plate. However, the positive wave of control voltage that is applied to V3A and V3B is not affected by these nonconducting tubes; therefore, it is applied to the R21-C7 filter. This filter causes a positive dc potential to appear across capacitor C7 and on the grid (pin 2) of V5A.

(7) As stated above, if there is an error signal input, the polarity of the dc potential applied to the grid of V5A is always the opposite of that applied to the grid of V5B. However, the relative polarity of the push-pull dc potentials applied to the grids of V5A and V5B during out-of-phase operation is opposite to the relative polarity of the dc potentials applied to the grids of V5A and V5B during inphase operation. Therefore, the polarity of these push-pull signals depends upon the phase of the 400-cps control voltage, which in turn, depends upon the direction of the pointing error. The magnitude of the push-pull dc signals is approximately proportional to the amplitude of the 400-cps control voltage, which in turn, depends upon the amount of the pointing error.

(8) The smoothed, demodulated control dc voltages of opposite polarities are developed across filter capacitors C7 and C8, and applied, through parasitic suppressors R23 and R24, to the grids of the cathode followers V5A and V5B, respectively. These tubes provide a low-impedance source for driving the high-power servoamplifiers. The screwdriver-adjustable potentiometer R27 enables compensation for any unbalance in the demodulator circuit by increasing the potential of one cathode and decreasing the potential of the other. Potentiometer R27 is adjusted so that the cathode-to-cathode voltage (measured across test points on the output circuits) is zero when the input to the preamplifier is zero. Because of the bias of -2.25 volts applied to the grids, the cathodes balance at very nearly zero voltage. The output of cathode follower V5A is applied to terminal 9 of plug P1, and the output of cathode follower V5B is applied to terminal 11 of plug P1.

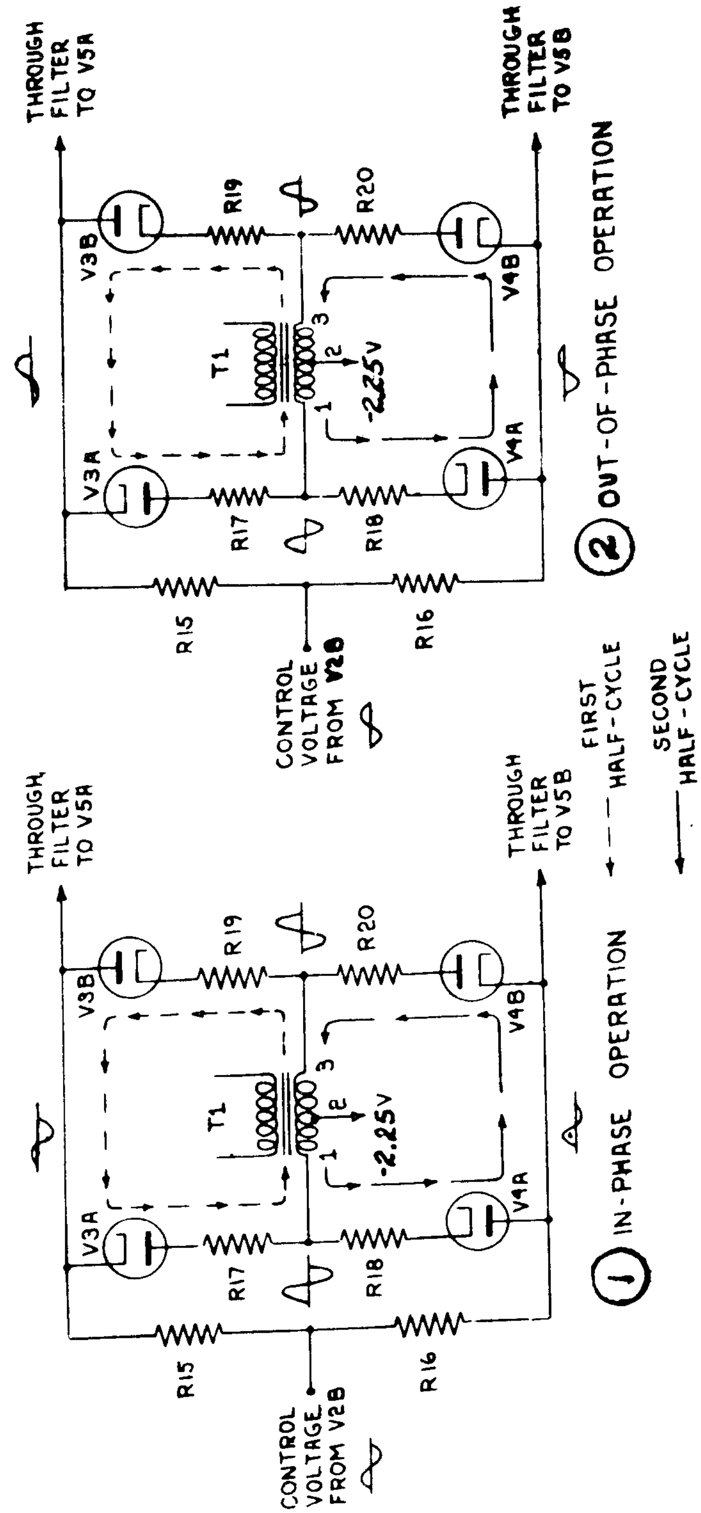

Figure 2. Phase sensitive demodulator, operational diagram.

Section XI. HIGH-POWER SERVOAMPLIFIER

36. PURPOSE

The high-power servoamplifiers convert the push-pull dc signals from the servopreamplifiers into 400-cps signals with a maximum power of 200 watts each. These signals are applied to the antenna drive servomotors. Four high-power servoamplifiers are used in the antenna azimuth positioning system, and two are used in the antenna elevation positioning system.

37. LOCATION (TM 9-5000-25, page 21).

The six high-power servoamplifiers are located in the second bay from the left in the antenna equipment enclosure. Three slides are installed in this bay, each holding two of the high-power servoamplifiers. The top slide holds azimuth high-power servoamplifiers 1 and 2; the center slide, the azimuth high-power servoamplifiers 3 and 4; and the bottom slide, the elevation high-power servoamplifiers 5 and 6. The left amplifier on each slide is the lower numbered of the two on that slide. The same type units, located in the same positions in the missile-tracking radar antenna equipment enclosure, are used in the missile-tracking radar antenna positioning system.

38. OPERATION (TM 9-5000-25)

a. Block diagram discussion (page 149). The push-pull dc signals from the servopreamplifier are applied to terminals 1 and 3 of plug P1. Across these input wires to the azimuth high-power servoamplifiers 1, 2, 3, and 4 are AZIMUTH TEST switches S5 and S6, in parallel. Switch S5 is mounted on the front of the upper high-power servoamplifier slide, and switch S6 is mounted on the front of the center high-power servoamplifier slide. Either of these switches, when closed, shorts out the input to these four high-power servoamplifiers. Across the input wires to the elevation high-power servoamplifiers 5 and 6 is ELEVATION TEST switch S7, which makes possible the shorting of the input to these high-power servoamplifiers. Switch S7 is mounted on the front of the lower high-power servoamplifier slide. The signals on terminals 1 and 3 of plug P1 are applied to the dc control windings of the magnetic modulator (saturable reactor) T1 through the dc amplifiers V1 and V2, respectively. DC amplifiers V1 and V2 accept the push-pull signals from the servopreamplifier and supply corresponding dc voltages to the dc control windings. BAL (balance) potentiometer R4 enables balancing of the unit so that the output of the magnetic modulator is measured to be zero at the test points connected to its output circuits, when the input voltage to the dc amplifiers V1 and V2 is zero (by closing the appropriate TEST switch). This potentiometer causes an increase in the current through one dc amplifier and a decrease in the current through the other dc amplifier. Phases A and B of the 400-cps servo excitation are applied to the primary ac windings of the magnetic modulator T1. The direct currents control the amplitude and the phase of the 400-cps signal induced in the output (secondary ac) windings of the magnetic modulator T1. That is, the amplitude is proportional to the differences in the magnitudes of the currents in the dc control windings of T1, and the induced current is either in phase or in phase opposition with the servo excitation, depending upon which of the control currents is greater in magnitude. The output of the high-power servoamplifier is connected to the control winding of the associated antenna drive servomotor through terminal 7 (motor red) of plug P1. External test points, located on the front of the appropriate high-power servoamplifier slides, also are connected to the output circuit through terminal 9 and to ground through terminal 5 of plug P1. Because the magnetic modulator T1 operates with its core saturated or partially saturated, its large leakage inductance appears as an additional inductor in series with the load. This additional inductance plus the inductance of the servomotor control winding would cause the voltage which appears across the motor control winding to lag behind the servo excitation (phase AB) by too great an amount, and the required 90° phase relationship between the motor control voltage and the motor excitation would not exist. To compensate for this lag, the output winding of the magnetic modulator is connected in parallel with a bank of phase correction capacitors. The total capacity of this bank can be varied by changing the strapping. At the factory, the bank is strapped correctly for the magnetic modulator T1 in the high-power servoamplifier.

b. Detailed circuit discussion (page 150).

(1) The push-pull dc control signals from the preamplifier are applied through terminals 1 and 3 of plug P1, developed across resistors R2 and R1, and then sent through parasitic suppressors R8 and R9 to the control grids (pins 1 and 7) of the pentodes V1 and V2. These tubes convert the push-pull voltages to push-pull control currents that are applied from their plates (pins 5) to the dc control windings of the magnetic modulator T1. The plate supply is applied to V1 and V2 through the ENABLE position of the ANTENNA DISABLE switch S1 (page 254) and the dc control windings of saturable reactor T1. Resistors R5 and R6, connected in series with the dc control windings of T1, provide sufficient plate-to-plate impedance for proper operation of V1 and V2. Resistors R3 and R4 provide cathode bias for V1 and V2. Potentiometer R4 enables the reducing of the current through one tube and the increasing of the current through the other tube in order to make the output of the magnetic modulator zero when the input voltage to V1 and V2 is zero. The screen voltage for V1 and V2 is obtained from the +250-volt supply through the ENABLE position of the ANTENNA DISABLE switch S1 (page 254), dropping resistor R7, and parasitic suppressors R10 and R11. Capacitors C1A and C1B are connected across the dc control windings of T1 to shunt out even harmonics of the carrier frequency

(800 cps, 1,600 cps, etc.) induced in these dc control windings from the secondary ac windings, thereby preventing additional loading of V1 and V2.

(2) In addition to the dc control currents applied to its dc control windings, the magnetic modulator T1 has 400-cps servo excitation (phase AB) applied to its primary ac windings. Figure 3, a simplified schematic of the magnetic modulator, shows that the windings of T1 are arranged on two magnetic cores, which are magnetically insulated from each other. Each of the cores forms a separate saturable-core reactor. Windings 1A and 1B are the dc control windings; 2A, 2B, 3A, and 3B are the primary ac windings; and 4A, 4B, 5A, and 5B are the secondary ac windings of T1. The magnetic flux density in the cores is not proportional to the magnetizing current, but varies approximately as indicated in the magnetization curve shown in figure 3. Therefore, the same variation of primary alternating current produces a greater change of flux when the core is operated at a steeper portion of the magnetization curve than when it is operated at a flatter portion. Since the voltage induced in the secondary ac windings is proportional to the change of flux, the ratio of the primary ac winding current to the secondary ac winding current depends upon the location of the core operating point on the magnetization curve. This operating point is established by the nonvarying flux induced by the dc control current (from V1 and V2) in the dc control windings. As the dc control current increases, the operating point is shifted from a steeper to a flatter portion of the magnetization curve, and the current induced in the secondary ac winding (4 or 5) is decreased. (The theory of saturable reactors is more fully discussed in TM 11-467, paragraph 35f.) The operation of this magnetic modulator is more fully discussed in the following subparagraphs:

(a) Under no-error conditions, the currents flowing through V1 and V2 are equal, and therefore, equal direct currents flow in the dc control windings (1A and 1B) of the two cores, inducing equal voltages at points X and Y with respect to T1 terminals 6 and 7, respectively. The output windings 4 and 5 are so connected in series that the voltages induced at points X and Y are in phase opposition with each other. Therefore, the two induced voltages, equal in amplitude and 180° out of phase, cancel under no-error conditions.

(b) When the direction of error is such as to increase the conduction of V1, the control current in the dc control winding 1B increases. This causes the operating point of the lower core to move to a flatter portion of the magnetization curve and thereby reduces the amplitude of the ac signal induced in the secondary ac windings 4A and 4B. At the same time, the conduction of V2 decreases, causing a corresponding decrease in the control current in the dc control winding 1A. This causes the operating point of the upper core to move to a steeper portion of the magnetization curve and thereby increases the amplitude of the ac signal induced in the secondary ac windings 5A and 5B. As a result, the output signal at T1 terminal 6 is in phase with the signal at point Y and has an amplitude equal to the difference between the voltages induced in the secondary ac windings 4 and 5.

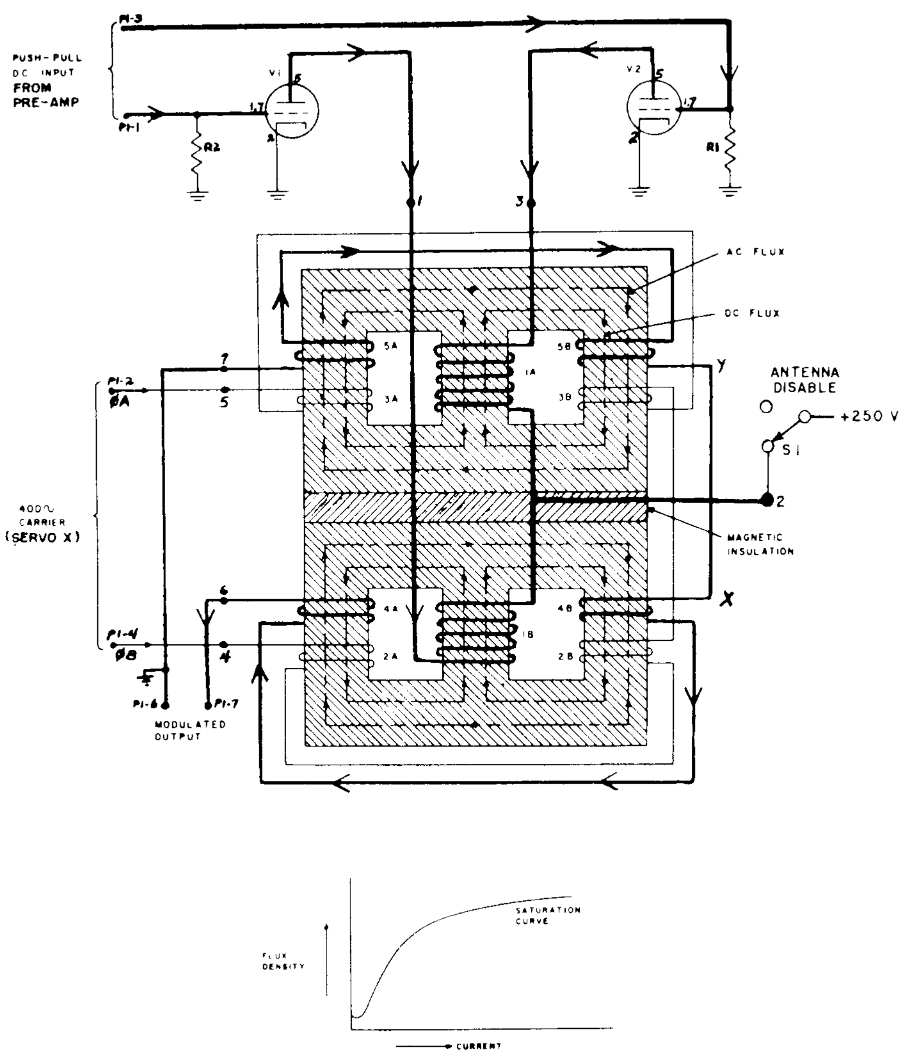

Figure 3. Magnetic modulator, simplified schematic.

(c) When the direction of error is reversed, the operation is reversed, and the amplitude of the ac signal induced in the secondary ac windings 4A and 4B increases and that induced in secondary ac windings 5A and 5B decreases. Therefore, the output signal at T1 terminal 6 continues to have an amplitude equal to the difference between the voltages induced in the secondary ac windings 4 and 5, but now is in phase with the signal at point X and in phase opposition with that at point Y.

(3) Capacitor C2 (probably plus one or more of capacitors C3A and C3B, C4A, C4B, and C5) is connected between the output terminal 6 of T1 and ground. The number of capacitors required in addition to capacitor C2 depends upon the capacitance required to resonate the particular magnetic modulator T1 with an antenna drive servomotor control winding. This amount of capacitance required is determined and the appropriate capacitors connected, by strapping, at the factor. (For some antenna drive servomotors, it may be necessary to change the strapping on a replacement high-power servoamplifier.)

(4) The 400-cps output signal then is applied through terminal 7 (motor red) of plug P1 to the control winding of the antenna drive servomotor. Terminal 12 (motor neutral) of plug P1 is connected to the other end of this control winding. Test points are connected through terminals 9 and 5 of plug P1 to motor red and to motor neutral, respectively. Each high-power servoamplifier slide has one motor neutral test point and has a motor red test point for each of its two high-power servoamplifiers.

Section XII. ANTENNA DRIVE SERVOMOTOR GENERATOR

39. PURPOSE

Four Diehl 2-phase induction motors are employed in the antenna azimuth positioning system, and two are used in the antenna elevation positioning system to convert the 400-cps signals from the high-power servoamplifiers into mechanical motions of the antenna. A 400-cps generator is connected to the output shaft of each motor to provide a feedback signal to the servo system. In addition, within each motor-generator housing is a blower motor that cools the servomotor generator.

40. LOCATION (TM 9-5000-25)

a. Antenna elevation drive servomotor generators (page 20). The antenna elevation drive servomotor B2A, blower motor B2B, and generator B4 are contained in the forward housing; the elevation drive servomotor B3A, blower motor B3B, and generator B5 are contained in the rear housing below the trunnion in the left, from the rear, trunnion arm of the antenna. The same type units are similarly located in the missile-tracking radar antenna.

b. Antenna azimuth drive servomotor generators (page 22). In the azimuth drive equipment enclosure, the antenna azimuth drive servomotor B2A, blower motor B2B, and generator B3 are contained in the rear housing; servomotor B4A, blower motor B4B, and generator B5, in the housing beside the curbside jack support; servomotor B6A, blower motor B6B, and generator B7, in the forward housing; and servomotor B8A, blower motor B8B, and generator B9, in the housing beside the front roadside jack support. The same type units are similarly located in the missile-tracking radar antenna.

41. OPERATION (TM 9-5000-25)

a. Elevation drive servomotor generators (pages 162 and 269).

(1) Terminals 7 and 12 of plug P1 on high-power servoamplifier 5 are connected, through the slipring assembly, to the control winding of the antenna elevation drive servomotor B2A; and terminals 7 and 12 of plug P1 on high-power servoamplifier 6 are similarly connected to the control winding of the antenna elevation drive servomotor B3A. Each of these 2-phase induction motors contains a squirrel-cage rotor and two stator windings, displaced in electrical quadrature. The 400-cps motor excitation is applied, through the ENABLE position of the ANTENNA DISABLE switch S1, to the other stator winding (page 252). When present, the 400-cps control signal from the associated high-power servoamplifier either leads or lags the motor excitation signal by 90°, depending upon the direction of the pointing error. This lead or lag determines the direction of rotation of the servomotor output shaft. A torque, roughly proportional to the error voltage, is applied to the output shaft by each motor. The output shafts of the motors are geared to the elevation drive shaft of the target-tracking radar antenna. Thus, the motors jointly drive the antenna in such an elevation direction as to reduce the pointing error, thereby reducing the control signal from the elevation high-power servoamplifiers.

(2) Generator B4 is on a common shaft with antenna elevation drive servomotor B2A; and generator B5 is on a common shaft with the elevation drive servomotor B3A. Each of these generators has two stator windings in electrical quadrature and a squirrel-cage rotor. A 400-cps tachometer excitation voltage is applied to one of the stator windings in each motor through PHASE (EL TACH ADJ) potentiometer R13 (page 252). The output windings of the two generators are connected in parallel to terminal 15 of the elevation coupling unit plug P1. The phase angle between the combined generator outputs and the excitation signal can be zeroed by PHASE potentiometer R13, purpose and operation of which is the same as that of PHASE potentiometer R2 in the handwheel drive, described in paragraph 16a. (The PHASE potentiometer R13 is located beside the rear right corner of the elevation handwheel drive assembly in the target-tracking radar control drawer (page 18).)

(3) To cool each of the antenna elevation drive servomotor generators, an impeller is mounted on a separate shaft that is driven continuously by a single-phase, capacitor-run induction motor. Blower motor B2B is used for the servomotor B2A-generator B4 combination, and blower motor B3B is used for the servomotor B3A-generator B5 combination. The two windings of each blower motor are connected to form a T, so that there are only three input leads. The 400-cps motor excitation is applied between the leads Y and G, the neutral side of the motor excitation being connected to G. The third lead, BK, is connected through a phase-shifting capacitor to the Y lead, providing the desired direction of rotation. The phase-shifting capacitor for blower motor B2B is C1 and for blower motor B3B is C2. Therefore, these blower motors operate whenever full excitation power is applied, regardless of whether or not the antenna elevation drive servomotor generator rotors are stationary.

b. Azimuth drive servomotor generators (TM 9-5000-25, pages 161 and 270)

(1) Terminals 7 and 12 of plug P1 on high-power servoamplifiers numbers 1, 2, 3, and 4 are connected to the control windings of the antenna azimuth drive servomotors B2A, B4A, B6A, and B8A, respectively. These motors are the same type as those used in the antenna elevation positioning system. The 400-cps motor excitation similarly is applied to the other motor stator windings through the ENABLE position of the ANTENNA DISABLE switch S1 (page 252). The motors are geared to the azimuth drive shaft of the target-tracking radar antenna, which they jointly drive. These four motors apply a torque to their output shafts which is approximately proportional to the error voltage. The direction of the torque is such as to drive the antenna toward the correct azimuth, thereby reducing the pointing error and the resulting error voltage.

(2) Generators B3, B5, B7, and B9 are each on a common shaft with the antenna azimuth drive servomotors B2A, B4A, B6A, and B8A, respectively. The 400-cps tachometer excitation voltage is applied to one stator winding in each motor through the PHASE (AZ TACH ADJ) potentiometer R14 (page 252). The output windings of all these generators are connected in parallel to terminal 15 of the azimuth coupling unit plug P1, and the purpose of potentiometer R14 is the same as that of PHASE potentiometer R13 in the antenna elevation positioning system (par 41a(2)). This potentiometer R14 is the second unit in front of low-power servoamplifier 6 in the target-tracking radar console control drawer (page 18).

