TM 11-5840-208-30

TECHNICAL MANUAL

DIRECT SUPPORT MAINTENANCE MANUAL

RADAR SET
AN/MPQ-4A
(NSN 5840-00-543-0759)

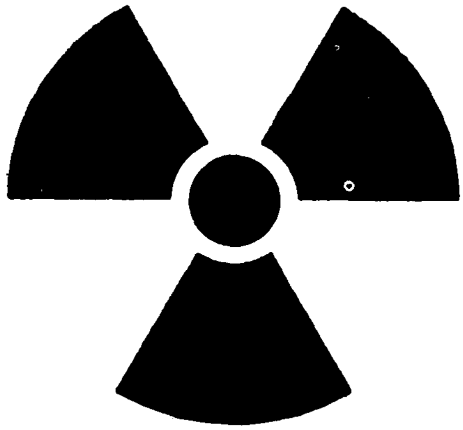
This copy is a reprint which includes current pages from Change 1.

HEADQUARTERS, DEPARTMENT OF THE ARMY

FEBRUARY 1977

WARNING

RADIATION HAZARD



STD-RW-2

Co. 60
Ni 63

Tube types OB2WA and 6560/BL-35 (TR tube) used in this equipment contain radioactive material. These tubes are potentially hazardous when broken; see qualified medical personnel and the Safety Director if you are exposed to or cut by broken tubes, Be extremely careful when replacing these tubes and follow safe procedures in their handling, storage, and disposal.

Do not place radioactive tubes in your pocket.

Be extremely careful not to break radioactive tubes while handling them.

Do not remove radioactive tubes from carton until ready to use them.

WARNING

When overheated, selenium rectifiers give off poisonous fumes (smell like garlic or rotten eggs) that are harmful to the human body'. When this odor is first noticed shutoff the equipment and evacuate the area. DO NOT reenter the area until it has been well ventilated. DO NOT handle selenium rectifiers that have been overheated (even after cooling) with the bare hands.

MICROWAVE RADIATION HAZARD

Potentially hazardous levels of microwave radiation exist immediately in front of Reflector, Antenna AT-634/MPQ-4A. Turn off the transmitter before standing on the radar trailer in front of the reflector. When it is absolutely necessary to use the telescope while the transmitter is turned on, remain in a crouched position while making observations through the telescope, and use maximum antenna angles whenever possible.

IONIZING RADIATION HAZARD

Potentially hazardous ionizing radiation may exist within the transmitter compartment. If the radar set is on and radiating with the door to the transmitter compartment open, keep 3 feet away from the type 5949A thyratron tube. If it is necessary to work within 3 feet of this tube while the radar set is operating with the transmitter compartment door open, keep exposure to a minimum. Limit the time of exposure to not more than 1 hour per week.

EXTREMELY DANGEROUS VOLTAGES EXIST IN THE FOLLOWING UNITS:

Duplexer TR tube assembly	700 volts
Power Supply PP-1588/MPQ-4A	700 volts
Azimuth and Range Indicator IP-375/MPQ-4A	14,000 volts
Modulator-transmitter	26,000 volts

CHANGE No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *15 December 1980*

Direct Support Maintenance Manual
RADAR SET AN/MPQ-4A
(NSN 5840-00-543-0759)

TM 11-5840-208-30, 28 February 1977, is changed as follows:

1. New or changed material is indicated by a vertical bar in the margin of the page.
2. Remove old pages and insert new pages as indicated below.

Remove	*Insert*
i and ii	i and ii
1-1/(l-2 blank)	1-1/(1-2 blank)
2-1 and 2-2	2-1 and 2-2
2-11 and 2-12	2 -11 and 2-l2
2-45 through 2-48	2-45 through 2-48
2-57 and 2-58	2-57 and 2-58
2-69 and 2-70	2-69 and 2-70
2-129 and 2-130	2-129 and 2-130
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3-221and 3-222	3-221 and 3-222
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3-239 and 3-240	3-239 and 3-240
3-249 through 3-252	3-249 through 3-252
3-261 and 3-262	3-261 and 3-262
3-279 and 3-280	3-279 and 3-280
A-1 and A-2	A-1 and A-2
Index 1 through Index 27	Index 1 through 26

3. File this change sheet in front of the manual for reference purposes.

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Ft Gordon (10)
Ft Carson (5)
Ft Gillem (10)
Ft Richardson (CERCOM Ofc) (2)
Army Dep (1) except
SAAD (30)
TOAD (14)
SHAD (2)
USA Dep (1)
Sig Sec USA Dep (1)
Units org under fol TOE:
29-207 (2)
29-610 (2)
6-100 (1)
6-115 (1)
6-155 (1)
6-156 (1)
6-186 (1)
6-200 (1)
6-300 (1)
6-365 (1)
6-366 (1)
7 (1)
7-100 (1)
11-97 (1)
11-98 (1)
11-117 (1)
11-127 (1)
11-500 (AA-AC) (1)
17 (1)
17-100 (1)
29-56 (1)
29-134 (1)
29-136 (1)
29-307 (1)
37 (1)
37-100 (1)
57 (1)
77-100 (1)

NG: None
USAR: None
For explanation of abbreviations used, see AR 310-50

TECHNICAL MANUAL No. 11-5840-208-30

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *28 February 1977*

DIRECT SUPPORT MAINTENANCE MANUAL RADAR SET AN/MPQ-4A (NSN 5840-00-543-0759)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You cut help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (RecommendedChanges to Publications and Blank Forms), or DA Form 2028-2 located in back of this manual direct to: Commander, US Army Communications and Electronics Materiel Readiness Command, ATTN: DRSEL-ME-MQ, Fort Monmouth, NJ 07703.

In either case, a reply will be furnished direct to you.

* This manual supersedes TM 11-5840-208-30, 2 October 1959, including all changes.

LIST OF ILLUSTRATIONS

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LIST OF TABLES

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. Scope

a. This manual contains direct support maintenance instructions for Radar Set AN/MPQ-4A. Included are general and detail analysis of the equipment, and inetmctions appropriate to direct support maintenance for troubleshooting, removing and replacing parts, and aligning and testing procedures. In addition, a list of abbreviations and definitions is contained in a glossary.

b. An asterisk in parentheses (*) is used to indicate models of an item of equipment that are sufficiently alike to be treated as a single model throughout the manual, thus: Dehydrator, Desiccant, Electric HD-264(*)/MPQ-4A represents the HD-264/MPQ-4A and the HD264A/MPQ-4A. When portions of these like models differ enough to require separate treatment, the applicable portions are identified throughout the manual.

c. Installation, operation, and operator's maintenance are covered in TM 11-5840-208-10. organizational maintenance is covered in TM 11-5840-208-20. Additional coverage on equipment differences is provided in applicable portions of the manual.

1-2. Indexes of Publications

DA Pam 310-4. Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

NOTE

For additional forms and records, refer to TM 11-5840-208-10.

1-3. Administrative Storage

Administrative storage of equipment issued to and used by Army activities shall be in accordance with TM 740-90-1.

1-4. Destruction of Army Electronics Materiel

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

Section II. DESCRIPTION AND DATA

1-5. Purpose and Use

a. Radar Set AN/MPQ-4A is a mobile, intercept-type (contracting) set designed primarily to locate hostile mortars and secondarily to adjust low-velocity artillery fire. Provision is made for local or remote operation of the radar set. The radar set operates in the 16,000 megaHertz frequency (K) band. Power is furnished by a trailer-mounted, gasoline engine generator set. Refer to TM 11-5840-208-10 for the complete listing of the operating components of the radar set.

b. A highly directional radio frequency beam is radiated and electro-mechanically traversed through two 445-mil horizontal arcs. One arc is displaced approximately 35 roils above the other. In the upper arc, the beam is known as the upper beam; in the lower arc, it is called the lower beam. A projectile passing through the beams causes signals (one from the lower beam and one from the upper beam) to appear on a cathode-ray indicator. The polar coordinates of the two points on the trajectory are established by the opertor and are introduced into an electromechanical computer which, by extrapolation and conversion, computes the grid reference of the weapon or point of burst.

1-6. Description

For a general description of the AN/MPQ-4A, refer to TM 11-5840-208-10.

1-7. Differences in Equipment

a. In several major components of Radar Set AN/MPQ-4A procured under contract number DAAB-05-67-C-2341, certain direct support maintenance repair parts having wide tolerance applications have been changed to conform to standard values. Although these parts differ from those in Radar Set AN/MPQ-4A procured under contract number DA-36-039-SC66333, both are interchangeable and will provide acceptable results.

b. For complete listing of differences in repair parts, refer to TM 11-5840-208-35P. The differences in models applicable to operation of the radar set are in TM 11-5840-208-10.

1-8. Tabulated Data.

For performance characteristics of the AN/MPQ-4A, refer to tabulated data in TM 11-5840-208-10.

CHAPTER 2

FUNCTIONING OF EQUIPMENT

Section I. OPERATION OF RADAR SET

2-1. Introduction to Complete Block Diagram

a. General. A complete block diagram of the radar set is used to show the interaction and interconnection of systems in the complete set. A thorough study of the block diagrams should be made before trying to understand individual systems in the set.

b. Purpose. The complete block diagram for the radar set presents the various systems of the radar set in one diagram. The block diagram shows how the systems are interconnected and how the operation of one system affects the operation of the other systems (fig. FO-1).

c. Layout. The radar set block diagram is laid out by systems. Individual assemblies or chassis are not shown on the block diagram. The parts of the synchronizing system that are contained within the antenna are shown near the antenna to facilitate discussion. Because of ita complexity, the computing system is shown as a single block. A complete block diagram of the computing system is found on FO-7 and a complete discussion is given in section VII.

2-2. Systems in Complete Block Diagram

a. Transmitting System. The transmitting system forms a pulse of radiofrequency (rf) energy and applies the pulse to the rf system for transmission into space. The frequency of the transmitted pulse must be correct, the amplitude must be high enough so that the target returns will be strong enough to be detected, the width must be accurate, and the time between pulses must be exact.

b. Rf System. The rf system primarily transmits rf energy from the transmitter to the antenna and from the antenna to the receiver. It also protects the receiving system during transmit time and protects the magnetron from any reflected energy.

c. Receiving System. The receiving system amplifies and detects the weak echo signals, forms them into video pulses, and then applies the video pulses to the indicating system.

d. Synchronizing System. The synchronizing system generates, shapes, and supplies trigger pulses to the transmitting, receiving, and indicating systems.

e. Indicating System. The indicating system visually presents the return echoes on the indicator screen.

f. Computing System. The computing system computes weapon location from azimuth, range, and elevation data and presents the weapon location in terms of rectangular coordinates.

g. Antenna Positioning System. The antenna positioning system accurately positions the antenna in azimuth and elevation and applies electrical data regarding antenna, azimuth, and elevation to the computing and indicating systems and to Simulator, Radar Target Signal AN/TPA-7 (TM 11-5840-287-35), when the AN/TPA-7 is used with Radar Set AN/MPQ-4A.

h. Dc Power Supplies System. The direct current (dc) power supplies furnish dc operating voltages to the receiving, transmitting, synchronizing, indicating, and computing systems.

i. Power Distribution and Control System. The power distribution and control system distributes and controls the application of primary alternating current (at) power required by the various components of the radar set. This system is not shown in the block diagram of the radar set.

j. Dehydrating system. The dehydrating system maintains the waveguides at a safe, dry, air pressure over a wide variety of climatic conditions. This system is not shown in the block diagram as an individual system, but is included as a block in the rf system.

2-3. Transmitting System
(fig. FO-1)

a. Trigger Pulse Amplifier.

(1) *Charging of pulse-forming network. Z1151.* Pulse-forming network *Z1151* charges because of the current flow through charging diode V1154A, charging reactor L1151, and 1-kilovolt (kv) power supply V1155. Charging reactor L1151 limits the current drawn when the pulse-forming network begins to charge. If too much current is drawn while charging 21151, relay K1105 energizes and removes sc power from the trigger amplifier.

(2) *Discharging of pulse-forming network* Z1151. Trigger pulses from the synchronizing system (para 2-6) are applied to cathode follower V1151A. The cathode follower acts as a buffer and

impedance matching device between the trigger voltage amplifier and the synchronizing system. The output of the cathode follower is applied to voltage amplifier V1151B which triggers blocking oscillator V1152A. The output of the blocking oscillator is a positive-going pulse which is applied to cathode follower V1152B. The output of cathode follower V1152B is applied to the grid of the thyratron V1153. The thyratron fires and acts as a switch in the pulse circuit. Pulse network Z1151 discharges rapidly through the thyratron and the primary of pulse transformer T1153. The pulse transformer inverts the negative-going pulse at the primary of the transformer and applies the positive-going ouptut pulse to the modulator. Pulse network Z1151 determines the width of the pulse. When Z1151 tries to charge in the opposite direction, reverse current diode V1154B conducts and passes the negative-going voltage to ground.

b. Modulator.

(1) *Charging of pulse-forming network Z1101.* Pulse-forming network Z1101 charges to approximately 4.5 kv through charging diode V1106, charging choke L_c(part of T1101), and high voltage rectifiers V1101 and V1102. Charging choke L_c limits the current drawn when Z1101 begins to charge. High voltage for V1101 and V 1102 is furnished by high voltage transformer T1101. The high voltage power supply is protected by overload relay K1101. Primary voltage for T1101 is furnished through voltage adjusting transformer T1102, variac T651, and power contactor K1104.

(2) *Discharging of pulse-forming network Z1101.* Pulses from the trigger amplifier are applied to the grid of thyratron V1104. The thyratron fires and pulse-forming network Z1101 discharges through V1104, saturable reactor L1101 and the primary of pulse transformer T1106. The charging choke L_c raises the 4.5-kv pulse to approximately 9 kv. When Z1101 tries to charge in a reverse direction, reverse current diode V1103 conducts and the negative-going current is passed to ground. Current diode V1103 is protected from overloads by reverse current overload relay K1102.

c. Transmitter. The pulse from pulse-forming network Z1101 is applied to pulse transformer T1106 which inverts and steps up the pulse to approximately 26 kv which is applied to magnetron V1105. The magnetron produces a high power pulse of rf energy which is applied to the rf system. The magnetron filament voltage is removed by filament cutout relay K1103 during normal operation. Magnetron current is indicated by magnetron current meters M1401 and M651. The time that the magnetron has operated is indicated by elapsed time meter M1403.

2-4. Rf System (fig. FO-1)

a. Operation of Rf System During Transmission of Rf Energy. The highpowered pulse of rf energy from the magnetron is transmitted by waveguide to the ferrite isolator.

(1) *Ferrite isolator.* The ferrite isolator allows energy from the magnetron to pass with negligible attenuation. Any energy traveling toward the magnetron is absorbed by the ferrite isolator which eliminates magnetron pulling due to reflected energy. The ferrite isolator couples the rf pulse to the duplexer.

(2) *Transmit portion of duplexer.* The duplexer performs three functions: It couples the pulse of rf energy from the magnetron to the waveguide sections leading to the scanner; it disconnects the receiving section while the magnetron is operating; it couples a portion of the transmitted pulse to the AFC crystal.

(3) *Bidirectional coupler.* Normally, the bidirectional coupler acts as a section of waveguide and the rf pulse is coupled to the scanner. For test purposes, the bidirectional coupler couples a portion of the transmitted pulse to the echo box.

(4) *Echo box.* The echo box is a tunable resonant cavity which is used to make measurements of the operating characteristics of the magnetron.

(5) *Dehydrator.* The dehydrator fills the waveguide with clean, dry air at a given pressure.

(6) *Scanner.* The scanner, or antenna, forms the RF energy into two beams which are separated by approximately 35 mile in elevation. The two beams of energy are swept or scanned through an azimuth of 445 roils (250,. The two beams of energy are directed toward the reflector.

(7) *Reflector.* The reflector directs the energy from the scanner into space.

b. Operation of Rf System During Reception of Rf Energy. Weak signals of rf energy from the target are directed into the seamer by the reflector. The scanner couples the received energy into the waveguide where it is coupled to the duplexer. The duplexer decouples the transmitter and couples the received energy to the receiving system.

2-5. Receiving System (fig. FO-1)

a. Mixer Oscillator Circuit. The received echo signals are coupled into the mixer arm of the duplexer. The received signale are beat with the output of klystron local oscillator V1501 to produce an intermediate frequency (if.). Three crystal diodes are used to perform the mixing function. Two crystal diodes CR1501 and CR1502, form a balanced if. mixer. Crystal diode CR1503 is an automatic frequency control (aft) mixer. The frequency of the klystron local oscillator is controlled by klystron drive assembly B1501 and the repeiier adjustment circuits.

b. Automatic Frequency Control Circuit. The 30-megaHertz if. output from afc crystal CR1503 is applied to if. amplifier V1301. The amplified output of V1301 is applied to if. amplifier V1303 and range calibrate output V1302. The output of range calibrate output V1302 is applied to range calibrate delay cell DL1301. Range calibrate delay cell DL1301 produces accurately spaced range markers which are applied to if. amplifier V1203. The output of if. amplifier V1303 is applied to the discriminator. If the frequency of the voltage appiied to discriminator V1304 is exactly 30 megaHertz, no output voltage will be produced. If the frequency of the applied voltage is above or below 30 megaHertz, the discriminator wiii produce an output voltage which is appiied to pulse amplifier V1305. The amplified output of V1305 is applied to pulse stretcher V1308. Pulse stretcher V1308 operates in such a manner that the output pulse is a varying dc voltage which is applied to the grid of afc output V1306. A sine wave voltage from phase-shift oscillator V1307 is applied to the grid of V1306 and causes the klystron to sweep a band of frequency untii the transmitter fires and the afc can lock onto the transmitter frequency. The output of V1306 is a direct current which adjusts the voltage to the repeller adjustment circuits of the klystron. The afc voltage raises or lowers the output frequency of the klystron so that the if. is always 30 megaHertz.

c. Intermediate Frequency Amplifier Circuit.

(1) *Low-noise amplifier.* The first two stages of the if. amplifier assembly, V1201 and V1202, form a caecode amplifier circuit. Cascode amplifiers have low-noise and high gain characteristics. Low noise is important in a receiver because it is amplified with, and sometimes maeks, weak echo signals. If the noise is eliminated, then weak target echoes may be seen and the ability of the radar set to detect targets is improved. The output of the low-noise amplifier is coupled to if. amplifier stages V1303, V1204, and V1205.

(2) *If. amplifier stages.* If. amplifier stages V1203, V1204, and V1205 act as normal tuned if. amplifier etagee. The input from the low-noise amplifier and the range marker input from the afc assembly (b above) is amplified by the if. amplifiers. An input from the sensitivity time control (stc) assembly is applied to V1204 and V1205.

(3) *Linear-logarithmic if. amplifier stages.* A linear-logarithmic (lin-log) if, amplifier circuit is composed of stages V1206 through V1209. When a normal strength signal is received, the tubes operate on the linear portion of the plate current characteristic curve. When a strong signal is received, the plate current of V1209 rises logarithmically until the tube reaches saturation. When V1209 reaches saturation, grid current flows and gird detection takes place. The video signal detected at the grid of V1209 is applied to the output stage through the delay network. The amount of delay through the network is equal to the transit time of the signal through the tube. Since the delay through the delay network is equal to the transit time through the tube, any portion of the signal which travels through the tube and is detected by CR1201 arrives at the grid of V1210 at the same time as the grid detected signal. As the received signal becomes stronger, lin-log amplifier stages V1208, V1207, and V1206 will saturate in turn and grid detection will take place in each.

(4) *Second detector.* The second detector, CR1201, is a crystal diode. When a normal signal is received, all video detection is performed by CR1201. When a strong signal is received, part of the video is detected by CR1201 and part by the lin-log amplifier.

(5) *Output.* Video amplifier V1210 and cathode follower V1211 form the output circuit for the if. amplifier assembly. The video output is applied to the indicating system.

d. Sensitivity Time Control Assembly. Pulses from the synchronizing system are applied to first pulse amplifier V4701A where they are amplified and applied to second pulse amplifier V4701B which amplifies the pulses and applies them to charging amplifier V4702A. The charging amplifier produces an exponential voltage which is amplified, inverted, and applied to the if. amplifier by stc cathode follower V4702B. The output of V4702B is a negative-going sawtooth wave which reduces the sensitivity of the if, ampiifier at short range so that close-in targets will not block the receiver. Manual if. gain is accomplished by the if. gain control which is applied to the if. amplifier through dc restorer CR4703. (The manual if. gain control voltage is also supplied to Simulator, Radar Target Signal AN/TPA-7, when the AN/TPA-7 is used with Radar Set AN/MPQ-4A).

2-6. Synchronizing System (fig. FO-1)

The subassembly identification (Z numbers) are used for easy cross reference between the subassemblies.

a. Long Gate Generator Z101. Oscillator V201A produces a sine wave output at a frequency of

7,000 Hertz per second. Regenerative amplifiers V201B and V202A produce positive-going square pulses at 7,000 pulses per second which are applied to trigger coupling V203A through trigger selector switch S109. The output of trigger coupling V203A triggers gate generator V204B. Gate generator V204E produces a square wave voltage which is applied to cathode follower V202B. Gate generator V204B produces a pulse until cut off by gate shutoff V204A which is triggered by a pulse from the timing sweep generator (b below). The grid of the cathode follower is clamped by diode clamp V203B and the output is applied to gated Miller sweep V231 and RANGE SELECTOR switch S101.

b. Timing Sweep Generator Z102. The gate voltage from gate cathode follower V202B (long gate generator Z101) triggers gated Miller sweep V231 causing it to conduct and produce a sawtooth output. The slope of the output sawtooth voltage is controlled by the RANGE SLOPE control. The output of V231 is applied to linear amplifier V232, amplified, and coupled to cathode follower V233, Cathode follower V233 couples the sawtooth voltage to cathode follower V235. The grid of V235 is clamped to a reference level by dc restorer V234A. Three outputs are taken from cathode follower V235. One output is fed back to V231 to improve the linearity of the sweep voltage. One output is applied to gate shutoff V234B which applies a pulse to gate shutoff V204A (Z101). One output is applied to the three pickoff amplifiers, Z107, Z108, and Z109.

c. Range Marker Trigger Pickoff Amplifier Z109. An input from cathode follower V235 (timing sweep generator Z102) is applied to comparator tube V401. Voltage from the range potentiometer (para 2-28b(5)) in the computer controls the time at which V401 will conduct. The output of V402 is applied to regenerative amplifier V403. The output of V403 triggers blocking oscillator V404 which produces range strobe pulses. The pulses from V404, are applied to the range strobe sharpener, V4604, in the indicating system.

d. Delay Trigger Pickoff Amplifier Z108. The operation of delay trigger pickoff amplifier Z108 is the same as range marker trigger pickoff Z109, The amplitude of the voltage output of V401 is controlled by EXPANDED SWEEP DELAY AT101. The output is applied to delay trigger amplifier V4651B in the indicating system (para 2-7).

e. Range Zero *Trigger Pickoff Amplifier Z107.* The operation of 2107 is the same as Z109. Amplitude of the output voltage of V401 is controlled by RANGE ZERO control R116 in the control system. The output is applied to gated trigger amplifier V457 1 (modulator trigger generator Z147.

f. Azimuth Marker Coils. Two dead time coils, L3201, and L3202, and a movable azimuth marker coil, L3203, are located on the stationary portion of the seamer. Synchronizing pulses are produced when three permanent magnets, E3201, E3202, and E3203 mounted on the rotating portion of the scanner, are moved past the coils. The pulses produced by L3201 and L3202 represent the end of one scan and the start of another scan. The pulse produced by marker coil L3203 is used to form the azimuth strobe which is displayed on the indicator. Azimuth marker coil L3203 is moved when the azimuth handwheels in the computer are rotated. Synchro data from the computer (para 2-8) is applied to servo motor B3202 which positions marker coil L3203 and synchro transmitter B3203. Synchro transmitter B3203 furnishes azimuth marker data to the computer. The dead time start, stop, and azimuth marker pulses are applied to the pulse shaper.

g. Pulse Shaper. Four dead time pulses and one marker pulse from the scanner are differentiated by the differentiating networks and clipped by clippers CR4701 and CR4702 and applied to marker amplifier V506B (azimuth synchronizer Z150).

h. Azimuth Synchronizer Z150. The pulses from the scanner are amplified and inverted by synchronizer marker amplifier V506B and applied to cathode follower V507A and blanking trigger amplifier V506A. The scanner pulses are applied to clipper V507B by V507A. Cathode follower V507A passes only the negative azimuth strobe pulse. The output of clipper V507B triggers azimuth strobe multivibrator V508. One output of V508 is applied to cathode follower V4652B (short gate and intensifier Z149). The other output is applied to reference cathode follower V505. The start and stop pulses from V506B are applied to blanking trigger amplifier V506A where they are amplified, inverted, and used to trigger blanking multivibrator V502. Blanking multivibrator V502 produces a negative-going square wave which is applied to azimuth gate amplifier V503A. One output from V503A applies an azimuth gate to clamp tube V4501B (azimuth sweep generator and driver Z145) and to the intensity mixer V4654 (short gate generator Z149). Another output is applied to trigger blanking amplifier V501A and to phase inverter V501B. The output of V501A is fed to gated trigger amplifier V4571 (modulator trigger generator Z147) and the output of V501B triggers range shift multivibrator V504. Range shift multivibrator V504 develops a square wave voltage which is amplified, inverted, and coupled to beam blanking amplifier V4551 (video blanking Z146) by range shift amplifier V503B. The outputs of reference cathode follower V505 are fed to blanking multivibrator V502 and range shift multivibrator V504 as a reference to reset V502 and V504 if they are operating incorrectly.

i. Modulator Trigger Generator Z147. Two simultaneous positive pulses are required to trigger gated trigger amplifier V4571. One positive pulse is obtained from blocking oscillator V404 (range zero trigger pickoff Z107, *e* above) and the other is obtained from trigger blanking amplifier V501A (azimuth synchronizer 2150, *h* above). The output of V4571 is coupled to modulator trigger gate generator V4572. The output of V4572 is a positive pulse which triggers the stc assembly in the receiving system and the transmitter.

j. Video Blanking Z146. A positive pulse form range shift amplifier V503B (azimuth synchronizer Z150) is applied to beam blanking amplifier V4551. A positive-going pulse and a negative-going pulse are applied to the first video amplifier V4601 in the indicating system through BEAM VIDEO switch S110. Grid clamp CR4551 clamps the grid voltage of voltage setting triode V4401A in the indicating system to definite levels determined by the RANGE SELECTOR switch S101 and RANGE SHIFT switch S103.

2-7. Indicating System (fig. FO-1)

a. Video Amplifier Z148. Video signals from the receiving system (para 2-5) and blanking signals from BEAM VIDEO switch S110 (para 2-6j) are applied to first video amplifier V4601. The output from V4601 is applied to second video amplifier V4802. Range strobe pulses from range trigger pickoff Z109 (pare 2-6c) are applied to range strobe sharpener V4604 where the range strobe pulses are sharpened and applied to V4802, Video signals from B4601 and range strobe pulses from V4604 are combined in V4602 and applied to third video amplifier V4603. The output of V4603 is applied to the cathode of the cathode-ray tube V101.

b. Azimuth Sweep Generator and Driver Z145. Positive gate pulses from azimuth gate amplifier V503A (azimuth synchronizer 2150, para *2-6h) are* applied to diode clamp V4501B. The action of the clamp starts operation of sweep generator V4502. Sweep generator V4502 produces a negative-going trapezoidal voltage which is applied to azimuth drivers V4503 and V4504. A positive-going linear sawtooth voltage from the plates of V4503 and V4504 is applied to one end of deflection coil L102. A negative-going sawtooth voltage taken from the cathodes of V4503 and V4504 is applied to automatic size control V4508B, to phase inverter V4505, clamp tube V4501A, and to sweep generator V4502. The negative-going sawtooth applied to the sweep generator increases, the linearity of the sweep. The output of V4508B is applied to automatic size control V4508A. Automatic size control tubes V4508B and V4508A sample the output of the azimuth drivers. If the speed of the scanner varies, the automatic size control tubes will adjust the length of the azimuth sweep. The output of phase inverter V4505 is applied to azimuth drivers V4506 and V4507. The negative-going trapezoidal voltage from V4506 and V4507 is applied to the opposite end of deflection coil L102.

c. Intensifier and Short Gate Generator Z149. A pulse from delay trigger pickouff amplifier Z108 (para. *2-6d)* is applied to delay trigger amplifier V4651B where is is amplified, inverted, and applied to short gate multivibrator V4653. A positive-going square pulse is applied to cathode follower V4651A and short gate inverter amplifier V4652A. The positive-going short gate output from cathode follower V4651A is applied to RANGE SELECTOR switch S101. The output of short gate inverter amplifier V4652A is direct coupled to intensifier amplifier V4655. The azimuth gate from azimuth gate amplifier V503A (azimuth synchronizer 2150, para *2-6h)* is applied to the grid of intensity mixer V4654. A long gate from gate cathode follower (long gate generator Z101, para 2-*6a)* or a short gate from V4651A is applied through RANGE SELECTOR switch S101 to the suppressor grid of V4654. When the two input pulses to V4654 occur simultaneously, a negative-going output pulse is developed and applied to intensifer amplifier V4655. An azimuth strobe from azimuth strobe multivibrator (Azimuth synchronizer Z150, para *2-6h)* is applied to cathode follower V4652B. The output from V4652B is applied to intensity amplifier V4655. A positive-going square wave voltage from V4655 is applied to the grid of the crt.

d. Range Sweep Generator and Driver Z144. A long gate or a short gate pulse (depending on the position of RANGE SELECTOR switch S101) is applied to clamp V4402B. Sweep generator V4401B produces a negative-going sawtooth voltage which is applied to range sweep driver V4404. When RANGE SHIFT switch S103 is on, a positive-going pulse is applied through grid clamp CR4551, voltage setting triode V4401A, and clamp V4402A to the grid of sweep generator V4401B, The range shift pulses move the position of the upper beam so target returns from the upper and lower beams wiil be separated by approximately 750 meters on the screen of the crt. The output of the range sweep drive is a positive-going sweep voltage which is applied to the range portion of deflection coil

L102. A negative-going sweep voltage from the cathode of V4404 is fed to V4401B to improve the linearity of the sweep. A negative-going sweep voltage is also applied to phase inverter V4403. The output from V4403 ia applied to azimuth sweep driver V4405 which applied a negative-going sweep voltage to the opposite end of deflection coil L102.

e. Focus Coil L103. Current for focus coil L103 is controlled by focus current control V4573.

f. High-Voltage. High voltage for the indicator tube V101 is furnished by high voltage oscillator V161 and high voltage rectifier Z161.

2-8. Computing System (fig. FO-1)

The block diagram analysis of the computing system is contained in paragraph 2-28 which presents the weapon location problem to be solved by the computer. Only after the problem is understood and basic computer systems and components have been identified as to purpose and function should the block diagram analysis of the computer be read. The computer has three inputs from the radar set. The antenna positioning system supplies the computer with azimuth and elevation synchro data. The synchronizing system supplies azimuth marker information in the form of synchro voltages. Two outputs from the computer are fed to the synchronizing system where they are converted and appear on the indicator as the range and azimuth strobes. All other inputs to the computer are operator inserted via handwheels and controls which are part of the computer. All outputs from the computer, except the two mentioned above, are read directly from computer indicators by the operator.

2-9. Antenna Positioning System (fig. FO-1)

a. Azimuth Drive and Data Synchros. The antenna may be rotated clockwise or counterclockwise by the azimuth drive motor. When the azimuth switch is actuated, power is applied to azimuth drive motor B3003 which rotates the antenna. Azimuth position synchro transmitters B3001 and B3002 transmit antenna azimuth position data to the computing system (para 2-8) and to Simulator, Radar Target Signal AN/TPA-7 (TM 11-5840-287-35), when the AN/TPA-7 is used with Radar Set AN/MPQ-4A.

b. Elevation Actuator and Data Synchro. When the elevation switch is actuated, power is applied to elevation actuator motor B3004 and the antenna is raised or lowered in elevation. Elevation data from elevation synchro transmitter B3005 is transmitted to the computer (pars 2-8) and to Simulator, Radar Target Signal AN/TPA-7 (TM 11-5840-287-35), when the AN/TPA-7 is used with Radar Set AN/MPQ-4A.

c. Scanner Drive. When the MAIN POWER switch is actuated, scanner drive motor B3201 rotates the rotor of the scanner.

2-10. Power Supplies System (fig. FO-1)

a. Receiver-Transmitter Power Supply. Regulated positive *300* volts is obtained from control tube V15606. Regulated positive 150 volts is obtained from control tubes V1607 and V1608. A regulated negative 300 volts is obtained from control tube V1609. Keep-alive voltage for the TR tube is obtained from keep-alive rectifier CR1601.

b. Control-Indicator Power Supply. A regulated positive 440 volts is obtained from control tubes V602 and V615. A regulated +220 volts is obtained from control tubes V606 and V607. A regulated negative 220 volts is obtained from control tube V611. Selenium rectifier CR601 furnishes 27 volts dc for the indicator system.

Section II. TRANSMITTING SYSTEM

2-11. General

a. The transmitting system produces high power pulses of radiofrequency energy at fixed intervals. The pulse width is 0.25 microsecond (usec) and the pulse repetition frequency (prf) is 7,000 pulses per second (pps). The prf is controlled by an oscillator in the synchronizing system. The frequency of the rf output is 16,000 ±160 megaHertz per second (MHz).

b. The relationship of the transmitting system with respect to other functional systems of the radar set is covered in paragraphs 2-2 through 2-10.

2-12. Transmitting System Block Diagram (fig. FO-2)

a. High Voltage Control Circuit. The high voltage control circuit consists of power contactor K1104, MAGNETRON POWER variac T651, and voltage adjust transformer T1102. The filament primary of high voltage transformer T1101 receives 120 volta ac when MAIN POWER switch S652 is turned ON. When START button S658 is pressed, 120-volts ac power is applied to the high voltage primary of T1101 and is controlled by variac T651 and voltage adjust transformer T1102.

b. High Voltage Power Supply. The high voltage power supply consists of high voltage transformer T1101, rectifiers V1101 and V1102, and high voltage overload relay K1101. The 4.5-kv output of the high voltage power supply is used to charge pulse-forming network Z1101.

c. Trigger Pulse Amplifier AM-1537/MPQ-4A.

(1) *Power supply V1155 (1 kv) and overload relay K1105.* High dc voltage for the trigger amplifier is developed by 1-kv power supply V1155 and T1154. Overload relay K1105 interrupts the ac input when an overload exists The 1,000-volt output is applied to charging reactor L1151 and charging diode V1154A.

(2) *Charging reactor L1151, charging diode V1154A, and pulse network Z1151.* The positive 1-kv dc applied to the plate of charging diode V1154A charges pulse network Z1151 through charging diode V1154A and L1151. Charging reactor L1151 is used to charge Z1151 to almost twice the output voltage of 1-kv power supply V1155.

(3) *Cathode follower V1151A.* A positive pulse of approximately 35 volts is applied to cathode follower V1151A from the modulator trigger generator in the synchronizing system. The cathode follower acts as an impedance matching device and a buffer between the modulator trigger generator and the trigger amplifier. The output of the cathode follower is applied to blocking oscillator V1152A through trigger voltage amplifier V1151B.

(4) *Blocking oscillator V1152A and trigger voltage amplifier V1151B.* Blocking oscillator V1152A is triggered by the pulse from trigger voltage amplifier V 1151 B and produces a positive pulse with an amplitude of 150 volts. The 150-volt pulse is applied to cathode follower V1152B.

(5) *Cathode follower V1152B.* Cathode follower V1152B acts as a buffer between blocking oscillator V1152A and thyratron switch V1153 to prevent any variations in load impedance being reflected to the blocking oscillator. The positive pulse output is applied to thyratron switch V1153.

(6) *Thyratron V1153.* Thyratron V1153 is normally nonconducting. The thyratron is used to discharge the pulse network. A positive pulse from cathode follower V115B is. applied to the grid, and the thyratron begins to conduct. Pulse network Z1151 ((2) above) discharges through V1153 and pulse transformer T1143.

(7) *Pulse transformer T1153.* A negative pulse is applied to the primary of pulse transformer T1153 when pulse network Z1151. discharges. The output of the pulse transformer is a positive square pulse which is applied to the modulator.

(8) *Reverse current diode V1154B.* The reverse current diode is used to eliminate any negative voltage which might develop during discharge of the pulse network.

d. Modulator.

(1) *Charging choke L_c, charging diode V1106, and pluse-forming network Z1101.* The pulse-forming network charges to approximately 9 kv through charging diode V1106 and charging choke L_c. Charging choke L_c is used to charge Z1101 to almost twice the output voltage of the 4.5-kv high voltage power supply.

(2) *Thyratron switch V1104.* Thyratron V1104 is normally nonconducting. The positive trigger pulse from pulse transformer T1153 triggers thyratron V1104, causing it to conduct. During conduction, thyratron V1104 acts as a short circuit to ground and pulse-forming network Z1101 discharges through thyratron V1104, saturable reactor L1101, and pulse transformer T1106.

(3) *Saturuble reactor L1101.* When pulseforming network Z1101 discharges, saturable reactor L1101 offers a maximum impedence to current flow during the first instant of discharge. This tends to limit the pulse applied to the primary of pulse transformer T1106 during the first instant of discharge.

(4) *Reverse current diode V1103 and reverse current overload relay K1102.* The negative voltage developed after discharge of Z1101 is bypassed to ground through VI 103. Reverse current overload relay K1102 will energize and open the ac voltage lines if the magnetron arcs.

(5) *Pulse transformer T1106.* The pulse transformer applies a negative pulse of ap proximately *26* kv to the magnetron.

(6) *Magnetron filament cutout relay K1103 and current metering circuits.* The magnetron cathode is returned to ground through magnetron current cutout relay K1103, MAGNETRON CURRENT meter M1401, and MAGNETRON CURRENT meter M651. The current meters art used for measuring the magnetron current. Relay K1103 removes filament voltage from the magnetron after the tube begins conducting thus prolonging tube life.

(7) *Magnetron V1105.* The pulse applied to the magnetron from pulse transformer T1106 causes the magnetron to oscillate. The magnetron produces a high power burst of RF energy which is applied to the waveguide.

(8) *MAGNETRON HOURS meter M1403.* When high voltage is applied to the transmitter, magnetron elapsed time meter M 1403 begins to operate. An accurate rneasurernent of the time that the magnetron has been operated is indicated by M1403.

2-13. Electronic Function, Transmitting System

a. Trigger Pulse *Amplifier AM-1537/MPQ-*

4A. The trigger pulse amplifier amplifies and reshapes the low amplitude pulses received from modulator trigger generator Z147 in the synchronizing system (para 2-6). Positive pulses from the modulator trigger generator have an amplitude of approximately 35 volts. These 35-volt positive pulses must be amplified to approximately 880 volts to trigger thyratron switch V1104 in the modulator-transmitter. A 35-volt pulse from the modulator trigger generator is applied to connector J2004 (fig. 2-1) in the receiver transmitter cabinet. Coaxial cable W2001 transmits the incoming pulse through connectors P1104 and J1104 to coaxial tee connector CP1107. Coaxial tee connector CP1107 applies the positive trigger pulse through connectors J1105 and P1105, and cable W 1509 to the stc assembly in the receiving system. The pulse is also transmitted through connectors J1107 and P1107 to low-pass filter FL1117. Low-pass filter FL1117 is a sealed filter containing a pi-network of capacitance and inductance. The low frequency components of the input pulse pass through the filter, but the high frequency components of the pulse are attenuated.

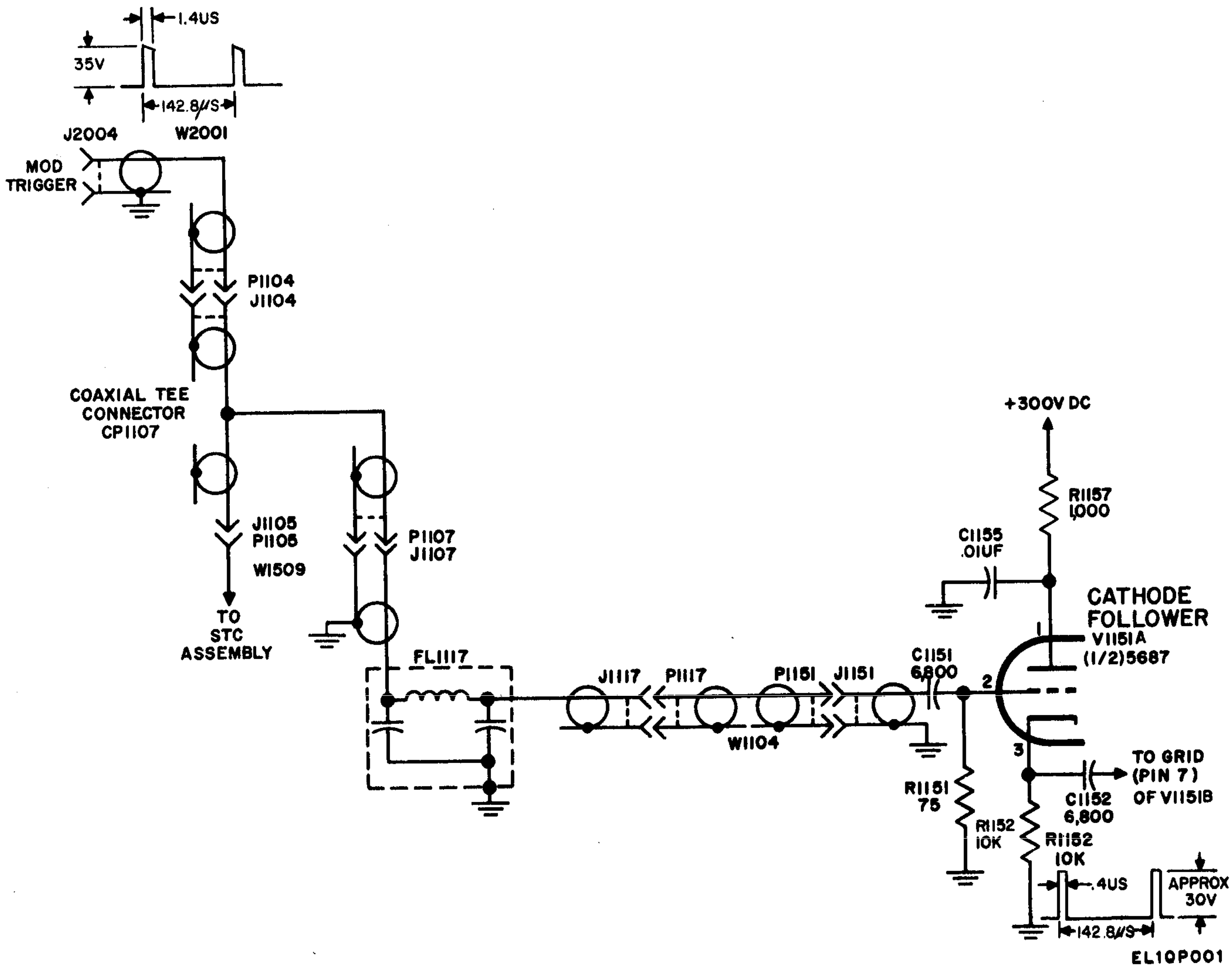


Figure 2-1. Cathode follower 1151A, simplified schematic diagram.

(1) *Cathode follower V1151A.*

(a) General. The positive pulse from low. pass filter FL1117 is conducted through coaxial cable W 1104 to trigger amplifier input connector J1151. The input pulse is applied to the grid (pin 2) of V1151A through differentiating network consisting of capacitor C1151 and resistor R1151(fig. 2-1).

(b) Circuit functioning. Cathode followers are used to match a low impedance load to a high impedance source, or to isolate critical circuits from loading effects. Cathode follower V1151A is used primarily to isolate modulator trigger generator Z147 from trigger voltage amplifier V1151B. the voltage gain of a cathode follower is less than unity, the power gain is high, and the

output is the same phase as the input. The positive differentiated pulse at the grid (pin 2), differentiated by capacitor C1151 and developed across grid resistor R1151, causes an increase in plate current. Resistor R1157 and capacitor C1155 in the plate circuit form a decoupling network. Plate current flowing through cathode resistor RI 152 develops an output voltage which is in phase with the input. The positive-going output pulse is applied to the grid (pin 7) of trigger voltage amplifier V1151B through coupling capacitor C1152.

(2) *Trigger voltage amplifier* V1151B *and blocking oscillator V1152A.*

(a) General. Normally, tube sections V1151B and V1152A are nonconducting because of the bias on the cathodes. The voltage-divider network consisting of resistor R1160 and cathode resistor P1154, connected between the positive 300-volt supply and ground, provides a potential of approximately 25 volts at the cathodes. Capacitor C1153 is the cathode bypass capacitor. Trigger voltage amplifier V1151B is a triggering tube for blocking oscillator V1152A (fig. 2-2).

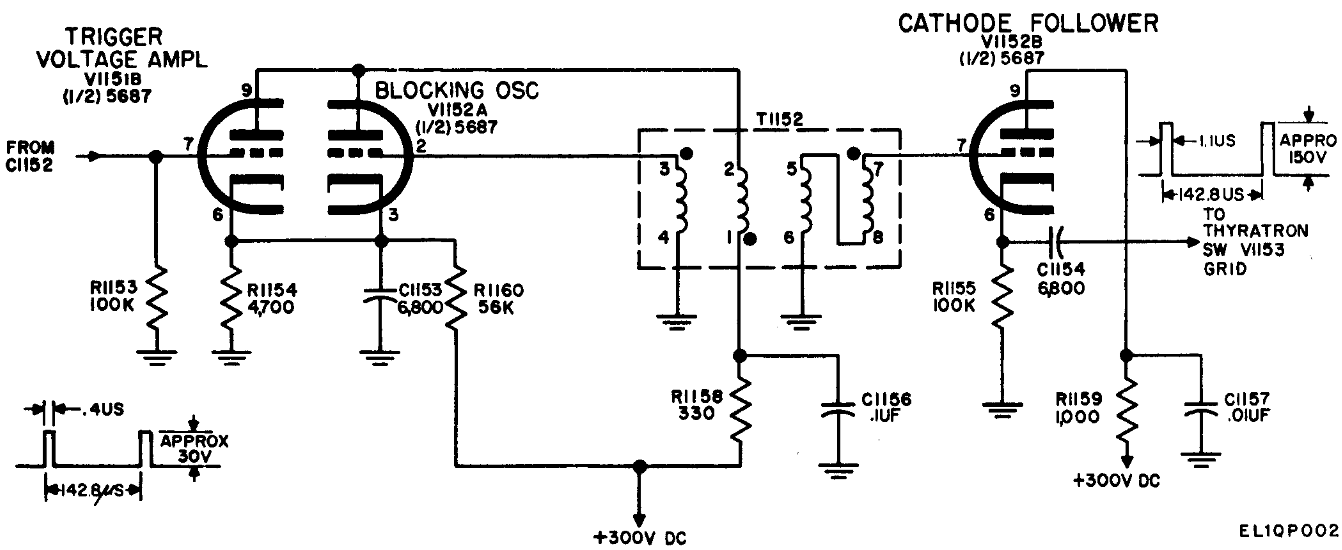


Figure 2-2. Trigger voltage amplifier V1151B, blocking oscillator V1152A and cathode follower V1152B, schematic diagram.

(b) Circuit functioning. The positive trigger pulse from cathode follower V1151A is applied to the grid of trigger voltage amplifier V1151B. Both V1151B and blocking oscillator V1152A are normally held in cutoff by the voltage divider action of resistora R1154 and R1160. When a positive trigger pulse is applied to the grid of V1151B, a pulse of current will flow through the primary winding (terminals 1 and 2) of pulse transformer T1152. The plate current flow from the trigger amplifier will instantly result in a positive-going voltage at terminal 3 of T1152. This will drive the grid of the blocking oscillator positive and cause a flow of plate current through the primary of T1152 which reinforces the action caused by the trigger voltage amplifier. Since the pulse fed back through T1152 from plate to grid of the blocking oscillator is regenerative, plate current will be driven to saturation very quickly. As the saturation condition is approached, the rate at which the plate current rises will decrease and the induced voltage of the secondary (terminals 3 and 41, which is proportional to the rate of change of plate current, will also decrease. The decrease in voltage at the grid of the blocking oscillator will cause a decrease in plate current and this in turn will allow the magnetic field, which was built up around the primary of T1152 during the plate current rise, to decrease or collapse. This collapsing field will induce a voltage into the secondary which is negative going at the grid of the blocking oscillator, returning it to cutoff until the next trigger.

(3) *Cathode follower V1152B.* Cathode follower V1152B is normally near cutoff because of the high value of cathode resistor R1155. The positive-going pulse at the grid (pin 7) of V1152B causes plate current to increase through V1152B and cathode resistor R1155. The increased current flow through cathode resistor R1155 develops a positive. going output pulse which is applied to the grid of thyatron switch V1153 through coupling capacitor C1154, Resistor R1159 and capacitor C1157 form plate decoupling network.

(4) *Charge and discharge of pulse network Z1151.*

(a) Purpose. By charging a pulse-forming network to a high potential and discharging it rapidly, a short-duration high voltage pulse can be produced. The pulse-forming network is essentially a section of an artificial transmission line. Pulse network Z1151, a hermetically sealed line, produces a 0.6-microsecond pulse which is applied to the modulator. (fig. 2-3 and 2-4).

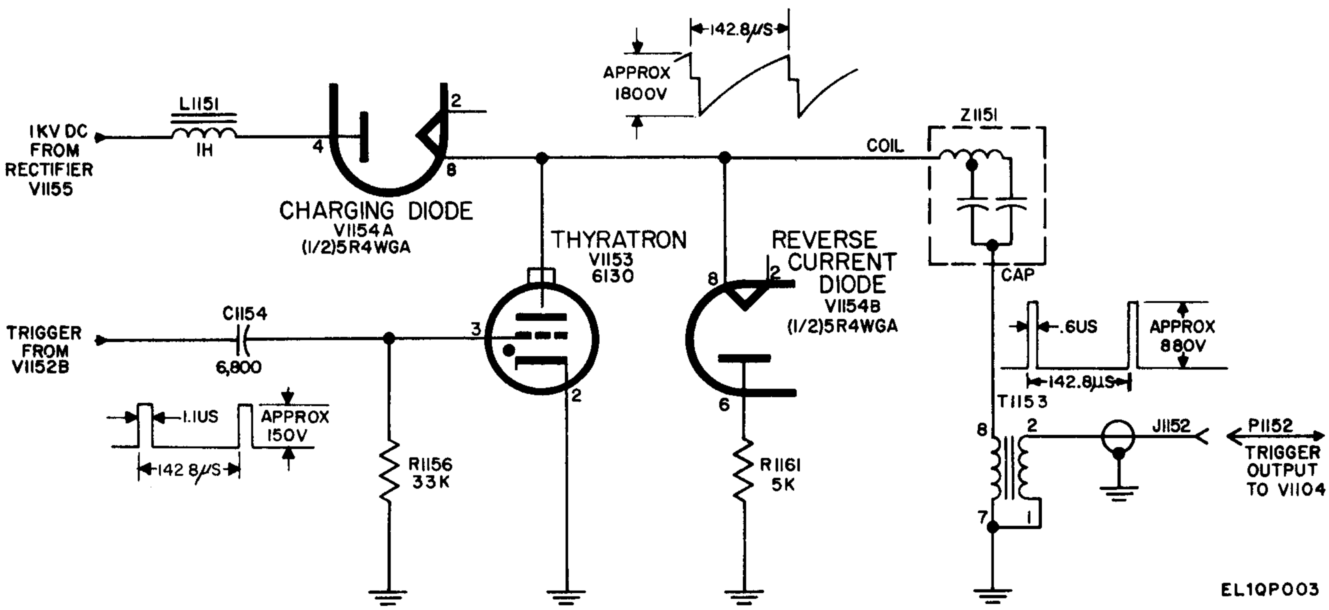


Figure 2-3. Charging diode V1154A, reverse current diode V1154B, and thyratron V1153, schematic diagram.

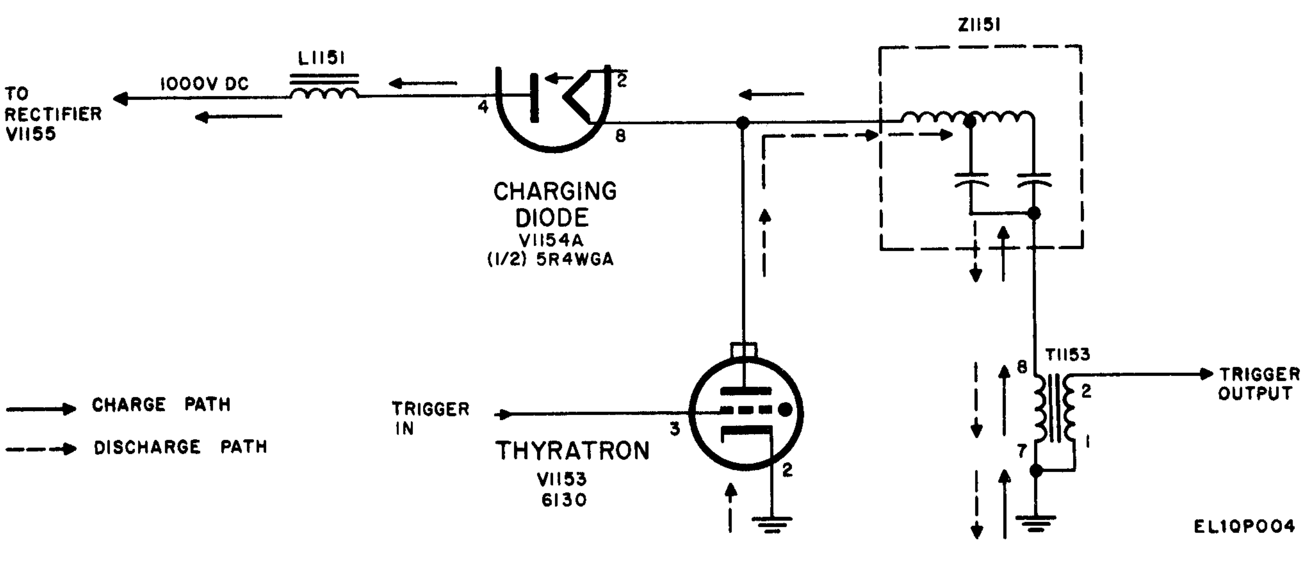


Figure 2-4. Charge and discharge paths of pulse network 21151, schematic diagram.

(b) Charging diode V1154A and charging reactor L1151 (fig. 2.3). Pulse network Z1151 is charged through pulse transformer T1153, charging diode V1154A, charging reactor L1151 and rectifier V1155. The charge path is shown by solid arrows in figure 2-3, The plate (pin 4) of charging diode V1154A. has 1,000 volts dc applied through charging reactor L1151 from rectifier V1155. Pulse network Z1151 is charged by the action of charging diode V1154A and charging reactor L1151. The

charging diode conducts through charging reactor L1151, charging Z1151 toward 1,000 volts and saturating the core of charging reactor L1151. When the charging current through V1154A tries to decrease becauee the charge across Z1151 is approaching the supply voltage, the magnetic field around the charging reactor collapses. This collapsing field induces a voltage in the coil which is additive to the supply voltage and causes V1154A to continue conducting until Z1151 is charged to approximately 1,800 volts.

(c) Discharge of pulse network Z1151. When pulse network Z1151 is completely charged, a high positive potential is present at the plate of thyratron V1153. The grid (pin 3) of thyratron V1153 is triggered by the positive pulse from cathode follower V1152B, and the thyratron conducts. When a positive-going trigger is applied on the grid, the grid immediately loses control over the amount of current drawn by the tube, and the tube conducts heavily. When the thyratron conducts, pulse network Z1151 discharges rapidly through pulse transformer T1153 and thyratron V1153. The rapid rise of current through the primary (terminal 8 to 7) of pulse transformer T1153 induces a positive-going output voltage in the secondary (terminals 1 and 2) of T1153. The discharge path of pulse network Z1151 is shown by dashed arrows in figure 2-4. When the pulse network has discharged to a voltage below the ionizing potential of the thyratron, it ceases to conduct and the grid of the thyratron resumes control of the tube until triggered again.

(d) Reverse current diode V1154B. Because of the resonant characteristics of the pulse network, caused by the inductance and capacitance of the network, pulse network Z1151 will tend to charge in the reverse direction. This charge could produce a negative overshoot in the output pulse. The thyratron is protected from damage by the negative overshoot by reverse current diode V1154B. Any negative overshoot voltage will cause reverse current diode V1154B (fig. 2-3) to conduct. This will dissipate the negative overshoot across reverse current diode V1154B and reverse current resistor R1161.

(e) Output pulse. During discharge of pulse network Z1151, a 0.6-microsecond pulse is developed in the secondary (terminals 1 and 2) of pulse transformer T1153 and applied to the modulator through J1152.

(5) *POSITIVE 1,000 volt rectifier V1155.*

(a) Functioning *of rectifier V1155.* Rectifier V1155 is a full-wave rectifier which obtains plate and filament voltage from transformer T1154. The 1,000-volt output voltage obtained at pin 8 is filtered by capacitors C1158 and C1159. Resistors R1162, R1163, R1164, and R1165 form a bleeder network across the output of the rectifier (fig. 2-5).

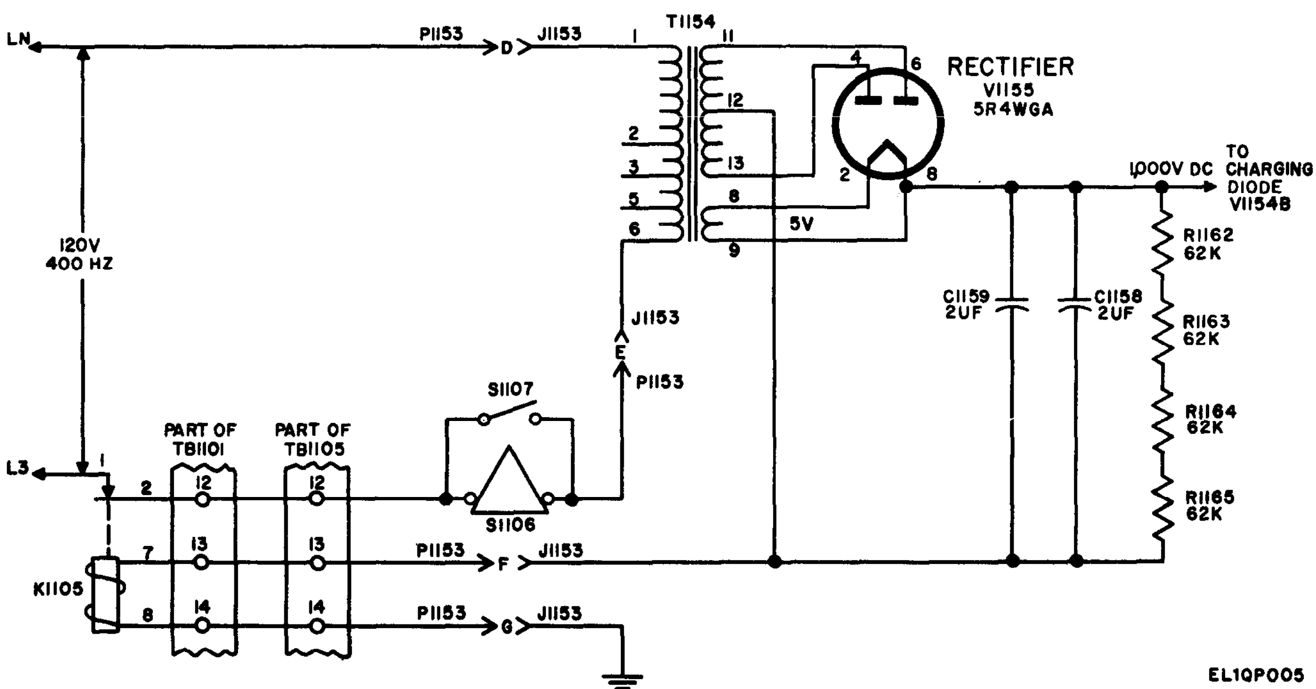


Figure 2-5. Rectifier V1155 and overload protection circuit, schematic diagram.

(b) Overload protection. The dc return of the rectifier is connected through pin F of P1153, J1153, terminal 13 of both terminal boards TB1105 and TB1101, relay K1105, terminal 14 of both terminal boards TB1101 and TB1105, and pin G of J1153 and P1153 to ground. Phase 3 of the ac voltage is applied to transformer T1154 through normally closed contacts 1 and 2 of relay K1105 to terminal 12 or both terminal boards TB1101 and TB1105. From TB1105 the voltage is applied through interlock switch S1106 pin E of P1153 and J1153 to terminal 6 of T1154. Interlock switch S1106 is paralleled by shorting switch S1107 so that the trigger amplifier may be operated with the transmitter door open. If an excessive amount of current (37 milliamperes (ma) or more) is drawn by the trigger amplifier, overload relay K1105 will energize, thus interrupting the ac input to the power supply.

b. Modulator-Transmitter.

(1) *Pulse-forming network Z1101.* Pulse-forming network Z1101 is an artificial transmission line which is used to form a 0.25-microsecond pulse with an amplitude great enough to pulse magnetron V1105.

(a) Charging circuit (fig. 2-6 and 2-7). When approximately 4.5 kv is applied to the plate of charging diode V1106, current flows through the diode, partially charging Z1101 and causing a magnetic field to build up around charging reactor L_C. The charge path for pulse-forming network Z1101 is through charging diode V1106, charging reactor L_c, the high voltage power supply, and the primary of pulse transformer T1106. Current through charging diode V1106 begins to decrease as pulse-forming network Z1101 is charged toward the supply voltage (4.5 kv). This allows the magnetic field around charging reactor L_C to collapse. The collapsing field induces a voltage across L_C which is an addition to the 4.5 kv Supply. This added voltage causes the charge on the pulse-forming network to build up to approximately 9 kv.

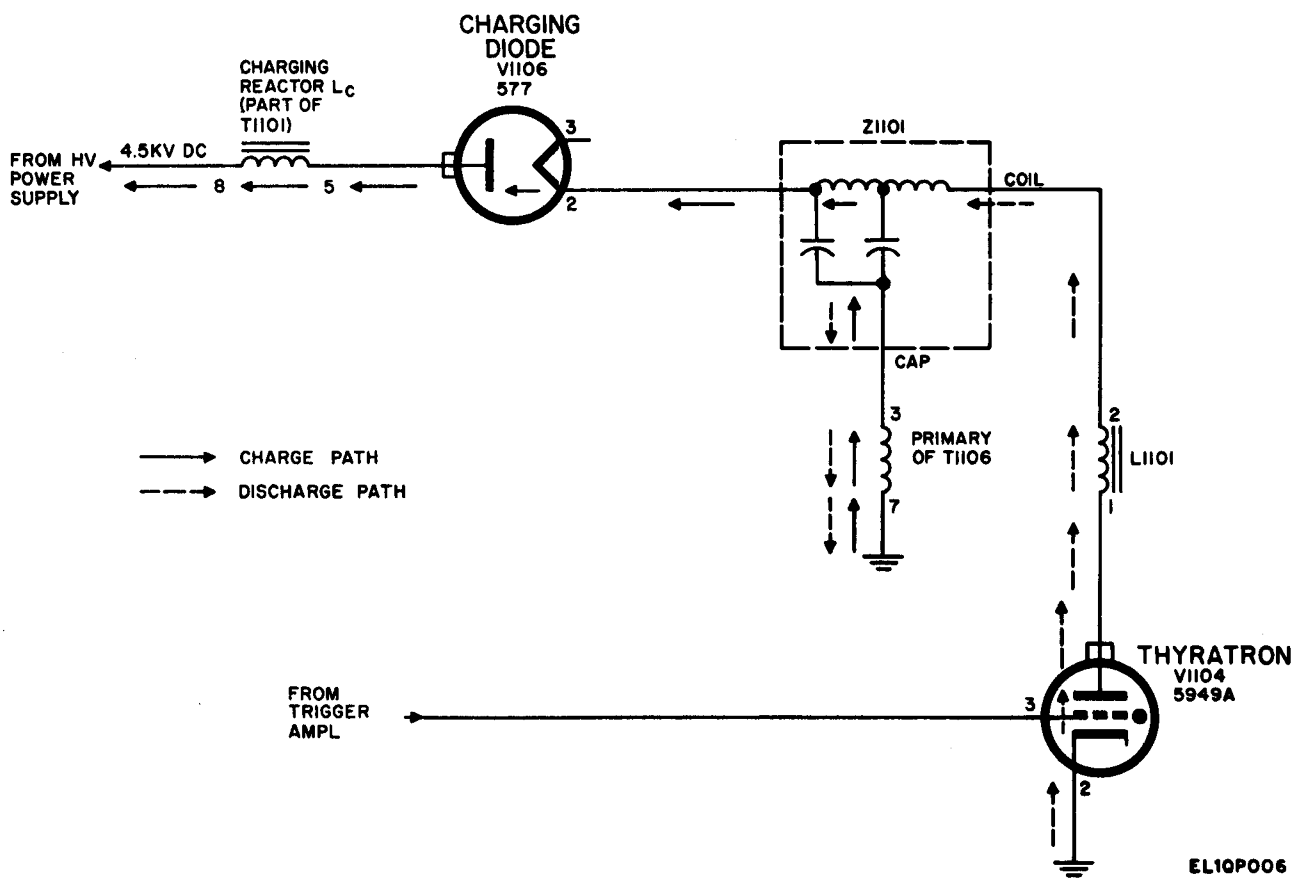


Figure 2-6. Charge and discharge paths of pulse-forming network Z1101, simplified schematic diagram.

(b) Discharge of Z1101. Trigger pulses from the trigger amplifier are applied to the grid of thyratron switch V1104. When the thyratron begins to conduct, a heavy current is drawn through the tube. Saturating reactor L1101 limits the current through V1104 during the beginning of the discharge of Z1101 until the reactor becomes saturated. This protects thyratron V1104 from an excessively high discharge current. Pulse-forming network Z1101 discharges rapidly through the primary of pulse transformer T1106, V1104, and L1101. The output pulse from T1106, during discharge of 21101, is a high power pulse of approximately 0.25-microsecond duration. If the transmitter is shut down for any reason before Z1101 is discharged, the charge will leak off through bleeder resistor R1110 (fig. 2-7).

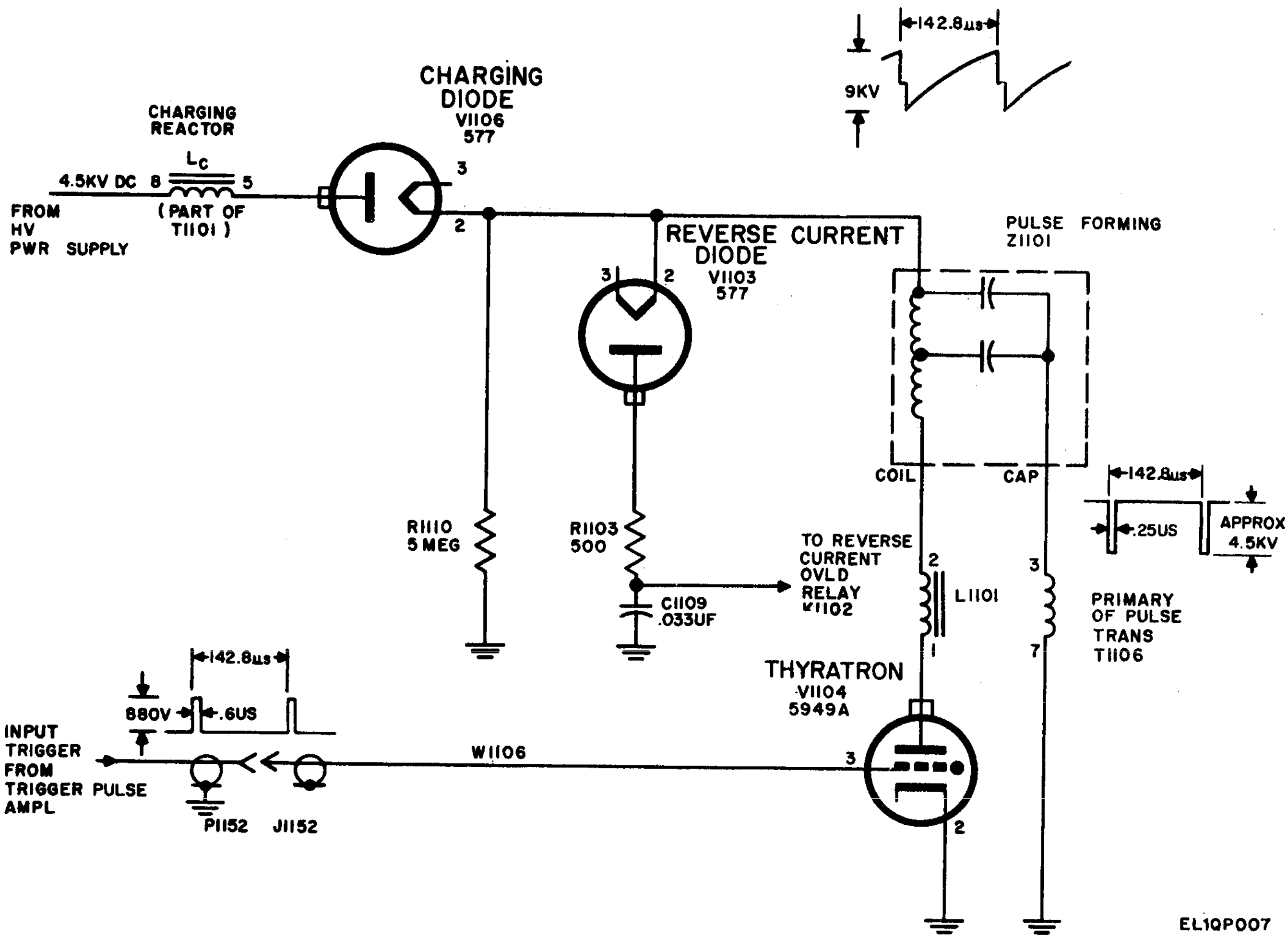


Figure 2-7. Charging diode V1106, reverse current diode V1103, and thyratron switch V1104, schematic diagram.

(c) Reverse current diode V1103 (fig. 2-7). Reverse current diode V1103 prevents negative-overshoot voltage from developing after discharge of Z1101. The negative-overshoot voltage is discharged to ground through reveres current diode V1103 and dissipated across resistor R1103. Capacitor C1109 is a bypass capacitor for relay K1102.

(2) *Magnetron V1105.* Magnetron V1105, which may be either type QK324, or types 7452 or 7452A, is a resonant cavity magnetron oscillator which generates extremely short pulses of high power rf energy at a frequency of 16,000 ±160 megaHertz. Type QK324 or type 7452 magnetron is a packaged unit consisting of the magnetron tube and magnet as one assembly.

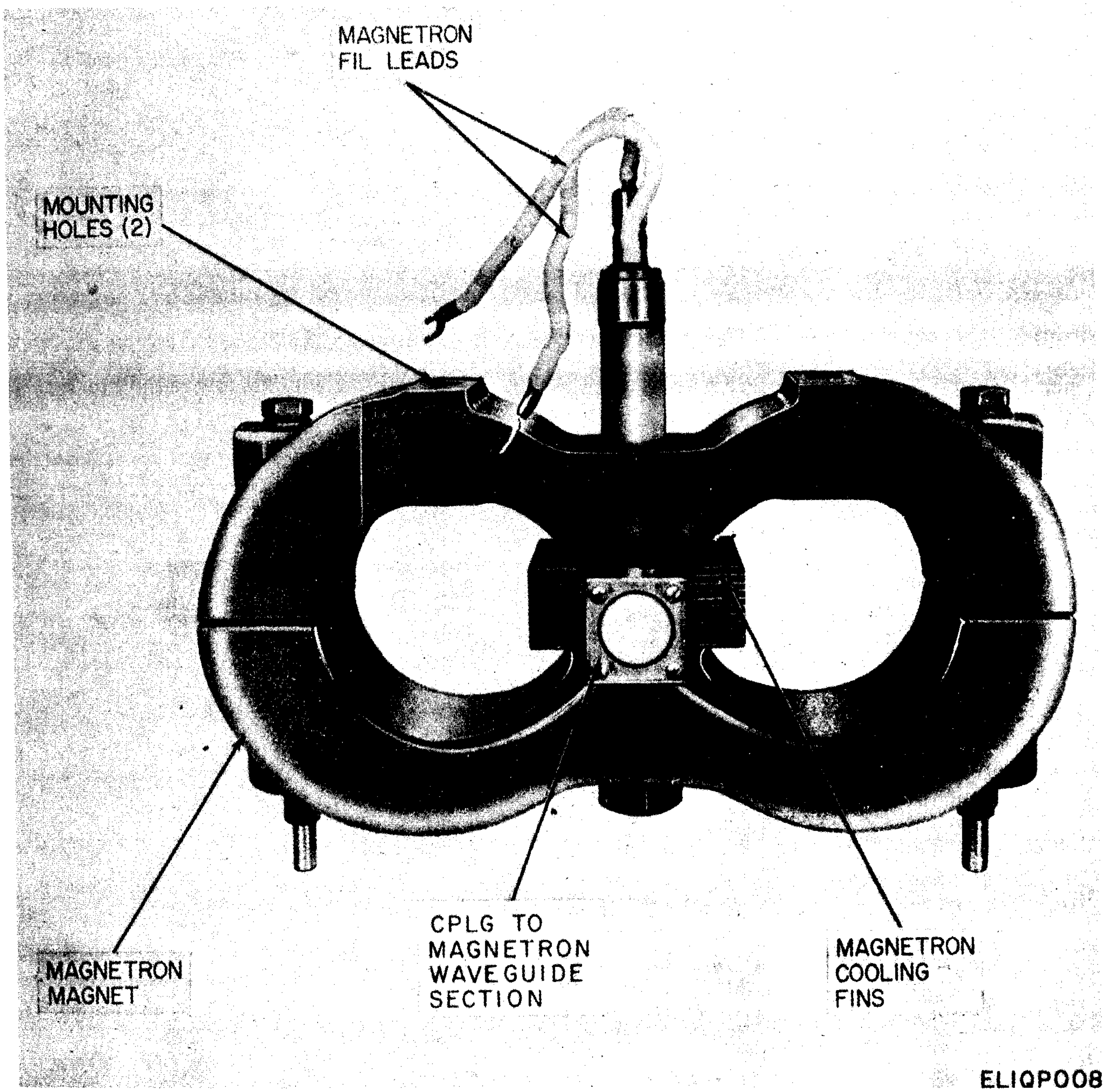


Figure 2-8. Magnetron V1105.

(a) Circuit functioning (fig. 2-9). A negative pulse of approximately 4.5 kv is applied across the primary of pulse and filament transformer T1106. Transformer T2206 steps the 4.5-kv pulse up to approximately 26 kv and applies the 26-kv pulse to the magnetron cathode. The magnetron oscillates and produces a burst of rf energy which is coupled to the waveguide and transmitted to the antenna.

(b) Output pulse test circuit. A portion of the pulse is coupled from the primary of pulse transformer T1106, through the impedance matching network (R1108, R1109, and C1110), cable W1105, and low-pass filter FL1116 to OUTPUT PULSE TEST jack J1402 on the control-monitor panel.

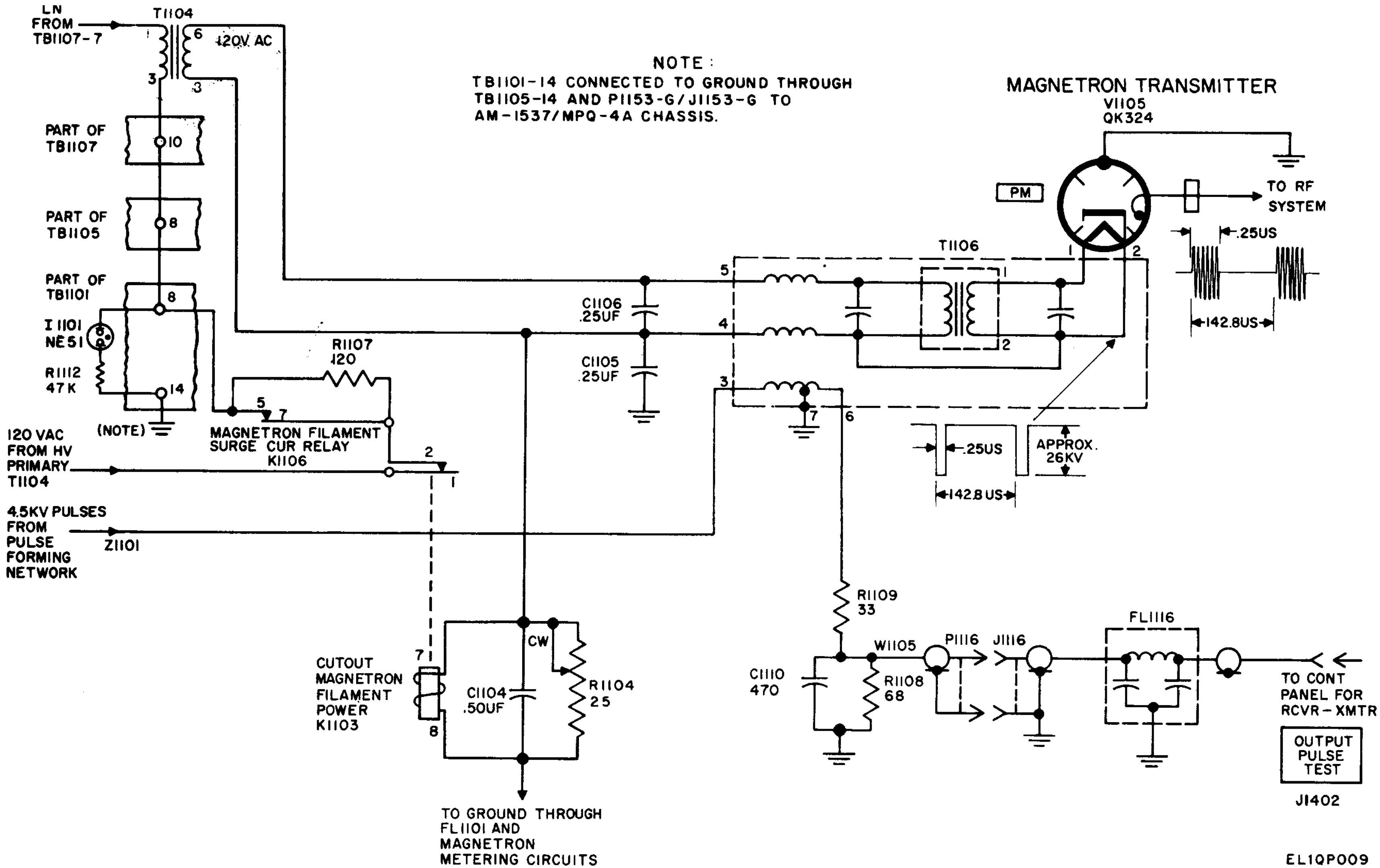


Figure 2-9. Magnetron transmitter, schematic diagram.

(3) High voltage rectifiers V1101 and V1102.

(a) High voltage transformer T1101. High voltage transformer T1101 consists of two separate transformers and two separate choke coils housed in a single case with high voltage insulation. The filament transformer, primary winding (terminals 3 and 4), supplies filament voltage to high voltage rectifier tubes V1101 and V 1102. Filament voltage for charging diode V1106 and reverse current diode V1103 is also supplied by this transformer section. The other transformer, primary winding (terminals 1 and 2), supplies ‘the high voltage secondary.

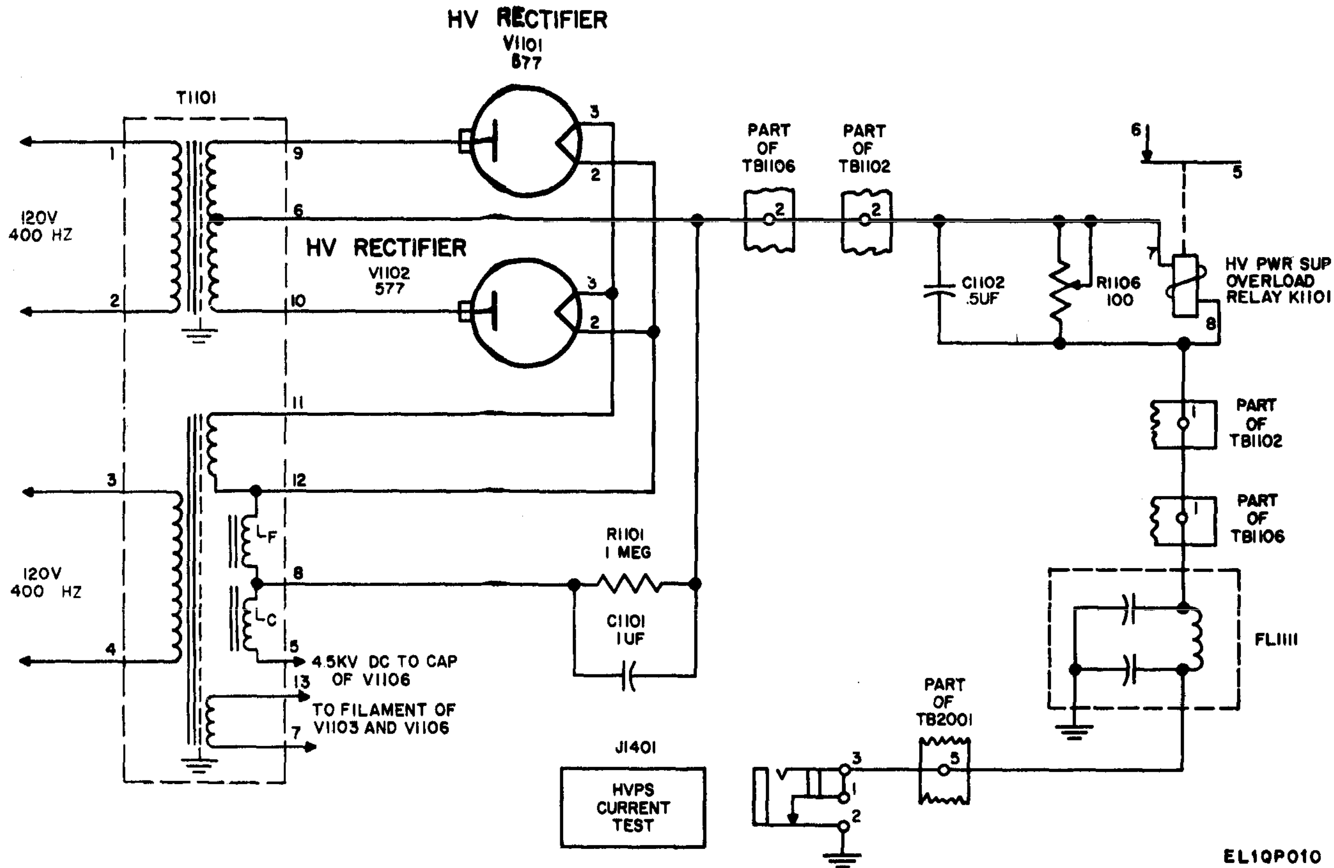


Figure 2-10. High voltage rectifier V1101 and V1102.

(b) Rectifier. The rectifier is a full-wave rectifier, and output voltage is obtained from pin 2 of both V1101 and V1102. The rectified output voltage is filtered by a reactor (terminals 12 and 8) of T1101 an C1101. Resistor R1101 is the bleeder resistor, The positive 4.5-kv dc output is applied to charging diode V1106 through a charging reactor (terminals 8 and 5).

(c) HVPS CURRENT TEST jack J1401. The current of the high voltage power supply may be measured at HVPS CURRENT TEST jack J 1401. The dc ground return of the high voltage power supply passes through terminal 2 of both terminal boards TB1206 and TB1102, high voltage power supply overload relay K1101. terminal 1 of both TB1102 and TB1106, low-pass filter FL1111, and terminal 5 of TB2001 to ground through J1401. If the power supply draws too much current, overload relay K1101 energizes to open contacts 5 and 6 and break the ac line to the primary of T1101. Resistor R1106 is an adjustment potentiometer for relay K1101, and capacitor C1102 is a bypass capacitor.

(4) *Voltage regulator VR1101 and thyratron powerstat T1107.*

(a) Thyratron V1104. Thyratron V1104 is a gas-filled triode tube. Filament voltage is furnished by the secondary of filament transformer T1105. The reservoir or capsule within the thyratron tube will furnish the correct hydrogen pressure within the tube so long as the correct value of operating voltage is maintained across the capsule, The

hydrogen pressure can be increased in the tube by increasing the capsule voltage, and decreased by decreasing the capsule voltage. If the capsule voltage is too high, the thyratron will not recover quickly enough between pulses. This causes the thyratron to fire irregularly. If the thyratron capsule voltage is too low, the tube may not deionize and the plate will overheat. The operating voltage of the thyratron capsule is marked on the base of the tube. The voltage is usually between 3 and 5.5 volts ac. The operating potential for the thyratron capsule can be adjusted to the correct value by using powerstat T1107, and voltage regulator VR1101 will maintain the correct voltage.

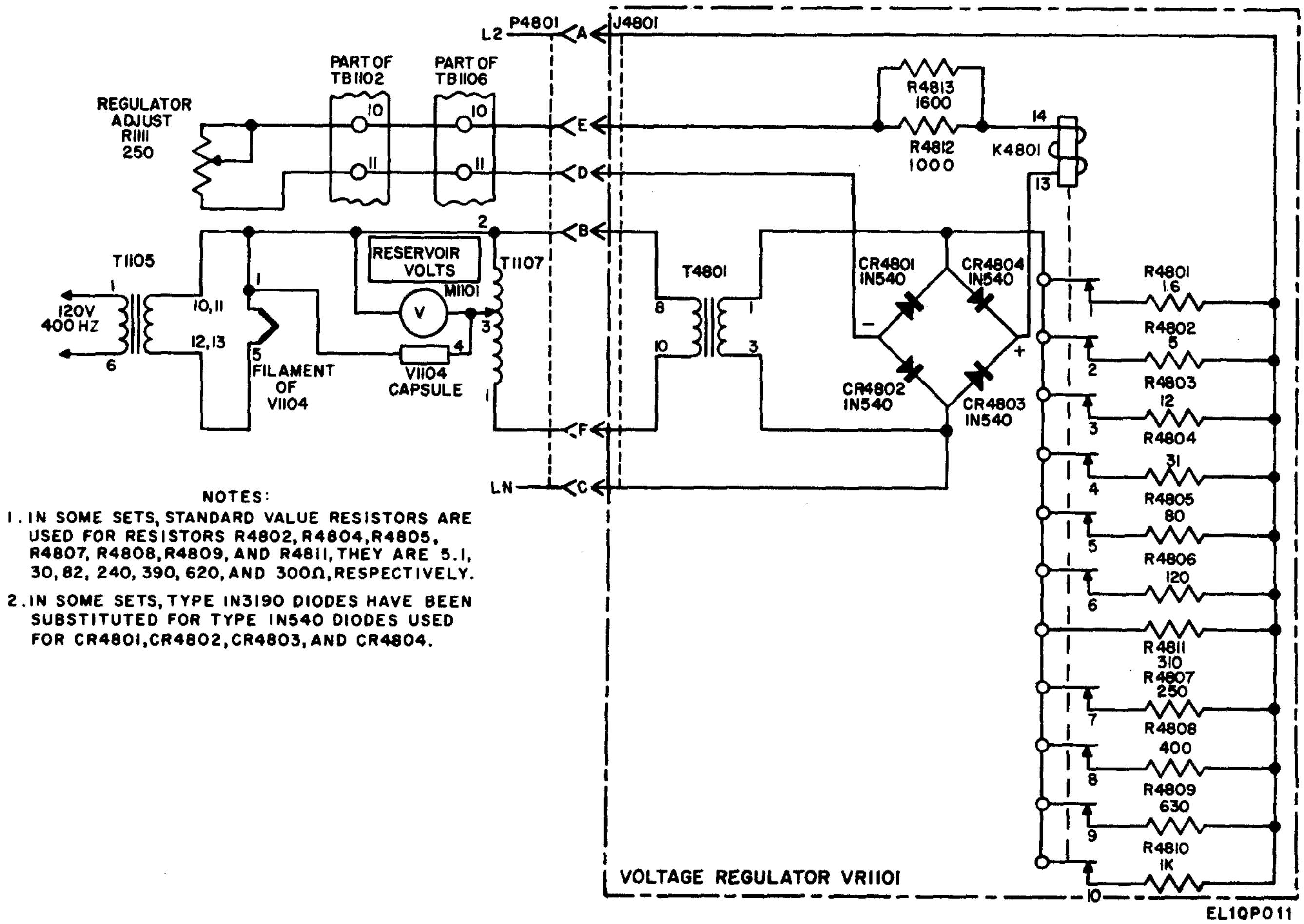


Figure 2-11. Voltage regulator VR1101 and powerstat T1107, schematic diagram.

(b) Circuit functioning of T1107. The capsule of V1104 receives operating voltage from powerstat T1107. The variable arm of T1107 can be adjusted until the correct operating voltage is obtained and indicated on thyratron RESERVOIR VOLTS meter M1101. Any change in input voltage, however, would change the capsule voltage. Regulation of the voltage applied to powerstat T1107 is provided by voltage regulator VR1101.

(c) Circuit functioning of VR1101. Voltage is applied to the primary (terminals 1 and 3) of transformer T4801 through pins A and C of J4801, voltage-dropping network (resistor R4801 through R4811) and the contacts of relay K4801. Since resistors R4801 through R4811 are in parallel when the relay contacts are closed, the voltage drop across them is small. Secondary voltage of T4801 (terminals 8 and 10) is applied across T1107 through pins B and F of J4801. Dc operating voltage for K4801 ia obtained from the bridge rectifier composed of silicon diodes CR4801 through CR4804 (1N540). Resistors R4812 and R4813 are current-limiting resistors. Contacts 1 through 5 are normally open if R1111 is adjusted correctly and the input is 120 volts ac. If the input voltage to the voltage regulator rises, the rectified voltage across the bridge rectifier rises, the rectified voltage across the bridge rectifier rises, and relay K4801 opens another relay contact. When another contact or relay K4801 opens, the resistance in series with the primary of transformer

T4801 is increased, which limits the voltage variation at the primary of T4801 to a small value. Transformer T4801 is a step down transformer; therefore voltage variations in the secondary will be proportionately smaller. If the line voltage continues to rise, more contacts of K4801 will open until finally only resistor R4811 is in series with the primary of T4801. The voltage at which relay K4801 energizes is determined by the setting of regulator adjust potentiometer R1111. If line voltage decreases from normal, contact 4,3,2, and 1 will close in turn, applying a larger percentage of the line voltage across the primary of T4801.

(5) *Metering and protection circuits.*

(a) Reverse current *overload relay K1102 (fig. 2-12).* Reverse current overload relay K1102 is a normally closed relay which is in the ground return circuit of reverse current diode V1103. If the reverse current diode draws too much current, overload relay K1102 will energize and open the ac primary power to the modulator-transmitter by tripping relay K1104. Capacitor C1103 is the relay bypass capacitor. Resistor R1105 determines the reverse current at which relay K1102 will energize.

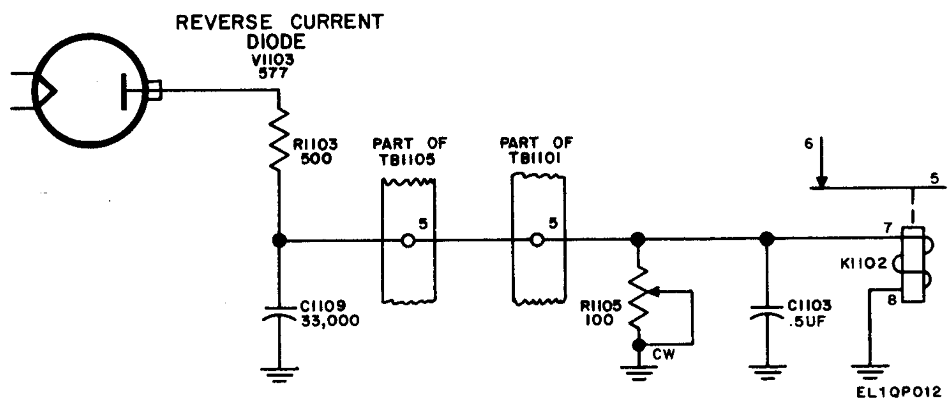


Figure 2-12. Reverse current overload relay K1102, schematic diagram.

(b) Output (fig. 2-13). A small portion of the magnetron pulse is sampled and connected to a test jack so that the output pulse can be observed. This output pulse is obtained from the primary of magnetron pulse transformer T1106 (terminal 6) and applied through an impedance matching network, composed of resistors R1108 and R1109 and capacitor C1110, to coaxial cable W 1105 which terminates in connector P1116. Connector J1116 is connected to low-pass filter FL1116. Coaxial tee connector CP1106 is connected to FL1116 by connector J1107. The sample pulse is directed along two paths by the coaxial tee connector. One path is along coaxial cable W2001 to connector J2008 (this connector is provided to interconnect two or more radars in a master-slave system). The other path is along coaxial cable W2206 to OUTPUT PULSE TEST jack J1402 on the control monitor. Resistor R1408 is a terminating resistance for cable W2006. The magnetron pulse may be monitored by attaching an oscilloscope to J1402.

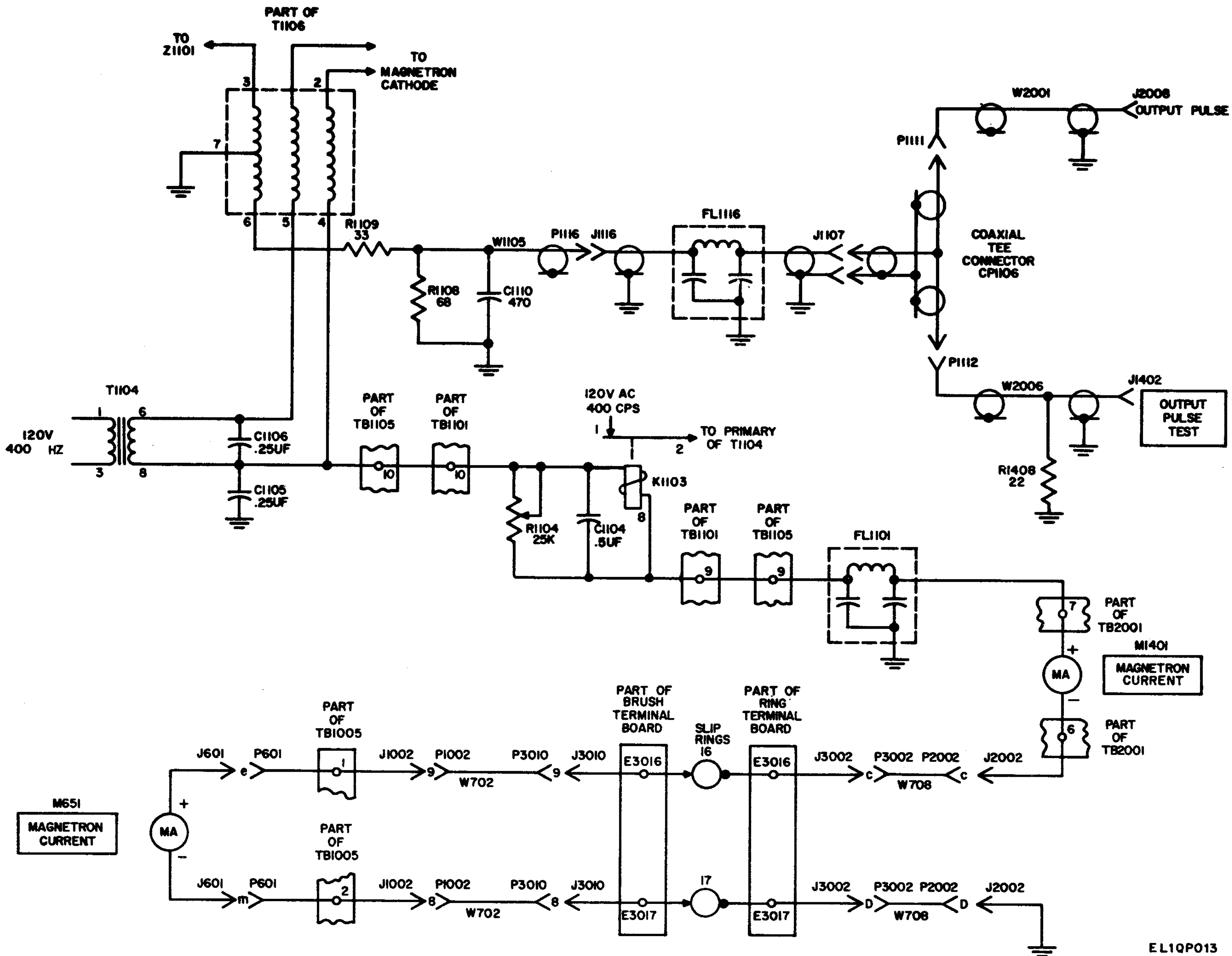


Figure 2-13. Magnetron metering and overload protection circuits, schematic diagram.

(c) Magnetron filament cutout relay K1103 and magnetron current meters (fig. 2-9 and 2-13). Magnetron filament cutout relay K1103 and two magnetron current meters are located in the magnetron cathode ground return. Capacitors C1105 and C1106 are bypass capacitors which bypass any high frequency components to ground. The magnetron cathode return circuit showing MAGNETRON CURRENT meter M1401 and MAGNETRON CURRENT meter M651 connections is shown in figure 2-13. Resistor R1104 normally is adjusted so that approximately 13 ma of magnetron current will energize relay K1103. When K1103 is energized, contacts 1 and 2 open, removing filament power from the magnetron. Neon lamp I 1101 monitors the operation of relay K1103. Observation of neon lamp I 1101 and MAGNETRON CURRENT meter M1401 will indicate whether relay K1103 is operating properly. When main power is applied, the light will remain unlighted approximately 3 seconds; it will light dimly for about 7 seconds and then attain full brilliance (magnetron filament 10-second surge current delay time). When the magnetron anode current reaches 13 milliamperes dc, neon I 1101 will go out if magnetron filament cutout relay K1103 is set properly.

(d) Magnetron filament surge current relay K1106 (fig. 2-14). When the set is turned in, resistor R1107 limits the primary voltage of magnetron filament transformer T1104. This provides reduced voltage for the magnetron filament, preventing a surge of filament current while the magnetron filament is cold. Magnetron filament surge current relay K1106 is a thermal delay relay. After power has been on for ap proximately 10 seconds, relay K1106 closes contacts 5 and 7 shorting resistor R1107. With resistor R1107 shorted, full filament voltage is applied to the magnetron.

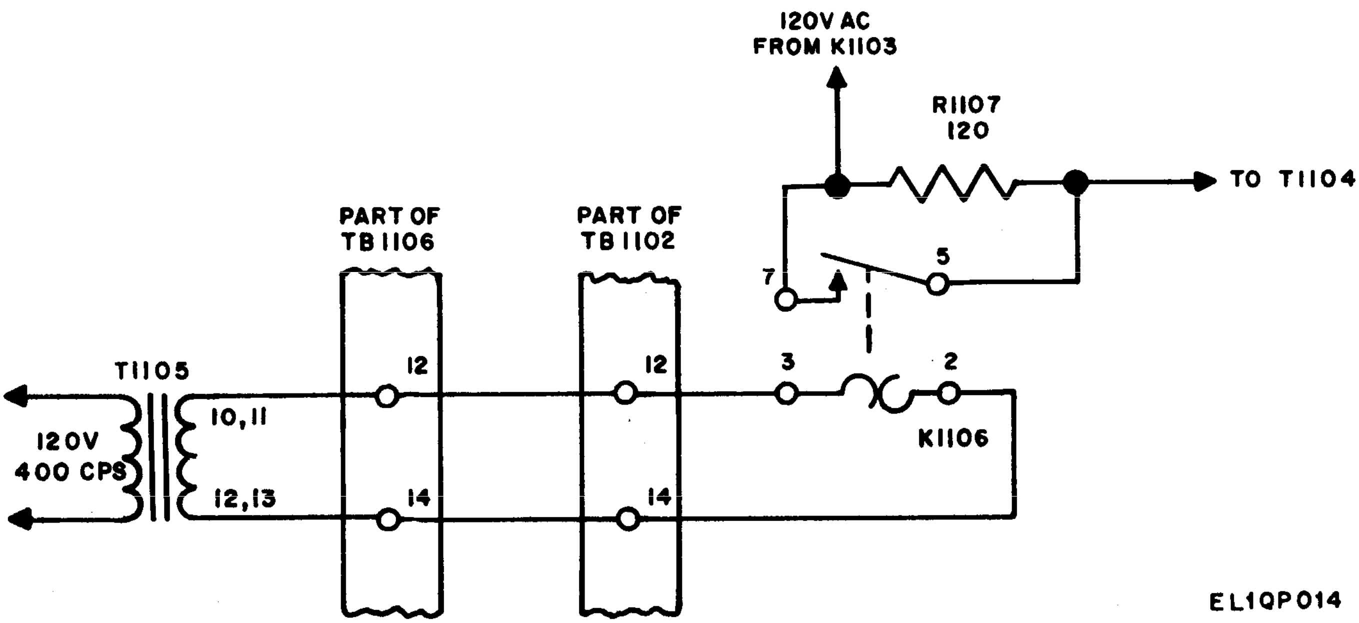


Figure 2-14. Magnetron filament surge current relay K1106, schematic diagram.

Section III. RF SYSTEM

2-14. General

a. The rf system provides a path for rf energy between the magnetron and the antenna, forms the energy into two controlled beams, provides a path between the antenna and the receiver, and decouples the receiver during transmit time. The rf system also provides an echo box to measure radar set performance.

b. The relationship of the rf system with respect to other functional systems of the radar set is covered in section II.

2-15. Rf System Block Diagram

a. Waveguide Sections. Sections of waveguide are used to couple the rf energy from the magnetron to the scanner, and from the scanner to the receiver.

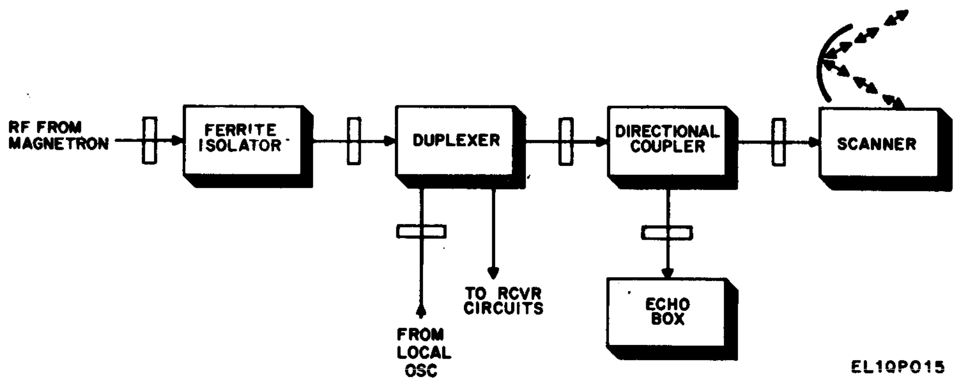


Figure 2-15. Rf system block diagram.

b. Ferrite Isolator. Rf energy from the magnetron is coupled to the ferrite isolator through two sections of waveguide. During transmission, the ferrite isolator allows energy to be coupled to the scanner and dissipates any reflected energy traveling toward the magnetron.

c. Duplexer. The duplexer is essentially a high-speed electronic switch. When the magnetron oscillates, energy is directed toward the scanner, and the receiver is disconnected. During receive time, the relatively low-powered echo signals are directed toward the receiver, and the transmitter is disconnected.

d. Directional Coupler. During normal operation, the directional coupler serves merely as a waveguide section. It also provides coupling for a small portion of the transmitted energy to the echo box in order to make performance tests of the radar set.

e. Scanner. A Foster type dual scanner forms the transmitted energy into two beams and causes them to scan anv desired 25° azimuth sector. The Foetar scanner is essentially a microwave antenna array which rotates around a cone. As it rotates, the wave front emanating from the array strikes the reflector from a constantly changing angle and, therefore, is reflected at a constantly changing angle. The scanner will emit abeam from the upper feedhorn for approximately 180° of its rotation; then a beam is emitted from the lower feedhorn for an equal period during the remaining 180° of rotation.

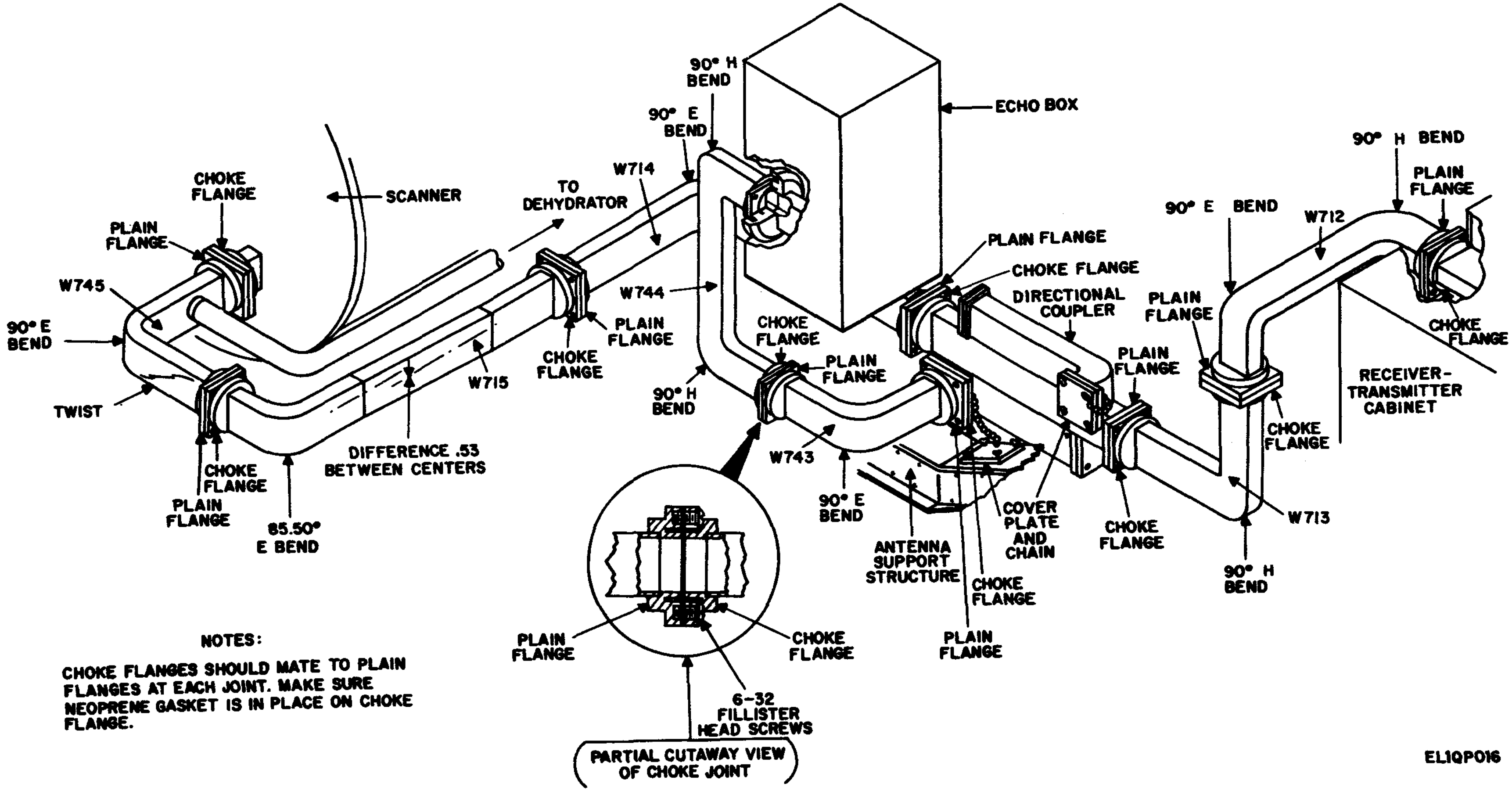
f. Reflector. The dual beams of rf energy from the scanner are reflected and shaped into sharply defined beams by the reflector.

g. Polarizer. A circular polarizer, which is permanently attached to the antenna, may be placed in the beam path between the feedhorne and the reflector to reduce the clutter resulting from rain.

2-16. Electronic Function, Rf System

a. Waveguides.

(1) General. A waveguide is a hollow single conductor used to conduct energy from point to point. During transmission, rf energy from the magnetron is conducted to the scanner by waveguide. The weak echo signals from a target also are conducted from the scanner to the receiver by waveguide. Waveguides are used to conduct rf energy at microwave frequencies because they offer lower attenuation of rf energy, greater power carrying capacity, and simpler mechanical construction than either transmission unes or coaxial cables. The waveguides in common use are the rectangular cross section type and the circular cross section type. Radar Set AN/MFQ-4A uses rectangular waveguides 1.58 centimeters (cm) wide and 0.789 cm high. The larger dimension is referred to as the *A* side and the smaller dimension as the B side (X, fig. 2-17).



NOTES:

CHOKE FLANGES SHOULD MATE TO PLAIN FLANGES AT EACH JOINT. MAKE SURE NEOPRENE GASKET IS IN PLACE ON CHOKE FLANGE.

Figure 2-16. Waveguide system.

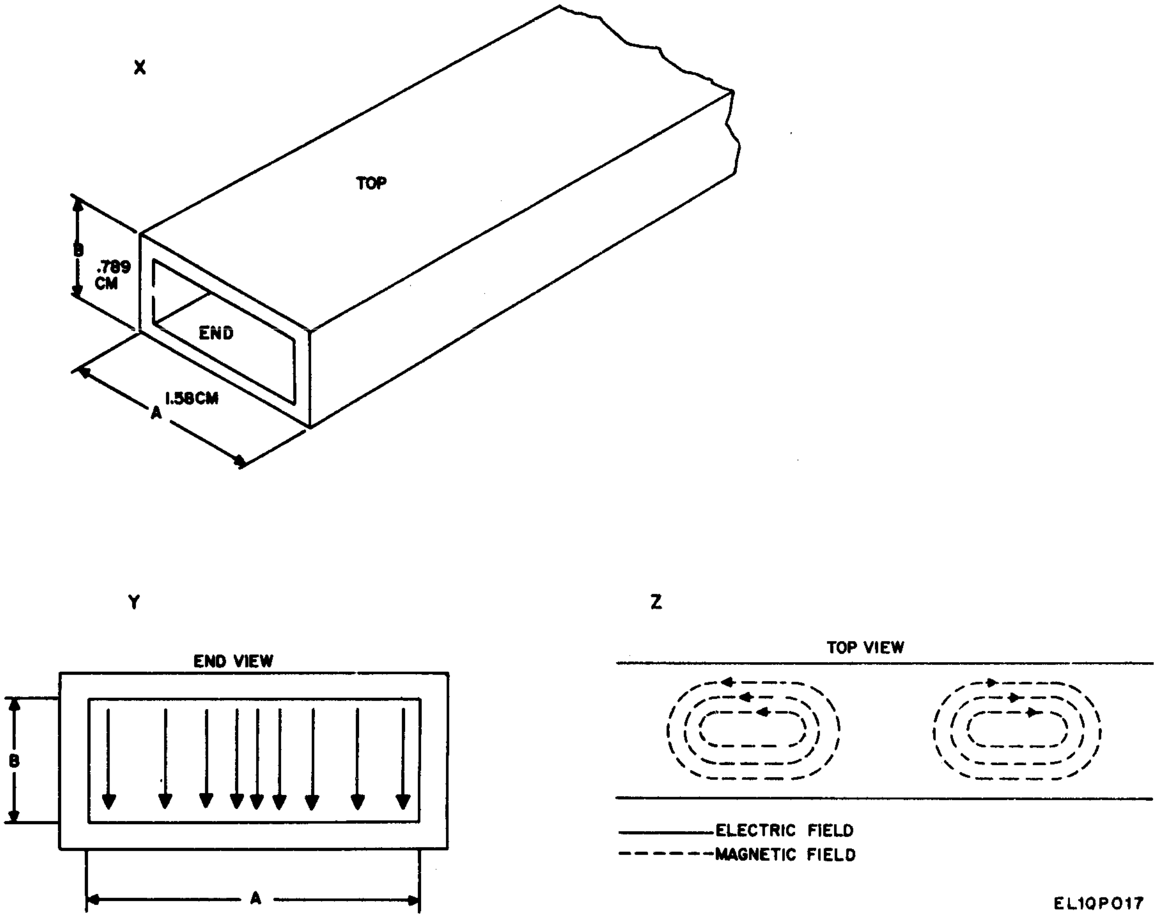


Figure 2-17. Field configuration in waveguide.

(2) *Modes.* A waveguide is capable of transmitting an infinite number of different types of electromagnetic waves. Each type of electromagnetic wave, or mode, has its own electric and magnetic field configuration and the type of wave is designated as a particular mode. Each mode has a lower critical frequency which is known as the cutoff frequency and is determined by the size of the waveguide. A frequency lower than the cutoff frequency will not be propagated, The cutoff frequency for the waveguide used in Radar Set AN/MPQ-4A is 9,490 megaHertz (MHz) or a wavelength of 3.16 cm. For any waveguide, the mode that has the lowest cutoff frequency is called the dominant mode. Two types of modes are possible in a waveguide. The modes of one type are called transverse electric (TE) modes, because the electric fields tranverse (cross) the axis of the waveguide. The dominant mode in the waveguide system of Radar Set AN/MPQ-4A is the $TE_{1,0}$ mode. The first subscript indicates the variation in intensity of the electric field along the A side of the waveguide (Y, fig. 2-17). The second subscript indicates the variation in the intensity of the electric field along the short or B side of the waveguide (Y, fig. 2-17), The intensity of the electric field (Y, fig. 2-17) varies sinusoidally along the A side from zero at one edge, to a maximum at the center, and to zero at the other edge. No variation in intensity exists along the B side of the waveguide; therefore, the second subscript is 0.

(3) *Choke joints,* Because a continuous section of waveguide cannot extend from the magnetron to the scanner, the waveguide sections must be joined. If the joint is poorly constructed, impedance mismatches will cause reflections of the propagated wave. A choke flange joint is used to join two sections of waveguide and eliminate reflections and power losses at the joint. A plain flange and a choke flange are shown in A, figure 2-

22. The L-shaped slot formed by the junction of the two flanges (B, fig. 2-22) may be thought of a B a half-wave shorted transmission line. Point Y in figure 2-22, is at a point, which is 1/2 wavelength away from the shorted end of the slot; therefore, the voltage across the gap is zero. Point X in B, fiire 2-22, is at a point which is 1/4 wavelength from the shorted end of the slot.

b. Ferrite Isolator W1503.

(1) *General.* The magnetron must be protected against any reflection occuring in the rf system which are caused by impedance mismatches. These reflections would *pull* or change the magnetron frequency, resulting in lower efficiency and probable damage to the magnetron. Ferrite isolator W1502 is inserted into the rf system to prevent any reflected energy from reaching the magnetron.

