CONFIDENTIAL Modified Handling Authorized

TM 9-1430-250-20/11

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

ORGANIZATIONAL MAINTENANCE MANUAL:

THEORY: LOW POWER ACQUISITION RADAR SYSTEM (ATBM)

(NIKE-HERCULES ANTI-TACTICAL BALLISTIC MISSILE SYSTEM) (U)

This copy is a reprint which includes current pages from Changes 1 through 6. Pages applying to all systems are inserted in proper numerical order in the manual. Pages which have different effectivities are inserted in the front of the manual. Pen-and-ink changes have been made. Read the instructions concerning these pages before using the manual.

HEADQUARTERS, DEPARTMENT OF THE ARMY

APRIL 1963

CONFIDENTIAL

READ THESE INSTRUCTIONS CAREFULLY

1 (U). These instructions pertain only to those pages which have different effectivities.

2 (U). The effectivity columns in paragraph 3 indicate the production cut-in serial number of materiel which has been modified, and the DA MWO which contains instructions for modifying existing materiel produced prior to this production cut-in serial number. Process these pages as follows:

a. If the serial number of the materiel in use is of the applicable production cut-in serial number or higher, apply changes as indicated in paragraph 3.

b. If the serial number of the materiel in use is below the applicable production cut-in serial number, and the pertinent DA MWO has been accomplished, apply changes as indicated in paragraph 3.

c. If the serial number of the materiel in use is below the applicable production cut-in serial number, but the pertinent DA MWO has not been accomplished, do not change the manual until such time as the modification is completed. Retain the change pages with this instruction sheet in the front of the manual. After the modification is completed, apply the changes as indicated in paragraph 3.

3 (U). In accordance with the instructions contained in paragraph 2, the new pages, as enumerated below, will be inserted in the manual and the old pages will be removed. The material on a new or revised page affected by these changes is indicated by a vertical line in the margin of the page. Added or revised illustrations are indicated by a vertical line adjacent to the RA PD or ORD G number.

Old pages	New pages	Effectivity DA MWO	Production cut-in serial no.
19-22	19-22(C2)	9-1400-250-50/28	See Note
19-22(C2)	19-22(C4)	9-1400-250-30/41	165
25, 26	25, 26, 26.1	9-1400-250-50/28	See Note
47, 48	47, 48	9-1400-250-50/28	See Note
57-59	57, 58, 58.1, 59	9-1400-250-50/28	See Note
61, 62	61, 62, 62.1	9-1400-250-50/28	See Note
67, 68	67, 68	9-1400-250-50/28	See Note
87, 88	87, 88	9-1400-250-50/28	See Note
103, 104	103, 104, 104.1	9-1400-250-50/28	See Note
117-120	117, 118, 118.1, 119, 120	9-1400-250-50/28	See Note
118.1(C3)	118.1(C6)	9-1430-251-30/27	K27
119, 120(C2)	119, 120(C6)	9-1430-251-30/27	K27
163-166	163-166	9-1400-250-50/28	See Note
193-197	193-196, 196.1, 197	9-1400-250-50/28	See Note

Note. Equipment changes as reflected in DA MWO 9-1400-250-50/28 will be cut-in to production systems with suffix serial numbers 160, 161, 164 through 168, 170 through 179, 182, and 186 through 196.

4 (U). Retain the transmittal sheets in the front of the manual for future reference.

(1) *LOPAR preknock pulse.* The LOPAR preknock, a positive, 40-volt, 1-microsecond pulse, occurs at a repetition rate of 500 pulses per second. This pulse has a steep leading edge that precedes the LOPAR sync and transmitter sync pulses by 23.5 microseconds. The LOPAR preknock triggers the MTI circuits, and supplies an IFF trigger (preknock) pulse to the SIF/IFF system. In addition, the LOPAR preknock triggers the acquisition-track synchronizer of the target tracking radar system, and the receiver and marker circuits whenever the acquisition radar-select circuits are conditioned for LOPAR system synchronization. Pretriggering is required for system stability before the LOPAR sync pulse triggers the LOPAR system into operation.

(2) *LOPAR sync pulse.* The LOPAR sync, a positive, 40-volt, 0.15-microsecond pulse, occurs at a repetition rate of 500 pulses per second. The sync pulse is initiated and synchronized by the LOPAR preknock pulse and delayed 23.5 microseconds. This LOPAR sync pulse triggers the PPI sweep circuits and marker circuits whenever the acquisition radar-select circuits are conditioned for LOPAR system synchronization.

(3) *Transmitter sync pulse.* The transmitter sync, a positive, 40-volt, 0.1-microsecond pulse, is in time coincidence with the LOPAR sync pulse. This narrow pulse is required for proper triggering of the acquisition trigger amplifier in the transmitter circuits because of a characteristic of the blocking oscillator transformer in the acquisition trigger amplifier.

(4) *MTI test pulse.* The MTI test pulse, a positive, 6-volt, 7-microsecond pulse, occurs 10 microseconds after the leading edge of each LOPAR preknock pulse. This delay effectively places the test pulse in time between the LOPAR preknock and LOPAR sync pulses. The test pulse is used by the MTI circuits for the generation of an internally used automatic gain control voltage and is also used during checks and adjustments of the MTI circuits.

(5) *Composite MTI auto sync and disabling pulse.* The MTI auto sync and disabling pulse is a composite pulse consisting of a positive 10-volt auto sync pulse and a negative 32-volt disabling pulse. The auto sync pulse, developed from each LOPAR preknock pulse, has a steep leading edge and a time duration of 1 microsecond. This pulse is used as a trigger pulse and is superimposed upon the leading edge of the disabling pulse. The disabling pulse has a steep negative-going leading edge, a flat portion with a duration of 1500 microseconds, and a positive-going exponential trailing edge with a duration of 500 microseconds. This pulse is used as a disabling gate. The auto sync pulse and the positive-going trailing edge of the disabling pulse occur simultaneously in the MTI circuits and are combined for application as a composite timing feedback to the input of the acquisition-track synchronizer. The application of this pulse causes the synchronizer to be accurately synchronized with the operation of the MTI circuits.

b. The presentation system and target tracking radar system can also be synchronized by the HIPAR system. The acquisition radar-select circuits (fig. 2) provide a means of selecting preknock and sync pulses from the LOPAR or HIPAR system. Other functions of the radar-select circuits are given in paragraph 13. Selection of these pulses permits video from the HIPAR or LOPAR system to be displayed on the presentation system. The HIPAR sync pulse and preknock pulse (TM 9-1430-250-20/10) occur at a repetition rate between 400 and 445 pulses per second and have a time duration of 1 microsecond.

18 (U). Acquisition-Track Synchronizer

The acquisition-track synchronizer (fig. 2) produces five output pulses at a repetition rate

of 500 pulses per second. The functional circuits, pulses, and their distributions are discussed in *a* through *d* below.

Note. The grid zone references shown in parentheses in *a* through *d* below refer to figure 24, TM 9-1430-254-20/6, unless otherwise indicated.

a. Preknock Pulse Circuits.

(1) During normal operation, a composite MTI auto sync and disabling pulse (fig. 3) from the trigger pulse-video amplifier (B3) is applied to the acquisition-track synchronizer (B5). Sync amplifier V1 (B5) is first triggered by the positive auto sync portion of the composite input pulse, and then cut off by the negative disabling portion of the same input pulse. The 1-microsecond LOPAR sync pulse from transformer T1 (B5) synchronizes repetition rate oscillator V2A (B5) at 500 pulses per second, which is the established pulse repetition rate of the LOPAR system. Oscillator V2A is a blocking oscillator. FREQ LOPAR variable resistor R6 (A4) permits manual adjustment of the free-running oscillations of V2A to a frequency lower than the repetition rate of the MTI auto sync pulses. Variable resistor R6 is adjusted with connector P39 (B3) disconnected to insure that V2A remains synchronized by oscillating at a frequency lower than the auto sync rate. The disabling pulse drives V1 (B4) far below cutoff to prevent premature triggering of V2A by spurious noise pulses.

(2) The output of repetition rate oscillator V2A (B5) is a positive 1-microsecond pulse which is applied to trigger amplifier V3A (A7) and through a voltage divider network consisting of resistors R47 and R48 to 10-microsecond delay network Z2 (B7) within the MTI test pulse circuits (par. 18*c*). The same pulse is also applied to the control grid of pulse amplifier V6A, and to connector J2 (B8). From connector J2, the LOPAR preknock pulse is distributed to the MTI oscilloscope (C8), delay line driver (D5), electronic gate (C9), and trigger pulse-video amplifier (B3) of the MTI circuits, and through contacts 1 and 6 (C16) of deenergized preknock/sync select relay K12 on the LOPAR control-indicator to the STC (D17) of the receiver circuits. This preknock pulse is also distributed to the acquisition interference suppressor (C12) and the FAST AGC amplifier (D12). The positive 35- to 45-volt output pulse developed in the cathode circuit of V6A (B8) is designated as the IFF trigger (preknock) pulse. This trigger pulse is supplied from connector J6 through the acquisition slip ring (B22) in the acquisition antenna pedestal to the coder-control unit of the IFF equipment (par. 124*d*(3)). In addition, the preknock pulse from connector J2 (B8) is applied through contacts 4 and 2 (C2) of deenergized preknock select relay K5 in the LOPAR relay assembly, to the acquisition range generator (C17) in the HIPAR control-indicator, and through cable run 24 (D20) to the acquisition-track synchronizer in the target radar control console of the trailer mounted tracking station. The HIPAR preknock pulse (B1), not used during LOPAR operation, is applied through contacts 8 and 6 of deenergized preknock select relay K5 to terminating resistor R1.

b. LOPAR Sync Pulse Circuits.

(1) The positive LOPAR preknock pulse from repetition rate oscillator V2A (B5) is amplified by trigger amplifier V3A (A7). This amplifier produces a negative pulse that triggers delay multivibrator V4A and V4B (A9), a monostable multivibrator which produces a negative output pulse. The output is applied to temperature controlled delay network Z1 (A10), a part of a delay circuit consisting of SYNC DELAY LONG PULSE variable resistor R21 (B10), contacts 6 and 1 (A10) of deenergized pulse width select relay K2, and pulse delay

diode V3B (B10). This circuit produces a negative 23.5-microsecond pulse, the width of which is controlled by variable resistor R21. Pulse width select relay K2 (B10) cannot be energized when the acquisition-track synchronizer is used as part of the LOPAR system. The negative pulse developed at the cathode of V3B is direct-coupled to pulse delay amplifiers V5A (B9) and V5B (B10), which are operated in cascade. The amplified output pulse from V5B is differentiated by blocking oscillator transformer T2 (A11). The resultant signal is a negative and a positive pulse. The negative pulse is coincident with the LOPAR preknock pulse, and the positive pulse occurs 23.5 microseconds after the LOPAR preknock pulse. This positive pulse triggers sync pulse blocking oscillator V2B (B11), operating as a single-swing blocking oscillator. The output of V2B appears in the cathode circuit as a positive 0.15-microsecond LOPAR sync pulse and is applied through connector J4 and network Z61 to contact 2 of LOPAR sync select relay K1 (B14) in the director station group. This sync pulse is applied through contacts of deenergized relay K1 and contacts of deenergized long range (LR) sync select relay K3 (B17) to the writing gun driver (A18), and pulse and logic generator in the LR PPI (B18). This same sync pulse is applied through deenergized short range (SR) sync select relay K2 (A17) to identical units in the SR PPI. These assemblies are part of the presentation system discussed in paragraph 83. LOPAR sync is also applied through contacts 2 and 6 (D16) of energized preknock/sync select relay K12 to the STC in the LOPAR control-indicator. The LOPAR sync pulse is applied to the auxiliary acquisition interconnecting box (D20) from network Z61 (B13) for use with the T1 trainer.

(2) During LOPAR video presentation, the HIPAR sync pulse is applied through contacts of deenergized HIPAR sync select relay K4 (C13). Then, as alternate HIPAR sync, it is applied through the contacts of energized SR sync select relay K2 (A17) to the SR PPI (D18) or through contacts of energized LR sync select relay K3 (B17) to the LR PPI (B18), whichever is selected for HIPAR video preview. During HIPAR video presentation, the LOPAR sync pulse is applied through contacts of energized LOPAR sync select relay K1 (B14). Then, as alternate LOPAR sync, it is applied through the contacts of energized SR sync select relay K2 to the SR PPI or through contacts of energized LR sync select relay K3 to the LR PPI, whichever is selected for LOPAR video preview. Refer to paragraph 13 for HIPAR and LOPAR preview control theory.

(3) From the output of sync pulse blocking oscillator V2B (B11) the LOPAR sync pulse is also applied to sync pulse amplifier V7A. The amplified output of V7A is applied through blocking oscillator transformer T4 to the grid of sync pulse blocking oscillator V7B (B12). Blocking oscillator V7B produces the positive 20- to 40-volt, 0.1-microsecond transmitter sync pulse. The transmitter sync pulse is applied through connector J5 and cable run 23 (A16) to SYNC test jack J5 (C21) in the acquisition RF power supply control in the acquisition receiver-transmitter where it can be monitored and used to synchronize test equipment. In addition, the transmitter sync pulse is applied through contacts 5 and 6 (B21) of deenergized arc suppressor relay K1 to the acquisition modulator (B23) to trigger the acquisition trigger amplifier.

c. MTI Test Pulse Circuit. The LOPAR preknock pulse from repetition rate oscillator V2A (B5) is applied through a voltage divider network consisting of resistors R47 and R48 to 10-microsecond delay network Z2 (B7). This delay line provides a 10-microsecond delay between its input and output signals. The delayed pulse is transformer-coupled to MTI test pulse blocking oscillator V6B (B8). The positive 8-volt, 7-microsecond MTI test pulse from V6B is applied to the MTI video amplifier (C3) and the delay line driver (D5) of the MTI system. This pulse occurs in time between the preknock and the LOPAR sync pulses. Test pulse adjust variable resistor R1 (D4) controls the pulse amplitude applied to the delay line driver.

d. Terminating Resistors. The five output pulses (par. 17) from the acquisition-track synchronizer are distributed to the various loads by means of a coaxial cable. This type of transmission line has only one characteristic impedance which is a determining factor in optimum matching of source to load. When a load impedance (equal to the characteristic impedance of the coaxial cable) is connected to the output end of the cable, an identical impedance appears at the input end of the cable. There is only one value of impedance which a cable assumes. If this cable is very long, a terminating resistor equal to the ac resistance of the cable will provide the optimum impedance match. Therefore, the type of signal, impedance matching, and length of transmission line, determine the need of a terminating resistor at the end of a coaxial cable. When the proper impedance matching is satisfied, problems of standing waves, ringing, pulse distortion, and power losses are minimized. The pulse distribution circuits from the acquisition-track synchronizer have an approximate characteristic impedance of 72 ohms. The reference designation, physical location, locational diagram reference, and functional diagram reference for each terminating resistor used is given in table IV, TM 9-1430-254-20/6.

(1) *LOPAR preknock pulse.* The LOPAR preknock, a positive, 40-volt, 1-microsecond pulse, occurs at a repetition rate of 500 pulses per second. This pulse has a steep leading edge that precedes the LOPAR sync and transmitter sync pulses by 23.5 microseconds. The LOPAR preknock triggers the MTI circuits, and supplies an IFF trigger (preknock) pulse to the SIF/IFF system. In addition, the LOPAR preknock triggers the acquisition-track synchronizer of the target tracking radar system, and the receiver and marker circuits whenever the acquisition radar-select circuits are conditioned for LOPAR system synchronization. Pretriggering is required for system stability before the LOPAR sync pulse triggers the LOPAR system into operation.

(2) *LOPAR sync pulse.* The LOPAR sync, a positive, 40-volt, 0.15-microsecond pulse, occurs at a repetition rate of 500 pulses per second. The sync pulse is initiated and synchronized by the LOPAR preknock pulse and delayed 23.5 microseconds. This LOPAR sync pulse triggers the PPI sweep circuits and marker circuits whenever the acquisition radar-select circuits are conditioned for LOPAR system synchronization.

(3) *Transmitter sync pulse.* The transmitter sync, a positive, 40-volt, 0.1-microsecond pulse, is in time coincidence with the LOPAR sync pulse. This narrow pulse is required for proper triggering of the acquisition trigger amplifier in the transmitter circuits because of a characteristic of the blocking oscillator transformer in the acquisition trigger amplifier.

(4) *MTI test pulse.* The MTI test pulse, a positive, 6-volt, 7-microsecond pulse, occurs 10 microseconds after the leading edge of each LOPAR preknock pulse. This delay effectively places the test pulse in time between the LOPAR preknock and LOPAR sync pulses. The test pulse is used by the MTI circuits for the generation of an internally used automatic gain control voltage and is also used during checks and adjustments of the MTI circuits.

(5) *Composite MTI auto sync and disabling pulse.* The MTI auto sync and disabling pulse is a composite pulse consisting of a positive 10-volt auto sync pulse and a negative 32-volt disabling pulse. The auto sync pulse, developed from each LOPAR preknock pulse, has a steep leading edge and a time duration of 1 microsecond. This pulse is used as a trigger pulse and is superimposed upon the leading edge of the disabling pulse. The disabling pulse has a steep negative-going leading edge, a flat portion with a duration of 1500 microseconds, and a positive-going exponential trailing edge with a duration of 500 microseconds. This pulse is used as a disabling gate. The auto sync pulse and the positive-going trailing edge of the disabling pulse occur simultaneously in the MTI circuits and are combined for application as a composite timing feedback to the input of the acquisition-track synchronizer. The application of this pulse causes the synchronizer to be accurately synchronized with the operation of the MTI circuits.

b. The presentation system and target tracking radar system can also be synchronized by the HIPAR system. The acquisition radar-select circuits (fig. 2) provide a means of selecting preknock and sync pulses from the LOPAR or HIPAR system. Other functions of the radar-select circuits are given in paragraph 13. Selection of these pulses permits video from the HIPAR or LOPAR system to be displayed on the presentation system. The HIPAR sync pulse and preknock pulse (TM 9-1430-250-20/10) occur at a repetition rate between 400 and 445 pulses per second and have a time duration of 1 microsecond.

18 (U). Acquisition-Track Synchronizer

The acquisition-track synchronizer (fig. 2) produces five output pulses at a repetition rate

of 500 pulses per second. The functional circuits, pulses, and their distribution are discussed in *a* through *d* below.

Note. The grid zone references shown in parentheses in *a* through *d* below refer to figure 24, TM 9-1430-254-20/6, unless otherwise indicated.

a. Preknock Pulse Circuits.

(1) During normal operation, a composite MTI auto sync and disabling pulse (fig. 3) from the trigger pulse-video amplifier (B3) is applied to the acquisition-track synchronizer. Sync amplifier V1 (B5) is first triggered by the positive auto sync portion of the composite input pulse, and then cut off by the negative disabling portion of the same input pulse. The 1-microsecond LOPAR sync pulse from transformer T1 (B5) synchronizes repetition rate oscillator V2A (B5) at 500 pulses per second, which is the established pulse repetition rate of the LOPAR system. Oscillator V2A is a blocking oscillator. FREQ LOPAR variable resistor R6 (A4) permits manual adjustment of the free-running oscillations of V2A to a frequency lower than the repetition rate of the MTI auto sync pulses. Variable resistor R6 is adjusted with connector P39 (B3) disconnected to insure that V2A remains synchronized by oscillating at a frequency lower than the auto sync rate. The disabling pulse drives V1 (B4) far below cutoff to prevent premature triggering of V2A by spurious noise pulses.

(2) The output of repetition rate oscillator V2A is a positive 1-microsecond pulse which is applied to cathode-follower V3 (A7) and through transformer T5 to the 10-microsecond delay network Z2 of the MTI test pulse circuits. The same pulse is also applied to the control grid of pulse amplifier V6A and to connector J2 (B8). From connector J2, the preknock pulse is distributed to the MTI oscilloscope (C8), delay line driver (D5), electronic gate, and trigger pulse-video amplifier (C3) of the MTI circuits. The positive 1-microsecond preknock pulse output from cathode-follower V3 (A7) is applied through connector J7 (B9) and distributed to the acquisition interference suppressor (D12), fast AGC amplifier, and to the STC (D17). In addition, the preknock pulse from connector J7 (B10) is applied through contacts 4 (C2) and 2 of deenergized preknock select relay K5, in the LOPAR relay assembly, to the acquisition range generator (C17) in the target designate control-indicator, and through cable run 24 (D16 and D20) to the acquisition-track synchronizer in the target radar control console of the trailer mounted tracking station (D24). The HIPAR AAR preknock pulse (B2), not used during LOPAR operation, is applied through contacts 8 and 6 of deenergized preknock select relay K5 to terminating resistor R1.

b. LOPAR Sync Pulse Circuits.

(1) The positive preknock pulse from repetition rate oscillator V2A is applied as a trigger pulse to delay multivibrator V4A and V4B (B8), a monostable multivibrator which produces a negative output pulse. The output is applied to temperature controlled delay network Z1 (B9), a part of a delay circuit consisting of DELAY LONG PULSE variable resistor R21 (A9), and DELAY SHORT PULSE variable resistor R52 and associated contacts 1 and 6 of pulse width select relay K2. Relay K2 is energized only when the acquisition-track synchronizer is used as part of the target tracking system described in paragraph 28, TM 9-1430-250-20/6. This circuit produces a negative 23.5 microsecond pulse, the width of which is controlled by DELAY LONG PULSE variable resistor R21. The negative 23.5-microsecond pulse is direct-coupled to pulse delay amplifiers V5A and V5B. The amplified output pulse from V5B is differentiated by blocking oscillator transformer T2. The resultant

signal is a negative and a positive pulse. The negative pulse is coincident with the LOPAR preknock pulse, and the positive pulse occurs 23.5 microseconds after the LOPAR preknock pulse. This positive pulse triggers sync pulse blocking oscillator V2B (B10), operating as a single-swing blocking oscillator. The output of V2B appears in the cathode circuit as a positive 0.15-microsecond LOPAR sync pulse and is applied through connector J4 and network Z61 to contact 2 of LOPAR sync select relay K1 (B14) in the director station group. In systems using AAR, the sync output from connector J4 (A25) is applied through connector J47 to network Z61. An additional sync output from connector J47 is applied through a cathode follower amplifier (B27) to connector J33 (D27) on the auxiliary acquisition interconnecting box for use by the ECCM console. This sync pulse is applied through contacts of deenergized relay K1 and contacts of deenergized long range (LR) sync select relay K3 (B17) to the writing gun driver (A18), and pulse and logic generator in the LR PPI (B18). This same sync pulse is applied through deenergized short range (SR) sync select relay K2 (A17) to identical units in the SR PPI. These assemblies are part of the presentation system discussed in paragraph 83. LOPAR sync is also applied through contacts 2 and 6 (D16) of energized preknock/sync select relay K12 to the STC in the LOPAR control-indicator. The LOPAR sync pulse is applied to the auxiliary acquisition interconnecting box (D20) from network Z61 (B13) for use with the T1 trainer.

(2) During LOPAR video presentation, the HIPAR sync pulse is applied through contacts of deenergized HIPAR sync select relay K4 (C13). Then, as alternate HIPAR sync, it is applied through the contacts of energized SR sync select relay K2 (A17) to the SR PPI (D18) or through contacts of energized LR sync select relay K3 (B17) to the LR PPI (B18), whichever is selected for HIPAR video preview. During HIPAR video presentation, the LOPAR sync pulse is applied through contacts of energized LOPAR sync select relay K1 (B14). Then, as alternate LOPAR sync, it is applied through the contacts of energized SR sync select relay K2 to the SR PPI or through contacts of energized LR sync select relay K3 to the LR PPI, whichever is selected for LOPAR video preview. Refer to paragraph 13 for HIPAR and LOPAR preview control theory.

(3) From the output of sync pulse blocking oscillator V2B (B10), the LOPAR sync pulse is also applied to sync pulse amplifier V7A. The amplified output of V7A is applied through blocking oscillator transformer T4 to the grid of sync pulse blocking oscillator V7B (B11). Blocking oscillator V7B produces the positive 20- to 40- volt, 0.1-microsecond transmitter sync pulse. The transmitter sync pulse is applied through connector J5 and cable run 23 (A16) to SYNC test jack J5 (C21) in the acquisition RF power supply control in the acquisition receiver-transmitter where it can be monitored and used to synchronize test equipment. In addition, the transmitter sync pulse is applied through contacts 5 and 6 (B21) of deenergized arc suppressor relay K1 to the acquisition modulator (B23) to trigger the acquisition trigger amplifier.

c. MTI Test Pulse Circuit. The LOPAR preknock pulse from repetition rate oscillator V2A (B5) is applied through transformer T5 (A6) to 10-microsecond delay network Z2 (B7). This delay line provides a 10-microsecond delay between its input and output signals. The delayed pulse is transformer-coupled to MTI test pulse blocking oscillator V6B (B8). The positive 6-volt, 7-microsecond MTI test pulse from V6B is applied to the MTI video amplifier (C3) and the delay line driver (D5) of the MTI system.

This pulse occurs in time between the preknock and the LOPAR sync pulses. Test pulse adjust variable resistor R1 (D4) controls the pulse amplitude applied to the delay line driver.

d. Terminating Resistors. The five output pulses (par. 17) from the acquisition-track synchronizer are distributed to the various loads by means of a coaxial cable. This type of transmission line has only one characteristic impedance which is a determining factor in optimum matching of source to load. When a load impedance (equal to the characteristic impedance of the coaxial cable) is connected to the output end of the cable, an identical impedance appears at the input end of the cable. There is only one value of impedance which a cable assumes. If this cable is very long, a terminating resistor equal to the ac resistance of the cable will provide the optimum impedance match. Therefore, the type of signal, impedance matching, and length of transmission line, determine the need of a terminating resistor at the end of a coaxial cable. When the proper impedance matching is satisfied, problems of standing waves, ringing, pulse distortion, and power losses are minimized. The pulse distribution circuits from the acquisition-track synchronizer have an approximate characteristic impedance of 72 ohms. The reference designation, physical location, locational diagram reference, and functional diagram reference for each terminating resistor used is given in table IV, TM 9-1430-254-20/6.

volt, 2-microsecond pulse is developed across winding 3, 4 of pulse transformer T3. Reverse current diode V3 prevents reverse charging of network Z1 or the oscillation of V2 after the discharge of Z1. Transformer T3 steps up and inverts the negative 550-volt pulse to a positive 800-volt pulse and applies the high-voltage trigger pulse through connector J2 (B4) to the acquisition modulator pulse-shaping circuits. The output pulse of T3 can be monitored at trigger pulse monitor test point TP2.

22 (U). Acquisition Modulator Pulse-Shaping Circuits

a. The acquisition modulator pulse-shaping circuits (fig. 4) are triggered by the positive 800-volt, 2-microsecond pulses from the acquisition trigger amplifier and develop 6- to 6.5-kilovolt, 1.3-microsecond pulses at a repetition rate of 500 pulses per second. The high amplitude of the output pulses is required to trigger the magnetron circuit.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 25, TM 9-1430-254-20/6.

b. The positive trigger pulse from the acquisition trigger amplifier is applied to thyratron switch V1 (B5). Prior to the application of this pulse to V1, the capacitors of pulse forming network Z1 (A6) are resonant-charged to approximately 12 kilovolts. The dc charging voltage is received from the acquisition HV power supply through charging inductor L3 (A5). When triggered, V1 (B5) ionizes and provides a discharge path for network Z1. Although network Z1 resonant-charges to approximately 12 kilovolts, the discharge pulse develops to one-half that voltage because of power transfer losses. Thus, a negative 6- to 6.5-kilovolt, 1.3-microsecond trigger pulse is developed across the primary of HV pulse transformer T1 (A13). As network Z1 discharges, a network consisting of inductor L2 (B5), resistor R2, and capacitor C1, in the plate circuit of thyratron switch V1, forms a step in the leading edge of the high-voltage pulse. This step reduces magnetron arcing, moding, and erratic operation. Inverse current diode V2 prevents reverse charging of network Z1 or the oscillation of V1 after the discharge of Z1. Inner cover shorting interlock switch S2 (B6) is provided to discharge network Z1 when the modulator access cover is removed. Capacitors C3 and C4 are provided for filtering of inverse current.

c. The modulator control-indicator (D3) provides the thyratron capsule heater voltage, which controls the acquisition modulator pulse-shaping circuits. Variable transformer T1 (D2) controls the voltage supplied to the primary winding of capsule voltage transformer T2. Transformer T2 supplies capsule heater voltage to thyratron switch V1 (B5). The capsule heater voltage is adjustable to provide an optimum gas pressure within V1. Overload relay K1 (D3) is a protective relay that removes high voltage should there be excessive inverse current through diode V2 (B5). Capacitor C1 (D3) insures that overload relay K1 does not respond to momentary surges of inverse current. Resistors R1 (D4), R2, R3, and R4 are provided to fix the operating range of relay K1 and are also used by the metering circuit. Inverse current may be monitored by modulator test meter M1 (D3) when meter switch S1 is set to INVERSE CURRENT (FS 100 MA). Meter M1 also monitors the heating element voltage of the gas capsule in thyratron switch V1 when switch S1 is set to THY—RES VOLTAGE FS 10V.

23 (U). Magnetron Circuits

a. The magnetron circuits are part of the transmitter circuits (fig. 4) and are located in the acquisition receiver-transmitter. These circuits produce 1.3-microsecond, 1-megawatt pulses of RF energy, using the high voltage dc pulse as a trigger.

b. The magnetron circuits consist of a HV pulse transformer circuit inside the magnetron hot box, a tunable magnetron—5795, and associated control and tuning circuits. The HV pulse transformer receives the negative 6- to 6.5-kilovolt, 1.3-microsecond trigger pulse from the acquisition modulator. The trigger pulse is stepped up to 40 to 50 kilovolts to trigger the magnetron. When triggered, the magnetron oscillates at a frequency in the S-band. The frequency of the magnetron can be varied over its normal operating range of 3100 to 3500 megacycles by using a reversible tuning drive. The 1 megawatt of RF energy generated by the magnetron is conveyed through the waveguide to the acquisition antenna system (par. 24) for radiation into space.

Note. The grid zone references shown in parentheses in *c* through *j* below refer to figure 25, TM 9-1430-254-20/6, unless otherwise indicated.

c. The negative 6- to 6.5-kilovolt trigger pulse from network Z1 (A6) in the acquisition modulator is applied to HV pulse transformer T1 (A13) in the magnetron hot box where the pulse is stepped up to 40 to 50 kilovolts and is applied to tunable magnetron V1 (A15). A small portion of this pulse is applied as an AFC gate pulse (par. 58*c*) through connector J7 (B14) to the acquisition AFC circuits. When the negative trigger pulse from transformer T1 is applied to the cathode of magnetron V1, the magnetron oscillates for the 1.3-microsecond duration of this pulse. Thus, the pulsations occur at a frequency between 3100 and 3500 megacycles, and develop an output peak power of 1 megawatt for 1.3 microseconds. The output from the magnetron occurring at a repetition rate of 500 pulses per second, is coupled through a 10-centimeter waveguide to the acquisition antenna system for transmission into space.

d. The operating frequency of magnetron V1 is linearly varied by a magnetron tuning drive powered by reversible split-phase motor B2 (C15). Driving voltages for this motor are controlled by two momentary contact switches and two push-button switch-indicators described in (1) through (4) below.

(1) MAG FREQ switch S2 (C13) on the acquisition RF power supply control provides local control.

(2) MAG FREQ switch S3 (C12) on the frequency and power meter provides local control during transmitter measurements.

(3) FREQUENCY INCREASE switch-indicator A5 (C8) on the LOPAR control-indicator provides remote control.

(4) FREQUENCY DECREASE switch-indicator A6 (C9) on the LOPAR control-indicator provides remote control.

(5) In systems using AAR, remote control of the magnetron frequency is transferred to the ECCM console through closed contacts 10-4 and 9-2 of energized transmitter control relay K6 (fig. 57, D3).

e. The operation of any one of these switches or switch-indicators determines the direction of rotation of motor B2 (C15) and the direction of change in the magnetron frequency. These frequency control signals are applied to the auxiliary acquisition interconnecting box (D10) for use by the T1 trainer. The rotation of B2 is determined by the phase relationship between the control voltages on the motor windings. The phase relationship between these voltages is determined by the applied ac phase and the effect of capacitors C3A (C14) and C4, which cause the voltage applied to one motor winding to be shifted approximately 90 degrees in phase. The switches and switch-indicators are interconnected so that only one can be used at a time to operate motor B2. When switch S3 (C12) or S2 (C13) is set to RAISE, or switch-indicator A5 (C8) is depressed, 120 volts ac is applied through terminals 1 and 3 of connector J25 (C15) to motor B2. Terminal 5 of connector J25 is permanently connected to neutral. When switch S3 (C12) or S2 (C13) is set to LOWER, or switch-indicator A6 (C9) is depressed, 120 volts ac is applied through terminal 3 of connector J25 to motor B2, and terminal 1 of connector J25 is connected to neutral. In this manner, the operation of switch S2 or S3 and switch-indicator A5 or A6 control the direction of rotation of motor B2. As the motor rotates, the size of the resonant cavity within tunable magnetron V1 (A15) is changed to vary the magnetron frequency. A relative indication of the frequency of magnetron V1 is provided by MAGNETRON FREQUENCY meter M1 (C7) on the LOPAR control-indicator. The meter scale is graduated from 0 to 100 in increments of 5, which represent divisions of the transmitter frequency spectrum. The lowest or zero indication on meter M1 corresponds to a frequency of 3100 megacycles, while the highest or full scale indication corresponds to 3500 megacycles. Voltage for meter M1 is supplied through magnetron frequency measure variable resistor R1 (D15) in the magnetron tuning drive. Resistor R1 is mechanically connected to motor B2 so that voltage for meter M1 is varied linearly whenever the magnetron frequency is changed. The output of resistor R1 is, therefore, proportional to the frequency of the magnetron. In systems using AAR, the voltage from R1 through meter M1 is applied to the ECCM console through closed contacts 9 and 2 of energized transmitter control relay K5 (fig. 57, C3).

f. Average magnetron current may be monitored by two metering circuits described in (1) and (2) below.

CONFIDENTIAL Modified Handling Authorized

CONFIDENTIAL

primary reflector, the 356-mil indicated angle corresponds to a maximum beam angle of 391 mils. Elevation data is also applied from elevation transmitter (synchro) B1 to the auxiliary acquisition interconnecting box (D7) for use by the T1 trainer. In systems using AAR, elevation data is applied from synchro B1 through closed contacts 12-7, 11-5, and 10-4 of transmitter control relay K5 (fig. 55, B3) in the auxiliary acquisition relay assembly to connector J33 for use by the ECCM console.

d. Four automatic elevation scanning conditions (table II) have been designated for setting the angular limits of primary reflector coverage, and secondary injection and retraction points of operation. Any of the four scan conditions (figs. 16 and 17) can be selected by changing the mechanical position of three microswitches in the electro-mechanical control box (par. 29*a*).

e. The pencil-shaped beam has a 5.5-degree vertical beam width at the half-power points and a constant 1.4-degree beam width in azimuth. The width of the RF beam in either the horizontal or vertical plane is different for any cross-section of the beam length. The effective beam width is chosen as that point along the beam (half-power point) having 3 db less power than the point having maximum power. This beam extends to an effective range of 250,000 yards. At a reflector elevation of zero degrees, the effective pencil-beam ground range is reduced because of earth curvature. When the pencil beam is changed into a cosecant-squared beam (fan-shaped), the effective range is shortened to provide a broader high-angle coverage. This fan-shaped beam has a constant 1.4-degree width in azimuth and an effective range of 175,000 yards. With a beam elevation of 22 degrees, detection of targets is possible up to an altitude of 195,000 feet.

29 (C). Control of Elevation Scanning

a. The electro-mechanical control box (figs. 15 and 18) controls scanning of the acquisition antenna (fig. 18) by providing electrical motive power for the primary and secondary actuators. Automatic scan limits of the primary reflector and injection of the secondary reflector are controlled by the mechanical adjustment of secondary inject-retract switch S1 (13, fig. 15), primary lower limit switch S2 (11, fig. 15), primary upper limit switch S3 (10, fig. 15). The mechanical operating limits of the primary and secondary actuators are protected by pressure-operated microswitches within the actuator housings (fig. 18). The primary actuator housing contains two microswitches, and the secondary actuator housing contains four microswitches. The function of the nine microswitches is given in *b* and *c* below.

b. The limits of automatic scan for the primary reflector are determined by the mechanical position of switches S3 and S2 (10 and 11, fig. 15) in the electro-mechanical control box. Switch S3 is a pressure-operated, momentary-contact microswitch that operates in conjunction with certain relays (2, fig. 15) on the electro-mechanical control panel. The function of S3 is to reverse the direction of rotation of motor B3 (fig. 18), which is mechanically coupled to the primary actuator whenever the primary reflector reaches

Table II (U). Automatic Elevation Scanning Conditions (U)

	Pencil beam			Cosecant bar injection begins		Cosecant bar injection completed		Upper auto scan limit			
Scan condition	Reflector angle	Beam angle	Ind dial mils	Reflector angle	Beam angle	Reflector angle	Beam angle	Reflector angle	Beam angle	Ind dial mils	Complete scan period in seconds
1 (fig. 16)	0°	2°	35	0°	2°	1°	6°	9°	22°	356	40
2 (fig. 16)	0° to 2°	2° to 6°	35 to 107	2°	6°	3°	10°	4.5°	13°	196	20
3 (fig. 17)	0° to 4°	2° to 10°	35 to 178	4°	10°	5°	14°	6.5°	17°	267	28
4 (fig. 17)	0° to 6°	2° to 14°	35 to 249	6°	14°	7°	18°	9°	22°	356	40

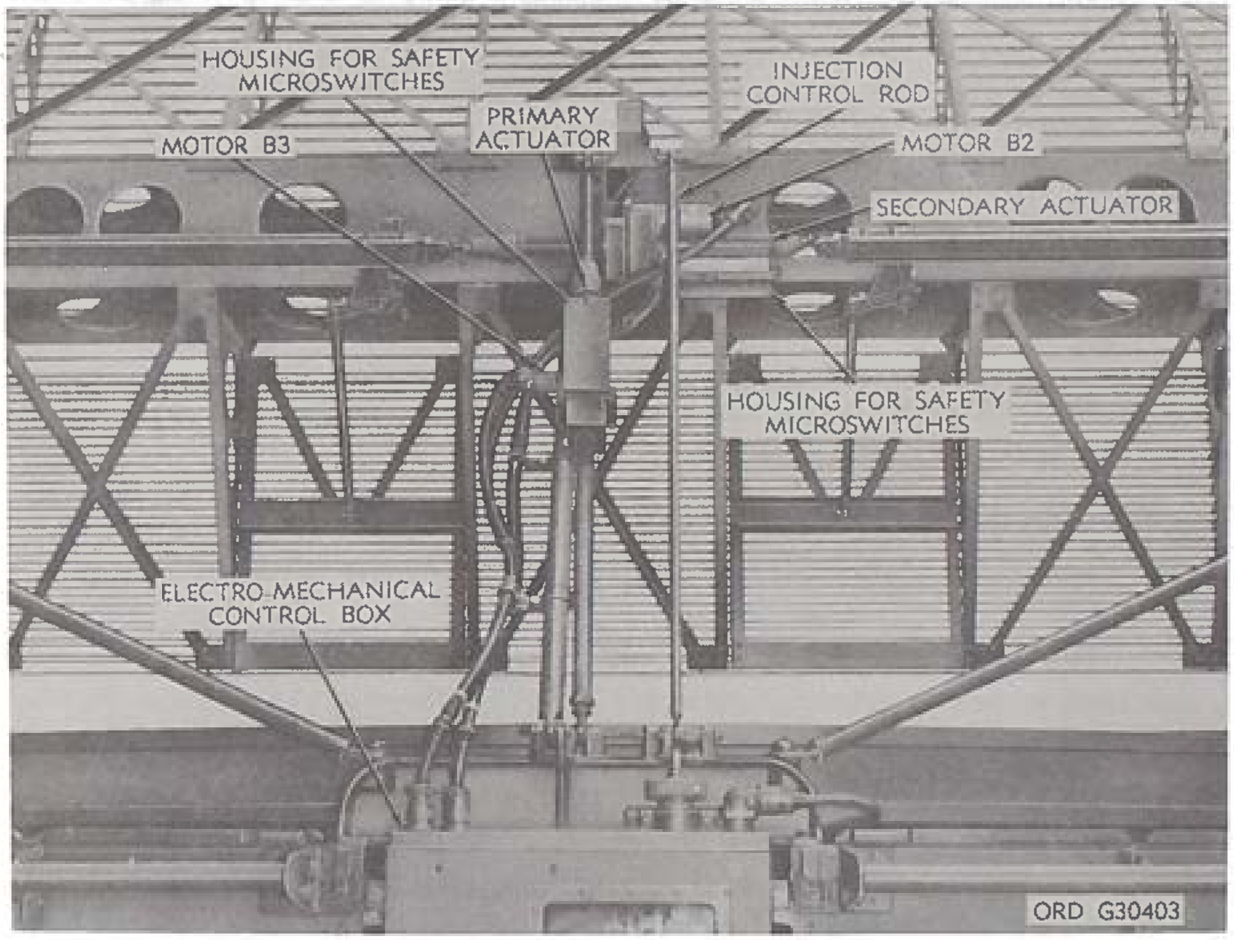


Figure 18 (U). Acquisition antenna—electro-mechanical control system—rear view (U).

a preselected upper limit of travel. Switch S2 (11, fig. 15) is also a pressure-operated microswitch that operates in conjunction with certain relays in the electro-mechanical control panel. This switch reverses the direction of the primary actuator motion when the primary reflector reaches a preselected lower limit of travel. Thus, the adjustment of S2 and S3 presets the angular limits of reflector motion determining the angular travel (scan) of the radiated beam. Two microswitches in a housing on the primary actuator (fig. 18) are safety limit switches for motor B3. One switch is designated the primary up safety switch and the other is designated the primary down safety switch. These switches, *e* below, stop the operation of motor B3 at either end of the actuator stroke should S2 and S3 in the electro-mechanical control box fail or be improperly adjusted.

c. The injection and retraction points of the secondary reflector (fig. 13) are determined by the mechanical position of secondary inject-retract switch S1 (13, fig. 15). Switch S1 and certain relays in the electro-mechanical control panel operate the secondary actuator and motor B2 (fig. 18). Switch S1 is mechanically operated by a small cam on a control switch plate (12, fig. 15) mechanically coupled to the primary actuator. The cam is connected by the injection-control rod (fig. 18) to the secondary reflector. The control switch plate moves up or down as the primary reflector angle is changed. As the angle of the primary reflector is increased, S1 is operated, relays are energized, the secondary actuator is driven by motor B2, and the secondary reflector bars are injected into the primary reflector. When the secondary reflector is fully injected, a dc voltage is applied across the field winding

CHAPTER 7 (C)

RECEIVING SYSTEM

Section I (C). GENERAL

31 (C). Purpose

a. The receiver circuits amplify and convert low-level S-band (3100 to 3500 megacycles) RF energy, supplied by the acquisition antenna system to video signals. These video signals are applied through the moving target indicator (MTI) system to the presentation system.

b. Through the use of two similar receiving channels, the main receiving channel (par. 33) and the auxiliary receiving channel (par. 45), three modes of operation are available in the receiver circuits; basic receiver, anti-jam display (AJD) receiver, and jam strobe (JS) only receiver. The basic receiver mode of operation is used, when no electronic countermeasures (ECM) environment exists, to amplify and convert reflected RF echoes from the main acquisition antenna to target video signals for presentation on the PPI's. For operation in ECM environments, either the AJD or JS only receiver mode is used. In the AJD mode, RF energy from both the main and auxiliary acquisition antennas is utilized to provide target and JS video to the PPI's. The RF echoes and jamming signals from the main antenna are processed through the main receiving channel and, at the same time, jamming signals from the auxiliary antenna are processed through the auxiliary receiving channel. Because the auxiliary antenna is omni-directional, and has a larger coverage pattern than any of the side lobes from the main antenna, the output from the auxiliary receiving channel is greater than that from the main channel at all azimuths except that of the main lobe of the main antenna. The output from the auxiliary channel is compared with the output from the main channel and at all azimuths except that of the main lobe, the larger output from the auxiliary channel effectively cancels the output from the main channel. In this manner, RF echoes from nonjamming targets are converted to video signals for conventional display on the PPI's, while RF echoes and jamming signals from jamming targets are converted to video signals for display as JS video, at all azimuths where the major lobe of the main antenna encounters a jamming signal. In the JS only receiver mode of operation, operation of the receiver circuits is essentially the same as that for the AJD mode; however, only JS video is applied to the PPI's.

32 (U). Block Diagram Analysis

a. General. The receiving circuits (fig. 19) are comprised of five groups of equipment located in two different areas of the NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) system. The groups are the acquisition antenna system and acquisition receiver-transmitter group, located in the LOPAR antenna-receiver-transmitter group; and the battery control console, auxiliary acquisition interconnecting group, and the director station group, located in the trailer mounted director station. The portion of the receiver circuits located in the acquisition antenna system and the acquisition receiver-transmitter group have two parallel channels, main and auxiliary, that operate in a similar manner to provide three 60-megacycle IF outputs to the receiver circuits in the auxiliary acquisition interconnecting group. These three outputs are processed through the interconnecting group and the director station group to provide video output signals corresponding to the selected receiver mode; i.e., basic receiver, anti-jam display (AJD) receiver, or jam strobe (JS) only receiver. Operation of the receiving circuits in each of the three modes of operation is discussed in *b* through *d* below.

b. Basic Receiver.

(1) In the basic receiver mode of operation only the main receiving channel is used. The RF echoes are received by the acquisition antenna and applied to the acquisition duplexer.

The acquisition duplexer functions as an electronic switch to allow received echoes to pass but prevents transmitted RF pulses from entering the receiver circuits. Received echoes from the duplexer are applied through the main noise generator (used to test receiver performance) to the main magnetic circuit located in the acquisition receiver-transmitter group. The magnetic circuit encases a microwave RF amplifier consisting of a traveling-wave tube. Control of the dc grid voltages used by the traveling-wave tube, and monitoring of grid current and grid voltage is provided by the acquisition RF power supply control. The amplified RF output of the main magnetic circuit is applied to the receiver-tuner. The receiver-tuner contains two nonamplifying tuned RF stages (preselectors), one for the main channel and one for the auxiliary channel. The receiver-tuner also contains a local oscillator and a tuning drive motor that are mechanically coupled to the main and auxiliary preselectors by a gear train, thereby providing auxiliary and main channel frequencies that are tuned in unison. The AFC circuits function as a servo loop to automatically adjust the receiver-tuner in step with changes in the acquisition transmitter frequency. The outputs of the receiver-tuner are described in (*a*) through (*c*) below.

(*a*) The amplified RF echoes received from the magnetic circuit are attenuated by the preselector in the receiver-tuner to remove noise and unwanted frequencies and then applied to the main signal frequency converter.

(*b*) The local oscillator output frequency is applied to the main signal frequency converter.

(*c*) A sample of the local oscillator output is applied to the automatic frequency control (AFC) circuits (par. 54).

(2) The attenuated RF echoes from the preselector and the local oscillator frequency, both from the receiver-tuner, are heterodyned in the main signal frequency converter to produce a 60-megacycle IF signal which is applied to the main IF pre amplifier. The main IF pre amplifier provides two stages of 60-megacycle amplification. This amplifier produces sufficient output to overcome transmission line losses and still provide a high signal-to-noise ratio at the load. The amplifier has two outputs. One output is applied to the main electronic frequency converter in the auxiliary acquisition interconnecting group, but this is not a signal flow path when the basic receiver mode is selected. The second output from the main IF pre amplifier is the main normal IF and is applied through normal IF select relay K2 to the acquisition IF pre amplifier. In the basic receiver mode of operation, the auxiliary receiving channel operates in a manner similar to that described above for the main channel. However, the output from the auxiliary IF pre amplifier is not used except during test purposes when normal IF select relay K2 applies auxiliary normal IF instead of the main normal IF to the acquisition IF pre amplifier. In certain selected systems, only one IF output is provided from the main IF pre amplifier. The 60-megacycle IF output supplies an IF input to the main electronic frequency converter and to the normal IF select relay K2.

(3) The gain of the acquisition IF pre amplifier is controlled by the sensitivity time control (STC) or the manual gain control located in the battery control console. The normal IF signal from the pre amplifier is applied through attenuator Z2 which provides

a match to the signal cable impedance to IF select relay K1. In the basic receiver mode of operation the normal IF signal is applied through K1 and the IF filter to the main acquisition IF amplifier. One video output from the main acquisition IF amplifier (pre-MTI video) is applied to the MTI

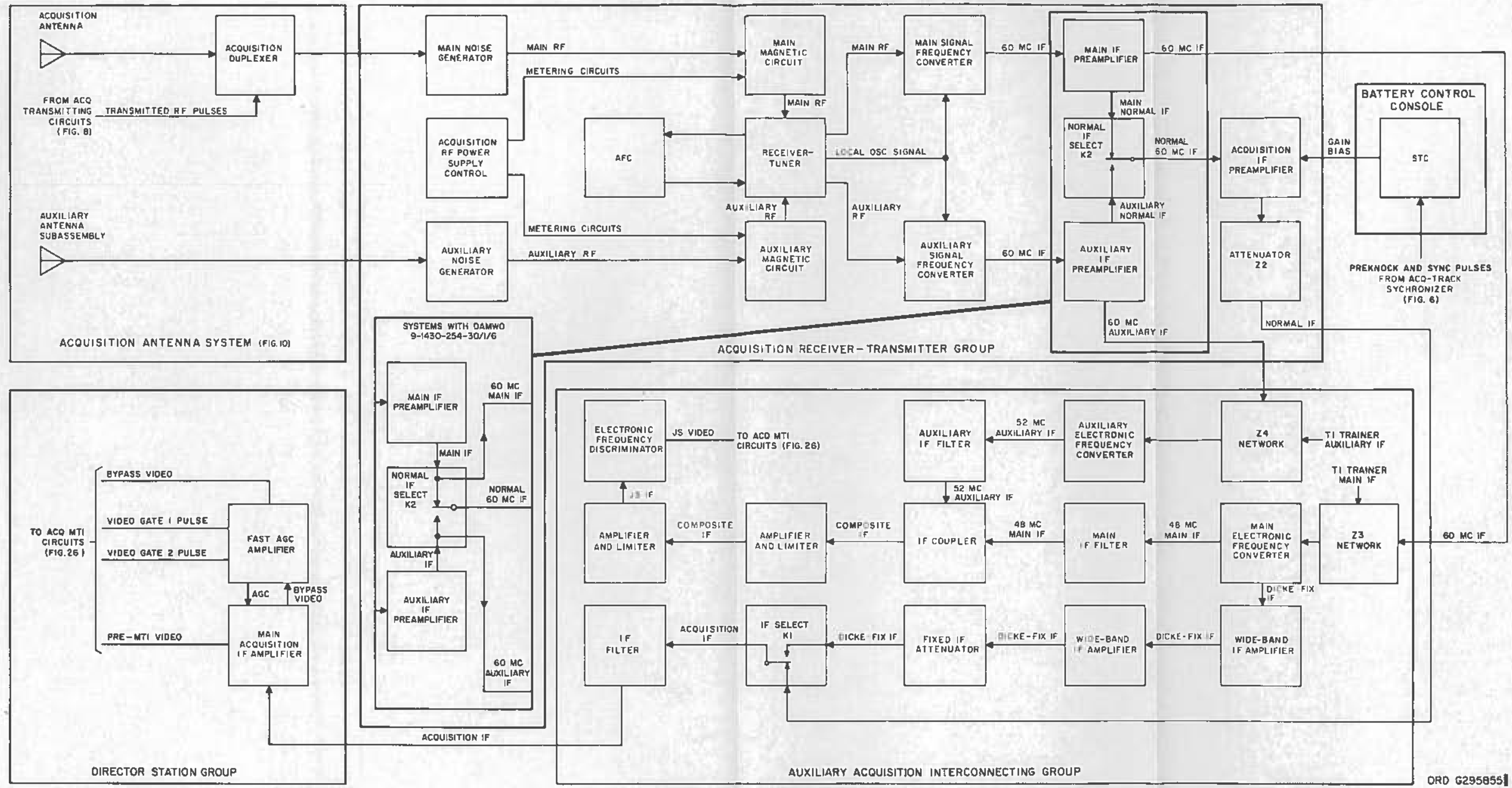


Figure 19 (U). Receiver circuits—block diagram (U).

circuits. The remaining output (bypass video) is applied to the fast AGC amplifier where an AGC control voltage is developed to control the gain of the main acquisition IF amplifier. The AGC voltage can either be a fixed value or a gated fast AGC voltage. The fast AGC amplifier reduces the effect of CW jamming signals through fast time constant circuits described in paragraph 53. The fast AGC amplifier also applies the bypass video signal and two gate pulses to the MTI circuits.

c. AJD Receiver.

(1) The AJD receiver mode of operation utilizes both the main and auxiliary receiver channels. The 60-megacycle main IF output from the main IF preamplifier is applied through network Z3 to the main electronic frequency converter. Network Z3 also provides an insertion point for main IF from the T1 trainer. The main electronic frequency converter supplies a dicke-fix IF input to the wide-band IF amplifier. The dicke-fix circuits consisting of two identical wide-band amplifiers, a fixed attenuator, IF filter, main acquisition IF amplifier, and a fast AGC amplifier, provide circuitry to reduce the effects of strong transmission jamming signals. The two wide-band amplifiers provide amplification and limiting of the dicke-fix IF. The output of the wide-band IF amplifier is applied to a fixed attenuator, through energized IF select relay K1 and the IF filter to the main acquisition IF amplifier. The IF select relay K1 is energized when the AJD mode of operation is selected. The use of a fixed attenuator at the output of the wide-band IF amplifier reduces the amplitude of the dicke-fix IF input to the main acquisition IF amplifier, thereby providing the same AGC level for both normal and dicke-fix IF inputs. The signal output from the wide-band amplifier is increased at the expense of the noise pulses. This action is due to the relative nonuniformity of the power density (noise being broadband) over the bandwidth of the amplifier. The main acquisition IF amplifier is a narrow-band IF amplifier. The narrow bandpass provides a correction factor for the wide-band amplifier signal input. Detection circuits within the main acquisition IF amplifier provide bypass video, applied to the fast AGC amplifier (par. 53) and pre-MTI video applied to the MTI circuits (par. 59). An AGC bias input from the fast AGC amplifier provides gain control feedback.

(2) An additional output from the main electronic frequency converter is a main IF signal that has been shifted in frequency from 60 to 48 megacycles. This 48-megacycle IF signal is applied through the main IF filter to the IF coupler where it is combined with the 52-megacycle auxiliary IF output of the auxiliary channel. The operation of the auxiliary receiving channel is identical to that of the main receiving channel up to the auxiliary IF pre amplifier, except that no duplexer is required because the auxiliary antenna is used only for receiving. The 60-megacycle auxiliary IF output from the auxiliary IF pre amplifier is applied through network Z4 to the auxiliary electronic frequency converter. Network Z4 also provides an insertion point for auxiliary IF from the T1 trainer. The auxiliary converter operates similar to the main converter; however, the shift in frequency is from 60 to 52 megacycles. The 52-megacycle IF signal is applied from the auxiliary converter through the auxiliary IF filter to the IF coupler. The 48-megacycle IF signal from the main IF filter and the 52-megacycle IF signal from the auxiliary IF filter are combined in the IF coupler to form a composite IF signal. The output from the IF coupler is applied to two amplifier and limiter stages. The two identical amplifier and limiter units

are used in cascade to provide the desired results of producing only one effective output, that being of the stronger signal. The process of producing an output at the stronger signal is known as stronger-signal FM capture. The stronger signal, either the 48-megacycle IF from the main channel, or the 52-megacycle IF from the auxiliary channel, is applied to the electronic frequency discriminator. The receiver gain has been set so that the stronger signal will be that of the main acquisition antenna at its major lobe.

(3) The electronic frequency discriminator is a dual channel discriminator. The discriminator will accept either a 48-megacycle or a 52-megacycle input from the amplifier-limiter. The discriminator will only produce a video output (JS video) when a 48-megacycle input is the stronger. The JS video from the electronic frequency discriminator is applied to the MTI circuit where it is mixed with the video from the dicke-fix circuits.

d. JS Only Receiver. When the JS only receiver mode of operation is selected, receiver operation is the same as with the AJD receiver mode of operation. Both JS video from the electronic frequency discriminator and dicke-fix video from the dicke-fix circuits are applied to the MTI circuits; however, the two video signals are not mixed as in AJD receiver mode. Only the JS video is applied from the MTI circuits to the presentation system.

Section II (C). MAIN ACQUISITION—RECEIVER CIRCUITS

33 (U). Purpose

a. The main receiver circuits amplify and convert the low-level RF echoes received by the acquisition antenna system into video signals. When jamming signals are present, the dicke-fix circuits can be used with the main receiver circuits to permit a better display of target information. A fast reacting automatic gain control (FAGC) is used with the dicke-fix circuits to compensate for rapid changes in signal level that are associated with certain types of jamming. The main receiver circuits will provide, in addition to the normal IF, a converted main IF for strobe generation in association with the auxiliary receiver circuits.

b. The main receiver circuits (fig. 19) consist of the acquisition antenna, acquisition duplexer, noise generator, main magnetic circuit, acquisition RF power supply control, receiver-tuner, main signal frequency converter, main IF pre amplifier, acquisition IF pre amplifier, sensitivity time control (STC), IF filter, and main acquisition IF amplifier. When the dicke-fix mode of operation is used, the main electronic frequency converter, two wide-band IF amplifiers, and the fixed IF attenuator are switched into the main receiver circuits.

34 (U). Acquisition Antenna System

a. The acquisition antenna system (fig. 5) conveys, radiates, and beams acquisition transmitter output RF pulses. During receiving intervals between transmitter pulses, the same system receives, beams, and conveys received RF to the acquisition receiver circuits.

b. During receiving intervals, the acquisition antenna receives and beams the received RF into the antenna pillbox (3, fig. 13). From the pillbox, the RF signals are conveyed through the rotary coupler (fig. 10) in the waveguide circuits to the acquisition duplexer (fig. 6), which terminates the acquisition antenna system. The duplexer acts as an electronic switch, short-circuiting receiver input during transmitting periods and blocking the transmitter during receiving periods. TR tube V4 (fig. 26, B14, TM 9-1430-254-20/6), prevents the passage of transmitted pulses to the receiver circuits. ATR tubes V2 and V3 prevent the passage of received RF signals to magnetron V1. Received RF signals passed by V4 are transferred through a noise generator (par. 43) to the magnetic circuit. When deenergized, the noise generator has no effect on the passage of signals.

35 (U). Main Magnetic Circuit

a. The magnetic circuit is an RF amplifier of microwave frequencies received from the acquisition duplexer. Amplification is provided by a traveling-wave tube enclosed by a magnetic circuit. The main channel magnetic circuit is identical in operation to the magnetic circuit used in the auxiliary channel. Be-

39 (C). Acquisition IF Pre Amplifier

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The IF input signal from normal IF select relay K2 is applied to the acquisition IF pre amplifier (A45). The signal selected by relay K2 is the main IF (normal) during the normal mode of operation and auxiliary IF (normal) during testing of the auxiliary channel (par. 46). The acquisition IF pre amplifier consists of a series of tuned IF amplifiers.

b. The first IF amplifier stage consists of V1 and V2 (A45) connected in a tuned cascode circuit to provide high gain and low noise. The amplifier stages consisting of V3, V4, and V5 provide tuned amplification of the 60-megacycle signal. Amplifier stages V3, V4, and V5 are supplied a gain bias from STC (par. 42) circuits through IF GAIN switch S3 (D47) in the NOR position. The IF GAIN-INCR variable resistor R8 (C47) provides a variable bias when IF GAIN switch S3 is set to the LOC position. The acquisition IF pre amplifier output at connector J1 (A47) is applied to attenuator Z2. Attenuator Z2 provides an impedance match between connecting cables. The output from attenuator Z2 is applied through IF select relay K1 (B80) and a narrow-band IF filter to the main acquisition IF amplifier (B81). The IF select relay K1 (B80) selects the normal IF signal from the acquisition IF amplifier in the deenergized state and terminates the dicke-fix IF (par. 51*c*).

40 (C). Main Acquisition IF Amplifier

a. The main acquisition IF amplifier (fig. 19) converts 60-megacycle signal pulses into video signals for the MTI circuits.

Note. The grid zone references shown in parentheses in *b* below refer to figure 26, TM 9-1430-254-20/6.

b. The main acquisition IF amplifier (D82) receives IF signal pulses from the IF filter. These signals are amplified by six stages of voltage amplification provided by IF amplifiers V1 through V6. From V6, the signal is further amplified by high gain IF power amplifier V7. The output of V7 is coupled through transformer T8 to video amplifier V8. Diode CR2 provides detection of the 60-megacycle IF and applies the detected signal to video amplifier V8. Video amplifier V8 supplies two video outputs for the MTI circuits (par. 61). Although both output video signals consist of approximately 1-microsecond pulses, the bypass video is negative, while the MTI video is positive. Bypass video is applied to the fast AGC amplifier and MTI video is applied to the delay line driver (par. 64).

c. The IF amplifiers, V1 through V5, are supplied with back-bias that protects these tube circuits from overloading effects produced by interference from strong signals of certain forms of continuous-wave jamming. Generation of this bias is determined by the amplitude and duration of the applied signal after 6 microseconds.

41 (C). Main Electronic Frequency Converter

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The main electronic frequency converter receives a 60-megacycle IF input from the main IF pre amplifier at connector J1 (A50). Test relay K1 provides a means of removing the dicke-fix 60-megacycle output at connector J3 during testing of the main channel. The 60-megacycle input is fed through the main electronic frequency converter to output connector J3. This output is applied to the wide-band IF amplifier (A73) as 60-megacycle dicke-fix IF (par. 51). Test relay K1 (B51) is energized when JS alignment switch S1 on the auxiliary acquisition control-indicator (D52) is set to the MAIN ADJ position. The IF amplifiers, V1 and V2, are transformer-coupled IF amplifier stages with a gain bias being applied from MAIN ADJ variable resistor R7 (C51) on the auxiliary acquisition control-indicator. The output from V2 is coupled through transformer T3 to impedance matching transformer T4. The secondary of transformer T4 provides a balance input impedance to parallel mixers V3 and V4.

b. A 108-megacycle oscillator circuit consisting of oscillator V6, crystal Y1, and associated components produce a local oscillator signal fed through buffer stage V7 to transformer T6. Transformer T6 provides a balance input to the two mixer stages, V3 and V4. The 60-megacycle IF input from transformer T4 is mixed with the local oscillator signal from transformer T6 to produce an IF frequency of 48 megacycles. The IF amplifier stage V5 provides one stage of 48-megacycle amplification through transformer T5 to output connector J2. The 48-megacycle IF output at connector J2 is applied through the main IF filter (B55) and attenuator J26 (B58) to the IF coupler (B60). The main IF filter provides a 3db, 0.9-megacycle bandwidth at a center frequency of 48 megacycles.

42 (U). Sensitivity Time Control

a. The sensitivity time control (STC) (fig. 19) generates a variable negative pulse to reduce the gain of the acquisition IF pre amplifier.

b. The RF echo signals reflected from nearby targets contain more energy than the reflected signals from distant targets, causing video displays of nonuniform brilliance on the radar indicators. The STC is, therefore, provided to reduce the gain of the acquisition IF pre amplifier for signals received from short ranges within the limits of 18,000 and 25,000 yards. This aids in minimizing overbrilliance at the center of the PPI and aids in improving video definition of short-range target displays. As a result, a uniform brilliance is provided over a full sweep range for indicators in the presentation system.

Note. The grid zone references shown in parentheses in *c* through *e* below refer to figure 26, TM 9-1430-254-20/6.

c. The STC (B34) controls the gain of the acquisition IF pre amplifier by producing a negative pulse whose flat portion may be adjusted for a duration of 10 to 30 microseconds and whose decay portion may be adjusted for a duration of 2 to 100 microseconds. This negative pulse is clamped to a dc voltage level, which is variable between 0 and —20 volts and applied through contacts 6 and 5 of IF GAIN switch S3 (D47) in the NOR position to tuned IF pre amplifiers V3, V4, and V5 (A45) in the acquisition IF pre amplifier.

d. The input signal (B33) to the STC is the positive acquisition preknock pulse from the acquisition-track synchronizer when the AGC is off. When GAIN AGC variable resistor R7 (C34) on the LOPAR control-indicator is turned to its full clockwise position, contacts A and B of the switch on R7 close illuminating AGC indicator DS6 and energizing preknock sync select relay K12 to turn on the AGC. When relay K12 energizes, contacts 2 and 6 (B32) apply HIPAR/LOPAR sync from the acquisition-track synchronizer to the input of the STC instead of the preknock applied when the AGC is off. The sync is used instead of the preknock to delay the STC AGC pulse to allow the AJD receiver to measure noise (par. 43*c*). The sync pulse occurs a measured time after preknock allowing time for the noise measurement. This input pulse is applied to FLAT variable resistor R2 (B33) and monostable multivibrator V1. Multivibrator V1 is triggered by the input pulse producing a positive square-pulse output. Variable resistor R2 controls the time duration of this square wave, thereby setting the range of maximum reduction of the IF pre amplifier gain. This positive pulse is passed without inversion or amplification through the cathode follower circuit of paraphase amplifier V2A (B34) to crystal diodes CR1 and CR4, and the resistance-capacitance (RC) discharge network consisting of capacitor C5, resistor R14, and DURATION variable resistor R13. Crystal diodes CR1 and CR4 prevent the discharge network from discharging back through V2A. As the RC network discharges, an exponential trailing edge is produced on the positive pulse. Since DURATION variable resistor R13 controls the discharge time of the RC network, R13 determines the maximum STC range. Adjusting R13 varies the pulse shape and range limits over which IF pre amplifier gain exponentially returns to normal. The modified positive square wave then passes through cathode follower V3A to converter amplifier V2B where signal inversion occurs. The input of V2B is clamped to a dc level by crystal diode CR2 producing amplitude limiting, so that the maximum duration of the exponential decay is limited to approximately 100 microseconds. Thus, IF pre amplifier bias returns to normal at approximately 18,000 yards. The output pulse from V2B is a negative STC pulse which is applied to OFF—STC variable re-

CHAPTER 8 (C)

MOVING TARGET INDICATOR SYSTEM

61 (U). Purpose

a. The moving target indicator (MTI) circuits in the MTI system reduce video interference from fixed objects and other radar systems. Since stronger RF echoes are received from fixed objects than from moving targets, the stronger RF echoes (clutter) frequently prevent efficient detection and accurate designation of the moving target. The MTI circuits reduce the intensity of clutter displayed on the cathode-ray tube indicators of the presentation system. Moving targets are visible when they are in an area where clutter is present. Common sources of clutter are mountains, hills, woodlands, cloud formations, and precipitation. The MTI circuits also remove clutter produced by other radar units and certain types of enemy jamming, and provide switching circuits for the selection of the various modes of operation as described in paragraph 63.

b. The MTI circuits make use of the fact that the amplitude of successive video signals received from a fixed object remains relatively constant, whereas the amplitude of those received from a moving target varies. A portion of the MTI circuit adds the signals algebraically to obtain a sum signal for application to the indicators in the presentation system. Another portion of the MTI circuits may be selected to compare successive pulse intervals in order to reject random or pulsed video signals that are not synchronized with the transmitted pulse rate. This reduces the clutter created by radars not operating with the same pulse repetition frequency (PRF). The resulting video information is amplified and applied to the indicators in the presentation system.

62 (U). Block Diagram Analysis

a. The delay line driver in the moving target indicator (MTI) circuits (fig. 26) receives MTI video from the main acquisition IF amplifier in the acquisition receiving system (par. 52). Video gate 1 pulse and video gate 2 pulse from the fast AGC amplifier (par. 53) in the acquisition receiving circuits are applied to the delay line driver. Three additional inputs, the LOPAR preknock pulse, processor feedback video, and the MTI test pulse are received. The input signals modulate a 15-megacycle sinusoidal carrier, generated within the delay line driver, and produce a compound signal. A portion of the compound signal is amplified and detected to produce the nondelay video supplied as one input to the trigger pulse-video amplifier. The remaining or undetected portion of the compound signal voltage is transferred to the MTI delay line as a modulated 15-mc carrier, wherein passage of signals is delayed 2000 microseconds. From the MTI delay line, the delayed modulated, 15-mc carrier is applied as delay video to the delay amplifier. After amplification and detection by the amplifier, the delay video is supplied as one of the inputs to the trigger pulse-video amplifier (par. 67). The delay video and nondelay video are added algebraically in the trigger pulse-video amplifier to cancel clutter. The delay and nondelay video signals are also applied to the acquisition interference suppressor. The algebraic sum of both video signals becomes the phase 1 and 2 video (residual video) signals applied to the MTI video amplifier. During this time, the delay preknock pulse from the delay amplifier and the preknock pulse from the acquisition-track synchronizer, are used to generate the MTI auto sync and disabling pulse. This pulse is utilized to synchronize the operation of the acquisition-track synchronizer in the director station group.

b. The phase 1 and 2 residual video output of the trigger pulse-video amplifier is applied to the MTI video amplifier for amplification and development into three signals: the MTI video, which is applied to the acquisition interference suppressor; the test video, which is applied to the MTI oscilloscope; and the automatic gain control (AGC) voltage, which is applied as a feedback signal to the delay amplifier. Of these outputs, only MTI video is supplied to the acquisition interference suppressor. The acquisition interference suppressor also receives delay and nondelay video from the trigger pulse-video amplifier and bypass video (dicke-fix video when operating in the AJD mode) from the acquisition IF amplifier. Video gate 1 pulse and gate 2 pulse from

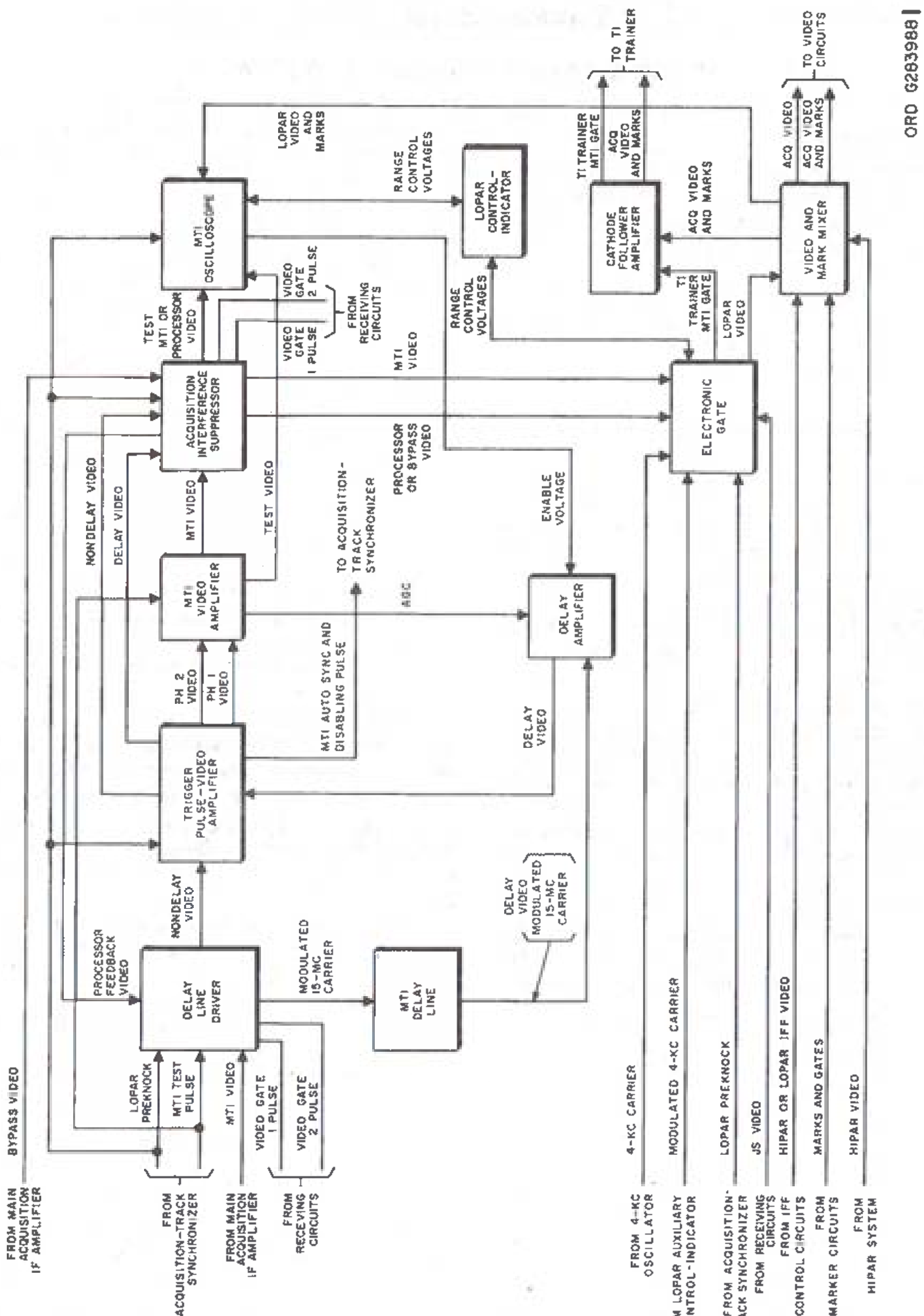


Figure 26 (U). MTI circuits—block diagram (U).

(B37) is energized removing the ground on V2 and one gate (A, fig. 29) appears for each antenna revolution at a time coincident with the azimuth point determined by sector selection and with a duration determined by the setting of SECTOR WIDTH variable resistor R8 (C32).

(*b*) *Range selector.*

1. The output of V2 (F, fig. 30 and B, fig. 29) (B33), consisting of a series of negative preknock pulses, is applied to range phantastron diode-1 V3A. For each preknock pulse supplied to V3A (functioning as an isolation stage), a negative output signal is produced. These signals are applied to the control grid of range phantastron V4, a conventional phantastron. The leading edge of the phantastron pulse (C, fig. 31) is in time coincidence with each gated preknock pulse (B, fig. 31). A negative pulse in the plate circuit of V4 is isolated from the loading effects of the range control circuits by range phantastron diode-2 V3B.

2. A fixed value dc voltage is applied to the cathode circuits of diode V3B. Current flows from ground through resistor R27 (D34), SECTOR RANGE variable resistor R25, connector P1–3, contacts 4 and 10 of energized sector MTI relay K5, contacts 4 and 5 of deenergized MTI mode relay K6, connector P1–7, MTI CKT TEST switch S1C (D30), P1–11, range phantastron diode–2 V3B, and resistor R16 toward +250 volts. This dc voltage and the operation of V3B (C33) limit the maximum plate voltage that can be developed at range phantastron V4. Varying the dc voltage varies the width of the phantastron output pulse, thereby controlling the range within which MTI video is displayed.

3. The negative rectangular wave output from the cathode of V4 (C, fig. 31) (B33) is differentiated by capacitor C15, and resistors R20 and R21. Differentiation produces sharp negative and positive spikes (D, fig. 31). The differentiated pulses are applied to the control grid of bistable gating multivibrator V5A (A32). When the negative pulse triggers V5A, it produces a positive gate pulse (E, fig. 31) applied to gate generator V6A. This same positive gate pulse is applied as an MTI gate pulse through connector J6 (B34) to cathode-follower amplifier (D51). The MTI gate pulse is applied through cathode-follower stage V3 to the T1 trainer. Tube V6 acts somewhat like a cathode follower, coupling the gate outputs from V5 to gating amplifier V7A. With a positive gate applied to the grid of V6A, plate current will increase, causing a large voltage drop across common cathode resistor R44 (A32). This positive voltage, also developed at the cathode of V7A, will bias the tube beyond cutoff. Therefore, the bypass video (dicke-fix video if IF select relay K1 is energized (par. 51*c*)), applied to the grid of V7A will not be amplified. With the negative gate applied to the grid of V6B, the tube will be cut off, reducing the voltage developed across common cathode variable resistor R45 (B31). With the bias on V7B reduced, the MTI video applied to its grid will be amplified. Conversely, when no MTI trigger is present, V6A will be cut off, reducing the voltage developed across common cathode resistor R44. With the bias on V7A reduced, any bypass or processor,

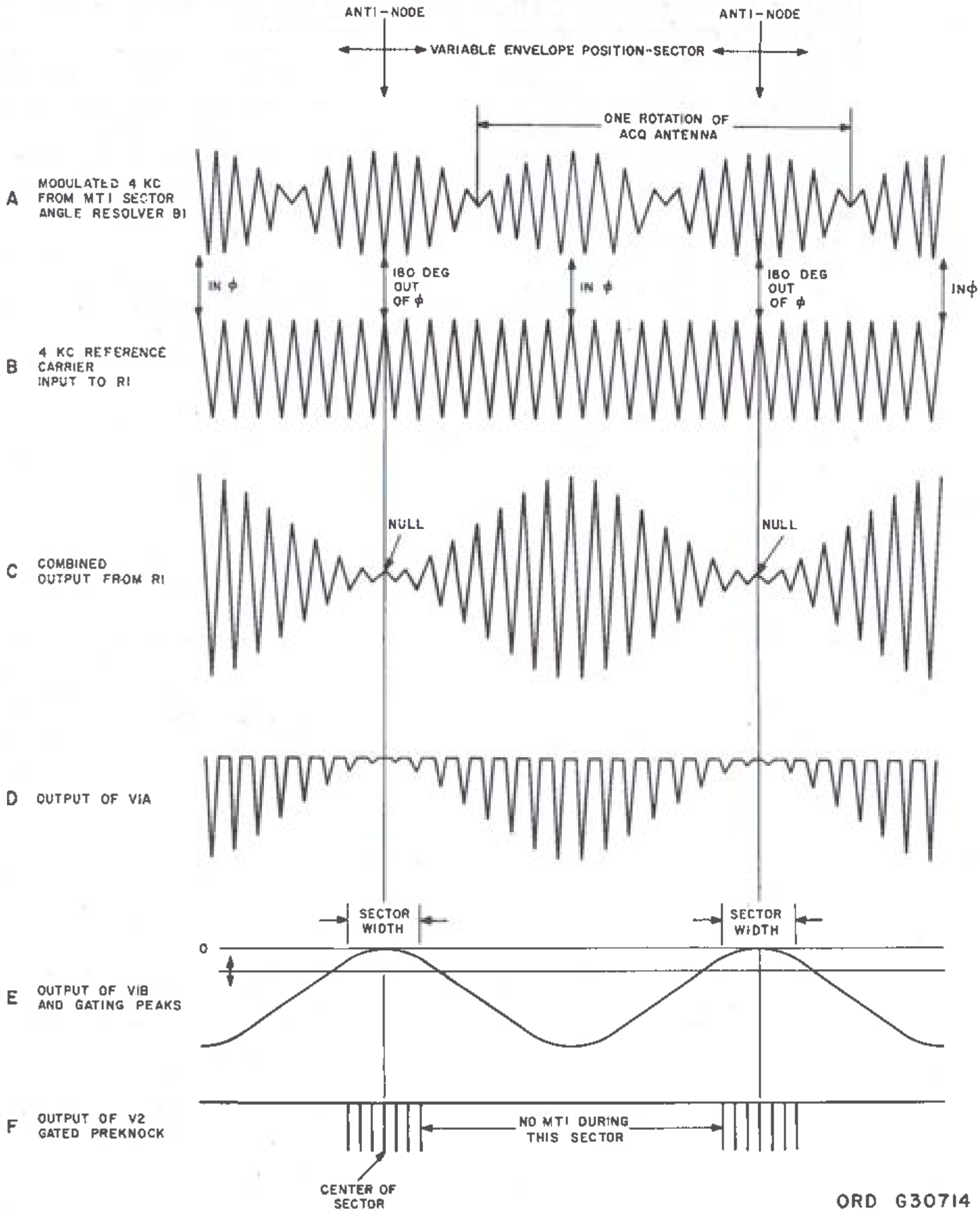


Figure 30 (U). MTI control circuits—waveforms—ideal (U).

or dicke-fix video applied to the grid will be amplified. By the same reasoning, V7B will now be cut off due to increased plate current through V6B. SW BAL variable resistor R45 is adjusted to equalize conduction on both halves of V7 so the switching waveform will not appear in the plate circuit.

(c) *MTI off.* When neither SECTOR MTI nor 360° MTI mode is selected (switch-indicators A8 and A7 illuminated white), the cathode-ray tube sweeps display bypass video only, and the output of 4-kc detector V1B (B32) is grounded through contacts 9 and 1 of deenergized relay K5 (A37), contacts 1 and 6 of deenergized MTI

PPI and by the setting of RANGE switch S1 on the side of the PPI. The range and gain switch limits the amplitude of the sweep sawtooth to a predetermined level regardless of the range selected.

g. The sweep sawtooth is then applied to the second dc amplifier where it is amplified to the level required by the deflection plates of the CRT (par. 86). Push-pull sweep voltages are then applied to the deflection plates of the CRT.

h. The X and Y sweep voltages are also applied to the fail-safe circuit (par. 87) in the pulse and logic generator. The fail-safe circuit is a relay amplifier with parallel inputs for the X and Y sweep voltages. If both sweeps are present in the PPI, normal collector voltage is applied to the CRT. If both sweeps are missing, a fail-safe collector voltage will be applied to the CRT. This insures that the CRT will not be damaged when the acquisition antenna is not rotating.

i. The writing gun driver (par. 83) also supplies a negative 2500-volt potential to the writing gun cathode in the CRT. During the normal sweep interval a video unblanking pulse modulates this voltage so that video at close range will not be too bright and video at maximum range will be of increased intensity.

77 (U). 4-KC Oscillator

a. The 4-kc oscillator generates a 4-kc sinusoidal carrier that supplies reference and excitation voltages for synchro resolvers and associated units in the marker, MTI, and sweep circuits.

Note. The grid zone references shown in parentheses in *b* below refer to figure 37, TM 9-1430-254-20/6.

b. The 4-kc oscillator (D2), located in the director station group, is comprised of oscillator V1, and power amplifiers V2 and V3, and associated circuits and controls. Although output transformer T3 (B4), a part of the director station group, is externally located, it is a functional part of the 4-kc oscillator. A functional analysis of the 4-kc oscillator is presented in (1) through (5) below.

(1) The 4-kc sinusoidal signal is generated by oscillator V1 (A2), a dual triode connected as a push-pull audio frequency oscillator. The frequency of oscillation is determined by the resonant frequency of a tank circuit consisting of inductor L1 (B2), and capacitors C1 and C3. Positive feedback is provided by the auto-transformer action of L1 and the coupling of C1 and C3. A degree of degenerative feedback is provided by C2 to offset part of the regenerative feedback. This prevents V1 from being driven alternately into cutoff and saturation, producing sine-wave oscillations that are distorted in amplitude. The plate voltage of V1 is determined by the setting of ACQ ADJ variable resistor R5 (B1), which is part of a voltage divider completed by resistors R4 and R6. Adjustment of R5 controls the output amplitude of V1.

(2) The 4-kc sinusoidal output from oscillator V1 is applied to power amplifiers V2 and V3 which are connected for push-pull operation. These amplifiers are provided with degenerative feedback through capacitors C5 and C6. This feedback limits the output signals to 240 volts peak-to-peak and improves amplifier stability in addition to decreasing signal distortion. The 240-volt outputs of V2 and V3, 180 degrees out of phase with each other, are applied across the primary of transformer T3 (B4) located in the director station group. At the secondary of T3, the 170-volt (peak-to-peak) output 4-kc carrier signal appears at terminal 3.

(3) The 4-kc carrier signal from terminal 3 of T3 (B4) is distributed to the following:

(a) The electronic gate (C5) in the director station group.

(b) The pulse persistence generators (C7 and C9) in the battery control sole.

(c) The B scope modulation eliminator (C11) in the target radar control console.

(d) The mark generator (C11) in the target radar control console.

(e) The azimuth blank generator (D11) in the target radar control console.

(4) The 4-kc carrier signal from terminal 2 of T3 (B4) is distributed to the following:

(a) Through the auxiliary acquisition interconnecting box (A9) for use by HIPAR or AAR Systems.

(b) Through the auxiliary acquisition interconnecting box (A9) for use by the T1 trainer.

78 (U). Acquisition Azimuth Resolver

a. Acquisition azimuth resolver B2 (fig. 32), is camparable to a small dual rotary transformer in which a cylindrical rotor (secondary) is mounted within a cylindrical stator (primary). The stator, consisting of two field windings, is so constructed that the magnetic fields of each winding are displaced 90 degrees from each other. The rotor is similarly constructed. The two rotor windings are designated the north-south (N–S) winding and the east-west (E–W) winding. When maximum coupling exists between a rotor winding and a stator winding, the resolver may be considered similar to a transformer with a 1:1 turns ratio. The rotor is considered oriented when the output signal of the N–S rotor is maximum as the azimuth position of the acquisition antenna reaches north (6400 mils) or south (3200 mils), and the output signal of the E–W rotor is maximum at east (1600 mils) or west (4800 mils). The functional application of this resolver is given in *b* below.

b. Acquisition azimuth resolver B2 (fig. 34, B2, TM 9-1430-254-20/6) in the acquisition antenna pedestal, uses only one of its two stator windings. One winding (S2–S4) is grounded and is, therefore, not used. The other winding (S1–S3) is energized by a 4-kilocycle CW sine-wave carrier with an amplitude of approximately 80 volts peak-to-peak. The 4-kilocycle input signal is received from the 4-kc oscillator (fig. 37, D2, TM 9-1430-254-20/6) discussed in paragraph 77. The resolver rotor, which is mechanically connected to, and rotates in synchronization with, the acquisition antenna receives induced 4-kilocycle signals from the stator winding. These 4-kilocycle signals are amplitude-modulated whenever the acquisition antenna is rotating. The modulation envelope of signals induced in the E–W rotor winding (R2–R4) is displaced by 90 electrical degrees from the modulated envelope, of those induced in the N–S rotor winding (R1–R3). The LOPAR N–S and E–W output signals from B2 are applied to the resolver amplifier (fig. 34, C2, TM 9-1430-254-20/6).

79 (U). Resolver Amplifier

a. The resolver amplifier (fig. 32) contains a channel of amplification for each of the two acquisition azimuth resolver output signals. The resolver amplifier increases the amplitude of the resolver LOPAR N–S and E–W signals to insure that the output signals have sufficient voltage to supply load requirements, and isolates the acquisition azimuth resolver from load variations.

Note. The figure and zone references shown in parentheses in *b* below refer to TM 9-1430-254-20/6.

b. The resolver amplifier (fig. 34, D2) contains a LOPAR N–S amplifier channel and a LOPAR E–W amplifier channel. Since these two signal channels are identical, only the functional analysis of the LOPAR N–S amplifier channel is given. The output of the N–S rotor winding (R1–R3) of acquisition azimuth resolver B2 is a modulated 4-kilocycle sine-wave signal that is applied to voltage amplifier V1 (fig. 34, C2). The amplified output of V1, a conventional resistance-coupled voltage amplifier, is applied to power amplifier V2. Amplifier V2 is a conventional power amplifier with transformer coupling to the load circuits. The output signal level of the modulated envelope is 70 to 80 volts peak-to-peak. Output transformer T2 matches the impedance of the resolver amplifier to the characteristic impedance of the distribution circuit used for the LOPAR N–S signal. The terminating impedance of the distribution circuit consists of resolver stator windings and transformer primary windings. Transformer T2 (fig. 34, C3) also provides a degenerative feedback voltage from its secondary winding to the input circuit of amplifier V1. The feedback voltage is used to minimize signal distortion. Antenna rotation is stopped when LOPAR ANTENNA ROTATION OFF switch-indicator A9 on the LOPAR auxiliary control-indicator (fig. 38, D1) is illuminated amber. When switch-indicator A9 is depressed, antenna rotation relay K2 is deenergized and its contacts 3 and 5 (fig. 17, B19) open to remove the +250-volt (SW) dc potential supplied to the resolver amplifier eliminating a personnel safety hazard and possible equipment damage. Interlock switch S3 (fig. 34, D1) is actuated whenever the access cover for the resolver amplifier on the acquisition antenna pedestal is removed. The LOPAR N-S and E-W amplified outputs of the resolver amplifier are applied to HIPAR select relay K1 (fig. 34, C5) located on the LOPAR auxiliary control-indicator. In selected systems using AAR, the LOPAR resolver signals are applied through normally closed contacts 5-15 of HIPAR/AAR select relay K1 (fig. 34, A1) and normally closed contacts 1 and 6 of HIPAR/AAR select relay K3 (fig. 34, A2) to the ECCM console.

80 (U). Auxiliary Resolver Amplifier

The auxiliary resolver amplifier (fig. 34, B4, TM 9-1430-254-20/6) compensates for line losses that occur in the cable between HIPAR and LOPAR systems and insure equal amplitude of the HIPAR and LOPAR resolver signals. Since the N-S and E-W channels of the auxiliary resolver amplifier are similar, operation of only the E-W channel is discussed. The HIPAR E-W signal from connector P1-2 (fig. 34, A4, TM 9-1430-254-20/6) is applied to transformer T3-1 in the auxiliary resolver amplifier. The signal is coupled across T3 and applied through E-W adjust variable resistor R27 to voltage amplifier V5. The amplified output of V5 is applied to power amplifier V6. The output of V6 is coupled through output transformer T4 to the LOPAR auxiliary control-indicator and to the HIPAR control-indicator. A feedback voltage from the secondary winding of T4 is applied to the input circuit of V5 to minimize signal distortion. HIPAR and LOPAR resolver signals are applied from their respective resolver amplifier through the auxiliary acquisition interconnecting box (fig. 34, B3, TM 9-1430-254-20/6) for use by the T1 trainer.

81 (U). Radar Select and Preview Circuits

a. The HIPAR and LOPAR resolver signals are applied to the radar select and preview circuits. In this section, sweep signals from one radar system will be selected for presentation on both PPI's. Either PPI can select alternate video for previewing. Refer to paragraph 13 for the functional description of the radar select and preview circuits.

b. The resolver signals from the selected acquisition radar system are applied to each pulse persistence generator. Since the pulse persistence generators and PPI's are identical, only the long range PPI sweep channel and associated pulse persistence generator will be discussed.

82 (U). Pulse Persistence Generator

a. The modulation eliminator section of the pulse persistence generator converts amplitude-modulated 4-kc carrier signals (resolver output signals) into low-frequency sinusoidal signals and applies them to sweep generating circuits of a cathode-ray tube (CRT) employing electrostatic deflection.

b. The modulation eliminator consists of two identical bridge-type demodulators using crystal diodes. This assembly demodulates the N-S and E-W acquisition antenna azimuth position signals and supplies two low-frequency quadrature voltages representing X and Y vector components of antenna beam azimuth to the sweep generator (par. 85).

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 34, TM 9-1430-254-20/6.

c. The two bridge-type demodulators (B11) are identical in operation. Each consists of an input transformer, a load resistor, and a bridge rectifier containing four crystal diode rectifiers and four precision resistors. Transformer T1 supplies a controlling reference voltage to diagonally opposite junctions of arms of each bridge demodulator. The rectifiers are silicon junction diodes having a high back impedance, a high inverse peak voltage, and a high current capacity. The precision resistor in series with the diode in each arm of the bridge compensates for slight differences in conduction of the crystal diodes. The load for the N-S signal demodulator is resistor R7 (B10), whereas the load for the E-W signal demodulator is resistor R8.

d. The N-S and E-W input signals are applied through X OFF—NOR—Y OFF switch S1 (B10) to the primaries of transformers T2 and T3, respectively. There is a phase differ-

auxiliary control-indicator (fig. 38, D1) is illuminated amber. When switch-indicator A9 is depressed, antenna rotation relay K2 is deenergized and its contacts 3 and 5 (fig. 17, B19) open to remove the +250-volt (SW) dc potential supplied to the resolver amplifier eliminating a personnel safety hazard and possible equipment damage. Interlock switch S3 (fig. 34, D1) is actuated whenever the access cover for the resolver amplifier on the acquisition antenna pedestal is removed. The LOPAR N-S and E-W amplified outputs of the resolver amplifier are applied to HIPAR select relay K1 (fig. 34, C5) located on the LOPAR auxiliary control-indicator. In selected systems using AAR, the LOPAR resolver signals are applied through normally closed contacts 5-15 of HIPAR/AAR select relay K1 (fig. 34, A1) and normally closed contacts 1 and 6 of HIPAR/AAR select relay K3 (fig. 34, A2) to the ECCM console.

80 (U). Auxiliary Resolver Amplifier

The auxiliary resolver amplifier (fig. 34, B4, TM 9-1430-254-20/6) compensates for line losses that occur in the cable between HIPAR and LOPAR systems and insure equal amplitude of the HIPAR and LOPAR resolver signals. HIPAR/AAR resolver signals at connector J30 (fig. 34, A3, TM 9-1430-254-20/6) are applied to differential resolver B1 (fig. 34, B6.6, TM 9-1430-254-20/6) before being applied to the auxiliary resolver amplifier. Differential resolver B1 provides correction for error or phase difference in acquisition azimuth orientation through the adjustment of the HIPAR AZIMUTH ZERO ADJUST knob. Distortion of HIPAR/AAR 4-kc resolver signals, caused by extra lengths of cable, is reduced by the use of a filter assembly (fig. 34, A6.4, TM 9-1430-254-20/6). The filter assembly contains various values of capacitance and inductance that may be switched into the line by switches S1C and S2L. The 4-kc line is tuned by the correct amount of inductance or capacitance and line losses are reduced to resistive losses only. Since the N-S and E-W channels of the auxiliary resolver amplifier are similar, operation of only the E-W channel is discussed. The HIPAR E-W signal from connector P1-2 (fig. 34, B6.1, TM 9-1430-254-20/6) is applied to transformer T3-1 in the auxiliary resolver amplifier. The signal is coupled across T3 and applied through E-W adjust variable resistor R27 to voltage amplifier V5. The amplified output of V5 is applied to power amplifier V6. The output of V6 is coupled through output transformer T4 to the LOPAR auxiliary control-indicator. A feedback voltage from the secondary winding of T4 is applied to the input circuit of V5 to minimize signal distortion. HIPAR and LOPAR resolver signals are applied from their respective resolver amplifier through the auxiliary acquisition interconnecting box (fig. 34, B3, TM 9-1430-254-20/6) for use by the T1 trainer.

81 (U). Radar Select and Preview Circuits

a. The HIPAR and LOPAR resolver signals are applied to the radar select and preview circuits. In this section, sweep signals from one radar system will be selected for presentation on both PPI's. Either PPI can select alternate video for previewing. Refer to paragraph 13 for the functional description of the radar select and preview circuits.

b. The resolver signals from the selected acquisition radar system are applied to each pulse persistence generator. Since the pulse persistence generators and PPI's are identical, only the long range PPI sweep channel and associated pulse persistence generator will be discussed.

82 (U). Pulse Persistence Generator

a. The modulation eliminator section of the pulse persistence generator converts amplitude-modulated 4-kc carrier signals (resolver output signals) into low-frequency sinusoidal signals and applies them to sweep generating circuits of a cathode-ray tube (CRT) employing electrostatic deflection.

b. The modulation eliminator consists of two identical bridge-type demodulators using crystal diodes. This assembly demodulates the N-S and E-W acquisition antenna azimuth position signals and supplies two low-frequency quadrature voltages representing X and Y vector components of antenna beam azimuth to the sweep generator (par. 85).

ence of 90 degrees between the input signals of T2 and T3, and these signals have only half the amplitude of the 4-kc reference signal supplied to transformer T1. This amplitude relationship insures that the 4-kc reference signal effectively gates the diode pairs of the bridge-rectifier circuits. Switch S1, when set to Y OFF or X OFF, removes the input signal to the respective modulation eliminator. By this means, the input transformer is grounded with respect to the load, and the output of the associated bridge circuit is zero. The X OFF and Y OFF positions of switch S1 are used during sweep generator adjustments.

e. The output signals of the modulation eliminator are developed from the two control input signals discussed in (1) and (2) below.

(1) The two control inputs are the N-S and E-W resolver signals received from the video select and preview circuits (par. 13). Each signal consists of an amplitude-modulated 4-kc carrier. The frequency of modulation is determined by the rotation speed of the acquisition antenna when an input to the PPI sweep circuits is supplied from acquisition azimuth resolver B2 (par. 78) in the acquisition antenna pedestal (D2). As the resolver rotor makes one complete revolution, the output voltage varies through a single cycle of amplitude modulation. In this manner, two envelopes, 90 degrees out of phase, with 100-percent modulation, having a maximum peak-to-peak amplitude of 80 volts, are generated for each 360 degrees of rotor rotation.

(2) The second control input is a 4-kc sinusoidal signal with a constant amplitude level of 170 volts peak-to-peak, received from the 4-kc oscillator (par. 77). This steady ac reference signal in the audio frequency band is used as excitation voltage for the primary of transformer T1 (A10). This transformer supplies the reference voltage to the two bridge-rectifier type demodulators.

f. With no resolver signal input to the demodulators, no current flows through load resistors R7 and R8 because the electrical bridge circuit of each demodulator is in a balanced condition. The condition of balance exists between the junction of conducting diode rectifiers in each bridge rectifier and the grounded center tap of transformer T1. When a resolver signal is received, the bridge circuit unbalances in proportion to the amplitude induced in the transformer secondaries, and current flows through alternate halves of T2 or T3 secondary and the associated load resistor during one input cycle. A change in phase of 180 degrees of the resolver signal with respect to the carrier reference from T1 occurs each 180 degrees of antenna rotation and causes the current to reverse its direction of flow through the associated load resistor (R7 or R8). The change in phase occurs because the phase of the voltage induced in the quadrature windings of the resolver rotor with respect to the 4-kc excitation stator voltage depends on the azimuth hemisphere through which the antenna is rotating. Thus, full-wave rectification of the modulated carrier appears at R7 and R8. This voltage is filtered by a dual section RC filter that removes the 4-kc carrier components. The RC filter for the X voltage output consists of resistors R9 (B11) and R10, and capacitors C3 and C4. The RC filter for the Y voltage output is identical to the X voltage filter and consists of resistors R5 and R6, and capacitors C1 and C2. These filters are designed to remove cross modulation products of the output voltages.

g. The signals from the modulation eliminator are two low-frequency ac outputs of equal amplitude. One output signal is the modified X sine-wave envelope having 40-volt peak-to-peak amplitude change, and the other is the modified Y sine-wave envelope of equal amplitude. These sine waves are 90 degrees out of phase, so that one represents a sine function with respect to the change of antenna azimuth and the other a cosine function.

h. The Y slope and X slope variable resistors R15 and R16 adjust the length of the sweep on the face of the CRT. Variable resistors R18 and R21 are zero setting variable resistors for the first dc amplifier stage in the sweep generators.

83 (C). Writing Gun Driver

a. The writing gun driver (fig. 32) receives a sync pulse to produce the negative and positive range pulses that control electronic gate 4 in the feedback circuit of the first dc amplifier in the X and Y sweep generators. This dc amplifier produces a sweep signal upon the application of the range pulses.

b. The writing gun driver also produces a negative video unblanking pulse that is applied to the cathode of the writing gun in the cathode-ray tube (CRT). The pulse is of such a shape that a target at close range will not appear at too high intensity and a target at

Note. The grid zone references shown in parentheses in *c* through *f* below refer to figure 34, TM 9–1430–254–20/6.

c. The two bridge-type demodulators (B11) are identical in operation. Each consists of an input transformer, a load resistor, and a bridge rectifier containing four crystal diode rectifiers and four precision resistors. Transformer T1 supplies a controlling reference voltage to diagonally opposite junctions of arms of each bridge demodulator. The rectifiers are silicon junction diodes having a high back impedance, a high inverse peak voltage, and a high current capacity. The precision resistor in series with the diode in each arm of the bridge compensates for slight differences in conduction of the crystal diodes. The load for the N-S signal demodulator is resistor R7 (B10), whereas the load for the E-W signal demodulator is resistor R8.

d. The N-S and E-W input signals are applied through X OFF—NOR—Y OFF switch S1 (B10) to the primaries of transformers T2 and T3, respectively. There is a phase difference of 90 degrees between the input signals of T2 and T3, and these signals have only half the amplitude of the 4-kc reference signal supplied to transformer T1. This amplitude relationship insures that the 4-kc reference signal effectively gates the diode pairs of the bridge-rectifier circuits. Switch S1, when set to Y OFF or X OFF, removes the input signal to the respective modulation eliminator. By this means, the input transformer is grounded with respect to the load, and the output of the associated bridge circuit is zero. The X OFF and Y OFF positions of switch S1 are used during sweep generator adjustments.

e. The output signals of the modulation eliminator are developed from the two control input signals discussed in (1) and (2) below.

(1) The two control inputs are the N-S and E-W resolver signals received from the video select and preview circuits (par. 13). Each signal consists of an amplitude-modulated 4-kc carrier. The frequency of modulation is determined by the rotation speed of the acquisition antenna when an input to the PPI sweep circuits is supplied from acquisition azimuth resolver B2 (par. 78) in the acquisition antenna pedestal (D2). As the resolver rotor makes one complete revolution, the output voltage varies through a single cycle of amplitude modulation. In this manner, two envelopes, 90 degrees out of phase, with 100-percent modulation, having a maximum peak-to-peak amplitude of 80 volts, are generated for each 360 degrees of rotor rotation.

(2) The second control input is a 4-kc sinusoidal signal with a constant amplitude level of 170 volts peak-to-peak, received from the 4-kc oscillator (par. 77). This steady ac reference signal in the audio frequency band is used as excitation voltage for the primary of transformer T1 (A10). This transformer supplies the reference voltage to the two bridge-rectifier type demodulators.

f. With no resolver signal input to the demodulators, no current flows through load resistors R7 and R8 because the electrical bridge circuit of each demodulator is in a balanced condition. The condition of balance exists between the junction of conducting diode rectifiers in each bridge rectifier and the grounded center tap of transformer T1. When a resolver signal is received, the bridge circuit unbalances in proportion to the amplitude induced in the transformer secondaries, and current flows through alternate halves of T2 or T3 secondary and the associated load resistor during one input cycle. A change in phase of 180 degrees of the resolver signal with respect to the carrier reference from T1 occurs each 180 degrees of antenna rotation and causes the current to reverse its direction of flow through the associated load resistor (R7 or R8). The change in phase occurs because the phase of the voltage induced in the quadrature windings of the resolver rotor with respect to the 4-kc excitation stator voltage depends on the azimuth hemisphere through which the antenna is rotating. Thus, full-wave rectification of the modulated carrier appears at R7 and R8. This voltage is filtered by a dual section RC filter that removes the 4-kc carrier components. The RC filter for the X voltage output consists of resistors R9 (B11) and R10, and capacitors C3 and C4. The RC filter for the Y voltage output is identical to the X voltage filter and consists of resistors R5 and R6, and capacitors C1 and C2. These filters are designed to remove cross modulation products of the output voltages.

g. The signals from the modulation eliminator are two low-frequency ac outputs of equal amplitude. One output signal is the modified X sine-wave envelope having 40-volt peak-to-peak amplitude change, and the other is the modified Y sine-wave envelope of equal amplitude. These sine waves are 90 degrees out of phase, so that one represents a sine function with respect to the change of antenna azimuth and the other a cosine function.

h. The Y slope and X slope variable resistors R15 and R16 adjust the length of the sweep on the face of the CRT. Variable resistors R18 and R21 are zero setting variable resistors for the first dc amplifier stage in the sweep generators.