(3) Each of the antenna azimuth drive servomotor generators also are cooled by a continuously driven blower motor. Blower motor B2B is used for the servomotor B2A-generator B3 combination; blower motor B4B, for the servomotor B4A-generator B5 combination; blower motor B6B, for the servomotor B6A-generator B7 combination; and blower motor B8B for the servomotor B8A-generator B9 combination. These motors, being of the same type and connected in the same way, operate the same as those in the antenna elevation positioning system (par 41a (3)). The phase shifting capacitor for blower motor B2B is C1, for blower motor B4B is C2, for blower motor B6B is C3, and for blower motor B8B is C4.

Section XIII. SYNCHROS

42. PURPOSE

In addition to the previously discussed synchros in the intermediate drive assemblies (par 22b), in the target designate control panel (par 26), and in the FDC coordinate converter (par 29), the antenna azimuth and elevation positioning systems each have four synchro transmitters geared to the antenna positioning drive servomotor shafts. The antenna azimuth positioning system also has another synchro, similarly connected, called the track azimuth resolver. The purpose of all these synchro transmitters is to provide remote indication, either of the position of the antenna or of the rate and direction (the velocity) of the antenna movement.

43. LOCATION (TM 9-5000-25)

a. Antenna elevation positioning system synchro transmitters.

(1) The 25-speed synchro control transmitter B1 is located to the rear of the trunnion in the right, from the rear, trunnion arm of the antenna (page 20).

(2) The 1-speed synchro control transmitter B1 is the lower synchro in the elevation data unit in the right, from the rear, trunnion arm of the antenna (pages 20 and 22).

(3) The 1-speed (coarse) synchro data transmitter B2 is located just above and to the left of the 1- speed synchro control transmitter B1 in the elevation data unit (page 22).

(4) The 16-speed (fine) synchro data transmitter B3 is located just above and to the left of the 1-speed (coarse) synchro data transmitter B2 in the elevation data unit (page 22).

b. Antenna azimuth positioning system synchro transmitters (page 22).

(1) The 25-speed synchro control transmitter B1 is located just to the rear of the pintle in the azimuth drive equipment enclosure.

(2) The 1-speed target acquisition synchro control transmitter B1 is the rearmost synchro in the azimuth data unit within the azimuth drive equipment enclosure.

(3) The 1-speed (coarse) synchro data transmitter B2 is located between the 1-speed target acquisition synchro control transmitter B1 and the 16-speed (fine) synchro data transmitter B3 in the azimuth data unit.

(4) The 16-speed (fine) synchro data transmitter B3 is the synchro nearest the antenna pintle in the azimuth data unit.

(5) The 1-speed track azimuth resolver B4 is the synchro farthest from the antenna pintle in the azimuth data unit.

44. OPERATION

a. Antenna elevation positioning system synchro transmitters.

(1) The shaft of the 25-speed synchro control transmitter B1 is geared to the antenna elevation drive shaft at a step-up speed ratio of 1:25. One end (R2) of the rotor winding is neutral and the other end (R1) is connected to servo excitation. The stator windings (S1, S2, and S3) are connected to the stator windings of the elevation intermediate drive assembly control transformer B1 (par 22b); and, when the track antenna control unit is connected, to the stator windings of the elevation remote control transformer B2 (par 49a and TM 9-5000-25, pages 162 and 269).

(2) The shafts of the 1-speed synchro control transmitter B1, the 1-speed (coarse) synchro data transmitter B2, and the 16-speed (fine) synchro data transmitter B3 are geared to the elevation data unit main shaft which, in turn, is geared to the antenna elevation drive gear (TM 9-5000-26, page 45). The ratio of synchro shaft rotation to antenna rotation is 1:1 for synchros B1 and B2, and is 16:1 for synchro B3. One end (R2) of the rotor windings of all three synchros is neutral, and the other end (R1) is connected to servo excitation in

the case of synchro B1 and to motor excitation in the cases of synchros B2 and B3 (TM 9-5000-26, page 44 and TM 9-5000-25, pages 252, 269, and 273). The stator windings (S1, S2, and S3) of the 1-speed synchro control transmitter B1 will be connected to the stator windings of the AN/GSG-2 coordinate converter elevation synchro control transformer; those of the 1-speed (coarse) synchro data transmitter B2 are connected to the like-numbered stator windings of the coarse synchro data repeater B1 on the target-tracking radar console elevation indicator chassis; and those of the 16-speed (fine) synchro data transmitter B3 are connected to the like-numbered stator windings of the fine synchro data repeater B2 on the same indicator chassis. These repeating synchros are excited by the same signal as are the transmitting synchros. Therefore, their rotor windings are synchronized and the dials on the repeater shafts indicate the elevation of the antenna (TM 9-5000-25, page 5 and FM 44-80, figure 26).

b. Antenna azimuth positioning system synchro transmitters (TM 9-5000-25)

(1) The shaft of the 25-speed synchro control transmitter B1 is geared to the antenna azimuth drive shaft at a step-up ratio of 1:25. One end (R2) of the rotor winding is neutral and the other end (R1) is connected to servo excitation. The stator windings (S1, S2, and S3) are connected to the stator windings of the azimuth intermediate drive assembly synchro control transformer B5 (par 22b); and, when the track antenna control unit is connected, to the stator windings of the azimuth remote control transformer B1 (par 49a and pages 161 and 270).

(2) The shafts of the 1-speed target acquisition synchro control transformer B1, the 1-speed (coarse) synchro data transmitter B2, the 16-speed (fine) synchro data transmitter B3, and the 1-speed track azimuth resolver B4 are geared to the azimuth data unit main shaft which, in turn, is geared to the antenna azimuth drive gear (TM 9-5000-26, page 43). The ratio of synchro shaft rotation to antenna rotation is 1:1 for synchros B1, B2, and B4 and 16:1 for synchro B3. One end (R2) of the rotor windings of synchros B1, B2, and B3 is neutral, and the other end (R1) is connected to servo excitation in the case of synchro B1 and to motor excitation in the cases of synchros B2 and B3 (TM 9-5000-26, page 42 and TM 9-5000-25, pages 252, 270, and 273). The stator windings (S1, S2, and S3) of the 1-speed synchro control transmitter B1 will be connected to the stator windings of the FDC coordinate converter azimuth synchro control transformer; those of the 1-speed (coarse) synchro data transmitter B2 are connected to the stator windings of the coarse synchro data repeater B1 on the target-tracking radar console azimuth indicator chassis; and those of the 16-speed (fine) synchro data transmitter B3 are connected to the stator windings of the fine synchro data repeater B2 on the same indicator chassis. These repeating synchros are excited by the same signal as are the

transmitting synchros. Therefore, their rotor windings are synchronized and the dials on the repeater shafts indicate the azimuth of the antenna (TM 9-5000-25, page 5 and FM 44-80, fig 27). The operation of the track azimuth resolver B4 is discussed in paragraph 113 of TM 9-5000-9. The positions of its rotor windings determine that the azimuth locations of the PPI electronic cross and of the target-tracking radar control console precision indicator presentation are identical to that of the antenna.

Section XIV. RELAYS, SWITCHES, AND LIGHTS

45. GENERAL

Table II identifies and locates each of the relays, switches, and lights that may be considered a part of or associated with the target-tracking radar antenna positioning system.

46. DETAILED OPERATION

The detailed, sequential operation of the relays, switches, and lights is covered in part two and part three. (Appendix I shows the relay energizing circuits in a simplified form.)

Section XV. TRACK ANTENNA CONTROL UNIT (FM 44-80, figure 128)

47. PURPOSE

The track antenna control unit is a piece of test equipment which, when connected to the antenna positioning system, causes the position control of the antenna in azimuth and in elevation to be transferred from the target-tracking radar console to the track antenna control unit. Therefore, it enables an operator, in the immediate vicinity of the antenna, to position the antenna by means of the track antenna control unit.

48. LOCATION (TM 9-5000-25)

The track antenna control unit, when not in use, is stored in the lower right bay of the roadside equipment enclosure of the antenna (page 21). For use, it is connected by means of its cable to jack J7, which is the next to the bottom jack in the rear bay of the curbside equipment enclosure. (In older systems, this jack is located in the lower right-hand corner of the bay below the azimuth data unit.) The cable enables the operator to carry the unit in the immediate vicinity of the antenna, and therefore, to control the antenna's position from any point in this vicinity. The same type unit is supplied with the missile-tracking radar.

49. OPERATION (TM 9-5000-25, page 158 or pages 269 and 270).

a. Remote synchro control transformers. When the track antenna control unit is connected to the antenna positioning system, the stator windings (S1, S2 and S3) of the azimuth remote synchro control transformer B1 are connected to the stator windings (S1, S2, and S3) of the azimuth 25-speed synchro control transmitter B1; and the stator windings (S1, S2, and S3) of the elevation remote synchro control transformer B2 are connected to the stator windings of the elevation 25-speed synchro control transmitter B1. One end (R2) of the rotor winding in each of these remote synchro control transformers is connected to one contact of the associated (azimuth or elevation) slew switch. When this switch is in the center (nonslew) position, this contact is connected to ground. When this slew switch is in either the INCREASE or the DECREASE position, this contact is open. The other end (R1) of the rotor winding is connected through the associated slew switch to the output terminal (R or N) of the cable plug P1 when the slew switch is in its center (nonslew) position. When the slew switch is in either its INCREASE or its DECREASE position, R1 also is open. Thus, each remote synchro control transformer has an output only when the associated slew switch is in its center position. This output is a 400-cps signal representing the differences in the positions of the rotor windings of each remote synchro control transformer and of its associated 25-speed synchro control transmitter (the antenna position) with respect to their stator windings. The rotor in each of the remote synchro control transformers is manually positioned by the operator by turning either the coarse (outer) or the fine (inner) control knob on the track antenna control unit. Thus the operator has direct control of the phase and amplitude of the 400-cps synchro signal.

b. Slewing. Servo excitation is applied to the primary of transformer T1 (page 252). With the slew switches in the center positions, the secondary of transformer T1 has no connection. With either slew switch in either its INCREASE or its DECREASE position, ground is applied to the center tap of the transformer T1 secondary; and the output terminal (R or N) of cable plug P1 is connected, depending upon the position of and through the operated switch, to one end or the other of the transformer T1 secondary. Thus, depending upon whether the switch is in the INCREASE or the DECREASE position, a 400-cps signal that is either in phase or in phase opposition with servo excitation is applied to the output terminal.

Table II. Antenna Positioning System Relays, Switches, and Lamps

NUMBER			NAME	COLOR	LOCATION	LOCATION REFERENCE TM 9-5000-
Relay	Switch	Lamp				
K1			Coast		Angle modulator	25, page 18
K1			Dither		Dither oscillator	25, page 19
K1			Elevation Remote Control		Left relay on chassis behind the elevation handwheel drive	25, page 18
K1			Plunge		Front relay on rear unit on slide in upper right bay of TTR console	25, pages 17 and 18
K2			DC Aid and Discharge		Angle modulator	25, page 18
K2			Elevation Acquire		2d relay from left on the chassis behind the elevation handwheel drive	25, page 18
K2			Servo Test		Rear relay on rear unit on slide in upper right bay of TTR console	25, pages 17 and 18
K2			Target Designated		Tactical signal panel	26, page 192 and FM 44-80, fig 7
K3			Elevation Man-Aid		2d relay from right on the chassis behind the elevation handwheel drive	25, page 18
K4			Elevation Man-Aid		Right relay on chassis behind the elevation handwheel drive	25, page 18
K4			Target Confirmed		Tactical signal panel	26, page 192 and FM 44-80, fig 7
K5			Remote Acquire		Left relay on chassis to the right of the elevation handwheel drive	25, page 18

Table II. Antenna Positioning System Relays, Switches, and Lamps (continued)

NUMBER			NAME	COLOR	LOCATION	LOCATION REFERENCE TM 9-5000-
Relay	Switch	Lamp				
K5			Target Tracked		Tactical signal panel	26, page 192 and FM 44-80, fig 7
K6			Acquire		2d relay from left on the chassis to the right of the elevation handwheel drive	25, page 18
K7			Trim		2d relay from right on the chassis to the right of the elevation handwheel drive	25, page 18
K8			Acquire		Right relay on chassis to the right of the elevation handwheel drive	25, page 18
K9			Remote Acquire		Left relay on the chassis behind the azimuth handwheel drive	25, page 18
K10			Azimuth Remote Control		2d relay from left on the chassis behind the azimuth handwheel drive	25, page 18
K11			Azimuth Local Acquire		3d relay from left on the chassis behind the azimuth handwheel drive	25, page 18
K12			Azimuth Man-Aid		4th relay from left on the chassis behind the azimuth handwheel drive	25, page 18
K13			Azimuth Man-Aid		5th relay from left on the chassis behind the azimuth handwheel drive	25, page 18
K14			ATC Disable		4th relay from right on the chassis behind the azimuth handwheel drive	25, page 18
K23			Local - Remote		Right relay on the chassis behind the range handwheel drive	25, page 18

Table II. Antenna Positioning System Relays, Switches, and Lamps (continued)

NUMBER			NAME	COLOR	LOCATION	LOCATION REFERENCE TM 9-5000-
Relay	Switch	Lamp				
	S1		ANTENNA DISABLE		2d switch from top in curbside equipment enclosure rear bay. (In older systems, switch to left of jack J1 in roadside equipment enclosure below azimuth data unit.)	25, page 20 (25, page 21)
	S1		AZIMUTH SLEW		Track antenna control unit	FM 44-80, fig 128
	S1		BALance		Azimuth angle modulator	25, page 18
	S1		BALance		Elevation angle modulator	25, page 18
	S1		BALance		Azimuth coupling unit	25, page 18
	S1		BALance		Elevation coupling unit	25, page 18
	S1		DITHER		Dither oscillator	25, page 19
	S1		TRACKED		1st switch to left of azimuth handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S2		0° Elevation Limit		In front of trunnion in left, from rear, antenna trunnion arm	25, page 20
	S2		ELEVATION SLEW		Track antenna control unit	FM 44-80, fig 128
	S2		OFF TARGET		2d switch to left of azimuth handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S3		180° Elevation Limit		Behind trunnion in left, from rear, antenna trunnion arm	25, page 20
	S4		DISABLE		1st switch to right of elevation handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S4		LOCAL-REMOTE		Below synchro dials on target designate control panel	26, page 193; and FM 44-80, fig 9
	S4		90° Elevation Limit		Forward switch above trunnion in left, from rear, antenna trunnion arm	25, page 20

Table II. Antenna Positioning System Relays, Switches, and Lamps (continued)

NUMBER			NAME	COLOR	LOCATION	LOCATION REFERENCE TM 9-5000-
Relay	Switch	Lamp				
	S5		ACQUIRE		3d switch to left of azi-azimuth handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S5		AZIMUTH TEST		Front of top high-power servoampli-fier slide	25, page 21
	S5		RELEASE		Lower left switch on target designate control panel	26, page 193; and FM 44-80, fig 9
	S5		90°Elevation Limit		Rear switch above trunnion in left, from rear, antenna trunnion arm	25, page 20
	S6		AZIMUTH TEST		Front of center high-power servoampli-fier slide	25, page 21
	S6		ELEVATION SLEW		1st switch to left of elevation handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S6		REMOTE EXAMINE		Upper right switch on target designate control panel	26, page 193; and FM 44-80, fig 9
	S7		ELEVATION TEST		Front of bottom high-power servoampli-fier slide	25, page 21
	S7		TRIM		Upper left switch on target designate control panel	26, page 193; and FM 44-80, fig 9
	S8		ELEVATION MAN-AID-AUTO		2d switch to left of elevation handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S8		DESIGNATE-ABANDON		Lower right switch on target designate control panel	26, page 193; and FM 44-80, fig 9
	S9		AZIMUTH MAN-AID-AUTO		4th switch to left of azimuth handwheel	25, pages 5 and 18; and FM 44-80, fig 29
	S12		TEST-OPERATE		Upper switch immedi-ately to right of azimuth handwheel	25, pages 5 and 18; and FM 44-80, fig 29

Table II. Antenna Positioning System Relays, Switches, and Lamps (continued)

NUMBER			NAME	COLOR	LOCATION	LOCATION REFERENCE TM 9-5000-
Relay	Switch	Lamp				
	S13		SERVOS TEST		Lower switch immediately to right of azimuth handwheel	25, pages 5 and 18; and FM 44-80, fig 29
		I1	DITHER	Neon	Dither oscillator	25, page 19
		I1	REMOTE EXAMINE	White	Upper right lamp on target designate control panel	26, page 193; and FM 44-80, fig 9
		I1	DESIGNATE	Amber	Target signal panel	25, page 5; and FM 44-80, fig 28
		XI1	COAST	Red	The light to right of elevation handwheel	25, page 5; and FM 44-80, fig 29
		I2	TRIM	White	Upper left lamp on target designate control panel	26, page 193; and FM 44-80, fig 9
		I2	DESIGNATE	Green	Target signal panel	25, page 5; and FM 44-80, fig 28
		XI2	REMOTE DATA	Green	The light to left of elevation handwheel	25, page 5; and FM 44-80, fig 29
		I3	CONFIRM	Amber	Target signal panel	25, page 5; and FM 44-80, fig 28
		I4	CONFIRM	Green	Target signal panel	25, page 5; and FM 44-80, fig 28
		I5	TRACK	Amber	Target signal panel	25, page 5; and FM 44-80, fig 28
		I6	TRACK	Green	Target signal panel	25, page 5; and FM 44-80, fig 28
		I8	ADVANCE DATA	White	Tactical control panel	26, page 193; and FM 44-80, fig 10
		I9	TARGET DESIGNATE	Green	Tactical control signal panel	26, page 192; and FM 44-80, fig 12

Table II. Antenna Positioning System Relays, Switches, and Lamps (continued)

NUMBER			NAME	COLOR	LOCATION	LOCATION REFERENCE TM 9-5000-
Relay	Switch	Lamp				
		110	TARGET DESIGNATE	Amber	Tactical control signal panel	26, page 192; and FM 44-80, fig 12
		111	TARGET CONFIRM	Green	Tactical control signal panel	26, page 192; and FM 44-80, fig 12
		112	TARGET CONFIRM	Amber	Tactical control signal panel	26, page 192; and FM 44-80, fig 12
		113	TARGET TRACK	Green	Tactical control signal panel	26, page 192; and FM 44-80, fig 12
		114	TARGET TRACK	Amber	Tactical control signal panel	26, page 192; and FM 44-80, fig 12

PART TWO

NORMAL SYSTEM OPERATION

CHAPTER 3

TARGET AZIMUTH DESIGNATION

Section I. LOCAL OPERATION

50. GENERAL OPERATION

In local operation, the battery control officer detects the aircraft on the battery control console plan position indicator (PPI), identifies the aircraft by IFF, and after evaluation, may designate it to the target-tracking radar operators as a target for them to track. The process of target designation consists of his manually causing the intersection of the range circle and the steerable azimuth line to appear over the PPI target pip, and then notifying the target-tracking radar operators by a light and a buzzer that the approximate azimuth and range of the designated target is available to them. (No target elevation data is made available.)

NOTE: It is not necessary that an aircraft be identified as FOE to designate it a target to track, but it is unlikely that the battery control officer would so designate an aircraft identified as FRIEND.

51. DETAILED OPERATION (TM 9-5000-25)

a. Making azimuth data available (fig 4 and TM 9-5000-25, pages 270 and 272).

(1) The LOCAL-REMOTE switch S4 is in its LOCAL position, the ACQUIRE switch S5 is in its nonacquire position, and the track antenna control unit is not connected. As a result, acquire relay K6, remote acquire relay K9, azimuth remote control relay K10, azimuth local acquire relay K11, and local-remote relay K23 all are deenergized. Because relay K6 is deenergized, no motor excitation or tachometer excitation voltages are applied to the target designate control panel servomotor generator B6. The stator windings of the target designate control panel azimuth synchro control transformer B5 are connected (through cable 41, contacts of deenergized remote acquire relay K9, and cable 44) to the stator windings of the target acquisition synchro control transmitter B1.

(2) The rotor of the azimuth data unit target acquisition synchro control transmitter B1 is positioned by the antenna azimuth drive gear, and the rotor of the target designate control panel synchro control transformer B5 is positioned by the target designate control panel control for the steerable azimuth line. A 400-cps signal, representing the difference in the positions of the two rotor windings with respect to their stator windings, is applied from R2 of the synchro control transformer B5 (through cable 41, contacts 1-9 of deenergized local-remote relay K23, and contacts 3-10 of deenergized azimuth remote control relay K10) to contact 5 of the deenergized azimuth local acquire relay K11.

(3) This operation may be traced, on a block diagram level, on page 151.

b. Notifying the target-tracking radar operators (page 219). After the signal that represents the difference in the azimuth of the steerable azimuth line and the azimuth of the antenna has been applied to contact 5 of the deenergized azimuth local acquire relay K11, the battery control officer notifies the target-tracking radar operators that this signal is available by placing the DESIGNATE-ABANDON switch S8 in its DESIGNATE position. This action applies a ground which:

(1) Is recorded on the event recorder,

(2) Sounds designate buzzer I13 on the target signal panel, and

(3) Energizes the target designated relay K2.

Energized relay K2 extinguishes the amber TARGET DESIGNATE lamps I1 and I10 and illuminates the green TARGET DESIGNATE lamps I2 and I9 on the target signal and tactical control signal panels. Relay K2 is held energized by a ground applied to its coil through contacts of deenergized abandon target relay K3 and through contacts of the now energized relay K2. (If the battery control officer desires to signal the target-tracking radar operators to abandon tracking the target, he places the DESIGNATE-ABANDON switch S8 in its ABANDON position. This again sounds the buzzer and energizes relay K3, opening the holding circuit for relay K2, deenergizing it and removing the ground from the event recorder channel 21. Deenergized relay K2 extinguishes the green and illuminates the amber TARGET DESIGNATE lamps.)