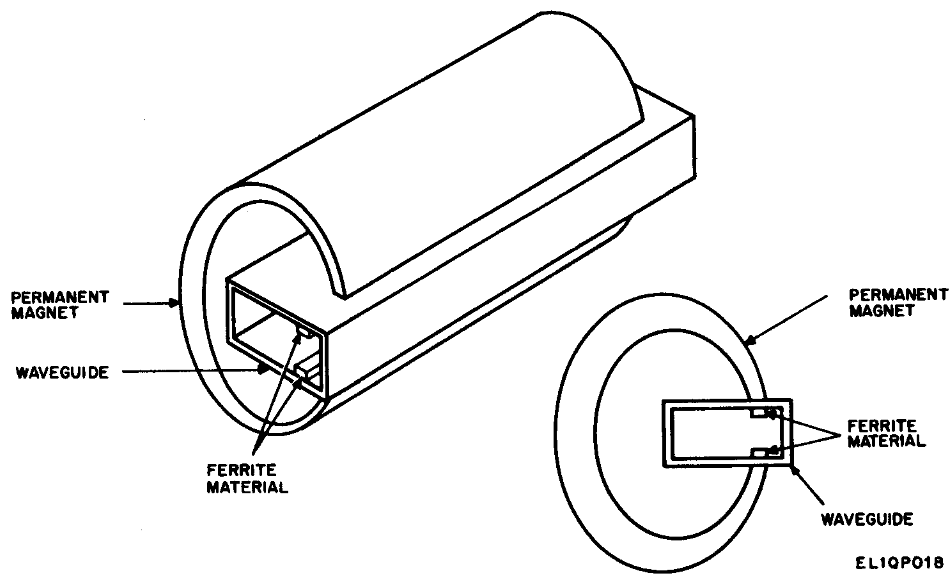


Figure 2-18. Ferrite isolator construction.

(2) Operation of ferrite isolator. Two slabs of ferrite material are attached to the inside walls of a section of waveguide (fig. 2-18) and extend along the length of the waveguide. A very strong permanent magnet is used to provide a dc magnetic field which causes the ferrite slabs to absorb any energy traveling through the waveguide toward the magnetron, but attenuate only slightly the energy transmitted from the magnetron.

c. Mixer Duplexer Assembly.

(1) One primary function of the mixer duplexer assembly is to pass pulsed rf energy from the transmitter to the antenna, and to pass return echo signals from the antenna to the receiver. To perform this function, the duplexer operates as an extremely high-speed electronic switch which preventa damage to the receiver during transmission of high level rf energy pulses, and prevents low level rf energy return echo pulses from being dissipated in the transmitter.

(2) The other major function of the mixer duplexer assembly is signal mixing. Echo signal returns resulting from transmitted pulses are passed through the duplexer to the signal mixer where they are combined with a local oscillator signal to produce beat frequencies containing the same information as the echo pulse, but at a much lower frequency. This lower frequency is the receiver intermediate frequency (if.). A second mixing function takes place during the transmitted pulse for the purpose of automatic frequency control (aft) of the receiver local oscillator. This insures that the if. produced by mixing the echo signal and the local oscillator signal will always be in the range of the receiver band pass.

d. Duplexer. The duplexer consists of waveguide sections, flanges, and a dual TR tube fabricated in such a manner as to give the desired switching action. The actual switching action is accomplished by using waveguide sections, known as short slot hybrids, together with the TR tube and proper dissipative terminations. The short slot hybrids consist of two short parallel lengths of waveguide mechanically joined on the narrow wall and electrically coupled by a slot in the joined walls. Two important electrical characteristics of a short slot hybrid are its ability to divide power equally between input and output sections and to shift phase. A total of four slot hybrids are used in the mixer duplexer assembly (fig. 2-19).

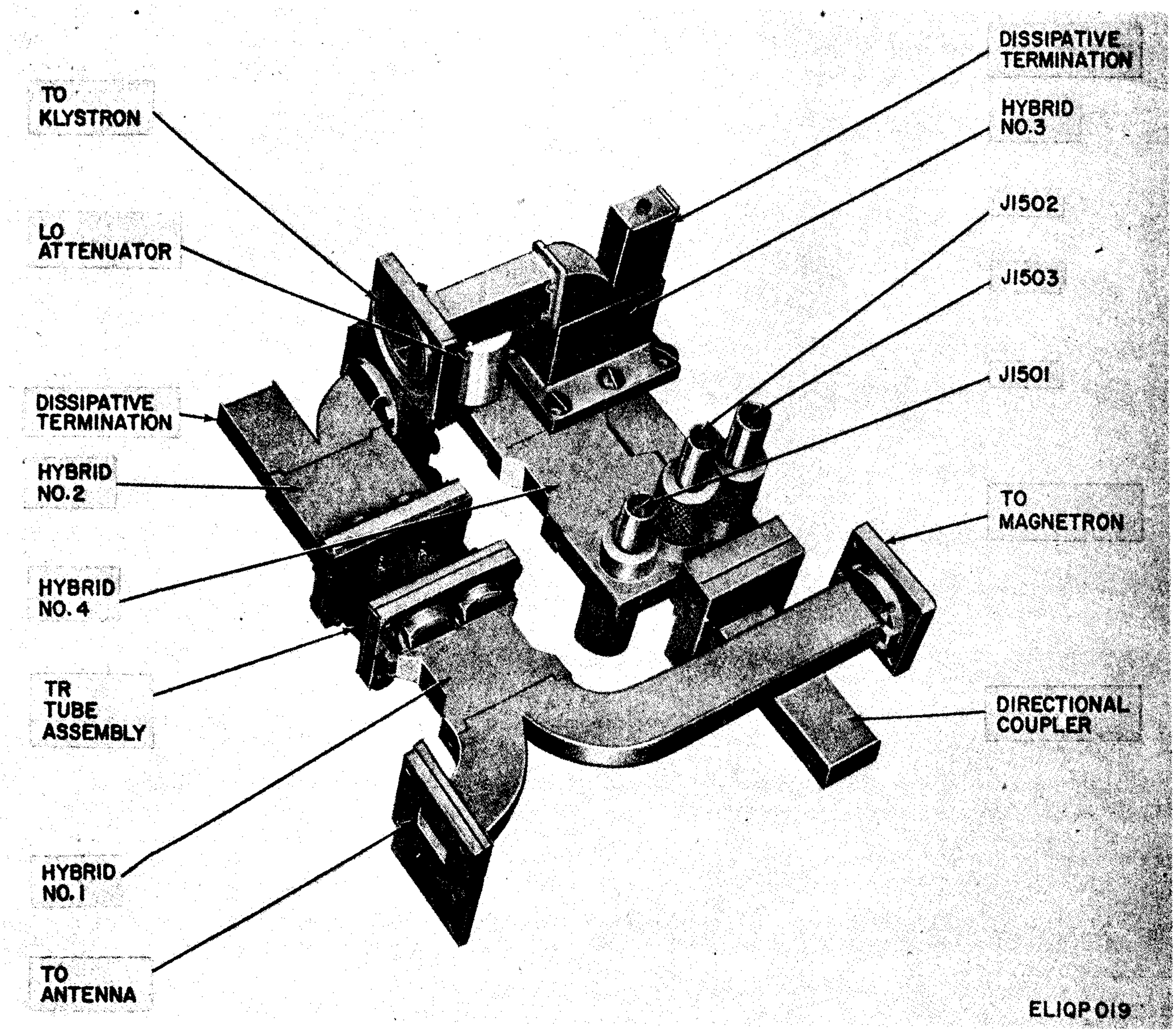


Figure 2-19. Duplexer CU-476/MPQ-4A.

e. Duplexer Transmit Operation.

(1) Rf energy from the magnetron travels down the waveguide and enters the duplexer through the magnetron arm of the transmitter assembly. Attached to the magnetron arm is a directional coupler. The combination of the directional coupler and the magnetron arm serves two functions: it samples the transmitter pulse through a 30-db attenuator which is then applied to the hybrid mixer assembly, and it directs the rf transmitter pulses to short slot hybrid No. 1 where it divides equally at the slot (A, fig. 2-20). Half the power passes through the slot into the antenna arm and half remains in the magnetrons arm. That portion of the energy which passes through the slot into the antenna arm is advanced 90° in the phase with respect to that in the magnetron arm. When the energy in both arms reaches the dual TR tube, the gas in the tube ionizes and short circuits both arms of the hybrid. A keep-alive voltage is applied to the TR tube which maintains the gas at a potential just below the level required for ionization. This insures that the TR tube will ionize and short the waveguide when the transmitter pulse appears at the tube. The power is then reflected back up both arms,

shifting the phase in each arm an additional 180° and dividing the power as it passes the slot (B, fig. 2-20). The energy being reflected up the antenna arm has been shifted 270° with respect to that from the magnetron arm. That portion passing back through the slot into the magnetron arm is advanced another 90° and is now shifted 3600. The energy reflected up the magnetron arm has experienced 180° of phase shift and is now 180° out of phase with the energy returning from the antenna arm, and thus, cancels. When the energy in the magnetron arm reflects, it also divides; the portion passing through the slot toward the antenna advances another 90° and encounters that portion of the power in the antenna arm which is traveling toward the antenna. Since these are in phase, they add vectorially (reinforce) and are transmitted to the antenna.

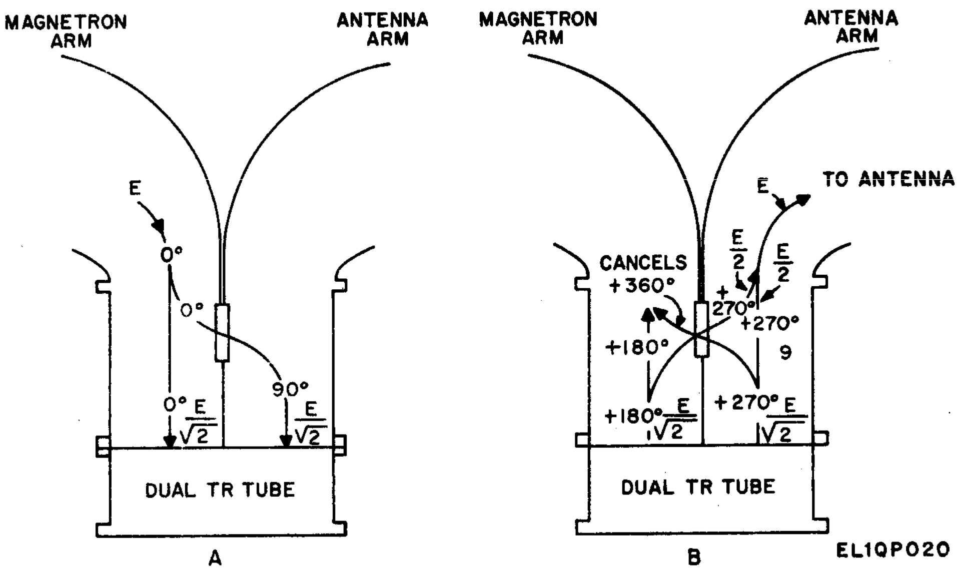


Figure 2-20. Duplexer transmit operation.

(2) It appears that only half the power is directed toward the antenna branch of the duplexer and half the power is dissipated. With this type of duplexer, however, this is not the case. Since the total power P in the duplexer is equal to voltage E times current 1, the operation will be easier to understand if only the voltage vector is considered. In A, figure 2-20, the power from the magnetron branch splits at the slot. Theretore, the quantity E /√2 (.7 of the original voltage) with 0° phase shift appears at the TR tube in the magnetron branch and the quantity E/ √2 with 90° phase shift appears at the TR tube in the antenna branch. Since the ionized TR tube appears as a short, both voltages will be reflected and shifted 180° in phase. When the reflected voltage in the magnetron branch passes the slot, the power again splits. Thus, the quantity E/2 (.7/ √2 or .5 of the original voltage) with 180° phase shift is directed along the magnetron branch and the quantity W/2 with 270° phase shift appears in the antenna branch (B, fig. 2-20). When the voltage in the antenna branch is reflected by the TR tube, the voltage also splits at the slot. The portion appearing in the magnetron branch is again shifted 90° for a total of 3600 shift. Since the two reflected voltages appearing in the magnetron branch are equal in amplitude E/2 and 180° out of phase, the two voltages cancel. The voltage directed toward the antenna is equal to E/2 with 90° phase shift. Since the phase of both reflected voltages appearing in the antenna branch is the same, the voltages add vectorically (E/2+E/2=E) and the full magnetron power is directed toward the antenna.

f. Duplexer Receive Operation.

(1) When echo signal returns are picked up by the antenna, they pass down the waveguide to the mixer duplexer assembly. On entering the duplexer, the signals encounter the same short slot hybrid (No. 1) as they did during transmission. The reflected energy (return echo) divides equally at short slot hybrid No. 1; half passes through the slot to the antenna arm towards the TR tube, and half passes down the antenna arm also towards the TR tube. The energy in the magnetron arm is now advanced 90° with respect to that in the antenna arm,) the TR tube does not ionize since the received energy is extremely low when compared with the transmitted energy. The received

energy passes through the TR tube section and into short slot hybrid No. 2, located directly below the TR tube. The waveguide section of hybrid No. 2, located below the antenna arm of hybrid No. 1, will also be referred to as the antenna arm. The energy passing down the mixer arm divides through short slot hybrid No. 2, resulting in another 90° phase shift or a total shift of 180°. The energy in the antenna arm divides at short slot hybrid No. 2, with the energy entering the mixer arm advanced 90°. This combines vectorially with energy from hybrid No. 1 width is also plus 90°. The two signals reinforce each other and pass toward the crystal mixers.

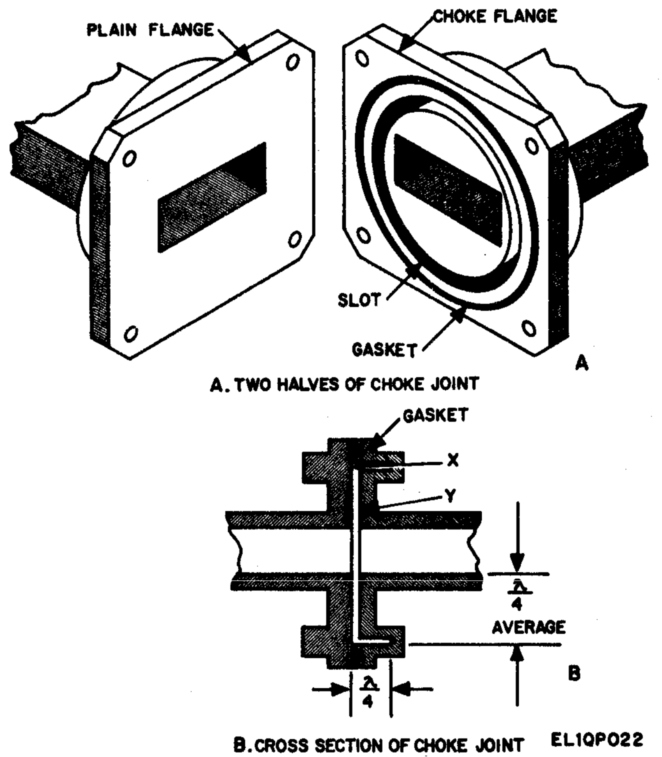


Figure 2-22. Choke joint.

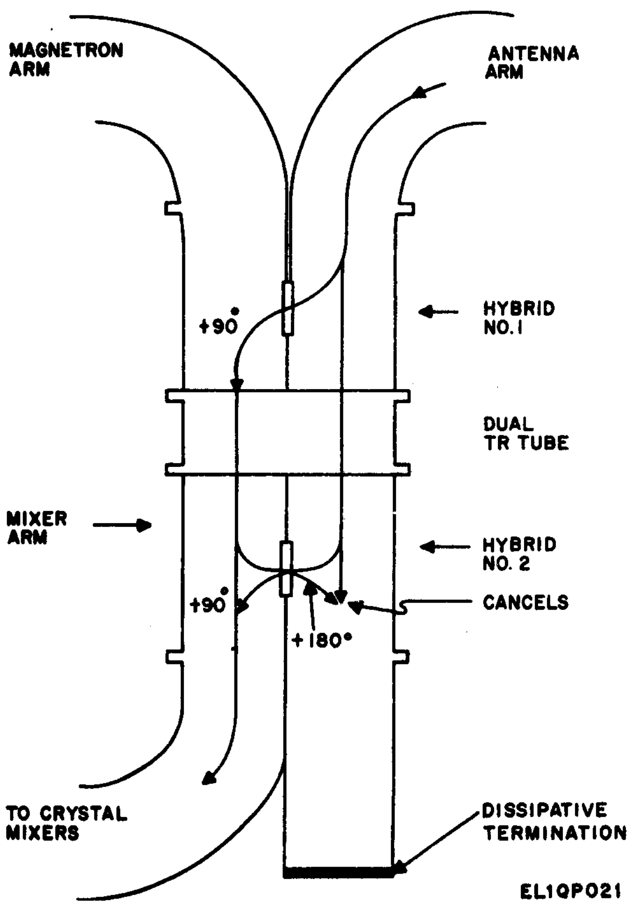


Figure 2-21. Duplexer receive operation.

(2) The portion of the energy that continued straight down the antenna arm reaches short slot hybrid No. 2 where it encounters energy, shifted 180°, entering from the mixer arm. Since no shift has taken place in the antenna arm, the two signals are 180° out of phase and cancel.

(3) The rf energy in the mixer arm continues toward the crystal mixers. To reach the mixers, the received rf energy passes through short slot hybrid No. 4 (fig. 2-19) where it mixes with the injected local oscillator signal coming from short slot hybrid No. 3. Hybrid No. 4 functions in the same way as the two discussed in (1) and (2) above. Hybrid No. 3 is discussed in paragraph 2-19a(2).

g. Directional Coupler CU-399/MPQ-4A.

(1) *General.* During normal operation, the directional coupler may be considered as a section

of waveguide. The directional coupler used is a dual directional coupler the lower arm (transmit coupler) is used to sample transmitted energy for echo box operation; the upper arm (receiver coupler) is used at higher maintenance echelons to perform VSWR testa of the scanner and rf components.

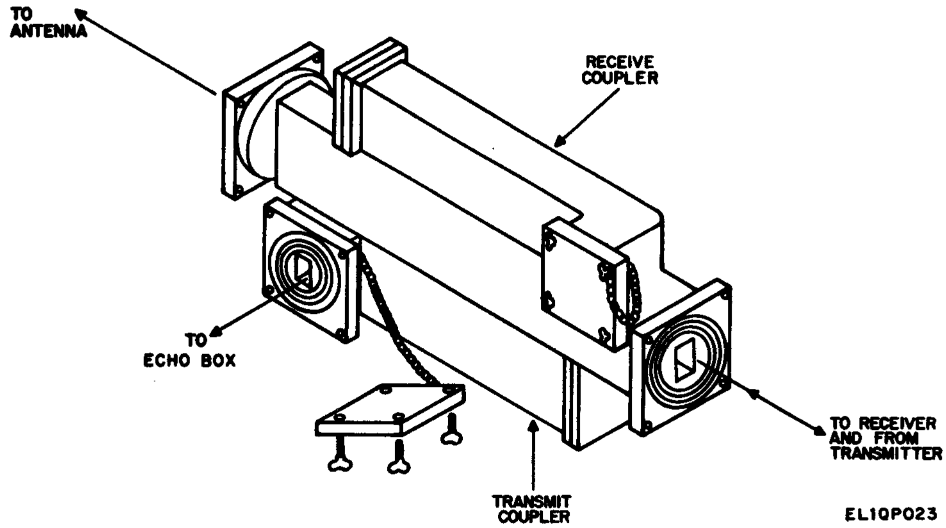


Figure 2-23. Directional Coupler CU-399/MPQ-4A.

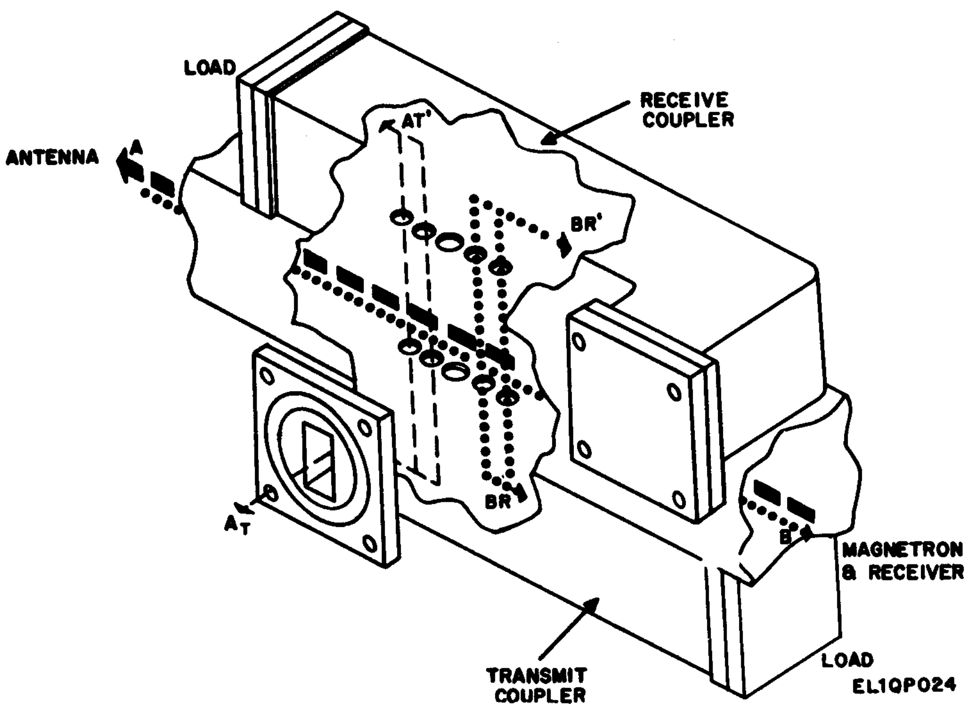


Figure 2-24. Directional coupler pictorial diagram.

(2) *Operation of coupler* (fig 2-24). Coupling between the waveguide section of the directional coupler and the coupler section is accomplished by slots (holes). The slots are positioned so that energy traveling in one direction in the waveguide section will be directed toward the output coupling, and energy traveling in the opposite direction in the waveguide section will be directed toward the load (nonreflective dissipative surface). The two coupler (receive end transmit) sections have their coupling slots so arranged that energy will be coupled to the output of the receive coupler when the energy is passing from the antenna to the receiver. Energy will be coupled to the output

of the transmit coupler when energy is passing from the magnetron to the antenna. Transmitted energy, represented by the heavy broken line (A, fig. 2-24), is coupled to the transmit coupler through the slots in the coupler. The position of the slots is such that the energy coupled through them will continue in the same direction as the transmitted energy. Since the energy continues in the same direction, an output, A_T (20 decibels (db) below energy A traveling along the waveguide), will appear at the output coupling of the transmit coupler arm; in the receive coupler, the operation will be identical for energy A_T1; however, the direction now couples the energy, A_T1; into the dissipative load where it is absorbed. Received energy, represented by the dotted line (B, fig. 2-24), is coupled to the couplers the same way the transmitted energy (A, fig. 2-24) is coupled. The energy, B_R, coupled into the transmit coupler is directed toward the load and dissipated, and energy B_R^1, is directed toward the output coupling of the receive coupler (in normal operation, this output coupling is capped and the energy is dissipated bv the cap) where it is used to make VSWR checks of the antenna system.

(3) *Operation of receive arm with echo box* (fig. 2-24). When the echo box is tuned to the transmitted frequency, it will return a portion of the energy it receives to the directional coupler. Echo box operation is discussed in detail in paragraph 2-16. This energy coming into the coupler will follow the same path, in reverse, that the transmitted energy did, and the echo box energy will be directed toward the magnetron and receiver.

h. Scanner.

(1) *General.* The scanner, in conjunction with the reflector, provides two narrow beams of rf energy which scan a 25° azimuth sector. The two beams of rf energy are displaced from each other by approximately 2° in elevation, and the beam width, in azimuth, is approximately 10. The scanner causes one beam to sweep or scan the 25° azimuth sector, switches to the other beam, and causes the other beam to scan a 25° azimuth sector. Each beam scans the 25° azimuth sector at the rate of 17 times per second.

(2) *Construction.* The scanner is cone-shaped and has two principal parts: the rotor and the stator (fig. 2-25). The conical rotor contains a slotted line (slotted waveguide) and a rotor tooth barrier. The conical stator consists of a lower cover, a waveguide shell, two upper covers, and the upper and lower feedhoms. The space between the rotor and the waveguide shell, between the rotor and the lower cover, and between the waveguide shell and the upper covers form the wave path for rf energy within the scanner. Since the parts making up the stator and the rotor are cone-shaped, a fixed dimension exists between the various parts along the entire length of the scanner. Rf energy enters the rotor through a rotary joint in the large end of the scanner and is fed to the slotted waveguide through a section of rigid waveguide.

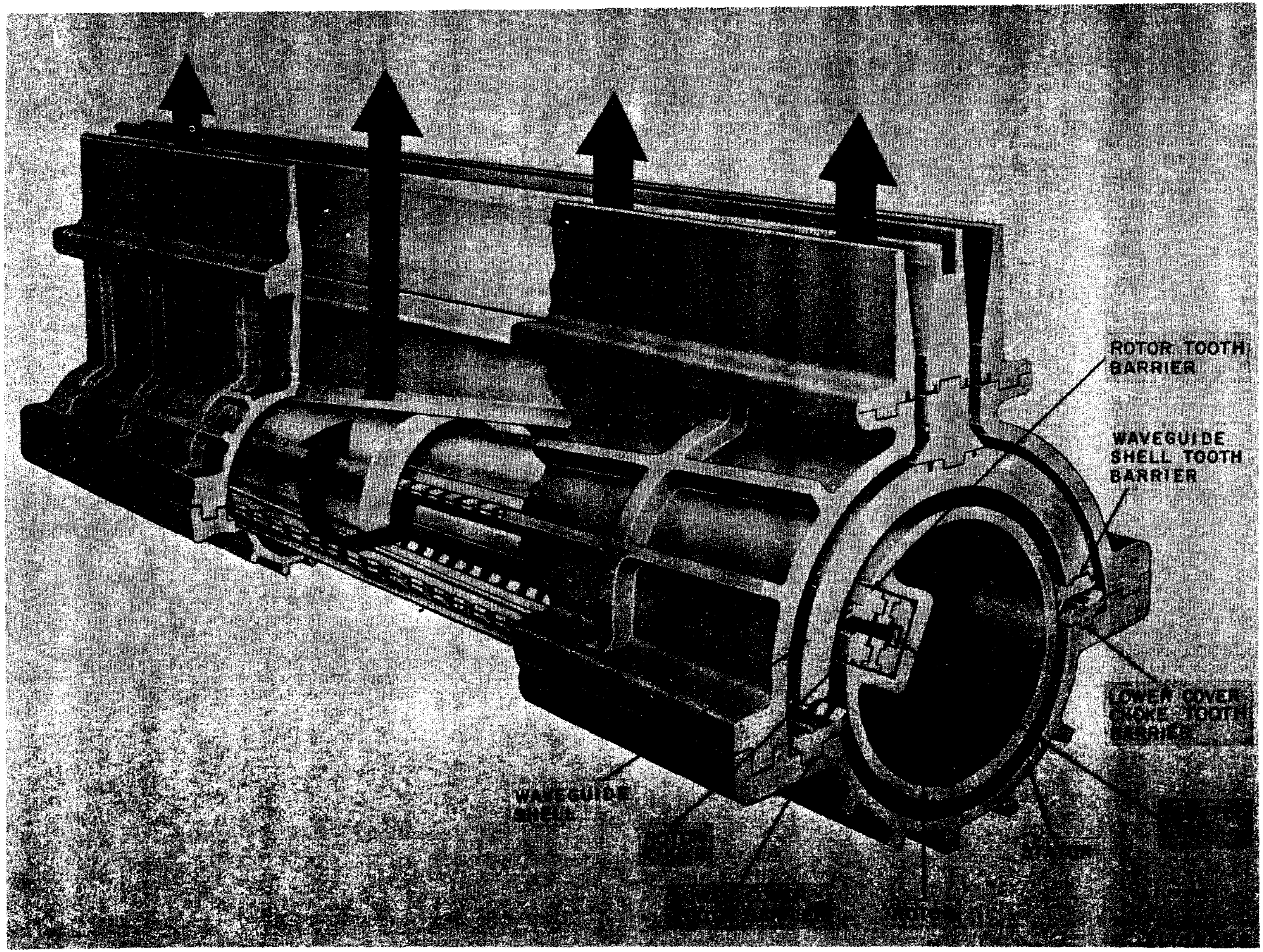


Figure 2-25. Scanner, pictorial diagram.

(a) Slotted waveguide. The slotted waveguide is a section of waveguide with slots cut into the wide side. The slots are spaced a half-wave length apart and are staggered on either side of the centerline. Since each slot may be considered to be a dipole oriented perpendicular to the slot, the entire slotted waveguide may be considered to be an array. With the half-wave spacing, the slots would normally be excited 180° out of phase, but staggering them on either side of the center line results in another 180° phase shift so that each slot is in phase with the others in the array. The energy from the slots combine to form a common wave front which is vertically polarized and is offset from the reflector by approximate 12.5° at the beginning and end of each scan.

(b) Tooth barriers. Three tooth barriers in the scanner guide the rf energy into the correct path through the scanner. One tooth barrier is mounted on the rotor, one on the waveguide shell, and one on the lower cover. The slots on the teeth are less than ½ wavelength; therefore, they present a maximum impedance to rf energy. The slots in the rotor tooth barrier and the slots in the other tooth barriers are spaced so that the teeth of the rotor tooth barrier pass through the slots of the other barriers when the rotor is in motion.

i. Beam Separation. The positions of the two feedhoms with respect to the reflector cause the upper beam and the lower beam to be separated by 2° in elevation. The position of the rotor determines which beam is transmitted at any given time. The rf energy propagated by the slotted line is directed into the scanner. The rf energy reaches the rot or tooth barrier which directs the energy in the proper direction (fig. 2-25). As the rotor rotates from the 0°, the rf energy will pass through the space between the rotor and the waveguide shell. The space between the rotor and waveguide shell acts as a waveguide, the length of which decreases as the rotor turns. Rf energy passes through the space between the rotor and waveguide shell until it strikes the lower tooth barrier. The lower cover tooth barrier acts as a high impedance to the energy traveling toward the lower cover. Consequently, the energy is directed toward the opening between the waveguide shell and the upper cover. As the rf energy is directed into the space between the waveguide shell and upper cover, it passes an rf choke which prevents impedance mismatches at the turn. The rf energy passes through the waveguide formed by the waveguide shell and the upper cover and is directed ito the lower feedhorn. Three rf chokes are included in the path to eliminate impedance mismatches and discontinuities. The lower feedhorn forms the rf energy into a beam and directs the beam toward the reflector. As the rotor rot ates from 0° to 180°, rf energy is directed into the lower feedhorn and the upper beam is propagated into space. W-hen the rotor reaches 180° of rotation, the rotor tooth barrier meshes with the waveguide shell tooth barrier, the magnetron is blanked, and no energy is propagated until the tooth barriers are out of mesh. As the rotor moves from 180° to 360°, rf energy is directed into the upper feedhorn by the rotor tooth barrier and the waveguide shell tooth barrier during which time the lower beam is propagated.

j. Formation of Azimuth Scan.

(1) *General.* The scanner electrically sweeps a 25° azimuth sector by varying the angle formed between the reflector and the radiating slotted waveguide. The scanner rotor is shaped like a cone which has vertex angle of 25°. A slotted waveguide is mounted along the length of the cone (A, fig. 2-26). As the rotor moves the slotted waveguide from 0° to 90° to 180° (A, fig. 2-26), the difference in path length for the wave front at the large end of the rotor and the path length for the wave front at the small end of the rotor decreases. The angle" at which the wave front strikes the reflector changes from 0° to 180°. As the scanner (rotor) rotates counterclockwise from 0° to 90° to 180°, the difference in wave path between the large end and the small end decreases, which causes the beam to scan from left to right, when. viewed from the rear of the reflector.

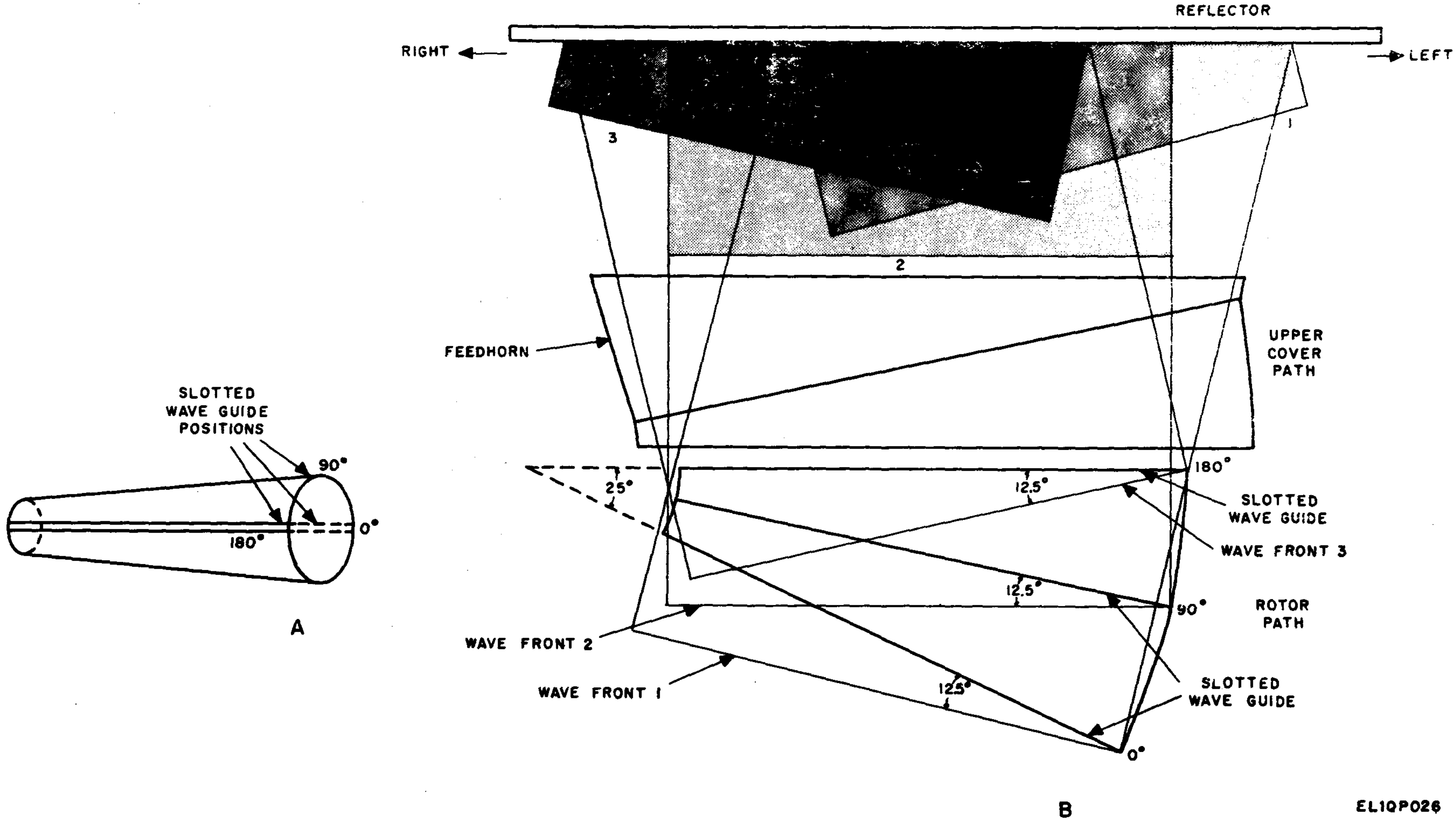


Figure 2-26. Formation of scan.

(2) *Functioning of scan.* For ease in discussion, the rotor has been shown as if it were bisected lengthwise and rolled flat (B, fig. 2-26). The angle of the wave front, with respect to the reflector, changes as the rotor revolves; therefore, the energy is reflected at a constantly changing angle during each 180° of rotation of the rotor.

(a) Condition of scan at rotor position 2. When the rotor is positioned with the slotted waveguide at 0° (B, fig. 2-26), the wave front strikes the reflector at an angle of 12.5° (from dead ahead). Since the wave front is reflected at the same angle as the angle at which the wave front strikes the reflector, the energy will be reflected 12.5° to the left.

(b) Condition of scan at rotor position 2. As the rotor revolves from 0° to 90°, the reflected energy will scan from left to right. When the slotted waveguide reaches 90°, the wave front is perpendicular to the reflector; therefore, the energy is directed straight ahead.

(c) Condition of scan at rotor position 3. When the slotted waveguide reaches 180°, the radiated wave front strikes the reflector at such an angle that the energy is reflected at an angle 12.5° to the right. Thus, when the rotor revolves the ‘slotted waveguide from position 1 to position 3, the beam has scanned a 25° sector; that is, a 12.5° sector left of dead ahead and a 12.5° sector right of dead ahead. The other beam scans in the same way.

k. Circular Polarizer MX-2219/MPQ-4A.

(1) *General.* The circular polarizer is used to reduce the radar return from rain or suspended moisture which appears as clutter on the indicator screen. The circular polarizer changes the polarization of the transmitted radiation and filters the reflected wave so that reflections from smooth regular objects, such as raindrops, do not appear on the indicator screen. Sharp edges and angles of mortar shell fins distort reflected radio energy so that the reflected energy will be detected by the radar set. The circular polarizer for the AN/MPQ-4A is in the form of a cylindrical sector which covers the feedhoms so that all radiated energy passes through it. The polarizer is constructed of thin aluminum slats, oriented at 45° to the incident voltage vector from the horns, and spaced and supported by dielectric strips (fig. 2-27). This assembly is further protected and weatherproofed by fiberglass laminated skins on both inside and outside surfaces.

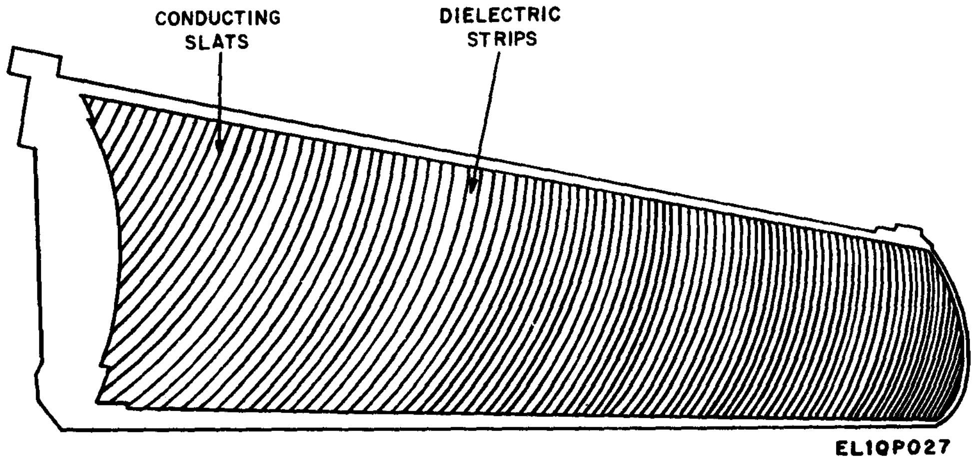


Figure 2-27. Circular Polarizer MX-2219/MPQ-4A.

(2) *Operation.*

(a) The effect of a small section of the polarizer on an incident vertically polarized wave is shown in figure 2-28. The incident wave is shown for an instant of time. The incident wave connects the tips of all the voltage vectors along the direction of propagation.

(b) The vertically polarized wave is equivalent to the resultant of two waves whose polarizations are perpendicular and parallel to the slots or the polarizer. These components are illustrated by dotted lines in figure 2-28.

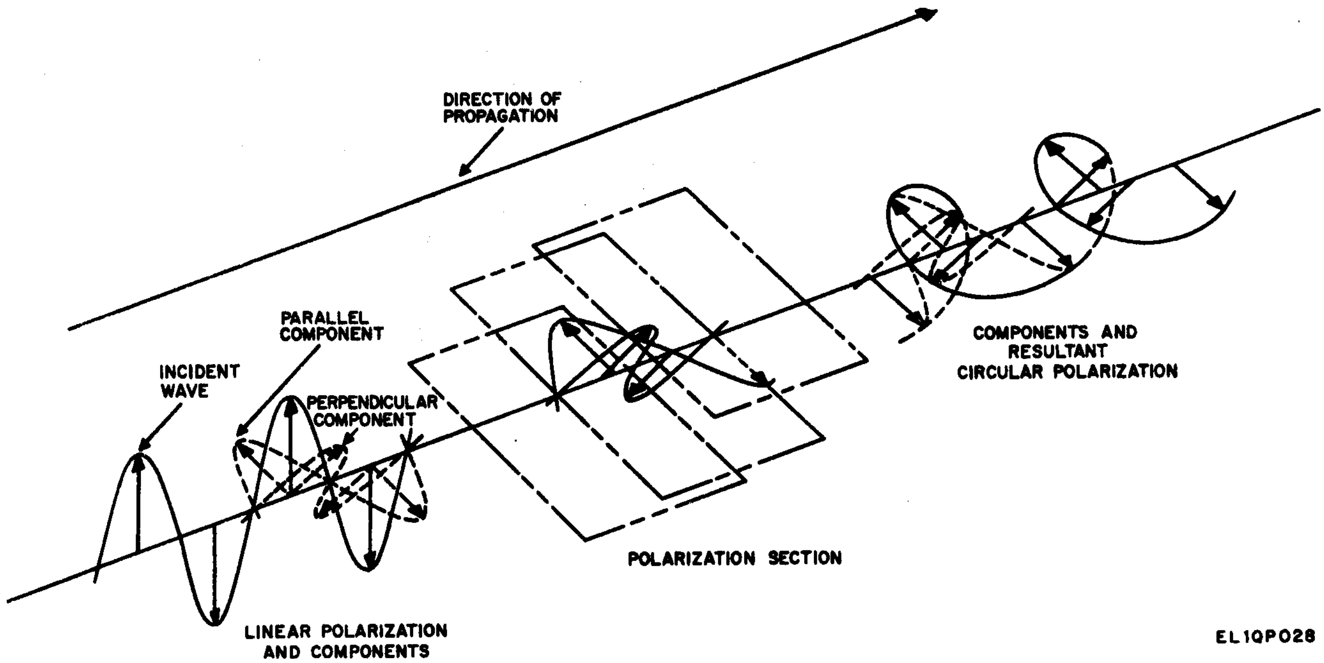


Figure 2-28. Phase relationships through circular polarizer.

(c) Within the polarizer itself, the propagation velocity. is different for the two incident wave components. The thickness of the polarizer has been chosen so that the perpendicular wave component undergoes exactly 1 cycle of phase shift (1 wavelength) in passing through, while the parallel component undergoes a 270° phase shift (3/4 wavelength). As a result, the two emerging wave components are at 90° with each other in both polarization and phase. Adding the two resulting components, which is automatically done at the outer surface of the polarizer, a circularly polarized wave is obtained. In other words, the radiated vector is constant in amplitude along the direction of propagation, but its polarization is continuously changing so as to make 1 full revolution every wave-length. The tips of the vector shown on the diagram describe a helix similar to that of a left-hand screw thread.

(d) The operation of the polarizer is reversible; therefore, if a left-hand circular wave were received from the right, a linear vertical output polarization would emerge at the left. This would be detected by the radar set in the normal manner. If a right-hand circular wave is received, the resulting linear output polarization would be horizontal, and the signal would not be detected by the vertically polarized feedhorns.

(e) The importance of this polarization characteristic lies in the manner in which objects of various shapes reflect a circularly polarized wave. If the object is symmetrical or has no sharp comers or edges and all radii of curvature are much larger than a wave length (raindrops or artillery shells), the reflected wave will be circular, but will have the opposite rotation from the incident wave. As a result, the echoes from clouds, rain, and even normal artillery shells will not be detected by the radar when the circular polarizer is in place.

(f) The effect of sharp edges (such as mortar shell fins) is to reflect predominately one linear component of the incident wave. This reflected linear component will be converted by the polarizer to circular polarization at the feedhorn. The vertical component of this wave will be detected by the radar.

(g) The overall effect of the polarizer on any echo is reduction in magnitude or in maximum detection range. This reduction is not as severe for mortar shells as for rain. Since the use of the polarizer reduces the maximum detection range of a mortar shell by about 40 percent, it should not be used unless serious atmospheric clutter is present.

l. Tuned Cavity FR-111/MFQ-4A.

(1) *General.* The echo box, Tuned Cavity FR-111/MFQ-4A, is provided as a means of testing the operation of the radar set. The echo box consists of a resonant cavity, a waveguide, a detector, and a meter. Energy is coupled from the directional coupler to the tunable cavity by a waveguide section (fig. 2-29). When the cavity is tuned, the energy within the cavity is detected and coupled to the meter.

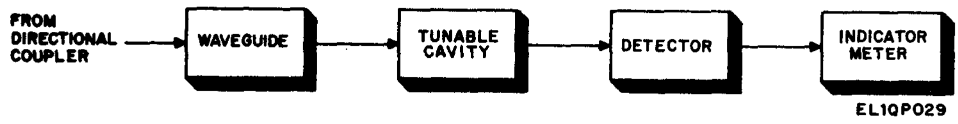


Figure 2-29. Echo box block diagram.

(2) *Operation of echo box.* Energy from the directional coupler is applied to the cavity of the echo box through a section of waveguide (fig. 2-29).

(a) Tunable cavity (fig. 2-30). The resonant cavity is tuned by moving the plunger (fig. 2-31) until the cavity is resonant at the operating frequency. The plunger is moved in the cavity by a screw and bellows. A did is attached to the screw and the frequency is read from the dial. When the cavity is tuned to the operating frequency, energy is stored in the cavity during the pulse interval. The energy stored in the cavity is coupled back to the receiver and displayed on the indicator for a measurement of the *ringtime* of the echo box. A small portion of the energy stored in the cavity is applied to the crystal detector.

(b) Crystal detector and meter. A small portion of the energy stored in the cavity is applied to the crystal detector through a hole in the wall of the cavity. The detector recfities the energy from the cavity and applies dc voltage to the meter. Since the meter responds to the instantaneous level of the transmitted pulse, the relative power of the transmitter can be plotted.

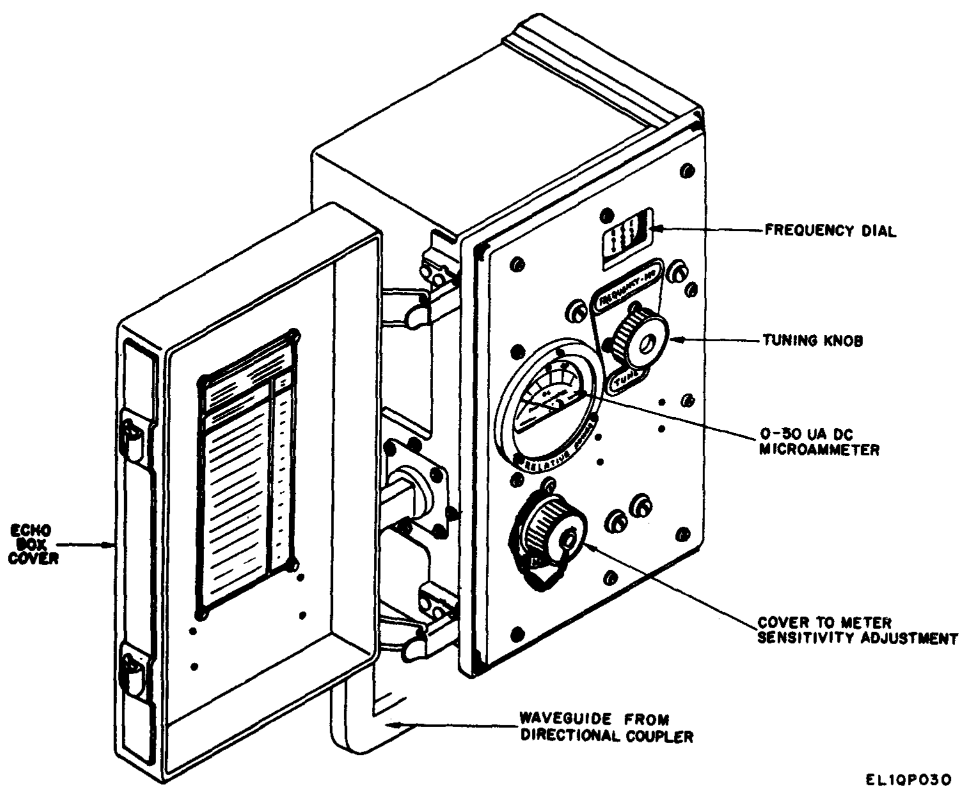


Figure 2-30. Echo box, pictorial diagram.

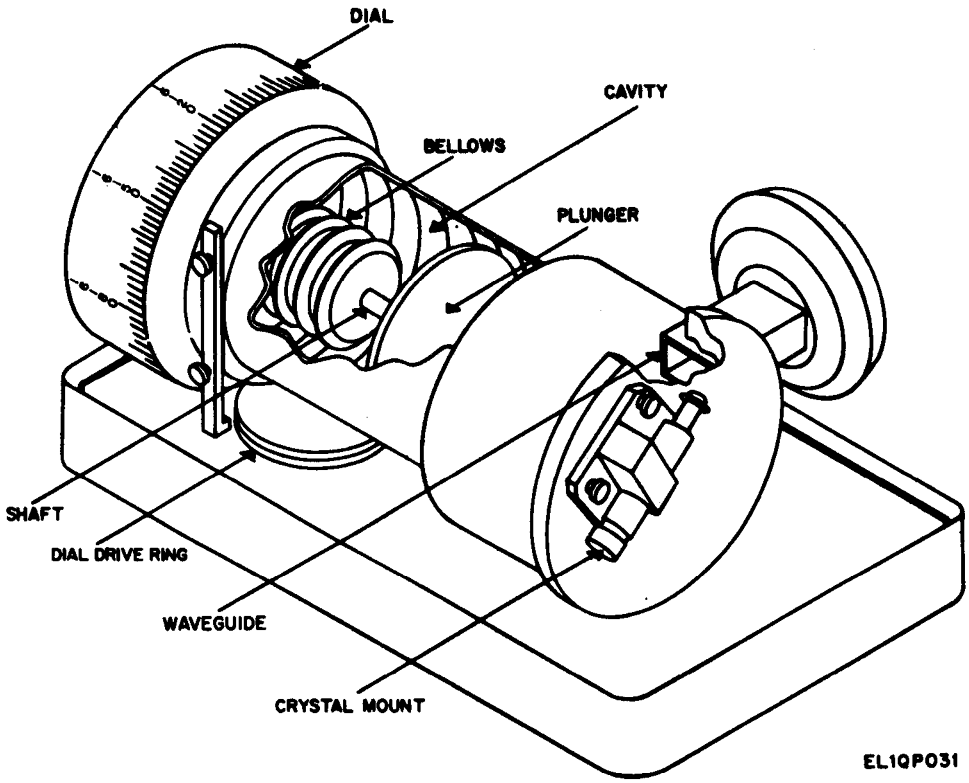


Figure 2-31. Echo box, construction diagram.

Section IV. RECEIVING SYSTEM

2-17. General

a. The receiving system amplifies and converts the weak echo signals into a suitable wave shape for presentation on the indicator screen. The receiving system consists of a local oscillator, a mixer, an if. amplifier, an afc assembly, and an stc assembly.

b. The relationship of the receiving system with respect to other functional systems of the radar set is covered in section II.

2-18. Receiving System, Block Diagram (fig. FO-3)

a. Mixer and Frequency Converter. Echo pulses from the antenna are applied to the mixer portion of the duplexer. Local oscillator V1501 produces a signal which is 30 megaHertz below the received frequency. The local oscillator frequency is controlled by the klystron cavity and by the repeller voltage of the klystron. The primary frequency of the local oscillator (klystron) is determined by the klystron cavity. The size of the cavity is changed by klystron drive assembly B1501. Minor adjustments in klystron frequency are made possible by varying the repeller voltage. Repeller voltage is changed by the afc assembly. The signal from the klystron beats with the incoming pulse to produce an intermediate frequency which is 30 megaHertz. Mixing of the local oscillator frequency with the incoming frequency takes place in balanced mixers CR1501 and CR1502. The intermediate frequency is applied to the if. amplifier. Refer to figure FO-3.

b. If. Amplifier. The first two stages, V1201 and V1202, of the intermediate frequency amplifier form a low-noise, or cascode amplifier. The low-noise stages allow a large amplification with very low noise. If. amplifier stages V1203, V1204, and V1205 are normal-tuned if. amplifier stages. Rangemarks, when desired, are applied to the input of if. amplifier V1203 from the afc amplifier (c below). A negative pubs is applied to the grids of V1204 and V1205 to decrease the sensitivity of the if. amplifier for a given period of time and to prevent overloading of the if. amplifier due to strong echo signals caused by near-by objects. This negative pulse is generated by the stc assembly (d below). If. amplifier stages V1206 through V1209 form a linear-logarithmic (lin-log) amplifier circuit. When a normal signal is received, the lin-log amplifier stages act as normal if stages, the output is detected by detector CR1201, amplified by video amplifier V1210, and transmitted to the indicating system by cathode follower V1211. When a strong signal is received, V1209 saturates and the signal is grid-detected. The signal detected by V1209 is transmitted by a delay network to video amplifier V1210 where it reinforces the signal from CR1201. If the received signal is very strong, V1208, V1207, and V1206 will saturate in turn and act as video detectors. The detected signal is transmitted to V1210 by a delay line.

c. Afc Assembly. A portion of the transmitted pulse is mixed with the local oscillator frequency in afc crystal CR1503. The resulting intermediate frequency is applied to the afc circuit. The first stage, V1301, is a normal if. amplifier with two outputs. The first output is applied to range calibration output V1302. The amplified pulse from V1302 is applied to delay crystal DL1301, which produces and applies accurately spaced range markers to the if. amplifier. The second output of V1301 is applied to if. amplifier V1303. The output of V1303 is coupled to discriminator V1304. If the frequency applied to V1304 is exactly 30 megaHertz, no output is produced by V1304. If the applied frequency is above or below 30 megaHertz, an output is applied to pulse amplifier V1305. Pulse amplifier V1305 amplifies the output of V1304 and applies the output pulses to pulse stretcher V1308. Pulse stretcher V1308 makes the pulse wider and applies the pulse to afc output V1306. Oscillator V1307 acts as a search oscillator. It sweeps the repeller voltage and lets it lock on if the klystron frequency is within ±10 MHz of the magnetron frequency.

d. Stc Assembly. A positive trigger input from the synchronizing system is applied to first pulse amplifier V4701A. The trigger pulse is amplified and inverted by first and second pulse amplifiers V4701A and V4701B and applied to charging amplifier V4702B. The charging amplifier produces a sharp negative pulse which is applied to stc cathode follower V4702B. The output of V4702B is negative pulse with a flat portion and is applied to if. amplifier stages V1304 and V1305 to reduce the sensitivity of the if. amplifier for a given range. Dc restorer CR4703 clamps the stc output to a dc level set in by the if. gain control.

2-19. Electronic Function, Receiving System

a. Frequency Converter. The frequency converter produces an intermediate frequency, which is 30 megaHertz. (L.O. is tuned 30 HZ below the magnetron frequency). The intermediate frequency is produced by beating the local oscillator frequency against the echo signals.

(1) *Local oscillator V1501.*

(a) General. Local oscillator V1501 is a reflex klystron with an externally tuned cavity. The cavity is tuned by klystron drive motor B1501. The repeller voltage is controlled by three potentiometers which are in the plate circuit of afc output tube V1306.

(b) Circuit functioning (fig. 2-32). The control grid of klystron V1501 is held at a positive potential with respect to the cathode. Electrons leaving the cathode are accelerated toward the cavity by the positive control grid. The electrons pass through the resonant cavity toward the repeller plate. The repeller has a negative potential and forces the electrons back toward the cavity grids. The electrons, passing through the cavity, cause an alternating electric field to be developed between the cavity grids. Electrons from the cathode, which reach the cavity when the ac voltage on the cavity grids goes through zero, encounter no electric field and travel through the cavity at normal velocity. Electrons reaching the cavity when the cavity voltage is positive, are accelerated, and those passing through the cavity, when the field is negative, are decelerated. The accelerated electrons go closer to the repeller before they are repelled. The acceleration and deceleration of the electrons cause the electrons to reach the cavity in bunches. The bunches of electrons reach the cavity at the proper time to be decelerated by the cavity grids. The energy is given up to the cavity and transmitted to the mixer by waveguide. The size of the cavity determines the frequency of the klystron. The klystron can be made to operate in several different modes; however, each mode depends on the difference between the repeller voltage and the cavity grid voltage.

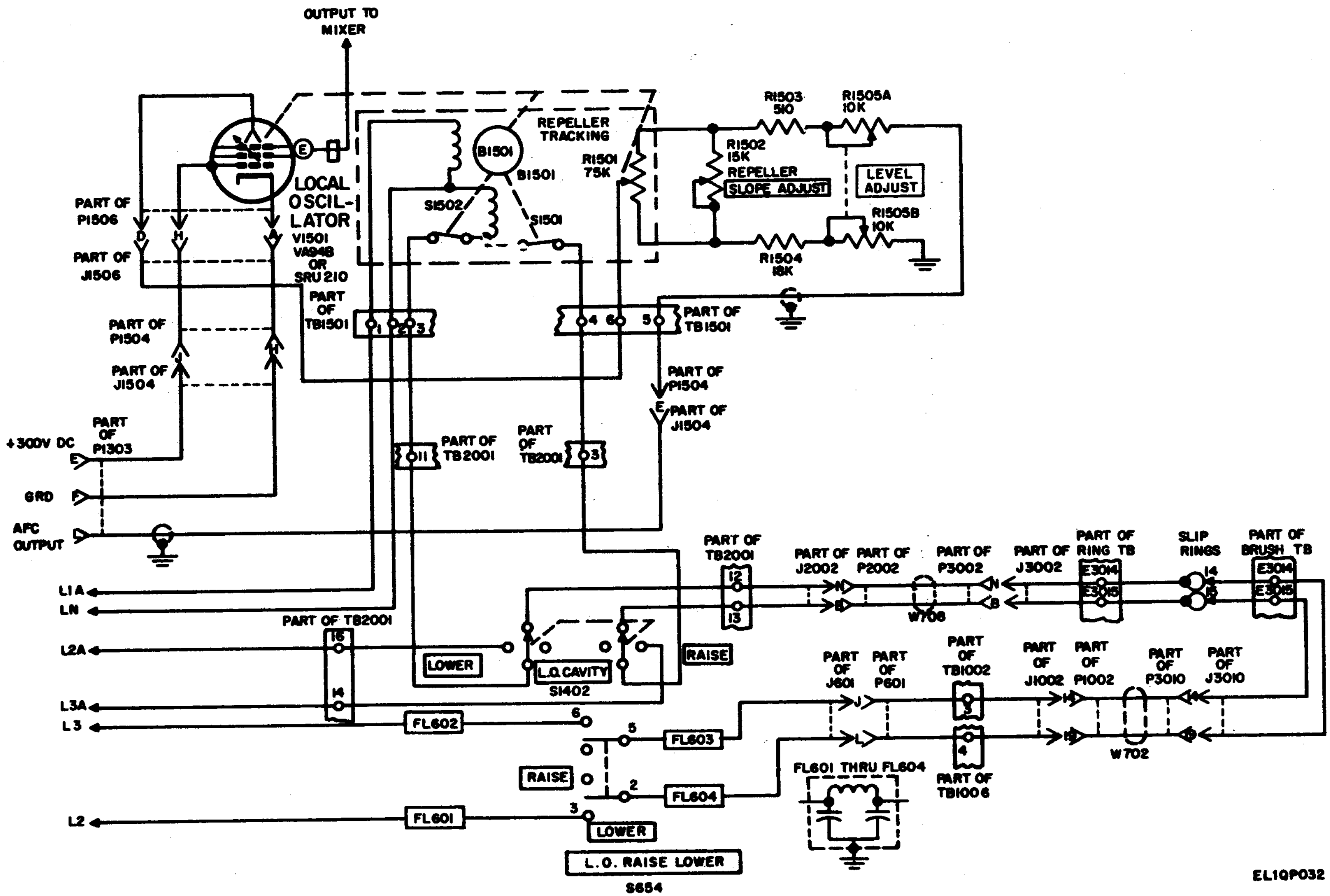


Figure 2-32. Local oscillator V1501, klystron drive motor B1501, and repeller adjustment circuit, schematic diagram.

(c) Klystron tuning. Klystron V1501 is tuned to the center frequency. The frequency can be raised or lowered by changing the size of the cavity. Small adjustments in frequency can be made by varying the repeller voltage.

1. Klystron drive motor B1501. Klystron drive motor B1501 is a two-phase reversible ac motor. Klystron drive motor B1501 is coupled to the klystron cavity so that the cavity is set at the center frequency. When L.O. CAVITY switch S1402 is placed in the RAISE position, phases L3A and L1A are applied to the motor windings. The motor will turn to raise the klystron frequency. Klystron drive motor B1501 can be energized by either L.O. CAVITY switch S1402 or L.O. switch S654. Switches S1501 and S1502 are mechanically connected to the motor shaft so that the switches will open when the motor reaches the limit of rotation. Repeller tracking potentiometer R1501 is mechanically connected to the shaft of B1501. As klystron drive motor R1501 rotates, the voltage across repeller tracking potentiometer R1501 varies and the voltage on the repeller plate varies with the size of the cavity.

2. Repeller adjustment circuit. The afc output is applied to the klystron repeller plate through an adjustment network consisting of R1501, R1402, R1503, R1504, and R1505. Repeller SLOPE ADJUST potentiometer R1502 adjusts the range of voltage applied to the repeller plate. Resistors R1503 and R1504 are voltage-dropping resistors for R1501. LEVEL ADJUST potentiometer R1505A and R1505B adjusts the level about which the voltage on the repeller plate can be varied by R1502.

(2) *Mixers CR1501, CR1502, and CR1503.* The local oscillator signal is injected through two short slot hybrida to receiver balanced mixers CR1501 and CR1502 and afc mixer CR1503. The amount of local oscillator energy injected into the mixers is controlled by an attenuator in the waveguide coupling assembly. Hybrid No. 3 of the duplexer (para 2-16d) differs from the other three hybrids in the way it divides the injected local oscillator signal; two-thirds of the signal pass toward the receiver mixers and one-third passes through the slot to the afc mixer.

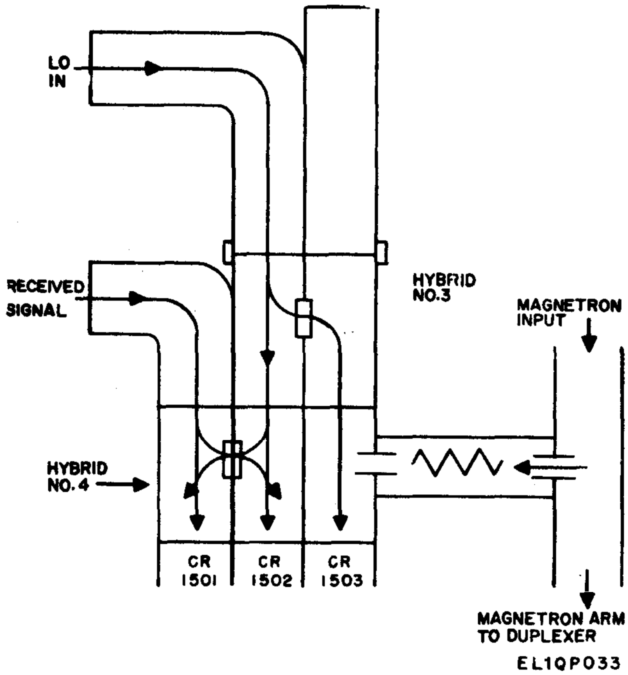


Figure 2-33. Receiver and afc mixer assembly.

b. Intermediate Frequency Amplifier AM-1538/MPQ-4A. The if. amplifier amplifies the weak echo signals from the mixer until the signals are strong enough to operate the indicator. The use of 'in-log amplifier stages prevents strong signals from blocking the amplifier.

(1) *Low-noise amplifier V1201 and grounded grid amplifier V1202.*

(a) General. Low-noise amplifier V1201 and grounded grid amplifier V1202 comprise a low-noise amplifier circuit, which uses two cascode connected triodee. A cascode amplifier has the ga of a pentode amplifier without the noise figure of a pentode. Low noise is important in a receiver front end because noise can mask echo signals.

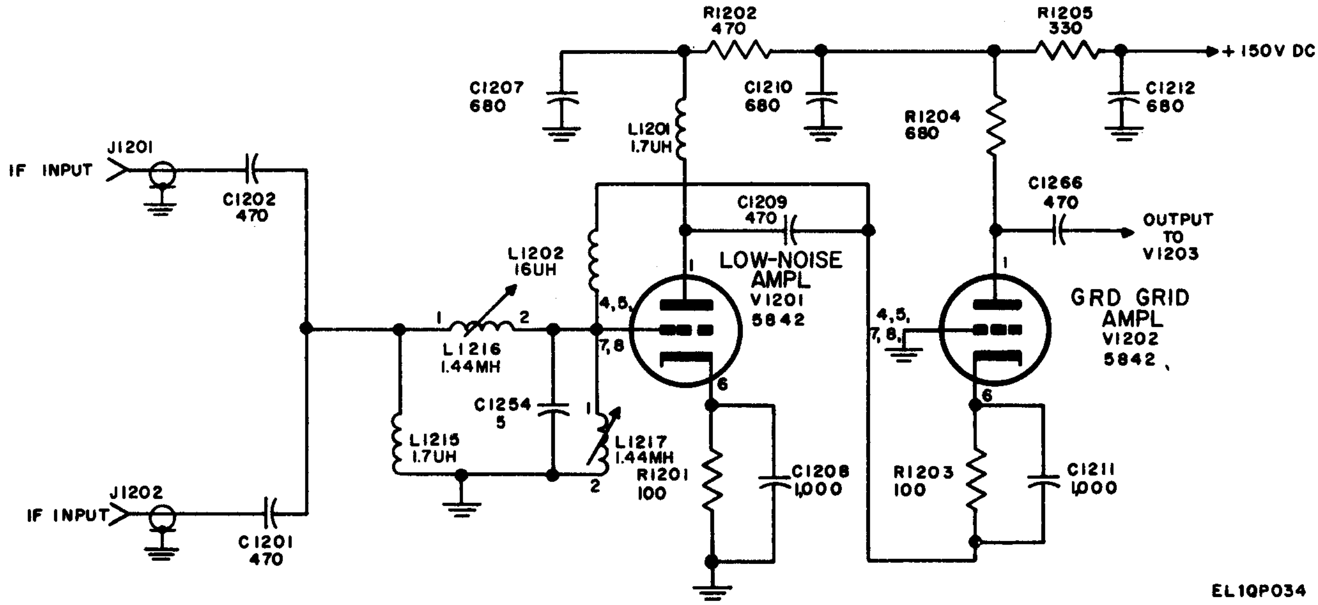


Figure 2-34. Low-noise amplifier V1201 and grounded grid amplifier V1202, schematic diagram.

(b) Circuit functioning. The 30-MHz signal from the mixers ia applied to the grid (pina 4, 5, 7, and 8) of V1201 through coupling capacitors C1201 and C1202 and a pi-network consisting of inductors L1215, L1216, L1217, and capacitor C1254. The pi-network is used to match the impedance of the crystal mixer to the grid of V1201. The amplified output voltage is developed across plate load inductor L1201 and applied to the cathode circuit of V1202 through capacitor C1209. A portion of the output signal is fed back to the grid through inductor L1202 to neutralize the tube and prevent oscillation. Cathode bias ia furnished by R1201. Capacitor C1208 is a bypass capacitor. The output of V1202 is applied to grounded grid amplifier V1202, which presents a low impedance amplifier V1201. The low impedance presented to V1201 loads V1201 very heavily, causing the voltage gain to be low and the stage to be very stable. Input voltage to V1202 is applied through cathode resistor R1203 and bypass capacitor C1211. Output voltage ia developed across plate load resistor R1204 and applied to if. amplifier V1203 through coupling capacitor C1266. Capacitors C1207, C1210, and C1212 and resistors R1202 and R1205 form an interstage decoupling network.

(2) *Normal if. amplifiers.*

(a) If. amplifier V1203 (fig. 2-35). The if. signal from V1202 ia developed across grid inductor L1218 and applied to the grid (pin 1) of if. amplifier V1203. The output of V1202 and the grid circuit of V1203 are tuned by inductance L1218. When desired, rangemarks from the afc assembly are applied to the grid of V1203. Resistor R1206 is the rangemark terminating resistor and resistor R1248 is a decoupling resistor. Cathode bias is developed across resistor R1207 which is bypassed by capacitor C1213. An amplified signal is developed across plate load resistor R1208 and applied to the primary of transformer T1201 through coupling capacitor C1214. Resistor R1209 and capacitor C1215 form a decoupling network.

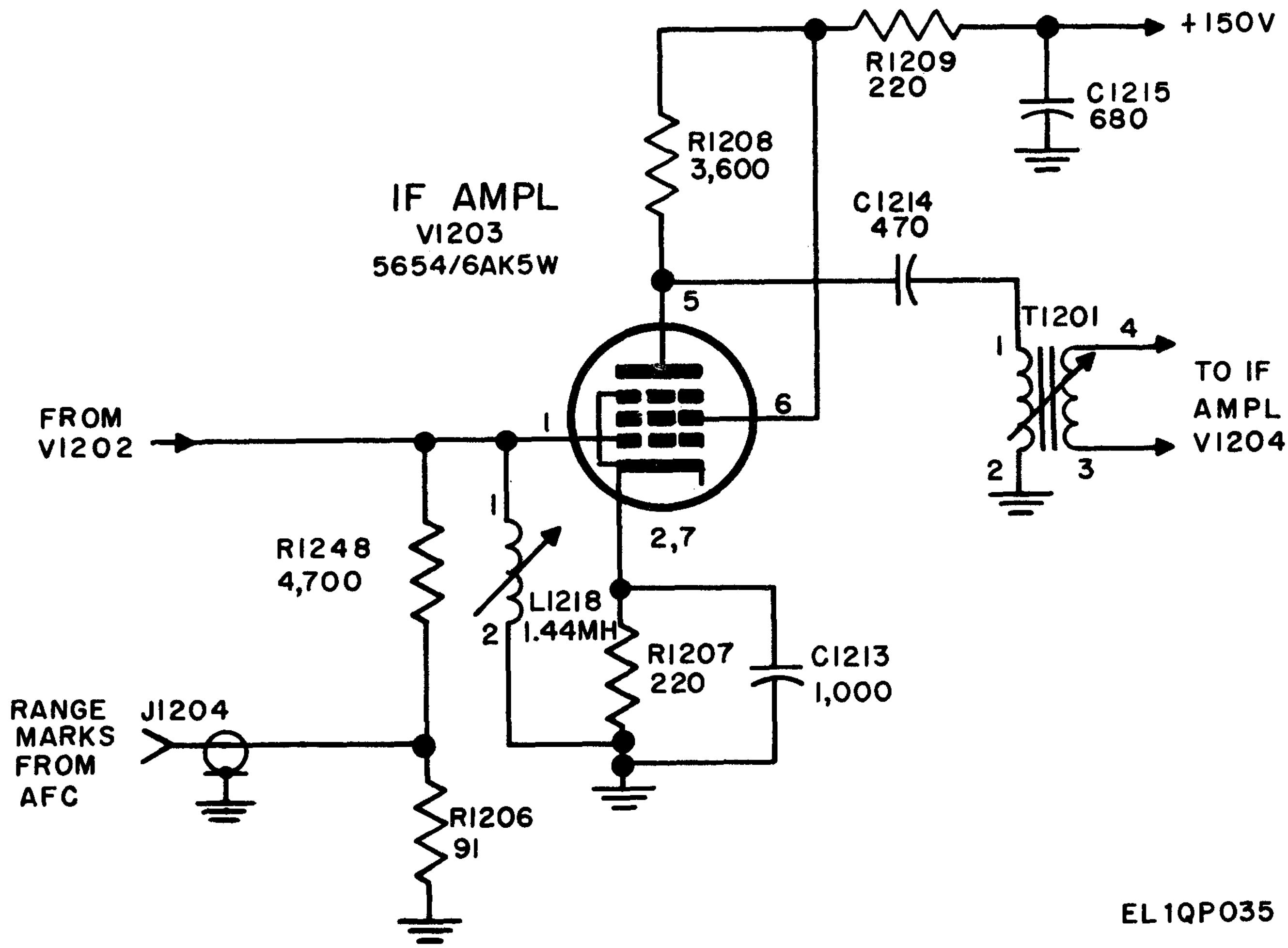


Figure 2-35. If. amplifier V1203, schematic diagram.

(b) If. amplifiers V1204 and V1205 (fig. 2-*36*). Signal voltage from V1203 applied to the grid (pin 1) of if. amplifier V1204 through transformer T1201. Resistor R1241 is connected across the secondary of T1201 to broaden the band pass of T1201. Stc and gain control voltages are applied to the grids of if. amplifiers V1204 and V1205 through decoupling networks consisting of resistors R1210 and R1214 and capacitors C1216 and C1220. The signal amplified in V1204 is applied to V1205 through coupling capacitor C1218 and slug-tuned interstate transformer T1202. Resistor R1242 is a grid resistor and broadens the band-pass characteristics of T1202. Bias for V1204 is furnished by cathode resistor R1211 and cathode bypass capacitor C1217. Signal voltage is developed across plate load resistor R1212. Cathode bias for V1205 is furnished by cathode resistor R1215 and cathode bypass capacitor C1221. Output signal voltage, developed across plate load resistor R1216, is applied to the primary of slug-tuned interstate transformer T1203 through coupling capacitor C1222. Inductor L1203, resistor R1213 and capacitors C1219 and C1223 form decoupling networks for V1204 and V1205. Stc and if. gain are introduced through J1206. The dc grid returns for V1204 and V1205 are provided by resistor R4715, which is located in the stc chassis. Capacitor C1272 suppresses radio frequency interference (RFI).

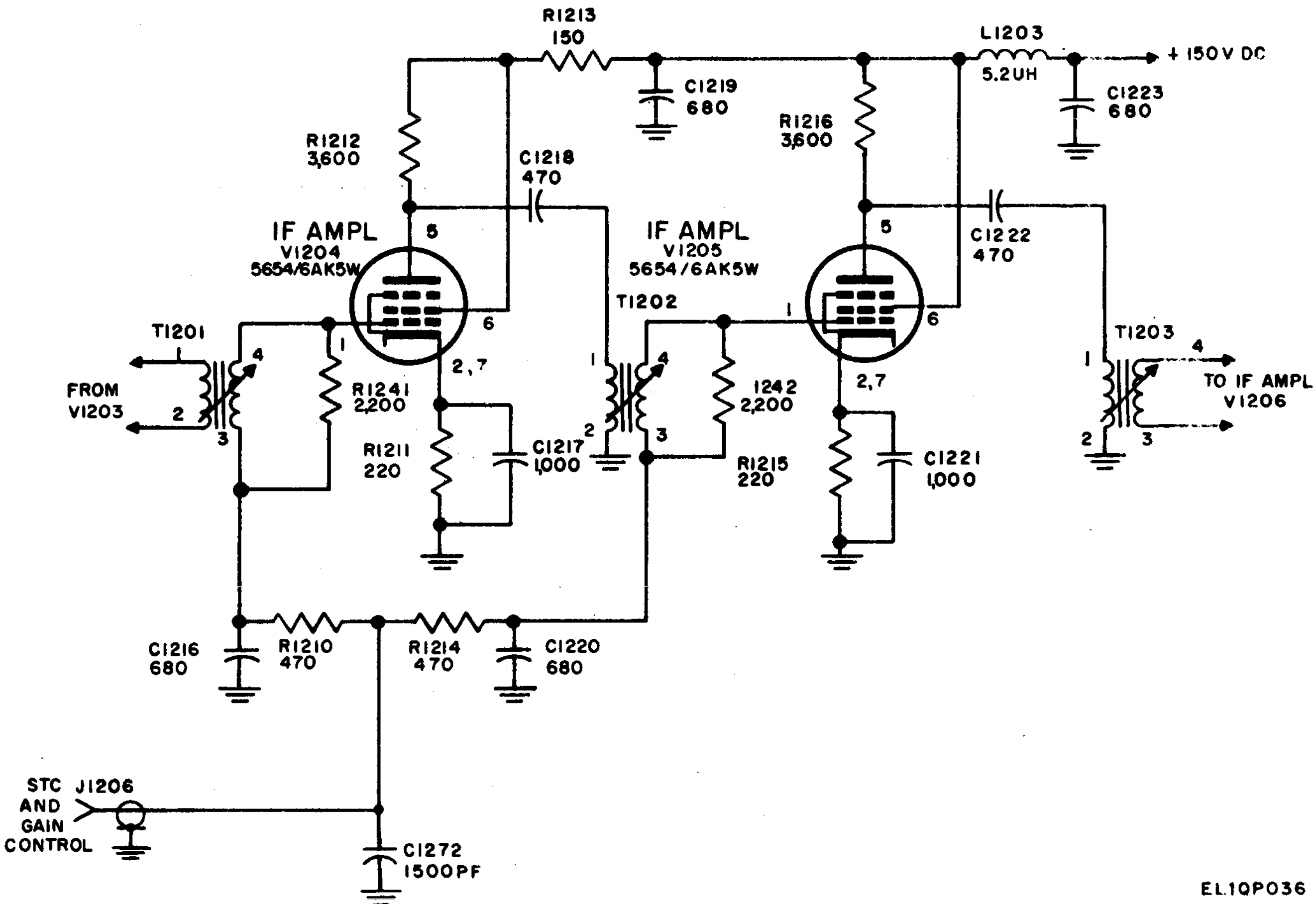


Figure 2-36. If. amplifiers V1204 and V1205, schematic diagram.

(3) *Lin-log if. amplifiers.*

(a) General. If. amplifiers V1206 through V1209 are linear-logarithmic amplifiers. At normal signal levels, the lin-log amplifiers operate on the linear portion of the plate current curve. When strong signal returns are received, the plate current of the lin-log amplifiers increases beyond the linear portion of the plate current curve and continues to rise at a logarithmic rate until the plates reach saturation.

(b) Functioning with normal signal returns. During normal signal returns, the lin-log if. amplifiers (fig. 2-37) V1206 through V1209 function as normal if. amplifiers ((2) above). Interstage coupling between stages is accomplished by coupling capacitors C1226, C1230, and C1234 and slug-tuned transformers T1203, T1204, T1205, and T1206. Resistors R1243, R1244, R1245, and R1246 are connected across the secondaries of the transformers to broaden the band-pass characteristics of the transformers. Resistors R1219, R1222, R1225, and R1228 are plate load resistors. Bias is furnished by cathode resistors R1218, R1221, R1224, and R1227. Capacitors C1225, C1229, C1233, and C1237 are cathode bypass capacitors. Inductors L1204, L1205, L1206, and L1207 and capacitors C1227, C1231, C1235, and C1239 form decoupling networks. The output of the lin-log amplifier is taken from the plate (pin 5) and applied to plate tuning inductor L1208 through capacitor C1238. The if. signal is demodulated by crystal diode CR1201 (1N198) and applied to the video amplifier across diode load resistor R1229. Capacitors C1240 and C1253 are if. filter capacitors and Z1203 is a filter network.

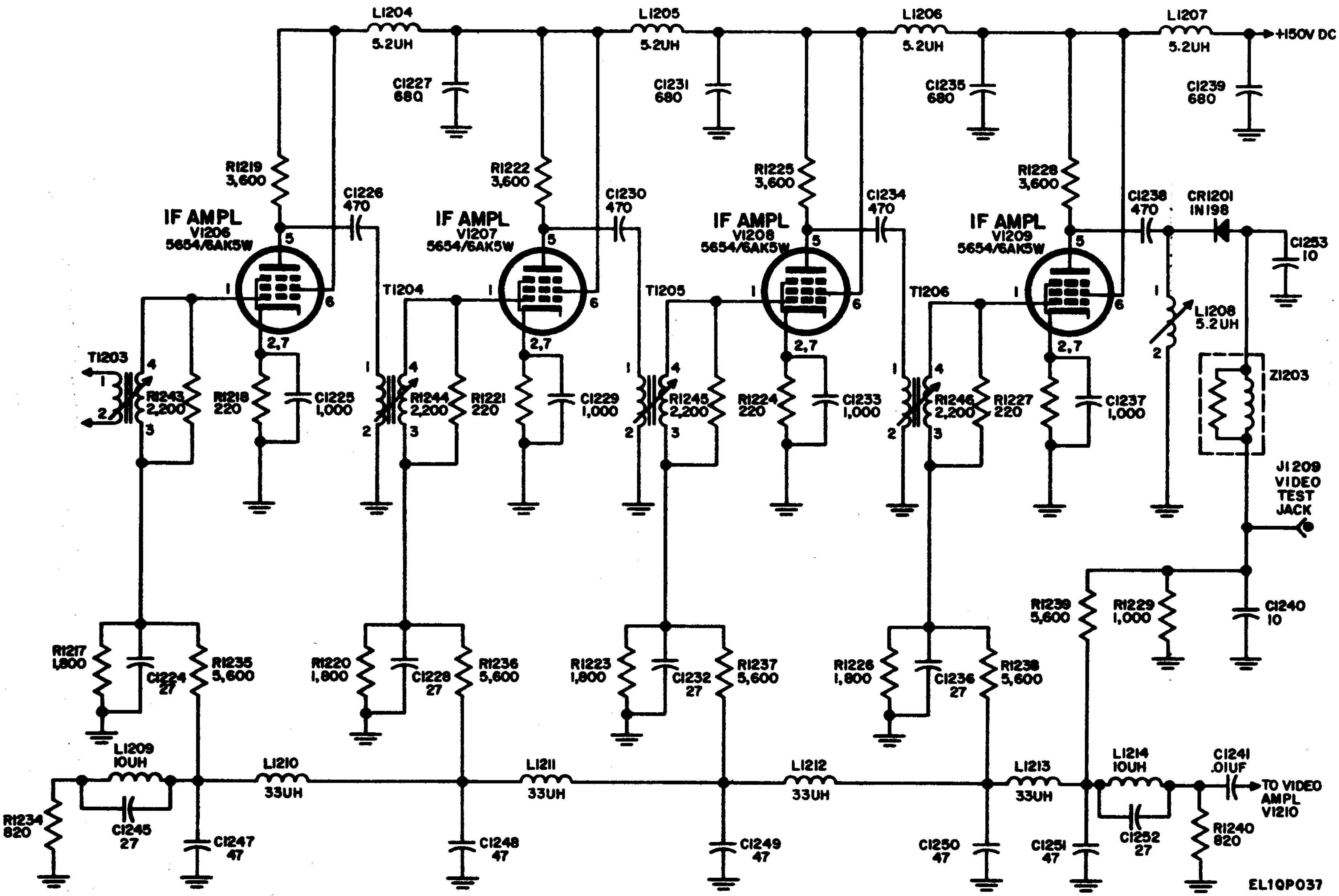


Figure 2-37. Lin-log amplifiers, schematic diagram.

(c) Functioning with strong signal returns. During periods of strong signal return, due to either ground clutter or close-in targets, the plate current of if. amplifier V1209 increases beyond the linear portion of the plate current curve and continues to rise at a logarithmic rate until the plate reaches saturation. When V1209 reaches saturation, the grid draws current, which causes grid detection to take place. The rectified video from the grid of V1209 and detector network R1226 and C1236 is applied to a delay line through R1238. Capacitor C1236 is an if. filter capacitor. The rectified video from the grid of V1209 is applied to the video amplifier through a delay network consisting of inductor L1213 and capacitor C1250. The delay network delays the video signal from the grid of V1209 equal to the time required for a signal to pass through the tube. Therefore, the signal voltage detected at the grid of V1209 and the signal voltage detected by the crystal diode arrive at the video amplifier in phase. If the signal remains strong, if. amplifier V1208 will saturate, the grid will draw current, grid detection will take place, and a video signal will be applied to the video amplifier through the delay line. Resistors R1223 and R1237 are voltage-dividing resistors, capacitor C1232 is a bypass capacitor, and inductor L1212 with capacitor C1249 form a delay network. If the signal return remains strong, if. amplifier V1207 and V1206 will saturate. The signal voltages detected at the grids of V1206 and V1207 will be applied to the video amplifier through sections of delay line consisting of inductors L1209, L1210, and L1211 with capacitors C1245, C1247, and C1248. Resistors R1234 and R1240 are delay line terminating resistors. Resistors R1217 and R1235 and R1220 and R1236 are voltage-divider resistors for the grid detected signals of V1206 and V1207. Capacitors C1224 and C1228 are if. bypass capacitors. The grid detected signals from V1206 through V1209, are sufficiently delayed by the delay line so that they arrive at the video amplifier in phase with the signal detected by CR1201. The in-phase signals are applied to video amplifier V1210 through coupling capacitor C1241 and through a section of the delay line consisting of inductor L1214 and capacitors C1251 and C1252. Resistor R1239 is a voltage divider.

(4) *Video amplifier V1210.* The detected video signal is applied to the grid (pin 1) of video amplifier V1210 through coupling capacitor C1241. Resistor R1230 is the grid resistor. The amplified output voltage developed across plate resistor R1231 is applied to cathode follower V1211 through coupling capacitor C1242. Resistor R1232 and capacitor C1244 form an interstage decoupling network.

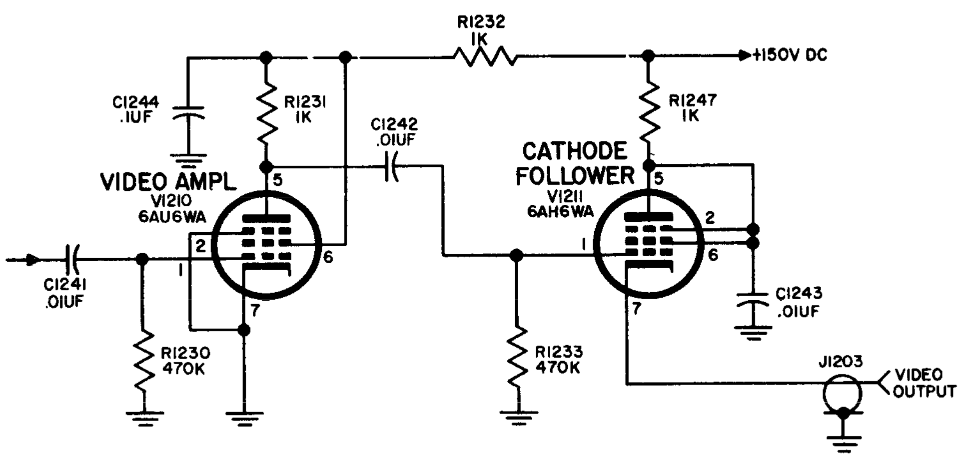


Figure 2-38. Video amplifier V1210 and cathode follower V1211, schematic diagram.

(5) *Cathode follower V1211.* Input signal voltage from the video amplifier is applied to the grid (pin 1) of cathode follower V1211 through coupling capacitor C1242. Resistor R1233 is the grid resistor. Resistor R1247 is the plate decoupling resistor. Output voltage is taken from the cathode (pin 7) and applied to the indicator. Resistor R101 and video gain potentiometer R102A in the indicating system (para 2-25d) are the cathode resistors for V1211. Capacitor C1243 is a bypass capacitor for the plate, screen, and suppressor.

(6) *Filament circuit.* Choke coils L1220 through L1229 and capacitors C1255 through C1265 form a filter network for the if. amplifier tubes. Capacitor C1271 suppresses RFI.

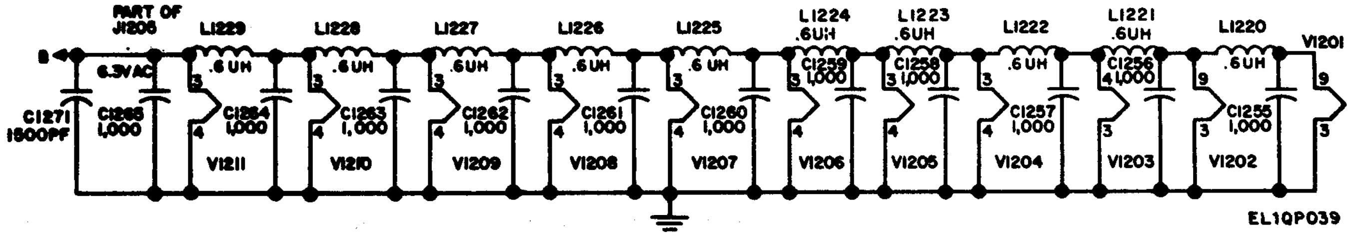


Figure 2-39. If. amplifier filament circuit.

c. Receiver Control C-2016/MPQ-4A. The afc circuit maintains the output of the local oscillator at 30 megaHertz below the output frequency of the transmitter. Automatic frequency control of the local oscillator is accomplished by mixing the local oscillator signal and a sample of the transmitted pulse. The resultant if. signal is amplified and fed to a discriminator, which produces an error voltage when the intermediate frequency is above or below the desired frequency. The error voltage is amplified and converted into a control voltage which is used to change the local oscillator frequency.

(1) *Afc-if. amplifiers V1301 and V1303.*

(a) If. amplifier V1301. The 30-megaHertz if. signal from afc mixer CR1503 is applied to the primary of transformer T1301. The primary of T1301 is tuned to the intermediate frequency by capacitor C1330. Crystal current is applied to the current meter through filters Z1301 and Z1302, Which are bypassed by capacitors C1301, C1302, and C1303. Reverse diodes CR1301 and CR1302 parallel the afc crystal current input circuit of Z1301 and Z1302 bypassed by C1301, C1302, and C1303 to protect the afc crystal from transient currents. Signal voltage is applied to the grid (pin 1) of if. amplifier V1301 through slug-tuned if. transformer T1301. Bias is furnished by cathode resistor R1301, which is bypassed by capacitor C1304. Capacitor C1305 is a screen grid bypass capacitor and resistor R1304 is a screen-dropping resistor. The amplified output of V1301 is applied to the grid of if. amplifier V1303 through slugtuned if. transformer T1302. Resistor R1302, across the primary, and resistor R1303, across the secondary of T1302, damp and broaden the bandpass characteristics of the transformer. The amplified output signal is also applied to range calibration output V1302 (para 2-19c(7)) through coupling capacitor C1333. Capacitor C1336 suppresses RFI.

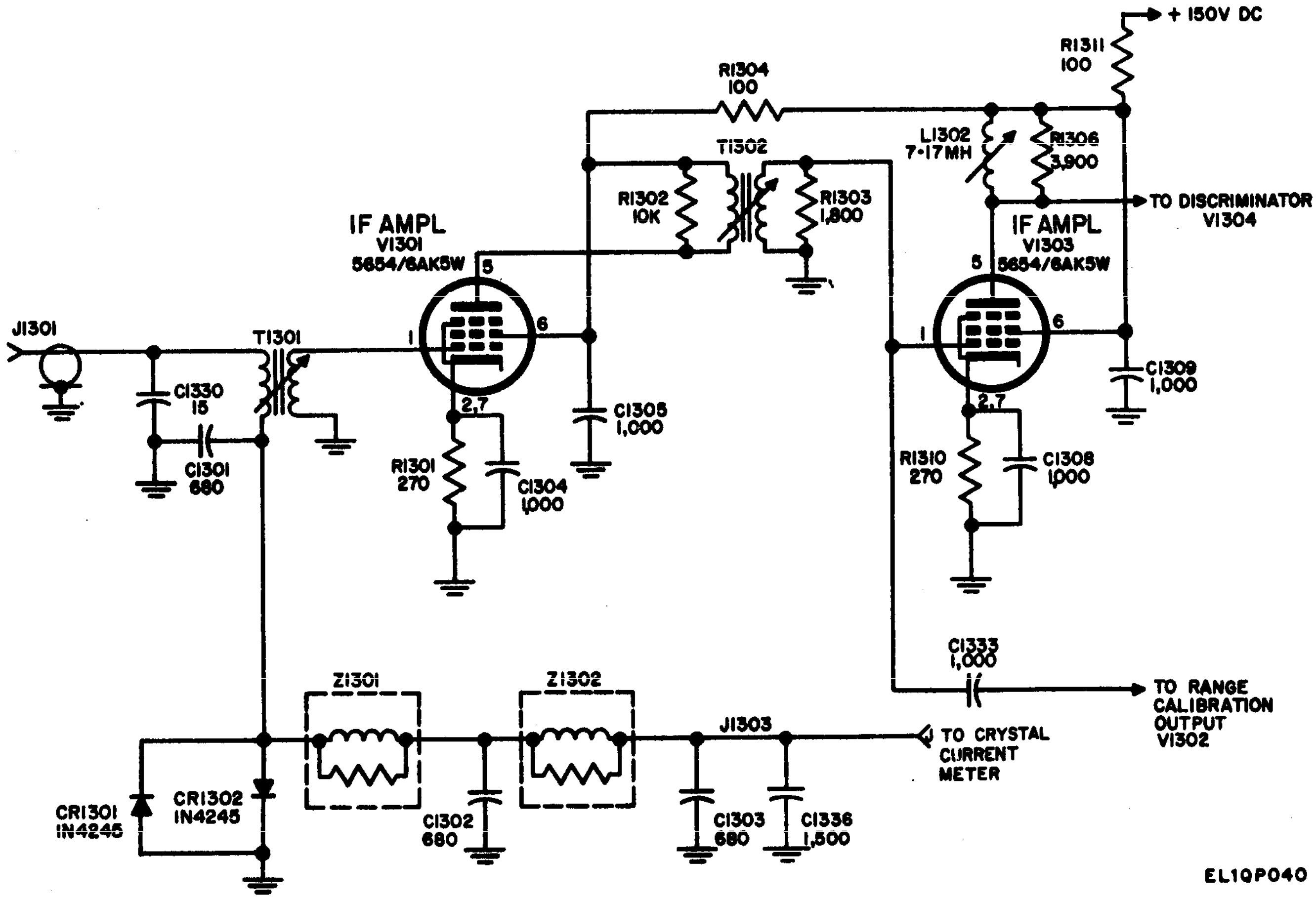


Figure 2-40. Afc-if. amplifer V1301 and V1303, schematic diagram.

(b) If. amplifier V1303. Bias for if. amplifier V1303 is furnished by cathode resistor R1310, which is bypassed by capacitor C1308. The screen grid is bypassed by capacitor C1309. The plate circuit of V1303 is tuned by inductor L1302, which has a broad band pass due to resistor R1306 Output voltage is applied to discriminator V1304.

(2) *Discriminator V1304.*

(a) General. The if. signal from V1303 (represented by voltage E, fig. 2-41) is applied across the discriminator at the junction of capacitors C1311 and C1310. Capacitors C1311 and C1310 together with inductance L1301 form a special tuned circuit which helps to determine what portion of input voltage E appears across V1304A as voltage E_1 and what portion of input voltage E appears across V1304B as voltage E_2. Resistors R1307 and R1308 provide a dc path between the plates of V1304 and load resistors R1312 and R1313.

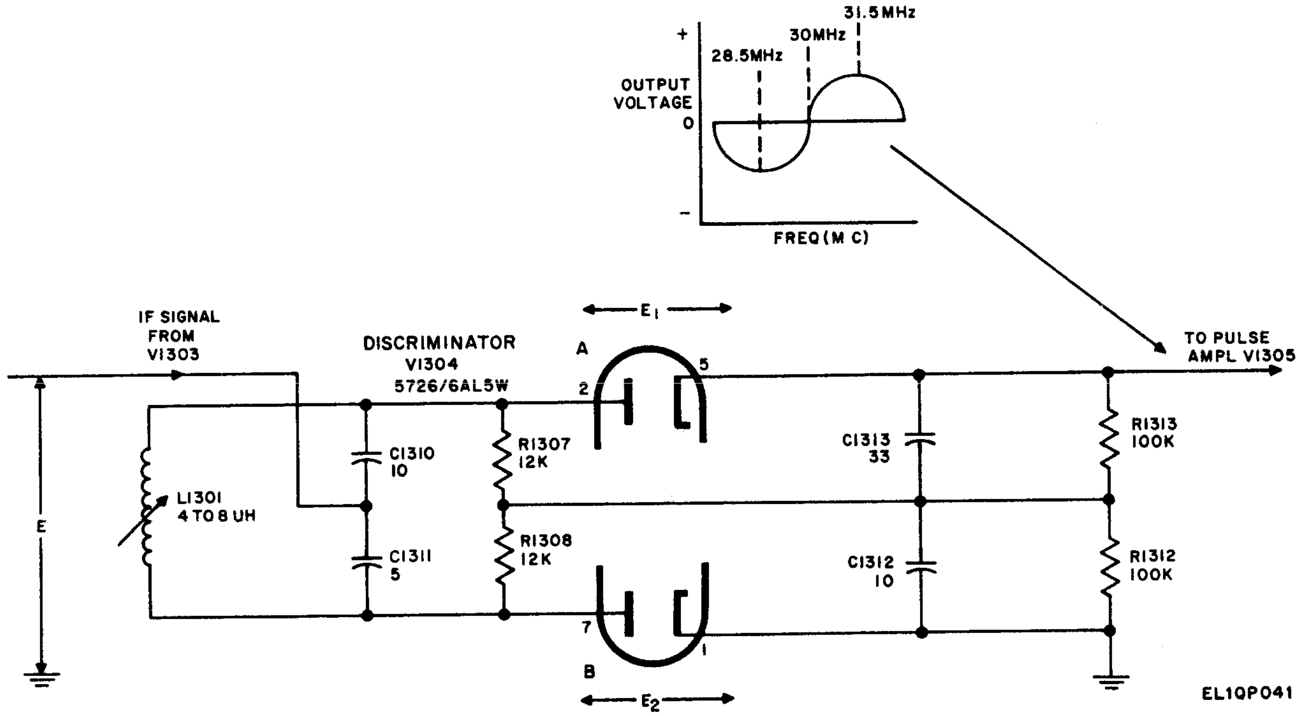


Figure 2-41. Discriminator V1304, schematic diagram.

(b) Operation. The tuned network consisting of C1311, C1310, and L1301 can be considered as parts of two series-resonant circuits. One series-resonant circuit consisting of C1311, L1301, the interelectrode capacitance of V1304A, C1313 and C1312 is resonant above 30 MHz. The other series-resonant circuit consists of C1310, L1301, and the interelectrode capacitance of V1304B, C1312 and C1313 is resonant below 30 MHz. When the frequency of the incoming signal voltage E is exactly 30 megaHertz, E_1 and E_2 will be equal and both sections of discriminator V1304 will conduct exactly the same amount of current. Thus, the output voltage developed across cathode load resistors R1312 and R1313 is 0 volt, as shown in the output voltage graph of fig 2-41. When the if. input voltage has a frequency higher than 30 megaHertz, the network consisting of C1311, L1301, and the interelectrode capacitance of V1304A ia nearer resonance than the other network. This causes E_1 to be larger than E_2 and V1304A will conduct more heavily than V1304B. Therefore, a positive voltage will appear at the output. The tuned circuit consisting of C1310, L1301, and the interelectrode capacitance of V1304B acts as a series-resonant circuit at frequencies lower than 30 megaHertz and V1304B will conduct more heavily than V1304A producing a negative voltage at the output.

(3) *Pulse amplifier V1305.*

(a) General. Pulse amplifier V1305 amplifies the discriminator output voltage to a level suitable for use in the pulse stretching circuit.

(b) Circuit functioning. The grid of pulse amplifier V1305 is connected to the discriminator output. When there is no output from the discriminator, V1305 remains in a steady state with no signal output. If the discriminator output goes negative, the effective grid bias on V1305 is increased and the plate voltage rises. Conversely, if the discriminator output goes positive, the bias on V1305 ia decreased, causing the tube to conduct more heavily and the plate voltage to drop. Resistor R1315 is the plate load resistor across which output signals are developed; R1316 is the screen-dropping resistor, bypassed by C1315; and R1314 is the cathode-biasing resistor, bypassed by C1314.

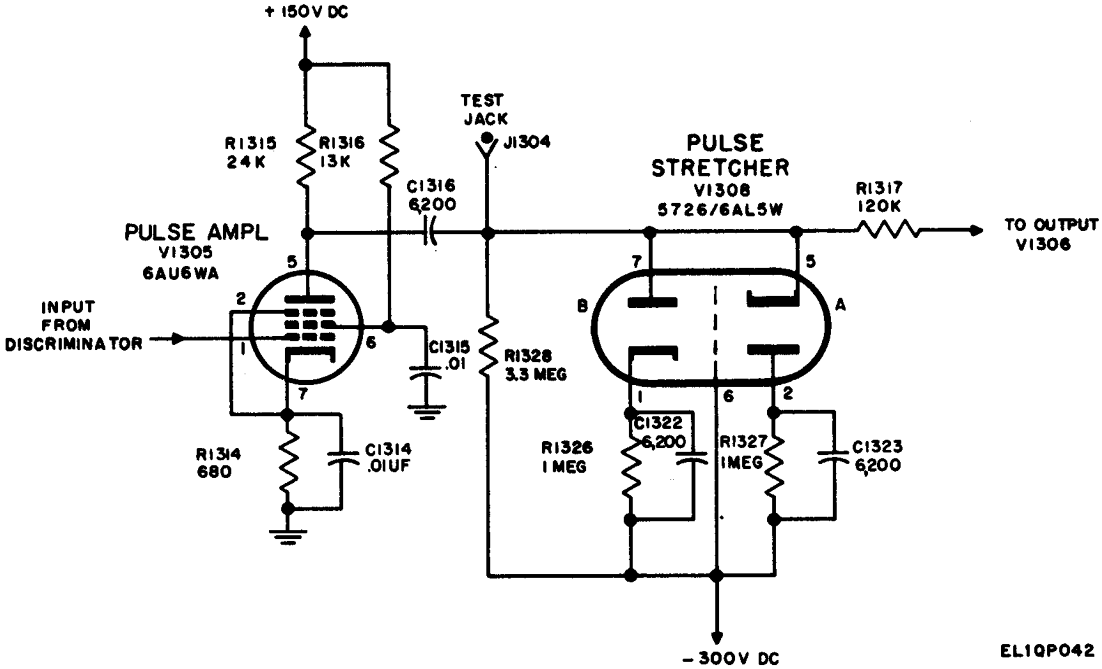


Figure 2-42. Pulse amplifier V1305 and pulse stretcher V1308, schematic diagram.

(4) *Pulse stretcher V1308.*

(a) General. The signal in the afc assembly is in the form of a series of pulses, which are the results of mixing the local oscillator frequency with a sample of the transmitted pulse. When the local oscillator frequency is incorrect, with reference to the magnetron frequency, the discriminator develops a pulse error voltage which is amplified by the pulse amplifier. To control the klystron frequency, a voltage must be applied to the repeller which will be available during the full cycle of the transmitter pulse and the interval between the pulses. The error voltage pulses are stretched so that their duration is much longer than the full transmitter cycle.

(b) Functioning of pulse stretcher V1308 when afc intermediate frequency is below 30 megaHertz. When the intermediate frequency is below 30 megaHertz, a series of positive pulses will appear at the plate of pulse amplifier V1305. The positive pulses, when applied to the plate (pin 7) of V1308B, cause V1308B to conduct and rapidly charge capacitor C1316 to approximately one-third the amplitude of the applied pulse (fig. 2-43). The charge path for capacitor C1316 is from -300 volts through capacitor C1322 to pin 1 of V1308B, by tube conduction from pin 1 (cathode) to pin 7 (plate), through capacitor C1316 to the positive pulse level output at the plate of pulse amplifier V1305. Since the charge path consists of two equal value capacitors in series with the resistance of the diode, the voltage distribution is approximately equal across each element in the charge path and approximately one-third of the input voltage will appear across each element. The charge across C1322 biases V1308B to approximately one-third of the input voltage (A, fig. 2-43). When the pulse at the plate of pulse amplifier V1305 swings in a negative direction, the amplitude of the negative swing is equal to the pulse amplitude and is coupled to the pulse stretcher by capacitor C1316. The charge across capacitor C1316 (left side positive, right side negative) drives the plate (pin 7) of V1308B to a new base level which is one-third the pulse amplitude below the original base level. Since the cathode of V1308B is now *more positive* than the plate, the tube is cut off. Resistor R1328 is a discharge path for capacitor C1316, but the time constant of the discharge path is so long that no appreciable discharge occurs between pulses; thus the new base level is maintained and the second pulse input will appear as a pulse on this new base level. Resistor R1326 is a discharge path for capacitor C1322 and again the time constant is so long that no appreciable voltage change occurs between pulses.

(c) *Functioning of pulse stretcher V1308 when afc intermediate frequency is above 30 megaHertz.* When the intermediate frequency is higher than 30 megaHertz a series of negative pulses will appear at the plate of puke amplifier V1305. The operation is similar to that described in *(b)* above, but the diode (V1308A) is connected in reverse. All other components in similar positions to components in *(b)* above perform similar functions.

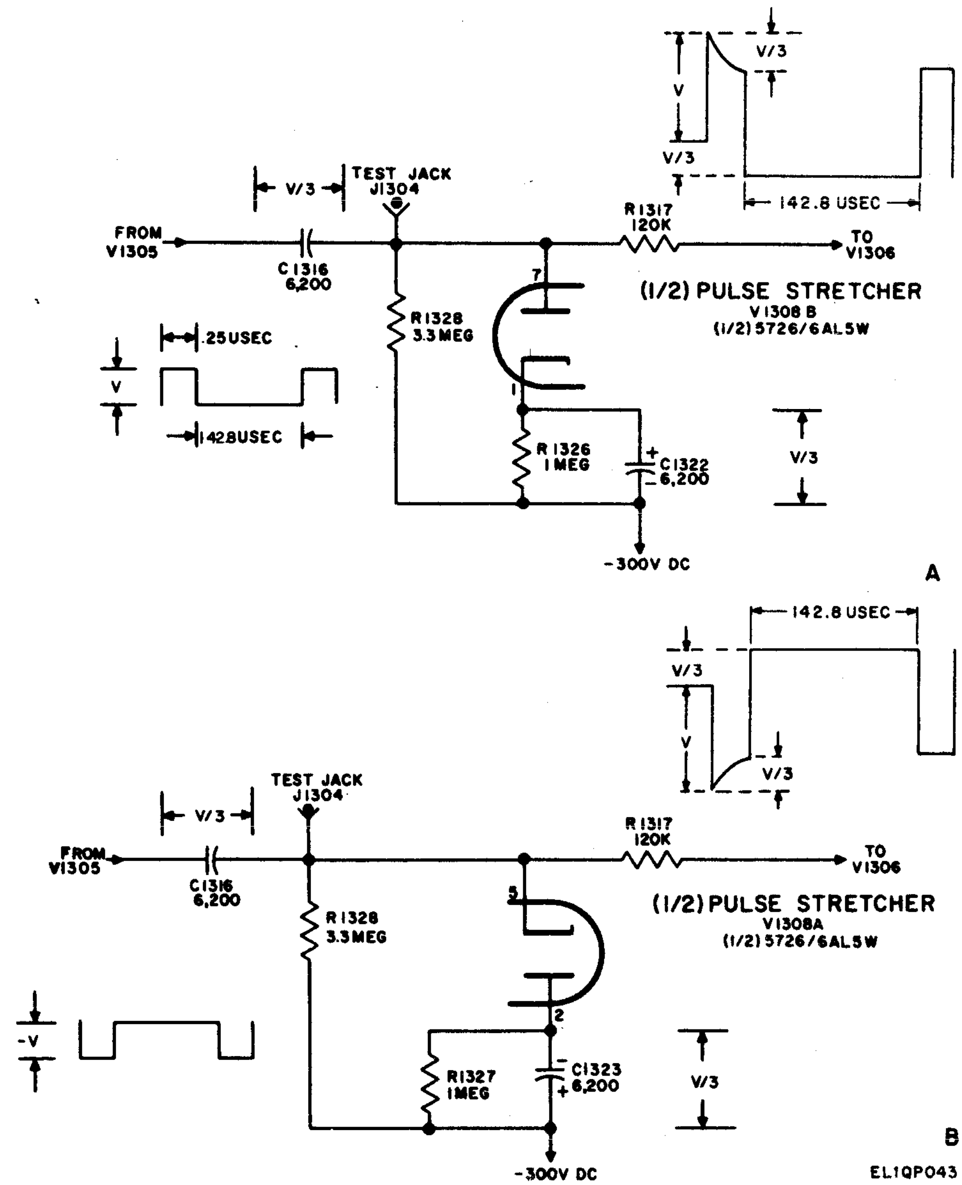


Figure 2-43. Clamping action of V1308.

(d) Combined action of pulse stretcher V1308. When pulses of changing amplitude are applied to the pulse stretcher, the action is as described in *(b)* and *(c)* above. Assume that a positive pulse was applied (as in *(b)* above) and that the next pulse was positive but of lesser amplitude, the pulse stretcher now sees a negative pulse which is equal in amplitude to the difference in the two pulse levels, and the action and level change would be in the direction that a negative pulse input would cause ((c) above), however it would not cause the base level to change polarity in relation to the original base line. The output of the pulse stretcher is the voltage level between pulses and is applied to the grid of afc output tube V1306.

(5) *Afc output V1306.* Two signals are applied to the grid of afc output V1306. One signal consists of the output from pulse stretcher V1308 and the other signal consists of the output from oscillator V1307 ((6) below). The cathode and screen grid of output of V1306 are operated at a high negative potential which makes the plate positive with respect to the cathode, but negative with respect to ground. If the grid of V1306 is driven negative by a signal from V1308, the output voltage applied to the repeller of the klystron is less negative. To locate the proper klystron operating

frequency, the kylstron signal is swept so that mixing covers the if. band pass by applying the output of a phase shift oscillator to the control grid of V1306. As the local oscillator sweeps through the band, the local oscillator frequency becomes such that a 30-megaHertz if. signal is produced, and no discriminator error voltage is produced. The afc circuit is in effect a degenerative feed-back loop. Resistor R1318 is the cathode resistor and resistors R1319 and R1320 are screen resistors. When aft-manual relay K1302 is energized, grid resistor R1355 is connected to the grid circuit and the error voltage from V1308 is disconnected.

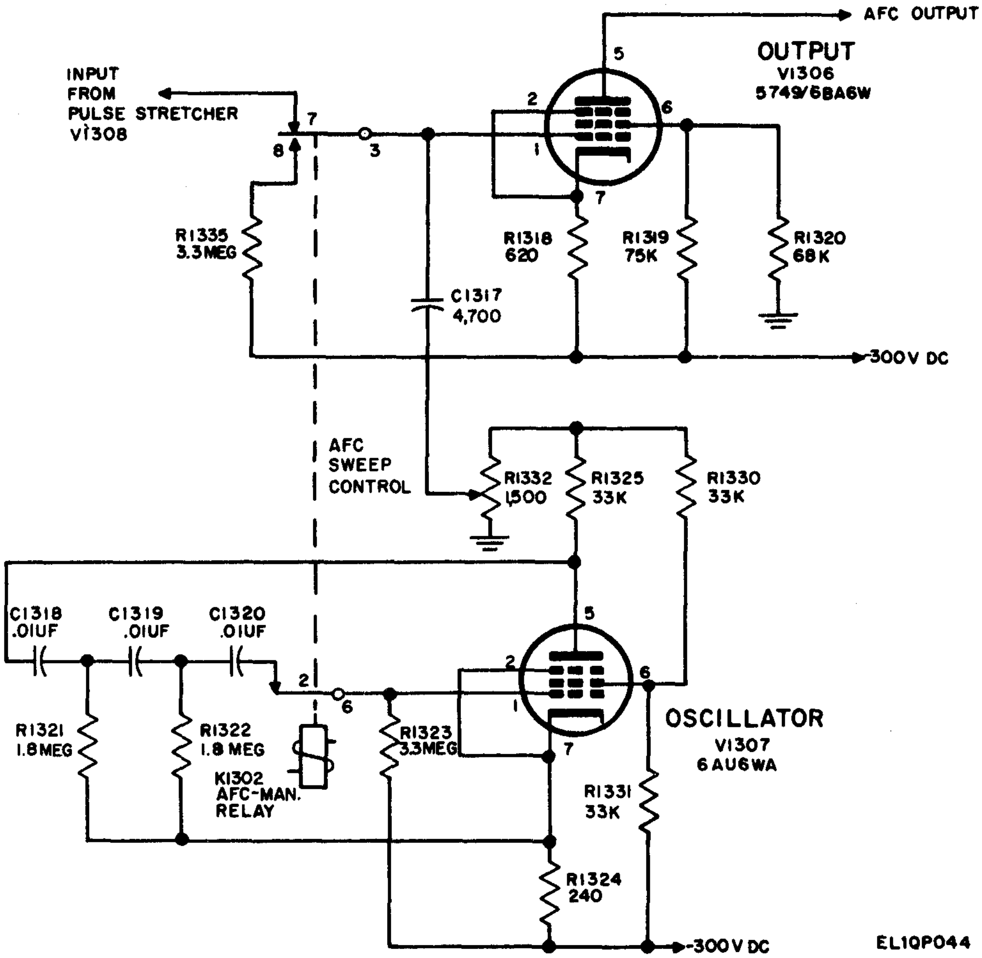


Figure 2-44. Afc output V1306 and oscillator V1307, schematic diagram.

(6) *Oscillator V1307.*

(a) *General.* The phase-shift oscillator operates on the principle of providing a 180° phase-shifted signal from the plate circuit to the grid circuit at only one frequency. All other frequencies produced in the plate circuit are fed back to the grid with incorrect phase relationship so that oscillations are not sustained.

(b) Circuit functioning. The screen grid and the cathode of phase-shift oscillator V1307 are held at a high negative potential while the plate is returned to ground. The plate is therefore held at a positive potential with respect to the grid and cathode. The feed-back network, consisting of resistors R1321, R1322, and R1323 and capacitors C1318, C1319 and C1320, feeds a signal a signal from the plate to the grid. One particular frequency is shifted 180° and oscillations are set up at this frequency (2 to 3 cycles per second (Hz). Resistor R1234 is the cathode resistor and resistors R1331 and R1330 from a voltage divider for the screen grid. Output voltage (2 to 3 Hz) developed across plate load resistors R1325 and R1322 is applied to V1306 through coupling capacitor C1317, Resistor 1332 is the afc sweep level control.