83 (C). Writing Gun Driver

a. The writing gun driver (fig. 32) receives a sync pulse to produce the negative and positive range pulses that control electronic gate 4 in the feedback circuit of the first dc amplifier in the X and Y sweep generators. This dc amplifier produces a sweep signal upon the application of the range pulses.

b. The writing gun driver also produces a negative video unblanking pulse that is applied to the cathode of the writing gun in the cathode-ray tube (CRT). The pulse is of such a shape that a target at close range will not appear at too high intensity and a target at

Table IV (CMHA). Target Designate Control Relay Energization (U)

Unit	PPI range display[1]	Energized relays	Deenergized relays
SR target designate control	75,000 yds 150,000 yds	K1 None	K2, K3 K1, K2, K3
LR target designate control (HIPAR system selected)	150,000 yds 350,000 yds	K2 K2, K3	K1, K3 K1
LR target designate control (LOPAR system selected)	150,000 yds 250,000 yds	None K3	K1, K2, K3 K1, K2

[1] For range selection theory refer to paragraph 111.

control (B6) set to maximum, RG METER MAX variable resistor R11 (B5) adjusts the indication on range meter M1 to 150 K yards.

h. Quadrant wound variable resistor R18 has two wiper arms set 90 degrees apart. The two arms of variable resistor R18 are mechanically coupled to the azimuth control. When the designate circle is positioned over target video, the azimuth control is positioned at the azimuth of the target video. The mechanical coupling between the azimuth disc and variable resistor R18 also positions the wiper arms at an angle equivalent to the azimuth of the target video. Since the wiper arms are 90 degrees apart, the outputs will be sine and cosine functions of the inputs. One input is negative and the other is positive so that a complete circle can be described in vector components. The two outputs from variable resistor R18 are range multiplied by the sine of the azimuth angle (R Sine A = X analog) and range multiplied by the cosine of the azimuth angle (R COS A = Y analog).

i. The X and Y analog outputs are then applied to cathode followers V4B (C4) and V4A. From the cathode circuit, these voltages are applied to the time share relay assembly (par. 102). The Y ZERO variable resistor R37 (C4) and X ZERO variable resistor R38 (C5) are adjusted for zero output from the cathode followers with no signal input.

j. If the designate circuits are in the designate enable condition, the time share relay assembly (par. 102) will provide the necessary signals to the pulse and logic generator (par. 103) to display the designate circle and designate semicircle on the PPI's.

Section V (U). VIDEO CIRCUITS

107 (U). Purpose

a. The video circuits (fig. 1), a part of the presentation system, use input signals from six sources in order to develop video signals for display (par. 73) on three cathode-ray tube (CRT) indicators.

b. The input signals for the video circuits are received from the moving target indicator (MTI) circuits (par. 61), the marker circuits (par. 117), the fire unit integration facility (FUIF) interconnecting equipment (par. 101), the plan position indicator (PPI) sweep circuits (par. 75), the time share relay assembly (par. 102), and the B scope indicator sweep circuits (par. 88). Although the inputs from the FUIF interconnecting equipment and the time share relay assembly are relay control grounds and not video signals, the inputs control the generation of symbols in the presentation system. The display of these symbols is discussed in the symbol positioning circuits (par. 99). The video signals developed in the video circuits are displayed upon two CRT indicators in the battery control console and upon one CRT in the target radar control console. These indicators are designated the short range (SR) PPI, the long range (LR) PPI, and the B scope indicator.

108 (U). Block Diagram Analysis

a. The two PPI's (fig. 37), through the functions of the writing gun drivers (par. 109)

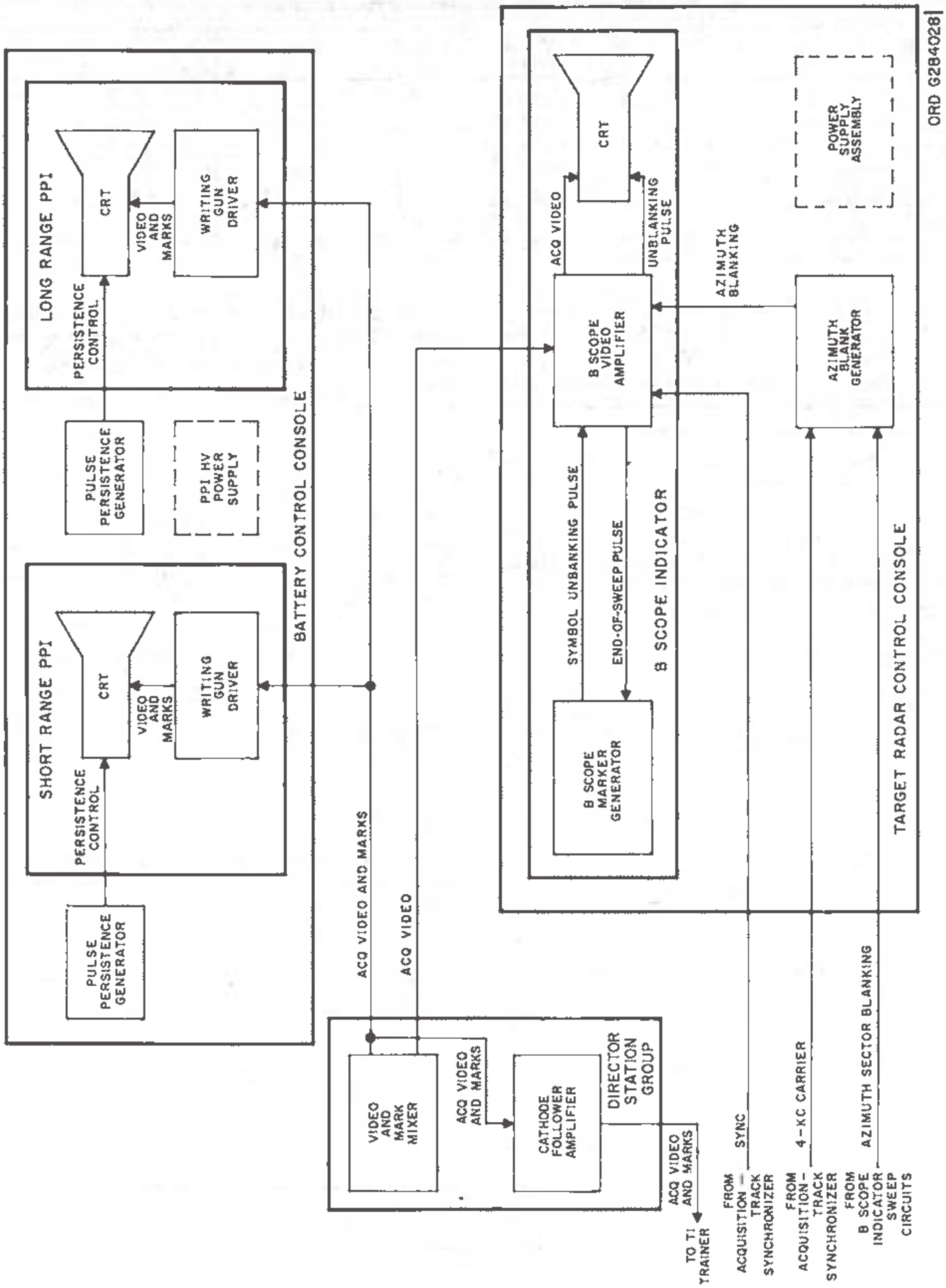


Figure 37 (U). Video circuits—block diagram (U).

and the CRT's enable the display of video signals. The CRT in use in each PPI is a 8¾-inch controlled persistence direct view storage tube.

b. The video and mark mixer (par. 71) in the MTI circuits supplies acquisition video and marks to the writing gun driver in each PPI and through the cathode follower amplifier to the T1 trainer. The writing gun driver amplifies the video and marks signals and applies them to the CRT. The video signals applied to each PPI are from the HIPAR system or the LOPAR system. The selection of video is discussed in the radar select and preview circuits (par. 13).

c. The video and mark mixer in the MTI circuits also supplies acquisition video only to the B scope indicator during normal operation.

d. The PPI HV power supply (par. 110) furnishes the required high dc potential as necessary for the operation of the PPI's.

e. The pulse persistence generator (par. 111) supplies the necessary signals to control the persistence and erase functions in the PPI.

f. The azimuth blank generator (par. 112), located in the target radar control console, receives azimuth sector blanking signals from the B scope indicator sweep circuits (par. 88) and 4-kc carrier input from the acquisition-track synchronizer. The azimuth blank generator supplies azimuth blanking signals to the B scope video amplifier, *h* below.

g. The B scope indicator (par. 113), located in the target radar control console, displays upon a 10-inch CRT, a selected area of the PPI presentation. The B scope indicator includes the video circuit portion of the B scope marker generator, *i* below, and the B scope video amplifier, *h* below. The display contains acquisition video received from the B scope video amplifier. The unblanking pulse, also received from this assembly, unblanks the CRT during the intervals of normal range sweep, azimuth sweep, and intersweep. During intersweep intervals, the target track antenna circle is displayed. The generation and application of this symbol is the function of the B scope indicator sweep circuits (par. 88).

h. The B scope video amplifier (par. 114), an assembly in the B scope indicator, amplifies the acquisition video received from the MTI circuits to the level required to intensity modulate the electron beam of the CRT in the B scope indicator. The B scope video amplifier also supplies unblanking pulses to the same CRT and generates an end-of-sweep pulse for application to the B scope marker generator.

i. The B scope marker generator (par. 115), an assembly in the B scope indicator, receives an end-of-sweep pulse at the end of each range (vertical) sweep from the B scope video amplifier. This end-of-sweep pulse enables the B scope marker generator to develop the symbol unblanking pulse for the B scope video amplifier.

j. The power supply assembly (par. 116*b* (2)), located in the target radar control console, supplies the necessary high dc potentials to the B scope indicator.

109 (U). Writing Gun Driver

a. The video amplifier section of the writing gun driver amplifies the video and marks from the video and mark mixer, and applies them to the writing gun grid in the CRT. It also produces the video unblanking pulse (par. 83) that allows video to be displayed on the CRT.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 30, TM 9-1430-254-20/6.

b. The video and marks from the video and mark mixer are applied through ACQ VIDEO GAIN variable resistor R9 (A8) to connector P3-2 on the writing gun driver (D10). ACQ VIDEO GAIN variable resistor R9 (A8) is used to vary the intensity of video presentation on the PPI.

c. The acquisition video and marks are then applied through capacitor C19 (A9) to the control grid of video amplifier V6. The control grid of V6 is clamped at approximately —6.6 volts by crystal diode CR16, video amplifier 1 grid bias variable resistor R57, and resistor R58. The video and marks are amplified and inverted by V6 and are then applied through capacitor C22 to the control grid of video amplifier V7. The control grid of V7 is clamped at approximately —6.6 volts by crystal diode CR17 (A10), and resistors R61 and R62. The signal is further amplified and inverted by V7 and applied to cathode follower mixer V8 (A11). The control grid of V8 is clamped at approximately —3 volts by crystal diode CR18, and resistors R66 and R67. The positive video and marks signal from V8 is then applied to the grid of the writing gun in the CRT (B14). The video signals modify the static potential of —2650 volts on the grid.

110 (U). Cathode-Ray Tube

a. The cathode-ray tubes (CRT's) used in the long range (LR) and the short range (SR) plan position indicators (PPI's) are high persistence direct-view storage tubes. The CRT produces a bright visual display for direct viewing of target information electrically stored within the viewing surface. By using external controls, the persistence of the display can be controlled or the display can be instantly erased.

b. The CRT is divided into three sections; the writing section, the flooding section, and the viewing section. As video signals modulate the electron beam from the writing gun, an image is displayed on the storage grid.

c. The two modes in which the CRT operates are the writing mode and the erase mode. The CRT has a high persistence, and, if left uncontrolled, the display would not fade out as a normal indicator would. To prevent this, the display on the CRT has to be removed periodically. The process of removing the display is called erasing and is covered in paragraph 111.

d. The writing gun section of the CRT consists of the writing gun, the writing gun grids, the deflection plates, and the storage grid. A beam of electrons is emitted by the writing gun and travels toward the more positive potential near the face of the CRT. The number of electrons in the electron beam is controlled by the potential on the first grid. The second and fourth grids have a positive potential and act as accelerating grids. Grid 3 is the focusing grid and the potential on this grid is controlled by the adjustment of a focus variable resistor in the writing gun driver. The focusing grid focuses the electron beam to a very fine point at the storage grid. The deflection plates deflect the beam in accordance with the sweep voltage or the symbol-modulated symbol positioning voltages. As the electron beam strikes the storage grid, electrons are emitted due to secondary emission and are collected by collector grid 5.

e. The flooding section consists of the viewing gun, flood grids 1 through 5, and the backing electrode. The backing electrode is capacitive-coupled to the storage grid in the writing gun section so that any potential seen on the backing electrode is also seen on the storage grid. There is no electrical connection to the storage grid.

f. The viewing gun emits a low velocity electron beam that forms a virtual cathode immediately before the storage grid. The electron beam is defocused by adjusting variable resistors on the side of the PPI so that the virtual cathode is of equal potential over the entire face of the storage grid. The electrostatic lens action of the viewing gun controls the spray of electrons such that it is collimated and approaches the storage grid as a parallel electron beam. When this spray of electrons reaches the storage grid, electrons will be passed only at the points where information has been written. This has the effect of controlling the storage function and the brightness of the display.

g. The imaging section consists of the virtual cathode formed by the viewing gun, the storage grid, and the phosphor screen. The storage grid serves as the persistence control element, and the phosphor screen serves as the collector.

h. The controlled persistence indicator provides a bright, nonflickering display of stored information for a predetermined length of time after the writing has been accomplished. This is accomplished by applying a continuous train of pulses from the pulse persistence generator (par. 111) to the backing electrode at a rate no lower than the phosphor flicker frequency.

Note. The grid zone references shown in parentheses in *i* through *k* below refer to figure 30, TM 9-1430-254-20/6.

i. The writing gun cathode connection on the CRT is connector J26-A (B14) and has an average potential of —2500 volts applied from the voltage regulator section in the writing gun driver (par. 83). This voltage is altered by the video unblanking pulse (par. 83) during the normal sweep interval. The writing gun grid connection on the CRT is connector J26-D (B14) and has an average potential of —2650 volts supplied by the volt-establishes the selected code for each of three modes of SIF/IFF operation and provides remote control circuits for the video decoder. These coding controls are readily accessible behind the acquisition operators. The control assembly is comprised of three multipole-multiposition rotary switches and one toggle switch, which are used in conjunction with three switch-indicators on each PPI in the IFF control circuits to provide three modes of SIF/IFF operation.

f. The functional operation of the IFF equipment (fig. 43) is presented in (1) through (6) below.

(1) The acquisition-track synchronizer (par. 18) produces timing pulses which synchronize the operation of the LOPAR transmitter circuits with the operation of the SIF/IFF system. One of these pulses is the 20- to 40-volt IFF trigger pulse. The IFF trigger pulse is in coincidence with the LOPAR preknock pulse (fig. 3). A second pulse is the transmitter sync pulse which is applied to the LOPAR transmitter circuits. This pulse occurs 23.5 microseconds after the LOPAR preknock pulse and triggers the transmitter circuits at 500 pulses per second. Pretriggering of the SIF/IFF circuits by the IFF trigger pulse is required by the coding characteristics of the IFF equipment.

Note. The grid zone references shown in parentheses in (2) through (6) below refer to figure 36, TM 9-1430-254-20/6, unless otherwise indicated.

(2) The IFF trigger pulse (preknock) is applied through acquisition slip ring terminal 22 (D14) to the coder-control unit (D16), where each trigger pulse is processed into pulse-pairs. These pairs carry the coding (interpulse spacing) of one of the three available challenge modes, *g* below. From the coder-control unit, the pulse-pairs are applied to the receiver-transmitter (fig. 43) where they initiate IFF transmitter operation and simultaneously establish the reception period of the IFF receiver.

(3) The transmitter section of the receiver-transmitter (A16) generates and applies to the IFF antenna an RF carrier which is pulse modulated by the selected coding developed in the coder-control unit. The IFF antenna radiates these RF challenge signals for transponder reception by any target detected by the LOPAR system. These IFF challenge signals are received by the receiver portion of the transponder equipment within the target. The transponder, in turn, transmits a reply comprised of coded RF signals at the frequency to which the IFF equipment is tuned.

(4) The coded RF reply signals transmitted from the target are received by the IFF antenna and applied to the receiver section of the receiver-transmitter. The receiver converts the RF input into LOPAR IFF video, a succession of pulses designated the coded pulse train (fig. 43). From the receiver section of the receiver-transmitter (A16), the LOPAR IFF video is applied through acquisition slip ring terminal 24 (A14) and deenergized IFF video select relay K2 (B9) to the video decoder (A8) in the equipment cooling cabinet, a part of the trailer mounted director station. The video decoder is conditioned by the remote switching control (B8) on the IFF auxiliary control-indicator.

(5) On the remote switching control, a two-position TEST—OPERATE switch (TM 11-5840-202-10) controls decoder group AN/TPA-3 (SIF portion of the IFF equipment). When set to TEST, this switch conditions the decoder group so that a coded pulse train from the receiver-transmitter is passed without change through the video decoder (par. 125*f*) to the video and mark mixer (fig. 31, D41, TM 9-1430-254-20/6). This conditioning of the decoder group permits normal IFF challenging from either PPI (A3 or B5).

(6) The video and mark mixer (fig. 43) combines the IFF video with bypass and MTI video. The resultant signals are then mixed with the acquisition marks.

The output of the video and mark mixer produces the LOPAR acquisition video and marks applied to the video circuits (fig. 37). The IFF video appears on the indicators of the presentation system as a symbol consisting of one or more arcs with the same azimuth, but at a position slightly greater in range than the target video. In this manner, the target video and its IFF identification symbol, if any, can be viewed to determine the target identity. Additional circuit features, provided by the IFF control circuits, promote accurate identification by means of various interrogation modes, *g* below.

Note. The grid zone references shown in parentheses in *g* and *h* below refer to figure 36, TM 9-1430-254-20/6, unless otherwise indicated.

g. The challenge mode is selected by depressing one of the three mode switch-indicators, IFF CHALLENGE MODE 1 switch-indicator A2 (A3), IFF CHALLENGE MODE 2 switch-indicator A3 (A2), or IFF CHALLENGE MODE 3 switch-indicator A4 (A1) located on either PPI. These switch-indicators are identical on both the long range and short range PPI's, have the same designation, and perform the same function. The three switch-indicators provide control of the challenging modes that may be transmitted by the IFF equipment physically located on the acquisition antenna, and condition the video decoder located in the equipment cooling cabinet (B8) to one of three modes. The three modes of video presentation and the functions of each switch-indicator are discussed in (1) through (4) below.

(1) When IFF CHALLENGE MODE 1 switch-indicator A2 on either PPI is illuminated green, mode 1 is selected. This mode is the normally used condition of IFF operation. Mode 1 permits interrogation and identification of all aircraft containing a transponder conditioned to respond to any mode challenge signal from the IFF equipment. When switch-indicator A2 is depressed, section S1D applies frame ground (LOPAR IFF mode 1) through the director station group (B5), to acquisition slip ring terminal 14 (C14) to energize a mode 1 relay in the coder-control unit (D16). This relay, in turn, conditions the interpulse code spacing to an interval of 3 microseconds. Section S1B (B3) applies frame ground (LOPAR IFF challenge) through deenergized contacts 15 and 5 (D3) of IFF select relay K4 and through the director station group to acquisition slip ring 20 (B14) to initiate the challenge mode in the coder-control unit. Section S1C applies frame ground to the video decoder (A8) to condition this unit for mode 1.

(2) When IFF CHALLENGE MODE 3 switch-indicator A4 (A1) is illuminated green, mode 3 is selected. This mode permits interrogation and identification of a group of aircraft by means of the IFF reply from the lead aircraft only. Thus, a selected transponder is actuated and a single IFF reply is returned. The use of this mode prevents crowding of the presentation system with a large number of IFF symbols which would be obtained if mode 1 were used. Switch-indicator A4, section S1D, applies frame ground (LOPAR IFF mode 3) through the director station group (B5) to acquisition slip ring terminal 18 (B14) to energize a mode 3 relay in the coder-control unit. This relay, in turn, conditions the interpulse spacing to an interval of 8 microseconds. Section S1B (B1) applies frame ground (LOPAR IFF challenge) through deenergized contacts 15 and 5 (D3) of IFF select relay K4 and through the director station group to acquisition slip ring 20 (B14) to initiate the challenge mode in the coder-control unit. Section S1C (B1) applies frame ground to the video decoder (A8) to condition this unit for mode 3.

(3) When IFF CHALLENGE MODE 2 switch-indicator A3 is illuminated green, mode 2 is selected. This mode

is intended for detailed recognition of a particular aircraft and, therefore, permits interrogation and identification of any single aircraft in a group of aircraft. The IFF reply is received from only that aircraft which has its transponder conditioned to reply in this mode. The reply is displayed on the PPI's as two defined arcs. With switch-indicator A3 depressed, a frame ground (LOPAR IFF challenge) is applied through deenergized contacts 15 and 5 (D3) of IFF select relay K4 and through the director station group to acquisition slip ring 20 (B14) to initiate the challenge mode in the coder-control unit.

(4) When any one of the three switch-indicators, A2, A3, or A4, is illuminated green the IFF equipment is conditioned to receive an emergency mode reply from a challenged target transponder.

(5) The IFF challenge indication is applied from the coder-control unit through acquisition slip ring 15 (C14), the director station group, and the auxiliary acquisition interconnecting box (D10) to the T1 trainer.

h. The IFF control circuits mounted on the auxiliary fire control-indicator and both PPI's remotely control the IFF or SIF equipment. Remote control is possible only after certain switches in the IFF equipment are properly set. The IFF controls and related switches (TM 9-1430-253-12/2) for remote operation are given in (1) through (5) below.

(1) When a LOCAL-REMOTE switch (TM 11-1191) on the coder-control unit is set to REMOTE, all front panel operating controls of the coder-control unit are electrically transferred to the auxiliary fire control-indicator and both PPI's. In order to challenge by remote control, a CHALLENGE toggle switch on the coder-control unit must be set to OFF. The coder-control CHALLENGE switch, when set to ON, overrides the three IFF CHALLENGE MODE switch-indicators, A4 (A1), A3, and A2, on the two PPI's.

(2) Since the IFF equipment has self-contained power supplies, only primary ac power is supplied from the LOPAR system. The dc power is furnished by the IFF power supply when the IFF POWER switch (TM 11-1191) on the receiver-transmitter (A16) and a similar switch at the coder-control unit are set ON. These switches are normally left in the ON position so that the IFF equipment is automatically energized when the LOPAR system is energized.

(3) Alternate action CHOP ON—CHOP OFF switch-indicator A18 (C2) on the auxiliary fire control-indicator is used under adverse presentation display conditions to distinguish IFF video from acquisition video. When switch-indicator A18 is depressed illuminating CHOP ON indicator green, a frame ground is applied through the director station group (B5) to acquisition slip ring terminal 11 (B14) to energize a chop circuit relay in the coder-control unit. This chop circuit periodically interrupts a succession of pulse-pairs used to develop the transmitter challenge signals. Accordingly, the IFF reply signals are also interrupted. The end result of the displayed video is a clearly defined series of short dashes forming an arc slightly greater in range than the acquisition target video. When switch-indicator A18 is depressed illuminating CHOP OFF indicator amber, frame ground is removed and the chop circuit does not operate.

(4) Alternate action LONG GTC—SHORT GTC switch-indicator A17 (C1) on the auxiliary fire control-indicator is used to conform with the operating range of the LOPAR system. When switch-indicator A17 is depressed illuminating SHORT GTC indicator white, a frame ground is applied through acquisition slip ring terminal 13 (B14), to control a GTC relay located in the

coder-control unit. Switch-indicator A17 is depressed illuminating LONG GTC indicator white when the video circuits (fig. 34, C31, TM 9-1430-254-20/6) are set for 250,000-yard displays. This setting will condition the receiver section of the receiver-transmitter (A16) to have a high gain for distant IFF video reception and to reduce the gain for relatively close IFF video reception in order to maintain a uniform intensity of IFF presentation. During SHORT GTC operation of switch-indicator A17, the gain of the receiver in the receiver-transmitter is reduced to a level required for short range signals and short range displays on the presentation system. The manual gain of the receiver is adjusted by IFF GAIN variable resistor R14A (C3). The brightness and definition of the IFF video symbols displayed by the presentation system is determined by the setting of IFF VIDEO variable resistor R69 (fig. 28, C46, TM 9-1430-254-20/6) on the video and mark mixer.

(5) The IFF POWER on indicator A19 (C3) (illuminated green), provides an indication that IFF power has been applied to the selected (HIPAR or LOPAR) system. When LOPAR is selected, IFF select relay K4 (D3) is deenergized. The ac power (LOPAR IFF power on) from the video decoder (A8) is applied through contacts 7 and 16 of deenergized K4 to a rectifier consisting of CR3, CR4, CR5, and CR6 (C3) in the auxiliary fire control-indicator. The dc voltage from the rectifier is applied to energize IFF power on relay K6, applying −28v LD through contacts 5 and 3 of K6 to illuminate green lamps DS1 and DS3 (C3). Selection of HIPAR will apply HIPAR select ground to energize K4 (D3). HIPAR IFF power is applied through contacts 8 and 16 of K4 to the rectifier consisting of CR3, CR4, CR5, and CR6. As long as ac power is received from either of the selected systems, indicator A19 is illuminated green. When the ac power is removed, indicator A19 is illuminated white.

124.1 (U). AAR IFF Equipment Integration and Operation

a. The identification friend-or-foe (IFF) equipment in AAR systems functions identically to the IFF equipment described in paragraph 124 for HIPAR systems. AAR IFF control circuits differ from IFF control circuits in systems using HIPAR in that certain functions are transferred to the AAR system through relays within the AAR relay assembly. A description of the AAR IFF control circuits that differ from those in systems using HIPAR is given in *b* through *f* below.

Note. The grid zone references shown in parentheses in *b* through *f* below, refer to figure 56, TM 9-1430-254-20/6 unless otherwise indicated.

b. The mode 1 and 3 relay control circuits in the LOPAR and AAR coder-control units are controlled through the switching provided by LOPAR-AAR select relay K2. When AAR is selected, contacts 1-2-9 and 3-4-10 of relay K2 (B7) remove the mode 1 and 3, activate ground circuits from the LOPAR coder-control, and apply mode 1 and 3 ground circuits to the AAR coder-control unit. The IFF challenge circuits for modes 1, 2, and 3 are switched through the contacts of IFF challenge relay K17 (B8). When IFF CHALLENGE MODE 1, 2, or 3 switch-indicator is depressed, a ground is applied from connector J2-P (B4) on the PPI to energize IFF challenge relay K17 (B8). Contacts 9 and 2 of relay K17 apply −28-volt challenge voltage to the AAR IFF system. During the LOPAR mode of operation an IFF challenge ground is applied through contacts 10-4 of K17 (B7) and through contacts 15 and 5 of deenergized relay K4 (D8) to the LOPAR IFF system. The IFF challenge ground applied through contacts 6-15 of energized IFF select relay K4 (D8) has no function in systems using AAR.

c. If the output power of the transmitter within the interrogator set is normal, the depressed IFF CHALLENGE MODE 1, 2, or 3 switch-indicator will illuminate. When the transmitter power is normal an ac voltage is applied from the LOPAR and AAR systems to contacts 8 and 7, respectively, of LOPAR-AAR challenge relay K3 (C7). Relay K3 applies the ac voltage through contact 12 to energize IFF challenge relay K7 (D3). Contacts 3-5 of K7 apply a ground to both long and short PPI's to illuminate the respective IFF mode switch-indicator.

d. CHOP ON—CHOP OFF switch-indicator A18 (C2) control circuit is transferred between the LOPAR and AAR IFF systems through contacts 1-2-9 of LOPAR-AAR select relay K1 (C7). The circuits controlled by LONG GTC—SHORT GTC switch-indicator A17 (C1) are switched between the LOPAR and AAR IFF systems through contacts 7-8-12 of relay K1 (C7).

e. The IFF control circuits are energized when IFF power on relay K6 (C3) is energized. AC power from the LOPAR or the AAR IFF system is applied to contacts 7 and 8, respectively, of IFF select relay K4 (D8). The ac power from the selected mode is applied through contact 16 to the bridge rectifier network consisting of diodes CR3 through CR6 to energize relay K6 (C3).

f. The IFF ground circuit is switched through contacts 7-8-12 of LOPAR-AAR select relay K2 (B7). IFF GAIN variable resistor R14B (C3) is supplied with an IFF ground from connector J31-44. Acquisition radar switch S1B (A5), contacts 1-2-3-12, has no function in AAR systems.

125 (C). Selective Identification Facility Equipment and Circuits

a. The selective identification facility (SIF) equipment is added to the identification friend or foe (IFF) equipment to form the SIF/IFF system (fig. 43). This system, in conjunction with the IFF remote control circuits, provides the IFF and SIF/IFF symbols used in the displays on the presentation system (fig. 1). The addition of the SIF equipment also provides greater flexibility in the interrogation of targets within range of the LOPAR system. The SIF equipment (fig. 43) consists of remote switching control C-1903/TPA-3, video decoder MX-1995/TPA-3, and associated controls and circuits.

b. The SIF/IFF control circuits include the controls and indicators which permit the SIF/IFF equipment to be remotely controlled from the PPI's and auxiliary fire control-indicator in the trailer mounted director station. For further information on the remote controls and indicators used with the SIF/IFF equipment (interrogator set AN/TPX-27), refer to TM 9-1430-253-12/2. Since the remote operation of SIF equipment and IFF equipment is similar, only pertinent controls and indicators of the SIF equipment are discussed in *c* through *e* below.

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 36, TM 9-1430-254-20/6, unless otherwise indicated.

c. When a TEST-OPERATE switch (TM 11-5840-202-10) on the remote switching control (B8) is set to OPERATE, the video decoder (A8), remote switching control, and mode switch-indicators, IFF CHALLENGE MODE 1 A2 (A3), IFF CHALLENGE MODE 2 A3, IFF CHALLENGE MODE 3 A4, become electrically effective, thereby causing the SIF equipment (fig. 43) to become operative. This requires that three rotary coding switches on the remote switching control be set to the proper numerical code associated with the prevailing mode selected by mode switch-indicator A2, A3, or A4. This conditioning of SIF circuits insures that

the IFF reply signals are decoded by the video decoder and IFF video is applied to the presentation system (fig. 1).

d. When the separately furnished SIF equipment for IFF decoder group AN/TPA–3 is not available, a temporary modification is required for the remote control of the IFF equipment. This modification connects input connector P204 (A8) to output connector P201 (B8) so that the video decoder is bypassed. Bypassing transfers the IFF video from the receiver-transmitter directly to the presentation system. In addition, it is necessary to add a temporary strap between terminals 126 (C5) and 156 (A9) in the director station group so that when ac power (LOPAR IFF power on) is applied, IFF power on relay K6 (C3) energizes, illuminating IFF POWER ON indicator lamps, DS1 and DS3 (C3). For normal SIF/IFF operation, when the SIF equipment is provided, the two temporary connections must be removed.

e. The three mode switch-indicators, A2 (A3), A3, and A4, allow the operators to select one of three modes. Each mode has a different number of codes available and varies the flexibility of the SIF/IFF system (fig. 43). In all three modes, the transmitted interpulse spacing is identical to normal IFF operation. When a TEST–OPERATE switch (TM 11–5840–202–10) located on the remote switching control (B8) is set to OPERATE, the video decoder (A8) and mode switch-indicators A2 (A3), A3, and A4 become electrically effective. With switch-indicator A2 depressed, IFF CHALLENGE MODE 1 is selected. This mode, in conjunction with the setting of one of three rotary switches (TM 11–5840–202–10) on the remote switching control, makes available 37 codes to the SIF/IFF system. With switch-indicator A3 depressed, mode 2 is selected. In this mode, the remote switching control (B8) makes available to the video decoder an additional 64 codes. With switch-indicator A4 depressed, mode 3 is selected and another 64 codes are added. Therefore, through the action of switch-indicators A2, A3, and A4 and the rotary switches (TM 11–5840–202–10) on the remote switching control, a total of 165 codes are provided in the SIF/IFF system. Emergency mode presentation, in conjunction with SIF/IFF operation, is identical to the emergency mode described in the normal IFF operation in paragraph 124*g*(4).

f. Either HIPAR or LOPAR IFF video is applied to the video decoder (A8). The type of video input is determined by which video is selected by contacts of IFF video select relay K2 (B9). This relay is controlled by VIDEO SELECTED—LOPAR READY switch-indicator A1 and VIDEO SELECTED—HIPAR READY switch-indicator A2 on the LOPAR control-indicator, and identical switch-indicators A3 and A2 on the HIPAR control-indicator (par. 13*b*). When relay K2 is energized, HIPAR IFF video is supplied to the video decoder. When LOPAR video is selected, relay K2 is deenergized and LOPAR IFF video is supplied to the video decoder.

g. Video decoder MX–1995/TPA–3 (A8) receives LOPAR IFF video (pulse train) from the output of the receiver section of the receiver-transmitter (A16). This LOPAR IFF video is amplified and applied to an internal delay line. The delay line transforms the time-sequential series of pulses into a time-coincident array. If the pulse spacing in the train is correct, the pulses will appear simultaneously at taps in the delay line. This array of pulses is applied through a bank of relays to a diode matrix, made up of two series of germanium diodes. The diode matrix, in conjunction with the relays, analyzes the pulse configuration to determine if the configuration corresponds to the code selection at the remote control box. If the code is satisfied, a positive voltage pulse is produced by the diode matrix. This pulse is clipped, amplified, and supplied at output connector J204 (A8) for use as LOPAR IFF video in the video and mark mixer. IFF video from the T1 trainer is applied to the video and mark mixer through the auxiliary acquisition interconnecting box (D10) during simulated exercises. If the code is not satisfied, this positive pulse either does not appear or is inhibited by a "killer" circuit so that there is little or no output from the video decoder.

WARNING

(Insert: RA PD 404264)

HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions

Never work on electronic equipment unless there is another person nearby who is familiar with the operation and hazards of the equipment and who is competent in administering first aid. When the technician is aided by operators, he must warn them about dangerous areas.

Whenever possible, the power supply to the equipment must be shut off before beginning work on the equipment. Take particular care to ground every capacitor likely to hold a dangerous potential. When working inside the equipment, after the power has been turned off, always ground every part before touching it.

Be careful not to contact high-voltage connections or 115 volt ac input connections when installing or operating this equipment.

Whenever the nature of the operation permits, keep one hand away from the equipment to reduce the hazard of current flowing through vital organs of the body.

EXTREMELY DANGEROUS POTENTIALS

greater than 500 volts exists in the following units:

Battery control console:
- PPI (LONG AND SHORT RANGE)
- PPI HV power supply (LONG AND SHORT RANGE)

Director station group:
- MTI oscilloscope
- Acquisition HV power supply
- -1000v power supply

LOPAR antenna-receiver-transmitter group:
- Acquisition modulator
- Acquisition receiver-transmitter

Target radar control console:
- Auxiliary acquisition control interconnecting group
- Azimuth indicator

Warning: Potentials less than 500 volts may cause death under certain conditions. Reasonable precautions should be taken at all times.

For artificial respiration, refer to FM 21-11.

RADIATION HAZARD

RA PD 461691

This equipment contains the following radioactive tubes:

OA2	OB2	OC3	6164	ATR5922
OA2WA	OB2WA	6163	ATR5921	TR5927

Refer to TM 38—250, AR 755—380, and AR 55—55 for safety information relative to shipping, storage, handling, and disposal of radioactive tubes.

—

FIRST AID FOR RADIOACTIVE CONTACT

The following first aid procedure for wounds caused by a radioactive particle represents the only reasonable first aid treatment which would possibly be available.

a. Stimulation of mild bleeding by normal pressure about the wound and by use of suction cups.

WARNING: Do not suck the wound by mouth. The wound must be washed with soap and flushed with plenty of clear water.

b. If the wound is of the puncture type, or the opening is quite small, an incision should be made to promote free bleeding and to facilitate cleaning and flushing of the wound.

c. Evacuate patient to a medical facility where monitoring of the wound can be accomplished. All such wounds should be examined by a medical officer.

d. For wounds involving the extremities, pending medical attention, place a lightly constricting band (tourniquet) 2 to 4 inches closer to the heart than the site of the wound. The band should be tight enough to halt the flow of blood in superficial blood vessels but not tight enough to stop the pulse (arterial flow)

CLEANING SURFACES ON WHICH TUBES HAVE BEEN BROKEN

Wet Method. Put on rubber or plastic gloves. Pick up large fragments with forceps; then, using a wet cloth, wipe across the area. Make one wipe at a time and fold cloth in half, using the clean side for wiping each time. When cloth becomes too small, discard and start again with a clean piece of cloth. Care must be taken not to rub the radioactive particles into the surface being cleaned by using a back and forth motion. All debris and cloths used for cleaning should be sealed in a container such as a plastic bag, heavy waxed paper, ice cream carton, or glass jar for disposal.

WARNING

NIKE-HERCULES ATBM RADIO-FREQUENCY RADIATION HAZARD

Radio-frequency radiations from radar antennas and associated equipment could present a potential hazard to battery personnel. The effect of rf radiation is not cumulative but it could be hazardous. Rf radiation heats the body tissues and when the intensity is high may produce enough heat to damage the tissues permanently. Damage to the body tissue is not immediately apparent. Precautions should be taken to insure that personnel are not exposed to rf radiations of hazardous intensity levels.

A power level of 0.01 watt per square centimeter, although not considered potentially hazardous, is stipulated by AR 40–583 as the maximum permissible exposure level for personnel subjected to rf radiation fields. Personnel should not be permitted to enter areas where they may be exposed to levels above 0.01 watt per square centimeter.

A power intensity of 0.01 watt per square centimeter is present along the axis of the transmitted beam at the following distances from NIKE-HERCULES ATBM radar antennas. In each instance, the intensity rapidly diminishes as the distance is increased.

ANTENNA	DISTANCE
High Power Acquisition Radar-Non Scanning	430 feet
High Power Acquisition Radar-Scanning	33 feet
Low Power Acquisition Radar-Non Scanning	125 feet
Missile Tracking Radar-NIKE-AJAX Mode	255 feet
Target Tracking Radar-Wide Pulse Mode	355 feet

The intensity of the beam from target tracking radar in the narrow pulse mode, the low power acquisition radar when scanning, the missile tracking radar in the NIKE-HERCULES mode, and the target ranging radar is inconsequential under operating conditions.

This information is based upon average power outputs and may be used as a guide to prevent radio-frequency radiation hazards.

TECHNICAL MANUAL No. 9–1430–250–20/11

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON, D. C., *25 April 1963*

LOW POWER ACQUISITION RADAR (ATBM) (U)

CHAPTER 1 (U)

INTRODUCTION

Section I (U). GENERAL

1 (U). Scope

a. This technical manual, containing theory of operation, is published for the information and guidance of organizational maintenance personnel engaged in the maintenance of the Radar Course Directing Central (RCDC) equipment of the NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) System. This is one of a series of technical manuals on operation, emplacement, and maintenance of the NIKE-HERCULES ATBM system. Refer to TM 9-1400-250-10/2 for a listing of publications indexes, administrative publications, forms and records publications, supply publications, and NIKE technical manuals.

b. This is one of five technical manuals covering Organizational Maintenance: Theory: RCDC with ATBM capabilities. These manuals are listed below.

(1) Low Power Acquisition Radar (LOPAR) System, TM 9-1430-250-20/11.

(2) High Power Acquisition Radar (HIPAR) System, TM 9-1430-250-20/10.

(3) Target Tracking, Target Ranging, and Missile Tracking Radar Systems and Radar Test Set Group, TM 9-1430-250-20/6.

(4) Computer System and Recording Devices, TM 9-1430-250-20/3.

(5) Tactical Control and Power Distribution System, TM 9-1430-250-20/12.

c. For a description of the relationship among all major systems in the RCDC refer to TM 9-1430-253-12/2. A block diagram level discussion of each major system is presented, followed by a block diagram level description of all systems contained in each major system. The theory of operation of all assemblies and main signal flow paths within each system is then covered at a functional schematic diagram level.

d. Throughout this manual, references to the functional schematic diagrams in TM 9-1430-254-20/6 are used to show the relationships of major circuits and to facilitate circuit tracing to various assemblies. Unit schematic diagrams in TM 9-1430-257-20 provide complete electrical schematics of the individual assemblies.

Note. Some of the functional diagrams in TM 9-1430-254-20/6 show circuits shared by the HIPAR and LOPAR systems, and the shared circuit signal flow names indicate both HIPAR and LOPAR operation. Only the theory of LOPAR operation is discussed in this manual. For the theory of HIPAR operation refer to TM 9-1430-250-20/10.

e. Theoretical waveforms discussed in this manual may differ from actual observed waveforms taken on the equipment in a typical system. Although the amplitude of the theoretical waveforms expressed in text may differ from the actual waveforms, the duration of theoretical and actual waveforms is consistent.

f. Knowledge of the operating information provided in TM 9-1430-253-12/2 is helpful in understanding the theory of operation presented in this manual.

g. (Deleted)

h. This manual is technically correct for all NIKE-HERCULES ATBM systems provided Department of the Army Modification Work Orders (DA MWO's) listed in the remainder of this subparagraph have been incorporated.

(1) 9-1400-250-30/40 provides better unit adjustments so that direct current level requirements can be met with a minimum of tube selection (all systems).

(2) 9-1400-250-30/41 modifies acquisition-track synchronizer to reduce peak sync output current and adds cathode follower stage to permit dividing of system preknock load (suffix serial numbers 001 through 026).

(3) 9-1400-250-50/28 provides facilities for connecting the radar-signal simulator station AN/MPQ-T1 (T1 trainer) and adds functions for annual service practice to the NIKE-HERCULES ATBM system (suffix serial numbers 001 through 026).

(4) 9-1430-251-30/25 reduces zero set drift in sweep generator and permits displacement of fire unit integration facility symbols from the plan position indicator (PPI) center during checks and adjustments to allow use of cathode-ray tubes which are burned in the center (all systems).

(5) 9-1430-251-30/27 (revised) improves HIPAR transfer time and reduces noise and distortion on the acquisition presentation (suffix serial numbers 001 through 026).

(6) 9-1430-251-30/29 equalizes video signal-to-noise ratio for LOPAR and HIPAR or AAR; eliminates need for PPI and B scope readjustment each time the video input is switched; and eliminates resistor overload by replacing the video and mark mixer (all systems).

(7) 9-1430-254-30/1/6 eliminates TV interference in the acquisition radar receiver (selected systems).

(8) Field change 1003 provides facilities and adds functions for system compatibility with the ECCM console for those NIKE-HERCULES ATBM systems having AAR (selected systems).

i. For a complete listing of DA MWO's applicable to the LOPAR system, refer to TM 9-1430-257-20.

2 (U). Nomenclature

Cross-reference indexes of technical manual nomenclature and official nomenclature for items of the RCDC of the NIKE-HERCULES ATBM system are provided in TM 9-1430-257-20, TM 9-1430-257-20/4, TM 9-1430-258-20, and TM 9-1430-259-20.

Section II (U). FORMS, RECORDS, AND REPORTS

3 (U). Forms, Records, and Reports

Refer to TM 38-750 for instructions on the use and completion of all forms required for operating and maintaining this equipment.

4 (U). Reporting of Equipment Manual Improvements

The direct reporting of errors, omissions, and recommendations for improving this manual by the individual user is authorized and encouraged. DA Form 2028 will be used for reporting these improvements. This form may be completed using pencil, pen, or typewriter. DA Forms 2028 will be completed by the individual using the manual and forwarded directly to: Commanding General, U. S. Army Missile Command, ATTN: AMSMI-SMPT, Redstone Arsenal, Alabama 35809.

CHAPTER 2 (CMHA)

LOW POWER ACQUISITION RADAR SYSTEM OPERATING DATA

5 (U). Synchronizing System

Input pulse	Composite MTI auto sync and disabling pulse at 500 pps
Pulse output frequency	500 pps established by MTI or self-contained circuitry
Output pulses	LOPAR preknock, IFF trigger (preknock), LOPAR sync, MTI test, transmitter sync
Delay	23.5 microseconds

6 (CMHA). Transmitting System

Transmitter type	Tunable magnetron (S-band) type 5795
Magnetron frequency	3100 to 3500 mc, 20 mc bandwidth extension
Magnetron current	30 ma
Range	250,000 yds
Warmup time	5 min
Frequency control	Automatic
Frequency tuning rate	18 mc/sec
Operating frequency range	3100 to 3500 mc in S-band
Type of modulation	Pulse
Pulse shape	Rectangular
Repetition rate	500 pps
Pulse duration	1.3 μsec
Peak RF power output	1 megw
Average RF power output	625w
Modulator type	Line type soft tube modulator
Peak modulator power output.	1.5 megw

7 (CMHA). Acquisition Antenna System

Antenna type	Pillbox-reflector
Cosecant-squared beam range.	175,000 yds
Pencil beam range	250,000 yds
Antenna coupling	TR and ATR duplexing
Antenna polarization	Horizontal
Antenna gain	35 db (pencil beam) 32 db (cosecant-squared beam)
Antenna backlash	Antenna backlash gear provided
Antenna beam elevation angle.	Variable from 35.5 to 391 mils
Antenna azimuth beam-width.	25 mils
Azimuth scan	Continuous through 6400 mils
Elevation scan method	Electro-mechanical
Elevation scan rate	40 sec (up and down from 35 to 391 mils)
Scan condition 1	Pencil beam at 35 mils; changes to cosecant-squared beam from 35 to 107 mils; cosecant-squared from 107 to 391 mils. Scans from 35 to 391 mils in automatic scan.
Scan condition 2	Pencil beam from 35 to 107 mils; changes to cosecant-squared beam from 107 to 178 mils; cosecant-squared from 178 to 391 mils. Scans from 35 to 231 mils in automatic scan.
Scan condition 3	Pencil beam from 35 to 178 mils; changes to cosecant-squared beam from 178 to 249 mils; cosecant-squared from 249 to 391 mils. Scans from 35 to 303 mils in automatic scan.
Scan condition 4	Pencil beam from 35 to 249 mils; changes to cosecant-squared beam from 249 to 320 mils; cosecant-squared from 320 to 391 mils. Scans from 35 to 391 mils in automatic scan.
Accuracy	±150 yds in range, 18 mils in azimuth
Drive	3-speed, 400-cps, 3-phase motor
Rotational speed	5, 10, or 15 rpm in azimuth
Operation limits	6400 mils (360°) continuous

8 (CMHA). Receiving System

Main channel:

Receiver type	Superheterodyne
RF amplifier	Traveling-wave tube type 6784
Local oscillator	6BL6 reflex klystron
IF bandwidth	4 mc
IF	60 mc
Noise figure	7.5 db
Video bandwidth	2 mc

Auxiliary channel:

Receiver type	Superheterodyne
RF amplifier	Traveling-wave tube type 6784
Local oscillator	6BL6 reflex klystron (shared with main receiver channel)
IF bandwidth	1 mc
IF	60 mc
Overall noise figure	8 to 9 db
Video bandwidth	700 to 750 kc

9 (U). MTI System

MTI type	Video cancellation
MTI mode	360-degree coverage; sector of any controllable azimuth and range; or off
MTI subclutter visibility	20 db at 5 rpm

10 (CMHA). Presentation System

PPI	On battery control console: two 8-3/4-inch controlled-persistence direct-view storage cathode-ray tubes with electrostatic deflection; continuous display in range and azimuth of area surrounding the NIKE-HERCULES ATBM system; coverage on each scope is 6400 mils in azimuth. The short range PPI covers 75,000 or 150,000 yds (selectable) in range. The long range PPI covers 150,000 or 250,000 yds (selectable) in range with LOPAR or 150,000 or 350,000 yds (selectable) in range with HIPAR.
B scope indicator	On target radar control console: 10-in. cathode-ray tube with electrostatic deflection. Modified B-type presentation displaying a sector of PPI display 220,000 yds in range and 1066 mils in azimuth.

11 (U). Miscellaneous Data

a. Complete System Power Requirements. Complete system power requirements are given in TM 9-1430-253-12/2.

b. Fire Unit Integration Facility (FUIF) System. Functional characteristics of FUIF are given in TM 9-1430-253-12/2 and TM 9-1430-250-20/12.

c. Identification Friend or Foe (IFF) System. Provisions have been made for use of SIF/IFF equipment AN/TPX-27 (Interrogator Set) in the IFF system. AN/TPX-27 incorporates the selective identification feature (SIF). Technical characteristics of the IFF system are given in TM 11-1191, TM 11-5840-202-20, and TM 11-5840-204-20.

CHAPTER 3 (C)

FUNCTIONAL DESCRIPTION OF LOW POWER ACQUISITION RADAR SYSTEM

Section I (C). RELATIONSHIP OF LOPAR SYSTEM TO NIKE-HERCULES ATBM SYSTEM

12 (C). Purpose

a. The low power acquisition radar (LOPAR) system (fig. 1), part of the Radar Course Directing Central (RCDC), is a complete microwave range and direction sensing system. The functions of the LOPAR system are to locate, interrogate, and designate targets in the area defended by the NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) system. A combination of NIKE-HERCULES ATBM systems may be employed as units of the Army Air Defense Fire Distribution System (AADFDS): Missile Master or Missile Monitor. In either of these integrated air defense systems, each NIKE-HERCULES ATBM system is tactically monitored and controlled by an Army Air Defense Command Post (AADCP). When the NIKE-HERCULES ATBM system is employed as an individual defense unit, the LOPAR system can be operated independently to provide surveillance of the air traffic in the surrounding defense area. When the NIKE-HERCULES ATBM system is used as a unit of an integrated air defense system, the LOPAR system receives target identification information from AADCP. This information is linked to the LOPAR system through a fire unit integration facility (FUIF) (par. 122) and is displayed on a long range plan position indicator (PPI) and a short range PPI in the trailer mounted director station.

b. The LOPAR system (fig. 1) is capable of detecting targets 15 square meters in size (B-58 type aircraft) within an RF beam range of 250,000 yards. The beam consists of pulsed RF energy with a focused radiation pattern. Target detection is accomplished by continuously rotating the beam through 360 degrees in azimuth and scanning in elevation between 2 and 22 degrees. The maximum elevation position affords detection in excess of the ceiling of modern aircraft. The LOPAR system allows rapid acquisition of selected targets by the target tracking radar system through simultaneous video presentation of acquisition video signals and certain mark signals on cathode-ray tube indicators. These signals represent range and azimuth information. When a target within the range of the target tracking radar system is designated, target range and azimuth position data is electrically transferred from the LOPAR system to the target tracking radar system. Since the range of the LOPAR system is greater in any given direction than the range of the missile, sufficient time is allowed for evaluation of the target, its designation to the target tracking radar system, and the launching of one or more missiles. Additional target information is available through the use of associated target identification and designation equipment (par. 123) consisting of the selective identification feature identification friend or foe (SIF/IFF) equipment and the FUIF equipment.

12.1 (U). Systems with Auxiliary Acquisition Radar (AAR) Capability

a. Certain ATBM systems have the capability of using the AAR acquisition radar in place of HIPAR. The AAR system is used with the electronic counter-countermeasures (ECCM) console to provide integration of the LOPAR and AAR acquisition radars. The ECCM console is located in a separate trailer and connected to the RCDC system through interarea cables. The video from both the LOPAR and AAR systems are observed simultaneously by personnel at the ECCM console to determine which video is more desirable for acquisition. An indication is given from the ECCM console to the battery control officer when a change in radar is desirable.

b. The radar-select circuits used in switching from LOPAR to AAR are functionally the same as those used in switching from LOPAR to HIPAR, described in paragraph 13. The HIPAR select switches select AAR in place of HIPAR in those systems using AAR. All radar-select functions are the same for systems using AAR as those using HIPAR with the exception of additional relay energizing circuits to the AAR relay assembly. Relays within the AAR relay assembly function to transfer control of certain circuits to the ECCM console. A functional description of the circuits controlled by the ECCM console and

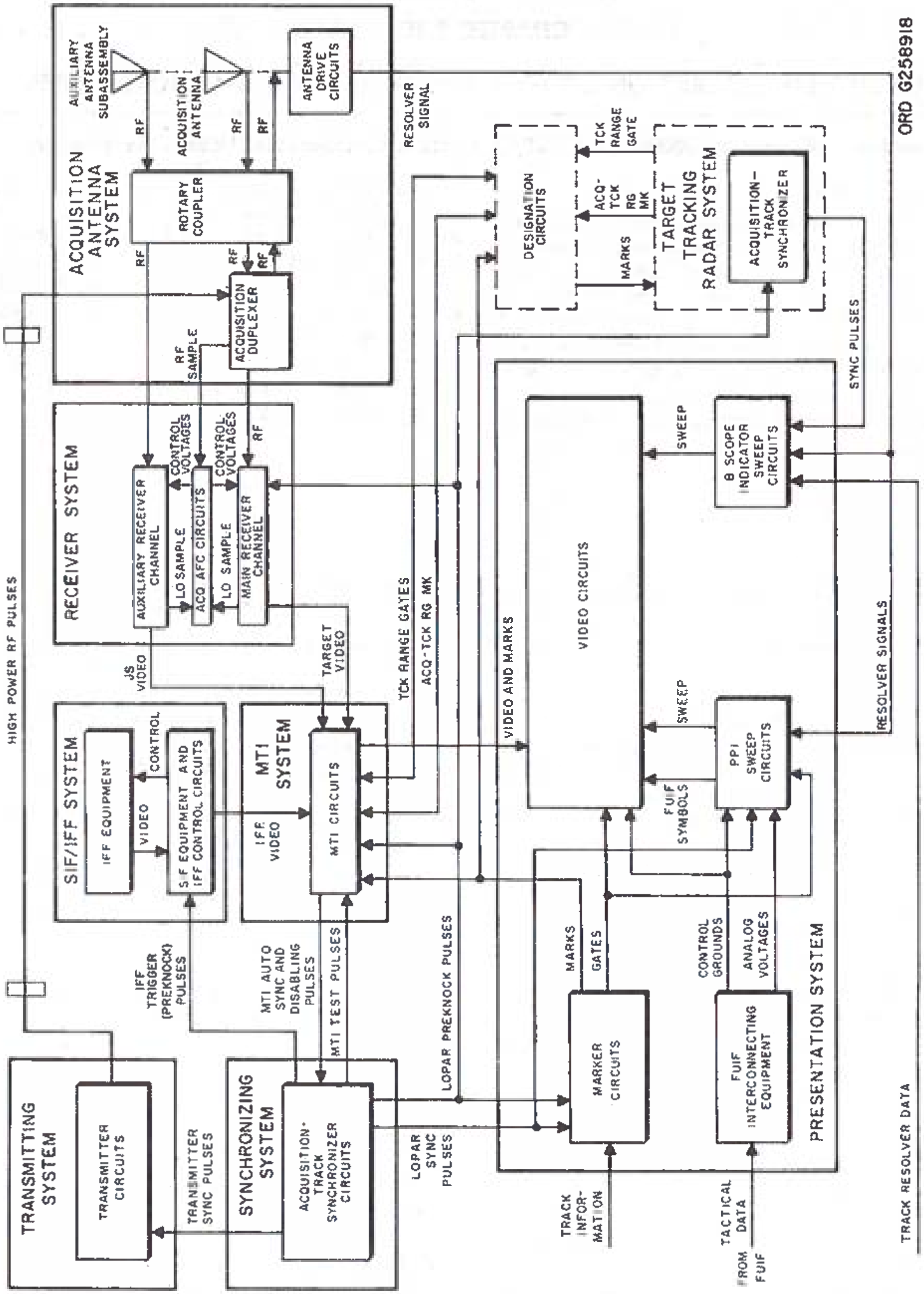


Figure 1 (U). LOPAR system—block diagram (U).

the tactical transfer procedures are given in TM 9-1430-250-20/12 under integrated auxiliary acquisition radar (AAR) capabilities.

c. Throughout the circuit functions, covered by this manual, the term HIPAR will indicate AAR for those systems using AAR and the circuit functions described are identical unless otherwise indicated.

13 (U). Combined Acquisition Radar Systems

a. General. The NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) system combines a high power acquisition radar (HIPAR) system (TM 9-1430-250-20/10) and a low power acquisition radar (LOPAR) system in the RCDC which utilizes one presentation system (par. 73) that is shared by the two radar systems. In addition, either acquisition radar system may furnish designated target position data to the target tracking radar system (TM 9-1430-250-20/6). With both acquisition radar systems, radar-select circuits are provided for manual selection of either the HIPAR system or the LOPAR system. The video of the radar system not selected may be previewed on either plan position indicator (PPI). If this alternate radar system provides a better presentation, it may be selected. This enables the battery control officer to change acquisition radar systems when the presentation is impaired due to the use of electronic countermeasures. The choice of which acquisition

radar system to use is a tactical decision dependent on the maximum effectiveness of each acquisition radar system for a given tactical situation. The selection is accomplished by manually depressing both VIDEO SELECTED — LOPAR READY switch-indicators simultaneously for the LOPAR acquisition radar system or both VIDEO SELECTED — HIPAR READY switch-indicators simultaneously for the HIPAR acquisition radar system. If no manual selection is made, the presentation system automatically receives video from the LOPAR acquisition radar system. The radar-select circuits used in switching to the LOPAR system or to the HIPAR system and previewing alternate video are given in *b* through *i* below.

Note. The figure and grid zone references shown in parentheses in *b* through *i* below refer to TM 9-1430-254-20/6, unless otherwise indicated.

b. HIPAR-LOPAR Switching. The acquisition radar-select circuits are controlled by VIDEO SELECTED — LOPAR READY switch-indicator A3 (fig. 23, A6) and VIDEO SELECTED — HIPAR READY switch-indicator A2 (fig. 23, A5) on the HIPAR control-indicator, and VIDEO SELECTED — LOPAR READY switch-indicator A1 (fig. 23, A1) and VIDEO SELECTED — HIPAR READY switch-indicator A2 (fig. 23, A2) on the LOPAR control-indicator. With both the long range (LR) and short range (SR) PPI's receiving LOPAR video, the VIDEO SELECTED indicators and the LOPAR READY indicators of VIDEO SELECTED — LOPAR READY switch-indicators A3 and A1 on the HIPAR and LOPAR control-indicators illuminate (green and amber, respectively). The HIPAR READY indicators of VIDEO SELECTED — HIPAR READY switch-indicators A2 on the HIPAR and LOPAR control-indicators illuminate amber, and the VIDEO SELECTED indicators of VIDEO SELECTED — HIPAR READY switch-indicators A2 on the HIPAR and LOPAR control-indicators extinguish. During LOPAR video presentation, HIPAR video may be previewed on the LR PPI by depressing and holding VIDEO SELECTED — HIPAR READY switch-indicator A2 (fig. 23, A5) on the HIPAR control-indicator or on the SR PPI by depressing and holding VIDEO SELECTED — HIPAR READY switch-indicator A2 (fig. 23, A2) on the LOPAR control-indicator. When the presentation system is receiving HIPAR video, the VIDEO SELECTED indicators and HIPAR READY indicators of VIDEO SELECTED — HIPAR READY switch-indicators A2 (fig. 23, A2 and A5) on the HIPAR and LOPAR control-indicators illuminate (green and amber, respectively), and the LOPAR READY indicators of VIDEO SELECTED — LOPAR READY switch-indicators A3 (fig. 23, A6) and A1 (fig. 23, A1) on the HIPAR and LOPAR control-indicators illuminate (amber). The VIDEO SELECTED indicators of VIDEO SELECTED — LOPAR READY switch-indicators A3 and A1 on the HIPAR and LOPAR control-indicators extinguish. LOPAR video may be previewed on the LR PPI by depressing and holding VIDEO SELECTED — LOPAR READY switch-indicator A3 on the HIPAR control-indicator or on the SR PPI by depressing and holding VIDEO SELECTED — LOPAR READY switch-indicator A1 on the LOPAR control-indicator.

c. Erase.

Note. Preview erase, (1) and (2) below, occurs when HIPAR or LOPAR video is selected for preview on either PPI, and select erase, (3) below, occurs when either HIPAR or LOPAR is selected for presentation on both PPI's.

(1) *LR PPI preview erase.* Due to the long persistence of the image on the LR PPI, it is necessary to erase the image of the presentation on the LR PPI prior to and after the preview presentation of HIPAR or LOPAR video. Depressing VIDEO SELECTED — HIPAR READY switch-indicator A2 (fig. 23, A5) on the HIPAR control-indicator energizes erase relay K3 (fig. 23, C6) by applying a ground to K3 through section S1D (fig. 23, B5). Erase relay K3 (fig. 23, C6) is also energized when VIDEO SELECTED — LOPAR READY switch-indicator A3 on the HIPAR control-indicator (fig. 23, A6) is depressed. Switch-indicator A3 supplies a ground to K3 through section S1D (fig. 23, B6) of switch-indicator A3.

When K3 energizes, contacts 2 and 9 (fig. 31, A5) provide a ground to erase relay K4 through capacitor C1. This causes K4 to energize momentarily until C1 charges to the drop-out voltage of K4. Contacts 5 and 3 (fig. 31, A5) of K4 close to apply —28 volts stored on capacitor C16 (fig. 31, C7) to manual erase relay K5 in the LR pulse persistence generator. Relay K5 is momentarily energized and its contacts 4 and 10 apply a momentary ground to initiate an erase pulse in the pulse persistence generator which is applied to the LR PPI. When the depressed switch-indicator is redepressed, relay K3 deenergizes. Contacts 1 and 9 (fig. 31, A5) of K3 close to provide a ground through capacitor C2 to momentarily energize relay K4 and the erase cycle is repeated. Resistor R2 is switched by contacts 5, 6, and 11 of K3 to assure that there is no charge on the capacitor that is to be switched into the relay circuit. Refer to paragraph 111 for display persistence and erase circuit theory.

(2) *SR PPI preview erase.* Due to the long persistence of the image on the SR PPI, it is necessary to erase the image on the SR PPI prior to the preview presentation of HIPAR or LOPAR video. Depressing VIDEO SELECTED — HIPAR READY switch-indicator A2 (fig. 23, A2) on the LOPAR control-indicator energizes erase relay K14 (fig. 23, C1) by applying a ground to K14 through section S1C (fig. 23, B2) of switch-indicator A2. Erase relay K14 is also energized when VIDEO SELECTED — LOPAR READY switch-indicator A1 on the LOPAR control-indicator (fig. 23, A1) is depressed. Switch-indicator A1 applies a ground to K14 through section S1D (fig. 23, B1) of switch-indicator A1. When K14 energizes, contacts 2 and 9 (fig. 31, C5) of K14 provide a ground to erase relay K15 (fig. 31, C5) through capacitor C4. This causes K15 to energize and remain energized until C4 charges to the drop-out voltage of K15. Contacts 5 and 3 (fig. 31, C5) of K15 close to momentarily energize manual erase relay K5 in the SR pulse persistence generator (fig. 31, D7). This initiates an erase pulse in the pulse persistence generator which is applied to the SR PPI. When the depressed switch-indicator is redepressed, relay K14 deenergizes. Contacts 1 and 9 (fig. 31, C5) close to provide a ground through capacitor C3 to momentarily energize K15 and the erase cycle is repeated. Resistor R10 is switched by contacts 5, 6, and 11 of K14 to assure that there is no charge on the capacitor that is to be switched into the relay circuit. Refer to paragraph 111 for display persistence and erase circuit theory.

(3) *HIPAR—LOPAR select erase.* Due to the long persistence of the images on both PPI's it is necessary to erase these images prior to the video display of the radar system selected for presentation. Depressing VIDEO SELECTED — HIPAR READY switch-indicators A2 (fig. 23, A2 and A5) energizes erase relays K14 (fig. 23, C1) and K3 (fig. 23, C6). Switch-indicator A2 (fig. 23, A2) while depressed applies a ground to K14 through section S1C of switch-indicator A2. Switch-indicator A2 (fig. 23, A5) while depressed applies a ground to K3 (fig. 23, C6) through section S1D of A2. Erase relays K14 (fig. 23, C1) and K3 (fig. 23, C6) may also be energized by depressing VIDEO SELECTED — LOPAR READY switch-indicators A1 (fig. 23, A1) and A3 (fig. 23, A6). Switch-indicator A1 while depressed applies a ground through section S1D (fig. 23, B1) to erase relay K14. Switch-indicator A3 while depressed applies a ground through section S1D to erase relay K3.

d. LOPAR Select. In LOPAR operation, a ground is applied to the VIDEO SELECTED indicators of VIDEO SELECTED—LOPAR READY switch-indicators A1 (fig. 23, A1) and A3 (fig. 23, A6) through normally closed contacts 7 and 16 (fig. 23, D5) of radar select relay K1 in the HIPAR control-indicator. LOPAR video is applied to the SR PPI through normally closed contacts 1 and 6 (fig. 28, C50) of video select relay K1 and related circuitry in the video and mark mixer to connector J7, and through normally closed contacts 3 and 2 (fig. 30, D6) of SR video preview relay K4 in the battery control console. LOPAR video is applied to the LR PPI through normally energized contacts 2 and 6 (fig. 28, C50) of video select relay K1 and related circuitry in the video and mark mixer to connector J7, and through normally closed contacts 3 and 2 (fig. 30, A6) of LR video preview relay K5. The SR PPI (fig. 24, D18) receives LOPAR sync from the acquisition-track synchronizer (fig. 24, B10) through normally closed contacts 3 and 2 (fig. 24, B14) of LOPAR sync select relay K1 in the director station group and normally closed contacts 3 and 2 (fig. 24, A17) of SR sync select relay K2 in the battery control console. The LR PPI (fig. 24, B18) receives LOPAR sync from the acquisition track-synchronizer (fig. 24, B10) through normally closed contacts 3 and 2 (fig. 24, B14) of LOPAR sync select relay K1 in the director station group, and normally closed contacts 3 and 2 (fig. 24, B17) of LR sync select relay K3. LOPAR resolver signals from acquisition azimuth resolver B2 (fig. 34, B2) are amplified by the resolver amplifier (fig. 34, C2) and applied through the demodulator circuits of the pulse persistence generator to the LR and SR PPI's. LOPAR resolver signals are applied to the LR PPI from the LOPAR resolver amplifier through normally closed contacts 1 and 13, and 5 and 15 (fig. 34, C5) of HIPAR select relay K1 in the LOPAR auxiliary control-indicator and normally closed contacts 1 and 13, and 3 and 14 (fig. 34, C8) of LR preview relay K7 in the battery control console. In systems using AAR, the LOPAR resolver signals are applied through normally closed contacts 5 and 15 of HIPAR/AAR select relay K1 (fig. 34, A1) and normally closed contacts 1 and 6 of HIPAR/AAR select relay K3 (fig. 34, A2). The SR PPI receives LOPAR resolver signals from the LOPAR resolver amplifier through normally closed contacts 1 and 13, and 5 and 15 (fig. 34, C5) of HIPAR select relay K1 in the LOPAR auxiliary control-indicator, and normally closed contacts 1 and 13, and 3 and 14 (fig. 34, C8) of SR preview relay K6 in the battery control console. Due to the long persistence of the image in the PPI's, the image has to be erased periodically. To perform this function, the pulse persistence generator provides the display storage tube in each PPI with a train of erase pulses. The erase pulses are generated automatically at 12,500-microsecond intervals. Refer to paragraph 111 for display persistence erase circuit theory. The relay contacts associated with IFF video select relay K2 (fig. 23, C11) are functionally a part of the IFF control circuits (par. 124). Relay K2 selects either HIPAR or LOPAR IFF video for display in the presentation system. With relay K2 deenergized, relay contacts 3 and 2 (fig. 36, B9) connect LOPAR IFF video to (and disconnect HIPAR IFF video from) the video decoder (par. 124) in the selective identification feature identification friend or foe (SIF/IFF) system. The relay contacts associated with preknock select relay K5 (fig. 23, C10) are functionally a part of the LOPAR sync distribution. These contacts (fig. 24, B2) select either HIPAR or LOPAR preknock pulses to control the synchronization of the target tracking radar system (TM 9-1430-250-20/6) and to control the operation of the acquisition range generator (par. 120). With relay K5 deenergized, contacts 4 and 2 (fig. 24, C2) apply the LOPAR preknock pulses to the acquisition-track synchronizer (fig. 24, D24) in the target radar control console and the acquisition range generator (fig. 24, C17) in the HIPAR control-indicator.

e. HIPAR Preview (LR PPI). With the presentation system in LOPAR operation, the HIPAR system video may be previewed on either the SR or LR PPI. Depressing and holding VIDEO SELECTED—HIPAR READY switch-indicator A2 (fig. 23, A5) on the HIPAR control-indicator allows the surveillance acquisition operator to preview HIPAR video on the LR PPI for the time that this switch-indicator is depressed. When switch-indicator A2 on the HIPAR control-indicator is depressed, a ground is applied to LR sync select relay K3 (fig. 23, C9), LR video preview relay K5 and LR preview relay K7 (fig. 23, D9) in the battery control console through closed contacts of section S1D (fig. 23, B5) of switch-indicator A2 causing these relays to energize. Energizing K5 applies preview acquisition video (HIPAR video) to the LR PPI through contacts 1 and 2 of energized LR video preview relay K5 in the battery control console. When K3 (fig. 24, B17) is energized, alternate sync (HIPAR sync) is applied to the LR PPI from the auxiliary acquisition interconnecting box through normally closed contacts 2 and 3 (fig. 24, C13) of HIPAR sync select relay K4 in the director station group, and contacts 1 and 2 (fig. 24, B17) of energized LR sync select relay K3 in the battery control console. Energizing LR preview relay K7 (fig. 34, C8) causes the application of alternate resolver signals (HIPAR resolver signals) to the LR PPI from the HIPAR resolver amplifier. These resolver signals are obtained from the auxiliary resolver amplifier (fig. 34, B5) and applied to the LR PPI through normally closed contacts 9 and 17 (fig. 34, D9), and 11 and 18 of radar select relay K1 in the HIPAR control-indicator, contacts 2 and 13 (fig. 34, C8), and 4 and 14 of energized LR preview relay K7 in the battery control console, and demodulator circuits in the LR pulse persistence generator.

f. HIPAR Preview (SR PPI). If the presentation system is in LOPAR operation, the HIPAR video may also be previewed on the SR PPI by depressing and holding VIDEO SELECTED—HIPAR READY switch-indicator A2 (fig. 23, A2) on the LOPAR control-indicator. The HIPAR video may be previewed for the time switch-indicator A2 is depressed. When switch-indicator A2 is depressed, a ground is applied to SR sync select relay K2 (fig. 23, C9), SR video preview relay K4 (fig. 23, D9); and SR preview relay K6 in the battery control console through the closed contacts of section S1C (fig. 23, B2) of switch-indicator A2 causing these relays to energize. Acquisition video (preview HIPAR video) is applied to the SR PPI through contacts 1 and 2 (fig. 30, D6) of energized relay K4 in the battery control console. When SR sync select relay K2 (fig. 24, A17) is energized, alternate sync (HIPAR sync) is applied to the SR PPI from the auxiliary acquisition interconnecting box through normally closed contacts 2 and 3 (fig. 24, C13) of HIPAR sync select relay K4 in the director station group, and contacts 1 and 2 (fig. 24, A17) of energized K2. Energizing SR preview relay K6 (fig. 34, C8) causes the application of alternate resolver signals (HIPAR resolver signals) to the SR PPI from the HIPAR resolver amplifier. The application of HIPAR alternate resolver signals occurs through normally closed contacts 9 and 17 (fig. 34, D9), and 11 and 18 of radar select relay K1 in the HIPAR control-indicator and contacts 2 and 13 (fig. 34, C8), and 4 and 14 of energized K6 in the battery control console.

g. HIPAR Select. The selection of the HIPAR system is accomplished by depressing VIDEO SELECTED—HIPAR READY switch-indicators A2 (fig. 23, A5 and A2) on the HIPAR and LOPAR control-indicators simultaneously. Selecting the HIPAR system energizes radar select relay K1 (fig. 23, C5) in the HIPAR control-indicator by applying −28 volts through section S1B (fig. 23, B5) of switch-indicator A2 on the HIPAR control-indicator, section S1D (fig. 23, B2) of switch-indicator A2 on the LOPAR control-indicator, and contacts 8 and 6 (fig. 23, B3) of energized alarm control relay K11 in the LOPAR control-indicator. In systems using AAR, −28V BC is applied directly to S1D on A2 without being applied through relay K11. As soon as the contacts of K1 close, it remains energized through holding contacts 15 and 6 (fig. 23, D5). Contacts 16 and 8 of K1 apply a ground to lamps DS1 and DS2 (fig. 23, A5 and A2) in VIDEO SELECTED—HIPAR READY switch-indicators A2 on both the HIPAR and LOPAR control-indicators causing the VIDEO SELECTED indicator of each of the switch-indicators to illuminate (green). A ground is applied through contacts 4 and 14 of K1 to the following relays causing them to energize: IFF select relay K4 (fig. 23, D2) in the LOPAR control-indicator; HIPAR select relay K1 (fig. 23, B11) in the LOPAR auxiliary control-indicator; HIPAR—LOPAR select relay K2 (fig. 23, C10) in the video and mark mixer; preknock select relay K5 in the LOPAR relay assembly; HIPAR sync select relay K4 (fig. 23, D10), LOPAR sync select relay K1 (fig. 23, D11), and IFF video select relay K2 (fig. 23, C11) in the director station group; and, except during preview, through normally closed contacts 5 and 15 (fig. 23, D9) of LR preview relay K7, and contacts 5 and 15 of SR preview relay K6 to control HIPAR relays in the PPI's. Contacts 4 and 14 of radar select relay K1 also supply a ground to energize HIPAR relay K2 in the designate control driver (fig. 32, D3). HIPAR relay K2 (fig. 23, B8) in the designate control driver supplies a HIPAR mode indication to the T1 trainer through energized contacts 7 and 12. Contacts

10 and 17 (fig. 34, D9), and 12 and 18 of radar select relay K1 close to condition alternate resolver signal circuits for LOPAR preview. LOPAR sync select relay K1 (fig. 24, B14) conditions the alternate sync circuits for LOPAR preview. Video select relay K1 (fig. 28, B50), and HIPAR—LOPAR select relay K2 (fig. 28, A48 and B50) provide the switching necessary to apply HIPAR video to the LR PPI through normally closed contacts 3 and 2 (fig. 30, A6) of LR video preview relay K5 and to the SR PPI through normally closed contacts 3 and 2 (fig. 30, D6) of SR video preview relay K4 in the battery control console. (Refer to paragraph 71 for theory of the video circuits in the video and mark mixer.) HIPAR sync select relay K4 (fig. 24, C13) applies HIPAR sync to the LR PPI (fig. 24, B18) and the SR PPI (fig. 24, D18) through contacts 2 and 1 (fig. 24, C13) of energized K4, and normally closed contacts 3 and 2 (fig. 24, A17) of SR sync select relay K2 for the SR PPI and normally closed contacts 3 and 2 (fig. 24, B17) of LR sync select relay K3 for the LR PPI. HIPAR resolver signals from the auxiliary acquisition interconnecting box (fig. 34, A3) are amplified by the auxiliary resolver amplifier (fig. 34, A4) and applied to the LR and SR PPI's. The HIPAR resolver signals are applied to the LR PPI from the auxiliary resolver amplifier through contacts 2 and 13 (fig. 34, C5), and 6 and 15 of energized HIPAR select relay K1 in the LOPAR auxiliary control-indicator, normally closed contacts 1 and 13 (fig. 34, C8), and 3 and 14 of LR preview relay K7 in the battery control console and demodulator circuits in the LR pulse persistence generator. The HIPAR resolver signals are applied to the SR PPI from the auxiliary resolver amplifier through contacts 2 and 13 (fig. 34, C5), and 6 and 15 of energized HIPAR select relay K1 in the LOPAR auxiliary control-indicator, closed contacts 1 and 13 (fig. 34, C8), and 3 and 14 of deenergized SR preview relay K6 in the battery control console and demodulator circuits in the SR pulse persistence generator. The relay contacts associated with IFF video select relay K2 (fig. 23, C11) and IFF select relay K4 (fig. 23, D2) are functionally a part of the IFF control circuits (par. 124). Relay K2 selects either HIPAR or LOPAR IFF video for display in the presentation system. With relay K2 energized, relay contacts 2 and 1 (fig. 36, B9) connect HIPAR IFF video to (and disconnect LOPAR IFF video from) video decoder MX-1995/TPA-3 in the SIF/IFF system. Contacts 3, 4, and 14 of IFF select relay K4 (fig. 23, D2) supply a PPI squelch ground to the antenna rotation control of the selected radar. The PPI presentations are squelched when the antenna is not rotating. Contacts 7, 8, and 16 (fig. 36, D3) of K4 control switching in the IFF power on indicator circuit so that the indication is for the selected radar. The relay contacts associated with preknock select relay K5 (fig. 23, C10) are functionally a part of the LOPAR sync distribution. These contacts (fig. 24, C2) select either HIPAR or LOPAR preknock pulses to control the synchronization of the target tracking radar system (TM 9-1430-250-20/6) and to control the operation of the acquisition range generator (par. 120). With relay K5 energized, contacts 5 and 2 (fig. 24, C2) apply HIPAR preknock pulses to the acquisition-track synchronizer (fig. 24, D24) in the target radar control console and the acquisition range generator (fig. 24, C17) in the HIPAR control-indicator.

h. LOPAR Preview (*LR PPI*). LOPAR video may be previewed when the presentation system is in HIPAR operation by depressing and holding either of the VIDEO SELECTED—LOPAR READY switch-indicators. If VIDEO SELECTED—LOPAR READY switch-indicator A3 (fig. 23, A6) on the HIPAR control-indicator is depressed, a ground is applied through section S1D (fig. 23, B6) of switch-indicator A3 to LR sync select relay K3 (fig. 23, C9), LR video preview relay K5, and LR preview relay K7 (fig. 23, D9) in the battery control console. Energizing LR video preview relay K5 (fig. 30, A6) applies preview acquisition video (LOPAR video) to the LR PPI through closed contacts 2 and 1 (fig. 30, A6) of energized K5 in the battery control console. When LR sync select relay K3 (fig. 24, B17) is energized, alternate sync (LOPAR sync) is applied to the LR PPI (fig. 24, A18) through contacts 2 and 1 (fig. 24, B14) of energized LOPAR sync select relay K1 in the director station group and contacts 1 and 2 (fig. 24, B17) of energized K3 in the battery control console. Energizing LR preview relay K7 (fig. 34, D8) applies alternate resolver signals (LOPAR resolver signals) to the LR PPI. The alternate resolver signals are applied through contacts 10 and 17 (fig. 34, D9), and 12 and 18 of energized radar select relay K1 in the HIPAR control-indicator, contacts 2 and 13 (fig. 34, C8), and 4 and 14 of energized K7 in the battery control console and the demodulator circuits of the LR pulse persistence generator.

i. LOPAR Preview (SR PPI). The LOPAR video may also be previewed on the SR PPI by depressing and holding VIDEO SELECTED—LOPAR READY switch-indicator A1 (fig. 23, A1) on the LOPAR control-indicator. Depressing switch-indicator A1 provides a ground to SR sync select relay K2 (fig. 23, C9), SR video preview relay K4, and SR preview relay K6 (fig. 23, D9) in the battery control console through section S1D (fig. 23, B1) of switch-indicator A1. Energizing SR video preview relay K4 applies preview acquisition video (LOPAR video) to the SR PPI through contacts 1 and 2 (fig. 30, D6) of energized K4 in the battery control console. When SR sync relay K2 (fig. 24, A17) is energized, alternate sync (LOPAR sync) is applied to the SR PPI (fig. 24, D18) through contacts 1 and 2 (fig. 24, B14) of energized LOPAR sync select relay K1 in the director station group, and contacts 1 and 2 (fig. 24, A17) of energized K2 in the battery control console. Energizing SR preview relay K6 (fig. 34, D8) applies alternate resolver signals (LOPAR resolver signals) to the SR PPI through contacts 10 and 17 (fig. 34, D9), and 12 and 18 of energized radar select relay K1 in the HIPAR control-indicator, contacts 2 and 13 (fig. 34, C8), and 4 and 14 of energized K6 in the battery control console, and through demodulator circuits in the SR pulse persistence generator.

j. AAR Select. When radar select relay K1 (fig. 23, D4) is energized by depressing VIDEO SELECTED-HIPAR READY switch indicator A2 on the LOPAR control-indicator (fig. 23, A2) and VIDEO SELECTED-HIPAR READY switch-indicator A2 on the HIPAR control-indicator (fig. 23, A5), a ground is applied through contacts 4 and 14 of relay K1 to energize the following relays within the auxiliary acquisition relay assembly: LOPAR-AAR select relay K9 (fig. 54, D3), LOPAR-AAR select relay K15, LOPAR-AAR select relay K1, LOPAR-AAR IFF challenge relay K3, and LOPAR-AAR select relay K2. Relay K15 supplies a ground through contacts 7 and 12 to energize transmitter control relays K5, K6, and K7 (fig. 54, C5) and receiver control relays K8, K13, K18, and MTI control relays K12 and K14. Relays within the auxiliary acquisition relay assembly function to transfer system operation to the AAR mode and ECCM console control.

(1) CONT REQ-CONT REL switch-indicator A11 (fig. 54, A1), CHANGE RADAR switch-indicator A13 (fig. 54, B1), and CONT TRAN AUTO-CONT TRAN REMOTE switch-indicator A12 (fig. 54, C1) are functionally a part of the ECCM console control circuits. The function of each relay within the auxiliary acquisition relay assembly and the ECCM console control circuits are described under integrated auxiliary acquisition radar (AAR) capabilities in TM 9-1430-250-20/12. The specific function of each relay within the AAR relay assembly, as it affects the contents of this manual, is described in the appropriate paragraphs.

(2) ACQUISITION RADAR switch S1A (fig. 54, B2) applies a squelch ground from contact 12, in either the LOPAR ONLY or HIPAR position, to energize squelch interlock relay K11 (fig. 54, C3). Energizing relay K11 removes the PPI squelch ground applied to contact 2 of LOPAR-AAR select relay K9 (fig. 54, C3). This action prevents the PPI from being squelched when in the HIPAR or LOPAR ONLY mode. Squelch interlock relay K11 is energized when using AAR from a ground applied to connector J30-57 on the auxiliary acquisition interconnecting box (fig. 54, D6). ACQUISITION RADAR switch S1A in the AAR position completes the remote control ground path from CONT TRAN AUTO-CONT TRAN REMOTE switch-indicator A12 (fig. 54, C1).

Section II (U). LOW POWER ACQUISITION RADAR SYSTEM

14 (U). Purpose

The primary purpose of the low power acquisition radar (LOPAR) system (fig. 1) is to detect targets approaching the area defended by the NIKE-HERCULES ATBM system. Associated equipment, consisting of a fire unit integration facility (FUIF) system (par. 122) or selective identification feature identification friend or foe (SIF/IFF) equipment (par. 124), challenges and designates the target as friend or foe. When a target is identified as a foe, target data is transferred from the LOPAR system to the target tracking radar system. This permits the target tracking radar system to acquire the target and the LOPAR system to revert to surveillance.

15 (U). System Division

The LOPAR system (fig. 1) is functionally divided into seven systems described in *a* through *g* below.

a. Synchronizing System. The acquisition synchronizing system (par. 16) synchronizes the operation of the complete LOPAR system. The synchronized systems are given in *b* through *g* below. The synchronization is produced by timing pulses generated in the acquisition-track synchronizer circuits. These

circuits provide four different pulses at a constant rate and time sequence for distribution by the synchronizing system to the six associated systems. The four pulses are: LOPAR preknock, moving target indicator (MTI) test, transmitter sync, and LOPAR sync. The LOPAR preknock pulse initiates the operation of the receiver, MTI, presentation, and as the IFF trigger, the operation of the selective identification feature/identification friend or foe (SIF/IFF) systems. In addition, the LOPAR preknock pulse triggers an identical acquisition-track synchronizer in the target tracking radar system. When triggered, this second synchronizer generates the preknock and sync pulses used by the target tracking radar system (TM 9-1430-250-20/6). The transmitter sync pulse triggers and times the operation of transmitter circuits in the transmitting system. The sync pulse synchronizes the operation of certain portions of circuits in the presentation system. The MTI test pulse is used in the adjustment and operation of the MTI system. The MTI auto-sync and disabling pulse synchronizes the acquisition-track synchronizer circuits with the MTI system.

b. Transmitting System. The transmitting system (par. 19) produces the 1-megawatt RF pulses that are radiated into space by the acquisition antenna. This system consists of the transmitter circuits and associated power supplies and control circuits. The transmitter circuits use transmitter sync pulses to initiate generation of the high-power RF pulses. When transferred to the antenna system, these pulses with peak power of 1 megawatt, are formed into a beam for radiation into space.

c. Acquisition Antenna System. The acquisition antenna system (par. 24) consists of a main channel and an auxiliary channel. The main channel provides a means for conveying, shaping, and radiating S-band RF pulse energy into the defense area of the NIKE-HERCULES ATBM system. It also provides the means for collecting the reflected S-band RF pulses and conveying these pulses through a waveguide and duplexer to the main receiver channel in the receiving system. The auxiliary channel is a receiving channel only and provides a means for collecting the ECM and/or reflected S-band RF energy and conveying these RF pulses through a waveguide to the auxiliary receiver channel in the receiving system. The antenna system includes the units that drive the antenna in azimuth and elevation, and furnishes azimuth positional information in the form of resolver signals to the sweep circuits of the presentation system.

d. Receiving System. The receiving system (par. 31) with AJD capabilities consists of a dual channel receiver (auxiliary and main) and automatic frequency control (AFC) circuits (par. 54). The dual channel receiver functions to convert the received RF echoes from the antenna system into target video that is ultimately displayed by the presentation system. The AFC circuits automatically tune the receiver to a proper operating frequency by sampling RF from the transmitter circuits and using the RF samples as a frequency reference.

e. MTI System. The MTI system (par. 61*a*) functions to reduce video interference from fixed objects. This system consists of the MTI circuits and the associated power supplies and control circuits. The MTI circuits, in developing the video from the receiving system (par. 31), electronically distinguish between moving target video and fixed target video (clutter). As a result, the MTI circuits provide improved displays of target video in the presentation system (par. 73). The MTI circuits also generate an automatic sync and disabling pulse which is used to accurately time the circuits in the acquisition-track synchronizer (par. 18). The mixing of IFF video, target video, and various presentation marks, though not an MTI function, is included in the discussion of MTI circuits for functional purposes.

f. Presentation System. The presentation system (par. 73) provides means of visually displaying all targets within range of the low power acquisition radar (LOPAR) system and high power acquisition radar (HIPAR) system. In addition, the presentation system provides a means of indicating the slant range and azimuth of any selected target and of applying target video and position data to the B scope indicator. The presentation system also displays IFF video received from the SIF/IFF system (par. 124). The presentation system consists of the marker circuits, PPI sweep circuits, symbol positioning circuits, B scope indicator sweep circuits, video circuits, and FUIF interconnecting equipment. The marker circuits (par. 117) provide signals to form marks for the video circuits. The video circuits (par. 107) enable the display of target video on the three indicators. The PPI's (par. 75) and B scope indicator presentation (par. 88) are synchronized with the acquisition antenna position. The B scope indicator sweep circuits present a selected expanded portion of the display presented by the PPI sweep circuits. The B scope indicator video and the sweep circuits are functionally associated with the LOPAR system. The fire unit integration facility (FUIF) interconnecting equipment (par. 101) electrically ties the presentation system through a tactical data link to FUIF equipment (par. 122). The FUIF equipment controls the generation of FUIF video symbols in the presentation system which, in turn, develops and displays the symbol video.

g. SIF/IFF System. The SIF/IFF system (par. 124) supplements the LOPAR system by enabling additional target identification information to be furnished to the presentation system (par. 73). The SIF/IFF system is provided as the source of local target identification when the LOPAR system is employed in an individual defense unit. However, when the LOPAR system is part of an integrated defense system, the LOPAR presentation system receives target identification information through FUIF equipment (par. 122) linked to the Army Air Defense Command Post (AADCP). The SIF/IFF system consists of three parts: the IFF equipment, the IFF control circuits, and the SIF equipment. The IFF equipment, although not a basic part of the LOPAR system, is provided as auxiliary equipment which can be used in conjunction with the operation of the LOPAR system. The IFF control circuits, an integral part of the LOPAR system, provide a means for remote control of the IFF equipment. The SIF equipment is added to the IFF equipment to make available a greater number of IFF codes and to permit rapid code changes. When IFF equipment is provided, it may be operated by the IFF control circuits in synchronization with the LOPAR system to interrogate a target. The response of the target is received by the SIF/IFF system and displayed in the presentation system.

CHAPTER 4 (U)

ACQUISITION SYNCHRONIZING SYSTEM

16 (U). Purpose

The synchronizing system (fig. 2) provides accurately timed pulses to synchronize the operation of the low power acquisition radar (LOPAR) system and the target tracking radar system. Identical acquisition-track synchronizers are used in both radar systems. The acquisition-track synchronizer which synchronizes the LOPAR system is also used to establish the timing pulses (LOPAR preknock) that trigger the acquisition-track synchronizer in the target tracking radar system. During LOPAR operation, the target tracking radar system is synchronized with the LOPAR system. Although the acquisition-track synchronizer in the LOPAR system can be self-triggered by internal circuits, it is normally triggered by a timing pulse (composite MTI auto sync and disabling pulse) from the moving target indicator (MTI) circuits. The pulse repetition rate established by the acquisition-track synchronizer for the LOPAR system and the target tracking radar system is 500 pulses per second.

17 (U). Block Diagram Analysis

a. The low power acquisition radar (LOPAR) synchronizing system (fig. 2) consists of pulse generating circuits in the acquisition-track synchronizer, and external distribution circuits. The acquisition-track synchronizer, located in the director station group of the trailer mounted director station, receives one input pulse and produces five output pulses. The input pulse is the composite MTI auto sync and disabling pulse from the moving target indicator (MTI) circuits. The output pulses are LOPAR preknock, LOPAR sync, transmitter sync, IFF trigger (preknock), and MTI test. These pulses (fig. 3) are discussed in (1) through (5) below.

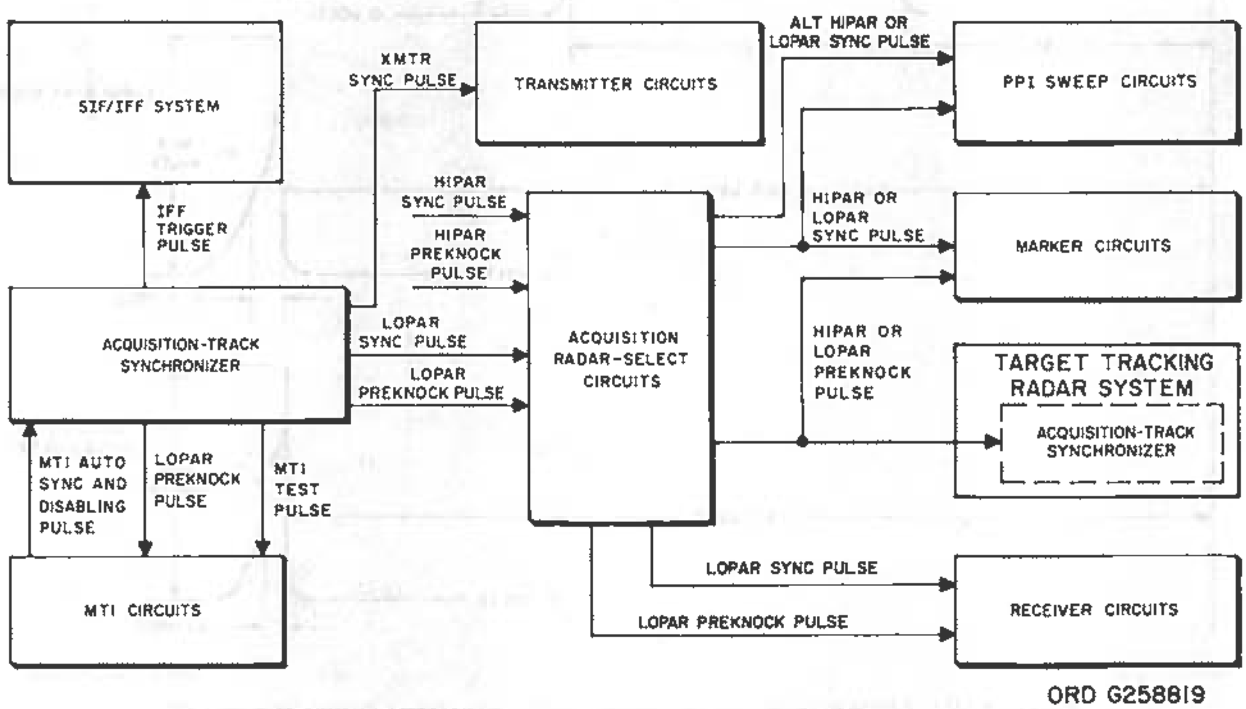


Figure 2 (U). LOPAR synchronizing system—block diagram (U).

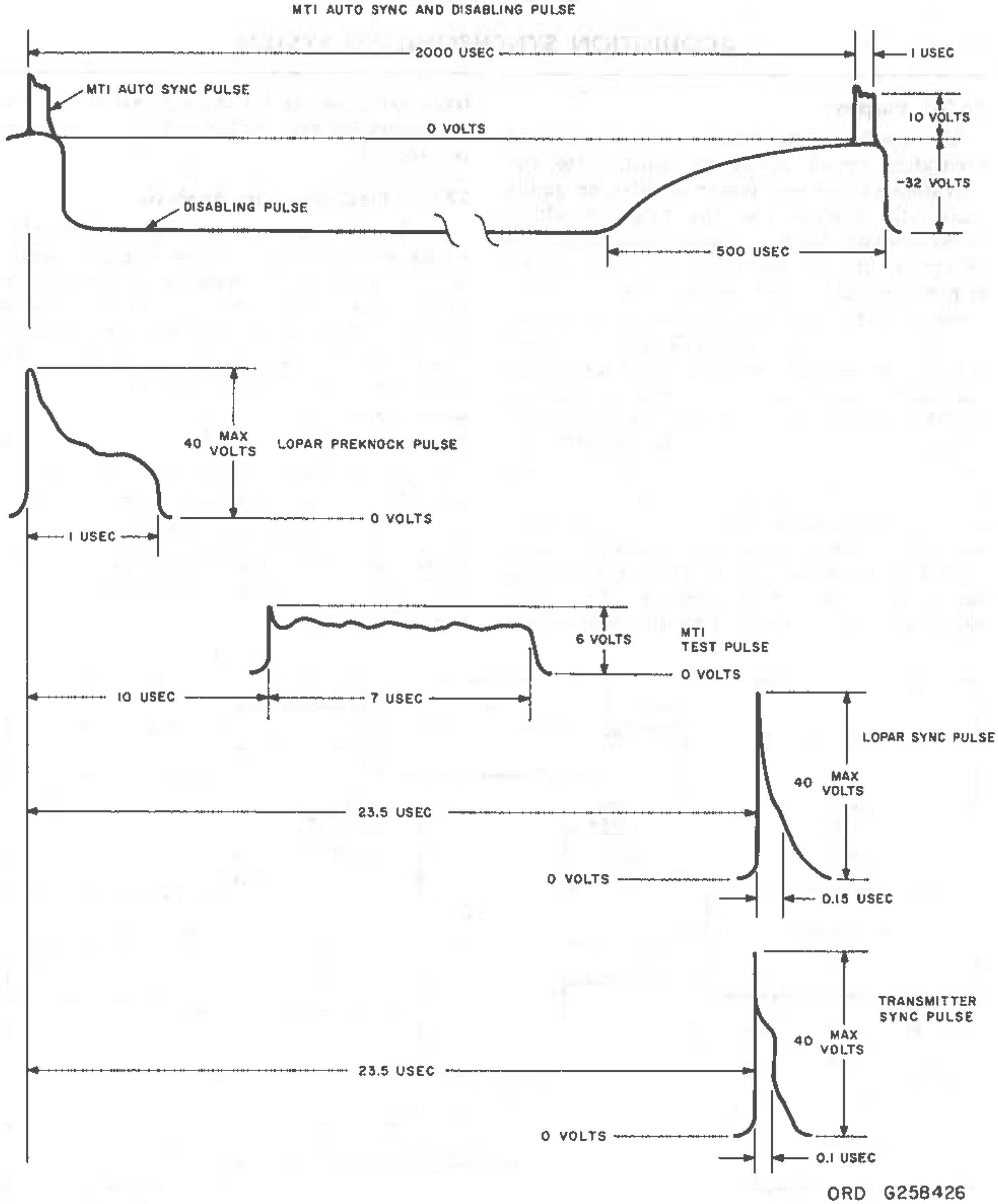


Figure 8 (U). LOPAR synchronizing system—ideal waveforms in time sequence (U).

(1) *LOPAR preknock pulse.* The LOPAR preknock, a positive, 40-volt, 1-microsecond pulse, occurs at a repetition rate of 500 pulses per second. This pulse has a steep leading edge that precedes the LOPAR sync and transmitter sync pulses by 23.5 microseconds. The LOPAR preknock triggers the MTI circuits, and supplies an IFF trigger (preknock) pulse to the SIF/IFF system. In addition, the LOPAR preknock triggers the acquisition-track synchronizer of the target tracking radar system, and the receiver and marker circuits whenever the acquisition radar-select circuits are conditioned for LOPAR system synchronization. Pretriggering is required for system stability before the LOPAR sync pulse triggers the LOPAR system into operation.

(2) *LOPAR sync pulse.* The LOPAR sync, a positive, 40-volt, 0.15-microsecond pulse, occurs at a repetition rate of 500 pulses per second. The sync pulse is initiated and synchronized by the LOPAR preknock pulse and delayed 23.5 microseconds. This LOPAR sync pulse triggers the PPI sweep circuits and marker circuits whenever the acquisition radar-select circuits are conditioned for LOPAR system synchronization.

(3) *Transmitter sync pulse.* The transmitter sync, a positive, 40-volt, 0.1-microsecond pulse, is in time coincidence with the LOPAR sync pulse. This narrow pulse is required for proper triggering of the acquisition trigger amplifier in the transmitter circuits because of a characteristic of the blocking oscillator transformer in the acquisition trigger amplifier.

(4) *MTI test pulse.* The MTI test pulse, a positive, 6-volt, 7-microsecond pulse, occurs 10 microseconds after the leading edge of each LOPAR preknock pulse. This delay effectively places the test pulse in time between the LOPAR preknock and LOPAR sync pulses. The test pulse is used by the MTI circuits for the generation of an internally used automatic gain control voltage and is also used during checks and adjustments of the MTI circuits.

(5) *Composite MTI auto sync and disabling pulse.* The MTI auto sync and disabling pulse is a composite pulse consisting of a positive 10-volt auto sync pulse and a negative 32-volt disabling pulse. The auto sync pulse, developed from each LOPAR preknock pulse, has a steep leading edge and a time duration of 1 microsecond. This pulse is used as a trigger pulse and is superimposed upon the leading edge of the disabling pulse. The disabling pulse has a steep negative-going leading edge, a flat portion with a duration of 1500 microseconds, and a positive-going exponential trailing edge with a duration of 500 microseconds. This pulse is used as a disabling gate. The auto sync pulse and the positive-going trailing edge of the disabling pulse occur simultaneously in the MTI circuits and are combined for application as a composite timing feedback to the input of the acquisition-track synchronizer. The application of this pulse causes the synchronizer to be accurately synchronized with the operation of the MTI circuits.

b. The presentation system and target tracking radar system can also be synchronized by the HIPAR system. The acquisition radar-select circuits (fig. 2) provide a means of selecting preknock and sync pulses from the LOPAR or HIPAR system. Other functions of the radar-select circuits are given in paragraph 13. Selection of these pulses permits video from the HIPAR or LOPAR system to be displayed on the presentation system. The HIPAR sync pulse and preknock pulse (TM 9-1430-250-20/10) occur at a repetition rate between 400 and 445 pulses per second and have a time duration of 1 microsecond.

18 (U). Acquisition-Track Synchronizer

The acquisition-track synchronizer (fig. 2) produces five output pulses at a repetition rate

of 500 pulses per second. The functional circuits, pulses, and their distributions are discussed in *a* through *d* below.

Note. The grid zone references shown in parentheses in *a* through *d* below refer to figure 24, TM 9-1430-254-20/6, unless otherwise indicated.

a. Preknock Pulse Circuits.

(1) During normal operation, a composite MTI auto sync and disabling pulse (fig. 3) from the trigger pulse-video amplifier (B3) is applied to the acquisition-track synchronizer (B5). Sync amplifier V1 (B5) is first triggered by the positive auto sync portion of the composite input pulse, and then cut off by the negative disabling portion of the same input pulse. The 1-microsecond LOPAR sync pulse from transformer T1 (B5) synchronizes repetition rate oscillator V2A (B5) at 500 pulses per second, which is the established pulse repetition rate of the LOPAR system. Oscillator V2A is a blocking oscillator. FREQ LOPAR variable resistor R6 (A4) permits manual adjustment of the free-running oscillations of V2A to a frequency lower than the repetition rate of the MTI auto sync pulses. Variable resistor R6 is adjusted with connector P39 (B3) disconnected to insure that V2A remains synchronized by oscillating at a frequency lower than the auto sync rate. The disabling pulse drives V1 (B4) far below cutoff to prevent premature triggering of V2A by spurious noise pulses.

(2) The output of repetition rate oscillator V2A (B5) is a positive 1-microsecond pulse which is applied to trigger amplifier V3A (A7) and to the 10-microsecond delay network (B7) of the MTI test pulse circuits (par. 18*c*). The same pulse is also applied as the LOPAR preknock pulse to connector J2 (B8). From connector J2, the preknock pulse is distributed to the MTI oscilloscope (C8), delay line driver (D5), electronic gate (C9), and trigger pulse-video amplifier (B3) of the MTI circuits, and through contacts 1 and 6 (C16) of deenergized preknock sync select relay K12 on the LOPAR control-indicator to the STC (D17) of the receiver circuits. This preknock pulse is also distributed to the acquisition interference suppressor (C12) and the FAST AGC amplifier (D12). The positive 35- to 45-volt output pulse developed in the cathode circuit of V6A (B8) is designated as the IFF trigger (preknock) pulse. This trigger pulse is supplied from connector J6 through the acquisition slip ring (B22) in the acquisition antenna pedestal to the coder-control unit of the IFF equipment (par. 124*d*(3)). In addition, the preknock pulse is applied through contacts 4 and 2 (C2) of deenergized preknock select relay K5 in the LOPAR relay assembly, to the acquisition range generator (C17) in the HIPAR control-indicator, and through cable run 24 (D20) to the acquisition-track synchronizer in the target radar control console of the trailer mounted tracking station. The HIPAR preknock pulse (B1), not used during LOPAR operation, is applied through contacts 8 and 6 of deenergized preknock select relay K5 to terminating resistor R1.

b. LOPAR Sync Pulse Circuits.