Section II. REMOTE OPERATION

52. GENERAL OPERATION

Prior to an engagement, the battery control officer is notified that the automatic fire direction center will automatically furnish the designated target's coordinates. He then positions the LOCAL-REMOTE switch S4 to its REMOTE position. The illuminating of the ADVANCE DATA light I8 is controlled by the FDC; and when lit, it notifies the battery control officer that the FDC has made the target designation coordinates available to him. The battery control officer now has two choices, which are to:

(1) Use the FDC-supplied data to position the range circle and the steerable azimuth line on the acquisition radar PPI, manually make necessary corrections in the position of their intersection, identify and evaluate the aircraft, and then designate the target to the target-tracking radar operators; or

(2) Assume the FDC-supplied coordinates to be correct, the target to be a FOE, and the threat to be evaluated, and therefore, immediately designate the target to the target-tracking radar operators.

The first choice normally is employed because it insures more accurate designation data, enables the battery control officer to know which target pip on the PPI is that of the designated target, and allows him to make his own identification and evaluation of the threat.

53. DETAILED OPERATION (TM 9-5000-25)

a. Making locally corrected, FDC-supplied azimuth data available (fig 4 and pages 270 and 272).

(1) The ACQUIRE switch S5 is in its nonacquire position, and the track antenna control unit is not connected. As a result, elevation remote control relay K1, acquire relay K6, remote acquire relay K9, azimuth remote control relay K10, and azimuth local acquire relay K11 all are deenergized. Positioning the LOCAL-REMOTE switch S4 to its REMOTE position provides a ground through its contacts 2-3 which energizes the remote acquire relay K5, illuminating the REMOTE DATA lamp XI2; and which, through contacts 11-6 of deenergized trim relay K7, energizes the local-remote relay K23. (The LOCAL-REMOTE switch S4 is not connected in systems that are not associated with an automatic FDC, and therefore, remote operation is not possible in such systems.)

(2) When the ADVANCE DATA lamp I8 illuminates, the battery control officer depresses the REMOTE EXAMINE switch S6. Contact 1 of this switch is grounded through contacts 3-2 of RELEASE switch S5 and contacts 2-3 of the LOCAL-REMOTE switch S4. When the REMOTE EXAMINE switch S6 is closed, this ground is applied through the switch contacts 1-2 to the coils of the acquire relay K6, of the remote acquire relay K9, and of the remote range relay K22, energizing these three relays. Relays K6, K9, and K22 are held energized by the ground applied

through contacts 2-3 of the LOCAL-REMOTE switch S4, contacts 3-2 of the RELEASE switch S5, contacts 11-7 of the deenergized acquire relay K8, contacts 9-1 of the deenergized trim relay K7, and contacts 9-2 of the now energized relay K6. (Thus when the condition of any of these relays or switches is changed, the holding circuit for relays K6, K9, and K22 is opened, deenergizing these relays and returning the system to its original remote condition.)

(3) Energizing acquire relay K6 applies ground through its contacts 12-7 to the REMOTE EXAMINE lamp I1, illuminating it; and causes motor excitation (through the relay contacts 4-10) and tachometer excitation (through the relay contacts 5-11) to be applied to the excitation windings of the target designate control panel servomotor generator B6. Energizing the remote acquire relay K9 transfers the connections of the target designate control panel synchro control transformer B5 stator windings from the stator windings of the azimuth data unit target acquisition synchro control transmitter B1 to the stator windings of the FDC coordinate converter azimuth synchro control transmitter.

(4) The rotor of the FDC coordinate converter azimuth synchro control transmitter is positioned by the FDC-supplied target azimuth coordinate, parallax-corrected; the rotor of the target designate control panel synchro control transformer B5 is positioned by the control for the steerable azimuth line. A 400-cps signal, representing the difference in the positions of the two rotors (the difference in the azimuth provided by the FDC and the azimuth of the steerable azimuth line), is applied from R2 of the target designate control panel synchro control transformer B5 (through cable 41, contacts 2-9 of energized remote acquire relay K9, resistor R13 in the range coupling unit, low-power servoamplifier number 5, and cable 19) to the control winding of the target designate control panel servomotor generator B6. This servomotor B6 drives the rotor of the target designate control panel azimuth synchro control transformer (and the steerable azimuth line) in such a direction as to reduce to zero the error signal originating at R2 of the transformer. Thus, the steerable azimuth line is positioned to the parallax-corrected azimuth transmitted from the FDC.

(5) The target designate control panel servomotor generator B6 generates a 400-cps signal as long as the associated servomotor B6 is driven. This 400-cps signal is applied, as a velocity feedback signal, from terminal 7 of the generator output winding (through cable 41 and range coupling unit resistor R15) to mix with the error signal in the range coupling unit.

(6) The above described operation may be traced on a block diagram level on the upper drawing on page 157.

(7) While the steerable azimuth line is being positioned to the FDC-supplied target azimuth, the range circle is being similarly positioned to the FDC-supplied target range. Thus, the intersection of the steerable azimuth line and the range circle on the PPI is at the azimuth and range, parallax-corrected, supplied by the FDC.

(8) If there is a target pip at this intersection, the battery control officer depresses the RELEASE switch S5, which opens the holding circuit for relays K6, K9, and K22, deenergizing them and extinguishing the REMOTE EXAMINE lamp I1. Thus, the system is returned to the original remote condition, and the FDC-supplied azimuth data may be made available as described in paragraph 53b.

(9) If the target pip is not at the intersection of the steerable azimuth line and the range circle, the battery control officer presses the TRIM switch S7, which completes the ground circuit from contacts 2-3 of the LOCAL - REMOTE switch S4 (through contacts 3-2 of the RELEASE switch S5, contacts 6-5 of the REMOTE EXAMINE switch S6, and contacts 1-2 of the now closed TRIM switch S7) to the coil of the trim relay K7, energizing relay K7. Trim relay K7 is held energized by ground applied through contacts 2-3 of the LOCAL-REMOTE switch S4, contacts 3-2 of the RELEASE switch S5, contacts 6-5 of the REMOTE EXAMINE switch S6, contacts 5-6 (the nontracked position) of the TRACKED switch S1, and contacts 10-4 of the now energized relay K7.

(10) By energizing, relay K7 opens the holding circuit for relays K6, K9, and K22, deenergizing them; opens the energizing circuit for relay K23, deenergizing it; and completes the ground circuit (through its contacts 12-7) to the TRIM lamp I2, illuminating it. Thus, the system is returned to the local condition, except that remote acquire relay K5 is energized.

(11) Since relay K5 has no effect on the antenna azimuth positioning system, a procedure identical to that described in paragraph 51 is used to designate the target, that is, the battery control officer manually positions the steerable azimuth line (and the range circle) over the PPI target pip, identifies and evaluates the target, and then designates it to the target-tracking radar operators.

(12) If for any reason, the battery control officer desires to return to the FDC-supplied coordinates, he presses the RELEASE switch S5. After the target-tracking radar is tracking the target, the target-tracking radar azimuth operator presses the TRACKED switch S1. Pressing either the RELEASE switch S5 or the TRACKED switch S1 breaks the holding circuit for relay K7, which deenergizes, extinguishing the TRIM lamp I2 and again energizing the local-remote relay K23. Thus, the system is

returned from essentially the local condition to the remote condition, enabling the battery control officer to examine the next designated target while his battery engages the original target.

b. <u>Making noncorrected, FDC-supplied azimuth data available (fig 4 and pages 270 and 272).</u>

(1) The conditions described in paragraph 53a(1) continue to exist.

(2) The stator windings of the target acquisition synchro control transmitter B1 are connected, through cable 44, to the stator windings of the FDC coordinate converter azimuth synchro control transformer. The rotor of the target acquisition synchro control transmitter B1 is positioned by the target-tracking radar antenna azimuth drive gear, and the rotor of the FDC coordinate converter azimuth synchro control transformer is positioned by the FDC-supplied target azimuth, parallax-corrected.

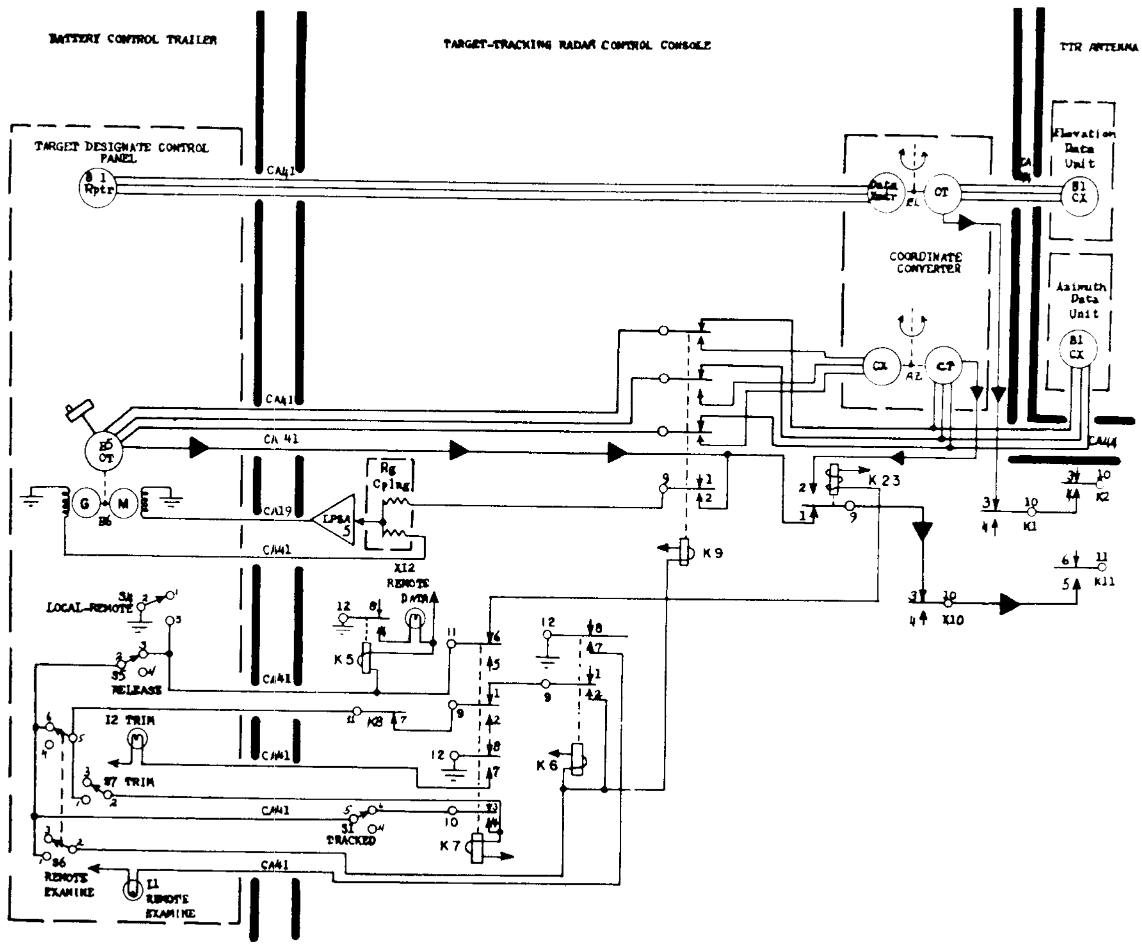

Figure 4. Designation of target coordinates.

(3) A 400-cps signal, representing the difference in the positions of the two rotor windings with respect to their stator windings (the difference in the azimuth of the antenna and the azimuth supplied by the FDC), is applied from the rotor winding R2 of the FDC coordinate converter azimuth synchro control transformer (through contacts 2-9 of energized relay K23 and contacts 3-10 of deenergized relay K10) to contact 5 of the deenergized azimuth local acquire relay K11.

(4) The above described operation may be traced, on a block diagram level, on page 151.

(5) When the ADVANCE DATA lamp I8 illuminates, the battery control officer places the DESIGNATE-ABANDON switch S8 in its DESIGNATE position. This causes the green TARGET DESIGNATE lamps to illuminate and sounds the designate buzzer as described in paragraph 51b.

CHAPTER 4

TARGET ELEVATION DESIGNATION

54. LOCAL OPERATION

The Nike system has no provision for the local acquisition radar elevation data to be made available for positioning the target-tracking radar antenna to the designated target's elevation. Instead, after the radar is on target in range and in azimuth, the target-tracking radar elevation operator must cause the antenna to search up and/or down until the target's return appears on his range scope.

55. GENERAL REMOTE OPERATION

a. Operation with the AN/GSG-2 system. Before an engagement, the battery control officer is notified that the automatic AN/GSG-2 fire direction center will automatically furnish the designated target's coordinates. He then positions the LOCAL-REMOTE switch S4 to its REMOTE position. This illuminates the REMOTE DATA lamp XI2 on the target-tracking radar control console and connects the target designate control panel ELEVATION dial so that it will provide him with a direct reading of the value of the parallax-corrected elevation coordinate when it is provided by the FDC. The lighting of the REMOTE DATA lamp informs the target-tracking radar elevation operator that he will not be required to hunt for the proper elevation, but that the elevation coordinate will be supplied for positioning the target-tracking radar antenna. The lighting of the ADVANCE DATA lamp I8 is controlled by the FDC; when illuminated, it notifies the battery control officer that the FDC has made the designated target's coordinates available to him. As stated in paragraph 52, he now may trim the azimuth and range coordinates; however, he can make no change in the elevation coordinate. He can only monitor its value as shown on his ELEVATION dial. Therefore, when he is satisfied with the azimuth and range coordinates, he designates the target (par 52). The lighting of the green TARGET DESIGNATE lamp and the sounding of the designate buzzer then notifies the target-tracking radar operators that the designated target's coordinates are available to them.

b. Operation with other automatic FDC systems. The method of presenting the designated target's elevation data received from the AN/FSG-1 or the AN/MSG-4 remote fire direction center systems has not been firmly decided as yet. This presentation may be a lag meter which could have as inputs the altitude at which the target-tracking radar is searching and the altitude supplied by the FDC. (The altitude at which the target-tracking radar is searching can be obtained by multiplying the range from the target-tracking radar range data potentiometer with the value of sin θ (from the sine potentiometer in the target-tracking radar elevation data converter). This lag meter would then deflect in one direction if the antenna was too low and in the other direction if the antenna was too high. The target-tracking radar operator then could manually position the antenna on target by moving it in such a direction as to zero the lag meter.

56. DETAILED REMOTE OPERATION WITH THE AN/GSG-2 SYSTEM (fig 4 and TM 9-5000-25, page 269)

a. Making FDC-supplied elevation data available to the target-tracking radar operators.

(1) The ACQUIRE switch S5 is in its nonacquire position, and the track antenna control unit is not connected. As a result, the elevation remote control relay K1 and the elevation acquire relay K2 are deenergized. The stator windings of the AN/GSG-2 coordinate converter elevation synchro control transformer are connected, through cable 44, to the stator windings of the 1-speed synchro control transmitter B1 in the elevation data unit. The rotor of the synchro control transmitter B1 is positioned by the target-tracking radar antenna elevation drive gear, and the rotor of the AN/GSG-2 coordinate converter synchro control transformer is positioned by the elevation signal, parallax-corrected, from the FDC.

(2) A 400-cps signal, representing the difference in the positions of the two rotor windings with respect to their stator windings (the difference in the elevation of the antenna and the elevation supplied by the FDC), is applied from rotor winding R2 of the coordinate converter elevation synchro control transformer (through contacts 3-10 of the deenergized elevation remote control relay K1) to contact 4 of the elevation acquire relay K2.

(3) This operation may be traced, on a block diagram level, on page 152.

(4) The target designation procedure is described in paragraph 51b.

b. Making FDC-supplied elevation data available to the battery control officer.

(1) The stator windings of the AN/GSG-2 coordinate converter elevation synchro data transmitter are connected, through cable 41, to the stator windings of the target designate control panel synchro data repeater B1. The rotor of the elevation synchro data transmitter is positioned by the elevation coordinate, parallax-corrected, received from the AN/GSG-2

FDC. Therefore, the rotor winding of the synchro data repeater B1 always assumes the same electrical position with respect to its stator windings as that of the coordinate converter elevation synchro data transmitter rotor winding with respect to its stator windings.

(2) Positioning the LOCAL-REMOTE switch S4 to its REMOTE position energizes the remote acquire relay K5 as described in paragraph 53a(1). This relay remains energized throughout remote operation, regardless of the presence or absence of the remote examine, trim, or release conditions.

(3) The energization of the remote acquire relay K5 reverses the application of motor excitation and of ground to the ends of the rotor winding in the AN/GSG-2 coordinate converter elevation synchro data transmitter. This results in the target designate control panel ELEVATION meter dial turning 180°, exposing its indexed face. The dial now provides a direct reading, in mils, of the FDC-supplied elevation coordinate, parallax-corrected.

CHAPTER 5

ACQUISITION OF THE TARGET IN AZIMUTH

Section I. GENERAL OPERATION

57. SLEWING OPERATION

The target-tracking radar azimuth operator, upon hearing the sounding of the designate buzzer and/or seeing the illumination of the green TARGET DESIGNATE lamp I2 on the target signal panel, immediately holds the ACQUIRE switch S5 closed, regardless of illumination condition of the REMOTE DATA lamp XI2. This causes the target-tracking radar to slew in azimuth and range (and, during remote AN/GSG-2 operation only, in elevation) to the provided coordinates of the designated target. The pip of the designated target now appears on the target-tracking radar control console precision indicator since this indicator shows an expanded portion of the area at the target-tracking radar's range and azimuth (TM 9-5000-9, fig 2). (In remote AN/GSG-2 operation, the pip also appears on the range scopes.)

58. INTERIM TRACKING OPERATION

When this slewing action ceases, the target-tracking radar azimuth operator releases the ACQUIRE switch which, being spring-loaded, opens. While the elevation operator searches for the correct antenna elevation, the target-tracking radar range and azimuth operators, with their positioning systems in the aided-manual condition, turn their handwheels in such a direction as to maintain the precision indicator target pip in its correct position with regard to the electronic cross. When the elevation operator finds the correct elevation, the target pip appears on the range scopes and the TRACKED switch S1 is pressed. At this time the acquisition phase is completed, and the tracking phase (described in ch 7) begins.

Section II. DETAILED OPERATION

59. SLEWING TO THE DESIGNATED TARGET'S AZIMUTH (fig 5 and TM 9-5000-25)

a. Switch and relay action. Immediately upon hearing the target signal panel designate buzzer I13 and/or seeing the illumination of the green TARGET DESIGNATE lamp I2 on the target signal panel, the target-tracking radar azimuth operator holds the ACQUIRE switch S5 closed. This action applies a ground through the switch contacts 5-4 to the coil of the acquire relay K8, energizing relay K8 (page 272); and applies a ground through the switch contacts 2-1 and energized target designated relay K2 contacts 5-11 to the coil of the

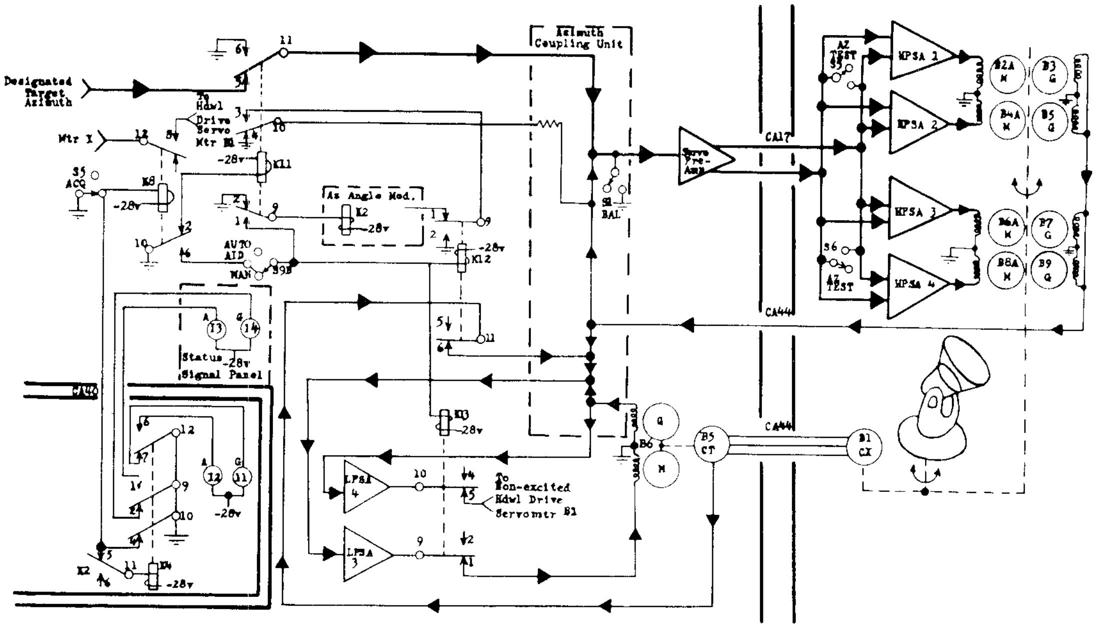

Figure 5. Slewing to the designated target's **azimuth**.

target-confirmed relay K4, energizing relay K4 (page 219). Target-confirmed relay K4 is held energized by a ground applied through its contacts 10-4 and through contacts 5-11 of the energized target-designated relay K2 to the coil of relay K4. When relay K4 is energized, it extinguishes the amber CONFIRM lamp I3 and the amber TARGET CONFIRM lamp I12 and illuminates the green CONFIRM lamp I4 and the green TARGET CONFIRM lamp I11 on the target signal and the tactical control signal panels. When the acquire relay K8 energizes, the opening of its contacts 12-8 removes the motor excitation from the azimuth handwheel drive servomotor B1 (page 252); the closing of its contacts 10-2 applies ground through these contacts to the coil of azimuth local acquire relay K11, energizing relay K11 (page 272). The energized relay K11 applies ground through its contacts 2-9 to the coil of the azimuth angle modulator dc aid and discharge relay K2, energizing this relay K2, which discharges the azimuth angle modulator capacitors C1 and C2 (par 12b). The opening of the energized acquire relay K8 contacts 10-6 and the opening of the energized azimuth local acquire relay K11 contacts 1-9 open the possible ground paths to the coils of the azimuth man-aid relays K12 and K13, keeping them deenergized regardless of the position of the MAN-AID-AUTO switch S9 (page 272). (Releasing spring-loaded ACQUIRE switch S5 causes deenergization of the azimuth angle modulator relay K2 and of the acquire relays K8 and K11.)

b. <u>Positioning the antenna in azimuth (page 270)</u>. The opening of the energized azimuth local acquire relay K11 contacts 10-3 prevents the output, if any, of the azimuth angle modulator from entering the antenna azimuth positioning system. The 400-cps signal, representing the designated target's azimuth (par 51a(2), par 53a(11), or par 53b(3)), now passes through contacts 5-11 of the energized azimuth local acquire relay K11 to terminal 7 of plug P1 on the azimuth coupling unit. The 400-cps signal from the antenna drive servomotor generators B3, B5, B7, and B9 enters the azimuth coupling unit on terminal 15 of plug P1. The mixed 400-cps designated target's azimuth and antenna drive servomotor generator velocity feedback signals are applied from terminal 14 of the azimuth coupling unit plug P1 to terminal 3 of plug P1 on the azimuth servopreamplifier. The servopreamplifier converts the signal to a push-pull dc signal that is applied from terminals 9 and 11 of its plug P1, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 1, 2, 3, and 4. Here the signal again is converted to 400 cps and is applied from terminals 7 and 12 of each high-power servoamplifier plug P1 to the control winding of the associated antenna drive servomotor B2A, B4A, B6A, or B8A. The rotors of these motors turn, rotating:

(1) The antenna toward the target's azimuth.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The shaft of the track azimuth resolver B4.