(7) *Range calibration output V1302.* The range calibration output circuit supplies accurate range calibration markers to the if. amplifier. A portion of the signal from first if. amplifier V1301 is applied to the grid of range calibration output V1302 through coupling capacitor C1333. Resistor R1329 is the grid resistor. Cathode bias is furnished by

resistor R1305, which is bypassed by capacitor C1306. The amplified output of V1302 is tuned by plate inductor L1303 and plate tuning capacitor C1331 end applied to single-ended delay cell DL1301 through coupling capacitor C1321. Delay cell DL1301 in a quartz crystal, and when excited by a signal from V1302, transmits a pulse of energy along the quartz bar. The beam of energy is reflected by the terminated end of the quartz bar end a series of accurately spaced pulses, decaying in amplitude, are fed through the contacts of K1301 to the if. amplifier. The temperature of the delay cell is regulated by a thermostatically controlled heater to prevent variation in crystal characteristics. Range calibrate marker intensity potentiometer R1333 controls the intensity of the markers by supplying a high negative bias through the center arm to the control grid of V1302. Resistor R1334 is a voltage-dropping resistor for R1333 and filter Z1305 is a filter network, which prevents marker signals from appearing in the dc supply. Filter Z1305 is bypassed by capacitor C1325. Filter Z1303 is a filter in the plate circuit which prevents marker signals from appearing in the dc supply. Resistor R1309 and capacitor C1332 form a plate decoupling network. Resistor R1332 is a screen grid voltage-dropping resistor and capacitor C1307 is a bypass capacitor. Rangemarks are turned on or off by MARKERS ON switch S105 on the indicator. Filter Z1304 is an output circuit filter (fig. 2-45).

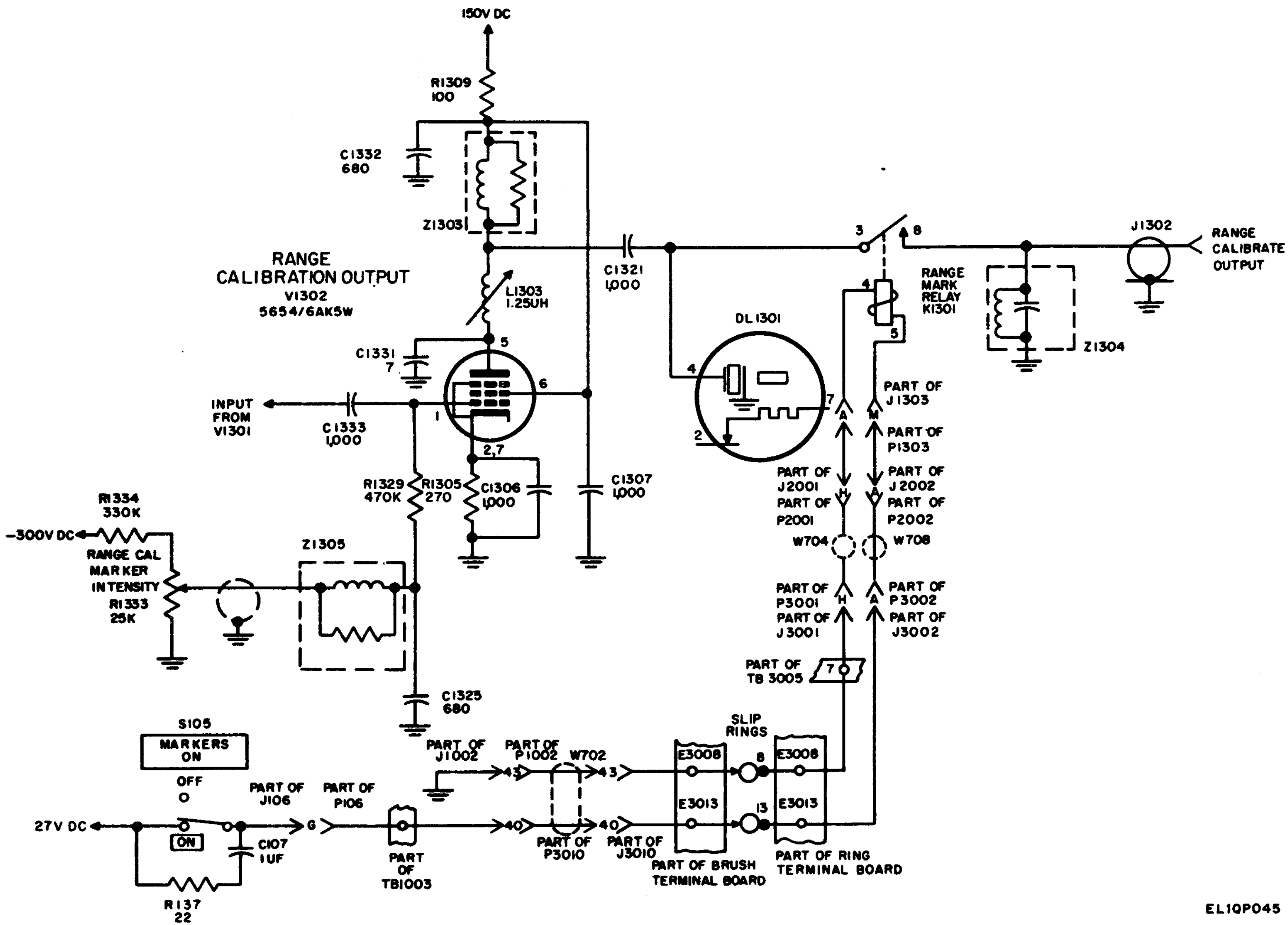


Figure 2-45. Range calibration output V1302, schematic diagram.

(8) *Filament circuit.* Choke coils L1304, L1306, and L1308, with capacitors C1324, C1326, and C1328, form filter circuits for the filaments of V1301, V1302, V1303, V1304, and V1305 (fig. 2-46).

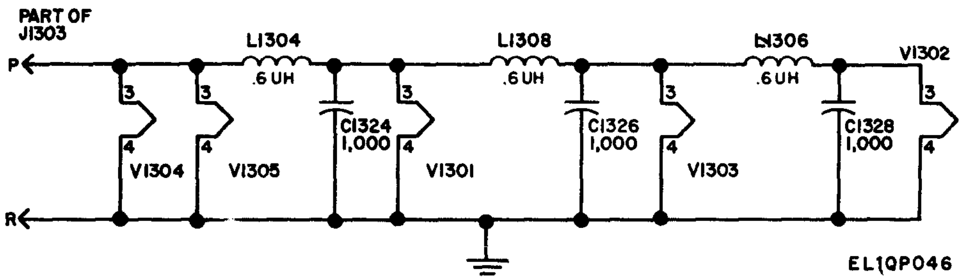


Figure 2-46. Afc assembly filament circuit.

d. Receiver Control C-2015/MPQ-4A. Receiver Control C-2015/MPQ-4A, or sensitivity time control (stc), prevents the receiver from becoming overloaded by undesirable nearby targets. The stc circuit furnishes a gating pulse which sharply reduces the sensitivity of the if. amplifier at the time of the main bang and then allows the sensitivity to gradually recover.

(1) *First pulse amplifier V4701A.* The system pulse from the synchronizing system (para 2-22h(2)) is applied to the grid of first pulse amplifier V4701A through coupling capacitor C4701. Resistor R4701 is the grid resistor and R4703 is the cathode resistor. The amplified and inverted pulse is applied to the grid of second pulse amplifier V4701B through coupling capacitor C4702. Resistor R4702 is a plate resistor and capacitor C4707 is a plate decoupling capacitor (fig. 2-47).

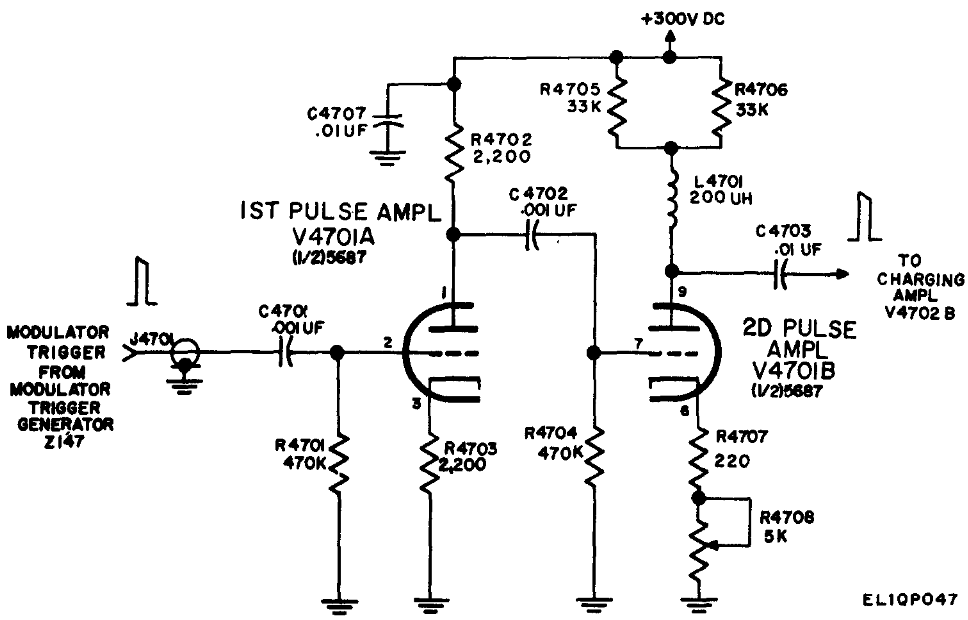


Figure 2-47. First and second pulse amplifiers V4701, schematic diagram.

(2) *Second pulse amplifier V4701B* (fig. 2-47). The negative pulse applied to the grid (pin 7) of second pulse amplifier V4701B across grid resistor R4704 causes the current through V4701B to decrease. The voltage at the plate of V4701B increases since the voltage drop across plate load resistors R4705 and R4706 is less. The positive-going output pulse is peaked by peaking coil L4701 and applied to the grid of charging amplifier V4702A through coupling capacitor C4703. The amplitude of the pulse applied to V4702A is controlled by potentiometer R4708. Resistor R4707 is the cathode resistor.

(3) *Charging amplifier V4702A* (fig. 2-48). The positive-going pulse from V4701B is applied to the grid (pin 2) of V4702A across grid resistor R4710. The positive pulse on the grid of V4702A causes an increase in current through the tube, causing the voltage drop across plate load resistor R4716 to increase and develops a negative-going output

pulse which is applied to V4702B through coupling capacitor C4704. During the time before V4702A conducts, charging capacitor C4705 discharges through resistors R4712 and R4713. When V4702A conducts, capacitor C4705 is charged quickly to a negative value, cutting off conduction in V4702B. When the sharp positive pulse on the grid of V4702A ends, the plate voltage tends to rise, and capacitor C4705 begins to discharge through R4713 and potentiometer R4712. The rate of discharge of capacitor C4705 is controlled by R4712.

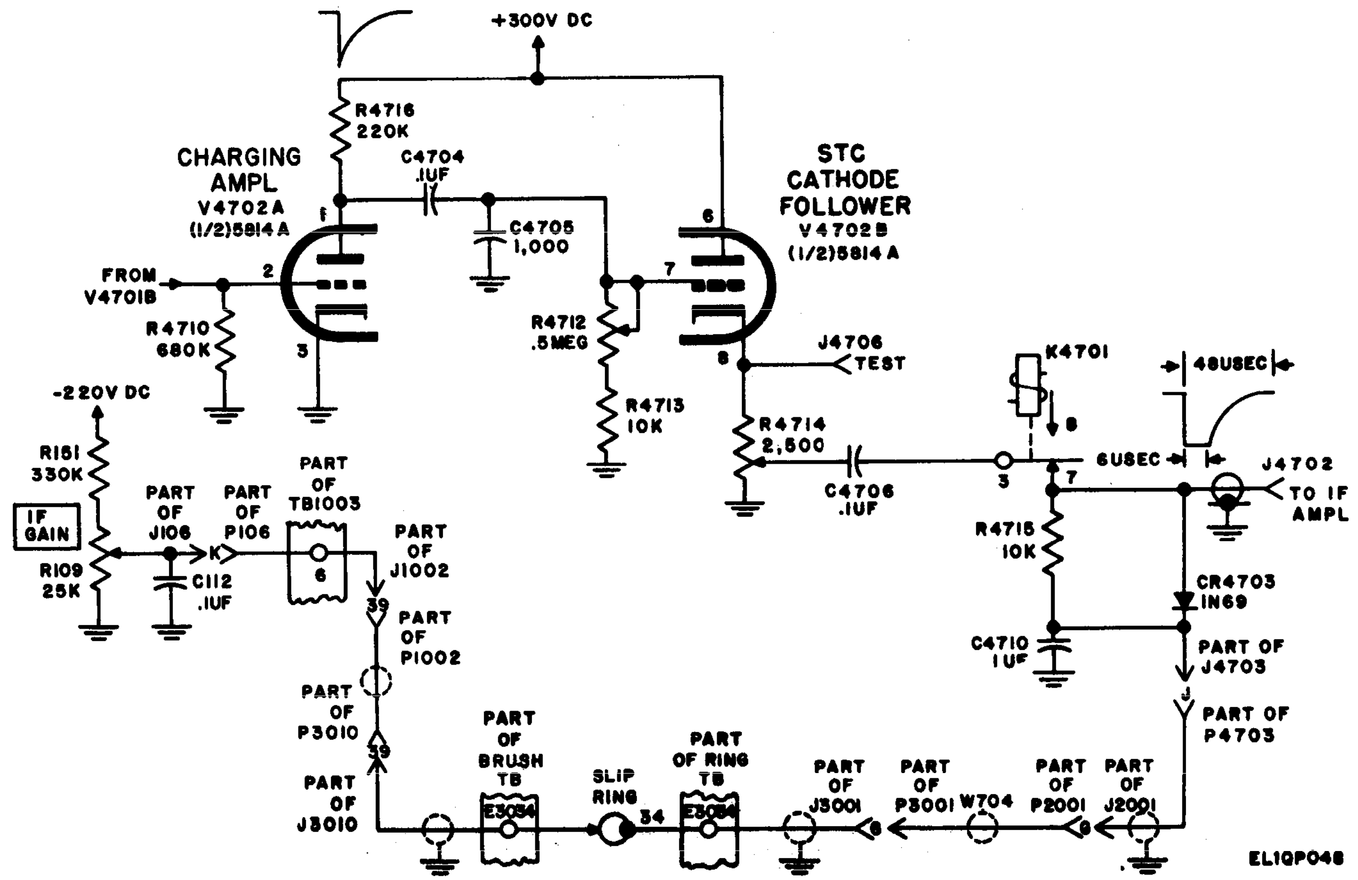


Figure 2-48. Charging amplifier V4702A and stc amplifier V4702B, schematic diagram.

(4) *Stc cathode follower* V4702B. The output of stc cathode follower V4702B is taken from the center arm of cathode potentiometer R4714. The negative-going pulse on the grid causes a negative-going output across R4714. Clipping occurs because the stc cathode follower is driven beyond cutoff. The output from the stc cathode follower is applied to the if. amplifier through coupling capacitor C4706 and the contacts of relay K4701. The stc output appears across resistor R4715. The amplitude of the output pulse is controlled by potentiometer R4714. Potentiometer R4708 (fig. 2-47) controls the length of time that a negative bias is applied to the grids of the if. amplifiers (the flat portion of the pulse) and potentiometer R4712 controls the width of the pulse. Crystal diode CR4703 clamps the stc pulse to the negative dc voltage set in by IF GAIN potentiometer R109. IF GAIN potentiometer R109 determines the point at which CR4703 will conduct. Resistor R151 is a voltage-dropping resistor and capacitor C112 is a bypass capacitor.

(5) *Pulse shaper.* The pulse shaper is attached to the stc chassis for convenience. Its function is covered in paragraphs 2-20 through 2-21.

Section V. SYNCHRONIZING SYSTEM

2-20. General

a. The synchronizing system produces pulses at fixed intervals for synchronizing the various circuits in the radar set. TM 11-5840-208-20 gives the overall function of each subassembly of the synchronizer.

b. The relationship of the synchronizing system with respect to other functional systems of the radar set is covered in paragraphs 2-2 through 2-10.

2-21. Synchronizing System Block Diagram (fig. FO-4)

a. Long Gate Generator Z101. Oscillator V201A produces a 7,000 Hertz sine wave (A, fig. 2-49) which is applied to regenerative amplifier V201B. Regenerative amplifiers V201B and V202A clip the negative half-cycle of the 7,000 Hz sine wave and square the positive half-cycle (B and C, fig. 2-49). The square pulse is applied to trigger coupling V203A through trigger selector switch S109. Trigger selector switch S109 is used to connect to an external synchronizing source if desired. Trigger coupling V203A is used to trigger gate generator V204B. Gate generator V204B produces a positive gate voltage (D, fig. 2-49) which is stopped after approximately 110.1 microseconds by gate shutoff V204A. Gate shutoff V204A is triggered by timing sweep generator Z102 (*b* below). The positive gate pulse from V204B is applied to cathode follower V202B. The output of V204B is clamped by diode clamp V203B and the output of the cathode follower (E, fig. 2-49) is applied to gated Miller sweep V231 and to RANGE SELECTOR switch S101.

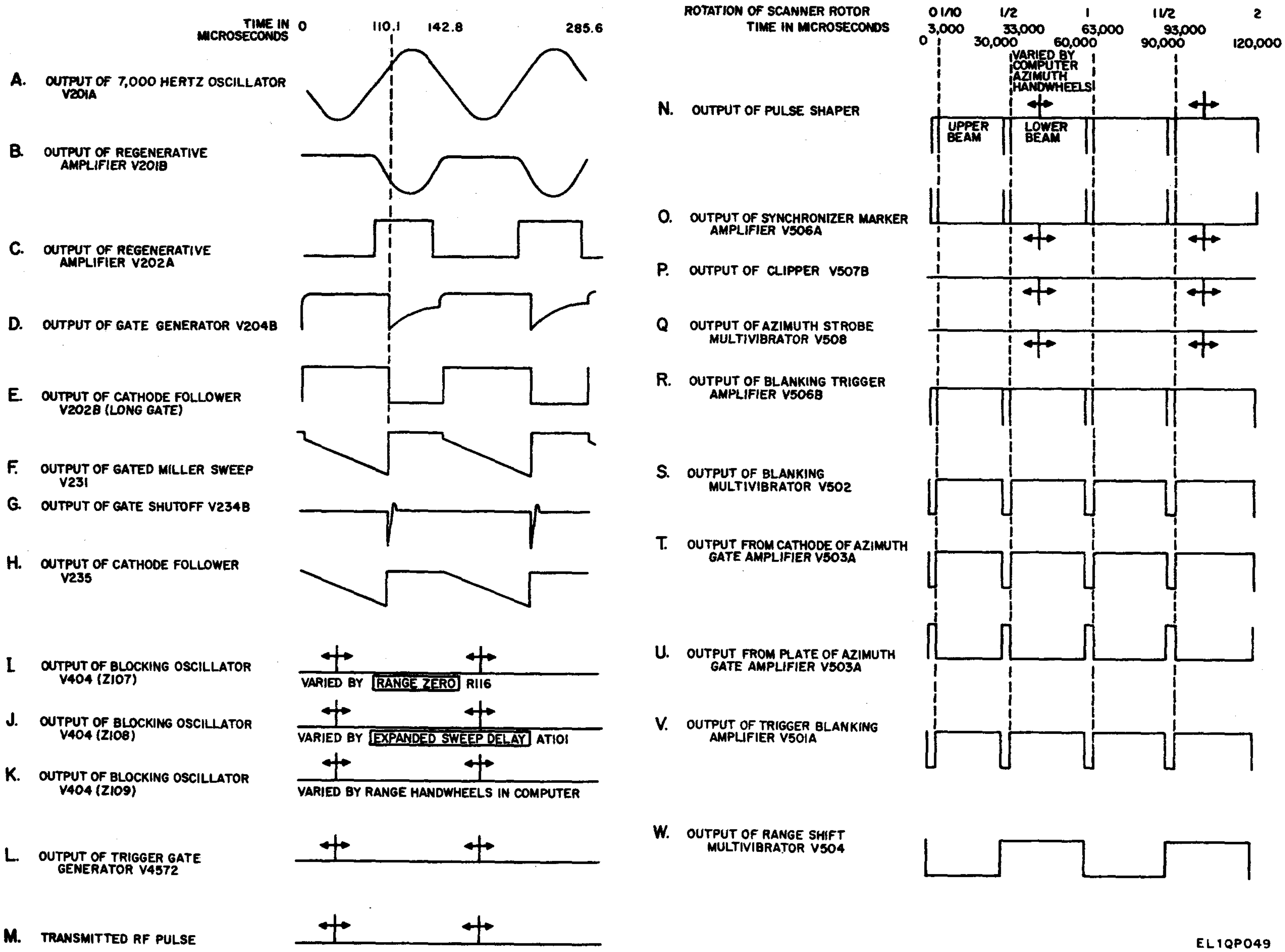


Figure 2-49. Synchronizing system, timing diagram.

b. Timing Sweep Generator Z102. Gated Miller sweep V231 produces a linear sweep voltage (F, fig. 2-49) when gated by the long gate. RANGE SLOPE control R119 controls the slope of the sweep voltage. The sweep voltage is coupled to cathode follower V235 by linear amplifier V232 and by cathode follower V233. The output of V233 is clamped by dc restorer V234A. A portion of the output of cathode follower V235 is fed back to V231 to improve the linearity of the sweep voltage. One output from V236 triggers gate shutoff V234B (G, fig. 2-49) which stops the long gate (*a* above). The output of timing sweep generator Z102 (F, fig. 2-49) is applied to pickoff amplifiers Z107, Z108, and Z109.

c. *Delay Trigger Pickoff Z108.* The sweep voltage from timing sweep generator Z102 is applied to comparator tube V401. The point at which comparator tube V401 begins operating is determined by the setting of EXPANDED SWEEP DELAY attenuator AT101. The output of V401 is coupled to blocking oscillator V404 through amplifier V402 and through regenerative amplifier V403. Blocking oscillator V404 produces one sharp pulse (I, fig. 2-49) for each cycle of oscillator V201A. The point at which the output of V404 occurs is determined by AT101. The output of V404 will determine the starting point of the short gate in 1,500-meter steps. The output of delay trigger pickoff Z108 is applied to short gate and intensifier Z149 (para 2-24 c) in the indicating System.

d. Range Marker (Strobe) Trigger Pickoff Z109. Range marker (strobe) trigger pickoff Z109 is identical with delay trigger pickoff Z108. The position of the output pulse, with respect to the sweep, is controlled by the range potentiometer in the computer (para 2-32h). The output of Z109 (K, fig. 2-49) is applied to video amplifier Z148 in the indicating system (para 2-25 d(3)) and will determine the position of the range strobe.

e. Range Zero Trigger Pickoff Z107. Range zero trigger pickoff Z107 and delay trigger pickoff Z108 are identical. The position of the output pulse, with respect to the sweep, is controlled by RANGE ZERO adjustment R116. The output pulse from Z107 (J, fig. 2-49) is applied to modulator trigger generator Z147 (*i* below) and will determine the starting point of the transmitter trigger.

f. Scanner Marker Coils. As the scanner rotates, permanent magnet E3201 passes dead time coil L3202 and produces a sharp positive then negative pulse. Approximately 3.000 usec later, E3202 passes dead time coil L3202, producing another sharp positive then negative pulse. These pulses are sent to the pulse shaper. The scanner continues to rotate and the lower radar beam is transmitted. One-half revolution later, another period of dead time occurs when magnets E3201 and E3202 pass dead time coil L3201. After this period of dead time, the upper radar beam is transmitted. During transmission of the lower beam, azimuth marker magnet E3203 passes azimuth marker coil L3203 and produces a negative, then positive pulse. The position of the pulse produced by L3203 is determined by the position of L3203, which is controlled by the azimuth handwheels in the computer (pars 2-31e(1)).

g. Pulse Shaper. The pulse shaper clips the positive and negative pulses from the scanner with clippers CR4701 and CR4702, then combines the pulses (N, fig. 2-49), and applies them to azimuth synchronizer Z150.

h. Azimuth Synchronizer Z150. The dead time pulses and the azimuth marker pulses are separated in azimuth synchronizer Z150. The pulses from the pulse shaper are amplified and inverted by synchronizer marker amplifier V506A (O, fig. 2-49). The dead time pulses are applied to blanking multivibrator V502 through blanking trigger amplifier V506B (R, fig. 2-49). Blanking multivibrator V502 produces a negative-going gate pulse (S, fig. 2-49) for every two input triggers. This means, for a dead time start pulse and a dead time stop pulse, one negative gate pulse is produced. The negative gate from V502 is applied to azimuth gate amplifier V503A. One output from V503A (T, fig. 2-49) is applied to short gate and intensifier Z149 (pars 2-25c(4)), to azimuth sweep generator and driver Z145 (para 2-25a), and to Simulator, Radar Target Signal AN/TPA-7, when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. Another output from V503A (U, fig. 2-49) is applied to trigger blanking amplifier V501A and phase inverter V501B. The output of trigger blanking amplifier V501A is a positive-going pulse during transmit time and a negative-going pulse during dead time (V, fig. 2-49). The output of V501A is applied to modulator trigger generator Z147 (*i* below). The azimuth marker pulse is coupled from synchronizer marker amplifier V506A to azimuth strobe multivibrator V508 through cathode follower V507A and through clipper V507B. One output of azimuth strobe multivibrator V508 is applied to short gate and intensifier Z149 and the other output is applied to referencing cathode follower V505. Referencing cathode follower V505 has two outputs which reset blanking multivibrator V502 and range shift multivibrator V504 if they operate incorrectly. Range shift multivibrator V504 is triggered by inverter V501B and produces a single output pulse for every two trigger pulses. The output of range shift multivibrator V504 is applied to range shift amplifier V503B. The output from V503B is applied to video blanking Z146 (*j* below).

i. Modulator Trigger Generator Z147. When the trigger pulse (I, fig. 2-49) from range zero trigger pickoff Z107 (*e* above) is applied to V4571, gated trigger amplifier V4571 conducts and applies a voltage to modulator trigger V4572. The output of V4572 is a sharp pulse (L, fig. 2-49) which goes to the trigger pulse amplifier and stc assembly and to Simulator, Radar Target Signal AN/TPA-7, when AN/TPA-7 is used with Radar Set AN/MPQ-4A. Modulator trigger generator Z147 produces output pulses only during the time of upper and lower beam scan. No output pulses are produced during scanner dead time.

j. Video Blanking Z146. The square wave from azimuth synchronizer Z150 is applied to beam blanking amplifier V4551. Two outputs (W, fig. 2-49) from the beam blanking amplifier are applied to video amplifier Z148 (para 2-25d) through BEAM VIDEO switch S110 and timer M101. The square wave from Z150 is also used in Z146 to produce a signal to be sent to range sweep generator Z144. This will provide for a 750-meter range shift of the upper beam video from the lower beam video.

2-22. Electronic Function, Synchronizing System

a. Long Gate Generator Z101.

(1) *Oscillator V201A.*

(a) General. Hartley oscillator V201A is tuned to a frequency of 7,000 Hertz by coil L201 and capacitors C201, C202, and C203. The frequency can be varied slightly by adjusting the core of coil L201. The frequency of the oscillator is held stable by temperature compensating capacitors C202 and C203.

(b) Circuit components. Oscillator V201A is biased by the action of the grid leak which consists of resistor R201 and capacitor C204. Resistor R202 establishes a minimum bias for tube V201A and feeds the signal of the cathode to the resonant tank circuit. Resistor R218 and capacitor C210 form a plate decoupling network. The sine wave generated in the resonant tank circuit is direct-coupled to the grid of regenerative amplifier, V201B.

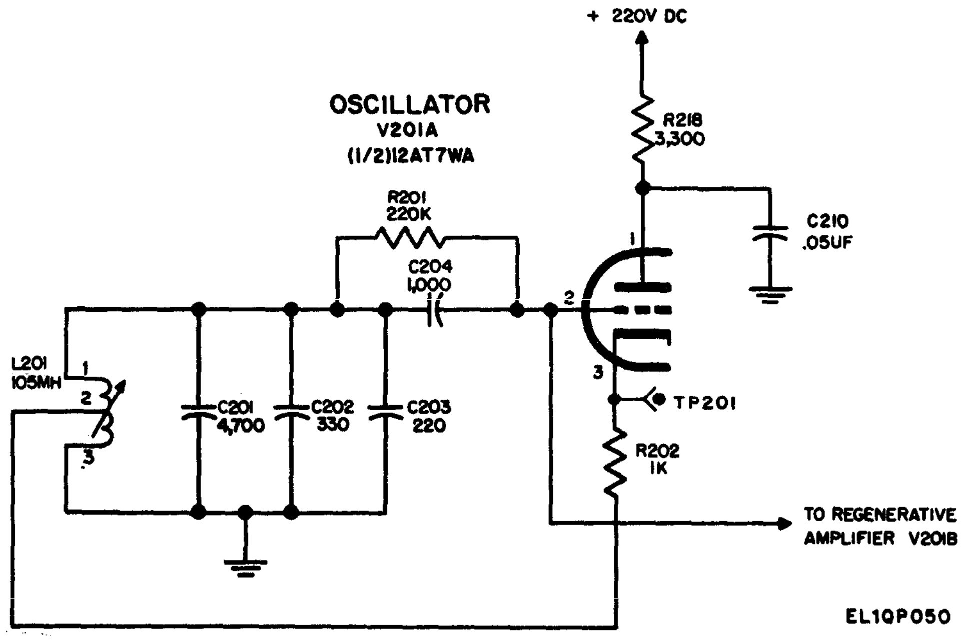


Figure 2-50. Oscillator V201A, schematic diagram.

(2) *Regenerative amplifiers V201B and V202A.* During the negative half-cycle of the sine wave from oscillator V201A, regenerative amplifier V201B is cut off. Tube V201B is direct-coupled to the grid of V201A and the grid leak bias developed by V201A is sufficient to cut off V201B; therefore, the negative half-cycle of the sine wave has no effect on V201B. Capacitor C205 is a high frequency shunt capacitor. When the positive half-cycle of sine wave voltage appears on the grid (pin 7) of V201B, the tube conducts. Plate current, flowing through plate load resistor R203, develops a negative-going rounded pulse which is applied to the grid (pin 2) of V202A through coupling capacitor C206. Resistor R205 is the grid return for V202A. The negative-going pulse drives V202A to

cutoff and a positive-going pulse is developed at the plate pin 1 of V202A. When the sine wave at pin 7 of V201B goes negative, V201B cuts off and V202A conducts and a negative going pulse is developed across plate load resistor R206. The output applied to trigger coupler V203 through trigger selector switch S109 is a square wave (C, fig. 2-49).

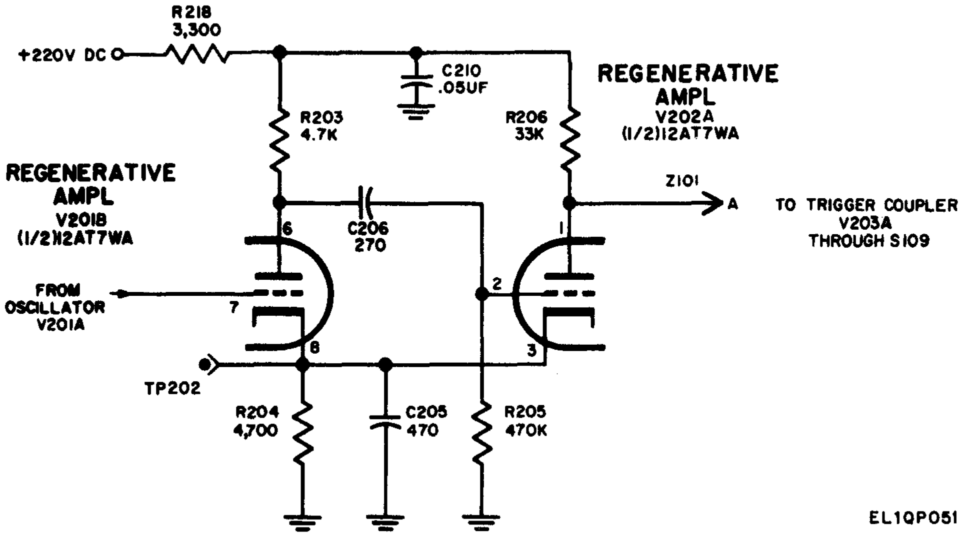


Figure 2-51. Regenerative amplifiers V201B and V202A, schematic diagram.

(3) *Trigger coupler V203A.* The square wave voltage from regenerative amplifier V202A is differentiated by capacitor C207 and resistor R207 and applied to the cathode (pin 5) of trigger coupler V203A. Trigger coupler V203A is normally nonconducting since the cathode and plate are at the same potential. When the negative pulse is applied, V203A conducts and a negative-going pulse is developed at the plate (pin 2) and applied to gate generator V204B and gate shutoff V204A.

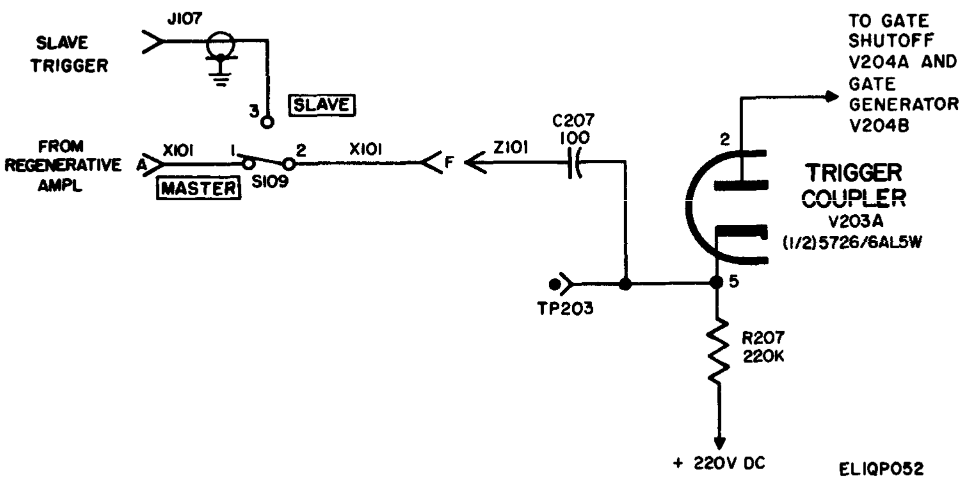


Figure 2-52. Trigger coupler V203A, schematic diagram.

(4) *Gate generator V204AB and gate shutoff V204A.*

(a) General. Gate generator V204B and gate shutoff V204A form a cathode-coupled one-shot multivibrator. Gate generator V204B generates a long gate until gate shutoff V204A operates.

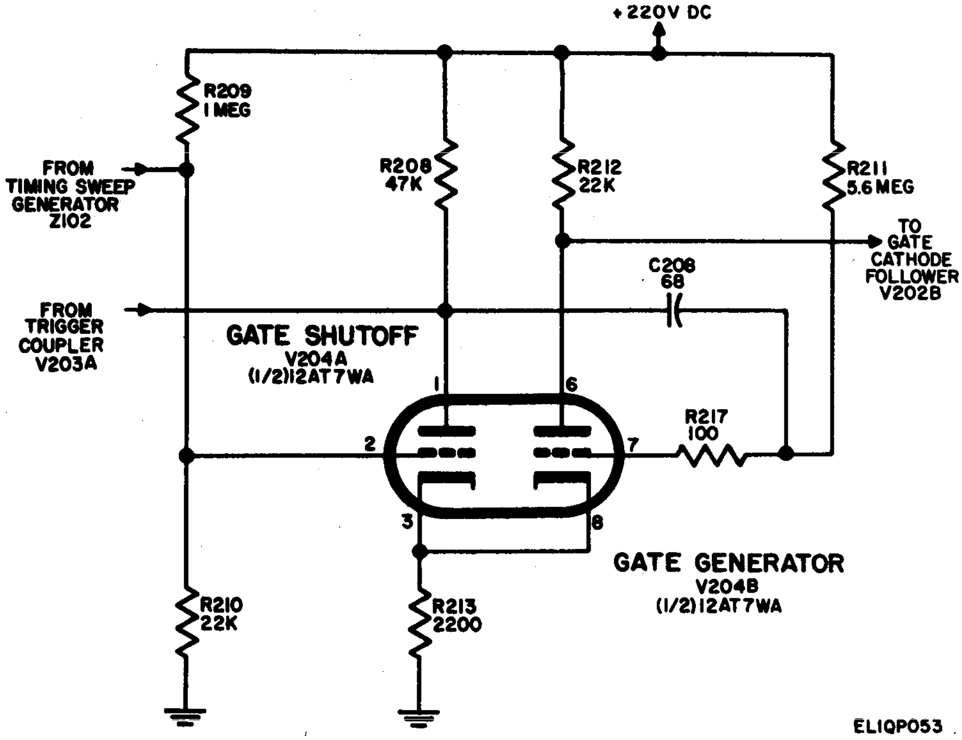


Figure 2-53. Gate generator V204B and Gate Shutoff V204A, schematic diagram.

(b) *Gate generator V204B*. Gate generator V204B normally conducts heavily and gate shutoff V204A is cut off by the voltage developed across common cathode resistor R213. The negative pulse from trigger coupler V203A is coupled by capacitor C208 to the grid (pin 7) of V204B through parasitic suppressor R217. When the negative-going pulse is applied to the grid of V204B, gate generator V204B cuts off and gate shutoff V204A starts to conduct. Gate generator V240B is kept at cutoff by the bias from common cathode resistor R213 and the negative output from the plate of V204A. A positive-going gate voltage is developed across plate resistor R212 and is coupled to the grid of gate cathode follower V202B. The duration of the positive-going gate pulse is approximately 110.1 microseconds and is controlled by a timing pulse from timing sweep generator Z102.

(c) *Gate shutoff V204A*. Gate shutoff V204A conducts heavily until a negative timing pulse from timing sweep generator Z102 (*b.* below) is applied to the grid (pin 2). The grid of gate shutoff V204A is driven beyond cutoff by the timing pulse and the plate goes positive. The positive-going pulse across plate load resistor R208 is coupled to the grid of V204B driving V204B into conduction. Resistors R209 and R210 form a voltage-dividing network for the grid of V204A.

(5) *Gate cathode follower V202B and diode clamp V203B*. The positive-going gate, from gate generator V204B, applied to the grid (pin 7) of cathode follower V202B and plate of diode clamp V203B causes V202B and diode clamp V203B to conduct. Diode clamp V203B clamps the input of V202B at zero level. The output of V202B is developed across cathode resistor R214 (E, fig. 2-49) end applied to timing sweep generator Z102 and to RANGE SELECTOR switch S101. Resistor R216 is the grid return for V202B. Resistors R214 and R215 form a voltage-divider network to fix the negative value that the cathode may reach. The output signal has two fixed levels with the positive level determined by diode clamp V203B and the negative value determined by the voltage divider.

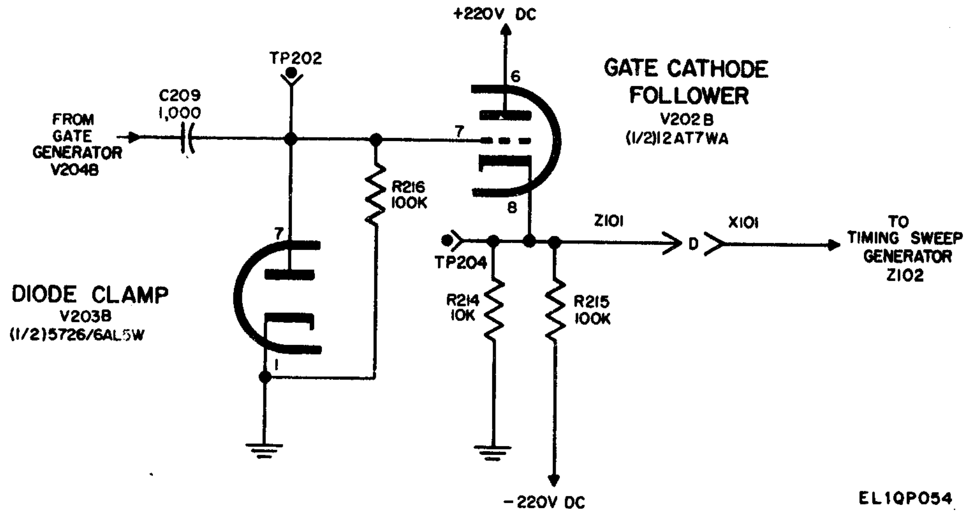


Figure 2-54. Gate cathode follower V202B and diode clamp V203B, schematic diagram.

b. Timing Sweep Generator Z102. The timing sweep generator produces a linear, negative-going sweep voltage. The input to the timing sweep generator is the positive-going long gate from the long gate generator. The negative-going sweep voltage generated in the timing sweep generator is fed to comparator tube V401 in each of the three pickoff assemblies and is used to synchronize the various circuits of the set. The negative-going sweep voltage is also used within the timing sweep generator to produce a gate shutoff pulse to accurately time the output of the long gate generator.

(1) *Gated Miller sweep V231* (fig. FO-5).

(a) General. Operation of gated Miller sweep V231 is based on the linear discharge cur of a capacitor when a constant current flow from the capacitor is maintained.

(b) Static condition of V231. The suppressor grid (pin 7) of V231 is negative with respect to cathode between long gate pulses. When the suppressor is negative, no plate current will flow and plate voltage will be at a high positive level. The control grid (pin 1) controls total cathode current and in the absence of an input, the grid will be positive in relation to the cathode, causing a large cathode-to-screen current flow. Sweep capacitors C231 and C232 are charged to approximately 220 volts with the bottom at +220 volts and the top end near 0 volt. With the plate current cut off by the suppressor grid, all cathode current must flow to the screen grid. This large screen current causes the screen to be at a low dc voltage level during static state condition.

(c) Operation during long gate input. When the positive long gate is applied to the suppressor grid (pin 7), plate current begins to flow and a small step voltage (represented by voltage E on the wave form at TP232) is developed. The plate voltage wave form is amplified and fed back to the bottom end of capacitors C231 and C232 by tubes V232, V233, and V235 (para 2-5b(2) and (3)). Since the voltage across a capacitor cannot change instanteously, the negative-going step voltage produced at the plate now appears on the grid (pin 1). The step voltage (at T_0) on the grid is sufficient to reduce conduction of the screen grid to a negligible amount. Since the control gird (pin 1) controls total cathode current and nearly all cathode current is now flowing to the plate, the plate current will be directly proportional to grid voltage and plate voltage will be inversely proportional to grid voltage. After the initial surge or step voltage has occurred, capacitors C231 and C232 start to discharge (see *(b)* above for charged condition), and cause the grid voltage to go in a positive direction (toward T_1). The plate voltage will go in a negative direction because of the grid action and a negative sawtooth wave form will result at TP232. If allowed to continue without feedback from plate to grid (through V232, V233, and V235), the wave form would be the exponential discharge curve of capacitors C231 and C232. With feedback, as capacitors C231 and C232 discharge, the current rate is held constant in the discharge circuit by driving the bottom ends of the capacitors in a negative direction. The exponential discharge of the capacitors tends to allow the grid to go in a positive direction and the negative-going sawtooth feedback applied to the bottom end of the

capacitors tends to pull the grid in a negative direction. Thus, the negative-going voltage cancels the exponential characteristic of the capacitor discharge ana a linear sawtooth wave form results.

(d) Operation at end of long gate. When the positive long gate ends at time T_1, the suppressor grid (pin 7) again goes negative, cutting off the plate, returning the plate to the stable state condition (high) very rapidly. The screen again receives all current flowing from the cathode and drops very rapidly to a low voltage level. The screen is saturated by the heavy cathode current so that small changes in grid (pin 1) voltage due to the charging currents of capacitors C231 and C232 do not affect the saturated condition and the voltage wave form at the screen approximates a square wave. Resistors R233, R234, and R235 make up a voltage divider and screen grid resistor network. Resistors R119 and R231 form the discharge path for capacitors C231 and C232 with resistor R119 controlling the slope of the sawtooth (RANGE SLOPE) by a small amount. RANGE RATE capacitor C232 establishes the rate of fall or time duration of the sawtooth portion of the plate voltage wave form over a small range. The output from the plate of the gated Miller sweep tube is direct-coupled to the cathodes of linear amplifier V232.

(2) *Linear amplifier V232 and cathode follower V233* (fig. FO-5).

(a) Linear amplifier V232. The input to linear amplifier V232 is the sawtooth wave form generated in the gated Miller sweep circuit which is direct-coupled to the cathodes of the tube. Resistor R238 is in series with the grid, pin 2, to prevent parasitic oscillations in the parallel-connected triode sections of the tube. The grids (pine 2 and 7) are held at approximately +55 volts dc by the voltage divider, consisting of resistors R236 and R237, and are kept at ac ground by capacitor C233. The cathodes are held at approximately +90 volts dc between input signals by the voltage divider, consisting of resistors R232 and R243, and tube conduction of V232. This +90 volts holds tube V232 beyond cutoff and is also the plate voltage for gated Miller sweep tube V231. Since linear amplifier V232 is beyond cutoff, the plates are at +440 volts dc. When the plate of Miller sweep tube V231 goes negative at T_0, linear amplifier V232 remains at cutoff until the voltage E has been developed at the cathode. After voltage E has been developed, linear amplifier V232 begins to conduct and amplifies the linear sawtooth portion of the wave between T_0 and T_1, without inversion. The ouput developed across plate load resistor R239 is a negative-going sawtooth voltage starting at +440 volts dc and ending at approximately +200 volts dc. At the end of the long gate, the plate of V231 again cuts off (goes positive) and linear amplifier V232 again goes to cutoff. Positive feedback is applied to the cathode through resistor R243 from cathode follower V233 to hold the gain of the stage constant as signal amplitude varies.

(b) Cathode follower V233. Cathode follower V233 acts as a buffer between linear amplifier V232 and output cathode follower V235. It also serves as part of the voltage divider network to supply plate voltage to gated Miller sweep tube V231. Between sawtooth sweeps, the tube is conducting heavily because the grids are at +440 volts dc (V232 is cut off). The +440 volts dc on the grids causes the cathodes to be held near +440 volts dc. Resistor R244 and capacitor C234 form a high-frequency bypass network and resistor R240 is a parasitic suppressor. The output voltage is developed across cathode resistors R241 and R242 and is coupled to cathode follower V235 through capacitor C235. A portion of the output is coupled through resistor R243 to the cathodes of linear amplifier V232. Resistor R245 holds the isolation winding of filament isolation transformer T231 near cathode potential to prevent filament-to-cathode breakdown of the tube.

(3) *Dc restorer V234A, cathode follower V235, and gate shutoff V234B* (fig. FO-5).

(a) Dc restorer V234A. Dc restorer V234A has +220 volts dc on its cathode and the signal is applied to the plate through C235. When the negative sawtooth input is applied, dc restorer V234A acts as an open circuit (plate negative in reference to cathode). When the sawtooth wave has passed, there is a rapid return to static conditions and the rapid return or rise of voltage would cause an overshoot or ringing in the circuit. Dc restorer V234A acts as a short circuit whenever the plate voltage tries to exceed cathode voltage and prevents the plate voltage from going above +220 volts dc, which is used as a reference level for cathode follower V235.

(b) Cathode follower V235. The grid of cathode follower V235 is held at +220 volts dc by grid resistor R246. Resistor R247 is a parasitic suppressor and the sections of the tube are parallel-connected. The cathodes are held at approximately +230 volts dc between input signals by tube conduction. The output developed across the cathode resistor network, consisting of resistors R248, R249, R250, R251, and R252, is a linear negative-going sawtooth. The linear sweep output starts at +230 volts dc and ends at approximately +5 volts dc. When the voltage falls below +5 volts V234B will conduct removing the input to V231 by cutting off the long gate. Resistor R253 holds the isolation

winding of filament isolation transformer T232 near cathode potential to prevent filament-to-cathode breakdown of the tube.

(c) Gate shutoff V234B. Gate shutoff V234B is normally nonconducting because of the high positive voltage applied to the cathode. When the sweep voltage has decreased to +5 volts and the cathode becomes negative with respect to the plate, the tube conducts and a negative output is sent to gate shutoff V204 (4) (c) above) to end the long gate.

c. Delay Trigger Pickoff Amplifier Z108.

(1) *Expanded sweep delay attenuator AT101* (fig. 2-55). Attenuator AT101 contains eleven 3,300-ohm resistors in series between positive 220 volts dc and ground. There are 11 taps from which voltage values may be chosen, from positive 20 volts to positive 220 volts in 20-volt steps. The output of the attenuator is applied to the plate (pin 7) of comparator tube V401B.

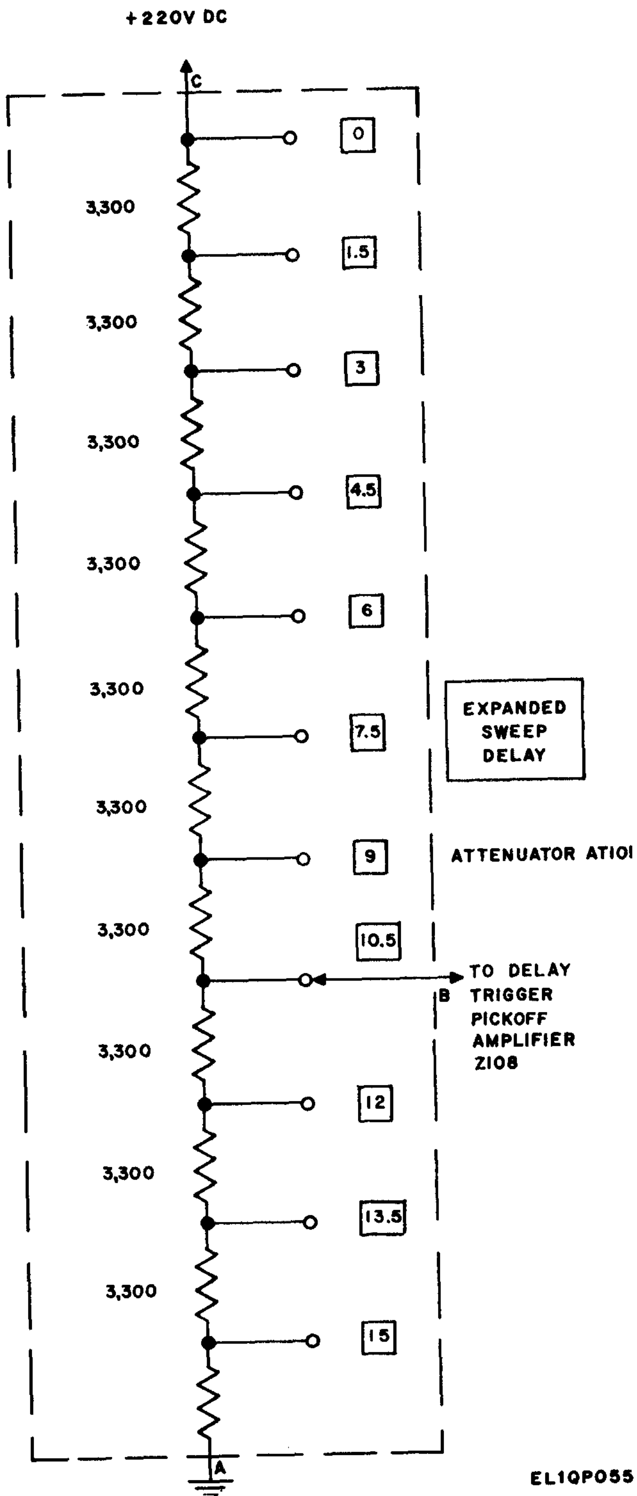


Figure 2-55. Expanded sweep delay attenuator AT101, schematic diagram.

(2) *Comparator tube V401* (fig. 2-56). Comparator tube V401 has two inputs and one output. The input applied to the plate (pin 7) of V401B is the dc voltage selected by attenuator AT101 (+20 to +220 volts in 20-volt steps). The input applied to the plate (pin 2) of V401A is the negative-going sawtooth output (+230 down to +5 volts).

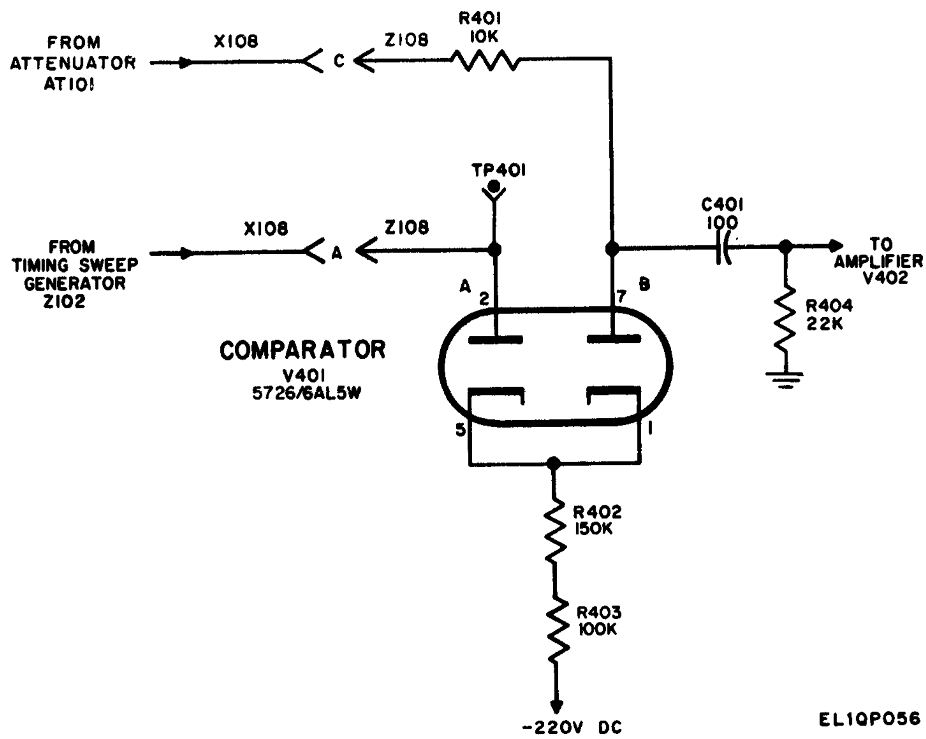


Figure 2-56. Comparator V401, schematic diagram.

(a) Stable state conditions. Between sawtooth inputs, the A section of V401 is conducting. Tube V401A has +230 volts applied to its plate from timing sweep generator Z102 and tube conduction holds the cathode at approximately +229 volts. The voltage applied to the B section is the voltage from AT101 (+20 to +220 volts dc) which, for discussion purposes, will be set at +200 volts. The cathodes are connected together and returned to the - 220-volt dc line through resistors R402 and R403. Tube V401B is cut off since its cathode is at +229 volts and the plate has +200 volts applied to it through plate load resistor R401.

(b) Operation during negative sawtooth. When the negative sawtooth wave is applied to the plate (pin 2) of V401A, the cathode goes negative at the same rate until it reaches the point that V401B begins to conduct (+200 volts). When V401B begins to conduct, a negative-going pulse is developed across plate resistor R401.

(c) Operation after negative sawtooth. After the negative sawtooth wave has passed, the plate of V401A again returns to +230 volts and the cathodes and plate of V401B return to their stable state condition (*(a)* above).

(d) Output. The negative-going pulse output of V401B is differentiated by capacitor C401 and resistor R404, resulting in sharp negative and positive spikes. The negative spike output can be varied in time by changing the voltage applied to the plate of V401B (*(b)* above) and is used to move the short gate in steps of 1,500 meters on the B-scope indicator.

(3) *Amplifier V402* (fig. 2-57). Pentode amplifier V402 amplifier and inverts the negative spike applied to the grid. Resistors R406 and R407 form a voltage-divider network for the screen grid. Input voltage is clamped to zero level by crystal diode CR401. Resistor R404 and R418 form a voltage divider to hold the grid at zero in absence of a signal. The output is a positive spike developed across plate load resistor R405 and it is applied to regenerative amplifier V403 through coupling capacitor C402.

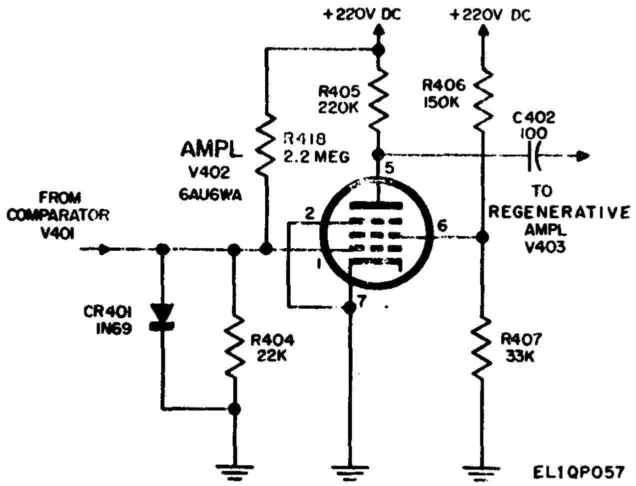


Figure 2-57. Amplifier V402, schematic diagram.

(4) Regenerative amplifier V403 and blocking oscillator V404.

(a) Regenerative amplifier V403. Regenerative amplifier V403 is a dual triode which is used to trigger blocking oscillator V404. Both sides of V403 are normally conducting but the B side is conducting more heavily. The positive-going trigger voltage from amplifier V402 is applied to the grid (pin 2) of V403A. Resistor R408 is the grid resistor. The triode conducts heavily and plate current through plate load resistor R409 develops a voltage drop across R409. The plate (pin 1) is direct-coupled to the grid (pin 7) of the second half of the dual-triode tube through coupling resistor R411. Capacitor C404 is connected between the plate (pin 1) and the grid (pin 7) to improve high frequency response. Resistor R412 is a grid return for the grid (pin 7). The negative-going voltage applied to the grid (pin 7) of V403B decreases the plate current flowing through the primary winding of transformer T401. Resistor R413 is a plate voltage-dropping resistor. Resistor R417 with capacitor C405 form a plate decoupling network. Resistor R410 and capacitor C403 form the cathode network (fig. 2-58).

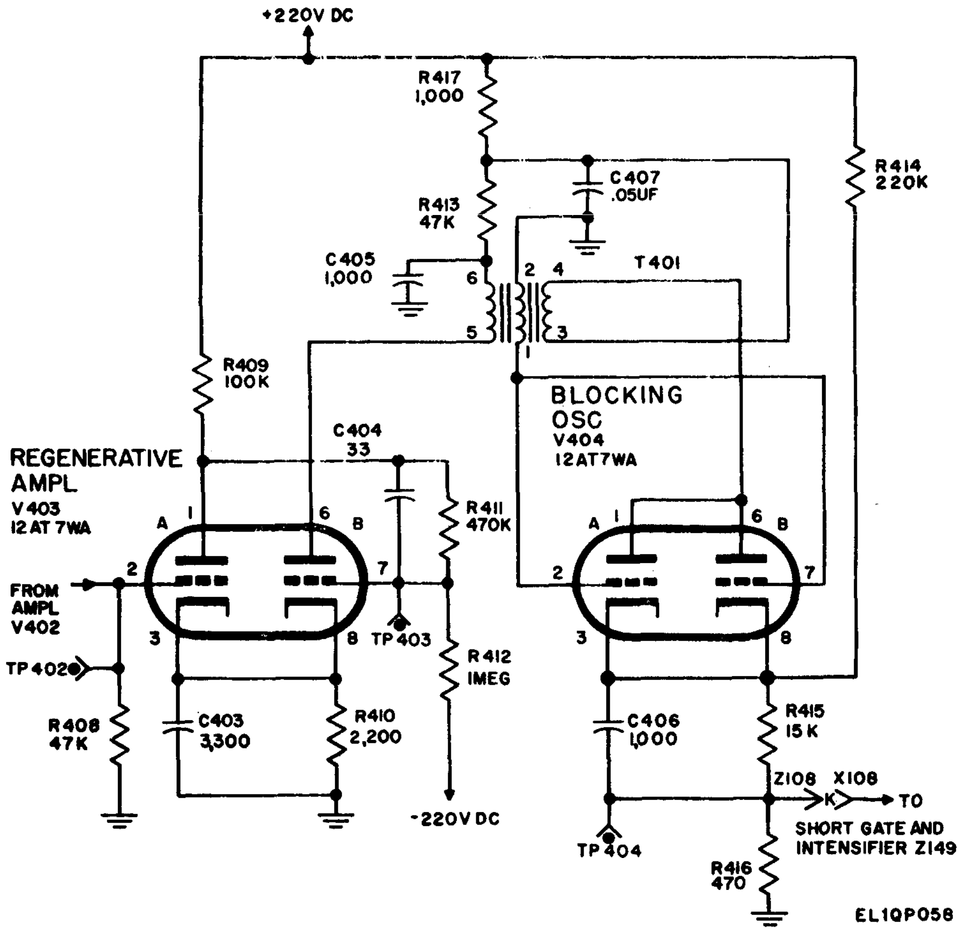


Figure 2-58. Regenerative amplifier V403 and blocking oscillator V404, schematic diagram.

(b) Blocking oscillator V404. The decreasing plate current of regenerative amplifier V403B passes through the primary of transformer *T401* and induces a voltage into the grid winding of T401. The voltage (positive) applied to the grid causes a heavy plate current to flow through the plate winding (3-4). Capacitor C407 is a plate decoupling capacitor. Resistors R414, R415, and R416 are cathode voltage dividers. The output of the blocking oscillator is a sharp pulse which is taken across cathode resistor R416. Capacitor C406 is a cathode bypass capacitor. The output of the blocking oscillator (J, fig. 2-49) is coupled to intensifier and short gate generator Z149.

d. Range (STROBE) Trigger Pickoff Amplifier Z109 and Range Zero Trigger Pickoff Amplifier Z107.

(1) *Range (STROBE) trigger pickoff amplifier* Z109. Range (strobe) trigger pickoff amplifier Z109 is identical with delay trigger pickoff amplifier Z108. The only difference in the operation of the two amplifiers is in one of the inputs. Range maker data (dc *voltage* level) from the computer (para *2-28d) are* coupled through J103 to the amplifier. The output of range marker trigger pickoff amplifier Z109 feeds range (strobe) markers to the video amplifier.

(2) *Range zero trigger pickoff amplifier Z107.* One input to comparator V401 is applied from timing sweep generator Z102. The other input to comparator V401 of range zero trigger pickoff Z107 is a dc voltage obtained across a resistor network (fig. 2-59). Resistors R117 and R118 and potentiometer R116 form a voltage divider. Capacitor C109 is a bypass capacitor. Potentiometer R116 is the RANGE ZERO adjustment which varies the plate voltage of V401 and the start time of the transmitter pulse. The output of range zero trigger pickoff amplifier Z107 is applied to modulator trigger generator Z147 *(h(1)* below).

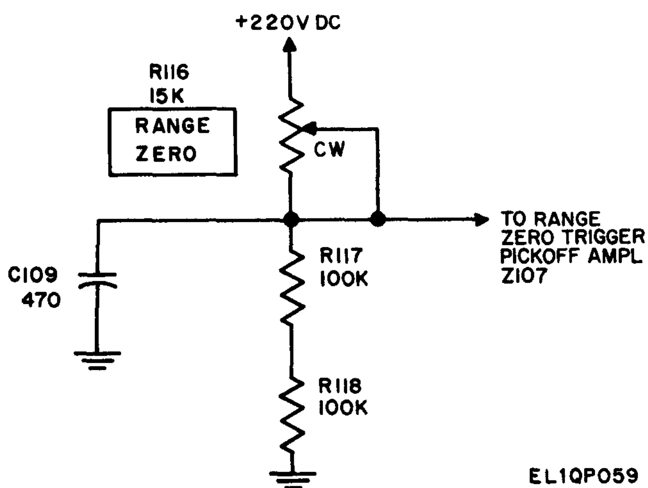


Figure 2-59. Range zero adjustment R116, schematic diagram.

e. Azimuth Marker Circuit.

(1) *Azimuth marker magnets* (fig. FO-6). Permanent magnets E3201, E3202, and E3203 are mounted on the rotating portion of the scanner (fig. 2-60). The magnets pass coils L3201, L3202, and L3203, which are mounted on the stationary portion of the scanner and induce a voltage into the coils. The pulses produced when the magnets pass the coils are transmitted to the pulse shaper. When dead time start magnet E3201 passes dead time fixed coil L3201, a pulse is produced (fig. 2-60). Approximately 3,000 microseconds later, dead time stop magnet E3202 passes dead time fixed coil L3201 and produces another pulse. After approximately 27,000 microseconds, during which time the upper beam is transmitted, dead time start magnet E3201 passes dead time adjustable coil L3202 and another pulse is produced. Dead time stop magnet E3202 then passes L3202 after 3,000 microseconds and produces a pulse. The lower beam is transmitted during the next 27,000 microseconds until E3201 again passes L3201. During the lower beam transmit time, azimuth marker magnet E3203 passes azimuth marker coil L3203 and produces a pulse. The position of L3203 can be moved by operating the computer azimuth handwheels. All the pulses are applied to the pulse shaper.

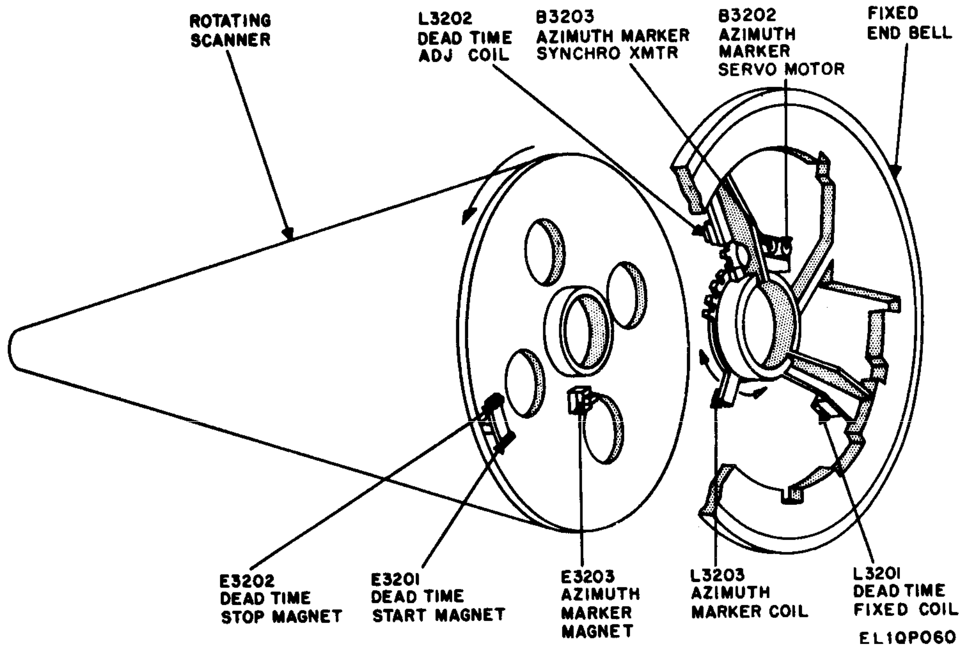


Figure 2-60. Scanner magnets and pickup coils.

(2) *Pulse shaper* (fig. 2-61), The dead time pulses are differentiated by capacitor C4709 and resistor R4720. The pulses are applied to azimuth synchronizer Z150 through CR4702. Azimuth marker pulses are differentiated by C4708 and R4719 and applied to Z150 through CR4701.

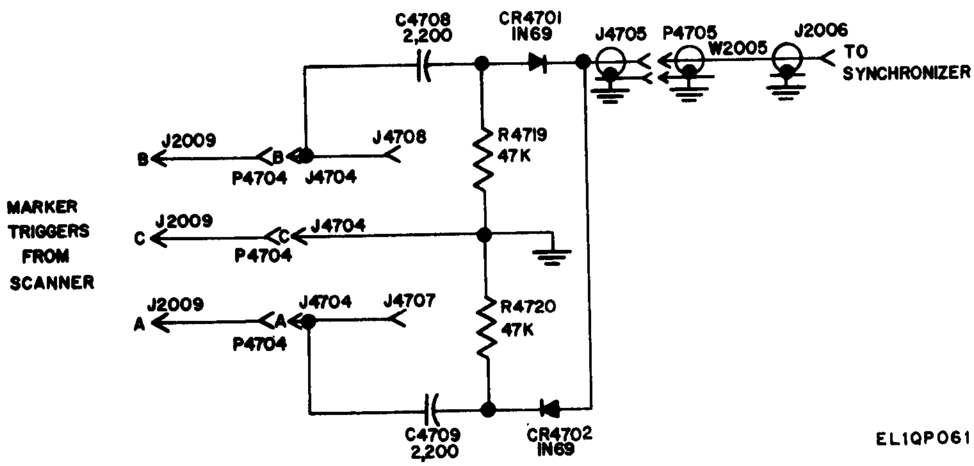


Figure 2-61. Pulse shaper, schematic diagram.

(3) *Azimuth marker synchro transmitter B3203 and azimuth marker servomotor B3202 (fig. FO-6 and 2-60)*. The rotor of azimuth marker synchro transmitter B3203 is mechanically connected to azimuth marker coil L3203. Azimuth marker information is transmitted from B3203 to the computing system. When the azimuth handwheels of the computer are rotated, an error signal is produced, which is applied to azimuth marker servomotor B3202. Servomotor B3202 positions marker coil L3203 and synchro transmitter B3203. The marker pulse produced by L3203 will move the azimuth marker on the indicator. The servomotor will null when no error voltage is transmitted.

f. Azimuth Synchroniser Z150.

(1) *Synchronizer marker amplifier V506A (fig. 2-62)*. The azimuth gate trigger and azimuth strobe triggers from the pulse shaper are coupled to the grid of synchronizer marker amplifier V506A through J105. Inductor L101 and capacitor C108 form an rf filter network. The trigger pulses are shown in figure 2-63. Resistor R547 is the AZIM SYNCH GAIN control which controls the signal input level to synchronizer marker amplifier V506A. Capacitor

C506 couples the voltage developed across R547 to the grid (pin 2) of V506A. Resistors R529 and R530 form a voltage divider which is used to bias the grid negative. Resistor R510 is the plate load resistor and the voltage developed across R610 is coupled to cathode follower V507A and trigger blanking amplifier V506B through coupling capacitor C507. The positive gate pulses and the negative strobe pulse from V506A follow two paths through azimuth synchronizer Z150.

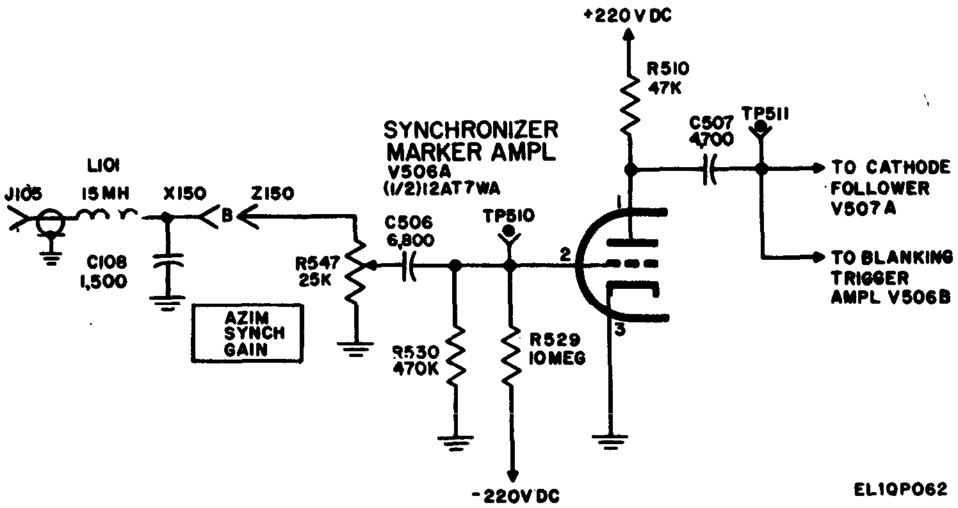


Figure 2-62. Synchronizer marker amplifier V506A, schematic diagram.

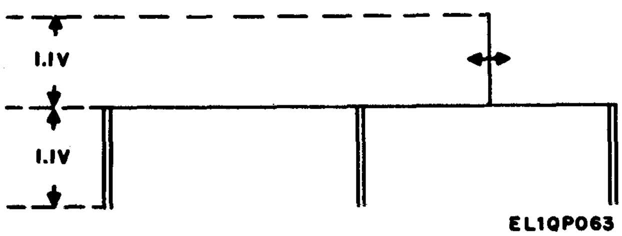


Figure 2-63. Waveforms for scanner trigger.

(2) Cathode follower V507A and clipper V507B (fig. 2-64). Cathode follower V507A and clipper V507B limit and clip the trigger pulses *(N,* fig. 2-49 and 2-65) from synchronizer marker amplifier V506A which are applied to the grid (pin 2) of V507A. The positive pulses developed across grid resistor R533 cause V507A to conduct heavily during each pulse. Plate current from V507A flows through common cathode resistor R534 and produces a more positive voltage at the cathode (pin 8) of V507B. This has no effect on V507B since it is held in cutoff by the negative voltage at its grid (pin 7), developed by voltage-divider resistors R535 and R536. When the negative pulse (N, fig. 2-49) is applied to the grid of V507A, the plate current of V507A decreases and the cathode (pin 8) of V507B goes negative. Clipper V507B conducts for the period of the negative pulse on the grid of V507A and produces a negative-going pulse which is applied to the grid (pin 7) of azimuth strobe multivibrator V508 through coupling capacitor C508.

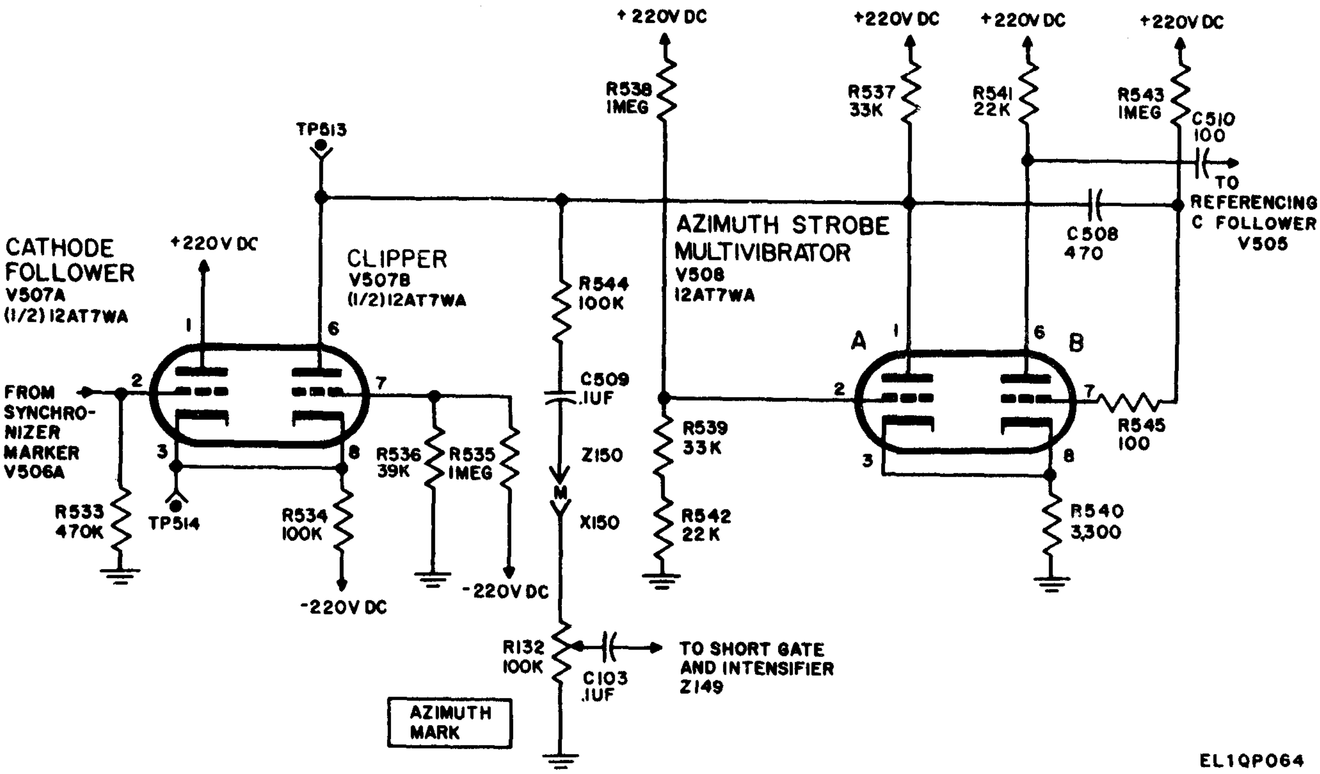


Figure 2-64. Cathode follower V507A, clipper V607B, and azimuth strobe multivibrator V508 schematic diagram.

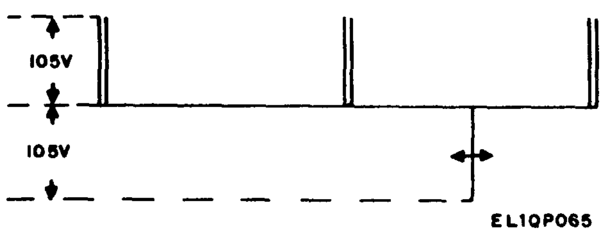


Figure 2-65. Waveforms for clipper and multivibrator.

(3) *Azimuth strobe multivibrator V508.*

(a) General. Azimuth strobe multivibrator V508 is a cathode-coupled one-shot multivibrator in which the A section (plate, pin 1) is normally nonconducting and the B section (plate, pin 6) is conducting heavily. The azimuth strobe multivibrator produces a negative gate pulse which is used for the azimuth strobe line on the indicator and a positive pulse which is applied to referencing cathode follower V505.

(6) Circuit *Functioning.* Tube V508A (plate, pin 1) is nonconducting because of the bias developed across common cathode resistor R540 when V508B is conducting. The grid (pin 3) of the V508A section is held at a fixed positive potential by the voltage divider consisting of resistors R538, R539, and R542. The negative pulse from clipper V507B is applied to the grid (pin 7) of the conducting section (V508B) through coupling capacitor C508 and parsitic suppressor R545, cuts the B section off. When plate current of the B section stops flowing through common cathode resistor R540, V508A begins to conduct. The length of time that the A section conducts is determined by the RC time constant of C508 and grid resistor R543. When V508A begins to conduct, the grid (pin 7) of the B section starts to rise exponentially toward positive 220 volts. As capacitor C508 begins to charge through R543, the grid (pin 7) rises above cutoff and the B section begins to conduct. The B section will conduct until another negative trigger reaches the grid. Resistor R541 is the plate load resistor for the B section and a positive pulse is produced during the time the B section is cut off. The positive pulse is applied to referencing cathode follower V505. A negative pulse (Q, fig, 2-49), developed across plate load resistor R537, is applied to short gate and intensifier Z149 (para 2-24c) through isolation resistor R544, coupling capacitor C509, AZIMUTH MARK potentiometer R132, and capacitor C103.

(4) *Referencing cathode follower V505.* Referencing cathode follower V505 is biased to cutoff by resistors R527 and R528. The positive and negative pulses from azimuth strobe multivibrator V508 are differentiated by coupling

capacitor C510 and resistor R527 and applied to the grids (pins 2 and 7) through grid-limiting resistor R526. The negative-going pulses have no effect on the cathode follower. The positive pulses cause current flow through V505. The positive pulse developed across cathode resistor R548 is applied to blanking multivibrator V502 ((5) below), and the positive pulses developed across cathode resistor R549 is applied to range shift multivibrator V504 ((8) below).

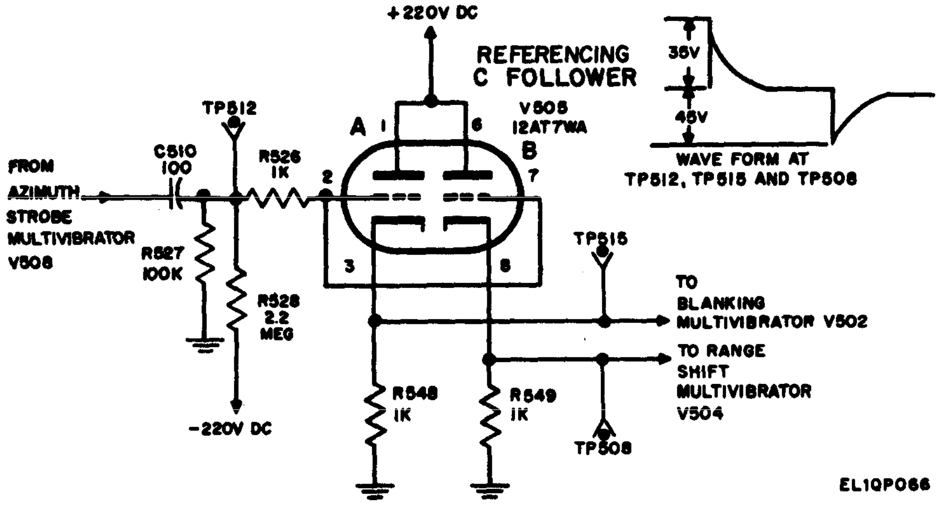


Figure 2-66. Referencing cathode follower V505, schematic diagram.

(5) *Blanking trigger amplifier V506B and blanking multivibrator V502.*

(a) *General.* Blanking multivibrator V502 is triggered by blanking trigger amplifer V506B. The output of the blanking multivibrator is one negative pulse for each two input triggers fig. 2-67).

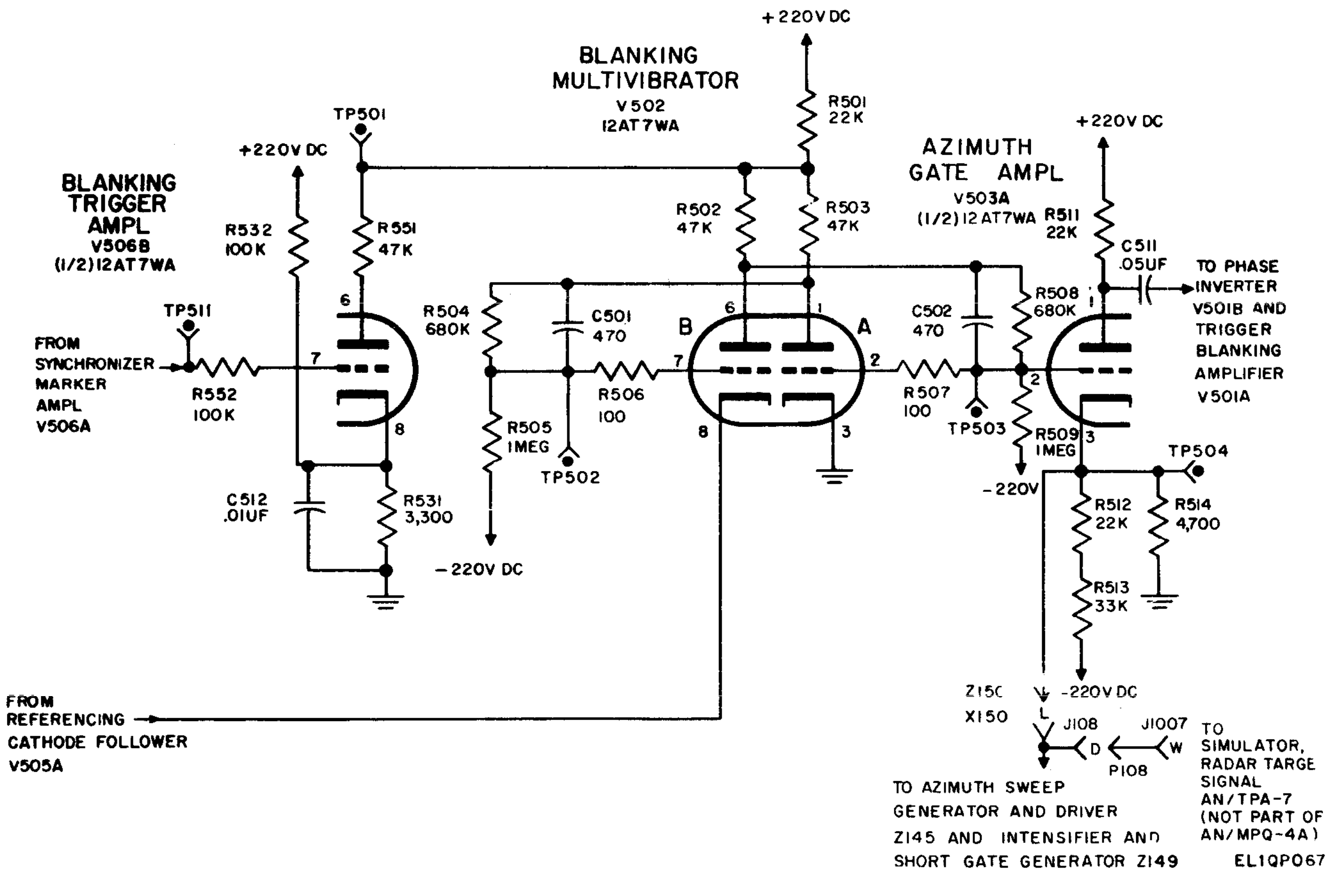


Figure 2-67. Blanking trigger amplifier V506B, blanking multivibrator V502, and azimuth gate amplifier V503A, schematic diagram.

(b) *Blanking trigger amplifier V506B.* Blanking trigger amplifier V506B is biased by the voltage-divider network consisting of resistors R531 and R532 so that the tube is nonconducting. Capacitor C512 is the cathode bypass capacitor. Trigger pulses from synchronizer marker amplifier V506A (0, fig. 2-49 and A, fig. 2-68) are applied to the grid of V506B through grid-limiting resistor R552. The positive pulses on the grid cause the stage to conduct heavily. Plate current from V506B passes through plate load resistor R551 and R501. That portion of signal developed across resistor R501 is used to trigger blanking multivibrator V502. Since blanking trigger amplifier V506B is at cutoff, except during the input pulse, it does not load blanking multivibrator V502.

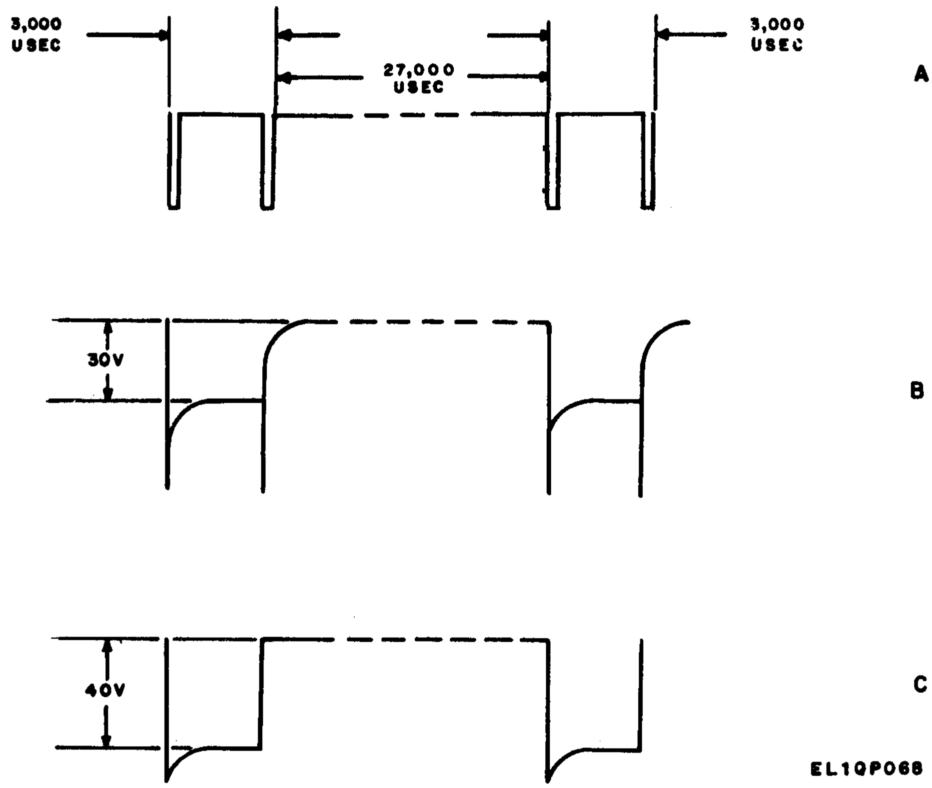


Figure 2-68. Waveforms for blanking multivibrator V502.

(c) Blanking multivibrator V502. Blanking multivibrator V502 has the A section (plate, pin 1) normally conducting heavily, and the B section (plate, pin 6) normally cutoff. When the first negative pulse (B, fig. 2-68) is applied to the junction of resistors R501, R502, R503, and R551, it is applied to the plate and grid (pins 6 and 7) of section B and the plate and grid (pins 1 and 2) of section A simultaneously. The negative pulse has no effect on section B, since section B is non-conducting. The negative pulse applied to the grid (pin 2) of the A section drives the grid below cutoff and section A becomes nonconducting. The voltage at the plate (pin 1) rises and a positive voltage is coupled to the grid (pin 7) of section B through resistor R504, high frequency compensating capacitor C501, and parasitic suppressor R506. Grid resistors R504 and R505 form a voltage divider between -220 dc and the potential present at the A section plate (pin 1). The positive voltage applied to the grid (pin 7) raises the grid voltage sufficiently for section B to begin conduction. Plate current flowing through plate load resistors R501 and R502 produces a negative pulse which is applied to the grid of azimuth gate amplifier V503A and V502A (C, fig. 2-68) through resistor R508. Capacitor (C502 is a high frequency compensating capacitor, resistor R507 is a parasitic suppressor, and R509 is a common grid resistor for V502A and V503A. Tube V502B continues to conduct until the second trigger is applied 3,000 microseconds later (A, fig. 2-68). When the second pulse is applied at the junction of plate resistors R501, R502, and R503, the B section will stop conducting and the A section will begin to conduct. The A section will conduct for approximately 27,000 microseconds (A, fig. 2-68) until the next trigger pulse is applied to the trigger blanking multivibrator.

(d) Reference pulse. A positive pulse from the cathode (pin 3) of referencing cathode follower V505 (fig. 2-66) is coupled to the cathode (pin 8) of V502, If V502 operates correctly, the reference pulse has no effect on the operation of the multivibrator. If V502 does not switch back to the original state (section A conducting) after the second pulse, the reference pulse will cause section B to cut off and section A will start conduction.

(6) *Azimuth gate amplifier V503A* (fig. 2-67). The negative-going pulses (A, fig. 2-68) are applied to the grid (pin 2) of azimuth gate amplifier V503A. Azimuth gate amplifier V503A is a paraphase amplifier. The cathode (pin 3) of V503A is biased by

a voltage divider consisting of resistors R512, R513, and R514. Negative-going pulses are coupled to azimuth sweep generator and driver Z145, and intensifier and short gate generator Z149 and to Simulator, Radar Target Signal AN/TPA-7, when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. A positive-going pulse is developed across plate load resistor R511 and is fed through coupling capacitor C511, to phase inverter V501B and trigger blanking amplier V501A.

(7) *Trigger blanking amplifier V501A and phase inverter V501B.* (fig. 2-69)

(a) *Tigger blanking amplifier V501A.* Negative square wave pulses are applied to the grid (pin 2) of trigger blanking amplifier V501A through parasitic suppressor resistor R525. Resistor R546 is a grid resistor for both sections of V501. The input pulses are amplified and inverted by V501A and applied to modulator trigger generator Z147 *(h(1)* below) as positive square wave pulses.

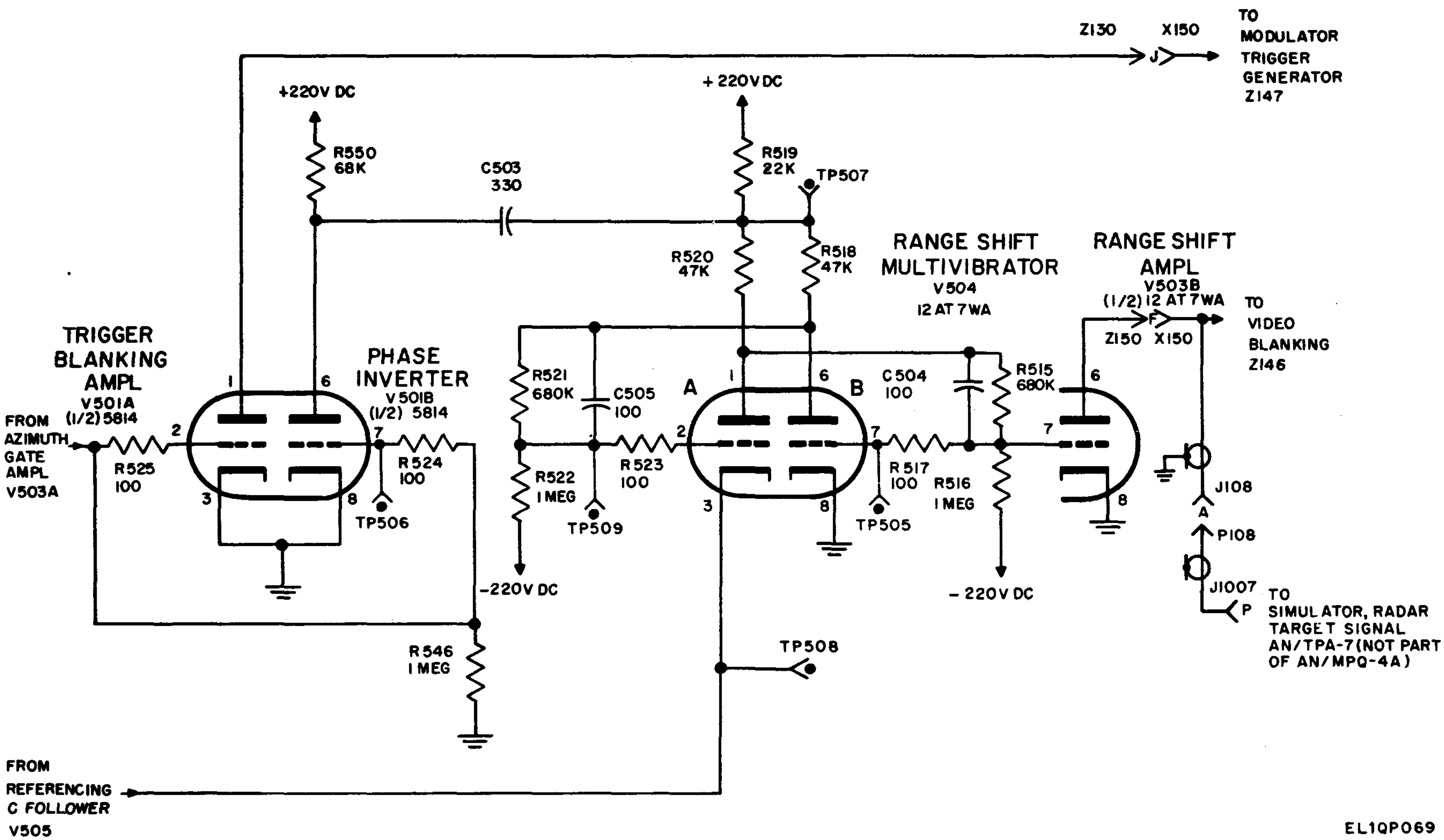


Figure 2-69. Phase inverter V501B, trigger blanking amplifier V501A, range shift multivibrator V504, and range shift amplifier V503B, schematic diagram.

(b) Phase inverter V501B. Negative square wave voltages am applied to the grid (pin 7) of V501B through parasitic suppressor R524. The signal is amplified and inverted, and coupled to range shift multivibrator V504 through capacitor C503.

(8) *Range shift multiuibrator V504* (fig. 2-69).

(a) *General. Range* shift multivibrator V504 produces one symmetrical output square wave for each two input pulses. Since the input is developed by blanking multivibrator V502, the output of range shift multivibrator V504 is one symmetrical output square wave for every four triggers at J105.

(b) Circuit functioning. Range shift multivibrator V504 is similar to blanking multivibrator V502 ((5) above). Capacitor C503 and resistor R519 form a differentiating circuit which differentiates the square wave voltage from V501B. Resistors R518 and R520 are plate load resistors. Capacitors C504 and C505 are coupling capacitors. Resistors R517 and R523 are connected to the grids (pins 2 and 7) to reduce parasitic oscillations, and resistors R515 and R516 and R521 and R522 form voltage-divider networks for the grids of V504. A square wave output voltage is applied to the grid (pin 7) of range shift amplifier V503B.

(c) *Reference pulse.* A positive pulse from referencing cathode follower V505 (fig. 2-66) is coupled to the cathode (pin 3) of V504A. If V504 operates correctly, the reference pulse has no effect. If V504 does not switch back to the original state (B section conducting) after the second pulse, the reference pulse will cause the multivibrator to switch.

(9) *Range shift amplifier V503B (fig. 2-69). Range* shift amplifier V503B applies a square wave through terminal F of XZ150 to video blanking amplifier 2146 and to Simulator, Radar Target Signal AN/TPA-7 when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. The plate load resistor for V503B is in the video blanking circuits ((g(2) below).

g. *Video Blanking Circuit Z146.* Video blanking circuit Z146 (fig. 2-70) receives a symmetrical square wave input signal with a time duration of 60,000 microseconds (1 complete scanner revolution). It provides a range shift voltage for physical range displacement of upper and lower beam displays on the indicator. It also provides beam blanking voltages so either the upper or lower beam can be blanked continuously or in sequence by operating the timer.

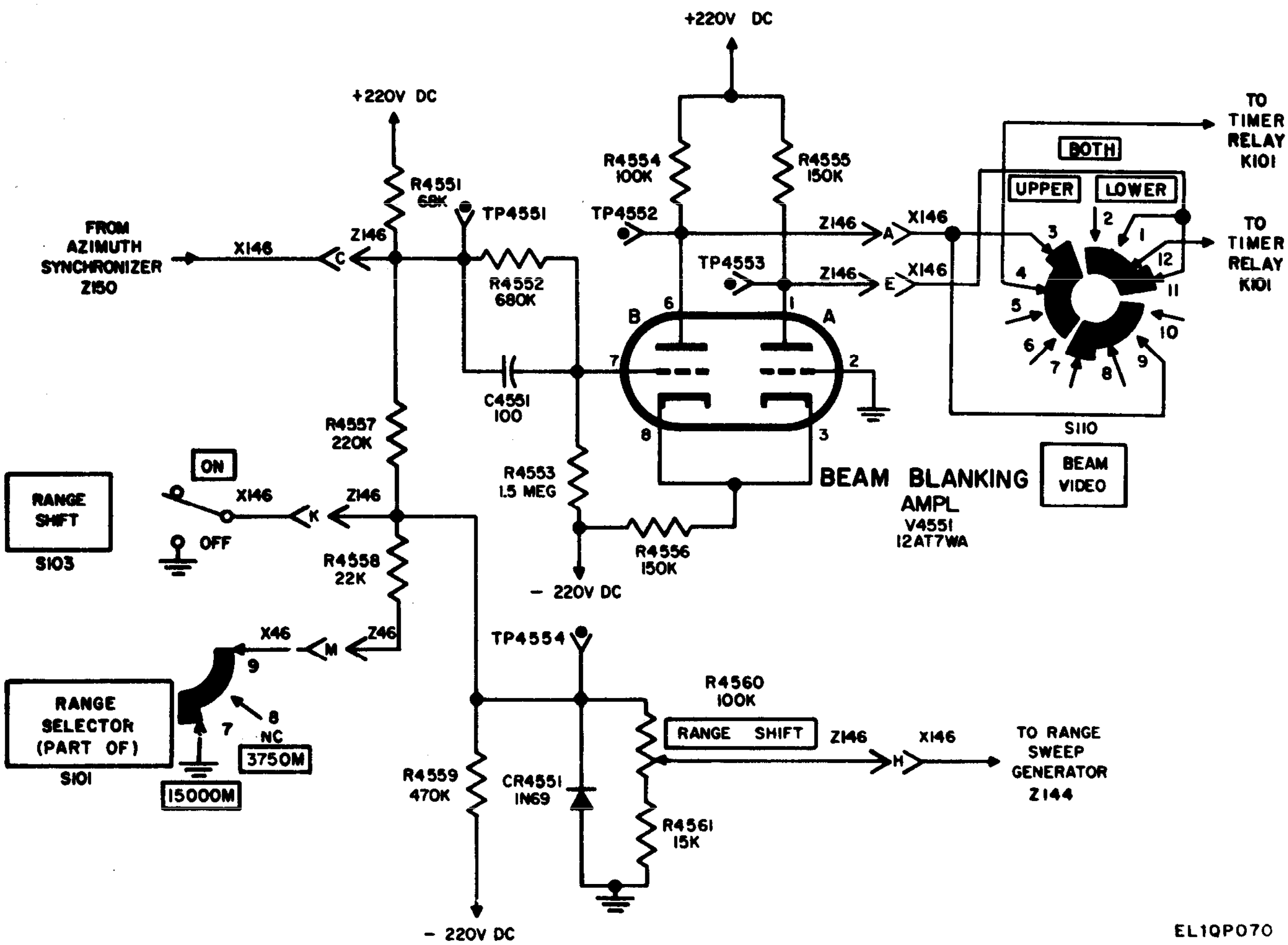


Figure 2-70. Video blanking amplifier Z146, schemataic diagram.

(1) *Range shift circuit* (fig. 2-70). Resistor R4551 is the plate load resistor for range shift amplifier V503B ((f(9) above) and a symmetrical square wave voltage is developed across it by V503B. If RANGE SHIFT switch S103 is in the ON position, the square wave voltage developed by V503B is coupled through voltage-dividing resistors R4557 and R4561 to RANGE SHIFT potentiometer R4560. Resistor R4558 is shunted across R4560 and R4561 when RANGE SELECTOR switch S101 is in the 15000M position and a smaller amount of the square wave is developed across RANGE SHIFT potentiometer R4560, resulting in a smaller output from R4560 and ultimately a smaller physical displacement of range shift on the indicator. Resistor R4559 returns the top end of CR4551 to negative 220 volts dc to hold the output of crystal clamper CR4551 at a zero reference level. The output to range sweep generator Z144 is a square wave voltage (W, fig. 2-49) clamped at 0 volt and swinging in a positive direction. If RANGE SHIFT switch S103 is in the off position, no output results from the circuit.

(2) *Beam blanking amplifier V4551* (fig. 2-70). Beam blanking amplifier V4551 is a cathode-coupled paraphase amplifier. The square wave voltage developed across resistor R4551 is direct-coupled to the grid (pin 7) through resistor R4552. Capacitor C4551 is for high frequency compensation and resistor R4553 is part of a voltage divider (R4553, R4552, and R4551) used to establish grid voltage and coupling of the signal into V4551. When the input signal swings positive, V4551B conducts and a negative-going output is developed across plate load resistor R4554 and fed to BEAM VIDEO switch S110. At the same instant, a positive-going signal is developed across common cathode resistor R4556, which causes V4551A to reach cutoff and a positive output is developed across plate load resistor R4555 and fed to BEAM VIDEO switch S110. When a negative-going input signal is felt at the grid (pin 7)

of V4551B, the tube cuts off and a positive-going output is fed from the plate. At the same instant, the cathode goes negative causing V4551A to conduct heavily with a negative-going output at the plate resulting. The outputs of the A and B sections are symmetrical square waves (W, fig. 2-49) 180° out of phase with each other. BEAM VIDEO switch S110 selects the desired output for upper or lower beam blanking. In the center position (BOTH) of S110, no output is coupled to the timer and both upper and lower beams are displayed on the indicator.

(3) *Timer M101* (fig. 2-71).

(a) General. Timer M101 is used to measure the time interval between projectile echo appearances on the indicator and also switches from lower to upper, or upper to lower beam displays on the indicator.

(b) *Beam blanking input.* The beam blanking voltages fed into relay K101 (contacts 5 and 7) are symmetrical square waves, equal in amplitude and 180° apart in phase. The negative portion of the inputs is used and each negative portion used will blank one complete upper or lower beams scan (30,000 µsec). Assuming that BEAM VIDEO switch S110 is in the LOWER position, then the input to contact 7 of relay K101 is negative during the upper beam display time on the indicator. If contact 7 is negative then contact 5 is positive, since these voltages are 1800 out of phase.

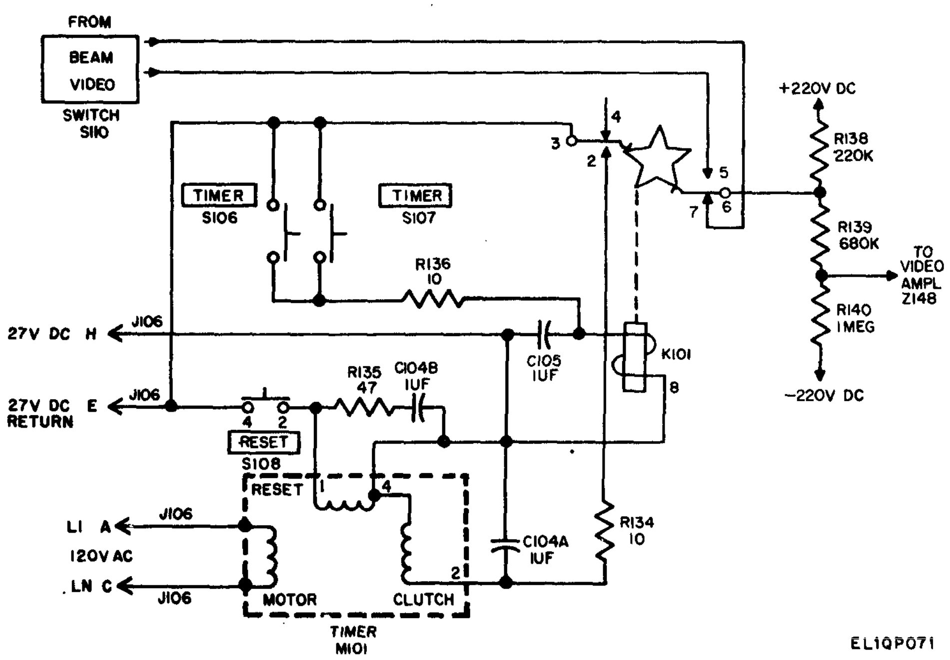


Figure 2-71. Timer M101, schematic diagram.

(c) Relay K101 and timer M101. Relay K101 is activated by either TIMER switch S106 or TIMER switch S107 and advances one step each time contact is made by either switch. In the position shown (LOWER), contacts 3 and 4 and contacts 6 and 7 are closed. Upper beam blanking voltagee are applied through the 6 to 7 contacts to video amplifier 2148 and, as a result, only lower beam information will be displayed on the indicator. Assuming that the operator sees an echo on the lower beam display, he immediately activates TIMER switch S106 or S107 and 27 volts dc is applied to the coil of relay K101, through current-limiting resistor R136, causing a one-step rotation of relay K101. The one-step rotation causes contact 6 to break with 7 and make with contact 5. Lower beam blanking is now applied to video amplifier Z148 and the indicator now displays only upper beam echoes. The one-step rotation also breaks connection between contacts 2 and 3 of K101, applying 27 volts dc to the clutch winding of timer M101, and the time pointer starts rotating to measure elapsed time. When the upper beam echo is observed, the operator again activates switch S106 or S107, which causes relay K101 to advance another step and the contacts return to their original positions (upper beam blanking and clutch winding deenergized). The dial pointer on the timer stops at whatever the elapsed interval of time was and stays at that reading until RESET switch S108 is activated. When RESET switch S108 is pushed, the reset winding of timer M101 returns the pointer to zero position. The motor of timer M101 is a synchronous 400-hertz continuous run device, Resistor R135 and capacitor C104B form

a filter network and capacitors C104A and C105 are filters. Resistors R138, R139, and R140 form a voltage-divider and coupling network for the input to the suppressor grid of first video amplifier V4601 in Z148 (para *2-25d*).

h. Modulator Trigger Generator Z147. Modulator trigger generator Z147 contains a gated trigger amplifier which triggers a blocking oscillator during periods when the scanner is in proper position of rotation for transmission of upper or lower beams. While the tooth barriers in the scanner are in mesh (dead time), no triggers are fed to the modulator or to Simulator, Radar Target Signal AN/TPA-7, when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. Modulator trigger generator Z147 also contains focus control tube V4573, which is part of the indicating system. The functioning of V4573 is discussed in paragraph 2-25*f*(2).

(1) *Gated Trigger Amplifier V4571* (fig. 2-72). Gated trigger amplifier V4571 has cutoff bias applied to both the control grid (pin 1) and suppressor grid (pin 7) in its stable state condition. When the scanner is in proper position for transmission of either upper or lower beams, a positive gate voltage (V, fig. 2-49) is applied to the suppressor grid through test switch S104 and the biasing voltage-divider network, consisting of resistors R4571, R4572, and R4573. Resistor R4571 is also the plate load for trigger blanking amplifier V501A in azimuth synchronizer Z150, and V501A is normally conducting heavily. Capacitor C4571 is a high frequency compensating capacitor. Tube V4571 remains at cut-off due to grid (pin 1) bias until a positive pulse from V404, in range zero trigger pickoff assembly Z107, is applied to the grid (pin 1). The positive trigger (I, fig. 2-49 7,000 Hz rate) is applied to the grid, pin 1, through coupling capacitor C4572. Resistors R4574 and R4575 form a voltage-divider bias network to hold grid pin 1 at cutoff when no input is applied. The output of gated trigger amplifier V4571 is fed to the primary of blocking oscillator transformer T4571 and consists of a series of triggers 110.1 µsec apart which start at 3,000 µsec and continue for 27,000 µsec and then stop for 3,000 µsec again. Resistors R4576 and R4577 form a screen grid voltage divider and capacitor C4573 is the screen bypass capacitor. Test switch S104 allows the transmitter to be triggered without the scanner rotating.

CAUTION

Test switch S104 must be in the ON position whenever the scanner is rotating and the transmitter is being triggered. Before turning test switch S104 to OFF, position the scanner rotor so no barrier teeth are engaged. Failure to follow these instructions will result in burned barrier teeth and destruction of the scanner assembly.

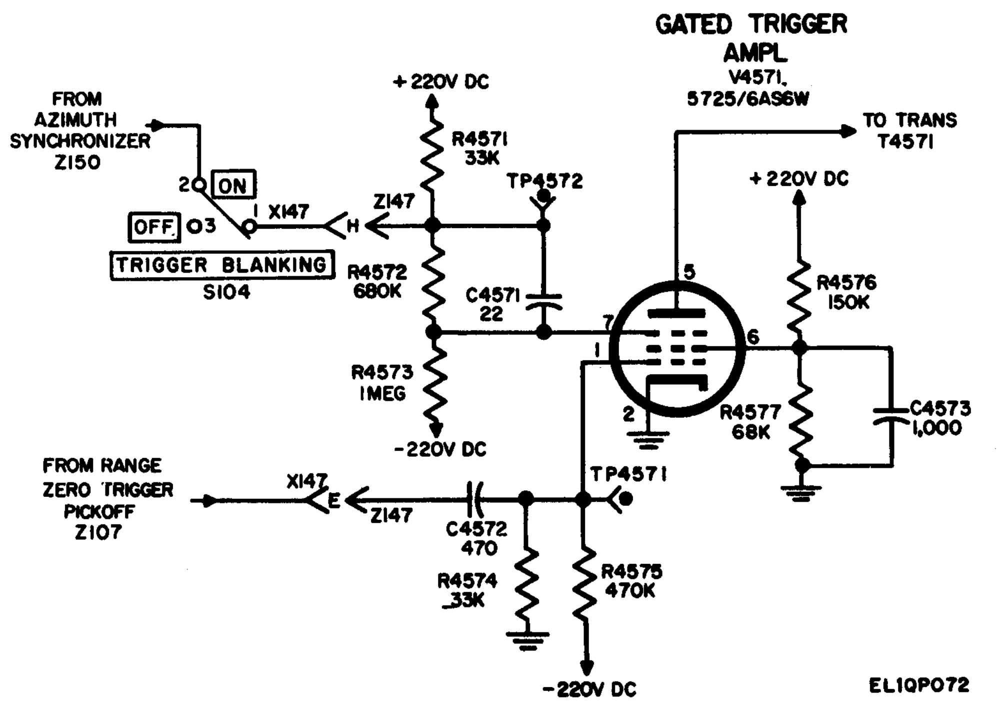


Figure 2-72. Gated trigger amplifier V4571, schematic diagram.

(2) *Modulator trigger V4572* (fig. 2-73). Modulator trigger *V4572 is* a blocking oscillator. Plate current from *V4571* flowing through the primary of transformer T4571 triggers the blocking oscillator. Resistor R4578 and capacitor C4574 form a plate decoupling network for V4572. Resistor R4579 is a grid damping resistor. Resistors R4580, R4581, R4582, and R4583 form a voltage-divider network for the cathodes (pin 3 and 6) of V4572. Capacitor C4575 is a cathode bypass. The plate current of V4572 is regeneratively transformer-coupled to the grid to produce the spike. The output is a 30-volt positive pulse, taken from the cathode circuit of V4572. The positive pulse is coupled through J101 to the trigger pulse amplifier and to Simulator, Radar Target Signal AN/TPA-7, when the AN/TPA-7 is used with Radar Set AN/MPQ-4A.

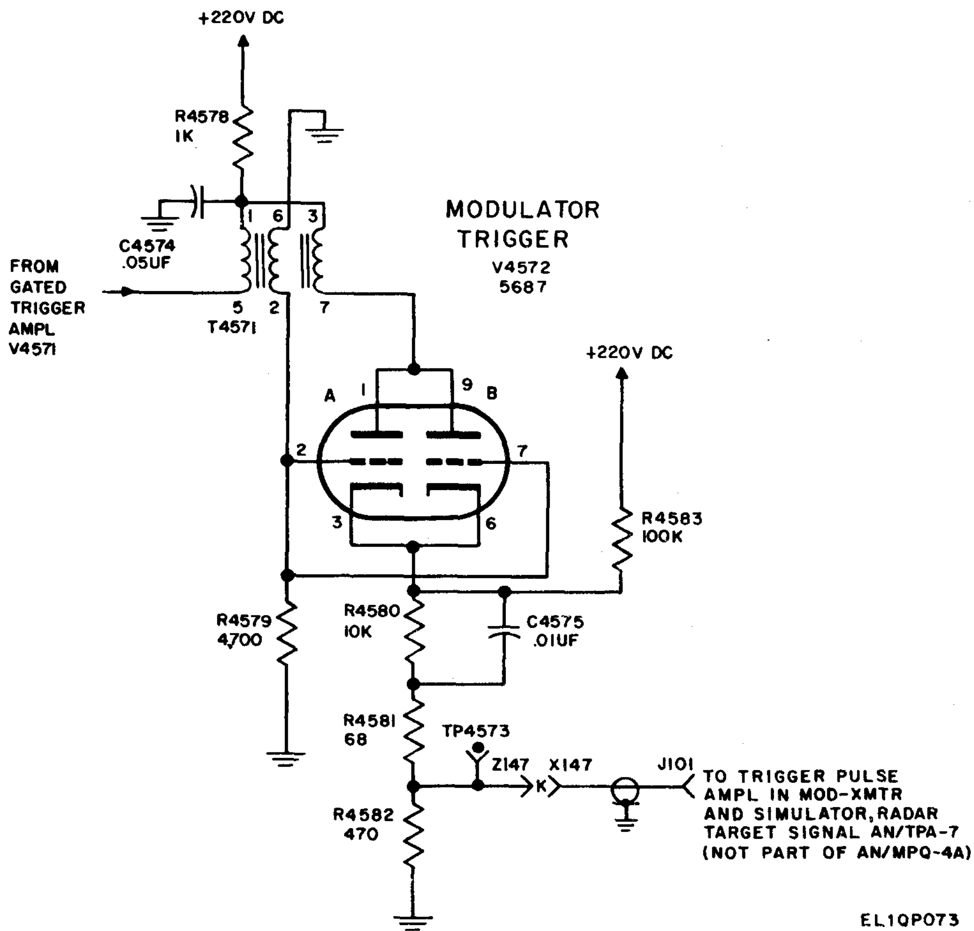


Figure 2-73. Modulator trigger V4572, schematic diagram.