(1) The positive LOPAR preknock pulse from repetition rate oscillator V2A (B5) is amplified by trigger amplifier V3A (A7). This amplifier produces a negative pulse that triggers delay multivibrator V4A and V4B (A9), a monostable multivibrator which produces a negative output pulse. The output is applied to temperature controlled delay network Z1 (A10), a part of a delay circuit consisting of SYNC DELAY LONG PULSE variable resistor R21 (B10), contacts 6 and 1 (A10) of deenergized pulse width select relay K2, and pulse delay diode V3B (B10). This circuit produces a negative 23.5-microsecond pulse, the width of which is controlled

diode V3B (B10). This circuit produces a negative 23.5-microsecond pulse, the width of which is controlled by variable resistor R21. Pulse width select relay K2 (B10) cannot be energized when the acquisition-track synchronizer is used as part of the LOPAR system. The negative pulse developed at the cathode of V3B is direct-coupled to pulse delay amplifiers V5A (B9) and V5B (B10), which are operated in cascade. The amplified output pulse from V5B is differentiated by blocking oscillator transformer T2 (A11). The resultant signal is a negative and a positive pulse. The negative pulse is coincident with the LOPAR preknock pulse, and the positive pulse occurs 23.5 microseconds after the LOPAR preknock pulse. This positive pulse triggers sync pulse blocking oscillator V2B (B11), operating as a single-swing blocking oscillator. The output of V2B appears in the cathode circuit as a positive 0.15-microsecond LOPAR sync pulse and is applied through connector J4 and network Z61 to contact 2 of LOPAR sync select relay K1 (B14) in the director station group. In systems using AAR, the sync output from connector J4 (A25) is applied through connector J47 to network Z61. An additional sync output from connector J47 is applied through a cathode follower amplifier (B27) to connector J33 (D27) on the auxiliary acquisition interconnecting box for use by the ECCM console. This sync pulse is applied through contacts of deenergized relay K1 and contacts of deenergized long range (LR) sync select relay K3 (B17) to the writing gun driver (A18), and pulse and logic generator in the LR PPI (B18). This same sync pulse is applied through deenergized short range (SR) sync select relay K2 (A17) to identical units in the SR PPI. These assemblies are part of the presentation system discussed in paragraph 83. LOPAR sync is also applied through contacts 2 and 6 (D16) of energized preknock/sync select relay K12 to the STC in the LOPAR control-indicator. The LOPAR sync pulse is applied to the auxiliary acquisition interconnecting box (D20) from network Z61 (B13) for use with the T1 trainer.

(2) During LOPAR video presentation, the HIPAR sync pulse is applied through contacts of deenergized HIPAR sync select relay K4 (C13). Then, as alternate HIPAR sync, it is applied through the contacts of energized SR sync select relay K2 (A17) to the SR PPI (D18) or through contacts of energized LR sync select relay K3 (B17) to the LR PPI (B18), whichever is selected for HIPAR video preview. During HIPAR video presentation, the LOPAR sync pulse is applied through contacts of energized LOPAR sync select relay K1 (B14). Then, as alternate LOPAR sync, it is applied through the contacts of energized SR sync select relay K2 to the SR PPI or through contacts of energized LR sync select relay K3 to the LR PPI, whichever is selected for LOPAR video preview. Refer to paragraph 13 for HIPAR and LOPAR preview control theory.

(3) From the output of sync pulse blocking oscillator V2B (B11), the LOPAR sync pulse is also applied to sync pulse amplifier V7A. The amplified output of V7A is applied through blocking oscillator transformer T4 to the grid of sync pulse blocking oscillator V7B (B12). Blocking oscillator V7B produces the positive 20- to 40- volt, 0.1-microsecond transmitter sync pulse. The transmitter sync pulse is applied through connector J5 and cable run 23 (A16) to SYNC test jack J5 (C21) in the acquisition RF power supply control in the acquisition receiver-transmitter where it can be monitored and used to synchronize test equipment. In addition, the transmitter sync pulse is applied through contacts 5 and 6 (B21) of deenergized arc suppressor relay K1 to the acquisition modulator (B23) to trigger the acquisition trigger amplifier.

c. MTI Test Pulse Circuit. The LOPAR preknock pulse from repetition rate oscillator V2A (B5) is applied through a voltage divider network consisting of resistors R47 and R48 to

10-microsecond delay network Z2 (B7). This delay line provides a 10-microsecond delay between its input and output signals. The delayed pulse is transformer-coupled to MTI test pulse blocking oscillator V6B (B8). The positive 8-volt, 7-microsecond MTI test pulse from V6B is applied to the MTI video amplifier (C3) and the delay line driver (D5) of the MTI system. This pulse occurs in time between the preknock and the LOPAR sync pulses. Test pulse adjust variable resistor R1 (D4) controls the pulse amplitude applied to the delay line driver.

d. Terminating Resistors. The five output pulses (par. 17) from the acquisition-track synchronizer are distributed to the various loads by means of a coaxial cable. This type of transmission line has only one characteristic impedance which is a determining factor in optimum matching of source to load. When a load impedance (equal to the characteristic impedance of the coaxial cable) is connected to the output end of the cable, an identical impedance appears at the input end of the cable. There is only one value of impedance which a cable assumes. If this cable is very long, a terminating resistor equal to the ac resistance of the cable will provide the optimum impedance match. Therefore, the type of signal, impedance matching, and length of transmission line, determine the need of a terminating resistor at the end of a coaxial cable. When the proper impedance matching is satisfied, problems of standing waves, ringing, pulse distortion, and power losses are minimized. The pulse distribution circuits from the acquisition-track synchronizer have an approximate characteristic impedance of 72 ohms. The reference designation, physical location, locational diagram reference, and functional diagram reference for each terminating resistor used is given in table IV, TM 9-1430-254-20/6.

CHAPTER 5 (U)

TRANSMITTING SYSTEM

19 (U). Purpose

a. The purpose of the transmitting system is to produce RF pulses in the S-band of frequencies. The pulse repetition frequency is determined by the transmitter sync pulse produced by the acquisition synchronizing system.

b. The transmitting system consists of the acquisition modulator, magnetron circuits, and various control and measuring circuits. These circuits are located in the LOPAR antenna-receiver-transmitter group, the auxiliary acquisition control interconnecting group, and the battery control console.

20 (U). Block Diagram Analysis

The acquisition transmitter circuits (fig. 4) receive the transmitter sync pulse (par. 18*b* (3)) from the acquisition-track synchronizer. The sync pulse is applied to the acquisition modulator to trigger the acquisition trigger amplifier. The 800-volt trigger pulse, coincident with each sync pulse, is used to trigger the pulse-shaping circuits. The pulse-shaping circuits utilize a 4- to 8-kilovolt dc potential from the acquisition HV power supply and the input trigger pulse to produce and shape a 6- to 6.5-kilovolt trigger pulse. Monitoring of inverse current and control of thyratron capsule voltage for the pulse-shaping circuits is provided by the modulator control-indicator. The 6- to 6.5-kilovolt trigger pulse is applied to the HV pulse transformer where it is stepped up to 40 to 50 kilovolts for application to the tunable magnetron. The HV pulse transformer also develops an AFC gate pulse (par. 58*c*) for use by the acquisition AFC circuits. The tunable magnetron converts the stepped-up modulator output trigger pulses into 1-megawatt RF pulses for application to the acquisition antenna system (par. 24). The magnetron is tuned by the magnetron tuning drive. Motor control voltages for the magnetron tuning drive are provided through switches on the frequency and power meter, the acquisition RF power supply control, and the LOPAR control-indicator. A relative indication of magnetron frequency is supplied from the magnetron tuning drive to a meter on the LOPAR control-indicator. When AAR is used in place of HIPAR, this indication is applied through the meter on the LOPAR control-indicator to the ECCM console. Average magnetron current may be monitored on meters on the acquisition RF power supply control on the LOPAR control-indicator and on the LOPAR auxiliary control-indicator.

21 (U). Acquisition Trigger Amplifier

a. The acquisition trigger amplifier (fig. 4) develops the 800-volt, 2-microsecond, high-voltage pulse used to trigger the acquisition modulator pulse-shaping circuits. The acquisition trigger amplifier is located in the acquisition modulator of the LOPAR antenna-receiver-transmitter group. This amplifier produces one trigger pulse for each acquisition transmitter sync pulse (par. 18*b* (3)) received from the acquisition-track synchronizer.

Note. The grid zone references shown in parentheses in *b* below refer to figure 25, TM 9-1430 254-20/6, unless otherwise indicated.

b. The acquisition transmitter sync pulse (fig. 3) from the acquisition-track synchronizer is applied through contacts 5 and 6 (A4) of deenergized arc suppressor relay K1 to sync pulse amplifier V1A (B2). The input synchronizing pulse is a positive 20- to 40-volt, 0.1-microsecond pulse occurring at a repetition rate of 500 pulses per second. Amplifier V1A amplifies and inverts the positive sync pulse. From V1A, the negative pulse is applied through blocking oscillator transformer T1 (B3) and appears as a positive trigger pulse at the control grid of single swing blocking oscillator V1B. Blocking oscillator V1B, normally biased to cutoff, oscillates and produces a positive 230-volt, 5-microsecond pulse at the output of T1. This pulse is applied to trigger switch V2. Prior to the application of this pulse to V2, the capacitors of 2-microsecond network Z1 are resonant-charged to approximately 640 volts dc by the application of 320 volts dc through inductor L1. When triggered, V2 provides a discharge path for network Z1. As Z1 discharges, a negative 550-

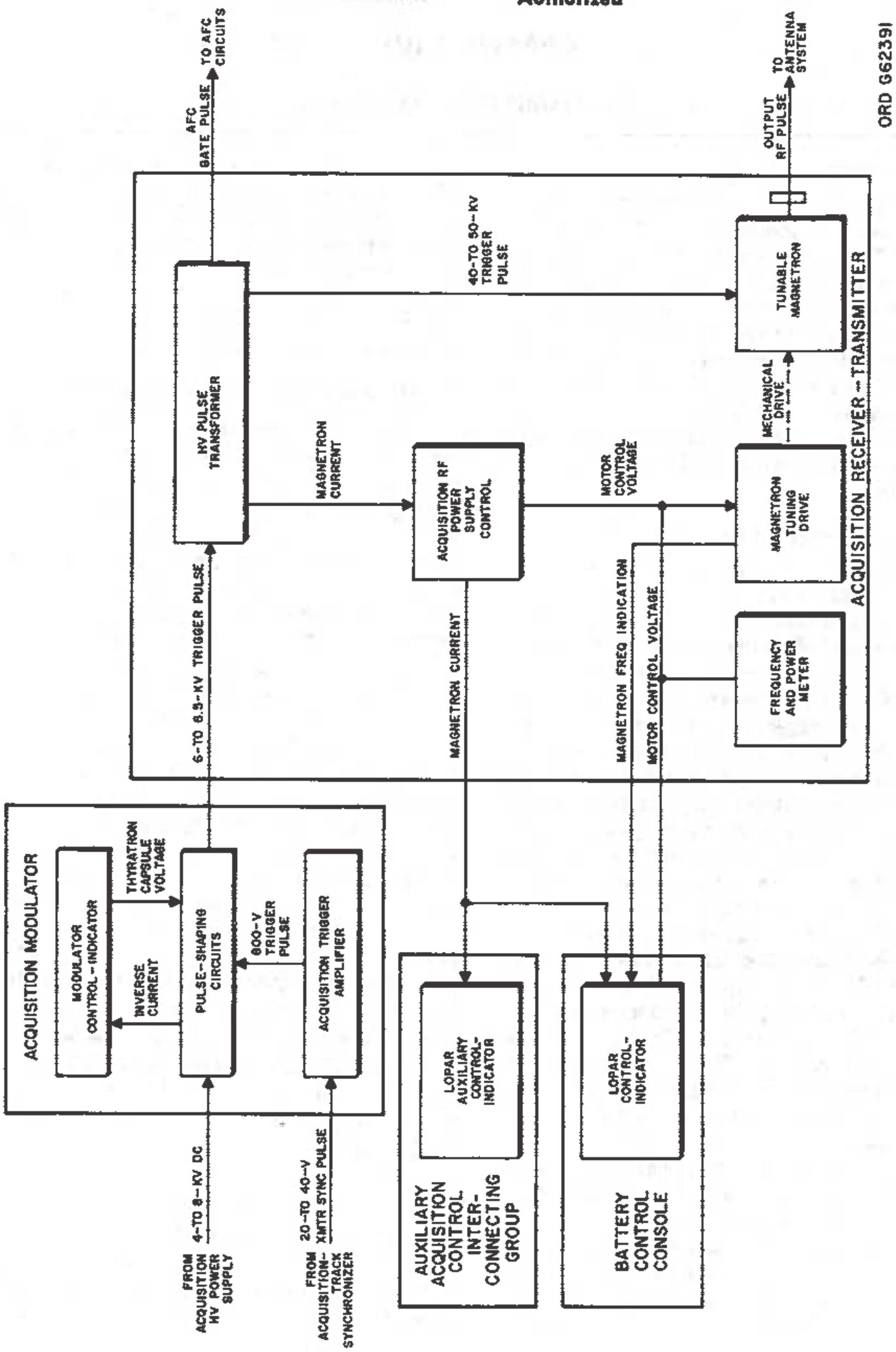


Figure 4 (U). Acquisition transmitter circuits—block diagram (U).

volt, 2-microsecond pulse is developed across winding 3, 4 of pulse transformer T3. Reverse current diode V3 prevents reverse charging of network Z1 or the oscillation of V2 after the discharge of Z1. Transformer T3 steps up and inverts the negative 550-volt pulse to a positive 800-volt pulse and applies the high-voltage trigger pulse through connector J2 (B4) to the acquisition modulator pulse-shaping circuits. The output pulse of T3 can be monitored at trigger pulse monitor test point TP2.

22 (U). Acquisition Modulator Pulse-Shaping Circuits

a. The acquisition modulator pulse-shaping circuits (fig. 4) are triggered by the positive 800-volt, 2-microsecond pulses from the acquisition trigger amplifier and develop 6- to 6.5-kilovolt, 1.3-microsecond pulses at a repetition rate of 500 pulses per second. The high amplitude of the output pulses is required to trigger the magnetron circuit.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 25, TM 9-1430-254-20/6.

b. The positive trigger pulse from the acquisition trigger amplifier is applied to thyratron switch V1 (B5). Prior to the application of this pulse to V1, the capacitors of pulse forming network Z1 (A6) are resonant-charged to approximately 12 kilovolts. The dc charging voltage is received from the acquisition HV power supply through charging inductor L3 (A5). When triggered, V1 (B5) ionizes and provides a discharge path for network Z1. Although network Z1 resonant-charges to approximately 12 kilovolts, the discharge pulse develops to one-half that voltage because of power transfer losses. Thus, a negative 6- to 6.5-kilovolt, 1.3-microsecond trigger pulse is developed across the primary of HV pulse transformer T1 (A13). As network Z1 discharges, a network consisting of inductor L2 (B5), resistor R2, and capacitor C1, in the plate circuit of thyratron switch V1, forms a step in the leading edge of the high-voltage pulse. This step reduces magnetron arcing, moding, and erratic operation. Inverse current diode V2 prevents reverse charging of network Z1 or the oscillation of V1 after the discharge of Z1. Inner cover shorting interlock switch S2 (B6) is provided to discharge network Z1 when the modulator access cover is removed. Capacitors C3 and C4 are provided for filtering of inverse current.

c. The modulator control-indicator (D3) provides the thyratron capsule heater voltage, which controls the acquisition modulator pulse-shaping circuits. Variable transformer T1 (D2) controls the voltage supplied to the primary winding of capsule voltage transformer T2. Transformer T2 supplies capsule heater voltage to thyratron switch V1 (B5). The capsule heater voltage is adjustable to provide an optimum gas pressure within V1. Overload relay K1 (D3) is a protective relay that removes high voltage should there be excessive inverse current through diode V2 (B5). Capacitor C1 (D3) insures that overload relay K1 does not respond to momentary surges of inverse current. Resistors R1 (D4), R2, R3, and R4 are provided to fix the operating range of relay K1 and are also used by the metering circuit. Inverse current may be monitored by modulator test meter M1 (D3) when meter switch S1 is set to INVERSE CURRENT (FS 100 MA). Meter M1 also monitors the heating element voltage of the gas capsule in thyratron switch V1 when switch S1 is set to THY—RES VOLTAGE FS 10V.

23 (U). Magnetron Circuits

a. The magnetron circuits are part of the transmitter circuits (fig. 4) and are located in the acquisition receiver-transmitter. These circuits produce 1.3-microsecond, 1-megawatt pulses of RF energy, using the high voltage dc pulse as a trigger.

b. The magnetron circuits consist of a HV pulse transformer circuit inside the magnetron hot box, a tunable magnetron—5795, and associated control and tuning circuits. The HV pulse transformer receives the negative 6- to 6.5-kilovolt, 1.3-microsecond trigger pulse from the acquisition modulator. The trigger pulse is stepped up to 40 to 50 kilovolts to trigger the magnetron. When triggered, the magnetron oscillates at a frequency in the S-band. The frequency of the magnetron can be varied over its normal operating range of 3100 to 3500 megacycles by using a reversible tuning drive. The 1 megawatt of RF energy generated by the magnetron is conveyed through the waveguide to the acquisition antenna system (par. 24) for radiation into space.

Note. The grid zone references shown in parentheses in *c* through *j* below refer to figure 25, TM 9-1430-254-20/6, unless otherwise indicated.

c. The negative 6- to 6.5-kilovolt trigger pulse from network Z1 (A6) in the acquisition modulator is applied to HV pulse transformer T1 (A13) in the magnetron hot box where the pulse is stepped up to 40 to 50 kilovolts and is applied to tunable magnetron V1 (A15). A small portion of this pulse is applied as an AFC gate pulse (par. 58*c*) through connector J7 (B14) to the acquisition AFC circuits. When the negative trigger pulse from transformer T1 is applied to the cathode of magnetron V1, the magnetron oscillates for the 1.3-microsecond duration of this pulse. Thus, the pulsations occur at a frequency between 3100 and 3500 megacycles, and develop an output peak power of 1 megawatt for 1.3 microseconds. The output from the magnetron occurring at a repetition rate of 500 pulses per second, is coupled through a 10-centimeter waveguide to the acquisition antenna system for transmission into space.

d. The operating frequency of magnetron V1 is linearly varied by a magnetron tuning drive powered by reversible split-phase motor B2 (C15). Driving voltages for this motor are controlled by two momentary contact switches and two pushbutton switch-indicators described in (1) through (4) below.

(1) MAG FREQ switch S2 (C13) on the acquisition RF power supply control provides local control.

(2) MAG FREQ switch S3 (C12) on the frequency and power meter provides local control during transmitter measurements.

(3) FREQUENCY INCREASE switch-indicator A5 (C8) on the LOPAR control-indicator provides remote control.

(4) FREQUENCY DECREASE switch-indicator A6 (C9) on the LOPAR control-indicator provides remote control.

e. The operation of any one of these switches or switch-indicators determines the direction of rotation of motor B2 (C15) and the direction of change in the magnetron frequency. The rotation of B2 is determined by the phase relationship between the control voltages on the motor windings. The phase relationship between these voltages is determined by the applied ac phase and the effect of capacitors C3A (C14) and C4, which cause the voltage applied to one motor winding to be shifted approximately 90 degrees in phase. The switches and switch-indicators are interconnected so that only one can be used at a time to operate motor B2. When switch S3 (C12) or S2 (C13) is set to RAISE, or switch-indicator A5 (C8) is depressed, 120 volts ac is applied through terminals 1 and 3 of connector J25 (C15) to motor B2. Terminal 5 of connector J25 is permanently connected to neutral. When switch S3 (C12) or S2 (C13) is set to LOWER, or switch-indicator A6 (C9) is depressed, 120 volts ac is applied through terminal 3 of connector J25 to motor B2, and terminal 1 of connector J25 is connected to neutral. In this manner, the operation of switch S2 or S3 and switch-indicator A5 or A6 control the direction of rotation of motor B2. As the motor rotates, the size of the resonant cavity within tunable magnetron V1 (A15) is changed to vary the magnetron frequency. A relative indication of the frequency of magnetron V1 is provided by MAGNETRON FREQUENCY meter M1 (C7) on the LOPAR control-indicator. The meter scale is graduated from 0 to 100 in increments of 5, which represent divisions of the transmitter frequency spectrum. The lowest or zero indication on meter M1 corresponds to a frequency of 3100 megacycles, while the highest or full scale indication corresponds to 3500 megacycles. Voltage for meter M1 is supplied through magnetron frequency measure variable resistor R1 (D15) in the magnetron tuning drive. Resistor R1 is mechanically connected to motor B2 so that voltage for meter M1 is varied linearly whenever the magnetron frequency is changed. The output of resistor R1 is, therefore, proportional to the frequency of the magnetron.

f. Average magnetron current may be monitored by two metering circuits described in (1) and (2) below.

(1) Local monitoring is provided by TEST 1 meter M5 (B13) on the acquisition RF power supply control when TEST 1 switch S8 is set to 1 (AVE MAG CUR—F.S.50 MA).

(2) Remote monitoring is provided by magnetron meter M2 (B7) on the LOPAR auxiliary control-indicator. Magnetron current is applied to meter M2 through normally closed contacts of MAGNETRON — RECTIFIER MA FS=1000 switch-indicator A6 (A8) and MA FS=50 — RECTIFIER KV FS=10 switch-indicator A7 (A9). If either switch-indicator A6 or A7 is depressed, magnetron current is removed and the function associated with the depressed switch-indicator is applied to meter M2.

g. The ground return circuit for magnetron current consists of three parallel-connected paths given in (1) through (3) below.

(1) *Normal.* The normal or primary current path is from ground through resistor R36 (B14), capacitors C2 and C7, and transformers T2 and T1 to the cathode of magnetron V1 (A15).

(2) *Metering.* The metering or secondary path is from ground through resistor R34 (C13), AFC motor disable relay K4, network Z1 (A14), which functions as a filter to prevent RF from appearing in the metering circuits, and through transformers T2 and T1 to the cathode of magnetron V1. The voltage developed across R34 (C13) is proportional to the actual magnetron current and is used to actuate meters M2 (B8) and M5 (B13).

(3) *Safety.* The safety or protective current path is from ground through voltage regulator V8 (B15), current limiting resistor R38, network Z1 (A14), and transformers T2 and T1 to the cathode of magnetron V1. Regulator V8 functions as a safety switch to open or close this current path and is normally deionized (open). If the normal current path, (1) above, should open, negative high voltage trigger pulses would appear throughout the magnetron current return circuits. In this case, regulator V8 would ionize and shunt the metering circuit path to protect components of the metering circuits from damage by excessive current.

h. AFC motor disable relay K4 (C14) and LOPAR ready relay K2 (C8), located in a magnetron current path, are deenergized until magnetron current starts to flow. Relay K4 is part of the AFC circuits (par. 54) in the acquisition receiving system. When magnetron current reaches a value of approximately 10 milliamperes, relay K4 energizes and its contacts (fig. 27, B16, TM 9-1430-254-20/6) close. This action completes part of the energizing circuit of motor-generator B3 in the receiver-tuner (par. 60). When magnetron current is not sufficient to energize relay K4, the AFC circuits are disabled. The magnetron current also causes LOPAR ready relay K2 (C8) to energize. Contacts 2 and 4 of energized K2 complete the energizing path for LOPAR on relay K1 (C8). Contacts 3 and 5 of energized K1 supply —28v LD power as —28V LPLD (LOPAR light dimmer) power to the LOPAR indicators and switch-indicators. Other contacts of K1 connect —28v BC power as —28v LP power for use in the LOPAR control-indicator.

i. An arc suppressor circuit is provided to prevent excessive waveguide arcing. Since arcs may travel down the waveguide and damage the magnetron window, the arc suppressor circuit shuts off the transmitter circuits whenever excessive arcing is detected. The arc suppressor circuit is composed of arc suppressor relay K1 (A15), capacitor C14, a probe in the arc suppressor (A16), and capacitor C1. A sustained arc energizes relay K1 (A4) which removes the transmitter sync pulse input to the acquisition trigger amplifier (par. 21) as long as the arcing exists. Capacitor C1 prevents relay K1 from energizing on short, sporadic arcs, while capacitor C14 (A15) keeps relay K1 energized for a short time after each arc. The acquisition duplexer and the frequency and power meter circuits are discussed in paragraph 26.

j. A forced air system is provided to cool the magnetron. The cooling system consists of the magnetron cathode blower (B11) and the magnetron anode blower (A11). The motors in these blowers are immediately activated when main power is applied to the LO-PAR system. As a precautionary measure, the magnetron cannot be activated until both motors are in operation. This safety feature is provided by two switches operated by the air stream pressure within the blower assemblies. In normal operation, 120 volts, phase A, is applied through hot box interlock switch S2, air actuated switch S1 in the magnetron cathode blower, and inductor L1 to the primary of filament transformer T2 (A13). This 120 volts, phase A, is also applied to air actuated switch S1 (A12) in the magnetron anode blower. This switch controls the application of 120 volts, phase A, to the 5-minute delay timer in the acquisition high-voltage circuits. Thus, either switch will prevent the application of magnetron high voltage if its associated blower fails to provide sufficient pressure to cool the magnetron. In addition, air actuated switch S1 in the magnetron cathode blower would prevent the application of magnetron filaments. The distribution of ac power for these circuits is given in TM 9-1430-250-20/12. Protection of personnel is provided by hot box interlock switch S2 in series with both air actuated switches. When the access cover to the magnetron hot box is removed, switch S2 opens to disable the magnetron filament and high-voltage circuits.

CHAPTER 6 (CMHA)

ANTENNA SYSTEM

24 (U). Purpose

The acquisition antenna system consists of a main channel and an auxiliary channel. The main channel provides a means for conveying, shaping, and radiating S-band RF pulse energy into the defense area of the NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) system. It also provides the means for collecting and conveying received S-band RF energy to the main receiver channel. The auxiliary channel is a receiving channel only and provides a means for collecting and conveying received S-band RF energy to the auxiliary receiver channel.

25 (U). Block Diagram Analysis

a. The main channel consists of the acquisition antenna (fig. 5), rotary coupler, acquisition duplexer, and frequency and power meter. The auxiliary channel consists of the auxiliary antenna subassembly and rotary coupler. The antenna drive circuits, compressor, and dehumidifier are common to the main and auxiliary channels. The 1-megawatt RF pulses from the transmitter circuits are conveyed through waveguide circuits to the acquisition antenna. These pulses travel as electromagnetic fields through an acquisition duplexer, which permits the use of a common antenna for both transmitting and receiving, to a rotary coupler. The rotary coupler applies the fields to the rotating acquisition antenna. The antenna shapes the fields by means of reflective elements into a beam and radiates it. The rotary coupler is pressurized with dehumidified air to prevent arcing. The relative positioning of the reflective elements is controlled by the electro-mechanical control box to provide two different beam shapes. Beam elevation is accomplished by varying the relative positioning of the elements and by increasing the elevation angle of the reflective surface. Beam elevation is indicated on a dial coupled to elevation receiver motor B1 on the LOPAR control-indicator. Antenna drive circuits are provided to rotate the antenna in azimuth at three different speeds.

b. The same antenna that radiates the pulsed energy also receives RF energy and collects and focuses this energy back into the waveguide circuits. This energy returns through the rotary coupler to the acquisition duplexer and is passed to the receiver circuits (pars 31 and 45).

c. An output taken from the transmitter is connected to a frequency and power meter for a check of transmitter operation. This meter is used for power and frequency measurements of the transmitted pulse.

d. The auxiliary antenna subassembly mounted on the acquisition antenna is a receiving antenna only. It receives reflected S-band energy and S-band jamming signals when the LOPAR system is operating in an electronic countermeasures (ECM) environment. The RF energy returns through the coaxial line and rotary coupler to the auxiliary receiver channel.

26 (U). Waveguide Circuits

Note. The grid zone references shown in parentheses below refer to figure 25, TM 9-1430-254-20/6, unless otherwise indicated.

The waveguide circuits (fig. 5) in the antenna system convey pulsed RF energy from the transmitter circuits to the acquisition antenna, and also convey received RF energy from the acquisition antenna and the auxiliary antenna subassembly to the main and auxiliary receiver channels. The waveguide circuits are that portion of the acquisition transmitter circuits between tunable magnetron V1 (A15) and the acquisition antenna (A18). When magnetron V1 oscillates, the output RF energy is coupled into the waveguide circuits. This RF energy, in the form of high-power RF pulses, ionizes TR tube V4 (A17), and ATR tubes V2 and V3, restricting the RF pulses to a path through the acquisition duplexer and the rotary coupler to the acquisition antenna. During the

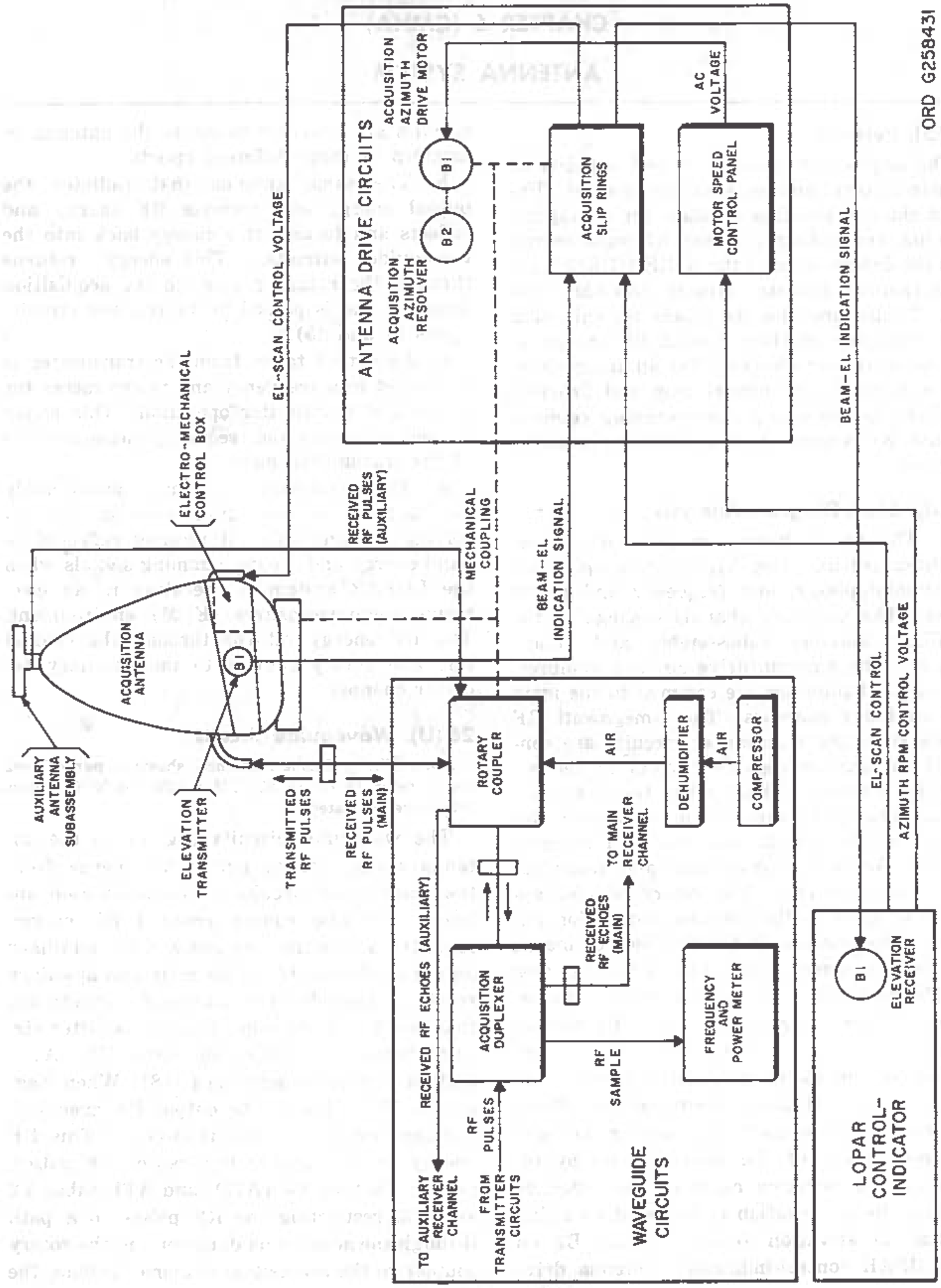


Figure 5 (U). Antenna system—block diagram (U).

time intervals when magnetron V1 is not oscillating, received RF from the antenna is transferred through the rotary coupler to the duplexer. At the duplexer, TR tube V4 (par. 34) passes the RF pulses to the acquisition receiver circuits, and ATR tubes V2 and V3 prevent the received signal from entering the transmitter circuits. The coaxial probe coupling in the waveguide circuits provides an RF energy sample (fig. 26, A15, TM 9-1430-254-20/6) of the magnetron output frequency for use in the acquisition AFC circuits (par. 54). The units and assemblies involved in the transfer of the RF energy through the waveguide circuits are discussed in *a* through *e* below.

Note. The key numbers shown in parentheses in *a* below refer to figure 6.

a. Acquisition Duplexer. The acquisition duplexer (fig. 6) is functionally common to the transmitter circuits and receiver circuits. The duplexer, functioning as an electronic switch, electrically disconnects the receiver from the acquisition antenna during transmitting time and the magnetron circuit from the acquisition antenna during receiving time. This duplexing action prevents the transmitter output pulse from entering and damaging the acquisition receiver circuits, and prevents received RF pulses from being absorbed in the transmitter circuits during receiving time. The waveguide circuits are thus used on a time-shared basis. The duplexer is a series of three sections of 10-centimeter waveguide connected between the tunable magnetron and the rotary coupler. The first section, mechanically and electrically coupled to the magnetron, performs the duplexing function. This duplexer section contains an arc suppressor probe (13), a transmit-receive (TR) tube (8), and two anti-transmit-receive (ATR) tubes (9). The second section is a flexible piece of waveguide that assures proper mechanical alinement of the waveguide circuits. The third section, coupled to the rotary coupler, contains a directional coupler (10) and an RF sampler probe permitting an RF sample to be obtained for the ACQ AFC circuits (6). These sections are discussed in (1) through (4) below.

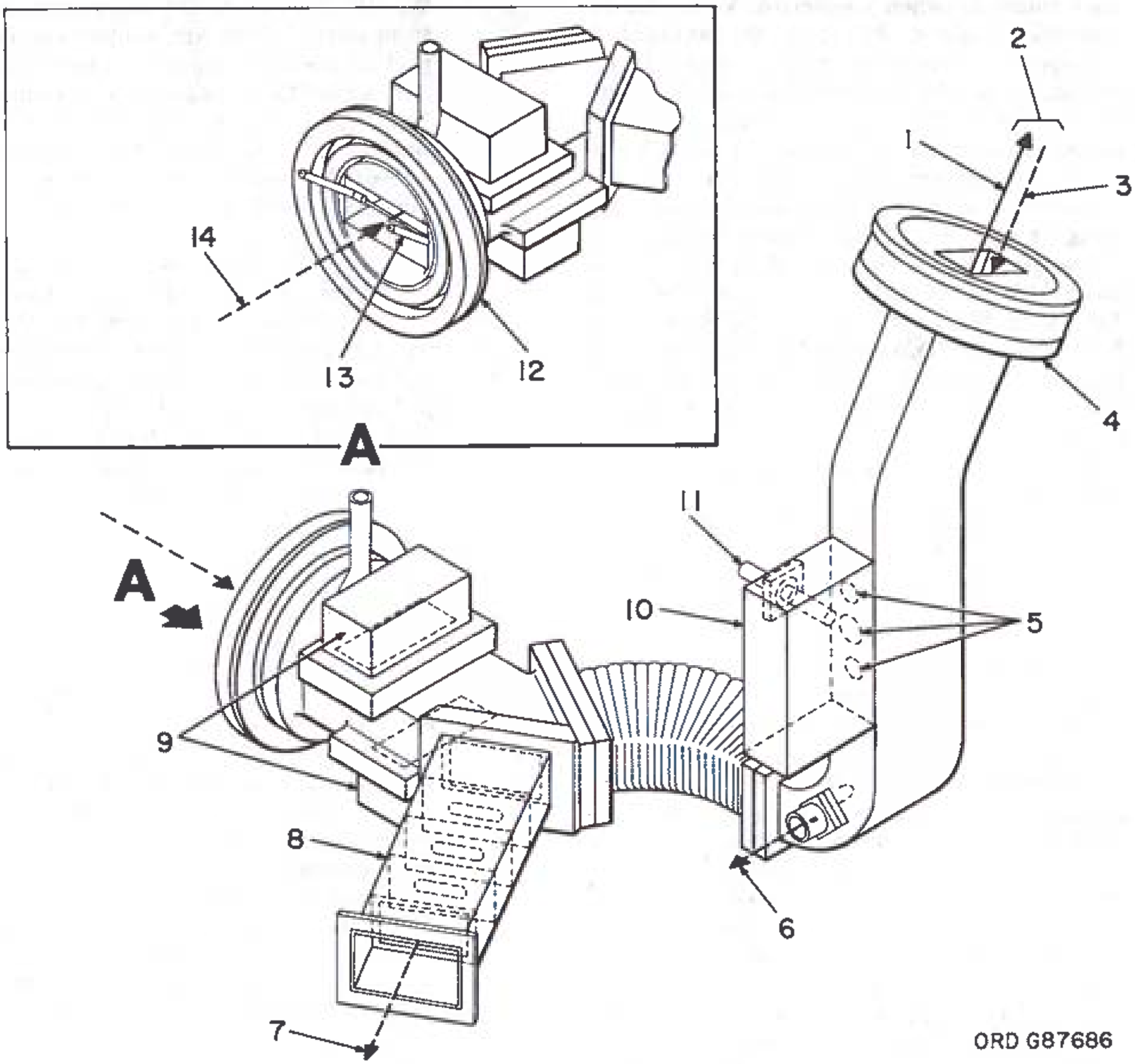
(1) The arc suppressor probe is a device in the end of the duplexer into which the RF pulse from the magnetron is transmitted. This arc suppressor is part of the arc suppressor circuit in the acquisition magnetron circuits (par. 23). The function of the arc suppressor is to detect and prevent waveguide arcing from traveling through the waveguide to the magnetron window.

(2) The TR and ATR tubes (8 and 9) are ionized by the RF pulses from the magnetron. When ionized, the TR tube presents a high impedance and the ATR tubes present a low impedance to the transmitter RF pulses. As a result, the transmitter RF pulses (1) pass on to the rotary coupler without entering the receiving circuits. During receiving time, the received RF signals (3) do not have sufficient energy to ionize the TR or ATR tubes. Therefore, the deionized ATR tubes present a high impedance at the output of the transmitting circuits and received RF energy is blocked from entering these circuits. At the same time, the deionized TR tube presents low impedance at the input to the receiving circuits, and received RF signals (7) pass freely into the main receiver channel.

(3) A waveguide probe, mounted adjacent to the directional coupler, samples a portion of the RF pulses from the transmitting circuits. This RF sample (6) is made available to the AFC circuits of the acquisition receiver system (par. 54).

(4) The directional coupler (10) is an inclosed rectangular waveguide cavity permanently attached to the side of the acquisition duplexer. The coupler receives an RF sample (11) through irises (5) in the waveguide wall. This RF sample (11) is made available for measurements of transmitter output by the frequency and power meter.

b. Frequency and Power Meter. The frequency and power meter (fig. 7) monitors the output power, output frequency, and output pulse shape of the transmitter circuits. This



1—Transmitter RF pulses
2—RF signals to and from acquisition antenna (fig. 5)
3—Received RF signals
4—Waveguide coupling flange to rotary coupler
5—Irises
6—RF sample to ACQ AFC circuits (fig. 1)
7—Received RF signals to main receiver channel (fig. 1)
8—TR tube
9—ATR tubes
10—Directional coupler
11—RF sample to frequency and power meter (fig. 5)
12—Waveguide coupling flange to magnetron
13—Arc suppressor probe
14—Transmitter RF pulses from magnetron

Figure 6 (U). Acquisition duplexer—functional diagram (U).

unit is a permanently mounted test set in the acquisition receiver-transmitter. Input signals are obtained through a single coaxial cable from the directional coupler. At the frequency and power meter, this normally disconnected coaxial cable is manually connected to one of three inputs discussed in (3) through (5) below. Output from the transmitter circuits is monitored on meter M1. The operation of M1 is determined by POWER switch S4 and TEST switch S2. The TEST switch has two positions (BAL and MEAS) which determine the use

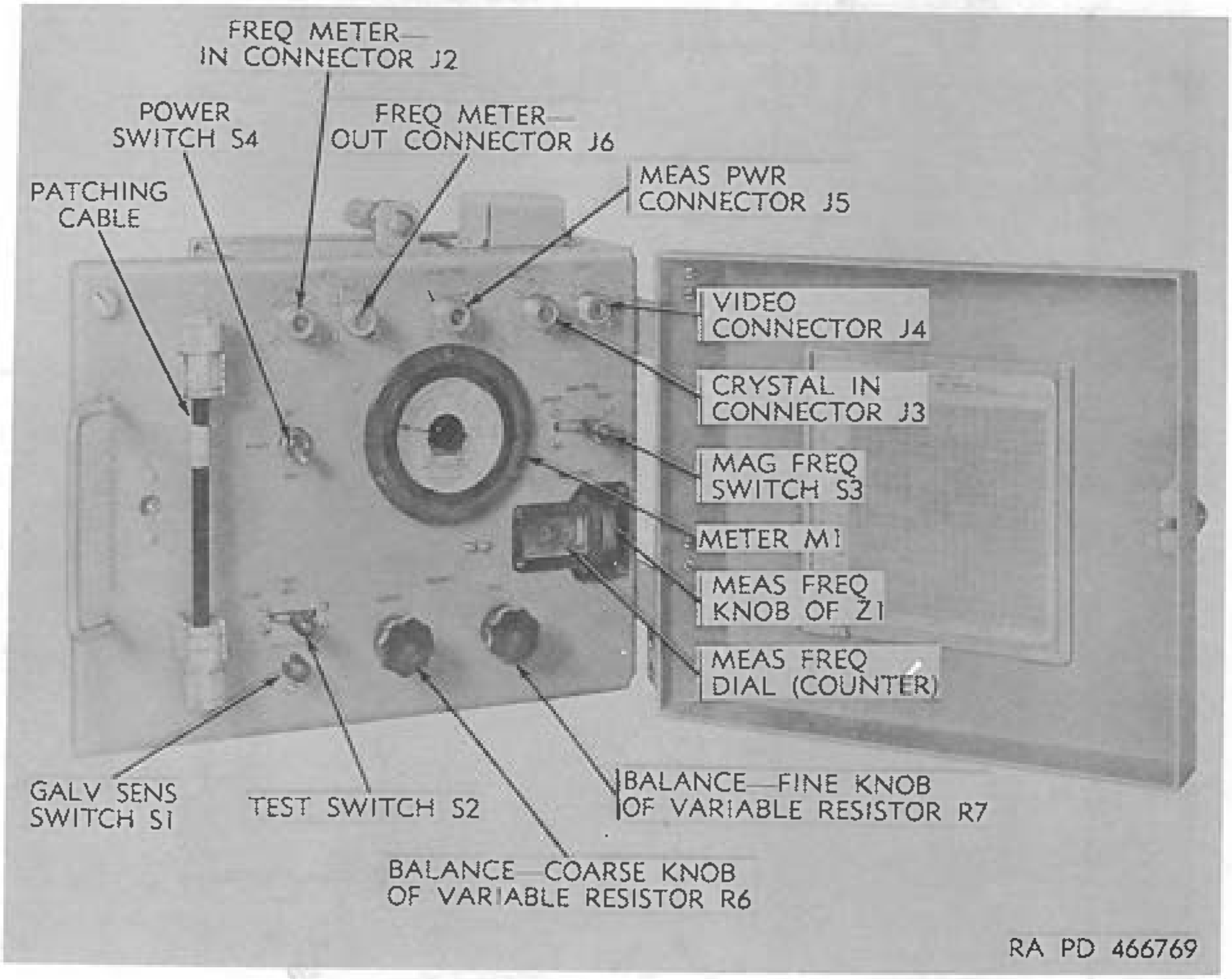


Figure 7 (U). Frequency and power meter (U).

of internal bridge circuits. The normal position of S2 is BAL, the spring-loaded position. Basic bridge circuits for both positions of S2 are given in (1) and (2) below.

Note. The grid zone references shown in parentheses in (1) through (5) below refer to figure 25, TM 9-1430-254-20/6, unless otherwise indicated.

(1) *Balance condition.* With TEST switch S2 (C16) set to BAL, the circuits are conventional bridge (A, fig. 8) with meter M1 connected to indicate bridge currents. Resistors R8, R11, and R12 function as a voltage divider providing a scaled voltage. Variable resistors R4, R6, and R7 provide adjustment of the voltage applied across the bridge circuit, and connector J5 provides the input under measurement to the bridge circuit.

(2) *Measure condition.* With TEST switch S2 (C16) in the MEAS position, the circuits are series-parallel (B, fig. 8) with meter M1 connected for calibration. With no signal applied to the metering circuit, M1 internally indicates branch current which is recorded as part of the power measurement procedure.

(3) *Frequency measurement.* When connector P9 (B17) is manually connected to FREQ METER—IN connector J2, the RF pulse sample is applied through MEAS FREQ tunable cavity Z1 to FREQ METER—OUT

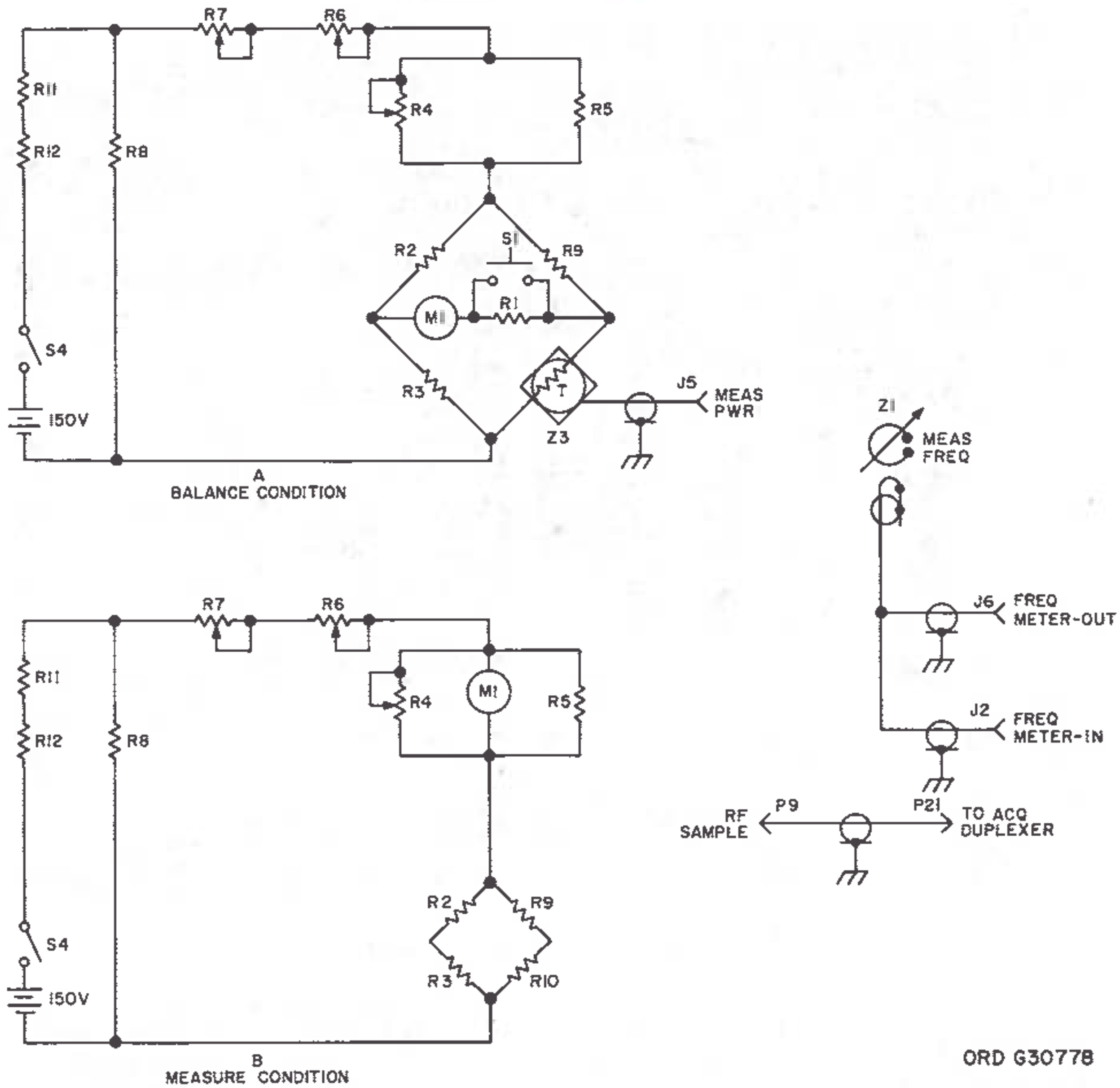


Figure 8 (U). Frequency and power meter—bridge circuit (U).

connector J6. When connector J6 is manually connected to MEAS PWR connector J5 by means of the patching cable (fig. 7), the RF sample is applied to thermistor Z3, through TEST switch S2 (C16) to meter M1. When cavity Z1 is tuned to resonance by the MEAS FREQ knob of Z1 (fig. 7), meter M1 indicates a peak. The MEAS FREQ dial, a mechanical counter attached to the tunable cavity, provides a numerical reference for interpretation of transmitter frequency. With the aid of a calibration chart, the MEAS FREQ counter reading is convertible to a frequency reading. This chart (fig. 9) is calibrated at the factory for a given meter assembly and the system with which it is to be used. The chart has five frequency divisions and five counter reading references. As a

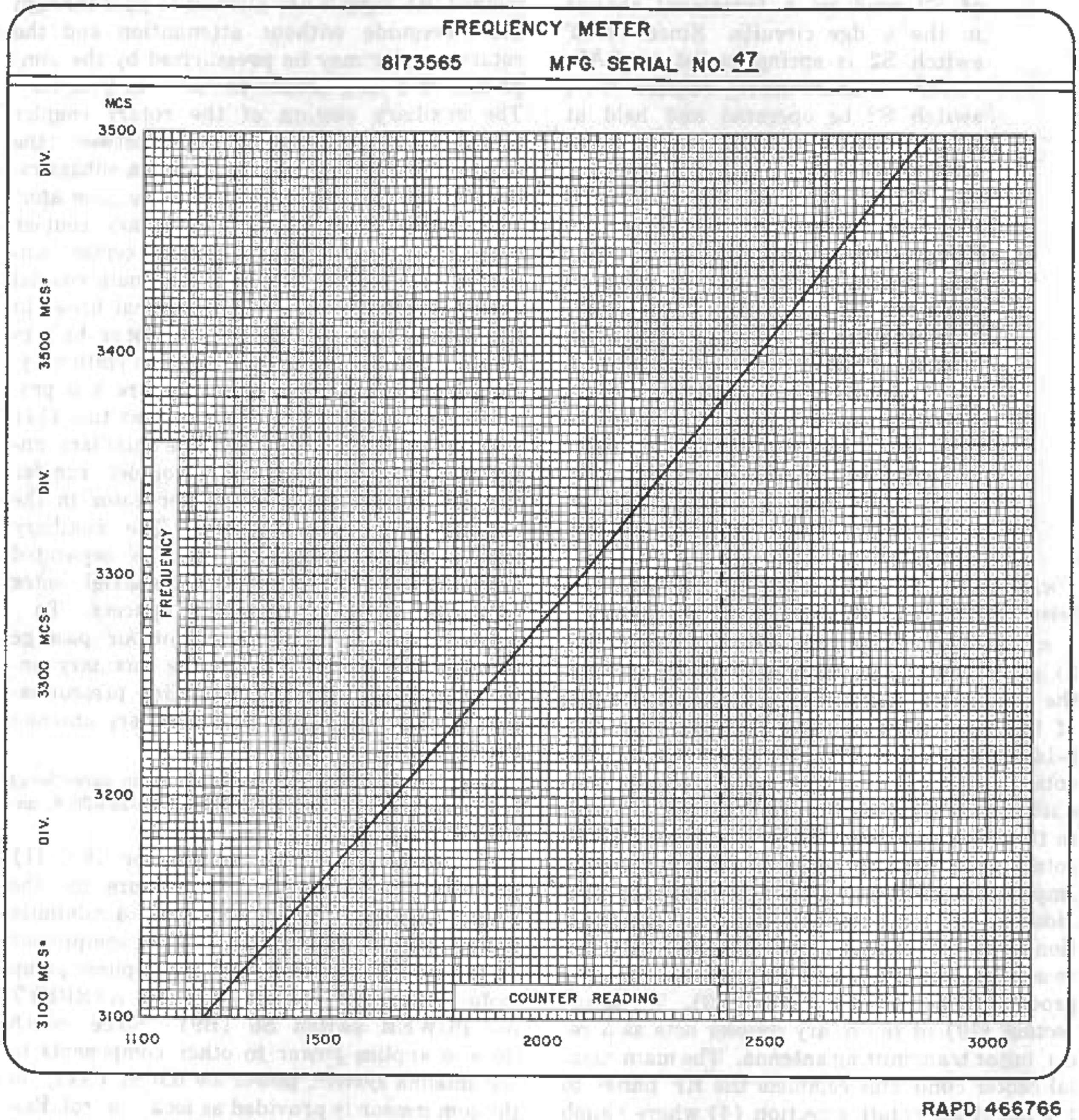


Figure 9 (U). Frequency and power meter—calibration chart (U).

conversion example, when the counter indicates 2400, the actual measured frequency is 3380 megacycles.

(4) *Pulse measurement.* When connector P9 (B17) is manually connected to CRYSTAL—IN connector J3 (fig. 7), the RF pulse sample is applied to network Z2 where the RF envelope is filtered by a diode. The video output is available at VIDEO connector J4 when viewing of the pulse shape on a test oscilloscope is desired.

(5) *Power measurement.* When connector P9 (fig. 8) is manually connected to MEAS PWR connector J5, the RF pulse sample is applied through thermistor Z3 and TEST switch S2 (C16) to a bridge circuit. Manual operation

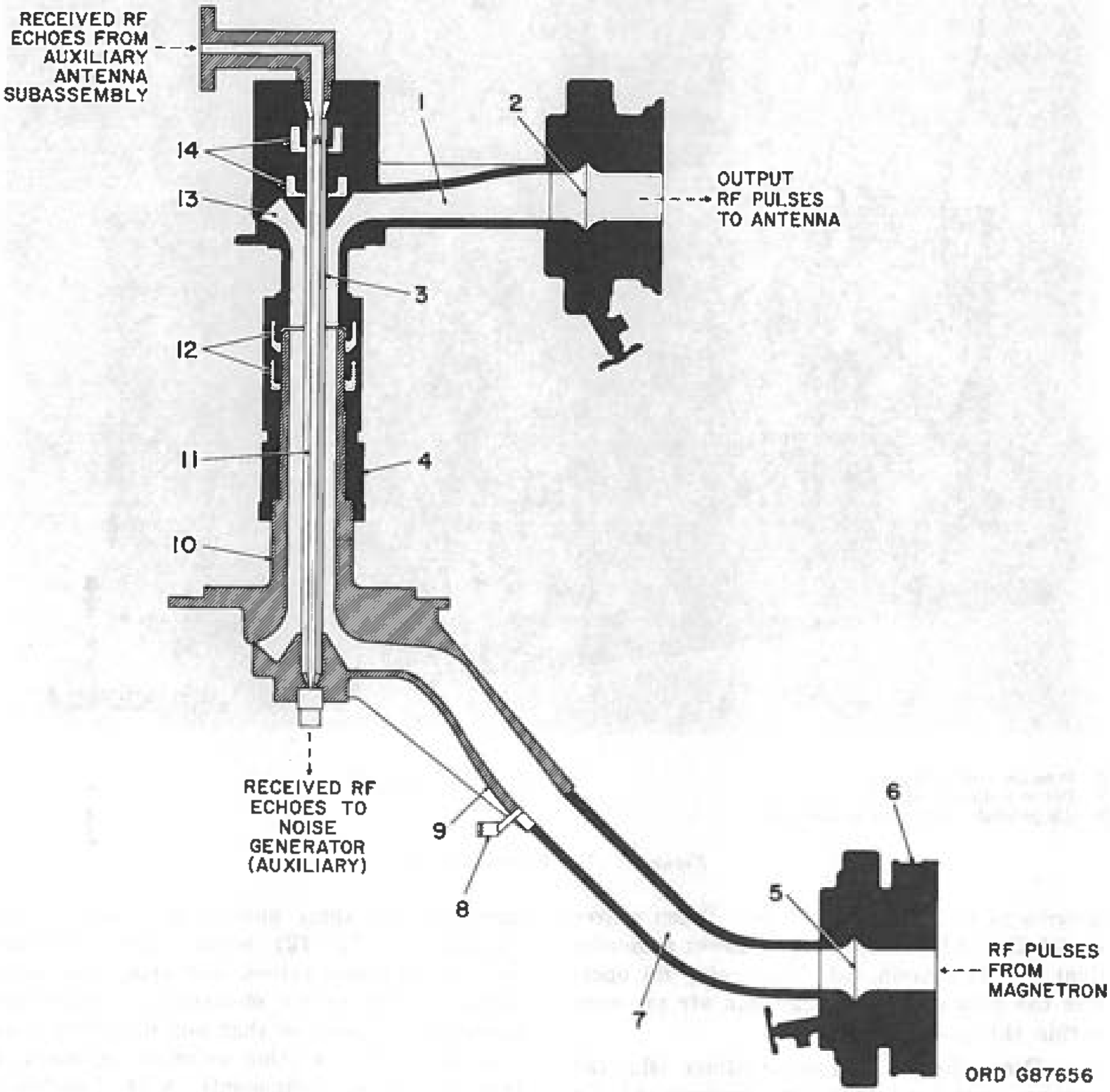
of S2 produces a functional change in the bridge circuits. Since TEST switch S2 is spring-loaded to BAL, power measurements require that switch S2 be operated and held at MEAS during measurements. BALANCE—COARSE variable resistor R6 (D17) and BALANCE—FINE variable resistor R7 balance the bridge circuits as indicated on meter M1. Series resistor R1 is removed from the M1 meter circuit by GALV SENS switch S1 (C16), a pushbutton switch. When switch S1 is depressed, meter sensitivity is increased. When POWER switch S4 (C17) is set to ON, the frequency and power meter is energized. When switch S4 is set to OFF, the meter is deenergized and a protective meter short is applied across meter M1.

Note. The key numbers shown in parentheses in *c* below refer to figure 10, unless otherwise indicated.

c. Rotary Coupler. The rotary coupler (fig. 5) serves as the waveguide coupling between the stationary waveguide and the waveguide of the acquisition antenna (fig. 25, A18, TM 9-1430-254-20/6). The main section of the rotary coupler is a section of rigid coaxial conductor with air dielectric. A mechanical break in the outer conductor allows the upper half to rotate while the lower half remains stationary. Impedance continuity around the break is provided by two main resonant cavities (12) functioning as RF chokes. Impedance matching between the waveguide and the coaxial section is provided by a tapered waveguide (9). The lower section (10) of the rotary coupler acts as a receiving or transmitting antenna. The main coaxial center conductor conducts the RF pulses to the top of the rotating section (4) where a knob junction radiates the RF pulses into the upper waveguide (1). The knob junction also acts as a receiving antenna for RF signals returning through the upper waveguide. While the rotary coupler provides both the mechanical and electrical continuity of the waveguide circuits, it also provides an air-tight section of the waveguide. The air-tightness is accomplished by means of a glass window (2 and 5) at both ends of the rotary coupler. By this method, RF signals are allowed to pass through the waveguide without attenuation and the rotary coupler may be pressurized by the compressor if arcing occurs in the rotary section. The auxiliary section of the rotary coupler serves as the coaxial coupling between the coaxial line to the auxiliary antenna subassembly and the coaxial line to the noise generator. The auxiliary section of the rotary coupler consists of the auxiliary coaxial center conductor (11) in the center of the main coaxial center conductor (3). A mechanical break in the outer conductor allows the upper half to rotate while the lower half remains stationary. Impedance continuity around the break is provided by two auxiliary resonant cavities (14) functioning as RF chokes. The auxiliary antenna subassembly and rotary coupler transfer the RF signals to the noise generator in the auxiliary receiving channel. The auxiliary coaxial center conductor (11) is separated from the outer conductor (main coaxial center conductor (3)) by dielectric spacers. The spacers contain holes to permit air passage through the coaxial line to the auxiliary antenna subassembly thus permitting pressurization of the coaxial line and auxiliary antenna subassembly.

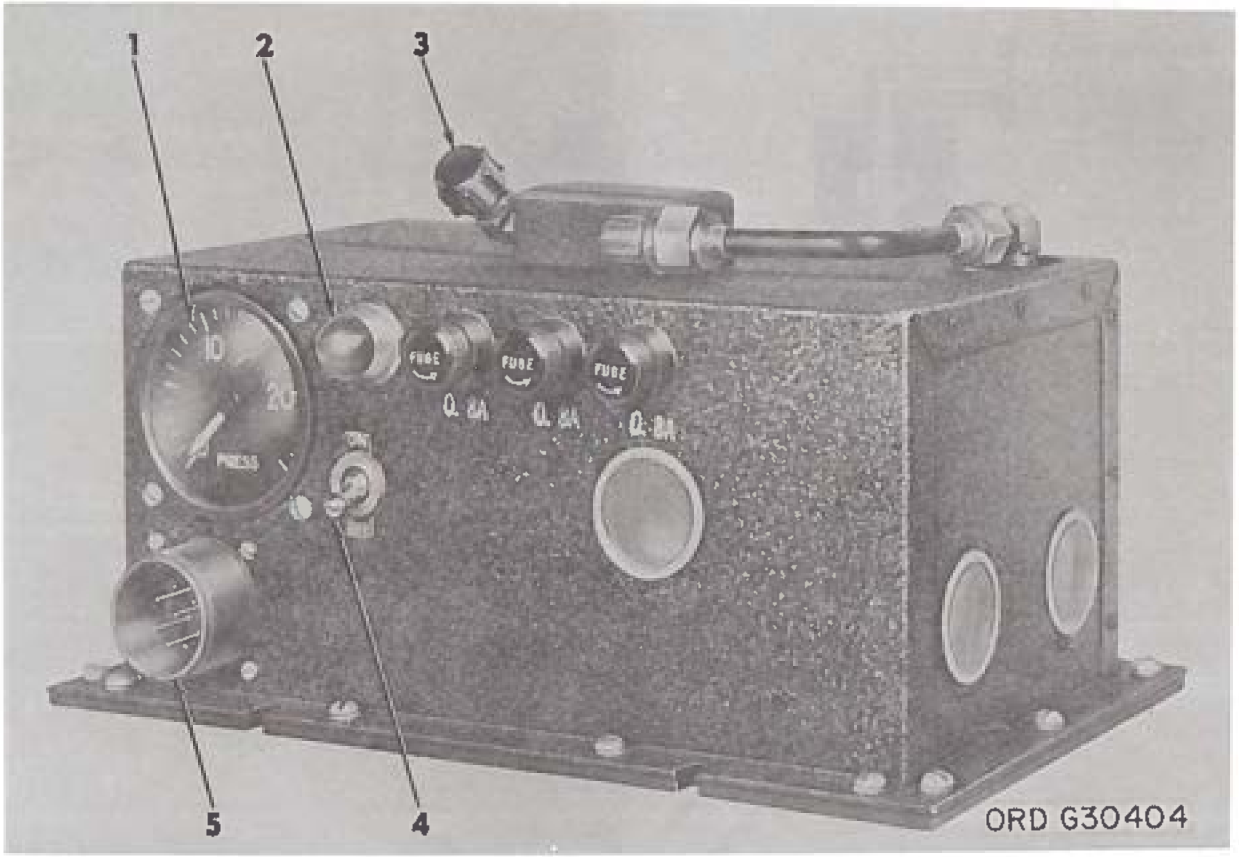
Note. The grid zone references shown in parentheses in *d* below refer to figure 38, TM 9-1430-254-20/6, unless otherwise indicated.

d. Compressor. The compressor (fig. 11) provides 10- to 16-psi air pressure for the rotary coupler. Pressure is used to minimize arcing within the coupler. The compressor (B13) receives 120-volt, 400-cps, 3-phase pump motor excitation voltage through BARBETT AC POWER switch S6 (B9). Since switch S6 also applies power to other components in the antenna system, power switch S1 (A12) on the compressor is provided as local control. Bellows switch S2 (A13) energizes start relay K1 when air pressure falls below 10 psi and deenergizes the compressor when the air pressure builds up to 16 psi. Pressure meter M1 indicates air pressure in the line to the rotary coupler. When bellows switch S2 fails to shut off the compressor at 16 psi, normally closed safety bellows switch S3 opens at 23 psi to deenergize start relay K1, shutting off compressor pump motor B1. Switch S3 closes when the pressure



1—Upper waveguide
2—Window
3—Main coaxial center conductor
4—Rotating section
5—Window
6—Waveguide mounting to duplexer
7—Pressurized waveguide
8—Pressurization connection
9—Tapered waveguide
10—Lower section
11—Auxiliary coaxial center conductor
12—Main resonant cavities
13—Knob junction
14—Auxiliary resonant cavities

Figure 10 (U). Rotary coupler—functional diagram (U).



1—Pressure meter M1
2—Power indicator light I1
3—Air pressure output to dehumidifier
4—Power switch S1
5—Connector J1

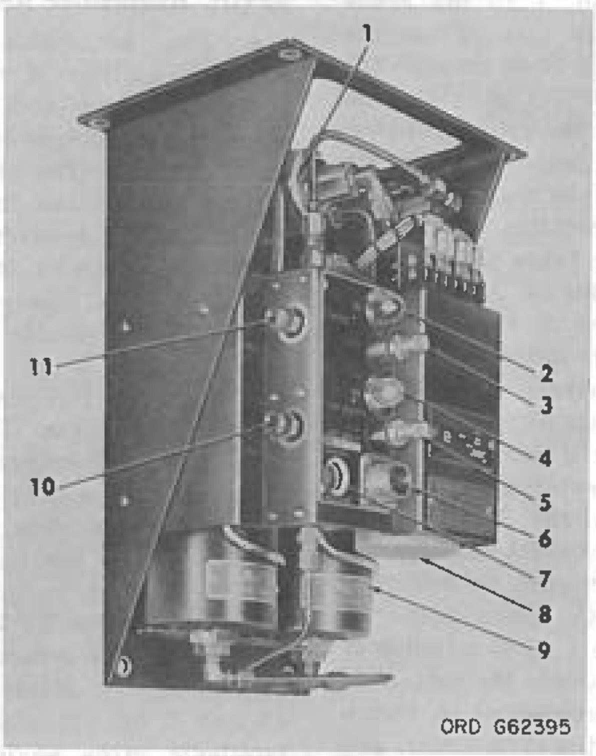
Figure 11 (U). Compressor (U).

is reduced by leakage to 17 psi. When power switch S1 (A12) is set to ON, power indicator light DS1 is illuminated. Start relay K1 operates the pump motor to maintain air pressure within the preset limits.

e. Dehumidifier. The dehumidifier (fig. 12) removes moisture from the pressurized air furnished by the compressor for the rotary coupler. Dry air reduces the corrosion and arcing in the rotary coupler. The dehumidifier consists of two regenerative desiccant tanks (9, fig. 12), a heating element for each tank, two solenoid-controlled air and steam valves, two capillary tubes, and a cycle timer (8, fig. 12). The cycle timer contains a 400-cps synchronous motor, three eccentric cams, and three microswitches. The motor drives the cams which operate the microswitches. These microswitches apply operating voltage to the solenoids (1, fig. 12) which open and close the air and steam valves, and apply excitation voltage to the heater elements. Dehumidifier operation is cycled so that one desiccant tank is in use while the other is being regenerated (dried). These components, with functional descriptions, are discussed in (1) through (3) below.

Note. The grid zone references shown in parentheses in (1) through (3) below refer to figure 38, TM 9-1430-254-20/6, unless otherwise indicated.

(1) When power is applied to the dehumidifier, ac motor B1 (C19) in the cycle timer is energized, —28 volts is applied to terminal 11 of the cycle timer, and 115V-400 CPS—ON indicator lamp I1 (4, fig. 12) and 28V



1—Solenoid (2)
2—28V DC—ON indicator lamp I2
3—28V DC—ON fuse F2
4—115V-400 CPS—ON indicator lamp I1
5—115V-400 CPS—ON fuse F1
6—Power connector J1
7—HUMIDITY INDICATOR
8—Cycle timer
9—Regenerative desiccant tank (2)
10—Outlet to rotary coupler
11—Inlet from compressor

Figure 12 (U). Dehumidifier (U).

DC—ON indicator lamp I2 (2, fig. 12) illuminate. The dehumidifier cycles continuously (table I) while power is applied and stops when power is removed. When power is applied again, the cycling continues from the phase in which it stopped. One full cycle requires three hours.

Table I (U). Complete Dehumidifier Cycle (U)

Component	Cam no.	Microswitch contacts	Time activated
Tank-1 solenoid L1	3	11-3	90-180 minutes
Tank-2 solenoid L2	3	11-4	0-90 minutes
Desiccant tank no. 1 (heater 1)	2	13-8	90-135 minutes
Desiccant tank no. 2 (heater 2)	1	12-6	0-45 minutes

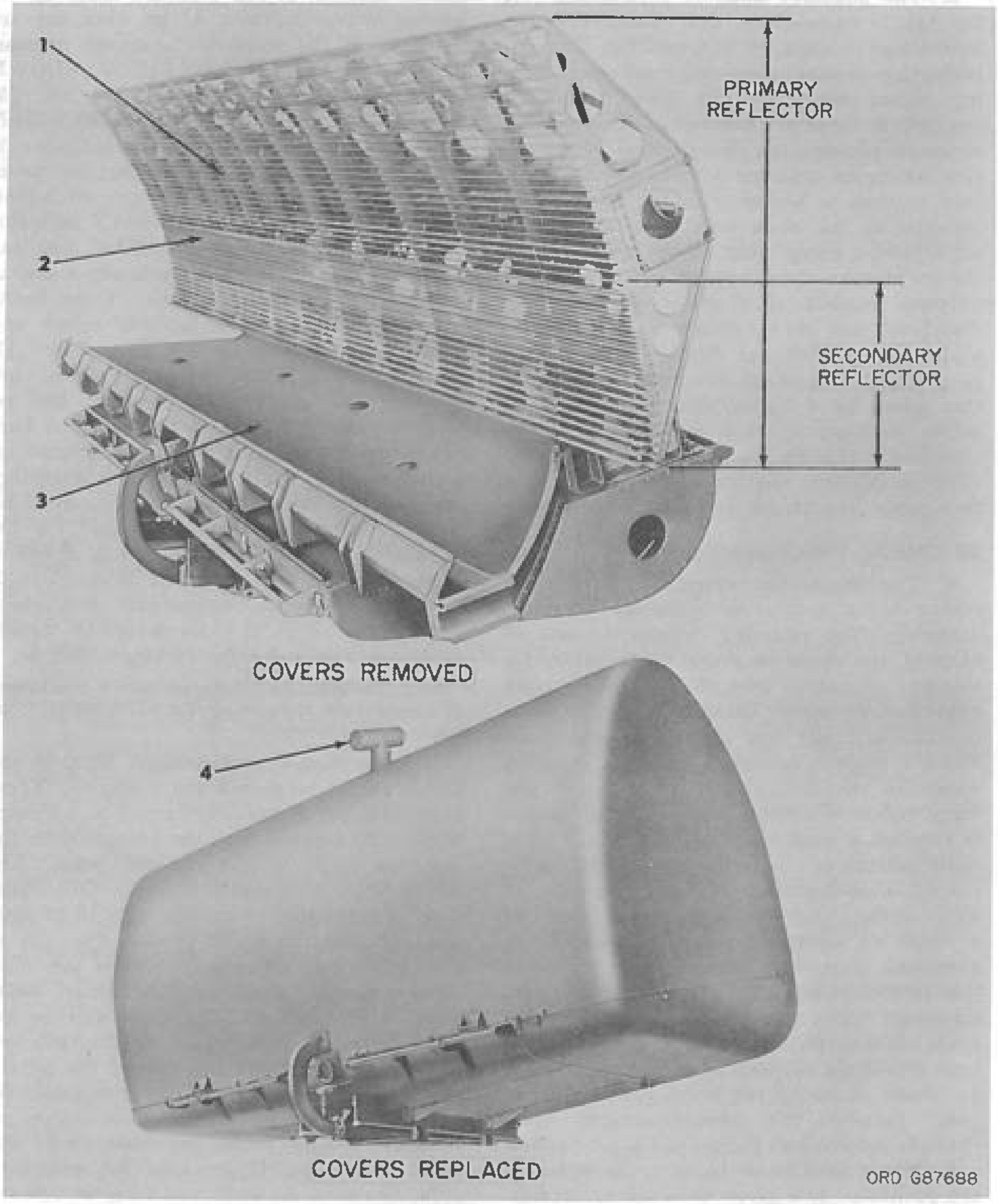
(2) When power is applied to the dehumidifier and cycling begins, a circuit between terminals 12 and 6, 13 and 7, and 11 and 4 on the cycle timer (B19) is closed. Tank-1 solenoid L1 remains deenergized, and tank-2 solenoid L2 is energized. The air and steam valve associated with solenoid L1 remains stationary, leaving the air ports open and the steam-outlet port closed. The air and steam valve associated with solenoid L2 (C18) is actuated and causes its associated air ports to close and steam-outlet port to open. Heater 1 (A19) has remained deenergized, while heater 2 (C19) energizes and vaporizes the moisture in the desiccant crystals of tank No. 2. Air under pressure from the compressor (A13) flows through the open air ports of

desiccant tank No. 1 to the check valve and capillary tube. From the check valve, the air flows through the HUMIDITY INDICATOR (B20) to the waveguide of the rotary coupler. During this cycle, moisture in the air stream is absorbed by the desiccant in tank No. 1. Regeneration of desiccant tank No. 2, which takes place during the first 45 minutes of the cycle, occurs when heater 2 vaporizes the moisture from the desiccant in tank No. 2 and discharges it as steam through the open steam valve. A small portion of the air stream from desiccant tank No. 1 supplies through its capillary tube and the capillary tube associated with desiccant tank No. 2 a form of back pressure to desiccant tank No. 2 to aid the steam discharge. At the end of the first 45 minutes of the cycle, cam 1 breaks the contact of the microswitch connected to terminals 6 and 12 of the cycle timer, and heater 2 is deenergized. At the end of 90 minutes, a new phase begins when cams 2 and 3 activate the associated microswitches. This causes heater 1 and solenoid L1 to energize and solenoid L2 to deenergize. Solenoid L1 actuates its associated air and steam valve which causes the air ports of desiccant tank No. 1 to close and its steam-outlet port to open. Similarly, solenoid L2 actuates the air and steam valve of desiccant tank No. 2. The air flow is then channeled to tank No. 2 while tank No. 1 is regenerated.

(3) The air stream leaving either desiccant tank passes through a small amount of desiccant visible through a window on the dehumidifier. This window and desiccant is the HUMIDITY INDICATOR (7, fig. 12). Dry desiccant crystals are blue; in absorbing moisture from the output air stream, the crystals become pink. The color of the crystals indicates whether or not the dehumidifier is providing dehydrated air to the rotary coupler.

27 (U). Acquisition Antenna

a. The acquisition antenna (fig. 13), mounted on top of the acquisition antenna pedestal, focuses and radiates into space the pulses of RF energy received from the waveguide circuits. The antenna also receives RF signals and focuses them into the waveguide for use by the receiver circuits. The elements within the antenna are protected from water and dust by a Fiberglas cover which has no adverse effect on the radiation pattern. The lower section within the cover is a pillbox antenna that receives RF energy from the waveguide circuits. The pillbox (3, fig. 13) reflects the RF energy to the deflector, which diverges this energy onto the complete reflective surface. The feed-point of the waveguide is offset one inch from the focal point of the pillbox to prevent standing waves and the resultant RF loss due to an impedance mismatch. The reflective surface is composed of two sets of evenly spaced horizontal bars (1 and 2, fig. 13) placed so that they form a parabolic cross section. One set, which is spaced throughout the total reflective surface, is the primary reflector (1, fig. 13). The other set, which is found only in the lower section, is the secondary reflector (2, fig. 13). The curvature of the reflective surface may be changed by retracting or injecting the secondary reflector bars. Changing the relative positioning of the reflective bars produces either a pencil-shaped or a fan-shaped beam in the vertical plane. The reflective surface angle can also be changed to vary the elevation angle through 9 degrees. Changing the reflective surface by both methods varies the radiated beam between 2 and 22 degrees from the horizontal. The beam width is a constant 1.4 degrees in azimuth, regardless of the elevation angle. Changing the elevation angle and the beam shape constitutes a scanning process which is produced by an electro-mechanical control assembly. Azimuth rotation of the antenna is produced by the antenna drive circuits (par. 30), operated either simultaneously with or independently of the scanning process. An antenna rotational speed of 5, 10, or 15 rpm is selected on the basis of tactical requirements.



1—Primary reflector bars
2—Secondary reflector bars
3—Pillbox
4—Auxiliary antenna subassembly

Figure 13 (U). Acquisition antenna—front view (U).

b. The auxiliary antenna subassembly (7, fig. 14) is mounted on and rotates with the acquisition antenna. It is a modified Yagi antenna that provides a coverage pattern extending beyond that of the side lobes of the main acquisition antenna. Because of the extended coverage pattern, the energy level of signals received from jamming sources by the auxiliary antenna is higher than the energy level received by the main acquisition antenna at all azimuths except that of the main lobe of the main acquisition antenna. The auxiliary antenna consists of a driver element, four directors, and three reflectors. The driver element is a U-shaped dipole which aids in providing the required coverage in excess of that given by a normal Yagi antenna. The entire auxiliary antenna subassembly is enclosed in a thin Fiberglas radome which provides an effective weather seal and also serves to support two of the reflectors.

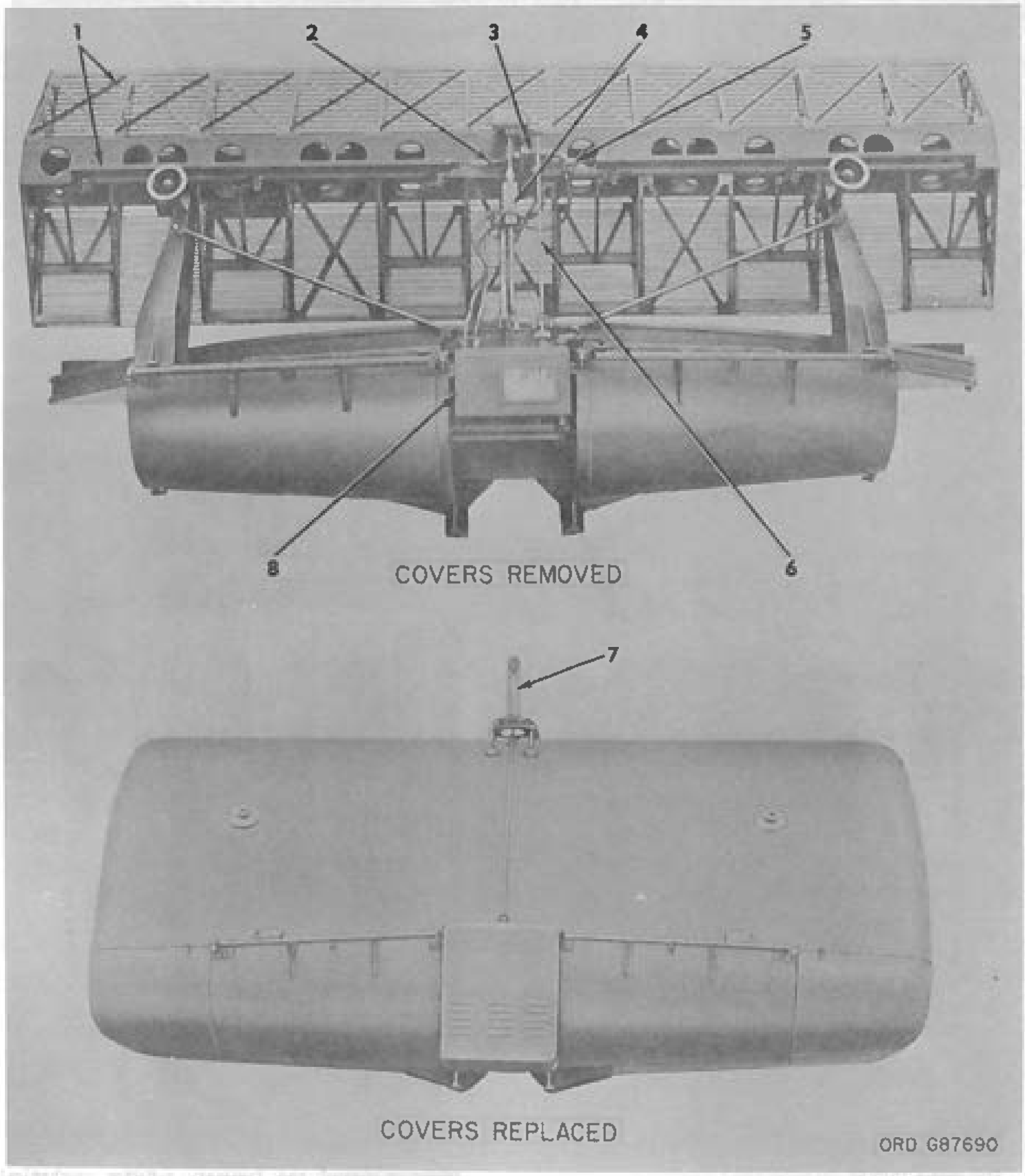
28 (CMHA). Elevation Scanning

a. The acquisition antenna (fig. 13) is equipped for manual or automatic elevation scanning. The scanning process consists of varying the elevation angle of the reflective surface. In manual scan, the reflective surface angle can be varied between 0- and 9-degree mechanical limits and stopped at any intermediate angle. Secondary reflector injection occurs in conjunction with variation of primary reflective angle. When reflector motion is stopped, a fixed beam pattern results. The beam pattern can be either the narrow pencil-shaped beam formed by the primary reflector alone or the broad fan-shaped beam formed as a result of secondary reflector injection. In automatic scan, depending on the scan condition (mode) selected, the primary reflector continuously traverses between the mechanical mode limits given in *d* below. Hence, automatic scan provides a variable beam pattern. During automatic scanning the beam varies continuously between the cosecant-squared (fan-shaped) pattern and the pencil-shaped pattern.

b. For a fixed beam pattern, the reflectors are positioned to a given elevation by depressing and holding ANTENNA UP switch-indicator A3 (fig. 38, A6, TM 9-1430-254-20/6) on the LOPAR control-indicator. The reflectors can be stopped at any elevation angle by releasing switch-indicator A3 or when the antenna is in the automatic scanning process, by depressing ELEVATION FIXED — DOWN SCAN switch-indicator A4 (fig. 38, B6, TM 9-1430-254-20/6) so that the ELEVATION FIXED indicator of the switch-indicator is illuminated. A continuously varying beam pattern is selected by depressing switch-indicator A4 so that the DOWN SCAN indicator of the switch-indicator is illuminated, resulting in the reflective surface automatically scanning between preset angular limits. These limits are determined by the primary upper and lower limit switches S3 and S2 (10 and 11, fig. 15) located in the electro-mechanical control box (8, fig. 15). The injection and retraction points of the secondary reflective bars are determined by the secondary reflector injection-control rod (6, fig. 14) and secondary inject-retract switch S1 (13, fig. 15). Switches S1, S2, and S3 are factory-adjusted for the angular limits of scan condition 2, *d* below. These switches are readjusted in the field to conform to tactical requirements peculiar to specific sites, such as those caused by terrain characteristics and expected target altitude.

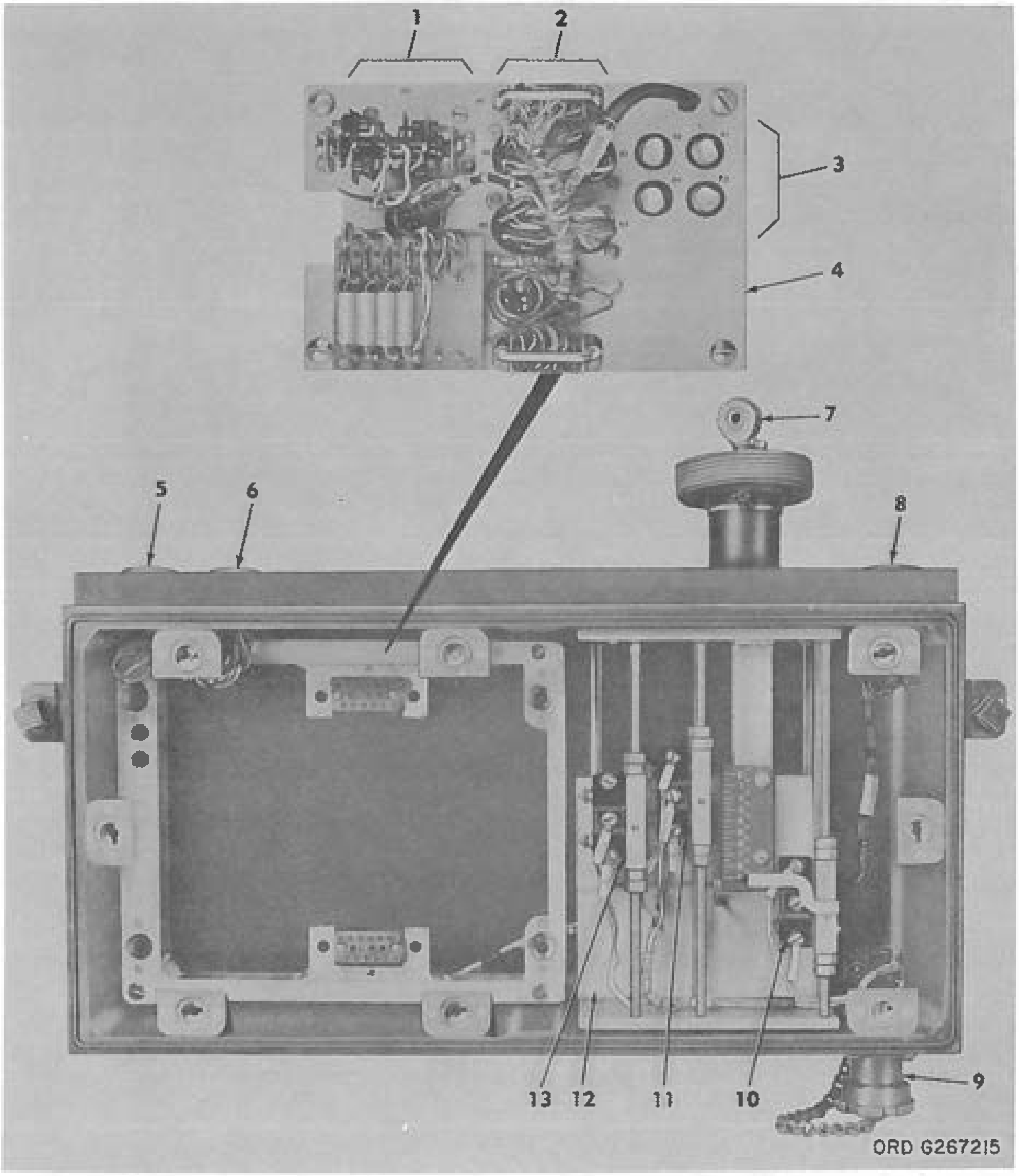
Note. The grid zone references shown in parentheses in *c* below refer to figure 38, TM 9-1430-254-20/6, unless otherwise indicated.

c. The reflective surface angle (figs. 16 and 17) is varied between 0 and 9 degrees. These angular limits of scan correspond to a change of 2 to 22 degrees from the horizontal in the elevation angle of the radiated beam. The ANTENNA ELEVATION dial (C5), however, is calibrated in angular mils (0 to 400) and indicates the limits of scan from 35 to 356 mils. The difference between the indicated reflective angle and the actual beam angle is due to a shift in beam axis as the beam pattern is changed. When the reflective angle is zero degrees, the axis of the pencil-shaped beam is 2 degrees (approximately 35 mils) above the horizontal. Each degree of reflective change causes the beam to be elevated 2 degrees. Injection of the secondary reflector causes an additional 2-degree upward shift in the beam axis during which time the beam shape changes to a cosecant-squared pattern. The injection of the secondary reflector



1—Primary reflector
2—Secondary actuator
3—Brake (primary)
4—Primary actuator
5—Brake (secondary)
6—Secondary reflector injection-control rod
7—Auxiliary antenna subassembly
8—Electro-mechanical control box

Figure 14 (U). Acquisition antenna—rear view (U).



1—DC power supply
2—DC relays and panel connectors
3—Fuses and blown fuse indicators
4—Electro-mechanical control panel
5—Connector J3
6—Connector J4
7—Control switch plate coupling to secondary reflector injection-control rod (primary reflector mechanical feedback)
8—Connector J5
9—Connector J6
10—Primary upper limit switch S3
11—Primary lower limit switch S2
12—Control switch plate
13—Secondary inject-retract switch S1

Figure 15 (U). Electro-mechanical control box—cover removed (U).

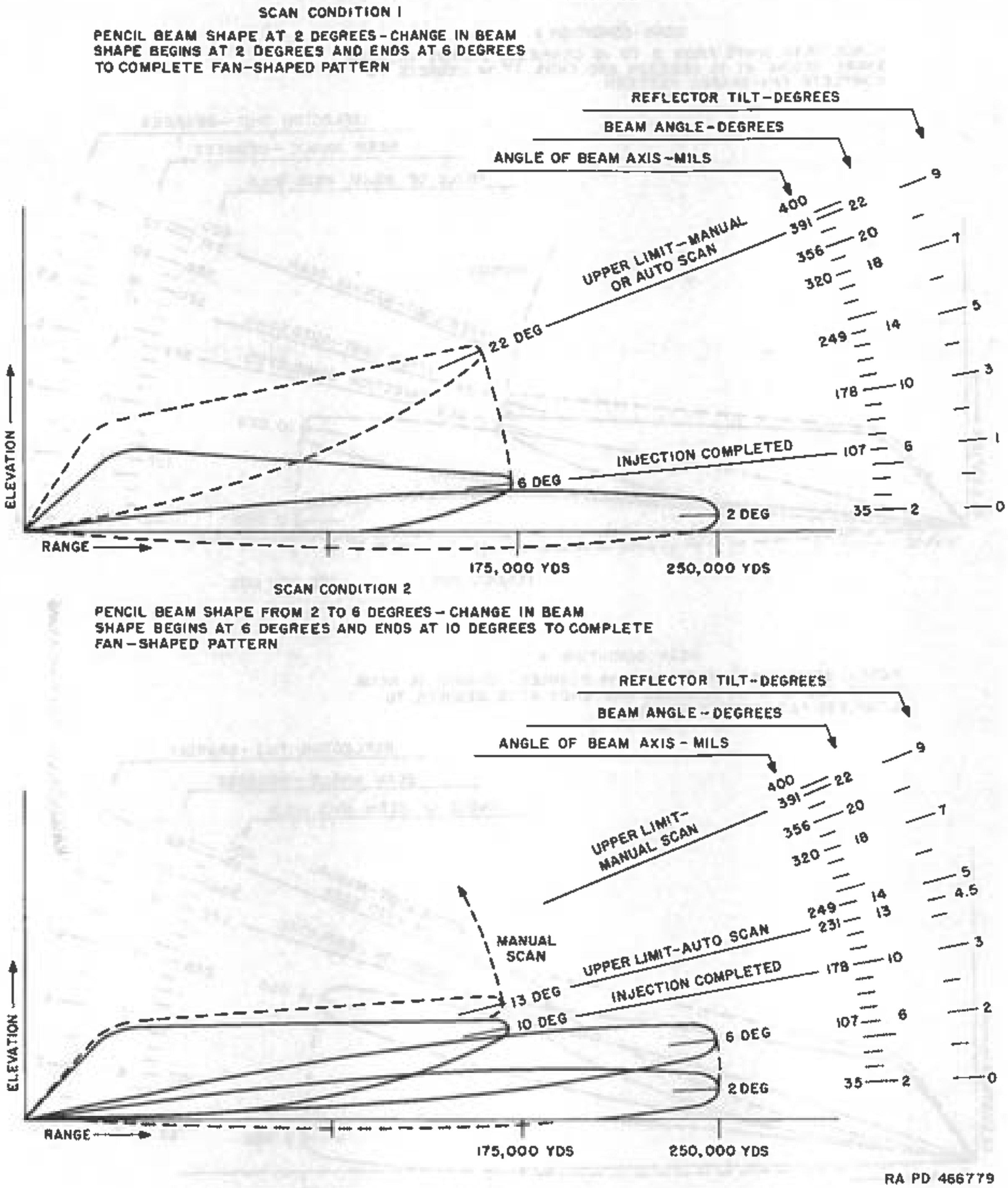


Figure 16 (CMHA). Acquisition antenna beam pattern—scan conditions 1 and 2 (U).

occurs while the primary reflector is in motion. The injection process is completed when the primary reflector is moved approximately 1 degree which corresponds to a change of 17.8 mils on the ANTENNA ELEVATION dial. Because the change from a pencil-shaped beam to a fan-shaped beam causes a 2-degree (35-mil) upward shift in the RF beam axis, antenna elevation transmitter (synchro) B1 (D34) sends apparent beam elevation data that is 35 mils displaced from the actual beam angle. Thus, at maximum elevation of the

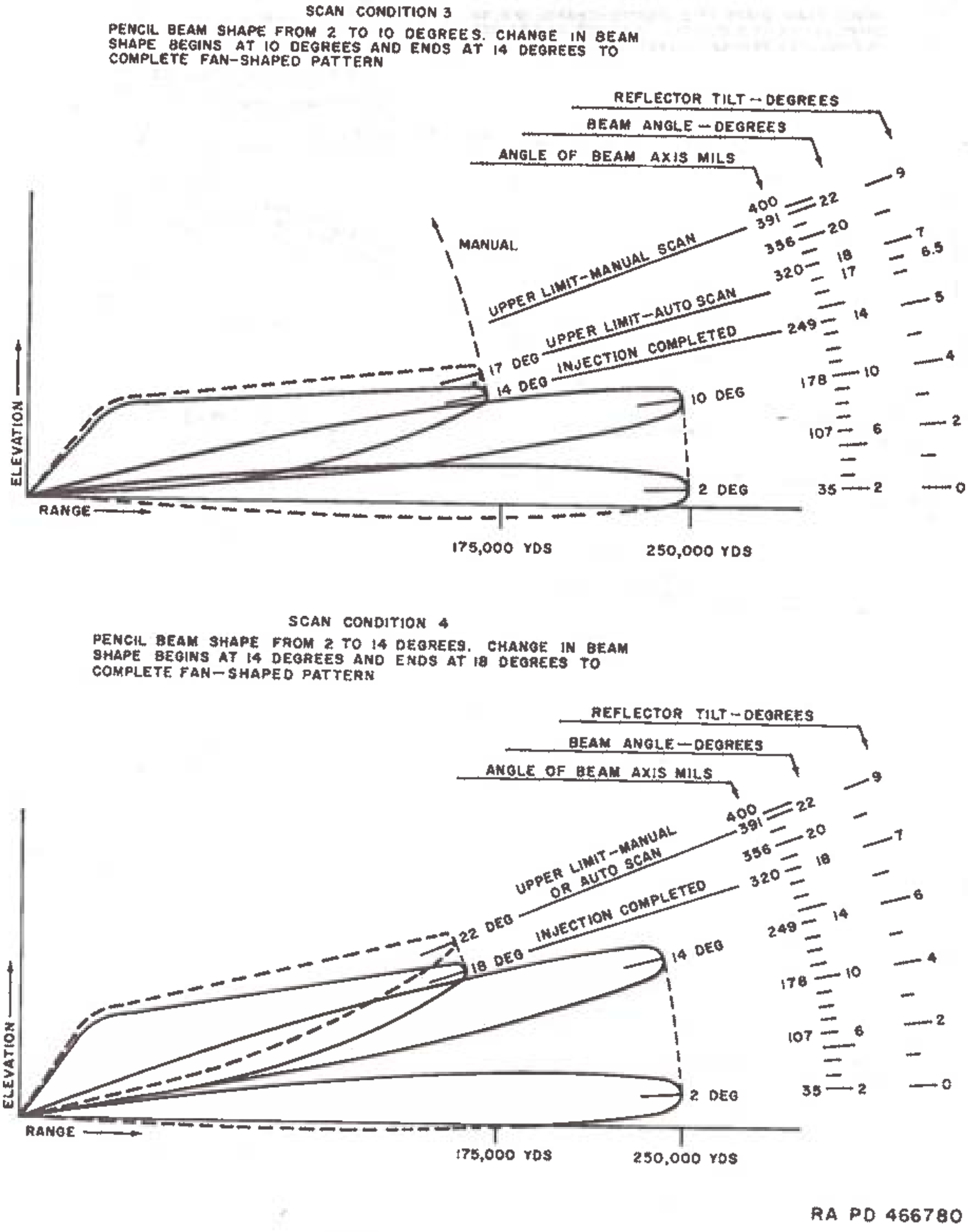


Figure 17 (CMHA). Acquisition antenna beam pattern—scan positions 3 and 4 (U).

primary reflector, the 356-mil indicated angle corresponds to a maximum beam angle of 391 mils.

d. Four automatic elevation scanning conditions (table II) have been designated for setting the angular limits of primary reflector coverage, and secondary injection and retraction points of operation. Any of the four scan conditions (figs. 16 and 17) can be selected by changing the mechanical position of three microswitches in the electro-mechanical control box (par. 29*a*).

e. The pencil-shaped beam has a 5.5-degree vertical beam width at the half-power points and a constant 1.4-degree beam width in azimuth. The width of the RF beam in either the horizontal or vertical plane is different for any cross-section of the beam length. The effective beam width is chosen as that point along the beam (half-power point) having 3 db less power than the point having maximum power. This beam extends to an effective range of 250,000 yards. At a reflector elevation of zero degrees, the effective pencil-beam ground range is reduced because of earth curvature. When the pencil beam is changed into a cosecant-squared beam (fan-shaped), the effective range is shortened to provide a broader high-angle coverage. This fan-shaped beam has a constant 1.4-degree width in azimuth and an effective range of 175,000 yards. With a beam elevation of 22 degrees, detection of targets is possible up to an altitude of 195,000 feet.