(5) The pickoff arm of the azimuth data potentiometer R7.

(6) The shaft of the target acquisition synchro control transmitter B1.

(7) The shaft of the 25-speed synchro control transmitter B1.

(8) The shafts of the antenna drive servomotor generators B3, B5, B7, and B9.

c. Results of antenna rotation.

(1) The rotation of the rotors of the coarse and fine synchro data transmitters B2 and B3 causes the dials of the coarse and fine synchro data repeaters B1 and B2 on the target-tracking radar control console azimuth indicator chassis to provide the target-tracking radar azimuth operator with the readings of the azimuth at which the antenna is pointed (par 44b(2) and page 273).

(2) The rotation of the shaft of the track azimuth resolver B4 makes the azimuth locations of the PPI electronic cross and of the target-tracking radar control console precision indicator presentation identical with that of the antenna (par 44b(2)).

(3) The signal that is picked off the azimuth data potentiometer R7 is converted to represent rectangular coordinates by part of the computer, but the converted signal is not used by the remainder of the computer at this time.

(4) Since the stator windings of the target acquisition synchro control transmitter B1 are connected, through cable 44, to those of the FDC coordinate converter azimuth synchro control transformer and (in local operation only, through cable 44, contacts of the deenergized remote acquire relay K9, and cable 41) to those of the target designate control panel azimuth synchro control transformer B5, the rotation of the shaft of the synchro control transmitter B1 causes a reduced target azimuth designation 400-cps signal to be applied from the rotor of the utilized synchro control transformer to contact 5 of the energized azimuth local acquire relay K11 (pars 51a and 53).

(5) Since the stator windings of the 25-speed synchro control transmitter B1 are connected, through cable 44, to those of the azimuth intermediate drive synchro control transformer B5, a 400-cps rotor position signal is generated by the synchro control transformer B5 because of the rotation of the shaft of the synchro control transmitter B1 (subpar d. below).

(6) The rotation of the shafts of the antenna drive servomotor generators B3, B5, B7, and B9 results in the generation of 400-cps signals, whose amplitude and phase represent the direction and speed (the velocity) of rotation of their shafts and, therefore, of the antenna. These signals are applied, through cable 44, to terminal 15 of the azimuth coupling unit plug P1.

d. Positioning the azimuth intermediate drive shaft (page 270). The 400-cps rotor position signal generated by the azimuth intermediate drive synchro control transformer B5 is applied (through contacts 11-6 of the deenergized man-aid relay K12) to terminal 8 of the azimuth coupling unit plug P1. In the azimuth coupling unit, it is mixed with the 400-cps forward feed signal, usually of like phase, from the antenna drive servomotor generators B3, B5, B7, and B9. This mixed 400-cps signal then is applied from terminal 11 of the azimuth coupling unit plug P1 to terminal 3 of low-power servoamplifier number 3 plug P1. The 400-cps output of this low-power servoamplifier is applied from terminal 11 of its plug P1 (through contacts 9-1 of the deenergized man-aid relay K13) to the control winding of the azimuth intermediate drive servomotor B6. This motor then drives the shaft of the intermediate drive synchro control transformer B5 (the intermediate drive shaft) and its attached rotor winding toward the same position as that assumed by the rotor winding of the 25-speed synchro control transmitter B1. While this motor operates, the azimuth intermediate drive servomotor generator B6 produces a 400-cps signal, that is applied as a velocity feedback signal to terminal 8 of the azimuth coupling unit plug P1. In the coupling unit, it is mixed with the 400-cps combined rotor position signal generated by the azimuth intermediate drive synchro control transformer B5 and forward speed signal generated by the antenna drive servomotor generators B3, B5, B7, and B9.

e. Block diagram discussion. This slewing operation also may be traced, on a block diagram level, on page 151.

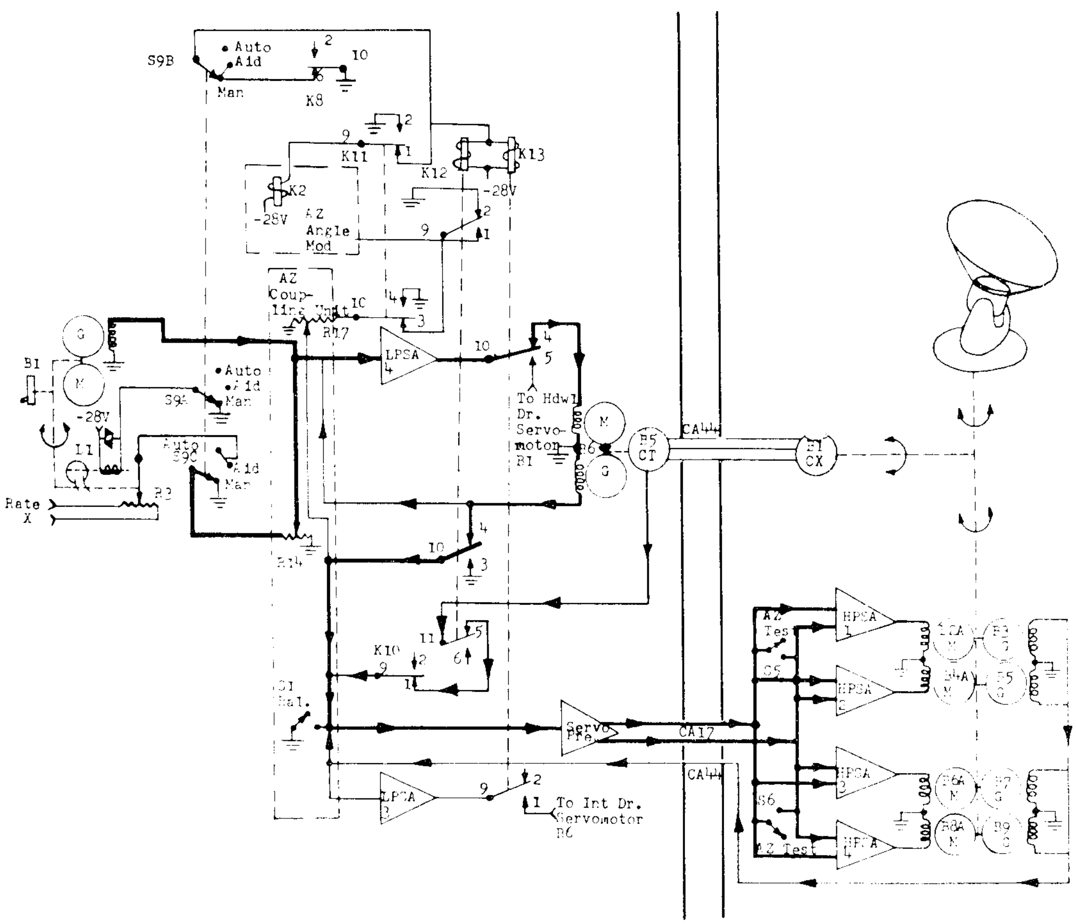

Figure 6. Azimuth aided-manual and manual operation.

60. AIDED-MANUAL OPERATION (fig 6 and TM 9-5000-25)

a. Switch, relay, and handwheel action (page 272). When the slewing action ceases, the target-tracking radar azimuth operator releases the ACQUIRE switch S5 and with his MAN-AID-AUTO switch S9 in the AID position, turns the azimuth handwheel in the proper direction to keep the precision indicator target pip in its correct horizontal position with regard to the vertical line of the electronic cross. With the azimuth MAN-AID-AUTO switch S9 in its AID position, deck A (contacts 2-A) of the switch opens the ground circuit to the azimuth handwheel drive magnetic clutch coil L1, deenergizing the coil and thereby causing the clutch to engage (par 15c). Ground from contacts 10-6 of the deenergized acquire relay K8 is applied (through deck B (contacts 2-B) of switch S9) to the coils of the man-aid relays K12 and K13, energizing relays K12 and K13; and (further through contacts 1-9 of the deenergized azimuth local acquire relay K2) to the coil of the azimuth angle modulator dc aid and discharge relay K2, energizing this relay K2 and thereby discharging the angle modulator capacitors C1 and C2 (par 12b).

b. Positioning the azimuth intermediate drive shaft (page 270). The rotation of the azimuth handwheel by the target-tracking radar azimuth operator turns the shaft of the azimuth drive servomotor generator B1 and, through the engaged magnetic clutch, positions the pickoff arm of the azimuth rate potentiometer R3. The 400-cps signal generated by the azimuth handwheel drive servomotor generator B1 is applied (as the second derivative signal) to terminal 5 of the azimuth coupling unit plug P1; and the 400-cps signal from the rate potentiometer R3 is applied (through deck C (contacts 2-C) of the MAN-AID-AUTO switch S9) to terminal 1 of the azimuth coupling unit plug P1. The mixed 400-cps signals from the azimuth rate potentiometer R3 and from the azimuth handwheel drive servomotor generator B1 are applied from terminal 9 of the azimuth coupling unit plug P1 to terminal 3 of the low-power servoamplifier number 4 plug P1. The 400-cps output of this low-power servoamplifier is sent from terminal 11 of its plug P1 (through contacts 10-4 of the energized man-aid relay K13) to the control winding of the azimuth intermediate drive servomotor B6, driving the motor and thereby turning the shafts of the azimuth intermediate drive servomotor generator B6 and synchro control transformer B5. The 400-cps output of the azimuth intermediate drive servomotor generator B6 is applied, as a velocity feedback signal, to terminal 9 of the azimuth coupling unit plug P1. Within the coupling unit, it is mixed with the combined 400-cps signals of the azimuth handwheel drive servomotor generator B1 and the azimuth rate potentiometer R3.

c. Positioning the antenna in azimuth (page 270). The 400-cps output of the azimuth intermediate drive servomotor generator B6 also is applied, as a forward feed signal (through contacts 4-10 of the energized man-aid relay K12), to terminal 6 of the azimuth coupling unit plug P1. The 400-cps rotor position signal is applied from the rotor of the azimuth intermediate drive synchro control transformer B5 (through contacts 11-5 of the energized man-aid relay K12 and contacts 1-9 of the denergized azimuth remote control relay K10) to terminal 2 of the azimuth coupling unit plug P1. The 400-cps velocity feedback signal from the antenna drive servomotor generators B3, B5, B7, and B9 enters the azimuth coupling unit on terminal 15 of plug P1. The opening of energized man-aid relay K12 contacts 9-1 prevents the output, if any, of the azimuth angle modulator from entering the antenna azimuth positioning system. The mixed 400-cps azimuth intermediate drive synchro control transformer B5 signal, azimuth intermediate drive servomotor generator B6 forward feed signal, and antenna drive azimuth servomotor generator velocity feedback signal is applied from terminal 14 of the azimuth coupling unit plug P1 to terminal 3 of the azimuth servopreamplifier plug P1. The servopreamplifier converts the signal to a push-pull dc signal, and the output from terminals 9 and 11 of its plug P1 is applied, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 1, 2, 3, and 4. Here the signal again is converted to 400 cps and applied from terminals 7 and 12 of each high-power servoamplifier plug P1 to the control winding of the associated antenna drive servomotor B2A, B4A, B6A, or B8A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The shaft of the track azimuth resolver B4.

(5) The pickoff arm of the azimuth data potentiometer R7 (TM 9-5000-26, page 43).

(6) The shaft of the target acquisition synchro control transmitter B1.

(7) The shaft of the 25-speed synchro control transmitter B1.

(8) The shafts of the antenna drive servomotor generatos B3, B5, B7, and B9.

d. Results of antenna rotation. The results of the antenna rotation are identical with those contained in paragraph 59c except that, since the target acquisition synchro control transmitter B1 is used only for determination of the 400-cps signal that represents the azimuth of the designated target, the rotation of its shaft is not effective at this time. However, in case of redesignation of this target or designation of another target, its rotor location would be used to determine the designated target's azimuth signal (pars 51a and 53).

e. Block diagram discussion. This aided-manual operation also may be traced, on a block diagram level, on page 145.

CHAPTER 6

ACQUISITION OF THE TARGET IN ELEVATION

Section I. GENERAL OPERATION

61. LOCAL ACQUISITION

a. Slewing. During local target designation, the REMOTE DATA lamp XI2 is extinguished and no signal is provided which represents the elevation of the designated target. Instead, the target-tracking radar elevation operator, after hearing the designate buzzer I13 and/or seeing the illumination of the green TARGET DESIGNATE lamp I2, must wait until the radar has slewed to the designated target's azimuth and range. Then he must cause the antenna to move up and/or down until the target's pip appears in or near the range notch of the sum sweep on his range scope. He does this by placing his SLEW switch S6 in either its UP or its DOWN position. This causes the antenna to move and probably will result in it moving slightly beyond the correct elevation as indicated by the target's pip appearing and then disappearing on the sum sweep of the range scopes.

b. Fine antenna elevation positioning. If the antenna slews beyond the correct elevation, the target-tracking radar elevation operator should release his SLEW switch S6 and then cause the antenna to move in the direction opposite to that in which it was slewing by means of the elevation handwheel (with the elevation MAN-AID-AUTO switch S8 in its MAN position) until the pip again appears in or near the range notch of the sum sweep on his range scope.

c. Interim tracking. When the antenna has been positioned to the correct elevation, the target-tracking radar elevation operator keeps it pointed at the target by placing the elevation MAN-AID-AUTO switch S8 in its AID position, and then turning the elevation handwheel in such a direction that the target pip remains on the sum sweep and that its amplitude on the error sweep is zero. (On systems that have no error sweep, he places the IMAGE SPACING switch S1 in its NOR (normal) position and maintains the two target pips on the sum sweep of his range scope at the same amplitude.) When the target pip is caused to continuously appear in the range notch of the sum sweep on the range scopes and the TRACKED switch S1 is pressed, the acquisition phase is completed and the tracking phase, which is described in chapter 7, begins. At this time, the target-tracking radar elevation operator reports ELEVATION ON TARGET.

62. REMOTE ACQUISITION WITH THE AN/GSG-2 SYSTEM

a. Slewing. During remote target designation when connected to the AN/GSG-2 system, the illuminated REMOTE DATA lamp XI2 notifies the target-tracking radar elevation operator that he is not to cause the antenna to slew, but that the closing of the ACQUIRE switch S5 by the target-tracking radar azimuth operator will position the antenna to the correct elevation. Because this action also positions the radar to the correct azimuth and range, the target pip appears in or near the range notch of the sum sweep on the elevation operator's range scope as soon as the slewing action is completed.

b. Interim tracking. Upon completion of the slewing action, the target-tracking radar elevation operator takes the action described in paragraph 61c. When the target pip is caused to continuously appear in the range notch of the sum sweep on the range scopes and the TRACKED switch S1 is pressed, the acquisition phase is completed and the tracking phase, described in chapter 7, begins.

63. REMOTE ACQUISITION WITH THE AN/FSG-1 OR AN/MSG-4 SYSTEMS

As stated in paragraph 55b, the method of remote acquisition with the AN/FSG-1 or the AN/MSG-4 systems is not yet fully determined.

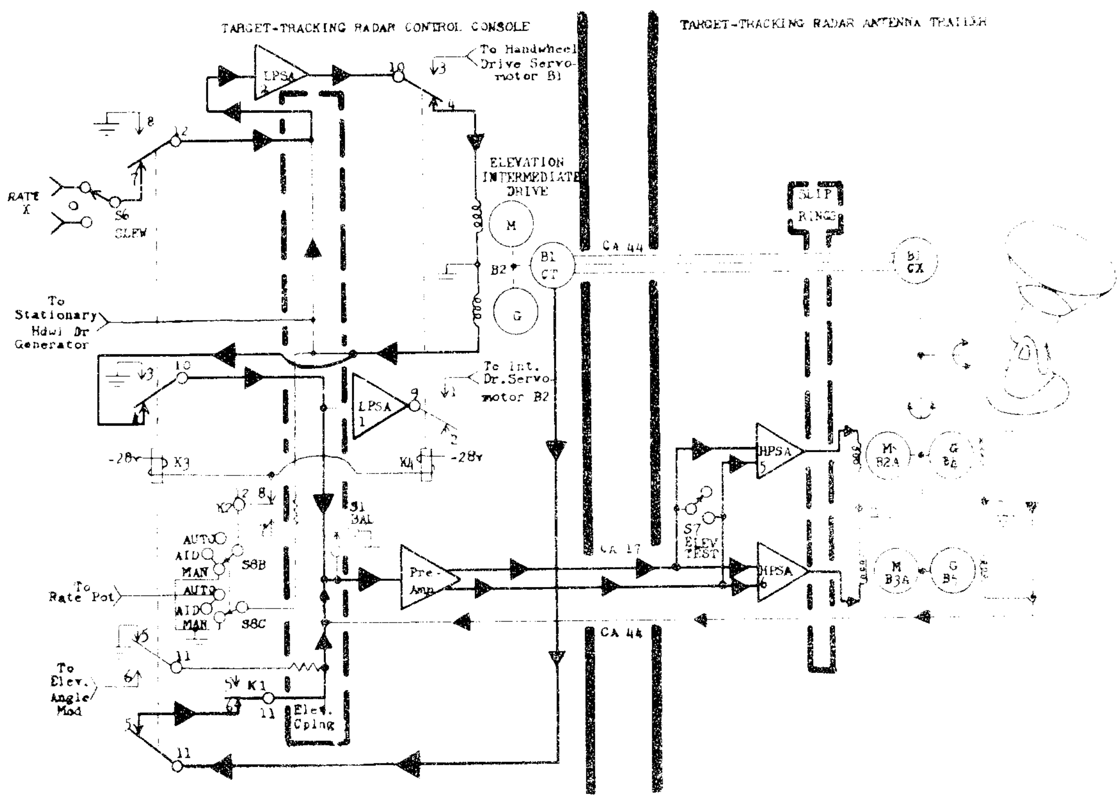

Figure 7. Slewing to the designated target's elevation (local).

Section II. DETAILED LOCAL OPERATION

64. SLEWING TO THE DESIGNATED TARGET'S ELEVATION (fig 7 and TM 9-5000-25)

a. Switch and relay action (page 272). The LOCAL-REMOTE switch S4 is in its LOCAL position, therefore elevation acquire relay K2 cannot be energized (fig 9). The elevation MAN-AID-AUTO switch S8 is in its MAN position. Ground is applied through deck A (contacts 1-A) of this switch to the elevation handwheel drive magnetic clutch coil L1, energizing the coil and thereby disengaging the magnetic clutch (par 15c). Ground is applied from deck B (contacts 1-B) of the MAN-AID-AUTO switch S8 (through contacts 12-8 of the deenergized elevation acquire relay K2) to the coils of the elevation man-aid relays K3 and K4, energizing these relays; and (through contacts 1-9 of the deenergized elevation acquire relay K2) to the coil of the elevation angle modulator dc aid and discharge relay K2, energizing this relay K2. The energized dc aid and discharge relay K2 causes the elevation angle modulator capacitors C1 and C2 to be discharged (par 12b). After the radar has slewed to the designated target's azimuth and range, the target-tracking radar elevation operator places the elevation SLEW switch S6 in either its UP or its DOWN position. This action applies one phase or the other of the 400-cps, 6.3-volt signal from the secondary of the rate excitation transformer T1 (through contacts 1-2 or 3-2 of the SLEW switch S6 and contacts 7-12 of the energized man-aid relay K3) to terminal 10 of the elevation coupling unit plug P1. (It also is possible to set up the slewing circuits with the MAN-AID-AUTO switch S8 in the AID position. This connects the centered rate potentiometer R3 to the circuit, but otherwise the action is the same as described above.)

b. Positioning the elevation intermediate drive shaft (page 269). The 400-cps slew signal leaves the elevation coupling unit on terminal 9 of its plug P1 and is applied to terminal 3 of the low-power servoamplifier number 2 plug P1. The 400-cps output of this low-power servoamplifier is applied from terminal 11 of its plug P1 (through contacts 10-4 of the energized man-aid relay K4) to the control winding of the elevation intermediate drive servomotor B2. Thus, the motor is driven, turning the shafts of the elevation intermediate drive servomotor generator B2 and synchro control transformer B1. The 400-cps output of the elevation intermediate drive servomotor generator B2 is applied, as a velocity feedback signal, to terminal 12 of the elevation coupling unit plug P1. Within the coupling unit, it is mixed with the 400-cps slew signal. Ground, instead of the output, if any, of the rate potentiometer R3, is applied (through deck C (contacts 1-C) of the elevation MAN-AID-AUTO switch S8) to the elevation coupling unit and the handwheel drive servomotor generator B1 is stationary.

c. Positioning the antenna in elevation (page 269). The 400-cps output of the elevation intermediate drive servomotor generator B2 also is applied, as a forward feed signal (through contacts 4-10 of the energized man-aid relay K3), to terminal 6 of the elevation coupling unit plug P1. Because the stator windings of the elevation intermediate drive synchro control transformer B1 are connected to the stator windings of the 25-speed synchro control transmitter B1, a 400-cps signal is generated by the rotor of this transformer when its shaft is turned. This signal is applied (through contacts 11-5 of the energized man-aid relay K3 and contacts 6-11 of the deenergized elevation remote control relay K1) to terminal 2 of the elevation coupling unit plug P1. The 400-cps velocity feedback signal from the antenna drive servomotor generators B4 and B5 is applied to terminal 15 of the elevation coupling unit plug P1. The opening of energized man-aid relay K3 contacts 6-11 prevents the output, if any, of the elevation angle modulator from being applied to the elevation coupling unit (page 269). The mixed 400-cps elevation intermediate servomotor generator B2 forward feed signal, elevation intermediate drive synchro control transformer B1 signal, and antenna drive servomotor generators B4 and B5 velocity feedback signal are applied from terminal 14 of the elevation coupling unit plug P1 to terminal 3 of the elevation servopreamplifier plug P1. The servopreamplifier converts the signal to a push-pull dc signal, and the output from terminals 9 and 11 of its plug P1 is applied, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 5 and 6. Here the signal again is converted to 400 cps and applied from terminals 7 and 12 of each high-power servoamplifier plug P1, through the sliprings, to the control winding of the associated antenna drive servomotor B2A or B3A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The pickoff arm of the elevation data potentiometer R7 (TM 9-5000-26, page 45).