Section VI. INDICATING SYSTEM

2-23. General

The indicating system consists of the cathode-ray tube and those associated circuits which are necessary for proper visual presentation of target data.

a. Vertical (range) and horizontal (azimuth) sweep circuits drive the crt deflection coils. Gate pulses supplied by the short gate generator (for short range operation) or the long gate generator (for long range operation) trigger the range sweep generator. The azimuth sweep generator is triggered by the azimuth synchronizer. An intensifier circuit is used to intensify a certain portion of the sweep. Video signals are amplified to drive the crt. A high voltage oscillator and a rectifier-multiplier furnish high voltage to the anode of the crt.

b. The relationship of the indicating system with repect to other functional systems of the radar set is covered in paragraph 2-1.

2-24. Indicating System Block Diagram (fig. FO-4)

a. *Azimuth Sweep Generator and Driver Z145.* A positive gate voltage from azimuth synchronizer Z150 is applied to clamps V4501A and V4501B. The clamps open and sweep generator V4502 begins conduction. Sweep generator V4502 produces a negative-going sweep voltage, which is applied to azimuth drivers V4503 and V4504. A positive-going sweep voltage taken from the plate circuits of V4503 and V4504 is applied to the deflection coil of indicator tube V101. A negative-going sweep voltage taken from the cathode circuits of V4503 and V4504 is applied to phase inverter V4505 and automatic size control V4508B. Automatic size controls V4508A and V4508B sample the sweep voltage; if the speed of the scanner varies, automatic size control V4508 alters the azimuth sweep to compensate for the change in scanner speed. An output from the cathode of azimuth driver V4504 is also fed to clamper V4501A to keep the sweep centered as the size changes. Phase inverter V4505 applies a positive-going sweep voltage to azimuth drivers V4506 and V4507. The output of V4506 and V4507 is a negative-going sweep voltage which is applied to the deflection coil of indicator V101.

b. *Range Sweep Generator and Driver Z144.* A positive-going short gate or long gate from RANGE SELECTOR switch S101 opens clamps V4402A and V4402B and starts sweep generator V4401B. The voltage set on the grid of voltage setting triode V4401A establishes the center of the range sweep on the screen of the crt by controlling the bias of V4401B. When RANGE SHIFT switch S103 (video blanking Z146) is in the ON position, grid clamp CR4551 is biased and the center of the sweep is moved upwards on the screen of the crt driving upper beam display time. Sweep generator V4401B produces a sweep voltage which is applied to range swrep driver V4404, The sweep voltage from V4404 is applied to the range deflection coil of the crt. An output from the cathode of V4404 is applied to phase inverter V4403, to voltage setting triode V4401A, and sweep generator V4401B. Phase inverter V4403 inverts the applied sweep voltage and drives range sweep driver V4405, which delivers a sweep voltage to the range deflection coil. The feedback to voltage setting triode V4401A keeps the sweep centered and the feedback to sweep generator V4401B improves linearity.

c. *Short Gate and Intensifier Z149.* The sharp positive pulse from delay trigger pickoff amplifier Z108 (para 2-22c) is amplified by delay trigger amplifier V4651B which triggers short gate multivibrator V4653. The positive square wave output of V4653 is applied to cathode follower V4651A and then to RANGE SELECTOR switch S101. The output of V4653 is also applied to intensifier amplifier V4655 through short gate inverter amplifier V4652A. A negative-going (azimuth strobe) pulse from azimuth synchronizer Z150 (para 2-22*f*) is applied to intensifier amplifier V4655 through cathode follower V4652B. A short gate or a long gate voltage from S101 is applied to intensity mixer V4654 together with a pulse from azimuth synchronizer Z150 (para 2-22*f*). The output of V4654 is applied to intensifier amplifier V4655. The output of V4655 is a positive square pulse (long gate) which has a movable range step (short gate) on top. The movable range step (short gate), controlled by AT101, causes an intensified band to appear on the crt display. The output is applied to the grid of the crt. Once during each revolution of the scanner, V4655 applies a positive square pulse (azimuth strobe) to the crt. When the square pulse (azimuth strobe) is applied the entire range sweep is intensified and appears on the crt display as an intensified vertical line.

d. *Video Amplifier Z148.* Video information from both the upper and lower radar beams is applied to first video amplifier V4601. The video from Simulator, Radar Target Signal AN/TPA-7 is also applied to first video amplifier V4601 when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. If BEAM VIDEO switch S110 is in the BOTH position, video information from both radar beams is applied to second video amplifier V4602. If S110 is in the LOWER position, only the lower beam video information will be applied to V4602. When S110 is in the UPPER position, only the upper beam video information will be applied to V4602. Range strobe pulses from range trigger pickoff amplifier Z109 (para 2-22d) are applied to range strobe sharpener V4604. The position of the range strobe is varied by the range handwheels in the computer. The gain of V4604 determines range strobe intensity and is controlled by RANGE MARK gain control R103. The output of V4604 is applied to second video amplifier V4602. The output of V4602 is applied to third video amplifier V4603. The video output of V4603 is applied to the cathode of the crt. Video information and range strobe appear on the screen of the crt and the range strobe can be moved on the face of the crt by rotating the range handwheels of the computer.

e. *Focus Current Control V4573.* Current for the crt focus coil is controlled by V4573.

f. High Voltage Power Supply. High voltage oscillator V161 produces a high frequency voltage which is rectified and multiplied by high voltage rectifier Z161 and applied to the highy voltage anode of V101.

2-25. Electronic Function, Indicating System

a. Azimuth Sweep Generator and Driver Z145.

(1) *Diode clamps V4501A and V4501B* (fig 2-74). Positive-going azimuth gate pulses from azimuth synchronizer Z150 (para 2-22*f*) are applied to clamps V4501A and V4501B through crystal diode CR4501. Normally, clamps V4501A and V4501B are conducting and the grid (pin 1) of azimuth sweep generator V4502 is clamped at a negative value. The value at which the grid of V4502 is clamped depends on the setting of HOR centering potentiometer R4517. When the positive pulses from azimuth synchronizer Z150 are applied to the cathodes of V4501, the clamps stop conducting and the grid of *V4502* begins to go positive. The point at which V4501A stops conduction is determined by resistors R4501, R4516, R4517, R4518, and the dc level of cathode voltage of sweep driver V4503 and V4504 between sweeps.

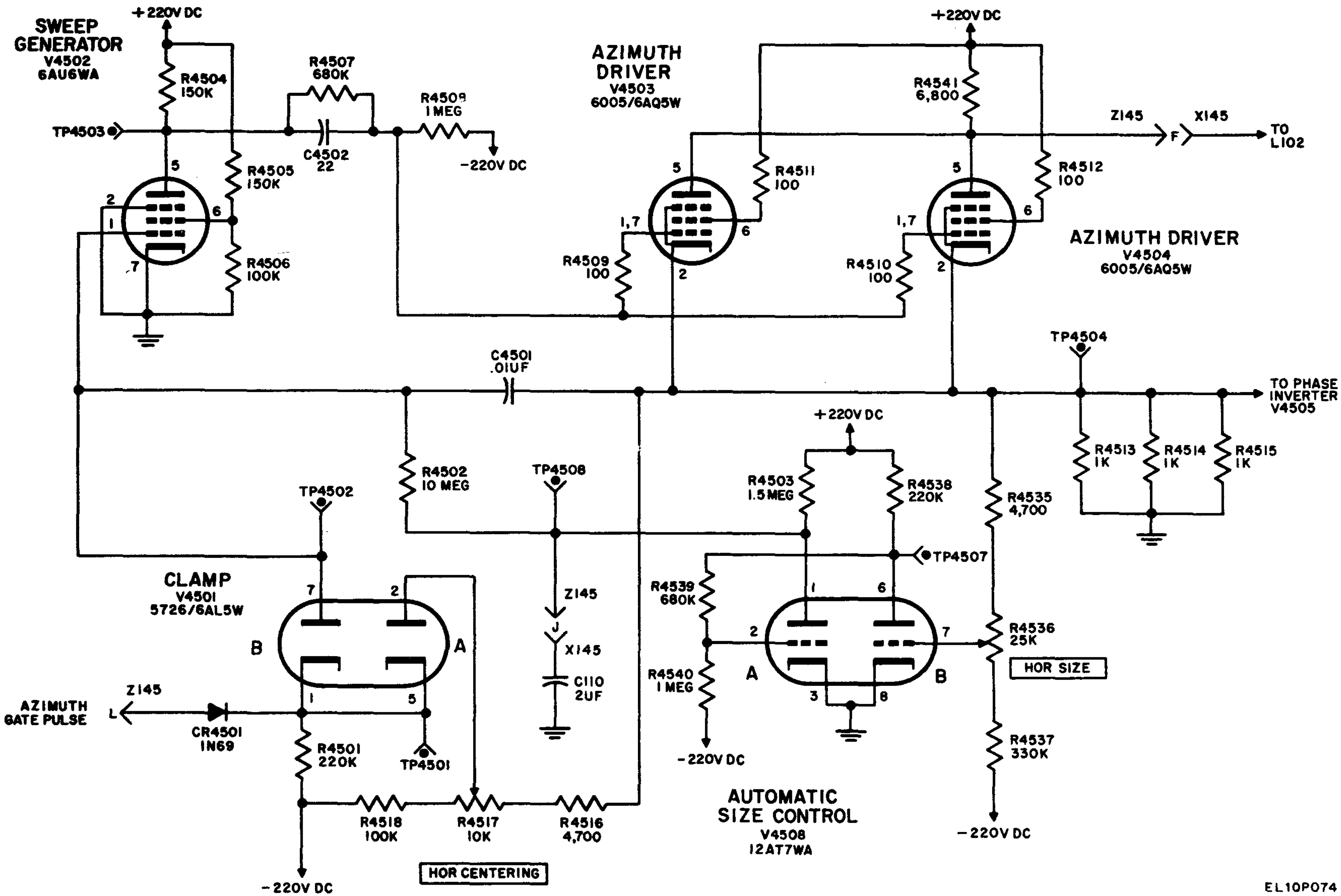


Figure 2-74. Diode clamps V4501, sweep generator V4502, azimuth drivers V4503 and V4504, and automatic size controls V4508A and V4508B, schematic diagram.

(2) Sweep generator V4502 (fig. 2-74).

(a) Circuit functioning. When the positive azimuth gate (A, fig. 2-75) is applied to clamps V4501A and V4501B, the clamps stop conducting and capacitor C4501 begins to charge through resistor R4502 to the positive potential across capacitor C110 ((4) below). As capacitor C4501 charges the voltage developed raises the voltage on the grid of V4502 (B, fig. 2-75). Plate voltage of V4502 is decreasing at the same rate that grid voltage is increasing (C, fig. 2-75). The rate of rise of grid voltage is determined by the rate of charge of C4501. Plate current of V4502 tends to rise rapidly and negative feedback is applied to the grid through C4501 from the cathode of sweep driver V4503 and V4604 and causes grid voltage to increase at a linear rate. The output of V4502 is a negative-going linear sawtooth voltage. Screen grid voltage for V4502 is furnished by a voltage-divider composed of resistors R4505 and R4506.

(b) *High frequency compensating network. The* sweep voltage developed across plate load resistor R4504 is direct-coupled to the grids of azimuth drivers V4503 and V4504 through a high frequency compensating network composed of capacitor C4502 and resistor R4507. Low frequencies are coupled through resistor R4507 and high frequency components are coupled through the relatively low impedance of C4502.

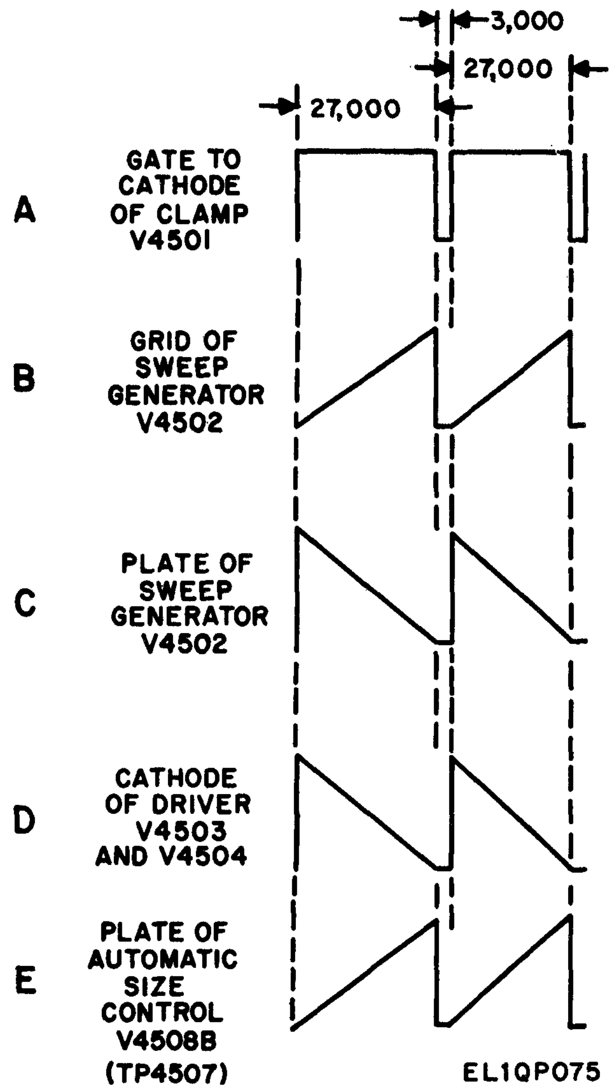


Figure 2-75. Waveforms of sweep generator V4502.

(3) *Azimuth drivers V4503 and V4504* (fig. 2-74). Azimuth drivers V4503 and V4504 are normally conducting. A negative-going sweep voltage which begins at approximately +200 volts and drops linearly to approximately +150 volts is applied to the grids through parasitic suppressor resistors R4509 and R4510. The grids are biased by a voltage-divider network consisting of resistors R4504, R4507, and R4508. Screen grid voltage for V4503 and V4504 is furnised through parasitic suppressor resistors R4511 and R4512. A positive going sawtooth sweep voltage is developed across azimuth sweep coil L102. Resistor R4541 shunts the azimuth sweep coil and protects the azimuth drivers from excessive screen current in the event of deflection coil failure. A negative-going sweep voltage developed across cathode resistors R4513, R4514, and R4515 is fed back to sweep generator V4502 through capacitor C4501 to improve linearity of the sweep. The negative-going voltage is also applied to automatic size control V4508B and phase inverter V4505.

(4) *Automatic size controls* V4508A *and* V4508B (fig. 2-74). The negative-going sawtooth voltage from the cathode of the azimuth drivers is applied to the grid (pin 7) of automatic size control V4508B through resistors R4535 and R4536. Resistors R4535, R4536, and R4537 form a voltage-divider network for the grid of V4508B. HOR SIZE potentiometer R4536 controls both signal amplitude and bias of V4508B. Plate current from automatic size control V4508B, flowing through plate load resistor R4538, develops a voltage which is direct-coupled to the grid (pin 2) of V4508A through resistor R4539. Resistors R4539 and R4540 form a voltage-divider network for the grid of V4508A. The input to the grid, pin 2, of automatic size control V4508A is a positive-going sawtooth with a time duration of 27,000 µsec and an off-time of 3,000 µsec. Plate current of automatic size control V4508A will increase at a linear rate for 27,000 µsec and be off for 3,000 µsec. Capacitor Cl10 and resistor R4503 form an averaging circuit connected across the plate, pin 1, of V4508A and will maintain an average voltage at the plate. The average voltage value depends on the average current through V4508A which in turn is determined by sweep duration and amplitude. If scanner speed is reduced, the azimuth gate duration increases; hence, sweep duration is increased and conduction time of V4508A is increased. An increase in conduction time of V4508A will result in a reduced voltage across capacitor Cl10. Capacitor Cl10 is the source for charging capacitor C4501 and with a reduced source voltage, charging time will be increased, resulting in an increase in physical size of the crt display.

(5) *Phase inuerter* V4505 (fig. 2-76). The negative-going sawtooth voltage from the cathodes of azimuth drivers V4503 and V4504 is applied to the grid (pin 1) of phase inverter V4505 through resistor R4519. Resistors R4519 and R4525 form a voltage-divider biasing network for V4505. Screen grid (pin 6) voltage for V4505 is supplied by a voltage divider composed of resistors R4527 and R4528. The positive-going sawtooth voltage developed across plate load resistor R4526 is applied to the grids of azimuth drivers V4506 and V4507 through resistor R4529 and capacitor C4503. Capacitor C4503 is a high frequency compensating capacitor. Negative feedback from the cathodes of azimuth drivera V4506 and V4507 is applied to the grid, pin 1, of V4505 through resistors R4520 and R4521 to keep the gin of V4505 at unity.

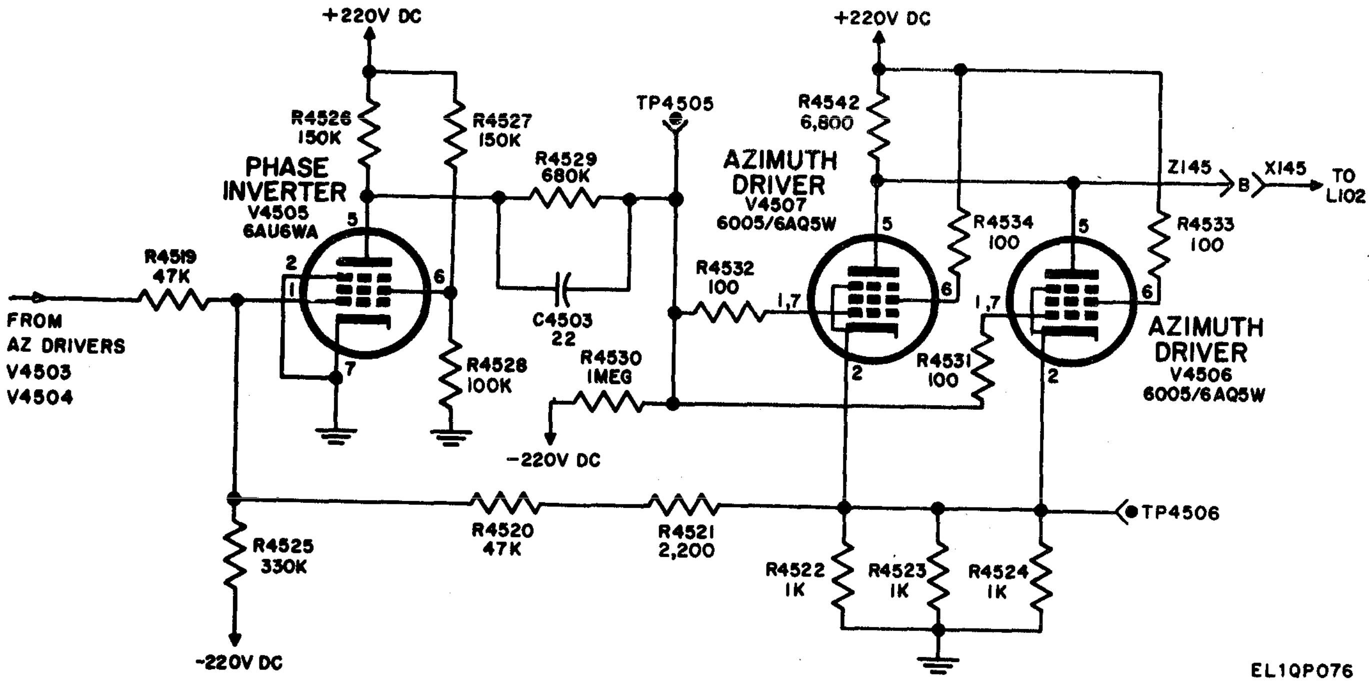


Figure 2-76. *Phase* inverter *V505 and azimuth drivers V4506 and V4507, schematic diagram.*

(6) *Azimuth drivers V4506 and V4507* (fig. 2-76). The positive-going sawtooth voltage from phase inverter V4505 is applied to the grids of azimuth drivers V4506 and V4507 through parasitic suppressor resistors R4531 and R4532. Resistors R4529, R4526, and R4530 form a voltage-dividing network for the girds of V4506 and V4507. Resistors R4533 and R4534 are parasitic suppressors. Resistor R4542 shunts the azimuth sweep coil and protects the azimuth drivers from excessive screen current in the event of deflection coil failure. A negative-going sawtooth sweep voltage is developed across azimuth sweep coil L102. A positive-going sawtooth voltage is developed across cathode resistors R4522, R4523, and R4524 and fed back to the grid (pin 1) of phase inverter V4505 through feed-back resistors R4520 and R4521 to improve stability and linearity.

b. Range Sweep Generator and Driver Z144.

(1) *Clamp V4402 and sweep generator V4401B (fig. 2-77).*

(a) Static state condition. With no input gate, both sections of clamp V4402 are conducting. Approximately - 20 volts is present at the long and short gate inputs (pars. 75 and 121) and is fed into RANGE SELECTOR switch S101. The - 20-volt dc is fed to the cathode (pin 1) of V4402B through the switch S101 and voltage-dropping resistor R4405. Conduction of V4402 pulls the plate (pin 7) in a negative direction until clamp V4402A conducts (approx. -3.5 volts dc). The point at which V4402A begins conduction is determined by a reference voltage present at the cathode of voltage setting triode, V4401A (par. 2-22). The grid (pin 7) voltage of sweep generator V4401B is direct-coupled to the clamped value present at the cathode (pin 5) of clamp V4402A.

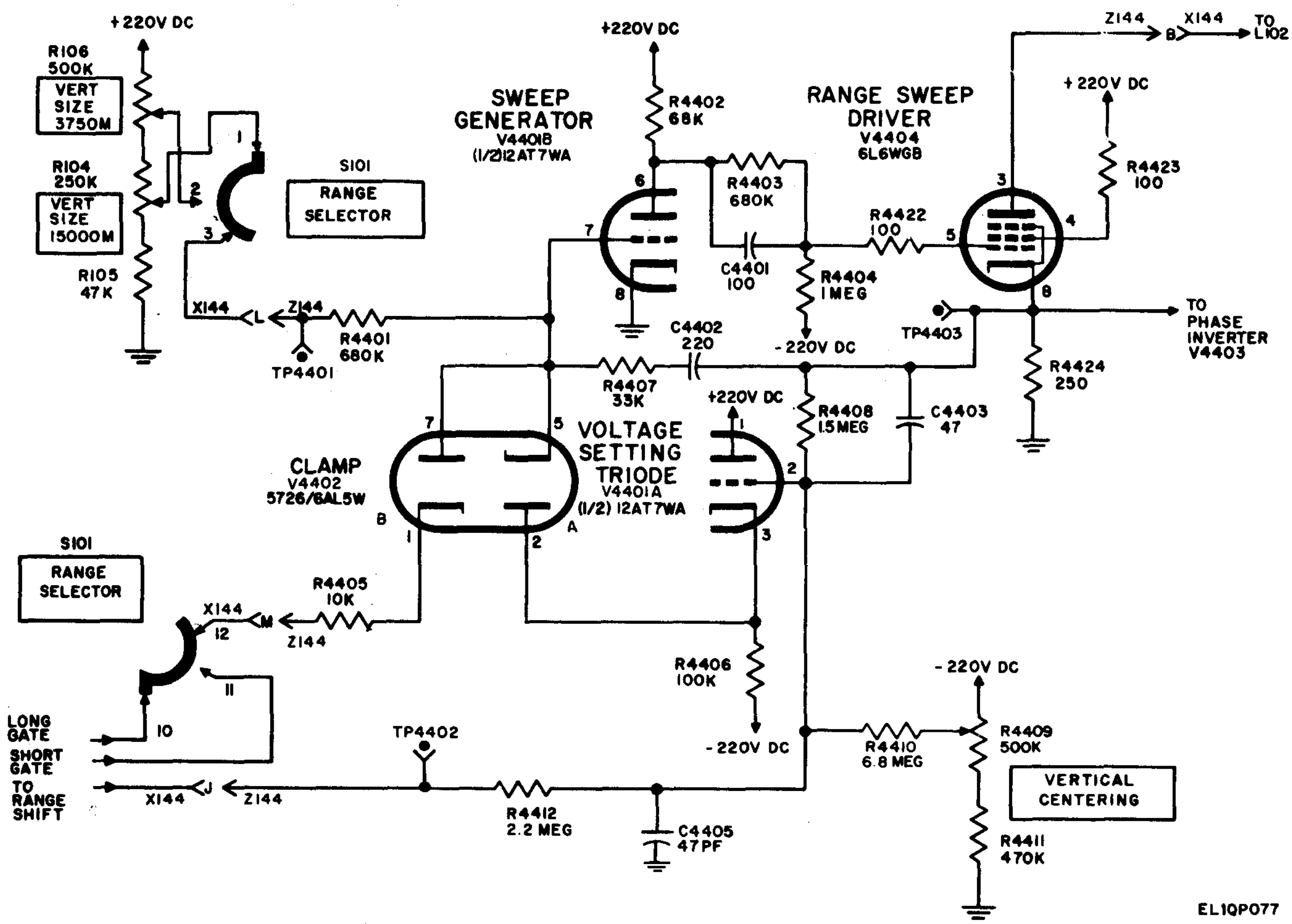


Figure 2-77. Sweep generator V4401B, voltage setting triode V4401A, clamp V4402, and range sweep driver V4404, schematic diagram.

(b) *operation during gate pulse.* When either the long or short gate (positive) pulse is applied through RANGE SELECTOR switch S101 and resistor R4405 to the cathode (pin 1) of clamp V4402B, V4402A and V4402B become nonconducting. The instant the clamps cut off, a positive step voltage is developed across resistor R4407 and applied to the grid (pin 7) of sweep generator V4401B. After the first instant of time, capacitor C4402 begins to charge. The charge path for capacitor C4402 is from ground, through R4424, C4402, R4407, and R4401 to the voltage established on the movable contact of resistor R104 or R106 as determined by the position of RANGE SELECTOR switch S101. The charge of capacitor C4402 is a positive-going sawtooth and is applied to the grid (pin 7) of sweep generator V4401B. A negative-going trapezoidal voltage is developed across plate load resistor R4402 and is direct-coupled to range sweep driver V4404 through the high frequency compensating network consisting of resistor R4403 and capacitor C4401. The charge across sweep capacitor C4402 increases at a linear rate because of feed-back voltage developed across resistor R4424 in the range sweep driver circuit ((2) below).

(2) *Range sweep driver V4404* (fig. 2-77). The negative-going trapezoidal voltage from sweep generator V4401B is applied to the grid (pin 5) of range sweep driver V4404 through parasitic suppressor resistor R4422 and a high frequency compensating network consisting of C4401 and R4403. Resistor R4404 is the grid resistor. Resistor R4423 is a parasitic suppressor. The positive-going trapezoidal voltage at the plate (pin 3) of V4404 is applied to range sweep coil L102. A negative-going trapezoidal voltage is developed across cathode resistor R4424 and is fed back to the sweep generator to improve the linearity of the charge of capacitor C4402. The negative-going trapezoidal voltage at the

cathode of V4404 is applied to phase inverter V4403 and also to voltage-setting triode V4401A.

(3) *Voltage-setting triode V4401A* (fig. 2-77 and 2-78). Bias for voltage-setting triode V4401A is furnished by VERTICAL CENTERING potentiometer R4409 and resistors R4411 and R4410. The center of the vertical (range) sweep on the screen of the crt is positioned by R4409. The voltage developed at the cathode (pin 3) determines the voltage to which the grid of sweep generator V4401B is clamped. When RANGE SHIFT switch S103 (fig. 2-78) is in the ON position, a positive-going voltage from range shift amplifier V503B in azimuth synchronizer Z150 is developed across voltage-dividing resistors R4557, R4558, and R4559 during upper beam display time and applied across R4560. Crystal diode CR4551 clamps the voltage at a zero reference level. The voltage applied to the grid of V4401A is varied by RANGE SHIFT potentiometer R4560 and is direct-coupled to the grid through resistor R4412. The positive pulse applied to the grid of voltage-setting triode V4401A changes the bias on the grid of sweep generator V4401B through clamp V4402 and shifts the position of the upper beam display on the crt screen. The negative-going sweep from the cathode of V4404 is applied to the grid of V4401A through a high frequency compensating network consisting of C4403 and R4408. The negative step of the sweep voltage immediately drops the cathode (pin 3) of voltage setting triode V4401A to a low negative value to achieve instantaneous cutoff of clamp V4402A.

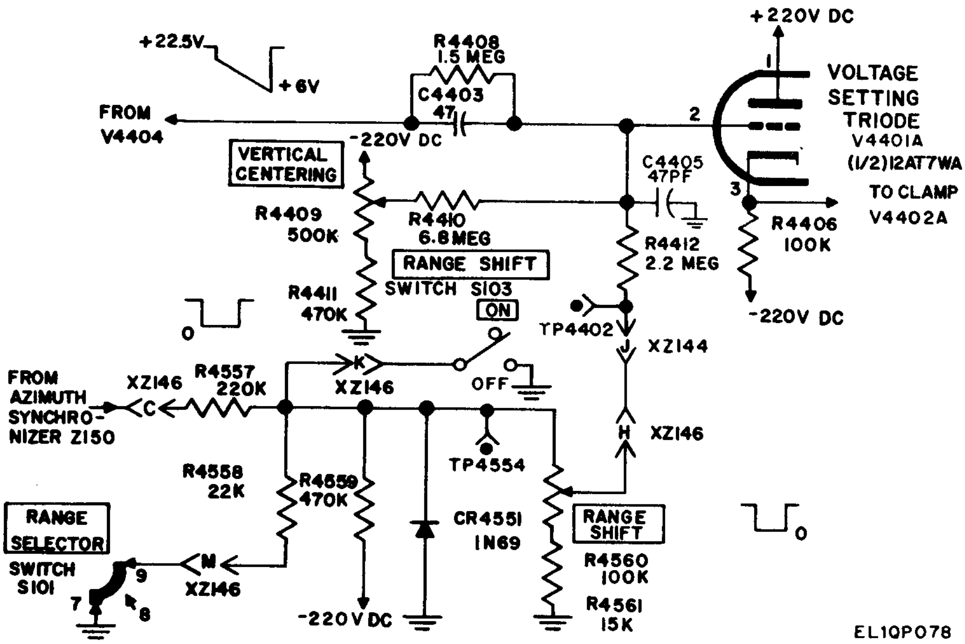


Figure 2-78. Range shift circuit, schematic diagram.

(4) *Phase inverter V4403* (fig. *2-79*). Phase inverter V4403 is biased by a voltage-divider network consisting of resistors R4413, R4414, and R4424 (fig. 2-77). The negative-going trapezoidal voltage applied to the grid (pin 1) of phase inverter V4403 from V4404 causes the current through V4403 to decrease. Screen grid (pin 6) voltage for V4403 is furnished by a voltage divider consisting of resistors R4420 and R4421. Decreasing current through plate load resistor R4419 causes a positive-going trapezoidal voltage to develop across R4419. The positive-going trapezoidal voltage is applied to the grid of range sweep driver V4405 through a coupling network consisting of resistor R4418 and capacitor C4404. Resistor R4418 passes the low frequency components of the trapezoidal voltage, and capacitor C4404 passes the high frequency components of the trapezoidal voltage.

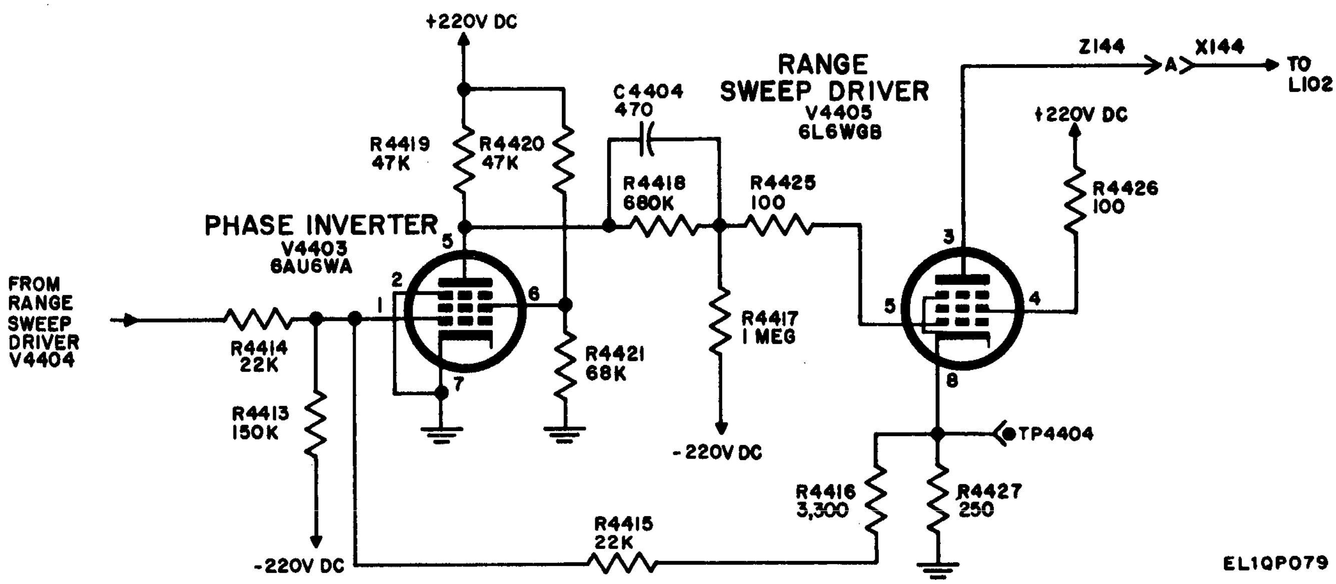


Figure 2-79. Phase inuerter V4403 and range sweep driver.

(5) *Range sweep driver V4405* (fig. 2-79). Resistors R4417, R4418, and R4419 form a voltage-divider biasing network for the grid (pin 5) of range sweep driver V4405. Resistors R4425 and R4426 are parasitic suppressors. The positive-going trapezoidal wave form from phase inverter V4403 produces a negative-going trapezoidal voltage at the plate of range sweep driver V4406 which is applied to range sweep coil L102. A positive-going trapezoidal voltage is developed across cathode resistor R4427 and fed back to phase inverter V4403 through feedback resistors R4415 and R4416. The feedback voltage to V4403 stabilizes the gain of the phase inverter to near unity.

c. Intensifier and Short Gate Generator Z149.

(1) *Delay trigger amplifier V4651B* (fig. 2-80). A positive trigger pulse from delay trigger pickoff amplifier Z108 is applied to the grid (pin 7) of delay trigger amplifier V4651B. Cathode bias is furnished by a voltage-divider network consisting of resistors R45651 and R4652. Capacitor C4651 is the cathode bypass capacitor. Part of the output voltage developed across the plate load, consisting of resistors R4653 and R4662, is applied to the grid (pin 2) of short gate multivibrator V4653, through capacitor C4653 and resistor R4666.

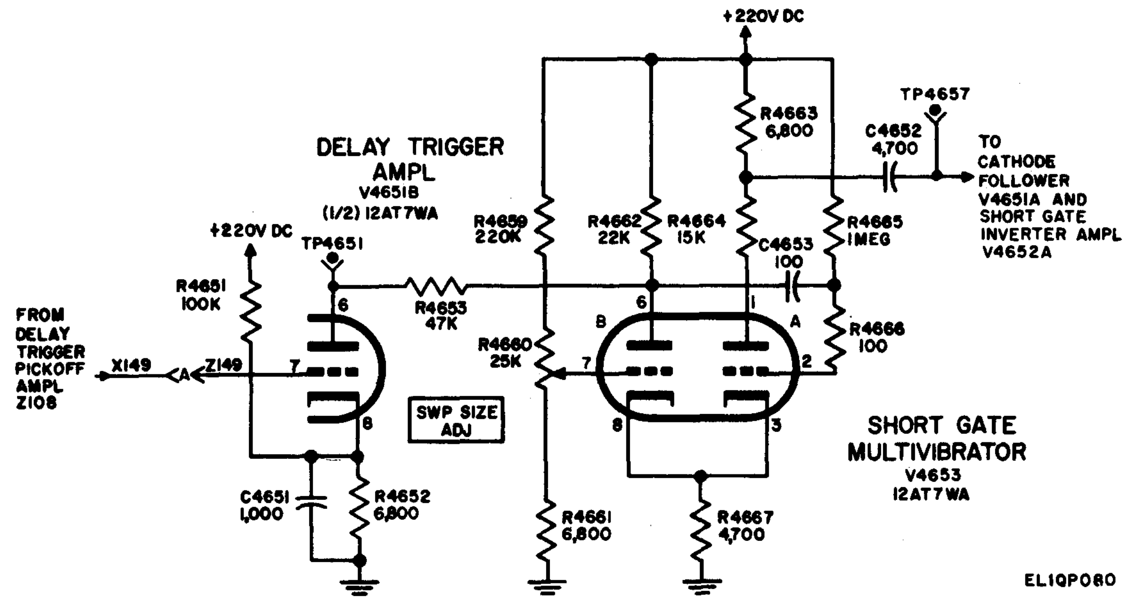


Figure 2-80. Delay trigger amplifier V4651B and short gate multivibrator V4653, schematic diagram.

(2) *Short gate multivibrator V4653* (fig. 2-80).

(a) *Operation during static conditions.* Normally, short gate multivibrator V4653A is conducting heavily because the grid is returned to +220 volts through grid resistor R4665. The bias developed by plate current flowing through common cathode resistor R4667 holds the B section at cutoff. The voltage-divider network, consisting of resistors R4659, R4661, and SWP SIZE ADJ potentiometer R4660, determines how far V4653B is below cutoff.

(b) *Operation with trigger.* A negative-going pulse from V4651B is applied to the grid (pin 2) of V4653A through coupling capacitor C4653. Application of a negative trigger to the grid of normally conducting V4653A cuts off the section. The reduced bias at the cathode of V46543 causes V4653B to start conducting. The amount of current through V4653B is determined by the setting of SWP SIZE ADJ potentiometer R4660. The negative-going voltage developed across plate load resistor R4662 is coupled to the grid (pin 2) of the nonconducting A section through C4653 and parasitic suppressor resistor R4666. Capacitor C4653 begins to discharge through resistor R4665. During the time that V4653A is nonconducting, a positive-going square wave voltage is developed across plate load resistors R4663 and R4664. The square wave voltage is applied to cathode follower V4651A and short gate inverter amplifier V4652A through coupling capacitor C4652. When C4653 becomes discharged, V4658A begins conducting and V4653B is again cut off.

(3) *Cathode follower V4651A* (fig. 2-81). The positive-going short gate voltage from short gate multivibrator V4653 is applied to the grid of cathode follower V4651A. The grid (pin 2) is held at a negative level between pulses by grid clamping action of V4652A ((4) below). A positive going gate voltage is developed across cathode resistor R4654 and applied to RANGE SELECTOR switch S101. Resistors R4654 and R4655 form a cathode-biasing network for V4651A.

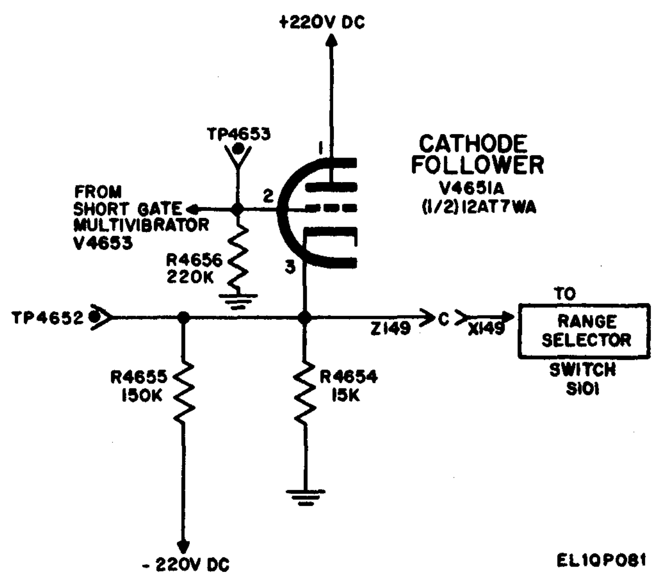


Figure 2-81. Cathode follower V4651A, schematic diagram.

(4) *Short gate inverter-amplifier V4652A and cathode follower V4652B* (fig. *2-82).*

(a) Short gate inverter-amplifier V4652A. Short gate inverter-amplifier V4652A acts as a clamp and an amplifier, Clamping action within V4652A takes place between the grid and the cathode. The grid acts as the plate of a diode clamp. When the positive signal voltage appears at the grid' of V4652A, the grid draws current and charges capacitor C4652 (fig. 2-80). When the capacitor becomes charged, the grid becomes slightly negative with respect to the cathode, and grid current ceases. The input signal is clamped at approximately +2 volts and extends in a negative direction. Resistor R4656 is the grid" resistor and also acts as the discharge path for capacitor C4652. Tube V4652A amplifies the clamped signal, and the output voltage developed across plate load resistors R4657 and R4658 is a negative-going short gate pulse. SWP INTEN ADJ potentiometer R4657 varies the amount of signal voltage coupled to the grid (pin 7) of intensity amplifier V4655 through the high frequency compensating network consisting of HF COMP capacitor C4658 and resistor R4675.

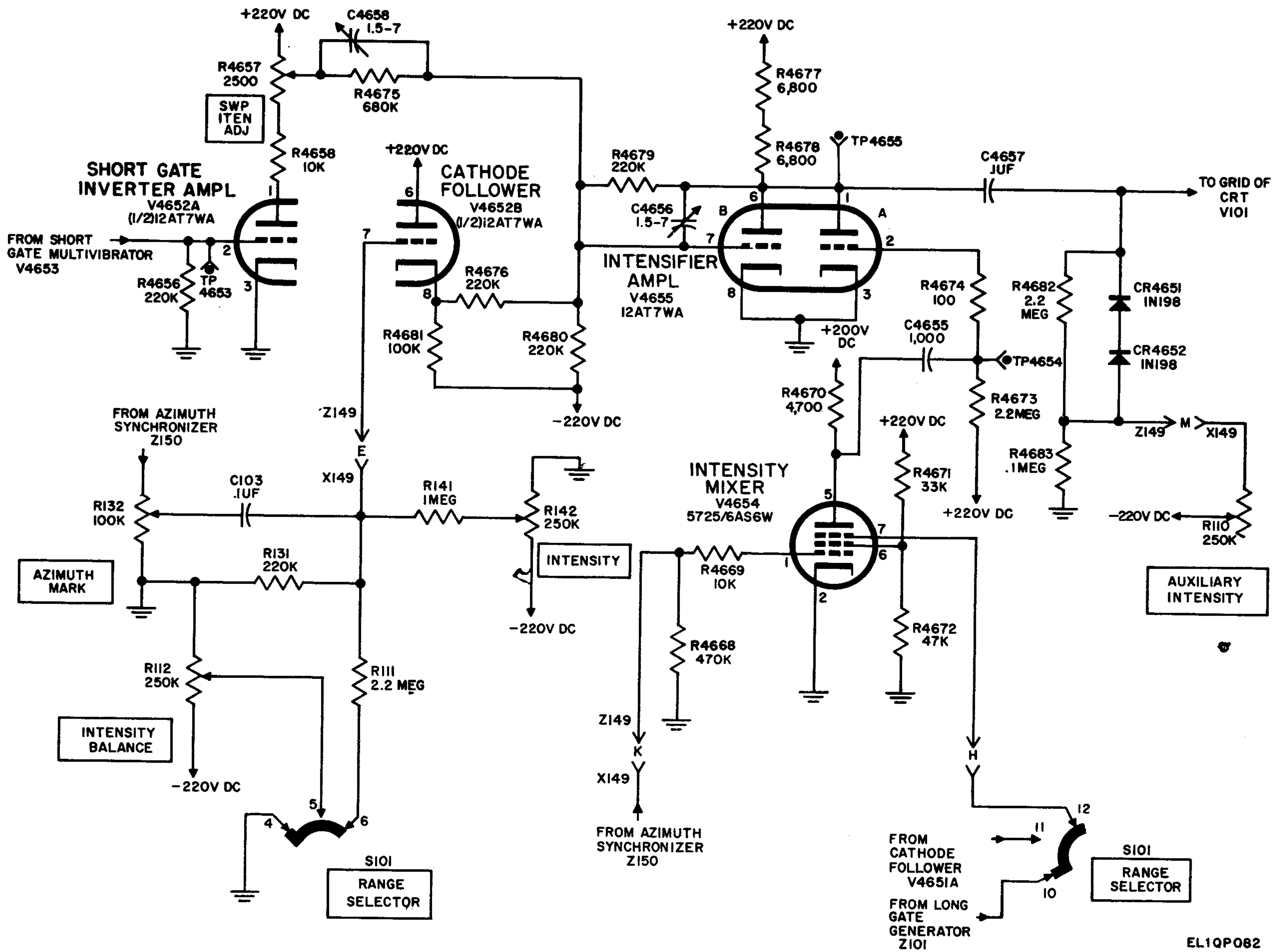


Figure 2-82. Short gate inverter-amplifier V4652A, cathode follower V4652B, intensity mixer V4654, and intensifier amplifier V4655, schematic diagram.

(b) Cathode follower V4652B. The bias on the grid (pin 7) of cathode follower V4852B is determined by R112 and R142 and is used to control the intensity of the sweep on the screen of the crt. When RANGE SELECTOR switch S101 is in the 3750M position (terminals 5 and 6 making contact), INTENSITY BALANCE potentiometer R112 and intensity mixing resistor R111 change the intensity on the crt screen to compensate for the faster sweep speed so that the intensity is the same for the 3750M position and 15000M position of switch S101. When S101 is in the 15000M position, resistor R112 is no longer in the circuit and resistor R111 is returned to ground. A negative-going (azimuth strobe) pulse from the azimuth synchroniser (para 2-22) is applied to the grid (pin 7) of cathode follower V4652B through AZIMUTH MARK potentiometer R132 and coupling capacitor C103. AZIMUTH MARK potentiometer R132 controls the amplitude of the negative pulse voltage applied to the grid of V4652B. A negative-going pulse is developed across cathode resistor R4681 and direct-coupled to the grid (pin 7) of intensifier amplifier V4655 through resistor R4676.

(5) *Intensity mixer V4654* (fig. 2-82). A positive-going asimuth gate pulse from azimuth synchroniser (para 2-22) is applied to the control grid (pin 1) of intensity mixer V4654 through grid limiting resistor R4669. Resistor R4688 is the grid resistor. Screen grid (pin 6) voltage is furnished by a voltage divider composed of resistors R4671 and R4672. A positive long gate or short gate voltage is applied to the suppressor grid (pin 7) through RANGE SELECTOR switch S101. When the azimuth gate on the control grid and the long or short gate on the suppressor grid are both present, current flows through V4654. A negative-going voltage developed across plate load resistor R4670 is applied to the grid (pin 2) of intensifier amplifier V4655 through coupling capacitor C4655 and parasitic suppressor resistor R4674.

(6) Intensifier amplifier V4655 (fig. 2-82).

(a) *General* Intensifier amplifier V4655 is a mixer amplifier circuit. Inputs from short gate inverter-amplifier V4652A and cathode follower V4652B are amplified in V4655B and an input from intensity mixer V4654 is amplified in V4655A. The inputs to the grids (pins 2 and 7) are amplified and mixed in the parallel plate circuit and applied to the grid of crt V101 as a positive square wave voltage with a movable pedestal.

(b) Inputs to B section. A positive clamped gate is coupled to the grid (pin 7) of V4655 from short gate inverter-amplifier V4652A through resistor R4675 and HF COMP capacitor C4658. Resistors R4675, R4676, R4679, R4681, and R4680 form a voltage-dividing network for the grid (pin 7) of V4655. A gate input from cathode follower V4652B is coupled to the grid (pin 7) of V4655 through resistor R4676. Capacitor C4656 and resistor R4679 are connected between the plate (pin 6) and the grid (pin 7) for negative feedback and high frequency compensation.

(c) *A section, input and output.* The negative output of intensity mixer V4654 is coupled to the grid (pin 2) of V4655 through coupling capacitor C4655 and parasitic suppressor resistor R4674. Resistor R4673 is the grid resistor. The plates (pins 1 and 6) of V4655 are tied together and the plate currents combine in plate load resistors R4677 and R4678 to develop an output voltage which is coupled to the grid of the crt through coupling capacitor C4657.

d. Video Amplifier Z148.

(1) First *video amplifier V4601* (fig. 2-83).

(a) The video input from the receiving system (para 2-19) is applied across resistor R101 and VIDEO gain potentiometer R102A. The output from R102A applied to the control grid of first video amplifier V4601 directly through a grid coupling network composed of resistor R4604 and parasitic suppressor R4603.

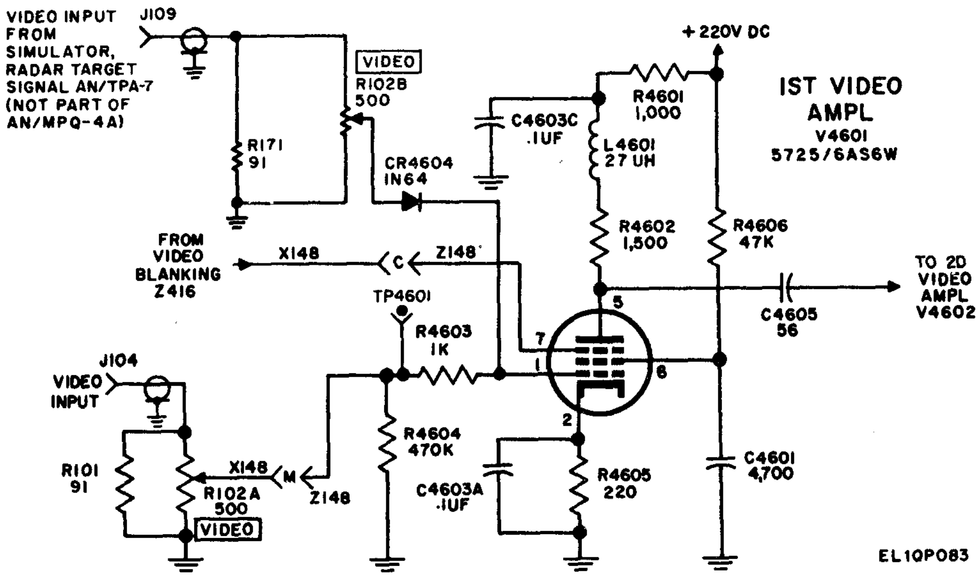


Figure 2-83. First video amplifier V4601, schematic diagram.

(b) When Simulator, Radar Target Signai AN/TPA-7 is used with Radar Set AN/MPQ-4A, the video input from the AN/TPA-7 is applied through J109 across resistor R171 and VIDEO gain potentiometer R102B. The output from R102B is coupled directly through diode CR4604 to the grid (pin 1) of first video amplifier V4601. Diode CR4601 isolates the AN/TPA-7 input circuit from the receiving system video circuit ((u) above).

(c) Blanking pulses are applied to the suppressor grid of V4601 from timer relay K101. When the BEAM VIDEO switch is in the LOWER position, a negative blanking voltage is applied to the suppressor grid of first video amplifier V4601 during the period of the upper beam. When the BEAM VIDEO switch is in the BOTH position, no blanking voltages are applied and both lower and upper beam video pass through the amplifier. When the BEAM VIDEO switch is in the UPPER position, a negative voltage is applied to the suppressor grid of V4601 during the period of lower beam scan. The function of the timer is covered in paragraph 2-22g(3).

(d) Bias for V4601 is developed across resistor R4605 and bypass capacitor C4603A. Screen grid voltage is applied through R4606 and C4601 is the screen bypass capacitor. Resistor R4601 and capacitor C4603C from a plate decoupling network. Output voltage is developed across coil L4601 and resistor R4602. Coil L4601 and R4602 form a high frequency shunt compensator circuit. The output video signal is coupled to second video amplifier V4602 through coupling capacitor C4605.

(2) *Second video amplifier V4602* (fig. *2-84).* Video signal voltages from first video amplifier V4601 are coupled to the grid (pin 1) of second video amplifier V4602 through coupling capacitor C4605. The grid of V4602 is biased slightly negative by the voltage-divider network consisting of resistors R4627, R4628, R4629, and R4607. Resistor R4610 is a parasitic suppressor. Crystal diode CR4601 clamps the grid at the negative value established across resistor R4628. Resistor R4608 and capacitor C4606 form a plate decoupling network and the positive-going output signal is developed across plate load resistor R4609 and coupled to third video amplifier V4603 through capacitor C4607. Screen grid voltage is supplied by a voltage-divider network consisting of resistors R4611, R4613, and VIDEO CLIPPING potentiometer R4612 and is applied through resistor R4630. Resistor R4630 is also the plate load *resistor* for range strobe sharpener V4604, which supplies sharp negative range strobe pulses to the screen of V4602. These negative pulses appear in the output as sharp positive pulses on the video signal. VIDEO CLIPPING potentiometer R4612 adjusts the gain of the second video amplifier so that a maximum peak signal level of 70 volts appears at test point TP4603. Capacitor C4604 is a decoupling capacitor.

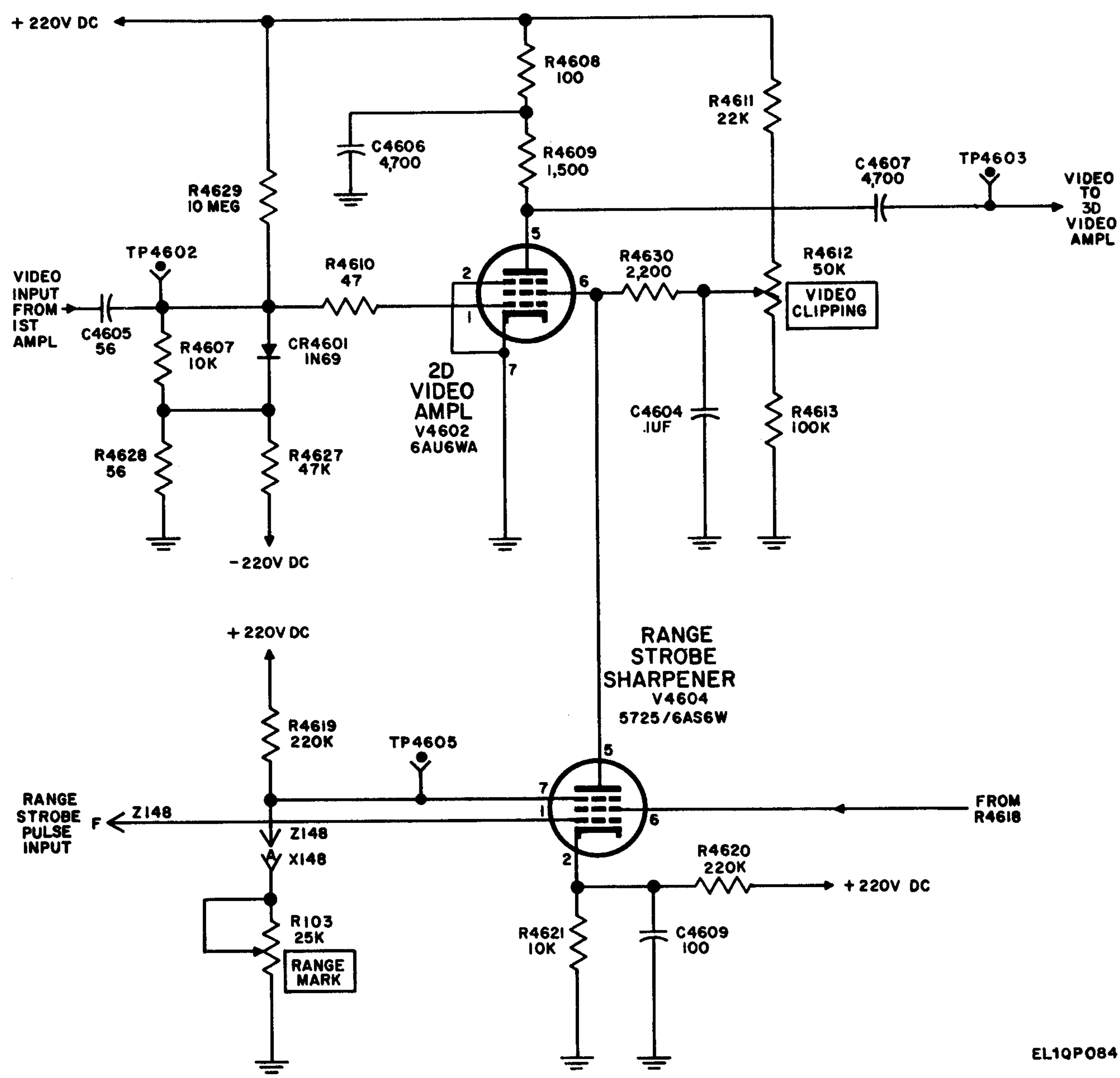


Figure 2-84. Second video amplifier V4602 and range strobe sharpener V4604, schematic diagram.

(3) *Range strobe sharpener* V4604 (fig. 2-84). Range strobe sharpener V4604 receives a positive input pulse from range trigger pickoff Z109. The position of the pulse in time is determined by the range handwheels in the computer. The pulses are amplified and inverted in range strobe sharpener V4604 and applied directly to the screen grid of second video amplifier V4602. Resistor R4619 and RANGE MARK potentiometer R103 form a voltage-divider network to establish suppressor grid (pin 7) voltage and control the gain of the stage. Resistors R4620 and R4621 form a biasing network to hold the cathode at approximately 10 volts positive. The +10 volts on the cathode biases the tube below cutoff so only the very narrow peak of the input signal brings the tube out of cutoff and the pulse is sharpened. Capacitor C4620 is the cathode bypass capacitor and the screen grid (pin 6) is parallel-connected with the screen grid of third video amplifier V4603 ((4) below).

(4) *Third video amplifier* V4603 (fig. 2-85). The positive-going video signal from second video amplifier V4802 is coupled to the grid (pins 1 and 7) of third video amplifier V4603 through capacitor C4607 and parasitic suppressor resistor R4615. Resistor R4614 is the grid resistor. The signal is

amplified, inverted, and fed to the cathode of crt V101 through peaking coil L4604 and coupling, capacitor C4610. Resistors R4622 and R4623, together with peaking coil L4603, are the plate load for V4603. Resistor R4624 and capacitor C4604A make up a decoupling network to prevent any of the video signal from appearing on the +220-volt dc line. Resistor R4617 and bypass capacitor C4604B provide cathode bias for V4603. Resistor R4618 is a common screen grid resistor for third video amplifier V4603 and range strobe sharpener V4604 ((3) above). Capacitor C4603B is the screen bypass capacitor. The negative-going output signal is developed across resistor R4625, which is the cathode resistor for crt V101. Crystal rectifiers CR4602 and are dc CR4603 restorers and are used to clamp the cathode of crt V101 at the negative value established by the voltage divider consisting of resistors R4626, R4616, and AUXILIARY INTENSITY potentiometer R110. Refer to *f* (4) below for crt functioning.

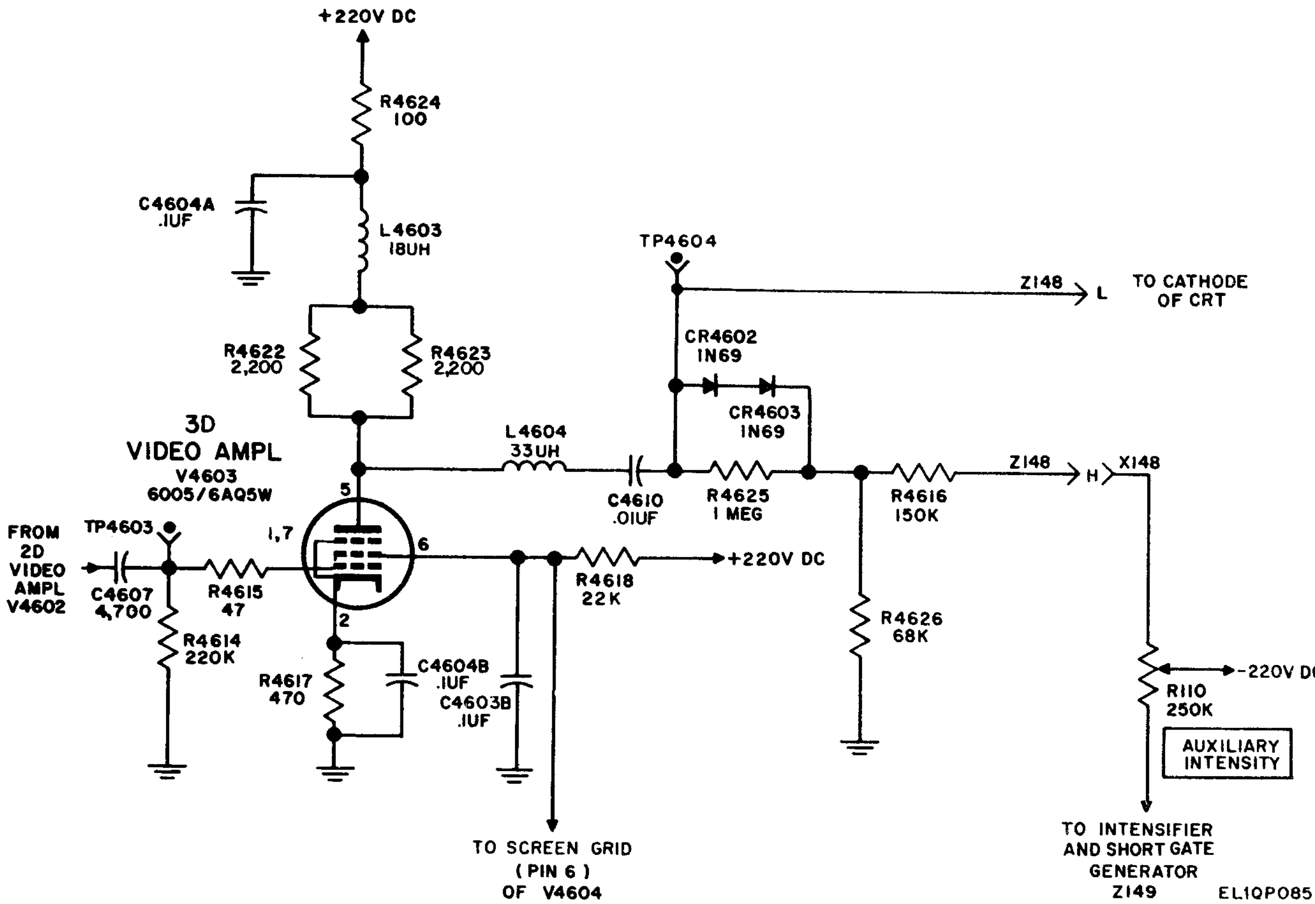


Figure 2-85. Third video amplifier V4603, schematic diagram.

e. High Voltage Oscillator and Rectifier-Multiplier.

(1) General. The high voltage power supply produces the crt accelerating anode (aquadag coating) voltage. The circuit consists of a high voltage oscillator, a step-up transformer, and a rectifier-multiplier.

(2) High voltage oscillator V161 (fig. 2-86. High voltage oscillator V161 supplies ac power to the rectifier. The frequency at which V161 operates is approximately 3 kHz. Screen voltage on V161 is applied through screen-dropping resistors R161 and R162. Capacitor C162 is a screen bypass capacitor. Plate and screen voltages are applied through HV ADJ potentiometer R164 and resistor R165. HV ADJ potentiometer R164 can be varied to change the high voltage output to any level between 12 and 14 kv.

(a) The output of V161 is applied across pins 2 and 3 of transformer T161. For ac voltages, the tap of T161 is effectively grounded by capacitor C161. A regenerative feedback (in phase with the control grid) is supplied at pin 1 of T161 and sustains oscillations in V161. Capacitors C163 and C164, togther with inductance of T161, determine the frequency of oscillation (approx. 3 kHz). Resistor R167 is the grid resistor and resistor R166 limits the current in the feed-back circuit.

(b) The voltage across the primary of T161 is stepped up to 2,000 volts rms by transformer action and applied to high voltage rectifier-multiplier Z161.

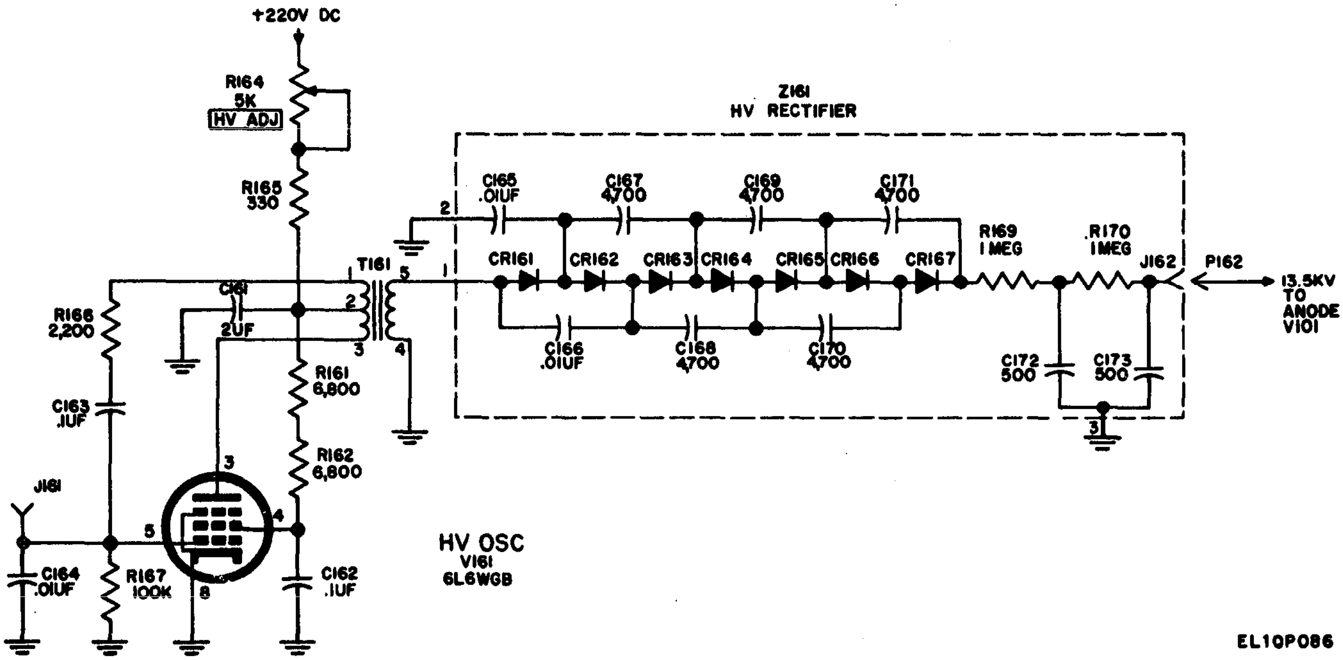


Figure 2-86. High voltage oscillator and rectifier schematic diagram.

(3) *Rectifier-multiplier* Z161 (fig. 2-86). Rectifier-multiplier 2161 is a voltage septupler circuit and receives about 2,000 volts rms from high voltage oscillator V161. It provides a dc output voltage of approximately 13.5 kv to the accelerating anode of crt V101.

(a) In the simplified circuit (fig. 2-87), the rectifier symbols have been replaced with diodes and for convenience of discussion, all capacitors are assumed to charge during 1 cycle and maintain their charge, whereas, actually several hundred cycles may be required to achieve full charge of the capacitors.

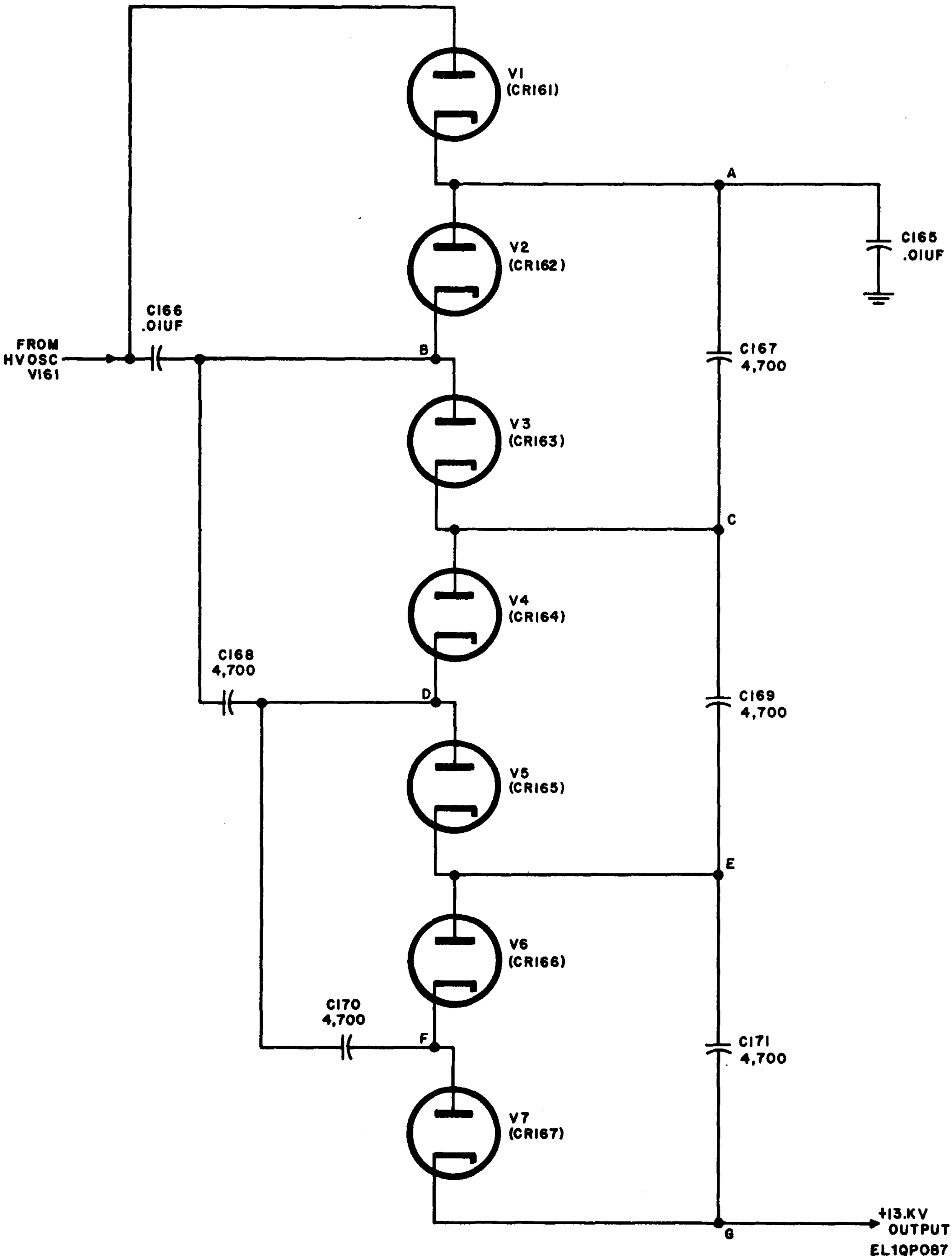


Figure 2-87. Voltage multiplier, simplified diagram.

1. When the input voltage is positive, rectifier V1 (CR161) conducts and current flows from the top of capacitor C165 through V1, charging capacitor C165 to approximately +2,000 volts.

2. When the input voltage is negative, rectifier V2 (CR162) conducts and current flows from capacitor C166 through V2 to the +2,000-volt side (point A) of C165. Since the input from the oscillator is negative 2,000 volts and point A is at a positive 2,000-volt level, capacitor C166 is charged to 4,000 volts.

3. When the input again goes positive, point B will become positive 6,000 volts (input 2,000 plus charge across C166 of 4,000) and V3 (CR163) will conduct, charging capacitor C167 to 4,000 volts. This action produces a potential at point C of +6,000 volts (2,000 volts at point A plus the 4,000-volt charge across C167).

4. On the next negative input alternation, - 2,000 volts again appear at the input. Since a charge of +4,000 volts exists across C166, point B is now at a +2,000-volt level. Point C was previously charged to +6,000 volts; therefore, V4 (CR164) will conduct, charging C168 to 4,000 volts. Point D is now at +6,000 volts.

5. When the input goes positive, point B again is at +6,000 volts (3 above) and point D is at +10,000 volts (+6,000 at point B plus the 4,000-volt charge on C168), causing V5 (CR165) to conduct and charge C169 to 4,000 volts, thus giving a total voltage at point E of +10,000 volts (+2,000 across Cl65 Plus +4,000 across C167 plus +4,000 across C169).

6. The operation of V6 (CR166) and V7 (CR167) to charge capacitors C170 and C171 is similar to (4) and (5) above resulting in approximately +14 kv at the output (point G).

(b) Resistors R169 and R170 (fig. 2-86) with capacitors C172 and C173 form a high voltage filter circuit to remove the 3-kc ripple from the output so that pure dc (13.5 kv) is applied to the crt V101.

f. Cathode-Ray Tube and Deflection Coils.

(1) *Cathode-ray tube V101.* Cathode-ray tube V101 is a metallized indicator tube which uses electromagnetic focusing and deflection. The tube has a small shell duo-decal (6 pin) base and a 6-inch screen. The screen of the crt is coated with type P7 phosphor. A type P7 phosphor coated crt will have a yellow color and long persistence. Heater voltage for the crt is 6.3 volts. The accelerator voltage at E161 is approximately 14,000 volts dc and is furnished by high voltage oscillator V161 and rectifier-multiplier Z161. Grid No. 2 (pin 10) voltage is 440 volts dc.

(2) *Focus coil L103 and focus current control V4573* (fig. 2-88). Focus coil L103 fits over the neck of the cathode-ray tube and is used to focus the electron stream on the face of the crt. Resistors R122 and R121 form a voltage-divider network to bias focus current control V4573. FOCUS potentiometer R121 is used to adjust the bias on the grid (pins 1 and 7) of V4573. Resistor R4584 is a grid current limiting resistor, resistor R4585 establishes a minimum cathode bias, and resistor R4586 is the screen-dropping resistor. Adjustment of FOCUS potentiometer R121 controls the current through the tube and through focus coil L103. The amount of current flowing through L103 controls the magnetic field of the coil and the focus of the electron stream.

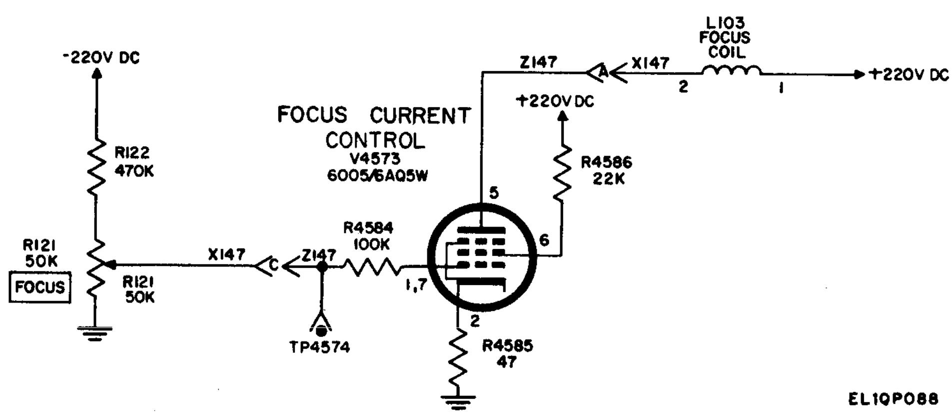


Figure 2-88. Focus coil L103 and focus current control V4573, schematic diagram.

(3) *Defection coil L102* (fig. 2-89).

(a) General. Deflection coil L102 contains vertical and horizontal deflection windings and is fitted around the neck of the crt. Each deflection winding has four sets of concentric coils.

(b) *Vertical deflection coils.* Range sweep voltages are applied across the vertical deflection coils. The vertical deflection coil is divided into two sets of concentric windings. The sets of coils are returned to different dc voltage levels because the range sweep drives are dc coupled. The set of windings with terminals D4 and N4 is coupled to the positive 440-volt dc supply. Resistor R123 and capacitor C111 form a range sweep decoupling net work. The other set of vertical deflection windings with terminals D2 and N2 is coupled to the positive 220-volt dc supply. Positive-going and negative-going trapezoidal waveforms are applied as shown in figure 2-89. Resistors R143, R144, R145, and R146 are damping resistors for the vertical deflection coils.

(c) Horizontal deflection coils. Horizontal deflection of the electron stream of the crt is performed by the horizontal deflection coils. Positive-going and negative-going sawtooth voltages are applied across the windings from the azimuth sweep generator and driver (fig. 2-89). Resistors R147, R148, R149, and R150 are damping resistors for the horizontal windings.

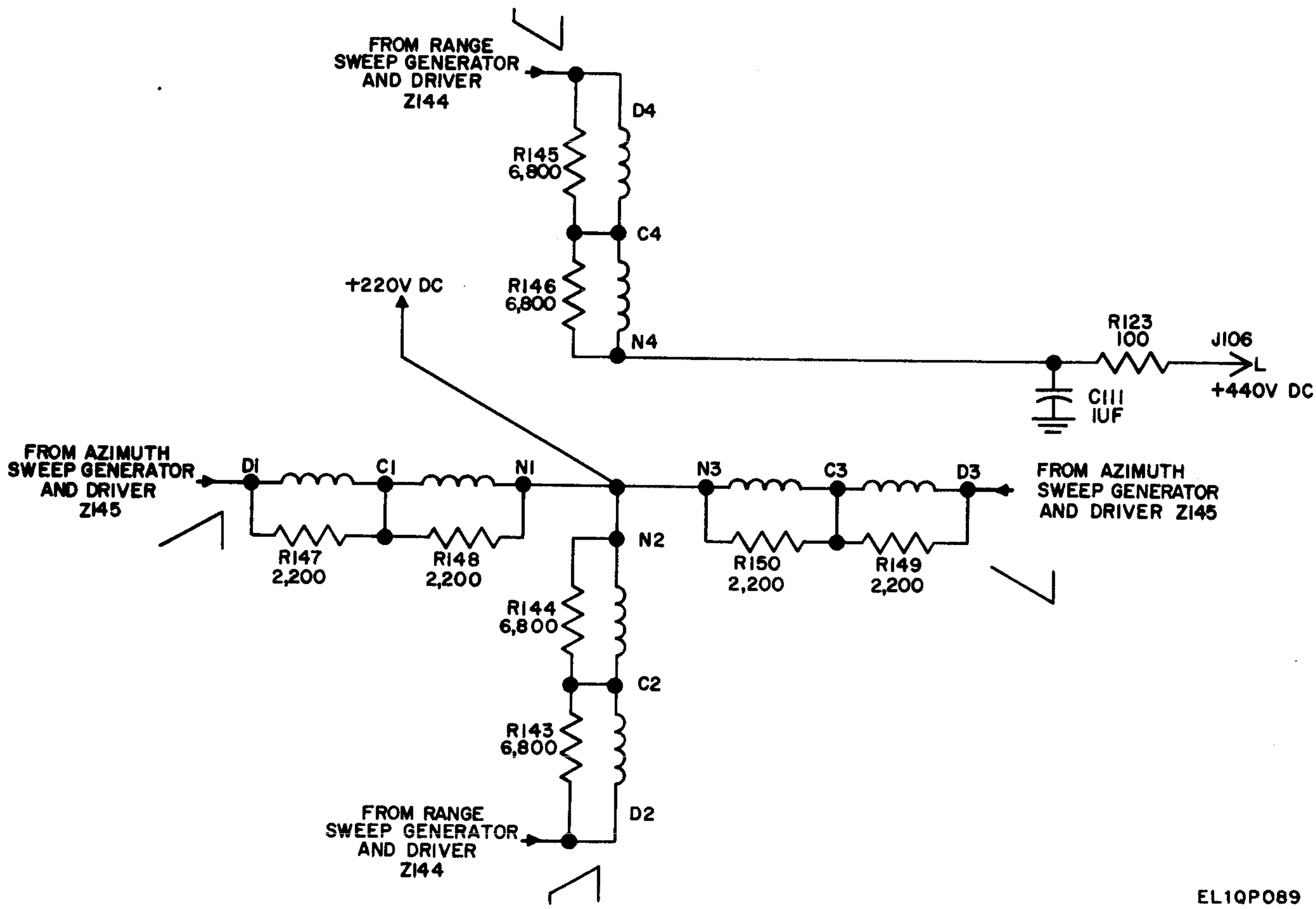


Figure 2-89. Deflection coil L102, simplified schematic diagram.

(4) Grid and cathode circuits of crt V101 (fig. 2-90). A positive-going intensifying pulse is applied to the grid (pin 2) of crt V101 from intensity amplifier V4655 in Z149 (c(6) above) to illuminate the crt during sweeptime. The negative-going video signal is applied to the cathode (pin 11) of the crt from third video amplifier V4603 (para 2-22d(4)), The return echoes appear as intense spots of light on the face of the crt.

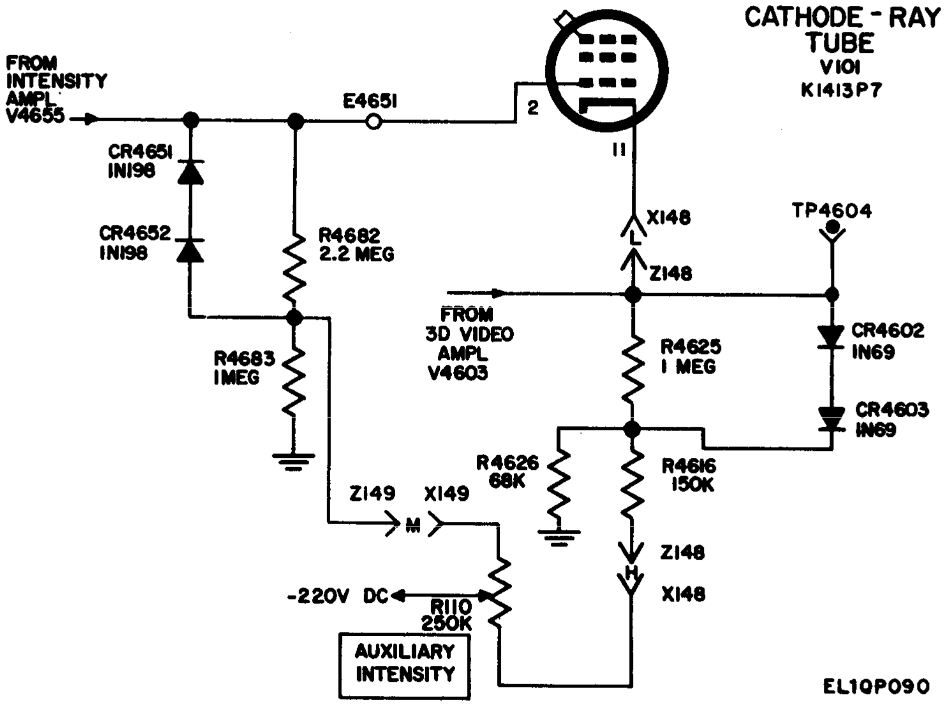


Figure 2-90. *(Grid and cathode circuits of crt V101.*

(a) Grid circuit. The grid circuit consists of grid resistor R4682, dc restorers CR4651 and CR4652, and a voltage-divider network consisting of resistor R4683 and AUXILIARY INTENSITY potentiometer R110. Crystal rectifiers CR4651 and CR4652 prevent the grid from going more negative than the negative value established across resistor R4683.

(b) Cathode circuit. The cathode circuit consists of cathode resistor R4625, dc restorers CR4602 and CR4603, and a voltage-divider network consisting of resistors R4626, R4616, and AUXILIARY INTENSITY potentiometer R110. Crystal rectifiers CR4602 and CR4603 prevent the cathode from going more positive than the negative voltage value established across resistor R4626.

(c) *AUXILIARY INTENSITY circuit.* AUXILIARY INTENSITY potentiometer R110 is common to the grid and cathode voltage-divider networks and its setting determine the negative values to which the grid and cathode are clamped.

Section VII. COMPUTING SYSTEM

2-26. Introduction to Weapon Location Problem.

a. General.

(1) *Problem* The computing system receives range, azimuth, and elevation information regarding the locations of two radar beam intercept points on the trajectory of a projectile. This information is used by the computer to determine the approximate location of the weapon which fired the projectile or the point of impact on the projectile.

(2) *Input.* The input to the computing system is the projectile position data at two points along its trajectory and consists of the following

(a) Antenna azimuth (AZ)

(b) Lower beam Horizontal Angle, from Antenna Azimuth (A_L)[1].

(c) Increment of azimuth (Δ A)[1].

(d) Lower beam range (R_L)[1].

(e) Increment of range (Δ R)[1].

(f) Lower beam elevation (E_L)

(g) Weapon height(H_W)[1].

(h) Increment of time (Δ T)[1].

(3) *Solution.* The computer uses the projectile position data at two points along its trajectory and, by extrapolation, calculates, with respect to the radar location, the polar coordinates of the weapon firing the projectile or the point of impact of the

[1]H and wheel inputs.

projectile. These polar coordinates, with previously inserted radar orientation data are converted to grid coordinates. The effect of *gravity* and the *speed* of the projectile enter into the *find* solution of the weapon location problem.

(4) *Outputs*. The outputs of the computing system give the rectangular coordinates of the weapon, as represented on a map of the area, and are presented as:

(a) WEAPON LOCATION EASTING.

(b) WEAPON LOCATION NORTHING.

b. Weapon Location Problem. The weapon location problem involves extrapolation of the arc between two points along a trajectory to find the ground position of the weapon firing the projectile.

(1) The position of the two points, L and U, along the trajectory of the projectile are obtained as the projectile passes through the planes of the two radar beams (fig. 2-91). By straight line extrapolation, the continuation of the line described in space by the points, U and L, would intersect the earth's surface at point W (fig. 2-92). If the projectile traveled in a straight line instead of a curved trajectory, point W would be the actual position of the weapon.

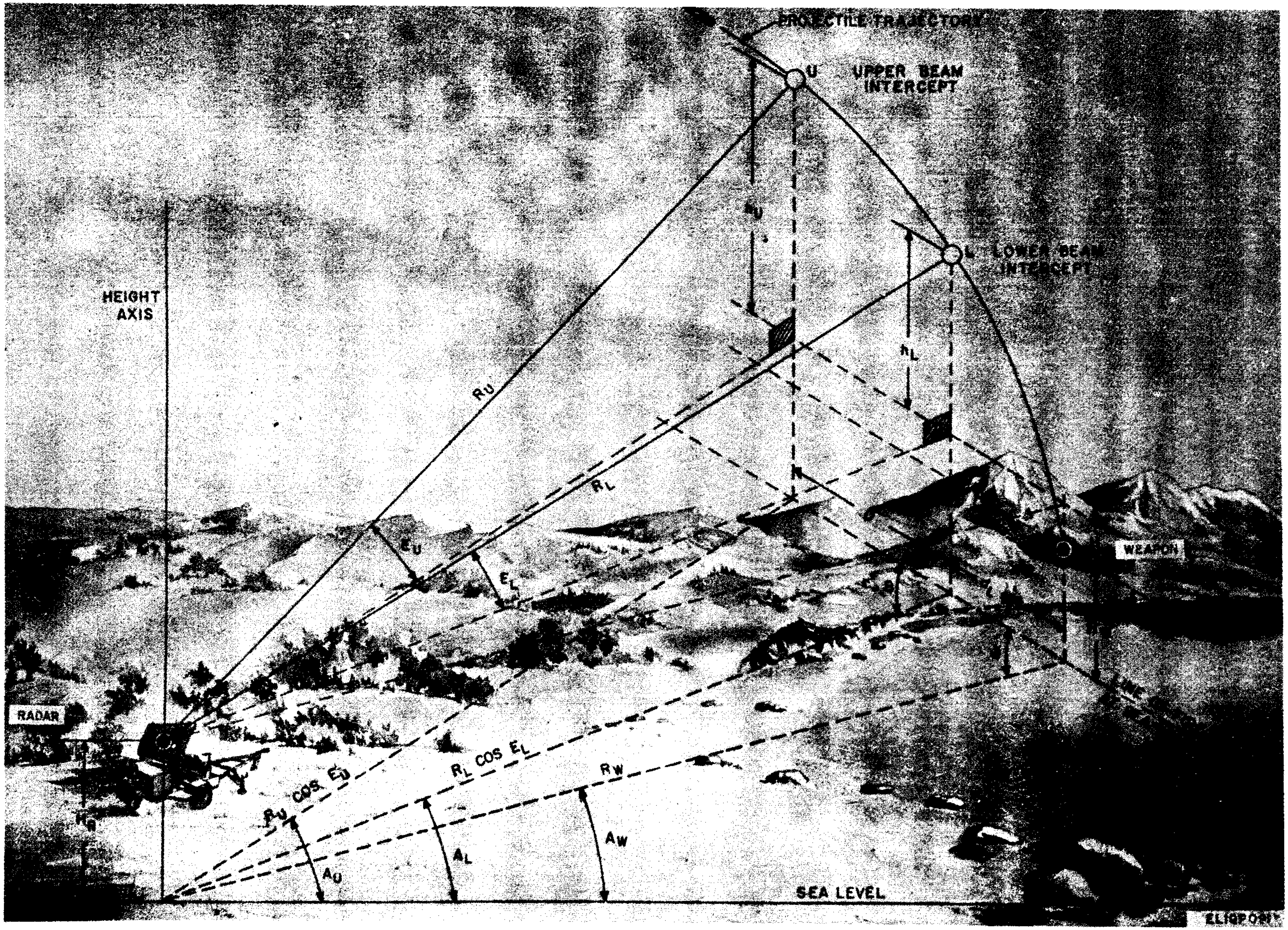


Figure 2-91. Geometry of weapon location problem.

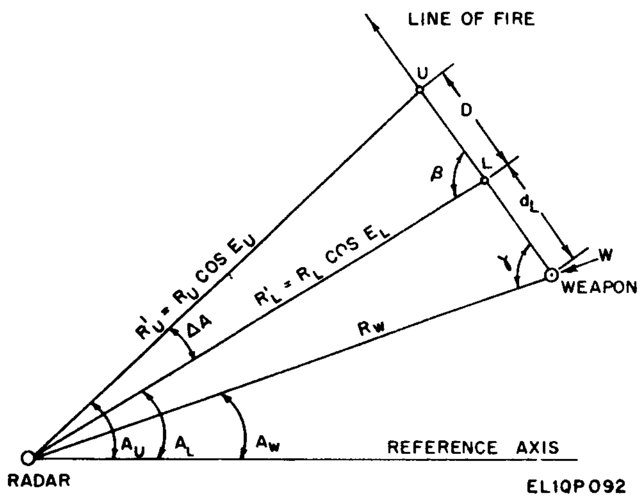


Figure 2-92. Plane view of weapon location geometry with azimuth angles.

(2) The effect of gravity causes the projectile to travel in a curved path. The slower the projectile travels, and the more time elapsing between the two radar beam intercepts, the more the trajectory of the projectile will be curved. To accurately locate the position of the weapon, the effect of gravity and the elapsed time between the radar beam intercepts are used as factors in the determination of the actual curved trajectory. The computer thus locates the ground position of the weapon by curvilinear extrapolation.

c. ***Glossary of Symbols.*** **Symbols are used throughout this manual to represent various items of data to simplify the explanation of system functioning.**

Symbol	name	
A_L	Lower beam horizontal angle.	Horizontal angle at the radar from antenna azimuth axis to lower beam intercept point.
A_U	Upper beam horizontal angle.	Horizontal angle at the radar from antenna azimuth axis to upper beam intercept point.
Δ A	Δ azimuth......	$A_U - A_L$.
A_W	Weapon azimuth	Azimuth angle from grid north to weapon position.
AZ	Antenna azimuth	Angle at the radar from grid north to antenna axis (center of sector scan).
AZ_{OR}	Azimuth orient information.	
C	A term used in azimuth and range computations.	The ratio of the extrapolated portion to the sampled portion of the trajectory. d_L/D.

Symbol	Name	Definition
D	. . . .	Datum plane projection of the distance between the two intersections of the radar beam with the radar beam with the projectile trajectory.
d_L	....	Datum plane projection of the distance from the weapon position to the interception of the lower beam with the projectile trajectory.
d_U	....	Datum plane projection of the distance from the weapon position of the interception of the upper beam with the projectile trajectory.
E_L	Lower beam elevation.	Angle of elevation of lower radar beam above a horizontal datum plane.
E_R	....	Radar easting.
E_U	Upper beam elevation.	Angle of elevation of upper radar beam above a horizontal datum plane.
E_W	....	Weapon easting.
H_R	Radar height	Height of radar set above sea level.
H_W	Weapon height...	Height of weapon above sea level.
H	Height..........	$H_R - H_W$.
h_L	Height of beam intercept.	Height of lower beam projectile intercept above a horizontal plane through the radar.
h_U	Height of beam intercept.	Height of upper beam projectile intercept above a horizontal plane through the radar.
N_R	....	Radar northing.
N_W	....	Weapon northing.
R_L	Lower beam range	Slant range from radar set to lower beam intercept point.
R'_L	Ground range to lower beam intercept.	
R_U	Upper beam range	Slant range from radar set to upper beam intercept point.
R'_U	Ground range to upper beam intercept.	
R_W	Weapon range....	Ground range from radar set to weapon location.
Δ R	Δrange........	$R_U - R_L$.
$R_{W(E)}$	dE	Difference in easting between radar and weapon.
$R_{W(N)}$	dN	Difference in northing between radar and weapon.
t_L	....	Time required for projectile to travel from the weapon location to point L.
t_U	....	Time required for projectile to travel from the weapon location to point U.
Δ T	Δ time.........	$t_L - t_U$.
B, θ, γ	Angles	Angles used in analysis.
≅		Symbol for approximately equals.

d. Coordinate Systems. The following two systems of coordinates are used to position the object in space.

(1) *Polar.* The location of the projectile in space, using the polar coordinate system, is accomplished by giving the distance to the projectile (R_L or R_U), the angle of elevation to the projectile (E_L or E_U), and the azimuth to the projectile (A_L or A_U).

(2) *Rectangular.* The location of the weapon, using the rectangular, coordinate system, is accomplished by giving the ground distance to the weapon from the north-south coordinate (E_R) and the ground distance to the weapon from the east-west coordinate (N_R).

e. Mathematical Solution.

(1) *Weapon location geometry.* The geometry of the location problem is shown in figure 2-91; the symbols used are defined *c* above. The location of the weapon requires that several problems be solved, using the information contained in figure 2-91.

(2) *Curvilinear extrapolation.* The following equations are solved to locate the weapon, using curvilinear extrapolation.

(a) Weapon mnge equation. To simplify the computer, ground ranges R_L and R_U are not used and only slant ranges RL and RU (fig. 2-91) are used. Angles of elevation, E_L and E_U, are small and a small error results, since

$$R'_L = R_L \cos E_L$$

and

$$R'_U = R_U \cos E_U.$$

The range equation which is solved by the computer is:

$$R_W = R'_L + C\,(R_L - R_U) \qquad (1)$$

where:

$$C = \frac{d_L}{D}$$

(b) Weapon azimuth equation (fig. 2-92). The law of sines maybe applied to the triangle with sides Rw, R_L cos E_L, and d_L, and the triangle with sides Rw, RU cos Eu, and ($D+d_L$) to form the following equations:

$$\frac{d_L}{\sin(A_L - A_W)} = \frac{R_L \cos E_L}{\sin}$$

and

$$\frac{D+d_L}{\sin(A_U - A_W)} = \frac{R_U \cos E_U}{\sin}$$

Note. The law of since states that the sides *of* a triangle are proportional to the dnee of the opposite angles. By trigonometric function then;

$$\sin.\theta = \frac{\text{opposite side}}{\text{hypotenuse}} \text{ and } \cos\theta = \frac{\text{side adjacent}}{\text{hypotenuse}}$$

Solving both equations for sin γ and setting the equations equal to each other gives:

$$\frac{\sin(A_L - A_W)}{\sin(A_U - A_W)} = \frac{d_L(R_U \cos E_U)}{(D+d_L)(R_L \cos E_L)}.$$

If $C = \frac{d_L}{D}$, then d_L=CD, and by substitution in the equation we have

$$\frac{\sin(A_L - A_W)}{\sin(A_U - A_W)} = \frac{CD}{D+CD}\left(\frac{(R_U \cos E_U)}{(R_L \cos E_L)}\right)$$

It is now possible to divide the right side of the equation by D, obtaining:

$$\frac{\sin(A_L - A_W)}{\sin(A_U - A_W)} = \frac{C}{1+C}\left(\frac{(R_U \cos E_U)}{(R_L \cos E_L)}\right)$$

or

$$\frac{\sin(A_L - A_W)}{\sin(A_U - A_W)} = \frac{C}{C+1}\left(\frac{(R_U \cos E_U)}{(R_L \cos E_L)}\right) \qquad (2)$$

Equation (2) determines the exact azimuth to the weapon. The angles (A_L - A_w) and (A_U - A_w) are normally less than 50; therefore, the sine of these angles can be replaced by the radians

$$\frac{\sin(A_L - A_W)}{\sin(A_U - A_W)} \text{ becomes } \frac{A_L - A_W}{A_U - A_W}$$

and since

$$\frac{R_U \cos E_U}{R_L \cos E_L} \cong 1$$

The equation (2) can be rewritten as:

$$\frac{A_L - A_W}{A_U - A_W} \cong \frac{C}{C+1} \qquad (3)$$

NOTES

1. One degree=.01745 = .01745 radians so that at the maximum expected value for an angle of 5°, the radian value is .08725. The sine value for a 5° angle is .0872 so that the values may be considered as equal in the formula. For angles smaller than 5°, the error is correspondingly smaller.

2. The beam separation between upper and lower beams is 2° so that the range of upper and lower beams will be very nearly equal. The cosine difference between the upper and lower beams can range bet ween .0006 and .0067 and may be considered as equals for practical calculations. (At the maximum range and maximum angle of elevation, only 57 meters of error would be introduced in the problems solution by setting forth that R_U cos $E_U \cong R_L \cos E_L$.)

Solving equation (3) for weapon azimuth (A_w) gives:

$$A_W \cong A_L + C\,(A_L - A_U) \qquad (4)$$

which is the equation solved by the computer,

(c) C *term equation. The C term* is derived in the computer to produce a correct value of C for each value of range, azimuth, and elevation. The C term is used in solving both range and azimuth equations. If the projectile follows a parabolic trajectory, the basic equations which describe the flight path are:

$$h = at - \tfrac{1}{2} gt^2$$

and

$$d = bt$$

where:

h=height of the projectile at any time(t)

a = $V_0 \sin \gamma$

b = $V_0 \cos \gamma$

d=horizontal distance from weapon to projectile at any time (t)

V_0=muzzle velocity of projectile

γ =vertical angle of fire of projectile g=acceleration of gravity.

The height of the projectile above the weapon at the upper and lower radar beam intercept points, L and U, as shown in figure 2-93, is

$$h_L = at_L - \frac{1}{2} g t_L^2 \qquad (5)$$

and

$$h_U = a(t_L + \Delta t) - \frac{1}{2} g (t_L + \Delta t)^2 \qquad (6)$$

The ground distance of the projectile at the upper and lower radar beam intercept points, Land U, is:

$$d_L = bt_L \qquad (7)$$

and

$$d_U = b(t_L + \Delta t) \qquad (8)$$

The distance Din figure 2-93 is:

$$D = d_U - d_L. \qquad (9)$$

Substituting equation (7) and equation (8) into equation (9) gives:

$$D = b \Delta t. \qquad (10)$$

Substituting equation (7) into equation (10) and rearranging gives:

$$D = \frac{d_L}{t_L} \Delta t$$

and

$$\frac{d_L}{D} = \frac{t_L}{\Delta t} = C \qquad (11)$$

which is the definition of C given in (2) (a) above.

Solving equation (5) for term a gives:

$$a = \frac{h_L + \frac{1}{2} g t_L^2}{t_L} \qquad (12)$$

Substituting equation (12) for term a in equation (6) gives:

$$h_U = \frac{h_L + \frac{1}{2} g t_L^2}{t_L} (t_L + \Delta t) - \frac{1}{2} g (t_L + \Delta \qquad (13)$$

Expanding equation (13), collecting terms, and substituting C for $\frac{t_L}{\Delta t}$, or $C\Delta t$ for t_L, then:

$$C[(C+1)\frac{1}{2} g \Delta t^2 + h_U - h_L] - h_L = 0. \qquad (14)$$

This equation is an exact expression involving C together with terms which can be easily measured or computed. When a difference in height (H) exists between the radar set and weapon sites, the terms h_L and h_U must be replaced by $(h_L + H)$ and $(h_U + H)$ as shown in figure 2-94.

The equation involving C ussd in the computer is

$$C[(C+1)\frac{1}{2} g \Delta t^2 + h_U - h_L] - (h_L + H) = 0 \qquad (15)$$

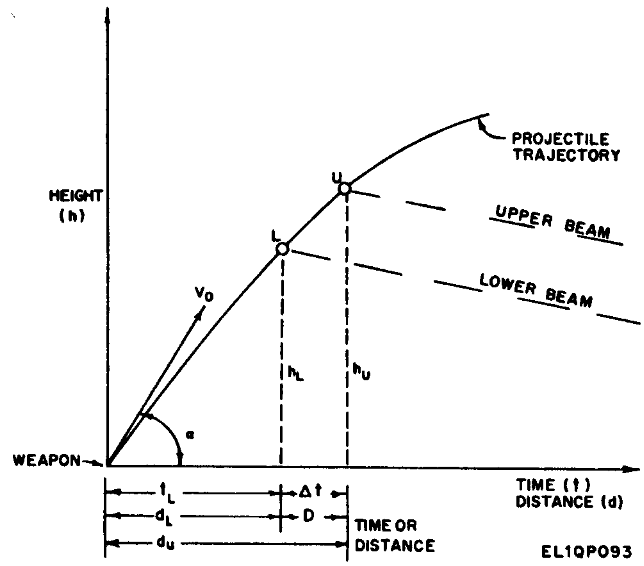


Figure 2-93. Elevation view of trajectory.

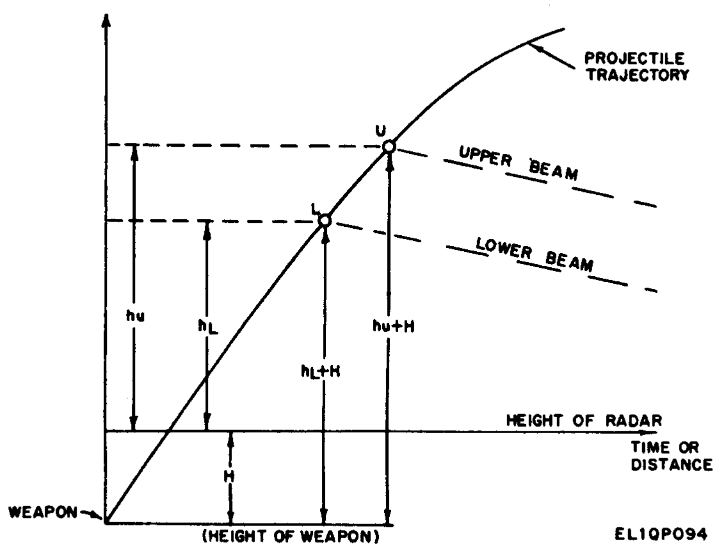


Figure 2-94. Elevation view of trajectory showing elevation difference, H.

(3) Straight line extrapolation. The straight line extrapolation method of solving the weapon location problem involves range, azimuth, and C equations.

(a) *Range equation:* The weapon range (R_W) as shown in figure 2-95 is:

$$R_W = R_L' + DR. \qquad (16)$$

If triangle ULX and triangle LWY are similar then:

$$\frac{h_U - h_L}{\Delta R} = \frac{h_L + H}{DR}. \qquad (17)$$

Solving equation (17) for DR gives:

$$DR = \left(\frac{h_L + h}{h_U - h_L}\right) \Delta R. \qquad (18)$$

Substituting equation (18) in equation (16) gives the equation:

$$R_W = R_L' + \left(\frac{h_L + H}{h_u - h_L}\right) \Delta R \qquad (19)$$

which is the straight line extrapolation for weapon range.

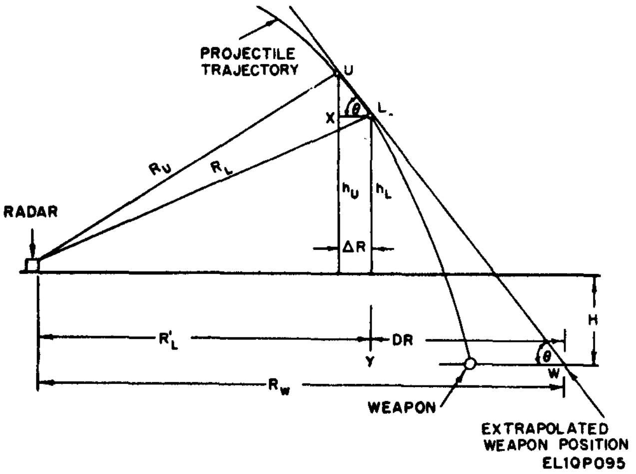


Figure 2-95. *Range geometry, simplified view.*

(b) Weapon azimuth equation. Weapon azimuth (A_W) as shown in figure 2-96, is equal to the algebraic sum of A_L and DA or:

$$A_W = A_L + DA. \qquad (20)$$

From the law of sines:

$$\frac{\overline{AB}}{\sin \Delta A} = \frac{\overline{BC}}{\sin DA} \qquad (21)$$

Since ΔA and DA are angles which are normally less than 5°, the sine of these angles can be replaced by the angle expressed in radians:

$$\frac{\overline{AB}}{\Delta A} = \frac{\overline{BC}}{DA}$$

or

$$DA = \left(\frac{\overline{BC}}{\overline{AB}}\right) \Delta A. \qquad (22)$$

If triangle ULX and triangle LWY are similar, then:

$$\frac{\overline{BC}}{\overline{AB}} = \frac{h_L + H}{h_U - h_L} \qquad (23)$$

If equation (23) is substituted in equation (22), then:

$$DA = \left(\frac{h_L + H}{h_U - h_L}\right) \Delta A \qquad (24)$$

Substituting equation (24) in equation (20) gives:

$$A_W = A_L + \left(\frac{h_L + H}{h_U - h_L}\right) \Delta A. \qquad (25)$$

which is the equation for the straight line extrapolation of weapon azimuth

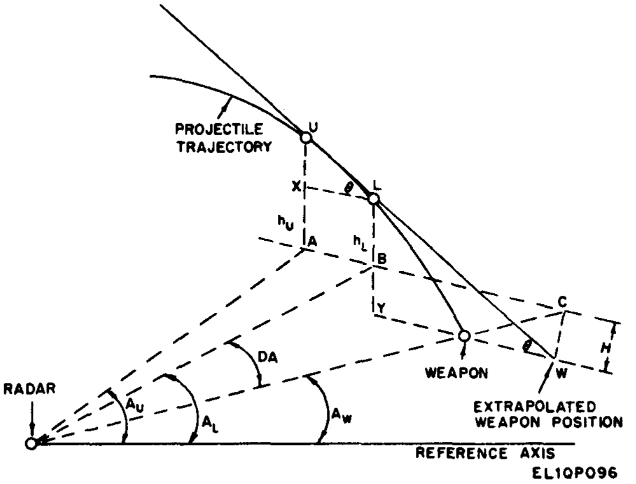


Figure 2-96. Azimuth geometry, simplified view.

(c) C term equation. The parabolic equation for the C term as solved in equation (15), is:

$$C[(C+1)\tfrac{1}{2}g\,\Delta t^2 + h_U - h_L] - (h_L + H) = 0. \qquad (15)$$

If Δt is set to0, or:

$$\Delta t = 0,$$

then:

$$C = \frac{h_L + H}{h_U - h_L} \qquad (26)$$

Equation (26) is the term contained within the brackets in equations (19) and (25).

(4) *Summary of Problem.* Since $C = \frac{h_L + H}{h_U - h_L}$ range equation (19) in (3) *(a)* above and azimuth equation (25) in (3) *(b)* above of straight line extrapolation are the same as range equation (1) in (2) *(a)* above and azimuth equation (4) in (2) *(b)* above for curvilinear, then:

$$R_W = R_L' + C(R_L - R_U) \qquad (1)$$

$$R_W = R_L' + C\,\Delta R \qquad (19)$$

where:

$$\Delta R = (R_L - R_U)$$

and:

$$A_W = A_L + C(A_L - A_U) \qquad (4)$$

$$A_W = A_L + C\,\Delta A \qquad (25)$$

where:

$$\Delta A = (A_L - A_U).$$

Because of wind resistance and drift, the projectile never follows a true parabolic path; therefore, the accuracy of the computer is improved by using slant range R_L in place of ground range R'_L. The equations actually used in the computer are:

$$R_W = R_L + C\Delta R \quad (27)$$

and:

$$A_W = A_L + C\Delta A. \quad (28)$$

2-27. Basic Computing and Electronic Devices

a. General. This paragraph contains a detailed discussion of the operating principles of the various mechanical, electromechanical, and electronic devices that are used in the computing system to solve the weapon location problem. A knowledge of the operating principles of these devices is necessary to understand the operation of the computing system in Radar Set AN/MPQ-4A. The phrasea *mechanical analog, analog voltage,* and *duta will be* used, and are defined as follows:

(1) Data-any information regarding azimuth, elevation, or range.

(2) Mechanical analog-A quantity represented by the rotation of a shaft through an angle.

(3) Analog voltage - a voltage which is proportional to a specific shaft rotation quantity.

b. Gear Trains and Differentials.

(1) *General.* Many of the operations within the computer are mechanical. Mechanical analogs are added and subtracted on differentials, and are transmitted from point to point through gear trains.

(2) *Gear trains* (fig. 2-97). In A, figure 2-96, rotation representing a mechanical analog is transferred from the driving gear to the driven gear and by a shaft to a third gear. In B, the bevel gears are used to transmit a mechanical analog through a 90° turn. In C, the mechanical analog is transmitted in two directions by the bevel gears. Individual gear traina associated with the various computing devices within the computer are covered in detail in paragraphs *2-30a* through *2-36f*.

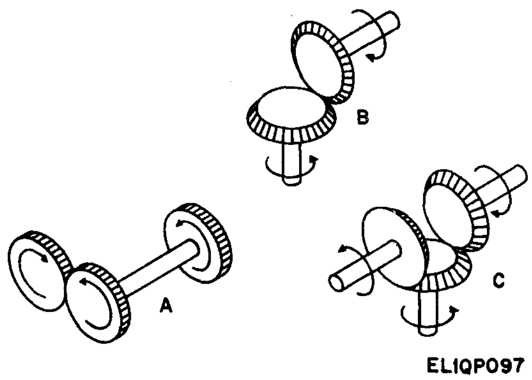


Figure 2-97. Basic gear motion.

(3) Differentials (fig. 2-98). Differentials are used to mechanically add or subtract the angular positions of two shafts.

(a) Basic operation. In A, figure 2-98, shaft A is held immovable and mechanical analog F2 is inserted, rotating shaft B in the direction indicated. The motion is transmitted to the differential through gears B and C, and shaft C. Differential gear D is connected to shaft C and transmits motion to differential geara E1 and E2. Gears E1 and E2 revolve around gear A and transmit a rotation to shaft D equivalent to F2. In B, shaft B is held stationary and shaft A is rotated. Gear A moves and drives gears E1 and E2 around gear D rotating shaft D equivalent to F1.

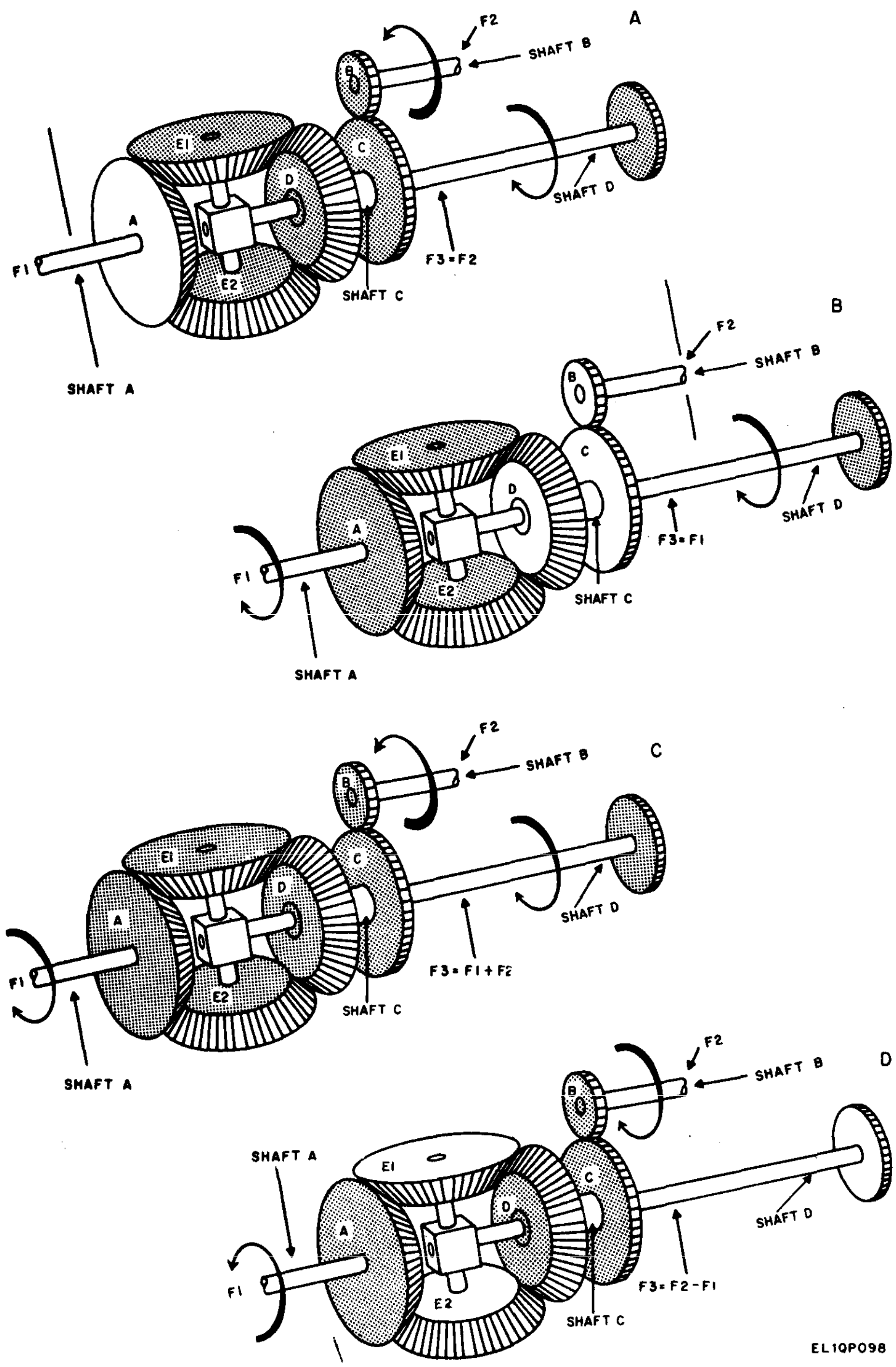


Figure 2-98. Basic operations of differential.