29 (CMHA). Control of Elevation Scanning

a. The electro-mechanical control box (figs. 15 and 18) controls scanning of the acquisition antenna (fig. 18) by providing electrical motive power for the primary and secondary actuators. Automatic scan limits of the primary reflector and injection of the secondary reflector are controlled by the mechanical adjustment of secondary inject-retract switch S1 (13, fig. 15), primary lower limit switch S2 (11, fig. 15), primary upper limit switch S3 (10, fig. 15). The mechanical operating limits of the primary and secondary actuators are protected by pressure-operated microswitches within the actuator housings (fig. 18). The primary actrator housing contains two microswitches, and the secondary actuator housing contains four microswitches. The function of the nine microswitches is given in *b* and *c* below.

b. The limits of automatic scan for the primary reflector are determined by the mechanical position of switches S3 and S2 (10 and 11, fig. 15) in the electro-mechanical control box. Switch S3 is a pressure-operated, momentary-contact microswitch that operates in conjunction with certain relays (2, fig. 15) on the electro-mechanical control panel. The function of S3 is to reverse the direction of rotation of motor B3 (fig. 18), which is mechanically coupled to the primary actuator whenever the primary reflector reaches a preselected upper limit of travel. Switch S2 (11, fig. 15) is also

Table II (U). Automatic Elevation Scanning Conditions (U)

Scan condition	Pencil beam			Cosecant bar injection begins		Cosecant bar injection completed		Upper auto scan limit			Complete scan period in seconds
	Reflector angle	Beam angle	Ind dial mils	Reflector angle	Beam angle	Reflector angle	Beam angle	Reflector angle	Beam angle	Ind dial mils	
1 (fig. 16)	0°	2°	35	0°	2°	1°	6°	9°	22°	356	40
2 (fig. 16)	0° to 2°	2° to 6°	35 to 107	2°	6°	3°	10°	4.5°	13°	196	20
3 (fig. 17)	0° to 4°	2° to 10°	35 to 178	4°	10°	5°	14°	6.5°	17°	267	28
4 (fig. 17)	0° to 6°	2° to 14°	35 to 249	6°	14°	7°	18°	9°	22°	356	40

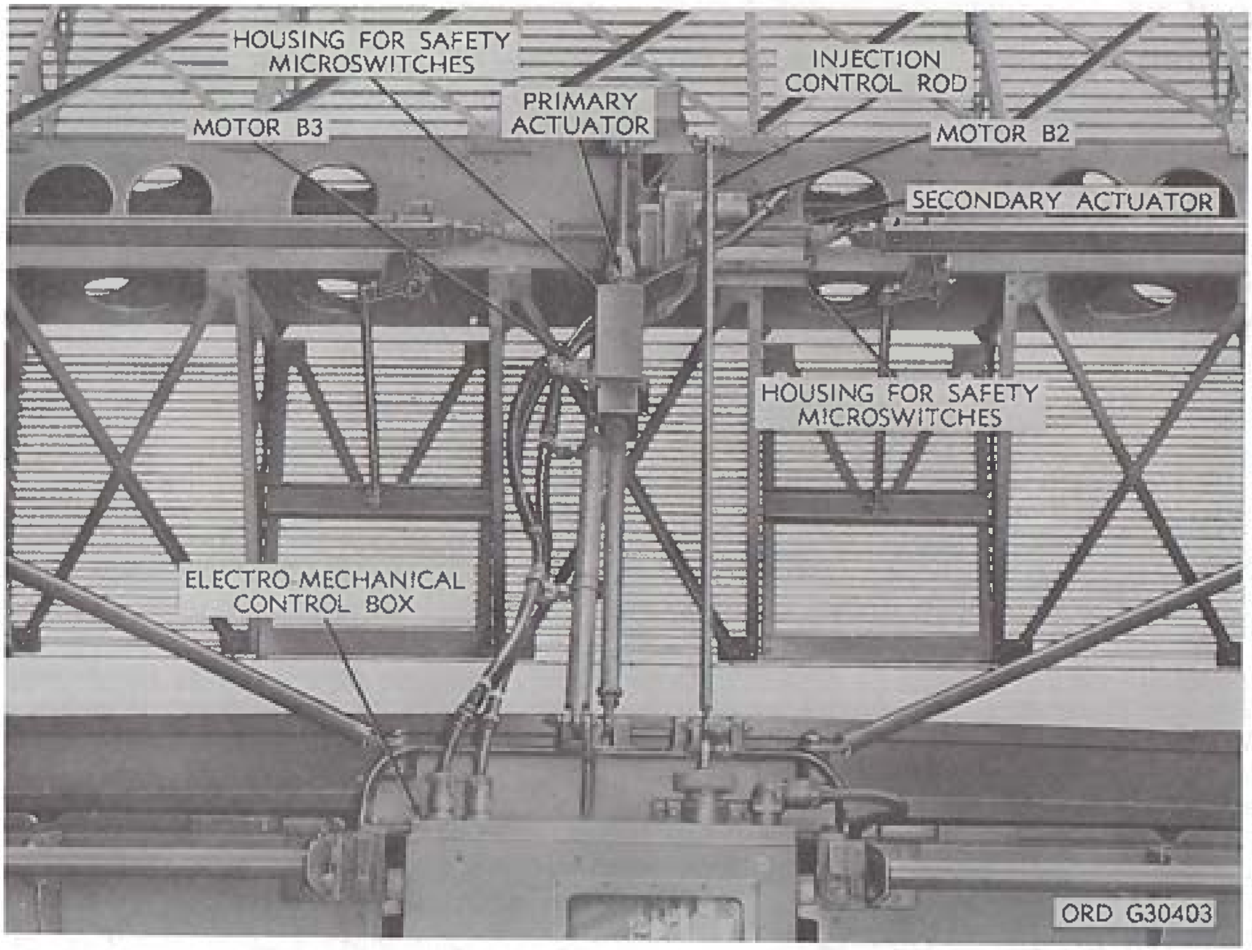


Figure 18 (U). Acquisition antenna—electro-mechanical control system—rear view (U).

a pressure-operated microswitch that operates in conjunction with certain relays in the electro-mechanical control panel. This switch reverses the direction of the primary actuator motion when the primary reflector reaches a preselected lower limit of travel. Thus, the adjustment of S2 and S3 presets the angular limits of reflector motion determining the angular travel (scan) of the radiated beam. Two microswitches in a housing on the primary actuator (fig. 18) are safety limit switches for motor B3. One switch is designated the primary up safety switch and the other is designated the primary down safety switch. These switches, *e* below, stop the operation of motor B3 at either end of the actuator stroke should S2 and S3 in the electro-mechanical control box fail or be improperly adjusted.

c. The injection and retraction points of the secondary reflector (fig. 13) are determined by the mechanical position of secondary inject-retract switch S1 (13, fig. 15). Switch S1 and certain relays in the electro-mechanical control panel operate the secondary actuator and motor B2 (fig. 18). Switch S1 is mechanically operated by a small cam on a control switch plate (12, fig. 15) mechanically coupled to the primary actuator. The cam is connected by the injection-control rod (fig. 18) to the secondary reflector. The control switch plate moves up or down as the primary reflector angle is changed. As the angle of the primary reflector is increased, S1 is operated, relays are energized, the secondary actuator is driven by motor B2, and the secondary reflector bars are injected into the primary reflector. When the secondary reflector is fully injected, of motor B2. This voltage produces electrical braking for the motor armature. When the primary reflector is operated to decrease the elevation of the radiated-beam, S1 is operated again, and the rotation of motor B2 is reversed, causing a reversal in the direction of secondary actuator travel. This reversal causes a retraction of the secondary reflector. The operation of the secondary actuator includes the functions of four normally-closed, pressure-operated microswitches in the secondary actuator housing (fig. 18). Secondary inject limit switch S1 and secondary retract limit switch S4 are factory-set to operate as electrical safety stops to limit the actuator strokes. This limiting is accomplished by removing voltages to motor B2. Secondary inject safety switch S2 and secondary retract safety switch S3 operate when the secondary reflector is fully injected or retracted. Switches S2 and S3 prevent over-driving motor B2 and the resultant damage to the antenna reflectors. The functional operation of the switches discussed in *e* below is identified for both electro-mechanical control panels, ordnance part numbers 9155212 and 9988941.

Note. The grid zone references shown in parentheses in *d* and *e* below refer to figure 38, TM 9-1430-254-20/6, unless otherwise indicated.

d. The mechanical power for moving both antenna reflectors is provided by the primary and secondary actuators (fig. 18). Mechanically, each actuator is a jackscrew driven by a 3-phase, 120-volt, 400-cps electric motor. Each jackscrew is a worm gear having a high step-down ratio designed to handle heavy mechanical loads. The primary actuator is operated by motor B3, and the secondary actuator is driven by motor B2. The application of field-coil energizing voltage for these motors is controlled by dc operated relays (2, fig. 15) on the electro-mechanical control panel and secondary inject-retract switch S1, primary lower limit switch S2, and primary upper limit switch S3 in the electro-mechanical control box. The electro-mechanical control panel (4, fig. 15) contains six dc relays, a 150-volt dc power supply, and four blown-fuse indicators. Control for primary and secondary actuator operation is provided by momentary contact ANTENNA UP switch-indicator A3 (A6) and alternate action ELEVATION FIXED—DOWN SCAN switch-indicator A4 (B6) on the LOPAR control-indicator. When switch indicator A4 is depressed and the ELEVATION FIXED indicator is illuminated, this condition disables the antenna-scan circuit; whereas, by depressing and holding switch-indicator A3 or by depressing switch-indicator A4 to illuminate the DOWN SCAN indicator, provides a ground to complete −28-volt relay circuits, *e* below, in the electro-mechanical control panel. When switch-indicator A3 is depressed and held, a manual scanning condition is selected causing the reflector to be driven upward, increasing elevation angle. When the upper mechanical limit of the reflector is reached, the reflector motion is automatically stopped by primary up safety switch S2 (B34). To tilt the reflector and decrease the elevation angle, switch-indicator A4 is depressed to illuminate the DOWN SCAN indicator selecting automatic scanning and the primary reflector is driven downward. The decreasing reflector angle can be stopped at any position by depressing switch-indicator A4 to illuminate the ELEVATION FIXED indicator of the switch-indicator. In systems using AAR, control of the antenna elevation is transferred to the ECCM console through contacts 9-2 and 10-4 (fig. 55, C3) of energized transmitter control relay K7 in the auxiliary acquisition relay assembly.

e. The functional operation of the electro-mechanical control system for antenna elevation scanning is provided mainly by the electro-mechanical control box (fig. 18). Operation of this control box and associated circuits is discussed in (1) through (10) below.

(1) Electrical power for the acquisition antenna electro-mechanical control system is applied to the electro-mechanical control box from two voltage sources (3-phase, 120 volts, 400-cps and −28 volts), at connector P1 (B23). The 120 volts ac is used to energize primary actuator motor B3 (A34), secondary actuator motor B2, and a 150-volt dc power supply. The −28 volts is used as energizing power for relays K3 through K6 given in (2) below. Upon application of ac voltage to the electro-mechanical control box, phase B energizes the dc power supply on the electro-mechanical control panel. This power supply,

consisting of power transformer T1 (B30), bridge rectifier CR1, and associated circuits, supplies 150-volts dc as dynamic braking voltage for the two actuator motors. The energizing path to those relay circuits associated with the mechanical position of the antenna reflectors is completed by ANTENNA UP or ELEVATION FIXED — DOWN SCAN switch-indicator A3 or A4 on the LOPAR control-indicator.

(2) Of the six relays in the electro-mechanical control panel (D26), three control the operation of primary actuator motor B3 (A34) and three control the operation of secondary actuator motor B2 (C34). In the primary reflector group, primary down relay K4 (B26) and primary up relay K5 (B28) control the application of 3-phase voltage to primary actuator motor B3. The relay coil of K4 is energized while the primary reflector is scanning downward; the relay coil of K5 is energized while the reflector is scanning upward. Primary braking relay K2 (C31) receives energizing power from the charge stored on capacitor C5B and controls the application of a dc braking voltage to motor B3. The remaining three relays are in the secondary reflector group. Secondary inject relay K6 (C28) and secondary retract relay K3 (C27) control the application of 3-phase voltage to secondary actuator motor B2. The relay coil of K6 is energized while the secondary reflector is being injected. Complete injection of this reflector forms a broad fan-shaped RF beam. The relay coil of K3 is energized while the secondary reflector is being withdrawn. Complete retraction of this reflector forms a narrow, pencil-shaped RF beam. Secondary braking relay K1 (C29) energized by the charge on capacitor C5A applies dc braking voltage to motor B2. The operational sequence of these relays is given in (3) through (10) below.

(3) When the primary reflector of the acquisition antenna is at an angle within 0 to 9 degrees, and with the ELEVATION FIXED indicator of ELEVATION FIXED — DOWN SCAN switch-indicator A4 illuminated and ANTENNA UP switch-indicator A3 depressed and held, the manual scanning circuit is activated and the reflector begins to drive upward (increasing elevation angle). The scanning action begins when switch-indicator A3 connects a ground to complete the ground path through connector P1-A (D23), connector P2-5 (B25), and contacts 16 and 7 of deenergized primary down relay K4 (B26) to terminal 22 of primary up relay K5 (B28). The —28-volt power is applied to K5-21 through primary up safety switch S2 (B34), contacts 15 and 5 of deenergized relay K4 (B26), connector P2-6 (B25), and connector P1-I (B23). With primary up relay K5 (B28) energized, 3-phase voltage is applied to primary actuator motor B3 (A34). Phase A is applied to primary actuator motor B3 through connector P1-J (A23), connector P2-2, fuse F4, contacts 12 and 18 of energized relay K5, and connectors P1-8, P3-A, and P1-A (A33). Phase B is applied to motor B3 through connector P1-H (A23) and connector P2-1, fuse F1, contacts 13 and 2 (A28) of energized relay K5, contacts 1 and 3 (A29) of deenergized primary braking relay K2, and connectors P1-7, P3-B, and P1-C. Phase C is applied to motor B3 through connectors P1-C (B23) and P2-3 (B25), fuse F2, contacts 4 and 14 (B28) of energized relay K5, contacts 6 and 4 (A29) of deenergized relay K2, and connectors P1-5, P3-D, and P1-D. When 3-phase power is applied to motor B3 by contacts of K5, the motor rotates and

the primary actuator begins to extend, causing mechanical links between the actuator and the reflector to retract. As the links retract, the reflector moves to increase its elevation angle. When the primary reflector moves, an injection control rod mechanically connected to the primary reflector, also moves. The opposite end of this rod is connected to a control switch plate in the electromechanical control box. This plate moves vertically (downward) when the rod moves downward. A horizontal ridge across the control switch plate functions as a fixed cam. As the plate passes momentary-contact, pressure-operated microswitches S1, S2, or S3, the cam operates each switch. The operational sequence of circuit microswitches is functionally described in (4) through (10) below.

(4) The injection point of the secondary reflector bars depends on the preset mechanical position of secondary inject-retract switch S1 (C24) and the angle of the primary reflector. When the cam on the control switch plate momentarily operates S1, secondary inject relay K6 (C28) is energized and 3-phase power is applied to secondary actuator motor B2 (B34). The energizing circuit to the coil of relay K6 is from ground through S1B and S1C of switch-indicator A4 (B6), S1A and S1B of depressed switch-indicator A3, connector P1-A (D23), connector P2-5, and contacts 16 and 7 of deenergized primary down relay K4 (B26) to the coil of K6. The −28-volt power is applied to K6 through contacts 13 and 1 (C28) of deenergized secondary retract relay K3, connector P1-15 (D32), secondary inject safety switch S2, secondary inject limit switch S1, connector P1-12, connector P2-9 (C25), and momentarily closed contacts of secondary inject-retract switch S1. When contacts of secondary inject-retract switch S1 open, after the ridge on the control switch plate has passed, relay K6 remains energized due to its holding contacts 14 and 4 (C26). With K6 energized, 3-phase ac voltage is supplied to motor B2. Phase A is applied through connector P1-J (A23), connector P2-2, fuse F4, contacts 6 and 15 (B27) of energized relay K6, and connectors P1-9 (B32), P4-A, and P6-A to motor B2. Phase B is applied through connector P1-H (A23), connector P2-1, fuse F1 (A27), contacts 17 and 10 of energized relay K6, contacts 2 and 3 (C29) of deenergized secondary braking relay K1, and connectors P1-10, P4-B, and P6-C to motor B2. Phase C is applied through connector P1-C (B23), connector P2-3 (B25), fuse F2, contacts 12 and 18 (C28) of energized relay K6, contacts 6 and 4 of deenergized relay K1 (C29), and connectors P1-11, P4-D, and P6-D to motor B2. When secondary inject relay K6 is energized, its contacts 16 and 8 (C30) close to apply a 150-volt dc charging potential from bridge rectifier CR1 (B31) to charge capacitor C5A (C30). With ac power applied, motor B2 rotates and causes the secondary actuator to begin injecting the secondary reflector bars. Normally closed secondary inject limit switch S1 (D33) is actuated when the proper amount of injection has occurred. When switch S1 is actuated (opened), the −28-volt circuit for the coil of relay K6 (C28) is opened, and relay K6 deenergizes. Action of K6 causes phase A, phase B, and phase C to be removed from secondary actuator motor B2 when contacts 15 and 6 (B26), 17 and 10 (C28), and 18 and 12 of K6 open. When K6 deenergizes while K3 is deenergized, the 150-volt dc braking voltage from bridge rectifier circuit CR1 (B31) is applied to secondary actuator motor B2. The load presented to CR1 by motor B2 causes the braking voltage to reduce to 100 volts. Application of the dc braking voltage

also depends on the action of relay K1. When K6 deenergizes, contacts 16 and 8 (C30) open, and contacts 16 and 7 close to disconnect the +150-volt dc charging potential from capacitor C5A and complete the discharge path for C5A. Capacitor C5A discharges through resistor R7, contacts 17 and 9 of deenergized K3, contacts 16 and 7 of deenergized K6, resistor R5, and the coil of secondary braking relay K1. The discharging of C5A through K1 causes K1 to become energized and to remain energized for approximately 400 milliseconds. While K1 is energized, its contacts 1 and 3 close to apply dc braking voltage through connector P6-C (C33) to one field winding of B2, and contacts 4 and 5 close to apply the same voltage through connector P6-D to another field winding of motor B2. Application of this dc braking voltage acts as a dynamic brake and stops the motor almost instantly, thus assuring that the secondary reflector will not coast. The primary reflector, with the secondary reflector completely injected, continues driving upward until a primary safety switch in the primary actuator is actuated.

(5) When ANTENNA UP switch-indicator A3 (A6) is depressed and held until the primary reflector drives to its upper limit, primary up safety switch S2 (B34) in the primary actuator is mechanically actuated. This safety switch, a pressure-operated microswitch, opens the —28-volt circuit to the coil of primary up relay K5 (B28) causing K5 to deenergize. Prior to the operation of primary safety switch S2, primary upper limit switch S3 (D24) operates. However, S3 has no effect on the upper limit of reflector travel even though it is operated by the cam on the control switch plate in the electro-mechanical control box. This switch determines the upper limit of reflector travel only when switch-indicator A4 is in the DOWN SCAN condition (automatic scan). During manual scan, as contacts 12 and 18 (A26), 13 and 2 (A28), and 14 and 4 of K5 open, phase A, phase B, and phase C are removed from primary actuator motor B3 (A34). In addition, when contacts 15 and 6 (C31) of K5 open to remove the 150-volt dc charging potential through crystal diode CR2 and resistor R8 for capacitor C5B, contacts 15 and 5 close to complete the discharge path for C5B. Capacitor C5B discharges through R8, contacts 15 and 5 of deenergized K5, contacts 13 and 1 of deenergized primary down relay K4, resistor R6, and the coil of primary braking relay K2. The discharging of C5B, through the coil of K2, causes K2 to become energized and to remain energized for approximately 400 milliseconds. During the charging cycle, CR2 enables C5B to charge to a voltage level which insures the energization of K2 during the discharge cycle. When K2 is energized, contacts 2 and 3 (A29), and 4 and 5 are closed. These contacts complete the 100-volt dc braking voltage circuit to two of the field windings of B3. When this voltage is applied across two windings, B3 stops almost instantly, thus assuring that the primary reflector is positioned at the same angle it is positioned when switch-indicator A3 is released. The difference between the 100-volt dc braking voltage and the 150-volt dc charging potential for C5B is due to the loading characteristics of the field windings of B3.

(6) The primary reflector remains at its upper limit until ELEVATION FIXED — DOWN SCAN switch-indicator A4 on the LOPAR control-indicator is depressed illuminating the DOWN SCAN indicator. Depressing switch-indicator A4 to illuminate the DOWN SCAN indicator places the electro-mechanical control system into automatic scan with the following results. A ground provided by switch-

indicator A4 completes the energizing path for primary down relay K4 (B26). This circuit is applied from ground through S1B and S1C of switch-indicator A4, connector P1-B (D23), normally closed contacts of primary lower limit switch S2 (C24), connector P2-10, and contacts 17 and 9 of deenergized primary up relay K5 to the coil of K4. From K4 the circuit is completed through primary down safety switch S1 (B34) to —28 volts at connector P2-6 (B25). When K4 is energized, 3-phase power is applied to primary actuator motor B3 (A34). Phase A is applied from connector P1-J (A23) through connector P2-2, fuse F4, contacts 12 and 18 (A26) of energized K4, and connector P1-A (A33) to B3. Phase B is applied from connector P1-H (A23) through connector P2-1, fuse F1 (A27), contacts 17 and 10 (A28) of energized K4, contacts 6 and 4 (B29) of deenergized primary braking relay K2, and connector P1-D (B33) to B3. Phase C is applied from connector P1-C (B23) through connector P2-3 (B25), fuse F2, contacts 4 and 14 (B26) of energized K4, contacts 1 and 3 (A29) of deenergized K2, and connector P1-C (A33) to B3. With the 3-phase voltage applied to B3 by contacts of K4 the primary reflector begins driving downward (decreasing elevation).

(7) At a preset elevation angle, secondary inject-retract switch S1 (C24) is actuated by the upward moving control switch plate. With S1 momentarily actuated, the energizing circuit is completed to the coil of secondary retract relay K3 (C27). This circuit is completed through normally closed contacts of secondary retract limit switch S4 (C34) and secondary retract safety switch S3, contacts 1 and 13 of deenergized secondary inject relay K6 (C28), the coil of K3, contacts 17 and 9 (B25) of deenergized primary up relay K5, normally closed contacts of primary lower limit switch S2 (C24), and contacts of S1B and S1C in switch-indicator A4 (B6). When the control switch plate passes S1 (C24), relay K3 (C27) is kept energized by its holding contacts 18 and 12 (C25). With K3 energized, 3-phase power is applied to secondary actuator motor B2 (C34). Phase A is applied from connector P1-J (A23) through connector P2-2, fuse F4, contacts 8 and 16 (B27) of energized K3, and connector P6-A (B33) to B2. Phase B is applied from connector P1-H (A23) through connector P2-1, fuse F1, contacts 15 and 6 (B28) of energized K3, contacts 6 and 4 (C29) of deenergized secondary braking relay K1, and connector P6-D (C33) to B2. Phase C is applied from connector P1-C (B23) through connector P2-3 (B25), fuse F2, contacts 4 and 14 (C28) of energized K3, contacts 2 and 3 (C29) of deenergized K1, and connector P6-C (C33) to B2. The secondary reflector retracts until secondary retract limit switch S4 (C34) is actuated.

(8) Secondary retract limit switch S4 is actuated when the secondary reflector is completely retracted. When actuated, S4 opens and causes —28-volts to be removed from the coil of secondary retract relay K3 (C27). With K3 deenergized, 3-phase power is removed from secondary actuator motor B2 (C34). In addition, contacts 9 and 17 (C30) of deenergized relay K3, and contacts 16 and 7 of deenergized secondary inject relay K6 complete a discharge path for capacitor C5A to energize secondary braking relay K1. Energized K1 applies a dc braking voltage to B2. This voltage circuit, completed by contacts of K1, is discussed in (4) above.

(9) When the primary reflector reaches a lower preset elevation angle, the ridge on the control switch plate actuates primary lower limit switch S2 (C24) in the electro-mechanical control box. When normally closed S2

opens, the ground from switch-indicator A4 (B6) is removed from primary down relay K4 (B26). When K4 is deenergized, power is removed from primary actuator motor B3 (A34) by the energizing of primary braking relay K2 (C31) for a brief moment. When the normally open contacts of S2 (C24) close, primary up relay K5 (B28) is energized. With K5 energized, phase B and phase C voltages applied to B3 are interchanged. Phase B is applied through fuse F1 (A27), contacts 13 and 2 (A28) of energized K5, and contacts 1 and 3 (A29) of deenergized K2 to connector P1-C (A33). Phase C is applied through fuse F2 (B25), contacts 4 and 14 (B28) of energized K5, and contacts 6 and 4 (B29) of deenergized K2 to connector P1-D (B33). This phase reversal causes B3 to reverse its direction of rotation, and the primary reflector begins to travel upward (increasing elevation angle). As a result, the control switch plate moves downward and returns S2 (C24) to a normally closed position. Relay K5 remains energized at this time through primary upper limit switch S3 (D24) and holding contacts 16 and 8 (C25) of energized K5. The primary reflector continues to travel upward, and the secondary bars are injected at a preset elevation angle of the primary reflector. Injection of the secondary reflector is given in (4) above. The primary reflector travels upward until the ridge on the control switch plate actuates primary upper limit switch S3 (D24) in the electro-mechanical control box. When S3 is actuated, the —28-volt circuit for K5 (B28) is opened, causing K5 to become deenergized. Contacts 17 and 9 (B25) of deenergized K5 complete the energizing circuit for K4 (B26), causing K4 to become energized. For a brief period before K4 is energized, contacts 15 and 5 (C31) of deenergized K5 allow K2 (C31) to become energized and apply a dc braking voltage to B3. When K4 is energized, the 3-phase voltage for B3 is transposed, and B3 reverses direction, causing the primary reflector to travel downward. This automatic scanning process continues until switch-indicator A4 is again depressed, illuminating the ELEVATION FIXED indicator.

(10) If primary lower limit switch S2 (C24) fails to operate, the primary reflector continues to be driven downward until primary down safety switch S1 (B34) in the primary actuator is mechanically actuated. This switch insures that primary down relay K4 is deenergized when the primary reflector reaches 0 degrees and the primary reflector travel is stopped. If S2 is actuated and becomes jammed in the operated position, the electro-mechanical control system functions the same as when ANTENNA UP switch-indicator A3 (A6) is depressed and held. Thus, a ground is applied from connector P1-B (D23) through S2 to connector P2-5 (B25). This condition causes the primary reflector to elevate until primary up safety switch S2 (B34) in the primary actuator is operated. Consequently, primary up relay K5 (B28) becomes deenergized, K4 (B26) remains deenergized, and primary actuator motor B3 (A34) stops. As a result, the primary reflector remains at maximum elevation.

30 (U). Antenna Drive Circuits

a. The antenna drive circuits (fig. 5) provide the motor power to rotate the antenna at selected speeds of 5, 10, and 15 rpm. These circuits consist of the components discussed in (1) through (4) below.

(1) The motor speed control panel (fig. 5) contains three power relays to select three rates of rotation.

(2) The acquisition slip rings (fig. 5) provide electrical connections between

the stationary acquisition antenna pedestal and the rotating acquisition antenna.

(3) Acquisition azimuth drive motor B1 (fig. 5) rotates the acquisition antenna at one of three speeds. This motor contains three separate sets of field windings, one set for each speed. Mechanical coupling is provided by a series of gears between the drive motor and the acquisition antenna.

(4) Acquisition azimuth resolver B2 (fig. 5) is also mechanically coupled to acquisition azimuth drive motor B1. As the antenna rotates, the output of B2 is used in developing sweep positioning voltages for the acquisition presentation system (fig. 1) when the LOPAR system is selected.

Note. The grid zone references shown in parentheses in *b* through *d* below refer to figure 38, TM 9-1430-254-20/6.

b. The antenna drive circuits receive 3-phase, 400-cycle excitation voltage through MAIN POWER switch S4 (B8), PRESENTATION POWER switch S5, and BARBETT AC POWER switch S6 on the acquisition power control panel. With any one of the 5 RPM A10, 10 RPM A11, 15 RPM A12 switch-indicators on the LOPAR auxiliary control-indicator (D1) depressed, and with both ANTENNA DISABLE switch S1 (C13) and azimuth drive interlock switch S4 (C14) on the acquisition antenna pedestal in the closed position, associated 5 rpm relay K1, 10 rpm relay K2, or 15 rpm relay K3 in the relay assembly (C14) (motor speed control panel) energizes. Since the relay circuits and switch-indicator battery circuits permit only one relay to operate at a time, only the relay associated with the speed selected can be energized. When the selected relay is energized, 3-phase power is applied to the appropriate field windings, and motor B1 rotates the antenna at the designated speed.

c. ANTENNA DISABLE switch S1 (C13) provides local control at the antenna pedestal for disabling the speed control relays while work is being performed on the antenna. In series with this switch, is azimuth drive interlock switch S4 (C14) which also disables the speed control relays. Switch S4 operates when the relay assembly (C14) is opened. The azimuth orientation indicator (C16), mechanically coupled to acquisition azimuth drive motor B1, indicates locally the azimuth position of the beam axis radiated by the acquisition antenna. This azimuth position is also electrically transmitted to the sweep circuits by acquisition azimuth resolver B2 (B16).

d. Switch-indicators A10 (A2), A11, and A12, contain holding coils so that when a switch-indicator is depressed the circuit connections will be held until another speed is selected or LOPAR ANTENNA ROTATION OFF switch-indicator A9 is depressed. To explain the operation of the rotation control circuits assume 5 RPM switch-indicator A10 is depressed. Contacts S1D-NC of switch-indicator A10 breaks any ground path to the holding coils of switch-indicator A11 or A12, causes switch-indicator A10 to illuminate (green), energizes holding coil L1 of switch-indicator A10, and energizes 5 RPM relay K1 (B15) of the relay assembly. The holding coil holds the contacts of switch-indicator A10 in the condition selected. Contacts of energized relay K5 perform switching to deenergize any other speed control relay that may be energized and to apply 3-phase power to acquisition azimuth drive motor B1 (B16). Contacts S1B-NC (B2) opens the circuit to extinguish the white indicators of switch-indicator A10 and completes the circuit to energize antenna rotation relay K2 (B2). Contacts 1, 2, and 6 of K2 switch to change the illumination of switch-indicator A9 from amber to white. Contacts S1A-NO of switch-indicator A9 are part of a squelch circuit which squelches the PPI presentation when the antenna is not rotating. If switch-indicator A11 or A12 is now depressed, the holding coil of switch-indicator A10 is deenergized and the switches of the depressed switch-indicator perform switching similar to that of switch-indicator A10. Depressing LOPAR ANTENNA ROTATION OFF switch-indicator A9 breaks the circuit for any energized holding coil, antenna rotation relay K2 (A2), and any energized motor control relay on the relay assembly (C15) will be deenergized to stop antenna rotation.

CHAPTER 7 (CMHA) RECEIVING SYSTEM

Section I (CMHA). GENERAL

31 (CMHA). Purpose

a. The receiver circuits amplify and convert low-level S-band (3100 to 3500 megacycles) RF energy, supplied by the acquisition antenna system to video signals. These video signals are applied through the moving target indicator (MTI) system to the presentation system.

b. Through the use of two similar receiving channels, the main receiving channel (par. 33) and the auxiliary receiving channel (par. 45), three modes of operation are available in the receiver circuits; basic receiver, anti-jam display (AJD) receiver, and jam strobe (JS) only receiver. The basic receiver mode of operation is used, when no electronic countermeasures (ECM) environment exists, to amplify and convert reflected RF echoes from the main acquisition antenna to target video signals for presentation on the PPI's. For operation in ECM environments, either the AJD or JS only receiver mode is used. In the AJD mode, RF energy from both the main and auxiliary acquisition antennas is utilized to provide target and JS video to the PPI's. The RF echoes and jamming signals from the main antenna are processed through the main receiving channel and, at the same time, jamming signals from the auxiliary antenna are processed through the auxiliary receiving channel. Because the auxiliary antenna is omni-directional, and has a larger coverage pattern than any of the side lobes from the main antenna, the output from the auxiliary receiving channel is greater than that from the main channel at all azimuths except that of the main lobe of the main antenna. The output from the auxiliary channel is compared with the output from the main channel and at all azimuths except that of the main lobe, the larger output from the auxiliary channel effectively cancels the output from the main channel. In this manner, RF echoes from non-jamming targets are converted to video signals for conventional display on the PPI's, while RF echoes and jamming signals from jamming targets are converted to video signals for display as JS video, at all azimuths where the major lobe of the main antenna encounters a jamming signal. In the JS only receiver mode of operation, operation of the receiver circuits is essentially the same as that for the AJD mode; however, only JS video is applied to the PPI's.

32 (U). Block Diagram Analysis

a. General. The receiving circuits (fig. 19) are comprised of five groups of equipment located in two different areas of the NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) system. The groups are the acquisition antenna system and acquisition receiver-transmitter group, located in the LOPAR antenna-receiver-transmitter group; and the battery control console, auxiliary acquisition interconnecting group, and the director station group, located in the trailer mounted director station. The portion of the receiver circuits located in the acquisition antenna system and the acquisition receiver-transmitter group have two parallel channels, main and auxiliary, that operate in a similar manner to provide three 60-megacycle IF outputs to the receiver circuits in the auxiliary acquisition interconnecting group. These three outputs are processed through the interconnecting group and the director station group to provide video output signals corresponding to the selected receiver mode; i.e., basic receiver, anti-jam display (AJD) receiver, or jam strobe (JS) only receiver. Operation of the receiving circuits in each of the three modes of operation is discussed in *b* through *d* below.

b. Basic Receiver.

(1) In the basic receiver mode of operation only the main receiving channel is used. The RF echoes are received by the acquisition antenna and applied to the acquisition duplexer.

The acquisition duplexer functions as an electronic switch to allow received echoes to pass but prevents transmitted RF pulses from entering the receiver circuits. Received echoes from the duplexer are applied through the main noise generator (used to test receiver performance) to the main magnetic circuit located in the acquisition receiver-transmitter group. The magnetic circuit encases a microwave RF amplifier consisting of a traveling-wave tube. Control of the dc grid voltages used by the traveling-wave tube, and monitoring of grid current and grid voltage is provided by the acquisition RF power supply control. The amplified RF output of the main magnetic circuit is applied to the receiver-tuner. The receiver-tuner contains two nonamplifying tuned RF stages (preselectors), one for the main channel and one for the auxiliary channel. The receiver-tuner also contains a local oscillator and a tuning drive motor that are mechanically coupled to the main and auxiliary preselectors by a gear train, thereby providing auxiliary and main channel frequencies that are tuned in unison. The AFC circuits function as a servo loop to automatically adjust the receiver-tuner in step with changes in the acquisition transmitter frequency. The outputs of the receiver-tuner are described in *(a)* through *(c)* below.

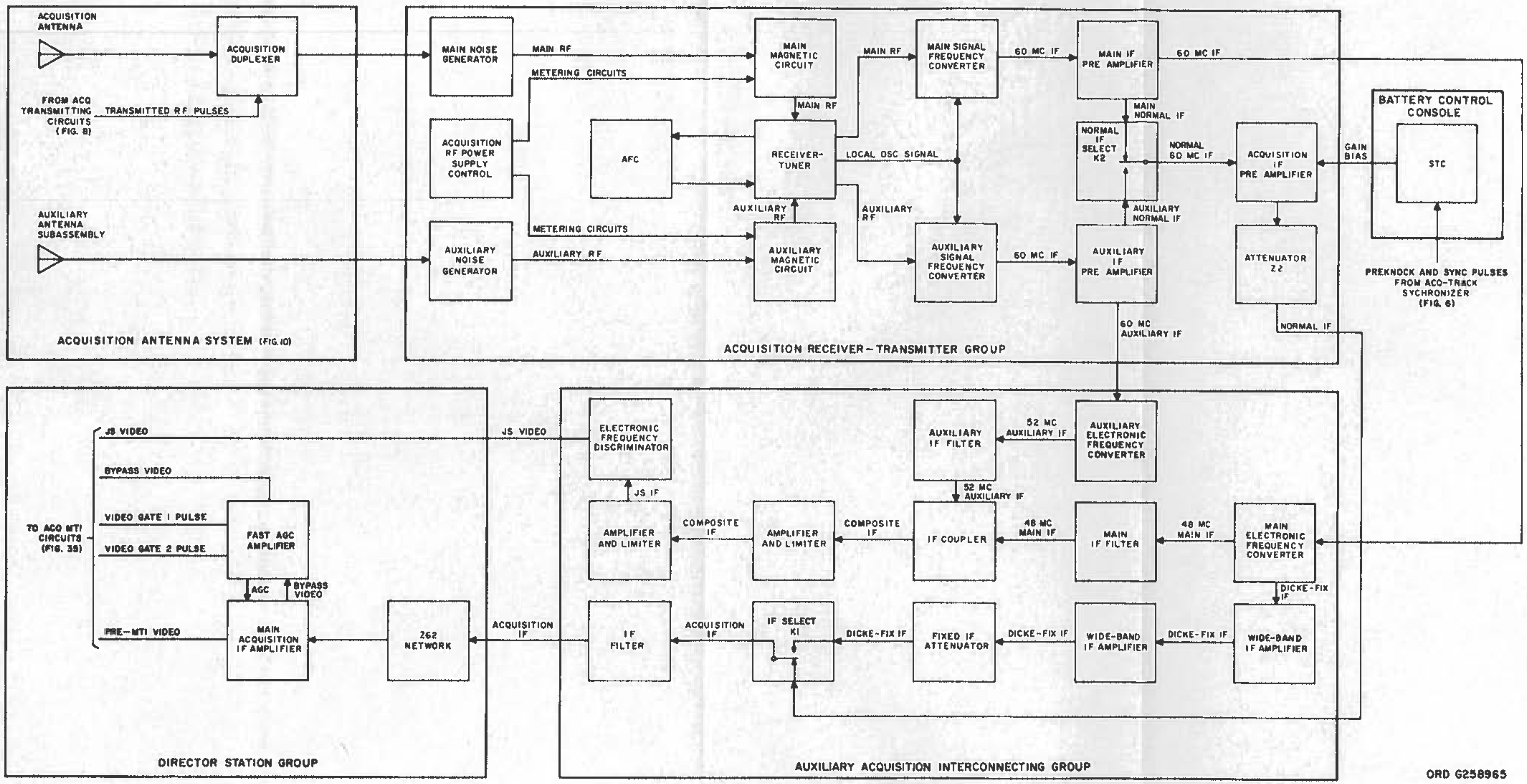
(a) The amplified RF echoes received from the magnetic circuit are attenuated by the preselector in the receiver-tuner to remove noise and unwanted frequencies and then applied to the main signal frequency converter.

(b) The local oscillator output frequency is applied to the main signal frequency converter.

(c) A sample of the local oscillator output is applied to the automatic frequency control (AFC) circuits (par. 54).

(2) The attenuated RF echoes from the preselector and the local oscillator frequency, both from the receiver-tuner, are heterodyned in the main signal frequency converter to produce a 60-megacycle IF signal which is applied to the main IF pre amplifier. The main IF pre amplifier provides two stages of 60-megacycle amplification. This amplifier produces sufficient output to overcome transmission line losses and still provide a high signal-to-noise ratio at the load. The amplifier has two outputs. One output is applied to the main electronic frequency converter in the auxiliary acquisition interconnecting group, but this is not a signal flow path when the basic receiver mode is selected. The second output from the main IF pre amplifier is the main normal IF and is applied through normal IF select relay K2 to the acquisition IF pre amplifier. In the basic receiver mode of operation, the auxiliary receiving channel operates in a manner similar to that described above for the main channel. However, the output from the auxiliary IF pre amplifier is not used except during test purposes when normal IF select relay K2 applies auxiliary normal IF instead of the main normal IF to the acquisition IF pre amplifier.

(3) The gain of the acquisition IF pre amplifier is controlled by the sensitivity time control (STC) or the manual gain control located in the battery control console. The normal IF signal from the pre amplifier is applied through attenuator Z2 which provides a match to the signal cable impedance to IF select relay K1. In the basic receiver mode of operation the normal IF signal is applied through K1 and the IF filter to impedance matching network Z62. From Z62 the IF signal is applied to the main acquisition IF amplifier. One video output from the main acquisition IF amplifier (pre-MTI video) is applied to the MTI



ORD G258965

Figure 19 (U). Receiver circuits—block diagram (U).

circuits. The remaining output (bypass video) is applied to the fast AGC amplifier where an AGC control voltage is developed to control the gain of the main acquisition IF amplifier. The AGC voltage can either be a fixed value or a gated fast AGC voltage. The fast AGC amplifier reduces the effect of CW jamming signals through fast time constant circuits described in paragraph 53. The fast AGC amplifier also applies the bypass video signal and two gate pulses to the MTI circuits.

c. AJD Receiver.

(1) The AJD receiver mode of operation utilizes both the main and auxiliary receiver channels. The main IF pre amplifier applies 60-mc IF signals to the main electronic frequency converter. The main electronic frequency converter supplies a dicke-fix IF input to the wide-band IF amplifier. The dicke-fix circuits consisting of two identical wide-band amplifiers, a fixed attenuator, IF filter, main acquisition IF amplifier, and a fast AGC amplifier, provide circuitry to reduce the effects of strong transmission jamming signals. The two wide-band amplifiers provide amplification and limiting of the dicke-fix IF. The output of the wide-band IF amplifier is applied to a fixed attenuator, through energized IF select relay K1, the IF filter, and network Z62, to the main acquisition IF amplifier. The IF select relay K1 is energized when the AJD mode of operation is selected. The use of a fixed attenuator at the output of the wide-band IF amplifier reduces the amplitude of the dicke-fix IF input to the main acquisition IF amplifier, thereby providing the same AGC level for both normal and dicke-fix IF inputs. The signal output from the wide-band amplifier is increased at the expense of the noise pulses. This action is due to the relative non-uniformity of the power density (noise being broadband) over the bandwidth of the amplifier. The main acquisition IF amplifier is a narrow-band IF amplifier. The narrow band-pass provides a correction factor for the wide-band amplifier signal input. Detection circuits within the main acquisition IF amplifier provide bypass video, applied to the fast AGC amplifier (par. 53) and pre-MTI video applied to the MTI circuits (par. 59). An AGC bias input from the fast AGC amplifier provides gain control feedback.

(2) An additional output from the main electronic frequency converter is a main IF signal that has been shifted in frequency from 60 to 48 megacycles. This 48-megacycle IF signal is applied through the main IF filter to the IF coupler where it is combined with the 52-megacycle auxiliary IF output of the auxiliary channel. The operation of the auxiliary receiving channel is identical to that of the main receiving channel up to the auxiliary IF pre amplifier, except that no duplexer is required because the auxiliary antenna is used only for receiving. The 60-megacycle auxiliary IF output from the auxiliary IF pre amplifier is applied to the auxiliary electronic frequency converter. The auxiliary converter operates similar to the main converter; however, the shift in frequency is from 60 to 52 megacycles. The 52-megacycle IF signal is applied from the auxiliary converter through the auxiliary IF filter to the IF coupler. The 48-megacycle IF signal from the main IF filter and the 52-megacycle IF signal from the auxiliary IF filter are combined in the IF coupler to form a composite IF signal. The output from the IF coupler is applied to two amplifier and limiter stages. The two identical amplifier and limiter units are used in cascade to provide the desired results of producing only one effective output, that being of the stronger signal. The process of producing an output at the

stronger signal is known as stronger-signal FM capture. The stronger signal, either the 48-megacycle IF from the main channel, or the 52-megacycle IF from the auxiliary channel, is applied to the electronic frequency discriminator. The receiver gain has been set so that the stronger signal will be that of the main acquisition antenna at its major lobe.

(3) The electronic frequency discriminator is a dual channel discriminator. The discriminator will accept either a 48-megacycle or a 52-megacycle input from the amplifier-limiter. The discriminator will only produce a video output (JS video) when the 48-megacycle input is the stronger. The JS video from the electronic frequency discriminator is applied to the MTI circuit where it is mixed with the video from the dicke-fix circuits.

d. JS Only Receiver. When the JS only receiver mode of operation is selected, receiver operation is the same as with the AJD receiver mode of operation. Both JS video from the electronic frequency discriminator and dicke-fix video from the dicke-fix circuits are applied to the MTI circuits; however, the two video signals are not mixed as in AJD receiver mode. Only the JS video is applied from the MTI circuits to the presentation system.

Section II (CMHA). MAIN ACQUISITION-RECEIVER CIRCUITS

33 (U). Purpose

a. The main receiver circuits amplify and convert the low-level RF echoes received by the acquisition antenna system into video signals. When jamming signals are present, the dicke-fix circuits can be used with the main receiver circuits to permit a better display of target information. A fast reacting automatic gain control (FAGC) is used with the dicke-fix circuits to compensate for rapid changes in signal level that are associated with certain types of jamming. The main receiver circuits will provide, in addition to the normal IF, a converted main IF for strobe generation in association with the auxiliary receiver circuits.

b. The main receiver circuits (fig. 19) consist of the acquisition antenna, acquisition duplexer, noise generator, main magnetic circuit, acquisition RF power supply control, receiver-tuner, main signal frequency converter, main IF pre amplifier, acquisition IF pre amplifier, sensitivity time control (STC), IF filter, and main acquisition IF amplifier. When the dicke-fix mode of operation is used, the main electronic frequency converter, two wide-band IF amplifiers, and the fixed IF attenuator are switched into the main receiver circuits.

34 (U). Acquisition Antenna System

a. The acquisition antenna system (fig. 5) conveys, radiates, and beams acquisition transmitter output RF pulses. During receiving intervals between transmitter pulses, the same system receives, beams, and conveys received RF to the acquisition receiver circuits.

b. During receiving intervals, the acquisition antenna receives and beams the received RF into the antenna pillbox (3, fig. 13). From the pillbox, the RF signals are conveyed through the rotary coupler (fig. 10) in the waveguide circuits to the acquisition duplexer (fig. 6), which terminates the acquisition antenna system. The duplexer acts as an electronic switch, short-circuiting receiver input during transmitting periods and blocking the transmitter during receiving periods. TR tube V4 (fig. 26, B14, TM 9-1430-254-20/6), prevents the passage of transmitted pulses to the receiver circuits. ATR tubes V2 and V3 prevent the passage of received RF signals to magnetron V1. Received RF signals passed by V4 are transferred through a noise generator (par. 43) to the magnetic circuit. When deenergized, the noise generator has no effect on the passage of signals.

35 (U). Main Magnetic Circuit

a. The magnetic circuit is an RF amplifier of microwave frequencies received from the acquisition duplexer. Amplification is provided by a traveling-wave tube enclosed by a magnetic circuit. The main channel magnetic circuit is identical in operation to the magnetic circuit used in the auxiliary channel. Because amplification is provided ahead of the receiver-tuner, sensitivity of the receiving circuits is considerably improved.

b. The functional parts of the magnetic circuit (fig. 20) are a magnetic focusing field, a traveling-wave tube, two coupling cavities with external coaxial cables, and two positioning screws. The magnetic focusing field is produced by permanent magnetic materials. This field encompasses the helix of the traveling-wave tube and focuses the electron stream into a narrow beam. The magnetic circuit used in this way insures a linear beam width over the entire beam length. The traveling-wave tube (fig. 20) is a medium-gain, low-noise electron tube consisting of an electron gun (analogous to those of cathode-ray tubes), a helix (a long, narrow, helically wound coil), and a collector. The traveling-wave tube design permits high frequency signal amplification with low noise level.

Note. The grid zone references shown in parentheses in *c* through *e* below refer to figure 26, TM 9-1430-254-20/6.

c. Input signals from the acquisition duplexer (B14) are applied through the noise generator to the input cavity in the main magnetic circuit (B21). From the input cavity, signals are inductively coupled to the helix which encircles the beam of electrons from the electron gun. Because of this encirclement, the axis of the helix is superimposed on the axis of the electron beam. The induced signal travels along the helix toward the collector. The signal flow initiates an electric field in the form of a traveling wave that is propagated along the helix at nearly the same velocity as the electron beam. The traveling wave modulates the electron beam and since the beam is in motion, energy is imparted to the original helix signal. Interaction between the helix fields and the electron beam continues as the signal currents travel the length of the helix. The wave is amplified as it moves toward the collector. The amplified signals are inductively coupled out of the output cavity and applied through a coaxial cable to the waveguide of the receiver-tuner (D25).

d. Micrometer positioning screws at one end of the magnetic circuit support the electron gun of traveling-wave tube V6, and allow the tube to be mechanically adjusted over a small arc for precise centering of the beam and the helix axes with the axis of the magnetic circuits. The proper alinement between the helix and the magnetic axes is indicated by minimum helix current on MAIN-HEL CUR meter M2 (C7) on the acquisition RF power supply con-

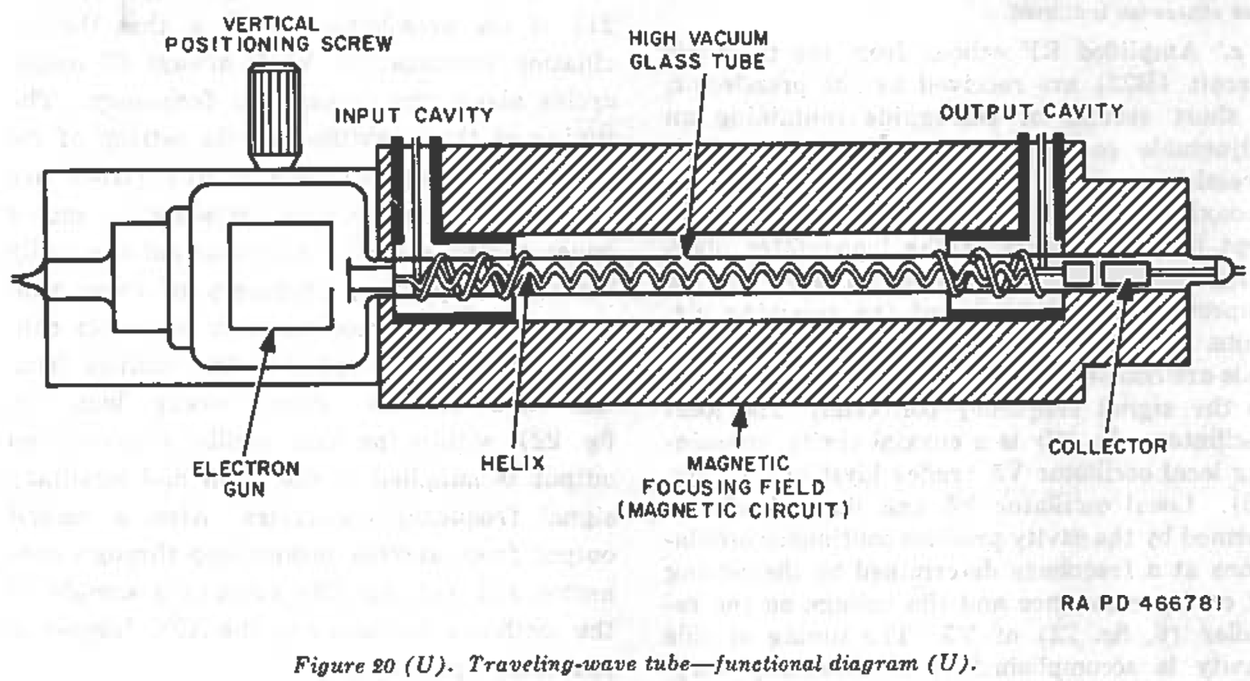


Figure 20 (U). Traveling-wave tube—functional diagram (U).

trol while the positioning screws are being turned. For maximum amplification, the velocity of the electron beam must be slightly faster than the axial propagation of the signal wave. Beam velocity is controlled by proper adjustment of the helix voltage.

e. Optimum operation of the traveling-wave tube is insured by well-regulated and adjustable voltages for each of the eight tube elements. The elements of V6 (B22) are the filament (heater), RF (beam-forming) cathode, accelerating anodes G1 through G4, helix (field amplifier), and plate (collector). The element voltages are supplied and controlled by the acquisition RF power supply control (par. 44).

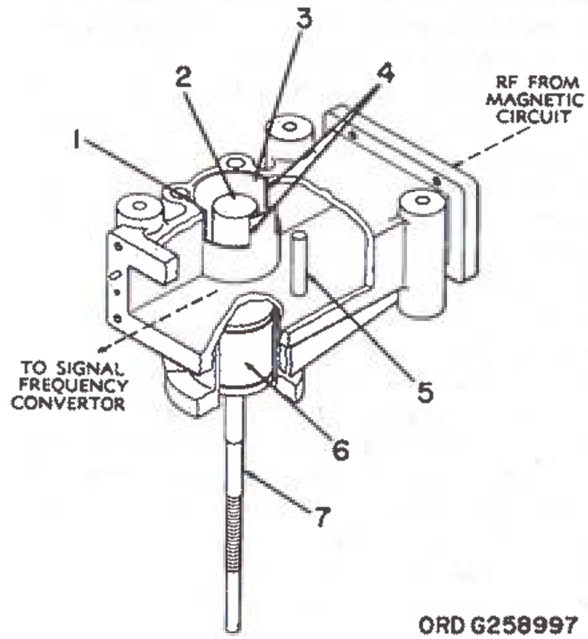
36 (CMHA). Receiver-Tuner

a. The receiver-tuner (fig. 19) consists of a nonamplifying tuned RF stage for the main channel and one for the auxiliary channel, with a tunable generator that produces an RF carrier of 3160 to 3560 megacycles.

b. The receiver-tuner consists of a main and auxiliary preselector (fig. 21), a local oscillator (fig. 22), a tuning motor, and associated equipment. The functional operation of the auxiliary preselector is identical to that of the main preselector.

Note. The grid zone references shown in parentheses in *c* below refer to figure 26, TM 9-1430-254-20/6, unless otherwise indicated.

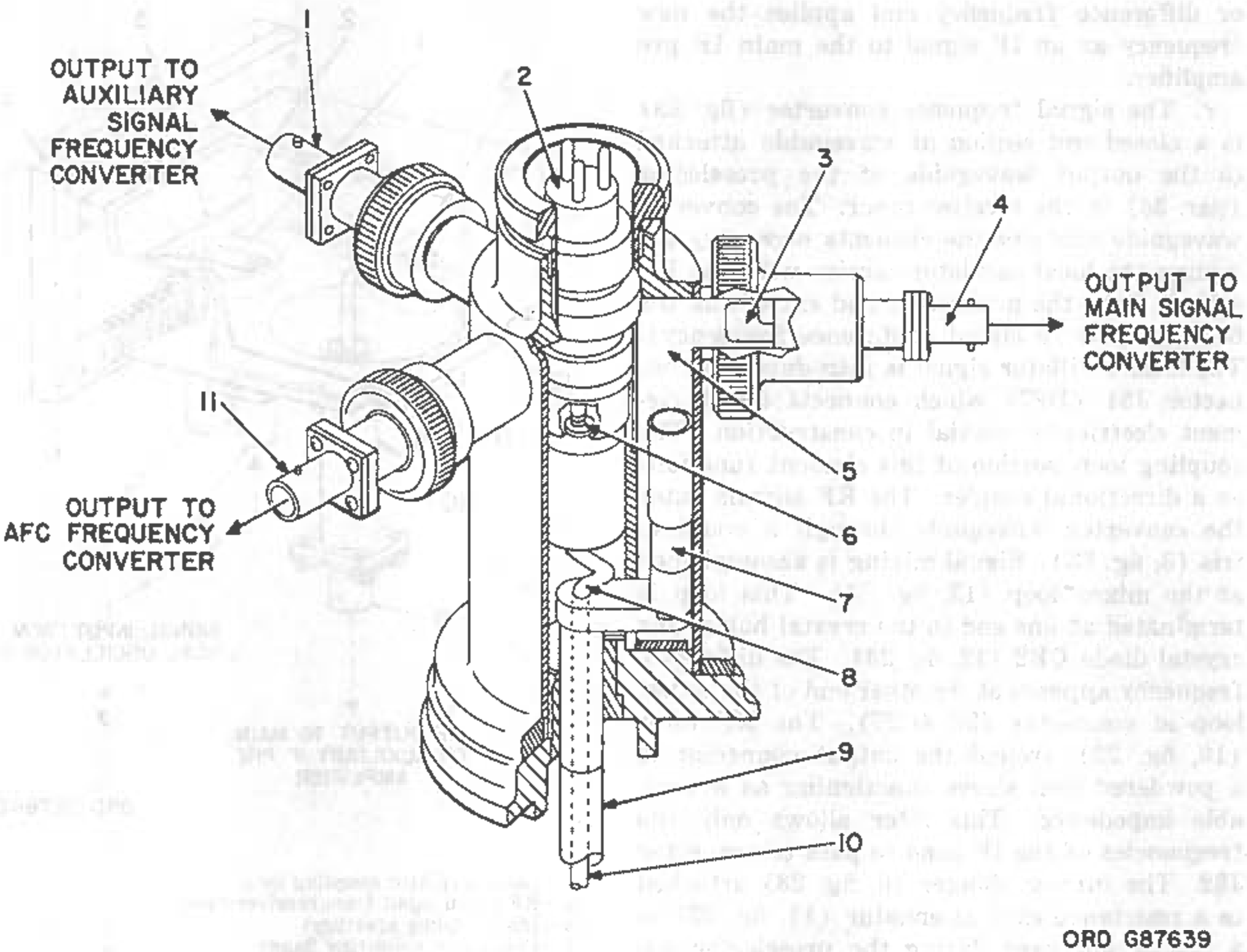
c. Amplified RF echoes from the magnetic circuit (B22) are received by the preselector, a short section of waveguide containing an adjustable coaxial cavity (3, fig. 21). This preselector cavity is a resonant cylindrical (coaxial) cavity that attenuates all signals except the RF signals at the transmitter operating frequencies. As a result, the preselector improves the selectivity of the receiving circuits. From the preselector, the selected signals are coupled through a section of waveguide to the signal frequency converter. The local oscillator (fig. 22) is a coaxial cavity, containing local oscillator V5 (reflex klystron) (2, fig. 22). Local oscillator V5 and its tank circuit formed by the cavity produce continuous oscillations at a frequency determined by the setting of cavity resonance and the voltage on the repeller (6, fig. 22) of V5. The tuning of this cavity is accomplished by mechanically vary-



1—Cavity outer conductor
2—Cavity inner conductor
3—Coaxial cavity
4—Coupling windows
5—Coupling post
6—Tuning plunger
7—Tuning shaft

Figure 21 (U). Preselector—simplified structural view (U).

ing tuning plunger (7, fig. 22) which is electrically alined with the tuning plunger (6, fig. 21) of the preselector cavity, so that the oscillation frequency of V5 is always 60 megacycles above the transmitter frequency. The tuning of these cavities and the setting of repeller plate variable resistor R32 (B25) are controlled by mechanical coupling to motor generator B3 (B25). This motor automatically varies the operating frequency of these subassemblies in the receiver-tuner whenever control voltages are supplied to its windings from the AFC circuits. From pickup loop (3, fig. 22) within the local oscillator cavity, an output is supplied to the main and auxiliary signal frequency converters. Also, a second output from another pickup loop through connector J11 (11, fig. 22) supplies a sample of the oscillator frequency to the AFC frequency converter (par. 56).



1—Connector J43
2—Local oscillator V5 (klystron)
3—Pickup loop
4—Connector J16
5—Coaxial cavity
6—Repeller voltage contact
7—Tuning plunger
8—Flexible lead
9—Tuning shaft
10—Repeller voltage flexible conductor
11—Connector J11

Figure 22 (U). Local oscillator—functional diagram (U).

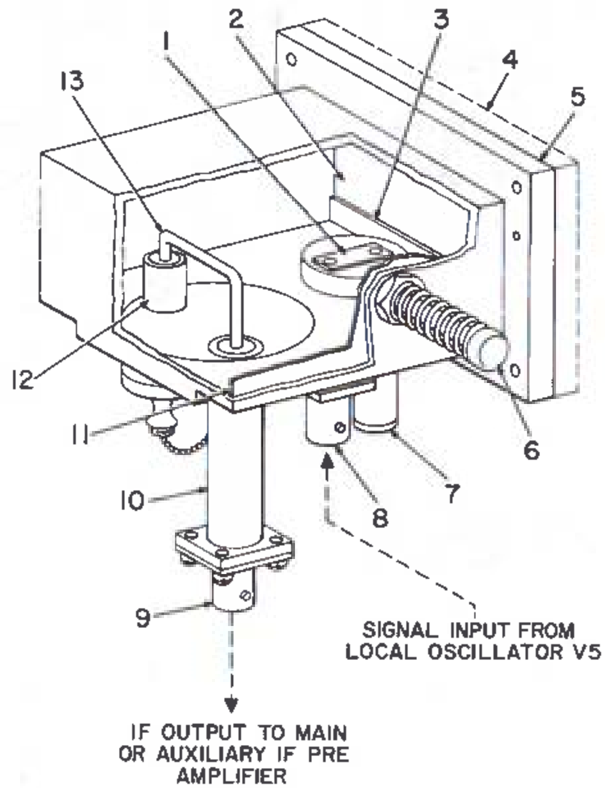
37 (CMHA). Main Signal Frequency Converter

a. The main signal frequency converter (fig. 19) combines two frequencies by heterodyne action to produce a third frequency. The auxiliary signal frequency converter is identical in function to the main signal frequency converter.

Note. **The grid zone references shown in parentheses in *b* and *c* below refer to figure 26, TM 9-1430-254-20/6, unless otherwise indicated.**

b. The main signal frequency converter (C27) receives selected RF signals and a steady carrier of continuous waves (CW) from the local oscillator. The RF signals have a frequency in the 3100- to 3500-megacycle band, while the CW carrier has a frequency 60 megacycles higher in the 3160- to 3560-megacycle band. The two input signals are applied across crystal diode CR2 where heterodyning occurs. From this action a 60-megacycle IF is produced. Crystal diode CR2 detects this lower or difference frequency and applies the new frequency as an IF signal to the main IF pre amplifier.

c. The signal frequency converter (fig. 23) is a closed-end section of waveguide attached to the output waveguide of the preselector (par. 36) in the receiver-tuner. The converter waveguide contains the elements necessary for mixing the local oscillator carrier with the RF signals from the preselector and extracting the 60-megacycle IF signal (difference frequency). The local oscillator signal is introduced at connector J31 (D27) which connects to an element electrically coaxial in construction. The coupling loop portion of this element functions as a directional coupler. The RF signals enter the converter waveguide through a coupling iris (3, fig. 23). Signal mixing is accomplished at the mixer loop (13, fig. 23). This loop is terminated at one end in the crystal holder for crystal diode CR2 (12, fig. 23). The difference frequency appears at the other end of the mixer loop at connector J32 (C27). The RF filter (10, fig. 23) around the output connector is a powdered-iron sleeve functioning as a variable impedance. This filter allows only the frequencies of the IF band to pass to connector J32. The tuning plunger (6, fig. 23) attached to a resistance card attenuator (11, fig. 23) is a tuning aid used during the preselector adjustments. When the plunger is depressed, the card moves into the converter waveguide and absorbs power. In this manner, the preselector is coupled to a more resistive impedance and can be accurately adjusted over the entire frequency bandwidth.



1—Local oscillator coupling loop
2—RF signal input from receiver-tuner
3—Iris (coupling aperture)
4—Preselector mounting flange
5—Waveguide mounting flange
6—Tuning plunger
7—Loop terminating impedance
8—Connector J31 (J41 connector on AUX SIG FRE CON)
9—Connector J32 (J42 on AUX SIG FRE CON)
10—RF filter
11—Resistance card attenuator
12—Crystal diode CR2 holder (CR3 on AUX SIG FRE CON)
13—Mixer loop

Figure 23 (U). Signal frequency converter—simplified structural view (U).

38 (CMHA). Main IF Pre Amplifier

a. The main IF pre amplifier (fig. 19) amplifies the 60-megacycle IF output from the main signal frequency converter.

Note. The grid zone references shown in parentheses in *b* below refer to figure 26, TM 9-1430-254-20/6.

b. The main IF pre amplifier (C29) consists of two grounded grid amplifier stages, V1 and V2, providing less feedback capacitance and thereby reducing the possibility of oscillations at the high IF frequency of 60 megacycles. The LC filter network at V1 prevents the input pulses from entering the current path of crystal diode CR2 in the main signal frequency converter. The output at connector J2 (C30) is at full gain while the output at connector J3 is 20db below the full gain output. The normal (attenuated) output at connector J3 is applied to normal IF select relay K2 (B44). The output at connector J2 is fed to the main electronic frequency converter (A50) to be used as IF for the dicke-fix channel, described in paragraph 41.

c. In certain selected systems, connector J2 provides the only IF output from the main IF pre amplifier. The IF output from J2 (C30.1, fig. 26, TM 9-1430-254-20/6) is applied to the amplifier relay assembly and to the main electronic frequency converter (A50). Resistors R6 and R5 (C30.2) within the amplifier relay assembly provide an attenuated (normal) input to normal IF select relay K2.

39 (CMHA). Acquisition IF Pre Amplifier

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The IF input signal from normal IF select relay K2 is applied to the acquisition IF pre amplifier (A45). The signal selected by relay K2 is the main IF (normal) during the normal mode of operation and auxiliary IF (normal) during testing of the auxiliary channel (par. 46). The acquisition IF pre amplifier consists of a series of tuned IF amplifiers.

b. The first IF amplifier stage consists of V1 and V2 (A45) connected in a tuned cascode circuit to provide high gain and low noise. The amplifier stages consisting of V3, V4, and V5 provide tuned amplification of the 60-megacycle signal. Amplifier stages V3, V4, and V5 are supplied a gain bias from STC (par. 42) circuits through IF GAIN switch S3 (D47) in the NOR position. The IF GAIN-INCR variable resistor R8 (C47) provides a variable bias when IF GAIN switch S3 is set to the LOC position. The acquisition IF pre amplifier output at connector J1 (A47) is applied to attenuator Z2. Attenuator Z2 provides an impedance match between connecting cables. The output from attenuator Z2 is applied through IF select relay K1 (B80) a narrow-band IF filter, and impedance matching network Z62 (A82) without attenuation to the main acquisition IF amplifier (B81). The IF select relay K1 (B80) selects the normal IF signal from the acquisition IF amplifier in the deenergized state and terminates the dicke-fix IF (par. 51*c*).

40 (CMHA). Main Acquisition IF Amplifier

a. The main acquisition IF amplifier (fig. 19) converts 60-megacycle signal pulses into video signals for the MTI circuits.

Note. The grid zone references shown in parentheses in *b* below refer to figure 26, TM 9-1430-254-20/6.

b. The main acquisition IF amplifier (D82) receives IF signal pulses from the IF filter through Z62. These signals are amplified by six stages of voltage amplification provided by IF amplifiers V1 through V6. From V6, the signal is further amplified by high gain IF power amplifier V7. The output of V7 is coupled through transformer T8 to video amplifier V8. Diode CR2 provides detection of the 60-megacycle IF and applies the detected signal to video amplifier V8. Video amplifier V8 supplies two video outputs for the MTI circuits (par. 61). Although both output video signals consist of approximately 1-microsecond pulses, the bypass video is negative, while the MTI video is positive. Bypass video is applied to the fast AGC amplifier and MTI video is applied to the delay line driver (par. 64).

c. The IF amplifiers, V1 through V5, are supplied with back-bias that protects these tube circuits from overloading effects produced by interference from strong signals or certain forms of continuous-wave jamming. Generation of this bias is determined by the amplitude and duration of the applied signal after 6 microseconds.

41 (CMHA). Main Electronic Frequency Converter

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The main electronic frequency converter receives a 60-megacycle IF input from the main IF pre amplifier at connector J1 (A50). Test relay K1 provides a means of removing the dicke-fix 60-megacycle output at connector J3 during testing of the main channel. The 60-megacycle input is fed through the main electronic frequency converter to output connector J3. This output is applied to the wide-band IF amplifier (A73) as 60-megacycle dicke-fix IF (par. 51). Test relay K1 (B51) is energized when JS alignment switch S1 on the auxiliary acquisition control indicator (D52) is set to the MAIN ADJ position. The IF amplifiers, V1 and V2, are transformer-coupled IF amplifier stages with a gain bias being applied from MAIN ADJ variable resistor R7 (C51) on the auxiliary acquisition control-indicator. The output from V2 is coupled through transformer T3 to impedance matching transformer T4. The secondary of transformer T4 provides a balance input impedance to parallel mixers V3 and V4.

b. A 108-megacycle oscillator circuit consisting of oscillator V6, crystal Y1, and associated components produce a local oscillator signal fed through buffer stage V7 to transformer T6. Transformer T6 provides a balance input to the two mixer stages, V3 and V4. The 60-megacycle IF input from transformer T4 is mixed with the local oscillator signal from transformer T6 to produce an IF frequency of 48 megacycles. The IF amplifier stage V5 provides one stage of 48-megacycle amplification through transformer T5 to output connector J2. The 48-megacycle IF output at connector J2 is applied through the main IF filter (B55) and attenuator J26 (B58) to the IF coupler (B60). The main IF filter provides a 3db, 0.9-megacycle bandwidth at a center frequency of 48 megacycles.

42 (U). Sensitivity Time Control

a. The sensitivity time control (STC) (fig. 19) generates a variable negative pulse to reduce the gain of the acquisition IF pre amplifier.

b. The RF echo signals reflected from nearby targets contain more energy than the reflected signals from distant targets, causing video displays of nonuniform brilliance on the radar indicators. The STC is, therefore, provided to reduce the gain of the acquisition IF pre amplifier for signals received from short ranges within the limits of 18,000 and 25,000 yards. This aids in minimizing overbrilliance at the center of the PPI and aids in improving video definition of short-range target displays. As a result, a uniform brilliance is provided over a full sweep range for indicators in the presentation system.

Note. The grid zone references shown in parentheses in *c* through *e* below refer to figure 26, TM 9-1430-254-20/6.

c. The STC (B34) controls the gain of the acquisition IF pre amplifier by producing a negative pulse whose flat portion may be adjusted for a duration of 10 to 30 microseconds and whose decay portion may be adjusted for a duration of 2 to 100 microseconds. This negative pulse is clamped to a dc voltage level, which is variable between 0 and —20 volts and applied through contacts 6 and 5 of IF GAIN switch S3 (D47) in the NOR position to tuned IF pre amplifiers V3, V4, and V5 (A45) in the acquisition IF pre amplifier.

d. The input signal (B33) to the STC is the positive acquisition preknock pulse from the acquisition-track synchronizer when the AGC is off. When GAIN AGC variable resistor R7 (C34) on the LOPAR control-indicator is turned to its full clockwise position, contacts A and B of the switch on R7 close illuminating AGC indicator DS6 and energizing preknock sync select relay K12 to turn on the AGC. When relay K12 energizes, contacts 2 and 6 (B32) apply HIPAR/LOPAR sync from the acquisition-track synchronizer to the input of the STC instead of the preknock applied when the AGC is off. The sync is used instead of the preknock to delay the STC AGC pulse to allow the AJD receiver to measure noise (par. 43*c*). The sync pulse occurs a measured time after preknock allowing time for the noise measurement. This input pulse is applied to FLAT variable resistor R2 (B33) and monostable multivibrator V1. Multivibrator V1 is triggered by the input pulse producing a positive square-pulse output. Variable resistor R2 controls the time duration of this square wave, thereby setting the range of maximum reduction of the IF pre amplifier gain. This positive pulse is passed without inversion or amplification through the cathode follower circuit of paraphase amplifier V2A (B34) to crystal diodes CR1 and CR4, and the resistance-capacitance (RC) discharge network consisting of capacitor C5, resistor R14, and DURATION variable resistor R13. Crystal diodes CR1 and CR4 prevent the discharge network from discharging back through V2A. As the RC network discharges, an exponential trailing edge is produced on the positive pulse. Since DURATION variable resistor R13 controls the discharge time of the RC network, R13 determines the maximum STC range. Adjusting R13 varies the pulse shape and range limits over which IF pre amplifier gain exponentially returns to normal. The modified positive square wave then passes through cathode follower V3A to converter amplifier V2B where signal inversion occurs. The input of V2B is clamped to a dc level by crystal diode CR2 producing amplitude limiting, so that the maximum duration of the exponential decay is limited to approximately 100 microseconds. Thus, IF pre amplifier bias returns to normal at approximately 18,000 yards. The output pulse from V2B is a negative STC pulse which is applied to OFF—STC variable resistor R9 (C35) on the LOPAR control-indicator. Since variable resistor R9 controls the pulse amplitude applied to cathode follower V3B, the IF pre amplifier gain may also be varied over the STC range by this resistor.

e. During the time V2B furnishes an output, paraphase amplifier V2A also produces an output from its plate circuit. This output, a negative 10- to 30-microsecond square-blanking pulse, is combined with the combined negative square pulse and exponential negative pulse from converter amplifier V2B, and the composite pulse is applied to cathode follower V3B. These negative pulses are combined at the input of V3B. When OFF—STC variable resistor R9 (C35) is turned fully counterclockwise, the output of V2B is effectively removed from R9 and only the output of V2A is applied to V3B. Switch contacts A and B of R9 close to illuminate OFF indicator DS3. Because the average output of V2A and V2B is applied to V3B, when the output of V2B is not added to the output of V2A, the input to V3B is considered attenuated. Cathode follower V3B assures linear reproduction of the composite STC pulse. The output from V3B is clamped by crystal diode CR3 to a variable dc level. This level is established by GAIN—AGC variable resistor R7 (C34) on the LOPAR control-indicator until R7 is turned to its full clockwise position, illuminating AGC indicator DS6, energizing relay K12 and switching to AGC. From V3B, the resultant composite negative signal is applied to IF GAIN switch S3 (D47) on the acquisition RF power supply control. With switch S3 in NOR position, the composite STC signal is applied to the grid bias circuits of V3, V4, and V5 in the acquisition IF pre amplifier (B45). With switch S3 in the LOC position, the STC has no control over IF pre amplifier gain. In systems using AAR, control of the LOPAR receiver gain is transferred to the ECCM console in the AAR mode. Closed contacts 11-5, 12-7, and 3-10 of receiver control relay K8 (fig. 26, D36.4) transfer received gain control to the ECCM console. Closed contacts 10-4 of energized receiver control relay K18 (fig. 26, C36.4) transfer the energizing path of preknock-sync select relay K12 (fig. 26, C36.2) to the ECCM console.

43 (U). Main Noise Generator

a. The noise generator is a microwave noise source that provides a standard for testing the performance of the acquisition radar receiving circuits.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 26, TM 9-1430-254-20/6.

b. The noise generator (B16), in conjunction with its external power supply and control circuits, comprises an assembly of permanent test equipment. This generator is a closed section of waveguide attached to the acquisition duplexer. The noise source consists of four gas-filled tubes connected in series. The noise signals are injected into the receiving circuits from the output of the acquisition duplexer, and the resultant signals are obtained at the bypass video output of the acquisition IF amplifier for metering. The RF echo signals must pass through this generator before reaching the magnetic circuit (B21), and the generator is automatically deenergized whenever the acquisition transmitter system is in operation. When the generator is energized, only noise signals are applied to the receiving circuits.

c. The noise generator tubes comprising V7 (B16) are filled with argon gas under low pressure. It is this gas that provides the source of stable noise. Because these tubes contain an inert gas and no filaments, high voltage is required for tube operation. The high voltage is supplied from 2500-volt, 400-cps transformers T3 and T4 (C44). These transformers also provide current regulation for the load by including a built-in inductor in series with their primary windings. Transformer T4 is used to supply high voltage for the auxiliary noise generator. Transformer T4 is connected in parallel with T3 and receives the same primary power. The function of the two noise generators is identical. Application of primary voltage to transformers T3 and T4 is controlled by either pushbutton NOISE GEN—EXC switch S1 (C46) on the acquisition RF power supply control or by NOISE ADJUST switch-indicator A2 (B39) on the LOPAR auxiliary control-indicator. Switch S1 directly applies 120 volts ac to transformers T3 and T4 whereas switch S1B of switch-indicator A2 energizes noise generator relay K1 (C46). Relay K1, in turn, applies 120 volts ac to T3 and T4. Switch-indicator A2 however, cannot apply dc energizing voltage to the coil of K1, while high voltage on relay K4 (D38) is energized. This relationship automatically prevents receiver sensitivity tests from being remotely performed at the battery control console while the acquisition mangetron is in operation. Because receiver sensitivity tests can be performed locally at the acquisition RF power supply control while the transmitter is in operation, two indicator lights are provided. NOISE GEN—HV ON indicator light DS1 (C46) (red) illuminates when the transmitter is off and NOISE ADJUST switch-indicator A2 (B39) is depressed or when JS alignment switch S1 (D53) is in MAIN ADJ position during JS testing. NOISE GEN—GEN ON indicator light DS2 (green) illuminates when the noise generator is in operation. Receiver sensitivity noise measurements performed while the transmitter is in operation result in erroneous meter indications. Upon application of the primary voltage to transformers T3 and T4, the high voltage ionizes and deionizes the argon gas at a 400-cps rate. As a result, a series of pulses containing noise signals over a broad band of frequencies enter the receiving circuits through a slotted section in the receiver waveguide. Monitoring of the noise signals in either channel is provided by either noise meter M1 (C40) on the LOPAR auxiliary control-indicator with IF GAIN switch S3 set to NOR (D47), or by TEST 2 meter M4 (D5) on the acquisition RF power supply control when associated TEST 2 switch S7 (D3) is in position 11 and IF GAIN switch S3 is set to LOC.

d. The generation of noise signals as a result of ionization follows exact physical laws of gaseous discharges. At a critical potential, depending upon the nature of gas present between the electrodes, dielectric stresses free electrons from the gas atoms producing a minute flow of displacement current. At this point, collision between the freed electrons and gas atoms produces more free electrons, positive ions, and electromagnetic fields of energy. An internal arc-over occurs between electrodes, the moment a critical level of displacement current is reached, resulting in continuous ionization. The electromagnetic energy released during this process of ionization occurs in many portions of the frequency spectrum. One energy component, uniformly distributed over the RF spectrum, is thermal noise. It is this noise that is the utilized output of the noise generator.

e. When the noise generator is energized, *c* above, the noise signals pass through normal receiving circuits to monitoring meters. Monitoring allows a receiver system performance figure to be calculated by determining the ratio of normal receiver noise to generated noise. With the noise generator injecting noise into the receiver circuits, receiver IF gain is adjusted to give a full scale reading on the associated monitoring meter. The noise generator is deenergized and the inherent random receiver noise is monitored on the same meter. The lower the meter indication (48 or less), the better the receiver sensitivity.

44 (U). Acquisition RF Power Supply Control

a. The acquisition RF power supply control furnishes operating voltages for the acquisition receiver-transmitter in addition to providing metering and control circuits for various components of the acquisition radar system.

b. The acquisition RF power supply control consists of a negative 800-volt power supply, a complex voltage divider network, and a control panel. The voltage divider network furnishes nine voltages to the magnetic circuit, the acquisition duplexer, and the receiver-tuner. Four meters are provided to measure various voltages and currents. Two of the meters measure currents of a traveling-wave tube. The other two meters, through the use of meter switching, measure all the voltages for the acquisition receiver-transmitter. There are also various controls provided on the panel to adjust the various power supply voltages, the local oscillator voltages, the operation of the noise generator, the frequency of the acquisition transmitting circuits, and the acquisition IF pre amplifier gain.

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 26, TM 9-1430-254-20/6, unless otherwise indicated.

c. Upon application of 120-volt, 400-cps primary power to transformer T1 (A2) the stepped-up secondary high voltage is applied to full-wave rectifier V1. The full-wave rectifier output voltage is filtered by the pi-filter network consisting of capacitor C1, inductor L1, and capacitor C2 in the negative return circuit of transformer T1. Because the dc voltage is taken off at the center tap of transformer T1, the power supply output has a negative polarity. This voltage is applied as keep-alive (ionization) voltage to TR tube V4 (B14) in the acquisition duplexer. The same voltage is also applied to a complex voltage divider and regulator network. Network outputs provide stable voltages to traveling-wave tube V6 (B22) in the magnetic circuit and to voltage regulator V9 (B6) (fig. 27, B18, TM 9-1430-254-20/6) in the acquisition AFC circuits (par. 55). These voltages are regulated by voltage regulators V2 (A2) through V8 and fixed and variable resistors R10 through R19, and R47 through R52. To insure optimum operation of traveling-wave tube V6 (B22), voltages to certain tube elements are adjustable. Adjustment of these voltages is provided by MAIN and AUX RF AMPLIFIER VOLTAGE CONTROLS: main channel G1 variable resistor R11 (A3), auxiliary channel G1 variable resistor R47, main channel G2 variable resistor R14, auxiliary channel G2 variable resistor R48, main channel G3 variable resistor R13, auxiliary channel G3 variable resistor R49, main channel G4 variable resistor R16, auxiliary channel G4 variable resistor R50, main channel HEL variable resistor R18, auxiliary channel HEL variable resistor R51, main channel COL variable resistor R19, and auxiliary channel COL variable resistor R52.

d. The addition of an auxiliary channel within the receiver circuits requires that the various circuits tested through TEST 2 switch S7 (D3) and meter M4 be switched from one channel to the other. This is accomplished through RCVR TEST switch S9 (D4).

e. For positions 1 through 6 of rotary TEST 2 switch S7, voltages applied from the voltage regulator circuits to traveling-wave tube V6 are monitored on TEST 2 meter M4 (D5). With switch S7 in position 7, meter M4 indicates the cathode voltage of voltage regulator V4 (B2) and the repeller voltage of local oscillator V5 (C25). The meter circuit in switch position 7, designated L—O VOLTS (625), is from the junction of V3 and V4 through multiplier resistors R54 (B4) and R28, switch S7A, switch 59 in MAIN position, meter M4, and switch S7C to ground. Switch positions 8 and 9 are used to monitor AFC limiter and AFC crystal currents, respectively. The meter circuit in switch position 8, designated AFC LIM CUR, is from connector P1-4 (fig. 27, D3, TM 9-1430-254-20/6) on the acquisition AFC, through connector J2-R on the acquisition RF power supply control, to meter shunt resistor R30 (fig. 27, D17, TM 9-1430-254-20/6) in parallel with a series path through switch S7A, meter M4 and switch S7C to ground. The meter circuit in switch position 9, designated AFC XTAL CUR, is from connector P1-6 (fig. 27, D3, TM 9-1430-254-20/6) on the acquisition AFC, through connector J2-P on the acquisition RF power supply control, to meter shunt resistor R29 (fig. 27, D16, TM 9-1430-254-20/6) in parallel with a series path through switch S7C, meter M4, and switch S7A to ground. The current of crystal diode CR2 (C27) in the main signal frequency converter is indicated on meter M4 when switch S7 is in position 10. When switch S7 is in position 11, the noise voltage generated by the noise generator is monitored by meter M4 when IF GAIN switch S3 (D47) is set to LOC and NOISE ADJUST switch-indicator A2 (B39) and NOISE MEAS switch-indicator A3 are not operated. At this time noise meter M1 (C40) is out of the circuit. TEST 1 meter M5 (fig. 25, B13, TM 9-1430-254-20/6) monitors average magnetron current when TEST 1 switch S8 (fig. 25, B14, TM 9-1430-254-20/6) is set to position 1. Meter M5 (fig. 17, A35, TM 9-1430-254-20/6) also indicates the low voltages supplied to units of the acquisition receiver-transmitter when switch S8 is set to positions 2 through 6.

f. MAIN and AUX COL CUR meters M3 (C6) and M7 (C7) are permanently connected to monitor current supplies to the collector of the traveling-wave tubes in their respective units. MAIN and AUX HEL CUR meters M2 (C7) and M6 are also permanently connected to monitor the respective helix currents.

g. Noise generator relay K1 (C46) controls the application of energizing voltage under certain conditions (par. 43*c*) to transformers T3 and T4 (C44). Relay K1 is controlled by NOISE ADJUST switch-indicator A2 (C39) on the LOPAR auxiliary control-indicator or JS alignment switch S1 (D53) when set to MAIN ADJ provided high-voltage on relay K4 (D38) on the acquisition power control panel is not energized. Relay K4 thus forms an interlock circuit that opens whenever high voltage is applied to the transmitting circuits. Therefore, the noise generator cannot be activated from LOPAR auxiliary control-indicator or the auxiliary acquisition control-indicator while the acquisition magnetron is operating.

Section III (C). AUXILIARY ACQUISITION RECEIVER CIRCUITS

45 (U). Purpose

The auxiliary acquisition receiver circuits present strobe lines on the PPI's, indicating the azimuth of jamming signals. The auxiliary receiver circuits are used when operating in an ECM environment.

46 (C). Auxiliary IF Pre Amplifier

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The auxiliary IF pre amplifier is identical to the main IF pre amplifier described in paragraph 38 with the exception of the output connections. The auxiliary IF normal output of connector J3 (A30) is terminated through de-energized contacts of normal IF select relay K2 to a terminating resistor (A44). The main IF normal output from the main channel is applied through contacts of normal IF select relay to the acquisition IF pre amplifier during normal operation as described in paragraph 38. The auxiliary IF normal signal is applied to the acquisition IF pre amplifier during testing of the auxiliary channel and the main IF normal signal is terminated when IF select relay K2 is energized. Relay K2 is energized when IF GAIN switch S3 (D47) on the acquisition RF power supply control is set to the LOC position and RCVR TEST switch S9 (C47) is set to the AUX position or during noise tests when MAIN CHANNEL — AUX CHANNEL switch-indicator A1 is depressed to illuminate the AUX CHANNEL indicator.

b. In certain selected systems, connector J2 provides the only IF output from the auxiliary IF pre amplifier. The IF output from J2 (A30.1) is applied to the amplifier relay assembly and to the auxiliary electronic frequency converter (C55). Resistors R7 and R4 within the amplifier relay assembly provide an attenuated (normal) input to normal IF select relay K2.

47 (C). Auxiliary Electronic Frequency Converter

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The auxiliary electronic frequency converter is almost identical to the main electronic frequency converter described in paragraph 41. The auxiliary 60-megacycle IF input from the auxiliary IF pre amplifier is applied to the converter at connector J1 (C55). Test relay K1 in the input circuit provides a means of attenuating the input during testing of the main channel. Test relay K1 is energized when JS alignment switch S1 (D53) on the auxiliary acquisition control-indicator is set to the MAIN ADJ position and SENSITIVITY CHK switch S2 (C53) is depressed.

b. The 60-megacycle input through test relay K1 is coupled through transformer T1 to IF amplifier stage V1. The IF amplifier stages V1 and V2 are transformer-coupled IF stages with gain bias being applied from AUX ADJ variable resistor R11 (D54) on the auxiliary acquisition control-indicator. The 60-megacycle IF output of V2 is coupled through impedance matching transformers T3 and T4 to a parallel mixer stage consisting of V3 and V4. The local oscillator consists of stage V6 and crystal Y1 with associated components. The local oscillator circuit produces a 112-megacycle signal fed through buffer stage V7 to the primary of transformer T6. Transformer T6 provides a balance input to the two mixer stages, V3 and V4. The 60-megacycle IF and the 112-megacycle local oscillator signal are mixed to produce an IF frequency of 52 megacycles. The IF amplifier stage V5 provides amplification of the 52-megacycle IF and applies this signal through transformer T5 to output connector J2. The 52-megacycle IF output is applied through an auxiliary IF filter to the IF coupler. The auxiliary IF filter has a 3db bandwidth of 1.15 megacycles at a center frequency of 52 megacycles. This is a bandwidth increase of 0.25 megacycle over the main IF filter (par. 41), thereby acting as a cover filter through its extra bandwidth.

48 (C). IF Coupler

Note. The grid zone references shown in parentheses in this paragraph refer to figure 26, TM 9-1430-254-20/6.

The IF coupler (B60) provides coupling of the main channel 48-megacycle IF with the

auxiliary channel 52-megacycle IF frequency. The IF coupler is basically a hybrid coupler with only a small signal attenuation in each channel. The output of the coupler at connector J3 is a composite IF signal consisting of both 48- and 52-megacycle frequencies. The composite IF signal is applied to an amplifier-limiter stage to be used as jam strobe video.

49 (CMHA). Amplifier-Limiter

Note. The grid zone references shown in parentheses in *a* through *d* below refer to figure 26, TM 9-1430-254-20/6.

a. Two identical amplifier-limiter units are used in the jam strobe (JS) channel to provide the necessary amplification and limiting. The composite IF input at connector J1 (B61) is applied to the first amplifier stage, V1. The IF amplifier stages are designed to have a center frequency of 50 megacycles with a bandwidth of 12 megacycles at 3db.

b. The output of V1 is transformer-coupled to IF amplifier stage V2. The output of V2 is applied through transformer T2 to the first amplifier-limiter stage, V3. Diodes CR1 and CR2 provide a 1-volt peak-to-peak limiting. Diodes CR1 and CR2 are low-capacity, high-speed switching diodes and each will conduct when the input signal is over 0.5 volt in their respective direction of conduction. Capacitor C21 across transformer T2 provides a filter to reshape the bandpass characteristics of the amplifier before the next limiting takes place in the next limiter stage.

c. Amplifier stage V3 provides a 12db increase in gain and applies the signal through transformer T3 to amplifier stage V4. Amplifier stage V4 provides another 12db increase and applies the signal through transformer T4 for filtering. The process of limiting and amplification is repeated in the last three stages, that is, amplification taking place in stages V5 and V6, and limiting taking place in V7. The output of V7 is applied through transformer T7 to output connector J2. The output at J2 is applied to a second identical amplifier-limiter. The use of two amplifier-limiter units reduces the bandwidth at 3db to 8 megacycles.

d. The process of amplification and limiting causes the amplifier-limiter to produce an output with the frequency of the stronger input signal. The stronger signal is designed to be that of the main channel, 48 megacycles as described in paragraph 32*c*. The output of the second amplifier-limiter is applied as JS IF to the electronic frequency discriminator.

50 (CMHA). Electronic Frequency Discriminator

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The jam strobe (JS) IF input from the second amplifier-limiter is applied at connector J1 (D67) on the electronic frequency discriminator. Input IF is applied to IF amplifier stage V1. Amplifier V1 is a 50-megacycle tuned IF stage. Tuning is accomplished by adjustment of capacitor C14. A negative bias of 10 volts is applied to amplifier V1 through contacts 9 and 2 of energized test enable relay K1 (C72) when JS alignment switch S1 is in the CAL position. Test enable relay K1 (D51) is energized from the —28-volt JS test enable supply applied through NOISE MEASURE switch-indicator A3 (B40) and NOISE ADJUST switch-indicator A2 on the LOPAR auxiliary control-indicator provided switch-indicators A3 (extinguished) and A2 (illuminated amber) are not operated. The negative 10-volt bias is applied in order to cut off the signal input at V1 while differential amplifier V4 is being balanced by adjustment of CAL variable resistor R16 (C71) on the auxiliary acquisition control-indicator. Amplifier stage V1 is also cut off during the period from preknock to sync by the application of JS blanking pulses of approximately 12 volts in amplitude. The JS blanking pulses are applied from the fast AGC amplifier (par. 53*d*) through diode CR3 (C71), and through JS alignment switch S1 in the OPERATE position or contacts 1 and 9 of deenergized K1. Detector V2B, with associated inductor L7 and variable capacitor C18, form a tuned 48-megacycle section while detector V2A, with associated inductor L8 and variable capacitor C19, form a tuned 52-megacycle section.

b. The output of the discriminator is developed at the junction of resistors R11 and R12. The detected signal is applied to cathode follower stage V3 to output connector J2. Diode CR1 (C70), connected across resistors

R10 and R12 through contacts 5 and 11 of de-energized K1 (C72), removes any negative output produced by 52-megacycle detector section V2A so that only a positive output from the 48-megacycle channel will be used as JS video. The output of JS video which exists only at the azimuth of a jamming signal is applied to the electronic gate as described in paragraph 70.

51 (CMHA). Wide-Band IF Amplifier

Note. The grid zone references shown in parentheses in *a* through *c* below refer to figure 26, TM 9-1430-254-20/6.

a. The 60-megacycle IF dicke-fix input from the main electronic frequency converter is applied at connector J1 (A73) on the wide-band IF amplifier. The input signal is amplified through each stage until the signal amplitude reaches the point of limiting. The gain of the amplifier stages is set in order to cause limiting of receiver noise in all stages of the second wide-band IF amplifier. The wide-band IF amplifier consists of three amplifier-limiting circuits. Each circuit consists of two amplifier stages with two switching transistors and associated components.

b. Amplifier V1 amplifies the applied 60-megacycle IF. The output of V1 is coupled through transformer T1 to amplifier stage V2. The signal is amplified by V2 and coupled to amplifier V3. Transistor Q2 (B75) is normally turned on by a small positive voltage at its base from the +150-volt supply through resistor R35. At this time the potential across Q2 is not great enough to turn on transistor Q1. Amplifier V2 receives cathode bias through the low impedance path from collector-to-emitter of Q2 when Q2 is turned on. With no signal input, the gain of V1 is at its minimum and the gain of V2 is maximum. When a jamming signal of sufficient amplitude causes the signal at the input of V3 to increase in amplitude, the voltage drop through diodes CR2 and CR7 causes the bias on the base of Q2 to drop, cutting off Q2. With Q2 cut off the cathode current for V2 flows through the higher emitter-to-base resistance of Q1 decreasing the gain of V2 and turning on Q1. Diodes CR2 and CR7 tend to unbalance large signals by clamping the negative peaks. When Q1 is turned on it shunts the normal cathode circuit of V1 and increases the gain of V1. During limiting, the overall gain of V1 and V2 combined is decreased. Diode CR1 provides degenerative feedback to the emitter of Q1 to stabilize operation.

c. The amplifying and limiting action causes the signal-to-noise ratio to decrease so that the output from the second wide-band IF amplifier is constant and depends upon noise. The signal strength of the jamming signal will determine the stage in which limiting begins. The next two limiting stages consisting of V3 and V4, transistors Q3 and Q4, and associated components, V5 and V6, and transistors Q5 and Q6, and associated components provide the same circuit function. Because of the limiting action of the wide-band amplifiers, the second amplifier will have a constant power output. The dicke-fix IF output from the second wide-band amplifier is applied through the deenergized contacts of AJD on relay K1 (D80) in the fixed attenuator to ground during the basic receiver mode of operation. When JS ONLY RECEIVER switch-indicator A14 (C33) or AJD RECEIVER switch-indicator A15 (C32) in the LOPAR control-indicator is depressed, contacts of energized relay K9 or K10 (D31) applies a ground, energizing AJD on relay K1 (D80) in the AJD fixed attenuator along with IF select relay K1 and AJD on relay K1 (C89) in the fast AGC amplifier (par. 53). When the AJD mode of operation is selected, dicke-fix IF is applied through the contacts of energized relay K1 in the AJD fixed attenuator and IF select relay K1 to the IF filter. The associated IF filter provides a correction factor for the wide-band amplifier output by limiting the bandpass. The acquisition IF output is applied to impedance matching network Z62 (A82).

52 (CMHA). Main Acquisition IF Amplifier (Fast AGC Operated)

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 26, TM 9-1430-254-20/6.

a. The 60-megacycle normal or dicke-fix IF is applied through connector J1 (B81) and transformer T1 to the first IF amplifier stage, V1. Transformer T2 provides coupling between V1 and the second amplifier stage, V2. Amplifier stages V3 through V7 provide additional 60-megacycle amplification. The output of V7 is coupled through transformer T8 to video amplifier V8.

b. Diode CR2 provides detection of the 60-megacycle IF and applies the detected signal to video amplifier V8. Video amplifier V8 supplies two video outputs. A positive video output is taken from the cathode circuit of V8, while a negative video output is taken from the plate circuit. The positive video output is applied through connector P2-10 to the delay line driver (par. 64) as pre-MTI video. The negative video output at connector P2-6 is applied as bypass video to the fast AGC amplifier. The fast AGC amplifier provides a feedback bias to control the main acquisition IF amplifier gain. This bias is supplied from P1-4 (B94) on the fast AGC amplifier to connector P2-5 (D81) on the main acquisition IF amplifier. The AGC bias provides stability over a wide range of amplitude changes. Diode CR1 (D83) provides a circuit connection to connector P2-9 for noise measuring tests.

53 (CMHA). Fast AGC Amplifier

Note. The grid zone references shown in parentheses in *a* through *d* below refer to figure 26, TM 9-1430-254-20/6.

a. The fast AGC amplifier receives bypass video from the main acquisition IF amplifier at connector J1 (B85). The video input is clamped by diode CR1 for a positive overswing and applied to video amplifier V1. The output video is applied through capacitor C3 to video amplifier V2A. Diode CR2 clamps the negative overswing. AGC on relay K2 is energized by contacts 5 and 3 (D35) of preknock sync relay K12 (par. 42) through contacts 5 and 11 of deenergized AJD on relay K1 (C89). AJD on relay K1 is energized by JS ONLY RECEIVER switch-indicator A14 as described in paragraph 51. Contacts 6 and 11 of energized K1 also complete an energizing path for K2.

b. AGC on relay K2 applies resistor R7 to the input circuit of V2A, thereby reducing the time constant of the coupling network. This provides a fast time constant to reduce the effect of CW jamming signals. The negative output of V2A is applied through BYPASS VID GAIN variable resistor R10 to connector J2. The output of V2A is also applied to amplifier V3. Zener diode CR19 is used to provide a constant voltage on the screen grid. Diode CR5 provides a bypass circuit for clutter noise through capacitor C10. The output of cathode follower V4A is applied to a gating circuit consisting of diodes CR6 through CR9. A positive 23-microsecond gate pulse is applied to the cathodes of CR7 and CR9 and a negative 23-microsecond gate pulse is applied to the anodes of CR6 and CR8. In the AJD mode, the signals are always passed to the grid of V4B.

c. The AGC voltage applied from cathode follower V4B is adjusted by AGC ADJ variable resistor R25 before being applied to cathode follower V5A. Stages V5B and V6A (B91) provide amplification of the AGC signal before being applied to cathode follower V6B. Cathode follower V6B provides input AGC voltage for driver stages V7A and V7B. The AGC output from driver stage V7B is applied through the contacts of energized AGC on relay K2 to the main acquisition IF amplifier (C81). The fast AGC bias changes the gain of the narrow-band circuits of the main acquisition IF amplifier to compensate for instantaneous changes in noise or jamming signals when dicke-fix IF is being used.

d. Multivibrator stage V9A receives positive preknock pulses through input connector J3 (D85). Multivibrator V9A and V9B produces negative video gate 2 out pulses applied to connector P1-3 (D94) and positive video gate 1 out pulses at connector P1-1. The positive video gate 1 out pulses are also applied to blanking amplifier V2B. Negative 23-microsecond blanking pulses from V2B are applied through diode CR3 (C71) on the auxiliary acquisition control-indicator to the electronic frequency discriminator (par. 50*a*). Multivibrator V8 is used with Zener diodes CR11 and CR16 to provide a sharp cutoff amplitude of V9 in order to maintain video 1 and 2 output pulses at 68 volts.

Section IV (U). AUTOMATIC FREQUENCY CONTROL CIRCUITS

54 (U). Purpose

The automatic frequency control (AFC) circuits (fig. 1), which are part of the receiving system, automatically tune the receiver circuits to the proper frequency for optimum operation. The AFC circuits electronically sense deviations in the intermediate frequency of the receiver. The AFC circuits function as a closed-loop servo system, electro-mechanically tuning the receiver to the transmitted frequency to insure proper reception of reflected RF signals.

55 (U). Block Diagram Analysis

The AFC circuits (fig. 24) in the acquisition receiver-transmitter receive a sample of the transmitted pulse from the acquisition duplexer and a continuous wave (CW) frequency from the local oscillator in the receiver-tuner. The AFC frequency converter combines these signals and applies the difference frequency to the acquisition AFC. The acquisition AFC develops 400-cps error signals according to the amount and direction of deviation of the difference frequency from 60 megacycles. An AFC gate pulse from the acquisition transmitter circuits is applied to the acquisition AFC to insure that the error signals are a function of the transmitted pulse and local oscillator frequency comparison, and not of random noise. These error signals are amplified by a low-power servo amplifier (LPSA). The resulting motor control voltages are applied to the tuning drive in the receiver-tuner. The tuning drive mechanically adjusts the size of both the main and auxiliary preselecter cavities, the size of the local oscillator cavity, and the amount of local oscillator repeller voltage. These adjustments maintain the intermediate frequency output from the signal frequency converter at 60 megacycles. The RF signals from the preselector in the receiver-tuner and the CW frequency from the local oscillator are mixed in the signal frequency converter to produce an intermediate frequency which is applied to the acquisition IF pre amplifier (par. 38). The AFC crystal current is monitored on the acquisition RF power supply control. An auto-search circuit in the acquisition RF power supply control provides hunt voltage switching to insure that the receiver-tuner locks on a frequency 60 megacycles above the acquisition transmitter frequency.

56 (CMHA). AFC Frequency Converter

a. The AFC frequency converter (fig. 25) is a coaxial mixing unit for microwave frequencies. This converter combines two signals within the 3100- to 3560-megacycle range and extracts the difference frequency. This difference frequency is applied to the acquisition AFC.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 27, TM 9-1430-254-20/6, unless otherwise indicated.

b. The AFC frequency converter (B5) receives two input signals. A sample of the transmitted RF pulse is taken from the acquisition duplexer and applied at connector J19 (A5) (7, fig. 25). A sample of the local oscillator frequency is applied at connector J20 (A6) (4, fig. 25). These two signals are heterodyned in a mixing line (1, fig. 25). The difference frequency (AFC IF) is detected by crystal diode CR1 (B6) and applied to transformer T1 (C2) of the acquisition AFC as an IF signal.

c. The AFC crystal current is monitored by TEST 2 meter M4 (D16) on the acquisition RF power supply control when associated TEST 2 switch S7 is set to position 9. The path for AFC crystal current is from ground through resistor R29 (D16), current limiting resistor R15 (D14), primary of transformer T1 (C2), to AFC crystal diode CR1 (B6). The meter circuit in switch position 9 is from connector P1-6 (D3) on the acquisition AFC, to meter shunt resistor R29 (D16), on the acquisition RF power supply control, in parallel with a series path through switch section S7C, contacts 5 and 3 of switch S9, meter M4, contacts 9 and 11 of S9, and switch section S7A to ground. Filter capacitor C10A (D13) prevents the IF signal from entering the metering circuit.

57 (U). Local Oscillator

a. The local oscillator (figs. 22 and 24) consists of a reflex klystron (2, fig. 22) and a tun-

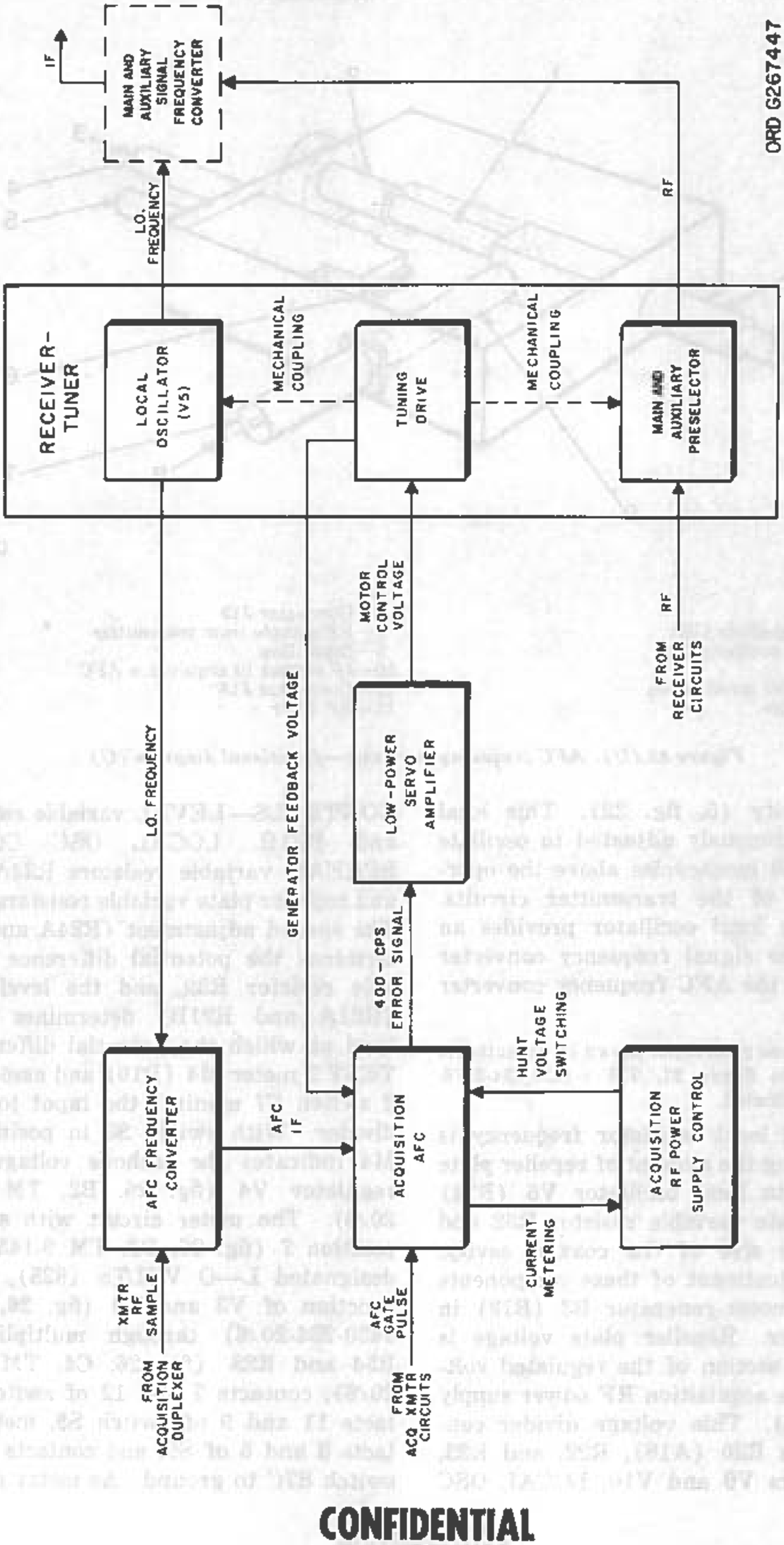
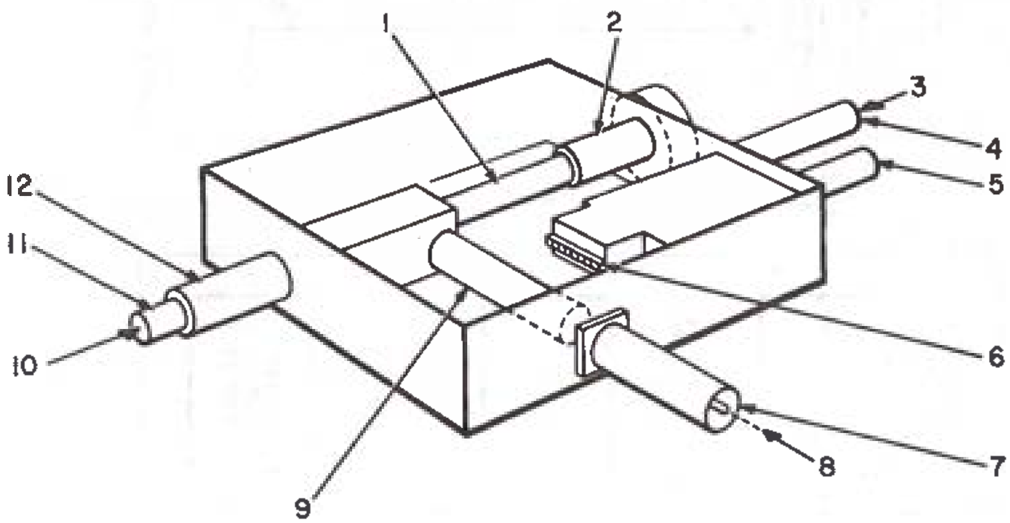


Figure 24 (U). AFC circuits—block diagram (U).