(5) The shaft of the 1-speed synchro control transmitter B1.

(6) The shaft of the 25-speed synchro control transmitter B1.

(7) The shafts of the antenna drive servomotor generators B4 and B5.

d. Results of antenna rotation.

(1) The rotation of the rotors of the coarse and fine synchro data transmitters B2 and B3 cause the dials of the coarse and fine synchro data

repeaters B1 and B2 on the target-tracking radar control console elevation indicator chassis to provide the target-tracking radar elevation operator with readings of the elevation at which the antenna is pointed (par 44a(2) and page 273).

(2) The signal picked off the elevation data potentiometer R7 is converted to represent rectangular coordinates by part of the computer, but the converted signal is not used by the remainder of the computer at this time.

(3) Since the 1-speed synchro control transmitter B1 is used only for the determination of the 400-cps signal representing the elevation of the AN/GSG-2 system's designated target, the rotation of its shaft is not effective at this time. However, in case the AN/GSG-2 system is used to provide coordinates to redesignate this target or to designate another target, its rotor location would be used to determine the designated target's elevation signal (par 56a(1)).

(4) Since the stator windings of the 25-speed synchro control transmitter B1 are connected, through cable 44, to those of the elevation intermediate drive synchro control transformer B1, a changed 400-cps rotor position signal is generated by the synchro control transformer B1 because of the rotation of the shaft of the synchro control transmitter B1 (subpar c, above).

(5) The rotation of the shafts of the antenna drive servomotor generators B4 and B5 results in 400-cps signals being generated whose amplitude and phase represent the direction and speed (the velocity) of rotation of their shafts and therefore, of the antenna. These signals are applied, through the sliprings and cable 44, to terminal 15 of the elevation coupling unit plug P1.

e. Block diagram discussion. This slewing operation also may be traced, on a block diagram level, on page 146 .

65. MANUAL OPERATION (fig 8 and TM 9-5000-25)

a. Switch, relay, and handwheel action (page 272). When and if the antenna slews past the correct elevation, the target-tracking radar elevation operator releases the spring-loaded elevation SLEW switch S6, thereby removing the slewing signal. Since the MAN-AID-AUTO switch S8 remains in the MAN position, it causes the relays to remain in the conditions described in paragraph 64a. The target-tracking radar elevation operator now turns his elevation handwheel in such a direction as to cause the antenna to move in the direction opposite to that in which it was slewing until the antenna again is pointed at the correct elevation.

b. Positioning the elevation intermediate drive shaft (page 269). The operator's turning of the elevation handwheel causes the handwheel drive servomotor generator B1 to generate a 400-cps signal. This signal is applied to terminal 5 of the elevation coupling unit plug P1. This signal passes through the coupling unit to terminal 9 of the elevation coupling unit plug P1, from which it is then applied to terminal 3 of the low-power servoamplifier 2 plug P1. The 400-cps output of this low-power servoamplifier is sent from terminal 11 of its plug P1 (through contacts 10-4 of the energized man-aid relay K4) to the control winding of the elevation intermediate drive servomotor B2, driving the motor and thereby turning the shafts of the elevation intermediate drive servomotor generator B2 and synchro control transformer B1. The 400-cps output of the elevation intermediate drive servomotor generator B2 is applied, as a velocity feedback signal, to terminal 12 of the elevation coupling unit plug P1. Within the coupling unit, it is mixed with the elevation handwheel drive servomotor generator B1 400-cps signal.

c. Positioning the antenna in elevation (page 269). The 400-cps output of the elevation intermediate drive servomotor generator B2 also is applied, as a forward feed signal (through contacts 4-10 of the energized man-aid relay K3), to terminal 6 of the elevation coupling unit plug P1. The 400-cps rotor position signal is applied from the rotor of the elevation intermediate drive synchro control transformer B1 (through contacts 11-5 of the energized man-aid relay K3 and contacts 6-11 of the deenergized elevation remote control relay K1) to terminal 2 of the elevation coupling unit plug P1. The 400-cps velocity feedback signal from the antenna drive servomotor generators B4 and B5 enters the elevation coupling unit on terminal 15 of plug P1. The opening of the energized man-aid relay K3 contacts 1-9 prevents the output, if any, of the elevation angle modulator from entering the antenna elevation positioning system. The mixed 400-cps elevation intermediate drive synchro control transformer B1 signal, the elevation intermediate drive servomotor generator B2 forward feed signal, and the antenna drive elevation servomotor generator velocity feedback signal are applied from terminal 14 of the elevation coupling unit plug P1 to terminal 3 of the elevation servopreamplifier plug P1. The servopreamplifier converts the signal to a push-pull dc signal, and the output from terminals 9 and 11 of its plug P1 is applied, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 5 and 6. Here the signal again is converted to 400 cps and applied from terminals 7 and 12 of each high-power servoamplifier plug P1, through the sliprings, to the control winding of the associated antenna drive servomotor B2A or B3A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The pickoff arm of the elevation data potentiometer R7 (TM 9-5000-26, page 45).

(5) The shaft of the 1-speed synchro control transmitter B1.

(6) The shaft of the 25-speed synchro control transmitter B1.

(7) The shafts of the antenna drive servomotor generators B4 and B5.

d. Results of antenna rotation. The results of the antenna rotation are identical to those stated in paragraph 64d.

e. Block diagram discussion. This manual operation also may be traced, on a block diagram level, on page 146.

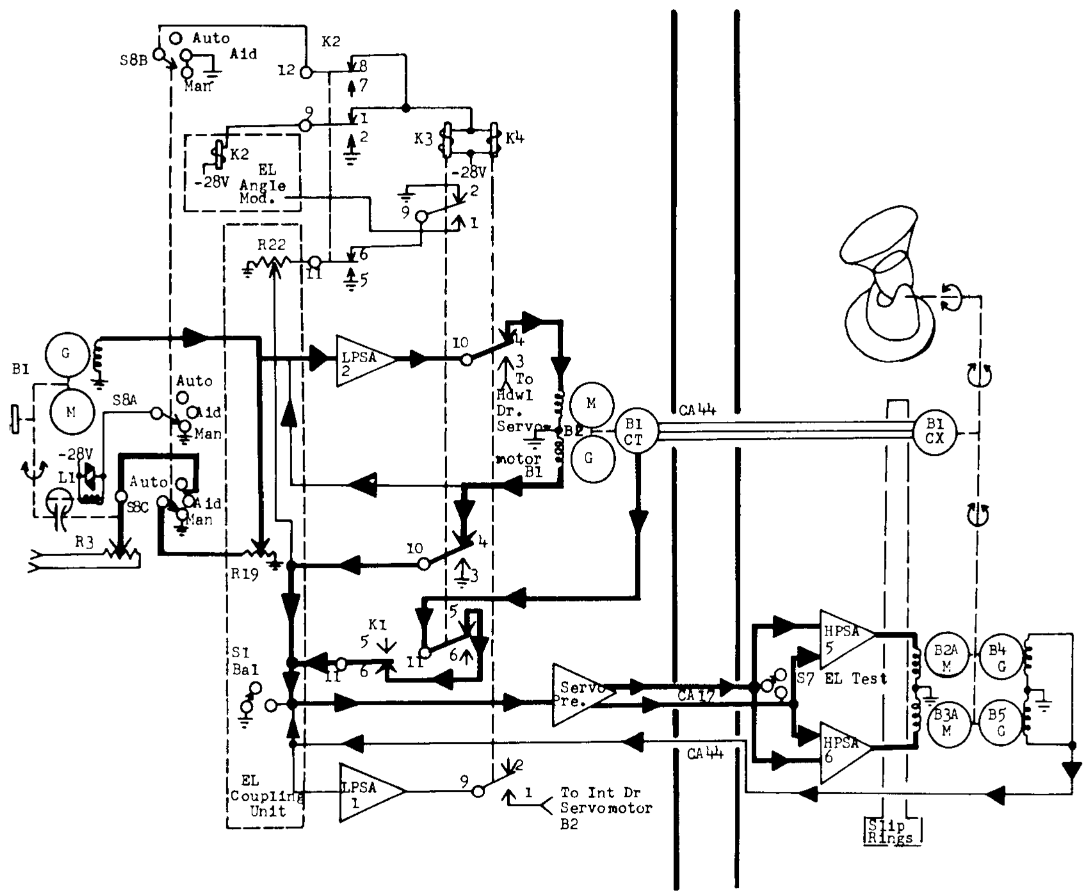

Figure 8. Elevation manual and aided-manual operation.

66. AIDED-MANUAL OPERATION (fig 8 and TM 9-5000-25)

a. Switch, relay, and handwheel action (page 272). When the antenna is pointed at the correct elevation, the target-tracking radar elevation operator positions the elevation MAN-AID-AUTO switch S8 to its AID position, and turns the handwheel in such a direction as to keep the antenna pointed at the target in elevation. The man-aid relays K3 and K4 and the elevation angle modulator dc aid and discharge relay K2 remain energized as described in paragraph 64a. Deck A of the switch no longer supplies a ground to the elevation handwheel drive magnetic clutch coil L1; and therefore, the coil is deenergized and the clutch engaged (par 15c). Thus, turning the handwheel positions the pickoff arm of the rate potentiometer R3.

b. Positioning the elevation intermediate drive shaft (page 269). The elevation intermediate drive shaft is positioned exactly as described in paragraph 65b except that the handwheel drive servomotor generator B1 400-cps signal is now called the second derivative signal and the principal driving signal is obtained from the rate potentiometer R3. This 400-cps rate potentiometer signal is applied (through deck C (contacts 2-C) of the elevation MAN-AID-AUTO switch S8) to terminal 1 of the elevation coupling unit plug P1. Within the coupling unit it is mixed with the handwheel drive servomotor generator B1 400-cps second derivative signal.

c. Positioning the antenna in elevation (page 269). The antenna is positioned in elevation exactly as described in paragraph 65c.

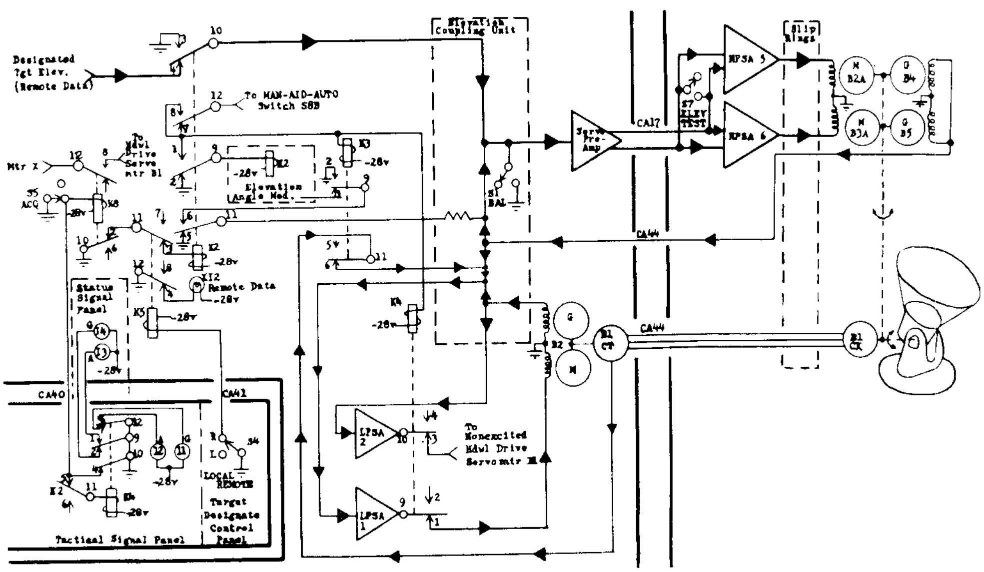

Figure 9. Slewing to the designated target' s elevation (remote).

d. Results of antenna rotation. The results of the antenna rotation are identical to those stated in paragraph 64d.

e. Block diagram discussion. This aided-manual operation also may be traced, on a block diagram level, on page 146.

Section III. DETAILED AN/GSG-2 REMOTE OPERATION

67. SLEWING TO THE DESIGNATED TARGET'S ELEVATION (fig 9 and TM 9-5000-25)

a. Switch and relay action (page 272). The conditions described in paragraph 56 exist. When the target-tracking radar azimuth operator closes the ACQUIRE switch S5 (in addition to the actions described in paragraph 59a), the following actions occur:

(1) The opening of contacts 12-8 of the energized acquire relay K8 removes motor excitation from the elevation handwheel drive servomotor B1.

(2) The closing of contacts 10-2 of the energized acquire relay K8 applies ground (through contacts 11-3 of energized remote acquire relay K5) to the coil of elevation acquire relay K2, energizing relay K2.

(3) The closing of contacts 2-9 of the energized elevation acquire relay K2 applies ground to the coil of the elevation angle modulator dc aid and discharge relay K2, energizing K2. (The energized dc aid and discharge relay K2 causes the elevation angle modulator capacitors C1 and C2 to be discharged (paragraph 12b)).

(4) The opening of contacts 8-12 of the energized elevation acquire relay K2 opens the possible ground path to the coils of man-aid relays K3 and K4, keeping them deenergized.

b. Positioning the antenna in elevation (page 269). The opening of contacts 6-11 of the energized elevation acquire relay K2 prevents the output, if any, of the elevation angle modulator from entering the antenna elevation positioning system. The 400-cps signal, representing the designated target's elevation (paragraph 56a(2)), now passes through contacts 4-10 of the energized elevation acquire relay K2 to terminal 8 of the elevation coupling unit plug P1. The 400-cps signal from the antenna drive servomotor generators B4 and B5 enters the elevation coupling unit on terminal 15 of plug P1. The mixed 400-cps designated target's elevation and antenna drive servomotor generator velocity feedback signals are applied from terminal 14 of the elevation coupling unit plug P1 to terminal 3 of plug P1 on the elevation servopreamplifier. The servopreamplifier converts the signal to a push-pull dc signal that is applied from terminals 9 and 11 of its plug P1, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 5 and 6. Here the signal again is converted to 400 cps and is applied from terminals 7 and 12 of each high-power servoamplifier plug P1, through the sliprings, to the control winding of the associated antenna drive servomotor B2A or B3A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The pickoff arm of the elevation data potentiometer R7 (TM 9-5000-26, page 45).

(5) The shaft of the 1-speed synchro control transmitter B1.

(6) The shaft of the 25-speed synchro control transmitter B1.

(7) The shafts of the antenna drive servomotor generators B4 and B5.

c. Results of antenna rotation. The results of the antenna rotation are as described in paragraphs 64d(1), 64d(2), 64d(4), and 64d(5). In addition, since the stator windings of the 1-speed synchro control transmitter B1 are connected, through cable 44, to those of the AN/GSG-2 coordinate converter elevation synchro control transformer, the rotation of the shaft of the synchro control transmitter B1 causes a reduced target elevation designation signal to be applied from the rotor of the synchro control transformer to contact 4 of the elevation acquire relay K2 (paragraph 56a).

d. Positioning the elevation intermediate drive shaft (page 269). The 400-cps rotor position signal generated by the elevation intermediate drive synchro control transformer B1 is applied (through contacts 11-6 of the deenergized man-aid relay K3) to terminal 3 of the elevation coupling unit plug P1. In the elevation coupling unit, it is mixed with the 400-cps forward feed signal, usually of like phase, from the antenna servomotor generators B4 and B5. This mixed 400-cps signal then is applied from terminal 11 of the elevation coupling unit plug P1 to terminal 3 of low-power servoamplifier number 1 plug P1. The 400-cps output of this low-power servoamplifier is applied from terminal 11 of its plug P1 (through contacts 9-1 of the deenergized man-aid relay K4) to the control winding of the elevation intermediate drive servomotor B2. This motor then drives the shaft of the intermediate drive synchro control transformer B1 (the intermediate drive shaft) and its attached rotor winding toward the same position as that assumed by the rotor winding of the 25-speed synchro control transmitter B1. While this motor operates, the elevation intermediate drive servomotor generator B2 generates a 400-cps signal which is applied as a velocity feedback signal to terminal 12 of the elevation coupling unit plug P1. In the coupling unit, it is mixed with the 400-cps combined rotor position signal generated by the elevation intermediate drive synchro control transformer B1 and forward speed signal generated by the antenna drive servomotor generators B4 and B5.

e. Block diagram discussion. This slewing operation also may be traced, on a block diagram level, on page 152.

68. AIDED-MANUAL OPERATION (fig 8)

When the slewing action ceases, the target pip appears on the range scopes and the antenna is pointed at the correct elevation. The target-tracking radar elevation operator positions the elevation MAN-AID-AUTO switch S8 to its AID position and turns the handwheel in such a direction as to keep the antenna pointed at the target in elevation. The circuit action is identical to that described in paragraph 66.

CHAPTER 7

TRACKING THE TARGET

Section I. GENERAL OPERATION

69. TRACKING THE TARGET (NORMAL)

When the target-tracking radar elevation operator has positioned the antenna to the target's elevation and reported ELEVATION ON TARGET, the target-tracking radar range operator normally places the range system in automatic tracking operation and, if the range tracking is satisfactory, reports RANGE IN AUTO. Upon hearing the report RANGE IN AUTO, the elevation operator normally positions the elevation MAN-AID-AUTO switch S8 to its AUTO position and, if the elevation tracking is satisfactory, reports ELEVATION IN AUTO. When the target-tracking radar azimuth operator has positioned the antenna to the target's azimuth and upon hearing the report RANGE IN AUTO, the azimuth operator normally positions the azimuth MAN-AID-AUTO switch S9 to its AUTO position. Upon receiving both reports, RANGE IN AUTO and ELEVATION IN AUTO, and if the azimuth tracking also is satisfactory with the MAN-AID-AUTO switch S9 in the AUTO position, the target-tracking radar azimuth operator presses the TRACKED switch S1. (This should occur within about 30 seconds after first detection of the target pip on the acquisition radar PPI.) This action lights the green TRACK lamp I6 on the target signal panel and TARGET TRACK lamp I13 on the tactical control signal panel. (The illumination of the green TARGET TRACK lamp I13 notifies the battery control officer that the target-tracking radar is properly tracking the target in all coordinates.) At this time, the three target-tracking radar operators remain prepared to return one or all of their systems to aided-manual tracking (par 70) in case unsatisfactory automatic tracking is indicated by the presentation on the range scopes. In case the target is lost, the target-tracking radar azimuth operator presses the OFF TARGET switch S2, which extinguishes the green TRACK and TARGET TRACK lamps (notifying the battery control officer that the target-tracking radar no longer is tracking the target) and which opens the firing circuits. When the battery control officer causes the green DESIGNATE (I2), CONFIRM (I4), and TRACK (I6) lamps on the target signal panel to be extinguished and the designate buzzer to sound (by positioning the DESIGNATE-ABANDON switch S8 to its ABANDON position), the three target-tracking radar operators position their MAN-AID-AUTO switches to the MAN positions and await the next designation of a target. (The next target designation is announced by the illumination of the green DESIGNATE lamp I2 and the sounding of the designate buzzer.)

70. TRACKING THE TARGET (UNUSUAL)

Two or more aircraft flying close together, the burst of a missile, countermeasures, or other interference may prevent the target-tracking radar range positioning system from satisfactorily tracking the target in automatic operation. In this case, the target-tracking radar range operator tracks the target in aided-manual operation. Likewise, in those rare cases when the target is flying a crossing course, with very little or no range rate, the target-tracking radar azimuth operator must be prepared to track the target in aided-manual operation whenever a change in the appearance of the signal on his range scope indicates that a burst has occurred or that countermeasures or other interference prevents the target-tracking radar antenna azimuth positioning system from satisfactorily tracking the target in automatic operation. It is conceivably possible that the target-tracking radar elevation operator similarly might also be required to track the target in aided-manual operation. As a check, the target-tracking radar range and/or azimuth operators may use the target-tracking radar control console precision indicator to insure that they are on the right target with the correct aid rate when operating in aided-manual. When clear of the burst or interference, the operators should return their systems to automatic operation. In these cases, the target-tracking radar azimuth operator may be required to press the TRACKED switch S1 upon receiving only the reports ELEVATION ON TARGET and RANGE ON TARGET and when the aided-manual azimuth tracking of the target is satisfactory. All other operations are as described in paragraph 69. Further, in case the target is lost, the antenna and the range positioning systems are so constructed that the radar will continue to track in all coordinates at the same rate that it was tracking when the target was last sensed. (In the cases of these positioning systems, the driving signals then originate at the range, azimuth, and elevation rate potentiometers.)