(b) Subtraction of mechanical analogs (D, fig. *2-98)*. Subtraction of mechanical analogs in a differential takes place when the analog inputs cause the output shaft to revolve in either direction. Mechanical analog F1 is inserted into the differential through shaft A and gear A in the direction indicated. Mechanical analog *F2* rotates shaft B in the direction indicated. Mechanical analog F1 transmits a rotation to shaft D through the differential. Mechanical analog F2 transmits a rotation to shaft D through the differential in the opposite direction. Mechanical analog output F3 appearing on shaft D will be equal to mechanical analog F1 minus mechanical analog F2, or F3 = F1 - F2. If the two

inputs cause equal and opposite rotations of shaft D, the resultant output will be zero. If mechanical analog F1 causes a greater rotation than the rotation caused by mechanical analog F2, the resultant rotation, F3, will be in the direction which would have resulted from F1 input alone, or F3=F1-F2. If mechanical analog F2 causes a greater rotation of shaft D than the rotation caused by mechanical analog F1, the resultant rotation of shaft D will be in the direction which would have resulted from F2 input alone, or F3=F2-F1.

(c) *Addition of mechanical analogs* (C, fig. 2-98). Adding takes place in a differential when two inputs combine to increase output shaft rotation. Mechanical analog F1 is inserted into the differential through shaft A and gear A in the direction indicated. At the same time, mechanical analog F2 is inserted in the direction indicated through shaft B, gears B and C, and shaft C causing differential gear D to rotate. Since each input would cause shaft D to rotate in the same direction the output is an addition of the two inputs. Therefore, mechanical analog F3 appearing on shaft D will be the sum of the two analog inputs, or F3=F1+F2.

c. Theory of Synchro Operation. Synchros are devices which convert either the angular motion of a shaft (mechanical analog data) to analog voltage (eletrical analog data), or analog voltage to angular shaft motion.

(1) *General.* The operation of the computer requires that analog voltage be converted to angular shaft rotation to position differentials or potentiometers. Servo motors operated by servo amplifiers convert analog voltages into angular shaft rotation. The two types of synchros used in the computer are synchro transformers and resolvers.

(2) *Synchro control transformers.* A synchro control transformer is used with a synchro transmitter to indicate the difference between the position of the synchro transmitter shaft and the position of the synchro control transformer shaft. The synchro control transformer produces a voltage called *error voltage* which indicates the difference in the angular positions of the shafts. Synchro control transformers have three stator windings, which are physically displaced 120°, and one rotor winding. A synchro control transformer connected to a synchro transmitter is shown in figure 2-99.

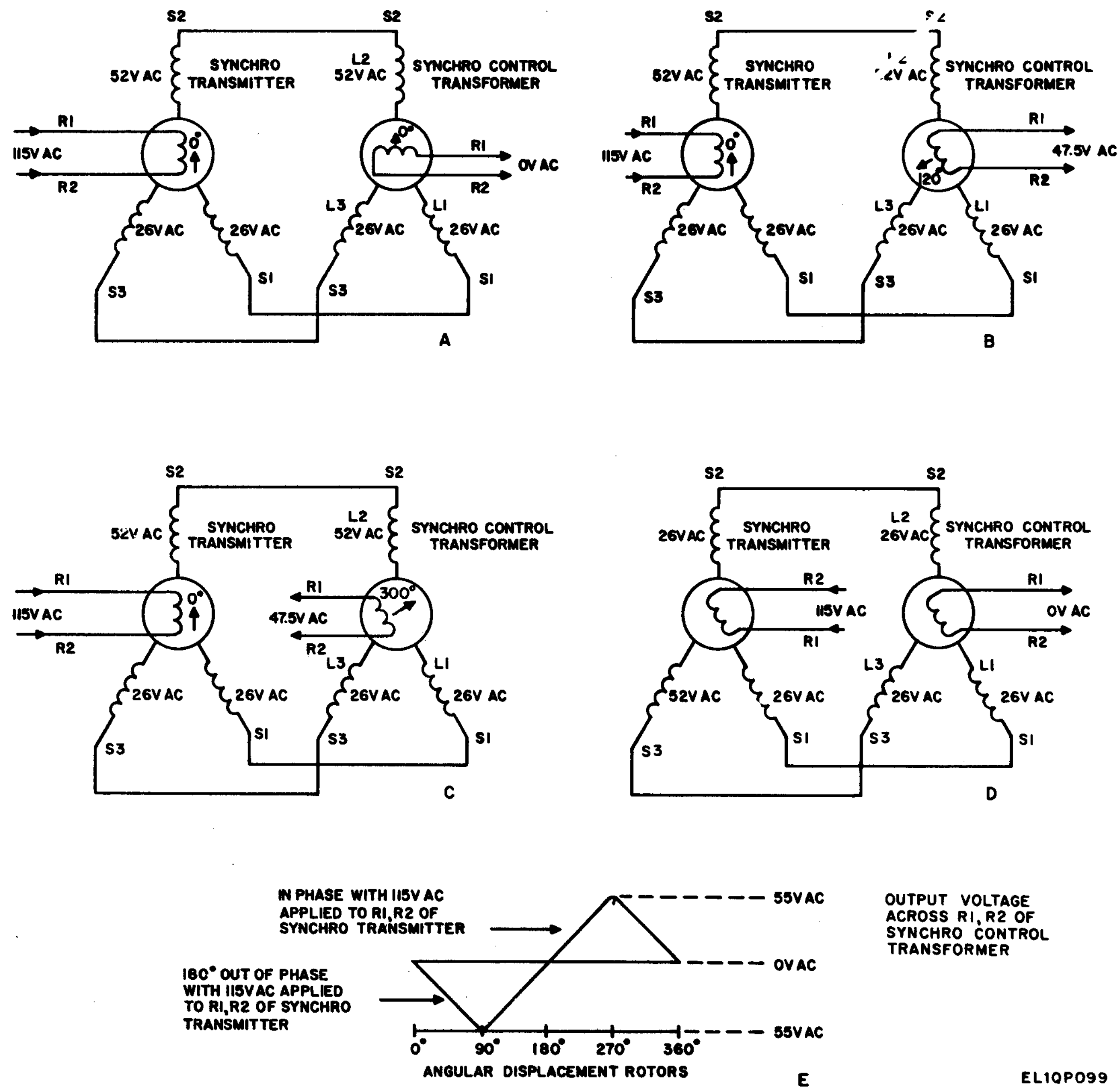


Figure 2-99. Synchro control transformer connected to synchro transmitter.

(a) In A, figure 2-99, the rotor winding of the synchro transmitter is shown in the electrical zero position. When the rotor of the synchro control transformer is in the position shown, no voltage will be induced in the rotor winding because the rotor winding is perpendicular to stator winding L2 and the voltage induced in the rotor winding from L3 and L1 will be equal and opposite in polarity. There are two positions of the synchro control transformer rotor winding which will produce zero output. Zero position of the synchro transformer is the position which produces zero output, and slight counterclockwise rotation of the rotor winding produces a voltage at the rotor winding of the synchro control transformer, which is in phase with the 115-volts ac applied to the rotor winding of the synchro transmitter.

(b) In B, figure 2-99, the rotor of the synchro transmitter has not changed position; however, the rotor winding of the synchro control transformer has been rotated 120° counterclockwise. No voltage would be induced in the synchro transformer rotor winding from L3, which is perpendicular to the rotor winding. The voltages induced in the rotor winding from L2 and L1 add to develop approximately 47.5 volts across the rotor winding. In this position of the rotor, the voltage across the rotor winding (R1 and R2) is in phase with the 115 volts ac applied to the rotor winding of the synchro transmitter.

(c) In C, figure 2-99, the rotor of the synchro transmitter is still at the zero position; however, the rotor winding of the synchro control transformer is rotated 300°, counterclockwise from the zero position. No voltage would be induced in the synchro control transformer rotor winding from L3, which is perpendicular to the rotor winding. The voltages induced in the rotor winding from L2 and L1 add to develop approximately 47.5 volts across the rotor winding. In this position of the rotor, the voltage across R1 and R2 is 1800 out of phase with the 115 volts ac applied to the rotor of the synchro transmitter.

(d) In D, figure 2-99, the rotors of both the synchro control transformer and the synchro transmitter are reduced 180° counterclockwise from the zero position. There is no displacement between the two rotors and there is no output voltage developed across the rotor winding of the synchro control transformer.

(e) The magnitude and polarity of the voltage output of the synchro control transformer is determined by the angular displacement between the two rotors and is plotted on the graph in E, figure 2-99. This output voltage is called error *voltage* and is used to rotate the rotor winding of the control transformer for zero error voltage.

d. Servomotors (fig. 2-100). There are eight servomotors in the computer system, one of which is notated in the scanner. These motors are used to produce mechanical rotation (mechanical analogs) of the potentiometer shafts, differentials, and control transformers from an analog voltage input. The servomotors are 2-phase ac motors with the field currents 90° out of phase. The current in the reference field winding is obtained from autotransformer T859. Torque is obtained by varying the magnitude of the control field; directional control is obtained by phase reversal in the control field. The voltage for the control field is obtained from a magnetic amplifier and servoamplifier.

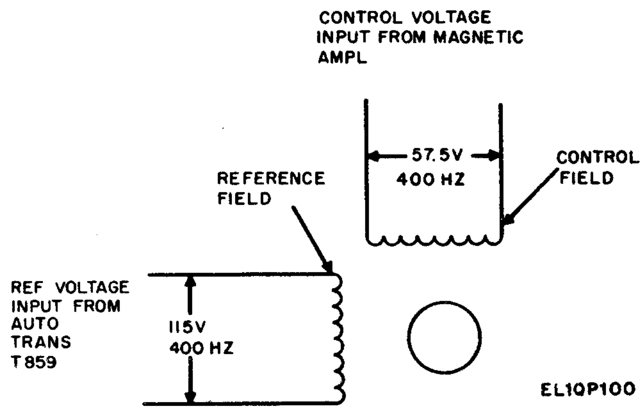


Figure 2-100. Servomotor, simplified schematic diagram.

e. Precision Potentiometers (fig. 2-101).

(1) *General.* The computer uses precision potentiometers to convert the mechanical position of the potentiometer shaft to a voltage. These potentiometers operate as described in (2) below. The applications of the individual potentiometers will be discussed in paragraphs *2-30a* through *2-36f.*

(2) *Operation.* Application of a constant potential to the potentiometer gives an output voltage at the brush which is proportional to the angle of shaft rotation. For example, if a potentiometer shaft is rotated by a servomotor or differential producing a mechanical analog (F1), the output voltage will be an analog voltage which is proportional to F1 (fig. 2-102). If the potentiometer is center tappea, the output will be a positive or negative function of the shaft position.

(3) *Multiplication.* Multiplication of a mechanical analog (F1) by an analog voltage (F2) is performed in the computer by means of potentiometers. When an analog voltage (F2) is used to excite the potentiometer and a mechanical dog (F1) is used to rotate the shaft of the potentiometer, the output is the product of F1 multiplied by F2.

(4) *Construction.* There are two types of precision potentiometers used in the computer. The difference between the two types is primarily a difference in construction.

(a) Single-turn potentiometers. Basically, the single-turn potentiometer consists of a single coil of resistance winding with a slider contact that is rotated to contact the winding from one end to the other as shown in B, figure 2-101.

(b) Multiturn potentiometers. The multiturn potentiometer consists of a long slide wire coiled into a helix as shown in A, figure 2-101. The slider contact is designated so that it follows the helical path from one end of the resistance winding to the other. The multiturn potentiometer usually have 10 turns of resistencewire.

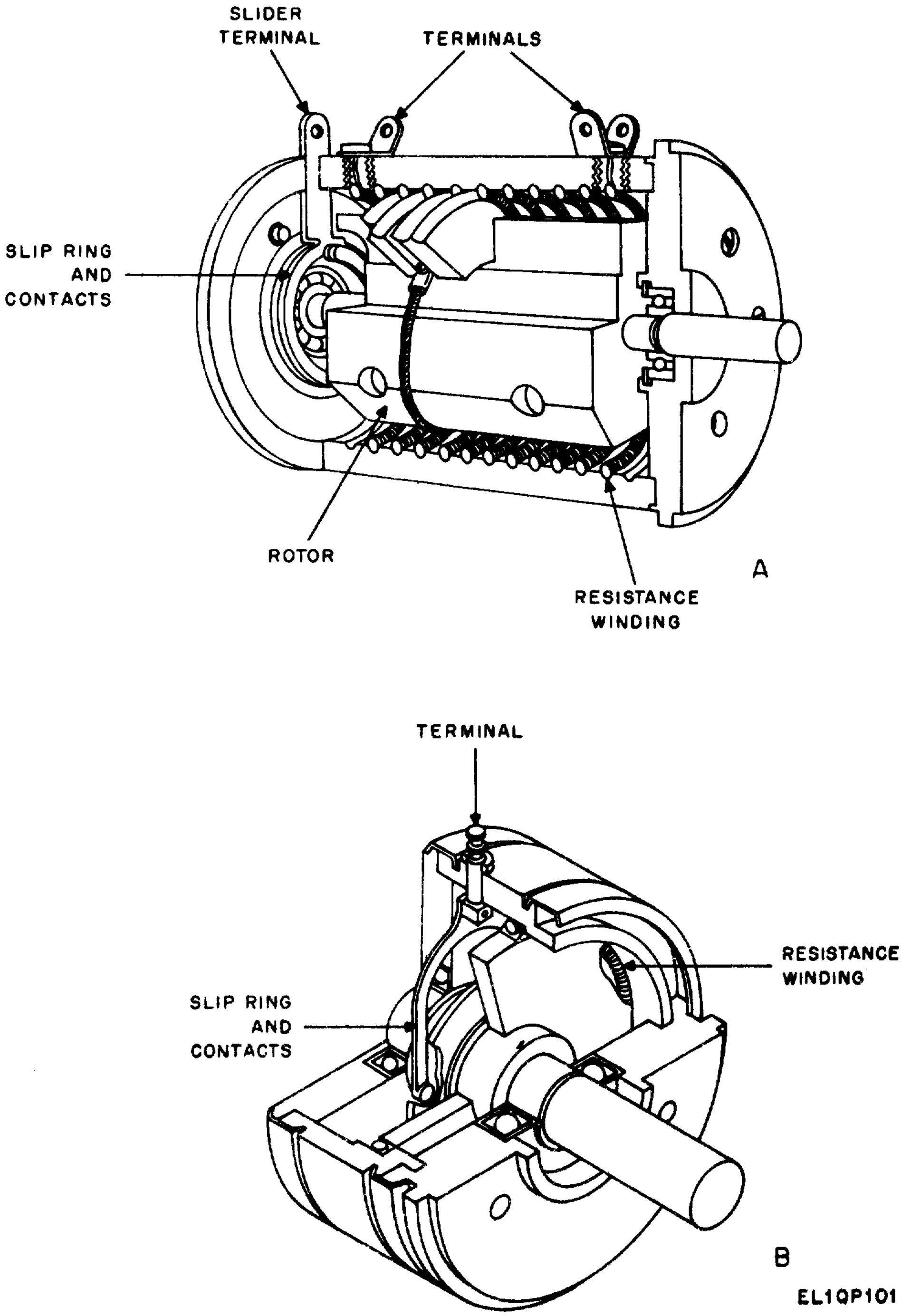


Figure 2-101. Precision potentiometer, construction diagram.

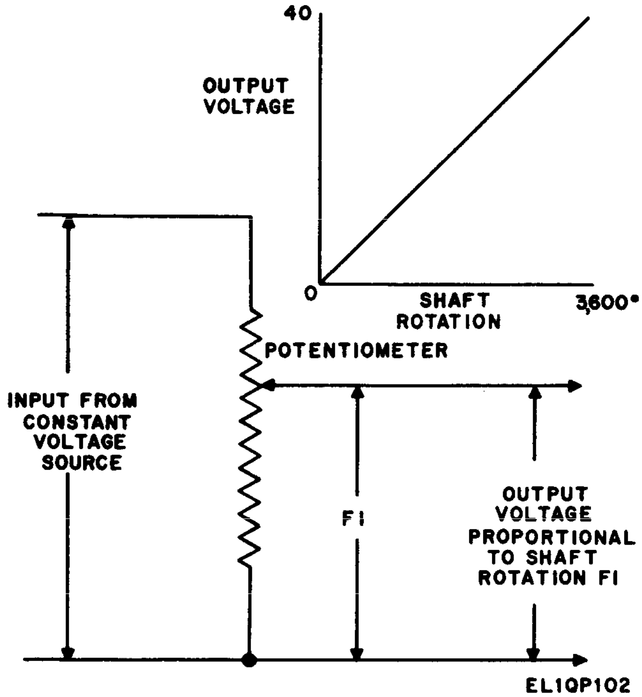


Figure 2-102. Potentiometer output proportional to shaft rotation.

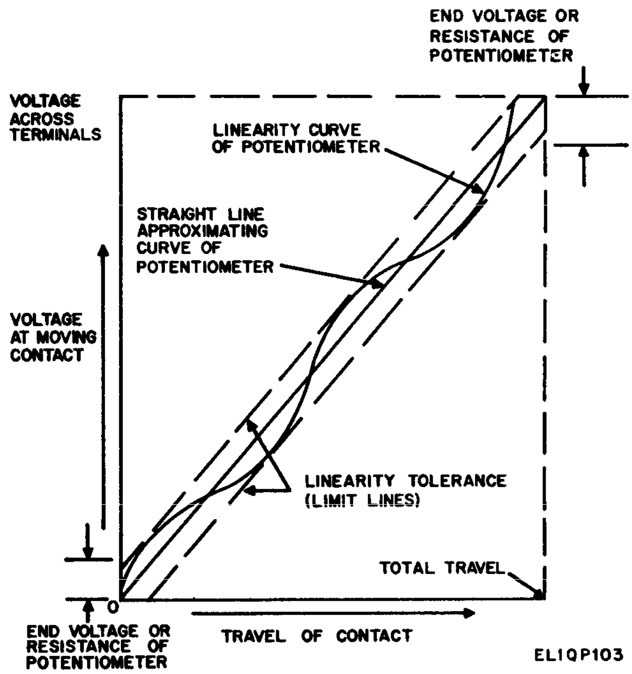


Figure 2-103. Potentiometer linearity curve.

(5) *Characteristics.* The most important characteristics of precision potentiometers are power rating, linearity, electrical rotation, end resistance, total resistance, loading error, resolution, and noise.

(a) Power rating. The power rating of the precision potentiometers is approximately 5 watts and the voltage applied is approximately 40 volts. Any variation of resistance with current due to heating would change the potentiometer linearity and affect the accuracy of the computer.

(b) Linearity. The linearity of a potentiometer is a measure of the variations in resistance of the sliding contact with shaft rotation. Linearity is defined as the deviation (in percent of the total measured resistance) of the actual resistance at any point from the best straight line drawn to the resistance rotation curve (fig. 2-103). The actual curve of a potentiometer with a linearity tolerance of 0.1 percent does not vary farther than 0.1 percent of the total resistance from a perfectly straight line.

(c) Electrical rotation. Electrical rotation is the angular displacement of the shaft which produces changes in resistance and voltage.

(d) End resistance. There is a slight resistance between the sliding contact at the end of travel and the adjacent end terminal in most precision potentiometers. This resistance is due to the resistance of the internal lead between the resistance winding and the terminal (fig. 2-103).

(e) Loading error. The voltage output from the sliding contact will not vary linearly with respect to the shaft position if current is drawn through the sliding contact. This characteristic is known as the *loading error* (fig. 2-104). The position of the shaft, as well as the magnitude of the maximum error, varies with the ratio of load resistance to potentiometer resistance. The equation for determining loading error at any point is:

$$\text{Percentage error} = \frac{R\theta^2\ (100-\theta)}{10^4\ \ L+R\theta(100-\theta)}$$

where R = potentiometer resistance (in ohms)
L = load resistance
θ = contact position in percent at total rotation

Loading error is reduced when the potentiometer is padded with fixed resistors as shown in figure 2-105. The padding resistors are added to improve the linearity of the potentiometer and to relieve the loading error of certain positions of the slider.

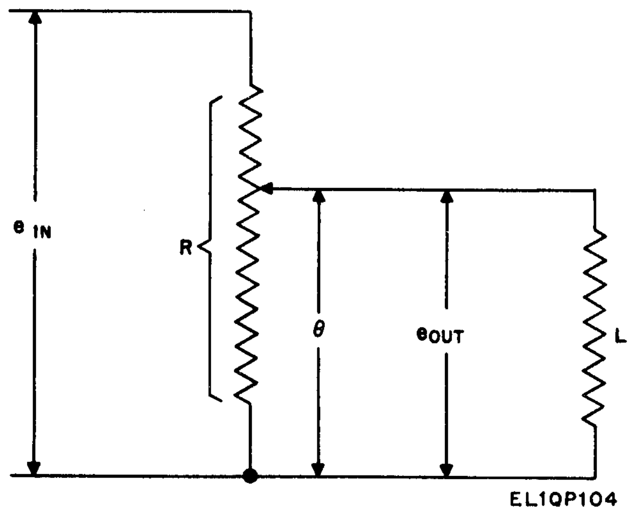


Figure 2-104. Potentiometer loading error.

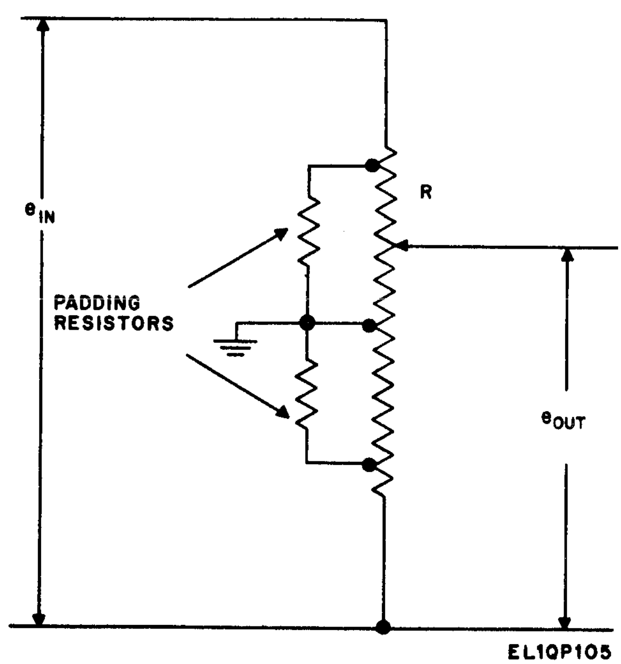


Figure 2-105. Resistance padding or potentiometer.

(f) Resolution. The resolution of a potentiometer is the minimum change of resistance output (obtained by rotating the shaft) expressed as a percentage of the total resistance of the potentiometer. Resolution depends on the number of turns of wire per inch on the winding and on the diameter of the arc upon which the brush (sliding contact) travels. The resolution of a potentiometer places an upper limit on the percentage of accuracy that can be obtained.

(g) Noise. Noise is a random or spontaneous fluctuation of voltage or resistance which is detectable by some types of highly sensitive circuits and is caused by the movable contact in motion. There are three types of noise which originate in a potentiometer.

1. The first type is known as *resolution noise* and is composed of a sawtooth waveform which is superimposed on the linear change of resistance between the movable contact and either end of the resistance winding as the shaft is rotated.

2. The second and more serious form of noise is known as *transient noise* and consists of rapid fluctuations of contact resistance which are caused by foreign material coming between the contact and the resistance winding. The two forms of noise mentioned are contact resistance variations and can be reproduced on an oscilloscope for viewing and measuring.

3. The third type of noise is a very low amplitude form of electrical noise caused by the extremely small amount of heat generated by the friction of the movable contact sliding against the resistance winding.

f. Servoamplifiers (fig. 2-106).

(1) *General.* Eight identical servoamplifiers are used in the computer. Two servoamplifiers are mounted on each of four plug-in chassis. The reference symbols used in this discussion refer to one amplifier in particular, but may be applied to all the servoamplifiers. Servoamplifiers are used in the computer to raise relatively small analog voltages to values great enough to drive magnetic amplifiers which drive the servomotors of the computer. Servoamplifiers must have a flat gain over a wide frequency range and little or no phase shift, since any shift in phase will cause an error in the computations. A servoamplifier must also have low noise and low impedance output. Signal distortion through the amplifier does not affect the operation of the servosystem; therefore, the amplifier stages are driven almost to saturation. The cathode bypass capacitors are also eliminated to increase stability.

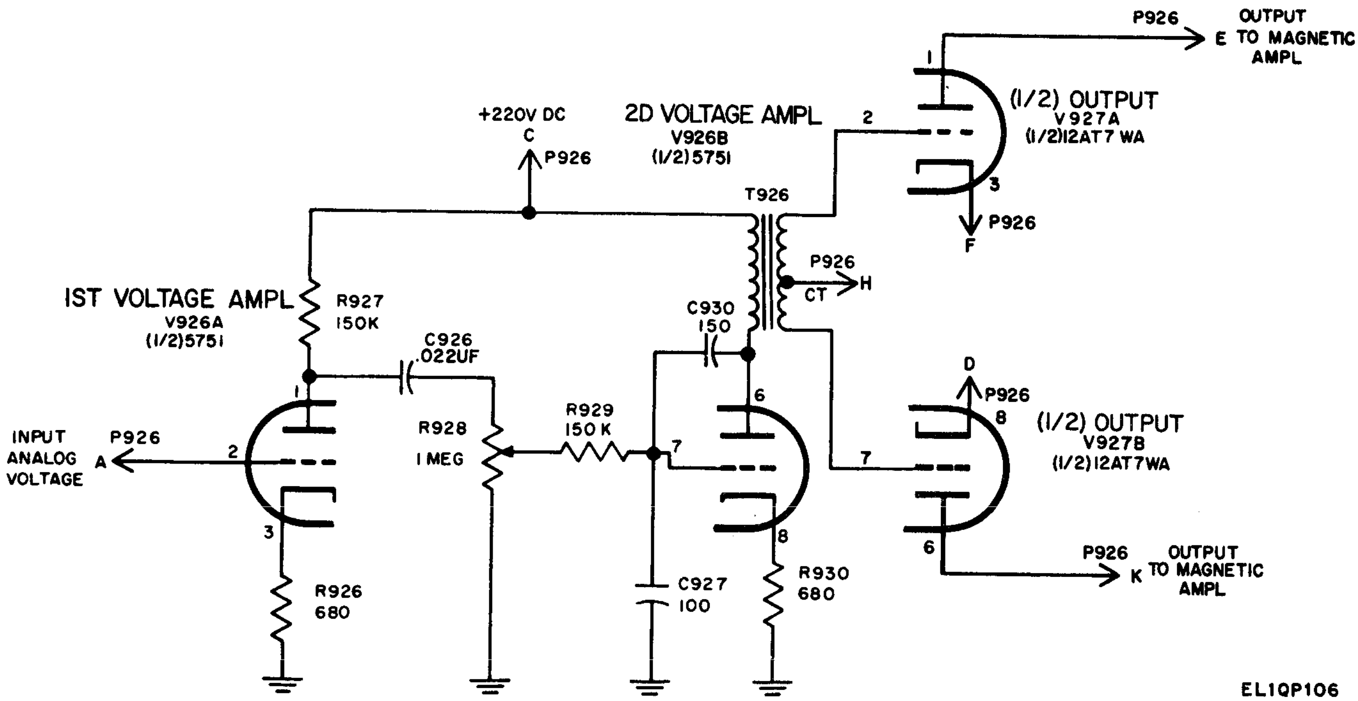


Figure 2-106. Servoamplifier, simplified schematic diagam.

(2) *First amplifier stage V926A.* The analog voltage (signal) is applied to the grid (pin 2) of V926A. Resistor R927 is the plate load resistor. Resistor R926 is the cathode resistor which develops the operating bias and provides a small amount of degeneration. The signal voltage is amplified by this stage and applied to the grid (pin 7) of the second stage through dc blocking capacitor C926.

(3) *Second amplifier stage V926B.* Signal voltage for the second stage is developed across variable resistor R928 and applied to the grid (pin 7) through grid-limiting resistor R929. Variable resistor R928 is a gain control and controls the gain of the servoamplifier by varying the amount of signal voltage applied to the grid of the second stage. Capacitors C927 and C930 form a degenerative feedback circuit, adding gain stability to the amplifier. Bias for the stage is developed across cathode resistor R930. The second stage amplifies the signal and applies it to the primary of transformer T926.

(4) *Output stage V927.* The grids (pins 2 and 7) of tube V927 are driven by the secondary of interstage transformer T926. The outputs from the plates (pins 1 and 6) feed a magnetic amplifier. The cathode (pins 3 and 8) of the output stages and the center tap of transformer T926 are connected to potentiometer R886 or R887 (fig. FO-13) to balance the servosystem in servoamplifier AR928A or AR929A. The cathodes (pins 3 and 8) and the center tap of transformer T926 of the other servoamplifiers (AR926A, AR926B, AR927A, AR927B, AR928B, and AR929B) are connected to ground.

NOTE

The term balance refers to a zero voltage or zero position.

g. Magnetic Amplifiers. Eight identical magnetic amplifiers are used in the computer. The magnetic amplifiers use the analog voltage output from the servoamplifiers to control the rotation of the servomotors. Since all the magnetic amplifiers act in a similar manner, only one amplifier will be discussed in detail.

(1) *Advantages.* The principle advantages of magnetic amplifiers are long life, little or no maintenance required, hermetically sealed, low heat dissipation, low heat rise, isolation of input circuits from output circuits, and high gain.

(2) *Basic magnetic amplifier* (fig. 2-107). A magnetic amplifier is a device for controlling the flow of power to a load by means of saturation of a magnetic core. When the control current is low, the impedance presented to the load is high, and currant I_{OUT} through the load R_L is small. When control current I_{IN} becomes large, the core will saturate; this causes the inductance of the load winding to decrease. The decrease of the load inductance will increase the current flowing through load resistor R_L, and increase the power through the circuit.

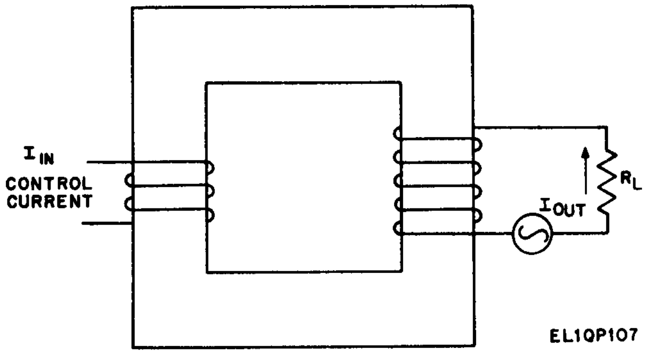


Figure 2-107. Basic magnetic amplifier, simplified schematic diagram.

(3) *Operation of magnetic amplifier T851* (fig. 2-108). The computer uses half-wave bridge type magnetic amplifiers consisting of two cores, each wound with four coils. The 120-volt ac voltage is applied through four coils of the control windings to the plate of the servoamplifiers. The 120-volt ac power is applied to the load windings through terminals 5 and 6. Resistor R943 limits the current drawn through the load windings to prevent overheating. With no signal from the servo amplifier applied to terminal 7 or 10, the cores are unsaturated and very little current flows in the load windings. The small currents which do flow are of equal magnitude and opposite phase, and cancel each other; therefore, when there is no signal applied, the servomotor does not turn. If the tube connected to terminal 10 conducts, the core that the plate current flows through saturates. The inductance of the output coil becomes small and current passes from terminal 5 through the coil to terminal 3, and then through terminal 4 of selenium rectifier CR851 to one side of the control field (terminal 5). The current passes through the control field to terminal 2, then up through CR851, terminal 1 and back to T851, terminal 1, through the coil to terminal 6. This causes the servomotor to rotate in one direction. If the tube connected to terminal 7 of T851 conducts, the current flow is from the line to terminal 5 through the coil to terminal 2 then through terminal 3 of CR851, and through the control winding (opposite direction) to terminal 5 of CR851, up through CR851 terminal 6 and back to T851, terminal 4, through the coil to terminal 6. The four selenium rectifiers prevent circulating currents, If a rectifier is shorted, circulating currents will flow; this results in decreased servomotor torque. If a rectifier is open-circuited, the servomotor will be able to run in only one direction.

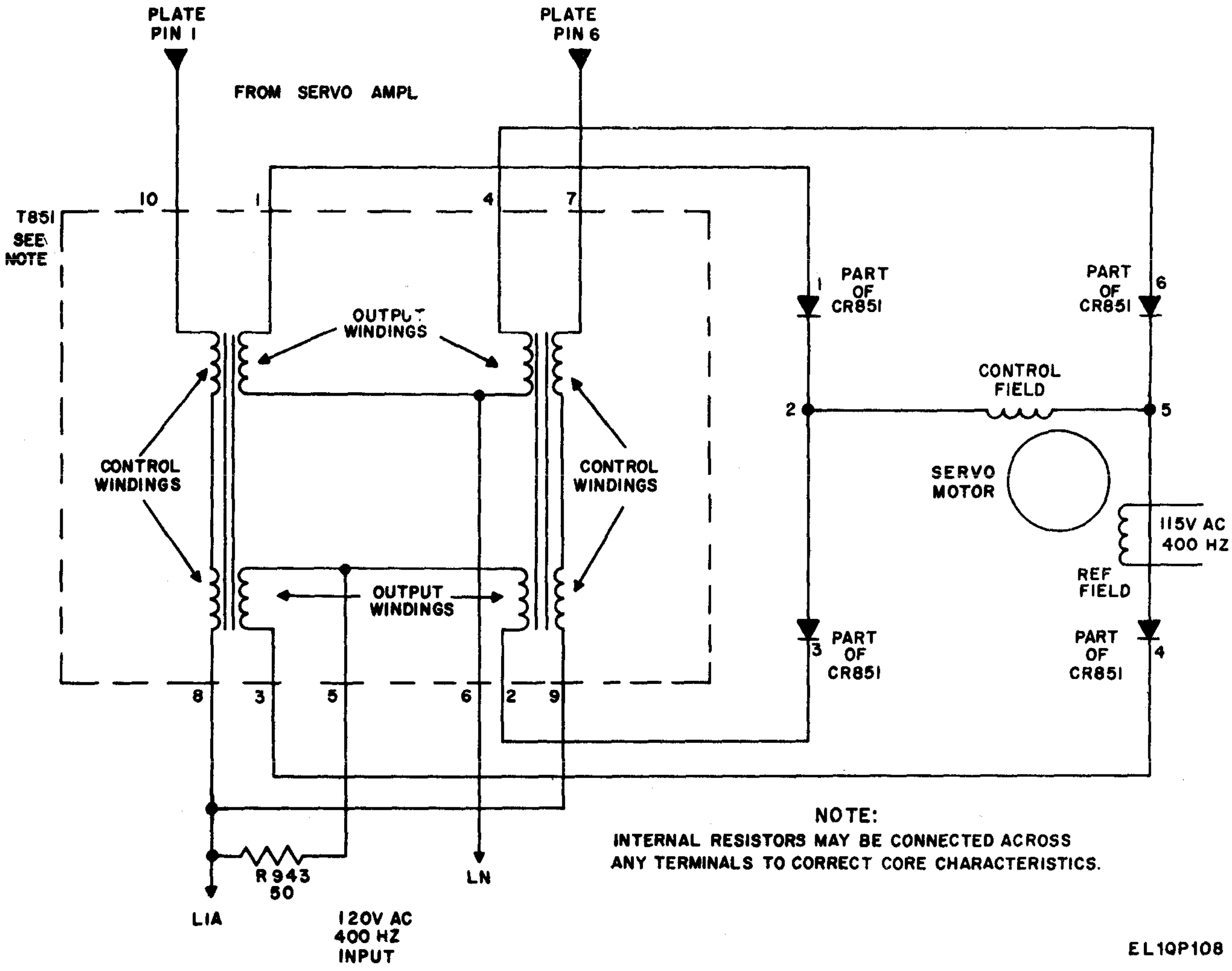


Figure 2-108. Magnetic amplifier simplified schematic diagram.

(4) *Resistors.* Resistors may be connected internally across any terminal of the magnetic amplifier. The resistors are used to correct core characteristics to make each magnetic amplifier meet an operational standard. Resistors may be connected across the input or output windings, or both; they may be connected on one core or both. The value of resistor used, if any, is approximately 300,000 ohms in most cases but will vary depending on the amount of correction required for the core in question.

2-28. Introduction to Computing System

a. Purpose. The purpose of the computing system is to present enemy weapon location in rectangular coordinates. The information regarding the range, azimuth, elevation, and time between intercepts (echoes) is fed into the computer to determine weapon location.

b. Computing System Data Flow by Sections (fig. FO-7).

(1) *General.* The computer uses eight sections in the computation of weapon location. A portion of the input data is set into the computer by synchros located in the antenna system. The remaining data is set into the computer by means of handwheels located on the front panel of the computer.

(2) *Elevation section.* The elevation section converts data received from the antenna elevation synchro into two analog voltage outputs. One analog voltage represents upper beam elevation (E_U) information and the other represent a lower beam elevation (E_L) information. A mechanical analog (shaft rotation) proportional to E_L is presented on LOWER BEAM ELEVATION counter M821 as a number.

(3) *Azimuth Section.* The azimuth section receives data from the antenna synchros, C section, range section, and handwheels and produces two analog voltage outputs that are applied to the coordinate sections.

(a) Inputs. Fine and coarse data from the antenna azimuth synchros are received at two separate inputs. Data from the azimuth marker synchro are fed into the azimuth section. Electrical analog R_w is fed in from the range section. Mechanical analog data are fed into the azimuth section by the LOWER BEAM AZIMUTH (A_L) handwheel and by the Δ azimuth handwheel Electrical analog **CΔA** is fed in from the C section.

(b) Outputs. Mechanical analog output Aw is presented on AZIMUTH counter M841. A_w is also used to position a resolver. Analog voltage **ΔA** is fed to the C section. Two analog voltages representing weapon northing R_w(N) and weapon casting R_w(E) are fed into the coordinate sections.

(4) *Time section.* The time section combines a mechanical analog representing Δ time and an analog voltage representing -(C+1)½g to produce an output representing the two inputs multiplied.

(a) Inputs. The input from the **ΔT** handwheel is mechanical analog **ΔT.** 'The other input, an analog voltage from the C section, is -(C+1) multiplied by one-half the force of gravity.

(b) Outputs. Mechanical output presents **ΔT** on A TIME counter M801. An analog voltage output represents -(C+1)½g multiplied by ΔT^2.

(5) *Range section.* The range section converts three electrical and two mechanical analog inputs into five analog voltage outputs and one mechanical analog output.

(a) Inputs. One mechanical analog input from the LOWER BEAM RANGE handwheel represents lower beam range (R_L). Another mechanical analog input from the Δ RANGE handwheel represents **ΔR.** . Electrical analog E_L and E_U come from the elevation section and electrical analog **CΔR** comes in from the C section.

(b) Outputs. A mechanical analog representing R_w is applied to RANGE counter M831. One analog voltage representing upper beam range (R_U) is applied to the indicator. Three analog voltage outputs representing **ΔR,** $-h_L$, and $+h_U$ are applied to the C section. Another analog voltage representing R_w is applied to the azimuth section.

(6) *Height section.* The height section converts mechanical analogs radar height (H_R) and weapon height (H_w) into analog voltage H, which is applied to the C section and represents the difference between H_R and H_w. The mechanical outputs, H_w and H_R, are presented digitally on RADAR HEIGHT counter M807 and weapon HEIGHT counter M806.

(7) *C section.* The C section converts six analog voltages representing range, elevation, azimuth, time, and height into three analog voltages representing the inputs multiplied by the value of C.

(8) *Coordinate sections.* The two identical coordinate sections convert two analog voltage inputa representing the polar coordinates of weapon location north and weapon location east into rectangular coordinates. The outputs are presented on WEAPON LOCATION easting and northing counters M816 of the casting and northing sections.

2-29. General Functioning of Computing System

a. General. Basically, the computer consists of eight sections. Information is inserted into the computer from six handwheels located on the front panel and from the antenna elevation and azimuth synchros.

b. Elevation Section (fig. FO-7). Antenna elevation synchro data (para 2-40a(3)) is fed into control transformer B822. The stator of control transformer B822 is positioned by the E_L adjustment. When the elevation data from the antenna cause an error voltage to be developed, the error voltage is transmitted to servoamplifier AR927B through resonant damping filter FL853. Servoamplifier AR927B amplifies the relatively small error voltage and applies the amplified output to magnetic amplifier T852. Magnetic amplifier T852 controls servomotor B821. Servomotor B821 will rotate and transmit a shaft rotation equivalent to mechanical analog E_L to LOWER BEAM ELEVATION counter M821, E_U potentiometer R822, E_L potentiometer R821, and the rotor of control transformer B822. Mechanical analog E_L (or shaft rotation) transmit ted to M821 will rotate the counter and the counter will indicate the elevation of the antenna in mils. Mechanical analog E_L, transmitted to control transformed B822, positions the rotor until the error voltage is canceled and effectively nulls or stops servomotor B821. Mechanical analog E_L, transmitted to E_L potentiometer R821 and E_U potentiometer R822, rotates the shafts of the potentiometers through a given angle. The output voltages of the potentiometers are analog voltages E_L and E_U which are applied to h_U potentiometer R832 and h_L potentiometer R831 in the range section.

c. Azimuth Section (fig. FO-7).

(1) *Δ AZIMUTH handwheel.* Azimuth data are inserted into the computer by rotating the Δ AZIMUTH handwheel. Mechanical analog ΔA_t, produced by rotating the handwheel, is transmitted to the A_U differential and to **Δ A** potentiometer R841. Analog voltage Δ A is produced by R841 and applied to C potentiometer R811C in the C section *(f* below).

(2) LOWER BEAM AIMUTH *handwheel. Lower* beam azimuth data are inserted into the computer by the LOWER BEAM AZIMUTH handwheel. Mechanical analog A_L is inserted into the A_U and the $A_L + C\Delta A$ differentials when the LOWER BEAM AZIMUTH handwheel is rotated.

(a) A_U differential. The A_U differential combines mechanical analog ΔA ((1) above) with mechanical analog A_L to produce mechanical analog A_U. Mechanical analog A_U is used to position the rotor of control transformer B846.

1. Control transformer B846 and resonant damping filter FL852. Data from the antenna azimuth marker synchro are fed into the stator of control transformer B846. When the rotor of B846 is positioned by A_U differential, an error voltage is produced and applied through resonant damping filter FL852 to servoamplifier AR926A.

2. Servoamplifier AR926A and magnetic amplifier T855. The error signal from B846 is amplified and applied to magnetic amplifier T855, which is used to control the azimuth marker servomotor that positions azimuth marker coil L3203 and the azimuth marker synchro transmitter in the scanner.

(b) $A_L + \Delta A$ differential. The $A_L + C\Delta A$ differential combines mechanical analog A_L with mechanical analog $C\Delta A$ *(2* below) to produce mechanical analog $A_L + C$ which is transmitted to the $A_L + C\Delta A + AZ$ differential.

1. Servoamplifier AR929B and magnetic amplifier T854. Analog voltage Δ A ((1) above) was applied to C potentiometer R811C in the C section where it was multiplied by C to produce analog voltage $C\Delta$ which is applied to servoamplifier AR929B, amplified, and transmitted to magnetic amplifier T854. Magnetic amplifier T854 controls servomotor B842.

2. Servomotor B842. Analog voltage CA A is applied to servomotor B842, which transmits a mechanical analog to the $A_L + C\ \Delta\ A$ differential and to $C\ \Delta A$ potentiometer R842.

3. $C\Delta A$ potentiometer R842. The shaft of $C\Delta$ A potentiometer R842 is rotated by servomotor B842 and produces analog voltage C ΔA which, in turn, is applied to servoamplifier AR929B. When analog voltage C from potentiometer R842 equals analog voltage $C\Delta$ A from the C section, the resultant voltage Φ applied to servomotor B842 is zero and the servomotor stops rotating. The resultant shaft rotation of B842 is an accurate mechanical analog C ΔA.

(c) $A_L + C\Delta AZ$ differential. $A_L + C\ \Delta A$ +AZ differential combines mechanical analog $A_L + C\Delta$ A from the $A_L + C\Delta A$ differential ((b) above) with mechanical analog AZ from servomotor B841 (5 below) to produce mechanical analog $A_L + C\Delta A + AZ$. +AZ. Mechanical analog $A_L + C\Delta A$ +AZ is transmitted to the Aw differential.

1. Nine-speed control transformer B845 and resonant damping filter FL851. Fine azimuth data from the 9-speed azimuth synchro transmitter in the antenna are applied to 9-speed control transformer B845. Any error produced in the control transformer is applied to servoamplifier AR926B through resonant damping filter FL851.

2. Servoamplifier AR926B and magnetic amplifier T851. Synchro data from the antenna azimuth synchro transmitter are amplified by the servoamplifier and applied to magnetic amplifier T851 and control servomotor B841.

3. One-speed control transformer B844. When the antenna is rapidly rotated in azimuth, an error voltage exceeding 5 volts is produced by 1-speed (coarse) control transformer B844. The 5-volt error from control transformer B844 is applied to dual-speed cutover amplifier AR951B.

4. Dual-speed cutover amplifier AR951B. When the antenna is rotated in small increments, dual-speed amplifier AR951B is inoperative. When the error voltage produced by B844 reaches 5 volts, dual speed amplifier AR951B operates and applies azimuth data from B844 to servoamplifier AR926B. The data applied to servoamplifier AR926B are greater than the voltage from control transformer B845; therefore, the action of servomotor B841 is faster.

5. Servomoter B841. Azimuth data applied to servo motor B841 cause the motor to rotate and create a mechanical analog equivalent to AZ. Mechanical analog AZ is transmitted to the $A_L + C\Delta A$+AZ differential and to the rotors of control transformers B844 and B845. When the rotors of B844 and B845 reach a position where no error voltage is produced, no voltage is applied to B841 and the motor stops.

(d) A_W differential. The A_W differential combines mechanical analog $A_L C\Delta A$ · +AZ *((c)* above) with mechanical analog AZ_{OR} to produce mechanical analog A_W. During installation of the radar set, azimuth orient adjustment motor B843 is operated to set mechanical analog AZ_{OR} into the differential. Mechanical analog A_W is transmitted to AZIMUTH counter M841 and to resolver B847.

(e) Resolver B847. Mechanical analog A_W is combined with analog voltage R_W in resolver B847 to produce two analog voltage outputs.

1. Analog voltage $R_{W(N)}$. An analog voltage output to the northing section represents weapon range (northing), or $R_{W(N)} = R_W \cos A_W$.

2. Analog voltage $R_{W(E)}$. An analog voltage output to the casting section represents weapon range (easting), or $R_{W(E)} = R_W \sin A_W$

d. Range Section (fig. FO-17).

(1) *ΔRANGE Handwheel.* Rotation of the Δ RANGE handwheel delivers range data to the R_U differential and to Δ R potentiometer R833.

(a) Δ R potentiometer R833. Rotation of the shaft of Δ R potentiometer R833 produces an analog voltage output, **ΔR,** which is applied to the C section.

(b) R_U *differential.* The R_U differential combines mechanical analog **ΔR** from the Δ RANGE handwheel with mechanical analog R_L from the LOWER BEAM RANGE handwheel ((2) below) to produce mechanical analog R_U. Mechanical analog R_U is transmitted to h_U potentiometer R832 and to range potentiometer R836.

(c) Range potentiometer R836. Mechanical analog R_U, delivered to the shaft of R836 at the rate of 1,650 meters per revolution, produces analog voltage R_U which is applied to the synchronizing system (para 2-22 *d).*

(d) h_U *potentiometer R832.* Analog voltage E_U *(b* above) is multiplied by mechanical analog R_U in h_U potentiometer R832 to produce analog voltage $+h_U$ which is applied to the C section.

(2) *LOWER BEAM RANGE handwheel.* The LOWER BEAM RANGE handwheel applies mechanical analog R_L to the R_U differential ((1) above), to the R_W differential, and to the h_L potentiometer.

(a) h_L *potentiometer R831.* Analog voltage E_L, from the elevation section *(b* above) is multiplied by mechanical analog R_L in h_L potentiometer R831 to produce analog voltage output $-h_L$ which is applied to servoamplifier AR927A and isolation amplifier AR901A.

(b) R_W *differential.* The R_W differential combines mechanical analog R_L with mechanical analog **CΔR** to produce mechanical analog R_W. Mechanical analog R_W is applied to RANGE counter M831 and R_W potentiometer R835.

1. Servoamplifier AR928B and magnetic amplifier T853. Analog voltage Δ R ((1)(a) above), applied to C potentiometer R811C in the C section and combined with C, is applied to servoamplifier AR928B as analog voltage **CΔR.** Analog voltage **CΔR** is amplified by servoamplifier AR928B and applied to magnetic amplifier T853 and then to servomotor B831.

2. Servomotor B831. Servomotor B831 transforms analog voltage **CΔR** into a shaft rotation which positions the R_W differential and **CΔR** potentiometer R834.

3. ***CΔR*** *potentiometer R834.* Analog voltage **CΔR** is produced by R834 and applied to servoamplifier AR928B. When analog voltage **CΔR** from R834 is equal to analog voltage **CΔR** from the C section, the resultant voltage applied to AR928B is zero and servomotor B831 stops operating.

(3) *RANGE counter M831.* Mechanical analog R_W from the R_W differential positions RANGE counter M831 so that the range, in meters, is indicated.

(4) R_W *potentiometer R835.* Mechanical analog R_W positions the shaft of R835 so that analog voltage R_W is produced. Analog voltage R_W is applied to booster amplifier AR951A.

(5) *Booster Amplifier AR951A.* The booster amplifier amplifies analog voltage R_W and applies it to resolver B847 (c(2)(e) above).

e. Time Section (fig. FO-7). The T handwheel delivers mechanical analog Δ T to Δ TIME counter M801 and to the shaft of **ΔT** potentiometer R801, **ΔT** potentiometer R801 multiplies analog voltage -(C+1)½g received from the C section by ΔT^2 to produce analog voltage -(C+1)½g to ΔT^2 which is delivered to the C section.

f. C Section (fig. FO-7). The C section receives inputs from the height, azimuth, time, and range sections. These various inputs are combined in the C section to derive the C term which is used in the computation of weapon location.

(1) The initial position of the shaft of servomoter B811 represents an arbitrary value of C. The shaft of servomotor B811 positions four-gang C potentiometer R811A, R811B, R811C, and R811D. (Maximum value of C possible is 8, any value over 3.8 for C will light a DOUBTFUL SOLUTION indicator.) Until the servosystem nulls, this value of C is incorrect for the value of range, elevation, and azimuth present.

(2) The two inputs from the range section to isolation amplifier AR901A represent analog voltage $+h_U$ and $-h_L$. These analog voltages are inverted in isolation amplifier AR901A and delivered to isolation amplifier AR901B as analog voltage $(h_L - h_U)$.

(3) The analog voltage -(C+1)1/2G T^2, from **ΔT** potentiometer R801, (para. 2-29e is fed into isolation amplifier AR901B.

(4) The isolation amplifier reverts and combines the two analog voltage inputs and produces analog voltage $(C+1\tfrac{1}{2}g\Delta T^2+h_U-h_L)$ which is delivered to C potentiometer R811A.

(5) C potentiometer R811A multiplies the analog voltage, delivered by the isolation amplifier, with the arbitrary C term to produce the analog voltage $C[(C+1)\tfrac{1}{2}g\Delta T^2+h_U-h_L]$.

(6) Servoamplifier AR927A is used to drive servomotor B811 and has three inputs.

(a) Analog voltage $C[(C+1)\frac{1}{2}g\Delta T^2+h_U-h_L]$ from C potentiometer R811A.

(b) Analog voltage -H from H potentiometer R806 except when H_w is equal to H_R and then H is zero.

(c) Analog voltage $-h_L$ from h_L potentiometer R831.

(7) The three analog voltages are amplified and inverted in servoamplifier AR927A and drive servomotor B811 until the correct value of C is found for the values of range, elevation, and azimuth. When the correct value of C is found, the servo nulls and the motor stops.

(8) The position of the shaft of the servomotor sets the four sections of C potentiometer R811 for the correct mechanical analog of C.

(9) Analog voltage Δ R from ΔR potentiometer R833 *(d* above) is combined with mechanical analog C in C potentiometer R811D to produce voltage C

(10) Analog voltage CΔR is applied to the range section as discussed in *d* above.

(11) Mechanical analog C is converted into analog voltage -(C+1) multiplied by the electrical analog of the constant ½g on C potentiometer R811B. The analog voltage -(C+1)½g is applied to the time section as discussed in paragraph 2-29e.

(12) Analog voltage Δ *(c* above) is combined with mechanical analog C in C potentiometer R811C to produce the analog voltage C which is fed to the azimuth section.

g. Coordinate Sections (fig. FO-7). There are two identical coordinate sections in the computer. One is used for casting and the other is used for northing. The coordinate sections convert the range and azimuth values into north and east map coordinates.

(1) Analog voltage $R_{W(N)}$ from resolver B847 in the azimuth section (c(2) above) is applied through resonant damping filter FL855 to servoamplifier AR929A and magnetic amplifier T858, which drives servomotor B816.

(2) Servomotor B816 produces mechanical analog $R_{W(N)}$ and delivers $R_{W(N)}$ to $R_{W(N)}$ potentiometer R816 and to N_W differential.

(3) Potentiometer R816 applies feedback analog voltage $R_{W(N)}$ to the resolver.

(4) Radar location northing motor B817 is operated by RADAR LOCATION NORTHING switch S852 to set the location of the radar set into the computer. The motor produces mechanical analog N_R which is sent to the N_W differential and positions RADAR LOCATION NORTHING counter M817.

(5) Mechanical analog $R_{W(N)}$ ((2) above) and mechanical analog N_R ((4) above) are combined in the N_W differential to produce mechanical analog N_W which positions WEAPON LOCATION NORTHING couter M816.

(6) Analog voltage $R_{W(E)}$ from the resolver is applied to servoamplifier AR928A and magnetic amplifier T857, which drives servomotor B816.

(7) Servomotor B816 delivers mechanical analog $R_{W(E)}$ to the E_W differential and to $R_{W(E)}$ potentiometer R816.

(8) Potentiometer R816 applies feedback analog voltage $R_{W(E)}$ back to the resolver.

(9) Radar location casting motor B817 sets radar location casting data into the computer and produces mechanical analog E_R which positions RADAR LOCATION EASTING counter M817 and appliers E_R to the E_W differential.

(10) Mechanical analog $R_{W(E)}$ (7) above) and E_R ((9) above are combined in the differential to produce mechanical analog E_W which positions WEAPON LOCATION EASTING counter M816.

h. Height Section (fig. FO-7), Radar height data are set into the computer by a control which produces mechanical analog H_R. The RADAR HEIGHT control is used to position RADAR HEIGHT counter M807 and applies mechanical analog H_R to the H_W differential. The WEAPON HEIGHT hand wheel applies mechanical analog H_W to the H_W differential and to H potentiometer R806. Mechanical analog H_W from the H_W differential is used to position weapon HEIGHT counter M806. Analog voltage H from the H potentiometer is fed into the C section. When H_R equals H_W, then H is zero.

2-30. Electrical and Mechanical Description of Elevation Section.

(fig. FO-8)

a. General. The elevation section consists of synchro control transformer B822, servoamplifier AR927B, magnetic amplifier T852, servomotor B821, E_1 potentiometer R821, E_U potentiometer R822, and LOWER BEAM ELEVATION counter M821.

b. Control Transformer B822 and Resonant Damping Filter FL853. Synchro data from the antenna elevation synchro are applied to control transformer B822. Any change in antenna elevation produces an error voltage which is applied to servoamplifier AR927B through resonant damping filter FL853. If the antenna elevation is not changed, no error signals is developed. The E_L adjustment is a mechanical adjustment which positions the stator of the control transformer with respect to the rotor. This adjustment is made during installation at the radar site. A detailed discussion of control transformers is contained in paragraph 2-27c. Five identical resonant damping filters are located in the computer. The resonant damping filters improve the stability and performance of the servo circuits. The filters are resonant at 400 Hertz and are designed to be as symmetrical as possible about this frequency. If the frequency should change appreciably from 400 Hertz, the filters will induce errors into the computer.

c. Servoamplifier AR927B. Analog voltage data from the control transformer are applied to the servoamplifier. The date are amplified to control magnetic amplifier T852. The principles of operation of servoamplifiers are discussed in paragraph 2-27f.

d. Magnetic Amplifier T852. The amplified data are applied to the magnetic amplifier from the servoamplifier. The magnetic amplifier controls servomotor B821. The principles of operation of the magnetic amplifier are discussed in paragraph 2-27g.

e. Servo motor B821. The servomotor converts the analog voltages representing E_L into an angular shaft rotation which is applied to the control transformer, the LOWER BEAM ELEVATION counter, and the E_L and E_U potentiometers. The principles of operation of servomotors are discussed in paragraph 2-27d.

f. Control Transformer B822. Servomotor B821 produces mechanical analog E_L which positions the rotor of control transformer B822. When the rotor of the control transformer is positioned, no further error voltage is developed and the servomotor nulls.

g. E_L *Potentiometer R821 and* E_U *Potentiometer R822.*

(1) E_L *potentiometer R821.* Reference voltage from reference transformer T861 is applied across the potentiometer through $+E_L$ adjustment potentiometer R983 and $-E_L$ adjustment potentiometer R984. The adjustment potentiometers are used to establish maximum values of $+E_L$ and $-E_L$ across R821. Resistors R823 and R824 are series resistors used for voltage dropping. Resistor R821A and R821B is a padding resistor which prevents loading of the potentiometer at points near the tap. The slider is rotated by mechanical analog E_L from servomotor B821. The output voltage is analog voltage E_L, and 35 mils of output analog voltage are produced for each revolution of the slider. Output analog voltage E_L, representing lower beam elevation, is applied to the h_U potentiometer R832 in the range section. A detailed discussion of precision potentiometers is contained in paragraph 2-27e.

(2) E_U *potentiometer R822.* Reference voltage from reference transformer T861 is applied across the potentiometer through $+E_U$ adjustment potentiometer R985, $-E_U$ adjustment potentiometer R986, and voltage-dropping resistors R825 and R826. The adjustment potentiometers are used to establish maximum values of $+E_U$ and $-E_U$ across R822. Resistor R822A and R822B is a padding resistor which prevents loading of the potentiometer at points near the tap. The slider of the potentiometer is rotated by mechanical analog E_L from servomotor B821. The slider of potentiometer R822 is offset mechanically 35 mils; this plus mechanical analog E_L produces analog E_U. Output analog voltage E_U, representing upper beam elevation, is applied to h_U potentiometer R832 in the range section.

h. Lower Beam Elevation Counter M821. Mechanical analog E_L is delivered to LOWER BEAM ELEVATION counter M821 at the rate of 10 mils per revolution of the shaft. Counter M821 offers a visual indication of the elevation angle of the radar beam. The counter is capable of recording lower beam elevation from 200 mils above zero elevation to 100 mils below zero elevation.

i. Mechanical Description of Elevation Subassembly. The gear train of the elevation subassembly is driven by servomotor B821 which inserts mechanical analog E_L into the system.

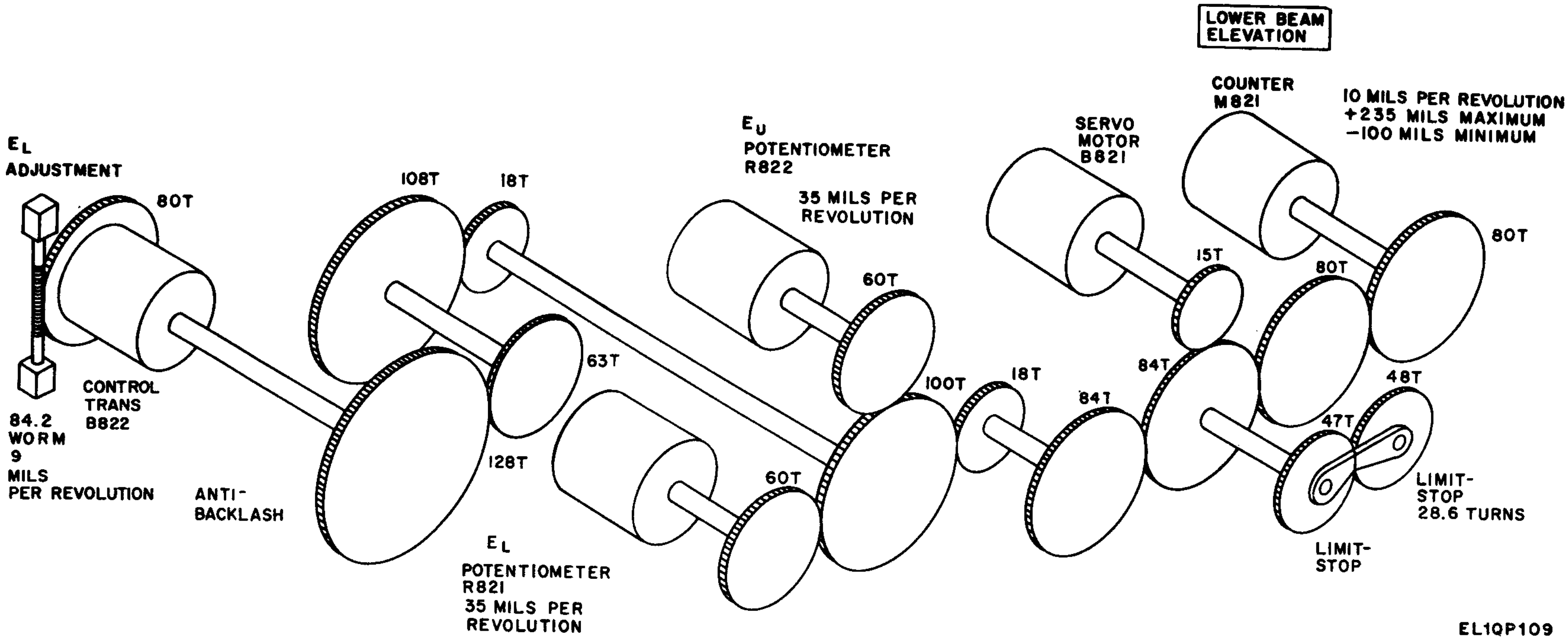


Figure 2-109. Elevation subassembly, simplified diagram.

(1) *Servomotor B821.* Servomotor B821 rotates and transmits motion to a 15-tooth spur gear. The 15-tooth gear is meshed with an 84-tooth gear. A 47-tooth gear is connected by a shaft to the 84-tooth gear driven by the motor gear.

(2) *Limit-stop assembly.* The limit stop assembly consists of two gears enmeshed with mechanical stops attached to the gears. The driving gear has 47 teeth and the driven gear has 48 teeth. The 48-tooth gear rotates through 28.6 turns before the limit-stop arms engage and stop all movement in the gear train.

(3) *Lower beam elevation counter. M821.* There are three gears between the 15-tooth driving gear at the motor and the shaft of the counter. An 80-tooth gear is meshed with the 84-tooth gear driven by the 15-tooth motor gear. One 80-tooth gear drives another 80-tooth gear which is attached to the lower beam elevation counter shaft and transmits mechanical analog E_L to the counter.

(4) E_L *potentiometer R821 and* E_U *potentiometer R822.* The 84-tooth gear driven by the 15-tooth gear, which is attached to the servomotor, drives a second 84-tooth gear to transmit motion to E_L and E_U potentiometers and to control transformer B822. An 18-tooth gear is connected by a shaft to the 84-tooth gear and transmits motion to a 100-tooth gear. The E_L and E_U potentiometer shafts are attached to 60-tooth gears which are meshed with the 100-tooth gear. The motion imparted to the potentiometer shafts represents mechanical analog E_L.

(5) *Control transformer B822.* There are three gears between the 100-tooth gear ((4) above) and the gear attached to the rotor shaft of the control transformer. An 18-tooth gear is attached to the 100-tooth gear by a shaft and drives a 108-tooth gear. The 108-tooth gear is attached to a 63-tooth gear by a shaft. Mechanical analog E_L is transmitted to the rotor shaft of the control transformer by a 128-tooth gear driven by the 63-tooth gear.

(6) E_L *adjustment.* The stator of control transformer B822 is positioned with respect to the rotor by the E_L adjustment. This adjustment is made during alignment to adjust the computer LOWER BEAM ELEVATION counter indication with the antenna elevation counter indication. Turning the E_L adjustment causes the body of the control transformer to rotate through a worm and spur gear. One revolution of the worm gear introduces an analog, equivalent to 9 mils, into the computer.

2-31. Electrical and Mechanical Description of AZIMUTH Section

(fig. FO-9)

a. *General.* The azimuth section consists of a mechanical subassembly, two servo servoamplifiers, and a dual speed cutover amplifier. The mechanical subassembly contains three control transformers, a servomotor, an azimuth orient motor, two computing potentiometers, a resolver, and an associated gear train.

b. *LOWER BEAM AZIMUTH Handwheel.* In operation, the LOWER BEAM AZIMUTH handwheel is rotated until the azimuth strobe line on the indicator screen bisects the lower echo. Rotation of the LOWER BEAM AZIMUTH handwheel sets mechanical analog A_L into the computer. Mechanical analog A_L is set into the A_U differential and into the $A_L+C\Delta$ differential at the rate of 70 mils per revolution of the LOWER BEAM AZIMUTH handwheel.

NOTE

For the purpose of discussion, the differentials in the computer will be referred to by the output analog; for example, the differential which produces mechanical analog A_U will be referred to as the A_U differential.

c. *AZIMUTH Handwheel.*

(1) General. The **ΔAZIMUTH** AZIMUTH handwheel is rotated until the azimuth strobe on the indicator screen bisects the upper echo. Rotation of the Δ AZIMUTH handwheel sets mechanical analog AA into the computer at the rate of 70 mils per revolution of the handwheel. Mechanical analogAA is set into the A_U differential and the slider of **ΔA** potentiometer R841 is moved to a position **representing ΔA.**

(2) *Detent switch S856 (fig. 2-110).* The Δ AZIMUTH handwheel can be rotated when detent switch S856 is placed in the DETENT RELEASE position. In this position, the 27-volt dc circuit energizes solenoids L831 and L841, in the range and azimuth subassemblies, disengaging **the ΔA and ΔR** handwheels from the detents. With detent switch S856 in the OFF position, the detent solenoids engage the gears so that the handwheels cannot be moved. When either solenoid is energized, switch S831 or S841 is closed and SET DETENT indicator lamp I 851 on the computer and SET DETENT indicator lamp I 109 on the indicator are lighted. When **both ΔA** and **ΔR** handwheels are in detent, switches S831 and S841 open, and lamps I 109 and I 851 go out. When detent switch S956 is placed in the AZIMUTH ORIENT position, solenoid L842 is engaged. The solenoid engages the gears of the LOWER BEAM AZIMUTH handwheel, switch S842 is closed, and AZIMUTH ORIENT indicator lamp I 863 is lighted. Voltage for indicator lamps I 109, I 851, and I 863 is furnished by T860.

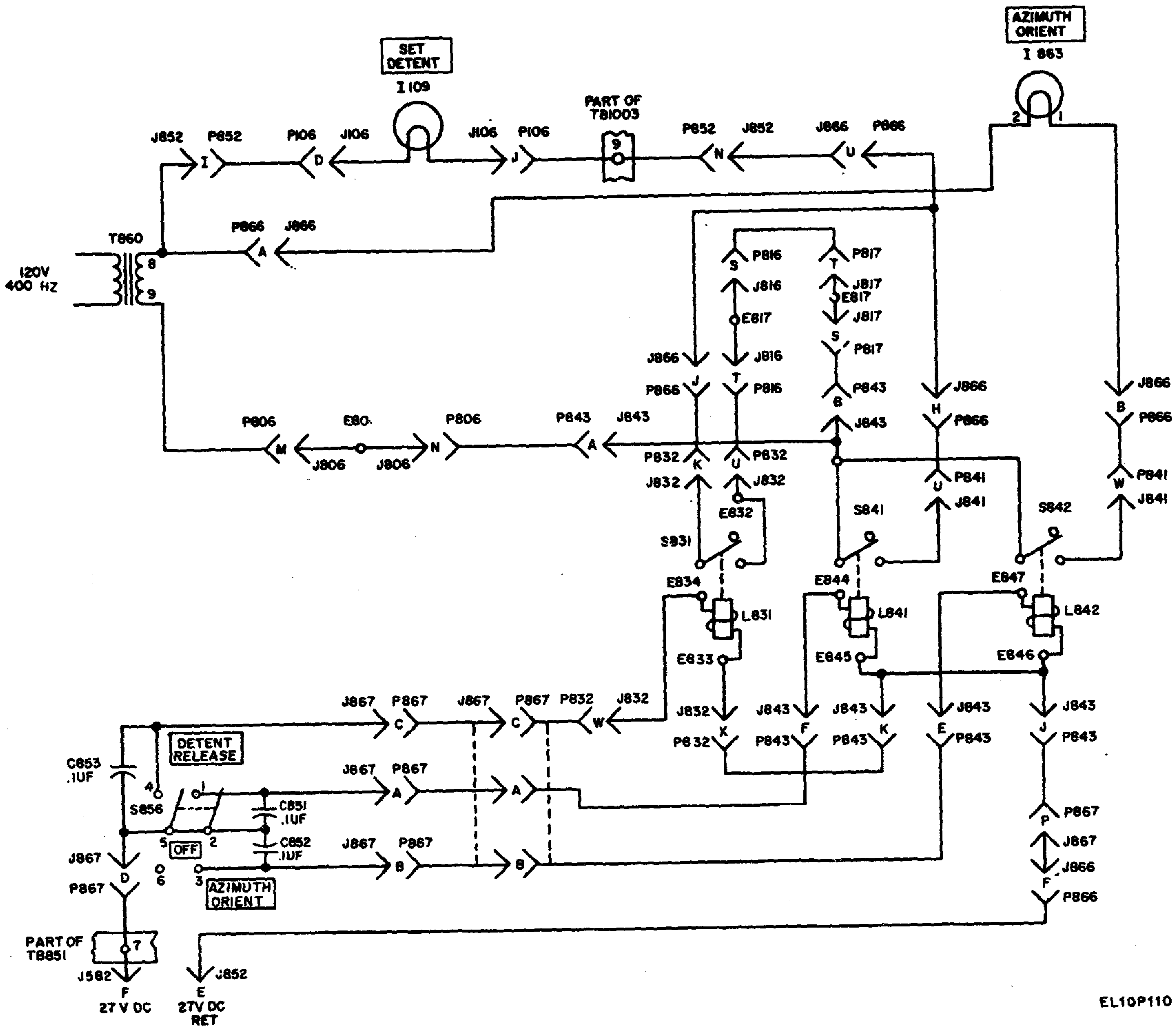


Figure 2-110. Set detent and azimuth orient indicator lamp circuits.

d. A_U Differential. Mechanical analog A_L from the LOWER BEAM AZIMUTH handwheel *(b* above) and mechanical **analog ΔA** from the **ΔA** AZIMUTH handwheel *(c* above) are added in the A_U differential to produce mechanical analog A_U. Mechanical analog A_U represents the horizontal angle from the antenna azimuth to the radar upper beam and is equal to $A_L \pm$ **ΔA.** Mechanical analog A_U. positions control transformer B846. Differentials are discussed in detail in paragraph 2-27b(3).

e. Azimuth Marker Synchro Circuit.

(1) *General* When either the LOWER BEAM AZIMUTH handwheel or the **ΔAZIMUTH** handwheel is rotated, mechanical analog A_U is delivered to the rotor of control transformer B846 at the rate of 700 mils per shaft revolution. The error voltage produced is amplified and used to control a servo motor located in the scanner. The servomotor in the scanner positions an azimuth marker coil which produces the pulse used to develop the azimuth strobe line on the indicator.

(2) *Control transformer B846.* Electrical data from a synchro transmitter, located in the scanner, are applied to the stator of control transformer B846. Mechanical analog A_U from the A_U differential positions the rotor of control transformer B846. The error voltage developed in the rotor winding of B846 is applied to resonant damping filter FL852.

(3) *Resonant damping filter FL852.* Resonant damping filter FL852 and resistor R889 attenuate the error signal from control transformer B846. The error signal is applied to servoamplifier AR926A.

(4) *Servoamplifier AR826A, magnetic amplifier T855, and Rectifier CR855.* Error voltage from FL852 is applied to the input of servoamplifier AR926A. The signal is amplified by the servoamplifier and applied to the magnetic amplifier. Magnetic amplifier T855 and rectifier CR855 are used to control the azimuth marker servomotor or in the antenna. Servoamplifiers are discussed in detail in paragraph 2-27f and magnetic amplifiers are discussed in detail in paragraph 2-27g.

***f.* ΔA** *Potentiometer R841.* A potentiometer R841 converts mechanical **analog ΔA** *(c* above) into analog voltage, **ΔA** which is applied to C potentiometer R811C in the C section. Reference voltage from reference transformer T861 is applied across R841 through **–ΔA** adjustment potentiometer R993 and **+** adjustment potentiometer R992. Potentiometers R992 and R993 are used to balance **the ΔA** potentiometer. Resistors R891 and R892 are voltage-dropping resistors. Resistors R841A and R841B are padding resistors which prevent loading of R841 at points near the tap. Mechanical analog **ΔA** is delivered at the rate of 14 mils per revolution of the slider shaft and the analog voltage A is applied to C potentiometer R811C in the C section. precision potentiometers are discussed in detail in paragraph 2-27e.

g. A_L+ ***CΔA*** *Differential.*

(1) *Analog* A_L. Mechanical analog A_L is set into the differential when the LOWER BEAM AZIMUTH handwheel is rotated *(b* above).

(2) *Analog* ***CΔA.*** Analog voltage **ΔA** is applied to C potentiometer R811C in the C section *(i* below) where it is multiplied by the C term.

(a) Servoamplifier AR929B. Analog voltage **CΔA** is applied to the input of servoamplifier AR929B through summing resistor R862. A small voltage from transformer T862 is applied across resistor R883. The voltage from the slider of R883 is applied to the input of servoamplifier AR929B through summing resistor R895. The voltage from R883 is used to balance the **CΔA** servo channel.

(b) Magnetic amplifier T854 and rectifier CR854. The output of the servoamplifier is applied to the magnetic amplifier. The magnetic amplifier controls servomotor B842. Magnetic amplifiers are discussed in detail in paragraph 2-27g.

(c) Servomotor B842. Voltage from the magnetic amplifier causes servomotor B842 to rotate until the shaft position is equivalent to C **Δ A.** The shaft of servo motor B842 is geared to the A_L +C **ΔA** differential and mechanical analog C **ΔA** is set into the differential. Servomotors are discussed in detail in paragraph 2-27d.

(3) Output. The output is mechanical analog **AL+C** and is applied to the **AL+C** differential.

h. ***CΔA*** *Potentiometer R842.* Reference voltage from reference transformer T861 is applied across **C** potentiometer R842 through **–** adjustment resistor R994 and **+** adjustment resistor R995. Resistors R994 and R995 are used to balance **C** potentiometer R842. The shaft of R842 is driven by B842 to a position corresponding to mechanical analog **C** The output voltage of R842 is analog voltage **C** which is applied to the input of servoamplifier AR929B through summing resistor R861. Analog voltage **C** applied to AR929B is applied at a maximum of plus or minus 175 mils. The **C** voltage from R842 causes the servosystem to null and the servomotor to stop when the shaft rotation is equal to **C** Precision potentiometers are discussed in detail in paragraph 2-27e.

i. ***AL+*** *Differential.*

(1) *Analog* ***AL+*** Mechanical *analog* **AL+** is set into the **AL+** differential by the A_L+C **ΔA** differential *(g* above).

(2) *Antenna azimuth data circuit.* The antenna azimuth data circuit sets analog AZ into the

A_L differential. Analog AZ represents the azimuth of the antenna. The antenna azimuth data circuit has two signal paths: one is used when the antenna is slowly rotated in azimuth, and the other is used when the antenna is rapidly rotated in azimuth.

(a) Control transformer B845 and resonant dumping filter FL851. When the antenna is rotated in azimuth, electrical synchro data from the antenna azimuth synchro are applied to control transformer B845. Control transformer B845 produces an error voltage which is applied to resonant damping filter FL851 through resistor R888. The output of FL851 is applied to the input of servo amplifier AR926B through summing resistor R860.

(b) Control transformer B844. When the antenna is rapidly rotated in azimuth, electrical synchro data from the antenna azimuth synchro are applied to control transformer B844. The error voltage produced by B844 is applied to dual speed cutover amplifier AR951B.

(c) Dual-speed cutover amplifier AR951B. Dual-speed cutover amplifier AR951B acts as a switch in the azimuth synchro system. When the antenna is rapidly rotated in azimuth, the servosystem cannot handle the changes in azimuth fast enough; therefore, the error voltage from control transformer B844 is coupled through dual speed amplifier AR951B to reinforce the voltage from B845.

1. Operation when input voltage is small. When the antenna is slowly rotated in azimuth, a small error voltage is applied to the input of AR951B. Control tube V953B is conducting heavily because of the low value of bias resistor R968. The plate current through plate relay K951 energizes the relay and the output of the dual speed cutover amplifier is opened. Resistor R967 is the grid resistor, and capacitor C957 is a filter capacitor.

2. Operation when input voltage is high. When the error voltage produced by B844 reaches 5 volts, the dc voltage developed at the grid of control tube V953B is great enough to stop V953B from conducting, and relay K951 deenergizes. Diode CR952 is a negative clamp and CR951 is a negative output rectifier. Capacitor C957 filters the input to control tube V953B. The 5-volt signal from B844 is amplified by the amplifier V953A and coupled to the output through coupling capacitor C956 and the contacts of relay K951. Resistor R965 is the plate load resistor, R963 is a current-limiting resistor, and R966 is the cathode resistor. The output of AR951B is applied to servoamplifier AR926B through summing resistor R859. When the large error voltage from B844 decreases, the charge on capacitor C957 leaks off through grid resistor R967 and control tube V953B conducts heavily, relay K951 energizes, and the output from control transformer B845 controls the servoamplifier.

(d) Servo amplifier AR926B, magnetic amplifier T851 and rectifier CR851. When the antenna is rotated slowly, the error signal from control transformer B845 is amplified and used to control servomotor B841. When the antenna is rapidly rotated in azimuth, the error signal from B845 and the out put of AR951B add and the combined voltage is used to control B841.

(e) Servomotor B841. Servomotor B841 sets mechanical analog AZ into the A_L differential and positions the rotors of control transformers B844 and B845. When the rotors of B844 and B845 reach a position where no error voltage is produced, the servosystem nulls, servomotor B841 stops, and the position of the shaft of B841 is an accurate representation of AZ.

(3) *Output analog.* Mechanical analog A_L + is transmitted to the A_w differential.

j. A_w *Differential.*

(1) *Analog* A_L+C Mechanical analog A_L+ is set into the A_w differential by the A_L+ differential *(i* above).

(2) *Analog* AZ_{OR} Mechanical analog AZ_{OR} (representing radar location) is set into the A_w differential by azimuth orient motor B843. When the radar set is installed in a new location, the location of the radar set must be set into the computer. When RADAR LOCATION AZ ORIENT switch S853 is placed in either the ADD or SUBT position, 27 volts dc is applied to azimuth orient adjustment motor B843 causing it to operate.

(a) RADAR LOCATION AZ ORIENT switch S853. When AZ ORIENT switch S853 is rotated so that contact 2 or 6 makes connection, 27 volts dc is applied to azimuth orient motor B843, causing it to rotate. Resistor R877 or R878 is placed in series with the motor when contact 3 or 5 makes contact and causes the motor to turn slowly. When contact 2 or 3 is closed, the motor will turn in one direction and when contact 5 or 6 is closed, the motor will turn in the opposite direction.

(b) Azimuth orient adjustment motor B843. Azimuth orient adjustment motor B843 is a 27-volt dc motor with a split-series field. When the motor runs in one direction, mechanical analog AZ is set into the A_w differential so that the mechanical analog adds. When the motor runs in the other direction, the mechanical analog subtracts Capacitors C842 and C843 are filter capacitors.

(3) *Output analog.* The A_w differential combines mechanical analog A_L+ with radar location mechanical analog AZ_{OR} to produce

mechanical analog A_w (representing the azimuth of the weapon). Mechanical analog A_w is used to position AZIMUTH counter M841 and the rotor of resolver B847.

k. Azimuth Counter M841. AZIMUTH counter M841 is a mechanical counter which indicates the azimuth of the weapon. The shaft of the counter is operated by the A_w differential.

l. Resolver B847.

(1) *General.* Resolvers are synchros wound with a symmetrical two-phase rotor and a two-phase stator. The resolver used in the computer has a built-in compensating (feedback) winding; therefore, accurate data are obtained over a wide range regardless of variations in voltage or temperature. The resolver is a precision component and is used to provide accurate trigonometric functions of a give input voltage, or a change from rectangular to polar coordinate data.

(2) *Input.* An input from booster amplifier AR951A is applied across stator winding terminals 2 and 6. This input represents analog voltage R_w (weapon range). Mechanical analog A_w from A_w differential ((j) (3) above) positions the rotor windings.

(3) *Weapon location problem* (fig. 2-111). The problem to be solved by the resolver is trigonometric in nature. Analog voltage R_w is fed into the rotor winding of the resolver from booster amplifier AR951A. R_w is represented by the hypotenuse in figure 2-111. Mechanical analog A_w rotates the stator windings through an angle representing the weapon azimuth (A_w). A_w is the angle of the triangle between the side which represents R_w and the side which represents weapon range easting $R_{W(E)}$.

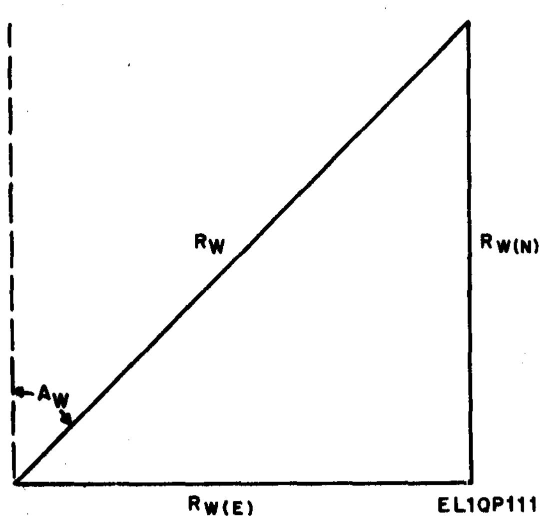


Figure 2-111. Trigonometric representation of resolver inputs and outputs.

(a) Trigonometric functions. If the hypotenuse and either side of a right triangle are known, the angle between the hypotenuse and either side may be found by using either the sine or cosine formula:

$$\cos A_W = \frac{R_{W(N)}}{R_W}$$

$$\sin A_W = \frac{R_{W(E)}}{R_W}$$

Similiarly, if the angle and the hypotenuse are known, either of the sides may be found by using:

$R_{W(n)} = R_w \cos A_w$ or $R_{W(E)} = R_w \sin A_w$.

(b) Solution. The two inputs to the resolver represent A_w and R_w. Mechanical analog A_w positions the stator windings of the resolver so that the output voltages from the rotor windings induced by analog voltage R_w in the stator windings are proportional to $R_w \cos A_w$ and $R_w \sin A_w$.

(4) *Circuit functioning.* An analog voltage appears across the stator winding, terminals 2 and 6, from booster amplifier AR951A (para 2-32m(3)). Stator winding, terminals 3 and 7, is not used and is shorted. Resistor R845 and capacitors C841 and C844, connected across the stator winding, act as a phase-lag circuit to keep the resolver from oscillating. Voltage is induced in the feedback winding, terminals 9 and 13, by the voltage across the stator winding. The voltage induced in the feedback winding is 180° out of phase with the stator voltage. This voltage is fed back into the input of booster amplifier AR951A through resistor R871. Resistor R871 is used to control the amount of feedback to the booster amplifier. The voltage induced in the rotor windings depends on the angular position between rotor and stator windings. Feedback winding, terminals 10 and 14, is not used and is shorted.

(5) *Outputs.* There are two outputs from the resolver. One output is proportional to weapon range north ($R_{W(N)}$) and is applied to the northing section across damping filter FL855 and resistor R900. The other output is proportional to weapon range east ($R_{W(E)}$) and is applied to the casting section across damping filter FL854 and resistor R899.

m. Mechanical Description of Azimuth Subassembly (FO-10). Motion of the gear train of the azimuth subassembly is caused by rotation of two handwheels, two servomotors, and a dc motor.

(1) *LOWER BEAM AZIMUTH handwheel.* Rotation of the LOWER BEAM AZIMUTH handwheel transmits mechanical analog A_L to a clutch and to a 56-tooth bevel gear. A 16-tooth bevel gear meshed with the 56-tooth bevel gear transmits the

motion along a shaft to a 96-tooth gear, which is meshed with a 30-tooth gear. The 30-tooth gear is attached to a cam, which is used to place the LOWER BEAM AZIMUTH handwheel in detent. When detent switch S856 (c(2) above) is placed in the AZIMUTH ORIENT position, detent solenoid L842 is activated. The acutating arm pivots, forcing the end toward the 30-tooth gear down. The LOWER BEAM AZIMUTH handwheel can be rotated until the roller on the end of the actuating arm drops into the slot in the cam. The arm drops away from detent switch S842 when the roller drops into the slot in the arm. The LOWER BEAM AZIMUTH handwheel will remain in detent until detent switch S856 is placed in the NORMAL position. The 30-tooth gear transmits the rotation along a shaft to a second 30-tooth gear, which is meshed with a 48-tooth gear. The 48-tooth gear sets mechanical analog A_L into the A_L+ differential and drives a second 48-tooth gear, which sets mechanical analog A_L into the A_U differential. The limit-stop halts the operation of the gears and allows only 700 mils of analog data to be inserted. The 47-tooth limit-stop gear on the clutch shaft meshes with the 48-tooth limit-stop gear.

(2) Δ *AZIMUTH handwheel.* Rotation of the Δ AZIMUTH handwheel transmits mechanical analog Δ through gears and shafts to transmit mechanical analog ΔA to A_U differential and to Δ potentiometer. Rotation is transmitted from the handwheel by shaft to the clutch, from the clutch to a 56-tooth bevel gear, a 90-tooth spur gear, and a 24-tooth spur gear attached to the clutch shaft.

(a) 24-tooth spur gear. The 24-tooth spur gear drives a 72-tooth spur gear. The 72-tooth gear has a cam and a pin attached to it. The pin allows the 72-tooth gear to rotate 235° before a limit-stop is reached. A roller on an arm travels on the cam until the detent position is reached. When the cam reaches the detent position, the roller drops in the cam and stops rotation of the gear.

(b) 90-tooth spur gear. The 90-tooth gear drives an 18-tooth gear which is attached to the shaft of ΔA potentiometer R841. A cam is attached to the 18-tooth gear. A second roller on the arm *((a)* above) travels along the cam until the detent position is reached. At the detent position, the roller drops into the notch in the cam and the gear stops rotating. When the detent arm is out of the detent position, microswitch S841 is closed.

(c) 16-tooth bevel gear. This gear engages the 56-tooth bevel gear and transmits motion to a shaft. A 96-tooth spur gear attached to the shaft engages a 48-tooth spur gear on the A_U differential and sets mechanical analog ΔA into the A_U differential.

(3) A_U *differential.* The A_U differential transmits mechanical analog A_U to control transformer B846 through seven gears. The differential combines mechanical analog A_L and ΔA to produce A_U. Mechanical analog A_U is transmitted by shaft to an 18-tooth spur gear which engages a 72-tooth gear. This gear transmits motion by shaft to a 15-tooth gear which drives a 75-tooth gear through a 60-tooth intermediate gear. The rotation is transmitted by shaft to a 27-tooth gear which drives a 48-tooth gear attached to the rotor shaft of control transformer B846. The electrical output of the control transformer changes 2 mils per revolution of the rotor shaft. A detailed discussion of differentials is contained in paragraph 2-27b(3).

(4) *Servomotor B842.* Servomotor B842 sets mechanical analog C into the A_L+ differential and positions C potentiometer R842.

(a) Limit-stop. A 15-tooth gear on the shaft of the servo motor drives a 90-tooth gear. The 90-tooth gear drives a 72-tooth gear and a 47-tooth gear attached to the 72-tooth gear by a shaft. The 47-tooth gear meshes with a 48-tooth gear. A mechanical limit-stop is attached to the two gears and limits the rotation of the 47-tooth gear to 35 turns.

(b) C potentiometer R842. The C potentiometer is linked to the servomotor through six gears and shafts. The 15-tooth gear on the shaft of the servomotor drives a 90-tooth gear which is attached by a shaft to a 24-tooth gear. The 24-tooth gear drives a 120-tooth gear which is attached by a shaft to an 18-tooth gear, The 18-tooth gear drives a 105-tooth gear attached to the C potentiometer shaft. The potentiometer inserts 350 mils of azimuth pershaft revolution.

(c) C input into differential. The 15-tooth gear on the motor shaft drives a 24-tooth gear. The 24-tooth gear is attached by a shaft to a second 24-tooth gear which drives a 75-tooth gear on the differential and sets mechanical analog C into the differential.

(5) A_L+ *differential.* The differential combines mechanical analog A_L The analog is taken from a 75-tooth gear which drives a 48-tooth gear through a 72-tooth intermediate gear to set analog A_L+ into the A_L+ differential. A detailed discussion of differentials is given in paragraph 2-27b(3).

(6) *Servomotor B841.* Servomotor B841 drives 9-speed control transformer B845, 1-speed control transformer B844, and seta mechanical analog AZ into the A_L+C differential.

(a) Nine-speed control transformer B845. A 15-tooth driving gear, attached to the servomotor B841, drives a 96-tooth gear. A shaft attached to the 96-tooth gear drives a 15-tooth gear. The 15-

tooth gear drives a 125-tooth gear attached by shaft to an 18-tooth gear which drives a 120-tooth gear. The 120-tooth gear is attached to 9-speed control transformer B845 and to an 18-tooth gear by a shaft. The 120-tooth gear delivers mechanical analog AZ to the 9-speed control transformer which delivers 711.1 mils of azimuth per revolution.

(b) One-speed control transformer B844. The 18-tooth gear drives a 54-tooth gear attached by a shaft to a second 18-tooth gear. This 18-tooth gear drives a second 54-tooth gear attached to the rotor shaft of 1-speed control transformer B844 and delivers analog AZ to the 1-speed control transformer. One-speed control transformer B844 delivers 6,400 mils of azimuth information per revolution.

(c) AZ input to A_L*+C differential.* The 15-tooth gear, attached to the shaft of servomotor B841, drives a 30-tooth gear. A shaft attached to the 30-tooth gear transmits motion to a second 30-tooth gear which drives a 96-tooth gear and delivers mechanical analog AZ into the AL+CAA+AZ differential.

(7) *~L-tCAA+AZ Differential.* The differential combines mechanical analog A_L+CAA ((5) above) with mechanical analog AZ ((6) above) to produce mechanical analog A_L+CdA+AZ which is delivered to a 128-tooth gear. The 128-tooth gear drives a 50-tooth gear and sets mechanical analog A_L+C AA+ AZ into the A_w differential. The operation of differentials is discussed in paragraph 2-27b(3).

(8) *Azimuth orient adjustment motor B843.* Azimuth orient adjustment motor B843 delivers analog AZ_{OR} to the A_w differential at a rate of ½ mil per revolution. A 15-tooth gear drives an 80-tooth gear through a 98-tooth intermediate gear and a 64-tooth intermediate gear. The 80-tooth gear is connected by shaft to a 16-tooth gear which drives an 80-tooth gear to set analog AZ_{OR} into the A_w differential.

(9) A_w *differential.* The A_w differential combines analog A_L+CAA+AZ AZ (i(1) above) with analog AZ_{OR} (i(2) above) to produce analog A_w at a 48-tooth gear. The 48-tooth gear drives a 24-tooth gear attached to AZIMUTH counter M841 through a 100-tooth gear. The counter indicates 10 mils of azimuth per revolution of the shaft. The 100-tooth gear is attached by a shaft to a 15-tooth gear which drives a 90-tooth gear. A second 15-tooth gear attached to the 90-tooth gear drives a 100-tooth gear. A 25-tooth gear attached by shaft to the 100-tooth gear drives a 96-tooth gear which is attached to the rotor of resolver B847 and delivers analog A_w to the resolver.

2-32. Electrical and Mechanical Description of Range Section

a. General. The range section consists of a mechanical assembly, a servoamplifier, a booster amplifier, and a magnetic amplifier.

b. LOWER BEAM RANGE Handwheel (fig. FO-11). In operation, the LOWER BEAM RANGE handwheel is rotated until the range strobe on the indicator bisects the lower beam intercept (echo). Rotating the LOWER BEAM RANGE handwheel sets mechanical analog R_L into the R_U and R_W differentials at the rate of 400 meters per revolution of the handwheel. Mechanical analog R_L is set into h_L potentiometer R831 at the rate of 1,650 meters per revolution of the potentiometer shaft.

c. h_L *Potentiometer R831* (fig. FO-11). Analog voltage E_L from the elevation section (para 2-30g(1)) is applied across h_L potentiometer R831. Since the analog input to R_L potentiometer R831 represents the elevation angle of the lower beam (fig. 2-112) and the rotation of the shaft of the potentiometer represents the slant range to the lower beam intercept, the output of the potentiometer will represent the height of the projectile at the lower beam intercept point or analog voltage h_L. Analog voltage $-h_L$ is applied to the C section. Resistor R831A and R831B is a padding resistor which prevents loading of the h_L potentiometer at points near the clockwise (cw) and counterclockwise (ccw) ends.

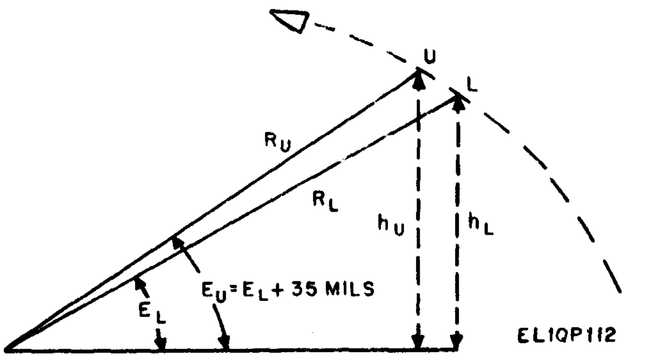


Figure 2-112. Computation of analog h_L and h_U.

d. ARANGE Handwheel. (fig. FO-11). In operation, the A RANGE handwheel is rotated until the range strobe on the indicator bisects the upper beam echo. Rotation of the ΔRANGE handwheel sets mechanical analog Δ R into the R_U differential at the rate of 600 meters per revolution of the handwheel, and mechanical analog Δ R into ΔR potentiometer R833 at the rate of 180 meters per revolution of the potentiometer shaft.

e. R Potentiometer R833 (fig. FO-11). ΔR potentiometer R833 converts mechanical analog Δ R to analog voltage ΔR which is applied to C potentiometer R811D in the C section at a maximum of plus or minus 600 meters. Voltage from reference transformer T861 is applied across R833 through + adjustment potentiometer R987 and – adjustment potentiometer R988. Potentiometers R987 and R988 are used to balance the ΔR potentiometer. Resistors R837 and R838 are voltage-dropping resistors, and R833A and R833B is a padding resistor that prevents loading of the ΔR potentiometer at points near the tap. Precision potentiometers are discussed in detail in paragraph 2-27e.

f. R_U *DIFFERENTIAL* (fig. FO-11). The R_U differential combines mechanical analog R_L *(b* above) with mechanical analog Δ *(e* above) to produce mechanical analog R_U which represents upper beam range. The output of the R_U differential positions the shafts of h_U potentiometer R832 and range potentiometer R836 at the rate of 1,650 meters per revolution of the potentiometer shafts.

g. h_U *Potentiometer R832* (fig. FO-11). Analog voltage E_U from the elevation section (para 2-30g(b)) is applied across h_U potentiometer R832. Since the analog input to h_U potentiometer R832 represents the angle of the upper beam (fig. 2-112) and the rotation of the shaft of the potentiometer represents the slant range to the upper beam intercept, the output of the potentiometer will represent the height of the upper beam intercept or analog voltage h_U. Analog voltage h_U is applied to the C section as analog voltage $+h_U$. Resistors R832A and R832B are padding resistors and prevent loading of the h_U potentiometer.

h. Range Strobe Potentiometer R836 (fig. FO-11). A potential of 220 volts dc is applied across range potentiometer R836. Dc analog voltage R_U is applied to the synchronizing system through connector J831 for the production of the range strobe on the indicator.

i. Analog **C** *to RW Differential* (fig. FO-11). Analog voltage **C** from C potentiometer R811D is the C section is the product of analog voltage Δ and C and is applied to servo amplifier AR928B through summing resistor R852. A small voltage from transformer T862 is applied through adjustment potentiometer R882 and summing resistor R894. The voltage from R882 is used for balancing the servo system.

(1) *Servoamplifier AR928B and Magnetic Amplifier T853.* Servoamplifier AR928B amplifies analog voltage **C** and applies the amplified voltage to magnetic amplifier T853. Magnetic amplifier T853 and selenium rectifier CR853 furnish control voltages for servomotor B831. Resistor R945 keeps the primary of T853 from overheating. Servoamplifiers are discussed in detail in paragraph 2-27f and magnetic amplifiers are discussed in paragraph 2-27g.

(2) *Servo motor B831.* The direction of rotation of servomotor B831 is controlled by magnetic amplifier T853 and selenium rectifier CR853. Rotation of servomotor B831 sets mechanical analog **C** into the R_w differential and the shaft of **C** potentiometer R834.

(3) ***C*** *potentiometer R834.* Voltage from reference transformer T861 is applied across **C** potentiometer R834 through + adjustment potentiometer R989 and – adjustment potentiometer R990. Adjustment potentiometers R989 and R990 balance the **C** potentiometer. Analog voltage **C** is applied to the input of servo amplifier AR928B through summing resistor R851. When the output of **C** potentiometer R834 is equal to the **C** input from the C section, the two voltages cancel and servomotor B831 stops.

j. R_w *Differential* (fig. FO-11). The R_w differential combines mechanical analog R_L *(b* above) with mechanical analog **C** *(i* above) to produce mechanical analog R_w. Mechanical analog R_w is equal to mechanical analog R_L plus mechanical analog **C** which satisfies the equation (27) (para 2-26e(4). Mechanical analog R_w is delivered to RANGE counter M831 and to R_w potentiometer R835.

k. RANGE COUNTER M831 (fig. FO-11) RANGE counter M831 is a mechanical counter which is operated by the R_w differential and indicates weapon range in meters.

l. R_w *Potentiometer R835* (fig. FO-11) Reference voltage from reference transformer T861 is applied across R_w potentiometer R835 through R_w adjustment potentiometer R991. Adjustment potentiometer R991 sets the maximum value of R_w across R_w potentiometer R835. Analog voltage R_w is applied to booster amplifier AR951A through summing resistor R872. Resistor R839 improves linearity. Precision potentiometers are discussed in detail in paragraph 2-27e.

m. Booster Amplifier AR951A (fig. FO-11). The booster amplifier is a three-stage amplifier with a voltage gain of unity. The power gain of the amplifier provides enough power to excite resolver B847. The most important characteristics of an amplifier used in this way are: constant gain, low noise, and very small, if any, phase shift.

(1) *First stage.* The input signal, representing analog voltage R_w, is fed to the grid (pin 2, V951A) of the first stage through summing resistor R872. Resistor R951 is the plate load resistor.

Resistor R952 is a cathode resistor and keeps the cathode (pin 3) at a potential of approximately 1.1 volts. The amplifier does not use cathode bypass capacitors. The input signal is amplified, inverted, and applied to the grid (pin 7) of the second stage through coupling capacitor C951 and through a phase leading network consisting of capacitor C952 and resistor R953.

(2) *Second stage.* The signal voltage is developed across resistor R954 and applied to the grid (pin 7) of V951B. Resistor R955 is the plate load resistor. Resistor R956 is the cathode resistor which develops a bias potential of approximately 2.6 volts. The amplified signal is fed to the third stage of the amplifier through dc blocking capacitor C954. Capacitor C953 and resistor R957 form a phase-lag circuit; and capacitor C955 and resistor R958 form a phase-lead circuit. These two circuits eliminate any phase shift that occurs in the stage or through the coupling capacitor.

(3) *Third stage.* The third stage of amplifier V952 uses a twin-triode tube with the sections connected in parallel. The cathodes (pins 3 and 8) are tied together and biased at approximately 2.3 volts by resistor R962. Resistors R960 and R961 are parasitic suppressors in series with the resolver winding. The signal voltage developed across grid resistor R959 is applied to the grids (pins 2 and 7). The signal is amplified by the state and fed to the stator winding of resolver B847.

(4) *Feedback.* A portion of the output signal voltage is fed back from the feedback winding of the resolver to the input of booster amplifier AR951A through resistor R871. The feedback from the resolver improves the overall stability of the amplifier and produces a constant output with variations in resolver resistance due to heat.

n. Mechanical Description of Range Subassembly. Three mechanical inputs are fed into the range subassembly: two from handwheels and one from servomotor B831.

(1) **Δ** *RANGE handwheel* The **Δ** RANGE handwheel sets 600 meters of **Δ** data into the computer per revolution. Mechanical analog **ΔR** is transmitted through a clutch to bevel gears which transmit the analog to **Δ** potentiometer R833 and to the R_U differential.

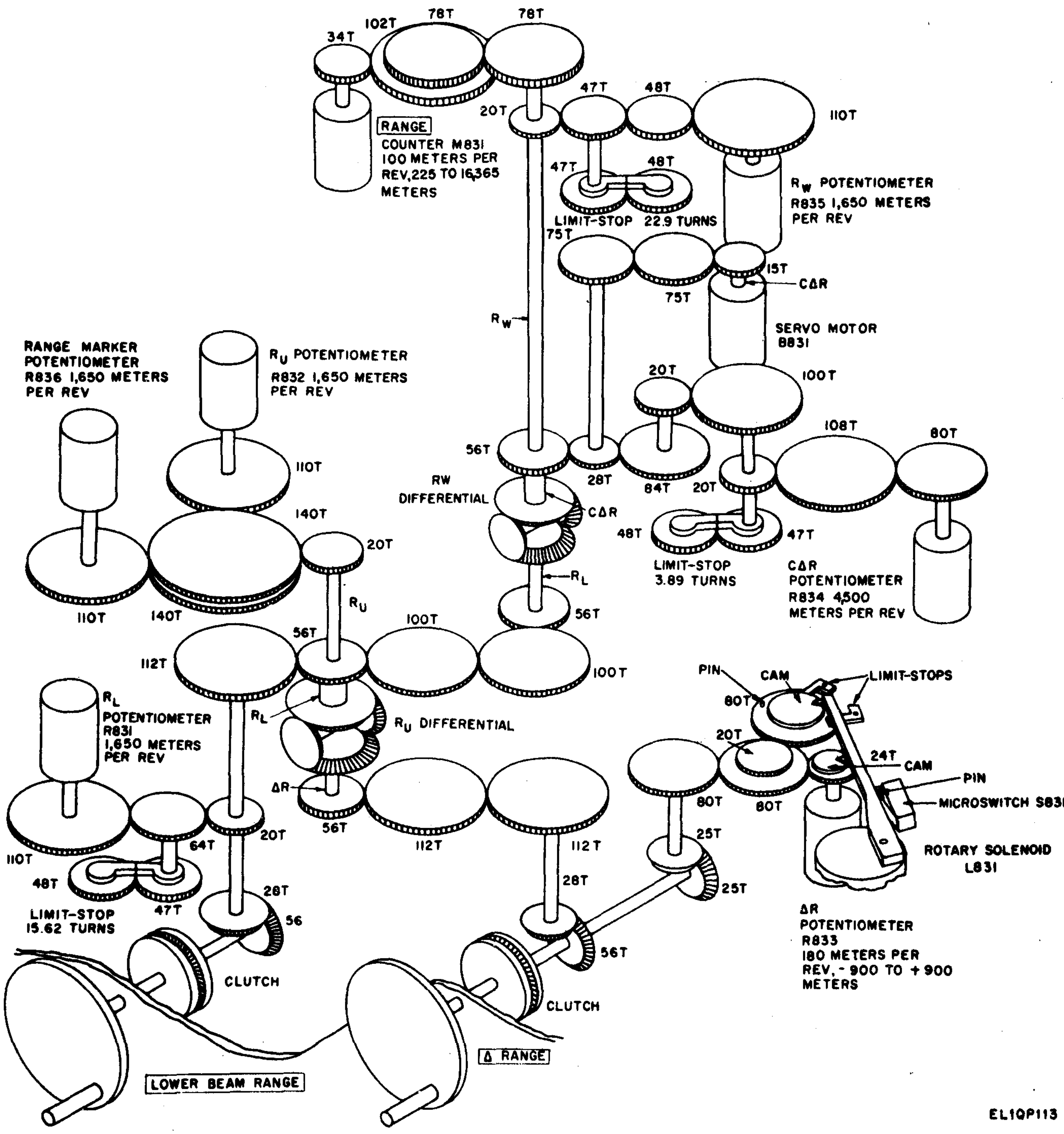


Figure 2-113. Range subassembly, simplified gearing diagram.

(a) Δ potentiometer R833. A 28 tooth bevel gear, attached by shaft to an 80-tooth spur gear, transmits angular motion from a 25 tooth bevel gear ((1) above) to a 24-tooth spur gear attached to the shaft of the Δ potentiometer through an 80-tooth intermediate gear. The Δ potentiometer will rotate if detent release solenoid L831 is activated an delivers 120 meters of Δ data to the system per revolution of the handwheel.

(b) Limit-stop and detent release solenoid. The 80-tooth intermediate gear is attached by shaft to a 20-tooth gear which drives an 80-tooth gear. A cam and a pin are attached to the 80-tooth gear. The pin allows the 80-tooth gear to revolve through 256° before the limit-stops strike the pin

and halt all movement. A cam is attached to the 24-tooth gear driving the Δ potentiometer. The 80-tooth gear and the 24-tooth gear cannot rotate unless solenoid L831 is activated if they are in detent. When the solenoid is activated, the arm lifts and closes switch S831. When the solenoid is not activated, the gears will revolve until the rollers on the arm drop into the notches in the cams and rotation stops.

(c) Δ *input to* R_U *differential.* A 28-tooth bevel gear meshed with a 56-tooth bevel gear ((1) above) and connected by shaft to a 112-tooth gear, drives a second 56-tooth input gear to the R_U differential through a 112-tooth intermediate gear.

(2) *LOWER BEAM RANGE handwheel.* The LOWER BEAM RANGE handwheel delivers mechanical analog R_L to h_L potentiometer R831, R_U differential, and R_W differential.

(a) h_L *potentiometer R831.* The handwheel is connected by shaft to a clutch and to a 56-tooth bevel gear that drives a 28-tooth bevel gear which is connected to a 20-tooth gear and a 112-tooth gear by a shaft. The 20-tooth gear drives a 110-tooth gear attached to R_L potentiometer R831 through a 64-tooth intermediate gear. The R_L potentiometer delivers 1,650 meters of R_L data per revolution of the shaft. The 64-tooth intermediate gear is connected by shaft to a 47-tooth gear which drives a 48-tooth gear. The 48-tooth gear is allowed to revolve through 15.62 revolutions before the mechanical limit-stop halts rotation.

(b) R_L *input to* R_U *and* R_W *differentials.* The 112-tooth gear attached to the shaft from the 48-tooth bevel gear drives a 56-tooth gear which sets mechanical analog R_L into the R_U differential. The 56-tooth gear of the R_U differential drives a second 56-tooth gear to set analog R_L into the R_W differential through two 100-tooth intermediate gears.

(3) R_U *differential.* The R_U differential combines mechanical analog R ((1) *(c)* above) with mechanical analog R_L ((2) *(b)* above) to produce mechanical analog R_U which is delivered to a 20-tooth spur gear. The 20-tooth spur gear drives a 140-tooth double gear. One section of the 140-tooth double gear drives a 110-tooth gear attached to h_U potentiometer R832. The other section of the 140-tooth double gear drives a second 110-tooth gear attached to range strobe potentiometer R836. Both potentiometers deliver 1,650 meters of range data per shaft revolution.

(4) *Servomotor B831.* The servomotor transmits mechanical analog **C** to the R_W differential and to **C**Δ R potentiometer R834.

(a) **C**Δ *input to* R_W *differential.* A 15-tooth gear attached to the shaft of the servomotor drives a 75-tooth gear through a 75-tooth intermediate gear. The 75-tooth gear is attached by shaft to a 28-tooth gear, which drives a 56-tooth gear to insert analog **C** into the differential, and drives an 84-tooth gear.

(b) **C** *potentiometer R834.* The shaft from the 84-tooth gear (*(a)* above) is attached to a 20-tooth gear which drives a 100-tooth gear. The 100-tooth gear is connected by shaft to a second 20-tooth gear which drives an 80-tooth gear attached to the shaft of the **C** potentiometer through a 108-tooth intermediate gear. The 100-tooth gear also drives a 47-tooth gear which drives a 48-tooth gear to set the limit-stops. The **C** potentiometer inserts 4,500 meters of **C** data into the computer per shaft revolution.

(c) Limit-stop. The 47-tooth driving gear and the 48-tooth driven gear form a mechanical limit-stop which limits the revolution of the 48-tooth gear to 3.89 turns.

(5) R_W *Differential.* The R_W differential combines mechanical analog R_L ((4) (b) above) with mechanical analog **C** ((4) (b) above) to produce mechanical analog R_W, which is transmitted to RANGE counter M381 and R_W potentiometer R835.

(a) RANGE counter M831. The 34-tooth gear on the counter shaft is driven by way of a dual (78-tooth/102-tooth) intermediate gear, by a 78-tooth gear attached by a shaft to the differential. The RANGE counter indicates range in meters from 225 to 16,365 meters at a rate of 100 meters per revolution on the counter shaft.

(b) R_W *potentiometer R835.* The 110-tooth gear on the potentiometer shaft is driven by a 20-tooth gear attached by shaft to the differential through a 47-tooth, and a 48-tooth intermediate gear.

(c) Limit-stop. The 47-tooth intermediate gear in the gear train which drives the potentiometer is attached to a 47-tooth gear which drives a 48-tooth gear. The combination forms a mechanical limit-stop which stops rotation after the 48-tooth gear has revolved through 22.9 turns.

2-33. Electrical and Mechanical Description of Time Section

a. General. The time section consists of a handwheel, a counter, a potentiometer, and associated gears.

b. Δ *T Handwheel* (fig. 2-114). Rotating the Δ handwheel sets mechanical analog Δ into the computer. The handwheel positions Δ potentiometer R801 and Δ TIME counter M801.

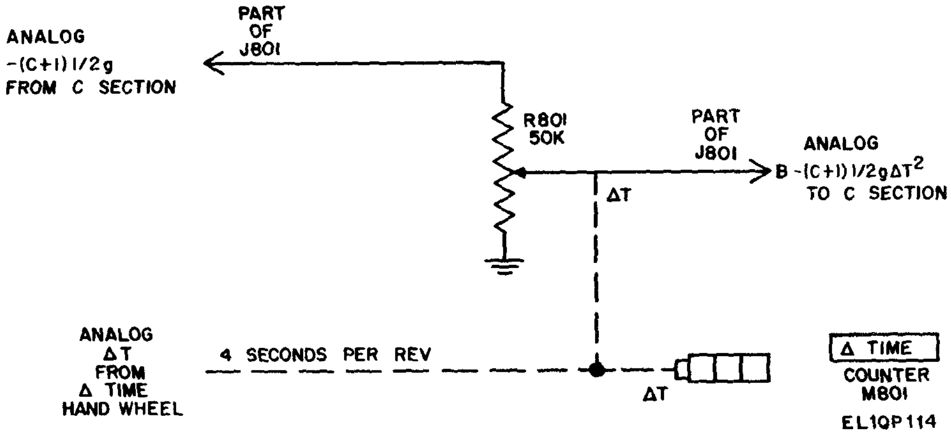


Figure 2-114. Time potentiometer, simplified schematic diagram.

c. Δ T Potentiometer R801 (fig. 2-114). The Δ T potentiometer is a square function potentiometer used to insert the function ΔT^2 into the computer. The potentiometer is wound so that the output voltage is proportional to the square of the shaft rotation. The voltage applied to the potentiometer represents the function -(C+1) ½g which is taken from C potentiometer R811B (para 2-34h). The shaft of the potentiometer is rotated to a position corresponding to Δ T by the Δ T handwheel. The output analog voltage represents the function -(C+1)½g ΔT^2 which is fed to isolation amplifier AR901B in the C section. The negative sign is chosen for the analog voltage output so that the polarity of the function will be correct after inversion by the isolation amplifier.

d. Mechanical Description of Time Subassembly (fig. 2-115). Rotation of the Δ T handwheel transmits motion to Δ TIME counter M801, to Δ T potentiometer R801, and to a mechanical limit-stop.

(1) *TIME counter M801.* The Δ T handwheel transmits motion through a clutch to a 20-tooth bevel gear which drives a 30-tooth bevel gear. The 30-tooth bevel gear transmits motion by shaft to a 122-tooth gear which drives a 126-tooth gear and a 20-tooth gear. The 126-tooth gear drives another 126-tooth gear; a pin on the second 126-tooth gear strikes the limit-stop. The 20-tooth gear is attached to the shaft of the Δ TIME counter. One revolution of the counter shaft indicates 1 second of Δ T data on the Δ TIME counter.