1—Mixing line
2—Holder for crystal diode CR1
3—Input from local oscillator V5
4—Connector J20
5—Directional coupler termination
6—Directional coupler
7—Connector J19
8—RF sample from transmitter
9—Input line
10—IF output to acquisition AFC
11—Connector J18
12—RF filter

Figure 25 (U). AFC frequency converter—functional diagram (U).

able coaxial cavity (5, fig. 22). This local oscillator is continuously adjusted to oscillate at a frequency 60 megacycles above the operating frequency of the transmitter circuits. Output from the local oscillator provides an RF carrier to the signal frequency converter (par. 37) and to the AFC frequency converter (par. 56*b*).

Note. The grid zone references shown in parentheses in *b* below refer to figure 27, TM 9-1430-254-20/6, unless otherwise indicated.

b. The output local oscillator frequency is varied by changing the amount of repeller plate voltage applied to local oscillator V5 (B14) from repeller plate variable resistor R32 and by changing the size of the coaxial cavity. Simultaneous adjustment of these components is provided by motor-generator B3 (B13) in the receiver-tuner. Repeller plate voltage is obtained from a section of the regulated voltage divider in the acquisition RF power supply control (par. 44). This voltage divider consists of resistors R20 (A18), R22, and R23, voltage regulators V9 and V10, LOCAL OSC CONTROLS—LEVEL variable resistors R21A and R21B, LOCAL OSC CONTROLS—SPREAD variable resistors R24A and R24B, and repeller plate variable resistors R32 (A15). The spread adjustment (R24A and R24B) determines the potential difference across variable resistor R32, and the level adjustment (R21A and R21B) determines the voltage level at which the potential difference occurs. TEST 2 meter M4 (D16) and associated TEST 2 switch S7 monitor the input to the voltage divider. With switch S7 in position 7, meter M4 indicates the cathode voltage of voltage regulator V4 (fig. 26, B2, TM 9-1430-254-20/6). The meter circuit with switch S7 in position 7 (fig. 26, D3, TM 9-1430-254-20/6), designated L—O VOLTS (625), is from the junction of V3 and V4 (fig. 26, B2, TM 9-1430-254-20/6) through multiplier resistors R54 and R28 (fig. 26, C4, TM 9-1430-254-20/6), contacts 7 and 12 of switch S7A, contacts 11 and 9 of switch S9, meter M4, contacts 3 and 5 of S9, and contacts 12 and 7 of switch S7C to ground. As motor-generator B3

(B13) directly varies repeller plate variable resistor R32 (A15), a portion of the voltage across R32 is applied to local oscillator V5. Variable resistors R21A, R21B, R24A, and R24B are adjusted to keep the receiver-tuner on a frequency 60 megacycles above the transmitted frequency over the entire range of transmitter frequencies. The operation of motor-generator B3 is controlled automatically by the acquisition AFC through the low-power servo amplifier. The output of the generator portion of motor-generator B3 is used by the AFC as velocity (damping) feedback.

58 (U). Acquisition AFC

a. The acquisition AFC (fig. 24) receives an AFC IF input from the AFC frequency converter. If the frequency of these IF pulses is other than 60 megacycles, an error signal is developed for use by the receiver-tuner in tuning the local oscillator and preselector.

Note. The grid zone references shown in parentheses in *b* through *g* below refer to figure 27, TM 9-1430-254-20/6.

b. The acquisition AFC (D5) receives an intermediate frequency from the AFC frequency converter. These signals are applied through transformer T1 (C2) to IF amplifiers V1, V2, and V3, connected as cathode-biased, transformer-coupled stages. Since sensitivity to signals deviating from 60 megacycles is required for AFC operation, the transformers are fixed-tuned to 60 megacycles with a band-pass of 10 megacycles. The amplified signal is coupled through transformer T4 to limiter V4. Limiter V4 limits the amplitude of the IF signal so that the discriminator stage responds only to frequency rather than amplitude variations. Limiting is attained by a combination of grid-leak and cathode biases which quickly drive V4 between saturation and cutoff, producing a constant amplitude output. The limited IF signal is coupled through zero discriminator transformer T5 (C4) into the discriminator stage. The negative bias produced in the grid circuit of V4 and monitored at test point TP3 is also used to control auto-search relay amplifier V11B (D4). The output of V11B is applied to relay amplifier V11A, *g*(1) below. The AFC limiter current may be monitored at TEST 2 meter M4 (D16) on the acquisition RF power supply control when associated TEST 2 switch S7 is set to position 8. The path for AFC limiter current is from ground through resistor R30 (D17), current limiting resistor R17 (D14), resistor R22 (C3), and the secondary of transformer T4 to the control grid of limiter V4. When S7 (D17) is set to position 8, associated meter M4 is connected in parallel with resistor R30.

c. The discriminator stage consists of dual-diode detector V5 (C5), connected as a shunt-type balanced discriminator. This stage detects frequency deviations from 60 megacycles during the time of the magnetron pulse and produces a video output pulse of approximately 1.3 microseconds with an amplitude proportional to the magnitude of frequency deviation. The polarity of these pulses is determined by the direction of frequency deviation. It is negative when the intermediate frequency is above 60 megacycles and positive for deviations below 60 megacycles. Input coupling transformer T5 (C4) is tuned to 60 megacycles by response discriminator variable capacitor C40 in the primary winding and by slug-tuning, in conjunction with capacitors C14 and C15, in the secondary winding. Whenever the IF signal varies from 60 megacycles, T5 becomes unbalanced, and V5 detects the frequency deviation. Detector V5 transforms these deviations into positive or negative video pulses which are amplified by video amplifier V6A. The output pulse of V5 may be measured at test point TP1 (C5). The amplitude and polarity of the waveform at TP1 are dependent on the amount and direction of the error. There is no signal to V6A when the IF signal is exactly 60 megacycles. From V6A, the output is applied to the center-tap of transformer T6. At the same time, a gate pulse from cathode follower V6B (B4) is applied to the primary winding of transformer T6. The secondary windings of T6 (C5) are part of pulse stretchers V7A and V7B. The input to V6B (B4), a sample pulse (AFC gate) received from the magnetron hot box (C1), is a positive gate pulse with a duration of approximately 1.3 microseconds and an amplitude of approximately 20 volts. Since this pulse is a sample of the tunable magnetron output, it has a repetition rate of 500 pulses per second. Crystal diode CR1 (B4) limits the input of V6B to 20 volts by clipping all positive excursions of the input pulses above this amplitude. The presence of the gate pulse at the primary of transformer T6 (C5) insures that the control voltage developed in the pulse stretcher circuits is a function of the transmitted pulse and local oscillator frequency comparison and not of random noise.

d. The pulse stretcher stages convert discriminator output pulses into dc error signals that are applied as steady control voltages to balance modulators V8 (B7) and V9. These modulators convert the error signals into 400-cps drive voltages.

(1) In the absence of a signal from video amplifier V6A (C5), the only input to pulse stretchers V7A and V7B is the gate applied from cathode follower V6B to the primary of transformer T6. The gate induced into the secondary windings of T6 results in two gates, equal in amplitude and opposite in polarity, appearing at T6-3 and T6-6. The gate applied to the plate of V7B from T6-3 is positive and the gate applied to the cathode of V7A from T6-6 is negative, which causes equal conduction in the two sections; capacitor C23 does not charge and there is no dc output. Capacitor C21 in the cathode circuit of V7A and capacitor C22 in the plate circuit of V7B charge to the peak voltage of the gates from V6B. Between gates, the large resistance of resistor R29A in the cathode circuit of V7A and resistor R29B in the plate circuit of V7B holds C21 and C22 charged to approximately the peak gate voltage. Capacitor C21 and resistor R29A place a positive bias voltage at the cathode of V7A while C22 and R29B place a negative bias voltage at the plate of V7B. Thus, V7A and V7B are cut off during the period between gates. Pulsating dc control voltages are developed across C23 when error pulses are received from V6A. Since V7A and V7B are cut off during the period between gates, the pulsating dc control voltages developed across C23 are only functions of the polarity and amplitude of the error pulses from V6A.

(2) When the output of V6A is positive, the positive error signal is added to the positive gate in winding 3, 4 of T6, causing V7B to conduct more than V7A. The resultant signal causes C23 to assume a positive dc level with the amplitude determined by the output of V6A.

(3) When the output of V6A is negative, the negative error signal is added to the negative gate in winding 5, 6 of T6, causing V7A to conduct more than V7B. The resultant signal causes C23 to assume a negative dc level.

(4) When the IF signal at transformer T1 (C2) varies from 60 megacycles by more than ±5 megacycles, the input signal to the pulse-stretching circuit is supplied by the auto-search circuit discussed in *g* below.

e. The balanced modulator, composed of modulators V8 (B7) and V9, transformer T7, and MOD BAL variable resistor R43, develops the 400-cps drive voltages that control motor-generator B3 (B13) in the receiver-tuner. Continuous 400-cps power from T7 and dc control voltages from pulse stretchers V7A (C6) and V7B form the input signals to V8 and V9. These electron tubes are dual-triodes connected as a balanced bridge circuit. With zero dc input, variable resistor R43 (C8) is adjusted to produce zero ac volts at the bridge output while MOD BAL switch S1 (C9) is depressed. With no dc control voltage at the bridge input and with the bridge balanced, no ac voltage appears at the output. When a dc control voltage appears at the modulator input, the modulator unbalances and produces an ac output voltage. The amplitude of the ac output voltage is directly proportional to the amplitude of the dc control voltage, and the phase is determined by the polarity of the dc control voltage. The phase and amplitude ultimately determine the direction and speed of rotation for motor-generator B3 (B13).

f. The push-pull, 400-cps output from the modulator provides the two input signals for cathode follower V10A (B9) and driver V10B which function as an amplifier phase-inverter circuit. This circuit is required to balance modulator loading and to suppress second harmonic distortion in the modulator output. Load balance is provided by V10A, part of the phase-inverter circuit. The ac error signal amplified by V10B is applied to a resistor network consisting of resistors R47 (C9), R48, and R49. A velocity feedback voltage is also applied at the junction of R48 and R49. The feedback voltage is a damper to prevent hunting of motor-generator B3 (B13). The AFC output signal, provided at the junction of R47 and R48, is applied to the low-power servo amplifier (C10).

g. An auto-search circuit provides a dc search voltage to the junction of resistors R47 (C9) and R48 when the AFC IF signal varies from 60 megacycles by more than ±5 megacycles. In addition, this search circuit insures that the receiver-tuner is locked on a frequency 60 megacycles above the acquisition transmitter frequency. The auto-search functions are provided by relay amplifiers V11A and V11B (D4), hunt relay K1 (C9), and associated network. AFC release relay K2 (D15) and AFC hunt relay K3 (C16) in the acquisition RF power supply control provide additional auto-search circuits. The functional operation of the auto-search circuits is discussed in (1) through (7) below.

(1) When the acquisition local oscillator frequency is 60 ±5 megacycles above the acquisition magnetron frequency, the 60 ±5-megacycle IF signals passed by V1, V2, and V3 (C3) develop limiter bias voltage at the grid of V4. The limiter bias voltage is applied from V4 through the low pass filter composed of resistor R23 and capacitor C5 to the grid of V11B (D4), biasing V11B to cutoff. A positive bias voltage is applied to the grid of V11A. The positive bias voltage causes V11A to draw grid current, which reduces the grid voltage to zero and induces plate current through V11A and hunt relay K1 (C9). Relay K1 energizes, closing contacts 2 and 3. This disconnects the hunt signal at connector P2-11, and bypasses C34 in the signal out circuit of V10B to ground. Motor-generator B3 (B13) is controlled by the error pulse output of V5 (C5), which operates modulators V8 (B7) and V9.

(2) If the acquisition local oscillator frequency is more than 65 megacycles above the acquisition magnetron frequency, the IF signals are outside of the 10-megacycle bandpass and are not passed by V1, V2, and V3. Limiter bias voltage is no longer developed at the grid of V4 and applied to the grid of V11B. The absence of limiter bias voltage at the grid causes V11B to conduct, resulting in a reduced plate voltage which is then applied to the grid of V11A, causing V11A to cut off. Current through relay K1 stops, causing K1 to deenergize. An ac auto-search signal, which can be either in or out of phase with V10B output is applied as an artificial drive voltage from connector P2-11 through contacts 1 and 3 (C9) of relay K1 and resistor R70 to connector P1-1, where it is summed with the signal output. Modulators V8 and V9 are operated by the detector V5 dc volts output generated by the frequency deviation, causing motor-generator B3 to retune the acquisition local oscillator to restore the 60-megacycle IF. Capacitor C34 (C9), connected from contact 3 of relay K1 to ground, is in the circuit only when the acquisition AFC is in auto-search operation (contacts 1 and 3 of relay K1 closed), and functions as a transient noise filter. RELAY AMP ADJ variable resistor R66 (C4) in the cathode circuit of V11B controls the operation of relay K1 by limiting current in V11B. Variable resistor R66 is adjusted to assure that the plate voltage drop of V11B does not cut off V11A until limiter bias voltage is removed from the grid of V11B.

(3) When the acquisition local oscillator is operating at the high end of its frequency range, more than 65 megacycles above magnetron frequency limit, switch S13 (B14), mechanically operated by motor-generator B3, is normally in the closed position, applying —28 volts through S13 to AFC hunt relay K3 (C16) located in the acquisition RF power supply control. Relay K3 energizes, causing contacts 2 and 3 to close. An ac auto-search signal is developed in the acquisition AFC across the voltage divider composed of resistor R56 (D9) located in the acquisition AFC and resistor R9 (C15) located in the acquisition RF power supply control, in parallel, through resistor R54 (D9) to terminal 1 of transformer T8 (D8). Resistor R9 is connected from the junction of R54 and R56, through connector P2-9 (D10) and contacts 6 and 4 of deenergized AFC release relay K2 (D15) to ground. The ac auto-search signal is applied through P2-9, contacts 2 and 3 of energized K3, P2-11, contacts 1 and 3 of deenergized K1, R70, and P1-1 to motor-generator B3 which retunes the local oscillator to a lower frequency, resulting in a lowered IF.

(4) When the acquisition local oscillator is operating at the low end of its frequency range, more than 65 megacycles below the acquisition magnetron frequency, the ac auto-search voltage is applied to connector P1-1, causing motor-generator B3 to retune the acquisition local oscillator to a lower frequency. At the low frequency limit of the acquisition local oscillator tuning range, S13 is mechanically actuated by motor-generator B3 removing the —28 volts from relay K3. Relay K3 deenergizes, causing contacts 3 and 1 to close. An ac auto-search signal is developed in the acquisition AFC across the voltage divider composed of resistors R57 (D8) and R55, connected from ground to terminal 3 of T8. This ac auto-search signal is shifted 180 degrees in phase from the ac signal which is developed across the divider composed of R54 and R56 because the center tap of T8 is grounded. The ac auto-search signal is applied through connector P2-7, contacts 1 and 3 of deenergized K3, P2-11, contacts 1 and 3 of deenergized K1, R70, and connector P1-1 to motor-generator B3, which retunes the local oscillator to the high frequency limit of its tuning range. The phase shift of 180 degrees in the ac auto-search signal causes the motor to reverse direction of rotation when relay K3 operates. At the same time, the grid of V11B is grounded through connector P2-13 and contacts 4 and 6 of deenergized K3. The grounded grid makes V11B insensitive to limiter bias voltage developed at the grid of V4 when the acquisition local oscillator passes through the sidebands which are ±60 megacycles from the acquisition magnetron frequency. The ac auto-search signal overrides any error pulses produced by V5. This prevents the acquisition local oscillator from locking on the 60-megacycle IF as the local oscillator frequency passes through the lower and upper sidebands. When motor-generator B3 has retuned the acquisition local oscillator to the high frequency limit of its tuning range, S13 is again mechanically actuated by the AFC motor-generator and —28 volts is again applied through S13 to energize relay K3. When relay K3 energizes, contacts 3 and 2 close. The ac auto-search signal at connector P2-9 is applied through contacts 2 and 3 of energized K3 and contacts 1 and 3 of deenergized relay K1 to P1-1 reversing the direction of rotation of motor-generator B3. Contacts 4 and 6 of energized relay K3 open, disconnecting ground from the grid of V11B. The ac auto-search signal causes motor-generator B3 to retune the ac-

quisition local oscillator to a lower frequency and the acquisition local oscillator locks on the 60 ±5-megacycle upper sideband.

(5) The acquisition AFC is prevented from locking on the upper or lower sidebands during the time the acquisition local oscillator is being tuned from the low to the high frequency limit of its tuning range. However, a condition of the auto-search circuits near the lower 60 ±5-megacycle sideband causes erratic operation of the acquisition local oscillator. This condition occurs when the difference frequency between the local oscillator frequency and magnetron frequency is less than ±55 megacycles. Limiter bias voltage is removed from the grid of V11B, causing V11B to conduct and deenergize K1. The ac auto-search signal is applied to connector P1-1, causing motor-generator B3 to retune the local oscillator to a lower frequency. The grid of V11B is not grounded through relay K3 at this time, since the local oscillator is not at the low frequency limit of its tuning range, and motor-generator B3 has not actuated switch S13. When the acquisition local oscillator is retuned to a frequency which is 60 ±5 megacycles below the acquisition magnetron frequency, limiter bias voltage is developed at the grid of V4 and applied to the grid of V11B. The limiter bias voltage cuts off V11B, causing relay K1 to energize.

(6) Normal AFC action tends to drive the receiver-tuner to a higher frequency, causing the IF signal to disappear and the auto-search provision to become operative. Consequently, relay K1 is alternately energized and deenergized, and motor-generator B3 tunes the receiver-tuner back and forth about the lower sideband. As this occurs, white AUTO FREQ CONTROL—HUNT indicator light I3 (C16) on the acquisition RF power supply control and red AFC indicator light DS1 (B22) on the LOPAR control-indicator blink at a slow rate. Release from the lower sideband is provided by either AUTO FREQ CONTROL—RELEASE switch S4 (C17) on the acquisition RF power supply control or AFC switch-indicator A12 (B22) on the LOPAR control-indicator. These pushbutton switches energize AFC release relay K2 which grounds the input of relay amplifier V11B. Relay amplifier V11B conducts, V11A cuts off, and relay K1 is deenergized. In systems using AAR, AFC circuit functions, controlled by AFC switch-indicator A12 (B22), are transferred to the ECCM console. Contacts 11-5 and 12-7 of energized transmitter control relay K7 (A20) transfer AFC control to the ECCM console. Since contacts 4 and 6 of K2 are now open, resistor R9 is removed from the voltage divider leaving only resistors R54 and R56 connected from ground to terminal 1 of T8. An increased ac auto-search developed across resistor R56 is applied through connector P2-9, contacts 2 and 3 of energized K3, P2-11, and contacts 1 and 3 of deenergized K1 to P1-1 which overrides the error pulses produced by V5, causing motor-generator B3 to retune the acquisition local oscillator to the low frequency limit of its tuning range.

(7) When the modulators are being balanced, the hunt signal voltage output of the auto-search circuit is connected to ground through depressed MOD BAL switch S1 (C9). The excitation circuit to motor-generator B3 is completed when AFC—MOTOR EXC switch S6 (B16) on the acquisition RF power supply control is set to ON, and contacts 2 and 3 of energized AFC motor disable relay K4 are closed. Relay K4 is energized when magnetron current begins to flow. Deenergized relay K4 disables the AFC circuits to prevent continuous searching when there is no magnetron current or when there is an insufficient amount of magnetron current.

59 (U). Low-Power Servo Amplifier

a. The low-power servo amplifier (LPSA) (fig. 24) is a four-stage amplifier which amplifies an imput signal to an ac power level high enough to drive a low-power ac motor.

b. The LPSA amplifies a 400-cps control signal from the acquisition AFC to a 10-watt level sufficient to operate the tuning drive in the receiver-tuner. A high gain of 50,000 at a low-noise level makes the LPSA sensitive to any small error signal inputs. The LPSA uses push-pull power output, and RC network, and two feedback loops to prevent circuit interference from harmonics.

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 27, TM 9-1430-254-20/6.

c. The 400-cps input signal from the acquisition AFC is applied to two-stage voltage amplifier V1B (C10) and V1A, which contains a degenerative feedback loop. This feedback stabilizes the amplifier operation. From V1A, the signal amplitude is further increased by a paraphase amplifier consisting of driver amplifier V2A and phase inverter amplifier V2B. Driver amplifier V2A is cathode-coupled to V2B. As a result the output of V2B has the same form and amplitude as V2A except that the two signals are 180 degrees out of phase. Thus, a balanced input is provided to push-pull power amplifiers V3 (C12) and V4. The resistor-capacitor (RC) network, consisting of C8 and R20, between the inputs to V3 and V4 prevents regeneration of undesired harmonics above 400 cps. Since the power amplifiers are operating as class AB, the input 400-cps control signal can be amplified to a 10-watt level across transformer T1 (C13). A voltage divider, consisting of resistors R21 (B12) and R22, provides amplitude control of the degenerative feedback from the secondary of transformer T1 (C13) and from the driving winding of the motor of B3 (B14). The output of this voltage divider is applied to an RC filter, *d* below. The full 400-cps output signal from T1 is applied to motor-generator B3 (B13) in the receiver-tuner and to resistors R5 (C17) and R6, in the acquisition RF power supply control. These resistors apply a portion of the output signal to AUTO FREQ CONTROL—HUNT indicator lamp I3 (C16) and to AFC indicator lamp DS1 (B22) on the LOPAR control-indicator.

d. The velocity feedback signal from motor-generator B3 (B13) contains many undesirable frequencies, the most pronounced of which is the third harmonic. This feedback signal is summed with the error control signal in the acquisition AFC. The resultant signal appears as the input for V1B (C10). If the undesirable frequencies are not removed, power losses and excessive heat occur in power amplifiers V3 (C12) and V4, transformer T1 (C13), and motor-generator B3 (B13). Since conventional methods of removing the undersired frequencies would also attenuate the desired 400-cycle error signal, a frequency selective filter is used. This filter is called a bridged-T network and is described in (1) and (2) below.

(1) The bridged-T network consists of capacitors C2 (B11) and C3, and resistors R6 and R7. The output of voltage amplifier V1A, containing the undersired frequencies, is applied to the bridged-T network at the junction of capacitor C3 and resistor R6. The degenerative feedback from transformer T1 (C13) is applied through a voltage divider, consisting of resistors R21 (B12) and R22 to the bridged-T network at the junction of capacitor C2 and resistor R7.

(2) The bridged-T network is frequency selective and offers maximum attenuation at 400 cps. Negligible impedance is offered to frequencies above and below 400 cps. Therefore, the undesired frequencies, above and below 400 cps, cancel by degeneration. The 400-cps feedback from transformer T1 is attenuated in the network by resistors R6 and R7, and only the desired 400-cps error signal from V1A is coupled through capacitor C3 to the grid of V2A. Hence, the LPSA has full gain at the desired 400-cycle error signal. Capacitors C6 (B12) and C7 shunt 400-cycle harmonics to insure highest possible gain at the output of transformer T1.

60 (U). Receiver-Tuner Motor-Generator

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 27, TM 9-1430-254-20/6.

a. Motor-generator B3 (B13) is a combination of a two-phase, 400-cps motor and a generator. The motor contains a squirrel-cage type rotor which is a cage of copper bars embedded in a laminated iron rotor. The generator is a drag-cup type attached to the common rotor shaft of B3. This generator consists of two stator windings displaced by 90 degrees and a drag-cup rotor that is a hollow cylinder with an open end. The drag-cup is considered an infinite number of shorted turns enclosing a soft iron core. Input stator winding 5, 6 receives continuous ac excitation and produces a constant magnetic field. When the rotor turns, induced eddy currents produce a second magnetic field that distorts the inducing field. The resultant field causes output stator winding 7, 8 to produce an output voltage. The magnitude and polarity of the voltage are dependent upon the speed and direction of rotation of B3. Since the rotor field pulls or drags the fixed stator field out of normal alinement, the rotor is termed a drag-cup. TACH PHASE ADJ variable resistor R2 (B10), in series with input stator winding 5, 6 is provided as a fine phase adjustment. This adjustment enables the generator output voltage to be set exactly 180 degrees out of phase with the output error signal of the acquisition AFC.

b. The purpose of motor-generator B3 is to mechanically adjust three components in the receiver-tuner associated with the main channel and one component in the auxiliary channel. The main and auxiliary preselector cavities, local oscillator cavity (B14), and variable resistor R32 (A15) are all positioned by the receiver-tuner motor-generator. Resistor R32 furnishes local oscillator repeller voltage (par. 57*b*). The generator (B13) provides electrical damping and braking for motor B3 by generating a feedback voltage, proportional to rotational speed, for the low-power servo amplifier (LPSA). The LPSA furnishes 400-cps drive voltage to one winding of motor B3. The other winding of motor B3 continuously receives a 120-volt ac excitation (par. 58*g*(7)). Motor-generator B3 operates whenever a control signal is applied from the LPSA. The phase and amplitude of the control signal determine the direction and rotational speed of motor B3. A control signal is received from the LPSA whenever the input to the acquisition AFC deviates from a frequency of 60 megacycles above the acquisition transmitter frequency.

CHAPTER 8 (CMHA)

MOVING TARGET INDICATOR SYSTEM

61 (U). Purpose

a. The moving target indicator (MTI) circuits in the MTI system reduce video interference from fixed objects and other radar systems. Since stronger RF echoes are received from fixed objects than from moving targets, the stronger RF echoes (clutter) frequently prevent efficient detection and accurate designation of the moving target. The MTI circuits reduce the intensity of clutter displayed on the cathode-ray tube indicators of the presentation system. Moving targets are visible when they are in an area where clutter is present. Common sources of clutter are mountains, hills, woodlands, cloud formations, and precipitation. The MTI circuits also remove clutter produced by other radar units and certain types of enemy jamming, and provide switching circuits for the selection of the various modes of operation as described in paragraph 63.

b. The MTI circuits make use of the fact that the amplitude of successive video signals received from a fixed object remains relatively constant, whereas the amplitude of those received from a moving target varies. A portion of the MTI circuit adds the signals algebraically to obtain a sum signal for application to the indicators in the presentation system. Another portion of the MTI circuits may be selected to compare successive pulse intervals in order to reject random or pulsed video signals that are not synchronized with the transmitted pulse rate. This reduces the clutter created by radars not operating with the same pulse repetition frequency (PRF). The resulting video information is amplified and applied to the indicators in the presentation system.

62 (U). Block Diagram Analysis

a. The delay line driver in the moving target indicator (MTI) circuits (fig. 26) receives MTI video from the main acquisition IF amplifier in the acquisition receiving system (par. 52). Video gate 1 pulse and video gate 2 pulse from the fast AGC amplifier (par. 53) in the acquisition receiving circuits are applied to the delay line driver. Three additional inputs, the LOPAR preknock pulse, processor feedback video, and the MTI test pulse are received. The input signals modulate a 15-megacycle sinusoidal carrier, generated within the delay line driver, and produce a compound signal. A portion of the compound signal is amplified and detected to produce the nondelay video supplied as one input to the trigger pulse-video amplifier. The remaining or undetected portion of the compound signal voltage is transferred to the MTI delay line as a modulated 15-mc carrier, wherein passage of signals is delayed 2000 microseconds. From the MTI delay line, the delayed modulated, 15-mc carrier is applied as delay video to the delay amplifier. After amplification and detection by the amplifier, the delay video is supplied as one of the inputs to the trigger pulse-video amplifier (par. 67). The delay video and nondelay video are added algebraically in the trigger pulse-video amplifier to cancel clutter. The delay and nondelay video signals are also applied to the acquisition interference suppressor. The algebraic sum of both video signals becomes the phase 1 and 2 video (residual video) signals applied to the MTI video amplifier. During this time, the delay preknock pulse from the delay amplifier and the preknock pulse from the acquisition-track synchronizer, are used to generate the MTI auto sync and disabling pulse. This pulse is utilized to synchronize the operation of the acquisition-track synchronizer in the director station group.

b. The phase 1 and 2 residual video output of the trigger pulse-video amplifier is applied to the MTI video amplifier for amplification and development into three signals: the MTI video, which is applied to the acquisition interference suppressor; the test video, which is applied to the MTI oscilloscope; and the automatic gain control (AGC) voltage, which is applied as a feedback signal to the delay amplifier. Of these outputs, only MTI video is supplied to the acquisition interference suppressor. The acquisition interference suppressor also receives delay and nondelay video from the trigger pulse-video amplifier and bypass video (dicke-fix video when operating in the AJD mode) from the acquisition IF amplifier. Video gate 1 pulse and gate 2 pulse from

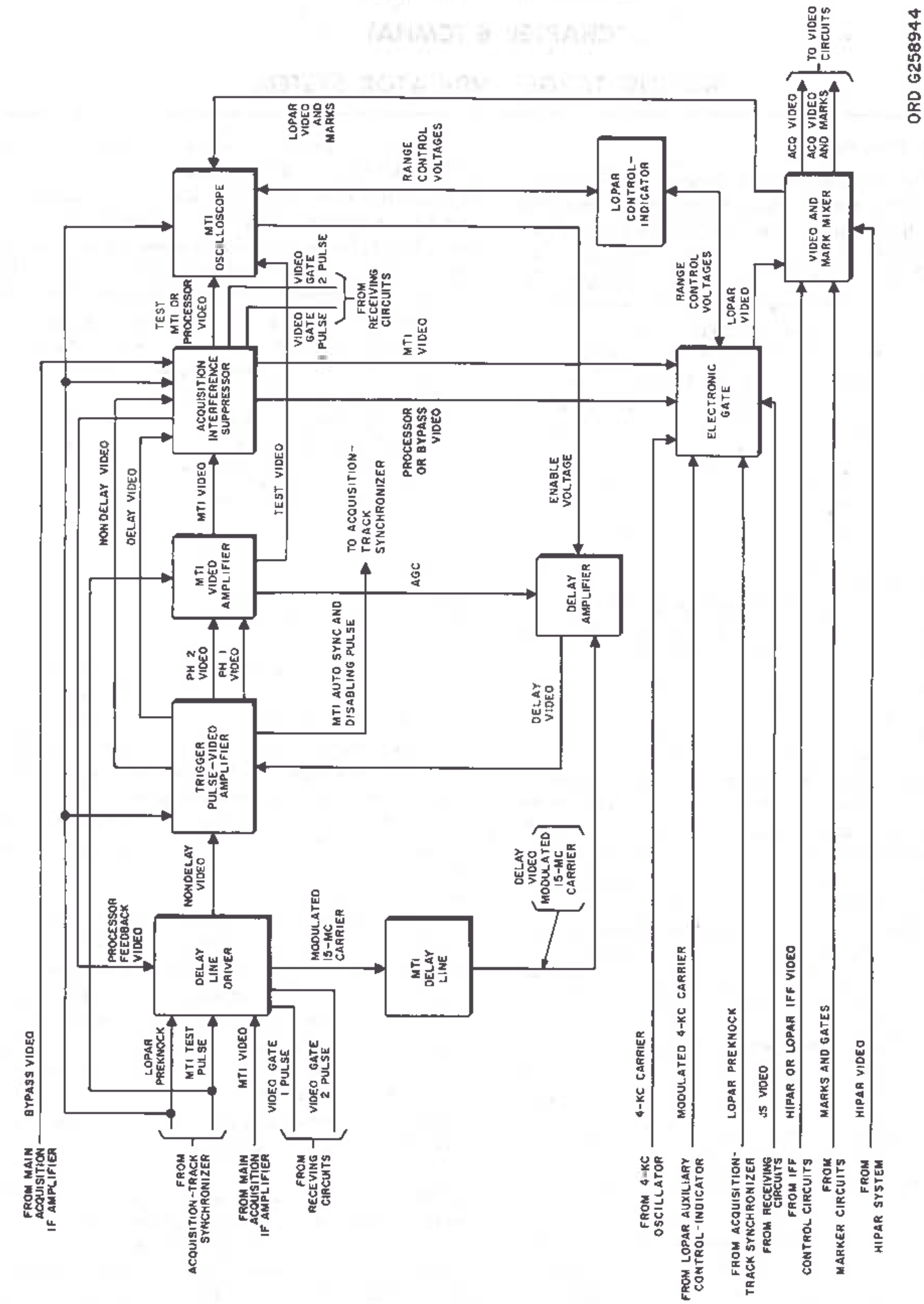


Figure 28 (U). MTI circuits—block diagram (U).

the fast AGC amplifier (par. 53) in the acquisition receiving circuits are applied to the acquisition interference suppressor. The acquisition interference suppressor functions to remove interfering video information from the MTI video signals. The resultant input video and bypass video (dicke-fix video when operating in the AJD mode) are applied to the electronic gate and either test MTI or processor video is applied to the MTI oscilloscope. The electronic gate receives three information inputs and four control inputs. The three information inputs are MTI video, jam strobe (JS) video, and bypass video (dicke-fix video when operating in the AJD mode), or a combination of interference suppressor or processed video from the acquisition interference suppressor. The four control inputs are the preknock pulse from the acquisition-track synchronizer in the director station group, the 4-kilocycle CW carrier from the 4-kc oscillator in the director station group, the modulated 4-kilocycle resolver signal, and MTI range control voltages from the LOPAR control-indicator.

c. The electronic gate alternately passes MTI video and bypass video or one of the selected video modes. The resultant video is combined with JS video during selection of the AJD mode to form the total acquisition video. Application of acquisition video to both the video and mark mixer, and the acquisition video circuits is controlled by the MTI sector and range voltages when either 360° MTI switch-indicator A7 or SECTOR MTI switch-indicator A8 is depressed. These voltages permit control of the adjustable range and the azimuth sector over which the MTI circuits operate. The video and mark mixer, not an electrical part of the MTI or other acquisition circuits, functions as a distinct signal mixing unit. For illustration and discussion purposes, this mixer is functionally subjoined to the MTI circuits (fig. 26). The acquisition video, upon application to the video and mark mixer, is combined with range mark signals from the acquisition marker circuits (par. 117). The combination of these signals produces the acquisition video and marks that are transferred to the acquisition video circuits (par. 108). MTI circuits consist of seven major units, and the video and mark mixer discussed in paragraphs 61 through 72.

d. The MTI oscilloscope, a unit of built-in test equipment, is permanently connected by a multipole switch to the MTI circuits for monitoring purposes. The oscilloscope, synchronized by preknock, is used to monitor the output signals of the MTI video amplifier (par. 68), acquisition interference suppressor, and the video and mark mixer (par. 71). In addition, MTI oscilloscope switching controls the application of dc enabling voltages to the delay amplifier (par. 66).

63 (C). MTI Operating Modes

Note. The grid zone references shown in parentheses in this paragraph refer to figure 29, TM 9-1430-254-20/6, unless otherwise indicated.

a. During basic receiver operation, the normal IF signal is applied to the main acquisition IF amplifier from the auxiliary interconnecting box through deenergized IF select relay K1 (C2). From the main acquisition IF amplifier (par. 52) the video signal is applied to the delay line driver (D8). The video input is applied from the delay line driver (par. 64) to the MTI video amplifier (fig. 28, C14, TM 9-1430-254-20/6) through the MTI delay line (par. 65) and trigger pulse-video amplifier (par. 67). The output of the MTI video amplifier (par. 68) is applied through circuits in the acquisition interference suppressor to the MTI gate in the electronic gate (D5) (par. 70). It is then applied through contacts of deenergized jam strobe (JS) only relay K2 (C5) to a JS mixer then as an input to the video and mark mixer for presentation.

b. When I.S. switch-indicator A10 or PROCESSOR switch-indicator A9 on the LOPAR control-indicator (B1) is illuminated white, bypass video is applied from the fast AGC amplifier (B5) through contacts of deenergized IS on relay K1 (A8) in the acquisition interference suppressor to the electronic gate (D5). Bypass video is applied to the video and mark mixer by the electronic gate as required by the selected video mode.

c. When I.S. switch-indicator A10 (A1) is illuminated green, IS on relay K1 in the acquisition interference suppressor (B8) (par. 69) becomes energized, and causes bypass video to be removed from the electronic gate (D5) and IS video to be substituted in its place.

d. When PROCESSOR switch-indicator A9 (B1) is illuminated green, processor on relay K7 (B1) is energized. If either BASIC RECEIVER switch-indicator A13 (B2) is illuminated green energizing basic receiver relay K8 (B2) or AJD

RECEIVER switch-indicator A15 (A2) is illuminated green energizing AJD receiver relay K10, processor on relay K2 and IS on relay K1 (B8) in the acquisition interference suppressor (par. 69), processor on relay K1 (C8) in the delay line driver (par. 64), processor on relay K1 (B9) in the trigger pulse-video amplifier (par. 67), and MTI mode relay K6 (A2) in the LOPAR control-indicator are energized. With relay K6 (A2) energized, a ground is applied to the MTI gate in the electronic gate and disables the MTI channel of that unit by setting the maximum MTI range to zero (par. 70*d*(2)(*c*)).

e. When AJD RECEIVER switch-indicator A15 is illuminated green, AJD receiver relay K10 (A2) and MTI mode relay K6 become energized. This assures that no MTI video is available for any AJD mode of operation (par. 70). This action also energizes AJD on relay K1 (B5), AGC on relay K2 (A5) in the fast AGC amplifier (par. 53), IF select relay K1 (C2) in the auxiliary acquisition control interconnecting group, AJD on relay K1 (D1) in the AJD fixed attenuator, and AJD on relay K1 (D5) in the electronic gate. The IF select relay K1 in the auxiliary acquisition cabinet removes the normal pre amplifier IF signal and connects the output from the wide-band IF amplifier to the narrow-band filter to give the proper dicke-fix arrangement (par. 32c). Bypass video (dicke-fix video when operating in the AJD mode) is applied through deenergized IS on relay K1 (B8) in the acquisition interference suppressor to the bypass gate in the electronic gate. Dicke-fix video is then applied through contacts of deenergized JS only relay K2 (D5) to the JS mixer, and JS video is applied through contacts of energized AJD on relay K1 (D5) to the JS mixer (par. 70). These signals are then mixed and applied to the video and mark mixer for simultaneous presentation on the PPI's.

f. When IS, dicke-fix plus JS video is desired, the action is as follows: dicke-fix video is supplied to the delay line driver on the MTI video line. The IS video utilizes a portion of the MTI circuit and its operation is the same as for the normal IS condition. The output from the acquisition interference suppressor (A7) is through IS on relay K1 (B8). The IS dicke-fix video is applied through contacts of deenergized JS only relay K2 (D5) in the electronic gate to the JS mixer. The JS video is applied to the JS mixer through contacts of energized AJD on relay K1 (D5). These signals are then mixed and supplied to the video and mark mixer for simultaneous presentation on the PPI's.

g. The dicke-fix video is supplied to the delay line driver as described in *f* above for dicke-fix plus JS. The MTI circuits and IS arrangements are the same as for processed or normal video. The electronic gate arrangement differs from the proceed normal video arrangement only by the addition of JS video through energized AJD on relay K1 in the electronic gate.

h. When JS ONLY RECEIVER switch-indicator A14 (A1) is illuminated green, AJD on relay K1 (B5), AGC on relay K2 (A5) in the fast AGC amplifier, IF select relay K1 (C2) in the auxiliary acquisition control interconnecting group, AJD on relay K1 (D1) in the AJD fixed attenuator, AJD on relay K1 in the electronic gate (D5), and JS only relay K2 are energized. AJD on relay K1 (D5) supplies JS video to the JS mixer and JS only relay K2 removes all other video.

i. During testing of the auxiliary channel, normal IF select relay K2 (C11) is energized. This action terminates the main normal IF signal and applies the auxiliary normal IF signal to the acquisition IF pre amplifier. Normal IF select relay K2 is energized when IF GAIN switch S3 (B11) is set to the LOC position and RCVR TEST switch S9 (B11) is in the AUX position.

j. In selected systems using AAR, control of the MTI operating modes is transferred to the ECCM console when AAR is selected. The MTI circuits controlled by I. S. switch-indicator A10 or PROCESSOR switch-indicator A9 on the LOPAR control-indicator (B1), are transferred to the ECCM console through contacts of energized receiver control relays K18 and K8 (A54). JS and AJD circuit functions, controlled by JS ONLY RECEIVER switch-indicator A14 (A41) and AJD RECEIVER switch-indicator A15 (B40), are transferred to the ECCM console through contacts of energized receiver control relay K13 (D56).

64 (U). Delay Line Driver

Note. The grid zone references shown in parentheses in this paragraph refer to figure 28, TM 9-1430-254-20/6, unless otherwise indicated.

a. The delay line driver (D3) supplies two video outputs when operating in either the normal or AJD mode. One output, an amplitude-modulated

15-megacycle carrier, is applied to the MTI delay line; the other, a nondelay video output, is applied to the trigger pulse-video amplifier. The MTI video is applied from the main acquisition IF amplifier to connector P1-9 (A2). MOD ADJ variable resistor R1 (A2) provides amplitude adjustment of the input video before being applied to a gate circuit consisting of diodes CR1 through CR4. The 23-microsecond gating pulses (gates 1 and 2) from the fast AGC amplifier are applied to operate the input gate. No signal can pass through the gate during the 23 microseconds between preknock and sync pulses. This is done so that the video test pulse at connector J2 (B2)

may be inserted during a noise-free period enabling the MTI AGC to function properly. The MTI video output from the gate is applied to cathode follower V6B. The MTI video output of cathode follower V6B is applied to modulator V7 (A4). The channel 1 modulator circuit consists of modulator V7 and 15-megacycle oscillator stage V3 with associated capacitor C16 and inductor L3 (C4).

b. The 15-megacycle output of V3 (B, fig. 27) is coupled to modulator stage V7 through capacitor C13. The 15-megacycle sinusoidal carrier is amplitude-modulated in modulator V7 by the MTI video input from cathode follower V6B, by the test pulse (during the time from preknock to sync), and by the preknock pulse input at connector J1 (A, fig. 27) (C2). The positive preknock pulse is inverted in transformer T1, with the resultant negative output being applied to modulator V7 in channel 1 and modulator V1 (D4) in channel 2. This negative pulse is used to cut off modulators V1 and V7 during the preknock period.

c. The amplitude-modulated output from modulator V7 (C, fig. 27) is amplified by nondelay amplifier V8 and applied through diode CR8 to nondelay amplifier V5 (A5) when processor on relay K1 (D3) is energized. Processor on relay K1 removes the video input to nondelay amplifier V5 when deenergized, thereby removing the nondelay video output from channel 1 at connector J3 (A6). A negative voltage is applied through contacts 1 and 6 (B4) of deenergized processor on relay K1 to diode CR9, causing CR9 to conduct and act as a short circuit. A negative voltage is also applied to diode CR8, causing CR8 to be back-biased and act as an open circuit. The video output of V5 is coupled through transformer T2 to video detectors CR16 and CR17, providing a negative video pulse at connector J3 (E, fig. 27). The CW amplitude of channel 1 is adjusted by CHANN 1 CARR LEVEL ADJ variable resistor R19 (A3).

d. Diodes CR11 through CR14 (D2) provide a gating circuit for the processor video input at connector P1-1. The processor gate functions the same as the MTI gate described in *a* above. The same gating pulses (gates 1 and 2) from the fast AGC amplifier are applied to operate the gate during preknock to sync. If the processor video mode is selected (par. 63*d*) processor video is applied from connector J7 (A24) of the acquisition interference suppressor, through the processor gate consisting of diodes CR11 through CR14 (D2), and contacts 3 and 5 of energized processor on relay K1 to cathode follower V6A. The output of V6A is applied to modulator V1 as is the 15-megacycle output of oscillator stage V3. Modulator V1 provides amplitude modulation of the negative inverted preknock pulse from transformer T1 and also of the processor video (C, fig. 27). The CW amplitude of channel 2 is adjusted by CHANN 2 CARR LEVEL ADJ variable resistor R25. The output from modulator V1 is amplified by delay amplifiers V2 and V4, and applied to the MTI delay line through connector P2 (D5).

e. When the MTI or interference suppressor video mode is used, the signal path is through the gate circuit consisting of diodes CR1 through CR4 (A2), contacts 4 and 5 of deenergized processor on relay K1, cathode follower V6A, and through channel 2 to the MTI delay line through connector P2 (D5). This output is also applied through diode CR9 to nondelay amplifier V5 (A5) in channel 1. The output of V5 is detected by diodes CR16 and CR17, and applied as negative nondelay video to the trigger pulse-video amplifier (D11).

f. In the processor video mode, both channels of the delay line driver function. This is accomplished by energizing processor on relay K1 as described in *c* above. During this time, channel 1 is used to provide MTI video, video test pulse, and preknock modulation of the 15-megacycle sinusoidal carrier, while channel 2 is used to provide processor feedback video, video test pulse, and preknock modulation of the 15-megacycle sinusoidal carrier produced by oscillator V3.

65 (U). MTI Delay Line

a. The MTI delay line (fig. 26) helps establish the pulse repetition rate of 500 pulses per second for the acquisition-track synchronizer in the director station group, which establishes time relationships throughout the entire LOPAR system. In addition, the MTI delay line delays the passage of signals between its input and output for 2000 microseconds, or the time of one pulse repetition rate. This signal delay allows comparison, in succeeding circuits, of the delayed video with nondelay video in order to produce residue video and the subsequent MTI video. The nondelay

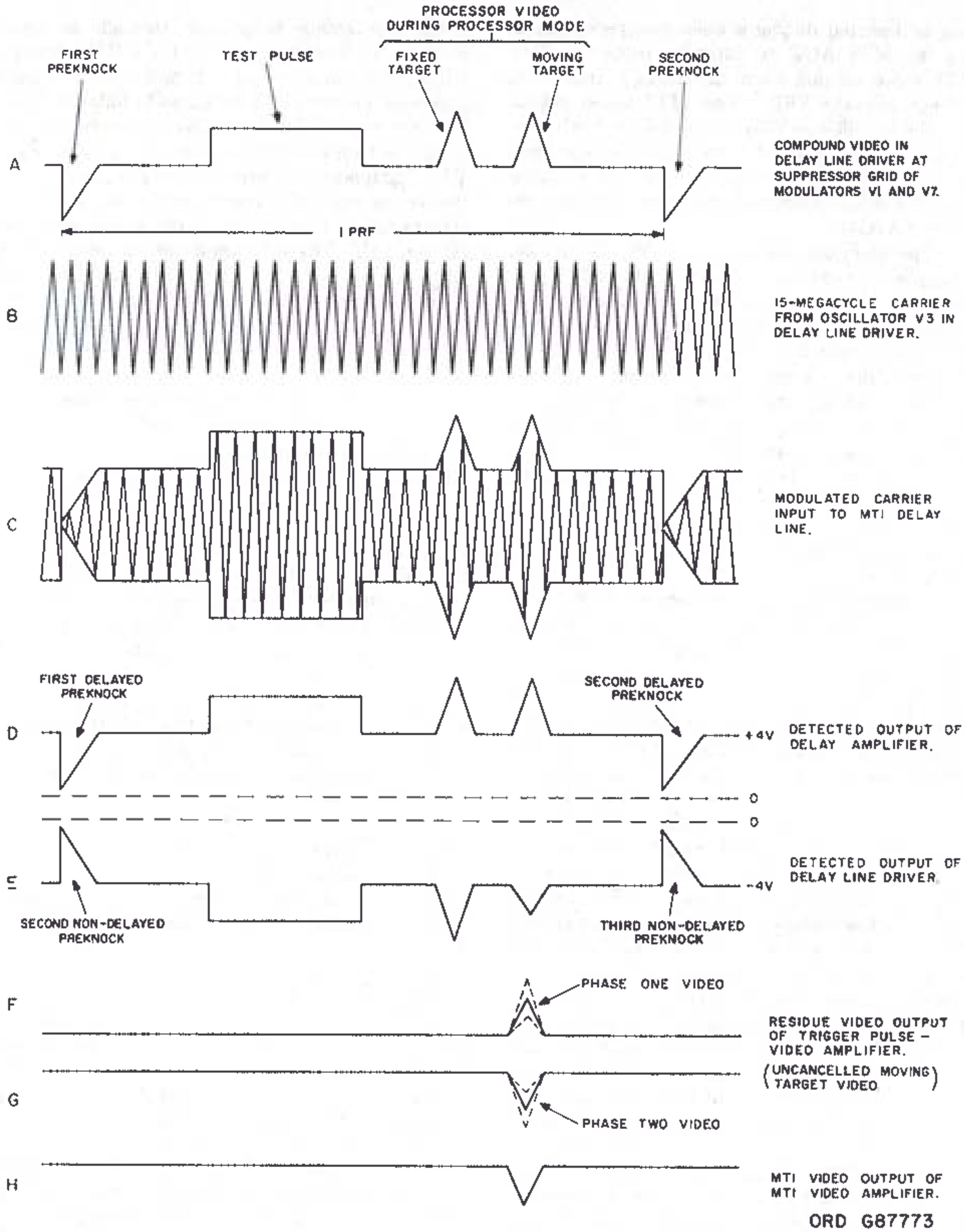


Figure 27 (U). MTI circuits—waveforms—ideal (U).

video, which is compared with the delay video, starts with the second preknock (E, fig. 27).

b. The MTI delay line is a multifaced, fused quartz wafer containing two peizo-electric crystal transducers. Input to the delay line is a compound signal received from the delay line driver (C, fig. 27), and consists of a 15-megacycle carrier modulated by preknock, MTI video, and MTI test pulses. When the compound signal is applied to the input crystal transducer, it is converted into ultrasonic vibrations which pass through the quartz wafer. The quartz wafer and path length attenuate the input signal 55 db and delay the output 2000 microseconds. The output transducer reconverts the vibrations into a 15-megacycle modulated carrier which is applied to the delay amplifier.

c. Automatic synchronization of the acquisition-track synchronizer holds the interval between successive pulses to a period equal to the delay time design of the quartz wafer. A portion of the delayed preknock pulse is removed in the trigger pulse-video amplifier (par. 67) for development into the auto sync pulse and supplied to the acquisition-track synchronizer in the director station group to synchronize the generation of preknock and sync pulses. Hence, if the delay time of a particular MTI delay line changes, the pulse repetition rate of the associated acquisition-track synchronizer is automatically adjusted to the changed delay time.

66 (U). Delay Amplifier

a. Output from the MTI delay line is amplified and demodulated by the delay amplifier (fig. 26). The resultant delay video signal is applied to the trigger pulse-video amplifier. Because the signal is attenuated in the MTI delay line, the delay amplifier provides the additional amplification needed insuring a balanced input for signal comparison by the trigger pulse-video amplifier.

Note. The grid zone references shown in parentheses in *b* below refer to figure 28, TM 9-1430-254-20/6, unless otherwise indicated.

b. The delay amplifier (B6) receives the delayed 15-megacycle carrier from the MTI delay line. The carrier is modulated by preknock, MTI test pulse, and target video and is applied to a three-stage, RF bandpass amplifier fixed-tuned to 15 megacycles. The bandpass amplifier consists of voltage amplifiers V1 and V2, and power amplifier V3. In addition to the modulated carrier, an AGC voltage is applied to the grid circuit of amplifier V1. This AGC voltage, developed in the MTI video amplifier (C14) and produced from MTI test pulse residue, automatically controls the gain of V1. By this means the necessary gain of delay video to compensate for the delay line attenuator is provided. Amplifiers V1, V2, and V3 amplify the delayed and modulated carrier which is then applied to the primary of transformer T1 (B8). Transformer T1 furnishes a balanced output to the detection (demodulation) circuit, a full-wave positive output rectifier composed of crystal diodes CR1 and CR2. The 15-megacycle delay carrier is removed, leaving the compound video signal superimposed on a positive 4-volt dc level. The demodulated signal (D, fig. 27) appears as the delay video output which is applied to the trigger pulse-video amplifier. The delay amplifier receives +150 volts through MTI CKT TEST switch section S1D (D9), which disables the delay amplifier when required for circuit adjustment of the MTI oscilloscope.

67 (U). Trigger Pulse-Video Amplifier

a. The trigger pulse-video amplifier (fig. 26) compares delay video with nondelay video, and produces an output containing moving target video and reduced fixed target video. This output, designated phase 1 and phase 2 video, is supplied to the MTI video amplifier. The trigger pulse-video amplifier also produces an MTI automatic synchronizing and disabling pulse with a repetition period equal to the delay time of the MTI delay line. This dual pulse is furnished to the acquisition-track synchronizer (par. 18) in the director station group. In addition, the trigger pulse-video amplifier supplies delay and nondelay video to the acquisition interference suppressor.

Note. The grid zone references shown in parentheses in *b* below refer to figure 28, TM 9-1430-254-20/6, unless otherwise indicated.

b. The delay video input to the trigger pulse-video amplifier, a compound demodulated signal (D, fig. 27) received from the delay amplifier, consists of negative 4-volt preknock pulses, positive 4-volt MTI test pulses delayed 5 microseconds after preknock, and positive 1-microsecond video pulses superimposed on a positive 4-volt dc level. The nondelay video input is also a compound demodulated signal (E, fig. 27), but is received from the delay line driver. This signal consists of positive 4-volt preknock pulses, negative 4-volt MTI test pulses delayed 5 microseconds after preknock, and negative 1-microsecond video pulses superimposed on a negative 4-volt dc level. The nondelay video is applied to the MTI comparison circuit discussed in (1) below and to the acquisition interference suppressor in (3) below. The delay video is divided into three signal paths, one applied to the MTI comparison circuit, (1) below, another to the MTI automatic synchronizing circuit, (2) below, and the third through the cathode follower circuit to the acquisition interference suppressor, (3) below.

(1) *MTI comparison circuit.* The MTI comparison circuit compares the delay video and the nondelay video to produce a residue video used to improve the display of moving targets. This circuit consists of a voltage divider made up of resistors R1 (B11), R2, and R3; fixed delay network Z1, a small fixed artificial transmission line; time balance variable delay network Z2, a continuously variable delay line; resistors R4 and R5, forming the signal summing junction; and phase splitting amplifier V5, which provides two residue signal outputs.

(*a*) The delay video is applied across resistors R1 (B11), and R3 to network Z1 where it is delayed 0.6 microsecond. This fixed delay corresponds with the time required to initiate and supply nondelay video to the summing junction of R4 and R5. The output signal of Z1 receives additional delay through time balance variable delay network Z2, a vernier adjustment for the MTI delay line which controls the delay time by an additional 0 to 0.3 microsecond. Network Z2, therefore, assures that delay video can be adjusted to exact time coincidence with the nondelay video. The resultant delay video is applied through resistor R5 to the junction of resistors R4 and R5 to be combined with the nondelay video.

(*b*) The nondelay video received from the delay line driver is applied through resistor R4 to the junction of resistors R4 and R5 to be combined with the delay video.

(*c*) Combining delay and nondelay video involves two compound signals of opposite polarity (D and E, fig. 27). Each signal consists of a dc reference level, preknock pulse, MTI test pulse, and MTI video which contains fixed and moving target video. After the amplitude and time relationships have been properly balanced in the preceding circuits, the compound signals tend to cancel each other when applied across resistors R4 and R5. During comparison, the algebraic sum of preknock pulse, dc reference level, and MTI test pulse in both the delay and nondelay video signals is zero. Since successive video pulses of fixed targets are equal, this portion of MTI video is cancelled out. However, successive video pulses of moving targets are not equal in amplitude. Therefore, when these pulses are compared, there is a residual pulse (F and G, fig. 27) caused by incomplete cancellation. The residual pulse may be positive or negative, depending upon which of the two moving target video pulses is larger.

(*d*) The residual signal from the junction of R4 and R5 (B12) is applied to phase splitting amplifier V5. One half of V5 inverts the residual signal and furnishes a residual video output designated phase one video (F, fig. 27). Part of this signal is cathode-coupled to the other half of V5, a grounded-grid amplifier. The output of this half of V5, designated phase two video (G, fig. 27), is also residual video which is 180 degrees out of phase with phase one video. These outputs are applied to the MTI video amplifier.

(2) *MTI automatic synchronizer circuit.* The MTI automatic synchronizing circuit selects a preknock pulse from the delay video which, together with a preknock pulse from the acquisition-track synchronizer, provides a combined auto sync

pulse and a disabling pulse for the acquisition-track synchronizer.

(*a*) The MTI auto sync and disabling pulse is developed by trigger selector diode V1A (B11), trigger selector amplifier V1B, and cathode follower V2A. The same delay video as that applied to the MTI comparison circuit is applied to V1 of the MTI automatic synchronizing circuit. Section V1A is designed to select the negative 4-volt delayed preknock pulse from the delay video compound signal. Since only a negative input to V1A affects conduction, only the negative preknock pulse is passed by V1A. This produces a negative output pulse that is amplified and inverted by V1B. From V1B the positive 66-volt pulse is applied to cathode follower V2A and is then combined with a negative 32-volt, 2000-microsecond disabling pulse from the output of phantastron V3 (D12). Since the first delayed preknock pulse occurs 2000 microseconds after the first nondelayed preknock pulse supplied by the acquisition-track synchronizer, each auto sync pulse occurs in time with each successive nondelayed preknock pulse.

(*b*) The disabling pulse is produced by phantastron V3, crystal diode CR2, cathode follower V4B, and crystal diode CR1 (C12). Phantastron V3 is a conventional phantastron triggered by LOPAR preknock received directly from the acquisition-track synchronizer. However, with the addition of cathode follower V4B, a modified phantastron circuit is formed. In this case, plate voltage changes at V3 are transferred through V4B to the control grid of V3. Diode CR2 limits the maximum value of V3 plate voltage, producing a shorter than normal gate width. Diode CR1 is a negative clamper which holds the negative gate from phantastron V3 below a zero reference level. The negative gate, designated the disabling pulse, has a total time duration of 2000 microseconds and contains a steep negative leading edge, a flat portion of approximately 1500 microseconds, and an exponentially rising trailing edge for a period of 500 microseconds. The leading edge of the disabling pulse appears in time immediately following the completion of the MTI auto sync pulse. The positive 10-volt MTI auto sync pulse (fig. 3) and the negative 32-volt disabling pulse are combined for application through a common cable to the acquisition-track synchronizer. When the pulses are combined, the positive-going trailing edge of the disabling pulse forms a pedestal for the auto sync pulse, with a peak-to-peak amplitude of approximately 42 volts.

(3) *MTI cathode follower circuits.*

(*a*) The nondelay video applied from the delay line driver to paraphase amplifier V5 is also applied to cathode follower V2B (A11).

(*b*) The delay video applied from the delay amplifier to paraphase amplifier V5 is also applied to cathode follower V4A (A12). Cathode follower V4A isolates the acquisition interference suppressor output from the input of V5.

c. During the time that the processor video mode and either the AJD or basic receiver are selected, processor on relay K1 (B11) is energized (par. 63*d*). Relay K1 is energized by a ground being applied through contacts 10 and 4 (D38) of energized AJD receiver relay K10 and contacts 4 and 10, and 9 and 2 of energized processor on relay K7 (C41) when the AJD receiver is selected. Relay K1 is also energized by a ground being applied through contacts 8 and 12 (C41) of energized basic receiver relay K8, and contacts 9 and 2 of energized relay K7 when the basic receiver is selected. Energizing relay K1 permits delay video to be applied to cathode follower V4A (A12) without being applied through delay networks Z1 and Z2. The delay video is applied to the acquisition interference suppressor (par. 69).

68 (U). MTI Video Amplifier

a. The MTI video amplifier (fig. 26) amplifies and detects residual video to produce the MTI video. In addition, this amplifier develops an AGC voltage for the delay amplifier.

Note. The grid zone references shown in parentheses in *b* below refer to figure 28, TM 9-1430-254-20/6, unless otherwise indicated.

b. The MTI video amplifier (C14) receives residual video, consisting of phase 1 video and phase 2 video, from the trigger pulse-video amplifier. These residual video signals are 180 degrees out of phase with each other and contain the uncancelled portion of the video pulses compared in the trigger pulse-video amplifier. Only the residue of moving target video appears at the input to the MTI video amplifier. The residual video is amplified and detected to produce negative MTI video (H, fig. 27). This MTI video circuit is discussed in (1) below. When residual video consists of more than uncancelled moving target video, additional circuits produce an AGC voltage to adjust the gain of the delay amplifier, (2) below.

(1) *MTI video circuit.* Phase 1 video is applied to phase 1 amplifier V1A (A14) while phase 2 video is applied simultaneously to phase 2 amplifier V1B. The amplified video outputs, 180 degrees out of phase with each other, are applied to the MTI video full-wave crystal rectifier consisting of crystal diodes CR1, CR2, CR3, and CR4 connected as a bridge circuit. Rectification of the two video inputs produces a negative video voltage that appears across MTI VIDEO variable resistor R10. The output voltage from R10, designated MTI video (H, fig. 27), is applied to the acquisition interference suppressor. Phase 2 amplifier V1B (B14) supplies a sample video signal designated MTI test video. The MTI test video is supplied to the MTI oscilloscope (par. 72) as a monitoring signal.

(2) *AGC circuit.* Whenever the gain of the delay and the nondelay channels is not equal, the MTI test pulse cannot be completely cancelled in the comparison circuit of the trigger pulse-video amplifier. Consequently, an MTI test pulse residue appears at the output of phase 2 amplifier V1B in the MTI video amplifier. A portion of this output is supplied to cathode follower V3A (B15) in the AGC circuit. The AGC circuit consists of cathode follower V3A, video amplifier V3B, push-pull amplifier V4A and V4B, gate stages V5 and V6, bistable multivibrator V7, and cathode follower V2B. From V3A the signal passes through grounded-grid video amplifier V3B without changing phase. Both positive and negative limiting is achieved in this stage. The output signal from V3B is further amplified and limited by cathode-coupled, push-pull amplifiers V4A and V4B, a phase-splitting circuit. The outputs from the plates of V4A and V4B are applied 180 degrees out of phase to gate stages V5 and V6, respectively.

(*a*) Stages V5 and V6 are gated open by the MTI test pulse (C15) received directly from the acquisition-track synchronizer in the director station group. The gating pulse (MTI test pulse) is applied through isolating resistor R29 and a capacitance voltage divider, consisting of capacitors C13 and C12. Gate stages V5 (C15) and V6 can produce outputs only when the gating pulse from C12 and a signal from V4A and V4B, respectively, are present simultaneously. For example, when the MTI test pulse is applied to the suppressor grids of V5 and V6, and the amplitude of nondelay video is greater than that of delay video, the MTI test pulse residue is negative at the input of phase 2 amplifier V1B. Consequently, the outputs of V1B, V3B, and V4B are positive, causing a positive pulse to appear at the output of V5 and a negative pulse at the output of V6.

(*b*) From gate stages V5 and V6, the two test pulse residue signals of opposite polarity are applied to opposite control points of bistable multivibrator V7. This multivibrator, consisting of two triode sections, develops an output signal which is integrated by resistor R40 (C14) and capacitor C16. From the junction of R40 and C16, the signal is applied through AGC cathode follower V2B to positive limiter crystal diode CR5, which prevents the integrated output voltage from going positive. This output is the negative AGC voltage (par. 66*b*) supplied as dc control bias to the delay amplifier. The value of this AGC voltage varies as the delay and nondelay channel balance varies, increasing or decreasing delay amplifier bias to counteract unbalance between the two channels.

69 (U). Acquisition Interference Suppressor

Note. The grid zone references shown in parentheses in this paragraph refer to figure 28, TM 9-1430-254-20/6.

a. The acquisition interference suppressor is part of the anti-jam display. All system video signals pass through this unit except jam strobe video. The video inputs to the acquisition interference suppressor are: bypass video, delay video, nondelay video, and MTI video. The video output may be processor, interference suppressor, or normal video depending on the mode selected and will appear as processor feedback, bypass video, processor video, or MTI video. In the basic receiver with MTI mode of operation, the bypass video and the MTI video are passed through the unit without alteration while the delay and nondelay videos are not used.

b. MTI video is applied through connector J5 (C19) to the base of emitter follower Q3 (D21). Diode CR33 clips the positive portions of the MTI video. Emitter followers Q1 through Q3 make up a transistor driven AND gate and have a high input impedance to minimize loading to the input sources. When operating in the normal mode, IS on relay K1 is deenergized and the bases of Q1 and Q2 are fixed at −3 volts by the voltage divider network made up of resistors R67 through R70 (D21) between −250 volts and ground. The −3 volts is obtained across R67 and applied through contacts 5 and 11 of deenergized relay K1, and through diodes CR37 and CR38 to transistors Q2 and Q1, respectively. This action permits MTI video to transfer through the AND gate. The MTI video signal is developed at the emitter of Q3 and is coupled through diode CR27, and applied to the grid of cathode follower V1B (D22). Diodes CR25, CR26, and CR27 isolate the three transistor stages and are part of the AND gate circuit. The output signal is applied directly to the grid of cathode follower V4B. Diode CR29 functions to prevent damage to V4B in the event that tube V1 is removed with power on. The output of cathode follower V4B is applied to connector J6 (D24).

c. When relay K1 is energized, the −3-volt bias is removed from the base of emitter followers Q1 and Q2. The MTI video signal output at connector J6 is dependent on the coincidence of delay, nondelay, and MTI video signals at the AND gate. The output of the AND gate is the smallest of three separate inputs, and since the delay and nondelay video signals are always larger than the MTI video, these act as gates for the MTI video. The amplitude of the output signal is determined by the amplitude of the MTI input signal. When the video signals are not coincident, there is no output from the AND gate, and extraneous noise and jamming signals are blocked.

d. Bypass video is applied through connector J3 (A19). During the normal mode of operation, the bypass video is applied through contacts 10 and 3 (A21) of deenergized relay K1, and through contacts 1 and 9 (A24) of deenergized relay K1 directly to connector J4 to the external circuit. During the interference suppressor mode of operation, bypass video is terminated through contacts 10 and 4 of energized relay K1 (A21), across resistor R1 to ground.

e. During the interference suppressor mode of operation, a signal at connector J4 is dependent on the time coincidence of the delay and nondelay video input signals. This random signal suppression reduces the effectiveness of random noise and side-lobe jamming as well as railing, walking pulses, and friendly interference signals.

f. Nondelay video is applied to connector J2 (C19), through secondary winding 5, 6 of transformer T1, and applied to the control grid of amplifier V7 (C21). Diode CR21 clips positive portions of the nondelay video signal. The nondelay video signal is amplified and inverted in amplifier V7, and coupled directly to grid 7 of nondelay bypass amplifier V6B (C23) and suppressor grid 7 of multiplier V3 (A22). Grid 7 of V3 functions as a control grid when this tube is used in a coincidence stage.

g. Delay video, which is delayed for one pulse repetition period from the nondelay video, is applied through connector J1 (B19), to the grid of amplifier V1A. The signal is amplified and inverted by V1A. The output of V1A is coupled through secondary winding 3, 4 of transformer T1 and applied to the control grid of amplifier V2 (A20). Diode CR2 clips any positive portions of the video signal. The signal is amplified and inverted by amplifier V2, and coupled directly to grid 3 of delay bypass amplifier V6A (B23) and to control grid 1 of multiplier V3.

h. The suppression of random signals and the amplification of sweep-to-sweep coincident signals is accomplished by the application of the delay and nondelay video signals to the two control grids of multiplier V3. Multiplier V3 is a dual control pentode. The interdependent control characteristics of the two grids of this tube permit biasing to points where the stage acts as an effective coincidence circuit. The amplitude of the signal present at control grid 1 may be considered as a controlling voltage that determines the multiplying constant for the signal present on grid 7. The output of multiplier V3 is applied to the grid of phase splitter V4A. Since the gain of V6A and V6B is almost negligible with processor on relay K2 deenergized, it contributes almost nothing to the input of phase splitter V4A (A23).

i. Phase splitter stage V4A has two outputs, one of which is applied through contacts 2 and 9 (A24) of energized relay K1 to connector J4. The other output signal from V4A is applied through connector J7 (A24) to the delay line driver (par. 64) as processor feedback.

j. Test switch S1 (B24) selects either MTI video or processor video to be applied to connector J8 for monitoring purposes.

k. When relay K2 (B20) is energized, relay K1 is also energized, since a ground connection is made through contacts 8 and 12 of energized relay K2 (B20). The cathode circuit of delay and nondelay bypass amplifiers V6A (B23) and V6B is changed by the application of +150 volts to terminal 1 of delay processor adjust variable resistor R35 (B23) through contacts 2 and 9 energized of relay K2, and to terminal 1 of nondelay processor adjust variable resistor R37 through contacts 10 and 4 of energized relay K2. This action causes the operating voltage on the cathodes of V6A and V6B to shift so that the gain of each section of V6 may have a maximum gain of 0.4. The gains of delay and nondelay bypass amplifiers V6A and V6B are now controlled by adjustment of variable resistors R35 and R37. During the processor mode of operation, the proportion of delay and nondelay video that bypass the multiplier stage can be independently controlled by the gain setting of the respective section of delay and nondelay bypass amplifiers V6A and V6B.

l. The grid bias of multiplier V3 (A22) is determined by the plate current of amplifier V2 (A20) for grid 1 and the plate current of amplifier V7 (C21) for grid 7. This requires that the plate current of amplifiers V2 and V7 be held constant for long periods of time to prevent performance degradation. The video gate, used to generate the video "quiet period" in the MTI system, is used to operate gates for sampling the grid signals of multiplier stage V3. Video gate 1 is applied through connector P1-1 (B19) coupled through capacitor C13 to the gate shaping circuit composed of diodes CR8 (B20), CR9, CR10, CR11, capacitor C14, and resistors R23 and R24. The action of the gate shaping circuit is explained in *m* below.

m. The operation of the video gates used in this circuit at a +150-volt reference requires that the video gate input be ac coupled. The gates must carry approximately 0.5 ma of current during the on time and must be back-biased to cause adequate isolation during off time. The charge accumulated on coupling capacitor C13, when the input gate signal is positive, is discharged through resistor R23 during the off time while the input gate signal is negative. The input signal is referenced to +142 volts which is obtained from the voltage divider network composed of resistors R26 and R28 between +150 volts and ground. Capacitor C14 stabilizes this voltage and holds it constant. When the positive input gate signal is coupled through capacitor C13 the total voltage is the sum of the reference voltage and the +68-volt input signal for a total voltage of +210. This voltage will close the gate switches for 23 microseconds and the gate output will rise to +150 volts. After the 23-microsecond interval, the voltage across resistor R23 goes negative and the gate switches open. The gate output will at this time return to +142 volts and remains for the remainder of the sweep time of approximately 2000 microseconds until the next positive gate pulse is applied at connector P1-1. The video gate 2 signal at connector P1-5 is equal and opposite in polarity to the video gate 1 signal. The input to the gates is prevented from rising above +210 volts in each channel by Zener diodes CR9 and CR10 which are 68-volt diodes. The input voltage to the gates is prevented from dropping below +142 volts by the reference voltage established in the voltage divider consisting of resistors R26 and R28.

n. For correct operation of the bias control loop it is necessary that there be no signal present on the grid of multiplier V3 (A22) during the time between preknock and the leading edge of the test pulse. The preknock pulse which is the opposite polarity of video is inserted into the circuit through J9 (C19) and the secondary windings of transformer T1 to insure that no signal appears at the multiplier grid during the time between the preknock pulse and the leading edge of the test pulse.

o. During the 23-microsecond on time of the diode gates (B20), a 7-microsecond positive signal and receiver noise is applied to the input of the two gates. One input is from the plate circuit of V7 and is applied at the junction of CR16 (B21) and CR17. The other signal is applied from the plate circuit of V2 to the junction of CR14 and CR15. Since the gates are on at this time, the positive 7-microsecond test pulse and receiver noise is passed through the gates and applied to the grid of V5A or V5B (C21). Since AGC amplifiers V5A and V5B are identical, only the action in stage V5B will be discussed. The grid of V5B is biased at a voltage between 0 and −10 volts by the voltage divider consisting of resistor R49 and nondelay bias adjust variable resistor R48 between −250 volts and ground. The amount of bias is determined by the setting of variable resistor R48. The 7-microsecond test pulse and receiver noise are applied through diode CR23 (C22), developed across resistors R47 and R46, and applied to the grid of V5B. The positive pulse is blocked from the grid bias reference circuit by diode CR24 but is passed through CR23. The current in V5B is held fairly constant for a long period of time. The output of V5B is coupled through Zener diode CR22 to the screen grid of V7. The voltage drop across normally conducting Zener diode CR22 is held constant at +68 volts so that the screen grid of V7 is operating at a relatively low potential. The gain of V7 is held constant for the long period of time between the video gate on pulses. During the gate on time, normal receiver noise causes the screen grid of V7 to rise to a voltage determined by the noise level. The effect of the 7-microsecond test pulse which is applied during the preknock to sync time is offset by the application of a distorted preknock pulse of the opposite polarity to the secondary windings of transformer T1. Therefore, the receiver noise level, which is applied during the gate on time, establishes the gain level for V7 during the remainder of the sweep time.

70 (C). Electronic Gate

a. The electronic gate in the moving target indicator (MTI) circuits consists of eight electronic tube stages performing eleven functions. This unit is adjusted to determine the sector area and range in which the MTI video is to be displayed on the plan position indicators (PPI's) in the presentation system.

b. The electronic gate receives three information and four control signal inputs. The information input signals are the MTI video, jam strobe (JS) video, and the bypass or processor video (dickefix when in the AJD mode). The gate circuits determine which of these signals appear in the output. The control input signals are the 4-kilocycle reference carrier, the modulator 4-kilocycle carrier, the MTI range control voltages, and the preknock pulse. These signals are used by the control circuits which determine the range and sector of MTI video presentation on the cathode-ray tube (CRT) indicators.

c. The MTI circuits can be used or bypassed without disrupting other operating portions of the system. While in use, these circuits may be operated to give full 360-degree coverage (3, fig. 28) on the face of the CRT (5, fig. 28), or over a selected sector of controlled width. The MTI circuits may also be operated over the full range or any portion of the range, of the system. When MTI is selected, it is electronically shut off at some predetermined range by the electronic gate and is replaced with one of the other modes for the remainder of the sweep range (4, fig. 28). In selected systems using AAR, MTI control relays K12 and K14 (C56) transfer sector and range control circuits to the ECCM console. The sector and range control circuits function identically when controlled from the ECCM console as described below.

Note. The grid zone references shown in parentheses in *d* below refer to figure 28, TM 9-1430-254-20/6 unless otherwise indicated.

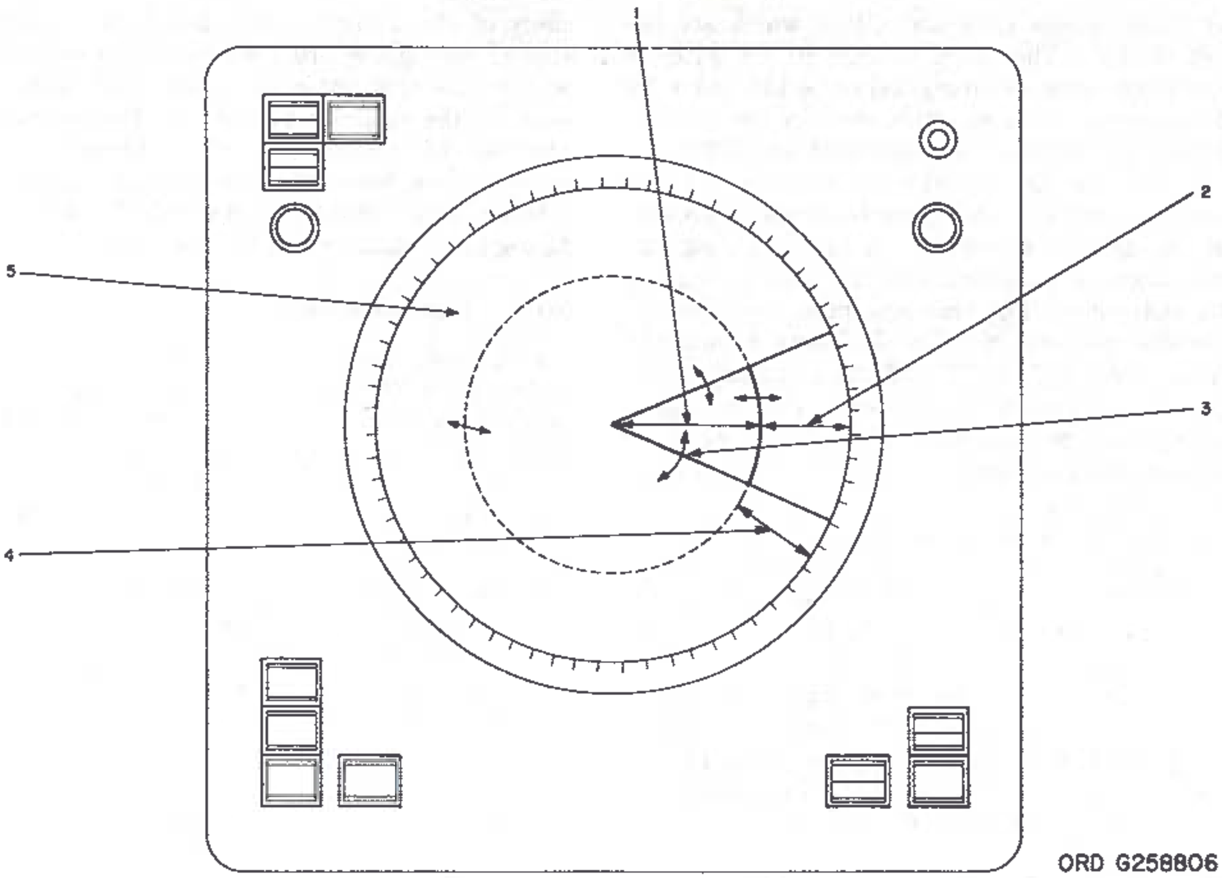


Figure 28(U). LOPAR video display areas—PPI (U).

1—Variable MTI video range (0 to 250,000 yds)
2—Variable bypass video range (0 to 250,000 yds)
3—Variable MTI and bypass video section (0 to 360 degrees)
4—Bypass video area remaining after MTI video range selection
5—Face of cathode-ray tube

Figure 28 (C). LOPAR video display areas—PPI—legend (U).

d. Within the electronic gate, the gating operation, (1) below, is performed by gating multivibrator V5A (A33) and V5B, gate generators V6A and V6B, gating amplifier V7A and V7B, and associated circuits. These stages acting as an electronic switch determine whether MTI video, or bypass or processor video is passed to the video and mark mixer (par. 71). When sector and range coverage is desired for the presentation of MTI video, the control operation discussed in (2) below is performed by clipper amplifier V1A (B32), 4-kc detector V1B, preknock selector V2, range phantastron diode-1 V3A, range phantastron V4, range phantastron diode-2 V3B, and associated circuits.

(1) *Gating circuits.* MTI video (H, fig. 27), consisting of negative pulses representing moving targets, is applied to gating amplifier V7B (B32). At the same time, bypass or processor video containing all target information is applied to gating amplifier V7A (A32). Diodes CR2 and CR3 provide positive clamping of their respective input signals. Gating multivibrator V5A and V5B, and gate generators V6A and V6B control the conduction of gating stages V7A and V7B, allowing only one tube to operate at a time. Consequently, this gating action determines whether MTI video, or bypass or processor video is passed to mixer V8A. Gating multivibrator V5A and V5B is triggered by a negative pulse

(D, fig. 29) from range phantastron V4 (B33) in the control circuits discussed in (2) below. This stage is a bistable multivibrator with a direct-coupled load.

Mixer stage V8A and V8B, and associated components provide mixing of JS video with the other selected modes. When V5A receives a trigger pulse from

range phantastron V4, a positive gate pulse (G, fig. 29) is produced at the output of V5A and coupled through V6A to V7A. This action cuts off V7A and no bypass or processor, or dicke-fix video can pass. At the same time, V5B produces a negative gate (F, fig. 29) for the input of V7B (B32). As V7B conducts during the gate time, MTI video is passed through V7B to V8A through contacts 1 and 6 of deenergized JS only relay K2 (A34). In order for V7A and V7B to supply an output of equal amplitude, SW BAL variable resistor R45 (B32) is provided for bias adjustments. The video outputs of V7A or V7B are applied to mixer V8A. The output of V8A is applied to the video and mark mixer.

(2) *Control circuits.* Gating multivibrator V5A (A33) and V5B, which determines whether V7A or V7B is gated open, is triggered by range phantastron V4 (B33). Development of the trigger pulse output of V4, with its sector and range selection components, is discussed in (*a*) through (*d*) below.

(*a*) *Sector and sector-width selection.* A steady 4-kilocycle reference carrier signal (B, fig. 30) from the 4-kc oscillator is applied to one end of 4KC ADJ variable resistor R1 (C31). A modulated 4-kilocycle carrier (A, fig. 30) from the rotor of MTI SECTOR ANGLE resolver B1 (B43), in the LOPAR auxiliary control-indicator, is applied to the opposite end of R1. The modulation is developed from the 4-kilocycle N-S and E-W acquisition antenna position signals which are applied to the acquisition azimuth resolver. For each 360 degrees of antenna rotation, one cycle of amplitude modulation is produced which contains two crests (A, fig. 30). When a crest (antinode) is out of phase with the reference carrier at 4KC ADJ variable resistor R1, a null is produced. The null (C, fig. 30) corresponds to the center of the sector over which MTI video is displayed. The frequency of the modulated 4-kilocycle output of R1 is dependent upon the speed of rotation of the acquisition antenna. When the MTI SECTOR ANGLE knob (B43) is turned to reposition the rotor of resolver B1, the frequency of the modulation envelope remains constant but the antinodes of the waveform (A, fig. 30) are moved to the left or right depending upon the direction of rotor change. From resistor R1 (C31) the resultant modulated 4-kilocycle signal (C, fig. 30) is applied to clipper amplifier V1A (B32). After the signal is amplified and clipped by V1A, only the negative half appears in the output (D, fig. 30). This output signal is demodulated and clipped above zero volts by 4-kc detector V1B, producing an output representing the negative modulation envelope (E, fig. 30). The level of V1B, clamped by SECTOR WIDTH variable resistor R8, determines the width of the zero voltage null (E, fig. 30). Since the null is used to gate preknock selector V2, widening of this portion increases clipping and produces a wider MTI sector (3, fig. 28). Preknock selector V2, a coincidence stage, receives both the negative azimuth gate pulse from V1B and the positive 1-microsecond preknock pulse (A, fig. 29) from the acquisition-track synchronizer in the director station group. The gated preknock output of V2 (B, fig. 29) is a series of negative preknock pulses. The number of these pulses that are passed depends upon the zero voltage time of each gate pulse and the selection of sector MTI mode of operation. During 360° MTI mode, the gating pulses for control of V2 (B33) are grounded through contacts 9 and 1 of deenergized sector MTI relay K5 (B37), contacts 1 and 6 of deenergized MTI mode relay K6, (*c*) below, and connector PI-13 (C35). All preknock pulses to V3A pass, causing MTI to be displayed over the full 360 degrees of azimuth (3, fig. 28). During sector MTI mode, relay K5

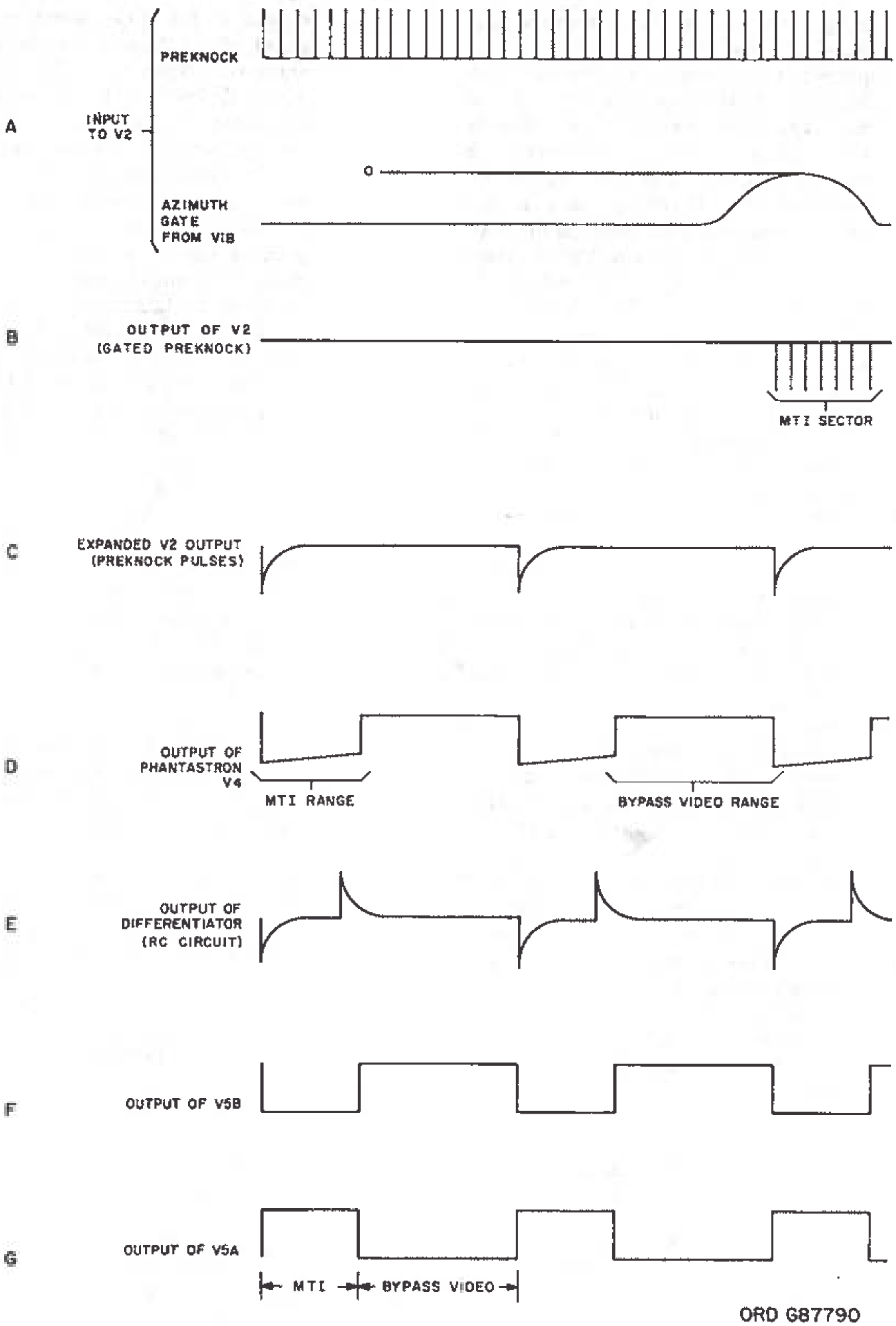


Figure 29 (U). MTI sector selection—waveforms—ideal (U).

(B37) is energized removing the ground on V2 and one gate (A, fig. 29) appears for each antenna revolution at a time coincident with the azimuth point determined by sector selection and with a duration determined by the setting of SECTOR WIDTH variable resistor R8 (C32).

(b) *Range selector.*

1. The output of V2 (F, fig. 30 and B, fig. 29) (B33), consisting of a series of negative preknock pulses, is applied to range phantastron diode-1 V3A. For each preknock pulse supplied to V3A (fuhctioning as an isolation stage), a negative output signal is produced. These signals are applied to the control grid of range phantastron V4, a conventional phantastron. The leading edge of the phantastron pulse (C, fig. 31) is in time coincidence with each gated preknock pulse (B, fig. 31). A negative pulse in the plate circuit of V4 is isolated from the loading effects of the range control circuits by range phantastron diode-2 V3B.

2. A fixed value dc voltage is applied to the cathode circuits of diode V3B. Current flows from ground through resistor R27 (D34), SECTOR RANGE variable resistor R25, connector P1-3, contacts 4 and 10 of energized sector MTI relay K5, contacts 4 and 5 of deenergized MTI mode relay K6, connector P1-7, MTI CKT TEST switch S1C (D30), P1-11, range phantastron diode-2 V3B, and resistor R16 toward +250 volts. This dc voltage and the operation of V3B (C33) limit the maximum plate voltage that can be developed at range phantastron V4. Varying the dc voltage varies the width of the phantastron output pulse, thereby controlling the range within which MTI video is displayed.

3. The negative rectangular wave output from the cathode of V4 (C, fig. 31) (B33) is differentiated by capacitor C15, and resistors R20 and R21. Differentiation produces sharp negative and positive spikes (D, fig. 31). The differentiated pulses are applied to the control grid of bistable gating multivibrator V5A (A32). When the negative pulse triggers V5A, it produces a positive pulse gate (G, fig. 31) to video gate V6A. Tube V6 acts somewhat like a cathode follower, coupling the gate outputs from V5 to gating amplifier V7A. With a positive gate applied to the grid of V6A, plate current will increase causing a large voltage drop across common cathode resistor R44 (A32). This positive voltage, also developed at the cathode of V7A, will bias the tube beyond cutoff. Therefore, the bypass video (dicke-fix video if IF select relay K1 is energized (par. 51c)), applied to the grid of V7A will not be amplified. With the negative gate applied to the grid of V6B, the tube will be cut off, reducing the voltage developed across common cathode variable resistor R45 (B31). With the bias on V7B reduced, the MTI video applied to its grid will be amplified. Conversely, when no MTI trigger is present, V6A will be cut off, reducing the voltage developed across common cathode resistor R44. With the bias on V7A reduced, any bypass or processor, or dicke-fix video applied to the grid will be amplified. By the same reasoning, V7B will now be cut off due to increased plate current through V6B. SW BAL variable resistor R45 is adjusted to equalize conduction on both halves of V7 so the switching waveform will not appear in the plate circuit.

(c) *MTI off.* When neither SECTOR MTI nor 360° MTI mode is selected (switch-indicators A8 and A7 illuminated white), the cathode-ray tube sweeps display bypass video only, and the output of 4-kc detector V1B (B32) is grounded through contacts 9 and 1 of deenergized relay K5 (A37), contacts 1 and 6 of deenergized MTI

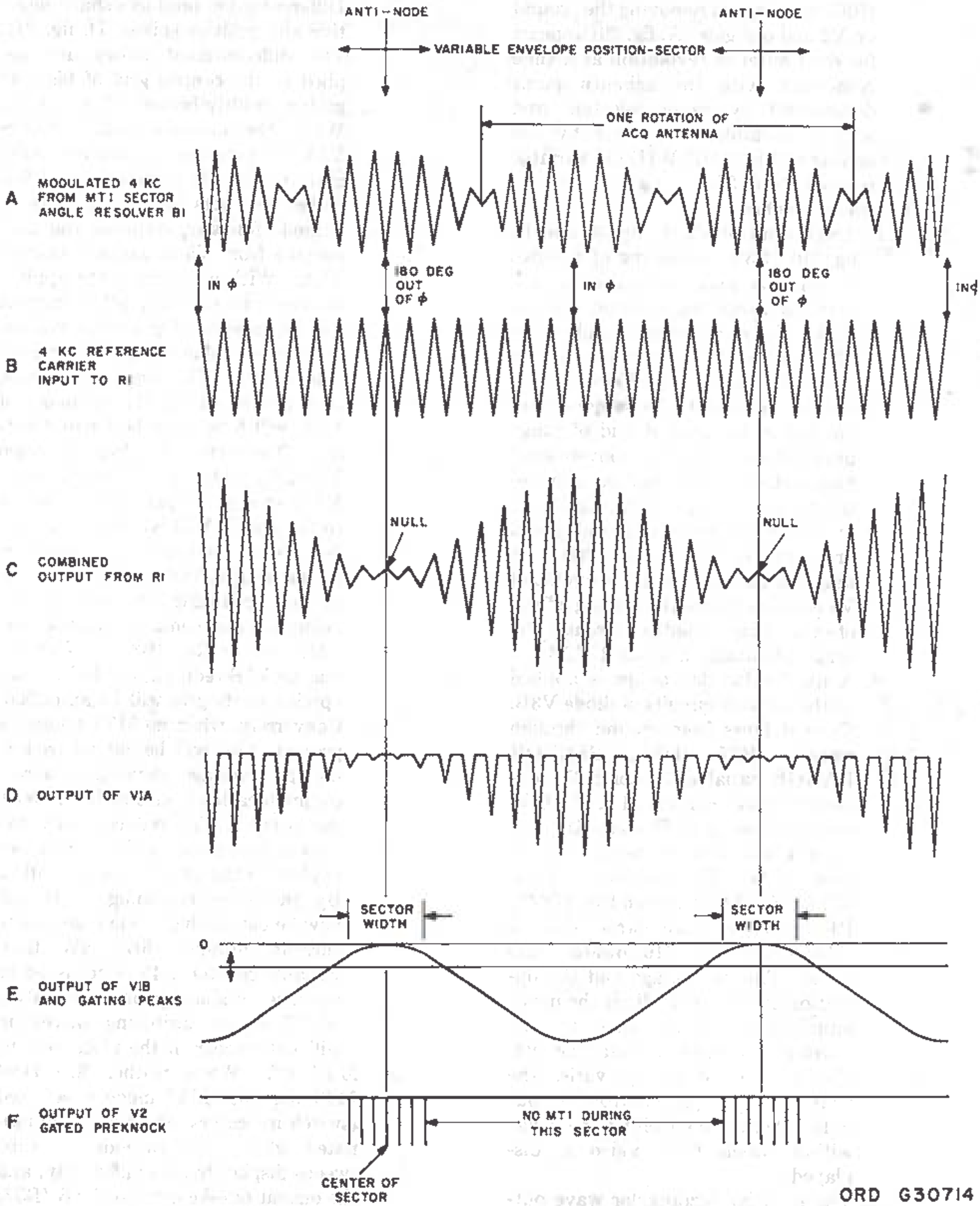


Figure 30 (U). MTI control circuits—waveforms—ideal (U).

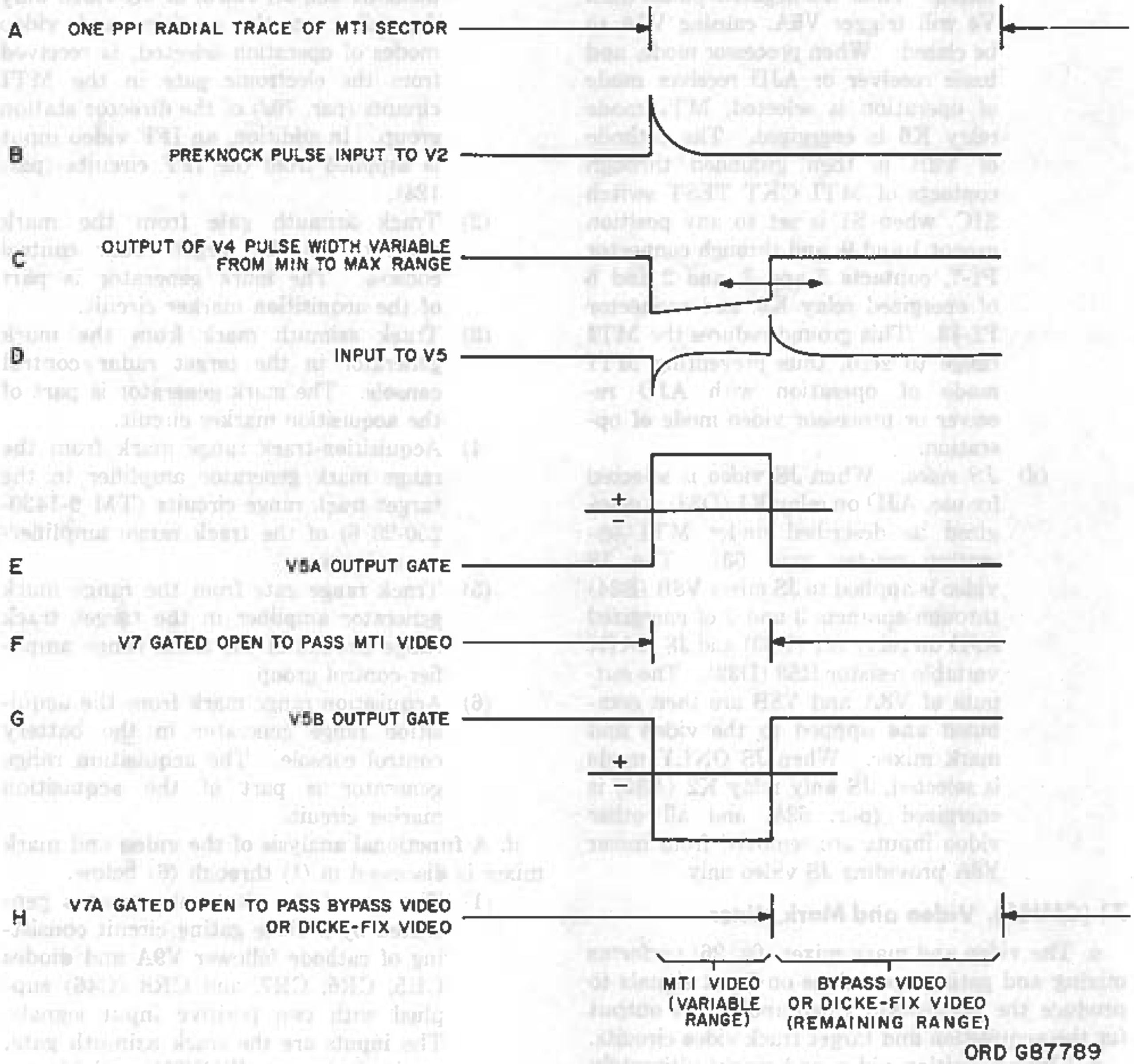


Figure 81 (U). MTI range selection—waveforms—ideal (U).

mode relay K6, and connector P1-13 (C35). At the same time, the cathode of V3B is grounded through contacts of MTI CKT TEST switch section S1C (C29) on the MTI oscilloscope when S1 is set to any position except 1 or 9, and through contacts 5 and 4 of deenergized relay K6, contacts 10 and 3 of deenergized relay K5, section S1D of switch-indicator A7, contacts 1 and 6 of deenergized relay K6, and connector P1-13. Since the output of V1B (C32) is grounded, there is no input gate supplied to preknock selector V2 (B33) and preknock pulses supplied from the acquisition-track synchronizer continuously pass through V2 and V3A to V4. Since the cathode of V3B is also grounded at this time, V4 operates as an amplifier stage to produce negative pulses too short in duration to be differentiated. Thus, the negative pulses from V4 will trigger V5A, causing V7A to be closed. When processor mode, and basic receiver or AJD receiver mode of operation is selected, MTI mode relay K6 is energized. The cathode of V3B is then grounded through contacts of MTI CKT TEST switch S1C, when S1 is set to any position except 1 and 9, and through connector P1-7, contacts 5 and 3, and 2 and 6 of energized relay K6, and connector P1-13. This ground reduces the MTI range to zero, thus preventing MTI mode of operation with AJD receiver or processor video mode of operation.

(*d*) *JS video.* When JS video is selected for use, AJD on relay K1 (D33) is energized as described under MTI operating modes (par. 63). The JS video is applied to JS mixer V8B (B34) through contacts 3 and 5 of energized AJD on relay K1 (D33) and JS GAIN variable resistor R53 (D32). The outputs of V8A and V8B are then combined and applied to the video and mark mixer. When JS ONLY mode is selected, JS only relay K2 (A34) is energized (par. 63*h*) and all other video inputs are removed from mixer V8A providing JS video only.

71 (CMHA). Video and Mark Mixer

a. The video and mark mixer (fig. 26) performs mixing and gating operations on input signals to produce the acquisition video and marks output for the acquisition and target track video circuits.

b. The acquisition video and marks ultimately displayed by the presentation system (par. 73) indicate the polar coordinates of the target (target video), the azimuth of the track antenna (radial segment of the electronic cross), the range setting of the target track range unit (arc of the electronic cross), and the IFF video symbols.

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 28, TM 9-1430-254-20/6, unless otherwise indicated.

c. The video and mark mixer (D47) receives the input signals listed in (1) through (6) below.

(1) LOPAR video, consisting of bypass or processor video with or without MTI, dicke-fix and JS video, or JS video only depending on the receiver and video modes of operation selected, is received from the electronic gate in the MTI circuits (par. 70*d*) of the director station group. In addition, an IFF video input is supplied from the IFF circuits (par. 124).

(2) Track azimuth gate from the mark generator in the target radar control console. The mark generator is part of the acquisition marker circuit.

(3) Track azimuth mark from the mark generator in the target radar control console. The mark generator is part of the acquisition marker circuit.

(4) Acquisition-track range mark from the range mark generator amplifier in the target track range circuits (TM 9-1430-250-20/6) of the track range amplifier-control group.

(5) Track range gate from the range mark generator amplifier in the target track range circuits of the track range amplifier-control group.

(6) Acquisition range mark from the acquisition range generator in the battery control console. The acquisition range generator is part of the acquisition marker circuit.

d. A functional analysis of the video and mark mixer is discussed in (1) through (6) below.

(1) The arc of the electronic cross is generated by a diode gating circuit consisting of cathode follower V9A and diodes CR5, CR6, CR7, and CR8 (C46) supplied with two positive input signals. The inputs are the track azimuth gate, received through WIDTH variable resistor R25 (C45), and the acquisition-track range mark, received through contacts 4 and 5 of track cross off relay K3. The acquisition-track range mark, a sharp, positive, 0.25-microsecond pulse, occurs at the rate of one for each PPI sweep generated. The track azimuth gate, a positive-going triangular pulse upon a pedestal, referenced to a negative, 70-volt level, occurs for several PPI sweeps. The diode gating circuit conducts only when both the mark and gate pulses are applied in time coincidence. A

voltage divider consisting of R19, R6, R29 (C46), R104, and R103 (D46) tend to set the anodes of CR5, CR7, and CR8 to a negative potential but CR6 clamps this level to 0 volt. The track azimuth gate applied through cathode follower V9A causes CR8 to cut off eliminating current flow through this leg of the voltage divider network. The acquisition-track range mark applied to C31 reduces the current through R19 and CR5 allowing the voltage at the anode of CR7 to rise proportionately. The mark is amplified by V1 and appears alone in the output as a series of negative pulses. The pulses appear for the duration of the azimuth gate, preventing a complete circle from being traced on the PPI. These pulses form the arc portion of the electronic cross. The time of presentation for the arc portion is adjusted by WIDTH variable resistor R25 (C45). This resistor varies the gate length so that V9A conducts for approximately 180 mils of the acquisition antenna rotation.