Section II. DETAILED OPERATION

71. AUTOMATIC OPERATION (AZIMUTH) (fig 10 and TM 9-5000-25)

a. Switch and relay action (page 272). Since the target-tracking radar is on target in range, the automatic tracking control unit relay K1 or relay K2 is energized. The DISABLE switch S4 is in its enable position. Ground is applied through the closed contacts 5-6 of the energized automatic tracking control unit relay K1 or relay K2 to the coil of the automatic tracking control unit relay K3, energizing K3, and further, through contacts 6-5 of the DISABLE switch S4 to the coil of the azimuth angle modulator coast relay K1, energizing K1 and allowing the error signal from the azimuth error pulse rectifier to enter the angle modulator (par 12b). The opening of the energized automatic tracking control unit relay K3 contacts 6-4 opens the ground path to the COAST lamp XI1 and (through contacts 3-2 of the DISABLE switch S4) to the coil of the ATC disable relay K14. The COAST lamp XI1 thus is kept extinguished, and the ATC disable relay K14 is kept deenergized. (If the target were lost, the automatic tracking control unit relays K1, K2, and K3 and the azimuth angle modulator coast relay K1 would deenergize; ground would be applied through the closed contacts 6-4 of the deenergized automatic tracking control unit relay K3 to the COAST lamp XI1 and, through contacts 3-2 of the DISABLE switch S4, to the coil of the ATC disable relay K14. Thus, if the target were lost, the azimuth error pulse rectifier error signal, if any, would not enter the azimuth angle modulator; the COAST lamp XI1 would illuminate; and the ATC disable relay K14 would energize.) The target-tracking radar azimuth operator positions the azimuth MAN-AID-AUTO switch S9 to its AUTO position. The acquire relay K8 is deenergized, and the opening of its contacts 9-1 opens the ground path (through contacts 3-A of the MAN-AID-AUTO switch S9 deck A) to the azimuth handwheel drive magnetic clutch coil L1, deenergizing the coil and thereby engaging the clutch (par 15c). The closing of deenergized acquire relay K8 contacts 10-6 applies ground to contact 4 of the ATC disable relay K14. As long as relay K14 remains deenergized, its contacts 4-10 are open, thereby opening the ground path (through contacts 3-B of the MAN-AID-AUTO switch S9 deck B) to the coils of the man-aid relays K12 and K13 and (further through contacts 1-9 of the deenergized azimuth local acquire relay K11) to the coil of the azimuth angle moculator relay K2. These relays K2, K12, and K13 thus remain deenergized provided the ATC disable relay K14 is deenergized. (In the case of a lost target however, this relay K14 would energize, closing its contacts 4-10 and thereby energizing the man-aid relays K12 and K13 and the azimuth angle modulator relay K2. The energizing of these three relays would set up circuits identical with those described in paragraph 72. Therefore, although the MAN-AID-AUTO switch S9 is in its AUTO position, in case of a lost target, the antenna azimuth positioning system is in the aided-manual mode of operation.)

b. Positioning the antenna in azimuth (page 270). The 400-cps error signal from terminal 3 of the azimuth angle modulator plug P1 is applied (through contacts 1-9 of the deenergized man-aid relay K12 and contacts 3-10 of the deenergized azimuth local acquire relay K11) to terminal 4 of the azimuth coupling unit plug P1. The 400-cps signal from the antenna drive servomotor generators B3, B5, B7, and B9 enters the azimuth coupling unit on terminal 15 of plug P1. The mixed 400-cps angle modulator error and antenna drive servomotor generator velocity feedback signals are applied from terminal 14 of the azimuth coupling unit plug P1 to terminal 3 of plug P1 on the azimuth servopreamplifier. The servopreamplifier converts the signal to a push-pull dc signal which is applied from terminals 9 and 11 of its plug P1, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 1, 2, 3, and 4. Here the signal again is converted to 400 cps and is applied from terminals 7 and 12 of each high-power servoamplifier plug P1 to the control winding of the associated antenna drive servomotor B2A, B4A, B6A, or B8A. The rotors of these motors turn, rotating:

(1) The antenna toward the target's azimuth.

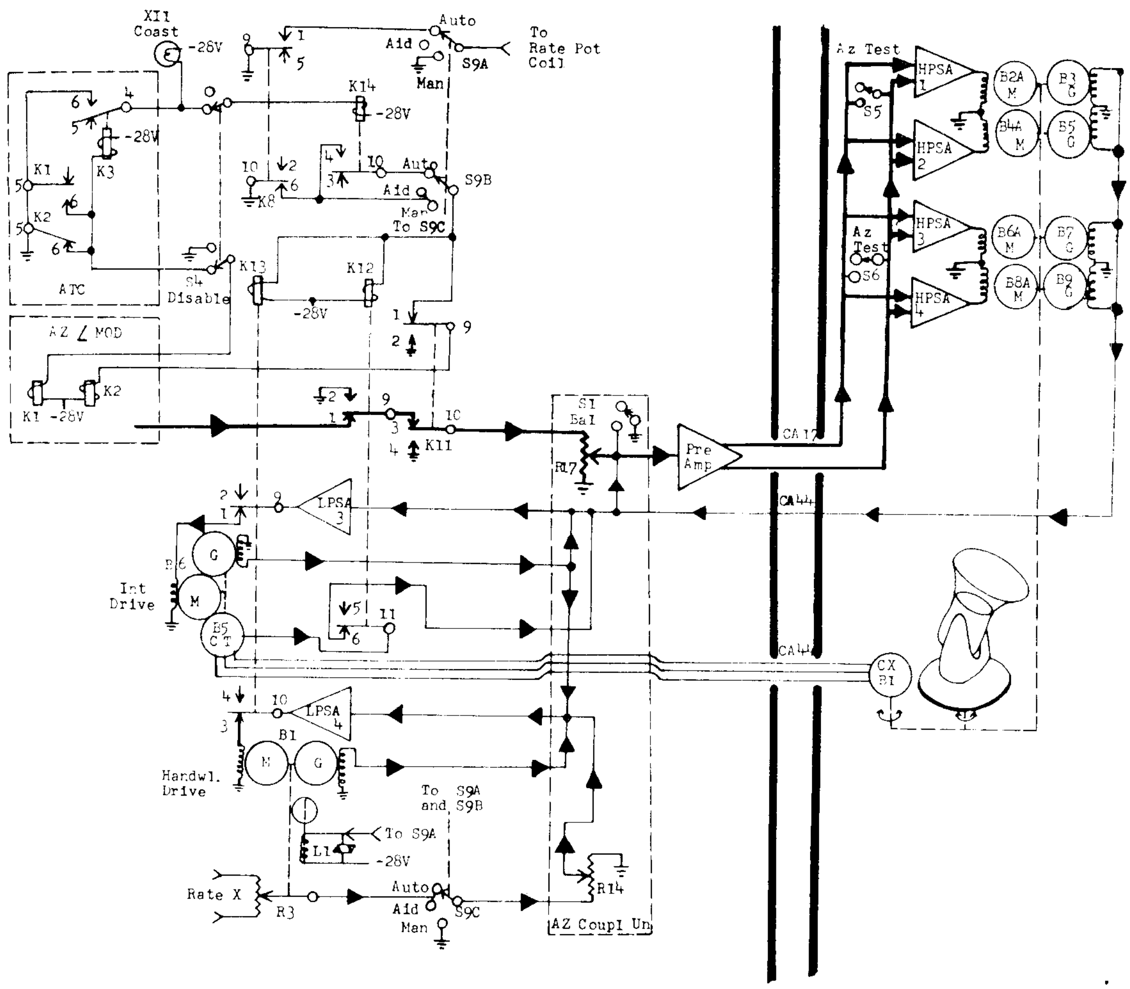

Figure 10. Azimuth automatic operation.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The shaft of the track azimuth resolver B4.

(5) The pickoff arm of the azimuth data potentiometer R7.

(6) The shaft of the target acquisition synchro control transmitter B1.

(7) The shaft of the 25-speed synchro control transmitter B1.

(8) The shafts of the antenna drive servomotor generators B3, B5, B7, and B9.

c. Results of antenna rotation. The results of the antenna rotation are identical to those stated in paragraphs 59c(1), 59c(2), 59c(5), and 59c(6). In addition, since the TRACKED switch S1 has been pressed, the signal picked off the azimuth data potentiometer R7 is converted to represent rectangular coordinates by part of the computer and the converted signal is used by the remainder of the computer. Further, since the target acquisition synchro control transmitter B1 is used only for determination of the 400-cps signal representing the azimuth of the designated target, the rotation of its shaft is not effective at this time. However, in case of redesignation of this target or designation of another target, its rotor location would be used to determine the designated target's azimuth signal (pars 51a and 53).

d. Positioning the azimuth intermediate drive shaft (page 270). The azimuth intermediate drive shaft is positioned exactly as described in paragraph 59d.

e. Positioning the azimuth rate potentiometer arm (page 270). The 400-cps signal from the azimuth intermediate drive servomotor generator B6 also is applied from terminal 9 of the azimuth coupling unit plug P1 to terminal 3 on the low-power servoamplifier number 4 plug P1. The 400-cps output of this low-power servoamplifier is applied from terminal 11 of its plug P1 (through contacts 10-3 of the deenergized man-aid relay K13) to the control winding of the azimuth handwheel drive servomotor B1. Through the engaged clutch, this motor then positions the pickoff arm of the azimuth rate potentiometer R3. While this motor operates, the azimuth handwheel drive servomotor generator B1 generates a 400-cps signal which is applied as a velocity feedback signal to terminal 5 of the azimuth coupling unit plug P1. The 400-cps output of the azimuth rate potentiometer R3 is applied (through contacts 3-C of the MAN-AID-AUTO switch S9 deck C) to terminal 1 of the azimuth coupling unit plug P1. Within the coupling unit, the 400-cps azimuth handwheel drive servomotor generator B1 velocity feedback signal and azimuth rate potentiometer R3 signal are mixed with the 400-cps signal from the azimuth intermediate drive servomotor generator B6. (The 400-cps signal from the azimuth rate potentiometer is of such a phase that when no signal is generated by the azimuth intermediate drive servomotor generator B6, the rate potentiometer signal passing through low-power servoamplifier number 4 to the control winding of the azimuth handwheel drive servomotor B1 drives the motor so as to position the rate potentiometer arm to its center, no signal, position.) Thus, the rate potentiometer arm is positioned so that if its output, after passing through the coupling unit, were applied to the servopreamplifier instead of that of the azimuth angle modulator, the antenna would continue to be driven in the same direction and at the same rate. As explained in paragraph 70, such an action occurs in case of a lost target.

f. Block diagram discussion. This automatic operation also may be traced, on a block diagram level, on page 151.

72. AIDED-MANUAL OPERATION (AZIMUTH) (fig 6)

The aided-manual tracking of a target in azimuth because of external interferences is as described in paragraph 60 except that since the TRACKED switch S1 has been pressed, the signal picked off the azimuth data potentiometer R7 is converted to represent rectangular coordinates by part of the computer and the converted signal is used by the remainder of the computer. Further, in the case of a lost target only (one whose echo cannot be seen on the range scopes), the target-tracking radar azimuth operator must not turn his handwheel, since that would move the rate potentiometer arm from the position at which it picks off the correct signal to keep the antenna moving at the same rate it was while automatically tracking the target.

73. AUTOMATIC OPERATION (ELEVATION) (fig 11 and TM 9-5000-25)

a. Switch and relay action (page 272). Since the target-tracking radar is on target in range, the automatic tracking control unit relay K1 or relay K2 is energized. The DISABLE switch S4 is in its enable position. Ground is applied through the closed contacts 5-6 of the energized automatic tracking control unit relay K1 or relay K2 to the coil of the automatic tracking control unit relay K3, energizing this relay K3; and further, through contacts 6-5 of the DISABLE switch S4 to the coil of the elevation angle modulator coast relay K1, energizing K1 and thereby allowing the error signal from the elevation error pulse rectifier to enter the angle modulator (par 12b). The opening of the energized automatic tracking control unit relay K3 contacts 6-4 opens the ground path to the COAST lamp XI1 and (through contacts 3-2 of the DISABLE switch S4) to the coil of the ATC disable relay K14. The COAST lamp XI1 thus is extinguished, and the ATC disable relay K14 kept deenergized. (If the target were lost, the automatic tracking control unit relays K1, K2, and K3 and the elevation angle modulator coast relay K1 would deenergize; and ground would be applied through the closed contacts 6-4 of the deenergized automatic tracking control unit relay K3 to the COAST lamp XI1 and, through contacts 3-2 of the DISABLE switch S4, to the coil of the ATC disable relay K14. Thus, if the target were lost, the elevation error pulse rectifier error signal, if any, would not enter the elevation angle modulator; the COAST lamp XI1 would illuminate; and the ATC disable relay K14 would energize.) The target-tracking radar elevation operator positions the elevation MAN-AID-AUTO switch S8 to its AUTO position. The acquire relay K8 is not energized, and the opening of its contacts 9-1 opens the ground path (through contacts 3-A of the MAN-AID-AUTO switch S8 deck A) to the elevation handwheel drive magnetic clutch coil L1, deenergizing the coil and thereby engaging the clutch (par 15c). The closing of deenergized acquire relay K8 contacts 10-6 applies ground to contact 2 of the ATC disable relay K14. As long as this relay K14 remains deenergized, its contacts 2-9 are open, thereby opening the ground path (through contacts 3-B of the MAN-AID-AUTO switch S8 deck B and contacts 12-8 of the deenergized elevation acquire relay K2) to the coils of the man-aid relays K3 and K4 and (further through contacts 1-9 of the deenergized elevation acquire relay K2) to the coil of the elevation angle modulator relay K2. These relays K2, K3, and K4 thus remain deenergized, provided that the ATC disable relay K14 is deenergized. (In case of a lost target, however, this relay K14 would energize, closing its contacts 2-9 and thereby energizing the man-aid relays K3 and K4 and the elevation angle modulator relay K2. The energizing of these three relays would set up circuits identical to those described in paragraph 74. Therefore, although the MAN-AID-AUTO switch S8 is in its AUTO position, in case of a lost target, the antenna elevation positioning system is in the aided-manual mode of operation.)

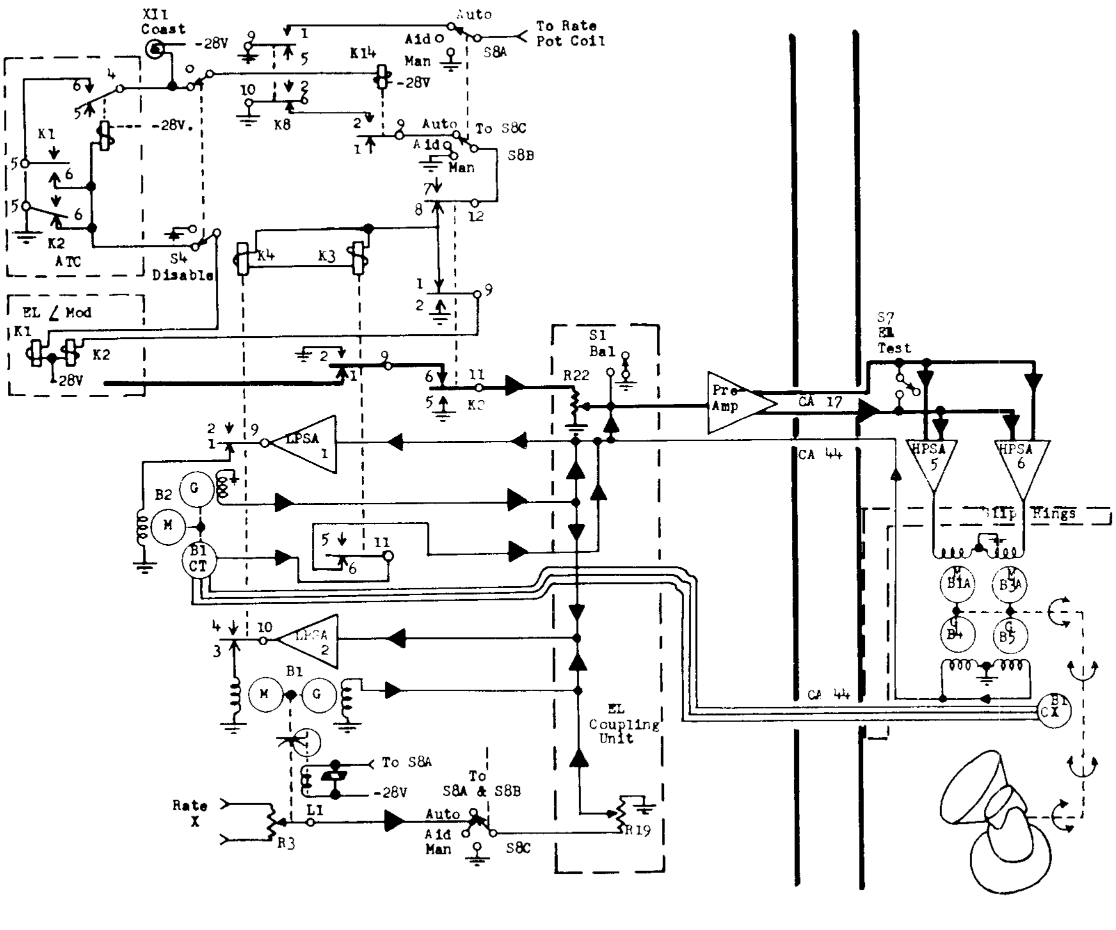

Figure 11. Elevation automatic operation.

b. Positioning the antenna in elevation (page 269). The 400-cps error signal from terminal 3 of the elevation angle modulator plug P1 is applied (through contacts 1-9 of the deenergized man-aid relay K3 and contacts 6-11 of the deenergized elevation acquire relay K2) to terminal 4 of the elevation coupling unit plug P1. The 400-cps signal from the antenna drive servomotor generators B4 and B5 enters the elevation coupling unit on terminal 15 of plug P1. The mixed angle modulator error and antenna drive servomotor generator velocity feedback signals are applied from terminal 14 of the elevation coupling unit plug P1 to terminal 3 of plug P1 on the elevation servopreamplifier. The servopreamplifier converts the signal to a push-pull dc signal that is applied from terminals 9 and 11 of its plug P1, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 5 and 6. Here the signal again is converted to 400 cps and is applied from terminals 7 and 12 of each high-power servoamplifier plug P1 through the sliprings to the control winding of the associated antenna drive servomotor B2A or B3A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The pickoff arm of the elevation data potentiometer R7.

(5) The shaft of the 1-speed synchro control transmitter B1.

(6) The shaft of the 25-speed synchro control transmitter B1.

(7) The shafts of the antenna drive servomotor generators B4 and B5.

c. Results of antenna rotation. The results of the antenna rotation are identical with those stated in paragraphs 64d(1), 64d(3), 64d(4), and 64d(5). In addition, since the TRACKED switch S1 has been pressed, the signal picked off the elevation data potentiometer R7 is converted to represent rectangular coordinates by part of the computer and the converted signal is used by the remainder of the computer.

d. Positioning the elevation intermediate drive shaft(pages 269). The elevation intermediate drive shaft is positioned exactly as described in paragraph 67d.

e. Positioning the elevation rate potentiometer arm (page 269). The 400-cps signal from the elevation intermediate drive servomotor generator B2 also is applied from terminal 9 of the elevation coupling unit plug P1 to terminal 3 of the low-power servoamplifier number 2 plug P1. The 400-cps output of this low-power servoamplifier is applied from terminal 11 of its plug P1 (through contacts 10-3 of the deenergized man-aid relay K4) to the control winding of the elevation handwheel drive servomotor B1. Through the engaged clutch, the motor then positions the pickoff arm of the elevation rate potentiometer R3. While this motor operates, the elevation handwheel drive servomotor generator B1 generates a 400-cps signal that is applied as a velocity feedback signal to terminal 5 of the elevation coupling unit plug P1. The 400-cps output of the rate potentiometer is applied (through contacts 3-C of the MAN-AID-AUTO switch S8 deck C) to terminal 1 of the elevation coupling unit plug P1. Within the coupling unit, the 400-cps elevation handwheel drive servomotor generator B1 velocity feedback signal and elevation rate potentiometer R3 signal are mixed with the 400-cps signal from the elevation intermediate drive servomotor generator B2. (The 400-cps signal from the elevation rate potentiometer is of such a phase that when no signal is generated by the elevation intermediate drive servomotor generator B2, the rate potentiometer signal passing through low-power servoamplifier number 2 to the control winding of the elevation handwheel drive servomotor B1 drives the motor so as to position the rate potentiometer arm to its center, no signal, position.) Thus, the rate potentiometer arm is so positioned that if its output, after passing through the coupling unit, were applied to the servopreamplifier instead of that of the elevation angle modulator, the antenna would continue to be driven in the same direction and at the same rate. As explained in paragraph 70, such action occurs in case of a lost target.

f. Block diagram discussion. This automatic operation also may be traced, on a block diagram level, on page 152.

74. AIDED-MANUAL OPERATION (ELEVATION) (fig 8)

The aided-manual tracking of a target in elevation because of external interferences is as described in paragraph 66 except that since the TRACKED switch S1 has been pressed, the signal picked off the elevation data potentiometer R7 is converted to represent rectangular coordinates by part of the computer and the converted signal is used by the remainder of the computer. Further, in the case of a lost target only (one whose echo cannot be seen on the range scopes), the target-tracking radar elevation operator must not turn his handwheel since that would move the rate potentiometer arm from the position at which it picks off the correct signal to keep the antenna moving at the same rate it was while automatically tracking the target.

75. SIGNALLING (TM 9-5000-25, pages 219 and 219.1)

a. Target tracked. Pressing the TRACKED switch S1 applies ground through contacts 2-1 of this switch (and contacts 5-11 of the energized target confirmed relay K4) to the coil of the target tracked relay K5, energizing relay K5, and to channel 21 of the event recorder, recording this action on the event recorder record. This relay is held energized by a ground applied through contacts 2-3 of the OFF TARGET switch S2, contacts 10-4 of the energized target tracked relay K5, and contacts 5-11 of the energized target confirmed relay K4 to the coil of the relay K5. (Thus, either opening the OFF TARGET switch S2 or deenergizing the target confirmed relay K4 will deenergize the target tracked relay K5.) The closing of the energized target tracked relay K5 contacts 5-11 enable the computer to use the signals representing the rectangular coordinates of the target. The closing of the energized target tracked relay K5 contacts 12-7 and the opening of this relay's contacts 12-8 complete the circuit for the green TARGET TRACK lamp I13, illuminating it; and open the circuit for the amber TARGET TRACK lamp I14, extinguishing it. The closing of the energized target tracked relay K5 contacts 9-2 and the opening of this relay's contacts 9-1 complete the circuit for the green TRACK lamp I6, illuminating it; and open the circuit for the amber TRACK lamp I5, extinguishing it.

b. Off target. Pressing the OFF TARGET switch S2 opens the holding ground circuit for the event recorder channel 21 and the target tracked relay K5, deenergizing it and thereby extinguishing the green TARGET TRACK and TRACK lamps, illuminating the amber TARGET TRACK and TRACK lamps, and opening the computer control circuits. With the removal of the holding ground from the event recorder channel 21, this action also is recorded on the event recorder record.

c. Abandon target. Placing the DESIGNATE-ABANDON switch S8 in its ABANDON position applies ground through its contacts 4-5 to the designate buzzer I13 sounding the buzzer. This same ground is applied through the switch contacts 2-1 to the coil of the abandon target relay K3, energizing the relay K3. Since this ground is obtained through contacts 9-1 of the deenergized fire relay K7, it is impossible to signal abandon target between fire and burst. The opening of the energized abandon target relay K3 contacts 10-3 opens the holding circuit for the target designated relay K2, deenergizing relay K2; and removes a ground from event recorder channel 21. This action extinguishes the green and illuminates the amber target designated lamps. The opening of the deenergized target designated relay K2 contacts 5-11 opens the holding circuit for the target confirmed relay K4, deenergizing relay K4. This action extinguishes the green and illuminates the amber target confirmed lamps. The opening of the deenergized target confirmed relay K4 contacts 5-11 opens the holding ground circuit for the target tracked relay K5, deenergizing the relay K5; and removes another holding ground from event recorder channel 21. This action extinguishes the green and illuminates the amber target tracked lamps. Since the two grounds are removed from channel 21, the event recorder record shows the simultaneous loss of target designated and target tracked when the battery control officer positions the DESIGNATE-ABANDON switch S8 to its ABANDON position.