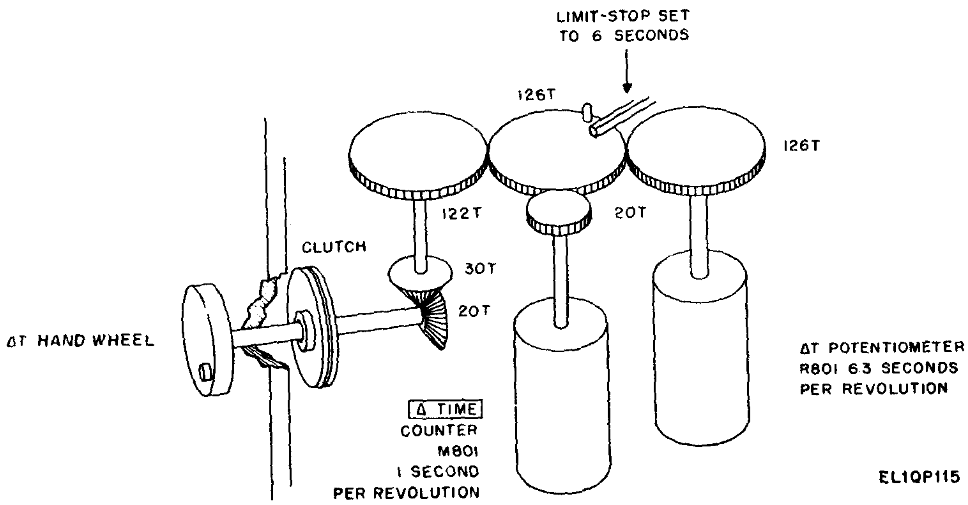


Figure 2-115. Time subassembly, simplified gearing diagram.

(2) *Δ T potentiometer R801.* The 126-tooth gear attached to the potentiometer shaft rotates the shaft of the potentiometer which inserts 6.3 seconds of Δ T data into the computer per shaft revolution.

(3) *Limit-stop.* The limit stop limits the data inserted by the A time handwheel to 6 seconds.

2-34. Electrical and Mechanical Description of C Section (fig. FO-12)

a. General. The C section consists of two identical isolation amplifiers (AR901A and AR901B) mounted on one chassis, servoamplifier AR927A, a mechanical subassembly which contains servomotor B811, four-gang potentiometer R811, and the associated gearing,

b. Isolation Amplifier AR901A. Two identical isolation amplifiers are in the C section. The desired characteristics of the isolation amplifiers are the same as those desired in a servoamplifier. Each isolation amplifier is a three-stage, high gain voltage amplifier.

(1) *First stage V901A.* An analog voltage ($-h_L$) from h_L potentiometer R831 (para 2-32c), is applied to the grid (pin 2) of V901A through summing resistor R868. An analog voltage ($+h_U$) from h_U potentiometer R832 (para 2-32g), is also applied to the grid (pin 2) of V901A through summing resistor R867. The two signals are added, amplified, and inverted in the first stage and applied to the grid of the second stage through a phase-lead network consisting of capacitor C902 and resistor R903. Resistor R901 is the plate load and bias is developed across cathode resistor R902.

(2) *Second stage V901B.* The signal from the first stage is developed across grid resistor R904 and applied to the grid (pin 7) of the second stage. Resistor R906 is the plate load. The amplified signal is fed to the grid of the third stage through dc blocking capacitor C905. Capacitor C904 and resistor R908 form a phase-lag network. The phase-lag and phase-lead networks keep the servomotor from oscillating.

(3) *Third stage V902A.* The signal applied to the grid (pin 2) is developed across grid resistor R910. The output signal appearing at the plate (pin 1) is developed across plate load resistor R911. The cathode is biased to approximately 2 volts by cathode resistor R912. A feedback network is formed by capacitor C903 and resistor R909. The feedback network improves amplifier stability. The signal is amplified and applied to isolation amplifier AR901B through dc blocking capacitor C906 and summing resistor R864. The output signal is an analog voltage representing the function $h_L - h_U$. The output is fed back into the first stage through resistor R869 to stabilise the amplifier and establish a gain of 3.75.

c. Isolation Amplifier AR901B. The operation of isolation amplifier AR901B is identical with that of isolation amplifier AR901A. Therefore, the detailed operation of the amplifier will not be discussed.

(1) *Input voltages.* An analog voltage representing the function $h_L - h_U$ is applied to the grid (pin 2) of V903 through summing resistor R864. An analog voltage representing the function $-(C + 1)\ ½\ g\ \Delta T^2$, is applied to the grid through summing resistor R863. This voltage is obtained from Δ T potentiometer R801 (para 2-33c). Feedback voltage is applied to the grid through resistor R865.

(2) *Output voltage.* Isolation amplifier AR901B (gain 2.5) amplifies and inverts the input voltages. The output analog voltage applied to potentiometer R811A represents the function $[(C + 1)\ ½g\ \Delta T^2\ T^2 + (h_U - h_L)]$.

d. Potentiometer R811A. Potentiometer R811 is a four-gang precision potentiometer. Potentiometer R811A multiplies the analog voltage from isolation amplifier AR901B by mechanical analog C from servomotor B811 (para 2-33g). Analog voltage $[(C + 1)\ ½g\ \Delta T^2\ T^2 + (h_u - hL)]$ is applied across the potentiometer: the shaft of the potentiometer is positioned by servomotor B811 to correspond to mechanical analog C. The output is an analog voltage which represents the function $C[(C + 1)\ ½g\ \Delta T^2\ T^2 + (h_U - h_L)]$, and is applied to servo-amplifier AR927A. Resistor R81lE is a padding resistor used to eliminate potentiometer end loading. A detailed discussion of precision potentiometers is given in paragraph 2-27e.

e. Servo amplifier AR927A and Magnetic Amplifier T856. Three input voltages are combined in servo-amplifier AR927A and are used to drive servomotor B811 through magnetic amplifier T856. One input voltage, from potentiometer R811A, represents analog voltage $C[(C + 1)\ ½g\ \Delta T^z + (h_U - h_L)]$ and is applied to the input of the servoamplifier through summing resistor R855. The second analog voltage input, from h_L potentiometer R831, represents the function $-h_L$ and is applied through TEST NORMAL switch S855 and summing resistor R854. The third input is an analog voltage, - H, from H potentiometer R806, and is applied through TEST NORMAL switch S855 and summing resistor R853. The servoamplifier combines the three analog voltages to give the correct value of C for the computer which is $C[(C + 1)\ ½g\ \Delta T^2\ T^2 + (h_U - h_L)] - (h_L + H) = 0$ (equation (15) para 2-26e(2)) and drives servomotor B811 through magnetic amplifier T856 and rectifier CR 856. Resistor R956 is a current-limiting resistor and prevents the primary of T856 from overheating. A detailed discussion of servoamplifiers and magnetic amplifiers is contained in paragraph 2-27g.

f. Adjustment Potentiometer R885. Adjustment potentiometer R885 applies a small analog voltage from transformer T862 through summing resistor R893 to the input of servoamplifier AR927A to balance the servosystem.

g. Servomotor B811. The combined analog voltages from the servo and magnetic amplifiers drive servomotor B811 which rotates the shaft of the motor to a value representing the function C. The function C will change for every value of range, azimuth, and elevation. When the correct value of C is reached for each value of range, azimuth, and elevation, the servo motor nulls and stops. The shaft rotation representing C is transmitted to four-gang potentiometer R811A, R811B, R811C, and R811D. A detailed discussion of servomotors is contained in paragraph *2-27d*.

h. Potentiometer R811B. The voltage impressed across potentiometers R811B, and R812 is multiplied by the function C to produce an analog voltage output. Input voltage from the reference transformer is applied through - (C + 1) adjusting potentiometer R978, which is used to balance R811B. The voltage drop across, resistor R812 represents the quantity ½ *g* (one-half the force of gravity). Resistor R811F is a padding resistor used to prevent end loading of the potentiometer. The output from the potentiometer is an analog voltage representing the function - (C + 1) ½ *g*, which is applied to the time section (para 2-33 *c).* Precision potentiometers are discussed in detail in paragraph 2-27 *e.*

i. Potentiometer R811C. Analog voltage Δ A from potentiometer R841 is applied to potentiometer R811C. Analog voltage AA is multiplied by the mechanical analog representing C, to produce electrical analgo C Δ A which is applied to servoamplifier AR929B in the azimuth section (para 2-31 *h).* The principles of multiplication by potentiometers are discussed in paragraph 2-27 *e.* Resistor R811G is a padding resistor used to prevent end loading of the potentiometer.

j. Potentiometer R811D. Analog voltage Δ R from potentiometer R821 in the range section is applied to potentiometer R811D where it is multiplied by mechanical analog C to produce analog voltage C Δ R. Analog voltage C Δ R is applied to servoamplifier AR928B in the range section (para 2-23 *i).* Resistor R811H is connected between one end and a tap on the potentiometer to prevent end loading of the potentiometer.

k. TEST NORMAL Switch S855 and Potentiometer R898. TEST NORMAL switch S855 and adjustment potentiometer R898 are used during alignment when it, is necessary to insert the quantity C=1, accurately into the computer.

(1) *TEST NORMAL switch S855.* Switch S855 is a two-position, three-section wafer switch. In the NORMAL position (fig. FO-12) of the switch, contacts 1 and 3 make connection and the analog voltage output of isolation amplifier AR901B is fed to potentiometer R811A. In the TEST position, a 400-cycle, 7.9-volt reference voltage is applied across potentiometer R811A through contacts 2 and 3 of the switch. In the NORMAL position, an analog voltage (- h_L) is fed to the input of servoamplifier AR927A through contacts 4 and 6. When the switch is in the TEST position, resistor R854 is connected to ground through contacts 5 and 6. The analog voltage (H) is fed into servo amplifier AR927A through contacts 7 and 9 when switch S855 is in the NORMAL position. In the TEST position, a voltage from potentiometer R898 is applied to the amplifier through contacts 8 and 9.

(2) *Adjustment potentiometer R898.* When switch S855 is in the TEST position, potentiometer R898 furnishes a voltage for alignment of the computer. A 7.9-volt, 400-cycle voltage from the reference transformer is impressed across potentiometer R898 and resistors R997 and R996. The potentiometer is adjusted until the output voltage applied to the input of servoamplifier AR927A, through contacts 8 and 9 of switch S855, is equal to the quantity, C=1 (as indicated by calibrated C gears, fig. 3-102).

l. DOUBTFUL SOLUTION Lamp 1 852. When servomotor B811 receives analog voltage inputs, which cause the value of C to reach a quantity greater than 4, microswitch S811 is closed mechanically. Closing the switch applies voltage to DOUBTFUL SOLUTION lamp I 852, indicating that the solution to the problem is in doubt.

m. Mechanical Description of C Subassembly. The gear train of the C subassembly is rotated by servomotor B811 to produce mechanical analog C and to transmit the mechanical analog to the C potentiometer.

(1) *Servomotor B811.* Servomotor B811 rotates a 15-tooth spur gear which drives a 105-tooth spur gear. The 105-tooth gear is connected by shaft to a 17-tooth spur gear and a 47-tooth spur gear. The 47-tooth spur gear drives a 48-tooth gear, and these two gears form a limit-stop assembly.

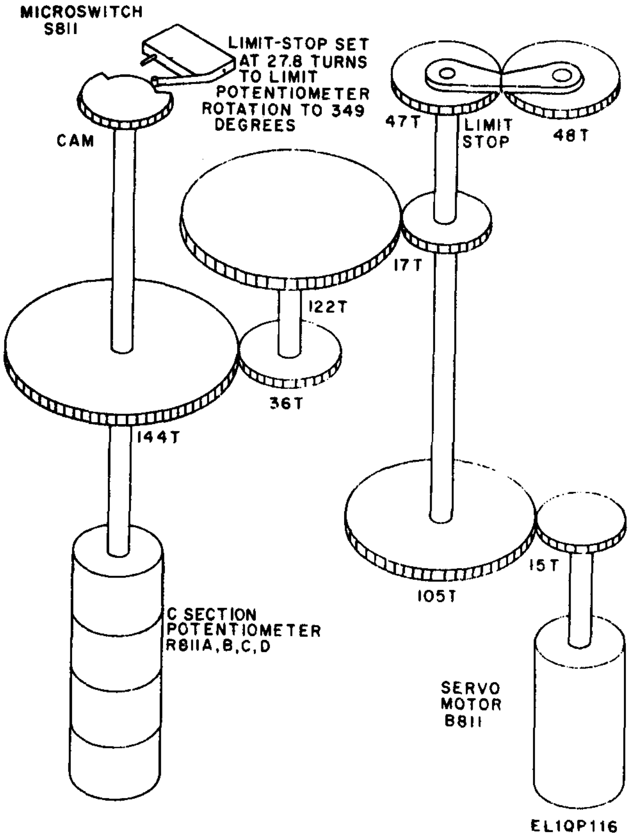


Figure 2-116. C subassembly, simplified gearing diagram.

(2) *Limit stop.* The limit stop is a mechanical assembly which is set to stop rotation of the gear train when the 47-tooth gear has turned 27.8 revolutions. The limit stop limits the rotation of the shaft of potentiometer R811 to 349°. The 17-tooth gear transmits angular motion through a 122-tooth gear and a 36-tooth gear to a 144-tooth gear which is connected to the shaft of the potentiometer.

(3) *Cam and switch.* A cam connected to the 144-tooth gear closes microswitch S811 when the value of C reaches a value greater than 4.

(4) *Calibrated gears.* The 105-tooth gear which drives the limit stop and the 144-tooth gear which drives the potentiometer are calibrated and the value of C may be read directly from them.

2-35. Electrical and Mechanical Description of Coordinate Sections

a. General. The two coordinate sections in the computer are identical in operation. One computer coordinate section is used for weapon location casting and the other for weapon location northing. Each coordinate section consists of a resonant damping filter, a servoamplifier, a magnetic amplifier, and a mechanical subassembly. The mechanical subassembly contains a servomotor, a computing potentiometer, two mechanical counters, and an associated gear train.

b. Servoamplifiers AR928A and AR929A (fig. FO-13). Resonant damping filters FL854 and FL855 are used between the resolver and the coordinate data servoamplifier to prevent oscillation in the servo systems. The input to servoamplifier AR928A is an analog voltage representing the difference in easting. The input to servoamplifier AR929A is an analog voltage representing the difference in northing. The servoamplifiers amplify the input voltages and apply them to magnetic amplifiers T857 and T858. A detailed discussion of servoamplifiers is contained in paragraph 2-27 *f.*

c. Magnetic Amplifiers T857 and T858 (fig. FO-13). The outputs from the two servoamplifiers are fed to the magnetic amplifiers which control the servomotors. A detailed discussion of magnetic amplifiers is contained in paragraph 2-27 *g.*

d. Servomotor B816 (fig. FO-13). The outputs of the magnetic amplifiers control casting or northing servo motor B816 to produce a shaft rotation which represents mechanical analog $R_{W(E)}$ in the casting subassembly or **R** in the northing subassembly. Mechanical analogs $R_{W(N)}$ or $R_{W(E)}$, position potentiometer R816 and the N_W or E_W differential. Servo meters are discussed in detail in paragraph 2-27 *d.*

c. Potentiometer R816 (fig. FO-13). Reference voltage is applied to the 15-turn potentiometer through adjustment potentiometers R979 and R980, or R981 and R982. The position of the potentiometer shaft determines the amount of $R_{W(E)}$ or $R_{W(N)}$ analog voltage fed back into the resolver rotor, and causes servomotor B816 to null. Precision potentiometers are discussed in detail in paragraph 2-27 *e.*

f. Slewing Motor B817. (fig. FO-13). The B817 slewing motors are used during installation to set the location of the radar into the computer. The easting slewing motor is controlled by RADAR LOCATION EASTING switch S851, located on the computer front panel. The northing slewing motor is controlled by RADAR LOCATION NORTHING switch S852 located on the computer front panel. Radar location switches are five-position rotary switches, spring-loaded to the center or off position. Contacts 5 and 6 of switches S851 or S852 cause the motor to run in one direction and contacts 2 and 3 cause the motor to run in the opposite direction. A 50-ohm resistor is connected in series with contacts 3 and 5 of the switches causing the motor to run slower. The slewing motor sets data into the N_W or E_W differential and RADAR LOCATION EASTING or NORTHING counter M817.

g. Brake Solenoid L816 (fig. FO-13). When either RADAR LOCATION NORTHING switch S852 or RADAR LOCATION EASTING switch S851 is rotated, the coil of brake solenoid L816 is activated, which releases the brake shoe and allows the gears to turn freely when driven by motor B817. The mechanical action of brake solenoid L816 is discussed in paragraph 2-35 *k* (1).

h. RADAR LOCATION EASTING and NORTHING Counter M817 (fig. FO-13). Slewing motor B817 rotates the shaft of the counter that indicates the rectangular coordinates of the counter that indicates the rectangular coordinates of the radar set.

i. N_W and E_W Differential (fig. FO-13). A mechanical analog representing radar northing or casting N_R or E_R (*f* above) is combined with the mechanical analog representing weapon range northing $R_{W(N)}$ or casting $R_{W(E)}$ (*d* above), to produce mechanical analog N_W or E_W which appears as rectangular coordinate information on WEAPON LOCATION EASTING AND NORTHING counters.

j. Weapon Location Easting and Northing Counter M816. The mechanical analog representing E_W or N_W rotates the shaft of the counter which indicates the location of the weapon from the radar set in rectangular coordinates.

k. Mechanical Description of Coordinate Subassemblies (fig. 2-117). The two coordinate subassemblies are identical in mechanical operation; therefore, only one gear train will be discussed.

(1) *Slewing motor B817.* Radar location is set into the computer during installation by operating switches S851 and S852, which cause slewing motor B817 to run. A 15-tooth gear attached to the motor shaft drives a 115-tooth bear. The slewing motor inserts 4.9 meters of data into the computer per shaft rotation. The 115-tooth gear is attached by shaft to a 15-tooth gear which drives the 40-tooth gear attached to counter M817 through an 80-tooth intermediate gear and a 60-tooth intermediate gear. RADAR LOCATION NORTHING or EASTING counter M817 indicates the radar location at a rate of 100 meters per revolution of the counter shaft. The 80-tooth intermediate gear drives a gear on the differential through a 40-tooth intermediate gear. BRAKE solenoid L816 is activated and releases the brake on the 80-tooth gear when it is driven by slewing motor B817.

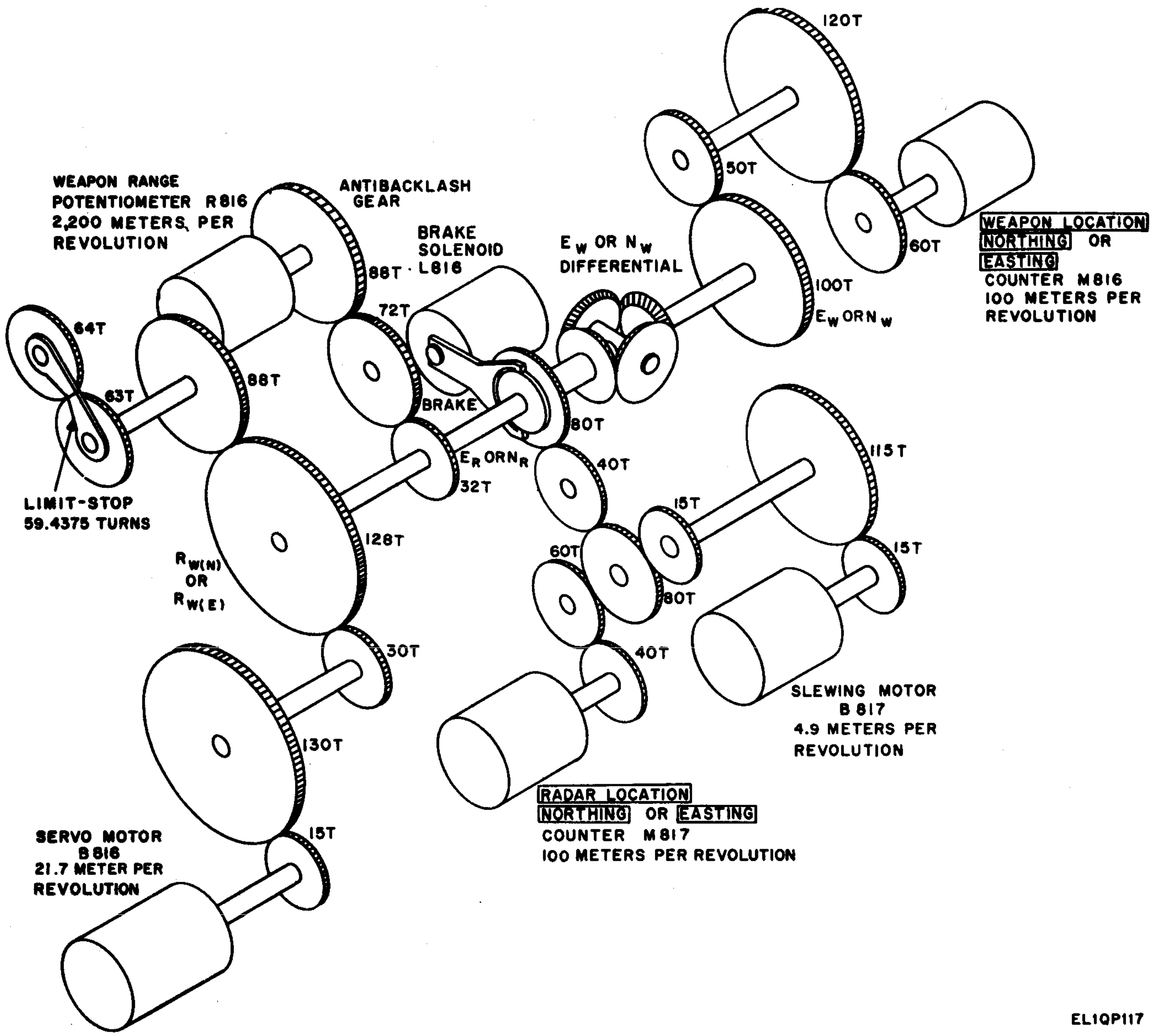


Figure 2-117. Coordinate subassemblies, simplified gearing diagram.

(2) *Servomotor B816.* Servomotor B816 inserts data at the rate of 21.7 meters per revolution of the motor shaft.

(a) $R_{W(E)}$ or $R_{W(N)}$ input to differential. A 15-tooth gear attached to the shaft of servomotor B816 drives a 130-tooth gear which is attached by shaft to a 30-tooth gear. The 30-tooth gear drives a 128-tooth gear which inserts $R_{W(E)}$ or $R_{W(N)}$ data into the differential. A 32-tooth gear is attached to the differential shaft and drives R_W potentiometer R816.

(b) Limit-stop. The 128-tooth gear which inserts weapon range data into the differential driveB an 88-tooth gear. A 63-tooth gear attached by shaft to the 88-tooth gear drives a 64-tooth gear. The 64-tooth gear and the 63-tooth gear form a mechanical limit-stop, which stops all gear movements when the 63-tooth gear has revolved through 59.4375 turns.

(c) *R_W potentiometer R816.* The 32-tooth gear located on the differential shaft drives an 88-tooth gear attached to the shaft of the potentiometer through a 72-tooth intermediate gear. The potentiometer feeds 2,200 meters of data back to the resolver for each shaft revolution.

(3) *E_W or N_W differential* The differential combines mechanical analog E_R or N_R ((1) above) with mechanical analog $R_{W(N)}$ or $R_{W(E)}$

((2) *(c)* above) to produce mechanical analog Ew or Nw

(4) *WEAPON LOCATION NORTHING or EASTING counter M816.* A 100-tooth gear from the differential drives a 50-tooth gear which is attached by shaft to a 120-tooth gear. The 120-tooth gear drives a 60-tooth gear attached to the counter. WEAPON LOCATION NORTHING or EASTING counter M816 indicates weapon location from the radar set in rectangular coordinates at the rate of 100 meters per shaft revolution.

2-36. Electrical and Mechanical Description of Height Section

a. General. The height section consists of a mechanical subassembly containing a potentiometer, a differential, two counters, a hand wheel, a screwdriver adjustment for setting in RADAR HEIGHT, and an associated gear train.

b. WEAPON HEIGHT Handwheel (fig. 2-118). Rotation of the weapon height handwheel sets mechanical analog Hw into the Hw differential and into H potentiometer R806.

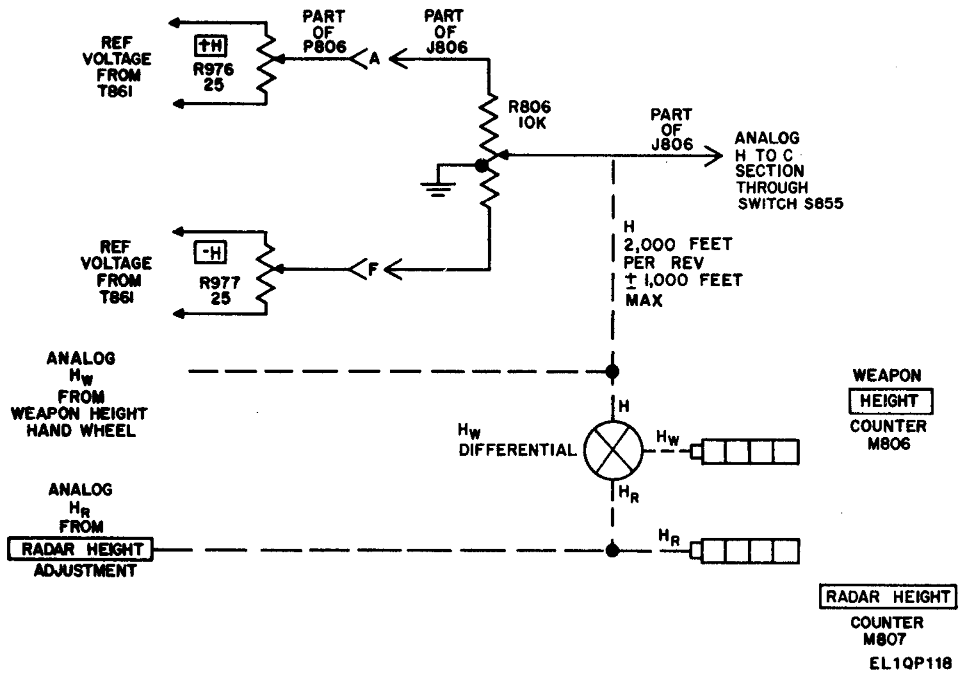


Figure 2-118. Height section, schematic diagram.

c. RADAR HEIGHT Adjustment (fig. 2-118). The RADAR HEIGHT adjustment is a screwdriver adjustment located on the computer front panel which sets mechanical analog HR into the Hw differential and rotates the shaft of RADAR HEIGHT counter M807.

d. H Potentiometer R806 (fig. 2-118). H potentiometer R806 produces an analog voltage output which is proportional to mechanical analog H. Voltage from the reference transformer is applied across potentiometer R806 through adjustment potentiometers R976 and R977. The output from potentiometer R806 is fed into the C section through a section of TEST NORMAL switch S855.

e. Hw Differential (fig. 2-118). The Hw differential combines mechanical analog Hw *(b* above) with mechanical analog HR *(c* above) to produce mechanical analog Hw, which is used to position weapon HEIGHT counter M806.

f. Mechanical Description of Height Subassembly (fig. 2-119). Data are set into the height subassembly by a handwheel and a screwdriver adjustment. The screwdriver adjustment sets the mechanical analog of radar height (H_R) into the computer. When the radar height (H_R) is set into the computor, it also sets the analog of weapon height into the weapon HEIGHT (Hw) counter through the Hw differential. The wiper of potentiometer R806 is at zero position when the RADAR HEIGHT (Hr) and WEAPON HEIGHT (Hw) counters indicate the same height.

(1) *RADAR HEIGHT adjustment.* When the RADAR HEIGHT adjustment is rotated, mechanical analog HR is transmitted to RADAR HEIGHT counter M807 and Hw differential at a rate of 91.5 meters per revolution of the adjustment.

(a) RADAR HEIGHT counter M807.

Motion is transmitted from the RADAR HEIGHT adjustment through a clutch to a 25-tooth bevel gear. Another 25-tooth bevel gear drives a 100-tooth gear by a shaft. The 100-tooth gear meshes with a second 100-tooth gear which transmits motion by shaft to a third 100-tooth gear. The third 100-tooth gear drives a 32-tooth gear which transmits motion to the differential and to a 40-tooth gear attached to RADAR HEIGHT counter M807. RADAR HEIGHT counter M807 indicates 36.5 meters of radar height per revolution of the counter shaft.

(b) H_R input to H_W differential. The 32-tooth gear meshed with the 100-tooth gear (*(a)* above) transmits motion by shaft to a second 32-tooth gear, which drives the 100-tooth gear of the differential through a 100-tooth intermediate gear.

(2) *Weapon height handwheel.* The weapon height handwheel sets mechanical analog H_W into the H_W differential and H potentiometer R806 at a rate of 91.5 meters per revolution of the handwheel.

(a) H potentiometer R806. Rotation of the handwheel is transmitted by clutch and shaft to a 25-tooth bevel gear. A second 25-tooth bevel gear transmits the motion by shaft to a 108-tooth gear and a 16-tooth gear. The 16-tooth gear drives a 128-tooth gear attached to H potentiometer R806 through a 64-tooth intermediate gear and a 47-tooth intermediate gear. The H potentiometer inserts 729.26 meters of H data into the computer per revolution of the potentiometer shaft.

(b) Limit-stop. The 47-tooth intermediate gear (*(a)* above) drives a second 47-tooth gear which is attached by shaft to a third 47-tooth gear. The third 47-tooth gear drives a 48-tooth gear; these two gears form a mechanical limit-stop which limits the gears to 2.62 revolutions or 715.4 meters of H data.

(c) H_W *analog input to H_W differential.* The 108-tooth gear driven by shaft by the 25-tooth bevel gear (*(a)* above) drives a second 108-tooth gear attached to the differential and sets mechanical analog H_W into the differential.

(3) *H_W Differential.* The H_W differential combines mechanical analog H_R ((2) *(b)* above) with mechanical analog H_W ((2) *(c)* above) to produce mechanical analog H_W, which drives weapon HEIGHT counter M806. A 160-tooth differential gear drives the 32-tooth gear attached to weapon HEIGHT counter M806 through an 82-tooth intermediate gear. The weapon HEIGHT counter indicates weapon height at a rate of 36.5 meters per revolution of the counter shaft.

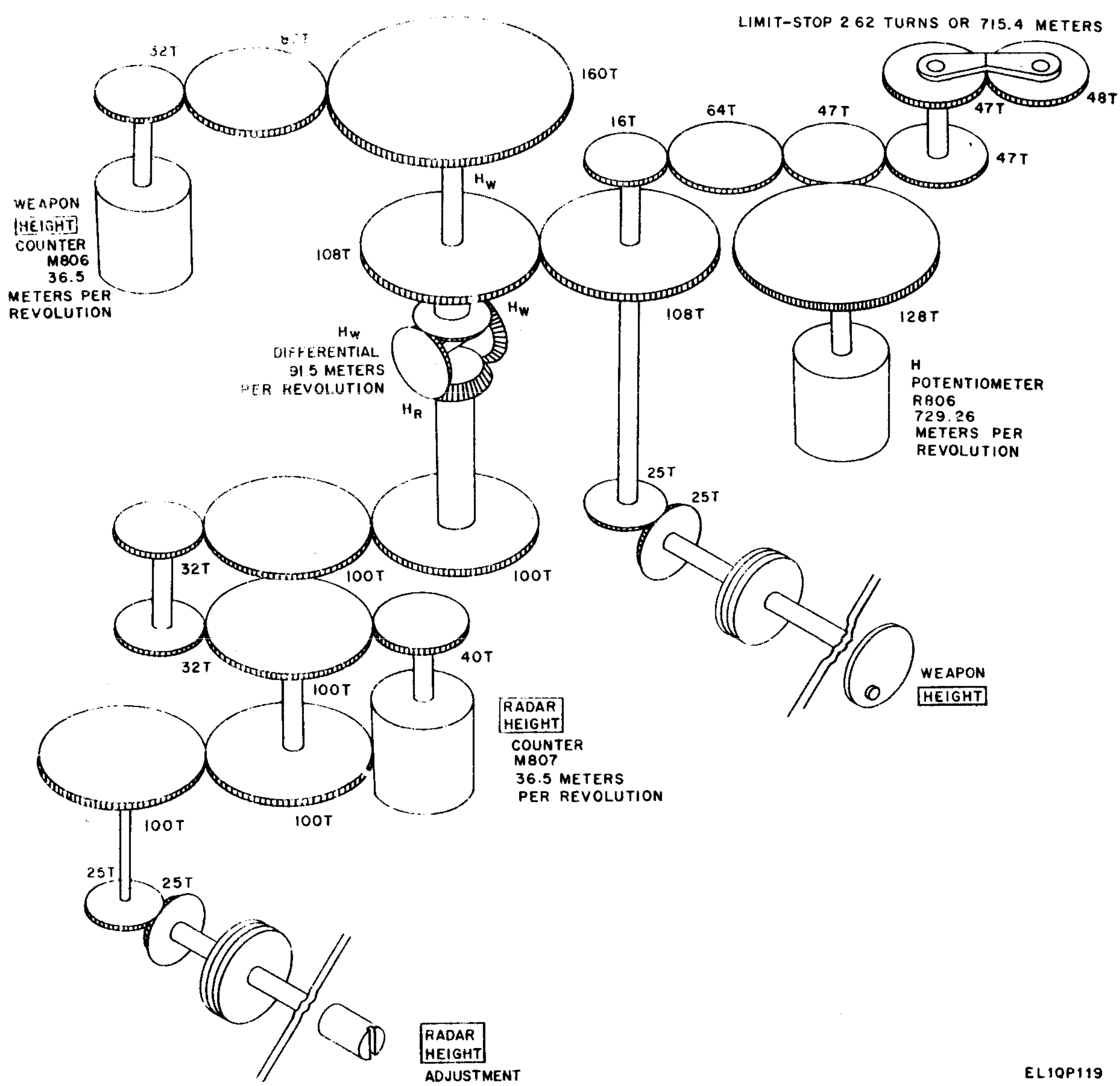


Figure 2-119. Height subassembly, simplified gearing diagram.

2-37. Summary of Computer System Operation, Using Computer Data Flow Chart

a. General. (fig. FO-14). The data flow chart presents the flow of data through the computer. Inputs and outputs are shown in addition to electrical-to-mechanical tielines of functions.

(1) *Mechanical tielines.* Mechanical tielines are used to show mechanical function connections. Direction of rotation or gear ratios of the gear trains are not indicated.

(2) *Electrical omissions.* Electrical components in which no change of data or function occurs have been omitted. Each servoamplifier drives a magnetic amplifier which, in turn, drives a servomotor; the magnetic amplifiers have been omitted since no change of function occurs in them.

b. Data Flow Through Computing System

(1) Elevation section. Elevation synchro data are applied to control transformer B822 from the elevation synchro transmitter located in the antenna positioning system (para 2-35 *d*). Mechanical adjustment EL positions the body of B822 during installation of the radar set. When the antenna is

moved in elevation, a voltage will be transmitted through resonant damping filter FL853 to servo-amplifier AR927B. Servoamplifier AR927B is a three-stage voltage amplifier which amplifies the input voltage and drives servomotor B821 through magnetic amplifier T852. Servomotor B821 drives LOWER BEAM ELEVATION counter M821, which visually indicates the elevation of the antenna in mils. Servomotor B821 positions the shafts of potentiometers R821 and R822 and the rotor of control transformer B822. When the rotor of B822 reaches the null position, no voltage is transmitted and servomoter B821 stops. The output from E_L potentiometer R821 is an analog voltage equal to E_L and is applied to h_L potentiometer R831. The housing of E_U potentiometer R822 is offset by 35 mils so analog voltage E_U **is** applied to h_U potentiometer R832.

(2) *Range section.* In operation, the LOWER BEAM RANGE handwheel is rotated until the range strobe on the indicator screen bisects the lower beam echo; Δ RANGE handwheel is then rotated until the range stobe bisects the upper beam echo.

(a) Rotating the LOWER BEAM RANGE handwheel rotates the shaft of h_L potentiometer R831 and causes movement of the R_U and R_W differentials. When the Δ RANGE handwheel is rotated, Δ R is set into the R_U differential. The R_U differential either adds or subtracts the two inputs and produces an output shaft rotation which is either the sum or difference of the two inputs; thus, $R_U = R_L \pm \Delta R$. R. The output of the R_U differential is used to rotate the shafts of h_U potentiometer R832 and range potentiometer R836. The output from potentiometer R836 (a dc voltage) is applied to the synchronizing system (para 2-6 c) for the production of the range strobe. The outputs of h_L and h_U potentiometer R831 and R832 are applied to the C section.

(b) The output voltage from h_L potentiometer R831 is analog - h_L since the analog voltage input to R831 is equal to the angle of elevation and shaft rotation R_L is an analog of the distance to the projectile. Therefore, R_L times E_L = - h_L (height of the lower beam intercept of the projectile). The output analog voltage of h_U potentiometer R832 is analog + h_U which is applied to the C section. Analog + h_U represents the height of the projectile when it intercepts the upper radar beam.

(c) Analog voltage C Δ R, which is analog voltage AR from **ΔR** R potentiometer R833 multiplied by mechanical analog C from the C section, is applied to servo amplifier AR928B and magnetic amplifier T853. The output of servoamplifier AR928B and magnetic amplifier T853 is converted to mechanical analog C Δ R by servomotor B831. The shaft of B831 rotates the shaft of C Δ R potentiometer R834 to null the servosystem and sets mechanical analog C Δ R into the R_W differential.

(d) The R_W differential adds mechanical analog R_L from the LOWER BEAM RANGE handwheel and mechanical analog C Δ R from servomotor B831 to produce mechanical analog R_W. The output of the R_W differential drives weapon RANGE counter M831 and R_W potentiometer R835. RANGE counter M831 indicates the range to the weapon in meters. The output of R_W potentiometer R835 (analog voltage R_W) is applied to booster amplifier AR951A. The output from the booster amplifier is applied to resolver B847 in the azimuth section.

(3) *Azimuth section.* During operation, the LOWER BEAM AZIMUTH handwheel is rotated until the azimuth strobe on the indicator screen bisects the lower beam echo, then the Δ AZIMUTH handwheel is rotated until the azimuth strobe line bisects the upper beam target. Rotation of the **ΔAZIMUTH** AZIMUTH handwheel rotates the A_U differential, setting mechanical analog Δ A into the differential. The Δ AZIMUTH handwheel also rotates the shaft of **ΔA** A potentiometer R841. The output of R841, which is analog voltage **ΔA**, A, is applied to R811C of the C section. Rotation of the LOWER BEAM AZIMUTH handwheel sets mechanical analog A_L into the A_U differential and into the A_L + C Δ A differential. The output of the A_U differential turns the rotor of control transformer B846. Azimuth marker data from synchro transmitter B3203 in the scanner (para 2-6 *f)* are applied to the stator windings of control transformer B846. When the rotor of control transformer B846 is rotated by the A_U differential, an error voltage is produced and applied to servoamplifier AR926A through resonant damping filter FL852. Servoamplifier AR926A and magnetic amplifier T855 transmit control voltages to servomotor B3202 (para 2-6 *f*).

(a) Analog voltage C **Δ A,** A, which is analog voltage Δ A from R841 multiplied by the C term at R811C, is applied to servoamplifier AR929B and magnetic amplifier T854. The outputs of AR929B and T854 control the rotation of servomotor B842. Servomotor B842 rotates the shaft of C Δ A nulling potentiometer R842 and sets mechanical analog C Δ A into the A_L + C Δ A differential. The output of R842 is fed back into servoamplifier AR929B to null or stop servomotor B842. The A_L + C Δ A differential adds mechanical analog A_L and mechanical analog C Δ A to produce mechanical analog A_L + C Δ A

which is set into the $A_L + C \Delta A + AZ$ differential.

(b) Antenna azimuth data are supplied to the computer by azimuth synchro transmitters B3001 and B3002. Coarse data from B3001 are applied to 1-speed control transformer B844 and fine data are applied to 9-speed control transformer B845. Charges in the azimuth position of the antenna cause output voltages to be developed at both B844 and B845. If the output from 1-speed control transformer B844 exceeds 5 volts, a relay in dual speed cutover amplifier AR951B is activated and the output from B844 is amplified by AR951B and coupled to servo amplifier AR926B where it is combined with the output from 9-speed control transformer B845. When the output from the 1-speed control transformer is less than 5 volts, the relay in AR951B is not activated and only the fine azimuth data from the 9-speed control transformer are applied to AR926B. Servoamplifier AR926B amplifies the combined azimuth data error voltages from B844 and B845. The output from AR926B is used to drive servomotor B841 through magnetic amplifier T851. When the antenna azimuth position is changed, servomotor B841 turns the rotors of B844 and B845 (nulling the servosystem) and sets mechanical analog AZ into the $A_L + C \Delta A + AZ$ differential.

(c) The $A_L + C \Delta A + AZ$ differential adds the $A_L + C \Delta A$ input from the $A_L + C \Delta A$ differential with the AZ input from servomotor B841 to produce mechanical output $A_L + C \Delta A + AZ$ which is applied to the A_w differential. During installation of the radar set, the azimuth of the radar set is set into the A_w differential by azimuth orient adjustment motor B843. The output of the A_w differential is applied to weapon AZIMUTH counter M841 and to the rotor of resolver B847. AZIMUTH counter M841 indicates the azimuth of the weapon in mils. Resolver B847 is a synchro with an input analog voltage R_w from the range section ((2) above) and the rotor is positioned by mechanical analog A_w from the A_w differential.

(d) There are two outputs from the resolver. One output represents weapon range casting or $R_w = R_w \sin A_w$, which is applied to the casting coordinate section. The other output represents weapon range northing or $R_w = R_w \cos A_w$, which is applied to the northing coordinate section.

(4) *Time section.* The Δ time handwheel is used to set the elapsed time between upper and lower beam intercepts of the projectile into the computer. The amount of time set into the computer appears on ΔTIME counter M801. Rotating the Δ time handwheel positions the shaft of Δ T potentiometer R801. Analog voltage $-(C + 1)$ ½ g from the C section is applied to Δ T potentiometer R801 and, since Δ T potentiometer R801 is a square function potentiometer, the output which is applied to the C section is analog voltage $-(C+1)½g \ \Delta T^2$. The ½g in the equation is one-half the force of gravity.

(5) *Height section.* During installation of the radar set, the height of the radar set (in meters above sea level) is set into the computer by the RADAR HEIGHT adjustment. This height is indicated on RADAR HEIGHT counter M807 and set into the H_w differential as mechanical analog H_R Weapon height information is set into the H_w differential and H potentiometer R806 by the weapon height handwheel. Analog voltage - H from R806 is applied to the C section. The H_w differential combines mechanical analog H_R with mechanical analog H to produce mechanical analog H_w which is transmitted to weapon HEIGHT counter M806. HEIGHT counter M806 indicates weapon height in meters.

(6) *C section.* The C section produces the C term which is derived from range, azimuth, elevation, height, and time data. An input representing the height of the projectile as it passes through the lower radar beam, analog $-h_L$, is applied to isolation amplifier AR901A from the range section (b above). Another input from the range section, analog $+h_U$, representing the height of the projectile as it passes through the upper radar beam, is also applied to isolation amplifier AR901A. Analog voltages $+h_U$ and $-h_L$ are added, inverted, and amplified by isolation amplifier AR901A to produce analog voltage $h_L - h_U$, which is applied to isolation amplifier AR901B. Analog voltage $h_L - h_U$ from isolation amplifier AR901A and analog voltage $-(C + 1)$ ½ g ΔT^2 are added, inverted, and amplified by isolation amplifier AR901B and applied to C potentiometer R811A. The shaft of C potentiometer R811 is positioned at an arbitrary value by mechanical analog C. The output, analog voltage $C\,[(C+1)½g \ \Delta T^2 + (h_U - h_L)]$, is applied to servoamplifier AR927A. Analog voltage $C\,[(C+1)½g \ \Delta T^2 + (h_U - h_L)]$ is combined with analog voltages - H from the height section ((5) above) and $-h_L$ from the range section and amplified by servoamplifier AR927A. Servoamplifier AR927A and magnetic amplifier T856 control the rotation of servomotor B811 which will position the shaft of four-gang C potentiometer R811 to the correct value of C for the given range, azimuth, and elevation data. C potentiometer R811D receives analog voltages Δ R, multiplies it by the C term, and applies analog voltage C Δ R

to the range section. C potentiometer R811C receives analog voltage Δ A, multiplies it by the C term, and applies analog voltage C Δ A to the azimuth section. C potentiometer R811B applies analog voltage - (C+1)½g to the time section.

(7) *Easting coordinate section.* Analog voltage $R_{w(E)} = R_w$ sin. A_w from the azimuth section ((3) above) is applied to servoamplifier AR928A through resonant damping filter FL854. Analog voltage $R_{w(E)}$ is amplified by servoamplifier AR928A and magnetic amplifier T851 and controls servomotor B816. Servomotor B816 rotates the shaft of $R_{w(E)}$ potentiometer R816 and sets mechanical analog $R_{w(E)}$ into the E_w differential. The output of R816 is fed back to servoamplifier AR928A to null servomotor B816 at the correct value of $R_{w(E)}$. During installation of the radar set, the map coordinates of the radar location are set into the E_w differential by radar location casting motor B817. RADAR LOCATION EASTING counter M817 indicates radar location in east map coordinates. The output of the E_w differential drives WEAPON LOCATION EASTING counter M816 which indicates the weapon location in east map coordinates.

(8) *Northing coordinate section.* The operation of the northing coordinate section is similar to the operation of the casting coordinate section. WEAPON LOCATION NORTHING counter M816 indicates the location of the weapon in north map coordinates.

Section VIII. ANTENNA POSITION SYSTEM

2-38. General

The antenna positioning system enables the operator to move the antenna in azimuth and elevation. The system is electromechanical in operation. Positioning is controlled by operator-activated switches to energize relays which determine the direction of antenna movement by means of motor and gear train assemblies. Antenna position data are indicated by counters on the antenna itself and are sent to the computer by synchro systems. Antenna position data are also sent to Simulator, Radar Target Signal AN/TPA-7 when the AN/TPA-7 is used with Radar Set AN/MPQ-4A.

2-39. Antenna Positioning System Block Diagram

(fig. 2-120)

a. Elevation section. The antenna is moved in elevation by activating ELEVATION switch S655. When ELEVATION switch S655 is placed in the RAISE position, it energizes elevation relay K1502 (up) which applies power to elevation actuator motor B3004. The elevation actuator motor turns and causes the actuators to raise the elevation of the radar beam. When ELEVATION switch S655 is placed in the LOWER position it energizes elevation relay K1501 (down), which applies power to elevation actuator motor B3004. The elevation actuator motor turns (opposite direction) and causes the actuators to lower the elevation of the radar beam. Movement of the antenna in elevation turns the elevation counter on the antenna, which indicates the angle of beam elevation in mils. The antenna movement also positions elevation synchro-transmitter B3005, and sets elevation data into the computer. Synchro-transmitter B3005 also transmits antenna elevation data to Simulator, Radar Target Signal AN/TPA-7 when AN/TPA-7 is used with Radar Set AN/MPQ-4A.

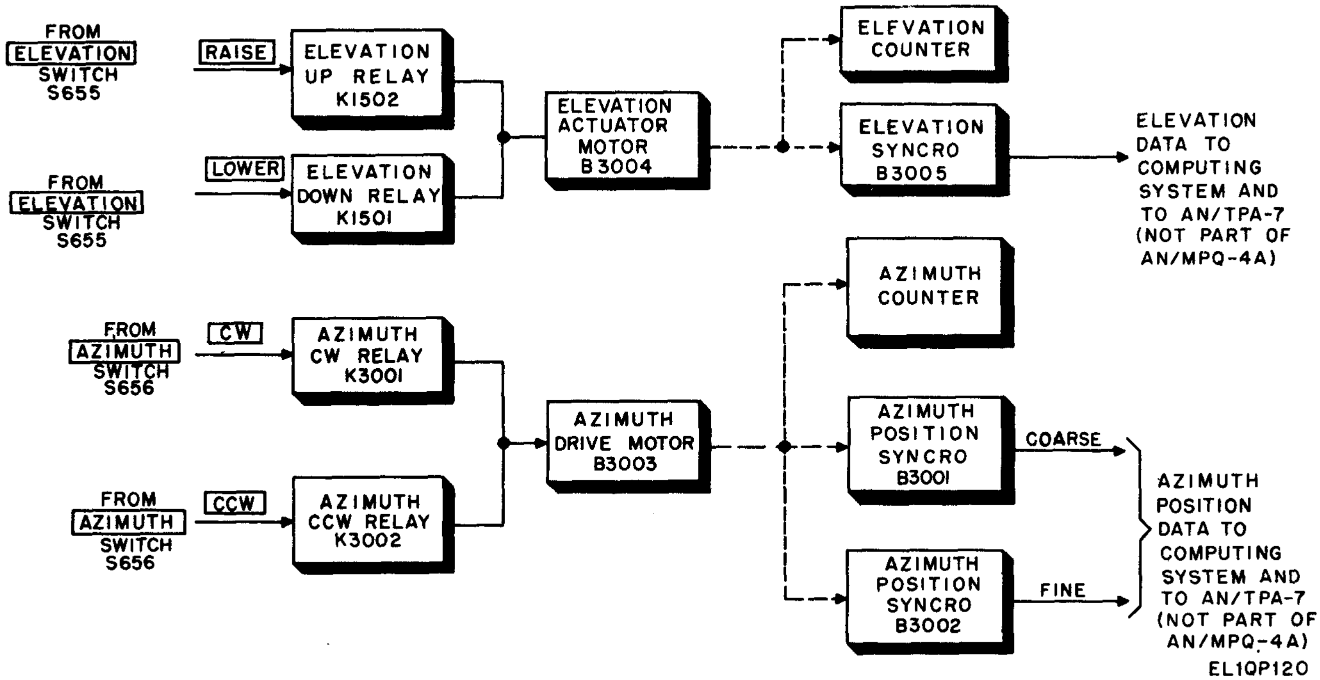


Figure 2-120. Antenna positioning system, block diagram.

b. Azimuth Section. The antenna is moved in azimuth by activating AZIMUTH switch S656. When AZIMUTH switch S656 is placed in the CW position, it energizes azimuth cw relay K3001, which applies power to azimuth drive motor B3003. The azimuth drive motor turns and causes the antenna to rotate in a clockwise direction. When AZIMUTH switch S656 is placed in the CCW position, azimuth ccw relay is energized and causes azimuth drive motor B3003 to turn in the opposite direction. This results in a counterclockwise rotation of the antenna. When the antenna moves in azimuth, the azimuth counter on the pedestal is positioned and indicates azimuth position in mils. The antenna movement also positions synchro-transmitters B3001 and B3002, and sets fine and coarse azimuth data into the computer and Simulator, Radar Target Signal AN/TPA-7 when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. Azimuth synchro B3002 makes 9 revolutions for each complete revolution of azimuth synchro B3001.

2-40. Electrical and Mechanical Description of Antenna Positioning System

a. Elevation Drive and Elevation Data Transmitter.

(1) *General.* The elevation drive raises or lowers the elevation of the antenna beam. An elevation synchro transmitter is mechanically connected to the elevation drive and transmits elevation data to the computing system and Simulator, Radar Target Signal AN/TPA-7 when the AN/TPA-7 is used with the Radar Set AN/MPQ-4A. A mechanical elevation counter indicates elevation angle in mils and is located on the antenna.

(2) *Elevation actuator motor B3004* (fig. FO-15). When ELEVATION switch S655 is placed in the RAISE position, elevation relay K1502 (up) is actuated and three-phase power is applied to elevation actuator motor B3004. Elevation motor B3004 operates and drives the actuators through a flexible shaft and the antenna is raised in elevation. If the antenna is raised above +200 mils, up limit switch S3009 is opened and relay K1502 is deenergized. Elevation relay K1501 (down) is energized when ELEVATION switch S655 is placed in the LOWER position. Down limit switch S3008 deenergizes relay K1501 when the antenna goes below -100 mils. Capacitors C1501 through C1505 prevent arcing across the relay contacts when the relays deenergize. Crystal diodes CR1504 and CR1505 are used to damp any inductive field that is guilt up across the relays when voltage is removed.

(3) *Mechanical drive, data transmitter and elevation counter* (fig. 2-121). When the antenna is raised or lowered in elevation by the elevation actuators, the hockey stocks rotate against fixed pivot points on the antenna pedestal.

(a) The fixed pivot, on the right side hockey stick, has a segment gear attached to it. The

segment gear, if complete, has 216 teeth and it drives a 24-tooth gear on the shaft of elevation data (synchro) transmitter B3005. Since the gear ratio is 9 to 1, 9 mils of synchro data are set into the computor for each mil the antenna is raised or lowered, thereby resulting in very accurate computor elevation data. Elevation transmitter B3005 is a conventional synchro transmitter.

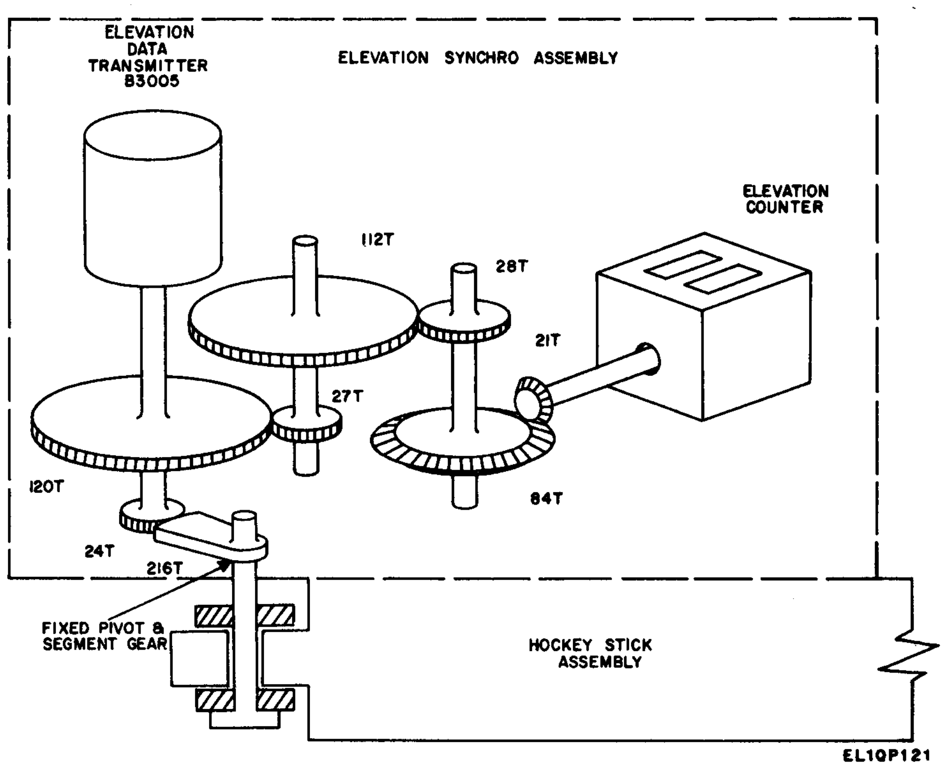


Figure 2-121. Elevation synchro, counter, and gearing, simplifed diagram.

(b) A 120-tooth gear is attached to the shaft of elevation data transmitter B3005 and drives a 27-tooth gear. The 27-tooth gear is connected by shaft to a 112-tooth gear, which drives a 28-tooth gear. The 28-tooth gear is shaft-connected to an 84-tooth bevel gear which drives a 21-tooth bevel gear attached to the elevation counter. The elevation counter indicates elevation data in mils.

b. Azimuth Drive and Azimuth Data Transmitters.

(1) *General.* The azimuth drive rotates the antenna in azimuth. The antenna may be moved in azimuth either manually or electrically. Data concerning the position of the antenna in azimuth is transmitted to the computer and Simulator, Radar Target Signal AN/TPA-7 when the AN/TPA-7 is used with Radar Set AN/MPQ-4A by synchro transmitters. The data can also be read from the azimuth counter at the antenna pedestal.

(2) *Azimuth drive motor B3003* (fig. 2-122). When AZIMUTH switch S656 is actuated in either the CW or CCW position, cw relay K3001 or ccw relay K3002 will be actuated. The ground return for the relays is through left-fender interlock switch S3004, right-fender interlock switch S3003, azimuth stow switch S3002, and azimuth handwheel switch S3001. When cw relay K3001 is energized, three-phase voltage is applied to azimuth drive motor B3003, and 27-volts dc is applied to the brake winding (B1 and B2) of the motor. The brake will release and the motor will rotate until S656 is released. When ccw relay K3002 is energized, the motor will rotate in the opposite direction. Filter capacitors. C3001 through C3006 are connected across the contacts of the relays to prevent arcing. Capacitors C3007 and C3008 are connected across the relay windings to damp the collapsing magnetic field.

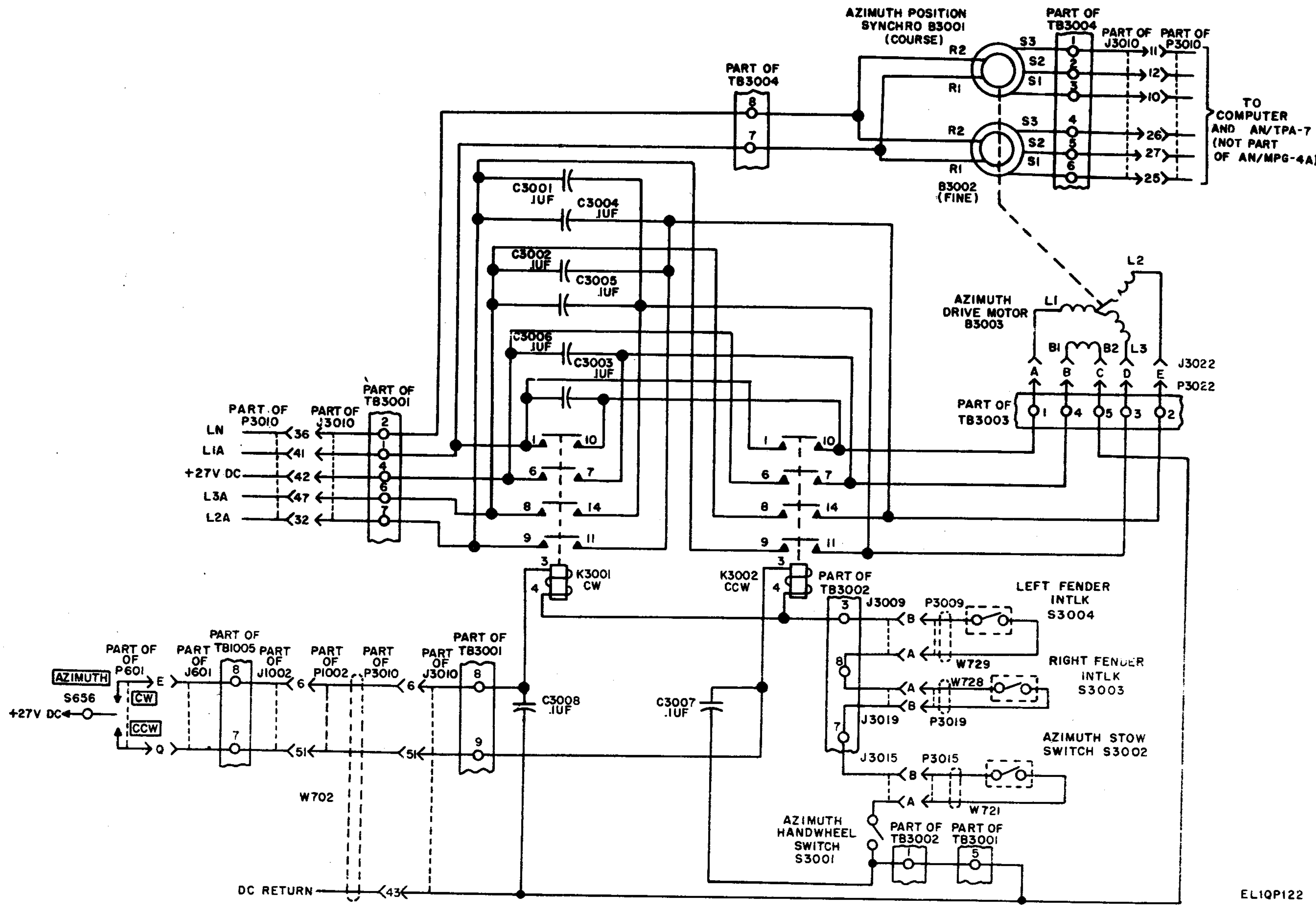


Figure 2-122. Azimuth drive motor B3003 and data transmitters, simplified schematic diagram.

(3) Azimuth position synchros B3001 and B3002 (fig. 2-122). The rotors of azimuth position synchros B3001 and B3002 are geared to the antenna. When the antenna rotates in azimuth, an error voltage is produced which is transmitted to the azimuth section of the computer (para 2-29 *c)* and to Simulator, Radar Target Signal AN/TPA-7 when the AN/TPA-7 is used with Radar Set AN/MPQ-4A. Synchro B3001 makes 1 complete revolution per antenna revolution. Synchro B3002 makes 9 complete revolutions for each antenna revolution and thus sets very accurate data into the computer.

(4) Mechanical drive.

(a) Motor drive (fig. 2-123). When azimuth drive motor B3003 is energized, the 16-tooth gear on the motor shaft drives an 82-tooth gear. The 82-tooth gear is attached by a shaft to a 22-tooth gear which drives an 88-tooth gear. A shaft connects the 88-tooth gear to a 22-tooth gear which drives a second 88-tooth gear. The 88-tooth gear is attached by a shaft to an 18-tooth gear, which drives a 72-tooth gear. A 27-tooth gear which is attached to the 72-tooth gear by a shaft drives the 288-tooth bull gear. The bull gear rotates the antenna pedestal in azimuth.

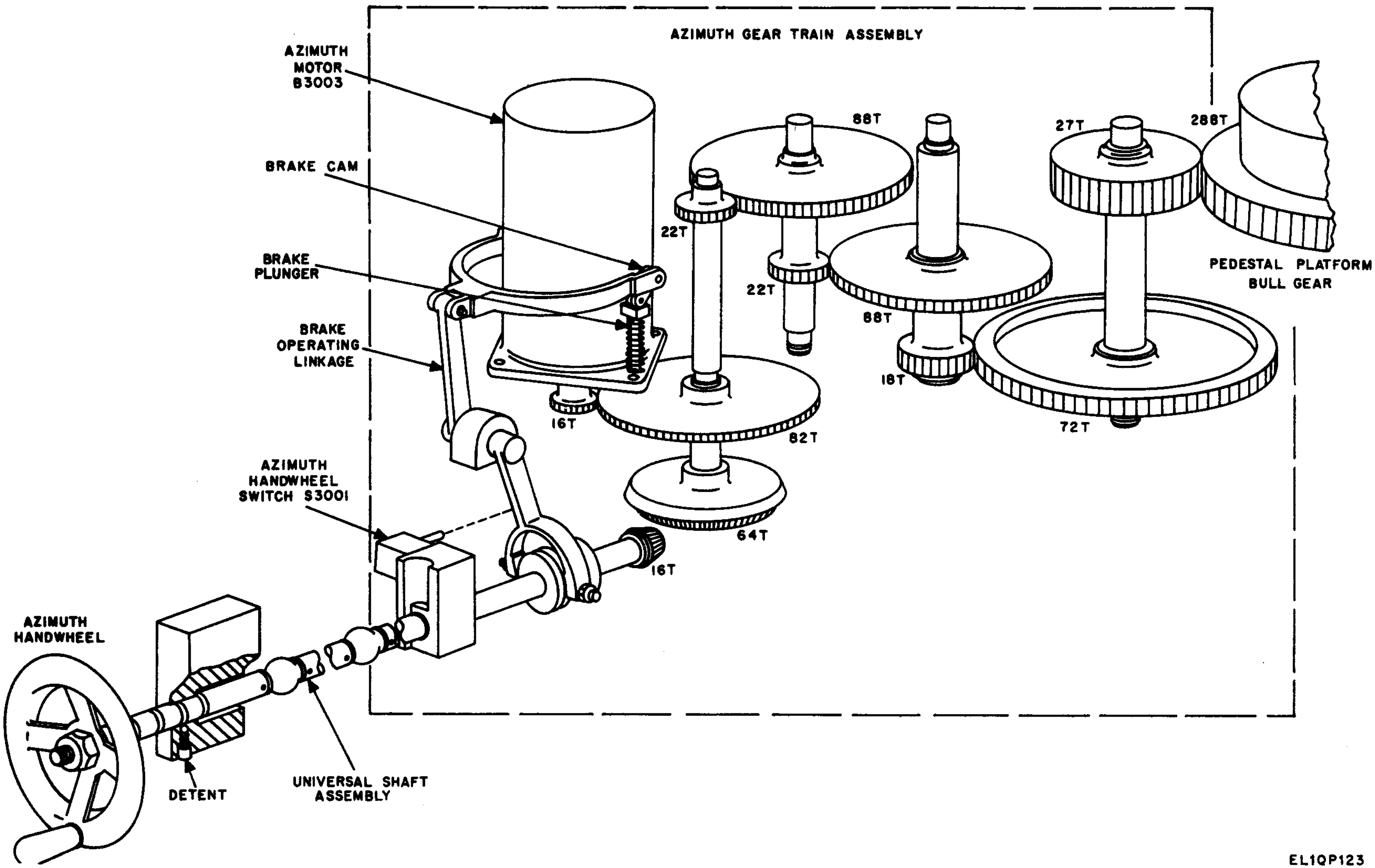


Figure 2-123. Azimuth drive, simplified gearing diagram.

(b) Azimuth handwheel (fig. 2-123). The azimuth handwheel maybe used to rotate the antenna in azimuth. The azimuth handwheel has three positions. When the handwheel is in the center position, the brake operating linkage opens azimuth handwheel switch S3001, which removes the voltage from motor B3003. At the same time, the brake plunger engages the 82-tooth gear and disengages it from the shaft. When the azimuth handwheel is in this position, the antenna can be turned by pushing on it. When the azimuth handwheel is pulled out, azimuth motor B3003 rotates the antenna in azimuth. When the azimuth handwheel is pushed in, a 16-tooth bevel gear on the universal shaft assembly engages a 64-tooth bevel gear. The 64-tooth bevel gear is attached by a shaft to the 22-tooth gear. The 22-tooth gear operates the same gear train as described in (a) above.

(c) Synchro transmitter drive (fig. 2-124). The 288-tooth bull gear ((a) above) drives a 32-tooth gear. The 32-tooth gear rotates a shaft which has a 16-tooth gear, a 112-tooth gear, and azimuth position synchro B3002 attached to it. The 16-tooth gear drives a 144-tooth gear on the shaft of azimuth position synchro B3001. The 112-tooth gear drives a 28-tooth gear. A shaft connects the 28-tooth gear to an 80-tooth gear, which drives an 18-tooth gear. The 18-tooth gear is connected to a 64-tooth bevel gear which drives a 16-tooth bevel gear. The 16-tooth bevel gear drives the extension shaft assembly, which is attached to a clutch gear. The clutch gear engages with a second clutch gear which drives the azimuth counter. The azimuth counter may be reset by pushing the reset handwheel forward. When the reset handwheel is pushed forward, a second set of clutch gears are engaged and the first set is disengaged. The reset handwheel now turns the counter.

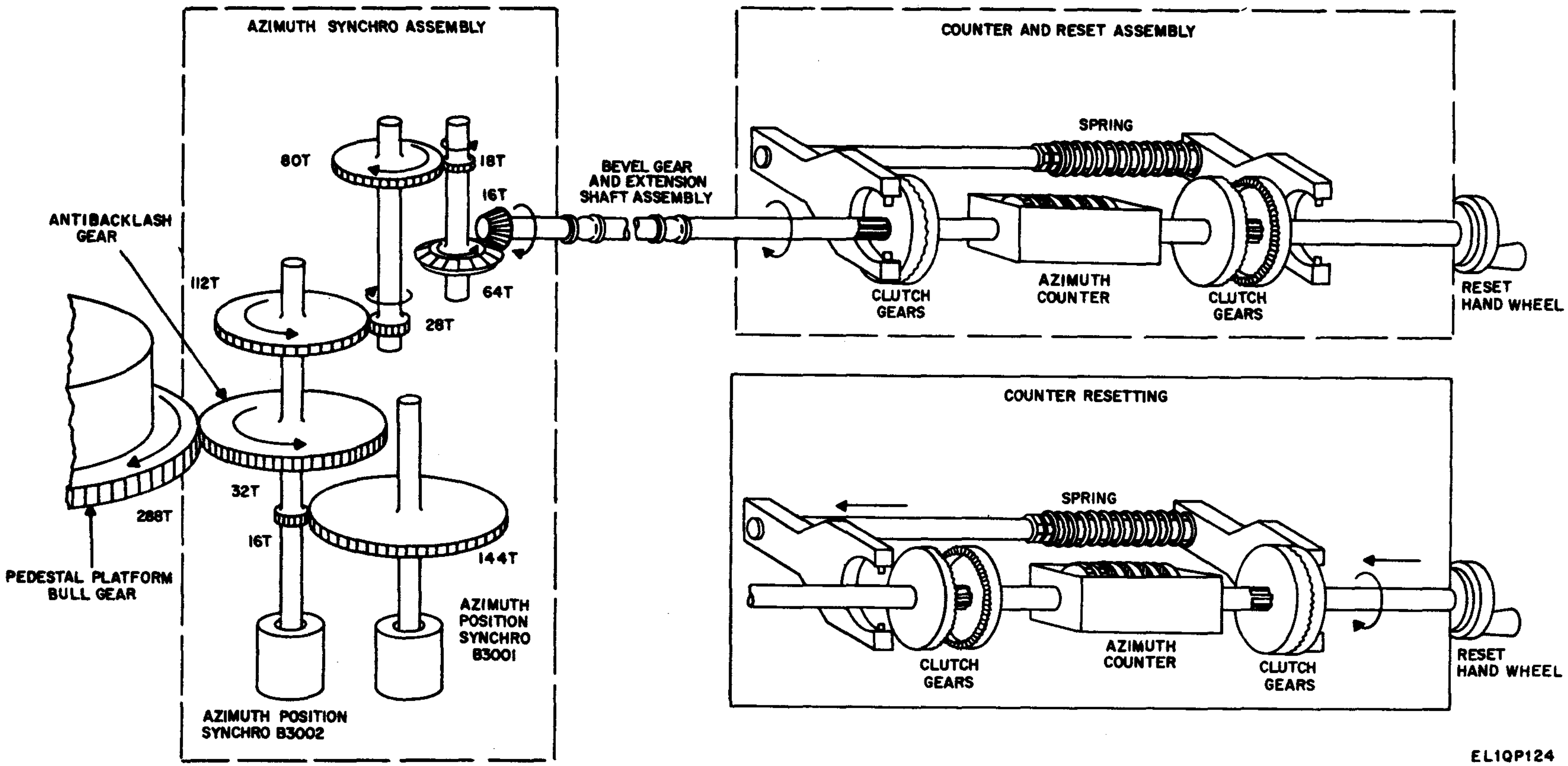


Figure 2-124. Azimuth position synchros, azimuth counter, and reset, simplified gearing diagram.

Section IX. DC POWER SUPPLIES SYSTEM

2-41. General

a. Two low voltage dc power supplies are used in Radar Set AN/MPQ-4A. Control-Power Supply C-2014/MPQ-4A furnishes dc operating voltages for the computing, synchronizing, and indicating systems and 27 volts dc for the complete radar set. Power Supply PP-1588/MPQ-4A furnishes dc operating voltages to the receiving system and the trigger amplifier, and furnishes keep-alive voltage to the TR tube.

b. The relationship of the dc power supplies system to other functional systems of the radar set is described in section II.

2-42. Power Supply PP-1588/MPQ-4A, Block Diagram

(fig. 2-125)

a. Regulated 300-Volt Supply. Positive 300-volt rectifier V1602 applies an unregulated dc voltage to an electronic voltage regulator. Positive 300-volt regulator V1606 and positive 300-volt amplifler V1610 form an electronic voltage regulator to hold the output voltage constant. The electronic voltage regulator is referenced by the negative 300-volt supply *(b* below). Regulated +300 volts dc is furnished to the stc assembly in the receiving system and to the trigger amplifier in the transmitting system.

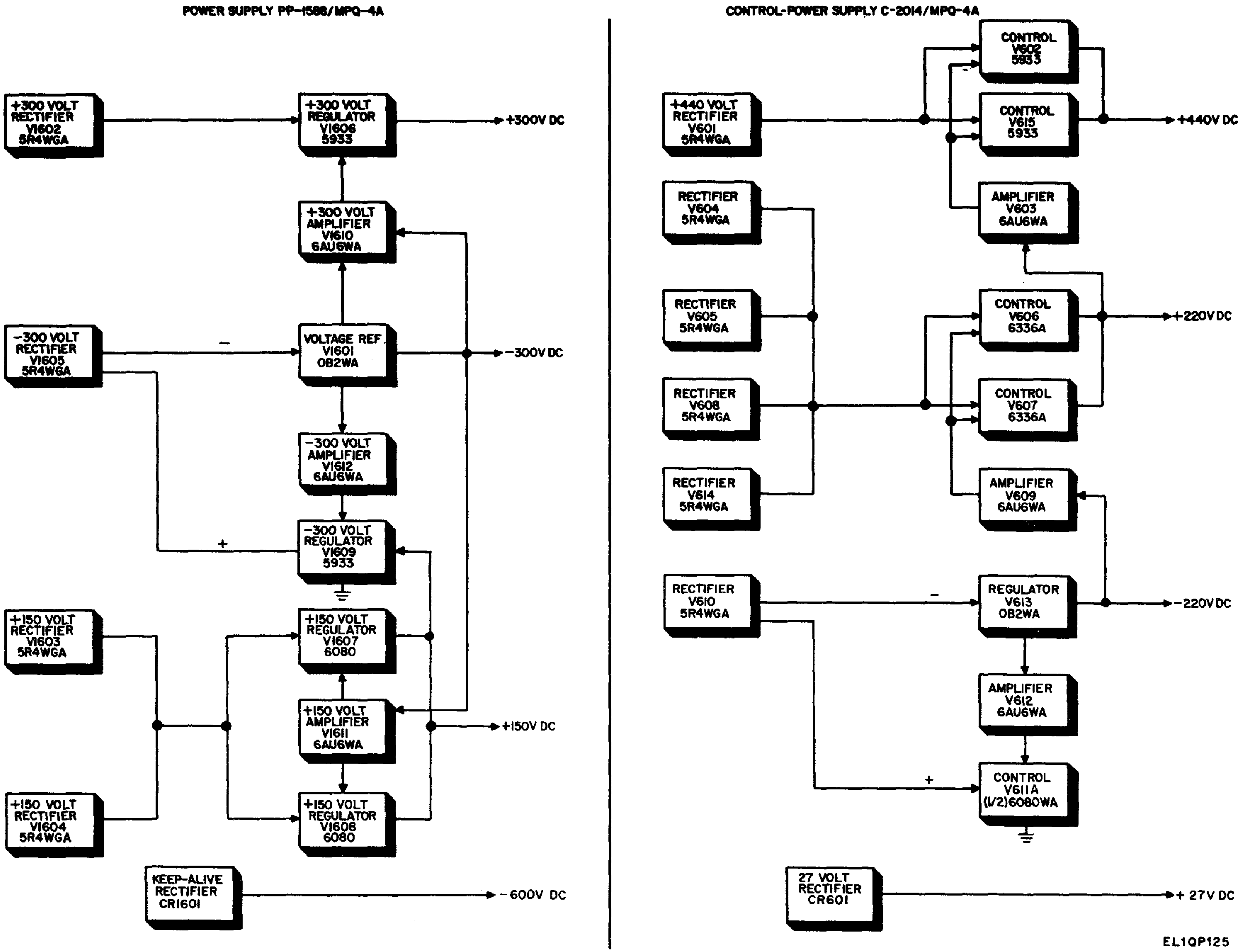


Figure 2-125. Dc power supplies, block diagram.

b. Regulated Negative 300-Volt Supply. An unregulated voltage is applied to the voltage regulator circuit by negative 300-volt rectifier V1605. Voltage reference V1601, negative 300-volt amplifier V1612, and negative 300-volt regulator V1609 form an electronic voltage regulator. Negative 300 volts are furnished to the positive 300-volt supply *(a* above) and to the positive 150-volt supply *(c* below). The negative 300-volt supply furnishes negative 300-volts dc to the afc assembly in the receiving system.

c. Regulated 150-Volt Supply. Positive 150-volt rectifiers V1603 and V1604 apply voltage to an electronic voltage regulator composed of positive 150-volt amplifier V1611 and positive 150-volt regulators V1607 and V1608. The positive 150-volt regulators supply regulated 150-volts dc to the IF amplifier in the receiving system.

d. Keep-Alive Rectifier CR1601. The keep-alive rectifier supplies approximately -600 volts to the TR tube.

2-43. Control-power. Supply C-2014/MPQ-4A, Block Diagram

(fig. 2-125)

a. Regulated 440-Volt Supply. Positive 440-volt rectifier V601 applies unregulated voltage to an electronic voltage regulator. Control tubes V602 and V615 and amplifier V603 form a voltage regulator which holds the output constant. The electronic voltage regulator is referenced by regulated positive 220-volts *(b* below). Positive 440-volts dc is applied to the indicator.

b. Regulated 220-Volt Supply. Four rectifiers, V604, V605, V608, and V614, operate in parallel and supply unregulated voltage to an electronic voltage regulator composed of control tubes V606 and V607, and amplifier V609. The electronic voltage regulator is referenced by negative 220-volts dc *(c* below). The positive 220-volt regulator supplies regulated 220-volts dc to the 440-volt supply *(a* above) and to the computor and indicator.

c. Regulated Negative 220-Volt Supply. Rectifier V610 supplies unregulated voltage to an electronic voltage regulator composed of regulator V613, amplifier V612, and control V611A. The negative 220-volt supply furnishes a regulated negative 220-volts dc to the indicator and to the positive 220-volt supply *(b* above).

d. Twenty-Seven-Volt Rectifier CR601. Selenium rectifier CR601 furnishes an unregulated 27-volts dc to the control circuits in the radar set.

2-44. Electronic Function, Dc Power Supplies System

a. *Control-Power Supply C2014/MPQ-4A.*

(1) *General* (fig. 2-125). The power supply for the computor and the indicator furnishes a regulated positive 440-volts dc to the indicator, a regulated positive 220 volts to both the indicator and the computer, a regulated negative 220 volts to the indicator, and positive 27 volts dc for the operation of relays. Amplifier and control tubes are used to regulate the voltage outputs. The positive 27-volt dc supply uses a full-wave bridge, selenium rectifier and is not regulated.

(2) *Negative 220-volt supply.*

(a) General. The negative 220-volt power supply furnishes a regulated dc voltage to the indicator. It also furnishes a reference voltage for the positive 220-volt dc supply. The negative 220-volt supply uses an electronic regulator circuit which maintains a constant output voltage even though the input voltage or the output load current varies.

(b) Rectifier V610 (fig. 2-126). Plate voltage for rectifier V610 is furnished by plate transformer T605 and filament voltage is furnished by transformer T602. The negative output from the center tap of the plate transformer is applied to the voltage regulator. The positive output from the filament (pin 8) of V610 is applied to the voltage regulator through a choke input filter consisting of inductor L603 and filter capacitor C605.

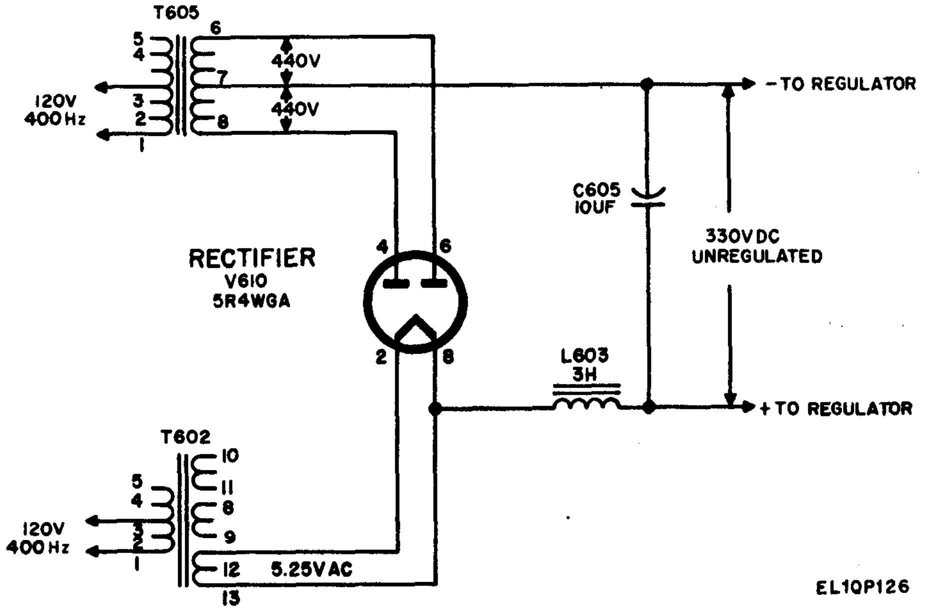


Figure 2-126. Rectifier V610, schematic diagram.

(c) Electronic Voltage Regulator V611A, V612, *and V613 (fig. 2-127).* The operation of the electronic voltage regulator is similar to a variable resistor connected in series with a fixed resistor across the unregulated output of a rectifier. Total supply voltage (output of rectifier) is present across the total resistance at all times; however, the amount of voltage across the fixed resistor is determined by the value of the variable resistance.

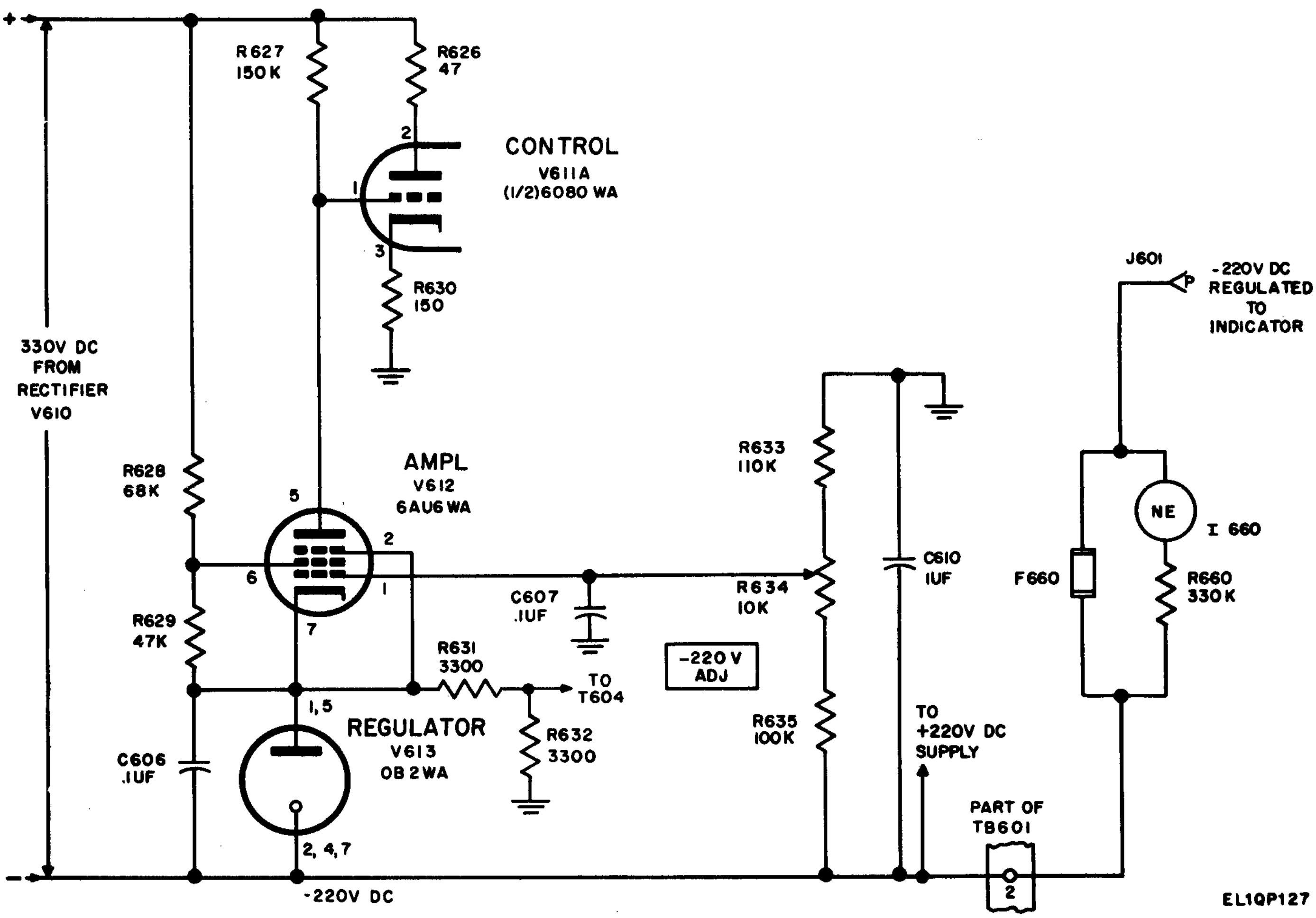


Figure 2-127. Electronic voltage regulator for negative 220-volt dc supply, schematic diagram.

1. The variable resistance in the electronic regulator is the internal resistance of control tube V611A The actual resistance of control tube V611A is determined by its grid voltage and is variable over a wide range.

2. The fixed resistance in the electronic regulator consists of resistors R633, R634, and R635. These three resistors are series-connected and have the load resistance connected in parallel.

3. In operation, adjustable resistor R634 is set so that the output at terminal 2 of TB601 is a negative 220 volts to ground.

(d) Regulator V613. Regulator V613 is a gas tube regulator used to establish a reference

voltage. The reference voltage is this case maintains the cathode of V612 at a level of negative voltage 105-volts less than the negative 220-volt dc output of the power supply. Plate voltage for V613 is furnished from a tap on the voltage-divider network consisting of resistors R628, R629, R631, and R632. Capacitor C606 is connected across the tube to suppress any noise generated within the tube.

(e) Amplifier V612. Amplifier V612 has its cathode connected to the plate of regulator V613 so that the cathode potential will always be 105-volts less negative than the output of the supply. Screen grid voltage is supplied from the junction of voltage divider resistors R628 and R629. Plate voltage is supplied from the positive output of rectifier V610 through plate load resistor R627. The control grid of amplifier V612 is held at some negative value determined by the setting of - 220V ADJ potentiometer R634. Capacitor C607 bypasses the grid, pin 1, to ground placing the grid at ground potential for AC variations in the output of the power supply.

(f) Control V611A. Control tube V611A acts as a variable resistor connected between the positive terminal of rectifier V610 and ground. The voltage across V611A is in series with the voltage output of the power supply, so that the negative output voltage decreases if the voltage across V611A increases and vice versa. The plate is connected to the positive terminal of the rectifier through parasitic suppressor resistor R626. Cathode resistor R630 provides a minimum bias voltage for V611A. The grid of V611A is direct-coupled to the plate of amplifier V612 so that any variation in plate voltage of V612 will cause a variation in grid voltage of V611A. When the grid voltage of V611A changes, the resistance of the tube will change, causing the voltage drop across the tube to change.

(g) Normal operation. During normal operation, the cathode of regulator V613 is at negative 220 volts dc and the plate is at - 115 volts dc. Amplifier V612 grid voltage is adjusted by - 220 V ADJ potentiometer R634 so that V612 conducts sufficiently to hold the grid of control V611A to the bias at which V611A will have the correct resistance to develop the difference between source voltage (330 volts direct current (vdc)) and the -220 vdc output.

(h) Operation when output voltage decreases. When the output voltage (– 220 vdc) decreases the decrease affects the cathode potential of regulator V613 which in turn affects the cathode potential of amplifier V612. A decrease in output voltage appears at the cathode of amplifier V612 as a positive-going change, thus increasing the bias on V612. The plate voltage of amplifier V612 will go in a positive direction, due to the increase in bias on the tube. The positive-going change felt on the grid of control tube V611A will cause its internal resistance to decrease, thus causing a decrease in the voltage drop across V611A. The voltage decrease across control tube V611A will continue until the difference between the source voltage from V610 and the drop across the control tube is 220 volts.

(i) Operation when output voltage increases. When the output voltage (- 220 volts dc) increases, the increase affects the cathode potential of regulator V613, which in turn affects the cathode potential of amplifier V612. An increase in output voltage appears at the cathode of amplifier V612 as a negative-going change, thus decreasing the bias on V612. Plate voltage of amplifiers V612 will go in a negative direction due to the decrease in bias on the tube. The negative-going change felt on the grid of control tube V611A will cause its internal resistance to increase, thus causing an increase in the voltage drop across V611A. The voltage increase across control V611A will reestablish the output voltage at - 220 vdc.

(j) Output voltage. A regulated negative 220 volts is applied to the indicator through F660. Indicator I660 is a blown-fuse indicator, protected by resistor R660. Negative 220 volts dc is also applied to the positive 220-volt regulator as a reference voltage.

(3) *Positive 220-volt power supply.*

(a) General. Four rectifier tubes are connected in parallel to supply the large amount of current drawn from the +220-volt supply. The electronic voltage regulator circuit uses two dual-triode tubes in parallel to handle the heavy current.

(b) Rectifiers V604, V605, V608 and V614 (fig. 2-128). Four full-wave rectifier tubes furnish rectified 350-volts dc through filter choke L602 and filter capacitor C603, to the electronic voltage regulator. Plate voltage for the rectifiers is furnished by plate transformer T601, and filament voltage is furnished by filament transformer T602.

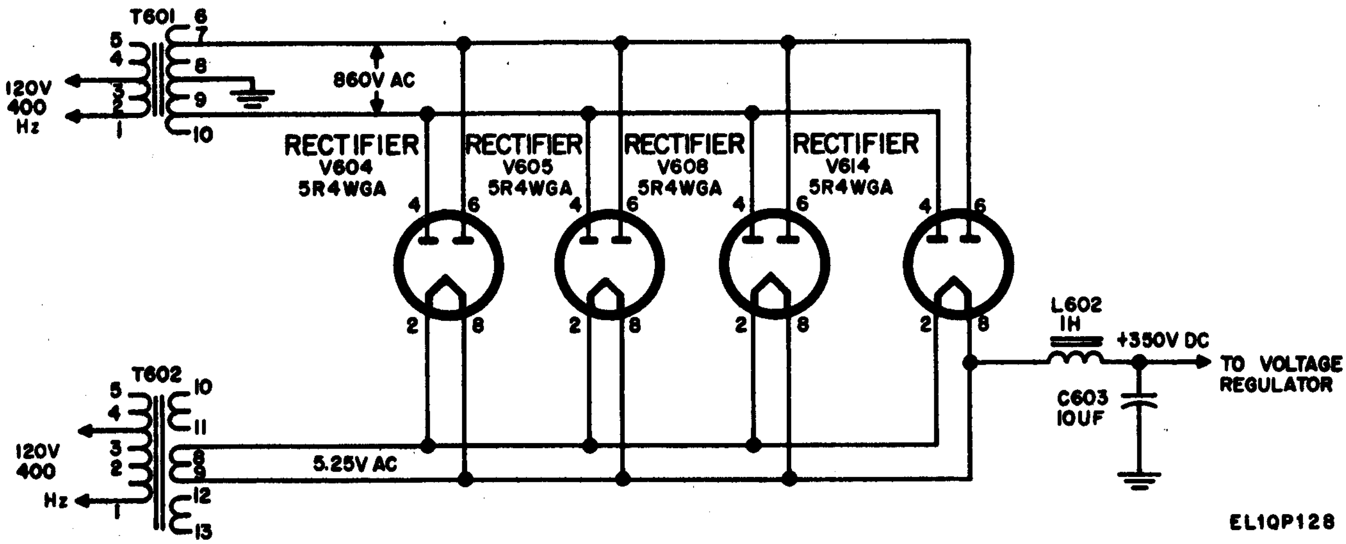


Figure 2-128. Postive 220-volt dc supply simplified schematic diagram.

(c) Electronic voltage regulator (fig. 2-129). The positive 220-volt electronic voltage regulator utilises two paralleled control tubes connected in series wth the voltage-divider network. The plate-to-cathode resistance of the control tubes acts as a variable resistor in the output voltage-divider network, to supply a regulated output voltage. A regulated negative reference voltage from the negative 220- volt regulator is applied to the control grid of amplifier V609 through resistor R623. Screen grid voltage is furnished by the voltage divider consisting of resistors R620 and R621. The positive 220-volt regulated output is obtained from a voltage-divider network consisting of control tubes V606 and V607 (connected in parallel) in seriea with resistors R624 and R625. Capacitor C609 filters the output of the regulator.

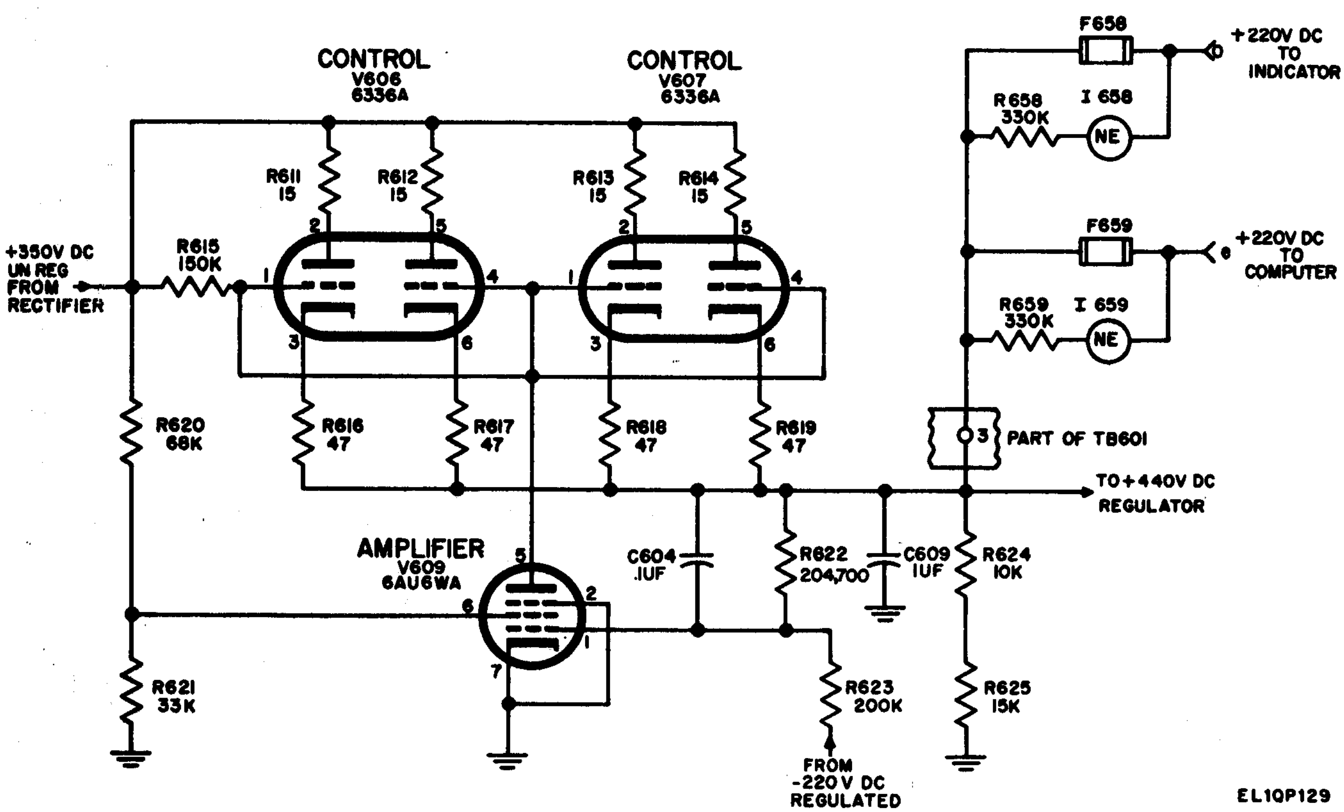


Figure 2-129. Electronic voltage regulator for positive 220-volt dc supply, schematic diagram.

1. Operation of regulator when load voltage decreases. When load voltage decreases, the decrease in voltage will be coupled to the grid of V609 through resistor R622. Capacitor C604 couples rapid fluctuations in output voltage to the grid of V609 and increases speed of correction. The decrease in voltage at the grid of V609 will decrease the current through the tube. The decrease in plate current will cause the plate of V609 and grids of control tubes V606 and V607 to go more positive, and thus decrease the resistance of the control tubes and the voltage drop across them. By decreasing the voltage drop across the control tubes, an increase in output voltage results. The output will continue to increase until normal output voltage is reached. Resistors R611, R612, R613, and R614 are parasitic suppressors. Resistors R616, R617, R618, and R619 are cathode resistors for V606 and V607 and equalize the current between the individual sections.

2. Operation of regulator when load voltage increases. When load voltage increases, the increase in voltage will be coupled to the grid of V609. An increase in grid voltage leads to an increase in plate current. The increased current through plate load resistor R615 causes a more negative voltage to appear at the grids of V606 and V607. The plate-to-cathode resistance of V606 and V607 increases and causes the voltage drop across the tubes to be greater. With a greater voltage dropped across V606 and V607 the output voltage will decrease to normal.

(d) Outputs. The regulated positive 220-volt output is applied to the indicator through F658 and to the computer through F659. Positive 220 volts is also applied to the cathode of V603 in the positive 440-volt regulator as a reference voltage. Indicators I 658 and I 659 are blown-fuse indicators and resistors R658 and R659 are voltage-dropping resistors.

(4) *Positive 440-volt power supply.*

(a) Rectifier V601. (fig. 2-130). Plate voltage for the rectifier is furnished by plate transformer T601, and filament voltage is furnished by filament transformer T602. The rectified output is taken from pin 8 of V601 and applied to the voltage regulator through a filter consisting of choke L601 and capacitor C601.

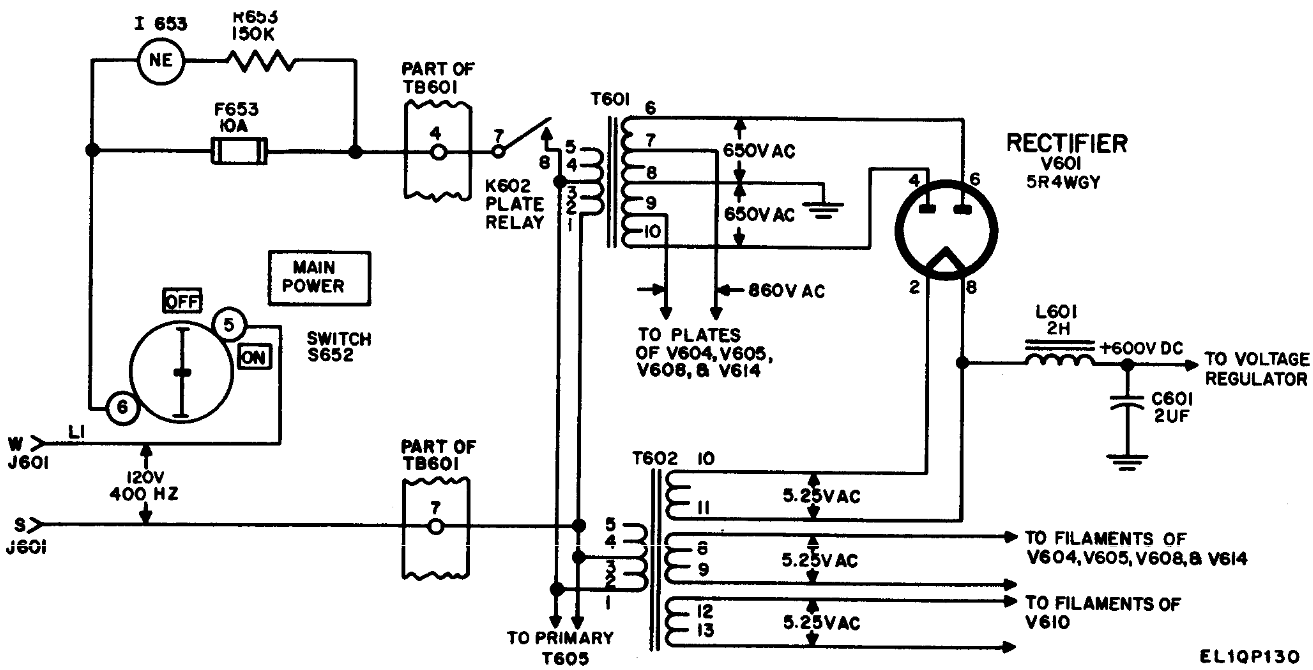


Figure 2-130. Positive 440-volt rectifier V601, schematic diagram.

(b) Voltage regulator (fig. 2-131). The electronic voltage regulator for the positive 440-volt dc supply consists of control tubes V602 and V615 and amplifler V603. Operation of the regulator is similar to the +220 vdc regulator described in paragraph 243. The cathode of amplifier V603 is held at a constant value by the regulated +220-volt power supply. Bias voltage for the grid (pin 1) of C603 is fumishedby the voltage-divider-network consisting of R609 and R610. Screen grid voltage for V603 is obtained from a voltage-divider network consisting of resistors R606 and R607. Grid bias for control tubes V602 and V615 is furnished by the voltage drop across plate resistor R605. Resistors R610, R602, R603, and R604, are parasitic sup preasors. Resistor R608 is a part of the plate load resistance for V603. Capacitor C602 couples rapid changes in output voltage to the grid, and C608 is a filter.

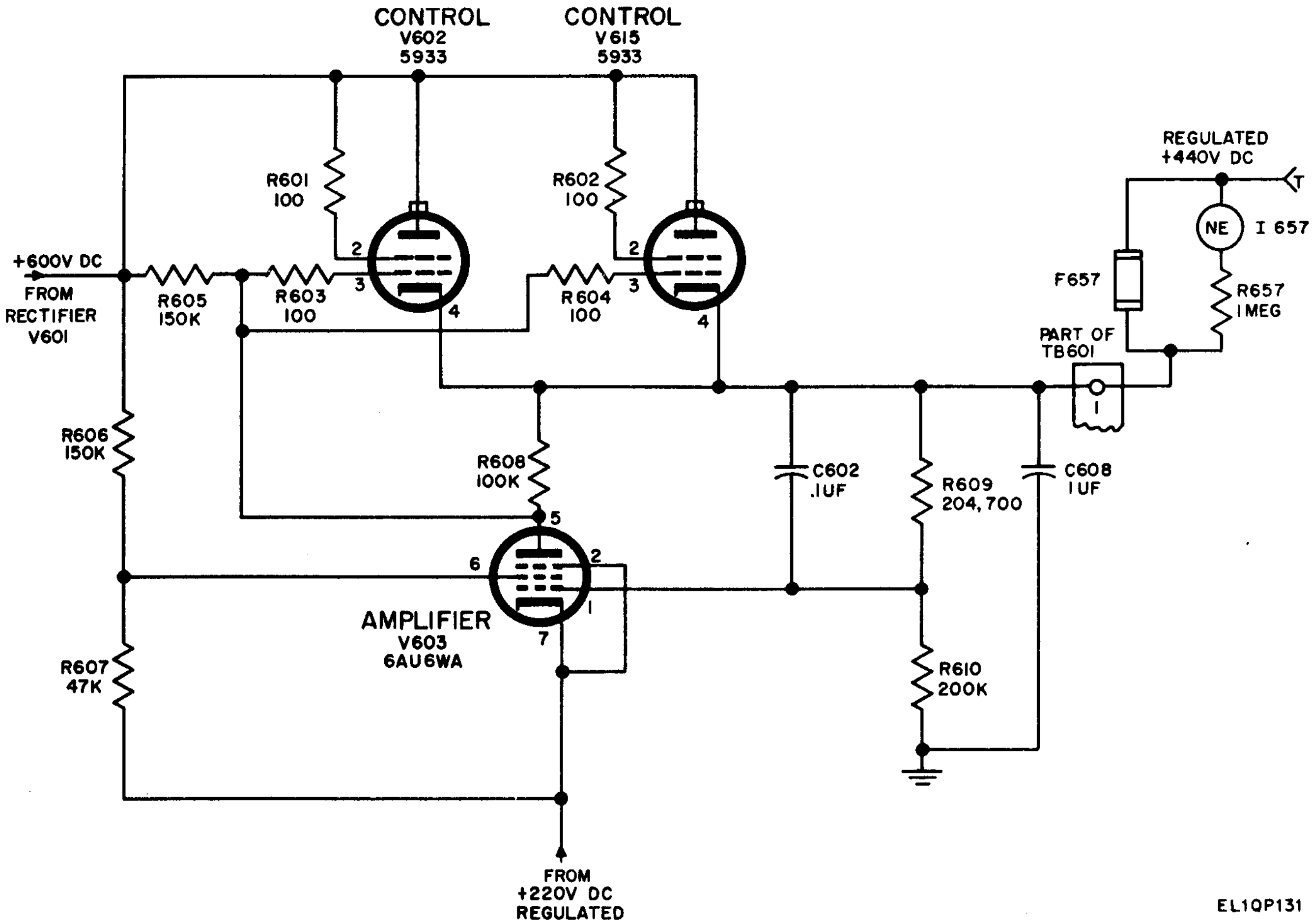


Figure 2-131. Positive 440-volt electronic voltage regulator, schematic diagram.

(5) *Dc supply, 27-volt* (fig. 2-132). Voltage for the 27-volt dc supply is obtained from terminals 14 and 15 of the transformer T603. The 27-volt dc supply uses a bridge-type selenium rectifier CR601. Capacitor C611 is used as a ripple filter. Output voltage is taken from pin V of J601. Fuse F661 protects the 27-volt rectifier against overloads and indicator lamp I 665 is the blown-fuse indicator which is protected by resistor R664.

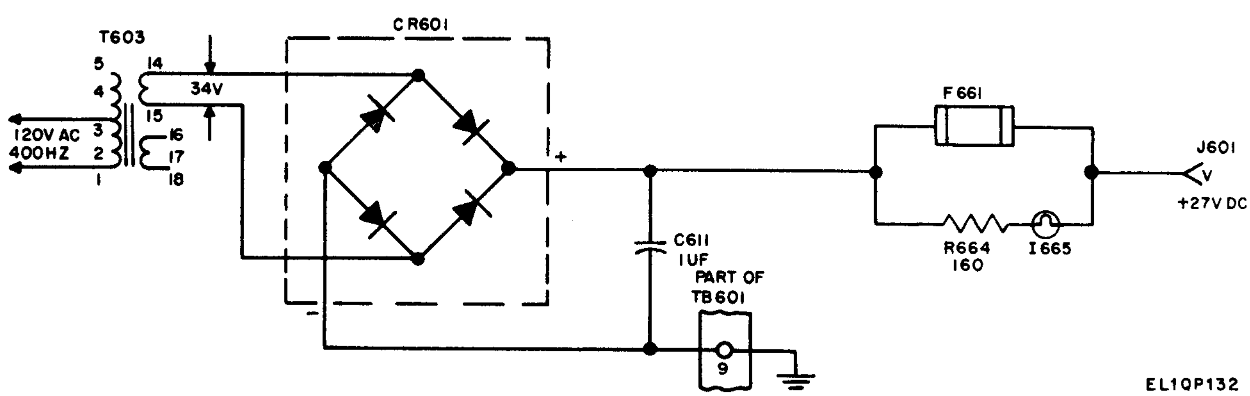


Figure 2-132. 27-volt rectifier CR601, schematic diagram.

(6) *TEST METER SELECTOR switch S651 and TEST METER M652* (fig. 2-133).

(a) General. TEST METER SELECTOR switch S651 and TEST METER M652 are used to measure the output voltage of the dc power supplies for Control-Indicator Group OA-

1256/MPQ-4A. TEST METER M652 has a 0-1 ma movement and is also used to indicate AFC crystal current.

(b) Functioning of circuit. TEST METER SELECTOR switch S651 is a three-section, six-position switch. The contacts of sections A and B of S651 are connected to TEST METER M652. When the switch is in the OFF position, contacts 1 and 12 are connected.

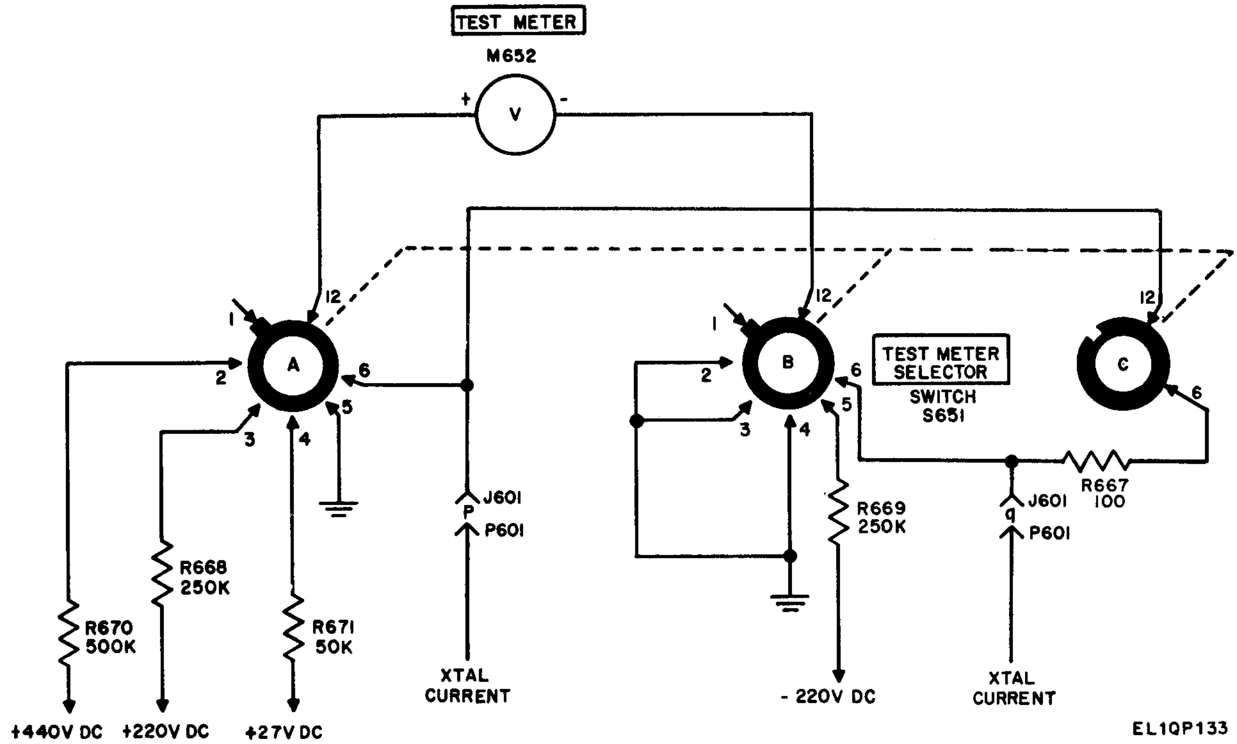


Figure 2-133. TEST METER SELECTOR switch S651 and TEST METER M652, schematic diagram.

1. *Contact No. 2 position.* When S651 is rotated to connect contacts 2 and 12, meter M652 is placed across the +440-volt dc supply. Resistor R670 is a meter multiplier which gives the meter a multiplication factor of 100. The output voltage of the 440-volt dc supply will be indicated on the meter when switch S651 is in the 440 V (X100) position.

2. *Contact No. 3 position.* When switch S651 is rotated to the 220 V (X50) position, contacts 3 and 12 on the A and B sections are connected and M652 is placed across the positive 220-volt dc supply. Resistor R668 is the meter multiplier resistor when measuring the positive 220-volt dc output. The indication on the meter must be multiplied by 50 to obtain the correct voltage.

3. *Contact No. 4 position.* When switch S651 is in the 27 V (X10) position, contacts 4 and 12, on the A and B sections of the switch are connected and M652 is placed across the output of the 27-volt dc supply. Resistor R671 is a multiplier resistor for meter M652. The meter indication must be multiplied by 10 to obtain a correct value of output voltage.

4. *Contact No. 5 position.* When switch S651 is placed in the -220 V (X50) position, contacts 5 and 12, of sections A and B are connected and M652 is placed across the negative 220-volt dc supply. Resistor R669 is the meter multiplier and the meter indication must be multiplied by 50 to obtain the correct value of voltage.

5. *Contact No. 6 position.* When switch S651 is placed in the AFC XTAL CUR position contacts 6 and 12 of sections A and B are connected and M652 measures afc crystal current. In the C section contacts 6 and 12 open when in the contact 6 position. These contacts are closed in all other switch positions,

b. Power Supply PP-1588/MPQ-4A.

(1) *General* (fig. 2-125). The dc supply furnishes a regulated positive 300-volts dc to the afc and stc circuits and the modulator-transmitter, a regulated negative 300-volts dc to the afc circuits, a regulated positive 150 v volts dc to the afc and if. circuits, and -630 volts dc as keep-alive voltage for the TR tube. The positive 300-volt, negative 300-volt, and positive 150-volt dc supplies use full-wave vacuum tube rectifiers. The ac power

is applied to these rectifiers by transformers in the power distribution and control circuits. Amplifier and control tubes are used to regulate the output voltages. The keep-alive 630-volts dc supply uses a half-wave selenium rectifier and is not regulated. Ac power to the selenium rectifier is supplied by plate transformer T1604.

(2) *Negative 300-volt supply.*

(a) *Negative 300-volt rectifier V1605 (fig. 2-134).* Plate voltage for negative 300-volt rectifier V1605 is furnished by part of plate transformer T1604, and filament voltage is furnished by filament transformer T1601. The center tap of transformer T1604 is returned to -300-volts dc. Choke coil L1601 and capacitor C1604 form a filter for the output which is taken from pin 8 of V1605. Resistor R1602 is a bleeder resistor.

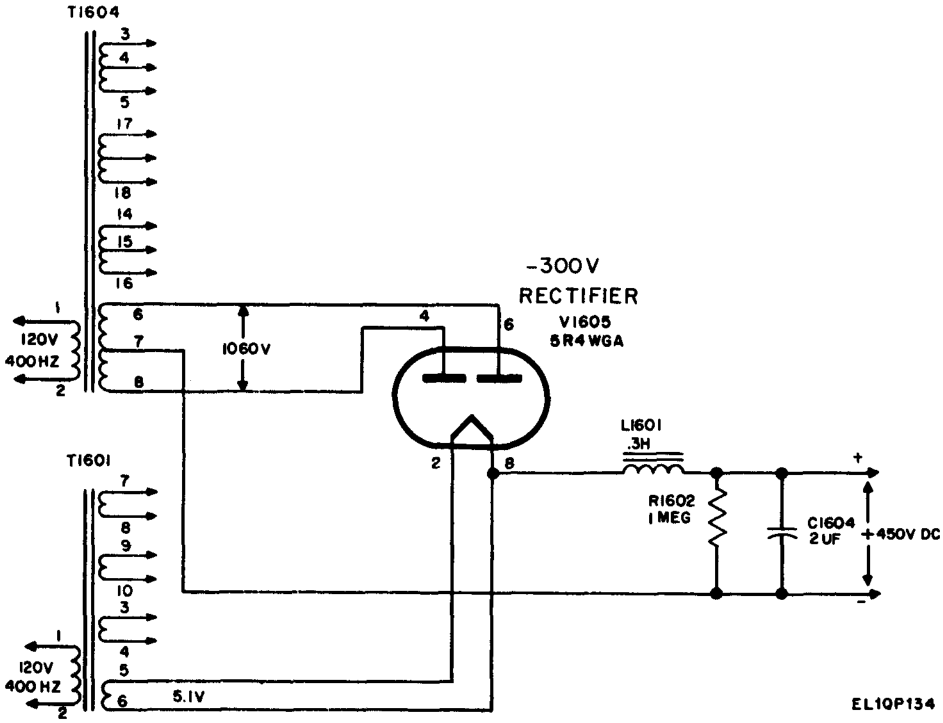


Figure 2-134. Negative 300-volt rectifier V1605, schematic diagram.