(2) The radial line of the electronic cross is generated by a gating circuit consisting of diodes CR12, CR13, CR14, and CR15 (D46) in a manner similar to generation of the arc of the electronic cross by diodes CR5, CR6, CR7, and CR8. However, the input signals are applied in time coincidence directly to the cathodes of diodes CR12 and CR14. These signals are the track azimuth mark, a positive, 1525-microsecond square wave, and the track range gate, a positive, 5000-yard (30 microseconds) square wave. When both pulses are applied simultaneously, the diode gate conducts and produces at its output a 5000-yard gate pulse, representing a segment of the track azimuth mark. This gate forms the radial line of the electronic cross and appears once per revolution of the acquisition antenna at the azimuth and range setting of the target track antenna.

(3) The inputs to amplifier V1 (D47) consist of a positive azimuth mark from CR7 and a positive 5000-yard range mark from CR13. In addition, the IFF video from diode CR19 (C46) is applied to V1. The amplitude of the IFF video is controlled by IFF VIDEO variable resistor R69 (C46). Crystal diodes CR19, CR7, and CR13 are used to prevent interaction between the three input signals to V1. The signals are amplified and inverted by V1 and applied to limiter V2 (D47). Limiter V2 along with CR3 and limit level variable resistor R15 limits the amplitude of the outputs of V2. Zener diode CR24 (C51) reduces the amount of power dissipated through limiter stages V2 and V5 by limiting the amount of current flow from the —250 volt source through V2 and V5. The output signals are applied through a dc restorer and cathode follower V3 (D50) to J12 (D52). The output of V2 is also applied to amplifier V4B (C50).

(4) The HIPAR video (A43) is applied from the HIPAR equipment through the auxiliary acquisition interconnecting box to a cathode follower and amplifier circuit in the auxiliary resolver amplifier. The HIPAR video is applied through cathode follower V1B (A44) to video amplifier V1A. The output of V1A is applied through cathode follower V2 to connector J9 on the video and mark mixer. The amplitude of the HIPAR video received from the input at connector J9 (A47) is adjusted with HIPAR–AAR VIDEO variable resistor R71 and is applied through a dc restorer to video amplifier V9B. The HIPAR output signal path from V9B and the LOPAR signal path from connector J6 depends upon which acquisition radar is selected as described in (5) below.

(5) The acquisition radar input to limiter stages V10 (B47) and V7 (A49) is determined by the acquisition radar selected. When LOPAR is selected,

HIPAR video from V9B (A48) is applied to limiter stage V10 (B47) through contacts 1 and 6 of deenergized HIPAR-LOPAR select relay K2 (B47) and contacts 6 and 5 of switch S1. LOPAR video from connector J6 (B47) is applied through contacts 4 and 5 of deenergized relay K2 (A48) to limiter stage V7 (A49). When the HIPAR mode is selected, HIPAR video from V9B (A47) is applied through contacts 3 and 5 of energized HIPAR-LOPAR select relay K2 to limiter stage V7. LOPAR video is applied, during HIPAR mode, through contacts 2 and 6 of energized HIPAR-LOPAR select relay K2 (B47), through contacts 6 and 5 of S1 (B47) to limiter V10.

(6) Limiter V10, in conjunction with crystal diode CR21 and limit level variable resistor R85, limits the amplitude of signal inputs to cathode follower V11 (B51). Zener diode CR25 (C48) functions to reduce the amount of power dissipated through limiter stages V10 and V7 (A49) by limiting current flow through these stages. The output of V10 is applied through a dc restorer network and contacts 3 and 5 of energized video select relay K1 (B50) to V11. Video select relay K1 is energized at all times by a ground applied through contacts 2 and 3 of switch S1 (C45). The HIPAR or LOPAR video output of cathode follower V11 is applied through connector J11 (C3, fig. 30) to the video preview switching circuits. In selected systems using AAR, the video output from connector J11 (A1) is applied through connector J102 to the video preview switching circuits and through a cathode follower amplifier to the ECCM console.

(7) The video input to limiter stage V7 may be HIPAR or LOPAR video depending upon which mode is selected as described in (4) above. The output level of limiter V7 is limited by diode CR16 and limit level variable resistor R61. Video pulses from V7 are applied through a dc restorer circuit and through PI Marks switch S2, contacts 1 and 2, to cathode follower V8. The HIPAR or LOPAR video output of V8 is applied to connector J10 for use in the B scope indicator (par. 113).

(8) The output of limiter V7 is also applied to amplifier V4A through contacts 2 and 6 of energized video select relay K1. The video pulses from V4A and mark pulses from V4B are combined into a composite video-mark signal across mixing resistors R94 and R95 and applied to limiter V5 (C51). Diode CR9, limit level variable resistor R43, and V5 limit the composite acquisition video and mark signal and applies it through a dc restorer and cathode follower V6 (C52) to the MTI oscilloscope and PPI's (par. 109). In selected systems using AAR, the IFF video and marks output from connector J12 (fig. 33, C12) on the video and mark mixer is applied to the ECCM console.

72 (U). MTI Oscilloscope

a. The MTI oscilloscope (fig. 26) in the director station group monitors and controls the MTI circuits. This oscilloscope, with its switching circuit, permits the analysis and interpretation of output signals from the various MTI circuits. Therefore, the MTI oscilloscope may also be used as a troubleshooting aid.

b. The MTI oscilloscope uses external sources of ac and dc power. Its multipole-multiposition switching of signal inputs controls the mode of operation of both the oscilloscope and the MTI circuits.

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 28, TM 9-1430-254-20/6.

c. The MTI oscilloscope (B27) consists of two circuits: a sweep circuit containing sweep gate multivibrator V1A (C25) and V1B, clamped horizontal sawtooth generator V2B (D26), and phase inverter sweep amplifier V3; and a video amplifier circuit containing vertical amplifier V2A (C29) and video amplifier V4. The output of the two circuits is applied to cathode-ray tube (CRT) V5, an electrostatic tube employing deflection modulation. A functional analysis of the two circuits is given in (1) and (2) below.

(1) *Sweep circuit.*

(*a*) A positive preknock pulse, from the acquisition-track synchronizer in the director station group, triggers sweep gate multivibrator V1A (C25) and V1B operating as a monostable, cathode-coupled multivibrator. When triggered, V1B produces a positive pulse and V1A a negative pulse output. The positive pulse is applied to CRT V5 (C28) as an unblanking gate pulse, and the negative output is applied to sawtooth generator V2B as a gating pulse. The width of the output pulses is determined by the time constant of an RC network composed of capacitors C2 (C25) and C3 (D29), and resistor R3. MTI CKT TEST switch section S1A (D28) controls the sweep and the unblanking pulse duration by connecting capacitor C3 in or out of the circuit to produce pulses of approximately 175- and 20-microsecond durations, respectively.

(*b*) The negative gate pulse from V1A is applied to clamped horizontal sawtooth generator V2B, stopping its conduction. The charge and discharge of the RC network, composed of capacitors C5 (D26) and C6 (D29), and resistor R9 produces a positive-going sawtooth pulse through V2B. From V2B this pulse is direct-coupled to phase inverter sweep amplifier V3. Switch section S1B adds or removes capacitor C6 from the RC network, changing its RC time constant. Hence, the steepness of the leading edge of the sawtooth wave is changed, causing faster or slower CRT sweeps.

(c) The sawtooth output pulse from V2B is amplified by sweep amplifier V3. Sweep amplifier V3 (C27), a cathode-coupled phase inverter, produces two sawtooth pulses. The two outputs are 180 degrees out of phase and have an amplitude of approximately 100 volts each. The outputs of V3 are applied to the horizontal deflection plates of CRT V5. The negative sawtooth pulse is applied to plate 10 of CRT V5 and the positive sawtooth is applied to plate 9 of CRT V5. HOR POS variable resistor R16 (C27) adjusts the operating bias of V3 to set the no-signal conduction level.

(2) *Video amplifier circuit.*

(a) Vertical amplifier V2A (C29) receives one of four inputs selected by MTI CKT TEST switch S1. These inputs are LOPAR test video and marks from the video and mark mixer, MTI test video from the MTI video amplifier, test MTI or processor video from the acquisition interference suppressor, and 6.3-volt, 400-cps filament voltage for calibration purposes. The parallel combination of resistor R40 (C29) and video bandpass variable capacitor C11 is used to attenuate the MTI test video. Variable capacitor C11 is adjusted for minimum frequency distortion of the test pulses. When switch section S1E is set to 5, 7, and 10, R40 and C11 are bypassed to allow the low-level video pulses to be measured without local attenuation. The output of amplifier V2A is applied through GAIN variable resistor R18 (C28) to video amplifier V4 for further amplification. Variable resistor R18 controls the amplitude of the signal applied to V4.

(b) The positive output of V4 is direct-coupled to one vertical plate of CRT V5. A dc voltage from VERT POS variable resistor R31 (D28) is supplied to the other vertical plate. This voltage is used for vertical positioning of the presentation upon the face of the CRT. The control grid and focusing anode voltages for CRT V5 are obtained from a voltage divider consisting of resistors R26 (C26), R27, R36, R34, and R33, INTENSITY variable resistor R28, and FOCUS variable resistor R35. The input of the voltage divider is obtained from the −1000v power supply (D14). This power supply, which includes transformer T1, bridge rectifier CR1, and a choke input filter, is a bridge-type, full-wave rectifier with a filtered output. Variable resistor R28 (C26) adjusts the bias at the control grid of V5 to set presentation intensity. Variable resistor R35 adjusts the dc voltage at the focusing anode of V5 for the optimum definition of the presentation.

d. MTI CKT TEST switch S1 (D30) is an eleven-position rotary switch consisting of sections A through E. Switch sections previously discussed are S1A, *c*(1) (*a*) above; S1B, *c*(1) (*b*) above; and S1E, *c*(2)(*a*) above. Switch section S1C selects either normal MTI as determined by 360° MTI switch-indicator A7 and SECTOR MTI switch-indicator A8, or a fixed range determined by resistors R37 (C29) and R38. MTI CKT TEST switch section S1D (D9) controls the 150-volt dc input to the delay amplifier in the MTI circuits. This switch section disables the delay amplifier as required by the MTI circuit adjustment procedure. The eleven positions of switch S1 are discussed in (1) through (11) below.

(1) Position 1 of S1 is used to display LOPAR video and marks. In this switch position, section S1E (C29) receives the LOPAR test video and marks through an attenuator consisting of video bandpass variable capacitor C12 (C30) and resistor R39. Variable capacitor C12 is adjusted for minimum frequency distortion of the input signal. Section S1A adds capacitor C3 (D29) to multivibrator V1B to increase unblanking time. Section S1B adds capacitor C6 to the RC network at the output of V2B (D26) to decrease sweep speed. Section S1C removes the range voltages to the electronic gate and replaces them with a fixed 48 volts from a voltage divider consisting of resistors R37 and R38 (C29). Section

S1D (D9) applies the +150 volts to enable the delay amplifier.

(2) Position 2 of S1 is used to calibrate the MTI oscilloscope. In this position section S1E receives a 6.3-volt, 400-cps reference signal used to adjust the oscilloscope sensitivity and for screen calibration. Sections A, B, and D of S1 function the same in position 2 as in position 1. Section S1C removes the fixed range voltage and restores control to the electronic gate range controls.

(3) Position 3 of S1 is used to display the nondelayed MTI test pulse for amplitude adjustment. In this position, section S1E receives noncancelled MTI test pulses from the MTI video amplifier through an RC network composed of video bandpass variable capacitor C11 and resistor R40. This is accomplished by section S1D disabling the delay amplifier, thus removing all delay video information from the MTI circuits. Section S1A removes capacitor C3 to decrease unblanking time. Section S1B removes capacitor C6 to increase sweep speed and section S1C functions the same in position 3 as in position 2.

(4) Position 4 of S1 is used to display both delay and nondelay test pulses for coincidence adjustment. In this position, section S1D enables the delay amplifier, causing delay video information to again be applied to the MTI circuits. Section S1E passes both test pulses to V2A. These pulses are received through an RC compensating network consisting of variable capacitor C11 and resistor R40. Section S1A adds capacitor C3 to the circuits of multivibrator V1A (C25) and V1B. Section S1B adds capacitor C6 (D29) to the output circuit of V2B, and section S1C functions the same in position 4 as in position 3.

(5) Position 5 of S1 is used to display the combined MTI test video pulses for adjustment of fixed target MTI residue. In this position, section S1E receives the MTI test video directly from the oscilloscope input at connector J3 (C26), bypassing variable capacitor C11 (C29), and resistor R40. Section S1A removes capacitor C3 from the sweep circuits. Section S1B removes capacitor C6, section S1C functions the same in position 5 as in positions 2, 3, and 4, and section S1D functions the same as in position 4.

(6) Position 6 of S1 is used to display the nondelay MTI test video for adjusting noise level interference and the amplitude of maximum fixed target and MTI test pulses. Position 6 functions the same as position 3 except that sweep time is changed. Section S1A adds capacitor C3 to the sweep circuits of V1A and V1B. Section S1B adds capacitor C6, and section S1C functions the same in position 6 as in positions 2, 3, 4, and 5. Section S1D disables the delay amplifier.

(7) Position 7 of S1 is used to display the nondelay MTI test video during adjustment of the IF attenuator for best signal-to-noise ratio. In this position, section S1E receives the nondelay MTI test video directly from input connector J3 (C26) for application to V2A (C29). Section A, B, C, and D of S1 function the same in position 7 as in position 6.

(8) Position 8 of S1 is used to display LOPAR test video and marks during adjustments of the MTI video applied to the electronic gate. In this position, section S1E receives LOPAR test video and marks through an attenuator consisting of video bandpass variable capacitor C12 and resistor R39. Sections A, B, and C of S1 function the same in position 8 as in positions 6 and 7. Section S1D disables the delay amplifier by removing the 150-volt potential.

(9) Position 9 of S1 is used to display full LOPAR test video and marks, at half the amplitude displayed in position 8 during adjustment of noise amplitude in the MTI region. In position 9, the functions of sections A, B, and E of S1 remain the same as in position 8. Section S1C removes the variable range voltages and substitutes the fixed 48-

volt dc range voltage to the electronic gate. Section S1D restores the delay amplifier to operation.

(10) Position 10 of S1 is used to display the MTI test video pulses to monitor the MTI video amplifier output during complete MTI circuit operation. In this position, section S1E receives the MTI test video pulses directly from the oscilloscope input at connector J3 (C26) for application to V2A (C29). Section S1A removes capacitor C3 from the sweep circuits. Section S1B removes capacitor C6, section S1C restores the variable range voltages to the electronic gate, and section S1D restores the delay amplifier to operation.

(11) Position 11 of S1 is used to display test MTI or processor video during adjustment of the acquisition interference suppressor. Section S1E receives interference-free processor or MTI video directly from the acquisition interference suppressor. Sections A, B, C, and D of S1 operate the same in position 11 as in position 10.

CHAPTER 9 (CMHA)

PRESENTATION SYSTEM

Section I (CMHA). DISPLAYS

73 (CMHA). Purpose

The presentation system displays visual target information upon the screen of the cathode-ray tube (CRT) indicators. The target information is displayed on a short range (SR) and a long range (LR) plan position indicator (PPI) associated with the acquisition radar system and on a B scope indicator associated with the target tracking radar system. This permits the same target information to be available to both radar systems. The SR PPI presents a radial sweep which rotates in synchronism with the rotation of the HIPAR or LOPAR antenna. Ranges of 75,000 or 150,000 yards can be selected for display on the SR PPI. This PPI is used to monitor low-altitude, short-range targets. The LR PPI presents a radial sweep which rotates in synchronism with the rotation of the HIPAR or LOPAR antenna. The minimum range display on the LR PPI is 150,000 yards. When video from the LOPAR system is selected for presentation on the PPI's, the maximum range display on the LR PPI is 250,000 yards. When video from the HIPAR system is selected for presentation on the PPI's, the maximum range display on the LR PPI is 350,000 yards. The LR PPI is used to monitor high-altitude, long-range targets. The B scope indicator (par. 88) provides a sector display of 1066 mils (60 degrees) in azimuth and 220,000 yards in range. The presentation on the B scope indicator is composed of target video and an electronic circle (target track antenna circle) denoting the range and azimuth settings of the target tracking radar system. The PPI's and B scope indicator presentations include target video, range and azimuth information, and IFF or SIF/IFF video representing recognition signals from targets. The PPI's also provide identification symbols from associated fire unit integration facility (FUIF) equipment.

74 (U). PPI and B Scope Indicator Presentations

For a discussion of the PPI and B scope indicator presentations, refer to TM 9-1430-253-12/2.

Section II (CMHA). PLAN POSITION INDICATOR SWEEP CIRCUITS

75 (CMHA). Purpose

a. The PPI sweep circuits translate the rotation function of the low power acquisition radar (LOPAR) system or the high power acquisition radar (HIPAR) system into an electronic matrix capable of displaying tactical plan-position information on the short range (SR) and long range (LR) PPI's. The PPI sweep circuits form the electronic matrix by correlating the azimuth of the rotating acquisition radar beam with the rotation of a radial sweep trace on both PPI cathode-ray tubes (CRT's). The PPI sweep circuits generate sawtooth sweep voltages which represent the vectoral components of the quadrature voltages developed in the selected acquisition azimuth resolver. The sweep voltages are applied to the electrostatic deflection plates of both PPI CRT's to produce a radial sweep trace which rotates in a clockwise direction with the origin at the center of each CRT.

b. The circumference of each CRT is marked off in radial (polar) coordinates (6400 mils) corresponding to the degrees of azimuth through which the acquisition antenna rotates. The PPI sweep circuits select the range represented in the display at the PPI's.

c. During each operational pulse cycle of the acquisition receiver-transmitter, the PPI sweep circuits can use symbol modulated analog deflection voltages for the first 900 microseconds to present indications of target status (FUIF data) or designating information, then switch to the normal sweep interval for video presentation.

d. There are two PPI's associated with the acquisition radar system, the LR PPI and the SR PPI. The SR PPI has selectable display ranges of 75,000 or 150,000 yards. The LR PPI has selectable display ranges of 150,000 or 250,000 yards if the LOPAR video is selected for presentation and 150,000 or 350,000 yards if the HIPAR video is selected for presentation.

76 (U). Block Diagram Analysis

a. The 4-kc oscillator (fig. 32) (par. 77) produces a 4-kc CW carrier that is applied to the stators of HIPAR azimuth resolver B1 in the HIPAR antenna and to acquisition azimuth resolver B2 (par. 78) in the LOPAR acquisition antenna pedestal. The 4-kc carrier input is used as a reference and source of excitation. Both resolvers receive a mechanical input from the associated antenna drives. The mechanical input is the azimuth angle of the rotating antenna.

b. Each azimuth resolver generates two output signals from the quadrature wound rotor. The two outputs are amplitude-modulated 4-kc signals that vary in amplitude in accordance with the sine and cosine of the antenna angle measured with respect to a reference azimuth. These signals, designated N-S (north-south) and E-W (east-west), are used to synchronize the sweeps on the PPI's to acquisition antenna beam azimuth. The resolver signals are amplified and matched to the load circuit by two channel resolver amplifiers (par. 79). The resolver outputs, from the LOPAR antenna are applied directly to the radar select and preview circuits (par. 13). The resolver outputs from the HIPAR antenna are applied to an auxiliary resolver amplifier (par. 80). The auxiliary resolver amplifier is used to match the gain of the HIPAR resolver signals to the LOPAR resolver signals. The HIPAR resolver signals are then applied to the radar select and preview circuits.

c. If LOPAR video is selected, and if the preview circuits are not energized, the N-S and E-W resolver signals from the LOPAR antenna will be applied to the SR and LR pulse persistence generators (par. 82). The operation of the pulse persistence generator and the PPI in each channel is identical so only the short range PPI and associated pulse persistence generator will be discussed.

d. The pulse persistence generator has a N-S and an E-W demodulation channel. The N-S and E-W demodulation channels receive a 4-kc reference signal from the 4-kc oscillator and the N-S and E-W resolver signals. The resolver signals are combined with the 4-kc reference signal and these signals are detected in the modulation eliminator section of the pulse persistence generator. The two outputs of the pulse persistence generator are the envelopes of the N-S and E-W resolver signals. The frequency of each signal is one cycle per complete revolution of the acquisition antenna. The N-S and E-W signals are applied to the Y and X sweep generators (par. 85), respectively.

e. The resolver signals are applied to the first dc amplifier in the sweep generator (par. 85). The writing gun driver (par. 83) receives HIPAR or LOPAR sync pulses from the radar select and preview circuits and produces + and −range pulses with a width determined by the condition of the LONG RANGE—SHORT RANGE switch-indicator on the front of the PPI and the setting of RANGE switch S1 on the side of the PPI. These pulses are applied to the first dc amplifier in the Y and X sweep generators, and determine the range display that will be presented on the PPI's. The output of the first dc amplifier in the sweep generators is a sawtooth with a predetermined width which is applied to gates 1 and 3. These gates operate as a single-pole, single-throw switch. The operation of the gates is governed by the + and −gate control pulses generated by the pulse and logic generator (par. 84). During the regular sweep interval, the gates will be conducting and the sweep sawtooth from the first dc amplifier will be applied to the range and gain switch. During the symbol interval (par. 99), the + and −gate pulses are applied to the gates so that gates 1 and 3 will not conduct.

f. The setting of the range and gain switch in the sweep generators is controlled by the condition of the LONG RANGE — SHORT RANGE switch-indicator on the front of the

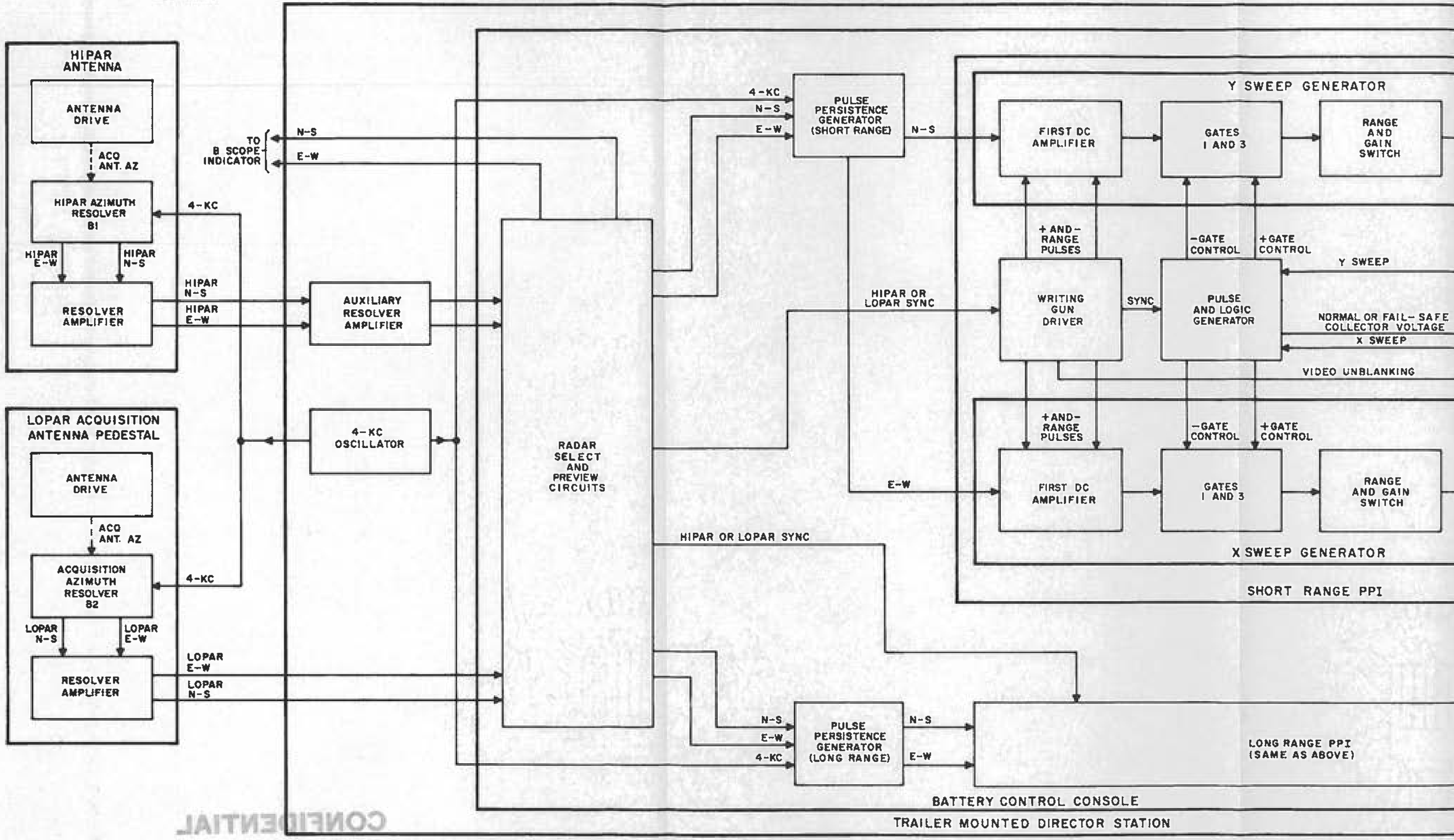


Figure 32 (U). PPI sweep circuits—block diagram (U).

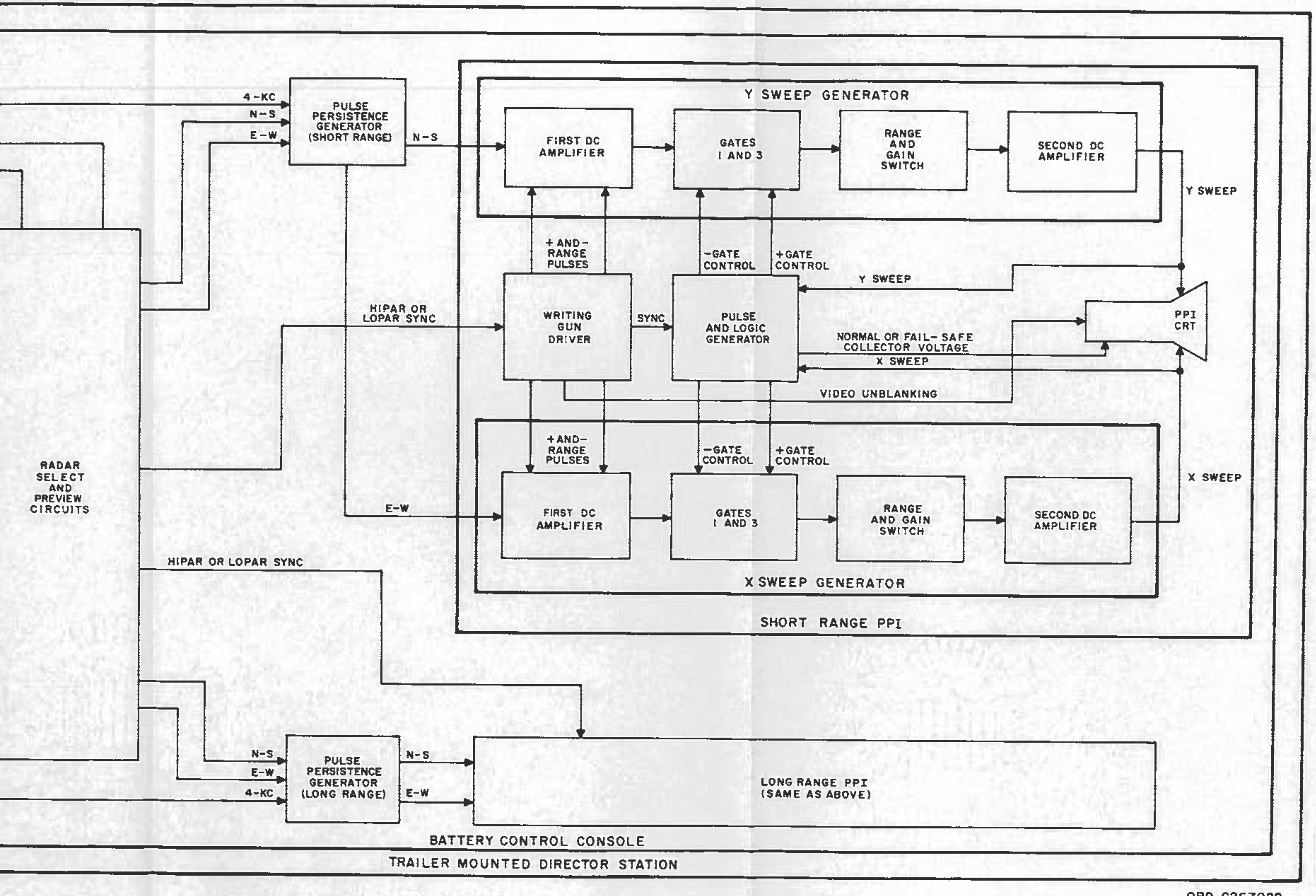


Figure 32 (U). PPI sweep circuits—block diagram (U).

PPI and by the setting of RANGE switch S1 on the side of the PPI. The range and gain switch limits the amplitude of the sweep sawtooth to a predetermined level regardless of the range selected.

g. The sweep sawtooth is then applied to the second dc amplifier where it is amplified to the level required by the deflection plates of the CRT (par. 86). Push-pull sweep voltages are then applied to the deflection plates of the CRT.

h. The X and Y sweep voltages are also applied to the fail-safe circuit (par. 87) in the pulse and logic generator. The fail-safe circuit is a relay amplifier with parallel inputs for the X and Y sweep voltages. If both sweeps are present in the PPI, normal collector voltage is applied to the CRT. If both sweeps are missing, a fail-safe collector voltage will be applied to the CRT. This insures that the CRT will not be damaged when the acquisition antenna is not rotating.

i. The writing gun driver (par. 83) also supplies a negative 2500-volt potential to the writing gun cathode in the CRT. During the normal sweep interval a video unblanking pulse modulates this voltage so that video at close range will not be too bright and video at maximum range will be of increased intensity.

77 (U). 4-KC Oscillator

a. The 4-kc oscillator generates a 4-kc sinusoidal carrier that supplies reference and excitation voltages for synchro resolvers and associated units in the marker, MTI, and sweep circuits.

Note. The grid zone references shown in parentheses in *b* below refer to figure 37, TM 9-1430-254-20/6.

b. The 4-kc oscillator (D2), located in the director station group, is comprised of oscillator V1, and power amplifiers V2 and V3, and associated circuits and controls. Although output transformer T3 (B4), a part of the director station group, is externally located, it is a functional part of the 4-kc oscillator. A functional analysis of the 4-kc oscillator is presented in (1) through (5) below.

(1) The 4-kc sinusoidal signal is generated by oscillator V1 (A2), a dual triode connected as a push-pull audio frequency oscillator. The frequency of oscillation is determined by the resonant frequency of a tank circuit consisting of inductor L1 (B2), and capacitors C1 and C3. Positive feedback is provided by the auto-transformer action of L1 and the coupling of C1 and C3. A degree of degenerative feedback is provided by C2 to offset part of the regenerative feedback. This prevents V1 from being driven alternately into cutoff and saturation, producing sine-wave oscillations that are distorted in amplitude. The plate voltage of V1 is determined by the setting of ACQ ADJ variable resistor R5 (B1), which is part of a voltage divider completed by resistors R4 and R6. Adjustment of R5 controls the output amplitude of V1.

(2) The 4-kc sinusoidal output from oscillator V1 is applied to power amplifiers V2 and V3 which are connected for push-pull operation. These amplifiers are provided with degenerative feedback through capacitors C5 and C6. This feedback limits the output signals to 240 volts peak-to-peak and improves amplifier stability in addition to decreasing signal distortion. The 240-volt outputs of V2 and V3, 180 degrees out of phase with each other, are applied across the primary of transformer T3 (B4) located in the director station group. At the secondary of T3, the 170-volt (peak-to-peak) output 4-kc carrier signal appears at terminal 3.

(3) The 4-kc carrier signal from terminal 3 of T3 (B4) is distributed to the following:

(*a*) The electronic gate (C5) in the director station group.

(*b*) The pulse persistence generators (C7 and C9) in the battery control sole.

(*c*) The B scope modulation eliminator (C11) in the target radar control console.

(*d*) The mark generator (C11) in the target radar control console.

(e) The azimuth blank generator (D11) in the target radar control console.

78 (U). Acquisition Azimuth Resolver

a. Acquisition azimuth resolver B2 (fig. 32), is comparable to a small dual rotary transformer in which a cylindrical rotor (secondary) is mounted within a cylindrical stator (primary). The stator, consisting of two field windings, is so constructed that the magnetic fields of each winding are displaced 90 degrees from each other. The rotor is similarly constructed. The two rotor windings are designated the north-south (N-S) winding and the east-west (E-W) winding. When maximum coupling exists between a rotor winding and a stator winding, the resolver may be considered similar to a transformer with a 1:1 turns ratio. The rotor is considered oriented when the output signal of the N-S rotor is maximum as the azimuth position of the acquisition antenna reaches north (6400 mils) or south (3200 mils), and the output signal of the E-W rotor is maximum at east (1600 mils) or west (4800 mils). The functional application of this resolver is given in b below.

b. Acquisition azimuth resolver B2 (fig. 34, B2, TM 9-1430-254-20/6) in the acquisition antenna pedestal, uses only one of its two stator windings. One winding (S2-S4) is grounded and is, therefore, not used. The other winding (S1-S3) is energized by a 4-kilocycle CW sine-wave carrier with an amplitude of approximately 80 volts peak-to-peak. The 4-kilocycle input signal is received from the 4-kc oscillator (fig. 37, D2, TM 9-1430-254-20/6) discussed in paragraph 77. The resolver rotor, which is mechanically connected to, and rotates in synchronization with, the acquisition antenna receives induced 4-kilocycle signals from the stator winding. These 4-kilocycle signals are amplitude-modulated whenever the acquisition antenna is rotating. The modulation envelope of signals induced in the E-W rotor winding (R2-R4) is displaced by 90 electrical degrees from the modulated envelope, of those induced in the N-S rotor winding (R1-R3). The LOPAR N-S and E-W output signals from B2 are applied to the resolver amplifier (fig. 34, C2, TM 9-1430-254-20/6).

79 (U). Resolver Amplifier

a. The resolver amplifier (fig. 32) contains a channel of amplification for each of the two acquisition azimuth resolver output signals. The resolver amplifier increases the amplitude of the resolver LOPAR N-S and E-W signals to insure that these output signals have sufficient voltage to supply load requirements, and isolates the acquisition azimuth resolver from load variations.

Note. The figure and zone references shown in parentheses in b below refer to TM 9-1430-254-20/6.

b. The resolver amplifier (fig. 34, D2) contains a LOPAR N-S amplifier channel and a LOPAR E-W amplifier channel. Since these two signal channels are identical, only the functional analysis of the LOPAR N-S amplifier channel is given. The output of the N-S rotor winding (R1-R3) of acquisition azimuth resolver B2 is a modulated 4-kilocycle sine-wave signal that is applied to voltage amplifier V1 (fig. 34, C2). The amplified output of V1, a conventional resistance-coupled voltage amplifier, is applied to power amplifier V2. Amplifier V2 is a conventional power amplifier with transformer coupling to the load circuits. The output signal level of the modulated envelope is 70 to 80 volts peak-to-peak. Output transformer T2 matches the impedance of the resolver amplifier to the characteristic impedance of the distribution circuit used for the LOPAR N-S signal. The terminating impedance of the distribution circuit consists of resolver stator windings and transformer primary windings. Transformer T2 (fig. 34, C3) also provides a degenerative feedback voltage from its secondary winding to the input circuit of amplifier V1. The feedback voltage is used to minimize signal distortion. Antenna rotation is stopped when LOPAR ANTENNA ROTATION OFF switch-indicator A9 on the LOPAR auxiliary control-indicator (fig. 38, D1) is illuminated amber. When switch-indicator A9 is depressed, antenna rotation relay K2 is deenergized and its contacts 3 and 5 (fig. 17, B19) open to remove the +250-volt (SW) dc potential supplied to the resolver amplifier eliminating a personnel safety hazard and possible equipment damage. Interlock switch S3 (fig. 34, D1) is actuated whenever the access cover for the resolver amplifier on the acquisition antenna pedestal is removed. The LOPAR N-S and E-W amplified outputs of the resolver amplifier are applied to HIPAR select relay K1 (fig. 34, C5) located on the LOPAR auxiliary control-indicator.

80 (U). Auxiliary Resolver Amplifier

The auxiliary resolver amplifier (fig. 34, B4, TM 9-1430-254-20/6) compensates for line losses that occur in the cable between HIPAR and LOPAR systems and insure equal amplitude of the HIPAR and LOPAR resolver signals. Since the N-S and E-W channels of the auxiliary resolver amplifier are similar, operation of only the E-W channel is discussed. The HIPAR E-W signal from connector P1-2 (fig. 34, A4, TM 9-1430-254-20/6) is applied to transformer T3-1 in the auxiliary resolver amplifier. The signal is coupled across T3 and applied through E-W adjust variable resistor R27 to voltage amplifier V5. The amplified output of V5 is applied to power amplifier V6. The output of V6 is coupled through output transformer T4 to the LOPAR auxiliary control-indicator and to the HIPAR control-indicator. A feedback voltage from the secondary winding of T4 is applied to the input circuit of V5 to minimize signal distortion.

81 (U). Radar Select and Preview Circuits

a. The HIPAR and LOPAR resolver signals are applied to the radar select and preview circuits. In this section, sweep signals from one radar system will be selected for presentation on both PPI's. Either PPI can select alternate video for previewing. Refer to paragraph 13 for the functional description of the radar select and preview circuits.

b. The resolver signals from the selected acquisition radar system are applied to each pulse persistence generator. Since the pulse persistence generators and PPI's are identical, only the long range PPI sweep channel and associated pulse persistence generator will be discussed.

82 (U). Pulse Persistence Generator

a. The modulation eliminator section of the pulse persistence generator converts amplitude-modulated 4-kc carrier signals (resolver output signals) into low-frequency sinusoidal signals and applies them to sweep generating circuits of a cathode-ray tube (CRT) employing electrostatic deflection.

b. The modulation eliminator consists of two identical bridge-type demodulators using crystal diodes. This assembly demodulates the N-S and E-W acquisition antenna azimuth position signals and supplies two low-frequency quadrature voltages representing X and Y vector components of antenna beam azimuth to the sweep generator (par. 85).

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 34, TM 9-1430-254-20/6.

c. The two bridge-type demodulators (B11) are identical in operation. Each consists of an input transformer, a load resistor, and a bridge rectifier containing four crystal diode rectifiers and four precision resistors. Transformer T1 supplies a controlling reference voltage to diagonally opposite junctions of arms of each bridge demodulator. The rectifiers are silicon junction diodes having a high back impedance, a high inverse peak voltage, and a high current capacity. The precision resistor in series with the diode in each arm of the bridge compensates for slight differences in conduction of the crystal diodes. The load for the N-S signal demodulator is resistor R7 (B10), whereas the load for the E-W signal demodulator is resistor R8.

d. The N-S and E-W input signals are applied through X OFF—NOR—Y OFF switch S1 (B10) to the primaries of transformers T2 and T3, respectively. There is a phase difference of 90 degrees between the input signals of T2 and T3, and these signals have only half the amplitude of the 4-kc reference signal supplied to transformer T1. This amplitude relationship insures that the 4-kc reference signal effectively gates the diode pairs of the bridge-rectifier circuits. Switch S1, when set to Y OFF or X OFF, removes the input signal to the respective modulation eliminator. By this means, the input transformer is grounded with respect to the load, and the output of the associated bridge circuit is zero. The X OFF and Y OFF positions of switch S1 are used during sweep generator adjustments.

e. The output signals of the modulation eliminator are developed from the two control input signals discussed in (1) and (2) below.

(1) The two control inputs are the N-S and E-W resolver signals received from the video select and preview circuits (par. 13). Each signal consists of an amplitude-modulated 4-kc carrier. The frequency of modulation is determined by the rotation speed of the acquisition antenna when an input to the PPI sweep circuits is supplied from acquisition azimuth resolver B2 (par. 78) in the acquisition antenna pedestal (D2). As the resolver rotor makes one complete revolution, the output voltage varies through a single cycle of amplitude modulation. In this manner, two envelopes, 90 degrees out of phase, with 100-percent modulation, having a maximum peak-to-peak amplitude of 80 volts, are generated for each 360 degrees of rotor rotation.

(2) The second control input is a 4-kc sinusoidal signal with a constant amplitude level of 170 volts peak-to-peak, received from the 4-kc oscillator (par. 77). This steady ac reference signal in the audio frequency band is used as excitation voltage for the primary of transformer T1 (A10). This transformer supplies the reference voltage to the two bridge-rectifier type demodulators.

f. With no resolver signal input to the demodulators, no current flows through load resistors R7 and R8 because the electrical bridge circuit of each demodulator is in a balanced condition. The condition of balance exists between the junction of conducting diode rectifiers in each bridge rectifier and the grounded center tap of transformer T1. When a resolver signal is received, the bridge circuit unbalances in proportion to the amplitude induced in the transformer secondaries, and current flows through alternate halves of T2 or T3 secondary and the associated load resistor during one input cycle. A change in phase of 180 degrees of the resolver signal with respect to the carrier reference from T1 occurs each 180 degrees of antenna rotation and causes the current to reverse its direction of flow through the associated load resistor (R7 or R8). The change in phase occurs because the phase of the voltage induced in the quadrature windings of the resolver rotor with respect to the 4-kc excitation stator voltage depends on the azimuth hemisphere through which the antenna is rotating. Thus, full-wave rectification of the modulated carrier appears at R7 and R8. This voltage is filtered by a dual section RC filter that removes the 4-kc carrier components. The RC filter for the X voltage output consists of resistors R9 (B11) and R10, and capacitors C3 and C4. The RC filter for the Y voltage output is identical to the X voltage filter and consists of resistors R5 and R6, and capacitors C1 and C2. These filters are designed to remove cross modulation products of the output voltages.

g. The signals from the modulation eliminator are two low-frequency ac outputs of equal amplitude. One output signal is the modified X sine-wave envelope having 40-volt peak-to-peak amplitude change, and the other is the modified Y sine-wave envelope of equal amplitude. These sine waves are 90 degrees out of phase, so that one represents a sine function with respect to the change of antenna azimuth and the other a cosine function.

h. The Y slope and X slope variable resistors R15 and R16 adjust the length of the sweep on the face of the CRT. Variable resistors R18 and R21 are zero setting variable resistors for the first dc amplifier stage in the sweep generators.

83 (CMHA). Writing Gun Driver

a. The writing gun driver (fig. 32) receives a sync pulse to produce the negative and positive range pulses that control electronic gate 4 in the feedback circuit of the first dc amplifier in the X and Y sweep generators. This dc amplifier produces a sweep signal upon the application of the range pulses.

b. The writing gun driver also produces a negative video unblanking pulse that is applied to the cathode of the writing gun in the cathode-ray tube (CRT). The pulse is of such a shape that a target at close range will not appear at too high intensity and a target at maximum range will appear as one target and not be distorted due to angular presentation.

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 34, TM 9-1430-254-20/6, unless otherwise indicated.

c. The writing gun driver receives either a HIPAR or LOPAR sync pulse through connector P3 (B26). The sync pulse is applied through diode CR2 to the control grid of monostable multivibrator V1 which produces positive or negative pulses. Cathode follower V2A provides fast recovery for multivibrator V1. The multivibrator will have a pulse repetition frequency of 410 to 440 pulses per second if HIPAR is selected or 500 pulses per second if LOPAR is selected. The pulse duration of the output of the multivibrator is determined by the setting of range select switch S1 (C32). The setting of range select switch S1 is determined by the setting of RANGE switch S1 (C36) and the condition of LONG RANGE—SHORT RANGE switch-indicator A11 (C33). The switch settings and video selection to obtain the four different range displays on the PPI's are listed in table III.

d. The range displayed on the PPI's is determined by the setting of RANGE switch S1 (C36) and the condition of LONG RANGE—SHORT RANGE switch-indicator A11 (C33) on the front of the PPI. The range display on the PPI's is controlled by range select switch S1 (B32) in the writing gun driver and range select switch S1 (C38) in the sweep generators. Since the operation of switches S1 in the writing gun driver and the sweep generators is identical, only the operation of the switch in the writing gun driver (D31) will be discussed. When LONG RANGE—SHORT RANGE switch-indicator A11 is depressed for long range operation, a ground is applied through the normally open contacts of section S1A and the LONG RANGE indicator on the switch-indicator will illuminate blue. A ground will also be applied through the normally open contacts of section S1B (C33) and will energize range relay K2 (D34). A ground will be applied through contacts 12 and 8 (C34) of energized range relay K2, through contacts 12 and 11 of RANGE switch S1B (C35), and then applied to the LR target designate control to energize long range relay K3 (fig. 32, D4, TM 9-1430-254-20/6). A ground is applied through contacts 9 and 2 of energized range relay K2 (C34), contacts 12 and 11 of RANGE switch S1A (C34), and then applied to the Y sweep generator (C50) as the control ground for switch S1 in the sweep generator. A ground is applied through contacts 10 and 3 of energized range relay K2 (C34), contacts 3 and 2 of RANGE switch S1A (C34), and then applied to terminal 9 of range select switch S1A (B32). The ground will then be applied through S1A, to terminal 5, through the deenergized relay contact and will energize coil L1. When L1 energizes, S1A and S1B (C31) will be rotated approximately 30 degrees counterclockwise and will also open the relay contact between terminals 2 and 5 of switch S1 (B31). With this relay contact opened, L1 will deenergize and the ground path through S1A will again be completed. The energizing and deenergizing process will continue until the notch in S1A is opposite the terminal with the ground (terminal 9). A ground is also applied through contacts 11 and 5 (C34) of range relay K2, contacts 3 and 2 of RANGE switch S1B, and will be applied as the control ground to the X sweep generator and range select switch S1A (C38). When

Table III (C). PPI Range Displays and Pulse Widths (U)

VIDEO SELECTED	RANGE switch S1 (C36)	LONG RANGE—SHORT RANGE switch-indicator A11 (C33)	Pulse width	Range displays
HIPAR or LOPAR	SHORT	SHORT RANGE	460 usec	75,000 yds
HIPAR or LOPAR	SHORT	LONG RANGE	902 usec	150,000 yds
LOPAR	LONG	LONG RANGE	1525 usec	250,000 yds
HIPAR	LONG	LONG RANGE	2135 usec	350,000 yds

LONG RANGE—SHORT RANGE switch-indicator A11 is again depressed, the SHORT RANGE indicator will illuminate green and range relay K2 will deenergize. A ground will then be applied as the control ground to the range select switches in the writing gun driver and the sweep generators. On the short range PPI, RANGE switch S1 is set to SHORT. The range selection is identical to that described above.

e. Variable resistors R1 (C31) and R3 are adjusted for a pulse width of 460 and 920 microseconds, respectively. Variable resistor R7 is adjusted for a pulse width of 1525 microseconds when LOPAR is selected. When HIPAR is selected, relay K1 is energized and variable resistor R5 is adjusted for a pulse width of 2135 microseconds.

f. The output of multivibrator V1B (C27) is applied to the control grid, pin 2, of cathode coupled push-pull power amplifier V3. The output at V3, pin 9, is the +range pulse. The output at V3, pin 1, is the −range pulse. The + and −range pulses from P2 on the writing gun driver are then applied to the first dc amplifier in the sweep generators.

g. The −range pulse from V3, pin 1, is applied through capacitor C9 to the control grid of cathode follower V4A. The +range control pulse is applied through capacitor C8 to the control grid of cathode follower V4B. The outputs of the two cathode followers are applied to the diode bridge consisting of CR6, CR7, CR8, and CR9. During the normal sweep interval, a pulse (−range control pulse) will be applied to the junction of CR6 and CR7, and a pulse (+range control pulse) will be applied to the junction of CR8 and CR9. With these polarities on the bridge, all diodes are back-biased and are not conducting. The junction of CR7, CR9, and R40 starts going negative at a rate determined by the time constant of R40 and the resistor capacitor combination selected by range select switch S1 (C32). The negative-going pulse is then applied to the control grid of unblanking generator V2B (fig. 30, B9, TM 9-1430-254-20/6). The video unblanking pulse from V2B is developed at the junction of R53 (fig. 30, B10, TM 9-1430-254-20/6) and R54. The video unblanking pulse is a negative pulse that starts at −30 volts and goes to −40 volts during the rest of the sweep interval. The slope of the pulse is determined by the resistor capacitor combination switched in by range select switch S1. Refer to table III for the pulse width of the video unblanking pulse. When the range display on the PPI is changed (par. 83*d*), a ground is applied from range select switch S1 in the writing gun driver (D31) and will energize video squelch relay K3 (C25). A ground will be applied through contacts 2 and 5 of energized relay K3 to crystal diode CR5 (fig. 30, B9, TM 9-1430-254-20/6). The video unblanking pulse will be conducted through CR5 to ground. Also, when LOPAR ANTENNA ROTATION OFF switch-indicator A9 (fig. 38, B1, TM 9-1430-254-20/6) is depressed and the antenna is not rotating, a PPI squelch ground will be applied to crystal diode CR5 and remove the video unblanking pulse. In selected systems using AAR, a PPI squelch ground is applied from squelch interlock relay K11 in the auxiliary acquisition relay assembly (fig. 54, B3) to contact 2 of deenergized LOPAR-AAR select relay K9 (fig. 54, D3). The PPI squelch ground is applied to the PPI if relay K11 is deenergized. Relay K11 is energized by a ground from the AAR equipment or by setting acquisition radar select switch S1A (fig. 54, B2) to the LOPAR ONLY or HIPAR position.

Note. The grid zone references shown in parentheses in *h* through *j* below refer to figure 30, TM 9-1430-254-20/6.

h. The video unblanking pulse is than applied to connector P1-1 and P1-2 of electronic gate A1 (B10). During the normal sweep interval, the positive gate control pulse from the pulse and logic generator is negative and is applied to terminal 7 of electronic gate A1. The negative gate control pulse is positive and is applied to P1-5 of electronic gate A1. The negative pulse at P1-7 causes the junction of diodes CR1, CR3, CR5, and resistor R1 to go negative. The positive pulse at P1-5 causes the junction of CR2, CR4, CR6, and resistor R2 to go positive. With these polarities, diodes CR1, CR5, CR2, and CR6 conduct and allow the video unblanking pulse to pass through to capacitor C16 and to the cathode of the writing gun section of the CRT. Electronic gate A2 is used to provide constant loading for the unblanking generator during the sweep and intersweep periods.

i. The average potential at the writing gun cathode is −2500 volts and the video unblanking pulse causes this voltage to go from −2530 to −2540 volts during the normal sweep interval. The negative 2500-volt potential is supplied by voltage regulator V5B (D10) within the writing gun driver. The reference potential is applied from the −3300-volt power supply, through series resistors R74 and R73,

Zener diodes CR12, CR11, and CR10 and resistors R45, R44, R43, R42, and R41 to ground. The average potential at the junction of CR12 and R73 is −2700 volts. Zener diodes CR10, CR11, and CR12 have a constant voltage drop of 350 volts and provide a stable reference of −2350 volts for voltage regulator V5B. Variable resistor R44 adjusts the potential of the focusing grid of the CRT between −1600 volts and −1850 volts.

j. Intensity variable resistor R8 (D8) is connected between J1-C and J1-D on the writing gun driver with the wiper arm connected through J1-B to the control grid of voltage regulator V5A. The adjustment point of variable resistor R8 determines the voltage at the junction of DS2, R51, and CR14. It also controls the voltage at the junction of DS4, R52, and CR15.

k. Crystal diode CR13 clamps the voltage at the cathode of V5A at 15 volts. Capacitor C9 filters out any noise which may appear at CR13. If there is a voltage change at DS1 and DS2, this change will be coupled by capacitor C14 to the control grid of V5A. The change in voltage will appear at the plate of V5A with opposite polarity and will be applied to the control grid of V5B. This potential will change the conduction level of V5B and return the potential at DS1 and DS2 to the proper level.

l. Neon lamps DS1, DS2, DS3, and DS4 provide protection for crystal diodes CR14 and CR15 during the interval when power is first turned on. Crystal diodes CR14 and CR15 prevent any signal feed-through to the voltage regulator circuit.

84 (CMHA). Pulse and Logic Generator

a. During the normal sweep interval, the pulse and logic generator produces the positive and negative gates to open and close the three electronic gates on each sweep generator, and electronic gates A1 and A2 in the writing gun driver.

Note. The grid zone references shown in parentheses in *b* through *d* below refer to figure 34, TM 9-1430-254-20/6, unless otherwise indicated.

b. The HIPAR or LOPAR radar sync pulse is applied to connector P2-1 (B24) on the pulse and logic generator. The sync pulse is applied through capacitor C25 to the control grid of monostable multivibrator V9 (B18). During the normal sweep interval, V9A is not conducting and V9B is conducting. Multivibrator V9 is held in this condition by bistable multivibrator V8. With the absence of an all data present (ADP) pulse, V8A is conducting and V8B is cut off. The control grid of V9A is held negative by the voltage at the wiper arm of PEDESTAL variable resistor R93.

c. As long as there is no ADP pulse from the FUIF equipment or from the time share relay assembly present, the HIPAR or LOPAR sync pulse will have no affect on multivibrator V9. The output of V9A will be a dc level of approximately +250 volts. The dc level of the output of cathode follower V1B is determined by the setting of negative gate control pulse dc level variable resistor R7 in the cathode circuit. During the normal sweep interval and as long as there is no ADP pulse, the negative gate control pulse has a positive polarity.

d. During the normal sweep interval, the output of V9B will be a dc level less than the output of V9A. The dc level of cathode follower V1A (B20) is determined by the setting of POS GATE CONT PULSE DC LEVEL variable resistor R2 in the cathode circuit. During the normal sweep interval and as long as there is no ADP pulse, the positive gate control pulse has a negative polarity.

e. The positive and negative gate control pulses when generated are applied to the three electronic gates in the sweep generators (par. 85) and the two electronic gates in the writing gun driver (par. 83).

85 (CMHA). Sweep Generator

a. The sweep generators transform the resolver signals into push-pull sweep voltages that are applied to the deflection plates of the CRT. The E-W and N-S signals are transformed into E-W and N-S deflection voltages that produce a rotating sweep on the PPI. The sweep generators also determine the range presentation on the PPI.

Note. The grid zone references shown in parentheses in *b* through *p* below refer to figure 34, TM 9-1430-254-20/6, unless otherwise indicated.

b. Each sweep generator (fig. 32) consists of a first dc amplifier with four electron tube stages, diode gating networks, and a range select switch, and a second dc amplifier with four electron tube stages. Since both sweep generators are identical, only the X sweep generator (C39) will be discussed.

c. The input signal to the X sweep generator is the low frequency east-west (X) demodulated resolver signal from the demodulator section of the pulse persistence generator (par. 82). The frequency of the signal is dependent upon the rotational speed of the acquisition antenna and the polarity of alternate half cycles is determined by the azimuth hemisphere of the resolver rotor. The sawtooth sweep pulse generated within the sweep generator at any given instant depends on the amplitude of the input sine-wave voltage. Thus, the amplitudes of successive sawtooth pulses vary as a sine function which is a replica of the input signal voltage variation. The sawtooth sweep voltages generated within the Y sweep generator are displaced 90 degrees from the sweep voltage generated within the X sweep generator. The 90-degree displacement originates within the azimuth resolver in each antenna, each of which has a 90-degree electrical displacement between windings.

d. The low frequency resolver input has a maximum amplitude of 40 volts. The maximum frequency of the input signal is 0.25 cycle per second corresponding to a 15-rpm rotation of the LOPAR antenna. This frequency is negligible when compared to the pulse repetition rate of 500 cps for the sweep circuits when video from the LOPAR radar is selected for presentation. For this reason, during the generation of one sawtooth pulse, the input voltage may be considered as a constant dc level.

e. The low frequency resolver input is applied from X slope variable resistor R16 (B11) in the pulse persistence generator through resistor R1 (B38) to the control grid of cathode follower V1A. The X slope variable resistor R16, resistor R1, and capacitor C7 (B41) form an integrating circuit so that the input to V1A is the voltage developed across C7. The input signal is cathode coupled to voltage amplifier V1B which amplifies the signal without changing the phase. The output of V1B is applied through resistor R6 to amplifier V2 which amplifies and inverts the resolver signal. The signal is then applied to the control grid of cathode follower V3 (B42). The output voltage of cathode follower V3 is opposite in polarity to the input signal to V1A and is applied to the plate of capacitor C7 opposite the input. Thus, C7 forms a degenerative feedback circuit from V3 to the input of V1A to produce a linear charge on C7. Capacitor C7 will charge until the integrating circuit is disabled by the action of electronic gate 4 (B40).

f. The operation of sweep control electronic gate 4, equivalent to a single-pole, single-throw switch, is controlled by the + and —range control pulses from the writing gun driver (par. 83). A negative pulse is applied to connector P1-5 of electronic gate 4 and a positive pulse is applied to P1-7. The duration of these pulses is determined by the setting of RANGE switch S1 (C36) on the side of the PPI and the position of LONG RANGE — SHORT RANGE switch-indicator A11 (C33) on the front of the PPI. Refer to table III (par. 83) for the duration of the pulses for each range setting. At the end of the range sweep time, the polarities of the + and —range pulses reverse.

g. With a negative pulse at P1-5 and a positive pulse at P1-7, electronic gate 4 does not conduct. In the nonconducting stage, the gate is electrically open and the integrating circuit is enabled. At the end of the selected range sweep period, a positive pulse is applied to P1-5 and a negative pulse to P1-7 of electronic gate 4. The gate will then be conducting and will short the input signal through CR1 or CR2 to the cathode of cathode follower V3 and disables the integrating circuit.

h. The time constant of the integrating circuit is determined by X slope variable resistor R16 (B11) in the pulse persistence generator, resistor R1 (B38), capacitor C7 and the gain of the first DC amplifier. The time constant can be lengthened or shortened by adjusting variable resistor R16. This will control the slope of the output sawtooth in the first dc amplifier stage. The X balance variable resistor R2 (B39) is adjusted to obtain a symmetrical sweep on the CRT. The X centering variable capacitor is used to move the origin of the sweep to the center of the CRT. The dc operating level of V1B is set by X zero set variable resistor R21 (B11) in the pulse persistence generator.

i. The amplitude of the sawtooth output of V3 (B42) is dependent upon the sweep time selected and the input resolver signal. The output of cathode follower V3 is applied to sweep time share electronic gate 1.

j. Electronic gates 1, 2, and 3 are controlled by the positive gate control pulse and the negative gate control pulse from the pulse and logic generator (par. 84). During a normal sweep interval, symbol time share electronic gate 2 will be nonconducting, and electronic gates 1 and 3 will be conducting. This will allow the sweep sawtooth to be passed through electronic gate 1 to range select switch S1 (C39). Any symbol position voltage is terminated through dummy load electronic gate 3 and resistor R19 to ground.

k. During the normal sweep interval, the positive gate control pulse is negative and is applied to connector P1-7 of electronic gates 1 and 3. The negative gate control pulse is positive and is applied to P1-5 of electronic gates 1 and 3. The sweep output of electronic gate 1 is applied from P1-3 to range select switch S1.

l. The setting of range select switch S1 is determined by the position of RANGE switch S1 (C36) and the position of LONG RANGE — SHORT RANGE switch-indicator A11 (B33). Since the output of cathode follower V3 is variable, depending upon the range selected for display on the PPI, range select switch S1 selects voltage limiting resistors in series to insure that the input to V4A is never greater than 30 volts. If the PPI range presentation selected is 75,000 yards, the sweep sawtooth will be applied through resistor R15 (C40) to the control grid of V4A. If the range selected is 150,000 yards, resistor R16 will be added in series with R15. If the range selected is 250,000 yards (LOPAR video selected), resistors R17, R16, and R15 will be in series. If the range selected is 350,000 yards (HIPAR video selected), relay K1 (C39) will energize and add resistor R18 in series.

m. The operating bias for the control grid of V4A (C41) is provided by resistor R24 connected in series with grid balance variable resistor R25 and the negative 250-volt power supply. Grid balance variable resistor R25 varies the starting point or origin of the sweep trace and is adjusted so that the sweep trace starts at the center of the face of the CRT. The input signal is amplified by V4A and coupled to amplifier V4B by C16. The X amplifier grid zero variable resistor R34 in the interstage coupling network is used to zero the dc amplifier so that there is no output with zero input. The sweep signal is then applied to voltage amplifier V5B. The grid bias of V5B is a fixed value so that with the plate potential of +600 volts, a maximum linear sweep voltage is produced.

n. The sweep output of V5B is applied through the network consisting of R54, R55, and gain adjust variable resistor R50A with parallel Zener diodes CR4, CR5, and CR6 to P1-20. The output sweep voltage from V5B, taken from the junction of variable resistor R50A and resistor R60, is approximately 63 volts and is applied through the filtering network consisting of R42 and R43 with parallel capacitors C20 and C21. This same signal is applied through the filtering network consisting of gain variable resistor R28 (C41) and resistors R31, R30, and R29 with parallel capacitors C11, C14, C13, and C12 as degenerative feedback to the input of V4A. Variable resistor R28 adjusts the overall gain of the sweep generator.

o. From the filtering network, the sweep signal is applied through resistors R47 (C45) and R48 to amplifier V5A. The output of V5A is 180 degrees out of phase with the output of V5B and is applied through the network consisting of resistors R57 and R56, and gain adjust variable resistor R50B with parallel Zener diodes CR7, CR8, and CR9 to P1-22. The voltage taken from the junction of variable resistor R50B and resistor R59 is applied to the network consisting of resistors R44 and R45 with parallel capacitors C22 and C23 as degenerative feedback. This feedback insures that the gain of V5B is unity. The +250 switch voltage is applied to the suppressor grids of V5 when IND. H.V. ON — IND. H.V. OFF switch-indicator A8 on the LOPAR auxiliary control-indicator is operated to IND. H.V. ON and PLATE VOLTS—OFF switch S9 on the acquisition power control panel is on.

p. The outputs of the Y sweep generator (C50) are applied to the vertical (north-south) deflection plates of the CRT. The outputs of the X sweep generator are applied to the horizontal (east-west) deflection plates of the CRT.

86 (U). Cathode-Ray Tube Deflection

Note. The grid zone references shown in parentheses in *a* and *b* below refer to figure 34, TM 9-1430-254-20/6, unless otherwise indicated.

a. The average potential appearing at the plates of V5A and V5B (B45) in the sweep generators is 300 volts. The plate potential for V5A and V5B is obtained from a supply of +600 volts furnished by 600v power supply (fig. 17, B27, TM 9-1430-254-20/6) in the PPI high voltage power supply. The average potential appearing on each of the four deflection plates of the CRT (B47) is 120 volts above ground. Zener diodes CR4, CR5, CR6, CR7, CR8, and CR9 with the parallel resistors are level shifting networks that drop the average potential of each output stage from 300 to 60 volts output to the CRT. Since the magnitude of voltages on the deflection plates used in an electrostatic deflection system is kept low to avoid high voltage insulation problems, negative voltage is applied to other elements of the CRT to obtain the large potential differences needed for the proper operation of the CRT. The voltages are applied by the 3.3kv power supply and the 8kv power supply (fig. 30, B20, TM 9-1430-254-20/6). Functional analysis of power supplies is given in TM 9-1430-250-20/12. The application of the remaining signals and voltages to the CRT is discussed in paragraphs 83, 110, and 111.

b. When the X and Y coordinate deflection voltages from the associated PPI dc amplifier are applied to the four deflection plates of the CRT (B48), the cathode-ray beam is deflected to a position that is determined by the vectorial resultant of the four applied quadrature voltages. The amplitude of the push-pull outputs of each PPI dc amplifier is determined by the azimuth angle of the acquisition antenna. Consequently, as the acquisition antenna rotates, the deflection voltages vary accordingly, and the azimuth position of the radial sweep rotates in synchronism with the azimuth of the acquisition antenna.

87 (U). Fail-Safe Circuit

Note. The grid zone references shown in parentheses in *a* through *f* below refer to figure 34, TM 9-1430-254-20/6, unless otherwise indicated.

a. The sweep voltages from connector P1-22 (B47 and B51) on each sweep generator are applied to the fail-safe circuit in the pulse and logic generator. The fail-safe circuits supply normal collector voltage to the CRT. Whenever the sweeps are missing, the fail-safe circuits supply fail-safe collector voltage to the CRT.

b. The sweep signal from the X sweep generator is applied through P1-22 (C15) on the pulse and logic generator, through resistor R51 and applied across X sweep amplitude variable resistor R52 and resistor R53. The X sweep amplitude variable resistor R52 controls the level of conduction of V5A. The sweep signal from the Y sweep generator is applied through P1-24 (C15) and resistor R54, and applied across Y sweep amplitude variable resistor R55 and resistor R56. The Y sweep amplitude variable resistor R55 controls the conduction level of V5B. Since the operation of V5A and V5B is identical, only the operation of V5A will be discussed.

c. If the input sweep signal to the control grid of V5A is positive, the signal at the plate will be inverted (negative). This signal will back-bias crystal diode CR15 and there will be no conduction. The signal at the cathode of V5A will be positive and will be applied through capacitor C21, crystal diode CR16, and then applied to capacitor C24.

d. If the input sweep signal to V5A is negative, the signal at the plate will be positive. This signal will be applied through capacitor C20, crystal diode CR15, and then to capacitor C24. The signal at the cathode will be negative. This signal will back-bias crystal diode CR16 and there will be no conduction.

e. The signals from V5A and V5B will charge capacitor C24. The discharge time of the capacitor is determined by the time constant of C24, resistor R69, and time control variable resistor R70 (C17). If both sweeps are present, capacitor C24 will be charged to a constant level. This level is applied to the control grid of relay control amplifier V6A. Zener diode CR19 clamps the cathode of V6A to 15 volts. The positive signal on the control grid makes V6A conduct, energizing fail-safe relay K4 (C23) in the plate circuit. This will apply normal collector voltage of +200 volts set by normal collector voltage adjust variable resistor R19 (C26) through contacts 1 and 6 of energized relay K4 to the collector of the CRT. The time constant of capacitor C24 is large enough so that normal collector voltage will not be lost during the period between successive sweeps.

f. If both sweeps are lost, capacitor C24 will discharge. There will not be enough signal on the control grid to keep V6A in conduction. Relay K4 will deenergize and apply fail-safe collector voltage of +25 volts set by fail-safe collector voltage adjust variable resistor R18 (C25) through contacts 8 and 6 of deenergized relay K4 to the collector of the CRT. Contacts 4 and 2 of deenergized relay K4 ground out the video unblanking pulse through crystal diode CR5 in the writing gun driver.

Section III (U). B SCOPE INDICATOR SWEEP CIRCUITS

88 (U). Purpose

a. The B scope indicator sweep circuits are those circuits of the presentation system (fig. 1) that produce azimuth (horizontal) and range (vertical) sweeps for the B scope indicator. These sweep circuits also generate and position a small circular symbol representing the azimuth and range of the target tracking radar system.

b. A 1066-mil (approximately 60 degrees) by 220,000-yard rectangular sector for video display is provided by the B scope indicator. This sector is centered on the target track antenna circle which is displayed at the center of the B scope indicator at the time of initial acquire.

c. The range sweep of the B scope indicator has a 1340-microsecond (220,000-yard) duration and occurs at the sync pulse repetition rate of 500 cps in the target tracking radar system. Although a range sweep is produced for each sync pulse received, the cathode-ray tube (CRT) B scope indicator is blanked except for a selected 1066-mil azimuth sector of acquisition antenna rotation. During this 1066-mil sector, the B scope indicator is unblanked and the range sweep appears as a vertical trace. At the same time azimuth sweep is produced which moves the vertical trace, in synchronization with the antenna rotation, from left to right across the face of the B scope indicator. Unblanking of the B scope indicator (par. 113) is controlled by the B scope video amplifier in the video circuits.

d. Timing of the B scope indicator sweep circuits is divided into two intervals within the 2000-microsecond period established by the sync pulse repetition rate. These intervals are the scan and symbol display discussed in (1) through (3) below.

(1) The scan interval is the normal 1340-microsecond range sweep time of the B scope indicator. This interval begins with each sync pulse and appears as an intensified trace on the B scope indicator only during the selected 1066-mil azimuth sweep.

(2) The symbol display interval occurs during the 660 microseconds of time remaining between the end of one range sweep and the start of the next. During the intervals between range sweeps, the sweep circuits of the B scope indicator generate signals which make up the target track antenna circle and apply them, at the correct range and azimuth, to the deflection plates of the CRT.

(3) The scan and symbol intervals are time-shared in the B scope sweep amplifiers. This is accomplished by alternately switching the scan and symbol data signals through electronic gating action which is initiated by pulses generated within the B scope video amplifier.

89 (C). Block Diagram Analysis

Note. Refer to figure 33 for the analysis given in *a* through *e* below.

a. Acquisition azimuth resolver B2 (par. 78) generates two output signals from an electrical and a mechanical input. The electrical input, used as a reference and a source of excitation, is a 4-kilocycle continuous wave carrier from the 4-kc oscillator (par. 77). The mechanical input is received through mechanical coupling from the acquisition azimuth drive motor (fig. 5). The two resolver outputs (fig. 33) supplied by the resolver rotor, are amplitude-modulated 4-kilocycle signals whose amplitudes vary with the sine and cosine of the azimuth angle of the antenna. These signals are designated the LOPAR N-S and LOPAR E-W resolver signals. The two signals are amplified and matched to the load circuit by a two-channel resolver amplifier (par. 79). The amplified N-S and E-W resolver signals are than applied through contacts of HIPAR select relay K1 in the LOPAR auxiliary control-indicator (par. 90) part of the auxiliary acquisition control interconnecting group, to the synchro assembly in the target radar control console. In selected systems using AAR, LOPAR RESOLVER signals are applied through normally closed contacts 5-15 of HIPAR/AAR select relay K1 (fig. 34, A1) and normally closed contacts 1 and 6 of HIPAR/AAR select relay K3 (fig. 34, A2) to the ECCM console.

b. The synchro assembly (par. 91) consists of symbol position control transformer B1, torque receiver B2, scan position resolver B3, and an electro-mechanical brake. These units, B1 and B2, and resolver B3, are connected to each other by mechanical linkage with a ratio of 1:1. The input to resolver B3 is the acquisition north-south (N-S) and east-west (E-W) resolver signals. Resolver B3 supplies azimuth scan position information to the B scope modulation eliminator and azimuth sector blanking information to an azimuth blank generator (par. 112) in the acquisition video circuits. Symbol position control transformer B1 in the synchro assembly receives azimuth information from azimuth control transmitter B1 in the target azimuth position transmitter and supplies symbol azimuth position signals to the B scope modulation eliminator. Torque receiver B2 functions as a synchro used only during reframe or acquire operations. When one of these operations is selected, the electro-mechanical brake is released, and torque receiver B2 receives positioning and excitation through contacts of framing relays K5 and K6. As a result, control transformer B1 and resolver B3 are mechanically repositioned to a setting corresponding to the current azimuth of the antenna in the target tracking radar system.

c. The B scope modulation eliminator (par. 92) contains two demodulator channels: an azimuth scan position channel, and a symbol azimuth position channel, discussed in (1) and (2) below.

(1) The azimuth scan position channel in the B scope modulation eliminator demodulates the 4-kilocycle azimuth scan position signal from scan position resolver B3. The demodulated output of this channel is applied as azimuth scan voltages to a channel of the B scope sweep generator (par. 94). The B scope sweep generator contains two channels: an azimuth sweep channel, and a range sweep channel. The two channels develop sawtooth deflection voltages for application to B scope electronic gates Z1 and Z3 (par. 97). During the scan interval (par. 88), Z1 and Z3 are gated by switching pulses generated in the B scope marker generator (par. 96). Electronic gates Z1 and Z3 switch the sawtooth deflection voltages to the B scope sweep amplifiers (par. 98) for application to the deflection plates of the B scope indicator.

(2) The symbol azimuth position channel in the B scope modulation eliminator demodulates the 400-cps symbol azimuth position signal from symbol position control transformer B1 located in the synchro assembly. The output of the symbol azimuth position channel is a dc analog voltage representing the angular difference between the present azimuth of the antenna in the target tracking radar system and the acquisition antenna azimuth displayed at the center of the B scope indicator. This analog voltage is applied to the azimuth position channel of the azimuth and range position amplifier (par. 93). Range analog voltage received from the target range position transmitter, part of the target tracking radar system, is amplified by the range position channel of the azimuth and range

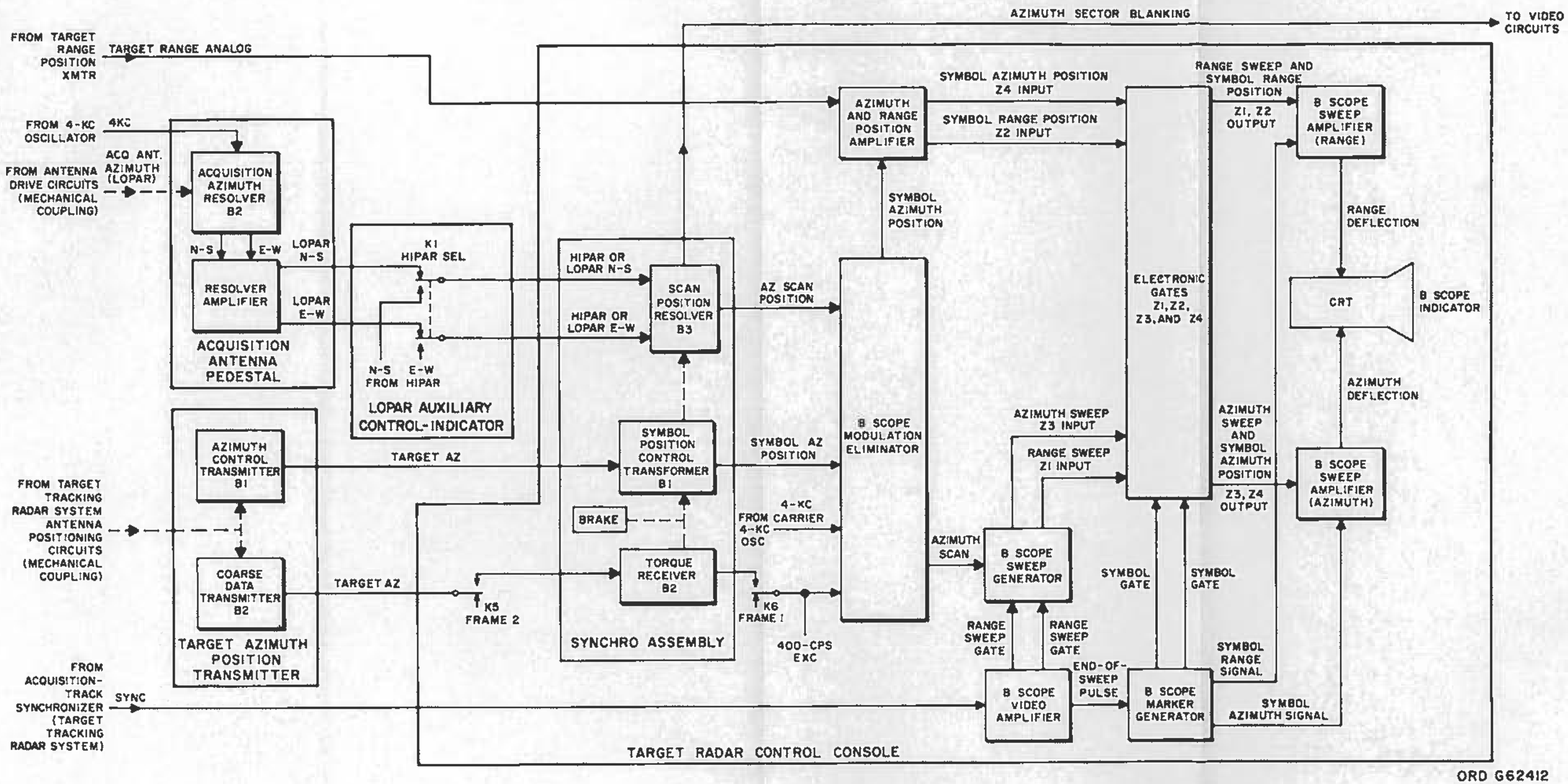


Figure 33 (U). B scope indicator sweep circuits—block diagram (U).

position amplifier. The amplified symbol range and symbol azimuth analog voltages are applied to electronic gates Z2 and Z4 (par. 97). During intersweep intervals, Z2 and Z4 are operated by symbol gate pulses from the B scope marker generator. These pulses reverse or switch the normal impedance conditions of Z2 and Z4 allowing the analog voltages used for symbol positioning to be applied through the azimuth and range B scope sweep amplifiers (par. 98) to the deflection plates of the cathode-ray tube (CRT).

d. The B scope video amplifier (par. 95) functions as the control unit of the B scope indicator. For every sync pulse received at the B scope video amplifier, two range sweep gates are developed for application to an electronic gate in the B scope sweep generator and an end-of-sweep pulse is developed for application to the B scope marker generator. The B scope marker generator uses the end-of-sweep pulse to initiate the symbol display interval (par. 88*d*) of the B scope indicator. Outputs of the B scope marker generator are: the symbol gate pulses applied to electronic gates Z1 through Z4 (par. 97); the symbol azimuth signal applied to the B scope sweep amplifier (azimuth); and the symbol range signal applied to the B scope sweep amplifier (range).

e. Electronic gates Z1, Z2, Z3, and Z4 are comparable to single-pole, single-throw switches. Their function is to control the application of input signals to the two B scope sweep amplifiers. Depending on the polarity of switching pulses applied to the electronic gates, the B scope sweep amplifiers receive either normal sweep voltages or analog symbol positioning voltages which represent the B scope scan interval and symbol display interval, respectively. The voltages are amplified by the B scope sweep amplifiers to the amplitude required at the deflection plates of the B scope indicator CRT.

90 (U). Acquisition Resolver Signal Switching

The selection of HIPAR or LOPAR acquisition resolver signals, applied to the B scope indicator sweep circuits, is controlled by HIPAR select relay K1 (fig. 34, C5, TM 9-1430-254-20/6) located in the LOPAR auxiliary control-indicator. Refer to paragraph 13 for a functional description of the radar select circuits. Refer to paragraphs 78 through 80 for a functional description of the resolver circuits.

91 (U). Synchro Assembly

a. The synchro assembly (fig. 33) provides both azimuth scan information and symbol azimuth position information to the sweep generating and symbol positioning circuits of the B scope indicator.

b. The synchro assembly contains four electro-mechanical devices: symbol position control transformer B1, torque receiver B2, scan position resolver B3, and an electro-mechanical brake. These electro-mechanical devices are mechanically connected by a common linkage at a gear ratio of 1:1.

Note. The grid zone references shown in parentheses in *c* below refer to figure 35, TM 9-1430-254-20/6, unless otherwise indicated.

c. The functional operation of the synchro assembly is described in (1) through (5) below.

(1) Torque receiver B2 (B5) in the synchro assembly provides the mechanical driving force which positions the rotors of symbol position control transformer B1 and scan position resolver B3 to the antenna azimuth of the target tracking radar system. The stator input voltage to torque receiver B2 is a 400-cps positioning signal produced by coarse data transmitter B2 (B2) in the azimuth position transmitter. The rotor input voltage to torque receiver B2 (B5) is a 120-volt, 400-cps servo excitation signal. The stator input is received through contacts 10 and 4, 11 and 6, and 12 and 8 of frame 2 relay K5 (B4), while the rotor input to torque

receiver B2 is applied through contacts 5 and 3 (B6) of frame 1 relay K6. These relays are normally de-energized. Only when relays K5 and K6 are energized, (5) below, does torque receiver B2 receive excitation and positioning voltages.

(2) Symbol position control transformer B1 (A5) in the synchro assembly receives a 400-cps stator input voltage from azimuth control transmitter B1 (A2) located in the azimuth position transmitter. The 400-cps input voltage contains antenna position information from the target tracking radar system. The rotor output of symbol position control transformer B1 (A5) is a 400-cps error voltage signal which represents, by phase and amplitude relationships, the relative angle between the present azimuth and the azimuth of the antenna in the target tracking radar system when the presentation was last reframed. The azimuth difference is established in the synchro assembly as a shaft position by the action of torque receiver B2 and its associated frame 1 relay K6 and frame 2 relay K5. The error voltage signal from the rotor of transformer B1 is applied to the B scope modulation eliminator (par. 92). As an end result, this error signal determines the azimuth (horizontal) position of the target track antenna circle on the B scope indicator CRT.

(3) Scan position resolver B3 (A5) in the synchro assembly has two stator windings and two rotor windings. The input to the stator windings of resolver B3 is the LOPAR N-S and the LOPAR E-W resolver signals from the resolver amplifier (fig. 34, D2, TM 9-1430-254-20/6). These signals consist of steady 4-kilocycle oscillations modulated by rotation of the acquisition antenna. The modulation produces an envelope consisting of two sinusoidal alternations for each 6400 mils of antenna rotation. This is similar to 100-percent modulation of the 4-kilocycle carrier by the waveshape developed across a resistive load in a full-wave rectifier during one cycle of the ac supply voltage. These envelope variations of the two stator input signals (LOPAR N-S and E-W) are 90 degrees out of phase. The rotor of scan position resolver B3 (A5) is wound in quadrature so that its two windings (R1-R3 and R2-R4) also produce output signals having modulation envelopes 90 degrees out of phase. However, as the rotor of scan position resolver B3 is displaced relative to its stator, the modulation envelopes of its output signals may be varied in phase, 0 through 360 degrees, with respect to the modulation envelopes of the stator signals. Since the rotor of scan position resolver B3 is mechanically coupled to torque receiver B2 (B5), the relative position of the stator and rotor of resolver B3 is determined by the position of the rotor of B2. The E-W rotor output of B3 is the scan position signal applied to the B scope modulation eliminator (B8). From this signal the modulation eliminator develops a sine wave, a part of which is used to develop the sweep voltages for the azimuth sweep of CRT V2 (B28). The N-S rotor output (called the resolver N-S quadrature signal because of 90-degree phase difference from the E-W signal) is applied to the azimuth blank generator (par. 112). Since this signal reaches a maximum amplitude when the acquisition antenna is passing through the center of the selected 1066-mil sector of display, it is used to develop an azimuth blanking control voltage. This control voltage, developed in the azimuth blank generator, insures that CRT V2 (B28) is unblanked only when the acquisition antenna is passing through the selected 1066-mil sector of display.

(4) Electro-mechanical brake solenoid L1 (B5) is normally energized and holds

the three servomechanisms locked in position. The brake is held energized as long as a complete path for the brake solenoid is maintained through contacts 6 and 1 (C6) of frame 1 relay K6 and brake release switch S1 (B5). When the servomechanisms are to be electrically zeroed, the brake is released by depressing brake release switch S1.

(5) Operation of the synchro assembly is controlled by ACQUIRE switch S5C (B4) in the target antenna control group, or REFRAME switch S1 (C8) on the front panel of the B scope indicator. Operating ACQUIRE switch S5C (B4) or depressing REFRAME switch S1 (C8) energizes frame 2 relay K5 (B4) and frame 1 relay K6 (C6). Energizing relays K5 and K6 deenergizes the electro-mechanical brake and applies excitation and positioning voltages to torque receiver B2 (B5). Torque receiver B2 repositions control transformer B1 and resolver B3 to the azimuth position of the antenna in the target tracking radar system. Relays K5 and K6 are connected so that K6 deenergizes before K5 setting brake L1 and removing the excitation before the stator input to B2 is removed. This procedure prevents any shift of the rotor of B2 due to transients that might occur during switching. Isolation diode CR2 (B4) prevents a lockup path for relays K5 and K6 and enables these relays to deenergize after the release of the ACQUIRE or REFRAME switches. ACQUIRE switch S5C (B4), in addition to energizing the framing relays, energizes circuits which position the antenna in the target tracking radar system to the azimuth of the designate circle from the acquisition radar. This positioning is the initial acquiring of a target. During target tracking, the target track antenna circle moves away from the center line of the B scope indicator if there is a variation in target azimuth. REFRAME switch S1 (C8) energizes framing relays K5 and K6, thereby recentering the video and symbol display on the B scope indicator.

92 (U). B Scope Modulation Eliminator

a. The B scope modulation eliminator (fig. 33) demodulates both symbol azimuth position and azimuth scan position signals received from the synchro assembly.

b. The B scope modulation eliminator contains two demodulator channels, an azimuth scan position channel, and a symbol azimuth position channel. The azimuth scan position channel operates at 4 kilocycles and phase demodulates the signal received from scan position resolver B3 in the synchro assembly (par. 91*c*). The output of this channel is an amplitude-limited sinusoidal signal with a peak amplitude of 10 volts and a duration equal to one acquisition antenna rotation period. The symbol azimuth position channel operates at 400 cps and phase demodulates the output of symbol position control transformer B1 in the synchro assembly. The output of this channel is dc analog voltage whose amplitude represents the angular difference between the present azimuth of the antenna in the target tracking radar system and the azimuth displayed at the center of the cathode-ray tube (CRT) of the B scope indicator. The polarity of the dc analog voltage determines the direction of this angular difference. The rotation of the antenna in the target tracking radar system through 6400 mils provides this channel with a sinusoidal output. Zero volts is developed when the antenna azimuth of the target tracking radar system is the same as the center azimuth of the B scope indicator.

c. The functional operation of the B scope modulation eliminator is discussed in (1) and (2) below. Since the operation of both channels is similar, only a brief discussion of the symbol azimuth position channel is given in (2) below.

Note. The grid zone references shown in parentheses in (1) and (2) below refer to figure 35, TM 9-1430-254-20/6.

(1) The azimuth scan position channel receives the modulated 4-kilocycle re-

solver E-W signal from scan position resolver B3 (A5). This signal is applied through SWP AMP variable resistor R1 (A8) to closed contacts 1 and 2 of NORMAL—SWP-ZERO switch S1 (set to SWP), connected in series with the primary of transformer T2. Transformer T2 couples the slowly varying 4-kilocycle signal to a crystal bridge demodulator (A10) which consists of crystal diodes CR1, CR2, CR3, and CR4, and precision resistors R2, R3, R4, and R5. The precision resistors compensate for slight differences in conduction of the crystal diodes. A 4-kilocycle reference signal (A8) is applied to the primary winding of coupling transformer T1 (A9). The secondary output of T1 is applied to the crystal bridge demodulator. Depending on the phase relationship between the 4-kilocycle reference signal and the modulated 4-kilocycle resolver E-W signal (azimuth scan position signal), the bridge demodulator is unbalanced in either of two current directions. Any bridge demodulator unbalance causes current to flow through load resistor R8 (A10). The direction of this current flow through R8 is controlled by the direction of the bridge demodulator unbalance. Since the azimuth scan position signal varies in amplitude and phase (0 to 180 degrees relative to 4-kilocycle reference) with acquisition antenna rotation, the current through R8 varies in amplitude and direction. Resistors R6 and R7, and capacitors C1 and C2 form a filter network which eliminates any 4-kilocycle component in the output waveform. Zener diodes CR9 (A11) and CR10, in series back-to-back, serve as sweep voltage limiters when NORMAL—LIMIT-OFF switch S3 (A11) is set to LIMIT. Diodes CR9 and CR10 have an inverse voltage rating (Zener effect) of 9.5 to 12 volts, thereby limiting the sweep output voltage to ±10 volts. The output of the scan position channel is an amplitude-limited sinusoidal signal applied to the B scope sweep generator (par. 94). Variable resistor R1 (A8) is used to adjust the amplitude of the azimuth scan position input signal. The setting of this adjustment is made with NORMAL—LIMIT-OFF switch S3 (B11) set to OFF. This switch setting removes the limiting action of CR9 and CR10, and allows a true measurement of azimuth scan voltage at SWP test point TP1. The output signal, applied to the B scope sweep generator, determines the width of the azimuth display on CRT V2 (B28). The ZERO position of S1 (A9) is used in conjunction with zero set variable resistor R24 (A13) when zeroing the azimuth scan sweep amplifiers in the B scope sweep generator.

(2) The symbol azimuth position channel receives an amplitude-modulated 400-cps symbol position error voltage from symbol position control transformer B1 (A5). This signal is applied through closed contacts 4 and 5 of NORMAL—POS-ZERO switch S2 (B9) (set to POS) to transformer T3. The output of T3 is applied to a crystal demodulator bridge which consists of crystal diodes CR5, CR6, CR7, and CR8 and precision resistors R12, R13, R14, and R15. These resistors compensate for slight differences in conduction of the crystal diodes. A 400-cps reference signal is applied through transformer T4 (B9) to opposite corners of the crystal bridge. The bridge output voltage is developed across load resistor R9 (B10). The amplitude and polarity of this voltage is dependent upon the amplitude and phase, respectively, of the input symbol position error voltage. Resistors R10 and R11, and capacitors C3 and C4 form a filter network to remove any 400-cps component in the demodulated output voltage. The output signal may be measured at

POS test point TP2 (B11). The output of the symbol azimuth position channel is a dc analog voltage whose amplitude and polarity indicate the azimuth setting of the target track antenna, is applied to the azimuth and range position amplifier. The ZERO position of S2 (B9) is used in conjunction with AZ ZERO SET variable resistor R4 (C3) for zeroing the dc amplifiers in the azimuth position channel of the azimuth and range position amplifier (par. 93).

93 (U). Azimuth and Range Position Amplifier

a. The azimuth and range position amplifier (fig. 33) adjusts and amplifies the dc input analog voltages which are subsequently used to position, in azimuth and range, the target track antenna circle displayed on the B scope indicator.

b. The azimuth and range position amplifier contains two channels: the azimuth position channel and the range position channel. These channels are used to adjust the respective analog scale factors, to shift the dc level, and to isolate input and output signals from each other.

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 35, TM 9-1430-254-20/6, unless otherwise indicated.

c. The input and output signals of the azimuth and range position amplifier (D2) are given in (1) and (2) below.

(1) The azimuth position channel consists of dc amplifiers V1A (C4), V1B and V2A (C5), voltage regulator V3, and associated controls and circuits. This channel receives azimuth analog voltage which is symbol azimuth position information in dc analog form from the B scope modulation eliminator. The output of this channel at connector P1-7 (C6) is the symbol azimuth position applied as a dc analog voltage to electronic gate Z4 (par. 97). During the symbol display interval, Z4 (D22) applies this voltage to the B scope sweep amplifier (azimuth) (par. 98*b*). The dc level of the analog voltage establishes the azimuth position of the target track antenna circle.

(2) The range position channel consists of dc amplifiers V4A (D4), V4B and V2B (D5), voltage regulator V5, and associated controls and circuits. This channel receives range analog voltage (D2) which is symbol range position information in dc analog form from the target range position transmitter in the target tracking radar system. The output of the range position channel at connector P1-9 (D6) is the symbol range position applied as a dc analog voltage to electronic gate Z2 (par. 97*d*). During the symbol display interval, Z2 (B22) applies this voltage to the B scope sweep amplifier (range) (par. 98*b*). The dc level of this analog voltage establishes the range position of the target track antenna circle.

d. Since the operation of the azimuth position channel and the range position channel is identical, a functional analysis of the azimuth position channel only is given in (1) and (2) below.

(1) Azimuth position voltage in dc analog form from the B scope modulation eliminator is applied through input resistor R1 (C3) to the grid of dc amplifier V1A. Amplifier V1A is the first in a series of three dc amplifiers, V1A, V1B, and V2A. These three amplifiers set the dc level and scale factor of the symbol azimuth position analog voltage. Voltage regulator V3 (D5) establishes a constant dc potential on the cathode of V2A which provides a more linear output from the azimuth and range position amplifier. Under normal conditions, the output scale factor of the azimuth position channel is 0.33 volt per azimuth degree. The symbol azimuth position analog voltage can be of either polarity, depending on the azimuth position of the antenna in the target tracking radar system with

respect to the azimuth displayed at the center of B scope indicator CRT V2 (B28).

(2) AZ ZERO SET variable resistor R4 (D3) is used to zero set the azimuth position channel. With no input voltage, variable resistor R4 is adjusted so that the output voltage is zero. This voltage may be measured at AZ OUTPUT test point TP3 (C6). AZ GAIN variable resistor R20 is the gain control of the azimuth position channel. The setting of variable resistor R20 determines the amount of feedback voltage to V1A, and variable resistor R20 is adjusted so that the output scale factor of the azimuth position channel is 0.33 volt per azimuth degree.

(3) Corresponding to variable resistors R4 (D3) and R20 (C6), (2) above, RG ZERO SET variable resistor R24 (D3) is adjusted so that the output voltage of the range position channel is zero when the input is zero, and RG GAIN variable resistor R39 (D6) adjusts the output scale factor of the range position channel to 0.6 millivolt per yard.

e. The symbol azimuth and range position analog voltage outputs of the azimuth and range position amplifier are applied to electronic gates Z4 and Z2, respectively (par. 97).

94 (U). B Scope Sweep Generator

a. The B scope sweep generator (fig. 33) functions to produce the horizontal and vertical sweep voltages required for a B scan presentation.

b. The B scope sweep generator has two independent channels, an azimuth sweep generating channel, and a range sweep generating channel. The input and output signals of the B scope sweep generator are given in (1) and (2) below.

(1) The input of the azimuth sweep channel of the B scope sweep generator is the azimuth scan position signal. This signal is a slowly varying, clipped sinusoidal voltage with an amplitude of ±10 volts. This limited sinusoidal waveform, received from the B scope modulation eliminator (par. 92), has a duration equal to the period of the acquisition antenna rotation. The output of the azimuth sweep channel is a ±dc voltage with near linear leading and trailing edges varying slowly between +10 volts and −10 volts. This voltage is ultimately used to sweep the electron beam of the B scope indicator cathode-ray tube (CRT) from left to right as the acquisition antenna passes through the selected azimuth sector.

(2) The input of the range sweep channel of the B scope sweep generator consists of positive and negative range sweep gates received simultaneously from the B scope video amplifier (par. 95). Both of these gates have a time duration of 1340 microseconds and a repetition rate of 500 pulses per second. The output of the range sweep channel is a positive sawtooth waveform, 1340 microseconds (220,000 yards) in duration. This sawtooth waveform is the range sweep pulse which is ultimately used to move the electron beam of the B scope indicator in range (from bottom to top).

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 35, TM 9-1430-254-20/6, unless otherwise indicated.

c. A functional analysis of the B scope sweep generator is given in (1) through (4) below.

(1) The input of the azimuth sweep channel is the azimuth scan signal (A12) from the B scope modulation eliminator. This signal is applied through resistor R19 to azimuth sweep amplifier V3 with amplifier V4 operating in cascade. The output of amplifier V4 is applied to cathode follower V5B. The azimuth sweep voltage from cathode follower V5B is applied to electronic gate Z3 (C22). The output of V5B (A14) is also applied through the parallel combination of resistor R38 and capacitor C6 (B13) as a feedback voltage to the input of V3.

This negative feedback increases the linearity of the azimuth sweep portion of the output waveform.

(2) Azimuth zero set variable resistor R24 (A13), part of a voltage divider including resistors R23 and R25, and Zener diodes CR3 and CR4, is used to balance the azimuth sweep channel output to zero when the input is zero.

(3) The inputs of the range sweep channel are the ±75-volt sweep gates (C12) from the B scope video amplifier. These sweep gates have a 1340-microsecond time duration for the range sweep interval and occur in time coincidence. They are used to switch electronic gate Z1 (D15) to its high impedance condition, *d*(2) below, during range sweep time. Electronic gate Z1 is a unidirectional gating network comparable to a single-pole, single-throw switch. When the high impedance of Z1 appears across capacitor C1 (D16), the negative voltage at the junction of resistors R35 (C14) and R36 is applied to capacitor C1. Capacitor C1 (D16), connected between the input of V1 and the output of V5A, is allowed to charge for 1340 microseconds. The charge rate of capacitor C1 is controlled by range slope adjust variable resistor R1 (C14). The negative variation caused by the charging of capacitor C1 is applied to the grid of amplifier V1 (C17). It is amplified by V1 and V2 and causes a positive rising potential to occur at the output of cathode follower V5A. The trailing edges of the 1340-microsecond range gate pulses switch Z1 back to its low impedance condition. In this condition of Z1, no sweep voltages are produced by the B scope sweep generator.

(4) Range slope adjust variable resistor R1 (C14), part of capacitor C1 charging circuit, varies the physical length of the range (vertical) sweep on the B scope indicator. Variable resistor R1 is adjusted so that the 220,000-yard range sweep covers the face of CRT V2 (B28). Range balance variable resistor R5 (D14) is used to balance the diode bridge of electronic gate Z1. This adjustment compensates for differences in forward resistances of the bridge diodes and insures that the grid of amplifier V1 is returned to the same voltage point after each sweep. By this function, variable resistor R5 insures proper potential balance on both sides of capacitor C1. Balance tuner variable capacitor C5 (D13) is used to balance the capacitance of the diode bridge in electronic gate Z1. Range zero set variable resistor R7 (D17), part of a voltage divider including R6 and R8, and Zener diodes CR1 and CR2, is used to balance the range sweep channel output to zero when the input is zero.

d. Electronic gate Z1 (D15) is comparable to a single-pole, single-throw switch that provides either a low or high impedance path. Electronic gate Z1 is controlled by the ±75-volt sweep gates from the B scope video amplifier. These sweep gates are coincident in time and of opposite polarity. The electronic gate is closed (low impedance condition) during the no-sweep interval. During this period, electronic gate Z1 acts as a short circuit across sweep-forming capacitor C1 (D16). As the sweep gates switch polarity in coincidence with system sync, electronic gate Z1 presents an open circuit (high impedance) across sweep-forming capacitor C1, allowing it to charge in a sawtooth manner and form the range sweep signal at the output of cathode follower V5A (C19). The low and high impedance conditions of electronic gate Z1 (fig. 34) are discussed in (1) and (2) below.

(1) During the 660-microsecond, no-sweep interval of the sweep gates applied to electronic gate Z1, all crystal diodes in the bridge circuit (CR1, CR2, CR5, and CR6) are conducting. The current flows from the —250-volt supply, through resistor R1, the two bridge arms, and resistor R2 to the

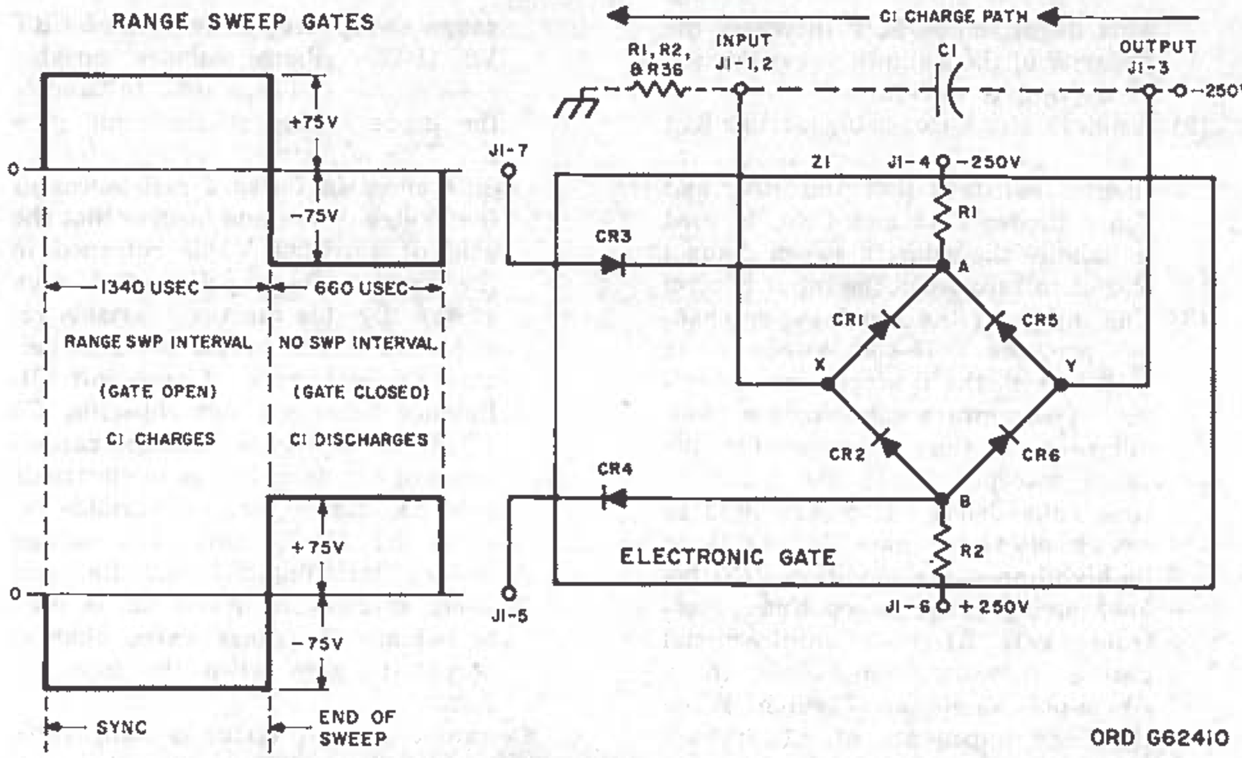


Figure 34 (U). B scope sweep generator—electronic gate—simplified schematic diagram (U).

+250-volt supply. Due to the forward bias on the diodes, all the diodes conduct, and the impedance from junction X to junction Y is extremely low. Since capacitor C1 is connected between junctions X and Y, the integrator circuit cannot function.

(2) During the 1340-microsecond range sweep interval when the positive and negative sweep gates arrive at connector J1, terminal 7 swings positive, diode CR3 conducts, and junction A becomes positive. At the same time, terminal 5 swings negative, diode CR4 conducts, and junction B becomes negative. With junction A positive and junction B negative, all bridge diodes are back-biased and, therefore, cut off. In this condition, the impedance from junction X to junction Y is extremely high, and the charging circuit for C1 (D16) is free to function.