CHAPTER 8

ELEVATION LIMITS

76. GENERAL OPERATION

To prevent the antenna lens from striking the platform of the antenna mount, regardless of the mode of operation, electrical and physical stops limit the forward angle of depression. (The electrical stops are operated at -79 mils for Nike I systems numbers 1 through 40; at -185 mils for systems numbers 41 through 87, and at -200 mils for systems numbers 88 and subsequent. It is possible that one system's antennas may be exchanged for another's, and therefore, variances in the above figures may occur.) In normal operation, the antenna is limited, electrically, to a maximum elevation angle of 1,600 mils on all systems. These electrical limits are imposed by cam-operated switches closing at the minimum and maximum elevation limits and allowing a strong control signal to be applied to the antenna elevation positioning system which will drive the antenna away from the limit.

NOTE: It is possible to damage the antenna by depressing it at such a high rate that the electrical stop cannot stop the antenna's downward movement before the physical stop is struck.

77. DETAILED OPERATION (TM 9-5000-25, pages 274, 146, and 154).

a. Circuit description. The elevation limit switches S2 (0° elevation limit) and S4 (90° elevation limit) are shown on the referenced pages in their nonlimit positions. The primary of transformer T2 carries the 400-cps servo excitation. Terminal 2, the centertap, of the secondary of T2 is connected to ground. Therefore, 400-cps signals in phase opposition with each other are present at terminals 1 and 3 of the secondary of T2. The signal present at terminal 3 is of the same phase, when applied to the antenna elevation positioning system, as an upward driving signal from the elevation angle modulator; the signal present at terminal 1 is of the same phase, when applied to the antenna elevation positioning system, as a downward driving signal from the elevation angle modulator. The nonlimit contact of the 0° elevation limit switch S2 is connected to ground; the limit contact S2 is connected to terminal 3 of T2; and the pivot S2 is connected to the nonlimit contacts of the 90° elevation limit switch S4 and of the 180° elevation limit switch S3. The limit contact of the 90° elevation limit switch S4 and the limit contact of the 180° elevation limit switch S3 are connected to terminal 1 of T2. The pivot of this switch S4 is connected through the sliprings and cable 45 to contact 4 of the TEST-OPERATE switch S12. The pivot (terminal 5) of the TEST-OPERATE switch S12 is connected to terminal

7 of the elevation coupling unit plug P1 (page 269). The TEST-OPERATE switch S12 is in its OPERATE position; and therefore, its contact 4 is connected to its terminal 5. (The pivot of the 180° elevation limit switch S3 is connected through the sliprings and cable 45 to the open contact 6 of the TEST-OPERATE switch S12; and therefore, the 180° elevation limit switch S3 is ineffective in normal operation.)

b. Minimum elevation limit. When the antenna depresses to its minimum elevation, a cam closes the 0° elevation limit switch S2, connecting the switch pivot to the limit contact. The upward driving signal from terminal 3 of the secondary of T2 is applied (through the limit contact and pivot of the 0° elevation limit switch S2, the nonlimit contact and pivot of the 90° elevation limit switch S4, the sliprings, cable 45, and contacts 4-5 of the TEST-OPERATE switch S12) to terminal 7 of the elevation coupling unit plug P1. Since the antenna has been driven downward, the control signal within the coupling unit probably is of the downward driving phase. The upward driving signal from the transformer T2 is of sufficient magnitude to overcome this downward driving signal. Therefore, the signal applied from terminal 14 of the elevation coupling unit plug P1 (through the elevation servopreamplifier, cable 17, the high-power servoamplifiers numbers 5 and 6, and the sliprings) to the antenna drive servomotors B2A and B3A results in the antenna being driven upward to the elevation at which the cam releases the 0° elevation limit switch S2, thereby removing the upward driving limit signal from the antenna elevation positioning system.

c. Maximum elevation limit. When the antenna elevates to approximately 1,600 mils, a cam closes the 90° elevation limit switch S4, connecting the switch pivot to the limit contact. The downward driving signal from terminal 1 of the secondary of T2 is applied (through the limit contact and pivot of the 90° elevation limit switch S4, the sliprings, cable 45, and contacts 4-5 of the TEST-OPERATE switch S12) to terminal 7 of the elevation coupling unit plug P1. Since the antenna has been driven upward, the control signal within the coupling unit probably is of the upward driving phase. The downward driving signal from the transformer T2 is of sufficient magnitude to overcome this upward driving signal. Therefore, the signal applied from terminal 14 of the elevation coupling unit plug P1 (through the elevation servopreamplifier, cable 17, the high-power servoamplifiers 5 and 6 and the sliprings) to the antenna drive servomotors B2A and B3A results in the antenna being driven downward to the elevation at which the cam releases the 90° elevation limit switch S4, thereby removing the downward driving limit signal from the antenna elevation positioning system.

d. No elevation limit. When the antenna is being driven between the minimum and maximum limits, the pivots of the 0° elevation limit switch S2 and the 90° elevation limit switch S4 are connected with the nonlimit contacts. The ground on the nonlimit contact of the 0° elevation limit switch S2 is applied (through the nonlimit contact and pivot of the 0° elevation limit switch S2, the nonlimit contact and pivot of the 90° elevation limit switch S4, the sliprings, cable 45, and contacts 4-5 of the TEST-OPERATE switch S12) to terminal 7 of the elevation coupling unit plug P1. This ground is used to develop the control signal within the coupling unit.

PART THREE

SYSTEM TEST OPERATIONS

CHAPTER 9

GENERAL ANTENNA POSITIONING SYSTEM TEST OPERATIONS

78. INTRODUCTION

All previously described modes of operation of the antenna positioning system may be and frequently are used in various tests of the target-tracking radar. (It is to be noted, however, that the 90° elevation limit switch S4 is ineffective if the TEST-OPERATE switch S12 is in its TEST position.) In addition, there are specific modes of operation of the antenna positioning system which are designed specifically for use in testing and adjusting the system. These are discussed generally in paragraphs 79 through 82 and, in detail, in chapters 10 through 13.

79. MANUAL OPERATION OF THE ANTENNA AZIMUTH POSITIONING SYSTEM

Frequently the antenna must be positioned to a given azimuth in testing the target-tracking radar. (Pointing the antenna toward the top of the collimation mast for use with the radar rf test set and pointing the antenna toward the corner reflector are examples of cases when it is necessary to point the target to a given azimuth.) To enable the target-tracking radar azimuth operator to easily position the antenna to a given azimuth, the antenna azimuth positioning system has a manual mode of operation. In this mode, the positioning system moves the antenna in a direction and at a rate controlled entirely by the target-tracking radar azimuth operator turning the azimuth handwheel.

80. PLUNGE

During orientation, it is necessary to elevate beyond 1,600 mils elevation. Whenever the TEST-OPERATE switch S12 is in its TEST position, the antenna may be plunged to a slightly depressed position and will continue to correctly sense azimuth errors.

81. SERVOS TEST

To adjust R17 and R22 (on the azimuth and elevation coupling units respectively) so that the rate of antenna rotation in the automatic mode of operation is correct, it is necessary that the outputs of the azimuth and elevation angle modulators be constant and of a known phase and amplitude. This is accomplished by the servos test circuit providing a constant dc signal of known polarity and magnitude as an input to both the angle modulators.

82. OPERATION WITH THE TRACK ANTENNA CONTROL UNIT

As discussed in section XV of chapter 2, the track antenna control unit is provided to enable an operator, in the immediate vicinity of the antenna, to position the antenna in azimuth and in elevation. It removes all control of the antenna's position from the target-tracking radar control console. This change of antenna position control is necessary for simplifying the leveling and orientation procedures.

CHAPTER 10

DETAILED MANUAL OPERATION OF THE ANTENNA AZIMUTH POSITIONING SYSTEM

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83. SWITCH, RELAY, AND HANDWHEEL ACTION (fig 6)

The target-tracking radar azimuth operator positions the azimuth MAN-AID-AUTO switch S9 to its MAN position. This action sets up the circuits described in paragraph 60a. In addition, instead of deck A of the switch being open, it supplies a ground to the azimuth handwheel drive magnetic clutch coil L1; and therefore, the coil is energized and the clutch disengaged (par 15c). Contacts 2-C of the azimuth MAN-AID-AUTO switch S9 deck C open and prevent the output, if any, of the azimuth rate potentiometer R3 from entering the antenna azimuth positioning system. When the operator turns the handwheel clockwise, the antenna moves in one direction; when the operator turns the handwheel counterclockwise, the antenna moves in the other direction; and when the operator stops turning the handwheel, the antenna remains stationary.

84. POSITIONING THE AZIMUTH INTERMEDIATE DRIVE SHAFT (TM 9-5000-25, page 270)

The azimuth intermediate drive shaft is positioned exactly as described in paragraph 60b, except that there is no rate potentiometer control signal present; the 400-cps output of the azimuth handwheel drive servomotor generator B1 is the only control signal present, and it is present only while the handwheel is being turned.

85. POSITIONING THE ANTENNA IN AZIMUTH (TM 9-5000-25, page 270).

The antenna is positioned in azimuth exactly as described in paragraph 60c.

86. RESULTS OF ANTENNA ROTATION

The results of the antenna rotation are identical to those contained in paragraph 60d.

87. BLOCK DIAGRAM DISCUSSION

This manual operation also may be traced, on a block diagram level, on page 145 of TM 9-5000-25.

CHAPTER 11

DETAILED PLUNGE CIRCUIT OPERATION

88. ELEVATION LIMIT SWITCH OPERATION (TM 9-5000-25, page 274)

a. Circuit description. The elevation circuit is as described in paragraph 77a except that, since the TEST-OPERATE switch S12 is in its TEST position, the pivot of the 90° elevation limit switch S4 is connected, through the sliprings and cable 45, to the open contact 4 of this switch S12 (and therefore the 90° elevation limit switch S4 is ineffective); and that the pivot of the 180° elevation limit switch S3 is connected (through the sliprings, cable 45, and the closed contacts 6-5 of the TEST-OPERATE switch S12) to terminal 7 of the elevation coupling unit plug P1 (page 269). In addition, there is a physical plunge limit stop.

b. Minimum elevation limit. The minimum elevation limit operation is as described in paragraph 77b except that, instead of the upward driving signal being applied from the pivot of the 0° elevation limit switch S2 through the non-limit contact and pivot of the 90° elevation limit switch S4, the sliprings, cable 45, and contacts 4-5 of the TEST-OPERATE switch S12 to terminal 7 of the elevation coupling unit plug P1; it is applied from the pivot of the 0° elevation limit switch S2 through the nonlimit contact and pivot of the 180° elevation limit switch S3, the sliprings, cable 45, and contacts 6-5 of the TEST-OPERATE switch S12 to terminal 7 of the elevation coupling unit plug P1.

c. Maximum elevation limit. Instead of the downward driving signal being applied as described in paragraph 77c, when the antenna elevates to its maximum plunged limit, a cam closes the 180° elevation limit switch S3, connecting the switch pivot to the limit contact. (The maximum plunged limit is 3,279 mils for systems 1 through 40, 3,281 mils for numbers 41 through 87, 3,261 mils for 88 through 144, and 3,360 mils for numbers 145 and subsequent. It is possible that one system's antennas may be exchanged for another's, and therefore, variances in the above figures may occur.) The downward driving signal from terminal 1 of the secondary of transformer T2 is applied (through the limit contact and pivot of the 180° elevation limit switch S3, the sliprings, cable 45, and contacts 6-5 of the TEST-OPERATE switch S12) to terminal 7 of the elevation coupling unit plug P1, driving the antenna off the limit (similar to the operation described in paragraph 77c) until the cam releases the 180° elevation limit switch S3, thereby removing the downward driving limit signal from the antenna elevation positioning system.

d. No elevation limit. When the antenna is being driven between the minimum and maximum limits, the pivots of the 0° elevation limit switch S2 and the 180° elevation limit switch S3 are connected with the nonlimit contacts. The ground on the nonlimit contact of the 0° elevation limit switch S2 is applied (through the nonlimit contact and pivot of the 0° elevation limit switch S2, the nonlimit contact and pivot of the 180° elevation limit switch S3, the sliprings, cable 45, and contacts 6-5 of the TEST-OPERATE switch S12) to terminal 7 of the elevation coupling unit plug P1. This ground is used to develop the control signal within the coupling unit.

89. AZIMUTH SENSING (TM 9-5000-25, pages 274 and 151)

If the antenna is facing north in its normal quadrant and a target is to the east, the signal sent from the azimuth angle modulator would cause the antenna to swing in the direction of increasing azimuth, i.e., toward the east. If, without changing the 0-mil azimuth setting, this antenna were plunged so that it faced south, and the target remained to the east, the azimuth angle modulator would continue to send a signal that would cause the antenna to swing in the direction of increasing azimuth (toward the west and away from the target), if it were not for an additional portion of the plunge circuits. The pivot of the 90° elevation limit switch S5 is connected, through the sliprings, to -28 volts. Whenever the antenna's elevation is greater than 1,600 mils this switch S5 is held closed by a cam, so that the -28 volts passes through the switch, the sliprings, and cable 17 to the coil of the plunge relay K1. With the TEST-OPERATE switch S12 in its TEST position, ground is applied through contacts 2-3 of this switch S12 to the coil of the plunge relay K1. Thus, whenever the antenna is elevated above 1,600 mils, the plunge relay K1 is energized. As stated in paragraph 12b(1), whenever the antenna is in its normal quadrant, servo excitation is applied (through contacts 1-9 of the deenergized plunge relay K1) to terminal 9 of the azimuth angle modulator plug P2; and neutral is applied (through contacts 3-10 of the deenergized plunge relay K1) to terminal 11 of the azimuth angle modulator plug P2. However, with the antenna plunged and plunge relay K1 energized, servo excitation is applied (through contacts 4-10 of the energized plunge relay K1) to terminal 11 of the azimuth angle modulator plug P2; and neutral is applied (through contacts 2-9 of the energized plunge relay K1) to terminal 9 of the azimuth angle modulator plug P2. As described in paragraph 12b(1), this reversing of neutral and servo excitation reverses the error sensing of the azimuth angle modulator. In the example, with the antenna plunged so that it faces south and, with the target to the east, the signal sent from the azimuth angle modulator now causes the antenna to swing in the direction of decreasing azimuth, i.e., toward the east and toward the target.

CHAPTER 12

DETAILED SERVOS TEST CIRCUIT OPERATION

90. SWITCH AND RELAY ACTION (TM 9-5000-25, pages 274, 151, 152, and 153)

The pivot 2 of the TEST-OPERATE switch S12 and the pivot 5 of the SERVOS TEST switch S13 are connected to ground. With the TEST-OPERATE switch S12 in its TEST position, ground is applied through contacts 2-3 of this switch S12 to pivot 2 of the SERVOS TEST switch S13. As described in paragraph 12b, when the DISABLE switch S4 is positioned to its DISABLE position, ground is applied through the switch contacts 4-5 to the coils of the azimuth and elevation angle modulators coast relays K1 (2x, page 272), energizing relays K1 and thereby allowing the dc error signals to enter the angle modulators. Positioning the SERVOS TEST switch S13 to its INC (increase) position applies ground through the switch contacts 2-3 to the coil of the servo test relay K2, energizing K2; and applies ground through the switch contacts 5-4 to the junction of resistors R1 and R2. Positioning the SERVOS TEST switch S13 to its DEC (decrease) position applies ground through the switch contacts 2-1 to the coil of the servo test relay K2, energizing K2; and applies ground through the switch contacts 5-6 to the junction of resistors R3 and R4.

91. CIRCUIT OPERATION (TM 9-5000-25, pages 274, 151, 152, and 153)

The TEST-OPERATE switch S12 is in its TEST position, and the DISABLE switch S4 is in its DISABLE position. The angle modulator coast relays K1 are energized. Positioning the SERVOS TEST switch S13 to its INC (increase) position sets up the voltage divider R2-R3-R4 between ground and -250 volts. The resulting -12.6-volt signal at the junction of resistors R2 and R3 is applied (through contacts 7-12 of the energized servo test relay K2) to terminal 11 of the azimuth angle modulator plug P1, and (through contacts 5-11 of the energized servo test relay K2) to terminal 11 of the elevation angle modulator plug P1. As described in paragraph 12a, the angle modulators accept this signal as if it were the outputs of the error pulse rectifiers and, if the antenna azimuth and/or elevation MAN-AID-AUTO switches are in the AUTO positions and since the automatic tracking control unit is made ineffective by the DISABLE switch, the antenna will revolve in the direction of increasing azimuth and/or will elevate at constant rates. Positioning the SERVOS TEST switch S13 to its DEC (decrease) position sets up the voltage divider R1-R2-R3 between +250 volts and ground. The resulting +12.6-volt signal at the junction of resistors R2 and R3 is applied to the angle modulators as described above for the -12.6-volt signal. Now, however, if the antenna azimuth and/or elevation MAN-AID-AUTO switches are in the AUTO positions and since the automatic tracking control unit is made ineffective by the DISABLE switch, the antenna will revolve in the direction of decreasing azimuth and/or will depress at constant rates. If the SERVOS TEST switch S13 is left in its center position, the voltage divider R1-R2-R3-R4 is set up between +250 volts and -250 volts, resulting in a zero-volt signal at the junction of resistors R2 and R3. The servo test relay K2 is deenergized, and ground is applied (through contacts 8-12 and 6-11 of this relay K2) to terminals 11 of the azimuth and elevation angle modulators plugs P1. This ground is used to develop the error pulse rectifiers output signals, if any, within the angle modulators.

CHAPTER 13

DETAILED OPERATION WITH THE TRACK ANTENNA CONTROL UNIT

92. ANTENNA AZIMUTH POSITIONING (fig 12 and TM 9-5000-25)

a. Relay action (page 272). Connecting the cable from the track antenna control unit to the antenna equipment enclosure jack J7 completes the circuit for -28 volts to be applied from terminal K of this jack J7 (through this cable, terminals K and L of the track antenna control unit jack J1, this cable again, terminal L of this jack J7, and cable 17) to the coils of the elevation remote control relay K1 and the azimuth remote control relay K10, energizing relays K1 and K10. The closing of contacts 9-2 of the energized elevation remote control relay K1 applies ground to the coil of the acquire relay K8, energizing K8. The opening of contacts 12-8 of the energized acquire relay K8 removes motor excitation from the azimuth handwheel drive servomotor B1. The opening of contacts 10-6 of the energized acquire relay K8 opens the possible ground path to the coils of the man-aid relays K12 and K13, keeping them deenergized regardless of the conditions of the ATC disable relay K14 or the MAN-AID-AUTO switch S9. The closing of contacts 10-2 of the energized acquire relay K8 applies ground to the coil of the azimuth local acquire relay K11, energizing K11. The closing of the contacts 2-9 of the energized azimuth local acquire relay K11 applies ground to the coil of the azimuth angle modulator dc aid and discharge relay K2, energizing K2 and thereby discharging the azimuth angle modulator capacitors C1 and C2 (paragraph 12b(2)).

b. Positioning the antenna in azimuth (page 270). The opening of contacts 2-10 of the energized azimuth remote control relay K10 prevents the designated target' s azimuth signal, if any, from entering the antenna azimuth positioning system. The opening of contacts 3-10 of the energized azimuth local acquire relay K11 prevents the azimuth angle modulator signal, if any, from entering the antenna azimuth positioning system. Either the 400-cps rotor position signal from the track antenna control unit azimuth remote synchro control transformer B1 or the 400-cps azimuth slew signal from the track antenna control unit (depending upon the condition of the track antenna control unit AZIMUTH SLEW switch S1) is applied (through terminal R of the antenna equipment enclosure jack J7, cable 44, and contacts 2-9 of the energized azimuth remote control relay K10) to terminal 2 of the azimuth coupling unit plug P1. The 400-cps signal from the antenna drive servomotor generators B3, B5, B7, and B9 enters the azimuth coupling unit on terminal 15 of plug P1. The mixed 400-cps track antenna control unit signal and the antenna drive servomotor generator velocity feedback signal are applied from terminal 14 of the azimuth coupling unit plug P1 to terminal 3 of the plug P1 on the azimuth servopreamplifier. The servopreamplifier converts the signal to a push-pull dc signal which is applied from terminals 9 and 11 of its plug P1, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers 1, 2, 3, and 4. Here the signal again is converted to 400 cps and is applied from terminals 7 and 12 of each high-power servoamplifier plug P1 to the control winding of the associated antenna drive servomotor B2A, B4A, B6A, or B8A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16- speed (fine) synchro data transmitter B3.

(4) The shaft of the track azimuth resolver B4.

(5) The pickoff arm of the azimuth data potentiometer R7.

(6) The shaft of the target acquisition synchro control transmitter B1.

(7) The shaft of the 25-speed synchro control transmitter B1.

(8) The shafts of the antenna drive servomotor generators B3, B5, B7, and B9.