(b) Electronic voltage regulator (fig. 2-135). The cathode (pin 7) of negative 300-volt amplifier V1612 is held at a reference level of 105 with regard to the output voltage by voltage reference tube V1601. Resistors R1616, R1617, R1618, and R1619 are voltage-dividing resistors for the screen grid (pin 6) of V1612. Capacitor C1609 is a bypass capacitor for the voltage divider. Grid (pin 1) voltage of V1612 is developed across a voltage divider consisting of R1620, R1621, and negative 300-volt adjustment resistor R1643. The output voltage of the negative 300-volt dc supply can be varied by adjusting R1643. Plate voltage for V1612 is supplied by the + 150-volt regulated supply and is applied through plate load resistor R1615. The plate of V1612 is direct-coupled to the grid (pin 3) of V1609 through parasitic suppressor R1629. Resistor R1628 is a parasitic resistor for the screen grid (pin 2) of negative 300-volt regulator V1609 and returns the screen grid to the +150 volt supply.

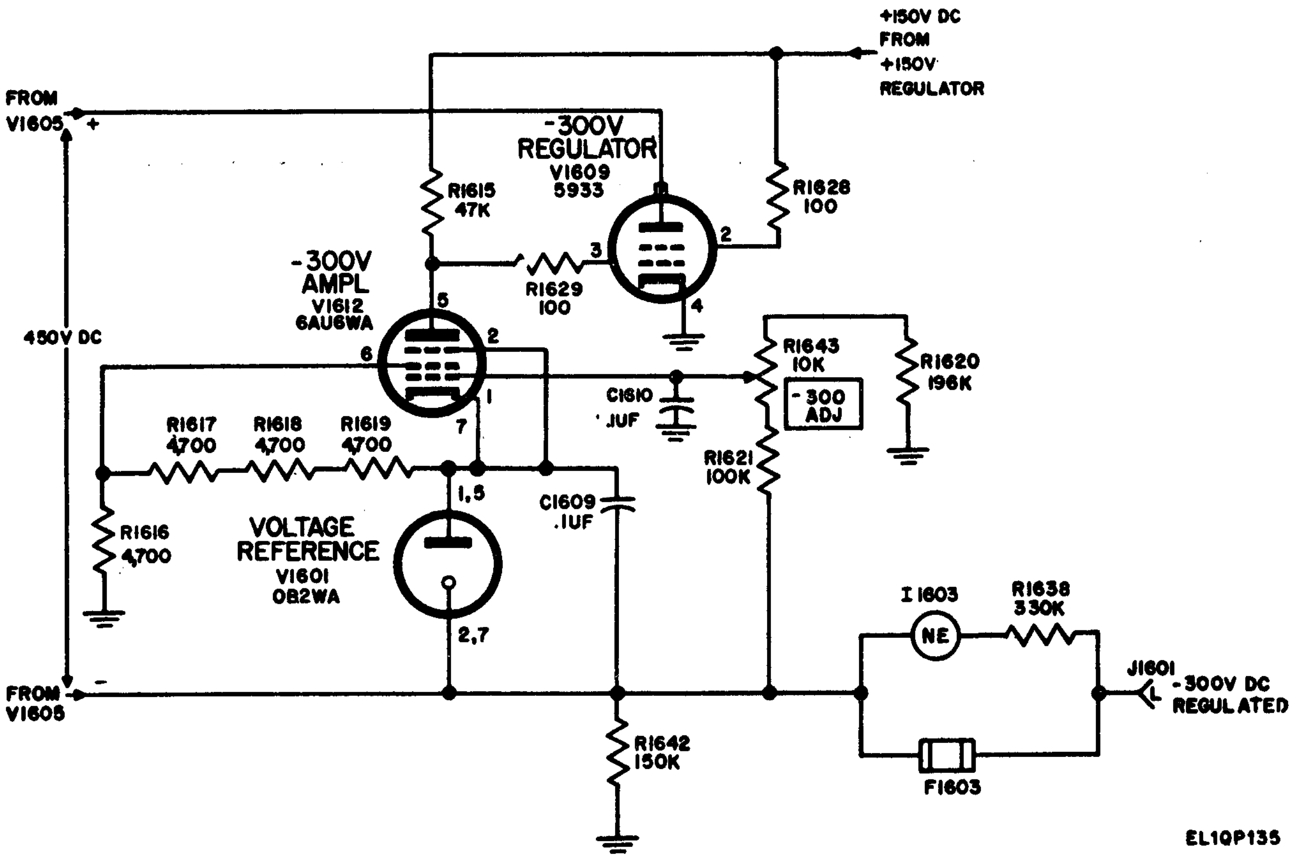


Figure 2-135. Electronic voltage regulator V1601, V1609, and V1612, schematic diagram.

(3) Positive 300-volt supply.

(a) Rectifier V1602 (fig. 2-136). Plate voltage is furnished by one winding of plate transformer T1604, and filament voltage is obtained from one winding of filament transformer T1601. Rectified voltage obtained from pin 8 of V1602 is applied to the electronic voltage regulator through a choke-input filter. Capacitor C1602 is the filter capacitor and L1602 is the choke coil.

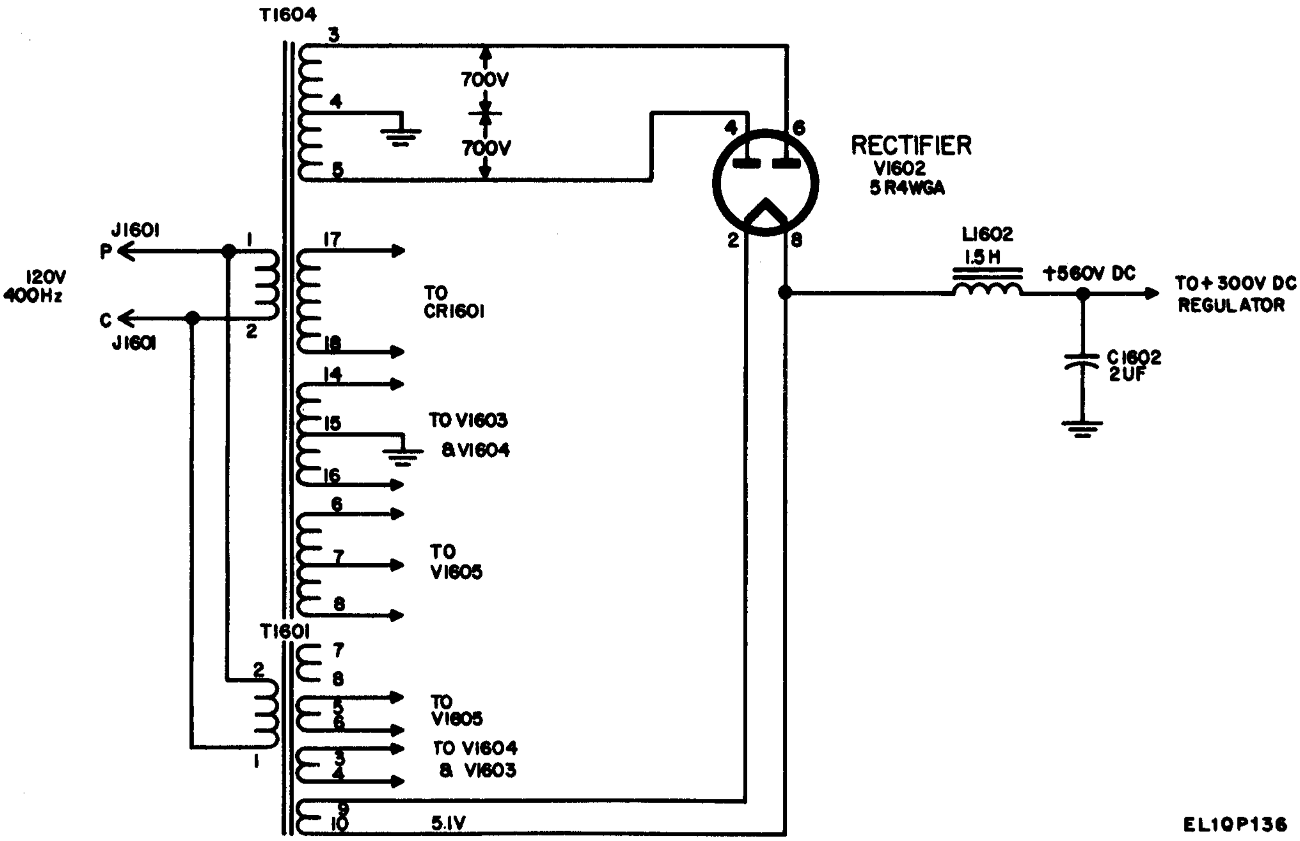


Figure 2-136. Positive 300-volt rectifier V1602, schematic diagram.

(b) Electronic voltage regulator (fig. 2-137). Positive 450-volts dc is developed across a bleeder and voltage-divider network consisting of the plate-to-cathode resistance of positive 300-volt regulator V1606, and resistors R1644, R1645, and R1646. Resistors R1605 and R1606 are shunt resistors across V1606. Resistor R1622 and resistor R1623 are parasitic suppressors. Resistors R1607, R1641, and R1608 form a voltage divider for the grid (pin 1) of positive 300-volt amplifier V1610. Capacitor C1605 couples rapid changes in output voltage to the grid of V1610. Resistor R1611 is the screen-dropping resistor for V1610, and resistors R1603 and R1604 are plate load resistors for V1610. Output voltage is applied to pins E and F of J1601 through fuse F1601. Indicator lamp I 1601 is the blown-fuse indicator for fuse F1601, and resistor R1636 is a current-limiting resistor for I 1601.

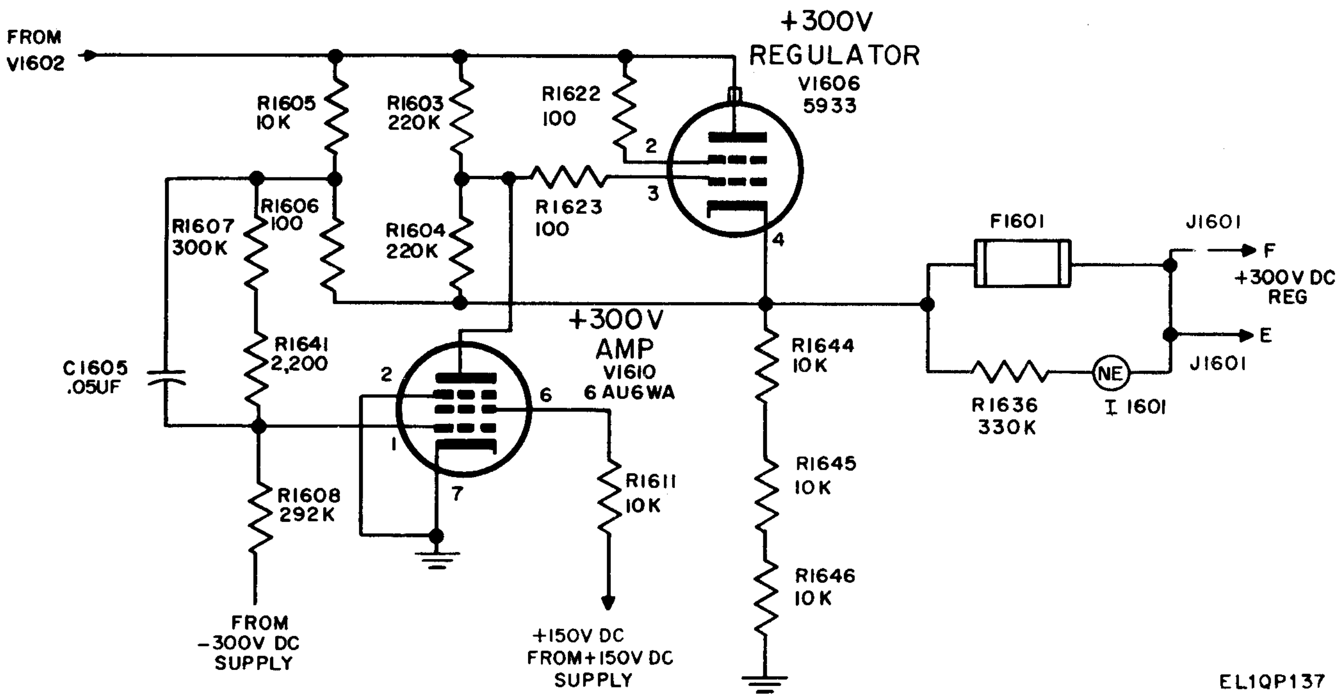


Figure 2-137. Voltage regulator for positive 300-volt dc supply V1606 and V1610, schematic diagram.

(4) *Positive 150-volt supply.*

(a) Positive 150-volt rectifier V1603 and V1604 (fig. 2-138). The positive 150-volt dc supply uses two full-wave rectifier tubes, V1603 and V1604, in parallel. Plate voltage is obtained from plate transformer T1604, and filament voltage is obtained from filament transformer T1601. Two rectifier tubes are connected in parallel to handle the high current. Output voltage is applied to the electronic voltage regulator through the filter consisting of choke coil L1603 and filter capacitor C1603.

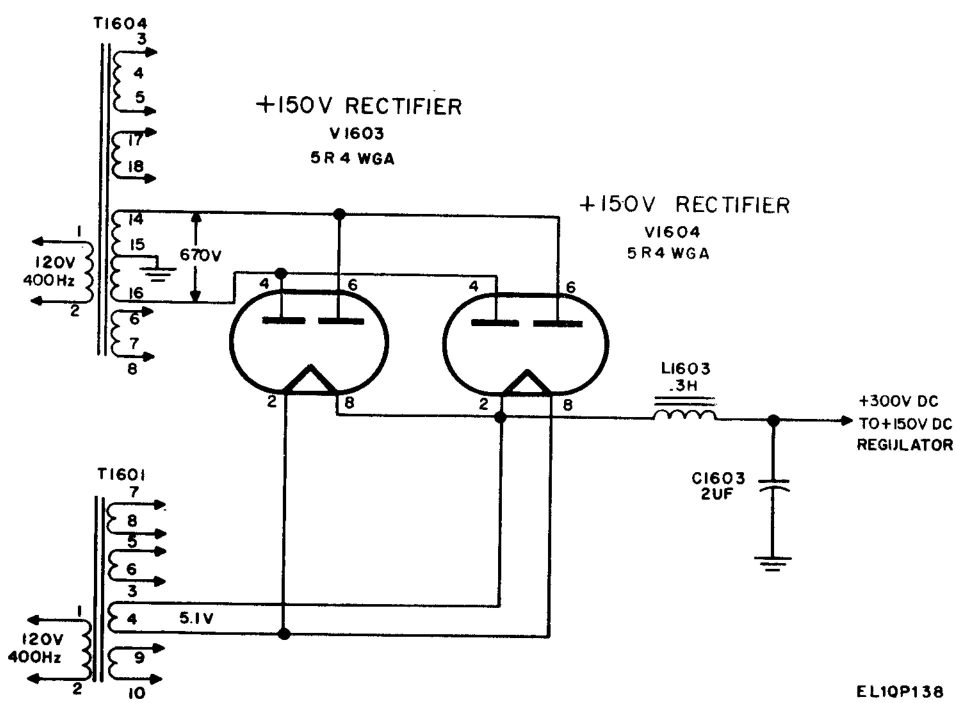


Figure 2-138. Positive 150-volt rectifier V1603, schematic diagram.

(b) Electronic voltage *regulator (fig.* 2-139).

1. Positive 150-volt amplifier V1611. Positive 150-volt amplifier V1611 regulates the current through regulators V1607 and V1608. The grid (pin 1) of V1611 is held negative by the negative 300-volt dc supply and voltage dividers resistors R1612, R1613, and R1614. Resistors R1609 and R1610 are plate load resistors for V1611. Resistor R1639 is a voltage-dropping resistor for the screen grid (pin 6) of V1611. The voltage drop across the plate load resistors of V1611 is applied to the grids (pins 1 and 4) of V607 and V608 through parasitic suppressor resistors R1624, R1625, R1626, and R1627.

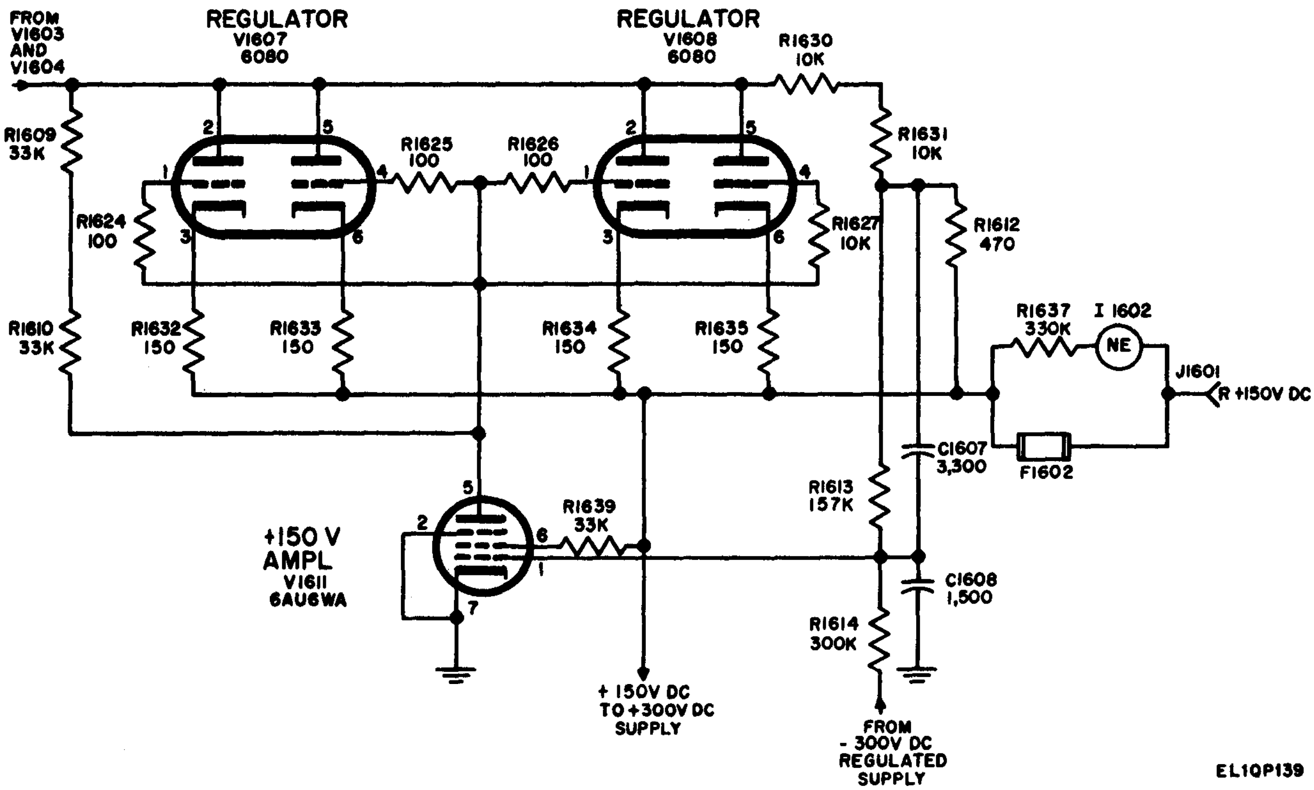


Figure 2-139. Electronic voltage regulator V1607, V1608, and V1611, schematic diagram.

2. Regulators V1607 and V1608. Plate voltage for regulators V1607 and V1608 is obtained from rectifiers V1603 and V1604. Four triodes sections are connected in parallel to supply the high current required. Resistors R1632, R1633, R1634 and R1635 are cathode resistors. Variations in output voltages are coupled to the grid of V1611 through resistor R1613. Capacitor C1607 improves the ac gain characteristics of the regulator and C1608 is a grid bypass. The positive 150-volt regulated output is applied to the receiver circuits through F1602. Indicator I 1602 is is a blown-fuse indicator and R1637 is a voltage-dropping protective resistor for I 1602.

(5) *Keep-alive supply for TR tube* (fig. 2-140). The keep-alive power supply for the TR tube utilizes a half-wave selenium rectifier. Voltage for the rectifier is obtained from plate transformer T1604. Capacitor C1601 filters the ripple from the dc voltage and resistor R1601 is a bleeder resistor. Dc voltage is applied to pins A and B of J1602.

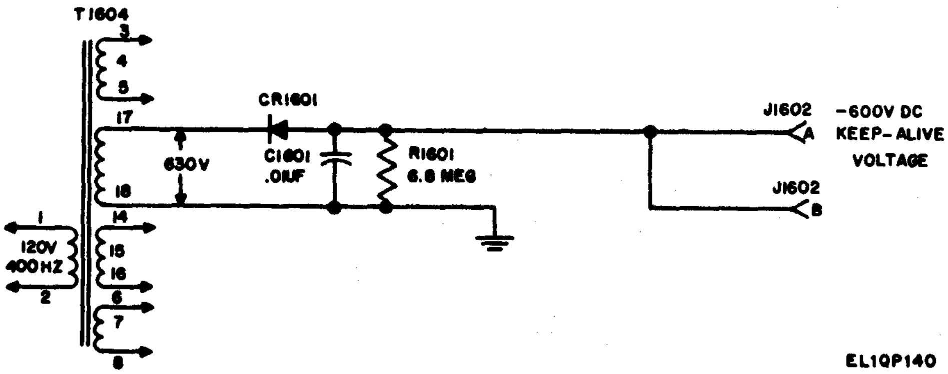


Figure 2-140. Keep-alive rectifier CR1601, schematic diagram.

(6) *Metering circuits.* (fig. 2-141). A metering circuit is provided on the control-monitor panel. When TEST METER SELECTOR switch S1401 is in the +300 V (X100) position, contacts No. 4 on S1401A and S1401B make contact and TEST METER M1402 is placed across the positive 300-volt dc supply. Resistor R1406 is the meter multiplier. Resistor R1407 and R1405 are the meter multipliers for the + 150 V and -300 V positions of TEST METER SELECTOR switch S1401. Positions 1, 2, and 3 are used for crystal currant indications and are described in another section.

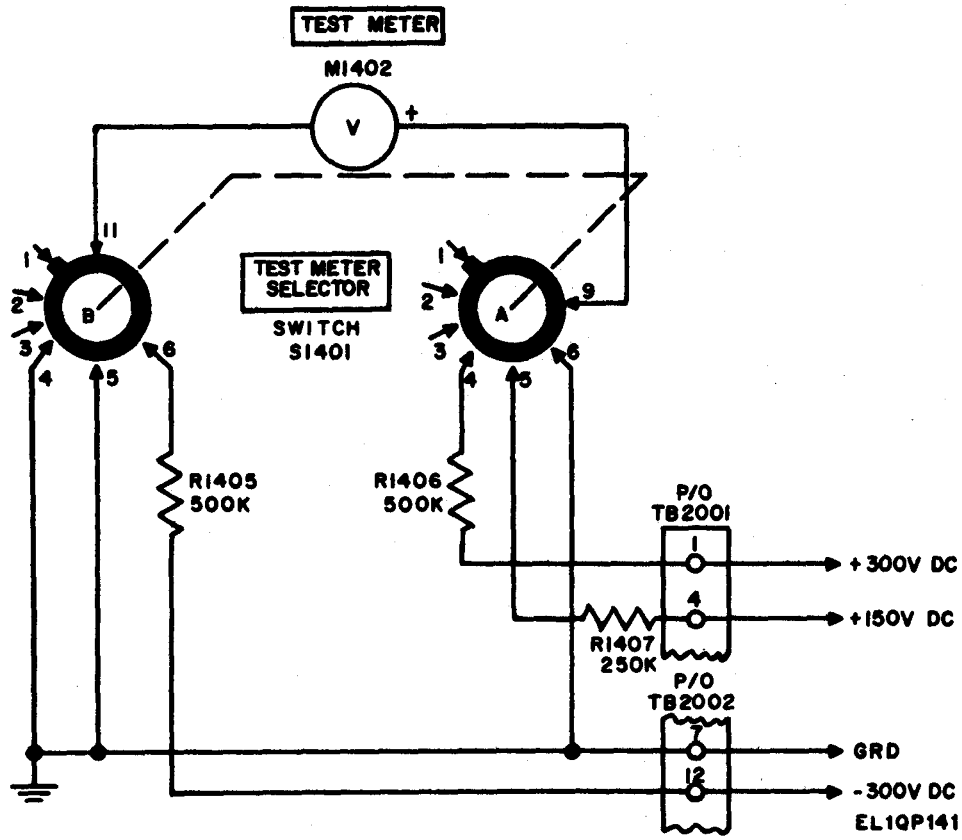


Figure 2-141. Metering circuits for positive 300-volt and positive 150-volt dc supplies, schematic diagram.

Section X. AC POWER DISTRIBUTION AND CONTROL SYSTEM

2-45. Introduction

a. General. Radar Set AN/MPQ-4A uses a three-phase (four-wire), 400-Hertz, 120-volt ac power system. Voltage for the radar set is furnished by a wye-connected motor-driven generator. Each phase of the input voltage is divided within the radar set so that easier distribution and more adequate fusing may be provided. (When Radar Set AN/MPQ-4A is used with Simulator, Radar Target Signal AN/TPA-7, primary power from lines L1 and L2 is supplied by Radar Set AN/MPQ-4A through J1007 to the AN/TPA-7).

b. Fuses and Blown-Fuse Indicators. **(fig. FO-16①).**

(1) *Power System.* There are six fuses and blown-fuse indicators in the ac power system. Phase 1 voltage is protected by 10-ampere fuse F651 (B-5). If fuse is blown, voltage across resistor R651 and 120 V AC indicator lamp I 651 causes I 651 to light. Resistor R651 is a voltage-dropping resistor. Phase 1A voltage is protected by 20-ampere fuse F652 (C-5); a blown fuse is indicated by I 652 and resistor R652 is a voltage-dropping resistor. The circuits supplied by phase 2 voltage are protected by 10-ampere fuse F653 (D-5). When fuse F653 is blown, 120 V AC indicator lamp I 653 lights. Resistor R653 is a voltage-dropping resistor. The circuits supplied by phase 2A voltage are protected by 20-ampere fuse F654 (E-5). Blown-fuse indicator I 654 lights when F654 is blown. Resistor R654 is a voltage-dropping resistor. Twenty-ampere fuse F655 (F-5) protects the circuits supplied by phase 3 voltage. Indicator lamp I 655 is the blow-fuse indicator for phase 3 voltage and R655 is a voltage-dropping resistor. The circuits supplied by phase 3A voltage are protected by 20-ampere fuse F656 (G-5) and I 656 is the blown-fuse indicator. Resistor R656 is a voltage-dropping resistor. Fuse F1001 (A-3) is connected in the phase 2 line which delivers phase 2 voltage to convenience outlet J1003 (A-3) to shelter light receptacle J1004 (A-4), and to shelter blower receptacle J1005 (A-4).

(2) *Twenty-seven volt dc system.* Fuse F661 (fig. FO-17) protects the 27-volt dc control system. If fuse F661 is blown, +27 V DC indicator lamp I 665 will light. Resistor R664 is a voltage-dropping resistor.

c. Interlocks.

(1) *Ac power system.* Trigger amplifier interlock S1106 (F-32, fig. FO-16② **removes voltage** from trigger amplifier high-voltage transformer T1154 when the door of the modulator-transmitter compartment is opened. When shorting switch **S1107 (fig. F-32, FO-16② is closed, the trigger** amplifier will operate.

(2) *Twenty-seven volt dc system.* Three sets of interlock switches are provided in the 27-volt dc system to control high-voltage circuits. A set of interlock switches is mounted in the cabinet of Control-Indicator Group OA-1256/MPQ-4A to remove high voltage from the control-indicator circuits when a drawer is pulled out. Shorting switches are provided so that the circuits within the control-indicator cabinet may be energized. A set of interlock switches is mounted in the cabinet of Receiver-Transmitter Group OA-1257/MPQ-4A to remove high voltage from the receiver-transmitter when a door is opened. When it is necessary to trouble shoot within the cabinet of Receiver-Transmitter Group OA-1257/MPQ-4A to remove high voltage from the receiver-transmitter circuits when a door opened. When it is necessary to trouble shoot within the cabinet, shorting switches are provided. Limit switches are provided with Antenna AS-835/MPQ-4A to protect the scanner.

(a) Control-Indicator Group OA-1256/MPQ-4A (fig. FO-17). Control-power supply interlock switch S1001 opens when the control-power supply is slid out of the control-indicator cabinet. Interlock switch S1001 is paralleled by shorting switch S1002 which may be closed so that power may be applied to the control-power supply with the drawer open. Indicator interlock switch S1003 is opened when the indicator drawer is opened. Power may be applied to the control-indicator group when the indicator is pulled out by closing shorting switch S1004. When the computer drawer is opened, computer interlock switch S1005 is opened. Shorting switch S1006 parallels S1005. Interlock switch S1008 is closed when the blower exhaust vent is open and interlock switch S1007 is closed when the blower intake vent is open. Since the five interlock switches are connected in series, when one drawer in the control-indicator group is opened, high voltage is removed from the entire cabinet.

(b) Receiver-Transmitter Group OA-1257 MPQ-4A (fig. FO-17). Waveguide switches S1101 and S1503 are mounted in sections of the waveguide air pressurization plumbing, and are operated by air pressure. If the pressure within the waveguide should fall below 12 pounds per square inch (psi), magnetron cutoff pressure switch S1101 in one plumbing section opens, and high voltage is removed from the transmitter. When the pressure within the waveguide reaches 16 psi, dehydrator

cutoff pressure switch S1503 in another plumbing section opens, deenergizing dehydrator control relay K1401, and removing voltage from the dehydrator motor. Switch S1503 closes and automatically turns on the dehydrator when the pressure chops below approximately 14 psi. When the door to the modulator-transmitter compartment is opened, interlock switches S1102 and S1104 are opened. Shorting switches S1103 and S1105 parallel S1102 and S1104. Low voltage power supply interlock S2006 which is paralleled by shorting switch S2009 provides protection when the low voltage power supply drawer is opened. Control-monitor interlock S2005, which is paralled by shorting switch S2008, provides protection when the control-monitor door is opened. When the air intake vent is opened, interlock switch S1108 is closed. When the exhaust vents are open, exhaust interlocks S2003 and S2004 are closed.

(c) *Antenna AS-835/MPQ-4A* (fig. FO-17). When scanner rotor, position limit, switches S3201, S3202, S3203, and S3204 are open, power is removed from the scanner motor.

d. Power Unit Indicator Lamp and Indicator Network.

(1) *General.* When all three phases of input ac voltage are present in correct sequence at the input of the radar set, POWER UNIT indicator lamp 1661 (E-3, fig. FO-16 ①) lights with normal brilliance.

(2) *Indicator network* (fig. 2-142). Resistors R661, R662, R663 and capacitor C651 form a network which is used in conjunction with POWER UNIT indicator lamp 1661 to determine if power is present.

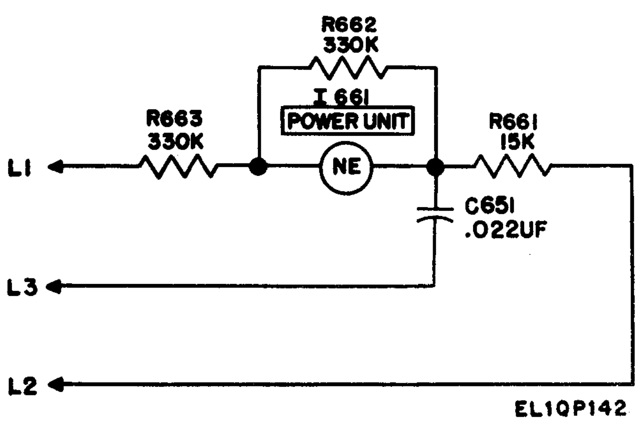


Figure 2-142. *Line voltage indicating circuit.*

e. Power Receptacles.

(1) *Power for Shelter S-134/MPQ-4A.* Ac power for the shelter blowers and shelter lights is furnished through shelter light receptacle J1004 (A-4, fig. FO-16 ①) and shelter blower receptacle J1005.

(2) *Convenience receptacle 115-volt, 400-cycle.* Receptacle J1003 (B-3, fig. FO-16 ①) on the control-indicator cabinet is a receptacle which may be used when power for test equipment is desired.

f. Line Filters.

(1) *Control-Indicator Group OA-1256/MPQ-4A.* The three-phase voltage from the power unit is applied to the radar set through line filters. Filter FL1001 (B-2, fig. FO-16①) is in the phase 1 line, FL1002 (C-2) is in the phase 2 line, FL1003 (D-2) is in the phase 3 line, and FL1004 (D-2) is in the neutral line.

(2) *Receiver-Transmitter Group OA-1257/MPQ-4A.* Filters FL2001 (A-27, fig. FO-16 ②) and FL2002 (A-26) filter the ac input to the receiver-transmitter low voltage power supply. Filters FL1008 (G-36), FL1109 (G-37), FL1110 (C-37), FL1112 (A-35), FL1113 (A-36), FL1114 (B-32), FL1115 (F-31), FL1120 (B-31), and FL1121 (B-32) protect the modulator-transmitter from any transient fluctuations in the ac power system.

g. MAIN POWER Switch S652. MAIN POWER switch S652 (G-4, fig. FO-16 ①) is a six-section switch which is located on the control-power supply. Phase 1 voltage is applied to sections 1 and 2 of S652 through pin W of connector J601. Phase 2 voltage is applied to sections 3 and 4 of S652 through pin Y of J601. Phase 3 power is applied to sections 5 and 6 of S652 through pin X of J601. Each phase of the three-phase voltage applied to the six sections of S652 is divided and applied to the radar set.

2-46. Circuits Energized by MAIN POWER Switch S652

a. General. This section describes the various circuits which are energized when MAIN POWER switch S652 is turned ON. Those circuits which are controlled by relays are described in paragraph 2-*47a* through *d.*

b. Filament Transformers (fig. FO-16). Ten filament transformed supply the filament voltages required for all the tubes in Radar Set AN/MPQ-4A.

(1) *Control-Power Supply C-2014/MPQ-4A.* Filament transformers T603 (C-8, fig. FO-16 ①) and T604 (E-8) furnish 6.3 volts ac to the filaments of the control and amplifier tubes of the power supply. Transformer T603 also furnishes power for rectifier CR601. The primaries of T603 and T604 receive 120 volts ac from terminals 6 and 7 of TB601.

(2) *Azimuth and Range Indicator IP-*

375/MPQ-4A. Filament transformer T101 (E-11, fig. **FO-16①**) furnishes 6.3 volts ac to the filaments of all the tubes in the indicator. The primary of T101 receives 120 volts ac from pins A and C of connector J106.

(3) *Radar Data Computer CP-319/MPQ-4A.* Filament transformers T860 (F-16, fig. FO-16①) furnishes 6.3 volts ac to all the tubes in the computer and 5-volts ac to the illumination lamps. The primary of T860 receives 120 volts ac from pins M and K of connector J852.

(4) *Power supply PP-1588/MPQ-4A.* Filament transformer T1602 (B-28, fig. FO-16②) furnishes 6.3 volts ac to all the control and amplifier tubes in the power supply. Filament transformer T1603 (A-28, fig. FO-16 ②) furnishes 6.3 volts ac to all tubes in the if. amplifier, local oscillator V1501, stc assembly and afc assembly. The primaries of T1602 and T1603 receive 120 volts ac from pins C and P of connector J1601. Rectifier filament transformer T1601 (C-28) furnishes 5 volts ac to the rectifier filaments 30 seconds after MAIN POWER switch S652 is turned ON. Primary voltage of 120 volts ac is received from pin P of connector J1601 and the contacts of plate relay K1602 (para 2-47 *d* (2)).

(5) *Trigger Pulse Amplifier AM-1537/MPQ-4A.* Filament transformer T1151 (E-31, fig. FO-16②) furnishes 6.3 volts ac to tubes V1151, V1152, and V1153 and 5 volts ac to charging and reverse current diode V1154. The primary of T1151 receives 120 volts ac from pins C and D of connector J1153.

(6) *Modulator-transmitter.*

(a) Thyratron filament transformer T1105. Thyratron filament transformer T1105 (D-32, fig. **FO-16②** furnishes 6.3 volts ac to the filament of thyratron V1104. The primary of T1105 receives 120 volts ac from line filter FL1114 and FL1121.

(b) High voltage transformer T1101. High voltage transformer T1101 (B-34, fig. FO-16 2) furnishes filament voltage to the high voltage rectifier, charging diode, and reverse current diode. The filament primary of T1101 receives 120 volts ac from line filters FL1114 (B-32, fig. **FO-16②**) and FL1115 (F-31).

c. Power Supply Transformers (fig. FO-16) There are six high-voltage power supply transformers in Radar Set AN/MPQ-4A.

(1) *Control Power Supply C-2014/MPQ-4A.* High voltage plate transformer T601 (B-8, fig. **FO-11**) furnishes 650 volts ac to the plates of the positive 440 volts dc and the positive 220 volt dc rectifier tubes. Plate transformer T605 (F-8) furnishes 430 volts ac to the plates of the negative 220-volt dc rectifier. The primaries of T601 and T605 receive 120 volts ac from terminal 7 of TB601 and from terminal 4 of TB601 through the contacts of plate relay K602 (D-7). Operation of K602 is discussed in paragraph 2-47 *b* (4).

(2) *Power Supply PP-1588/MPQ-4A.* High voltage transformer T1604 (A-29 fig. **FO-16②**) furnishes 1,060-volts ac, 670 volts ac, and 400-volts ac to the plates of the rectifier tubes. It also supplies 630 volts to rectifier CR 1601. The primary of T1604 receivers 120 volts ac from pins P and C of connector J1601. The line from pin C of connector J1601 goes through the contacts of relay K1602 (C-27). Operation of relay K1602 is discussed in paragraph 2-47 *d* (2).

(3) *Trigger Pulse Amplifier AM-1588/MPQ-4A.* High voltage transformer T1154 (F-32, fig. **FO-16②**) furnishes filament and plate voltage for the rectifier tube. The primary of T1154 receives 120 volts ac from pins D and E of connector J1153. Voltage is applied to pin E of J1153 only when interlock switch S1106 and the contacts of trigger amplifier overload relay K1105 are closed. Operation of relay K1105 is discussed in paragraph 2-13 *a* (5).

(4) *Modulator-transmitter.* High voltage transformer T1101 (B-34, fig. **FO-16②**) furnishes high ac voltage for the high voltage rectifiers. The primary of T1101 receives 120 volts ac from terminals 1 and 2 of TB1105 (B-33) and TB1101 (B-33). Voltage at the terminals of TB1101 is received from terminals 3 and 4 of TB1102 (C-34) through the contacts of power contactor K1104 (C-34). Operation of relay K1104 is discussed in paragraph 2-47 *d* (1).

d. Synchros and Servomotors (fig. FO-16).

(1) *Azimuth position synchros.* The rotors of azimuth position synchros B3001 (B-15, fig. FO-16①) and B3002 (C-15) receive 120 volts ac from terminals 7 and 8 of TB3003 (B-15).

(2) *Azimuth marker synchro B3203.* The rotor of azimuth marker synchro B3203 (C-22, fig. FO-16①) receives120 volts ac from terminals 1 and 5 of TB 3005 (B-19) through pins D and G of connectors JP 3008 (C-19) and JP3203 (C-21), and terminals 4 and 5 of TB3202 (C-21).

(3) *Elevation synchro B3005.* The rotor of elevation synchro B3005 (D-22, fig. FO-16 ①) receives 120 volts ac from terminals 1 and 5 of TB 3005 through pins A and B of connectors JP3013 (D-20) and JP 3014 (D-21).

(4) *Azimuth marker servomotor B3202.* The rotor of azimuth marker servomotor B3202 (G-23, fig. **FO-16①**) receives 120 volts from terminals 3 and 4 of TB 3005 (H-19) through pine E and F of connectors JP3008 (G-20), JP3203 (G-21), and terminals 4 and 6 of TB3203 (G-22).

e. Antenna Drive Motors.

(1) *Scanner drive motor B3201.* Scanner drive motor B3201 (E-24, fig. FO-16①) is a three-phase ac motor which receives voltage from terminals 2, 3, and 4 of TB3005 (B-19 and H-19) through the contacts of relay K3003 (F-20) and pins A, B, and C of connectors JP3011 (F-22) and JP3201 (F-24). Operation of relay K3003 is discussed in paragraph 2-47 *c.*

(2) *Azimuth drive motor B3003.* Azimuth drive motor B3003 (D-18, fig. FO-16①) is a three-phase ac motor which receives ac voltage through the contacts of relay K3001 (D-17) or K3002 (E-17). Operation of relays K3001 and K3002 is discussed in paragraph 2-40 *b* (2).

(3) *Elevation actuator motor B3004.* Elevation actuator motor B3004 (C-48, fig. FO-16②) is a three-phase ac motor which receives ac power through the contacts of relay K1501 (D-43) or relay K1502 (C-43). Relays K1501 and K1502 are discussed in paragraph 2-40 *a* (2).

f. Cabinet Blowers. There are two blowers in the receiver-transmitter cabinet and one blower in the control-indicator cabinet.

(1) *Blower B1001.* Three-phase voltage is applied to blower B1001 (D-10, fig. FO-16①) from terminals 1, 2, 3, and 4 of TB1008 (D-10 and E-10).

(2) *Blowers B1101 and B1102.* Three-phase voltage is applied to blower B1101 (C-30 fig. FO-16 2) from terminals 1, 2, 3, and 4 of TB1103 (B-31). Three-phase voltage is applied to blower B1102 (D-30) from terminals 1, 2, 3, and 4 of TB1104 (D-30).

g. Miscellaneous Circuits.

(1) *MAGNETRON POWER variac T651.* MAGNETRON POWER varias T651 (G-6, fig. FO-16 ①) receives 120 volts ac from pin 5 of connector J601 (H-6) and fuse F655.

(2) *Five-minute delay relay K603.* The motor windings of 5-minute delay K603 (G-7, fig, FO-16 ①) receive receive 120 volts ac from terminal 7 of TB601 (G-8) and fuse F653. Operation of K603 is discussed in paragraph 2-47 *b* (5).

(3) *SECONDS timer M101.* The motor windings of SECONDS timer M101 (G-11, fig. FO-16 ①) receive 120 volts ac from pins A and C of connector J106 (D-11 and G11). The operation of M101 is discussed in paragraph 2-22 *g* (3).

(4) *Reference transformer T861.* Reference transformer T861 (C-11, fig. FO-16 ①) furnishes reference voltage to the data potentiomteers of the computer. The primary of T861 receives 120 volts ac from pins A and K of connector J852 (B-11 and H-12).

(5) *Magnetic amplifiers T851 through T858.* Magnetic amplifiers T851 (E-15, fig. FO-16 ①) through T858 receive 120 volts ac through pin K of the connector J852 (H-12) and contacts of relay K852 (C-12).

(6) *Autotransformer T859.* Autotransformer T859 (G-17, fig. FO-16 ①) receives 120 volts ac from pins J and M of connector J852 (G-17).

(7) *Azimuth counter illumination transformer T3001.* Azimuth counter illumination transformer T3001 (D-15, fig. FO-16 ①) receives 120 volts ac from terminals 1 and 2 of TB 3001 (B-14).

(8) *Delay cell DL1301.* The heating element of delay cell DL1301 (B-29, fig. FO-16 ②), receives 120 volts ac from pins U and X of connector J1303 (A-30). Operation of DL1301 is discussed in paragraph 2-19 *c* (7).

(9) *Repeller tracking motor B1501.* One winding of repeller tracking motor B1501 (C-37, fig. FO-16 ②) receives 120 volts ac from terminals 1 and 2 of TB1501 (A-37). Operation of B1501 is discussed in paragraph 2-19 *a* (1) *(c)* 1,

(10) *Voltage Regulator VR1101.* Resistors R4801 (C-38, fig. FO-16 ②) through R4811, rectifiers CR4801 (G-39) through CR4804, transformer T4801 (G-38), and relay K4801 (G-38) are parts of voltage regulator VR1101. Voltage regulator VR1101 receives 120 volts ac from pins A and C of connector J4801 (E-38 and D-38). Operation of VR1101 is discussed in paragraph 2-13 *b* (4).

2-47. Circuits Energized by 27-Volt Control Circuit (fig. FO-17)

a. General. The 27-volt control circuit energizes relays which apply ac voltage to the high voltage circuits. Since the interlocks are in the 27-volt control circuits, high voltage is removed from the radar set when the interlock switches are opened. When MAIN POWER switch S652 is turned ON, 27 volts dc is produced by selenium rectifier CR601.

b. Control-Indicator Group OA-1256/MPQ-4A.

(1) *Blown-fuse indicator I 665 and fuse F661.* Fuse F661 is a 5-ampere fuse which protects the 27-volt dc circuits. Blown-fuse indicator lamp I 665 lights when F661 is blown. Resistor R664 is a voltage-dropping resistor.

(2) *Interlock circuit.* When interlock switches S1001, S1003, S1005, S1007, and S1008 are closed, MAIN POWER ON & INTLK CLOSED lamp I 666 lights, Resistor R665 is a voltage-dropping resistor. When the interlocks are closed, dc voltage is delivered to the contacts of relay K601.

(3) Thirty-second delay relay K601. The thermal element of 30-second delay relay K601 receives 27 volts dc from terminals 9 and 10 of TB601. Thirty seconds after S652 is closed, the contacts of K601 close and 27 volts is applied to

plate relay K02 and to terminal 5 of 5-minute delay relay K602.

(4) *Plate relay K602.* Plate relay K602 energizes as soon as voltage is applied, and ac voltage is applied to T601 and T605 (para 2-46 *c* (1)).

(5) *Five-minute delay relay K603.* When ac power is applied to the motor windings of relay K603 (para 2-46 *g*), the motor drives the contacts together. After a period of 5 minutes, the contacts close and ac voltage is removed from the motor windings. The clutch windings of K603 hold the relay closed until the 27-volt dc circuit is interrupted. Twenty-seven volts dc is applied from contact 7 of K603 to modulator START switch S658 and modulator STOP switch S659.

c. Antenna Group. When rotor limit switches S3201, S3202, S3203, and S3204 are closed, relay K3003 receives 27 volts dc from terminals 7 and 8 of TB3005 through switch contact C8. If scanner drive motor B3201 draws excessive current, the thermal elements of relay K3003 will open contact C8, deenergizing relay K3003 (contacts T1, T2, T3) and removing the ac line voltage from scanner drive motor B3201.

d. Receiver-Transmitter Group OA-1257/MPQ-4A.

(1) *Power contactor K1104.* When modulator START switch S658 is closed, +27 volts dc is applied to terminal 4 of relay K1104. Line filter FL1107 filters out any transients in the dc voltage. The -27 volt line is applied to terminal 3 of K1104 through waveguide switch S1101, interlock switches S1102, S1104, S1108, S2003, S2004, S2005, S2006, contacts of overload relays K1101 and K1102, and line filter FL1104. When K1104 closes, voltage is applied to terminal 4 through holding contacts 8 and 14 and modulator STOP switch S659. Modulator STOP switch S659 deenergizes K1104 when pressed.

(2) *Thirty-second delay relay K1601 and plate relay K1602.* The 30-second thermal delay relay K1601 energizes when S652 is turned ON and the contacts close after a delay of 30 seconds. When the contacts of K1601 close, 27 volts dc is delivered to K1602 and K1602 is activated. Relay K1602 closes holding contacts 7 to 8, and will stay closed until an interlock is opened or STOP switch S659 is pushed. Contacts 3 to 4 open when K1602 is activated therby removing the 27b volts dc from the thermal element of relay K1601 and allowing K1601 to reenergize. If power is removed from relay K1602 for any reason, the 30-second delay of relay K1601 will occur before relay K1602 can be reactivated, thus protecting the transmitter circuits.

Section XI. VENTILATING AND DEHYDRATING SYSTEMS

2-48. Introduction

a. General. The ventilating system provides a flow of air within the receiver-transmitter cabinet and the control-indicator cabinet to dissipate the heat generated within the cabinets. A dehydrator is provided to pressurize the waveguide and keep the air in the waveguide dry. Two blowers are provided for ventilation of the operating shelter. An intake vent and an exhaust vent are provided for ventilation of the scanner.

b. General Functioning of Ventilating System.

(1) *Control-Indicator Group OA-1256/MPQ-4A* (fig. 2-143). Air is pulled into the control-indicator group through a vent on the left of the cabinet. Blower B1001 forces the cool air past the control power supply and into the other half of the cabinet. The air is forced around the computer and indicator drawers and through the exhaust vent on the right side of the cabinet.

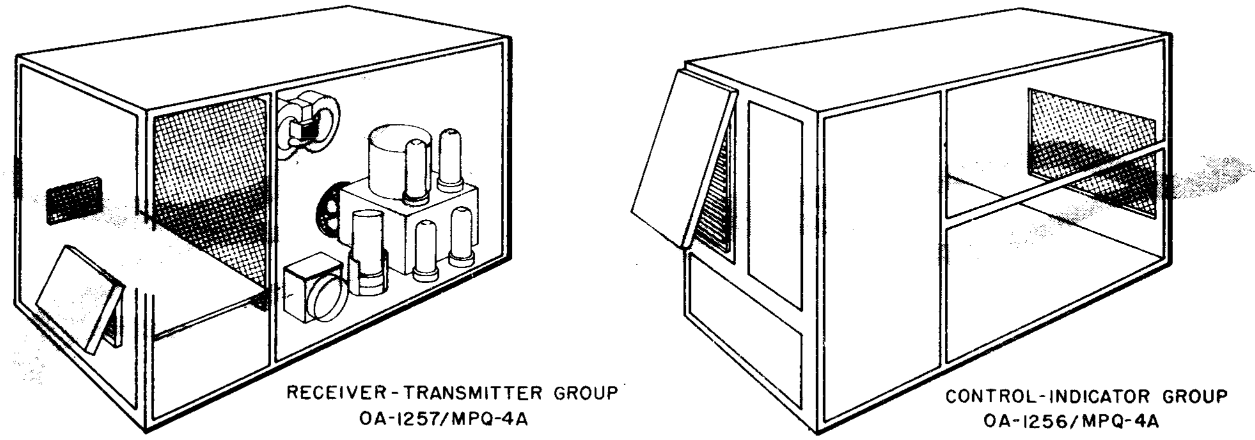


Figure 2-143. Ventilating system, air flow diagram.

(2) *Receiver-Transmitter Group OA-1257/MPQ-4A* (fig. 2-143). Cabinet blower B1101 brings air through an air intake vent in the rear of the cabinet and forces air around the transformers and tubes of the modulator. Magnetron blower B1102 brings air through an air intake vent in the rear of the cabinet and forces cool air around the magnetron. Air from blowers B1101 and B1102 combines in the modulator cabinet. The combined stream of air then splits, part of it going past the receiver-transmitter low voltage power supply and through an exhaust vent on the left side of the cabinet. The other part of the air is forced through the receiver compartment and out through an exhaust vent at the rear of the cabinet.

(3) *Electrical equipment shelters* (fig. 2-144).

(a) Equipments with serial numbers 1 through 24 use Electrical Equipment Shelter S-134/MPQ-4A. In this shelter, air is drawn in by Intake. Shelter Blower Assembly HD-279/MPQ-4A, circulated through the shelter, and exhausted by Exhaust Shelter Blower Assembly HD-278/MPQ-4A.

(b) Equipments with serial numbers 25 and above use Electrical Equipment Shelter S-134A/MPQ-4A. In this shelter, air is drawn into the shelter by two Shelter Intake Blower Assemblies HD-399/MPQ-4A, circulated through the shelter, and exhausted through two vents in the rear of the shelter.

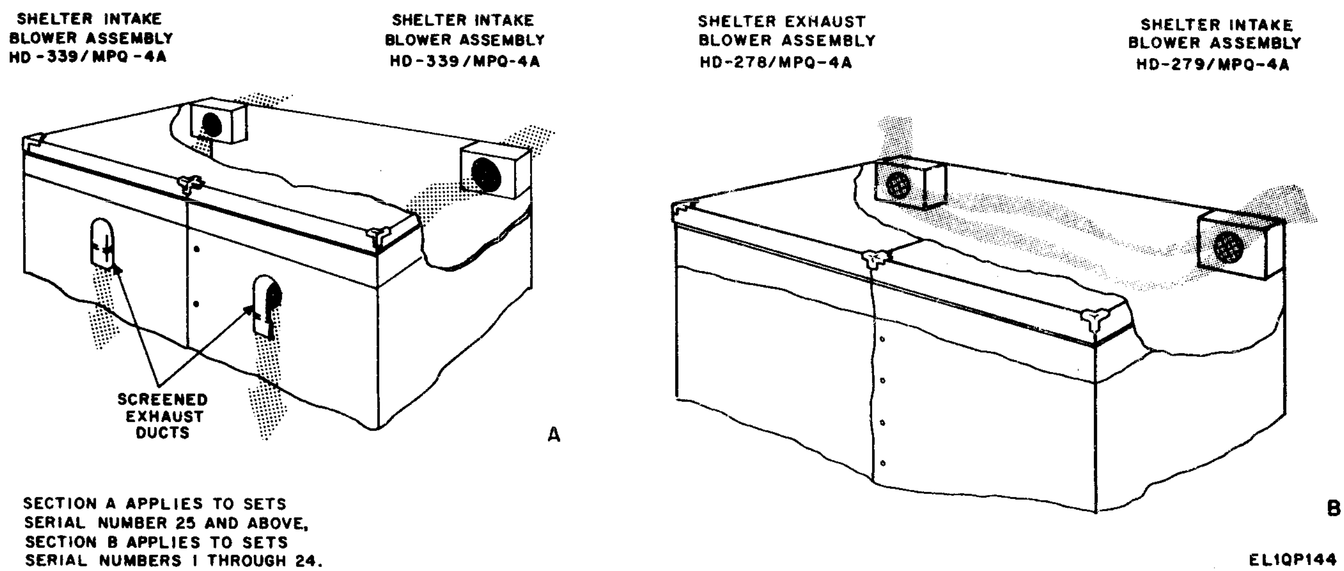


Figure 2-144. Shelter, airflow diagram.

2-49. Circuit Functioning.

a. Blowers.

(1) *General.* All the blowers in the system operate as soon as MAIN POWER switch S652 is turned ON. The blowers operate on 400-cycle, three-phase power.

(2) *Ventilation of receiver-transmitter cabinet.* Three-phase, 400-cycle power is applied to blower motors B1101 and B1102 (fig. 2-145) as soon as MAIN POWER switch S652 is turned ON. The motors turn fans which pull air through the intake vents on the cabinet.

(3) *Ventilation of control-indicator cabinet.* The blower in the control-indicator cabinet operates in the same manner as the blower in the receiver-transmitter cabinet.

(4) *Ventilation of Electrical Equipment Shelter S-134/MPQ-4A* (fig. 2-146). Phase 2 voltage is applied to the shelter intake blower when blower switch S1010 is closed and phase 2 voltage is applied to the shelter exhaust blower when blower switch S1011 is closed. Capacitors C1001 and C1002 are motor start capacitors.

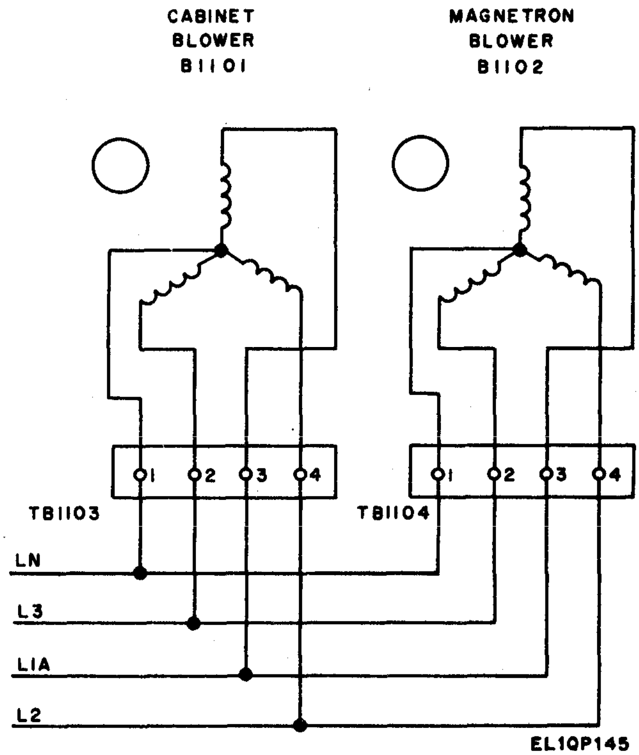


Figure 2-145. Receiver-transmitter, blowers, partial schematic diagram.

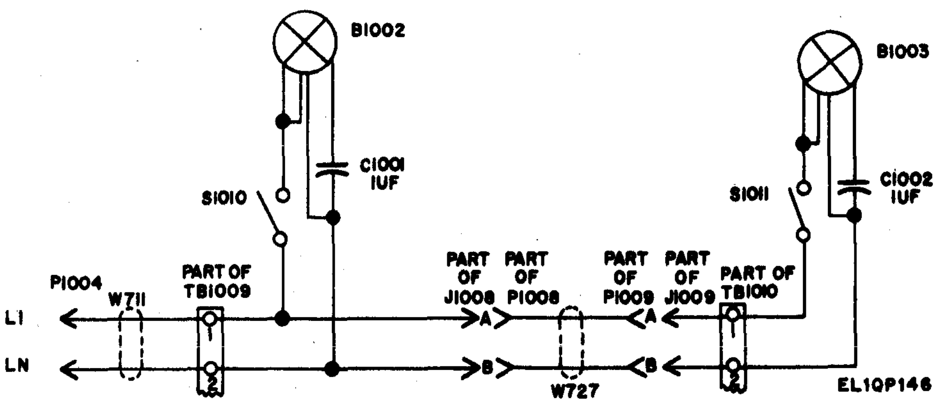


Figure 2-146. Shelter blowers, schematic diagram.

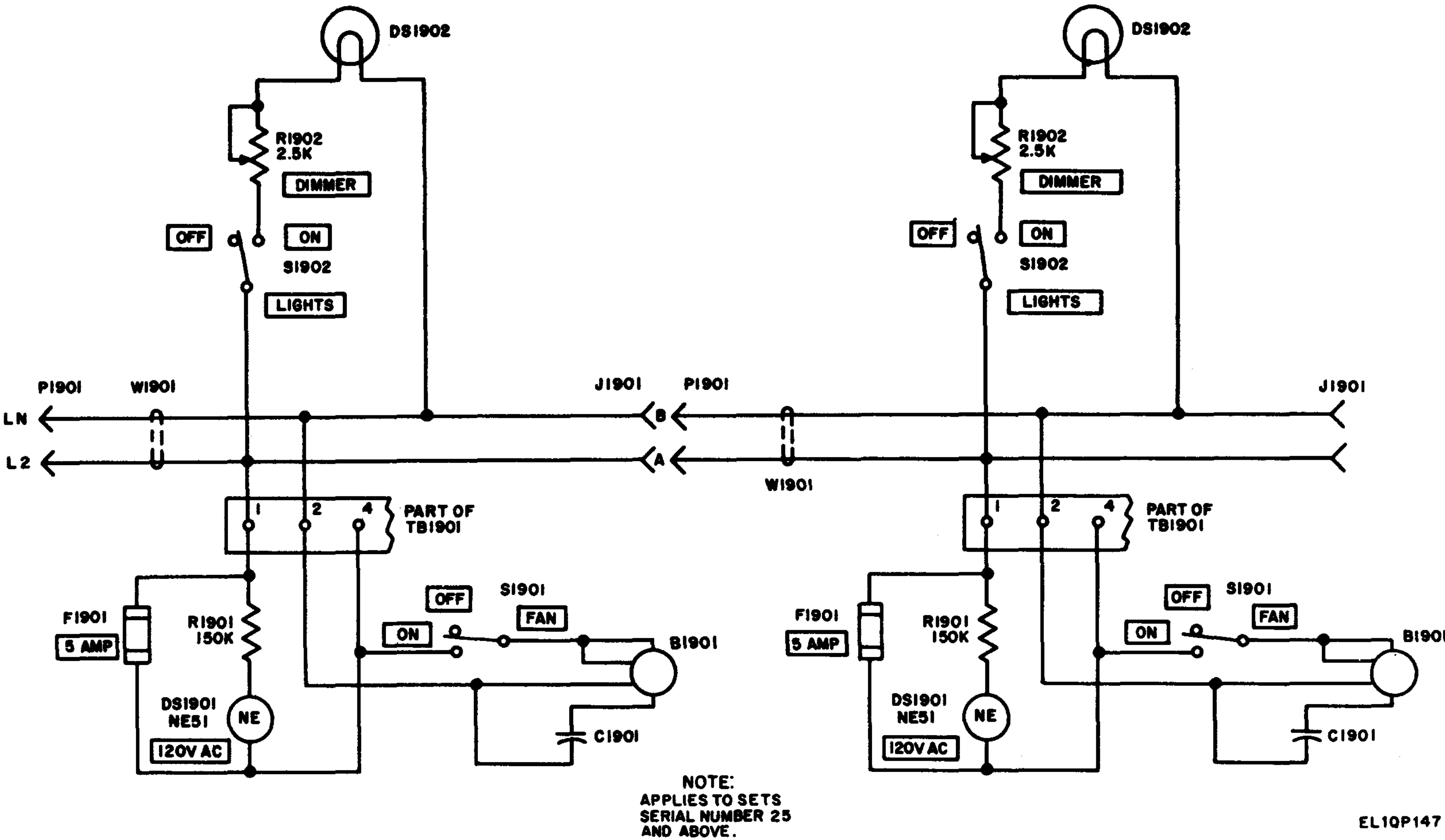


Figure 2-147. Shelter blowers, schematic diagram.

(5) *Ventilation of Electrical Equipment Shelter S-134/MPQ-4A* (fig. 2-147). The shelter uses two identical intake blowers. L 2 voltage is applied to the blowers when FAN switch S1901 is placed in the ON position. Fuse F1901 protects blower motor B1901. Resistor R1901 is a current limiting resistor for blown fuse neon indicator DS1901. Shelter lights are controlled by LIGHTS switch S1902 which applies L 2 power to lamps DS1902 through DIMMER potentiometer R1902 when placed in the ON position.

b. Dehydrator, Desiccant, Electric HD-264 (*)/MPQ-4A.

(1) *Purpose.* The dehydrator furnishes dry pressurized air to the waveguide. Air is drawn through the vent on the front of the dehydrator where it is, pressurized, dried, and passed into the waveguide. For system functioning, see TM 11-5840-208-20.

(2) *Electrical operation* (fig. 2-148 and 2-149). Three-phase, 400-Hertz power is applied to connector J3301. When the cover on the air vent is open, switch S3301 closes and applies power to motor B3301, through fuses F3301, F3302, and F3303. If the HD-264A/MPQ-4A is used, power is applied through circuit breaker CB3301 to motor B3301. The motor is a three-phase, 400-Hertz, ac motor which is used to operate the air compressor. Automatic control of dehydrator operation is provided (para 2-45 *c* (2) *(b)*).

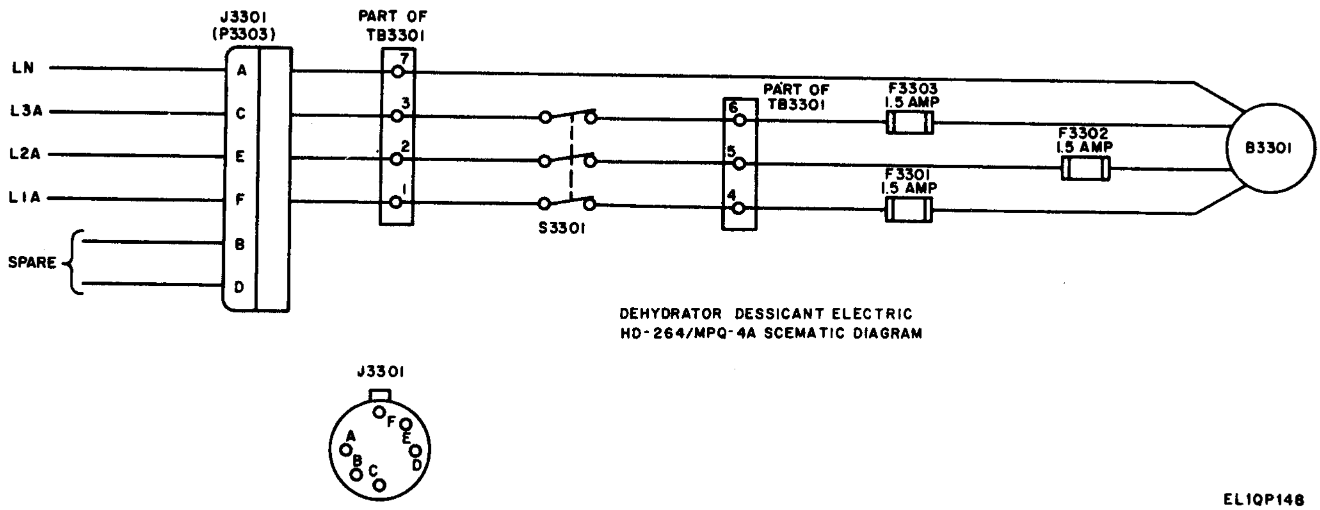


Figure 2-148. Dehydrator, Desiccant, Electric HD-264/MPQ-4A, schematic diagram.

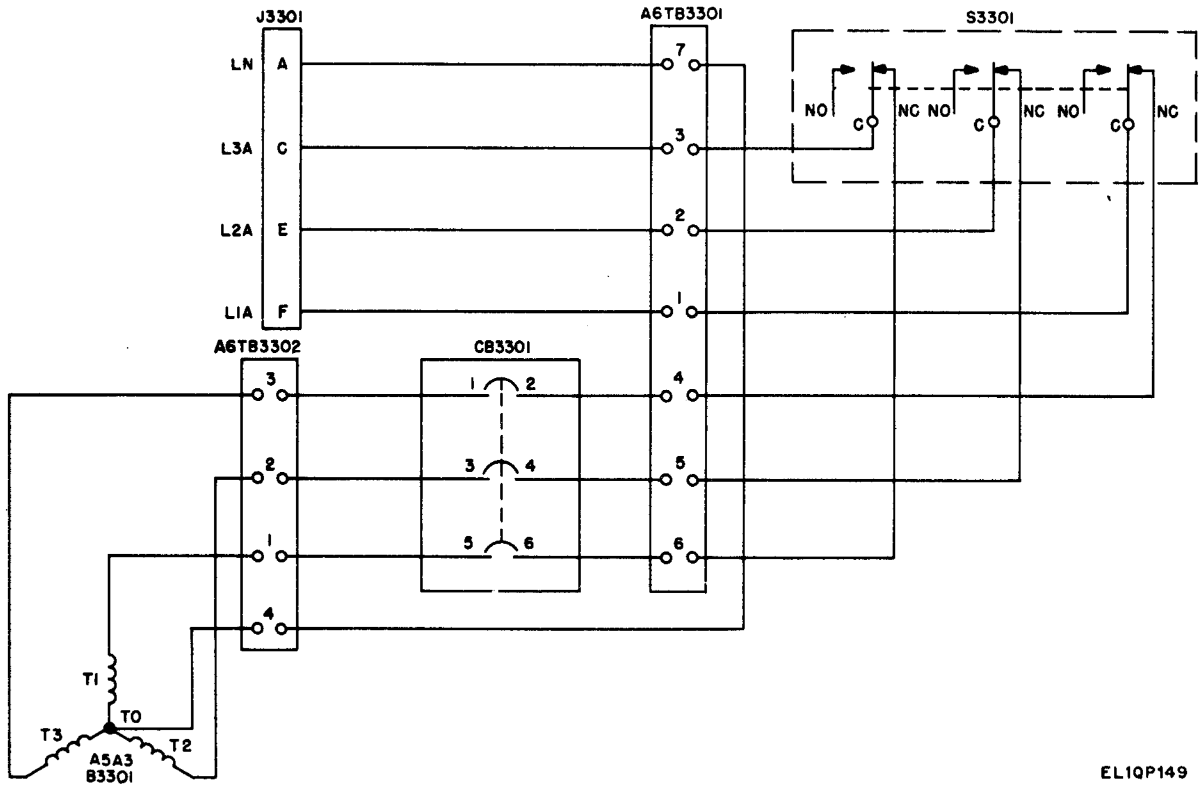


Figure 2-149. Dehydrator, Desiccant, Electric HD-264A/MPQ-4A, schematic diagram.

c. Functional Analysis of Dehydrator (fig. 2-150).

(1) *Motor and compressor assembly.*

(a) The motor is a 115/230-volt, 400-hertz three-phase wye-connected motor, rated a 0.1 horsepower, and designed for continuous duty. The motor is cooled by an integral fan, located on one end of the motor housing. The end of the motor housing is positioned with the air intake next to a filter retainer. A gasket seals the motor housing to the filter retainer so that cooling air must pass from the outside of the dehydrator cabinet through the filter. This air is then exhausted from the motor housing to the cabinet interior. A return line, incorporating a purge valve, is provided to recylcle the air, preventing moisture from collecting within the waveguide.

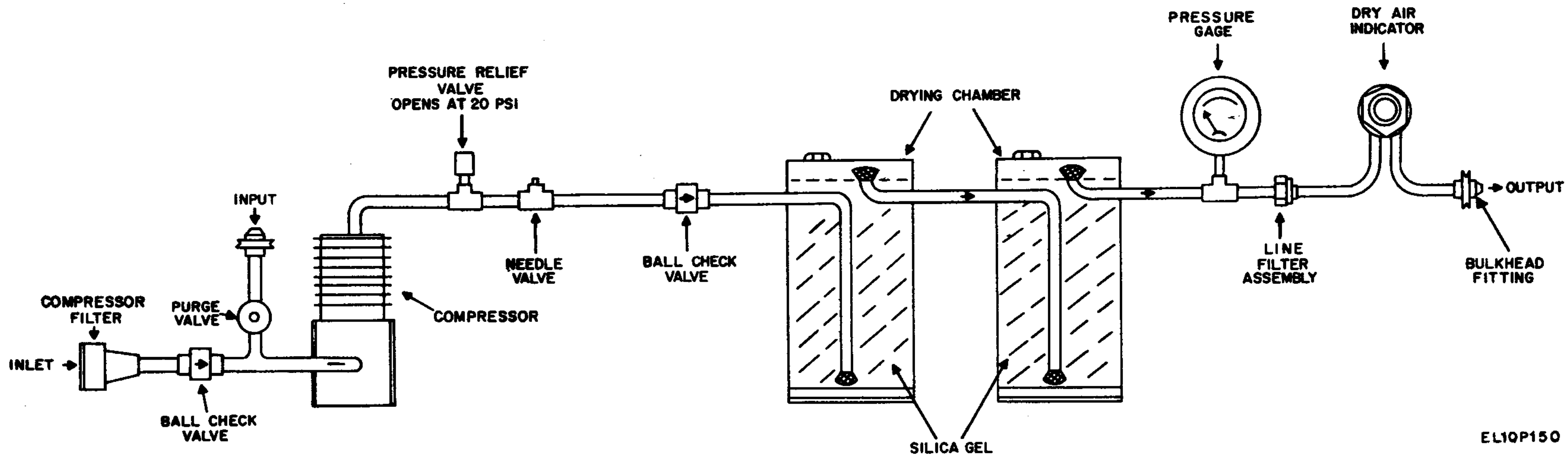


Figure 2-150. Dehydrator, functional diagram.

(b) The compressor is a single-cylinder air compressor, and is mounted on a gear-box which is secured to the end of the motor frame. The reduction gears of the gearbox operate in an oil bath. Air at atmospheric pressure is drawn from the interior of the dehydrator cabinet through the filter into the compressor case inlet. The action of the piston in the cylinder compresses the air and delivers it at higher pressure through the compressor discharge check valve to the compressor outlet.

(2) *Pressure relief value.* The pressure relief valve is spring-operated and preset to open at a pressure of approximately 20 psi, which is somewhat higher than the operating pressure of the air compressor, The pressure relief valve is installed in the system as a safety feature, to relieve pressure if other outlets of the system become plugged. If the pressure relief valve opens and allows air to escape, it is an indication that the system is not functioning properly and that a restriction exists in the system.

(3) *Needle value.* This valve has a restricting orifice to limit the flow of air. The restricted air flow reduces pressure pulsations from the output of the compressor, and thus prolongs the life of the spring in the pressure relief valve. The needle valve is preset, and does not require further adjustment. If for any reason the needle valve becomes plugged and restricts or stops the normal flow of air, the pressure relief valve will open to, relieve the pressure developed at the compressor output.

(4) *Ball check valves.* Each valve contains a spring-loaded steel ball resting against a seat. The ball check valve prevents moisture from entering the drying chambers or waveguide during periods when the compressor is not operating. The ball check valve at the output of the compressor filter permits air to circulate through the radar waveguide as a closed loop system to remove moisture, when the purge valve is open.

(5) *Drying chambers.* Two drying chambers, one in each rear comer of the dehydrator, are secured to the mounting brackets of the dehydrator cabinet with two stainless steel clamps. The two drying chambers are connected in series, with the outlet of one, hose-connected to the inlet of the other. The inlet of the first drying chamber is hose-connected to the ball check valve and the outlet of the second drying chamber is hose-connected to a tee fitting located on the pressure gage.

(a) Each drying chamber contains approximately 4 pounds of silica gel. A dry air indicator is provided in the top of each drying chamber to indicate the state of the silica gel within the chamber. The exact condition of the air available to the waveguide is determined by viewing the dry air indicator through the flange port on the front of the dehydrator cabinet.

(b) The drying chambers are tubular in construction, with inlet and outlet elbow fittings located near the top of the chambers. The inlet is connected to a length of copper tubing which passes down through the center of the silica gel to a point near the bottom center of the chamber. The end of the inlet tube is capped with fine-mesh brass wire cloth, to prevent the silica gel from entering the tube. The outlet is connected to a short lenght of copper tubing which passes up through the silica gel into the bronze-wool pad and terminates near the top center of the chamber. This tube is also capped with fine-mesh brass wire cloth. The bronze wool pad, located between the silical gen and the top of the chamber, permits an even distribution of airflow through the chamber, and also acts to remove silica gel particles from the air before it enter the outlet tube.

(c) Air under pressure enters the drying chamber through the inlet tube and passes to the bottom of the chamber, where it is dispersed throughout the silica gel. The air gives up its moisture as it reise through the silica gel, and passes through the bronze-wool pad to the outlet. In a static condition, where there is no flow of air and the waveguide is pressurized, the silica gel continues to be active and removes moisture from the air to reduce the humidity of the air contained in the waveguicte.

(d) When the silica gel is no longer active, as determined from the dry air indicator, it may be reactivated.

(6) *Pressure gage.* The pressure gage may be viewed through the flange port on the front of the dehydrator cabinet. The gage, which is calibrated for 0-30 psi, indicates the pressure in the waveguide of the radar set.

(7) *Filter assembly.* The filter consists of a felt pad held between two brass screens. The filter is designed to keep all dust and foreign particles from entering the waveguide.

(8) *Dry air indicator.* Dry air indicator may be viewed through the flange port on the front of the dehydrator cabinet. The dry air indicator is a small chamber filled with a quantity of silica gel and equipped with a transparent window through which the color of the silica gel may be observed. The dry air indicator is used to indicate the relative humidity of the air supplied to the waveguide.

(a) Silica gel is deep blue when the relative humidity is very low. The color gradually changes as the relative humidity increases, changing to

light blue when the relative humidity is about 20 percent, and to pink or white when the relative humidity is 30 percent or more. The drying chambers should be replaced or reactivated when the moisture content is such that the dry air indicator appears pink.

(b) After reactivation or replacement of the drying chambers, the silica gel in the dry air indicator gradually changes and returns to deep blue. This is a normal condition, and initially should not be interpreted as an indication of faulty drying chambers. The silica gel of the dry air indicator must release its moisture to the dry air being supplied from the drying chambers, and as this action takes place, the color of the dry air indicator will return to blue.

(9) *Bulkhead fitting.* The bulkhead fitting is located at the rear of, and extends through, the dehydrator cabinet. The connection at this fitting is made to pressurize the waveguide of the radar set. The connection should be maintained at all times, so that the active silica gel of the drying chambers may remove moisture from the waveguide. If, for any reason, the pressurizing tube is removed from the bulkhead fitting, the fitting should be sealed to prevent the entrance of moisture.

(10) *Purge valve.* The purge valve is used to circulate dry air in the dehydrating system, and purge the waveguide of moisture.

Section XII. TEST FACILITIES KIT MK-387/MPM-49

2-50. General

Test Facilities Kit MK-387/MPM-49 furnishes ac and dc operating voltages, interconnecting points, and switching between the components of Radar Set AN/MPQ-4A and test equipment for bench servicing and testing. Test Facilities Kit MK-387/MPM-49 consists of Control-Power Supply C-2014/MPQ-4A, Power Supply PP-1588/MPQ-4A, Interconnecting Box J982/MPM-49, interconnecting cables, and transit cabinets for the power supplies. For a description of the functioning of the Test Facilities Kit MK-387/MPM-49, refer to TM 11-6625-520-15.

CHAPTER 3

DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

Section I. INTRODUCTION

3-1. Purpose

a. General. This part of the manual contains information pertinent to direct support maintenance. The extent of repair that can be performed by units having direct support maintenance responsibility is limited only by the tools, test equipment, availability of replacement parts, and the skill of the repairman. The information contained in this chapter will aid the repairman in detecting abnormal operation, locating and correcting equipment trouble that causes abnormal operation, and in checking the serviceability of repaired equipment in a minimum amount of time. Instructions for performing preventive maintenance and lubrication are contained in the operator's and organizational maintenance manuals, TM 11-5840-208-10 and TM 11-5840-208-20. This information is provided to keep the equipment in good working order so that breakdowns and needless interruptions during operation will be kept to a minimum.

NOTE

If Simulator, Radar Target Signal AN/TPA-7 is being used with Radar Set AN/MPQ-4A, disconnect the AN/TPA-7 from the radar set before attempting any maintenance procedures.

b. Detecting Faulty Operation. Indications of both normal and abnormal operation are given in the various troubleshooting tables contained in this part of the manual. In addition to the indications contained in the troubleshooting tables, the normal indications that should be obtained at test jacks, the normal readings that should be obtained on meters, and the functioning of controls are listed at the beginning of each of the sections in this chapter.

c. Locating Trouble. The following types of troubleshooting tables are provided to aid in locating trouble in a minimum amount of time.

(1) *Troubleshooting based on starting procedure.* A troubleshooting table based on the starting procedure (pare 3-16 *f)* will enable the repairman to locate trouble based on indications obtained while starting the equipment.

(2) *System symptom troubleshooting tables.* A system symptom troubleshooting table is located in each system direct support maintenance section. These tables are based on symptoms which indicate the location of trouble in the system. In general, the system symptom troubleshooting table will isolate trouble more quickly than the system step-by-step troubleshooting table ((3) below).

(3) *System step-by-step troubleshooting tables.* A system step-by-step troubleshooting table is located in each system direct support maintenance section. These tables consists of a series of steps designed to evaluate all phases of operation of the particular system. In general, the system step-by-step table is more comprehensive than the symptom table ((2) above) and should be used if the symptom table does not isolate the trouble.

(4) *Component troubleshooting tables.* Component or chassis troubleshooting tables, which are located in each system direct support maintenance section, are designed to locate trouble in components when the chassis or component is connected to test equipment that is provided for bench servicing. These tables are located in the troubleshooting and repair section covering the system in which the particular chassis or component functions.

d. Correcting Trouble. The following information is included to aid in correcting equipment trouble that causes faulty operation.

(1) Corrective measures are given in each troubleshooting table.

(2) Paragraphs covering the removal and replacement of parts follow each troubleshooting table.

(3) Instructions for performing alignment procedures are included after the removal and replacement of parts paragraphs.

(4) Instructions for performing a complete alignment on the radar set are contained in paragraph 3-59.

e. Checking Serviceability. Testing procedures designed to check the serviceability of repaired items of equipment are included after the alignment procedures. Instructions for testing the complete radar set are contained in paragraph 3-64.

3-2. Troubleshooting Techniques

a. General. To be effective, troubleshooting must be systematic. It is seldom possible to observe a symptom of trouble and immediately diagnose that cause. Generally, it will be necessary to perform a sequence of operational checks, observations, and measurements before the cause of a trouble is revealed. If the proper sequence is followed, the trouble will be traced first to either a component or a system, then to a portion of the system or component, and finally to the defective part. The sequence of steps is commonly referred to as a sectionalization, localization, and isolation of trouble.

b. Sectionalization. The first aim in troubleshooting is to sectionalize trouble to either a system or a component. Sectionalization can be accomplished through visual checks and operational checks and measurements contained in the troubleshooting table based on the starting procedure.

(1) If troubleshooting is to be accomplished with the components of the radar set interconnected, proceed from the troubleshooting table based on the starting procedure to the system troubleshooting table referenced in the troubleshooting table based on the starting procedure.

(2) If troubleshooting is to be accomplished by bench servicing components, proceed from the troubleshooting table based on the starting procedure to the component troubleshooting table referenced in the troubleshooting table based on the starting procedure.

c. Localization. After the trouble has been sectionalized, the troubleshooting table based on the starting procedure will reference either a system, a component, or a chassis troubleshooting table. The system, component, and chassis troubleshooting table localize the trouble to a portion (usually a stage) of the system, component, or chassis.

d. Isolation. After the trouble has been localized to a portion (usually a stage) of a system, component, or chassis, use visual inspection, voltage and resistance measurements (para 3-6), waveform analysis (para 3-5), and substitution (para 3-10) to determine the defective part.

3-3. Troubleshooting Data

a. General. In addition to the troubleshooting tables, other troubleshooting information is supplied to help repairman rapidly locate troubles. A list of the specific troubleshooting data which will help locate troubles in each particular system is given in the reference data paragraph contained in the beginning of each troubleshooting and repair section. The following types of troubleshooting data are supplied and should be consulted when necessary.

b. Block Diagram. The block diagram give the electrical and mechanical interrelationships among the systems, components, and stages of the radar set. By observing the symptoms and reasoning possible causes, it is often possible to trace the cause of faulty operation to a trouble in a particular block.

c. Cabling Diagram. This diagram is located in TM 11-5840-208-10 and shows the cabling between components of the radar set. This type of diagram can be used to check the cabling.

d. Interconnection Diagram. This diagram (fig. FO-21) shows all the interconnections between components of the radar set. It shows the wiring between terminal boards and receptacles in one component to terminal boards and receptacle in another component. This diagram is especially useful for tracing troubles between components.

e. Complete Schematic Diagrams. A complete schematic diagram is provided for each major component. This type of diagram shows all of the circuitry in the component and can be used to determine the faulty part in a particular component. Complete coverage of the radar set is accomplished by using the complete schematic diagrams in conjunction with the interconnection diagram *(d* above).

f. Simplified Schematic Diagrams. Simplified schematic diagrams which are located in this manual are functional segments of complete schematic diagrams. These diagrams make it easier to follow the electrical and mechanical functioning of the circuits.

g. Voltage and Resistance Diagrams. A voltage and resistance diagram is provided for each major component. This type of diagram gives normal voltage and resistance measurements at all tube socket pins and at other significant points, and is helpful when making voltage and/or resistance measurements to trace the fault to a specific part. When using these diagrams, carefully read the notes and exactly duplicate the conditions under which the readings were obtained.

h. Location of Parts Illustrations. Illustrations showing the location of each part in a component or chassis are contained in each of the system maintenance chapters. These illustrations help to rapidly locate a part.

i. Waveform Illustrations. Wave form illustrations are provided for the synchronizing and indicating system, the if. amplifier, the stc assembly, and the afc assembly. Troubles may be isolated rapidly by using the wave forms given. A complete explanation on the use of the wave forms is contained in paragraph 3-5.

j. Power Distribution and Control Diagrams. The power distribution and control diagrams show the distribution of ac power throughout the system, and the relays, interlocks, and switches which affect the distribution of ac voltages. These diagrams will be useful when sectionalizing a trouble to a particular system.

k. Color Codes. Resistor and capacitor color codes aid in determining the values of resistors and capacitors. These illustrations (fig. FO-19) give the MIL STD color codes for resistors, capacitors, and standoff and feedthrough capacitors.

l. Normal Panel Meter Indications. A table listing the normal indications of panel meters is included in each system section. Any deviation from normal may be an indication of trouble in that particular system.

m. Normal Indications at Test Jacks. A table giving the normal indications at test jacks is included in each section. These indications may be waveforms, voltage, or resistance measurements. Any deviation from the normal indication at the teat jacks indicates trouble.

n. Dc Resistance of Transformers and Coils. A table of the dc resistance of transformers and coils of each system is included. These tables will be beneficial in isolating troubles to a particular part in a system.

3-4. Reference Designation Number Location Table

To aid in parts location, a block of reference designation numbers has been assigned to each major component and circuit board of Radar Set AN/MPQ-4A. For example, all parts in Control-Power Supply C-2014/MPQ-4A are given 500 numbers; that is, fuses in this component are designated as F651 and F653; and switches are designated as S658 and S659. Table 3-1 lists the block of reference designation numbers assigned to each major component and circuit board. Since parts of the various systems are located in different components, the table lists the system in which the part operates.

Table 3-1. Reference Designator Number Location Table

Reference designation No.	Component	System
100-151	Azimuth and Range Indicator IP-375/MPQ-4A (cabinet).	Synchronizing, indicating, and receiving.
161-175	Azimuth and Range Indicator IP-375/MPQ-4A (hv rectifier).	Indicating.

Table 3-1. Reference Designation Number Location Chart –Continued

Reference designation No.	Component	System
200-230	Azimuth and Range Indicator IP-375/MPQ-4A (long gate generator Z101).	Synchronizing.
231-260	Azimuth and Range Indicator IP-375/MPQ-4A (timing sweep generator Z102).	Synchronizing.
400-420	Azimuth and Range Indicator IP-375/MPQ-4A (range zero trigger pick-off amplifier Z107, delay trigger pick-off amplifier Z108, and range trigger pick-off amplifier Z109).	Synchronizing.
500-560	Azimuth and Range Indicator IP-375/MPQ-4A (azimuth synchronizer Z150).	Synchronizing.
600-699	Control-Power Supply C-2014/MPQ-4A.	Dc power supplies.
700-799	System intercabling and waveguide.	Rf (in part).
800-999	Radar Date Computer CP-319/MPQ-4A.	Computing.
1000-1099	Control-Indicator Group OA-1256/MPQ-4A (cabinet) Electrical Equipment Shaker S-134/MPQ-4A (blowers).	Ventilating.
1100-1150	Modulator-transmitter	Transmitting.
1151-1199	Trigger Pulse Amplifier AM-1537/MPQ-4A.	Transmitting.
1200-1299	Intermediate Frequency Amplifier AM-1538/MPQ-4A.	Receiving
1300-1399	Receiver Control C-2016/MPQ4-A (afc assembly.	Receiving (antenna positioning in part).
1400-1499	Control-Monitor C-2102/MPQ-4A.	
1500-1599	Receiver compartment of receiver-transmitter group.	Receiving.
1600-1699	Power Supply PP-1588/MPQ-4A.	Dc power supplies.
1700-1799	Tuned Cavity FR-11-MPQ-4A.	Rf.
2000-2099	Receiver-Transmitter Group OA-1257/MPQ. 4A (receiving section of cabinet).	
2600-2699	Test Facilities Kit MK-387/MPQ-4A.	Not part of Radar Set AN/MPQ. 4A.
3000-3099 3200-3299	Antenna Group OA-1258MPQ-4A.	RF, antenna positioning and synchronizing.

Table 3-1. Reference Designation Number Location Chart -Continued

Reference designation No.	Component	System
1-99, 3300-3399	Electric Desiccant Dehydrator HD-264(*) MPQ-4A.	Dehydrating.
3300-3399	Electric Desiccant Dehydrator HD-264/MPQ-4A.	Dehydrating.
4400-4499	Azimuth and Range Indicator IP-375/MPQ-4A (range sweep generator and driver Z144).	Indicating.
4500-4550	Azimuth and Range Indicator IP-375/MPQ-4A (azimuth sweep generator Z145).	Indicating.
4551-4570	Azimuth and Range Indicator IP-375/MPQ-4A (video blanking Z146).	Synchronizing.
4571-4599	Azimuth and Range Indicator IP-375/MPQ-4A (modulator trigger generator Z147).	Synchronizing.
4600-4650	Azimuth and Range Indicator IP-375/MPQ-4A (video amplifier Z148).	Indicating.
4651-4699	Azimuth and Range Indicator IP-375/MPQ-4A (in. tensifier and short gate generator Z149).	Indicating.
4700-4799	Receiver Control C-2015/MPQ-4A,	Receiving (Syn. chronizing, in part).
4800-4899	Thyratron Voltage Regulator VR1101.	Transmitting.

3-5. Waveform Analysis

a. Waveforms may be observed at various test jacks and at other significant points in the circuits of Radar Set AN/MPQ-4A by using Oscilloscope AN/USM-281C. Detailed instructions for operating the oscilloscope are contained in TM 11-6625-2658-14. The normal waveforms that should be obtained at test jacks and at other significant points are shown on waveform illustrations located in each maintenance section. By comparing observed waveforms with the normal waveforms, troubles can sometimes be quickly located.

b. Before comparing the waveforms with the normal waveforms, carefully read the notes on the waveform illustrations and exactly duplicate the conditions under which the normal waveforms were obtained.

c. Abnormal waveforms indicate trouble between the point at which the waveform is observed to be normal and the point at which the waveform is observed to be abnormal. For example, if a waveform is normal at the grid of a stage and abnormal at the plate of the same stage, trouble is in that stage. When trouble is indicated in a stage, replace the tube before making any further tests. If replacing the tube does not correct the trouble, replace the original tube in the socket and take voltage and resistance measurements at the tube socket pins (para 3-6).

d. When a waveform at a certain point is observed to be abnormal, the cause may be the absence of a signal from another component. The point at which to start checking waveforms is at the component input trigger jack. To determine whether a signal is reaching the grid of the first tube in a particular channel when a test jack is not provided, remove the first tube in the channel and insert the oscilloscope test lead into the grid correction of the tube socket.

3-6. Voltage and Resistance Measurements

a. Voltage and resistance measurements are an aid in determining circuit condition and in evaluating clues in the course of troubleshooting. Electronic Multimeter ME-26/U and Multimeter TS-352B/U are provided and should be used to measure these quantities. Detailed instructions for operating Electronic Multimeter ME-26/U are contained in TM 11-6625-200-15-12; Multimeter TS-352B/U in TM 11-6625-366-15.

b. Compare the measured values of voltage and resistance diagrams located in each maintenance section. Use the specific multimeter on which the normal indications were obtained. Carefully read the notes on the diagrams and exactly duplicate the conditions under which the normal indications were obtained.

c. When making measurements greater than 300 volts, observe the following precautions:

(1) Shut off the power.
(2) Discharge high voltage capacitors.
(3) Connect the multimeter leads to the test points.
(4) Step away from the multimeter.
(5) Turn on the power.
(6) Note the indication on the multimeter.
(7) Turn off the power.
(8) Discharge high voltage capacitors.
(9) Remove the multimeter leads.

3-7. Replacing Parts

Careless replacement of parts often creates new troubles. When replacing parts, observe the following precautions:

a. Before a part is unsoldered, note the position of the leads. If a part, such as a transformer or a switch, has a number of connections, tag each lead so that the proper connections will be made when replacing the part. Be careful not to damage other leads by pulling or pushing them away.

b. It is very important to make well-soldered joints. A carelessly soldered joint may create a new trouble and is one of the most difficult troubles to locate. Do not allow drops of solder to fall into the equipment as they may cause short circuits.

c. When a part is replaced in the rf or if. circuit, be sure to place it in exactly the same position as the original part. A part which has the same electrical value but different physical size may cause trouble in high frequency circuits. In such circuits, use the same type capacitor for replacement and the same length lead because of the self-resonant frequencies of different types of capacitors. When replacing parts in high frequency circuits, use the same ground as in the original wiring. Failure to observe these precautions may result in decreased gain or possibly in unwanted oscillations.

d. Whenever a part has been replaced, make necessary adjustments and check the performance of the equipment to be sure that the original trouble has been remedied and that no new trouble has developed in the equipment as a result of the repair.

3-8. Cable Check and Repair

The cables and connectors used for connections between the components of Radar Set AN/MPQ-4A are supplied as completely fabricated assemblies (para 3-10).

a. Continuity. Very often a cable is too long to be measured for continuity with the ohmmeter leads at each end of the cable. Perform the following procedures to determine the condition of a cable.

(1) Place a resistor of known value (50,000 ohms or more) from one end of the cable to ground.

(2) Connect the ohmmeter leads between the cable and ground at the other end of the cable.

(3) If the meter indicates approximately 50,000 ohms, the cable has continuity.

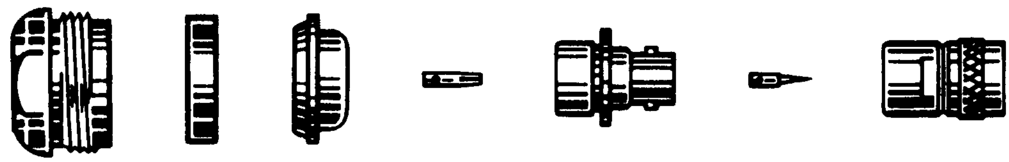
(4) If the meter indicates infinite resistance, the cable is open.

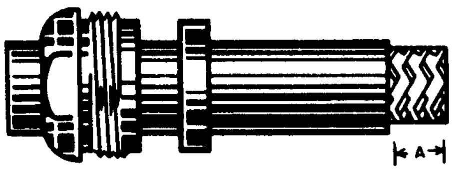
(5) If the meter indicates zero resistance, the cable is shorted to ground.

(6) If the meter indicates much less than 50,000 ohms, but not necessarily zero, the cable has a dc leakage path to ground.

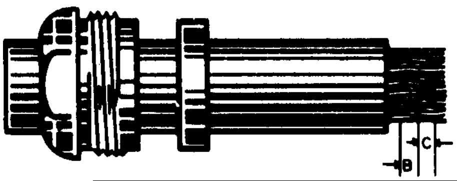
b. Repair. A damaged cable connector cannot be repaired; it must be replaced. Broken cables are spliced by placing a male connector on one end of the break and a female connector on the other end. The cables are then joined by mating the two connectors. The procedure for attaching connectors to cable ends is shown in Figures 3-1 and 3-2.

ASSEMBLY OF TYPE C CONNECTORS

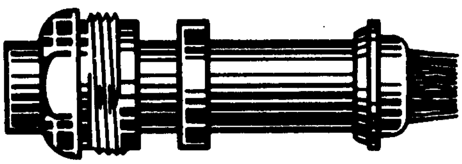




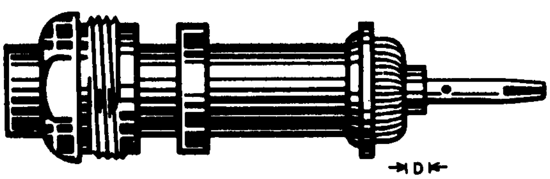
PLACE NUT AND GASKET OVER CABLE AND JACKET TO DIMENSION A.



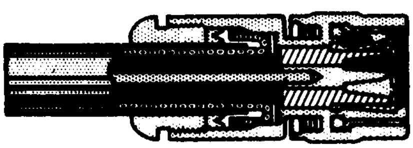
COMB OUT BRAID AND FOLD OUT. CUT CABLE DIELECTRIC TO DIMENSION B.



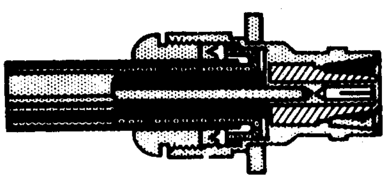
PULL BRAID WIRES FORWARD AND TAPER TOWARD CENTER CONDUCTOR. PLACE CLAMP OVER BRAID AND PUSH BAKC AGAINST CABLE JACKET.



FOLD BACK BRAID WIRES PROPER LENGHT, AND FORM OVER, CLAMP AS SHOWN. SOLDER CONTACT TO CENTER CONDUCTOR. DIMENSION D SHOULD BE AS SHOWN.



INSERT CABLE AND PARTS INTO CONNECTOR BODY. MAKE SURE SHARP EDGE OF CLAMP SEATS PROPERLY IN GASKET. TIGHTEN NUT. END OF CONTACT IN PLUG SHOULD BE FLUSH WITH INSULATOR. THERE SHOULD BE A CLEARANCE OF .010 IN. BETWEEEN END OF CONTACT AND INSULATOR IN JACK.



TYPE NUMBERS	A	B	C	D
570-U, 571-U, 573-U 626-U, 629-U, 630-U	9/32	1/8	5/32	1/16
62[illegible]-U, 631-U,	3/8	7/32	5/32	5/32
628-U, 632-U	19/32	7/16	5/32	11/32

EL1QP154

Figure 3-1. Assembly C-type connector.

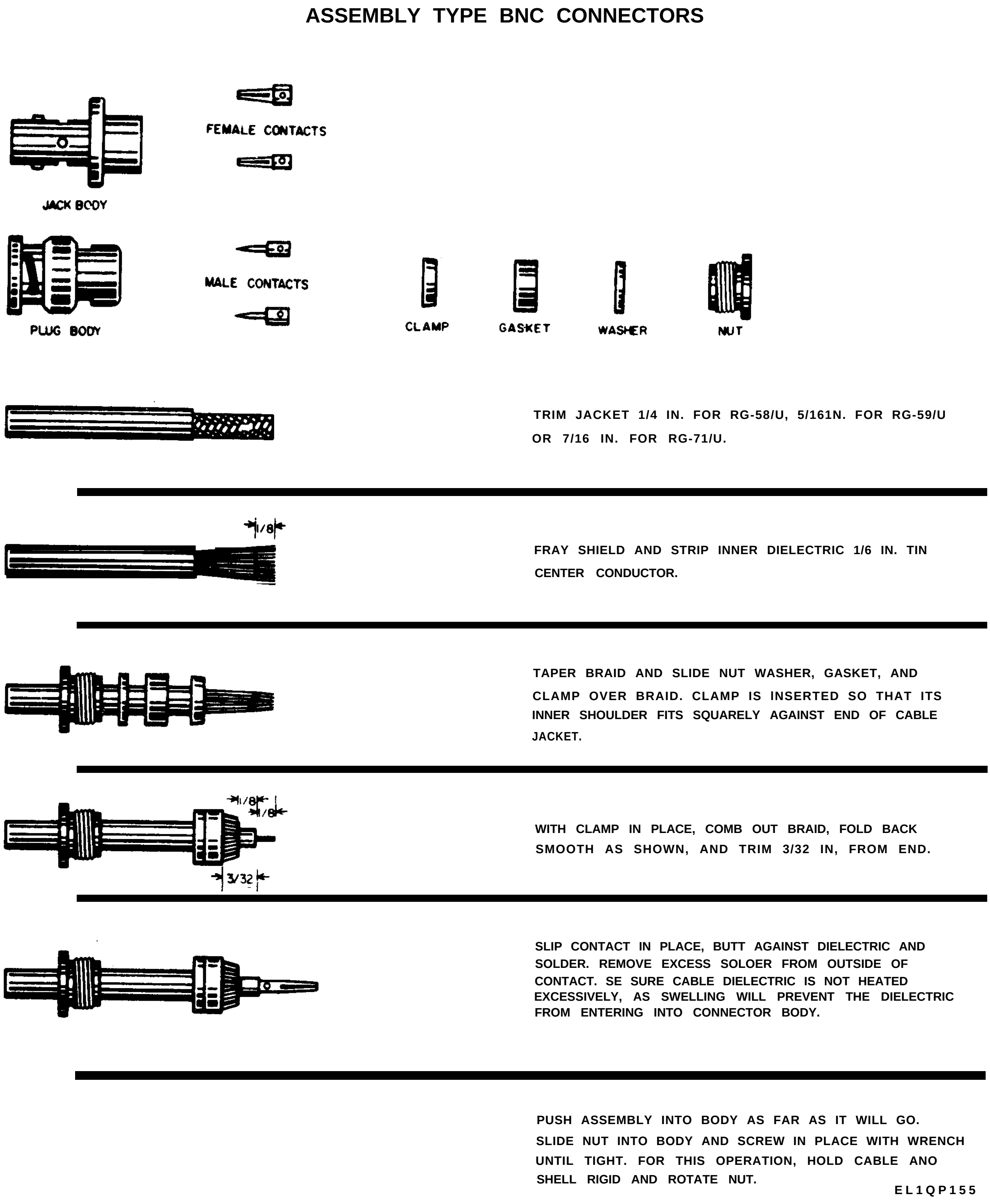


Figure 3-2. Assembly BNC connectors.

c. *Precautions To Be Observed.* To avoid repairing cables, observe the following precautions:

(1) Avoid sharp bends in cahbles.

(2) Provide slack in cables to avoid strain on the connectors and the connecting panel.

(3) When measuring cables, allow 2½ inches

for mounting a straight plug. Allow an additional inch for every 10 feet of cable run, but keep all cables to a minimum.

(4) Use only resin-core solder, and after soldering clean off any excess resin.

d. Fabrication of Cables. Several multiconductor types of cables are supplied with Radar Set AN/MPQ-4A. These cables are terminated in either a C-type connector or a BNC connector (fig. 3-1 and 3-2).

e. Internal Cable Check. Check all internal cables for looseness at their plug ends or terminal board lugs. See that cables go to the proper jack or terminal screw. For a pictorial diagram and cabinet connection diagrams of the receiver-transmitter group, see TM 11-5840-208-10.

3-9. Ground Connection

Check all ground connections thoroughly, because erratic operation may be cawed by loose or broken ground connection. Check the grounding bar on high voltage to see if it grounds out residual high voltage when the modulator door is opened. This check is especially important because of the danger of electrical shock by operating or maintenance personnel.

3-10. Parts Substitution

a. Do not substitute parts indiscriminately; substitute only when-

(1) The trouble has been isolated to a specific stage.

(2) The tube has been replaced.

(3) All voltage indications are normal.

(4) All resistance indications are normal.

b. Type of troublea which would satisfy all of the above conditions are: open bypass or coupling capacitors, capacitors that have changed value, and an interstate transformer with shorted turns.

c. When an *open* capacitor is suspected, connect a known good capacitor of equal value across the capacitor and check the operation of the component.

d. When all other possibilities of trouble are ruled out, substitute a good part for the one which is suspected of being defective.

3-11. Intermittent

a. If the operation of a component is intermittently faulty, the trouble may be difficult to locate when the component is functioning normally. Such troubles can often be found by lightly tapping each part in the suspected stage or portion of the component with a nonmetallic pencil or insulated rod, and at the same time, watching the indicator screen. Lightly tap all of the parts including tubes and wiring. If the screen presentation remains normal, repeat the tapping process at adjoining stages until the normal indications change.

b. Intermittent operation can be caused by loose connections, broken wires, or parts (including tubes) with internal defects. Sometimes intermittent troubles can be located by observing erratic behavior of one of the controls.

Section II. TOOLS AND TEST EQUIPMENT

3-12. Tads Supplied.

The following tools are supplied with Radar Set AN/MPQ-4A.

Quantity	Tool
1	Pawl fastener wrench.
1	TL-111 6-inch angle, adjustable wrench.
1	strap wrench.
1	5/16 Spintite wrench.
1	7/16-inch Spintite wrench.
1	TL-567/U, Allan wrench.
1	5/64-inch AUan wrench.
1	2- to 4-9/4-inch spanner wrench.
1	1-1/4- to 3-inch spanner wrench.
1	Reversible screwdriver with a No. 6 Allen wrench on one and and a No. 10 Allen wrench on the other end.

3-13. Tools Required.

The following tools are required to maintain Radar Set AN/MPQ-4A, but are not supplied with the radar set.

Quantity	Tool
1	Tool Kit, Electronic Equipment TK-100/G.
1	Radar Repair Tool Kit TK-94/MPQ-4A.

3-14. Test Equipment Contained in Maintenance Kit, Electronic Equipment MK-673/MPQ-4A

a. Table 3-2 lists the items of test equipment which are part of Maintenance Kit, Electronic Equipment MK-673/MPQ-4A. The table also lists a brief description of the use of each item.

Table 3-2. Test Equipment, Maintenance Kit Electronic Equipment MK-673/MPQ-4A

Test equipment	Use
Electrical Dummy Load DA-205/MPQ-4A	Dummy load for teating Control-Power Supply C-2014/MPQ-4A.
Electrical Dummy Load DA-206/MPQ-4A	Dummy load for testing Power Supply PP-1588/MPQ-4A

Table 3-2. Test Equipment, Maintenance Kit, Electronic Equipment MK-673/MPQ-4A – Continued

Test equipment	use
Motor-Generator PU-20C/C	Furnishes single-phase ac power for bench servicing.
Motor-Generator PU-335/MPM-25	Furnishes three-phase power for bench servicing.
Test Facilities Kit MK-387/MPM-49 (table 3-3).	Furnishes interconnecting points, control, power, and cabling for bench servicing component.
Radar Repair Tool Kit TK-94/MPQ-4A (teble 3-4).	
Electronic Equipment Maintenance Kit MK-399/MPQ-4A (table 3-5).	Bore sighting the radar set.
Attenuator, Variable CN-491G	Vswr tests.
Attenuator, Variable CN-492/G	Vswr tests.
	Vswr tests.
coupler, Directional CU. 673/U	Scanner teste.
	Scanner tests.
Simulator, Antenna Position SM-154/MPQ-4A	Furnishes antenna data and pulses for bench servicing.

b. Table 3-3 lists the items contained in Test Facilities Kit MK-387/MPM-49.

c. Table 3-4 lists the tools contained in Radar Repair Tool Kit TK-94/MPQ-4A.

d. Table 3-5 lists the items contained in Electronic Equipment Maintenance Kit MK-399/MPQ-4A.

3-15. Test Equipment Required for Testing

Table 3-6 lists the items of test equipment which are used to perform direct support maintenance and tests on Radar Set AN/MPQ-4A. The table also lists the literature that covers each item and gives a brief description of the use of each item.

Table 3-3. Test Equipment, Test Facilities Kit MK-387/MPM-49

Quantity	item	use
1	Control-Power Supply C-2014/MPQ-4A with cover CW-475/MPM-49.	Furnishes dc voltages for bench servicing.
1	Power supply PP-1588/MPQ-4A with Cover CW-476/MPM-49.	Furnishes dc voltages for bench servicing.
1	Interconnecting Box J. 982/MPM-49.	Furnishee inter-connecting point for bench servicing.
1	Set of cable assemblies.	For interconnecting components end test equipment.

Table 3-4. Tools, Rodor Repair Tool Kit TK-94/MPQ-4A

Quantity	Tool
1	Screw driver, No. 0 point size, Phillips.
1	Screw driver, special (GE drawing No. 7415697)
1	Wrench, spanner, 1¼ to 3 inch.
1	Wrench, spanner, 2 to 4¾ inch.
1	Wrench, strap, 1/8 to 2 inch.
1	Wrench, TL-112, 10-inch adjustable.
1	Wrench, pawl (GE drawing No. 122070).

Table 3-5. Electronic Equipment Maintenance Kit MX-399/MPQ-4A

Test equipment	Use
Antenna Group OA-1967/MPM-25.	Bore sighting the radar set.
Frequency Mixer Stage CV. 662/G.	Bore sighting the radar set.
Waveguide Probe RF-74/U......	Bore sighting the radar set.
Flexible Waveguide CG-539/U.	Bore sighting the radar set.
1 set cable assemblies	Bore sighting the radar set.
Case, Accessories CY-3684/MPQ-4A	Case.

Table 3-6. Test Equipment Required for Testing

Test equipment	Literature	use
Spectrum Analyzer AN/UPM-58	TM 11-5099	To check magnetron spectrum.
Signal Generator SG-299/U	TM 11-6625-258-14	To furnish a square wave trigger voltage at the correct repetition rate.
Computer Teat Set TS-909/PPM	TM 11-1223	To align the computer.

Table 3-6. Test Equipment Required for Testing-Continued

Test equipment	Litarature	Use
Electron Tube Test Set TV-7/U.	TM 11-6625-274-12	To test tubes.
Radar Test Set AN/UPM-60A	TM 11-6625-228-12	To furnish an RF signal for bore sighting the radar set.
Crystal Rectifier Test Set TS-288E/U	TM 11-1242	To check crystal diodes.
Multimeter TS-352B/U	TM 11-6625-366-15	Voltage and resistance measuremants.
Electron Tube Test Set TV-13/U	TM 11-6625-404-12	To teet klystron tube.
Radar Test Set AN/UPM-96	TM 11-6625-393-12	To make microwave noise teats.
Variable Power Transformer TF-171/USM		To teet power supplies and capsule voltage ragulator.
Amplifier, Radio Frequency AM-1881/U	TM 11-6625-353-12	Bore sighting.
Signal Generator TS-452C/U	TM 11-6625-283-12	If. alignment.
Pulse Generator AN/PPM-1	TM 11-6625-237-14	Furnishes pulses for bench servicing.
Voltmeter, Electronic ME-30B/U	TM 11-6625-320-12	Voltage measurements.
Multimeter ME-26B/U	TM 11-6625-200-15	Voltage and resistence measurements.
Electronic Counter, Digital Readout AN/USM-207	TM 11-6625-700-10	Synchronizer repetition rate measurement.
Oscilloscope AN/USM 281C	TM 11-6625-2658-14	Waveform display end measurement.
Pressure gage, 0 to 20 pei, accuracy ±0.5 psi		Accuracy check of dehydrator pressure gage.
Outlet adapter, air, to fit 7/16 x 30 external thread		Accuracy check of dehydrator **pressure gage.**

Section III. TROUBLESHOOTING BASED ON STARTING PROCEDURE

3-16. Troubleshooting Information

a. General. The troubleshooting table based on the starting procedure (para 3-16f) will aid in detecting abnormal operation of the radar set and in locating faulty parts causing abnormal operation.

(1) Follow the step-by-step starting procedure while carefully observing the normal indications listed for each step.

(2) If the normal indications are not obtained, observe the abnormal indications and check the abnormal indications column for the particular abnormal indications obtained.

(3) Perform the checks given in the corrective measures column for the particular abnormal indications obtained.

NOTE

Troubleshooting and maintenance procedures are baaed on the equipment being in the dual-beam mode unless otherwise stated.

b. Reference Data The data given below will be helpful in using troubleshooting table based on the starting procedure to troubleshoot the radar set.

Reference	Data
Pera *2-45a* through *g.*	Functioning of circuits in the power distribution end control System.
Para 3-16 *c*	Fuses and interlock.
Fig. FO-17	Dc control circuits diagram.
Fig. FO-16	AC power distribution diagram.
Fig. FO-21	Radar Set AN/MPQ-4A, intercabling diagram.
Fig. 3-3	Control-Indicator Group OA-1256/MPQ 4A, front panel.
Fig. 3-4	Receiver. Transmitter Group OA-1257/MPQ-4A, front palled.
Fig. 3-6	Control-indicator cabinet, left aide view showing air intake vent and terminal boards.
Fig. 3-7	Control-Power Supply C-2014/MPQ-4A, rear view of control panal.
Fig. 3-9	Elevation relays K1501 and K1502.
Fig. 2-148	Dehydrator, Dasiccant, Electric HD-264/MPQ-4A Schematic diagram.
Fig. 2-149	Dehydrator, Desiccant, Electric HD-284A/MPQ-4A schematic. diagram.