95 (U). B Scope Video Amplifier

Note. The grid zone references shown in parentheses in *a* through *c* below refer to figure 35, TM 9-1430-254-20/6.

a. A portion of the B scope video amplifier functions as a channel of the B scope indicator sweep circuits (fig. 33). The remaining portion (par. 114) functions as a channel of the B scope video circuits (par. 107). The sweep circuit channel generates both sweep gates applied to the B scope sweep generator and the end-of-sweep pulse input to the B scope marker generator (C15).

b. The sweep circuit channel of the B scope video amplifier (D9) consists of range sweep gate multivibrator V1 (D10), cathode follower V2A (C10), gate amplifiers V3A and V3B (C11), and associated controls and circuits. The functional operation of these circuits is explained in *c* below.

c. The input to the B scope video amplifier (D9) is a positive 20- to 40-volt sync pulse from the acquisition-track synchronizer in the target tracking radar system. This pulse is applied through crystal diode CR1 to range sweep gate multivibrator V1. Cathode-coupled monostable multivibrator V1 is biased so that one section (pins 1, 2, and 3) is normally cut off and the other section (pins 6, 7, and 8) is normally conducting. Cathode follower V2A is normally conducting because of the positive dc voltage applied to its grid from plate pin 1 of V1. When the positive sync pulse is applied to the normally cutoff section of V1, this section conducts, driving both V2A and the other section of V1 into cutoff. Crystal diode CR1 prevents residual negative pulses from affecting V1. In this condition, capacitor C7 charges through resistor R8 and RANGE ADJ variable resistor R17. As capacitor C7 charges, the voltage at grid pin 7 of V1 rises exponentially. After 1340 microseconds, determined by adjustment of R17, this section (pins 6, 7, and 8) of V1 is driven into conduction. By cathode coupling, the other section of V1 is cut off and V2A again conducts, completing the cycle of operation. Cathode follower V2A provides a current path for rapid discharge of C7. The rapid discharge of C7 forms a steep trailing edge on the negative 1340-microsecond pulse developed by V1. This steep trailing edge is used as an end-of-sweep pulse by the B scope marker generator (par. 96). The positive square wave from plate pin 6 of V1 is applied to gate amplifier V3A (C11). The amplified negative output of V3A is applied to connector J2-1 and gate amplifier V3B. The amplified positive output of V3B is applied to connector J2-3. The 1340-microsecond sweep gates from connector J2 are applied to the B scope sweep generator (par. 94).

96 (U). B Scope Marker Generator

a. A portion of the B scope marker generator (fig. 33) is a functional part of the B scope indicator sweep circuits. The rest is a functional part of the video circuits (par. 115). The function of the B scope marker generator used in the B scope indicator sweep circuits is to produce, during intersweep intervals, symbol azimuth and range signals. These signals produce the target track antenna circle which is displayed on the face of the cathode-ray tube (CRT) in the B scope indicator. The B scope marker generator also produces symbol gate pulses used for switching control of the electronic gates (par. 97). These gate pulses control the switching of input signals to the B scope sweep amplifiers.

b. The B scope marker generator receives a negative, 1340-microsecond end-of-sweep pulse from the B scope video amplifier (par. 95). The trailing edge of this pulse represents the end of the normal range sweep, and therefore, the beginning of the symbol display interval of the B scope indicator. The display of the target track antenna circle requires 160 microseconds. During this 160-microsecond period, the B scope marker generator applies symbol gate pulses to the electronic gates (par. 97). The electronic gates then pass the symbol range and symbol azimuth positioning voltages received from the azimuth and range position amplifier (par. 93) to the respective sweep amplifiers. Since the B scope sweep amplifier (par. 98) outputs are directly connected to the deflection plates of the CRT, the first 80-microsecond period is used to position the electronic beam of the CRT and to superimpose on that beam the azimuth and range symbol. During this first 80 microseconds, the CRT is blanked by the B scope video amplifier so that undesired positioning traces will not be displayed. During the second 80 microseconds, the CRT is unblanked by an 80-microsecond pulse from the B scope video amplifier and the symbol is displayed. The combination of the symbol azimuth and range signals, and the symbol positioning voltages from the B scope marker generator, produces the target track antenna circle at a position determined by the range and azimuth of the target tracking radar system. At the end of the second 80-microsecond interval, or 160 microseconds after end-of-sweep, the CRT is returned to blanked condition and the gate pulses applied to the electronic gates are reversed in polarity. Since the impedance condition of the electronic gate is changed by the reversal in polarity of the gate pulses, the electronic gates are ready to pass the next range sweep applied to the B scope sweep generator.

Note. The grid zone references shown in parentheses in *c* below refer to figure 35, TM 9-1430-254-20/6.

c. A functional diagram discussion of the B scope marker generator (B15) is given in (1) through (6) below.

(1) Operation of the B scope marker generator is initiated by the trailing edge of the negative, 1340-microsecond end-of-sweep pulse received from the B scope video amplifier (par. 95). This pulse is differentiated by the input RC circuit consisting of capacitor C1 (A15) and resistor R1. The leading edge of the end-of-sweep pulse produces a short negative pulse, and the trailing edge produces a short positive pulse. The negative pulse is not used. The positive pulse is applied as an end-of-sweep signal to the first triode section of monostable multivibrator V1, a dual triode. Pedestal adjust variable resistor R5 (B16), part of a voltage divider circuit, controls the bias of the first triode section of V1. Since V1 is monostable, the bias of the first triode section determines the point at which multivibrator action resets, and thus determines the operating time of V1. Variable resistor R5 is adjusted so that the positive end-of-sweep signal triggers V1 into operation for a 200-microsecond period starting at the end of normal sweep time.

(2) Outputs from both triode sections of V1 are used. The second triode section produces a positive 200-microsecond pulse applied to monostable multivibrator V4 (A20). The negative 200-microsecond pulse from the first triode section of V1 is applied through crystal diode CR1 (A17) to gating amplifier V2A. Crystal diode CR1 functions as a signal clipper and prevents interaction between the functions of V1 and V2A. The negative 200-microsecond pulse from V1 cuts off V2A which was current-loading the LC tank circuit of start-stop oscillator V2B (A18). The tank circuit of V2B consists of capacitor C7 and tapped inductor L1. Prior to being biased into cutoff, V2A conducts through L1 thereby holding the oscillator circuit inoperative. The resonant frequency of the parallel combination of C7 and L1 is 12.5 kilocycles. Capacitor C11 and oscillator adjust variable resistor R15 provide the necessary coupling and feedback between the tank circuit and V2B. Variable resistor R15 controls the feedback level to the oscillator tank circuit thereby controlling the amplitude of oscillations. Since V2B is allowed to operate for only 200 microseconds at a frequency of 12.5 kilocycles, the output of the tank circuit is 2-1/2 cycles of oscillation. The oscillator circuit has two outputs, one from the cathode of V2A, and the other from the cathode of V2B. From V2A, the oscillations are coupled through cathode follower V6A (B18) to symbol size variable resistor R41. Both the symbol azimuth and range signals are tapped from variable resistor R41. The symbol azimuth signal is phase-shifted 45 degrees by capacitor C28 (C20) and resistor R56. The symbol range signal is phase-shifted 45 degrees by resistor R57 (B20) and capacitor C29. These phase displacements produce a 90-degree phase-shift between the symbol azimuth and range signals, which, when applied to the deflection plates of the CRT in the B scope indicator, produce a circular lissajous figure.

(3) The second output of the oscillator circuit of V2B (A18) is supplied by the cathode of V2B. From V2B the oscillations are coupled to squaring amplifier V3A (B19) where the oscillations are squared and inverted. The inverted squared wave from V3A is coupled through cathode follower V3B to the junction of resistor R23 and capacitor C15.

(4) The positive 200-microsecond pulse from multivibrator V1 (A16) is applied to the second triode section of monostable multivibrator V4 (A20), a dual triode. This pulse triggers V4 and initiates the multivibrator action. Coupling between triode sections of

V4 is provided by the parallel combination of crystal diode CR2 and resistor R32. This coupling insures a steep leading edge in the output pulse. Multivibrator action is complete when, after 160 microseconds, V4 is switched back to its original condition by a composite step voltage received from capacitor C15, (5) below.

(5) When gating amplifier V2A (A17) is cut off by the negative 200-microsecond pulse from multivibrator V1 (A16), an instantaneous rise of plate voltage is prevented by a shaping circuit consisting of capacitor C6 (A19) and resistor R13. This shaping circuit drives the plate voltage of V2A positive at an exponential rate and is applied to resistor R23 (A19). This exponential voltage rise is mixed with the squared oscillations from the output of V3B. The resulting waveform, starting at the end of range sweep time, is an exponentially rising step-voltage waveform having two equal 80-microsecond steps. This composite waveform is coupled by capacitor C15 (B19) to the first triode section of multivibrator V4. Gate pulse adjust variable resistor R25 (A20), in the control grid circuit of the first triode section of V4, is used to adjust the slope of the step-voltage waveform so that the second 80-microsecond step reaches a potential sufficiently positive to cause the first triode section of V4 to conduct. The second triode section of V4, previously triggered into conduction by the 200-microsecond pulse from V1, is cut off because of common cathode resistor R28 (B20) which completes multivibrator action. Thus, the two outputs of V4 are positive and negative 160-microsecond pulses, occurring in time coincidence at the end of each range sweep.

(6) Both the positive and the negative outputs of V4 are used. The positive 160-microsecond pulse from the first triode section of V4 is applied to cathode follower V5B (B21). The negative 160-microsecond pulse from the second triode section of V4 is applied to cathode follower V5A. These two pulses of opposite polarity and occurring in time coincidence are supplied by the respective cathode followers as gating pulses to electronic gates Z1 through Z4 (par. 97). With a negative pulse at the output of V5A and a positive pulse at the output of V5B, electronic gates Z2 and Z4 pass symbol positioning voltage to the B scope sweep amplifiers (par. 98). After 160 microseconds, multivibrator V4 is switched back to its original condition. A positive pulse then appears at the output of V5A, and a negative pulse at the output of V5B. These pulses switch electronic gates Z2 and Z4 back to their original impedance conditions. This switching marks the end of the symbol display interval of the B scope indicator.

97 (U). Electronic Gates

a. Four electronic gates compose a circuit that is part of the B scope indicator sweep circuits (fig. 33). The electronic gates are used in pairs with their outputs connected so that each pair operates similarly to a single-pole, double-throw switch. These gates, used at the input of the B scope sweep amplifiers, allow the amplifier inputs to be electronically switched between the outputs of the B scope sweep generator, and the azimuth and range position amplifier.

b. Each of the four electronic gates consists of six crystal diodes and two precision limiting resistors. Either an input sweep signal or an input dc symbol positioning potential is passed through each gate. These electronic gates are switched by two symbol gate pulses of opposite polarity which operate in unison to open or close these electronic gates. These gate pulses are received from the B scope marker generator (par. 96*c*). Two electronic gates receive, as an information input, azimuth and range sweep voltages from the B scope sweep generator (par. 94). The two remaining electronic gates receive as an information input, azimuth and range symbol positioning voltages from the azimuth and range position amplifier (par. 93).

Note. The grid zone references shown in parentheses in *c* through *f* below refer to figure 35, TM 9-1430-254-20/6.

c. The electronic gates (A22) consist of electronic gates Z1 through Z4. The four electronic gates are identical and interchangeable with electronic gate Z1 (D15) in the B scope sweep generator (par. 94*d*) except for the source of input signals, application of the gate function, and use of the output signals.

d. The information input signals are applied to terminals 1 and 2 of each electronic gate. The sources of these signals are given in (1) through (4) below.

(1) The information input to electronic gate Z1 (A22) is the range sweep signal received from the range sweep channel of the B scope sweep generator (C19). This input is a succession of positive-going sawtooth pulses occurring 500 times a second. These pulses have a linearly-rising leading edge (ramp) and a steep trailing edge (sharp cutoff). Each sawtooth pulse has a ramp duration of 1340 microseconds, corresponding to a range of 220,000 yards.

(2) The information input to electronic gate Z3 (C22) is the azimuth sweep signal received from the azimuth sweep channel in the B scope sweep generator (A14). This input signal has the configuration of a clipped sine wave varying between the limits of ±10 volts and having a period equal to the time duration of one acquisition antenna revolution. There are two transition intervals per acquisition antenna revolution when the waveform slowly changes polarity. One of these transition intervals generates the azimuth sweep during the time when the 1066-mil azimuth sector is displayed on the B scope indicator. The other interval occurs 3200 mils from the first when the video display of the B scope indicator is blanked and causes the B scope indicator cathode-ray tube (CRT) to retrace in preparation for the next display period.

(3) The information input to electronic gate Z2 (B22) is the symbol range position analog voltage received from the azimuth and range position amplifier (D6) (par. 93*c*). This input is symbol range position voltage in dc analog form. The amplitude of this voltage is dependent on the range setting of the target tracking radar system.

(4) The information input of electronic gate Z4 (D22) is the symbol azimuth position analog voltage received from the azimuth and range position amplifier (par. 93*c*). This input is symbol azimuth position voltage in dc analog form. The amplitude and polarity of the voltage is dependent on the position of the target tracking radar antenna with respect to the azimuth displayed at the center of the CRT.

e. The two symbol gate pulses of opposite polarity are applied by the B scope marker generator (A21) to each electronic gate. One gate pulse is applied to terminal 5 and the other to terminal 7. These two gate pulses arrive simultaneously as square-wave switching signals during the period between normal range sweeps. Both pulses have a duration of 160 microseconds and amplitudes of approximately ±50 volts. Since the electronic gates are switched in pairs, the two gate pulses are applied to terminals 7 and 5 of electronic gates Z1 and Z3, and to terminals 5 and 7 of electronic gates Z2 and Z4. Transposition of gate pulses at two of the electronic gate terminals allows two electronic gates to open while two electronic gates close. This causes alternate electronic gate operation so that single-pole, double-throw switching action is obtained. Thus, the passage of information to the common output circuit, *f* below, of each pair of electronic gates (Z1 and Z2 or Z3 and Z4) is alternated between input information signals received at each electronic gate.

f. The output signal of each electronic gate appears at terminal 3. In each case, the input signal is passed through the electronic gate to the output terminal when symbol gate pulses electronically switch the electronic gate. Because the gate pulse input terminals are transposed at two of the electronic gates, two electronic gates supply an output while the other two electronic gates have no output. Terminals 3 on electronic gates Z3 and Z4 are connected in parallel, as are terminals 3 of electronic gates Z1 and Z2. Electronic gates Z1 and Z2 switch the inputs of the B scope sweep amplifier (range) (A23) alternately between the symbol range position voltage from the azimuth and range position amplifier, and the sawtooth range sweep signals from the B scope sweep generator. Simultaneously, electronic gates Z3 and Z4 switch the inputs of the B scope sweep amplifier (azimuth) (C23) alternately between the symbol azimuth position voltage from the azimuth and range position amplifier, and the azimuth sweep signals from the B scope sweep generator.

g. Coincident with the trailing edge of the range sweep signals, a pair of symbol gate pulses is produced by the B scope marker generator (par. 96*c*). These pulses change the normal impedance condition of each electronic gate for 160 microseconds. During this period of time, electronic gates Z1 and Z3 are effectively an open circuit, whereas electronic gates Z2 and Z4 are effectively a closed circuit. Thus, only the azimuth and range analog positioning voltages are applied to the B scope sweep amplifiers. At the end of 160 microseconds, the gate pulses are completed, and the normal impedance conditions of electronic gates Z1 through Z4 are restored. This impedance change, or switching action, results in alternately presenting normal sweep voltages and symbol positioning voltages to the B scope sweep amplifiers.

h. When a negative symbol gate pulse (fig. 34) is applied to terminal 5 and a positive symbol gate pulse is applied to terminal 7 of an electronic gate, the crystal diodes within the bridge of the electronic gate are biased so as to prevent the information signal voltage at input terminals 1 and 2 from being coupled to terminal 3. This is the high impedance or open condition. Current flow within the electronic gate is described in paragraph 94*d*.

i. When a positive symbol gate pulse is applied to terminal 5 and a negative symbol gate pulse is applied to terminal 7 of an electronic gate, crystal diodes CR3 and CR4 pass only leakage current through a high inverse resistance, and the diodes are considered cut off or effectively out of the bridge circuit. Therefore, output voltage appearing at terminal 3 is caused by the applied information input voltage at terminals 1 and 2. This operation is the low-impedance or closed condition. The resulting current flow is described in (1) through (3) below.

(1) With the polarities of gate pulses as described in *i* above, the electronic gate remains quiescent until the information input voltage is applied. When a positive information signal appears at terminals 1 and 2, current flows from terminal 4 through resistor R1 and crystal diode CR1 to terminal 1. Although some back-bias is developed in three bridge arms, the voltages are not large enough to completely cut off crystal diode CR2 or crystal diode CR5 unless the input signal exceeds 50 volts. The back-bias causes CR2 and CR5 to offer an increased forward impedance, and also causes an unbalance between the bridge diodes. Current then flows into terminal 3 from an external load resistance in series between terminal 3 and ground. From terminal 3, the current flows through CR6 and R2 to terminal 6 and the positive voltage supply. As the impedance of CR2 and CR5 changes, so does the current flow through CR6. Therefore, the voltage at output terminal 3 is established at the potential of input terminal 1 and the gate is considered closed. Thus, the electronic gate passes a positive signal input to the output.

(2) When a negative information signal appears at electronic gate terminals 1 and 2, current flows through CR2 and R2 to terminal 6 and the positive

supply voltage. Then, with an order of unbalance between the crystal diodes, current also flows from terminal 4 through CR5 to terminal 3 and through the external resistive load to ground. As the impedance of CR1 and CR6 is varied by the signal voltage, the current flow through CR5 changes. Therefore, the output voltage at terminal 3 follows the input voltage at terminal 1. Thus, the electronic gate passes a negative signal to the output.

(3) When the information signals at the input exceed 50 volts, peak clipping occurs. When the excessive information signal is positive, CR2 and CR5 are biased to cutoff. The voltage output at terminal 3 reaches an amplitude of 50 volts and rises no higher. When the excessive information signal is negative, CR1 and CR6 are biased to cutoff and the output at terminal 3 does not exceed 50 volts. The result is negative or positive peak clipping of the input signal with the electronic gate output limited to 50 volts.

98 (U). B Scope Sweep Amplifier

a. Two B scope sweep amplifiers (fig. 33) are used in the B scope indicator sweep circuits. These sweep amplifiers develop three types of low-level signals into high-amplitude deflection voltages for application to electrostatic deflection elements of the B scope indicator cathode-ray tube (CRT). The two sweep amplifiers are identical and interchangeable except for the source of the input signals and the use of the output signals.

b. The B scope sweep amplifier (range) produces a push-pull sweep deflection signal applied to the vertical deflection plates of the B scope indicator CRT. The B scope sweep amplifier (azimuth) produces a push-pull sweep deflection signal applied to the horizontal deflection plate of the same CRT. The sweep amplifiers receive the three information signal inputs given in (1) and (2) below.

Note. The grid zone references shown in parentheses in (1) and (2) below refer to figure 35, TM 9-1430-254-20/6.

(1) The B scope sweep amplifier (range) (B25) receives three input signals. Due to the switching action of electronic gates Z1 (A22) and Z2 (B22) the input signals are applied to the sweep amplifier (range) in sequence. The first input is the range sweep (C20), which is a sawtooth waveform having a duration of 1340 microseconds. The range sweep occurs at the pulse repetition rate of the selected acquisition radar. If the LOPAR system is selected, the pulse repetition frequency is 500 pps. If the HIPAR system is selected, the pulse repetition frequency is 410 to 440 pps. The range sweep is applied to terminals 1 and 2 of electronic gate Z1. At the end of the range sweep, a negative end-of-sweep pulse (B14) is produced, which in turn develops the symbol gate pulses (A21) for switching of the four electronic gates. Switching allows one of the two remaining inputs to be applied to the range sweep amplifier. The second input is a dc analog voltage (C20) which is switched by electronic gate Z2. This voltage is used to position the range symbol and is referred to as the symbol range position analog voltage. The third input is the symbol range signal (B23) which is produced in the B scope marker generator (C18) (par. 96). This signal is initiated by the end-of-sweep pulse (B14) and is not switched by the electronic gates.

(2) The B scope sweep amplifier (azimuth) (D25) receives three input signals. Due to the switching action of electronic gates Z3 (C22) and Z4 (D22) the input signals are applied to the B scope sweep amplifier (azimuth) in sequence. The first input is the azimuth sweep voltage (C20) developed by the B scope sweep generator (par. 94) and transferred by electronic gate Z3. The duration of this

sweep voltage is the time the acquisition antenna requires to rotate through the selected 1066 mils (60 degrees) of azimuth on the B scope indicator. The operation of electronic gates Z3 and Z4 is switched at the end of each 1340-microsecond azimuth sweep time causing Z3 to open and Z4 to close for 160 microseconds. This switching action occurs in synchronism with the repetition frequency of the NIKE-HERCULES ATBM system. When Z4 closes, symbol azimuth position analog voltage (C20) is transferred to the input circuit of the B scope sweep amplifier (azimuth) thus, replacing the azimuth sweep voltage. The 160-microsecond period is used to develop and display the azimuth symbol on the B scope indicator. The symbol azimuth position voltage, the second input to the B scope sweep amplifier, is received through Z4 from the azimuth and range position amplifier (D6). This voltage is in dc analog form, and is used to position, in azimuth, the target track antenna circle on CRT V2 (28). The third input is the symbol azimuth signal received directly from the B scope marker generator. This symbol is generated at the same time as the symbol range signal in the B scope marker generator (par. 96).

c. The B scope sweep amplifier is a four-stage, direct-coupled amplifier stabilized by degenerative feedback loops. The first and second stage of the sweep amplifier is a dual triode with each section operating as a conventional voltage amplifier. The third and fourth stage consists of a dual-section, high-voltage, pentode amplifier. One section of this dual pentode operates as a phase inverter with unity gain so that the pentode provides two output signals in push-pull. Since the B scope sweep amplifiers for azimuth and range are identical, the functional analysis of the sweep amplifier (range) only is given in *d* below.

Note. The grid zone references shown in parentheses and *d* through *f* below refer to figure 35, TM 9-1430-254-20/6, unless otherwise indicated.

d. The B scope sweep amplifier (range) consists of voltage amplifiers V1A (A24) and V1B, phase splitting amplifiers V2A and V2B, and associated controls and circuits. A functional analysis of the sweep amplifier (range) is given in (1) through (4) below.

(1) The outputs of electronic gates Z1 (A22) and Z2 (B22) are alternately applied to the input of the B scope sweep amplifier (range). The output of electronic gate Z1 is the range sweep signal consisting of a succession of 1340-microsecond sawtooth pulses. The output of electronic gate Z2 is a symbol range position voltage in dc analog form.

(2) One input signal of voltage amplifier V1A (A24) is received through GAIN SET variable resistor R1. However, a second input signal is received from the B scope marker generator (par. 96*b*). This input is the symbol range signal which is supplied directly to the grid of V1A. By controlling the amplifier gain, variable resistor R1 also controls the sweep length. The operating bias for the grid of V1A is provided by resistor R3 (B24), DC BAL variable resistor R4, and resistor R6 (B23) connected in series to a negative 250-volt supply. A fixed bias reference level of −87 volts is provided by voltage regulator V1 (B23), common to both sweep amplifier units. This regulator provides a negative reference level at the junction of resistors R4 and R6. The DC BAL variable resistor R4 (B23) varies the starting or reference point of the input signal. Therefore, variable resistor R4 is used to position the start of the range sweep on the CRT face.

(3) The input signals are amplified by V1A and are direct-coupled to V1B. Capacitor C3 (A24) is used to maintain a proper signal division with the input capacitance of V1B and to reduce the phase shift of the interstage

coupling network. ZERO SET variable resistor R29 (A25) in the interstage coupling network is used to zero the B scope sweep amplifier. Thus, variable resistor R29 is adjusted to provide zero output from the sweep amplifier when no input signal is applied to V1A. From V1B, the amplified signals are direct-coupled to phase-splitting amplifier V2A, operating as one output amplifier stage. The output of V2A, developed across resistor R27 (A27), supplies a signal to three circuits. One circuit applies to the output signal directly to an electro-static deflection plate of CRT V2 (B28). A second circuit applies the output of V2A through a degenerative feedback circuit to the input of V1A. This circuit consists of resistors R14, R13, R12, R11, and R2; capacitors C7, C6, and C5; and variable capacitor C17. The parallel combination of resistor R2 and variable capacitor C17 (B24), in series with the feedback circuit, functions as a frequency and phase compensating network to provide the correct input impedance for the feedback voltage. The overall RC feedback circuit improves stability and minimizes frequency and phase distortion in phase splitting amplifier V2A. The third circuit from V2A applies the output signal through a compensating RC filter (A26) and attenuation resistors to phase splitting amplifier V2B. The filter consists of resistors R17, R18, and R19 and capacitors C9, C10, and C11. This filter provides a flat frequency and phase characteristic to the signal applied to the control grid of phase splitting amplifier V2B.

(4) The output of the series RC filter, (3) above, appearing at R19 (A26) is passed through resistors R32 and R33 before application to V2B. Resistors R32 and R33 form an attenuation network for the input of V2B and are also a part of a second feedback circuit to voltage amplifier V1A. A degenerative signal, appearing across R32 from the plate circuits of V2A and V2B, is passed through crystal diodes CR2 and CR3 to V1A. Since a push-pull output of equal amplitude is required from the sweep amplifier, V2B operates as a phase inverter with amplifier characteristics identical to V2A. In order to maintain the required stage gain, V2B has a feedback loop provided from its plate circuit to its grid. This loop reduces the open loop gain of V2B so that the signal gain from the plate of V2A to the plate of V2B is unity when the input signal to V2B has the same amplitude as the input signal to V2A. In order to maintain a flat frequency and phase characteristic similar to that required by V2A, a series RC filter is provided in the feedback loop of V2B. The RC filter consists of resistors R25, R24, R23, R32, and R33 and capacitors C12, C13, and C14 connected in parallel with R23, R24, and R25, respectively. The output of V2B is applied directly to one electro-static deflection plate of CRT V2.

e. The output sawtooth sweep voltages of amplifiers V2A and V2B are directly applied to a pair of deflection plates in CRT V2 (B28). The outputs of V2A and V2B in the B scope sweep amplifier (range) are applied to the vertical deflection plates of V2 while the outputs of V2A and V2B in the B scope sweep amplifier (azimuth) are applied to the horizontal deflection plates of V2.

f. When the range and azimuth deflection voltages from the associated sweep amplifiers are applied to the four deflection plates of CRT V2, the electron beam of V2 is deflected to a point determined by the vectorial resultant of the four applied voltages. During the scan interval of the B scope indicator, these voltages are the normal range and azimuth sawtooth sweep voltages. Cathode-ray tube V2 is unblanked for range sweeps only during the 1066-mil azimuth sweep. Since the 1066-mil azimuth sweep corresponds to a selected 1066-mil sector of antenna rotation, 5334 mils of antenna rotation occur while no range sweeps are presented. The range sweep duration is 1340 microseconds and occurs at the same rate as the pulse repetition frequency (PRF) of the selected radar. For 160 microseconds, during the time interval between range sweeps (symbol display interval), the B scope sweep amplifiers produce an output of dc analog symbol positioning voltages which are applied to the deflection plates of V2. During the second 80 microseconds of this 160-microsecond period, ac symbol voltages appear superimposed on the dc analog positioning voltages. The vectorial resultant of the analog positioning voltages positions the CRT electron beam, and the superimposed ac symbol voltages cause the beam position to vary. At this time, the CRT is unblanked by a pulse from the B scope video amplifier (par. 113*c*(2)) in the video circuits. Thus, the target track antenna circle is displayed at the range and azimuth determined by the dc analog voltages.

Section IV (CMHA). PPI SYMBOL POSITIONING CIRCUITS

99 (U). Purpose

a. During the first 900 microseconds of each sweep cycle, the PPI sweep circuits are capable of using symbol-modulated deflection voltages to present indications of target status (FUIF data) or target designating information. The information that is presented on the plan position indicator (PPI) during the symbol interval is dependent upon the condition of the target designate circuits.

b. If the target designate circuits associated with each PPI are not in the designate enable condition, fire unit integration facility (FUIF) data can be presented on the PPI's. If the designate circuits are in the designate enable condition, FUIF data will be removed and the designate circle and the designate semicircle are displayed on the PPI's.

100 (CMHA). Block Diagram Analysis

a. The time share relay assembly (fig. 35) receives the following signals from the fire unit integration facility (FUIF) equipment or the plan position indicator (PPI) test panel: battery, friend, foe, ADP (all data present) pulse, FUIF X (positioning voltage for the X axis), and FUIF Y (positioning voltage for the Y axis). Designate enable information and designate analog voltage are supplied to the time share relay assembly from either or both of the target designate controls. The time share relay assembly is able to supply identical information to both PPI's. If the designate circuits for both PPI's are not in the designate enable condition, then both PPI's will display FUIF information. If the designate circuits for both PPI's are in the designate enable condition, the PPI's will display the designate circle, the designate semicircle, and the electronic cross. Depending on the condition of the target designate circuits, it is possible for one PPI to display FUIF information and the other to display the designate circle. If the designate circuits for both PPI's are not in the designate enable condition, the signal flow through both PPI's will be identical, so only one PPI will be discussed in the block diagram.

b. If the designate circuits are not in the designate enable condition, the battery, friend, foe, and ADP pulse can be applied to the pulse and logic generator. The ADP (all data present) pulse is a random-occurring enabling pulse. This pulse sets up the sweep circuits in the pulse and logic generator so that when the next sync pulse is received, the sweep circuits will be able to display symbol information. The pulse and logic generator generates the X and Y symbols ± gate control and write pulses. The ADP pulse determines the polarity of the + and −gate control pulses out of the pulse and logic generator.

c. The + and −gate control pulses from the pulse and logic generator are applied to the gates in the sweep generators. Gates 1 and 3 will be cut off and gate 2 in each sweep generator will conduct allowing the X and Y analog voltages from the time share relay assembly to pass through to the range select switch. The range select switch modifies the amplitude of the X and Y analog voltages to compensate for the range settings of the PPI. The X and Y analog voltages are then applied to the second dc amplifier in the sweep generators. The analog voltages are then modulated in the

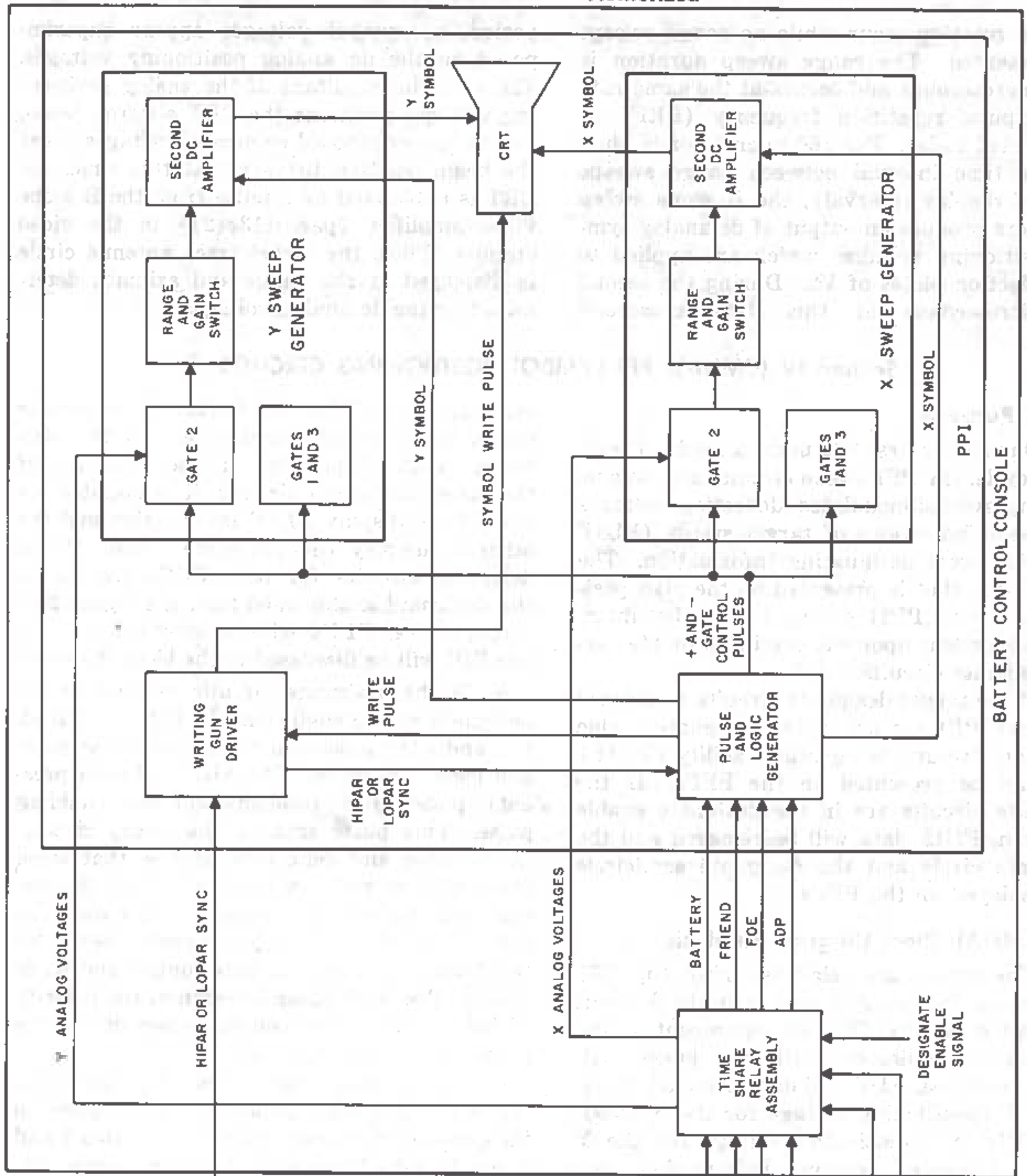


Figure 35 (U). FUIF symbols positioning circuits—block diagram (U).

second dc amplifier by the X and Y symbol voltages from the pulse and logic generator. The sweep voltages are then applied to the deflection plates of the cathode-ray tube (CRT).

d. The pulse and logic generator generates a write pulse that is applied to the writing gun driver. The writing gun driver produces a symbol write pulse that is used to compensate for the lack of the video unblanking pulse that is used during the normal sweep interval. The symbol write pulse controls the intensity of the symbols on the face of the CRT. The symbols will appear on the face of the PPI as described in (1) through (3) below.

(1) The battery symbol is a cross.

(2) The friend symbol is a semicircle with the open side down.

(3) The foe symbol is a circle.

e. If the target designate circuits for both PPI's are in the designate enable condition, each target designate control will supply a designate enable signal to the time share relay assembly (fig. 36). Each target designate control supplies X and Y analog voltages to the time share relay assembly. The analog voltages are the vectoral representations of the azimuth and range settings.

f. The designate enable signal enables a multivibrator in the time share relay assembly. The multivibrator generates an internal ADP pulse for use by the pulse and logic generator in each PPI so that the designate circles can be generated.

g. The time share relay assembly supplies the short range (SR) PPI with a circle indication, and X and Y analog voltages from the SR target designate control. The X and Y analog voltages represent the range and azimuth of the SR target designate control. It also supplies the SR PPI with a semicircle indication, and X and Y analog voltages from the LR target designate control. The X and Y analog voltages represent the range and azimuth settings of the LR target designate control. The time share relay assembly supplies the LR PPI with a circle indication, and X and Y analog voltages from the LR target designate control. The X and Y analog voltages represent the range and azimuth of the LR target designate control. It also supplies the LR PPI with a semicircle indication, and X and Y analog voltages from the SR target designate control. The X and Y analog voltages represent the range and azimuth settings of the SR target designate control.

h. The signal flow within the PPI's for the designate symbols is the same as for the FUIF symbols.

101 (U). Auxiliary Acquisition Group

a. Auxiliary Acquisition Interconnecting Box.

(1) The auxiliary acquisition interconnecting box functions as part of the fire unit integration facility (FUIF) interconnecting equipment which, in turn, serves as the tactical data link between FUIF (par. 122) and the low power acquisition radar (LOPAR) system. The auxiliary acquisition interconnecting box, located in the wall of the trailer mounted director station, provides termination for the tactical data cables from external FUIF equipment and provides input connections to FUIF distribution circuits in the acquisition presentation system.

(2) The external FUIF equipment supplies the Radar Course Directing Central (RCDC) with tactical data collected by the Army Air Defense Command Post (AADCP). This tactical data is divided into three categories; target position coordinate data, target identification data, and tactical control data. The target position coordinate data and the target identification data are decoded, parallax corrected, and processed within the FUIF equipment and are then applied through the auxiliary acquisition interconnecting box to the presentation system. The tactical control data, however, is decoded within the FUIF equipment and applied through the auxiliary acquisition interconnecting box to the tactical control circuits (TM 9-1430-250-20/12) in the trailer

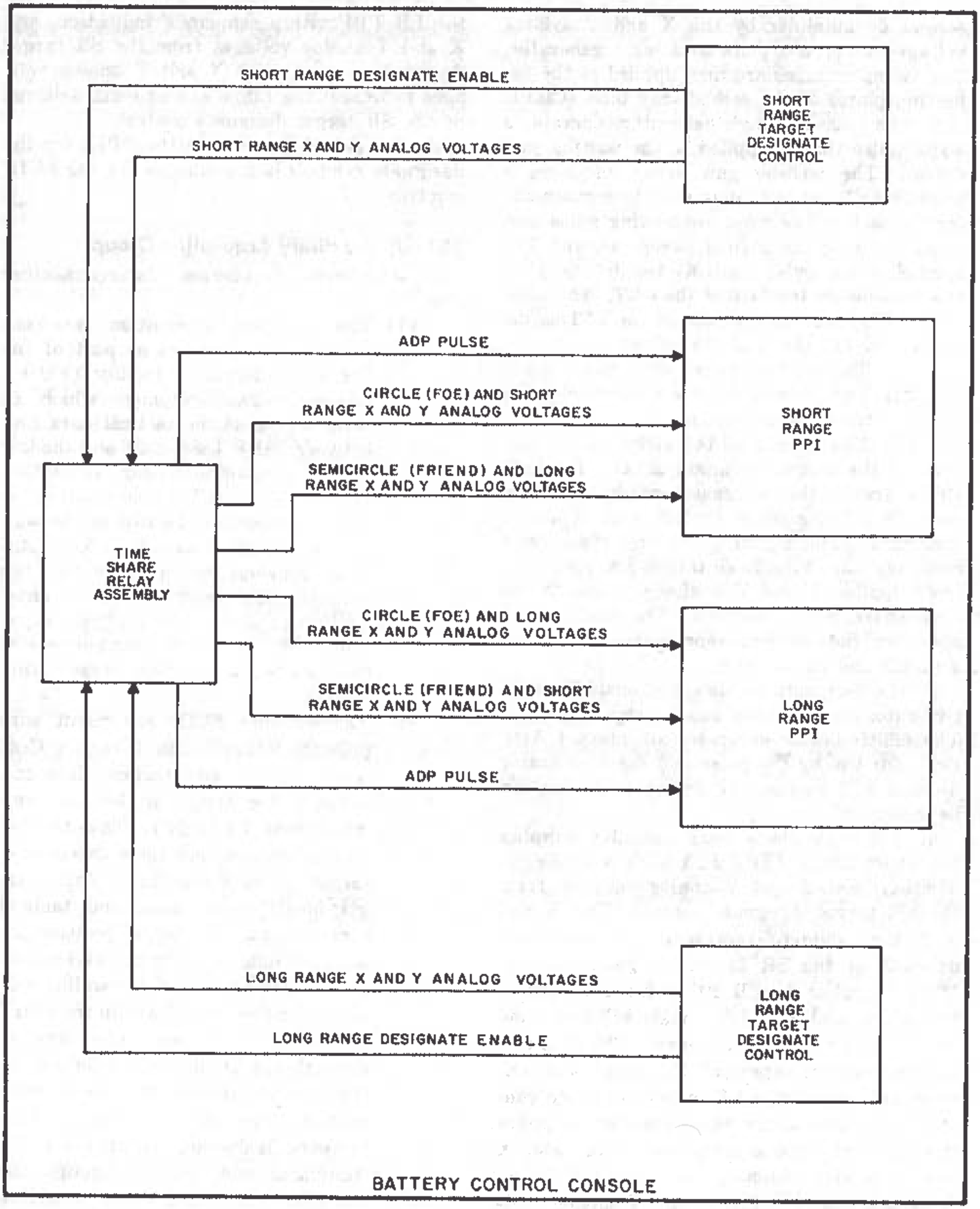


Figure 36 (U). Designate symbols positioning circuits—block diagram (U).

mounted director station, causing various switch-indicators to illuminate or to be extinguished, signifying tactical commands.

Note. Only those circuits of the FUIF interconnecting equipment associated with the symbol positioning circuits are functionally illustrated in figure 32, TM 9-1430-254-20/6.

(3) Included in the FUIF interconnecting equipment is the plan position indicator (PPI) test panel, *b* below. The circuits of this test panel also connect through the auxiliary acquisition interconnecting box to the presentation system.

Note. The figure and grid zone references shown in parentheses in (4) and (5) below refer to TM 9-1430-254-20/6.

(4) The auxiliary acquisition interconnecting box (fig. 32, B22) connects common ground signals for friend and foe indications to the PPI test panel (fig. 32, D23), and the time share relay assembly (fig. 32, D19), from the external FUIF equipment (fig. 32, D23). The auxiliary acquisition interconnecting box also supplies the X and Y analog voltages that are used to position the FUIF symbols on the PPI's.

(5) Terminal 50 (fig. 30, B4) in the auxiliary acquisition interconnecting box connects the battery signal from the control circuit to the two PPI's and the time share relay assembly (par. 102). This control circuit is a ground supplied to terminal 161 (fig. 30, B3) through section S1D (fig. 30, A3) of TEST switch S1 to terminal 50 (fig. 30, B4) from the external FUIF equipment (fig. 30, B1). A second control circuit is a ground applied to terminal 50 (fig. 30, B4) from the PPI test panel (fig. 30, A3) by TEST switch S1D. The PPI test panel, *b* below, enables simulated conditions to replace signals from the external FUIF equipment so that tests of local circuits can be performed. TEST switch S1 (fig. 30, A2), when set to BATTERY, supplies a ground to enable battery relays K3 (fig. 30, C17) and K1-1 (fig. 32, B12).

b. PPI Test Panel.

(1) The PPI test panel, an assembly of the auxiliary acquisition control interconnecting group, is located in the trailer mounted director station and is used when testing and adjusting the PPI. The PPI test panel generates and supplies synthetic positioning and symbol voltages to represent FUIF data. This insures that the actual FUIF data will be correctly represented.

Note. The grid zone references shown in parentheses in (2) through (5) below refer to figure 32, TM 9-1430-254-20/6, unless otherwise indicated.

(2) The PPI test panel (C23) consists of PULSE GENERATOR neon lamp I1, a relaxation oscillator; a precision resistor network consisting of resistors R2, R3, and GEN ADJUST variable resistor R1, functioning as a precision voltage divider; impedance network Z1, a fixed precision voltage divider; and TEST switch S1, a nine-position rotary switch.

(3) The purpose of PULSE GENERATOR neon lamp I1 (A23) is to simulate the all data present (ADP) pulse by producing negative, 10-microsecond pulses. Lamp I1 and its circuit produce voltage oscillations having sawtooth waveforms with a repetition rate of approximately 3 cps. The oscillator circuit comprises dc operated lamp I1, variable resistor R1, resistors R2, R3, and R4 and capacitor C3. The oscillator circuit is connected to a fixed +250-volt supply through the contacts of switch section S1A (B23), variable resistor R1, and resistor R2 to ground. The oscillator output is developed across capacitor C3 and resistor R4. Variable resistor R1 controls the charge rate of capacitor C3 and controls the ionization and deionization time of lamp I1. When switch S1A is set to NORMAL, no voltage is applied to the oscillator circuit and no syn-

thetic ADP pulse is provided. However, in any other position of switch S1A, synthetic ADP pulses are supplied to the pulse and logic generator through the SYMBOL ON—SYMBOL OFF switch-indicator A5 on the related PPI.

(4) Network Z1 (B24) provides synthetic positioning voltages that represent the FUIF dc analog positioning voltages for X and Y coordinates. Switch section S1B applies ±250 volts to Z1–1 when S1 is in the X-AXIS, Y-AXIS, BATTERY, FOE, or FRIEND test positions, terminal 2 of Z1 supplies an output of +15.6 volts with S1 in the +X-AXIS or +Y-AXIS position. With S1 in the –X-AXIS, –Y-AXIS, BATTERY, FOE, or FRIEND position –15.6 volts appear at terminal 2 of Z1. The output of S1A (C24) is the positive or negative synthetic X positioning voltage applied to the X analog channel. The output of S1B (B24) is the positive or negative synthetic Y positioning voltage applied to the Y analog channel.

(5) Switch sections S1C (C23) and S1D control the local activation of the friend, foe, and battery symbol circuits in the pulse and logic generator.

(6) A summary of TEST switch S1 positions is given in (*a*) through (*i*) below.

(*a*) *Switch S1 to NORMAL.* The AADCP, through the FUIF equipment, has control of the FUIF symbol circuits, and the PPI test panel is inoperative.

(*b*) *Switch S1 to ZERO.* The PPI test panel is operative and the friend, foe, and normal X and Y analog voltages from the FUIF equipment are disconnected. The simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 on the PPI to the related pulse and logic generator. A spot is displayed in the center of the PPI.

(*c*) *Switch S1 to +X-AXIS.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 of the PPI to the related pulse and logic generator. The X deflection channel is connected to the +15.6-volt output of Z1. The Y deflection channel is grounded. A spot is displayed on the PPI at a simulated range of 102,250 yards at 1600 mils azimuth.

(*d*) *Switch S1 to –X-AXIS.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 of the PPI to the related pulse and logic generator. The X deflection channel is connected to the –15.6-volt output of Z1. The Y deflection channel is grounded. A spot is displayed on the PPI at a simulated range of 102,250 yards at 4800 mils azimuth.

(*e*) *Switch S1 to +Y-AXIS.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 of the PPI to the related pulse and logic generator. The X deflection channel is grounded. The Y deflection channel is connected to the +15.6-volt output of Z1. A spot is displayed on the PPI at a simulated range of 102,250 yards at 0 mils azimuth.

(*f*) *Switch S1 to –Y-AXIS.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 of the PPI to the related pulse and logic generator. The Y deflection channel is connected to the –15.6-volt output of Z1. The X deflection channel is grounded. A spot is displayed on the PPI at a simulated range of 102,250 yards at 3200 mils azimuth.

(g) *Switch S1 to BATTERY.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 of the PPI to the related pulse and logic generator. The X deflection channel is grounded and the Y deflection channel is connected to the —15.6-volt output of Z1. The battery symbol circuits within the pulse and logic generator will be enabled and a cross will appear at the center of the PPI.

(h) *Switch S1 to FOE.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 on the PPI to the related pulse and logic generator. A ground is applied to the foe circuits in the pulse and logic generator and a circle is displayed at the center of the PPI. The X deflection channel is grounded and the Y deflection channel is connected to the —15.6-volt output of Z1.

(i) *Switch S1 to FRIEND.* Normal friend, foe, and X and Y analog voltage data inputs are disconnected. A simulated ADP pulse is applied through SYMBOL ON—SYMBOL OFF switch-indicator A5 on the PPI to the related pulse and logic generator. A ground is applied to the friend circuits in the pulse and logic generator. A semicircle with the open side down will be displayed on the PPI. The X deflection channel is grounded and the Y deflection channel is connected to the —15.6-volt output of Z1.

102 (U). Time Share Relay Assembly

a. The time share relay assembly provides the necessary switching circuits to enable fire unit integration facility (FUIF) circuits for symbols to be displayed on one plan position indicator (PPI) and target designate symbols to be displayed on the other PPI. If the designate circuits for both PPI's are in the designate enable condition, the time share relay assembly generates an internal all data present (ADP) pulse, so that symbols can be generated by the pulse and logic generator in each PPI, and provides for time-sharing of the designate information. When the designate circuits are not in the designate enable condition, all of the circuits in the time share relay assembly are deactivated and the FUIF data is supplied to both PPI's.

b. There are four different modes of operation for the time share relay assembly. These modes are determined by the condition of the target designate circuits associated with each PPI. The four modes are: the short range (SR) and long range (LR) PPI's not in designate enable; the SR and LR PPI's in designate enable; the SR PPI not in designate enable and the LR PPI in designate enable; and the SR PPI in designate enable and the LR PPI not in designate enable.

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 32, TM 9-1430-254-20/6, unless otherwise indicated.

c. Designate Enable. When the range control on the LR target designate control (D3) is depressed, ENABLE switch S1 (B6) is activated and a ground is applied to the time share relay assembly as the LR designate enable signal. When the range control on the SR target designate control (A8) is depressed, it supplies the SR designate enable signal to the time share relay assembly. When the range controls are released, the designate circuits are taken out of the designate enable condition.

d. LR and SR PPI's not in Designate Enable.

(1) If the designate controls for both PPI's are not in the designate enable condition, there will be no designate enable sginals applied to the time share relay assembly. LR designate

enable relays K4 (B15) and K3 (B16) and SR designate enable relays K5 and K6 (C15) will be deenergized.

(2) The ADP pulse from the FUIF equipment (D23) is applied through coaxial connector J3 (A20) in the time share relay assembly, contacts 1 and 13 of deenergized LR designate enable relay K4 (B15), and connector J2 to the LR PPI (A11). The ADP pulse is also applied through contacts 1 and 13 of the deenergized SR designate enable relay K5 (C15) to the SR PPI.

(3) The X analog from the FUIF equipment is applied through contacts 15 and 14 of S1A (C24), connector P2-4 (C20), and contacts 3 and 14 of deenergized relay K4 (B15) to the LR PPI. The X analog voltage is also applied through contacts 3 and 14 of deenergized relay K5 (C15) to the SR PPI.

(4) The Y analog voltage from the FUIF equipment is applied through contacts 3 and 2 of S1B (C24), connector P2-6 (B20), and contacts 5 and 15 of deenergized relay K4 (B15) to the LR PPI. The Y analog voltage is also applied through contacts 5 and 15 of deenergized relay K5 (C15) to the SR PPI.

(5) The friend signal (ground) from the FUIF equipment or the friend test signal (ground) from the PPI test panel is applied through switch S1B (B23), S1C, connector P2-3 (D20), and contacts 3 and 14 of deenergized SR designate enable relay K6 (C15) to the coil of SR friend symbols relay K1-2 (C12) in the battery control console. When relay K1-2 energizes, the friend signal (ground) is applied through contacts 24 and 25 to the SR PPI (C11). The friend signal is also applied through contacts 3 and 14 of deenergized LR designate enable relay K3 (B16) to the coil of LR friend symbols relay K1-3 (B12). When relay K1-3 energizes, the friend signal (ground) is applied through contacts 34 and 35 to the LR PPI (A11).

(6) The foe signal (ground) from the FUIF equipment or the foe test signal (ground) from the PPI test panel is applied through switch S1D (C23) or S1C, connector P2-5 (D20), and contacts 7 and 16 of deenergized relay K6 (C15) to the coil of SR foe symbols relay K1-4 (C12). When relay K1-4 energizes, the foe signal (ground) is applied through contacts 44 and 45 to the SR PPI. The foe signal is also applied through contacts 7 and 16 of deenergized relay K3 (B16) to the coil of LR foe symbols relay K1-5 (B12). When relay K1-5 energizes, the foe signal (ground) is applied through contacts 54 and 55 to the LR PPI.

(7) The battery symbol (ground) from the FUIF equipment or the battery test symbol from the PPI test panel is applied through switch S1D (fig. 30, A3) TM 9-1430-254-20/6) to the coil of battery relay K1-1(C12). When relay K1-1 energizes, the battery symbol (ground) is applied through contacts 14 and 15 of K1-1 and contacts 5 and 15 (C16) of deenergized SR designate enable relay K6 to the SR PPI. This same battery symbol is also applied through contacts 5 and 15 (B16) of deenergized LR designate enable relay K3 to the LR PPI.

(8) A relay ground is applied through contacts 17 and 9 of deenergized relay K6 (C15), and contacts 18 and 11 of deenergized relay K3 to terminal 491 (A21) in the battery control console. This relay ground energizes track cross off relay K1 (fig. 28, C45, TM 9-1430-254-20/6) in the video and mark mixer. This relay removes the track cross from the video when battle designate circuits are not in the designate enable condition.

e. LR and SR PPI's in Designate Enable.

(1) When the range controls on both target designate controls are depressed, designate enable signals (grounds)

will be applied to the time share relay assembly. Relays K4 (B15), K3, K5, and K6 will be energized. A ground is applied through contacts 8 and 16 of energized relay K4, and contacts 16 and 8 of energized relay K5 to time share multivibrator V2 (C19). A ground is also applied through contacts 17 and 10 of energized relay K4 in parallel with contacts 17 and 10 of energized relay K5 to ADP multivibrator V1 (B19).

(2) Free running multivibrator V1 is enabled by the ground that is applied to the cathode. The frequency of the multivibrator is approximately 10 pulses per second. During one period of oscillation, V1A will conduct for approximately 35 milliseconds, then V1B will, conduct for approximately 65 milliseconds. Capacitor C5 (C16), which establishes the pulse rate of multivibrator V1, is connected between the plate of V1B and the control grid of V1A by contacts 13 and 2 of energized relay K3 and contacts 13 and 2 of energized relay K6. The out-

put of the multivibrator is the synthetic 10-pps ADP pulse and is taken from the plate of V1A. A negative, 35-millisecond pulse is applied through capacitor C4 and crystal diode CR1 (B19). The pulse is then applied through contacts 2 and 13 of energized relay K5 (C16) to the SR PPI. The pulse is also applied through contacts 2 and 13 of energized relay K4 (B15) to the LR PPI.

(3) Bistable multivibrator V2 (C19) is enabled by the ground that is applied to the cathodes. The output from the plate of V1B (B20) is a negative 65-millisecond pulse. This negative pulse is applied through capacitor C3 and crystal diode CR4 (C20) to the control grid of V2B and through CR2 to the control grid of V2A. The negative pulse will cut off the side of multivibrator V2 that is conducting and cause the other side to conduct. The next time the plate of V1B goes negative, V2 will be returned to its original state. Since only the negative pulses from the plate of V1B will trigger V2, it will oscillate at one-half the frequency of V1 or at approximately 5 pulses per second. Time share relay K7 (A18) is connected in the plate circuit of V2A and energizes when V2A conducts.

(4) When time share relay K7 is energized, a ground is applied through its contacts 8 and 6 (B18), and contacts 18 and 12 of energized relay K3, and energizes LR analog relay K2 (A17).

(a) The LR X analog voltage is applied from the LR target designate control (D3) to connector P1-14 (A13) on the time share relay assembly. The LR X analog voltage is then applied through contacts 6 and 15 of energized relay K2, and contacts 4 and 14 of energized relay K4 (B15) to the LR PPI. The LR X analog voltage is also applied through contacts 4 and 14 of energized relay K5 to the SR PPI.

(b) The LR Y analog voltage is applied from the LR target designate control to connector P1-16 (A13). The LR Y analog voltage is then applied through contacts 8 and 16 of energized relay K2, and contacts 6 and 15 of energized relay K4 (B15) to the LR PPI. The LR Y analog voltage is also applied through contacts 6 and 15 of energized relay K5 (C15) to the SR PPI.

(c) A ground is applied through contacts 4 and 14 of energized relay K2 (A17), and contacts 8 and 16 of energized relay K3 (B16) to the coil of LR foe symbols relay K1-5 (B12). When relay K1-5 energizes, a ground is applied through contacts 54 and 55 to the LR PPI and causes a circle representing the range and azimuth of the LR target designate control to be displayed on the PPI. The designate circle is positioned on the LR PPI by the LR X and Y analog voltages.

(d) A ground is applied through contacts 2 and 13 of energized relay K2, and contacts 4 and 14 of energized relay K6 (C15) to the coil of SR friend symbols relay K1-2 (C12). When relay K1-2 energizes, a ground is applied through contacts 24 and 25 to the SR PPI and causes a semicircle representing the azimuth and range of the LR target designate control to be displayed on the PPI. The designate semicircle is positioned on the SR PPI by the LR X and Y analog voltages.

(5) When time share relay K7 is deenergized, a ground is applied through contacts 8 and 7, and contacts 12 and 18 of energized SR designate enable relay K6 (C15) energizing SR analog relay K1 (C17).

(a) The SR X analog voltage is applied from the SR target designate control (A8) to connector P1-10 (D13) on the time share relay assembly. The SR X analog voltage is then applied through contacts 6 and 15 of energized relay K1 (C17), and

contacts 4 and 14 of energized relay K5 (C15) to the SR PPI. The SR X analog voltage is also applied through contacts 4 and 14 of energized relay K4 (B15) to the LR PPI.

(*b*) The SR Y analog voltage is applied from the SR target designate control (A8) to connector P1-12 (D13) on the time share relay assembly. The SR Y analog voltage is then applied through contacts 8 and 16 of energized relay K1 (C17), and contacts 6 and 15 of energized relay K5 (C15) to the SR PPI. The SR Y analog voltage is also applied through contacts 6 and 15 of energized relay K4 (B15) to the LR PPI.

(*c*) A ground is applied through contacts 4 and 14 of energized relay K1 (C17), and contacts 8 and 16 of energized relay K6 to the coil of SR foe symbols relay K1-4 (C12). When relay K1-4 energizes, a ground is applied through contacts 44 and 45 to the SR PPI and causes a circle representing the range and azimuth of the SR target designate control to be displayed on the PPI. The designate circle is positioned on the SR PPI by the SR X and Y analog voltages.

(*d*) A ground is applied through contacts 2 and 13 of energized relay K1 (C17), through contacts 4 and 14 of energized relay K3 (B16) to the coil of LR friend symbols relay K1-3 (B12). When relay K1-3 energizes, a ground is applied through contacts 34 and 35 to the LR PPI and causes a semicircle representing the range and azimuth of the SR target designate control to be displayed on the PPI. The designate semicircle is positioned by the SR X and Y analog voltages.

f. SR PPI in Designate Enable, LR PPI not in Designate Enable.

(1) The designate enable signal from connector J1-j (A9) on the SR target designate control energizes SR desinate enable relays K5 (C15) and K6. Contacts 17 and 9 of deenergized LR designate enable relay K3 (B16) apply a ground through contacts 12 and 18 of energized relay K6 (C15) energizing SR analog relay K1 (C17). A ground is applied through contacts 17 and 10 of energized relay K5 to ADP multivibrator V1 (B19).

(2) Free running multivibrator V1 is enabled by the ground that is applied to the cathode. The frequency of the multivibrator is approximately 5 pulses per second. During one period of oscillation, V1A will conduct for approximately 35 milliseconds, then V1B will conduct for approximately 165 milliseconds. Capacitor C2 (B17), which establishes the pulse rate of multivibrator V1, is placed between the plate of V1B and the control grid of V1A by contacts 1 and 13 of deenergized relay K3. The output of the multivibrator is the synthetic 5-pps ADP pulse and is taken from the plate of V1A. A negative, 35-millisecond pulse is applied through capacitor C4 and crystal diode CR1 (B19). The pulse is then applied through contacts 2 and 13 of energized relay K5 (C15) to the SR PPI. The FUIF ADP pulse (D23) is applied through contacts 1 and 13 of deenergized LR designate enable relay K4 to the SR PPI.

(3) The X and Y analog voltages (A9) from the SR target designate control are applied through contacts 6 and 15, and 8 and 16 of energized relay K1, and contacts 4 and 14, and 6 and 15 of energized relay K5 to the SR PPI. The X and Y analog voltages from the FUIF equipment are applied through contacts 5 and 15, and 3 and 14 of deenergized relay K4 to the LR PPI.

(4) The friend signal (ground) from the FUIF equipment is applied through contacts 3 and 14 of deenergized relay K3 to the coil of relay K1-3 (B12). When relay K1-3 energizes, the friend

signal (ground) is applied through contacts 34 and 35 to the LR PPI. There will be no designate semicircle applied to the SR PPI.

(5) A ground is applied through contacts 4 and 14 of energized relay K1 (C17), and contacts 8 and 16 of energized relay K6 to the coil of relay K1-4 (C12). When relay K1-4 energizes, a ground is applied through contacts 44 and 45 to the SR PPI and causes a circle representing the range and azimuth of the SR target designate control to be displayed on the PPI. The designate circle is positioned on the SR PPI by the SR X and Y analog voltages.

(6) The foe signal is applied to the LR PPI as described in *d*(6) above. The friend and foe symbols positioned by the X and Y analog voltages from the FUIF equipment are displayed on the LR PPI.

(7) There will be no ground applied to terminal 491 (A21) for track cross off relay K1 (fig. 28, C45, TM 9-1430-254-20/6). The relay will be deenergized and the track electronic cross will be applied to the presentation on both PPI's.

g. LR PPI in Designate Enable, SR PPI not in Designate Enable.

(1) The designate enable signal (B6) from the LR target designate control energizes LR designate enable relays K4 (B15) and K3. Contacts 17 and 9 of deenergized SR designate enable relay K6 (C16) apply a ground through contacts 18 and 12 of energized relay K3 (B16) energizing LR analog relay K2 (A17). A ground is applied through contacts 17 and 10 of energized relay K4 to ADP multivibrator V1 (B19).

(2) Free running multivibrator V1 is enabled by the ground that is applied to the cathode. The frequency of the multivibrator is approximately 5 pulses per second. During one period of oscillation, V1A will conduct for approximately 35 milliseconds, then V1B will conduct for approximately 165 milliseconds. Capacitor C2 (B17), which establishes the pulse rate of multivibrator V1, is connected between the plate of V1B and the control grid of V1A by contacts 1 and 13 of deenergized relay K6, and contacts 2 and 13 of energized relay K3. The output of the multivibrator is the synthetic 5-pps ADP pulse and is taken from the plate of V1A. A negative, 35-millisecond pulse is applied through capacitor C4 and crystal diode CR1 (B19). The pulse is then applied through contacts 2 and 13 of energized relay K4 (B15) to the LR PPI. The FUIF ADP pulse (D23) is applied through contacts 1 and 13 of deenergized SR designate enable relay K5 to the SR PPI. Bistable multivibrator V2 (C19) is not enabled and there is no time sharing.

(3) The X and Y analog voltages (C6) from the LR target designate control are applied through contacts 6 and 15, and 8 and 16 of energized relay K2, and contacts 4 and 14, and 6 and 15 of energized relay K4 to the LR PPI. The X and Y analog voltages from the FUIF equipment are applied through contacts 5 and 15, and 3 and 14 of deenergized relay K5 to the SR PPI.

(4) The friend signal (ground) from the FUIF equipment is applied through contacts 3 and 14 (C16) of deenergized relay K6 to the coil of relay K1-2 (C12). When relay K1-2 energizes, the friend signal (ground) is applied through contacts 24 and 25 to the SR PPI. There will be no designate semicircle applied to the LR PPI.

(5) A ground is applied through contacts 4 and 14 of energized relay K2 (A17), and contacts 8 and 16 of energized relay K3 to the coil of relay K1-5 (B12). When relay K1-5 energizes, a ground is applied through contacts 54 and 55 to the LR PPI and causes a circle representing the range and azimuth of the LR target designate control to be displayed on the PPI. The designate

circle is positioned on the LR PPI by the LR X and Y analog voltages.

(6) The foe signal is applied to the SR PPI as described in *d*(6) above. The friend and foe symbols positioned by the X and Y analog voltages from the FUIF equipment are displayed on the SR PPI.

(7) There will be no ground applied to terminal 491 (A21) for track cross off relay K1 (fig. 28, C45, TM 9-1430-254-20/6). The relay will be deenergized and the track electronic cross will be applied to the presentation on both PPI's.

103 (U). Pulse and Logic Generator

a. Each PPI contains a pulse and logic generator which generates the positive and negative gate control pulses that open and close the electronic gates in the sweep generators. These gates will divide the normal sweep time into a symbol positioning interval and a sweep interval. The symbol positioning interval is approximately 900 microseconds during the first part of the sweep. The pulse and logic generator also generates the symbols using the radar sync pulse as the time reference.

b. The pulse and logic generator will generate symbols when a symbol signal and an all data present (ADP) pulse are received from the time share relay assembly. The ADP pulse is a random occurring pulse. If the ADP pulse is coming from the FUIF equipment, the repetition rate is approximately 10 pulses per second. If HIPAR video is selected for viewing on the PPI, FUIF symbols will be presented on the PPI 40 times a second. If LOPAR video is selected for viewing on the PPI, FUIF symbols will be presented on the PPI's 50 times a second. When the designate circles are being displayed on the PPI, they will be displayed ten times a second. If the symbol signals and the ADP pulse are generated within the PPI test panel (par. 101), symbols will be displayed on the PPI approximately three times per second.

Note. The grid zone reference shown in parentheses in *c* through *l* below refer to figure 34, TM 9-1430-254-20/6, unless otherwise indicated.

c. The ADP pulse input to the pulse and logic generator (D16) can be selected from two sources by means of SYMBOL OFF—SYMBOL ON switch-indicator A5 (B14). When the SYMBOL OFF—SYMBOL ON switch-indicator is depressed (SYMBOL ON indicator illuminated), the ADP pulse is supplied from the time share relay assembly (par. 102). If the SYMBOL OFF—SYMBOL ON switch-indicator is again depressed (SYMBOL OFF indicator illuminated), the ADP pulse is supplied by the PPI test panel (par. 101).

d. The negative ADP pulse is applied through connector P2-2 (B15) and capacitor C35 to the cathode of grounded grid amplifier V7A and amplified without inversion. The negative pulse from the plate of V7A is applied through capacitor C26 and crystal diode CR20 to bistable multivibrator V8. Crystal diode CR20 is a positive clipper and removes any positive excursions in the ADP pulse. Section V8A of the multivibrator is normally conducting and V8B is cut off. When the negative pulse is applied to the control grid of V8A, V8A will be cut off and V8B will start conducting. The rise in potential at the plate of V8A is applied through resistor R91, pedestal variable resistor R93, and resistor R95 to the control grid of multivibrator V9A (B18). Pedestal variable resistor R93 is adjusted so that the pedestal voltage applied, conditions V9A just below the triggering level. Multivibrator V9A is normally cut off and V9B is conducting. When the next LOPAR or HIPAR sync pulse is applied to the control grid of V9A through capacitor C25 (B24), V9A will conduct and V9B will be cut off. Multivibrator V9A and V9B will remain in this condition for approximately 900 microseconds, then return to their original condition. At the end of the 900-microsecond period, the potential at the plate of V9B will go negative. This negative pulse will be coupled through capacitor C29 to the control grid of V8B. This pulse will cut off V8B and return multivibrator V8 to its original condition.

e. During the 900-microsecond symbol interval, the potential at the plate of V9A will go in the negative direction. This negative potential is applied through capacitor C4 to the control grid of cathode follower V1B. Negative gate control pulse dc level variable resistor R7 in the cathode circuit of V1B adjusts the dc level of the negative gate control pulse. During the 900-microsecond symbol interval, the negative gate control pulse will be negative. During the symbol interval, the potential at the plate of V9B will go positive. This positive potential is applied through capacitor C1 (B19) to the control grid of cathode follower V1A. Positive gate control pulse dc level variable resistor R2 in the cathode circuit of V1A adjusts the dc level of the positive gate control pulse. During the 900-microsecond symbol interval, the positive gate control pulse will be positive. The positive and negative gate control pulses from cathode followers V1A and V1B are then applied to the sweep generators and to the writing gun driver.

f. The positive gate control pulse from the cathode of V1A is differentiated across capacitor C2 (fig. 30, B16, TM 9-1430-254-20/6). This differentiated pulse is applied through crystal diode CR21 to the suppressor grid of phantastron V10. Phantastron V10 will conduct for 80 microseconds. A negative, 80-microsecond pulse appears at the cathode of V10 and is applied through capacitor C38 to monostable multivibrator V11 (fig. 30, C16, TM 9-1430-254-20/6). Multivibrator V11A is normally cut off and V11B is conducting. The negative leading edge of the pulse from phantastron V10 will have no affect on multivibrator V11. The positive going trailing edge of the pulse triggers V11A into conduction and will cut off V11B. Multivibrator V11 will remain in this condition for either 80 microseconds or 160 microseconds, depending on the condition of battery relay K3 (fig. 30, C17, TM 9-1430-254-20/6). If relay K3 is energized, V11A will conduct for 160 microseconds. The output of V11B is a positive 80- or 160-microsecond pulse and is applied through capacitor C34 to the control grid of cathode follower V6B. A positive 70-volt pulse from cathode follower V6B is a symbol write pulse and is applied to the writing gun in the CRT. This pulse must be applied to the CRT in coincidence with the symbol modulated sweep voltages that are applied during the symbol interval.

g. The negative 900-microsecond gate control pulse from the plate of V9A (B18) is also applied through crystal diode CR1, capacitor C3, and resistor R4 to the control grid of oscillator V4A (C17). Oscillator V4B and the associated tank circuit will oscillate for 900 microseconds at a frequency of 12.5 kilocycles per second. The gate length is enough to produce 12 cycles of oscillation, each cycle having a duration of approximately 80 microseconds. The frequency of oscillation is determined by the tank circuit consisting of inductor L1 and capacitor C11, C12, C13, and C14. The amplitude of oscillations is determined by the setting of oscillator level variable resistor R41. The output of the oscillator is then applied through resistors R42 and R43 to the primary winding of transformer T1 (B19), to T2-1, and T3-1. There will be no output from the transformers unless T2-2 or T3-2 is grounded.

h. If a foe signal (ground) (par. 102*d*(6)) is applied to connector P1-13 (A15) on the pulse and logic generator, terminal 2 of transformer T2 is grounded completing a circuit through the primaries of T1 and T2. The output of the secondary winding of T1 will be shifted 90 degrees from the input signal due to the action of resistor R45 (B20) and capacitor C16, and will be applied to X symbol amplitude variable resistor R48. Variable resistor R48 adjusts the amplitude of the signal. The signal from variable resistor R48 is then applied through contacts 8 and 6 of deenergized battery relay K2 (C23), and contacts 8 and 6 of deenergized height designate relay K1 to the second dc amplifier in the X sweep generator. The signal appearing at the secondary winding of transformer T2 will be in phase with the input signal and will be applied to Y symbol amplitude variable resistor R49 (C20). Variable resistor R49 adjusts the amplitude of the signal. The signal from variable resistor R49 is applied through contacts 4 and 2 of deenergized relays K2 (C23) and K1 to the second dc amplifier in the Y sweep generator. Since there is an 80-microsecond delay introduced by phantastron V10, *f* above, and the symbol write pulse is 80 microseconds in duration, the second cycle of the outputs of T1 and T2 will be displayed on the CRT. The symbol displayed on the PPI will be a circle.

i. If a friend signal (ground) is applied (par. 102*d*(5)) to connector P1-14 (B15) on the pulse and logic generator, a ground will be applied to terminal 2 of transformer T3 completing a circuit through the primaries of T1 and T3. The output of transformer T1 will be shifted 90 degrees, *h* above, and applied to the X sweep generator. The output of the secondary winding of transformer T3 is subjected to full-wave rectification by crystal diodes CR13 and CR14. The output of transformer T3 is a series of half sine waves 40 microseconds wide. This signal is then applied through resistor R46, Y symbol amplitude variable resistor R49, contacts 4 and 2 of deenergized relays K2 and K1 to the second dc amplifier in the Y sweep generator.

j. If a battery signal is applied to the pulse and logic generator, a ground is applied through connector P1-3 (A15) and energizes battery relays K2 (B23) and K3 (fig. 30, C17, TM 9-1430-254-20/6). Contacts 5 and 2 of energized relay K3 connect resistor R85 in the circuit to produce a symbol write pulse of 160 microseconds from V11.

k. The positive gate control pulse from V1A (B2) is differentiated by capacitor C2 (fig. 30, B16, TM 9-1430-254-20/6) and resistor R22 (C19). The positive spike at the leading edge of the pulse is applied through capacitors C42 and C5 to monostable multivibrator V2. Diode CR22 reduces negative overshoot at the input to V2. The normal condition of the multivibrator is V2A cut off and V2B conducting. The positive spike at the control grid of V2A causes V2A to conduct. The negative going plate potential of V2A is applied through capacitor C7 to the control grid of V2B, causing V2B to be cut off. Resistors R23, R24, and R25 establish the grid and cathode bias on V2A and the cathode bias on V2B. The multivibrator will remain in this condition for 160 microseconds. The positive pulse appearing at the plate of V2B is coupled through capacitor C8 and resistor R12 to cathode follower V3B (C21). Resistors R13, R14, and R15 establish the cathode bias on V3B. The negative pulse appearing at the plate of V2A is coupled through capacitor C9 and resistor R26 to cathode follower V3A. The positive pulse taken from cathode follower V3B is applied to crystal diodes CR2 and CR4. The negative pulse taken from cathode follower V3A is applied to crystal diodes CR3 and CR5. With a positive pulse at CR2, CR2 will be cut off and crystal diode CR6 will conduct normally. With a negative pulse at crystal diode CR3, CR3 will be cut off and crystal diode CR7 will conduct normally. The positive pulse at crystal diode CR4 and the negative pulse at CR5 will change the potential at resistors R35 and R34 to back-bias crystal diodes CR9 and CR8 and they will not conduct. The 12.5-kc signal from oscillator level variable resistor R41 (D18) is applied to the junction of resistors R17 (D22) and R18, and to the junction of resistors R31 and R32. The signal applied to R17 and R18 is applied through conducting crystal diodes CR6 and CR7, and will appear across X cross amplitude variable resistor R21. Since crystal diodes CR8 and CR9 are back-biased, no signal is applied to Y cross amplitude variable resistor R37. These outputs will remain for 160 microseconds. The output from variable resistor R21 is applied through contacts 1 and 6 of energized battery relay K2, and contacts 8 and 6 of deenergized height designate relay K1 to the second dc amplifier stage of the X sweep amplifier. Since the symbol write pulse is delayed by 80 microseconds, only the last 80 microseconds of the output of variable resistor R21 will be displayed on the CRT. Since there is no signal applied to the Y sweep generator, a straight horizontal line will be displayed.

l. At the end of 160 microseconds, multivibrator V2 (C20) will return to its original condition. The output of cathode follower V3B will then be negative and the output of cathode follower V3A will be positive. With these polarities, crystal diodes CR6 and CR7 are back-biased and nonconducting, and crystal diodes CR8 and CR9 are forward-biased and conducting. The 12.5-kc signal applied to the junction of resistors R31 and R32 will appear across Y cross amplitude variable resistor R37. There will be no output from variable resistor R21 to the X sweep generator. The output from variable resistor R37 is applied through contacts 5 and 2 of energized relay K2, and contacts 4 and 2 of deenergized relay K1 to the second dc amplifier in the Y sweep generator. The first 80 microseconds of the symbol write pulse are used to display the horizontal line and the remaining 80 microseconds are used to display a straight vertical line on the CRT, completing the presentation of the battery cross. The Y symbol balance variable resistor R33 and X symbol balance variable resistor R20 are adjusted for a zero dc level of the cross symbol and cause a symmetrical cross to be displayed.

104 (U). Sweep Generator

a. The sweep generators generate normal sweep voltages and symbol positioning voltages during the 900-microsecond symbol interval. During the symbol interval, the gating action allows only the symbol positioning voltages to be applied to the CRT.

b. The voltages applied to the PPI are symbol modulated sweep voltages positioned by the X and Y analog voltages from the time share relay assembly (par. 102). Since the operation of the sweep generators is identical, only the X sweep generator will be discussed.

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 34, TM 9-1430-254-20/6.

c. During the 900-microsecond symbol interval, the positive gate control pulse has a positive polarity and the negative gate control pulse has a negative polarity. With these polarities applied, sweep time share electronic gate 1 (B44) will present a high impedance to the range sweep voltages generated in the first dc amplifier section (V1, V2, and V3) of the sweep generator and dummy load electronic gate 3 (B45) will present a high impedance to the X symbol position voltage so that all of this voltage is applied through symbol time share electronic gate 2, which is conducting. The X symbol position voltage is then applied through range select switch S1 (C39) and the selected resistor combination to the control grid of amplifier V4A (C41).

d. The symbol voltage from the pulse and logic generator (par. 103) is applied through connector P1-16 (C38) on the sweep generator, and capacitor C26 to the filtering network consisting of resistor R20 and X symbol centering variable capacitor C9. This network is a filtering network used to stabilize the symbol presentation on the CRT. Capacitor C9 adjusts the centering of the E-W portion of the symbol. The symbol signal is then applied to the control grid of V4A with the dc analog voltage. This combined signal is amplified by V4 and V5, and then applied to the horizontal deflection plates of the CRT to display a symbol at an azimuth and range determined by the X and Y analog voltages. Refer to paragraph 85 for operation of the sweep generator.

105 (U). Writing Gun Driver

a. The writing gun driver uses the write pulse from the pulse and logic generator to produce a symbol write pulse with a potential that is useable by the CRT. The symbol write pulse is used in the absence of the video unblanking pulse to display the symbols on the face of the CRT.

Note. The grid zone references shown in parentheses in *b* through *d* below refer to figure 30, TM 9-1430-254-20/6.

b. If symbols from the FUIF equipment are selected for display on the PPI (par. 102), the symbol write pulse from the pulse and logic generator is applied through contacts 9 and 1 of deenergized intensity control relay K1 (D15) and applied to SYMBOL INTENSITY variable resistor R2. The SYMBOL INTENSITY variable resistor is used to vary the intensity of the FUIF symbols displayed on the PPI's.

c. If the designate circles are selected for display on the PPI's (par. 102), the write pulse is applied through contacts 9 and 2 of energized relay K1 to SYMBOL INTENSITY variable resistor R3 which controls the intensity of the designate symbols.

d. The write pulse is then applied through deenergized contacts 3 and 10 or 4 and 10 of relay K1 to connector P2-2 (B12) on the writing gun driver. The write pulse has an amplitude of approximately +55 volts and is applied through Zener diode CR19. Zener diode CR19 is a voltage regulator and isolator, and maintains the grid of cathode follower V8B at approximately 1-1/2 volts when there is no signal present. The 55-volt write pulse is coupled through Zener diode CR19 to the control grid of cathode follower V8B. A positive pulse is taken from the cathode of V8B through capacitor C18 and applied to the grid of the writing gun in the CRT. The average potential appearing at the grid is approximately —2650 volts (par. 83). The write pulse raises the potential to —2600 volts during the symbol interval. This negative potential is supplied by voltage regulator V5 (D10) through crystal diode CR15.

106 (CMHA). Designate Circles

a. When the range control on the target designate control is depressed, a designate circle is displayed on the associated PPI. The azimuth and range controls on the target designate control are positioned so that the designate circle encloses the target to be designated. The designate circles are displayed on the PPI using the same circuits that are used to generate the friend and foe symbols. When the azimuth and range controls are positioned, X and Y analog voltages are developed within the target designate control that are used to position the designate circle on the PPI.

b. If the target designate controls associated with the two PPI's are in the designate enable condition (par. 102), each PPI will display a designate circle at the azimuth and range of the associated target designate control, and a semicircle at the azimuth and range settings of the target designate control associated with the other PPI.

Note. The grid zone references shown in parentheses in *c* through *i* below refer to figure 32, TM 9-1430-254-20/6, unless otherwise indicated.

c. There are two methods of obtaining designate enable. During normal operation, designate enable is obtained by depressing the range control. The azimuth and range controls can then be positioned so that the designate circle encloses the target video. For testing purposes, a designate enable locking switch, connected mechanically to enable switch S1 (B6), can be depressed while the control is lifted and the designate circuits will be locked in the designate enable condition. The designate circuits can be unlocked by depressing the range control momentarily.

d. The range control is connected mechanically to designate range variable resistors R1A and R1B (A6), and the wiper arms will be moved as a function of range whenever the range control is positioned in range. The negative voltage from the wiper of R1A is applied to the voltage divider network consisting of resistor R24 (B2), —SYM MAX variable resistor R21, resistors R22, R23, R25, and R27. Variable resistor R21 adjusts for coincidence of the designate circle and the track electronic cross at maximum range at approximately 4000 mils azimuth. The voltage at the junction of R21 and R22 represents a maximum of 350,000 yards. The voltage at the junction of R22 and R23 represents a maximum of 250,000 yards. The voltage at the junction of R23 and R25 represents a maximum of 150,000 yards. The voltage at the junction of R25 and R27 represents a maximum of 75,000 yards.

e. The positive voltage from the wiper arm of R1B is applied to the voltage divider network consisting of resistors R12 (C2), +SYM MAX variable resistor R13, resistors R14, R15, R16, and R17. Variable resistor R13 is adjusted for coincidence of the designate circle and the electronic cross at maximum range at approximately 800 mils. The voltage at the junction of variable resistor R13 and resistor R14 represents a maximum of 350,000 yards. The voltage at the junction of R14 and R15 represents a maximum of 250,000 yards. The voltage at the junction of R15 and R16 represents a maximum of 150,000 yards. The voltage at the junction of R16 and R17 represents a maximum of 75,000 yards.

f. Since the range of the designate circle is a function of the radial distance of the designate circle from the center of the PPI, relays K1, K2, and K3 are used to switch in resistor combinations to compensate for the different range presentations (table IV).

g. The selected range scale factors are applied to cathode followers V2 (A4) and V1 (B4). The output of cathode follower V2 is taken from —SYM ZERO variable resistor R28 and applied to terminal 3 on quadrant wound variable resistor R18. Variable resistor R28 is used to adjust the zero position of the designate circle at 4000 mils azimuth. The output of cathode follower V1 is taken from +SYM ZERO variable resistor R8 and applied to terminal 1 of variable resistor R18 and to range meter M1. Variable resistor R8 is used to adjust the zero position of the designate circle at 800 mils azimuth. With the PPI set for 150,000-yard presentation and the range

Table IV (CMHA). Target Designate Control Relay Energization (U)

Unit	PPI range display[1]	Energized relays	Deenergized relays
SR target designate control	75,000 yds 150,000 yds	K1 None	K2, K3 K1, K2, K3
LR target designate control (HIPAR system selected)	150,000 yds 350,000 yds	K2 K2, K3	K1, K3 K1
LR target designate control (LOPAR system selected)	150,000 yds 250,000 yds	None K3	K1, K2, K3 K1, K2

[1] For range selection theory refer to paragraph 111.

control (B6) set to maximum, RG METER MAX variable resistor R11 (B5) adjusts the indication on range meter M1 to 150 K yards.

h. Quadrant wound variable resistor R18 has two wiper arms set 90 degrees apart. The two arms of variable resistor R18 are mechanically coupled to the azimuth control. When the designate circle is positioned over target video, the azimuth control is positioned at the azimuth of the target video. The mechanical coupling between the azimuth disc and variable resistor R18 also positions the wiper arms at an angle equivalent to the azimuth of the target video. Since the wiper arms are 90 degrees apart, the outputs will be sine and cosine functions of the inputs. One input is negative and the other is positive so that a complete circle can be described in vector components. The two outputs from variable resistor R18 are range multiplied by the sine of the azimuth angle (R Sine A = X analog) and range multiplied by the cosine of the azimuth angle (R COS A = Y analog).

i. The X and Y analog outputs are then applied to cathode followers V4B (C4) and V4A. From the cathode circuit, these voltages are applied to the time share relay assembly (par. 102). The Y ZERO variable resistor R37 (C4) and X ZERO variable resistor R38 (C5) are adjusted for zero output from the cathode followers with no signal input.

j. If the designate circuits are in the designate enable condition, the time share relay assembly (par. 102) will provide the necessary signals to the pulse and logic generator (par. 103) to display the designate circle and designate semicircle on the PPI's.

Section V (U). VIDEO CIRCUITS

107 (U). Purpose

a. The video circuits (fig. 1), a part of the presentation system, use input signals from six sources in order to develop video signals for display (par. 73) on three cathode-ray tube (CRT) indicators.

b. The input signals for the video circuits are received from the moving target indicator (MTI) circuits (par. 61), the marker circuits (par. 117), the fire unit integration facility (FUIF) interconnecting equipment (par. 101), the plan position indicator (PPI) sweep circuits (par. 75), the time share relay assembly (par. 102), and the B scope indicator sweep circuits (par. 88). Although the inputs from the FUIF interconnecting equipment and the time share relay assembly are relay control grounds and not video signals, the inputs control the generation of symbols in the presentation system. The display of these symbols is discussed in the symbol positioning circuits (par. 99). The video signals developed in the video circuits are displayed upon two CRT indicators in the battery control console and upon one CRT in the target radar control console. These indicators are designated the short range (SR) PPI, the long range (LR) PPI, and the B scope indicator.

108 (U). Block Diagram Analysis

a. The two PPI's (fig. 37), through the functions of the writing gun drivers (par. 109)

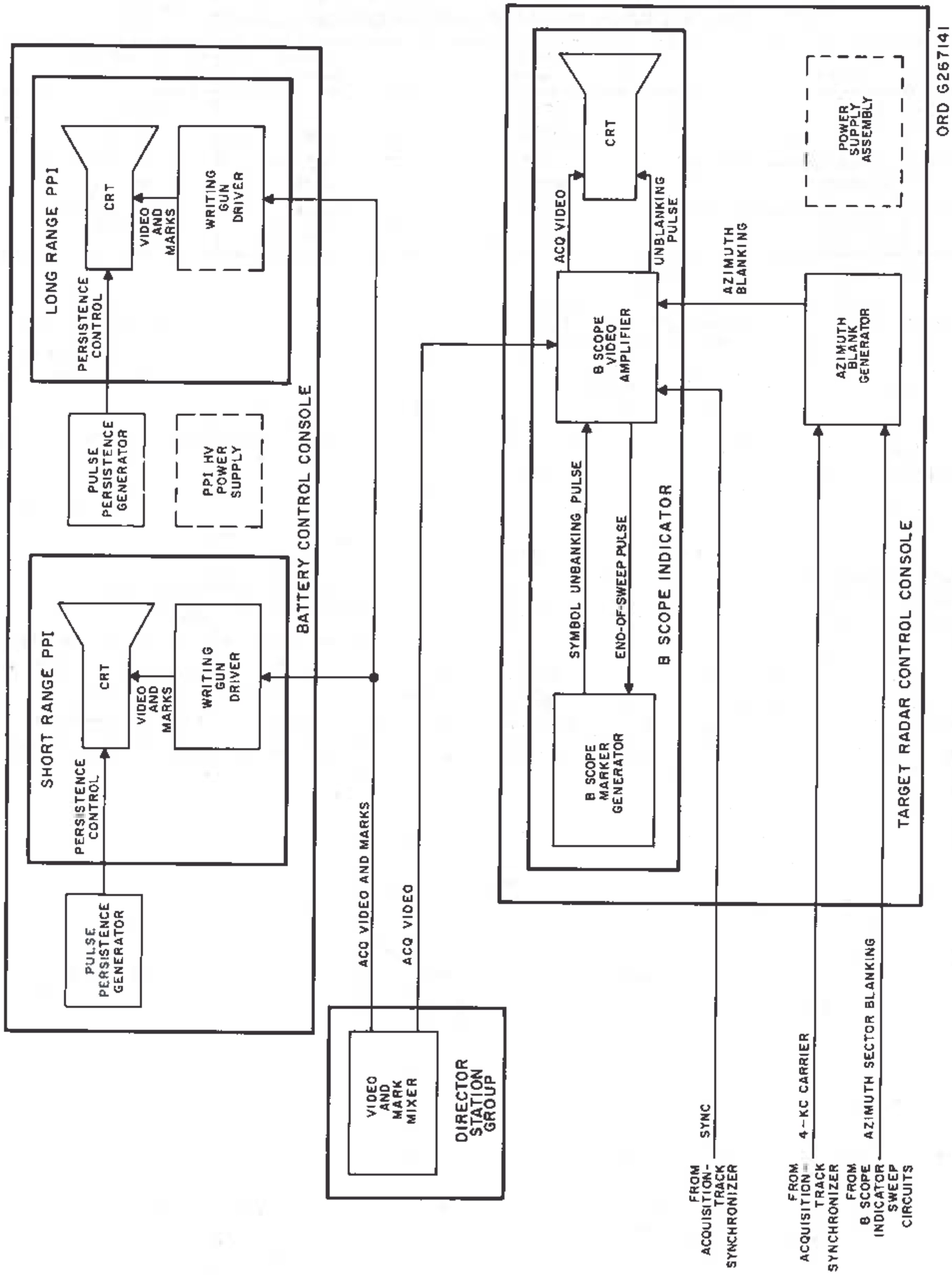


Figure 87 (U). Video circuits—block diagram (U).

and the CRT's enable the display of video signals. The CRT in use in each PPI is a 8-3/4-inch controlled persistence direct view storage tube.

b. The video and mark mixer (par. 71) in the MTI circuits supplies acquisition video and marks to the writing gun driver in each PPI. The writing gun driver amplifies the video and marks signals and applies them to the CRT. The video signals applied to each PPI are from the HIPAR system or the LOPAR system. The selection of video is discussed in the radar select and preview circuits (par. 13).

c. The video and mark mixer in the MTI circuits also supplies acquisition video only to the B scope indicator during normal operation.

d. The PPI HV power supply (par. 110) furnishes the required high dc potential as necessary for the operation of the PPI's.

e. The pulse persistence generator (par. 111) supplies the necessary signals to control the persistence and erase functions in the PPI.

f. The azimuth blank generator (par. 112), located in the target radar control console, receives azimuth sector blanking signals from the B scope indicator sweep circuits (par. 88) and 4-kc carrier input from the acquisition-track synchronizer. The azimuth blank generator supplies azimuth blanking signals to the B scope video amplifier, *h* below.

g. The B scope indicator (par. 113), located in the target radar control console, displays upon a 10-inch CRT, a selected area of the PPI presentation. The B scope indicator includes the video circuit portion of the B scope marker generator, *i* below, and the B scope video amplifier, *h* below. The display contains acquisition video received from the B scope video amplifier. The unblanking pulse, also received from this assembly, unblanks the CRT during the intervals of normal range sweep, azimuth sweep, and intersweep. During intersweep intervals, the target track antenna circle is displayed. The generation and application of this symbol is the function of the B scope indicator sweep circuits (par. 88).

h. The B scope video amplifier (par. 114), an assembly in the B scope indicator, amplifies the acquisition video received from the MTI circuits to the level required to intensity modulate the electron beam of the CRT in the B scope indicator. The B scope video amplifier also supplies unblanking pulses to the same CRT and generates an end-of-sweep pulse for application to the B scope marker generator.

i. The B scope marker generator (par. 115), an assembly in the B scope indicator, receives an end-of-sweep pulse at the end of each range (vertical) sweep from the B scope video amplifier. This end-of-sweep pulse enables the B scope marker generator to develop the symbol unblanking pulse for the B scope video amplifier.

j. The power supply assembly (par. 116*b* (2)), located in the target radar control console, supplies the necessary high dc potentials to the B scope indicator.

109 (U). Writing Gun Driver

a. The video amplifier section of the writing gun driver amplifies the video and marks from the video and mark mixer, and applies them to the writing gun grid in the CRT. It also produces the video unblanking pulse (par. 83) that allows video to be displayed on the CRT.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 30, TM 9-1430-254-20/6.

b. The video and marks from the video and mark mixer are applied through ACQ VIDEO GAIN variable resistor R9 (A8) to connector P3-2 on the writing gun driver (D10). ACQ VIDEO GAIN variable resistor R9 (A8) is used to vary the intensity of video presentation on the PPI.

c. The acquisition video and marks are then applied through capacitor C19 (A9) to the control grid of video amplifier V6. The control grid of V6 is clamped at approximately −6.6 volts by crystal diode CR16, video amplifier 1 grid bias variable resistor R57, and resistor R58. The video and marks are amplified and inverted by V6 and are then applied through capacitor C22 to the control grid of video amplifier V7. The control grid of V7 is clamped at approximately −6.6 volts by crystal diode CR17 (A10), and resistors R61 and R62. The signal is further amplified and inverted by V7 and applied to cathode follower mixer V8 (A11). The control grid of V8 is clamped at approximately −3 volts by crystal diode CR18, and resistors R66 and R67. The positive video and marks signal from V8 is then applied to the grid of the writing gun in the CRT (B14). The video signals modify the static potential of −2650 volts on the grid.

110 (U). Cathode-Ray Tube

a. The cathode-ray tubes (CRT's) used in the long range (LR) and the short range (SR) plan position indicators (PPI's) are high persistence direct-view storage tubes. The CRT produces a bright visual display for direct viewing of target information electrically stored within the viewing surface. By using external controls, the persistence of the display can be controlled or the display can be instantly erased.

b. The CRT is divided into three sections; the writing section, the flooding section, and the viewing section. As video signals modulate the electron beam from the writing gun, an image is displayed on the storage grid.

c. The two modes in which the CRT operates are the writing mode and the erase mode. The CRT has a high persistence, and, if left uncontrolled, the display would not fade out as a normal indicator would. To prevent this, the display on the CRT has to be removed periodically. The process of removing the display is called erasing and is covered in paragraph 111.

d. The writing gun section of the CRT consists of the writing gun, the writing gun grids, the deflection plates, and the storage grid. A beam of electrons is emitted by the writing gun and travels toward the more positive potential near the face of the CRT. The number of electrons in the electron beam is controlled by the potential on the first grid. The second and fourth grids have a positive potential and act as accelerating grids. Grid 3 is the focusing grid and the potential on this grid is controlled by the adjustment of a focus variable resistor in the writing gun driver. The focusing grid focuses the electron beam to a very fine point at the storage grid. The deflection plates deflect the beam in accordance with the sweep voltage or the symbol-modulated symbol positioning voltages. As the electron beam strikes the storage grid, electrons are emitted due to secondary emission and are collected by collector grid 5.

e. The flooding section consists of the viewing gun, flood grids 1 through 5, and the backing electrode. The backing electrode is capacitive-coupled to the storage grid in the writing gun section so that any potential seen on the backing electrode is also seen on the storage grid. There is no electrical connection to the storage grid.

f. The viewing gun emits a low velocity electron beam that forms a virtual cathode immediately before the storage grid. The electron beam is defocused by adjusting variable resistors on the side of the PPI so that the virtual cathode is of equal potential over the entire face of the storage grid. The electrostatic lens action of the viewing gun controls the spray of electrons such that it is collimated and approaches the storage grid as a parallel electron beam. When this spray of electrons reaches the storage grid, electrons will be passed only at the points where information has been written. This has the effect of controlling the storage function and the brightness of the display.

g. The imaging section consists of the virtual cathode formed by the viewing gun, the storage grid, and the phosphor screen. The storage grid serves as the persistence control element, and the phosphor screen serves as the collector.

h. The controlled persistence indicator provides a bright, nonflickering display of stored information for a predetermined length of time after the writing has been accomplished. This is accomplished by applying a continuous train of pulses from the pulse persistence generator (par. 111) to the backing electrode at a rate no lower than the phosphor flicker frequency.

Note. The grid zone references shown in parentheses in *i* through *k* below refer to figure 30, TM 9-1430-254-20/6.

i. The writing gun cathode connection on the CRT is connector J26-A (B14) and has an average potential of −2500 volts applied from the voltage regulator section in the writing gun driver (par. 83). This voltage is altered by the video unblanking pulse (par. 83) during the normal sweep interval. The writing gun grid connection on the CRT is connector J26-D (B14) and has an average potential of −2650 volts supplied by the voltage regulator section of the writing gun driver (par. 83). This voltage is altered when the symbol write pulse is applied (par. 105) during the symbol interval or when video is applied during the normal sweep interval. The focusing grid connection on the CRT is connector J26-E (B14) and the potential on this grid can be adjusted between the limits of —1600 to —850 volts by focus variable resistor R44 (C11) in the writing gun driver (par. 83). The average potential across the electrostatic deflection plates (B14) is +120 volts which is supplied by the sweep generators (par. 85).

j. The potential on the flood gun grids is supplied by bias adjust variable resistors R14, R15, R12, and R13 (C14) which control the collimation of the electron beam from the flood gun cathode. Test switch S2 (C14) and bias test indicator lights DS9 and DS10 are used during the flood gun adjustment. The flood gun collector grid connection is connector J28-B (B14). The collector voltage is either normal collector voltage (200 volts) or fail-safe collector voltage (25 volts) supplied by the fail-safe circuit (par. 87) in the pulse and logic generator. The backing electrode bias to connector J28-A (B14) is applied from the pulse persistence generator (par. 111).

k. The PPI HV power supply (B20) consists of a —3.3kv power supply, an 8kv power supply, and a HV regulator. When IND. H.V. ON — IND. H.V. OFF switch-indicator A8 (A24) is depressed to illuminate the IND. H.V. ON indicator green, 120-volt, single-phase, 400-cps power is applied to the two power supplies through the HV regulator (B22). Since both power supplies are floating (no internal ground reference) output polarity for the load circuits is established by frame grounding the positive output of the —3.3kv power supply and the negative output of the 8kv power supply. The —3.3kv power supply applies —3300 volts to the SR PPI (D20) for use in the voltage regulator section of the writing gun driver. The —3300 volts is also applied to the writing gun driver (D10) in the LR PPI. The 8kv power supply applies +8000 volts to the phosphor screen (B14) in the LR PPI. The power supply also supplies the +8000-volt potential to the SR PPI (D20). The +8000-volt potential is dropped to less than +2000 volts when voltage regulator V1 (A15) conducts. The conduction of V1 is determined by the output of the pulse persistence generator (par. 111) during the erase function. A functional description of the operation of the PPI HV power supply is given in TM 9-1430-250-20/12.

111 (U). Pulse Persistence Generator

a. General. The pulse persistence generator consists of two functional units, the modulation eliminator circuits and the display persistence and erase circuits. Only the display persistence and erase circuits are discussed in this paragraph. Due to the long persistence of the image on each PPI, it is necessary to periodically erase the image to provide a ghost-free presentation of the constantly changing information received from the radar systems. The function of periodically erasing the image or reducing the persistence of the display on each PPI is performed by the pulse persistence generator. A pulse persistence generator is associated with each of the two PPI's. Since these pulse persistence generators are identical, only one pulse persistence generator is discussed. Erasing is accomplished by changing the potential of the phosphor screen from +8000 to less than +2000 volts, extinguishing the display storage tube in each PPI and, after a delay, increasing the positive potential on the storage grid of the display storage tube. Increasing the potential on the storage grid of the display storage tube causes the storage grid to collect electrons. The collection of electrons causes the potential of the storage grid to decrease to the cathode potential of the display storage tube or 0 volts. This change of potential removes the storage display in the viewing gun. The duration of this automatic erase is 30 microseconds for long persistence operation and 175 microseconds for short persistence operation. In addition to the periodic erase, a manual erase circuit is provided. The manual erase circuit is utilized for the removal of the PPI presentation prior to preview, a change in the range of the acquisition radar, selection of the other acquisition system, for manual erase and after preview. The duration of manual erase is approximately 1 second.

Note. The figure and grid zone references shown in parentheses in *b* and *c* below refer to TM 9-1430-254-20/6.

b. Periodic Erase. The periodic erase is automatically generated in the pulse persistence generator (fig. 31, C9). A free-running phosphor blanking multivibrator consisting of V1A (fig. 31, C11) and V1B generates a positive pulse every 12,500 microseconds. The duration of the output pulse from V1B is determined by capacitor C5, resistor R26 and phosphor blanking period variable resistor R25. Variable resistor R25 is adjusted for a 600-microsecond pulse duration. Capacitor C7 and resistor R29 (fig. 31, B9) differentiate the output pulse from V1B. The negative pulses from the differentiator are bypassed to ground through diode CR10 and the positive pulses are applied to the control grid of erase delay multivibrator V3A. Stages V3A and V3B (fig. 31, C9) form a monostable multivibrator with V3B normally conducting. The positive pulse applied to the control grid of V3A triggers V3A into conduction and cuts off V3B. The duration of the negative output pulse from V3A is determined by capacitor C10, resistor R34, and erase pulse delay variable resistor R33. Variable resistor R33 is adjusted for a 250-microsecond pulse duration. Capacitor C11 (fig. 31, B8) and resistor R36 differentiate this negative pulse. This differentiation delays, by 250 microseconds, the triggering of persistence multivibrator V4A which is the nonconducting stage of monostable persistence multivibrator V4. The output of V4 is a positive pulse taken off the plate of V4B (fig. 31, A8). This output may be one of two positive pulses designated long persistence and short persistence. Short persistence relay K4 (fig. 31, B7) determines which of the two pulses is supplied by V4B to the control grid of cathode follower V5 (fig. 31, A10). If K4 (fig. 31, B7) is deenergized, the output of V4B (fig. 31, A8) is a long persistence pulse. The duration of the long persistence pulse is determined by capacitor C12 and long persistence variable resistor R40. Resistor R40 is adjusted for a 30-microsecond pulse. If K4 (fig. 31, B7) is energized, the output of V4B (fig. 31, A8) is a short persistence pulse. The duration of the short persistence pulse is determined by capacitor C12 (and C18 in systems 2 and above) and short persistence variable resistor R23. Variable resistor R23 is adjusted for a 175-microsecond pulse duration. One of these positive pulses is applied to cathode follower V5 through erase pulse amplitude variable resistor R55 (fig. 31, A9) and the output of V5 is coupled through capacitor C15 to the backing electrode in the CRT (fig. 30, B15). Variable resistor R55 (fig. 31, A9) is adjusted for a pulse amplitude of +4 volts. Diodes CR12 and CR13 bypass any negative voltages to ground. Due to capacitive coupling between the backing electrode and the storage grid, the potential of the storage grid is increased to +4 volts. This positive potential on the storage grid causes electrons to be attracted to the surface reducing its potential to 0 volt. At the trailing edge of the positive 4-volt pulse, the backing electrode will return to its normal operating point and by capacitive coupling will reduce the voltage on the storage grid by 4 volts causing it to be 4 volts negative in respect to the viewing gun cathode. This erases any stored voltage on the storage grid. The positive output of V1B (fig. 31, C10), one stage of free-running multivibrator V1, is coupled through capacitor C8 (fig. 31, B10) to the control grid of cathode follower V2. Diode CR9 in the grid circuit of V2 bypasses any negative voltages to ground. The positive pulse output of V2 is applied to the control grid of voltage regulator tube V1 (fig. 30, A15) in the PPI through contacts 8 and 6 (fig. 31, C11) of deenergized phosphor erase relay K1 (fig. 31, C11), and contacts 8 and 6 of deenergized phosphor erase pulse relay K2. The output of V2 causes V1 (fig. 30, A15) to conduct. When V1 conducts, the plate voltage of V1 is decreased from +8000 volts to less than +2000 volts. Since the plate of V1 is directly connected to the phosphor screen in the CRT (fig. 30, B15), a decrease in the plate voltage of V1 is a decrease in the potential on the phosphor screen. At this lower voltage the phosphor screen will not illuminate.

c. Manual Erase. Manual erase occurs whenever manual erase relay K5 (fig. 31, C7) is energized. Relay K5 is energized when one of the following actions occurs: alternate video is previewed (par. 13), the other acquisition radar is selected (par. 13), LONG RANGE — SHORT RANGE switch-indicator A11 (par. 76) is depressed, or ERASE switch-indicator A14 (fig. 31, B2) is depressed. Switch-indicator A14 is used to remove any undesired stored display on the PPI. When switch-indicator A14 is depressed or either of the other three actions above occur the —28-volt charge on capacitor C16 is applied to K5. Relay K5 energizes and remains energized for approximately 1 second until C16 discharges to the drop-out voltage of K5. Contacts 10 and 4 of K5 apply a ground to the control grid of relay control V6B (fig. 31, C9) triggering V6B into conduction. When V6B conducts, relay K2 energizes, and after a short time delay, relay K3 also energizes. Contacts 2 and 5 of relay K3 close to apply a ground to the grid of relay control V6A (fig. 31, C11) triggering V6A into conduction. The conduction of V6A energizes relay K1. Contacts 6 and 1 of K2 remove the positive phosphor erase pulses and a ground is supplied from contacts 5 and 2 of K1 to the control grid of voltage regulator V1 (fig. 30, B15) in the PPI causing V1 to conduct. The conduction of V1 decreases the plate voltage of V1 from +8000 to less than +2000 volts. The plate of V1 is directly connected to the phosphor screen of the CRT (fig. 30, B15) so that any decrease in the plate voltage of V1 is also a decrease in phosphor screen potential. At this low voltage the phosphor screen does not illuminate. Contacts 2 and 5 (fig. 31, A10) of K2 place resistor R56 in parallel with resistor R58 making the control grid of cathode follower V5 sufficiently negative to cut off V5. When V5 stops conducting, the erase pulse is removed from the backing electrode of the CRT (fig. 30, B15) in the PPI. After a short delay, contacts 6 and 1 (fig. 31, A11) of K3 close to remove the existing potential from the backing electrode (fig. 30, B14) in the CRT and apply a 4-volt potential to the backing electrode in the CRT.