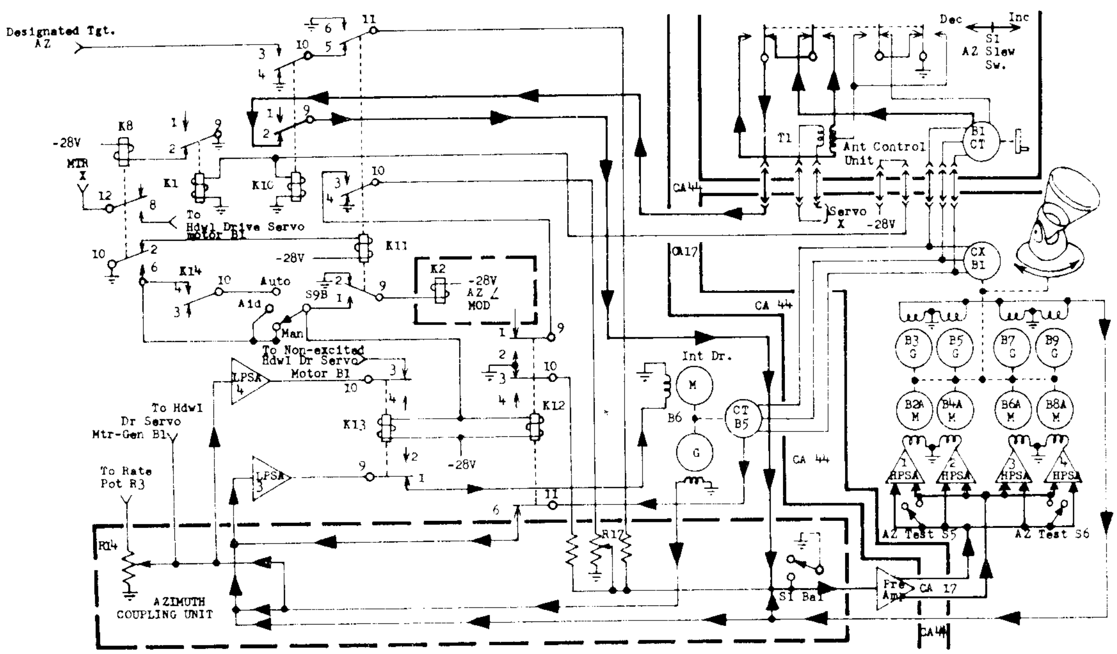


Figure 12. Track antenna control unit azimuth operation.

c. Results of antenna rotation. The results of the antenna rotation are as stated in paragraphs 59c(1), 59c(2), 59c(3), 59c(5), and 59c(6). In addition, since the stator windings of the 25-speed synchro control transmitter B1 also now are connected, through the track antenna control unit cable, to those of the azimuth remote synchro control transformer B1, a 400-cps rotor position signal is generated by the synchro control transformer B1 because of the rotation of the shaft of the synchro control transmitter B1. Further, since the target acquisition synchro control transmitter B1 is used only for the determination of the 400-cps signal that represents the azimuth of the designated target, the rotation of its shaft is not effective at this time. However, in case of designation of the target, after disconnecting the track antenna control unit, its rotor location would be used to determine the designated target' s azimuth signal (par 51a and 53).

d. Positioning the azimuth intermediate drive shaft (page 270). The azimuth intermediate shaft is positioned exactly as described in paragraph 59d.

e. Block diagram discussion. This track antenna control unit azimuth operation also may be traced, on a block diagram level, on page 151.

93. ANTENNA ELEVATION POSITIONING (fig 13 and TM 9-5000-25)

a. Relay action (page 272). Connecting the cable from the track antenna control unit to the antenna equipment enclosure jack J7 energizes the elevation remote control relay K1 as described in paragraph 92a. The closing of contacts 9-2 of the energized elevation remote control relay K1 applies ground to the coil of the acquire relay K8, energizing this relay K8. The opening of contacts 12-8 of the energized acquire relay K8 removes motor excitation from the elevation handwheel drive servomotor B1. The closing of contacts 10-2 of the energized acquire relay K8 applies ground (through contacts 12-7 of the energized elevation remote control relay K1) to the coil of the elevation acquire relay K2, energizing this relay K2. The opening of contacts 12-8 of the energized elevation acquire relay K2 opens the possible ground path to the coils of the man-aid relays K3 and K4, keeping them deenergized regardless of the conditions of the ATC disable relay K14 or the MAN-AID-AUTO switch S8. The closing of the contacts 2-9 of the energized elevation acquire relay K2 applies ground to the coil of the elevation angle modulator dc aid and discharge relay K2, energizing this relay K2 and thereby discharging the elevation angle modulator capacitors C1 and C2 (paragraph 12b).

b. Positioning the antenna in elevation (page 269). The opening of contacts 3-10 of the energized elevation remote control relay K1 prevents the designated target' s elevation signal, if any, from entering the antenna elevation positioning system. The opening of contacts 6-11 of the energized elevation acquire relay K2 prevents the elevation angle modulator signal, if any, from entering the antenna elevation positioning system. Either the 400-cps rotor position signal from the

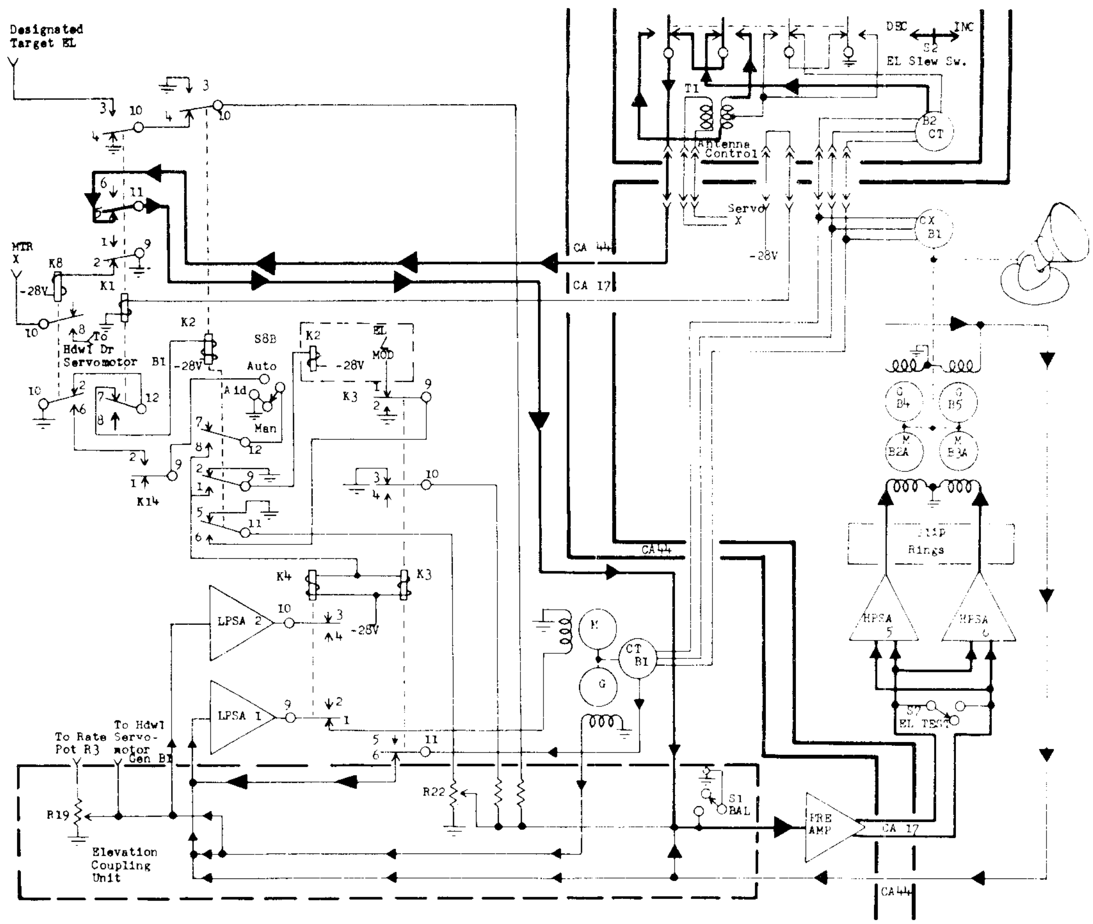


Figure 13. Track antenna control unit elevation operation.

track antenna control unit elevation remote synchro control transformer B2 or the 400-cps elevation slew signal from the track antenna control unit (depending upon the condition of the track antenna control unit ELEVATION SLEW switch S2) is applied (through terminal N of the antenna equipment enclosure jack J7, cable 44, and contacts 5-11 of the energized elevation remote control relay K1) to terminal 2 of the elevation coupling unit plug P1. The 400-cps signal from the antenna drive servomotor generators B4 and B5 enters the elevation coupling unit on terminal 15 of plug P1. The mixed 400-cps track antenna control unit signal and the antenna drive servomotor generator velocity feedback signal are applied from terminal 14 of the elevation coupling unit plug P1 to terminal 3 of plug P1 on the elevation servopreamplifier. The servopreamplifier converts the signal to a push-pull dc signal which is applied from terminals 9 and 11 of its plug P1, through cable 17, to terminals 1 and 3 of plugs P1 on the high-power servoamplifiers numbers 5 and 6. Here the signal again is converted to 400 cps and is applied from terminals 7 and 12 of each high-power servoamplifier plug P1 through the sliprings to the control winding of the associated antenna drive servomotor B2A or B3A. The rotors of these motors turn, rotating:

(1) The antenna.

(2) The shaft of the 1-speed (coarse) synchro data transmitter B2.

(3) The shaft of the 16-speed (fine) synchro data transmitter B3.

(4) The pickoff arm of the elevation data potentiometer R7.

(5) The shaft of the 1-speed synchro control transmitter B1.

(6) The shaft of the 25-speed synchro control transmitter B1.

(7) The shafts of the antenna drive servomotor generators B4 and B5.

c. Results of antenna rotation. The results of the antenna rotation are stated in paragraph 64d. In addition, since the stator windings of the 25-speed synchro control transmitter B1 also now are connected, through the track antenna control unit cable, to those of the elevation remote synchro control transformer B2, a 400-cps rotor position signal is generated by the synchro control transformer B2 because of the rotation of the shaft of the synchro control transmitter B1.

d. Positioning the elevation intermediate drive shaft (page 269). The elevation intermediate drive shaft is positioned exactly as described in paragraph 67d.

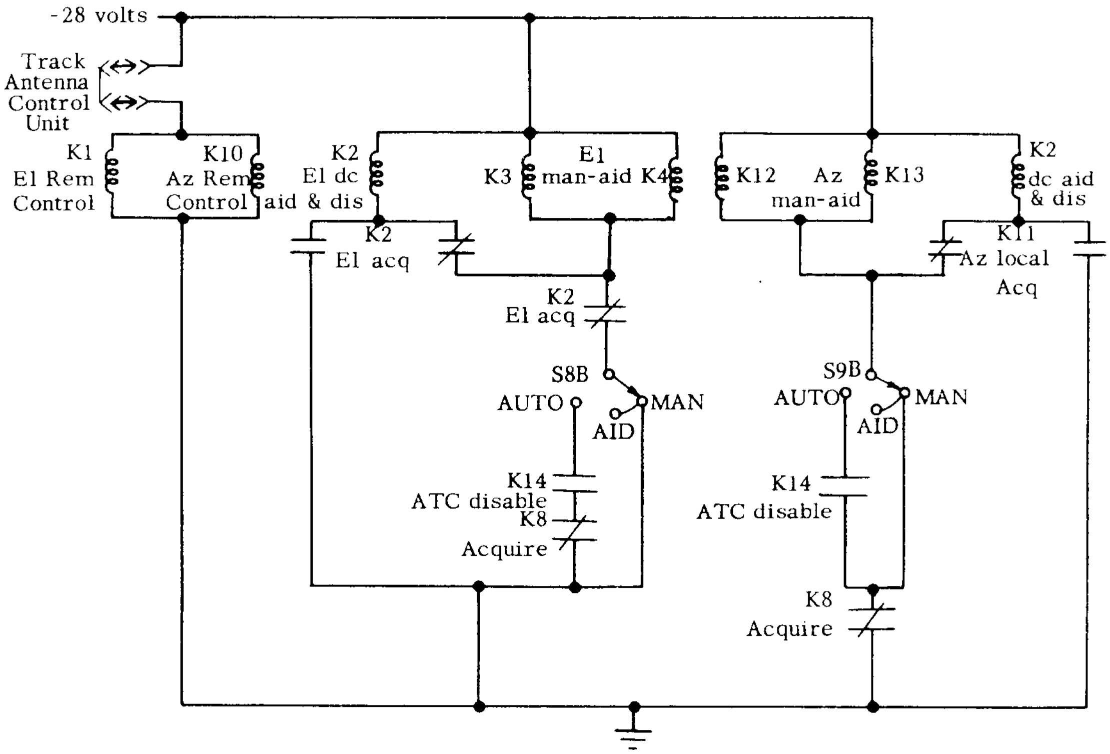
e. Block diagram discussion. This track antenna control unit elevation operation also may be traced, on a block diagram level, on page 152.

APPENDIX

RELAY ENERGIZING CIRCUITS

This appendix shows the schematics of the relay energizing circuits.

K1	K10	K2	K3	K4	K12	K13	K2
El Rem Control	Az Rem Control	El dc aid & dis	El man-aid	El man-aid	Az man-aid	Az man-aid	Az dc aid & dis



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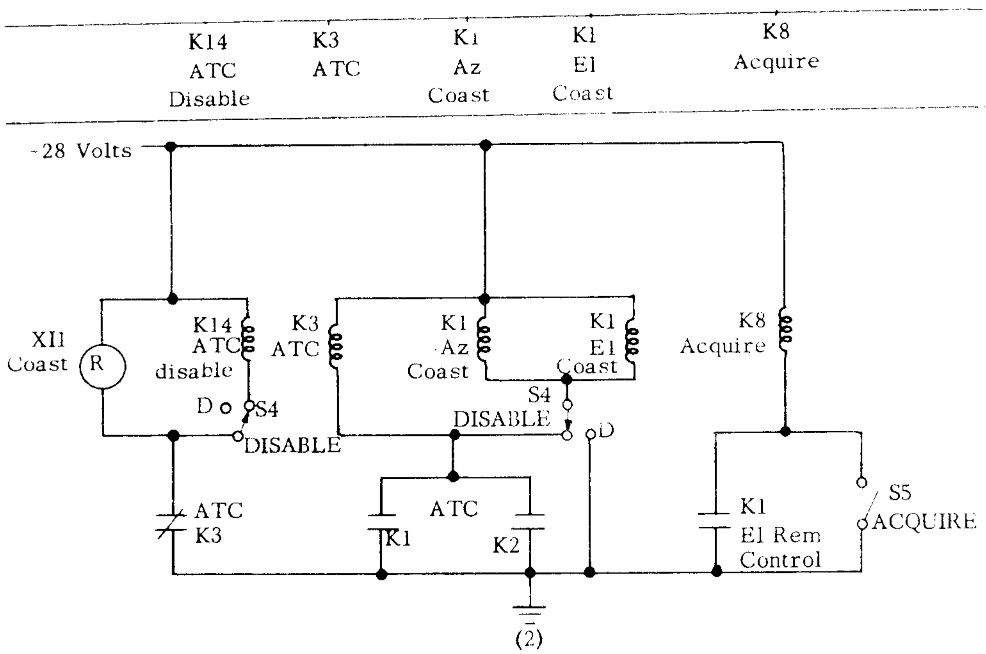
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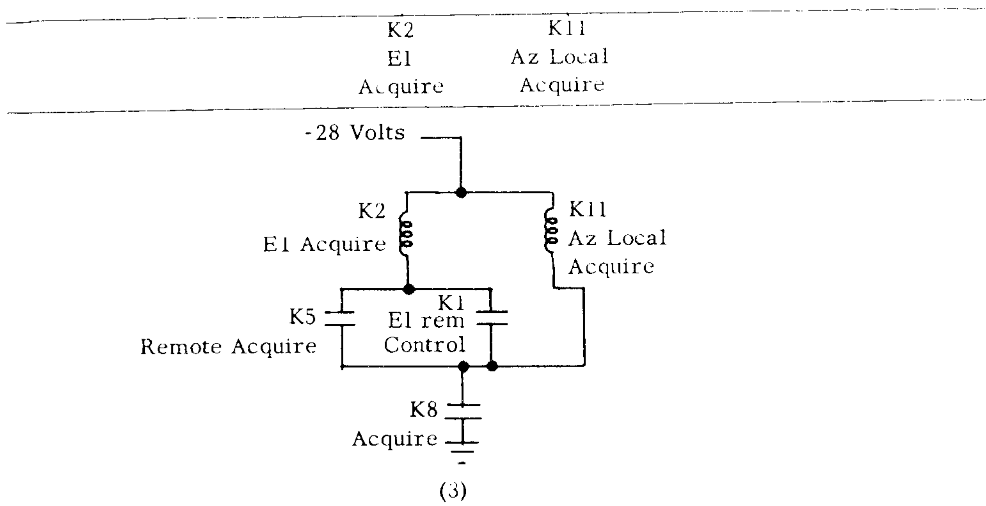
ATC
Disable
K3
ATC
K1
Az
Coast
K1
El
Coast
K8
Acquire
-28 Volts
XI1
Coast
R
K14
ATC
disable
D
S4
DISABLE
K3
ATC
K1
Az
Coast
K1
El
Coast
S4
DISABLE
D
K8
Acquire
ATC
K3
ATC
K1
K2
K1
El Rem
Control
S5
ACQUIRE
(2)


K2
El
Acquire
K11
Az Local
Acquire
-28 Volts
K2
El Acquire
K11
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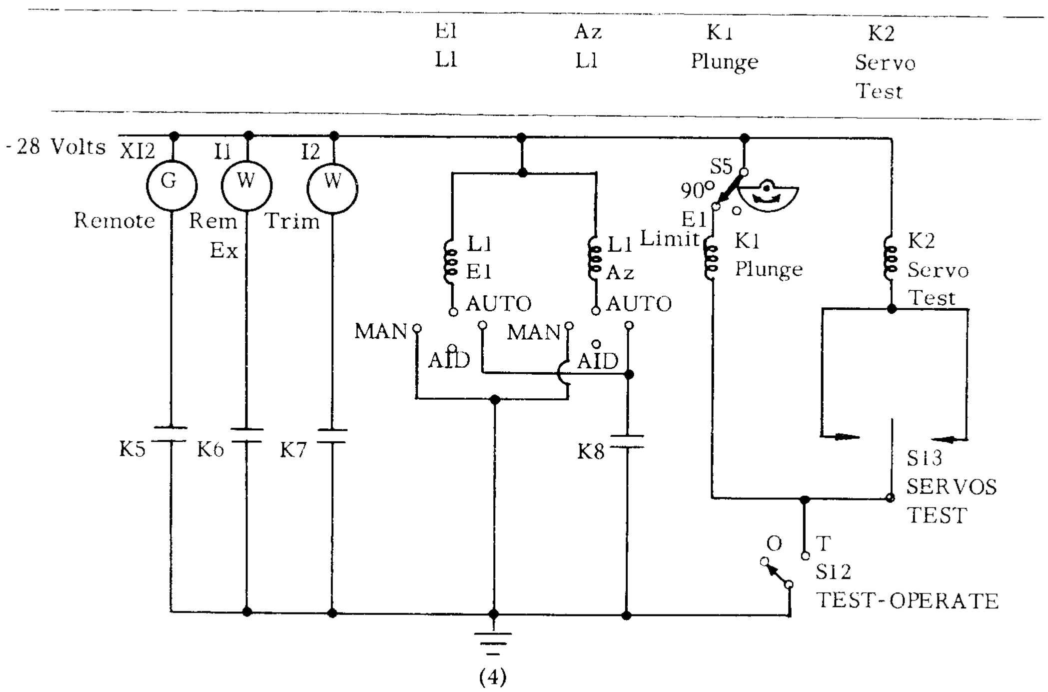
Acquire
K5
Remote Acquire
K1
El rem
Control
K8
Acquire
(3)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Az L1
K1 Plunge
K2 Servo Test
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XI2
I1
I2
G
W
W
Remote
Rem Ex
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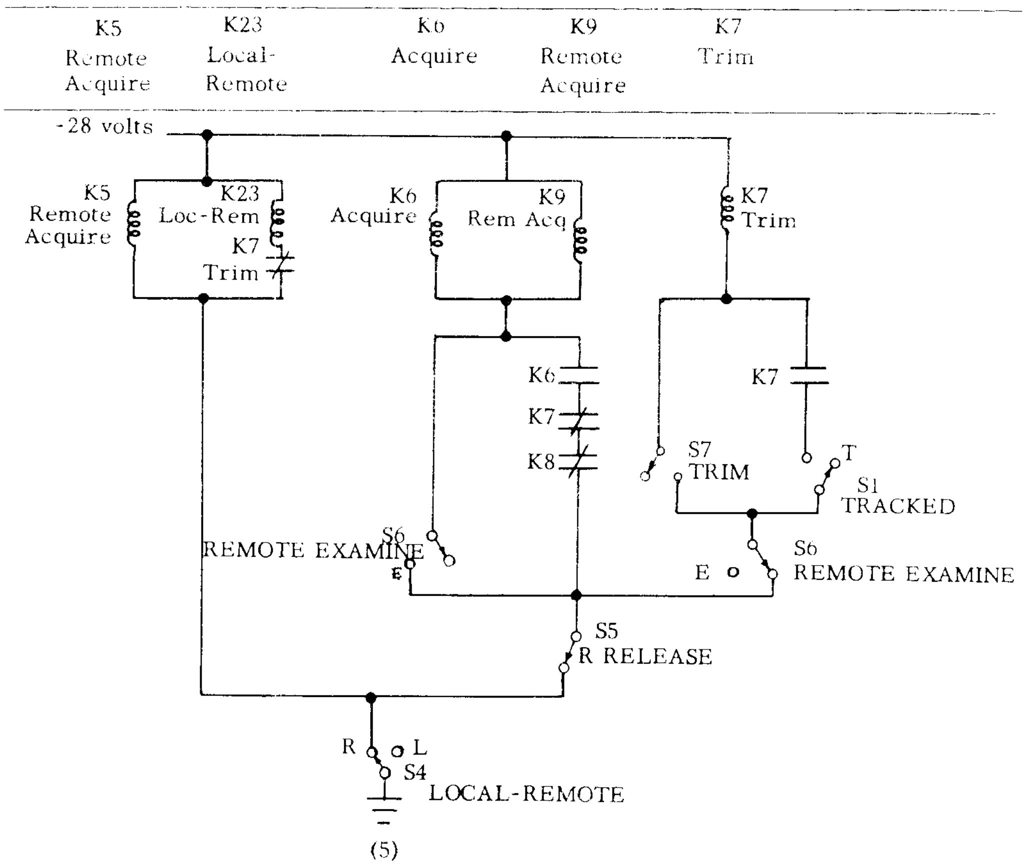
L1 Az
AUTO
AUTO
MAN
AID
MAN
AID
S5
90°
El Limit
K1 Plunge
K2 Servo Test
K5
K6
K7
K8
S13 SERVOS TEST
O
T
S12 TEST-OPERATE
(4)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Remote
Acquire
K23
Local-
Remote
K6
Acquire
K9
Remote
Acquire
K7
Trim
-28 volts
K5
Remote
Acquire
K23
Loc-Rem
K7
Trim
K6
Acquire
K9
Rem Acq
K7
Trim
K6
K7
K8
K7
S7
TRIM
T
S1
TRACKED
S6
REMOTE EXAMINE
E
E
S6
REMOTE EXAMINE
S5
R RELEASE
R
L
S4
LOCAL-REMOTE
(5)

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