112 (U). Azimuth Blank Generator

a. The azimuth blank generator, although physically an assembly of the target radar control console, is functionally a part of the video circuits (fig. 37). The function of the azimuth blank generator is to produce a B scope azimuth blanking control signal for the B scope indicator. This signal, applied to the B scope video amplifier, insures that the cathode-ray tube (CRT) will be unblanked for the range (vertical) sweep, only while the acquisition antenna is passing through the selected 1066-mil sector of display.

b. The azimuth blank generator receives two input information signals. One information input, designated the azimuth sector blanking, is sinusoidal and consists of 4-kilocycle oscillations modulated by rotation of the acquisition antenna so that the period of the sinusoid corresponds to 6400 mils of rotation. The phase and amplitude relationship of this signal is such that maximum amplitude occurs and is in phase with the 4-kilocycle carrier as the acquisition antenna passes through the center of the selected 1066-mil sector of B scope display. The second input signal of the azimuth blank generator is a 4-kilocycle carrier, of constant amplitude and phase, from the 4-kc oscillator (par. 77).

Note. The grid zone references shown in parentheses in *c* below refer to figure 30, TM 9-1430-254-20/6, unless otherwise indicated.

c. The azimuth blank generator (D23) consists of quadrature amplifier V1A, monostable multivibrator V2, cathode follower V1B, and associated controls and circuits. A functional diagram discussion of the azimuth blank generator is given in (1) and (2) below.

(1) The modulated 4-kilocycle N-S quadrature resolver signal and the unmodulated 4-kilocycle carrier are applied to opposite ends of CARRIER NULL variable resistor R3 (C23). The N-S quadrature resolver signal varies in amplitude as the antenna rotates and has a phase reversal every 180 degrees of antenna rotation. Mixing this signal at variable resistor R3 with the 4-kilocycle carrier of constant phase and amplitude results in cancellation and reinforcement of alternate half cycles. Variable resistor R3 is adjusted so that the signal applied to quadrature amplifier V1A consists of 4-kilocycle oscillation with a maximum peak amplitude about equal to the carrier and a minimum

amplitude of zero, once every antenna rotation. The peak amplitude of these 4-kilocycle oscillations occurs as the antenna passes through the center of the selected 1066-mil sector of B scope display. This composite signal is amplified and inverted by V1A and applied to crystal diode CR1. Diode CR1 and capacitor C3 function as a detector-demodulator circuit. Diode CR1 removes the positive portion of the output of V1A and C3 filters out the 4-kilocycle component, leaving only the slowly varying modulation envelope applied to monostable multivibrator V2.

(2) Monostable multivibrator V2, a dual triode, is triggered from one stable condition to the other by the slowly varying modulation envelope output of the detector-demodulator circuit in (1) above. The output of V2, coupled through cathode follower V1B to the B scope video amplifier (par. 114) is either positive 2 volts or negative 50 volts, depending on the position of the acquisition antenna. During the time the acquisition antenna is not in the selected 1066-mil sector of B scope indicator display, the output of the azimuth blank generator, taken from V2 (C24), is a positive 2 volts. As the acquisition antenna approaches the selected 1066-mil sector of display, the modulation envelope applied to V2 is approaching a negative peak. BLANK ADJ variable resistor R11 (C23), part of a voltage divider, determines the point on the negative-going envelope at which V2 is switched from its previous stable condition. When the condition of V2 is switched by the negative-going envelope, the output of V2 is a negative 50 volts. Multivibrator V2 remains in this condition until the modulation envelope swings positive. This switches V2 back to the original condition with a positive 2 volts as the output. BLANK ADJ variable resistor R11 (C23) is adjusted so that V2 is switched to the negative 50-volt output condition as the negative-going modulation envelope reaches a point which corresponds to the acquisition antenna entering the selected 1066-mil sector of display. Since the modulation envelope goes in a positive direction corresponding to antenna rotation, V2 will be switched to the positive 2-volt condition as the antenna leaves the selected 1066-mil sector of display. The output of the azimuth blank generator is the negative 50 volts while the acquisition antenna is in the selected 1066-mil sector and the positive 2 volts during the remaining 5334 mils of rotation. This output is applied to the B scope video amplifier as azimuth blanking.

113 (U). B Scope Indicator

a. The B scope indicator, containing a 10-inch cathode-ray tube (CRT) of the electrostatic type is physically located in the target radar control console and is part of the acquisition video circuits (fig. 37). This indicator presents an expanded view of a 1066-mil by 220,000-yard sector of acquisition video. The B scope indicator presentation sector is centered on an azimuth determined by the synchro assembly (par. 91) in the B scope indicator sweep circuits (fig. 33).

b. Parts of two assemblies in the B scope indicator (fig. 37) form functional assemblies of the acquisition video circuits. These assemblies are the B scope marker generator (par. 96) and the B scope video amplifier (par. 95). The remaining parts of the B scope marker generator and the B scope video amplifier form functional assemblies of the B scope indicator sweep circuits (par. 88). Those parts of the B scope marker generator and B scope video amplifier in the B scope indicator sweep circuits operate in conjunction with the remaining assemblies of the B scope indicator to produce horizontal (azimuth) and vertical (range) sweep voltages and to generate voltages which produce the target track antenna circle. The B scope indicator and symbol sweep voltages are produced by the B scope indicator sweep circuits. There will be no presentation unless the B scope indicator CRT is unblanked by pulses developed in the B scope indicator portion of the acquisition video circuits.

c. The functional assemblies of the B scope indicator used in the acquisition video circuits are discussed in (1) through (4) below.

(1) The B scope video amplifier (par. 95), an assembly of the B scope indicator, amplifies acquisition video received from the MTI circuits (par. 61) and applies this video to the B scope indicator CRT. The B scope video amplifier also develops an unblanking pulse which is applied to the CRT circuits (par. 116) during normal range (vertical) sweeps and during intersweep intervals when the target track antenna circle is displayed.

(2) The B scope marker generator (par. 115), an assembly of the B scope indicator, generates voltages which produce the target track antenna circle. These voltages are generated in the portion of the B scope marker generator (par. 96) that is in the B scope indicator sweep circuits. In order to unblank the B scope indicator CRT so that the target track antenna circle may be displayed, the section of the B scope marker generator in the video circuits generates a symbol unblanking pulse. This pulse is supplied to the B scope video amplifier for application to the elements of the B scope indicator CRT.

(3) The azimuth blank generator (par. 112), although an assembly of the target radar control console, is a functional part of the B scope indicator circuits. The azimuth blank generator provides an output signal that controls azimuth blanking of the B scope indicator. This output signal is used by the B scope video amplifier as a gating signal to insure that video is applied to the B scope indicator only during a selected 1066-mil azimuth sector.

(4) The CRT circuits (par. 116) of the B scope indicator include both the CRT and a high-voltage regulator circuit of the cathode-clamper type. The purpose of this high-voltage regulator is to keep the intensity of the electron beam in the CRT constant by providing dc restoration of applied signals.

114 (U). B Scope Video Amplifier

a. One section of the B scope video amplifier, an assembly of the B scope indicator, operates as a portion of the video circuits (fig. 37). The functions of this section are to amplify acquisition video to an amplitude high enough to intensity modulate the electron beam of the cathode-ray tube (CRT) and to supply unblanking pulses for the same CRT. The unblanking pulses enable the display of either acquisition video or the target track antenna circle on the B scope indicator.

b. The B scope video amplifier receives acquisition video from the video and mark mixer (par. 71) in the MTI circuits, a symbol unblanking pulse from the B scope marker generator (par. 96), an azimuth blanking pulse from the azimuth blank generator (par. 112), and a sync pulse from the acquisition-track synchronizer (TM 9-1430-250-20/6).

Note. The grid zone references shown in parentheses in *c* through *e* below refer to figure 30, TM 9-1430-254-20/6, unless otherwise indicated.

c. The video circuit portion of the B scope video amplifier consists of video amplifier V4A (C26), cathode follower V4B, video amplifier V5, and associated circuits and controls. GAIN variable resistor R4, although physically located on the front panel of the B scope indicator, is functionally a part of the B scope video amplifier.

d. The functional operation of the B scope video amplifier is discussed in (1) through (6) below.

(1) Positive LOPAR video is applied to GAIN variable resistor R4 (C25) in the B scope indicator. This input signal consists of bypass, and/or MTI and IFF video. Variable resistor R4 applies LOPAR video to the control grid of video amplifier V4A in the B scope video amplifier. Crystal diode CR4, across the input of V4A, clips any negative signals that appear with

the positive LOPAR video. This causes the variations in intensity on the face of CRT V2 (C29) to follow the signals displayed by LOPAR video without the presence of noise signals.

(2) Video amplifier V4A (C26) conducts only while cathode follower V4B is cut off. This condition exists during the normal range (vertical) sweep time of the B scope indicator while the acquisition antenna passes through the desired 1066-mil sector of display. Since V4A must conduct for 1340-microsecond (220,000-yard range sweep) intervals only during this 1066-mil sector, V4B must be gated by two separate control signals in order to maintain correct time relationship. One control signal, applied through capacitor C4 and parallel resistor R9, is a negative 1340-microsecond gating pulse from the plate of gate amplifier V3A (fig. 35, C11, TM 9-1430-254-20/6) in the B scope indicator sweep circuits (par. 88). The repetition frequency of this pulse is 500 pps. The second control signal applied to V4B (C26) is received from the azimuth blank generator. This signal, designated azimuth blanking, is a control voltage which is —50 volts while the acquisition antenna passes through the desired 1066-mil sector of display and +2 volts during the remaining 5334 mils of antenna rotation. When azimuth blanking is +2 volts, crystal diodes CR7 and CR5 conduct to ground the control grid of video amplifier V5, and crystal diodes CR2 (D26) and CR3 conduct to ground the control grid of V4B. During this time the negative 1340-microsecond pulses from V3A (fig. 35, C11, TM 9-1430-254-20/6) has no effect on V4B and the potential across common cathode resistor R44 will keep V4A cut off. During this 5334-mil sector of antenna rotation, no presentation except the target track antenna circle in (6) below is displayed on CRT V2 (C29).

(3) During the time the acquisition antenna passes through the desired 1066-mil sector of display, azimuth blanking to the B scope indicator from the azimuth blank generator (D23) is —50 volts. Crystal diode CR2 (D26) is back-biased by this negative potential and will not conduct. The negative 1340-microsecond pulses coupled through capacitor C4 and parallel resistor R9 back-biases CR3 and cuts off cathode follower V4B. Video amplifier V4A is allowed to conduct because the voltage across R44 decreases and supplies negative video on a negative pedestal to video amplifier V5 (C27) during the 1340-microsecond intervals when V4B is cut off. Pedestal adjust variable resistor R42 (C27) in the cathode circuit of V4A determines the level of the negative pedestal on which the video will be superimposed. The pedestal is to unblank CRT V2.

(4) The same negative 1340-microsecond gating pulses which cut off cathode follower V4B are reduced in amplitude by resistors R23 (fig. 35, D11, TM 9-1430-254-20/6) and R24, and applied to the control grid of video amplifier V5 (C27). Crystal diode CR8 is forward-biased to pass the negative gating pulses at the range sweep interval. This negative voltage pulse adds to the negative pedestal from video amplifier V4A to increase the amount of unblanking. At end-of-sweep, CR8 is back-biased by the positive-going portion of the gating pulse, and CRT V2 (C29) is momentarily blanked. The control grid input of V5 is LOPAR video gated into 1340-microsecond periods and any positive excursions are clamped by crystal diode CR5.

(5) Video amplifier V5 (C27) is a medium-gain amplifier used to amplify and invert the video signals from video amplifier V4A. The positive video signals from the plate of V5 are applied to the control grid of

CRT V2 in 1340-microsecond periods. The periods of LOPAR video are displayed on the range (vertical) sweep (par. 96) of CRT V2 (C29).

(6) Eighty microseconds after the end of each 1340-microsecond period in which video is supplied to CRT V2 (C29), video amplifier V5 (C27) receives a negative rectangular pulse from cathode follower V2B. This negative pulse, with a duration of 80 microseconds, functions as a symbol unblanking pulse that enables the target track antenna circle to be displayed between the intervals of normal range (vertical) sweep. This negative symbol unblanking pulse, generated in the B scope marker generator, is applied to SYMBOL INT ADJ variable resistor R25 (C28). The symbol unblanking pulse amplitude at variable resistor R25 is adjusted and applied through V2B to the screen grid of V5. Video amplifier V5 inverts the symbol unblanking pulse which appears at the control grid of CRT V2. The CRT is unblanked for a period of 80 microseconds during intersweep intervals and the target track antenna circle is displayed. The 1340-microsecond periods of video are applied to the CRT only while the acquisition antenna is passing through the selected 1066-mil sector of display; the symbol unblanking pulse occurs at a rate of one each pulse repetition period and is not affected by antenna rotation. The target track antenna circle, if located in the area covered by the display, is continuously displayed on the B scope indicator. Acquisition video is displayed for only 1066 mils of each 6400 mils of antenna rotation.

e. Range sweep gate multivibrator V1 (C27) and cathode follower V2A are functionally part of the B scope indicator sweep circuits and have been previously discussed in paragraph 95*b*. Only that function which enables the B scope marker generator to generate a symbol unblanking pulse is briefly discussed in (1) and (2) below.

(1) Range sweep gate multivibrator V1 (C27) is triggered into operation by 20- to 40-volt sync pulses received from the acquisition-track synchronizer in the target radar control console (TM 9-1430-250-20/6). Each sync pulse received causes V1 to produce a negative 1340-microsecond pulse which is applied through cathode follower V2A to the B scope marker generator. This pulse is designated the end-of-sweep pulse.

(2) The end-of-sweep pulse occurs in coincidence with the range (vertical) sweep of CRT V2 (C29). This time relationship enables the end-of-sweep pulse to be differentiated and used to mark the beginning of the intersweep interval of the B scope indicator.

115 (U). B Scope Marker Generator

a. A section of the B scope marker generator, an assembly of the B scope indicator, operates as a section of the video circuits (fig. 37). The function of this section is to generate an unblanking pulse for the video circuits of the B scope video amplifier so that the target track antenna circle is displayed on the B scope indicator CRT during intersweep intervals.

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 30, TM 9-1430-254-20/6.

b. The video circuit section of the B scope marker generator consists of pulse amplifiers V6B (A29), V7A, and V7B, and associated controls and circuits. The functional discussion of this section is given in *c* below. The remaining tubes, controls, and circuits of the B scope marker generator are functionally part of the B scope indicator sweep circuits and have been functionally discussed in paragraph 96. Only that function which pertains to the development of the symbol unblanking pulse for the video circuits is briefly discussed in (1) and (2) below.

(1) The negative 1340-microsecond end-of-sweep pulse from the B scope video

amplifier (par. 114) is applied to the differentiator circuit composed of capacitor C1 (A26) and resistor R1. When differentiated, the trailing edge of this end-of-sweep pulse produces a positive trigger pulse. This trigger pulse, coincident with the end of the range (vertical) sweep of CRT V2 (C29), triggers monostable multivibrator V1 into operation for a period of 200 microseconds. The positive 200-microsecond pulse from the plate of the second section of V1 triggers monostable multivibrator V4 (B28) into operation. The negative 200-microsecond pulse from the plate of the first section of V1 (A26) cuts off gating amplifier V2A. With V2A cut off, start-stop oscillator V2B (B27) produces oscillations for a 200-microsecond period. Since V2B oscillates at a frequency of 12.5 kilocycles, only 2-1/2 cycles are produced in the 200-microsecond period. These oscillations are amplified by squaring amplifier V3A, and applied through cathode follower V3B to the junction of resistor R23 and capacitor C15.

(2) The negative 200-microsecond pulse from the first section of monostable multivibrator V1 (A26) cuts off gating amplifier V2A, causing an exponential rise in plate voltage produced at the plate of V2A. This exponential rise in voltage is applied through resistors R22 (A28) and R23 to the junction of R23 and capacitor C15. The 12.5-kilocycle oscillations from cathode follower V3B are superimposed on the exponential rise in voltage. This positive-going composite waveform, coupled through C15, reaches a potential sufficiently positive to trigger the first triode section of monostable multivibrator V4 (B28) back to its original condition 160 microseconds after V1 (A26) is triggered by the end-of-sweep pulse. When V4 (B28) is triggered back to its original condition, the plate of the first triode section in V4 swings negative. This negative swing is coupled through capacitor C23 and the parallel combination of crystal diode CR3 and resistor R43 to the control grid of pulse amplifier V6B. Crystal diode CR3 shunts R43 during the negative portion of the pulse.

c. The symbol unblanking input signal for normally cut-off pulse amplifier V6B (A29) is a composite signal composed of the 12.5-kilocycle oscillations from cathode follower V3B (B28) superimposed on the exponential rise in plate voltage of gating amplifier V2A, (2) above. The bias on V6B (A29) is such that the composite signal applied to the control grid reaches a potential sufficiently positive to cause V6B to begin conduction 80 microseconds after the finish of the end-of-sweep pulse. The bias level of V6B is set by write pulse adjust variable resistor R46, part of a negative voltage divider. Eighty microseconds after V6B begins conduction, the negative voltage swing produced at the plate of the first triode section of monostable multivibrator V4, (2) above, causes V6B to cut off once more. Pulse amplifier V7A amplifies and inverts the negative 80-microsecond pulse produced at the plate of V6B and applies the resulting positive pulse to pulse amplifier V7B. The output of V7B is a negative 80-microsecond pulse, designated the symbol unblanking pulse. This pulse occurs 80 microseconds after each range (vertical) sweep on CRT V2 (C29) and is then applied to connector P9 at the B scope video amplifier (par. 114).

116 (U). B Scope Indicator Cathode-Ray Tube Circuits

a. The cathode-ray tube (CRT) circuits of the B scope indicator, except for the electrostatic deflection plates, are a functional part of the video circuits. The CRT circuits consists of a high-voltage regulator (clamping) circuit and a CRT which presents visually a rectangular sector of video with a coverage of 220,000 yards in range and 1066 mils in azimuth. During intersweep intervals, a small target track antenna circle denotes the azimuth and range of the antenna in the target tracking radar system.

Note. The grid zone references shown in parentheses in *b* below refer to figure 30, TM 9-1430-254-20/6, unless otherwise indicated.

b. The CRT circuits of the B scope indicator consist of CRT V2 (C29); intensity regulator V3; crystal diodes CR1, CR2, and CR3; surge protector lamps DS5, DS6, and DS7; and associated controls and circuits. Functional inputs to the CRT circuits are discussed in (1) and (2) below.

(1) The LOPAR video or the symbol unblanking pulse is applied directly to control grid pins 12 and 13 of CRT V2 (C29) from the B scope video amplifier. Positive LOPAR video is applied to the control grid of CRT V2 in periods of 1340 microseconds. A symbol unblanking pulse 80 microseconds in duration appears at the control grid of CRT V2 after the end of each range (vertical) sweep. Unlike LOPAR video which occurs only during a selected 1066-mil sector of acquisition antenna rotation, the symbol unblanking pulse occurs continuously, maintaining the same time relationship, independent of acquisition antenna rotation.

(2) A voltage divider consisting of resistors R24 (B30), R9, and R26, FOCUS variable resistor R10, resistor R26 in parallel with V3, and INTENSITY variable resistor R13 provides scaled voltages from a —8000-volt input for the elements of CRT V2 (C29). The high-voltage input is received from the power supply assembly (fig. 58, D50, TM 9-1430-256-20/3) in the target radar control console. The power supply assembly supplies a B scope ground for the B scope indicator to establish a reference for the —8000-volt potential. Bypass capacitor C1 in the power supply assembly is connected between frame ground and the CRT circuits. This ac return circuit is designated —8000 volts prime. When R10 (C29) is correctly adjusted, the CRT display is in focus. The cathode-to-grid bias of CRT V2 is regulated by intensity regulator V3. The intensity bias for CRT V2 is controlled by R13. The grid resistance of this circuit is furnished by resistors R14 and R15, in parallel with crystal diodes CR1, CR2, and CR3. The diodes are in series to provide higher voltage breakdown operation. Surge protector lamps DS5, DS6, and DS7 are connected across CR1, CR2, and CR3 to protect the diodes from excessive switching transient voltages. The surge protector lamps also prevent surge currents, produced by the charging of the output circuit of video amplifier V5 (C27) in the B scope video amplifier, from damaging the diodes.

Section VI (CMHA). MARKER CIRCUITS

117 (U). Purpose

The marker circuits are an integral part of the presentation system (fig. 1). The marker circuits perform three functions: determine the slant range of a designated target by the target tracking radar system; determine the beam azimuth of the track antenna reflector assembly for the purpose of displaying the electronic cross; and produce an acquisition range mark for the target track and target range circuits. The marker circuits include manually operable controls which position the designate circle (par. 119) in the PPI display to enclose the target video. Positioning of the designate circle to enclose the target video generates acquisition range information which is transferred to the target range and target track antenna positioning system to enable the target tracking radar system to slew rapidly to the range setting determined for the designated target. The marker circuits include mark generators which develop timing control pulses for determining the position of the electronic cross in the PPI display. Azimuth gates and marks are derived from azimuth resolver outputs in the acquisition and target tracking radar systems. These resolvers are synchronized by means of common stator voltages received from the acquisition azimuth resolver, and the 4-kc excitation and reference output of the 4-kc oscillator (par. 77). A synchro resolver rotor is mechanically coupled to a transformer which transmits target azimuth data to the target track azimuth slew circuits during acquire procedures. The track azimuth mark which makes the radial line of the electronic cross is derived from a resolver in the target tracking radar system. The acquisition track range mark which makes the arc of the electronic cross is derived from the target range and target track range circuits. The marker circuits furnish timing control pulses to the video circuits (par. 107) which are used to correlate the display of the designate circle in the PPI display. The marker circuits (fig. 38) comprise sections of the battery control console, the target tracking radar system, and the director station group. Sections of the battery control console included are the target designate control and the HIPAR control-indicator. The target designate control contains a range control circuit and a synchro resolver. The HIPAR control-indicator contains the acquisition range generator mark circuit. Sections of the target tracking radar system included in the marker circuits are the target range mark generator circuits in the target range amplifier control group, the track azimuth resolver circuits in the azimuth position transmitter of the target track antenna support base, and the mark generator gate and mark circuits in the target radar control console.

118 (CMHA). Block Diagram Analysis

a. The battery control console (fig. 38) contains the azimuth 6400-mil synchro resolver circuits which designate targets from the low power acquisition radar (LOPAR) system or the high power acquisition radar (HIPAR) system by the application of azimuth designate signals to the antenna positioning system in the target tracking radar system. The assembly in the battery control console which affects the ranging function is the range control circuits of the target designate control. The outputs of the azimuth synchro resolver and the range control circuits are determined by the positions of the azimuth dial and the range control knob, respectively. The range control circuits provide a dc control voltage (the designate range signal) to the acquisition range generator in the HIPAR control-indicator. A HIPAR or LOPAR preknock pulse is also applied to the acquisition range generator. With these two inputs present, an acquisition range mark is generated by the acquisition range generator and applied to the video and mark mixer. The video and mark mixer connects the acquisition range mark to the target range slew control amplifier (fig. 52, D50, TM 9-1430-256-20/3) in the target tracking radar system to enable the range circuits to slew to the designated target range. Track azimuth resolver B4 in the target track antenna support base supplies HIPAR or LOPAR resolver signals to the mark generator gate circuit in the target radar control console. The mark generator gate circuit also receives a constant amplitude 4-kc reference voltage from the 4-kc oscillator. The target radar control console also contains the mark generator mark circuit. These two circuits effect the configuration of the electronic cross and its position in the PPI display. The gate circuit generates the track azimuth gate and applies it to the video and mark mixer in the MTI circuits (par. 71) and to the mark generator mark circuit. The mark circuit is triggered by the HIPAR or LOPAR sync pulse and supplies the track azimuth mark to the video and mark mixer. The track range gate and acquisition-track range mark, generated by the target range mark generator in the target tracking radar system, are applied to the video and mark mixer where they are mixed with the track azimuth gate and mark to generate the electronic cross.

b. In summary, the marker circuits supply azimuth and range signals (marks) which indicate the range setting of the range control circuit, the azimuth setting of azimuth 6400-mil synchro resolver B1, and the azimuth setting of track azimuth resolver B4. This relationship is discussed in (1) through (4) below.

(1) The range and azimuth settings of the range control circuits appear in the PPI display as a designate circle. The range setting is used to generate

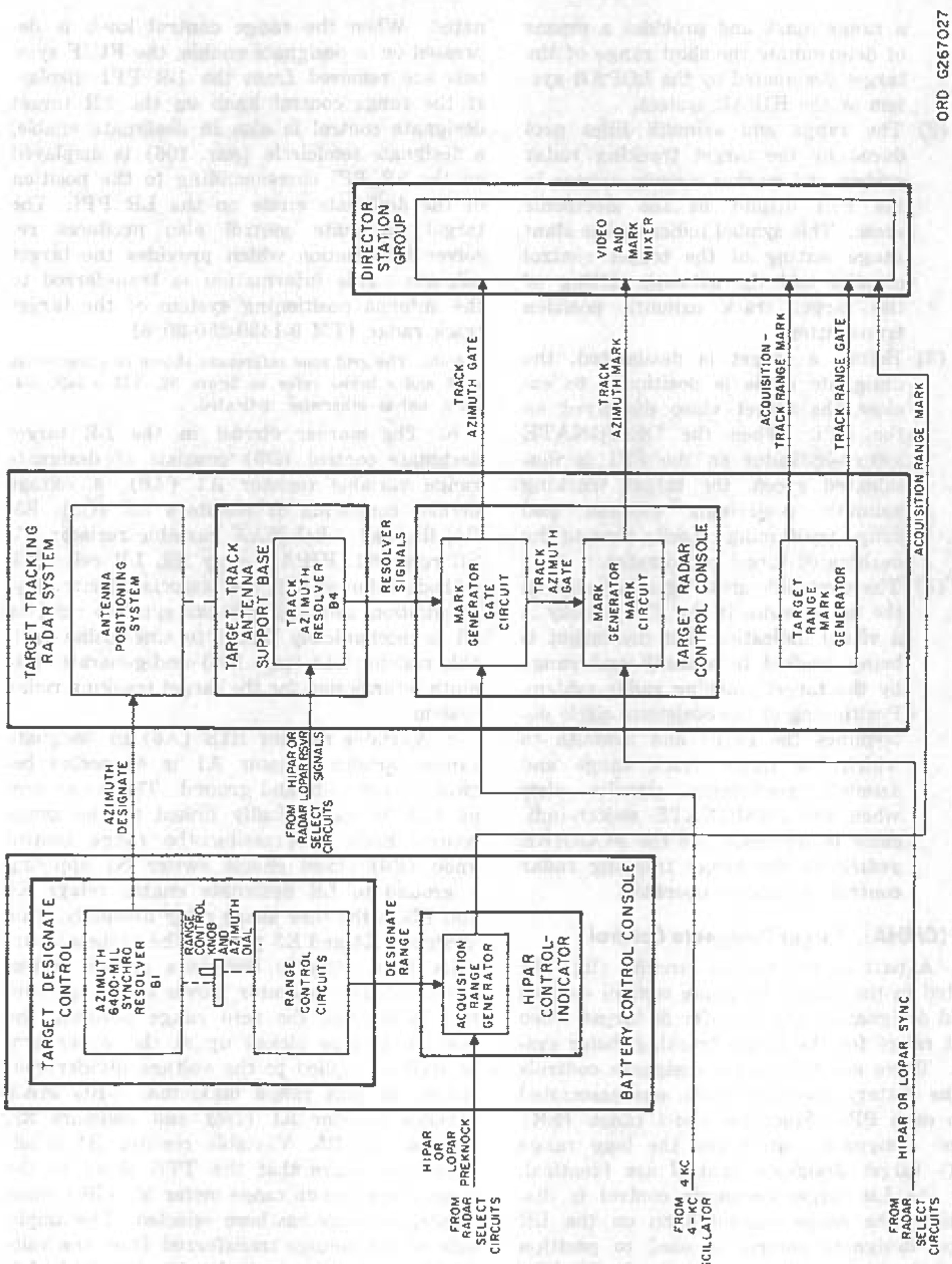


Figure 38 (U). Marker circuits—block diagram (U).

a range mark and provides a means of determining the slant range of the target designated by the LOPAR system or the HIPAR system.

(2) The range and azimuth lines produced by the target tracking radar system and marker circuits appear in the PPI display as the electronic cross. This symbol indicates the slant range setting of the target control circuits and the azimuth setting of the target track azimuth position transmitter.

(3) Before a target is designated, the designate circle is positioned to enclose the target video displayed on the PPI. When the DESIGNATE switch-indicator on the PPI is illuminated green, the target tracking azimuth positioning circuits and range positioning circuits slew to the designated target coordinates.

(4) The electronic cross superimposed on the target video in the PPI display is a visual indication that the target is being tracked in azimuth and range by the target tracking radar system. Positioning of the designate circle determines the range and azimuth to which the target track range and azimuth positioning circuits slew when the DESIGNATE switch-indicator is depressed and the ACQUIRE switch on the target tracking radar control console is operated.

119 (CMHA). Target Designate Control

a. A part of the marker circuits (fig. 38) located in the target designate control enables rapid designation and transfer of target video slant range for the target tracking radar system. There are two target designate controls in the battery control console, one associated with each PPI. Since the short range (SR) target designate control and the long range (LR) target designate control are identical, only the LR target designate control is discussed. The range control knob on the LR target designate control is used to position the designate circle (par. 106) on the LR PPI to the slant range of the target to be designated. When the range control knob is depressed or in designate enable, the FUIF symbols are removed from the LR PPI display. If the range control knob on the SR target designate control is also in designate enable, a designate semicircle (par. 106) is displayed on the SR PPI corresponding to the position of the designate circle on the LR PPI. The target designate control also produces resolver information which provides the target azimuth. This information is transferred to the antenna positioning system of the target track radar (TM 9-1430-250-20/6).

Note. The grid zone references shown in parentheses in *b* and *c* below refer to figure 32, TM 9-1430-254-20/6, unless otherwise indicated.

b. The marker circuit in the LR target designate control (D3) consists of designate range variable resistor A1 (A6), a voltage divider consisting of resistors R2 (C2), R3, R4, R5, and +RG MAX variable resistor R1, SR relay K1, HIPAR relay K2, LR relay K3, cathode follower V3, and associated circuitry. In addition, azimuth 6400-mil synchro resolver B1 is mechanically linked to sine-cosine variable resistor R18 (par. 106) and generates azimuth information for the target tracking radar system.

c. Variable resistor R1B (A6) in designate range variable resistor A1 is connected between +150 volts and ground. The wiper arm of R1B is mechanically linked to the range control knob. Depressing the range control knob (B6) closes enable switch S1 applying a ground to LR designate enable relays K4 and K3 in the time share relay assembly. This energizes K4 and K3 putting the designate circuits (par. 102) in designate enable. When the acquisition operator moves the range control knob from the zero range position, the positive voltage picked up at the wiper arm of R1B is applied to the voltage divider consisting of plus range maximum +RG MAX variable resistor R1 (D2) and resistors R2, R3, R4, and R5. Variable resistor R1 is adjusted to insure that the TTR slews to the range displayed on range meter M1 (B6) when maximum range has been selected. The amplitude of the voltage transferred from the voltage divider to the control grid of cathode follower V3 (D4) is dependent upon the condition of variable resistor R1 (D2) and three relays: SR relay K1 (D3), HIPAR relay K2, and LR relay K3. Table IV (par. 106) indicates the conditions required to energize each of these three relays in relation to the appropriate target designate control. Cathode follower V3 (D4) is normally conducting and the positive voltage applied from the voltage divider through the relay circuits increases this conduction. This increases the potential on the cathode of V3 in a positive direction. This increase in potential is applied to the acquisition range generator through range RG ZERO variable resistor R34 (D5), and contacts 7 and 16 (D7) of dc energized SR designate relay K13 in the LOPAR control-indicator. Variable resistor R34 (D5) is adjusted to insure that the TTR slews to a range of 30,000 yards when meter M1 (B6) in the target designate control indicates 30,000 yards.

120 (CMHA). Acquisition Range Generator

a. The slant range of a target displayed at the PPI in the presentation system (fig. 1) is determined by measuring the interval between the occurrence of the transmitter pulse and the video of the target echo. Extreme accuracy is not required of the acquisition radar system since the obtained slant range data is used primarily for target designation to the target tracking radar system. Range accuracy of plus or minus 150 yards, corresponding in time to 0.9 microsecond, is considered satisfactory.

b. Time (range) measurement to a target is made by positioning a designate circle to enclose the target video. The time delay between the transmitter pulse and the range mark is controlled by a designate range variable resistor geared to a dial calibrated in yards. The designate circle (par. 102*e* (4) *(c)* and (5) *(c)*) is displayed on the cathode-ray tubes of the PPI's. The designate range variable resistor in the target designate control is mechanically controlled by a range control knob. The output of the variable resistor is used as a range control voltage for the gate circuit in the acquisition range generator (fig. 38).

c. The acquisition range generator is an assembly of the HIPAR control-indicator, which is a part of the marker circuits. This assembly generates the acquisition range mark.

Note. The grid zone references shown in parentheses in *d* through *g* below refer to figure 33, TM 9-1430-254-20/6, unless otherwise indicated.

d. Operation of the acquisition range generator (D3) begins 23.5 microseconds before the output RF pulse of the transmitter circuits. The operation is triggered by a 1-microsecond LOPAR preknock pulse (par. 18*a*) received from the acquisition-track synchronizer or a 1-microsecond HIPAR preknock pulse from the auxiliary acquisition interconnecting box. The acquisition range generator then produces an acquisition range mark with a 0.2-microsecond duration. The acquisition range mark is supplied to the video and mark mixer (C12).

e. The acquisition range generator consists of a phantastron delay circuit and a range mark circuit. A functional analysis of these circuits is discussed in *f* and *g* below.

f. Action of the phantastron delay circuit in the acquisition range generator is described in (1) and (2) below.

(1) The phantastron delay circuit provides a variable time delay by means of a voltage output having a controlled linear variation from which the acquisition range mark is generated. This circuit consists of blocking diode V1A (D3), blocking diode V1B, phantastron V2, and cathode follower V3A. The positive LOPAR or HIPAR preknock pulse is applied through V1B (C3) to trigger the phantastron at the repetition rate of the selected radar. Diode V1B is used as an isolation stage between the phantastron and the LOPAR or HIPAR preknock circuits. The dc range control voltage from designate range variable resistor A1 (fig. 32, A6, TM 9-1430-254-20/6) is applied through V1A (D3) to the plate of the phantastron. The applied dc voltage from resistor A1 determines the duration of the phantastron output pulse. Since the input dc control voltage is variable, the output time delay is also variable. This variable time delay

determines the position of the acquisition range mark displayed at the PPI. The phantastron output is a negative, 70- to 80-volt (maximum) cathode pulse with a maximum duration of approximately 1524 microseconds.

(2) The leading edge of the phantastron output pulse is coincident in time with the leading edge of the LOPAR or HIPAR preknock pulse. As designate range variable resistor A1 is varied in a direction to increase the range setting, a higher voltage appears at the cathode of blocking diode V1A and the trailing edge of the phantastron output pulse moves in time, producing a broader pulse of the same amplitude. The trailing edge of the output pulse corresponds to a variable delay time of approximately 5 to 1524 microseconds. RATE variable resistor R13 (D4) is provided for adjusting the slope of the phantastron pulse time. This adjustment insures accurate ranging of the output of the acquisition range generator as designate range variable resistor A1 is varied throughout its limits. Therefore, the acquisition range circle and the electronic cross can be more closely alined at any given range. The phantastron pulse is supplied to differentiating and clipping amplifier V3B in the range circuit.

g. The acquisition range generator mark circuit is described in (1) through (4) below.

(1) The delayed negative pulse from the phantastron circuit is applied to differentiating and clipping amplifier V3B. This stage does not respond to the leading edge of the input pulse. The trailing edge, however, causes V3B to produce a sharp negative pulse of approximately 110 volts. The delayed output pulse from V3B is used to trigger monostable multivibrator V4. When triggered, V4 generates a 150-microsecond, 30- to 40-volt rectangular pulse. The duration of this pulse is controlled by GATE LENGTH variable resistor R20 (D5).

(2) The positive pulse from monostable multivibrator V4 (D5) is amplified and inverted by network driver V5B (D6) before application to range mark delay variable network Z1, a delay network operating as a quarter-cycle oscillator. From Z1, a negative pulse with a steep leading edge and a sinusoidal recovery towards reference is applied to pulse forming triode V6A (D7). Pulse forming triode V6A, normally conducting, is cut off for approximately 75 microseconds, the factory-adjusted duration of the Z1 output pulse. A 75-microsecond pulse is formed on the plate of V6A. This pulse is amplified, clipped (squared), and inverted by V6B. The negative square wave from V6B is differentiated by capacitor C16 and resistor R46 in the input circuit to differentiating and clipping amplifier V7.

(3) The differentiated square wave results in a positive and a negative pulse. The negative pulse has its leading edge in coincidence with the leading edge of the applied square wave. The positive pulse has its leading edge in coincidence with the trailing edge of the same square wave. The negative pulse is ineffective at the input of V7 because of baseline clippings (cutoff bias). However, the positive pulse is amplified and inverted by V7. The negative output pulse of V7 appears 75 microseconds after the negative pulse applied to Z1. From V7, the negative pulse is inverted by transformer T1 which provides impedance matching to the distribution circuit.

(4) The output from T1 is the positive 10- to 18-volt acquisition range mark with an approximate duration of 0.2 microsecond. The acquisition range mark is supplied to the video and mark mixer in the MTI circuits (par. 71*c*(6)).

121 (CMHA). Mark Generator

a. The mark generator (fig. 38) in the target radar control console receives two 4-kc voltages which vary as the sine-cosine of the rotor positions of a track azimuth resolver. The mark generator receives the 4-kc reference carrier and the sync pulse from the acquisition-track synchronizer. From these input signals, the mark generator develops a track azimuth gate and a track azimuth mark for each revolution of the acquisition antenna. The gate and the mark are supplied to the MTI circuits (par. 71*c* (2) and (3)).

b. The mark generator consists of a gate circuit and a mark circuit. A functional analysis of the mark generator is given in *c* and *d* below.

Note. The grid zone references shown in parentheses in *c* and *d* below refer to figure 33, TM 9-1430-254-20/6, unless otherwise indicated.

c. The gate circuit consists of clipper limiter V1A (B7), gate amplifier V3A, gate cathode follower V3B, coincidence detectors V4A and V4B, and associated circuits.

(1) The modulated east-west (E-W) signal (A, fig. 39) received from track azimuth resolver B4 (A4) is applied to clipper limiter V1A (B7). This signal is clipped and limited by V1A, except for a 720-mil (41-degree) section (B, fig. 39) which is unaffected. The center of this unaffected section is at the null point of the E-W modulated 4-kc input signal. The null point occurs every 3200 mils of antenna rotation. The output from V1A is applied to coincidence detector V4A and clipper limiter V1B. This unaffected 720-mil signal is detected by V4A to remove the positive section. The re-

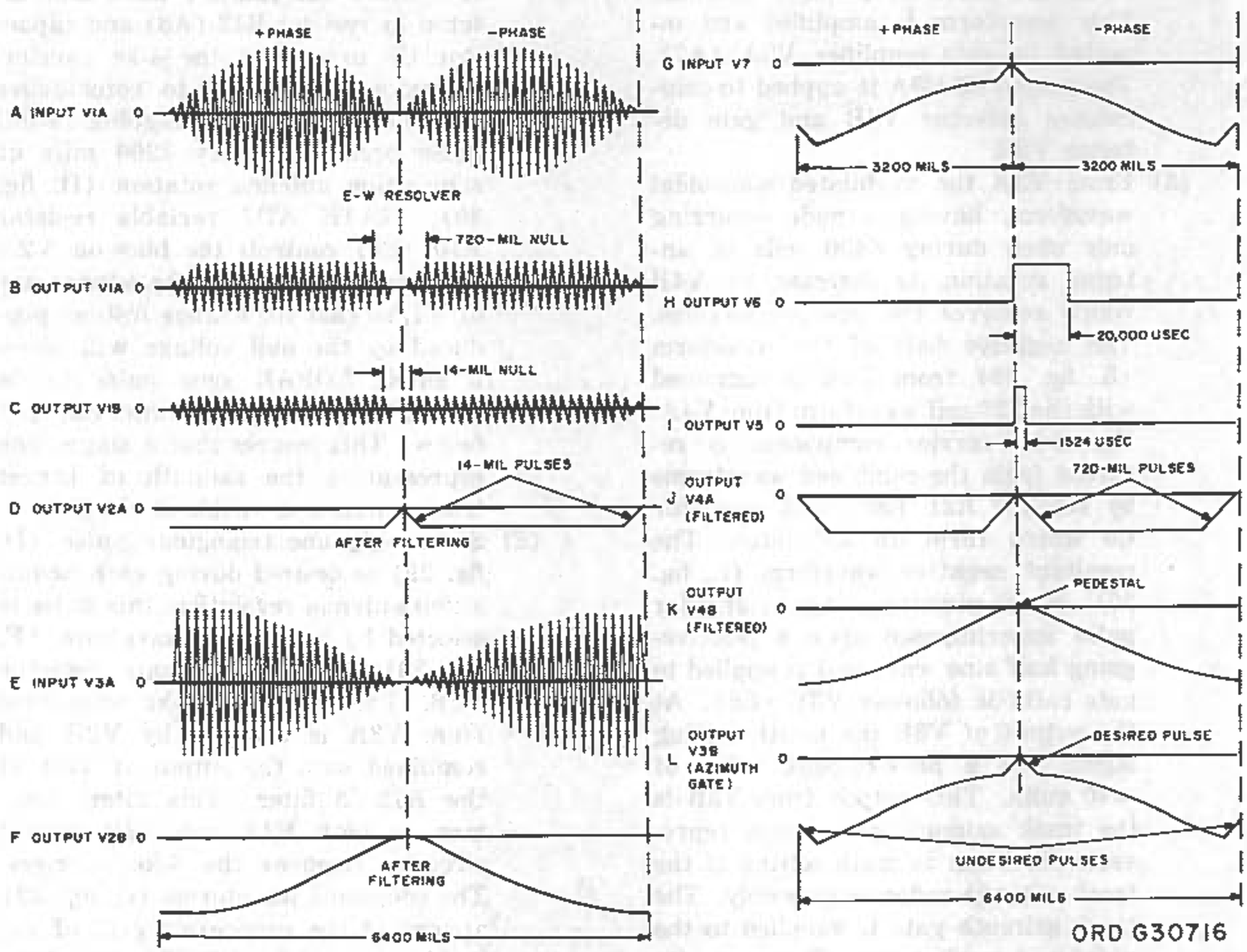


Figure 39 (U). Marker generator—waveforms—ideal (U).

sulting 720-mil signal (J, fig. 39) from V4A is superimposed on a pedestal waveform from coincidence detector V4B.

(2) The pedestal waveform is developed by gate amplifier V3A (A7) from two signals appearing across 4KC ADJ variable resistor R20. One signal is the north-south (N-S) modulated 4-kc signal from track azimuth resolver B4 (A4). This signal is combined with a second, the 4-kc reference carrier received from the 4-kc oscillator (par. 77) at resistor R20. The combination of signals results in the cancellation or reinforcement of alternate half cycles of the modulation envelope. This causes a waveform (E, fig. 39) having one maximum and one minimum point per revolution of the acquisition antenna. This waveform is amplified and inverted in gate amplifier V3A (A7). The output of V3A is applied to coincidence detector V4B and gate detector V2B.

(3) From V3A the modulated sinusoidal waveform, having a node occurring only once during 6400 mils of antenna rotation, is detected by V4B which removes the positive sections. The negative half of the waveform (K, fig. 39) from V4B is combined with the 720-mil waveform from V4A. The 4-kc carrier component is removed from the combined waveforms by resistor R21 (B8) and capacitor C5 which form an RF filter. The resultant negative waveform (L, fig. 39) is a positive-going triangular pulse superimposed upon a positive-going half sine wave and is applied to gate cathode follower V3B (B8). At the output of V3B the positive-going signal has a peak-to-peak value of —70 volts. This output from V3B is the track azimuth gate which represents the beam azimuth setting of the track antenna reflector assembly. The track azimuth gate is supplied to the video and mark mixer. This unit uses the gate as an aid in the development of the LOPAR video and marks, an output of the MTI circuits (par. 71).

d. The mark circuit consists of clipper limiter V1A and V1B, gate detectors V2A and V2B, coincidence amplifier V7, monostable multivibrators V6 and V5, and associated circuits.

(1) The amplitude-modulated waveform (B, fig. 39) from V1A is further clipped and limited by V1B to yield two 14-mil (0.8-degree) nulls (C, fig. 39) per acquisition antenna revolution. One of these nulls occurs the instant the acquisition antenna radar beam azimuth coincides with the beam azimuth setting of the track antenna reflector assembly while the other occurs 3200 mils later. The resultant waveform is detected by V2A (B8) to remove the positive half, and filtered by resistor R12 (A8) and capacitor C3 to remove the 4-kc carrier. Therefore, the input to coincidence amplifier V7 is a positive-going 14-mil pulse occurring every 3200 mils of acquisition antenna rotation (D, fig. 39). GATE ADJ variable resistor R10 (B8) controls the bias on V2A and hence the bias on the suppressor of V7, so that the change in bias produced by the null voltage will allow a single LOPAR sync pulse to be passed during the gate interval, (2) below. This insures that a single line representing the azimuth of target track antenna is visible at the PPI.

(2) Since only one triangular pulse (D, fig. 39) is desired during each acquisition antenna revolution, this pulse is selected by a pedestal waveform (F, fig. 39) developed by gate detector V2B. The modulated 4-kc waveform from V3A is detected by V2B and combined with the output of V2A at the R12-C3 filter. This filter, common to both V2A and V2B output circuits, removes the 4-kc carriers. The combined waveforms (G, fig. 39) appear at the suppressor grid of coincidence amplifier V7. The second in-

put to V7 is a positive LOPAR sync pulse from the acquisition-track synchronizer or HIPAR sync from the auxiliary acquisition interconnecting box. Upon application of the combined signals to V7, the positive-going triangular pulse superimposed on the pedestal conditions V7 so that a sync pulse occurring during the triangular pulse is amplified. A negative output pulse of sufficient amplitude to trigger monostable multivibrator V6 is produced. Since the undesired triangular pulse is at the minimum point of the pedestal waveform (G, fig. 39) applied to V7, the pulse has no effect on V7 and no output is produced when it occurs.

(3) Multivibrator V6 develops a pulse of relatively long duration (20,000 microseconds) when triggered. Thus, V6 is unable to respond to any sync pulse but the first one selected by the 14-mil gate applied to the suppressor grid of V7. The positive square wave from V6 (H, fig. 39) is differentiated by capacitor C9 (A9) and resistors R25 and R26, and applied to monostable multivibrator V5 every 6400 mils of acquisition antenna rotation. The first triode section of V5 is normally cut off by the bias supplied from the voltage divider consisting of resistors R24 and R25 connected between ground and —250 volts. The positive spike, corresponding to the leading edge of the positive pulse output of V6, causes the first triode section of V5 to conduct. In this manner, V5 develops a positive 5- to 10-volt rectangular pulse output (I, fig. 39) at the cathode of its first triode section from a positive input. The acquisition azimuth mark pulse has a maximum duration adjusted to 1524 microseconds (250,000 yards) by MARK LENGTH variable resistor R32 for LOPAR system operation. This adjustment insures that the radial line of the electronic cross may be presented at the selected maximum range. The output of V5 is the track azimuth mark supplied to the video and mark mixer in the MTI circuits. The track azimuth mark and the track range gate produce the radial line of the electronic cross.

CHAPTER 10 (CMHA)

ASSOCIATED TARGET IDENTIFICATION AND DESIGNATION EQUIPMENT

Section I (CMHA). FIRE UNIT INTEGRATION FACILITY SYSTEM

122 (CMHA). Integration and Data Transmission

a. A fire unit integration facility (FUIF) system (fig. 40) is used with missile master AN/FSG-1 to provide an integrated air defense for a particular defense area. This integrated system is designated to relay accurate and nearly instantaneous designation data and/or information of high-speed aircraft and missiles between the Army Air Defense Command Post (AADCP) and related NIKE-HERCULES Anti-Tactical Ballistic Missile (ATBM) systems. Twenty-four NIKE-HERCULES ATBM systems and their associated FUIF equipment can be used in a single defense area. All FUIF units within a defense area, however, cannot transmit data simultaneously. All can receive data from the missile master at the same time. To avoid unintelligible combinations of information, a method of time sharing is provided by the master timer, an integral part of the missile master. This timer provides a sequential interrogate signal to each FUIF system in order, interrogating and listening for the report-back, a procedure known as "reference". In less than 0.15 second each NIKE-HERCULES ATBM system can be interrogated and give a report-back to the missile master. At least five such systems can be interrogated once every second. The report-back is then regenerated: data transmitted to the missile master from one battery is stored and retransmitted by the missile master to other FUIF systems in the defense area. When NIKE-HERCULES ATBM system I, for example, is tracking a target in a sector also defended (overlapped) by NIKE-HERCULES ATBM system II, system II can obtain and observe the regenerated target data of NIKE-HERCULES ATBM system I.

b. The data transmissions of the missile master at the AADCP and the FUIF equipment at a given NIKE-HERCULES ATBM system are linked by three telephone lines: the battery data link (BDL) line is primarily used by the missile master to provide each system with reference data; the automatic data link (ADL) line is used to provide the NIKE-HERCULES ATBM system with broadcast data (mission tracks and identities); and the report-back line is used by the missile master to obtain reference data and confirmation of commands from the FUIF equipment at each NIKE-HERCULES ATBM system. Designations and commands sent from AADCP to specific systems are transmitted simultaneously along both the ADL and BDL lines (par. 123*a*).

c. Precise coordination of target range, azimuth, and altitude information between the missile master and associated NIKE-HERCULES ATBM systems is necessary. Sector orientation within a defense area by means of a topographical grid system provides an accurate and simple means of coordinating firing missions. Each defense area is represented by a master grid which covers the area assigned to the AADCP, and local grids which lay within, or partially overlap, the master grid. Each local grid represents the sector assigned to a NIKE-HERCULES ATBM system. To enable the coordination of positional data between AADCP and local systems, all grids have established points of reference. The reference point of the master grid is its center point; the reference point of each local grid, with the NIKE-HERCULES ATBM system located at the center, is the southwest corner of that particular grid. The distance from the reference point of the master grid to the reference point of the local grid is called parallax. The east-west parallax is the X parallax (P_X); the north-south parallax is the Y parallax (P_Y). Height, which is referenced to sea level, is H parallax (P_H). All parallax and positional data are presented in quanta in both master and local grids. The X and Y coordinates (horizontal) are each subdivided into 1024 quanta, and the H coordinates (vertical) into 512 quanta. One quantum represents 625 yards, which gives a total of 640,000 yards (1024 x 625) per side for each local and the master grid. The distance in X, Y, and H from the reference of the local grid to the target is called the target coordinate position data. The sum of target coordinate position data and the parallax of system position with respect to AADCP

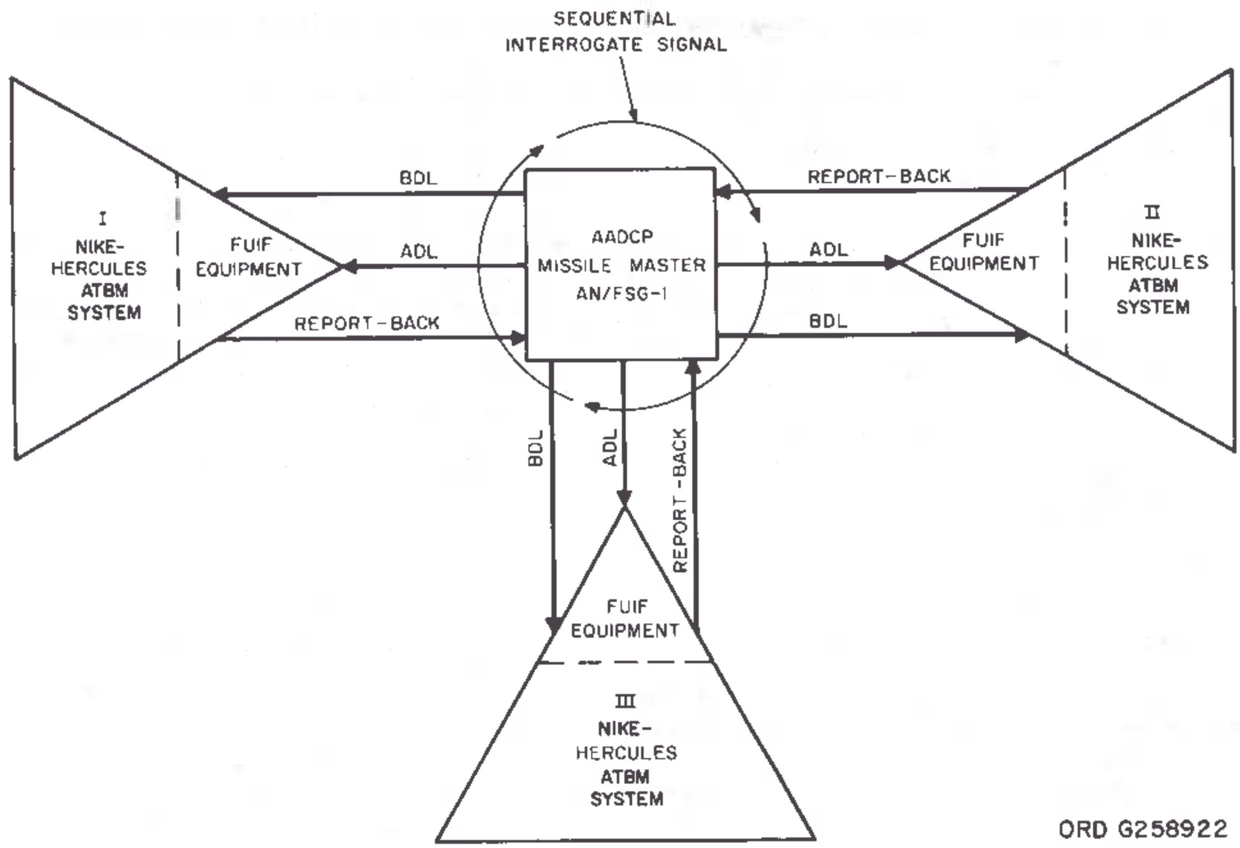


Figure 40 (U). Integrated air defense system—block diagram (U).

is presented as a line code, *d* below, at the output of the FUIF system. This parallax corrected coordinate data, referenced to the south-west corner of the local grid, is furnished to the AADCP.

d. The line code is binary to simplify the representation of decimal numbers. It is a logarithmic function, but differs from common or Briggsian logarithms in having a base of 2 rather than 10. By using two conditions, "on" or "off" (1 or 0), all decimal numbers can be represented. This facilitates electronic computation and provides a simple means of storing and transferring data. This data is transmitted in the form of pulse code modulation (PCM) (fig. 41) which is modulated by a frequency and spaced by time slots. If the frequency is present in a particular time slot, the number 1 is indicated; a time slot with no frequency represents 0.

e. Data is exchanged between AADCP and batteries in NIKE-HERCULES ATBM systems by the use of PCM data frames. There are three different data frames: a reference (category) PCM data frame and a designate (category) frame, both transmitted by the AADCP, and a report-back frame transmitted by FUIF units. Each data frame is divided into 55 time slots, or bits, of 1.3 milliseconds duration. Each frame contains the receiving equipment synchronizing signal, auxiliary word, and target data. The time slot represents a binary digit (bit) in the form of a 1500-cps signal. A binary 1 bit is represented by two cycles of the 1500-cps signal. Five data words are peculiar to each frame; a ready-sync word (time slot 0 through 7), an auxiliary word (time slot 8 through 17), an H coordinate word (time slot 18 through 27), an X coordinate word (time slot 28 through 40), and a Y coordinate word (time slot 41 through 53). A frame-guard slot, which allows the receiving equipment to be reset at the end of the data frame, is contained

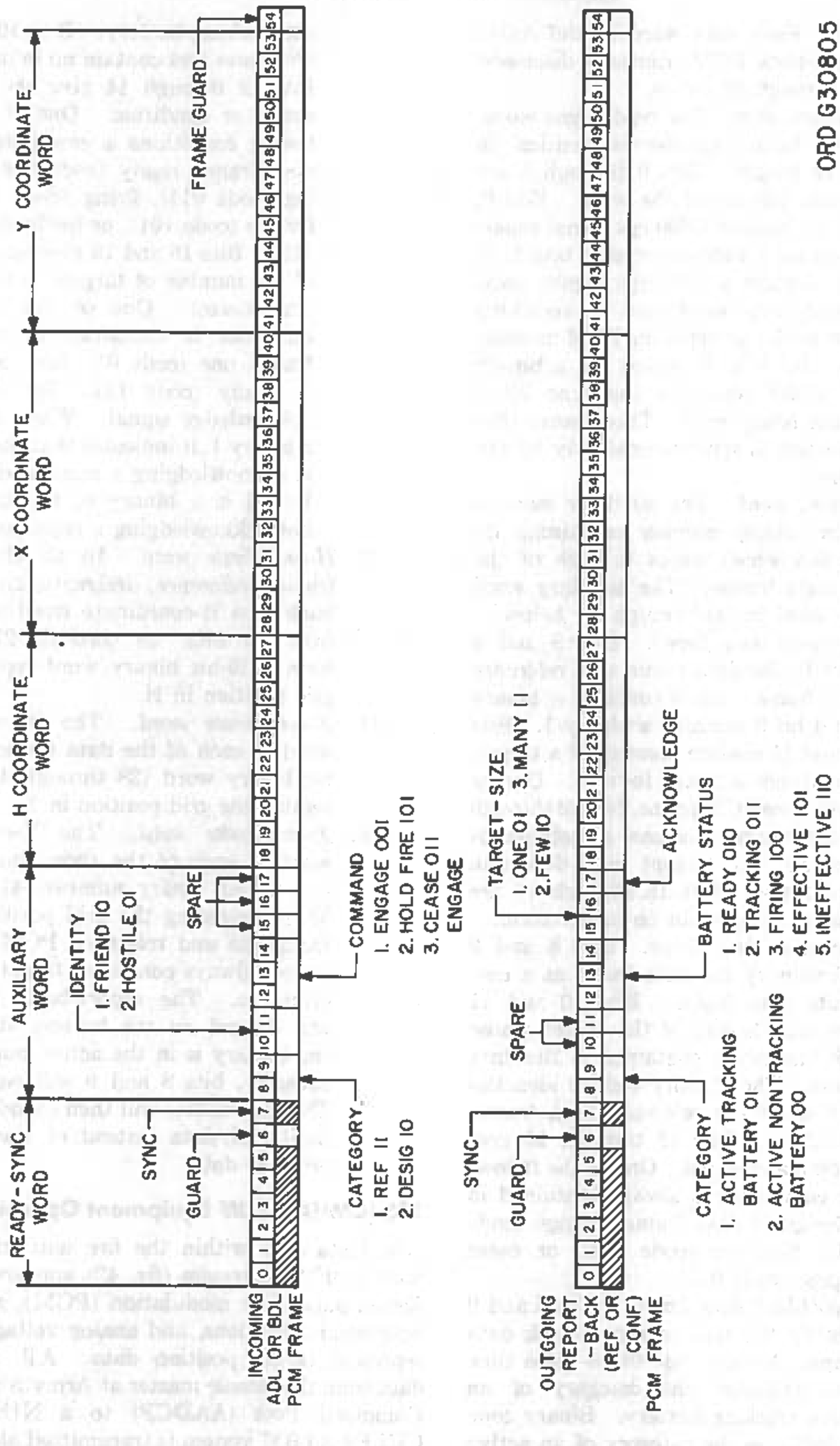


Figure 41 (U). Pulse code modulation—data frames (U).

in time slot 54. Each data word in the ADL, BDL, and report-back PCM frames is discussed in detail in (1) through (5) below.

(1) *Ready-sync word.* The ready-sync word, an 8-bit binary number is identical in all three frames. Bits 0 through 5 are the ready portion of the word. Bits 0, 1, and 2 comprise a 600-cps signal superimposed on a 1500-cps signal; bits 3, 4, and 5 contain a 1500-cps signal only. The ready-sync word arms the receiving equipment for an incoming PCM message frame. Bit 6 is the guard bit, a binary 0 bit which separates the sync bit 7 from the ready word. This insures that the receiver is synchronized only by the sync bit.

(2) *Auxiliary word.* The auxiliary word is a 10-bit binary number containing information which varies in each of the three data frames. The auxiliary word is discussed in (*a*) through (*c*) below.

(*a*) *Reference data frame.* Bits 8 and 9 identify the data frame as a reference data frame. Bit 8 contains a binary 1 and bit 9 contains a binary 1. Bits 10 and 11 contain identity of a target. Friend code is 10 and foe is 01. During a reference PCM frame, bits 12 through 14 are binary zeros used as commands and are only present in a designate data frame. Bits 15 through 17 are spares, and contain no information.

(*b*) *Designate data frame.* Bits 8 and 9 will identify the data frame as a designate data frame. Bits 10 and 11 give the identity of the target whose coordinates are contained in the data frame. The identity code is identical to that of the reference data frame, (*a*) above. Bits 12 through 14 give a command signal. One of the following commands is always contained in a designate data frame: engage (code 001), hold fire (code 101), or cease engage (code 011).

(*c*) *Report-back data frame.* Bits 8 and 9 identify the type of report-back data frame. Binary code 01 in these time slots indicates the category of an active tracking battery. Binary code 00 indicates the category of an active nontracking battery. Bits 10 and 11 are spares and contain no information. Bits 12 through 14 give the battery status or condition. One of the following conditions is contained in the data frame; ready (code 010), tracking (code 011), firing (code 100), effective (code 101), or ineffective (code 110). Bits 15 and 16 give an estimate of the number of targets in formation (target-size). One of the following estimates is contained in the data frame: one (code 01), few (code 10), or many (code 11). Bit 17 is an acknowledge signal. When bit 17 is a binary 1, it indicates that the battery is acknowledging a command. When bit 17 is a binary 0, the battery is not acknowledging a command.

(3) *H-coordinate word.* In all three data frames (reference, designate, and report-back) the H-coordinate word is formed from 10 bits, 18 through 27, which form a 10-bit binary word representing grid position in H.

(4) *X-coordinate word.* The X-coordinate word of each of the data frames is a 13-bit binary word (28 through 40) representing the grid position in X.

(5) *Y-coordinate word.* The Y-coordinate word of each of the three data frames is a 13-bit binary number, 41 through 58, representing the grid position in Y. Designate and reference PCM message frames always consist of target data coordinates. The report-back, however, will depend on the battery status. If the battery is in the active nontracking category, bits 8 and 9 will register 00. The transmitter will then encode battery positional data instead of tracking coordinate data.

123 (CMHA). FUIF Equipment Operation

a. Data flow within the fire unit integration facility (FUIF) system (fig. 42) appears in three forms: pulse code modulation (PCM), ground or no-ground conditions, and analog voltages which represent target position data. All designate data from the missile master at Army Air Defense Command Post (AADCP) to a NIKE-HERCULES ATBM system is transmitted along auto-

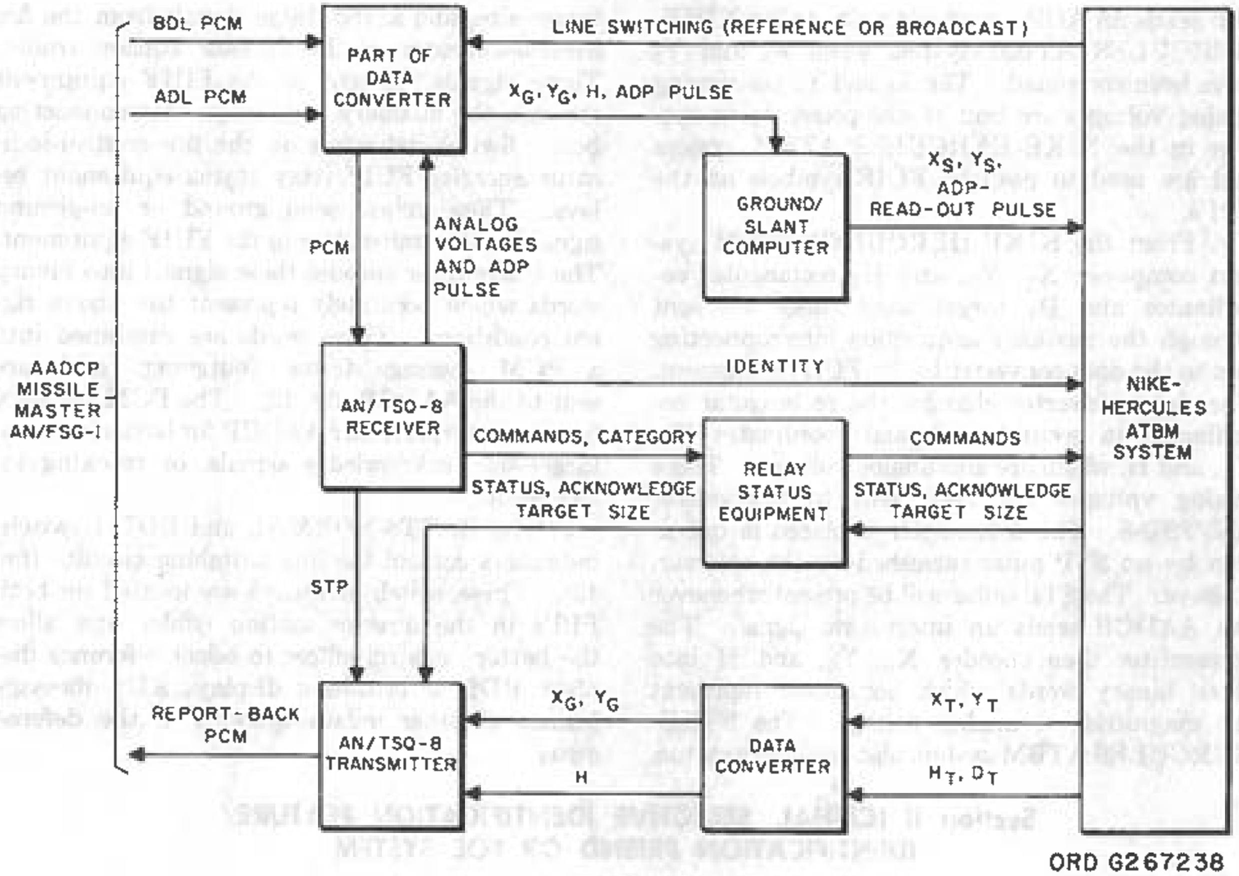


Figure 42 (U). FUIF equipment—block diagram (U).

matic data link (ADL) and battery data link (BDL) lines. Reference information from one NIKE-HERCULES ATBM system to another is regenerated by the missile master and transmitted along a BDL line. The BDL and ADL PCM data are applied to the line-switching circuits, part of the data converter. The line-switching circuits select for presentation either broadcast information (par. 122*b*) transmitted on the ADL line or reference information transmitted on the BDL line. Designation and command signals are transmitted simultaneously over ADL and BDL lines. This insures that the designation and command signals are displayed in either mode of line switching, and are displayed in case either line is damaged or destroyed. From the line-switching circuits, the PCM data is sent to receiver AN/TSQ-8. The receiver makes a parallax correction, converts PCM data to analog voltages (X_G, Y_G, and H), and develops an all-data present (ADP) pulse. From the receiver the analog voltages with the ADP pulse are applied through the data converter to the ground/slant computer. In addition, the receiver supplies a start transmitter pulse (STP) to transmitter AN/TSQ-8 and applies a ground or no-ground condition representing target identities to the presentation system in the NIKE-HERCULES ATBM system. Commands and categories signals are sent from the receiver as ground or no-ground signals to the relay status equipment at the FUIF. Here relays are energized or de-energized applying ground or no-ground through the auxiliary acquisition interconnecting box to the fire control-indicator where FUIF indicators are either illuminated or extinguished. For further information on FUIF indicators refer to TM 9-1430-250-20/12.

b. The ground/slant computer (fig. 42) converts X_G, Y_G, and H, which are ground conformal coordinates measured along the curvature of the earth, to X_S and Y_S, which are slant coordinates measured in the NIKE-HERCULES ATBM system reference plane. The ground/slant computer also sends an ADP—read-out pulse to the NIKE-HERCULES ATBM system when X_S and Y_S have been computed. The X_S and Y_S positioning analog voltages are sent to the presentation system in the NIKE-HERCULES ATBM system and are used to position FUIF symbols on the PPI's.

c. From the NIKE-HERCULES ATBM system computer, X_T, Y_T, and H_T rectangular coordinates and D_T target slant range are sent through the auxiliary acquisition interconnecting box to the data converter in the FUIF equipment. The data converter changes the rectangular coordinates to ground conformal coordinates X_G, Y_G, and H, which are also analog voltages. These analog voltages are then sent to transmitter AN/TSQ-8. The transmitter is placed in operation by an STP pulse furnished by the receiver, *a* above. The STP pulse will be present whenever the AADCP sends an interrogate signal. The transmitter then encodes X_G, Y_G, and H into three binary words which accurately represent the magnitude of analog voltage. The NIKE-HERCULES ATBM system also originates status, target-size, and acknowledge signals from the fire control-indicator in the director station trailer. These signals are sent to the FUIF equipment through the auxiliary acquisition interconnecting box. Switch-indicators on the fire control-indicator energize FUIF relay status equipment relays. These relays send ground or no-ground signals to the transmitter in the FUIF equipment. The transmitter encodes these signals into binary words which accurately represent the above signal conditions. These words are combined into a PCM message frame (outgoing) and are sent to the AADCP (fig. 42). The PCM message frame is interpreted by AADCP for battery status, target-size, acknowledge signals, or tracking information.

d. The BATTS-NORMAL and BOTH switch-indicators control the line switching circuits (fig. 42). These switch-indicators are located on both PPI's in the director station trailer and allow the battery control officer to select reference displays BDL or broadcast displays ADL message frames of other missile systems in the defense area.

Section II (CMHA). SELECTIVE IDENTIFICATION FEATURE/IDENTIFICATION FRIEND OR FOE SYSTEM

124 (CMHA). IFF Equipment Integration and Operation

a. The identification friend or foe (IFF) equipment (interrogator set AN/TPX-20) supplements the NIKE-HERCULES ATBM system to furnish one of the available means for identifying targets as friendly or hostile. With the selective identification feature (SIF) added to the IFF equipment, the combination is designated the Mark X SIF/IFF equipment (AN/TPX-27). The units of the Mark X SIF/IFF equipment are operated as auxiliary equipment in conjunction with the low power acquisition radar (LOPAR) system (fig. 1). Provisions for the remote operation of the SIF/IFF equipment are furnished by the SIF/IFF and LOPAR control circuits.

b. The SIF/IFF system can be used to challenge any target detected by the LOPAR system. The challenging action is initiated by remote controls located on the PPI's at the battery control console in the trailer mounted director station. If the challenged target is equipped with a suitable transponder unit operating at the designated frequency and code, the transponder transmits an IFF signal as a reply. This signal appears on the PPI displays as an IFF video symbol (fig. 32) together with the target video.

c. The interrelationship of the LOPAR system and the SIF/IFF system is shown in figure 43. Circuits and connections in the LOPAR system are provided to coordinate the operation of the SIF/IFF equipment. These provisions are primary ac power, IFF trigger pulses (preknock) to synchronize the IFF challenging signals with the transmitted RF pulses of the LOPAR system, and a presentation system to display the IFF coded return (reply) video signals. In addition, the LOPAR system provides mounting space for the IFF equipment and associated IFF antenna, remote controls and circuits to operate the SIF/IFF equipment from the trailer mounted director station, and mounting for the SIF equipment (decoder group AN/TPA-3) within the director station trailer. The units of the SIF/IFF equipment are separately furnished except for the remote controls and indicators. A detailed analysis of the SIF/IFF equipment is provided in other

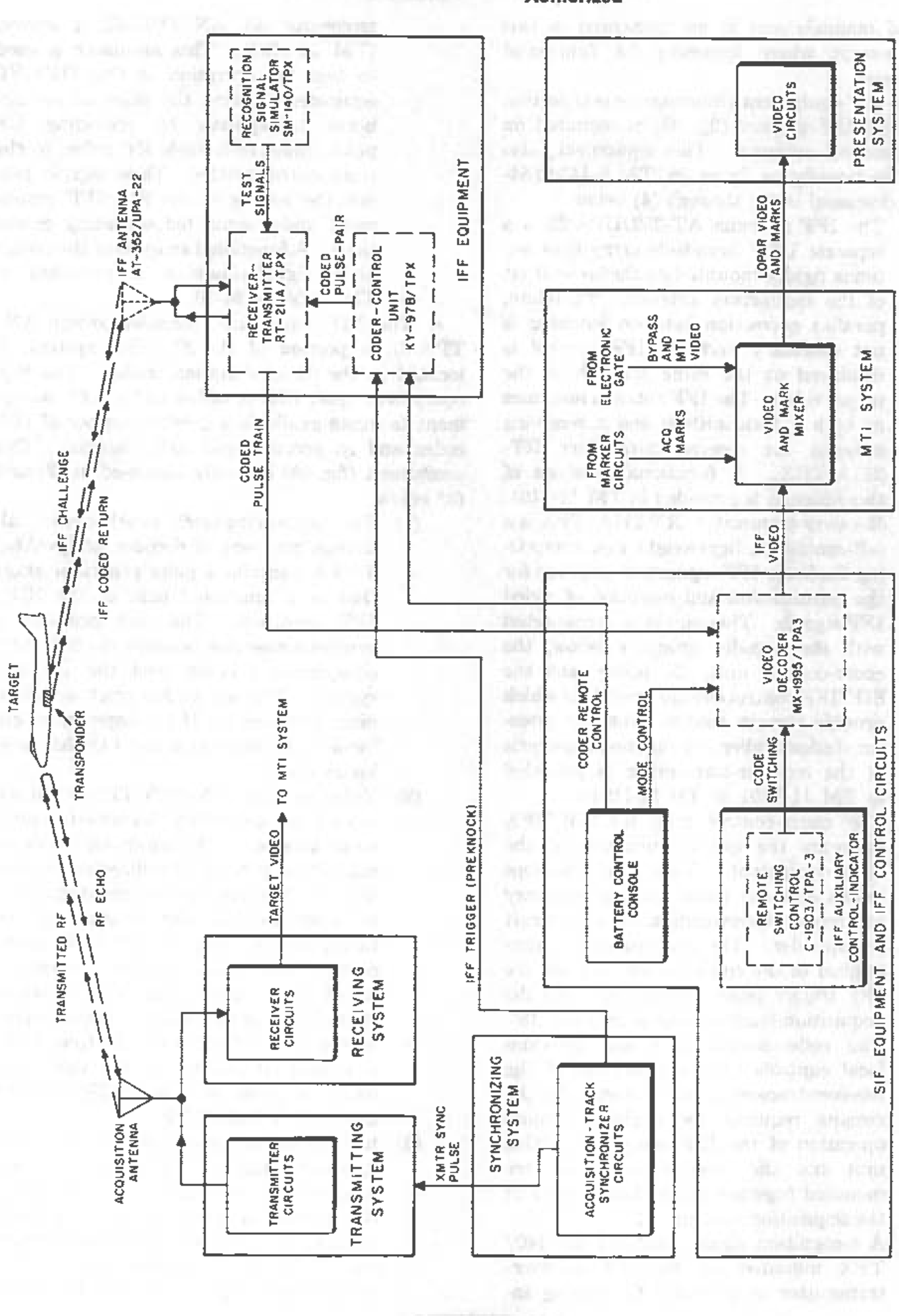


Figure 48 (U). SIF/IFF system—block diagram (U).

technical manuals and is not presented in this section except where necessary for functional clarification.

d. The IFF equipment (interrogator set) portion of the SIF/IFF system (fig. 43) is mounted on the acquisition antenna. This equipment, also shown functionally on figure 36, TM 9-1430-254-20/6, is discussed in (1) through (4) below.

(1) The IFF antenna AT-352/UPA-22 is a separate UHF broadside array-type antenna rigidly mounted on the lower front of the acquisition antenna. Therefore, parallax correction between antennas is not necessary and the IFF symbol is displayed at the same azimuth as the target video. The IFF antenna functions as both a transmitting and a receiving antenna for receiver-transmitter RT-211A/TPX. A functional analysis of this antenna is provided in TM 11-1191.

(2) Receiver-transmitter RT-211A/TPX is a self-contained, lightweight unit comprising the basic IFF equipment required for the transmission and reception of coded IFF signals. This unit is interconnected with the decoder group, *e* below, the coder-control unit, (3) below, and the SIF/IFF control circuits (par. 125) which provide remote control from the director station trailer. A functional analysis of the receiver-transmitter is provided in TM 11-1191 or TB 11-1191-1.

(3) The coder-control unit KY-97B/TPX performs the coding functions of the IFF equipment. This unit develops pulses and the pulse spacing necessary for proper interrogation of an aircraft transponder. The synchronizing pulses applied to the coder-control unit are the IFF trigger pulses (preknock) from the acquisition-track synchronizer (par. 18). The coder-control unit also provides local controls for the operation of the receiver-transmitter and incorporates the circuits required for enabling remote operation of the IFF equipment. This unit and the receiver-transmitter are mounted together on the bottom-rear of the acquisition antenna.

(4) A recognition signal simulator SM-140/TPX mounted on the IFF receiver-transmitter is provided for testing interrogator set AN/TPX-27, *a* above, (TM 11-1191). This simulator is used to test the operation of the SIF/IFF equipment, taking the place of an airborne transponder by providing RF pulse trains, or a single RF pulse, to the receiver-transmitter. These signals permit the testing of the SIF/IFF equipment under simulated operating conditions. A functional analysis of the recognition signal simulator is provided in TM 11-5840-204-10.

e. The SIF equipment (decoder group AN/TPA-3), a portion of the SIF/IFF system, is located in the director station trailer. The SIF equipment (par. 125) is added to the IFF equipment to make available a greater number of IFF codes and to permit rapid code changes. This equipment (fig. 43) is briefly discussed in (2) and (3) below.

(1) The acquisition-track synchronizer, although not part of decoder group AN/TPA-3, contains a pulse generator stage that is a functional part of the SIF/IFF operation. This unit provides a synchronizing link between the SIF/IFF equipment, *f* below, and the LOPAR system. The acquisition-track synchronizer produces an IFF trigger pulse coincident in time with the LOPAR preknock pulse.

(2) Video decoder MX-1995/TPA-3, an assembly of separately furnished equipment located in the equipment cooling cabinet is part of the director station trailer. The purpose of this decoder is to determine the identification of the target transmitting an SIF/IFF coded reply. The video decoder receives a coded pulse train from the receiver-transmitter and produces a signal representing the LOPAR IFF video (par. 125). A functional analysis of the video decoder is given in TM 11-5840-202-10 and TM 11-5840-202-20.

(3) Remote switching control C-1903/TPA-3, an assembly of separately furnished equipment, is mounted on the IFF auxiliary control-indicator in the auxiliary acquisition control interconnecting group, part of the director station trailer. The remote switching control (TB 11-1191-1)

establishes the selected code for each of three modes of SIF/IFF operation and provides remote control circuits for the video decoder. These coding controls are readily accessible behind the acquisition operators. The control assembly is comprised of three multipole-multiposition rotary switches and one toggle switch, which are used in conjunction with three switch-indicators on each PPI in the IFF control circuits to provide three modes of SIF/IFF operation.

f. The functional operation of the IFF equipment (fig. 43) is presented in (1) through (6) below.

(1) The acquisition-track synchronizer (par. 18) produces timing pulses which synchronize the operation of the LOPAR transmitter circuits with the operation of the SIF/IFF system. One of these pulses is the 20- to 40-volt IFF trigger pulse. The IFF trigger pulse is in coincidence with the LOPAR preknock pulse (fig. 3). A second pulse is the transmitter sync pulse which is applied to the LOPAR transmitter circuits. This pulse occurs 23.5 microseconds after the LOPAR preknock pulse and triggers the transmitter circuits at 500 pulses per second. Pretriggering of the SIF/IFF circuits by the IFF trigger pulse is required by the coding characteristics of the IFF equipment.

Note. **The grid zone references shown in parentheses in (2) through (6) below refer to figure 36, TM 9-1430-254-20/6, unless otherwise indicated.**

(2) The IFF trigger pulse (preknock) is applied through acquisition slip ring terminal 22 (D14) to the coder-control unit (D16), where each trigger pulse is processed into pulse-pairs. These pairs carry the coding (interpulse spacing) of one of the three available challenge modes, *g* below. From the coder-control unit, the pulse-pairs are applied to the receiver-transmitter (fig. 43) where they initiate IFF transmitter operation and simultaneously establish the reception period of the IFF receiver.

(3) The transmitter section of the receiver-transmitter (A16) generates and applies to the IFF antenna an RF carrier which is pulse modulated by the selected coding developed in the coder-control unit. The IFF antenna radiates these RF challenge signals for transponder reception by any target detected by the LOPAR system. These IFF challenge signals are received by the receiver portion of the transponder equipment within the target. The transponder, in turn, transmits a reply comprised of coded RF signals at the frequency to which the IFF equipment is tuned.

(4) The coded RF reply signals transmitted from the target are received by the IFF antenna and applied to the receiver section of the receiver-transmitter. The receiver converts the RF input into LOPAR IFF video, a succession of pulses designated the coded pulse train (fig. 43). From the receiver section of the receiver-transmitter (A16), the LOPAR IFF video is applied through acquisition slip ring terminal 24 (A14) and deenergized IFF video select relay K2 (B9) to the video decoder (A8) in the equipment cooling cabinet, a part of the trailer mounted director station. The video decoder is conditioned by the remote switching control (B8) on the IFF auxiliary control-indicator.

(5) On the remote switching control, a two-position TEST—OPERATE switch (TM 11-5840-202-10) controls decoder group AN/TPA-3 (SIF portion of the IFF equipment). When set to TEST, this switch conditions the decoder group so that a coded pulse train from the receiver-transmitter is passed without change through the video decoder (par. 125*f*) to the video and mark mixer (fig. 31, D41, TM 9-1430-254-20/6). This conditioning of the decoder group permits normal IFF challenging from either PPI (A3 or B5).

(6) The video and mark mixer (fig. 43) combines the IFF video with bypass and MTI video. The resultant signals are then mixed with the acquisition marks.

The output of the video and mark mixer produces the LOPAR acquisition video and marks applied to the video circuits (fig. 37). The IFF video appears on the indicators of the presentation system as a symbol consisting of one or more arcs with the same azimuth, but at a position slightly greater in range than the target video. In this manner, the target video and its IFF identification symbol, if any, can be viewed to determine the target identity. Additional circuit features, provided by the IFF control circuits, promote accurate identification by means of various interrogation modes, *g* below.

Note. The grid zone references shown in parentheses in *g* and *h* below refer to figure 36, TM 9-1430-254-20/6, unless otherwise indicated.

g. The challenge mode is selected by depressing one of the three mode switch-indicators, IFF CHALLENGE MODE 1 switch-indicator A2 (A3), IFF CHALLENGE MODE 2 switch-indicator A3 (A2), or IFF CHALLENGE MODE 3 switch-indicator A4 (A1) located on either PPI. These switch-indicators are identical on both the long range and short range PPI's, have the same designation, and perform the same function. The three switch-indicators provide control of the challenging modes that may be transmitted by the IFF equipment physically located on the acquisition antenna, and condition the video decoder located in the equipment cooling cabinet (B8) to one of three modes. The three modes of video presentation and the functions of each switch-indicator are discussed in (1) through (4) below.

(1) When IFF CHALLENGE MODE 1 switch-indicator A2 on either PPI is illuminated green, mode 1 is selected. This mode is the normally used condition of IFF operation. Mode 1 permits interrogation and identification of all aircraft containing a transponder conditioned to respond to any mode challenge signal from the IFF equipment. When switch-indicator A2 is depressed, section S1D applies frame ground (LOPAR IFF mode 1) through the director station group (B5), to acquisition slip ring terminal 14 (C14) to energize a mode 1 relay in the coder-control unit (D16). This relay, in turn, conditions the interpulse code spacing to an interval of 3 microseconds. Section S1B applies frame ground (LOPAR IFF challenge) through the director station group, to acquisition slip ring terminal 20 (B14) to initiate the challenge mode in the coder-control unit. Section S1C applies frame ground to the video decoder (A8) to condition this unit for mode 1.

(2) When IFF CHALLENGE MODE 3 switch-indicator A4 (A1) is illuminated green, mode 3 is selected. This mode permits interrogation and identification of a group of aircraft by means of the IFF reply from the lead aircraft only. Thus, a selected transponder is actuated and a single IFF reply is returned. The use of this mode prevents crowding of the presentation system with a large number of IFF symbols which would be obtained if mode 1 were used. Switch-indicator A4, section S1D, applies frame ground (LOPAR IFF mode 3) through the director station group (B5) to acquisition slip ring terminal 18 (B14) to energize a mode 3 relay in the coder-control unit. This relay, in turn, conditions the interpulse spacing to an interval of 8 microseconds. Section S1B (B1) applies frame ground (LOPAR IFF challenge) through the director station group to acquisition slip ring terminal 20 (B14) to initiate the challenge mode in the coder-control unit. Section S1C (B1) applies frame ground to the video decoder (A8) to condition this unit for mode 3.

(3) When IFF CHALLENGE MODE 2 switch-indicator A3 is illuminated green, mode 2 is selected. This mode is intended for detailed recognition of a particular aircraft and, therefore, permits interrogation and identification of any single aircraft in a group of aircraft. The IFF reply is received from only that aircraft which has its transponder conditioned to reply in this mode. The reply is displayed on the PPI's as two defined arcs. With switch-indicator A3 depressed, a frame ground (LOPAR IFF

challenge) is applied to acquisition slip ring terminal 20 (B14) to initiate the challenge mode in the coder-control unit.

(4) When any one of the three switch-indicators, A2, A3, or A4, is illuminated green the IFF equipment is conditioned to receive an emergency mode reply from a challenged target transponder.

h. The IFF control circuits mounted on the auxiliary fire control-indicator and both PPI's remotely control the IFF or SIF equipment. Remote control is possible only after certain switches in the IFF equipment are properly set. The IFF controls and related switches (TM 9-1430-253-12/2) for remote operation are given in (1) through (5) below.

(1) When a LOCAL-REMOTE switch (TM 11-1191) on the coder-control unit is set to REMOTE, all front panel operating controls of the coder-control unit are electrically transferred to the auxiliary fire control-indicator and both PPI's. In order to challenge by remote control, a CHALLENGE toggle switch on the coder-control unit must be set to OFF. The coder-control CHALLENGE switch, when set to ON, overrides the three IFF CHALLENGE MODE switch-indicators, A4 (A1), A3, and A2, on the two PPI's.

(2) Since the IFF equipment has self-contained power supplies, only primary ac power is supplied from the LOPAR system. The dc power is furnished by the IFF power supply when the IFF POWER switch (TM 11-1191) on the receiver-transmitter (A16) and a similar switch at the coder-control unit are set ON. These switches are normally left in the ON position so that the IFF equipment is automatically energized when the LOPAR system is energized.

(3) Alternate action CHOP ON—CHOP OFF switch-indicator A18 (C2) on the auxiliary fire control-indicator is used under adverse presentation display conditions to distinguish IFF video from acquisition video. When switch-indicator A18 is depressed illuminating CHOP ON indicator green, a frame ground is applied through the director station group (B5) to acquisition slip ring terminal 11 (B14) to energize a chop circuit relay in the coder-control unit. This chop circuit periodically interrupts a succession of pulse-pairs used to develop the transmitter challenge signals. Accordingly, the IFF reply signals are also interrupted. The end result of the displayed video is a clearly defined series of short dashes forming an arc slightly greater in range than the acquisition target video. When switch-indicator A18 is depressed illuminating CHOP OFF indicator amber, frame ground is removed and the chop circuit does not operate.

(4) Alternate action LONG GTC — SHORT GTC switch-indicator A17 (C1) on the auxiliary fire control-indicator is used to conform with the operating range of the LOPAR system. When switch-indicator A17 is depressed illuminating SHORT GTC indicator white, a frame ground is applied through acquisition slip ring terminal 13 (B14), to control a GTC relay located in the coder-control unit. Switch-indicator A17 is depressed illuminating LONG GTC indicator white when the video circuits (fig. 34, C31, TM 9-1430-254-20/6) are set for 250,000-yard displays. This setting will condition the receiver section of the receiver-transmitter (A16) to have a high gain for distant IFF video reception and to reduce the gain for relatively close IFF video reception in order to maintain a uniform intensity of IFF presentation. During SHORT GTC operation of switch-indicator A17, the gain of the receiver in the receiver-transmitter is reduced to a level required for short range signals and short range displays on the presentation system. The manual gain of the receiver is adjusted by IFF GAIN variable resistor R14A (C3). The brightness and definition of the IFF video symbols displayed by the presentation system is determined by the setting of IFF VIDEO variable resistor R69 (fig. 28, C46, TM 9-1430-254-20/6) on the video and mark mixer.

(5) The IFF POWER ON indicator A19 (C3) (illuminated green), provides an

indication that IFF power has been applied to the selected (HIPAR or LOPAR) system. When LOPAR is selected, IFF select relay K4 (D3) is deenergized. The ac power (LOPAR IFF power on) from the video decoder (A8) is applied through contacts 7 and 16 of deenergized K4 to a rectifier consisting of CR3, CR4, CR5, and CR6 (C3) in the auxiliary fire control-indicator. The dc voltage from the rectifier is applied to energize IFF power on relay K6, applying −28v LD through contacts 5 and 3 of K6 to illuminate green lamps DS1 and DS3 (C3). Selection of HIPAR will apply HIPAR select ground to energize K4 (D3). HIPAR IFF power is applied through contacts 8 and 16 of K4 to the rectifier consisting of CR3, CR4, CR5, and CR6. As long as ac power is received from either of the selected systems, indicator A19 is illuminated green. When the ac power is removed, indicator A19 is illuminated white.

125 (CMHA). Selective Identification Facility Equipment and Circuits

a. The selective identification facility (SIF) equipment is added to the identification friend or foe (IFF) equipment to form the SIF/IFF system (fig. 43). This system, in conjunction with the IFF remote control circuits, provides the IFF and SIF/IFF symbols used in the displays on the presentation system (fig. 1). The addition of the SIF equipment also provides greater flexibility in the interrogation of targets within range of the LOPAR system. The SIF equipment (fig. 43) consists of remote switching control C-1903/TPA-3, video decoder MX-1995/TPA-3, and associated controls and circuits.

b. The SIF/IFF control circuits include the controls and indicators which permit the SIF/IFF equipment to be remotely controlled from the PPI's and auxiliary fire control-indicator in the trailer mounted director station. For further information on the remote controls and indicators used with the SIF/IFF equipment (interrogator set AN/TPX-27), refer to TM 9-1430-253-12/2. Since the remote operation of SIF equipment and IFF equipment is similar, only pertinent controls and indicators of the SIF equipment are discussed in *c* through *e* below.

Note. The grid zone references shown in parentheses in *c* through *g* below refer to figure 36, TM 9-1430-254-20/6, unless otherwise indicated.

c. When a TEST-OPERATE switch (TM 11-5840-202-10) on the remote switching control (B8) is set to OPERATE, the video decoder (A8), remote switching control, and mode switch-indicators, IFF CHALLENGE MODE 1 A2 (A3), IFF CHALLENGE MODE 2 A3, IFF CHALLENGE MODE 3 A4, become electrically effective, thereby causing the SIF equipment (fig. 43) to become operative. This requires that three rotary coding switches on the remote switching control be set to the proper numerical code associated with the prevailing mode selected by mode switch-indicator A2, A3, or A4. This conditioning of SIF circuits insures that the IFF reply signals are decoded by the video decoder and IFF video is applied to the presentation system (fig. 1).

d. When the separately furnished SIF equipment for IFF decoder group AN/TPA-3 is not available, a temporary modification is required for the remote control of the IFF equipment. This modification connects input connector P204 (A8) to output connector P201 (B8) so that the video decoder is bypassed. Bypassing transfers the IFF video from the receiver-transmitter directly to the presentation system. In addition, it is necessary to add a temporary strap between terminals 126 (C5) and 156 (A9) in the director station group so that when ac power (LOPAR IFF power on) is applied, IFF power on relay K6 (C3) energizes, illuminating IFF POWER ON indicator lamps DS1 and DS3 (C3). For normal SIF/IFF operation, when the SIF equipment is provided, the two temporary connections must be removed.

e. The three mode switch-indicators, A2 (A3), A3, and A4, allow the operators to select one of three modes. Each mode has a different number of codes available and varies the flexibility of the SIF/IFF system (fig. 43). In all three modes, the transmitted interpulse spacing is identical to normal IFF operation. When a TEST-OPERATE switch (TM 11-5840-202-10) located on the remote switching control (B8) is set to OPERATE, the video decoder (A8) and mode switch-indicators A2 (A3), A3, and A4 become electrically effective.

With switch-indicator A2 depressed, IFF CHALLENGE MODE 1 is selected. This mode, in conjunction with the setting of one of three rotary switches (TM 11-5840-202-10) on the remote switching control, makes available 37 codes to the SIF/IFF system. With switch-indicator A3 depressed, mode 2 is selected. In this mode, the remote switching control (B8) makes available to the video decoder an additional 64 codes. With switch-indicator A4 depressed, mode 3 is selected and another 64 codes are added. Therefore, through the action of switch-indicators A2, A3, and A4 and the rotary switches (TM 11-5840-202-10) on the remote switching control, a total of 165 codes are provided in the SIF/IFF system. Emergency mode presentation, in conjunction with SIF/IFF operation, is identical to the emergency mode described in the normal IFF operation in paragraph 124*g*(4).

f. Either HIPAR or LOPAR IFF video is applied to the video decoder (A8). The type of video input is determined by which video is selected by contacts of IFF video select relay K2 (B9). This relay is controlled by VIDEO SELECTED — LOPAR READY switch-indicator A1 and VIDEO SELECTED — HIPAR READY switch-indicator A2 on the LOPAR control-indicator, and identical switch-indicators A3 and A2 on the HIPAR control-indicator (par. 13*b*). When relay K2 is energized, HIPAR IFF video is supplied to the video decoder. When LOPAR video is selected, relay K2 is deenergized and LOPAR IFF video is supplied to the video decoder.

g. Video decoder MX-1995/TPA-3 (A8) receives LOPAR IFF video (pulse train) from the output of the receiver section of the receiver-transmitter (A16). This LOPAR IFF video is amplified and applied to an internal delay line. The delay line transforms the time-sequential series of pulses into a time-coincident array. If the pulse spacing in the train is correct, the pulses will appear simultaneously at taps in the delay line. This array of pulses is applied through a bank of relays to a diode matrix, made up of two series of germanium diodes. The diode matrix, in conjunction with the relays, analyzes the pulse configuration to determine if the configuration corresponds to the code selection at the remote control box. If the code is satisfied, a positive voltage pulse is produced by the diode matrix. This pulse is clipped, amplified, and supplied at output connector J204 (A8) for use as LOPAR IFF video. If the code is not satisfied, this positive pulse either does not appear or is inhibited by a "killer" circuit so that there is little or no output from the video decoder.

APPENDIX (U)

REFERENCES (U)

1 (U). Publication Indexes

The following indexes should be consulted frequently for the latest changes or revisions of references given in this appendix and for new publications relating to materiel covered in this manual.

Index of Administrative Publications	DA Pam 310-1
Index of Blank Forms	DA Pam 310-2
Index of Tables of Organizations and Equipment, Tables of Organizations, Types of Tables of Distribution, and Tables of Allowances	DA Pam 310-7
Index of Technical Manuals, Technical Bulletins, Lubrication Orders, and Modification Work Orders	DA Pam 310-4
Index of Training Publications	DA Pam 310-3

2 (U). Forms and Records

The following forms and records pertain to this materiel:

Logistics (General): Malfunctions Involving Ammunition and Explosives	AR 700-1300-8
Recommended Changes to DA Technical Manuals, Parts List, or Supply Manual 7, 8, or 9	DA Form 2028
The Army Equipment Record System and Procedures	TM 38-750

3 (U). Supply Manuals

The following supply manuals of the Department of the Army Supply manuals pertain to this materiel:

a General.

Introduction	ORD 1

b. Repair and Rebuild.

Operator and Organizational Maintenance Manual: Radar Course Directing Central: Repair Parts and Special Tools Lists for Antenna-Receiver-Transmitter Group, Acquisition OA-1601/T, OA-1596/T and A Frame, Vehicle Mounting (NIKE-HERCULES/Improved NIKE-HERCULES Air Defense Guided Missile Systems)	TM 9-1430-250-12P/2/2
Organizational Maintenance: Radar Course Directing Central: Repair Parts and Special Tools List for Director Computer Group, Guided Missile (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1430-250-12P/9/2
Operator and Organizational Maintenance Manual: Radar Course Directing Central: Repair Parts and Special Tools Lists for Antenna-Receiver-Transmitter Group, Acquisition (EFS) and (EFS/ATBM) (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1430-253-12P/1/2

4 (U). Other Publications

The following explanatory publications contain information pertinent to this materiel and associated equipment.

a. General.

Accident Reporting and Records	AR 385-40
Air Defense Artillery Missile Battalion, NIKE-HERCULES	FM 44-95
Army Safety Policy	AR 385-10
Authorized Abbreviations and Brevity Codes	AR 320-50
Dictionary of United States Army Terms	AR 320-5

Disposal of Radioactive Materials	AR 755-380
First Aid for Soldiers	FM 21-11
Hazards to Health from Microwave Energy	AR 40-583
Military Symbols	FM 21-30
Military Training	FM 21-5
Ordnance Major Item and Major Combination and Pertinent Publications	SB 9-1
Organizational Policy and Responsibilities for Maintenance Operation	AR 750-5
Technique of Military Instruction	FM 21-6

b. Technical Bulletins.

Electrical Tests and Minor Maintenance of Alternating Current and Universal Motors	TB ORD 669
Guided Missiles: Ordnance Spot Check and Command Maintenance Inspection	TB 9-212/1
Interrogator Set AN/TPX-27 and IFF Mark X (SIF) System	TB 11-1191-1

c. Technical Manuals.

Ordnance Maintenance: Materials used for Cleaning, Preserving, Abrading, and Cementing Ordnance Materiel and Related Materials Including Chemicals, Lubricants, Indicators, and Hydraulic Fluids	TM 9-247
Interrogator Set AN/TPX-20	TM 11-1191
Operator's Manual: Decoder Group AN/TPA-3	TM 11-5840-202-10
Recognition Signal Simulator SM-140/TPX; Operators Manual	TM 11-5840-204-10
Decoder Group AN/TPA-3; Organizational Maintenance; Second Echelon	TM 11-5840-202-20
Operators Manual: Overall System Description (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1400-250-10/2
Operators and Organizational Maintenance Manual: Voice Communication Systems (NIKE-HERCULES and Improved NIKE-HERCULES Air Defense Guided Missile Systems)	TM 9-1400-251-12
Operator and Organizational Maintenance Manual: Check Procedures: Electronic Frequency Selection/Anti-Tactical Ballistic Missile High Power Acquisition Radar (NIKE-HERCULES Anti-Tactical Ballistic Missile System)	TM 9-1430-250-12/5
Organizational Maintenance: Theory: Radar Course Directing Central: Computer System and Recording Devices (NIKE-HERCULES Antiaircraft Guided Missile System)	TM 9-1430-250-20/3
Organizational Maintenance Manual: Theory: Target Tracking, Target Ranging, and Missile Tracking Radar Systems and Radar Test Set Group (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1430-250-20/6
Organizational Maintenance Manual: Theory: Electronic Frequency Selection/Anti-Tactical Ballistic Missile High Power Acquisition Radar (NIKE-HERCULES Anti-Tactical Ballistic Missile System)	TM 9-1430-250-20/10
Organizational Maintenance Manual: Theory: Radar Course Directing Central: Tactical Control and Power Distribution (ATBM): (NIKE-HERCULES Anti-Tactical Ballistic Missile System)	TM 9-1430-250-20/12
Assembly and Emplacement: Radar Course Directing Central (NIKE-HERCULES and Improved NIKE-HERCULES Air Defense Guided Missile Systems)	TM 9-1430-251-10
Operators Manual: Siting Requirements for Radar Course Directing Central (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1430-251-10/2
Operator and Organizational Maintenance Manual: Check Procedures: Low Power Acquisition Radar and Computer (ATBM) (NIKE-HERCULES Anti-Tactical Ballistic Missile System)	TM 9-1430-251-12/2
Organizational Maintenance Manual: Checks and Adjustments: Radar Course Directing Central (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1430-251-20/2
Operators and Organizational Maintenance Manual: Check Procedures: Target Tracking, Target Ranging, and Missile Tracking Radar Systems and Radar Test Set Group (Improved NIKE-HERCULES Air Defense Guided Missile System)	TM 9-1430-252-12/3

214-752 O - 66 - 18

(U) INDEX

CONFIDENTIAL Modified Handling Authorized

CONFIDENTIAL

By Order of the Secretary of the Army:

EARLE G. WHEELER,
General, United States Army,
Chief of Staff.

Official:
J. C. LAMBERT,
Major General, United States Army,
The Adjutant General.

Distribution:

To be distributed in accordance with DA Form 12-32, Section II (Clas) requirements for Improved Nike-Hercules—TM—Ground Control Equipment.

U. S. GOVERNMENT PRINTING OFFICE: 1966 O - 214-752

CONFIDENTIAL - Modified Handling Authorized

CONFIDENTIAL