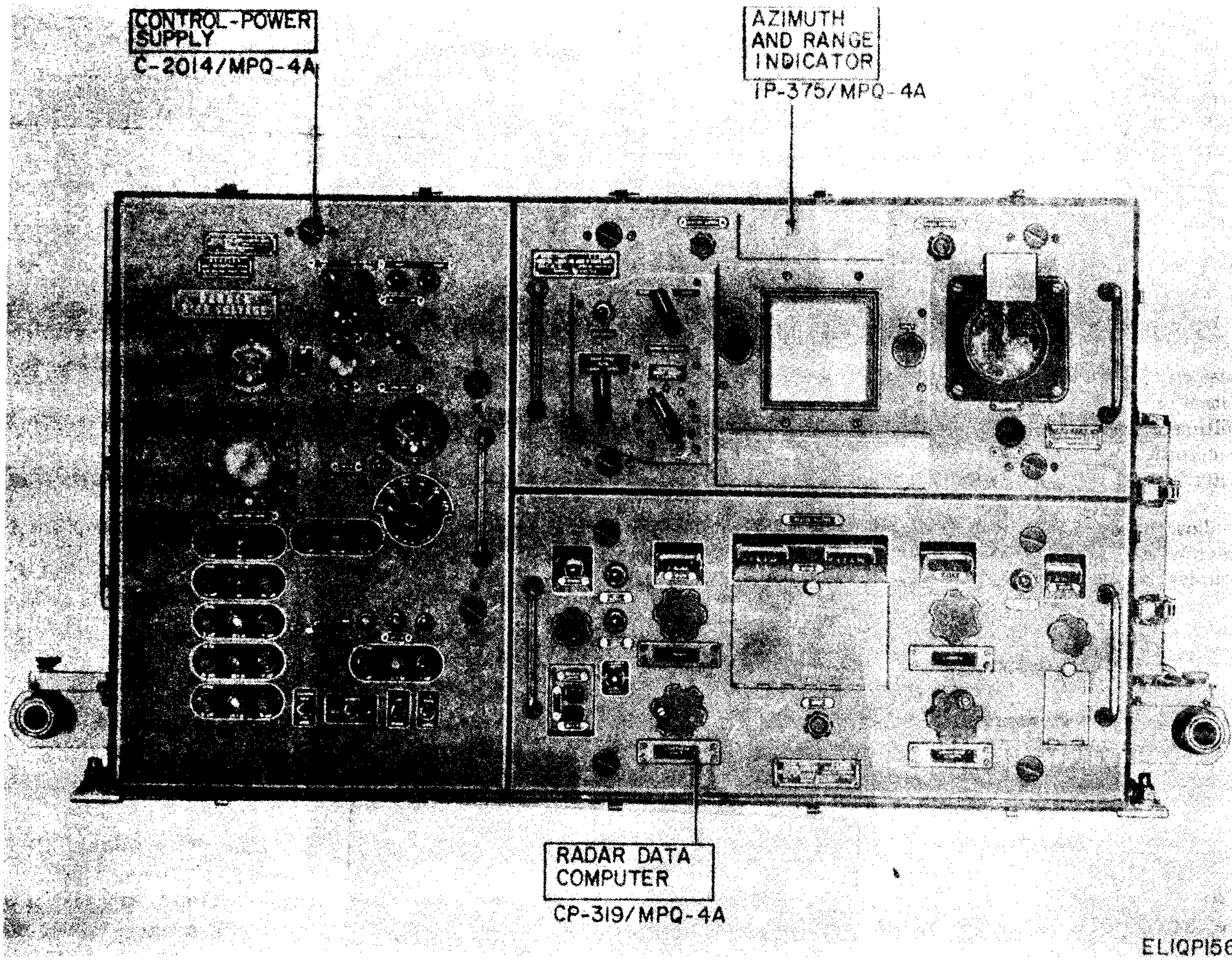


Figure 3-3. Control-Indicator Group OA-1256/MPQ-4A, front panel,

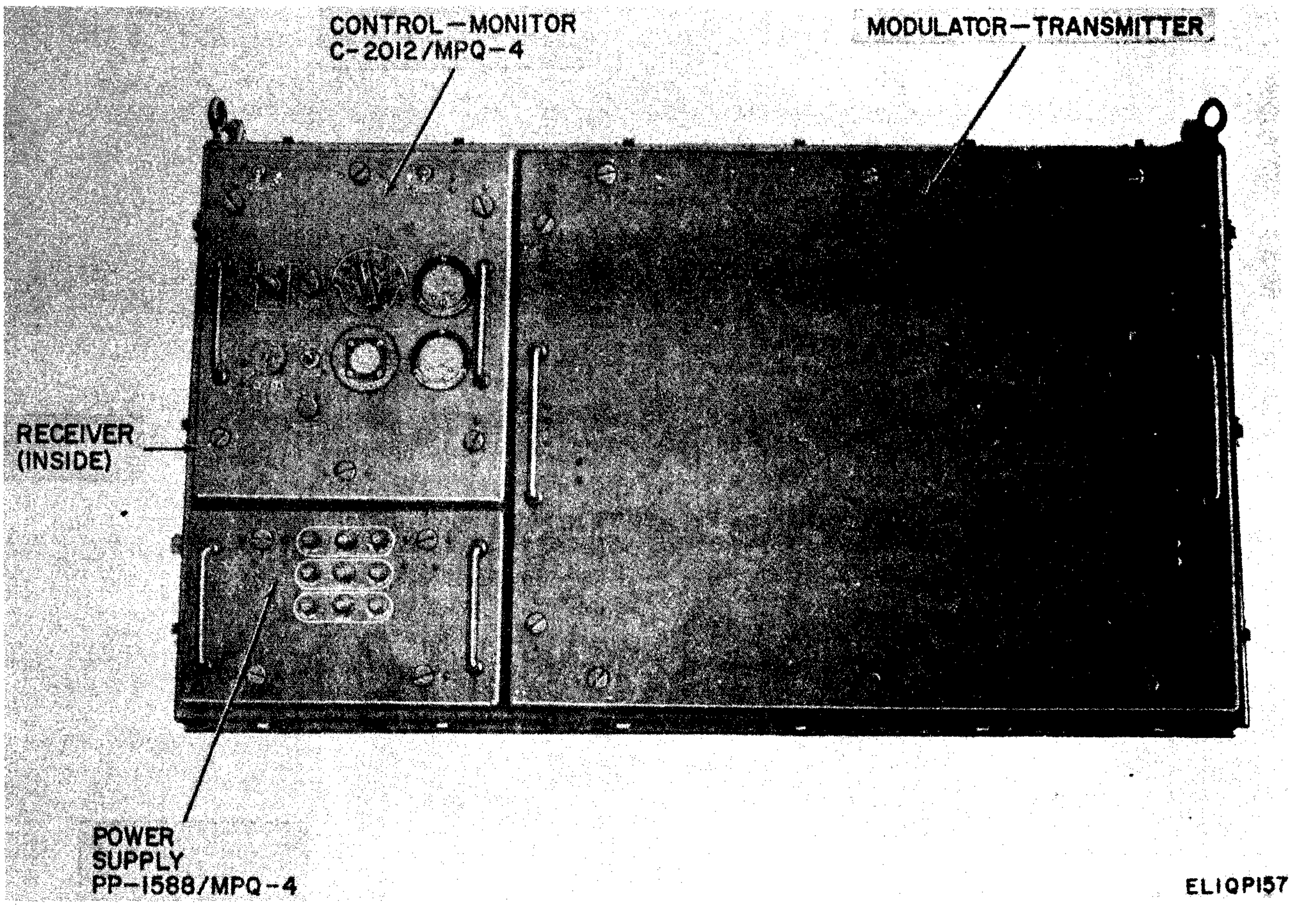


Figure 3-4. Receiuer-Transmitter Group OA-1257/MPQ-4A front panel.

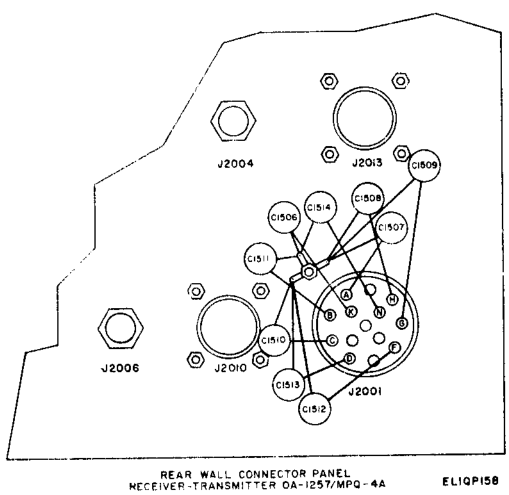


Figure 3-5. Receiver-Transmitter OA-1257/MPQ-4A rear wall, RFI suppression capacitor connections.

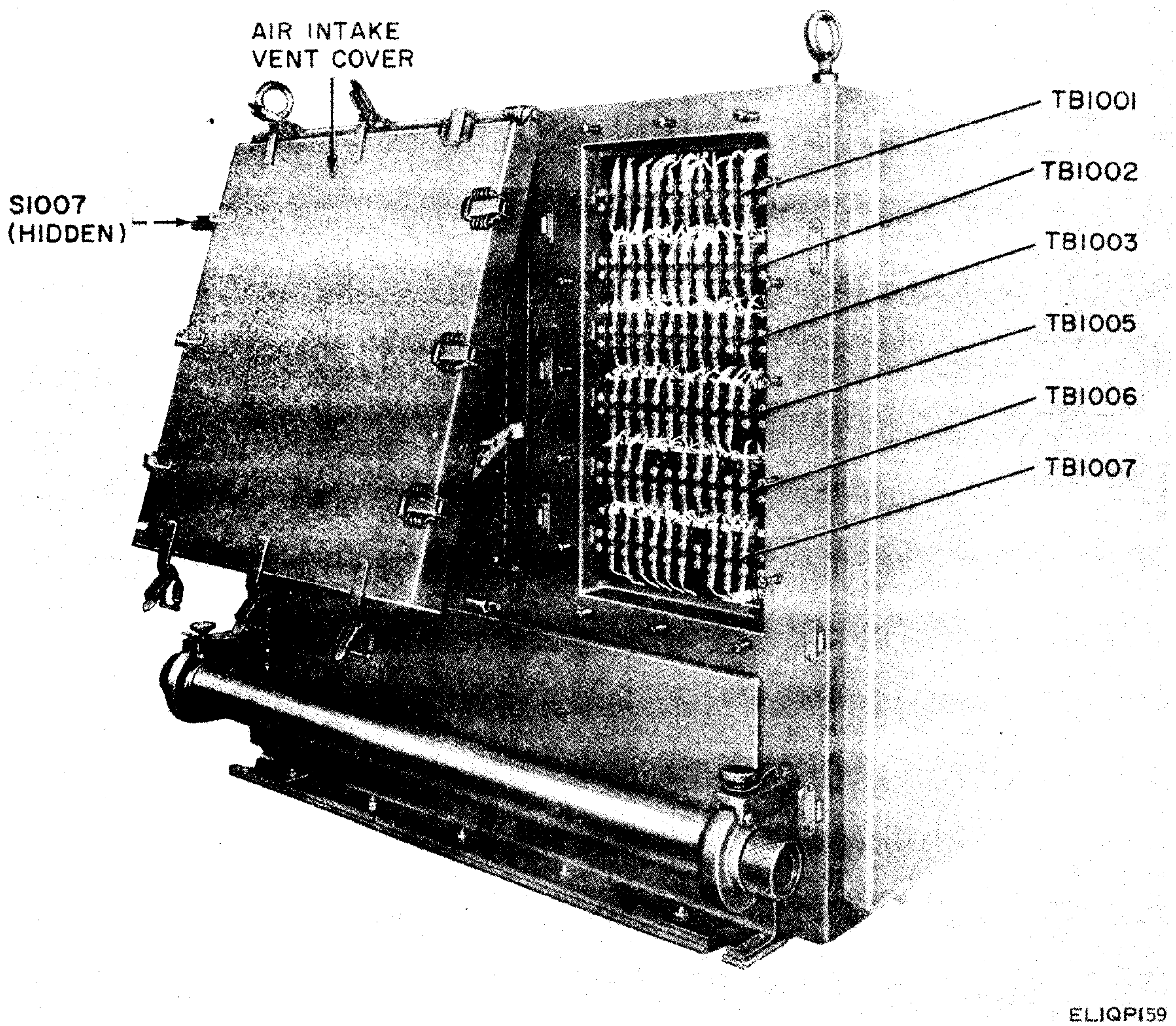


Figure 3-6. Control-indicator, left-side showing air intake vent and terminal board.

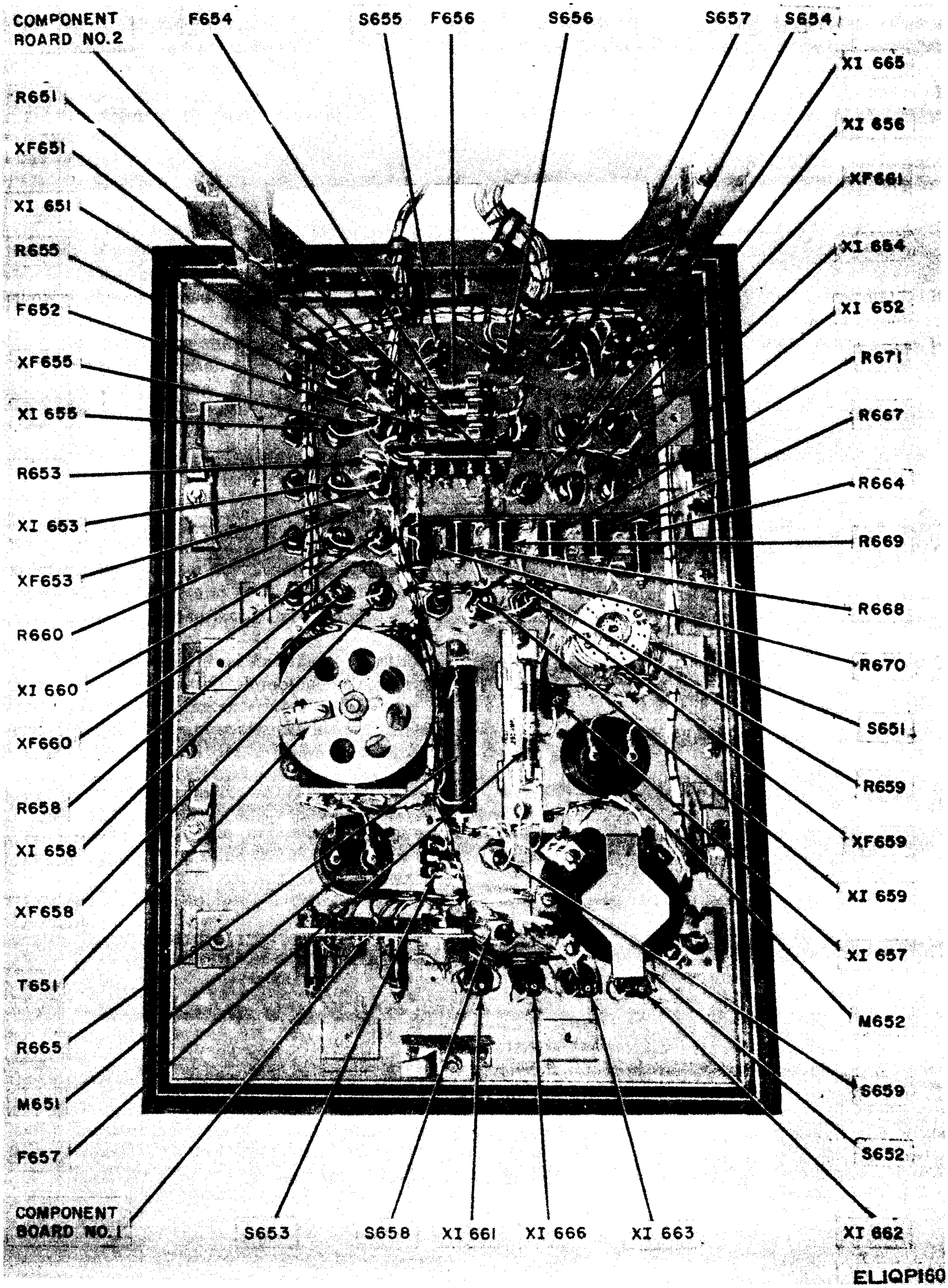


Figure 3-7. Control-Power Supply C-2014/MPQ-4A, rear view of control panel.

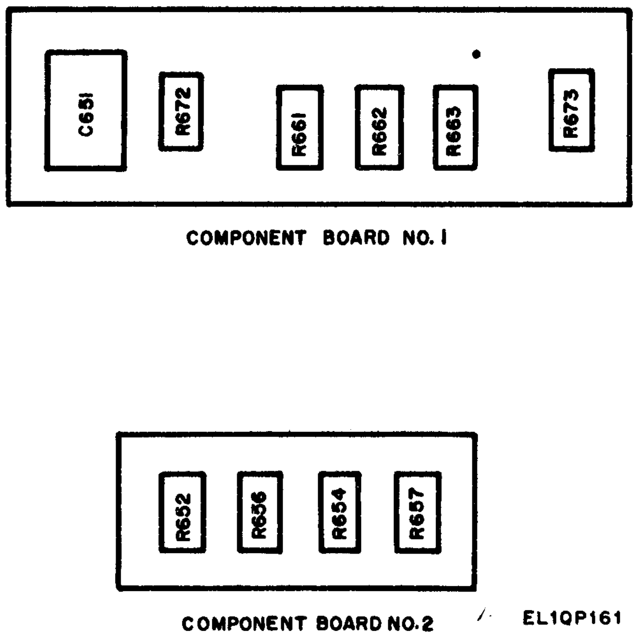


Figure 3-8. Control-Power Supply C-2014/MPQ-4A, component boards.

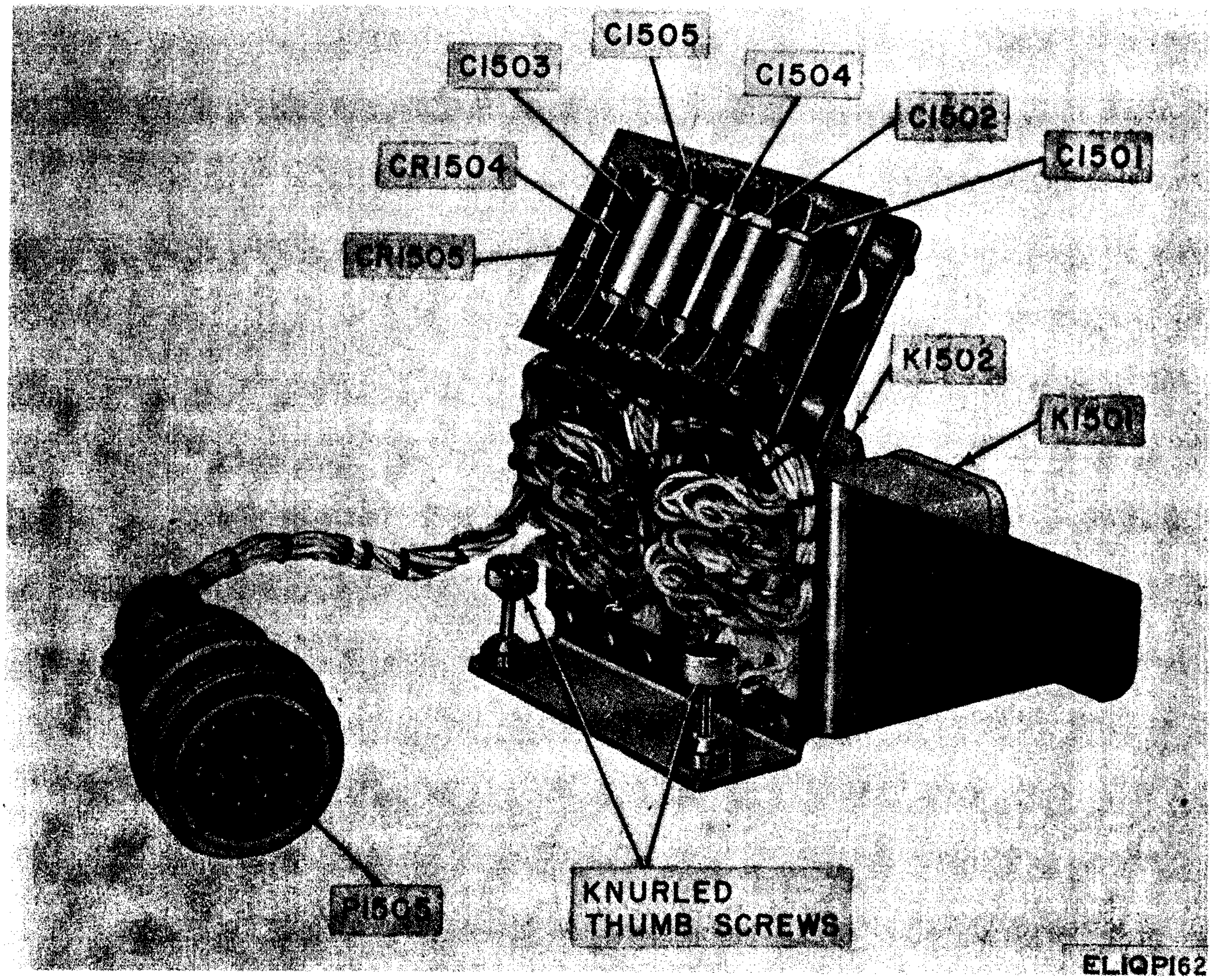


Figure 3-9. Elevation relays K1501 and K1502.

c. *Fuses and Interlocks.*

(1) *Fuses.* The table 3-7 lists the fuses in the ac power distribution and control system (fig. FO-16 and FO-17). The table also lists the rating of each fuse, a blown-fuse indicator that lights when the fuse is blown, and the circuits that each fuse protects. The fuses and blown-fuse indicators are located on the front panel of the control-power supply and the low voltage power supply (fig. 3-15 and 3-4). Dehydrator fuses are located inside the HD-264/MPQ4A.

CAUTION

Always replace a blown fuse with one that has the same rating. If a replacement fuse blows, do not install another fuse until the trouble has been remedied.

Table 3-7. Fuses in Ac Power Distribution Control System

Fuse	Rating		Blown-fuse indicator	Protected circuit
	Volts	Amp		
F651	250	10	I 651	The 120-volt, phase 1, ac supply.
F652	125	20	I 652	The 120-volt, phase 1A, ac supply.
F653	250	10	I 653	The 120-volt, phase 2, ac supply.
F654	125	20	I 654	The 120-volt, phase 2A, ac supply.
F655	125	20	I 655	The 120-volt, phase 3, ac supply.
F656	125	20	I 656	The 120-volt, phase 3A, ac supply.
F657	1,000	0.25	I 657	The positive 440-volt, dc circuits in the indicator.
F656	250	0.5	I 658	The positive 220-volt, dc circuits in the indicator.
F659	250	0.25	I 659	The positive 220-volt, dc circuits in the computer.
F660	250	0.125	I 660	The negative 220-volt de circuits in the indicator.
F661	250	5	I 665	The 27-volt dc circuits.
F1001	250	10	None	The 120-volt 400,~ convenience outlet J1005 (indicator compartment).
F1601	250	0.125	I 1601	The positive 300-volt, dc circuits in the receiver and transmitter.
F1602	250	0.250	I 1602	The positive 150-volt, dc circuits in the receiver.
F1603	250	0.062	I 1603	The negative 300-volt, dc circuits in the receiver.
A6F3301	250	1.5	None	Dehydrator motor.
A6F3302	250	1.5	None	Dehydrator motor.
A6F3303	250	1.5	None	Dehydrator motor.

(2) *Interlocks.* The table 3-8 lists the interlocks in Radar Set AN/MPQ-4A. The table also gives the operation, function, and a disabling procedure for each interlock.

WARNING

To protect personnel against injury from voltages greater than 500 volts, when an interlock is disabled, observe the following precautions:

1. Avoid personal contact with all parts.
2. Do not permit any part of the body to make direct contact with ground.
3. Keep both hands in pockets or behind back when making observations of energized circuits.
4. Follow the procedure outlined in paragraph 3-6c to make high voltage measurements.

d. Test Equipment Required. The following items of test equipment are required for troubleshooting Radar Set AN/MPQ-4A when using the troubleshooting table based on the starting procedure.

Test equipment	Common name	Technical manual
Multimeter TS-352B/U	. . . . Multimeter	TM 11-6625-366-15
Electron Tube Test Set TV-7/U	Tube Tester	TM 11-6625-274-12

Table 3-8. Interlocks, Radar Set AN/MPQ-4A

Interlock	OPERATION	Function	Disabling procedure
S1001	Opens when control-power supply drawer is opened.	Removes 28 volts dc from relay K602 and removes regulated dc voltages from the computer and indicator.	Actrate interlock shorting switch S1002.
S1003	Opens when indicator drawer is opened.	Same as S1001	Actuate interlock shorting switch S1004.
S1005	Opens when computer drawer is opened.	Same as S1001	Actuate interlock shorting switch S1006.
S1007 (fig. 3-6)	Opens when air intake panel is closed.	Same as S1001	None.
S1008	Opens when air exhaust panel is closed.	Same as S1001	None.
S1001	Opens when air pressure falls below 12 psi.	Removes 28-volt dc to power contactor K1104 which removes power from modulator.	None.
S1102 (fig. 3-11)	Opens when modulator door is opened.	Opens 26-volt dc power to modulator-transmitter.	Actuate interlock shorting switch S1103 (fig. 3-11).
S1104 (fig.3-11)	Opens when modulator door is opened.	Opens 28-volt dc power to modulator-transmitter.	Actuate interlock shorting switch S1105 (fig. 3-11).

Table 3-8. Interlocks, Radar Set AN/MPQ-4A – Continued

Interlock	Operation	Function	Disabling procedure
S1106 (fig. 3-11).	Opens when modulator door is opened (trigger amplifier and power supply).	Opens 120-volt, 400-cycle power to trigger amplifier.	Actuate interlock shorting switch S1107 (fig. 3-11).
S1108 (fig. 3-161)	Open until the air intake panel is opened.	Opens 28-volt dc power to modulator-transmitter.	None.
S1503	Opens when waveguide sir pressure builds up to 16 psi. When closed (following drop of air pressure to 14 psi ±1) provides power to dehydrator.	When open, removes 28 volts dc to dehydrator control relay K1401, which removes power from the dehydrator, When closed, dehydrator is automatically turned on.	None.
S3301	Opene when dehydrator filter cover is closed.	Removes power to dehydrator compressor motor.	None.
S2003	Open until air exhaust panel is opened.	Opens 28-volt dc power to modulator-transmitter.	None.
S2204	Open until air exhaust panel is opened.	Same as S2003	None.
S2005 (fig. 3-26)........	Opens when receiver compartment is opened	Same as S2003	Actuate interlock shorting switch S2008 (fig. 3-26)
S2006	Opens when low voltage power supply drawer is opened.	Same as S2003..................	Actuate interlock shorting switch S2008.
S3001	Opens when azimuth hand wheel is engaged.	Opens power to azimuth drive motor B3003.	None.
S3002 (fig. 3-150)	Opens when azimuth stowlock is engaged.	Opens power to azimuth drive motor B3003.	None.
S3003	Opens when curb-side fender of trailer is in running position.	Opens power to azimuth drive motor B3003.	None.
S3004 (fig. 3-150)........	Opens when road-side fender of trailer is in running position	Opens, power to azimuth drive motor B3003.	None.
S3201	Opens when scanner exceeds normal coverage.	Opens power to drive motor	None.
S3202	Opens when scanner exceeds coverage.	Opens power to drive motor	None.
S3203	Opens when scanner exceeds coverage.	Opens power to drive motor	None.
S3204	Opens when scanner exceeds coverage.	Opens power to drive motor	None.

e. Preliminary Checks and Control Settings.

(1) *General* Before using the troubleshooting table based on the starting procedure (para 3-16*f*) check the cabling of the set (TM 11-5840-208-10) and set the switches and controls as listed in (4) below.

(2) *Checks.* Additional damage will be caused if power is applied to equipment in which a complete or partial short circuit exists, When any of the following conditions apply, check for short circuits before applying power to the equipment.

(a) A replaced fuse blows.

(b) Smoke is seen coming from a component.

(c) Overheated parts are seen or smelled.

(d) A defective component is being serviced apart from other components of the radar set.

(e) Abnormal symptoms reported from operational tests indicate possible partial or complete short circuits.

(3) *Receiver-Transmitter Group OA-1257(MPQ-4A (fig.* 3-4). Set A.F.C. MANUAL switch S1403 on the control-monitor panel to the A.F.C. position. All other operating controls for this component are located on the control-power supply panel in Control-Indicator Group OA-1256/MPQ-4A.

(4) *Control-Power Supply C-2014/MPQ-4A* (fig. 3-3). Preliminary settings of switches on the Control-Power Supply C-2014/MPQ-4A Panel are listed in table 3-9.

(5) *Azimuth and Range Indicator IP-375/MPQ-4A* (fig. 3-3). Preliminary settings of controls and switches for the Azimuth and Range Indicator IP-375/MPQ-4A are listed in table 3-10.

(6) *Generator Set PU-304C/MPQ-4.* Refer to TM 5-6115-365-15 for preliminary operating procedures.

(7) *Antenna Group OA-1268/MPQ-4A,* Make sure the stowlock is off, the handwheel is unlocked, and the trailer fenders are down.

(8) *Interlock system.* Close the following interlocks to insure equipment operation:

(a) On the control-indicator group, secure the control-power supply, indicator, and computer drawers (closing S1001, S1003, and S1005). Open the air intake and air exhaust panels on the left and right sides of the cabinet (closing S1007 and S1008).

(b) On the receiver-transmitter group, secure the control-monitor panel (closing S2005), the power supply drawer (closing S2006), and the transmitter door (closing S1102, S1104, and S1106). Open the air intake and air exhaust panels at the rear of the cabinet (closing S1108 and S2004), and the air exhaust panel on the left side (Closing S2003).

(c) On the dehydrator, open the air intake panel on the left side of the front panel (closing S3301).

Table 3-9. Presettings of Control-Power Supply C-2014/MPQ4A

Control	Position
POWER UNIT switch S653	STOP
MAIN POWER switch S652	OFF
AFC-MANUAL switch S657	MANUAL
TEST METER SELECTOR switch S651.	28V position

Table 3-10. Presetting of Azimuth and Range Indicator IP-375/MPQ-4A

Control	Position
PLOTTER DIMMER potentiometer R133 . . .	Fully cw
PANEL DIMMER potentiometer R133	Fully ccw
EXPANDED SWEEP DELAY (X-1500M) switch AT101.	7.6
RANGE SELECTOR switch S101	1500M
BEAM VIDEO selector switch S110.	BOTH
MARKERS-ON switch S105	Off (Down)
RANGE SHIFT switch S103	off (down)
RANGE MARK potentiometer R103	Midposition
AZIMUTH MARX potentiometer R132.	Midposition

f. Troubleshooting Table Based on Starting Procedure.

CAUTION

Be sure all personnel are clear *of* the antenna before placing the radar set in operation.

Table 9-11. Troubleshooting Toble: Starting Procedure

Step	Procedure	Normal indication	Abnormal indications	Carrective measures
1	Press POWER UNIT switch S653 to START position or turn circuit breaker on at the power unit if S653 is not used.	POWER UNIT indicator lamp I 661 lights.	I661 does not light	Replace indicator lamp. Check cables. Press switch to STOP. Refer to power unit manual.
2	Turn MAIN POWER switch S852 to ON position.	MAIN POWER ON & INTKL CLOSED indicator lamp I 666 goes on. 120-volt ac blown-fuse indicators do not light. READY indicator lamp I 663 goes on after 5-minute period. While waiting for I 663 to light, perform steps 3 through 23.	I666 does not light . . . . . Blown-fuse indicator bmpe light.	Make certain panels and drawers are closed. Replace blown fuses.
3	Turn TEST METER SELECTOR switch S651 to AFC XTAL CUR position	Dial pointer oscillates on TEST METER M652 (2.5 ±.5).	Abnormal reading on M652.	Rep lace afc crystal CR1503. Troubleshoot receiver (table 3-25)
4	After 30 seconds, check B-scope for normal raster.	Raster on B-scope.	No raster on B-scope . . .	Troubleshoot indicator (table 3-37)
5	Check for operation of two blowers in receiver-transmitter and control indicator.	Air is drawn into intake vent and exhausted through exhaust vent.	No air flow indicated when a small piece of paper is held before the vents.	Check blower (para 3-56b).
6	Turn TEST METER SELECTOR switch S1401 to XTAL 1 position.	TEST METER M1402 reads 2.5 ±.5.	Abnormal reading on M1402.	Replace CR1501. Troubleshoot receiver (table 3-26)
7	Turn S1401 to XTAL 2 position.	TEST METER M1402 reads 2.5 ±.5.	Abnormal reading on M1402.	Replace CR1502. Troubleshoot receiver (table 3-25)
8	Turn S1401 to AFC XTAL position.	TEST METER M1402 reads 2.5 ±.5.	Abnormal reading on M1402.	Replace afc crystal CR1503. Troubleshoot receiver (table 3-26)
	Turn S1401 to + 150 position	TEST METER M1402 made 3.0	Abnormal reading on M1402	Troubleshoot power supply (para 3-48) (table 3-61)

Table 3-11. Troubleshooting Table, Startin Procedure-Continued

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
10	**Turn S1401 to +300 V position**	TEST METER M 1402 reads 3.0	Abnormal reading on M1402	Troubleshoot power supply (para 3-48) (table 3-61)
11	Turn S1401 to - 300 V position	TEST METER M 1402 reads 3.0	Abnormal reading on M1402	Troubleshoot power supply (para 3-48) (table 3-61)
12	Turn TEST METER SELECTOR switch S651 to OFF.	TEST METER M652 reads 0.	Abnormal reading on M652.	Check TEST METER SELECTOR switch 8651.
13	Turn S651 to 440 V position.	TEST METER M652 reads 4.4.	Abnormal reading on M652.	Troubleshoot power supply. (para 3-48) (table 3-61)
14	Turn S651 to 220 V position.	TEST METER M652 reads 4.4.	Abnormal reading on M652.	Multimeter should indicate 220 V dc. If reading is abnormal, troubleshoot power supply. (para 3-48) (table 3-61)
15	Turn switch S651 to 27 V position.	TEST METER M652 reads 2.7.	Abnormal reading on M652.	Troubleshoot power supply. (para 3-48) (table 3-61)
16	Turn switch S651 to - 220 V position.	TEST METER M652 reads 4.4.	Abnormal reading on M652 .	Troubleshoot power supply (table 3-59) and 3-60). (para 3-48) (table 3-61)
17	Operate AZIMUTH switch S656 in the CW and then in the CCW position.	The antenna should move in azimuth.	Antenna does not move in azimuth.	Check cabling. Check stowlock. Check azimuth drive motor (pars 3-45c). Troub leehoot antenna positioning circuits (para 3-45c).
16	Operate ELEVATION switch S655 in the RAISE position and then in the LOWER position.	In the RAISE position, the reflector should move down. In the LOWER position, the reflector should move up.	Erratic movement or no movement of reflector in either the RAISE or LOWER position of S655.	Check cabling. Check antenna elevation motor (para 3-45c). Troubleshoot antenna positioning circuits (para 3-45c).
19	Set RADAR LOCATION EASTING counter M817 to east map coordinate by operating RADAR LOCATION EASTING switch S851 .	Counter should indicate coordinates.	Wrong or no indication on counter.	Troubleshoot computar (para 3-37a).
20	Set RADAR LOCATION NORTHING counter M817 to north map coordinate by operating RADAR LOCATION NORTHING switch S852.	Same as step 19	Same as step 19	Same as step 19.
21	Set RADAR HEIGHT counter M807 to height of radar aat as determined from map.	Counter M807 should indicate height.	Counter doaa not move.	Troubleshoot computer (table 3-43 and para 3-37).
22	Sat weapon HEIGHT counter M806 to same height setting as previous step.	Counter M806 should indicate height of weapon.	Counter doea not move. .	Troubleshoot computer (table 3-43 and para 3-37).
28	Set RANGE counter M831 to 01500.	RANGE counter M831 should read 01500 meters.	Incorrect reading on counter.	Troubleshoot computer (table 3-42 and para 3-37).
24	Sat the Δ RANGE handwheel to zero.	SET DETENT indicator lamp flows if AZIMUTH handwheel also is not on zero.	ΔIRANGE handwheel will move.	Troubleshoot computer (table 3-43 and para 3-37).
25	Set the Δ AZIMUTH hand. wheel to zero.	SET DETENT indicator lamp glows if A RANGE handwheel also is not on zero.	Δ,AZIMUTH handwheel will not move.	Troubleshoot computer

Table 3-11. Troubleshooting Table, Starting Procedure-Continued

Step	Procedure	Normal indications	Abnormal Indications	Corrective measures
26	Sat the Δ time handwheel to Zero.	Δ TIME counter M801 indicates zero.	Δtime handwheel cannot be moved.	Troubleshoot computer table 3-43 and para 3-37e).
	5 minute READY indicator lamp I 633 lights.	I 663 lights	I 663 does not light. . .	Check voltage at pin 7 of K603 (fig. 3-157). Check R662 and I 663 Check K603,
27	Press START switch S658	RADIATE indicator lamp I 662 lights.	I 662 does not light....	Check interlock circuit (TM 11-6840-208-10). Check voltage between pin 4 of S658 and terminal 5 of TB1001 , Check R673, I 662, and S658.
28	Adjust MAGNETRON POWER control T651 for propar meter indication.	MAGNETRON CURRENT mater M651 indicates 18 ma.	Abnormal indication of M651.	Troubleshoot transmitter (table 3-17). Troubleshoot dehydrator and check waveguide pressure switch S1101.
29	Turn MARKERS-ON switch S105 to ON position.	Rangemarkers will be visible, diminishing, at ranges of 2,000, 4,000, 6,000, 6,000, 10,000, 12,000 and 14,000 meters.	Rangemarkers not all visible or intensity does not diminish consistently .	Tune local oscillator. Check afc assembly (para 3-30g).
30	Operate L. O. RAISE-LOWER switch S654 in the RAISE and than in the LOWER position for proper indication.	Maximum video return appears on B-scope.	Video return does not change or diminish.	Check klystron motor B1501. Check cabling. Check tightness of coupling between drive motor and klystron.
31	Place AFC MANUAL switch S657 in the AFC position.	Signal inteneity remains the **same.**	Signal intensity dacreases.	Adjust receiver (para 3-27d).
32	Check dry air indicator in dehydrator.	Dehydrator pressure gage indicates approximately 16 psi, and dry air indicator is blue in color. Air pressure can drop as low as 14 psi±1 before dehydrator turns on. When pressure reaches 16 psi, S1503 in the receiver compartment opens, deenergizing relay K1401, which removes power from the dehydrator.	Abnormal indication of pressure gage. Dry air indcator is pink.	Troubleshoot dehydrator (table 3-65). Check K1401, including relay activation circuitry (Fig. FO-16 and FO-17).
33	Turn RANGE SHIFT switch S103 to ON.	An additional strobe line is provided 750 maters above lower beam raster.	An additional strobe line dose not appear,	Troubleshoot synchronizing system (table 3-35),
34	Press AZIMUTH switch S656 to CW or CCW to rotate antenna	Antenna will rotate	Antenna dose not move .	Troubleshoot antenna positioning system (para 3-45c).
35	Press ELEVATION switch S655 to RAISE or LOWER so that the elevation angle is 15 mils above the highest hill in the **expected area.**	Ground clutter decreases to a minimum.	Ground clutter doea not decrease.	Check K1501, K1502, CR1504, or CR1505, Troubleshoot antenna positioning system (para 3-45c).
36	Set EXPANDED SWEEP DELAY switch AT101 so that the bright band on the B-scope encloses the approximate position of the target.	Two indications of the target will appear on the screen a Short inteval apart.	No intensified sweep appears on B-scope.	Troubleshoot synchronizing system (para 3-32d).
37	Turn tha LOWER BEAM RANGE handwheel to set the range strobe lines within the bright band.	Range strobe line appears on indicator.	No range strobe on indicator.	Troubleshoot computer (table 3-43). Troubleshoot synchronizing system (para 3-32d).

Table 3-11. Troubleshooting Table, Starting Procedure-Continued

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
38	Turn RANGE SELECTOR switch S101 to 2500 M.	Bright band ie expanded over *entire screen area.*	Bright band does not appear or does not cover entire screen area.	Troubleshoot synchronizing system (para 3-32d).
39	At the instant the firat echo is seen on the expanded B-scope, prose either TIMER switch S106 or S107 to start the clock, and mark the target presentation with a grease pencil. When the second echo lppears, press either TIMER switch again to etop the clock and mark the second target presentation.	The elapsed tima between echoes appears on SECONDS timer M101.	The elapsed time does not appear on SECONDS timer M101.	Check SECONDS timer M101.
40	Turn the LOWER BEAM RANGE handwheel for proper display.	The lower range strobe line intersects the firat (lower beam echo on the B-scope).	Range strobe line dues not appear.	Troubleshoot computer (table 3-43). Troubleshoot antenna positioning system (pare 3-45c).
41	Place detent switch S856 in the DETENT RELEASE position.	The Δ RANGE and Δ AZIMUTH handwheels can be rotated. SET DETENT indicator lamp lights.	ΔRANGE and Δ AZIMUTH handwheels cannot be moved. SET DETENT indicator lamp. Doaa not light.	Troubleshoot computer (table 3-43).
42	Rotate the Δ RANGE handwheel for proper presentation.	The upper range strobe line intersects the second (upper beam) echo on B-scope.	Same as step 37	Same as step 37.
43	Rotate the Δtime handwheel for propar indication.	Ths time lapse between the two echoes appears on the counter.	Same as step 23	Same as step 29.
44	Read the WEAPON LOCATION EASTING and NORTHING counters M816.	Weapon location is indicated.	No indication on counter	Troublshoot computer (table 3-43).
45	Check the derived location of the weapon on a contour map. If the elevation at the weapon location is different from that of the radar site eat into weapon HEIGHT counter M806 the weapon location elevation noted on the map.	DOUBTFUL SOLUTION indicator lamp I 852 does not light.	Indicator lamp I 852 lights.	Recompute problem. Troubleshoot computer (table 3-43).
46	Read the final values on WEAPON LOCATION EASTING and NORTHING counters M816 to obtain the location of weapon position.	Same as step 41	Same as step 41	Same as step 41.
47	Place detent switch S856 in tha NORMAL position.	SET DETENT indicator lamp goes out.	SET DETENT indicator lamp remains lighted.	Troubleshoot computer (table 3-43).
48	Reset the RANGE and AZIMUTH handwheels to their detent (zero) position.	SET DETENT indicator lamp lights.	SET DETENT indicator lamp does not light	Troubleshoot Computer table 3-43).
49	Press RESET switch S108 to return the timer to zero.	Clock hands return to zero.	Clock hands do not return to zero.	Check switch connection.

3-17. Removal and Replacemant of Parts in Ac Power Distribution and Control Circuit

a. Removal and Replacement of S-Minute Delay Relay K603.

(1) *Removal*

(a) Loosen the six pawl fasteners that hold Control-Power Supply C-2014/MPQ-4A in place and pull the drawer forward.

(b) Loosen the four thumbscrews that hold the hinged power supply chassis in place and swing the chassis out.

(c) Tag, unsolder, and disconnect the leads to relay K603.

(d) Unscrew and remove the four nuts that hold the relay in place.

(e) Remove the relay.

(2) *Replacement.*

(a) Position the replacement relay in place.

(b) Replace and tighten the nuts that hold the relay.

(c) Connect and solder the leads to the relay.

(d) Swing the hinged chassis in place and tighten the four thumbscrews.

(e) Slide the control-power supply drawer forward and fasten the six pawl fasteners.

b. Removal and Replacement of Plate Relay K602.

(1) *Removal.*

(a) Perform the steps in *a(1)(a)* and *(b)* above.

(b) Tag, unsolder, and disconnect the leads to the relay.

(c) Remove the four locknuts that hold the relay in place.

(d) Remove the relay.

(2) *Replacement.*

(a) Position the relay in place.

(b) Replace and tighten the four nuts.

(c) Connect and solder the leads to the relay.

(d) Perform the steps given in paragraph *a(2)(d)* and (e) above.

c. Removal and Replacement of MAIN POWER Switch S652 (fig. 3-7).

(1) *Removal.*

(a) Release the four pawl fasteners on the front panel of the control-power supply.

(b) Pull out the drawer as far as it will go.

(c) Loosen the captive screws that hold the front panel in position and carefully drop the panel forward.

(d) Remove the knob from the shaft of S652.

(e). Tag, unsolder, and disconnect the leads from S652.

(f) unscrew and remove the four screws and lockwashers that hold the switch to the front panel. Save the screws and lockwashers.

(g) Remove the switch.

(2) *Replacement.*

(a) Position the switch in place.

(b) Replace the four screws and lockwashers that ware removed as instructed in (l)(g) lbove.

(c) Connect and colder the leads to the switch. Make sure the correct lead is connected to each terminal.

(d) Replace the knob.

(e) Raise the front of the panel and fasten it in plum with the captive screws.

(f) Slide the drawer back and fasten the four pawl fasteners.

d. *Removal and Replacement of TEST METER SELECTOR Switch S651* (fig. 3-7).

(1) Removal.

(a) Perform the steps given in *c(1)(a), (b),* and *(c)* above.

(b) Loosen the setscrew that holds the knob on the shaft of S651 and remove the knob.

(c) Tag, unsolder, and disconnect the leads to S651 .

(d) Loosen and remove the seal nut that holds S651 on the panel.

(e) Remove the switch.

(2) *Replacement.*

(a) Position the switch in place.

(b) Fasten the switch in place with the seal nut removed as instructed in (1)(d) above.

(c) Connect and solder the leads to the switch. Make sure the correct lead is connected to each terminal.

(d) Perform the steps given in c(2)(e) and *(f)* above.

e. Removal and Replacement of MAGNETRON POWER Control T651 (fig. 3-7).

(1) *Removal.*

(a) Perform the steps given in *c(1)(a), (b),* and *(c)* above.

(b) Tag, unsolder, and disconnect the leads to T651 .

(c) Remove the knob from the shaft of T651.

(d) Remove the screws and lockwashers that hold T651 to the panel.

(c) Remove T651.

(2) *Replacement.*

(a) Position the transformer in place.

(b) Replace and fasten the screws and lock. washers that hold the transformer in place.

(c) Connect and solder the leads to the transformer.

(d) Replace the knob on the shaft.

(e) Perform the steps given in *c(2)(e)* and *(f)* above.

f. Removal and Replacement of START Switch S658 and/or STOP Switch S659 (fig. 3-7).

(1) *Removal.*

(a) Perform the steps in *c(2)(a),(b),* and *(c)* above.

(b) Tag, disconnect, and remove the leads to the switch.

(c) Unscrew and remove the nut and lock-washer that hold the switch.

(d) Remove the switch.

(2) *Replacement.*

(a) Place the switch in position.

(b) Replace and tighten the nut and lock-washer.

(c) Replace the leads to the switch.

(d) perform the steps given in c(2)(e) and *(f)* above.

g. Removal and Replacement of Power Contractor K1104 (fig. 3-14).

(1) *Removal.*

(a) Loosen the 10 pawl fasteners that hold the door of the modulator-transmitter compartment, grasp the handles, pull forward, and swing open the door.

(b) Loosen the two fasteners on the relay chassis that hold the chassis in place and swing out the chassis.

(c) Tag, unsolder, and disconnect the leads to relay K1104.

(d) Loosen, remove, and retain the three locknuts that hold the relay.

(e) Remove the relay.

(2) *Replacement.*

(a) Position the replacement relay in place.

(b) Replace and tighten the locknuts on the relay.

(c) Connect and solder the leads to the relay.

(d) Swing the hinged chassis closed and fasten the two thumb fasteners.

(e) Swing the modulator-transmitter compartment door closed and fasten the 10 pawl fasteners.

h. Removal and Replacement of Potentiometer R1104, R1105, or R1106 (fig. 3-14).

(1) *Removal.*

(a) Perform the steps given in g(l)(u) and *(b)* above.

(b) Tag, unsolder, and disconnect the leads of the potentiometer being replaced.

(c) Loosen and remove the nuta and lockwashers that hold the potentiometer.

(d) Remove the potentiometer.

(2) *Replacement.*

(a) Position the potentiometer in place.

(b) Replace the nuts and lockwashers.

(c) Tighten the nuts.

(d) Connect and solder the leads to the potentiometer.

(e) Follow the instructions in paragraph 3-21 to adjust the potentiometers.

(f) Perform the steps given in *g(2)(d)* and *(e)* above.

i. Removal and Replacement of Relay K1501 or K1502 (fig. 3-9).

(1) *Removal*

(a) Loosen the six pawl fasteners on the receiver compartment door, grasp the handles, pull the door forward, and swing open the door.

(b) Disconnect the cables from the afc assembly (fig. 3-26).

(c) Loosen the two thumbscrews at the front of the afc chassis.

(d) Pull the afc assembly forward and remove it from the receiver compartment.

(e) Disconnect the cables from J1504 and J1505.

(f) Loosen the two thumbscrews at the front of the bracket that holds relays K1101 and K1102.

(g) Slide the bracket forward and remove the bracket from the receiver compartment.

(h) Tag, unsolder, and remove the leads from the relay.

(i) Loosen and remove the six screws and nuts that hold the relay.

(j) Remove the relay.

(2) *Replacement.*

(a) Position the relay in place.

(b) Replace and tighten the six screws and nuts that hold the relay.

(c) Connect and solder the leads to the relay.

(d) Replace the relay bracket in the receiver compartment and tighten the two thumbscrews.

(e) Connect the cables to J1504 and J1505.

(f) Slide the afc assembly in place and secure the two thumbscrews.

(g) Connect the cables to the afc assembly.

(h) Close the receiver compartment door and fasten the pawl fasteners.

j. Removal and Replacement of Relay K1401 (fig. 3-36).

(1) *Removal.*

(a) Tag, unsolder, and remove the leads from the relay.

(b) Loosen and remove the six screws and nuts that hold the relay.

(c) Remove the relay.

(2) *Replacement.*

(a) Position the relay in place.

(b) Replace and tighten the six screws end nuts that hold the relay.

(c) Connect and solder the leads to the relay.

Section IV. TRANSMITTING SYSTEM TROUBLESHOOTING AND REPAIR

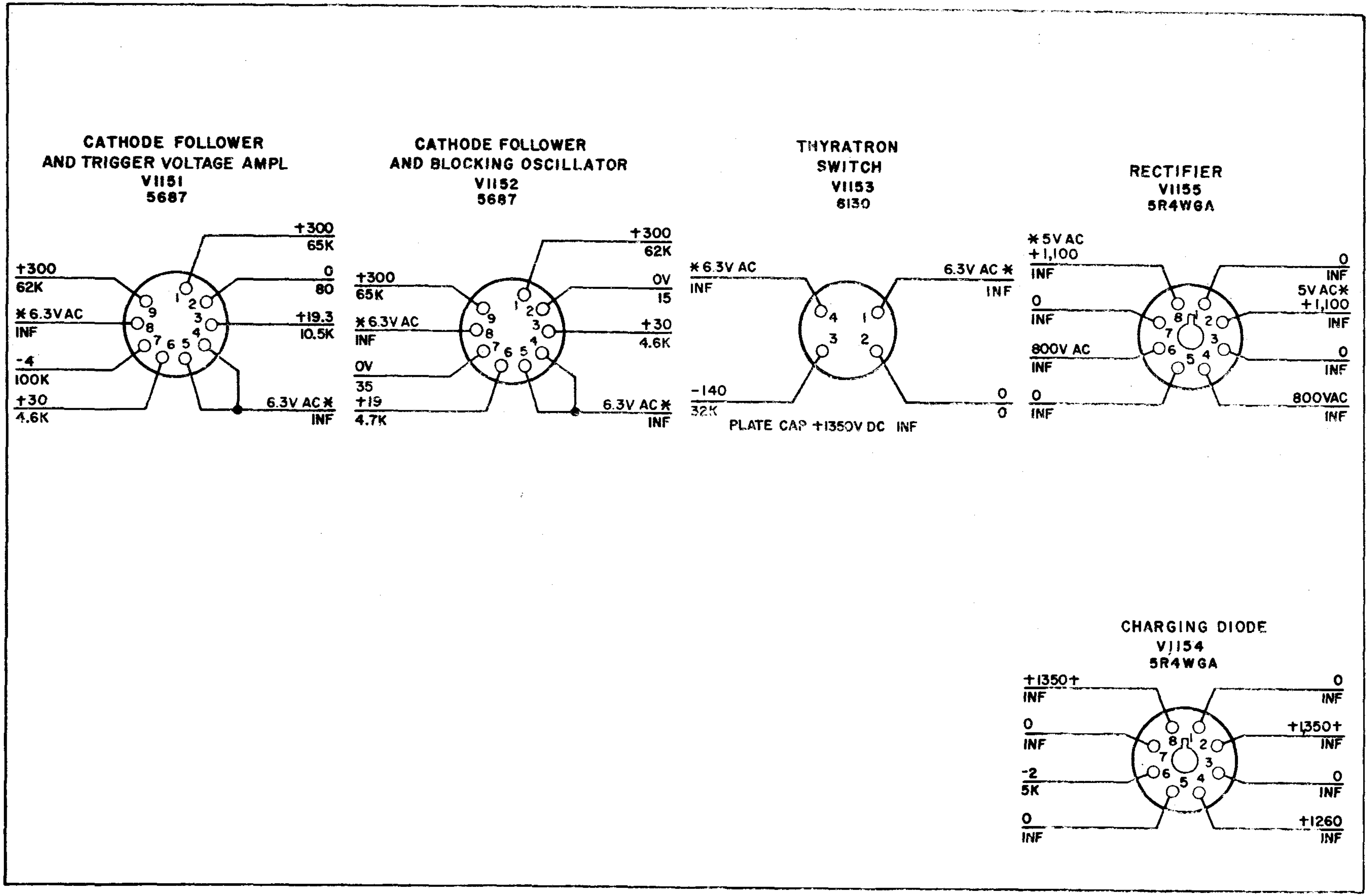
WARNING

Extremely dangerous voltages exist in Receiver-Transmitter Group OA-1257/MPQ-4A. In the transmitter, the thyratron has 1,000 volts applied to the anode. In addition, the magnetron has 26,000 volts applied to the filaments.

3-18. Transmitting System Troubleshooting Information

a. Reference Data. The following information will be helpful when troubleshooting and/or repairing the transmitting system.

Reference	Data
FO-2	Transmitting system, block diagram
Para 2-11, 2-12 and 2-13	Functioning of circuits in the transmitting system.
Fig. 2-1 through 2-7, 2-9 though 2-14.	Transmitting system, simplified schematic diagrams.
Fig. FO-24	Receiver-transmitter group, schematic diagram.
Fig. FO-23	Modulator-transmitter, schematic diagram.
Fig. FO-21	Radar Set AN/MPQ-4A, intercabling diagram.
Fig. 3-10	Trigger Pulse Amplifier AM-1537/MPQ-4A, voltage and resistance diagram.
Fig. 3-11	Modulator-transmitter, front view
Fig. 3-12	Trigger Pulse Amplifier AM-1537/MPQ-4A, top view.
Fig. 3-13	Trigger Pulse Amplifier AM-1537/MPQ-4A, bottom view.
Fig. 3-14	Transmitter door, rear view showing relay panel.
Fig. 3-15	Control-Power Supply C-2014/MPQ-4A, front view.
Fig. 3-16,	Control-monitor, front view
Fig. 3-17,	OUTPUT PULSE TEST J1402, wave form diagram.
Fig. 3-18	Voltage regulator VR1101



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE
3. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
4. * INDICATES READINGS BETWEEN PINS.

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Figure 3-10. Trigger Pulse Amplifier AM-1537/MPQ-4A, voltage and resistance diagram.

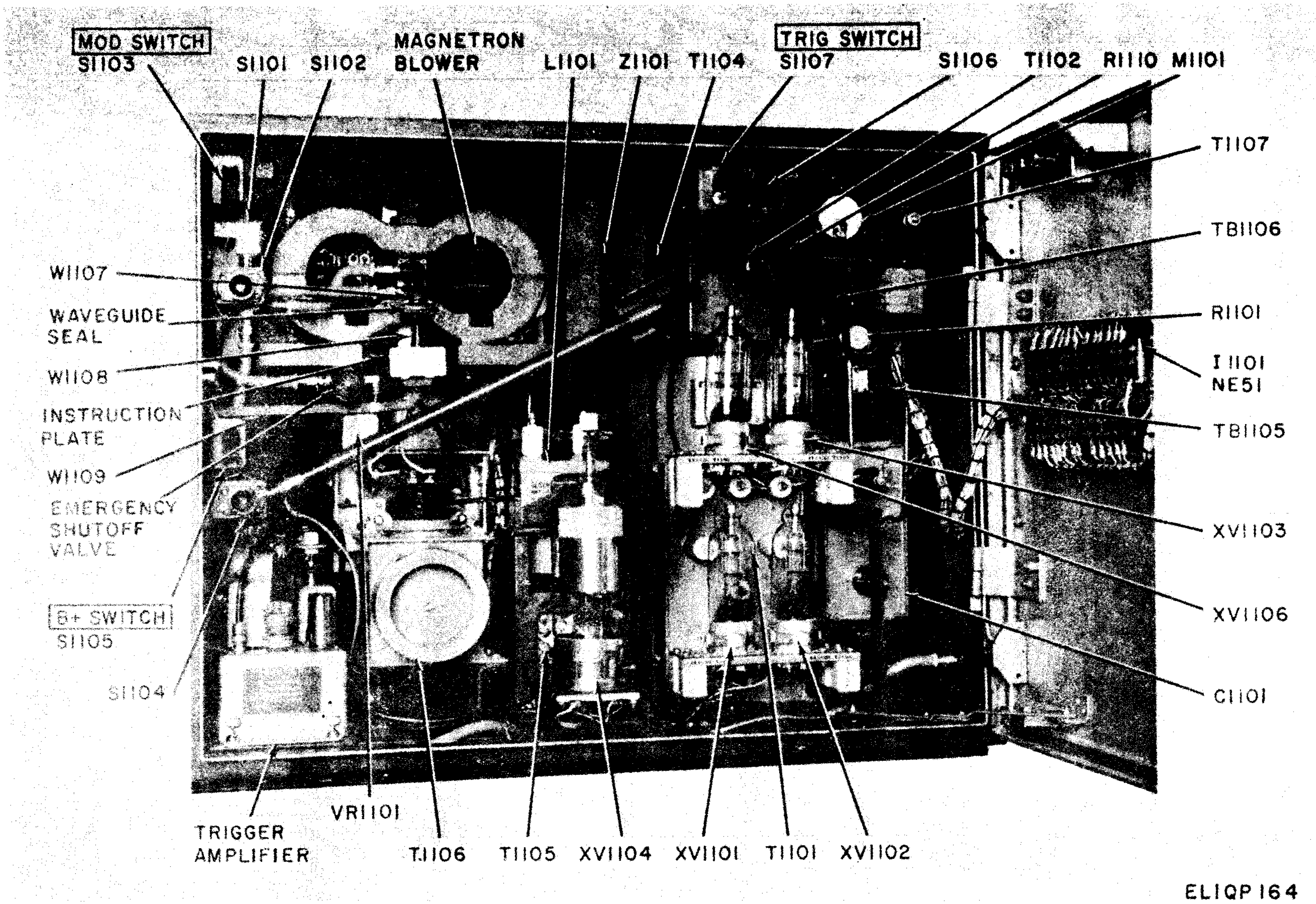

Figure 3-11. Modulator-transmitter, front view.

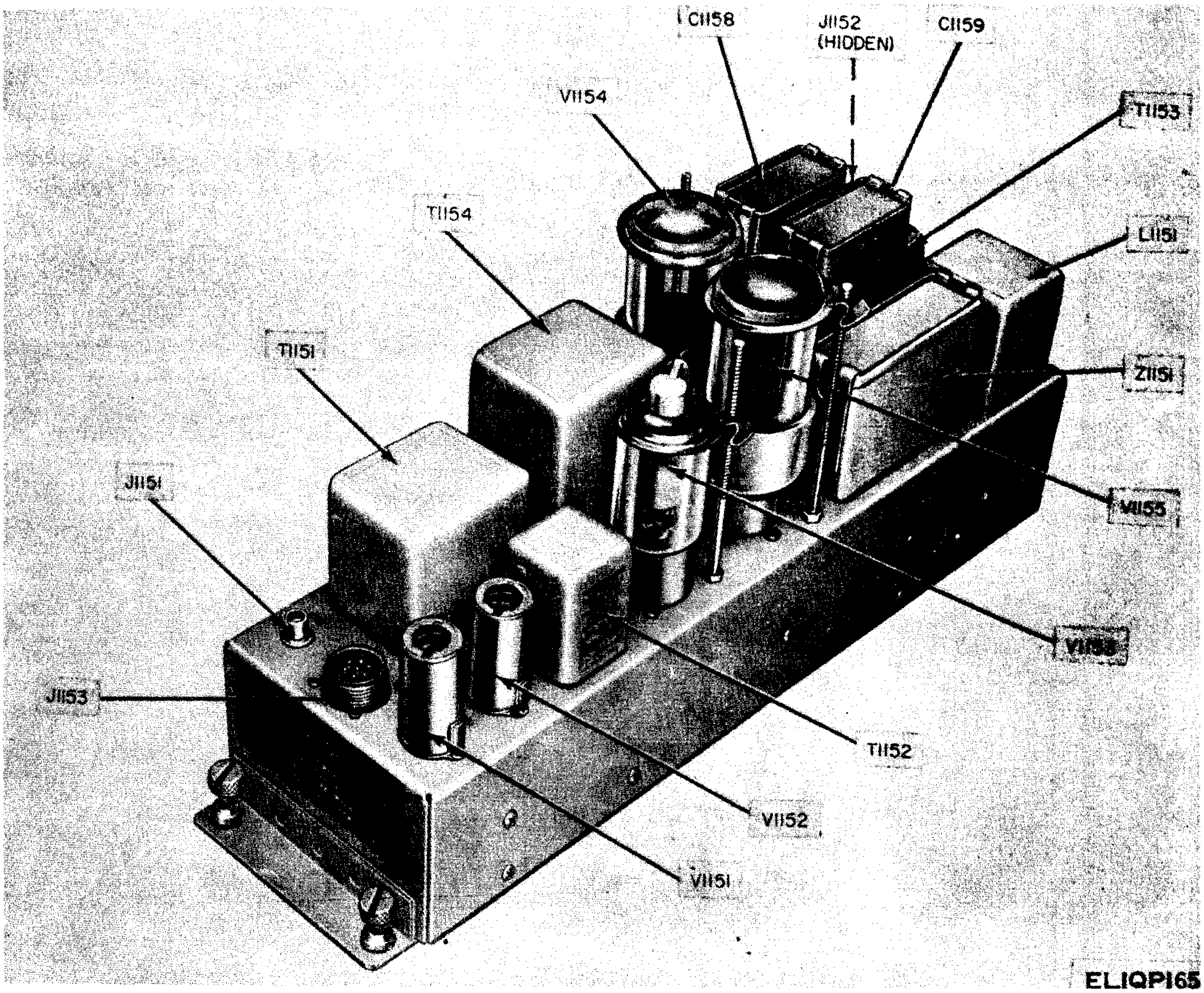

Figure 3-12. Trigger Pulse Amplifier AM-1537/MPQ-4A top view.

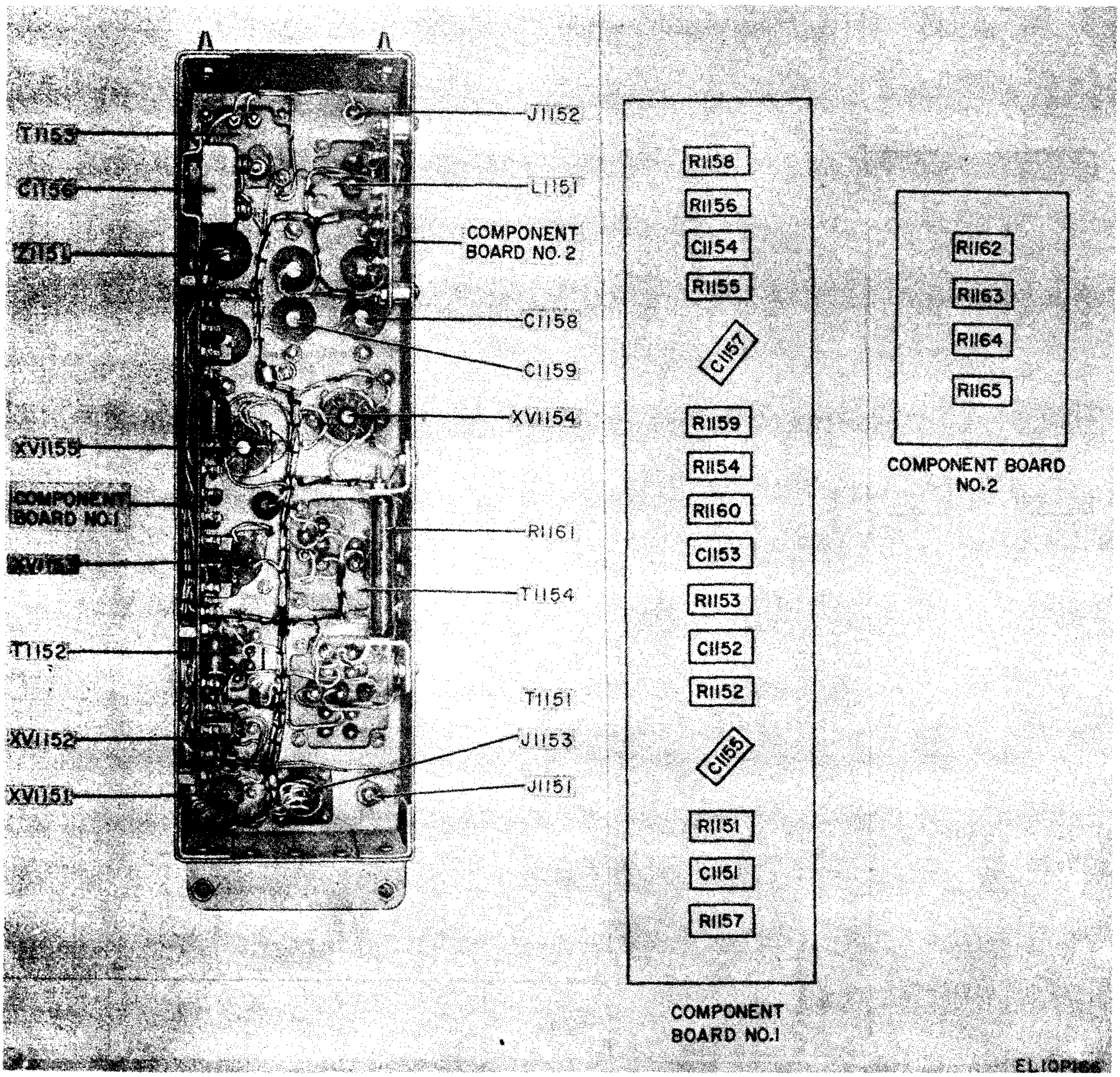

Figure 3-13. Trigger Pulse Amplifier AM-1537/MPQ-4A, bottom view

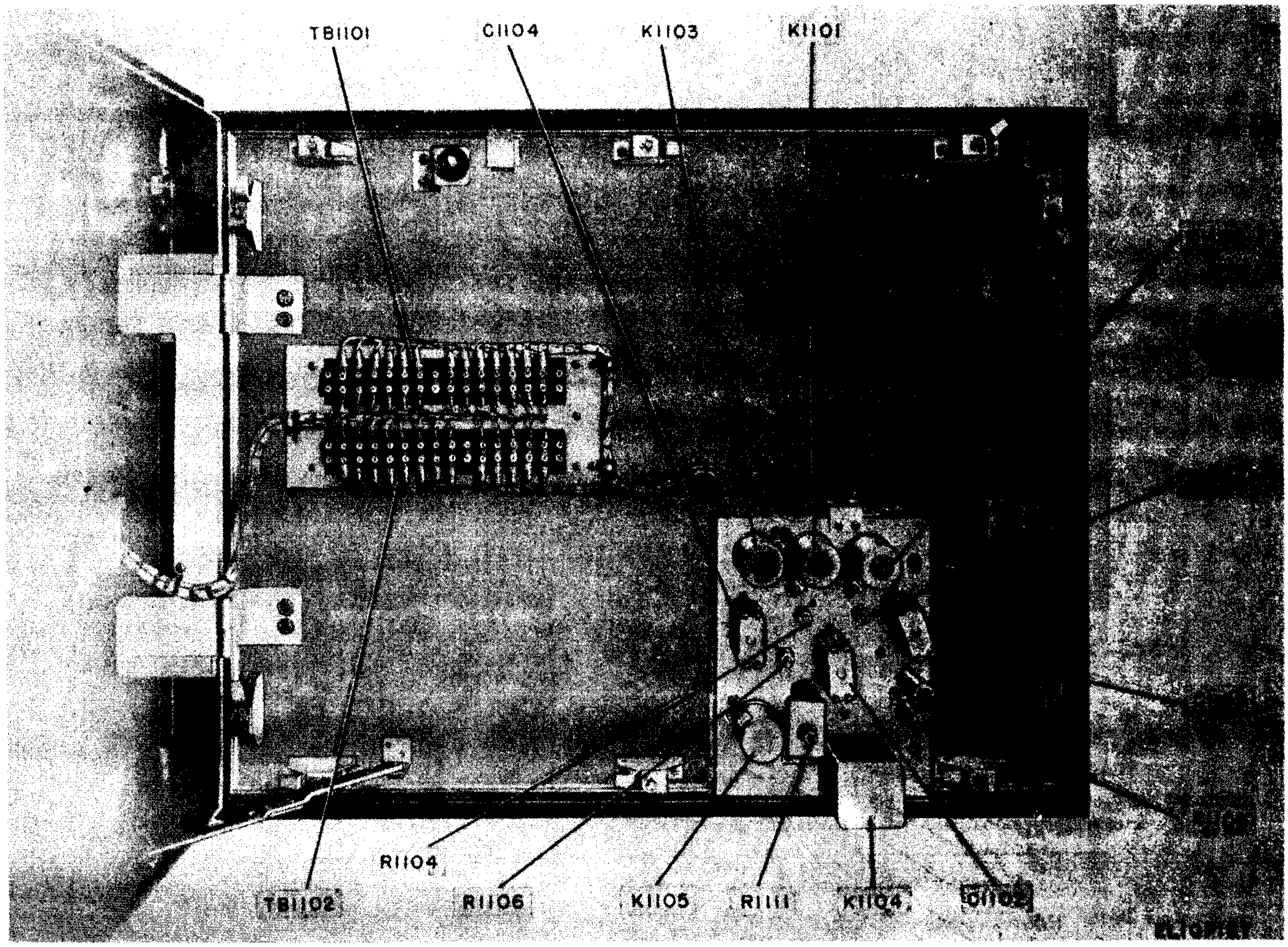

Figure 3-14. Trunsmitter, door, rear view showing relay panel.

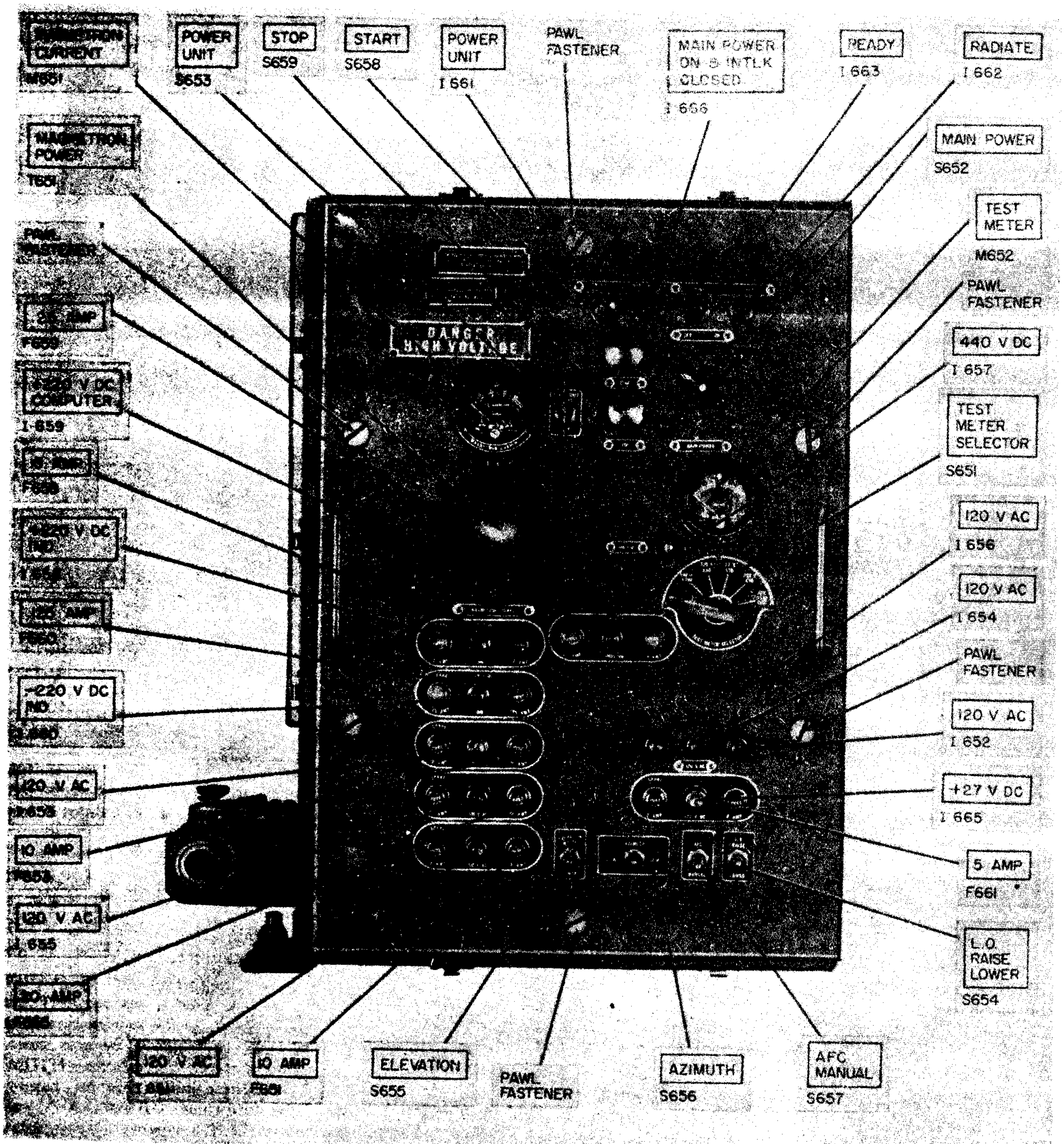

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Figure 3-15. Control-Power Supply C-2014/MPQ-4A, front view,

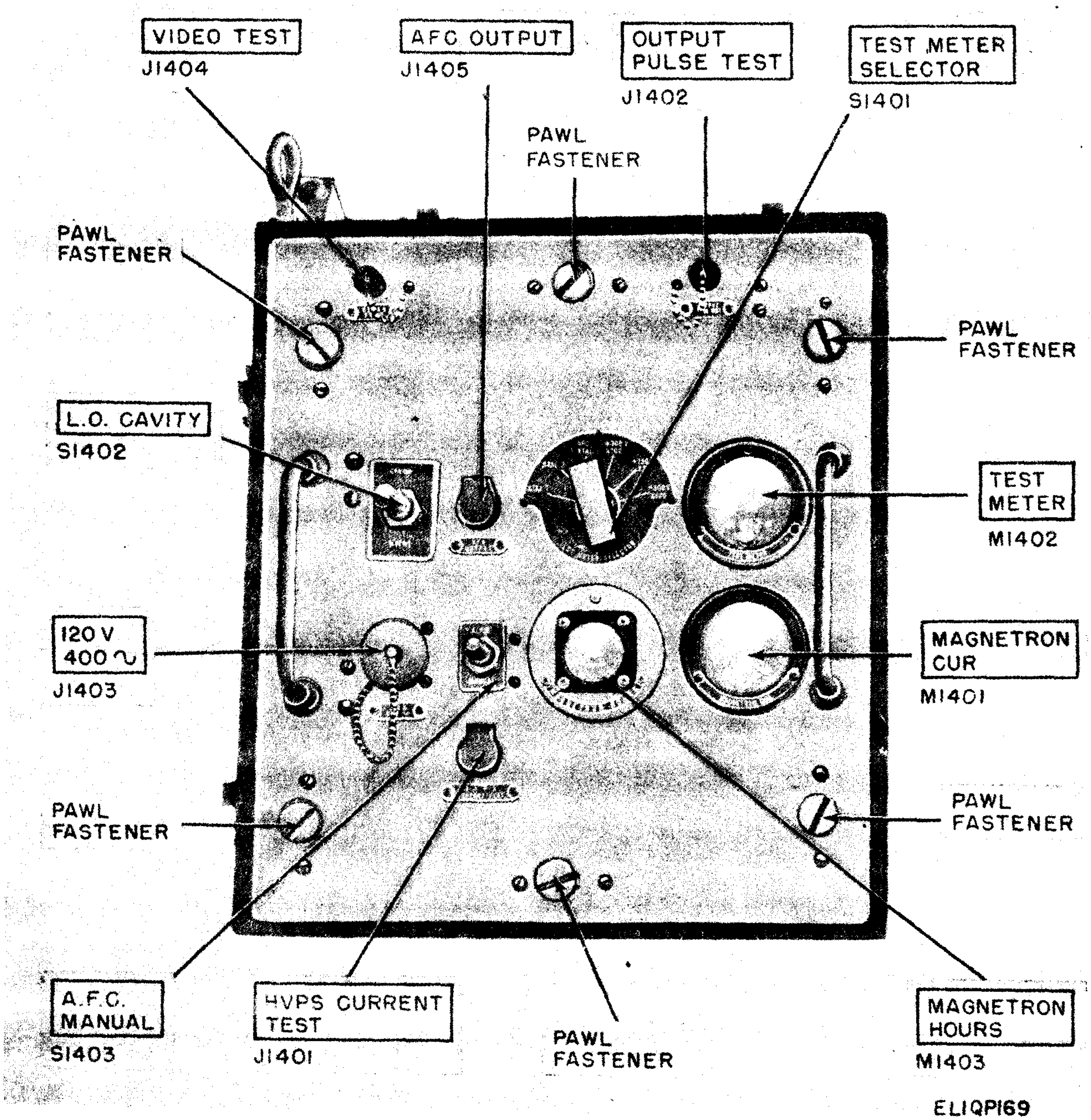


Figure 3-16. Control-monitor, front view.

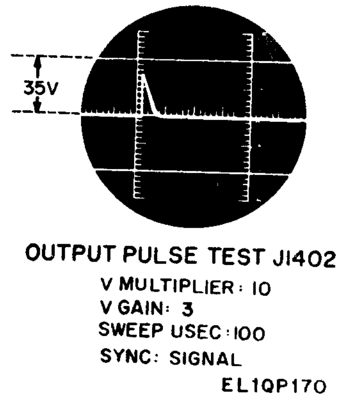


Figure 3-17. OUTPUT PULSE TEST J1402, waveform diagram.

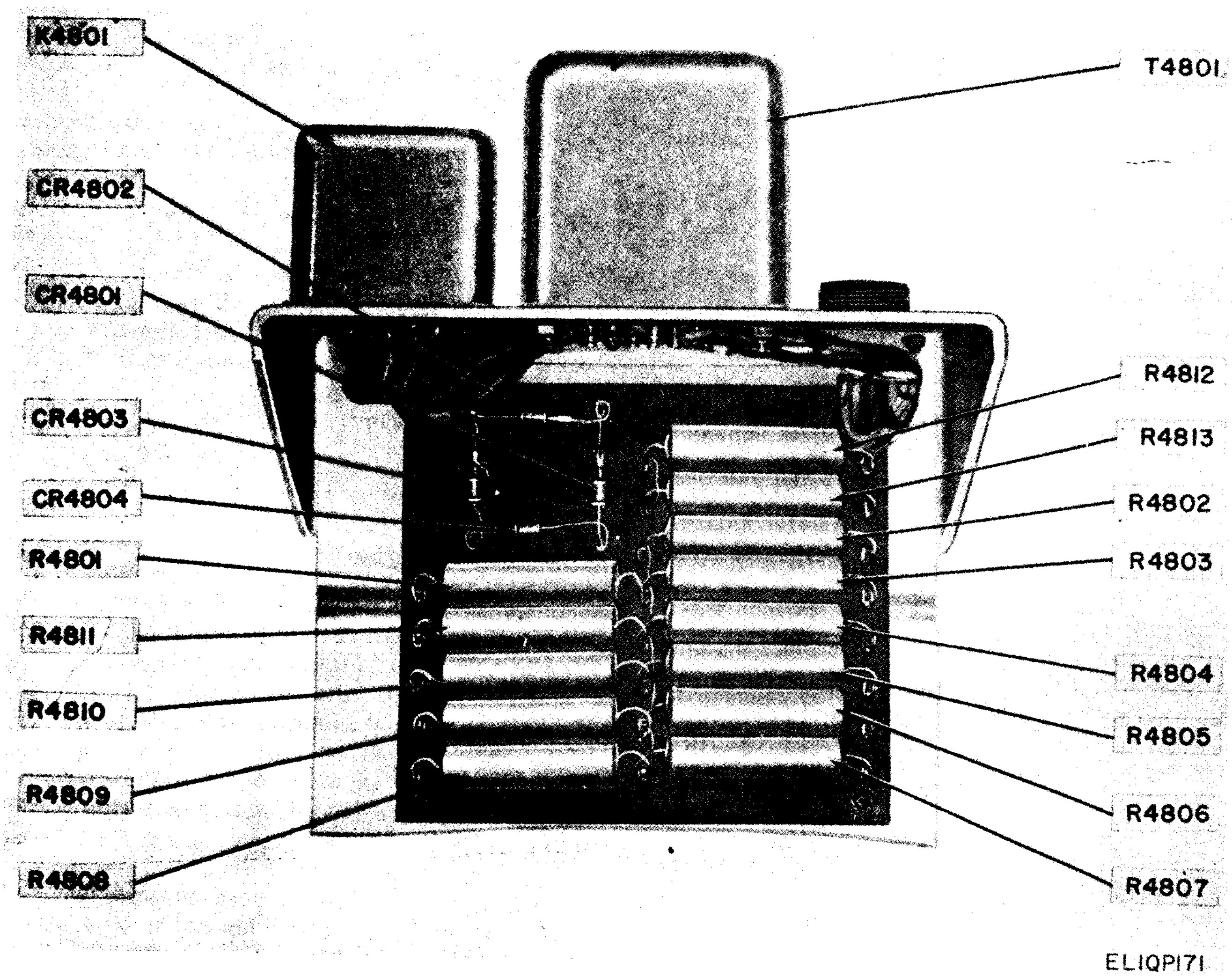


Figure 3-18. Voltage regulator VR1101

b. Transmitting System Controls and Adjustments. Table 3-12 lists the controls and adjustments that are functional parts of the trans. mitting system.

c. Transmitting System Fuse. Fuse F1601 is 125 milliamperes and protects the +300-volt dc supply to the trigger amplifier. Blown-fuse indicator I 1601 lights when F1601 is blown.

d. Normal Indications of Transmitting System Panel Meters. Table 3-13 lists the meters which monitor all phases of operation of the transmitting system, references a figure that shows the location of each meter, and gives the function of each meter.

e. Normal Indications at Transmitting System Test Points. Table 3-14 lists the test points which are provided to test the operation of circuits in the transmitting system, references a figure that shows the physical location of each test point, and gives or references the normal indication at each test point,

Table 3-12. Transmitting System Controls and Adjustments

Controls and adjustments	Location (fig.)	Function
RADIATE indicator lamp I 662.	3-15	Lights when switch S658 is pressed. Indicates transmitter is operating.
START switch S658....	3-15	Energizes high voltage power supply of transmitter.
STOP switch S659. . .	3-15	Removes power from high voltage power supply.

Table 3-13. Transmitting System Panel Meters

Meter	Location (fig.)	Function
MAGNETRON CURRENT meter M651 (0-1- to 50-ma dc scale).	3-15	Indicates magnetron current. Normal indication is 18 ma.
MAGNETRON CUR meter M1401 (0-1- to 50-ma dc scale)	3-16	Indicates magnetron current. Normal indication is 18 ma.
MAGNETRON HOURS meter M 1403.	3-16	Indicates the total time that the magnetron has operated.

Table 3-14. Transmitting System Test Points

Test point	Location (fig.)	Normal indication
HVPS CURRENT TEST jack J1401.	3-16	Used to teet current of high voltage power supply. Should indicate 195 ma ±10 when M 1401 indicates 18 ma.
OUTPUT PULSE TEST jack J1402.	3-16	0.25 μsec pulse, 7,000 prf (fig. 3-17).

f. Dc Resistance of Transmitting System Transformers and Coils. Table 3-15 lists the transformers and coils in the transmitting system, references a figure that shows the location of each, and gives the dc resistance of every winding.

Table 3-15. Transmitting System Transformers and CoilS

Transformer or coil	Location (fig.)	Terminals	Dc resistante (ohms)
Modulator-transmitter			
Higher voltage power supply transformer T1101.	3-11	1-2	0
		3-4	0.5
		9-10	270
		11-12	0
		8-5	25
		12-8	170
Voltage-adjusting transformer T1102	3-11	1-2	0.2
		3-4	0
Isolation transformer T1104 . . .	3-11	1-3	1.5
		3-4	2.0
Thyratron filament transformer T1105	3-11	1-9	0.3
		9-10	0
Pulse transformer T1106		1-2	0
		4-5	6
		3-6	0
Pulse.forming network 21101	3-11	1-2	0.2
Saturating reactor L1101.	3-11	1-2	0
Trigger amplifier			
Filament transformer T1151 . .	3-12 and 3-13	1-5	6
		6-7	0
		8-9	0
		10-11	0
Blocking oscillator transformer T1152	3-12 and 3-13	1-2	16
		3-4	16
		5-6	20
		7-8	20
Pulse transformer T1153 .	3-12 and 3-13	1-2	0
		7-8	0.5
Plate and filament transformers for supply T1154.	3-12 and 3-13	1-6	3
		11-13	0
		8-9	500
Charging reactor L1151		1-2	190

3-19. Transmitting System Troubleshooting

a. General Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the transmitting system.

(1) *Symptom troubleshooting (d below).* Troubles that have been sectionalized to the transmitting system can usually be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a channel, circuit, or stage. The symptoms given in *d* below consist of indications obtained on M651 or M1401. To troubleshoot the transmitting system based on symptoms, proceed as follows:

(a) Observe the indications obtained on M651 or M1401.

(b) Compare the indications obtained with those listed in each of the symptoms.

(c) If the indications obtained correspond to

those listed in a particular symptom, follow the procedure given to isolate the trouble.

(d) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleehooting table ((2) below).

(2) *Step-by-step troubleshooting table (e Mow).* The transmitting system step-by-step troubleshooting table consists of a series of steps designed to evaluate all phases of operation of the transmitting system. Use this table if the trouble cannot be isolated by symptom troubleshooting ((1) above). To troubleshoot the transmitting system using the step-by-step troubleshooting table, proceed as follows:

(a) Locate the test point given in step 1 of the table 3-17.

(b) Connect the test equipment and set the controls on the test equipment as directed in the *Test equipment* column.

(c) Set the controls as directed in the *Radar set* controls column.

(d) Compare the indications obtained on the test equipment with the indications which are given or referenced in the Normal indications column.

(e) If the indications obtained on the test equipment are normal, procead either to the next step or as directed in the Normal indications column.

(f) If the indications obtained are abnormal, proceed as directed in the Corrective measures column.

b. Test Equipment Required to Troubleshoot Transmitting System. Table 3-16 lists the items of test equipment that are required to troubleshoot the transmitting system:

c. *Preliminary Checks, Adjustments, and Control Settings.*

(1) *System troubleshooting tables.* Before using the system troubleshooting tables, check the cabling of the receiver-transmitter group (fig. FO-22).

(2) *Step-by-step troubleshooting table.* Prior to using the step-by-step troubleshooting table, check the cabling of the receiver-transmitter group (fig. FO-22).

WARNING

Before following the procedure in (3) below, make sure that MAIN POWER switch S652 is in the OFF position.

Table 3-16. Test Equipment Required to Troubleshoot Transmitting System

Test equipment	Common name	Technical manual
Spectrum Analyzer AN/UPM-58.	Spectrum analyzer.	TM 11-5099
Oecilloscope AN/USM-281C.	Oscilloscope	TM 11-6625-1703.15
Electronic Multimeter ME-26/U	Vtvm (vacuum-tube voltmeter).	TM 11-6625 -200-5
Multimeter TS-352B/U	Multimeter.	TM 11-6625-366-15

(3) Modulator-transrnitter. To make the modulator-transmitter accessible for troublashooting, aligning, and/or testing, proceed as follows:

(a) Loosen the 10 pawl fasteners on the modulator-transmitter compartment.

(b) Close shorting switches S1103, S1104, and S1107 (fig. 3-11).

(c) Turn MAIN POWER switch S652 to the ON position (fig. 3-15).

(d) Press START button S658 (fig. 3-15).

d. Transmitting System Symptom Trouble-shooting.

(1) *Symptom 1.* MAGNETRON CURRENT meter M651 or MAGNETRON CUR meter M1401 indicates zero.

(a) High voltage rectifier tubes V1101 and V1102, charging diode V1106, and reverse current diode V1103 filaments are lighted; the thyratron filament is out.

1. Check relays K1101, K1102, and K1104 located on the transmitter compartment door (fig. 3-14).

2. If the relays are normal, visually check waveguide switch S1101 (fig. 3-11).

(b) All tubes in the transmitter compartment are lighted.

1. Check the output pulse from the trigger amplifier.

2. If no output pulse is present, check trigger amplifier.

(2) *Symptom 2.* MAGNETRON CURRENT meter M651 or MAGNETRON CUR meter M1401 indicates less than normal. Check modulator trigger output from indicator.

Table 3-17. Transmitting System Step-by-Step Troubleshooting Table

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1	Terminals No. 1 and No. 2 of terminal board TB1101 (fig. 3-14).	Multimeter TS-352B/U, controls set to measure 115 volts ac.	Set MAIN POWER switch S652 to ON.	0 volt .... Modulator compartment filaments light and blowers operate.	Troubleshoot the interlock circuit. If filaments do not light, proceed with steps 2 through 6.
2	Terminals No. 11 and No. 12 of T1101.	Set multimeter controls to measure 10 volts ac.	Same as step 1	5 volts ac.............	Check fuse F655.
3	Terminals No. 7 and No. 13 of T1101.	Same as step 2	Same as step 1	5 volts ac.............	Same as step 2.
4	Terminals No. 12 and No. 14 of TB1102.	Same as step 2	Same as step 1	6.3 volts ac	Troubleshoot T1107 and VR1101.
5	Terminals No. 1 and No. 2 of T1106.	Same as step 2	Same as step 1	5.5 volts ac max	Check T1104 and T1106.
6			Press START button S658.	RADIATE indicator lamp I 662 lights. MAGNETRON CURRENT meter M651 indicates magnetron snap-on current. Normal snap-on current is between 7 and 12 ma. Snap-on current varies with age.	Troubleshoot low voltage power supply and interlock circuits. Check thyratron V1104, charging diode V1106, and trigger amplifier (para 3-32*e*).
7	J1401	Plug on end of cord CX-468/U plugged into multimeter controls set to measure 500-ma dc.	Same as step 6	195-ma dc	If indication is low, adjust T651. If indication is still low, check HV rectifiers V1101 and V1102. Troubleshoot thyratron circuit. If indication is low, troubleshoot voltage regulator VR1101. If indication is zero, check high voltage rectifier and trigger amplifier.
8	Terminals 1 and 2 of TB1101.	Electronic Multimeter ME-26/U controls set to measure 120 volts ac.	Same as step 1	0 volt	Check power contactor K1104. Check 28-volt dc control circuit.

3-20. Removal and Replacement of Parts in Transmitting System

a. General. The transmitting system consists of all parta in the modulator-transmitter,

WARNING

Extremely dangerous voltages up to 30,000 volts exists in the modulator-transmitter compartment. Make certain all power is turned off, and discharge all high voltage capacitors before entering the compartment.

b. Removal and Replacement of Magnetron Filament Transformer T1106,

(1) *Removal.*

(a) Unscrew the 10 pawl fasteners on the front door of the modulator-transmitter compartment, grasp both handles and pull out to engage hinges, then open the door by using the handles on the left side.

(b) Tag and disconnect the two magnetron leads on the top of T1106 (fig. 3-11).

(c) Unscrew and remove the four Phillips head screws and lockwashers in the base of the T1106 assembly.

(d) Tilt the top of T1106 forward, tag and disconnect the three leads on the top rear of T1106.

(e) Lift T1106 out of the modulator-transmitter compartment.

(2) *Replacement.*

(a) Position T1106 in place, and identify and connect the three leads on the top rear of the transformer.

(b) Secure T1106 with the four Phillips-head screws and lockwashers.

(c) Connect the two magnetron leads to terminals 1 and 2 on the top of T1106. Note that one magnetron lead has a spade lug painted red, and there is a red dot along aide of terminal 2 of T1106. Connect the red spade lug to terminal 2.

(d) Close the modulator-transmitter front door and secure it with the pawl fasteners.

c. Removal and Replacement of Trigger Amplifier.

(1) *Removal.*

(a) Unscrew the 10 pawl fasteners on the door of the receiver-transmitter compartment, grasp both handles and pull out to engage hinges, then open the door by using the handle on the left side.

(b) Disconnect plugs P1151, P1152, and P1153 from the trigger amplifier chassis.

(c) Unscrew the two knurled fasteners that hold the trigger amplifier chassis to the cabinet floor.

(d) Remove the trigger amplifier chassis from the cabinet.

(2) *Replacement.*

(a) position the trigger amplifier in place in the cabinet.

(b) Secure the chassis in position with the two knurled fasteners.

(c) Connect plugs P1151, P1152, and P1153.

(d) Close the modulator-transmitter front door and secure with the pawl fasteners.

d. Removal and Replacement of Transformers T1151, T1152, T1153, T1154, Choke L1151; Capacitors C1158 and C1159; and Filter Network 21151 (fig. 3-13).

(1) *Removal.*

(a) Remove the trigger amplifier from the equipment as described in *c(1)* above.

(b) Tag, unsolder, and disconnect the wires on each component.

(c) With a socket wrench, remove the screws that hold each component in place.

(d) Lift each component out of the chassis.

(2) *Replacement.*

(a) Position each component in its proper position in the chassis.

(b) Tighten the screws that hold the component in position with a socket wrench.

(c) Connect and solder wires on each component.

(d) Replace the trigger amplifier as described in *c(2)* above.

e. Removal and Replacement of Magnetron V1105. Refer to TM 11-5840-208-20 for removal and replacement procedures.

f. Removal and Replacement of Filter Capacitor C1101 (fig. 3-11).

(1) *Removal.*

(a) Unscrew the 10 pawl fasteners on the front door of the modulator-transmitter compartment, grasp both handles and pull out to engage hinges, then open the door by using the handles on the left side. Use the built-in shorting stock to discharge high voltage capacitor C1101,

(b) Tag and disconnect the two leads on the terminals of C1101.

(c) Loosen and remove the four screws and lockwashers that hold C1101 in place,

(d) Remove C1101 from the equipment.

(2) Replacement.

(a) Position C1101 in place in the compartment and secure it with four screws and lockwashers.

(b) Connect the two leads on the terminals of C1101.

(c) Close the modulator-transmitter front door and secure with the pawl fasteners.

g. Removal and Replacement of High Voltage Power Transformer T1101. (fig. 3-11).

(1) *Removal.*

(a) Loosen and remove the four screws that hold the left bracket between the reverse current diode assembly and the high voltage rectifier assembly. Remove the bracket.

(b) Loosen and remove the four screws that hold the right bracket between the reverse current diode assembly and the high voltage rectifier assembly. Remove the bracket.

(c) Remove V1101, V1102, V1103, and V1106 from their sockets.

(d) Tag and disconnect the leads to the reverse current diode assembly.

(e) Unscrew and remove the four Phillips-head screws and lockwashers that hold the reverse current diode assembly to T1101.

(f) Tag and disconnect the leads to the high voltage rectifier assembly.

(g) Unscrew and remove the four Phillips-head screws and lockwashers that hold the high voltage rectifier assembly to T1101.

(h) Tag and disconnect the leads of T1101.

(i) Unscrew and remove the four Phillip shead screws and lockwashers at the top of the support brace.

(j) Unscrew' and remove the bracket that holds L1101.

(k) Unscrew and remove the 10 screws and lockwashers that hold T1101 to the mounting bracket.

(l) Lift T1101 out of the cabinet.

(2) *Replacement.*

(a) Position T1101 in place and replace and tighten the screws.

(b) Replace the four screws at the top of the support brace.

(c) Connect the leads to T1101.

(d) Replace the bracket that holds L1101.

(e) Replace the high voltage rectifier assembly.

(f) Connect the leads to the high voltage rectifier assembly.

(g) Replace the reverse current diode assembly.

(h) Connect the leads to the reverse current diode assembly.

(i) Replace the right side bracket.

(j) Replace the left side bracket.

(k) Replace V1101, V1102, V1103, and V1106.

h. Removal and Replacement of Coil L1101. (fig. 3-11)

(1) *Removal.*

(a) Remove thyratron V1104.

(b) Tag and disconnect the two leads from the top of L1101.

(c) Unscrew and remove the three Phillips-head screws that hold the bradket to the upright brace.

(d) Remove the four screws that hold L1101 in place and lift out of equipment.

(2) *Replacement.*

(a) Position L1101 in place in the compartment and secure it with the four screws.

(b) Replace the brace.

(c) Connect the two leads on the top of V1104.

(d) Replace thyratron V1104.

i. Removal and Replacement of Transformer T1105 (fig. 3-11).

(1) *Removal.*

(a) Remove thyratron V1104.

(b) Loosen and remove the four screws and lockwashers that hold the thyratron tube socket assembly.

(c) Carefully place the thyratron tube socket assembly to one side.

(d) Tag, disconnect, and remove the leads to transformer T1105.

(e) Loosen and remove the four Phillips-head screws and lockwashers that hold transformer T1105.

(f) Remove T1105 from the cabinet.

(g) Loosen and remove the four nuts that hold the plate to T1105.

(2) *Replacement.*

(a) Position the plate on T1105 and fasten in place with the four nuts removed as instructed in *(1)(g)* above.

(b) Position the transformer in place in the compartment.

(c) Replace and tighten the four Phillips-head screws and lockwashers removed as instructed in *(1)(e)* above.

(d) Connect the leads to T1105.

(e) Position the thyratron tube socket assembly in place and replace and tighten the four screws and lockwashers removed as instructed in *(1)(b)* above.

(f) Replace thyratron V1104.

j. *Removal and Replacement of Transformers T1102, T1104, and Pulse-Forming Network Z1101.*

(1) *Removal.*

(a) Remove reverse current diode tubes V1103 and V1106.

(b) Unsnap and remove R1101 and R1103 from the upper right hand corner of the modulator-transmitter compartment (fig. 3-11).

(c) Tag and disconnect the leads on each component that is to be removed.

(d) Remove the screws that hold each component in place and lift out of modulator-transmitter compartment.

(2) *Replacement.*

(a) Position each component in place in the compartment and secure it with screws.

(b) Connect leads on each component.

(c) Replace R1101 and R1103 in position in the upper right hand corner of the compartment (fig. 3-11).

(d) Replace reverse current diode tubes V1103 and V1106.

k. Removal and Replacement of Voltage Regulator VR1101 (fig. 3-11).

(1) *Removal.*

(a) Remove the trigger amplifier as described in c(1) above.

(b) Disconnect the cable from J4801.

(c) Remove the screws that hold the voltage regulator to the rear wall.

(d) Remove the voltage regulator from the cabinet.

(2) *Replacement.*

(a) Position the voltage regulator in place against the rear wall of the modulator-transmitter compartment.

(b) Replace and tighten the screws that hold the regulator in place.

(c) Connect the cable to J4801.

(d) Replace the trigger amplifier as described in c(2) above.

3-21. Transmitting System Adjustment

a. *General.*

(1) This paragraph covers all the adjustments in the transmitting system. These adjustments are in the modulator-transmitter compartment and the procedures for making the adjustments are the same whether the components are on the bench or interconnected with the other components of the radar set. The complete alignment and adjustment of the radar set are covered in paragraph 3-59.

(2) The following alignment and adjustment procedures are covered in this section-

(a) Adjustment of thyratron switch.

(b) Adjustment of K1103.

(c) Adjustment of K1102 and K1101.

b. Alignment. The transmitter operates on a fixed frequency and requires no tuning. Certain voltage adjustments are required, however, when thyratron tube V1104 is replaced. It is also possible to check the performance of relay K1103, after replacement, with the facilities provided in the equipment.

c. Test Equipment Required. Multimeter TS 352B/U is required to completely align the transmitting system.

d. Alignment Procedure.

WARNING

Do not reach into the transmitter compartment during the following adjustments. Voltage in excess of 30,000 volts is present.

(1) *Thyratron switch adjustments.* The adjustment of thyratron voltage regulator VR1101 and powerstat T1107 may be accomplished by the use of RESERVOIR VOLTS meter M1101 as an indicating device.

CAUTION

Do not turn the magnetron on until instructed to do so (*(e)* below) because the hydrogen pressure in the thyratron may be too high, causing the thyratron to act as a short across the high voltage power supply.

(a) Prior to installing a new thyratron tube, record the capsule voltage stamped on the base of the tube. Install the new tube.

(b) Turn MAIN POWER switch S652 to ON.

(c) At the modulator-transmitter cabinet, adjust powerstat T1107 (fig. 3-11) fully cw.

(d) Adjust R1111 (fig. 3-14) for an indication on RESERVOIR VOLTS meter M1101 (fig. 3-11) that is midway between the lowest and highest indication that can be obtained by turning R1111 ccw and then cw.

(e) Adjust T1107 for the capsule voltage that was recorded in *(a)* above while observing M1101; allow approximately 3 minutes for the thyratron gas pressure to stabilize before radiating.

CAUTION

Required capsule voltage may change with age and temperature extremes, requiring a slightly different voltage setting (usually lower than that stamped on the base of the tube) to prevent irregular firing and plate overheating.

(2) *Adjustment of K1103.* Refer to TM 11. 5840-208-20 for K1103 adjustment procedures.

(3) *Adjustment of K1101* (fig, 3-15 and 3-16). The adjustment for K1101 is R1106. This is a preset adjustment which removes hv when the current drain in the high voltage power supply exceeds 300 ma. This adjustment should only be accomplished while the radar set is in the maintenance facility; however, a method of checking the operation of the relay, and thereby checking on the high voltage power supply, is as follows.

(a) At Control-Monitor C-2102/MPQ-4A front panel, connect Multimeter TS-352B/U to HVPS CURRENT TEST jack J1401 (fig. 3-16).

(b) Adjust the multimeter to measure 500 ma of dc.

(c) Place MAIN POWER switch S652 at ON.

(d) Press START button S658.

(e) Turn MAGNETRON POWER variac T651 cw from zero to a setting which produces 18 ma of magnetron current while observing the

multimeter. Note that the multimeter indicates approximately 195 ma of Current when M1401 indicates 18 ma.

(4) *Adjustment of K1102.* The adjustment for K1102 is R1105 (fig. 3-14), which is preset so that the contacts open when the modulator reverse current reaches 160 ma. This adjustment should only be accomplished while the radar set is in the maintenance facility.

3-22. Transmitting System Testing

a. General This paragraph describes testing procedures required to check the serviceability of a repaired transmitting system when the components of the radar set are interconnected.

b. Test Equipment Required. Spectrum Analyzer AN/UPM-58 is the only item of test equipment required to completely test the serviceability of the transmitting system. Instructions for using the spectrum analyzer are contained in TM 11-5099.

c. Check of Magnetron Spectrum.

(1) Turn MAIN POWER switch S652 to OFF.

(2) Disconnect the echo box from the directional coupler.

(3) Connect Spectrum Analyzer AN/UPM-58 to the directional coupler.

(4) Turn MAIN POWER switch S652 to ON.

(5) Press START button S658.

(6) Observe indications on the spectrum analyzer. There should be little evidence of double moding or missing pulses observed on the spectrum analyzer. The magnetron spectrum should not be more than 10 megaHertz wide between the first pair of zeros. Side lobes should be a minimum of 6 db down from the main lobes.

(7) Press STOP button S659 and turn MAIN POWER switch S652 to OFF.

(8) Disconnect the spectrum analyzer from the directional coupler.

(9) Connect the echo box to the directional coupler.

d. Check of a Magnetron Frequency and Ringtime.

(1) Turn MAIN POWER switch S652 to ON.

(2) Press START button S658.

(3) Place A AZIMUTH and A RANGE handwheels on the computer front panel in their detent positions.

(4) Adjust TUNE knob E1702 on the echo box for a maximum indication on FREQUENCY scale N1701 (fig. 3-19).

(5) Rotate the LOWER BEAM RANGE handwheel on the computer until the noise begins to build up on the B-scope.

(6) Record the indication on RANGE counter M831. This is the ring-time.

(7) Adjust METER SENSITIVITY adjustment R1702 on the echo box until the deflection of RELATIVE POWER meter M1701 is approximately one-half scale (fig. 3-19).

(8) Record the indication of FREQUENCY scale N1701. Minimum acceptable limits are: Ringtime should be 1200 meters, RELATIVE POWER meter M1701 indication should be one-third full-scale, and frequency should be 16,000 MHz ±160 MHz.

Section V. RF SYSTEM TROUBLESHOOTING AND REPAIR

3-23. Rf System Troubleshooting Information

a. Reference. Data. The following information will be helpful when troubleshooting and/or repairing the rf system.

Reference	Data
Fig. 2-15	Rf system, block diagram.
Para *2-16a* through *l* . . .	Rf syetem operation.
Fig. 2-16 through 2-31	Rf system diagrams.
Fig. 3-19	Tuned Cavity FR-111/MPQ-4A.
Fig. 3-20	Echo box adjueting screws.
Fig. 3-21	Echo box, location of parts.

b. Rf System Controls and Adjustments. Table 3-18 lists the controls and adjustments that are functional parts of the rf system.

c. Normal Indication of Rf System Meters, RELATIVE POWER meter M1701 (fig. 3-19) on the echo box is the only meter in the rf system. The meter indicates the relative power of the radar set when the echo box cavity is tuned to resonance.

Table 3-18. Rf System Controls and Adjustments

Controls and adjustment	Location (Fig.)	Function
L.O. ADJUST.	3-26	Attenuates the signal from the local oscillator.
TUNE control E1702. . .	3-19	Tunes the cavity of the echo box.
FREQUENCY-MC dial N1701,	3-19	Indicates the frequency of the radar eat.
METER SENSITIVITY potentiometer R1702.	3-19	Adjusts the sensitivity of RELATIVE POWER meter M1701.

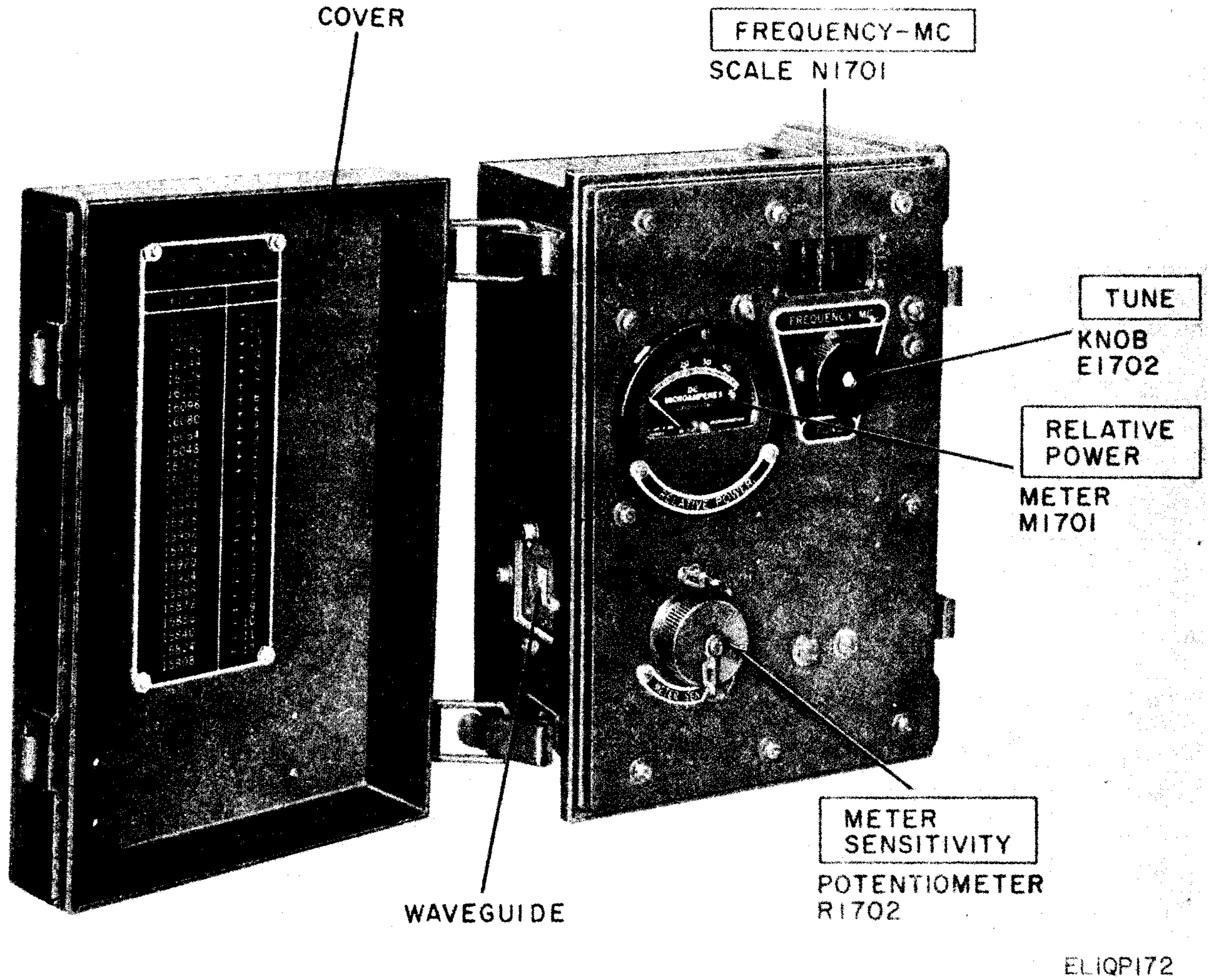


Figure 3-19. Tuned Cavity FR-111/MPQ-4A.

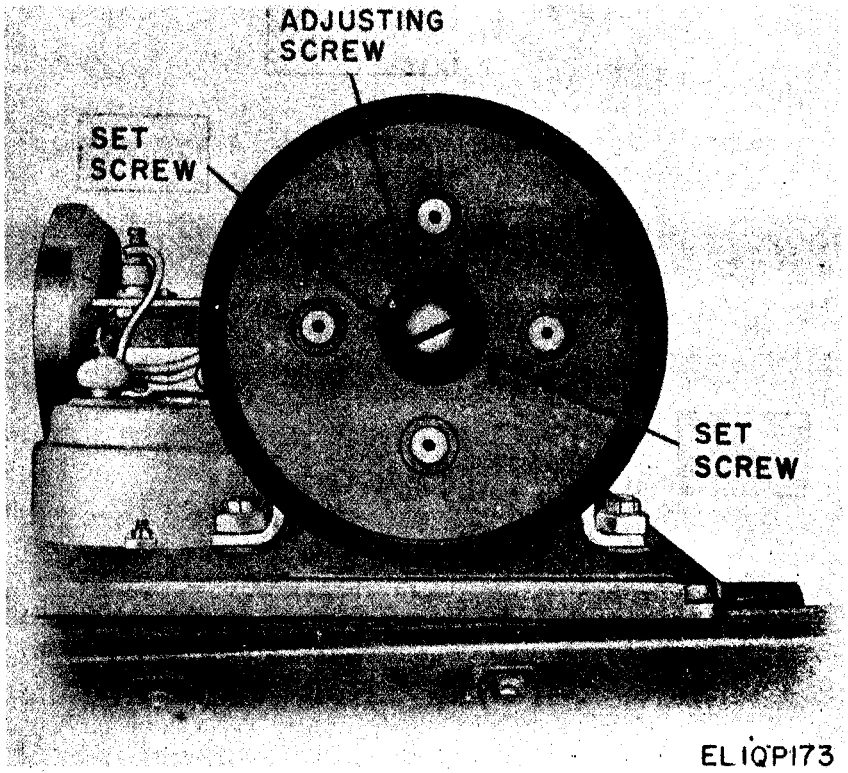


Figure 3-20. Echo box adjusting screws.

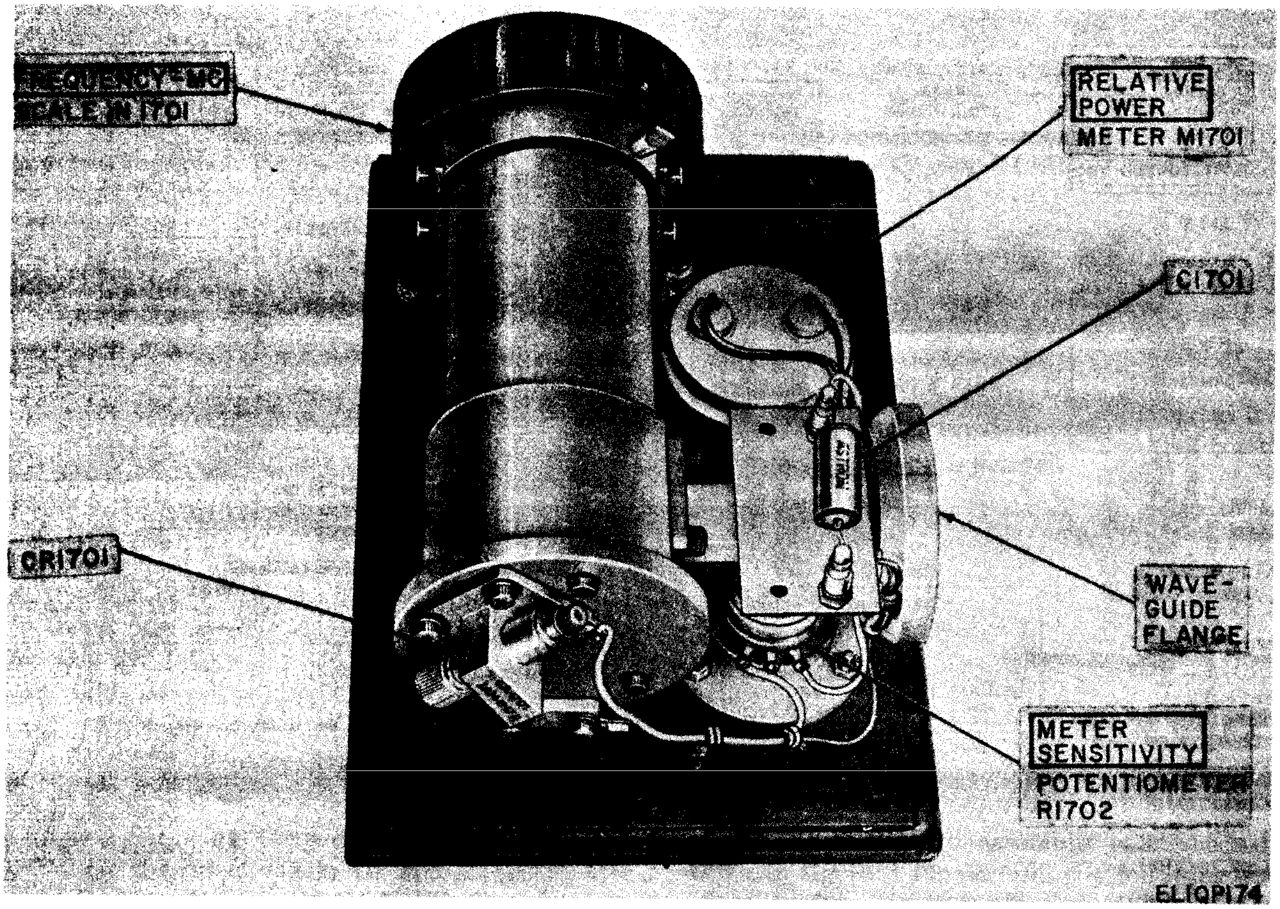


Figure 3-21. Echo box, location of parts,

3-24. Removal and Replacement of Parts in Rf system

a. General The rf system. consists of all the waveguide sections, the ferrite isolator, the duplexer, the directional coupler, the echo box, the antenna (scanner), the circular polarizer, and the reflecter.

WARNING

Extremely dangerous voltages exist in the modulator and the receiver-transmitter. When removing or replacing parts in either of these components, heed the high voltage warnings.

b. Removal and Replacement of Waveguide Sections in Modulator-Transmitter Cabinet (fig. 3-11)

CAUTION

Be careful when removing and replacing waveguide components as they can be easily damaged. Be sure that all waveguide seal O-rings are properly replaced.

NOTE

When making threaded pipe joints, seal the joint with thread sealant tape (¼-inch wide, No. 48).

(1) *Removal and replacement of waveguide section W-1107.*

(a) Removal of W1107.

1. Remove the two airhoses connected to W1107.

2. Remove the four screws and lock-washers that secure W 1107 to W 1108. Remove the two O-rings and waveguide seal (window), noting position of seal.

3. Remove the four screws and lock-washers that secure W1107 to the magnetron. Remove the O-ring.

4. Remove W1107 from the cabinet.

5. Remove pipe adapters from W1107,

(b) Replacement of W1107.

1. Replace pipe adapters on W1107, being careful not to overtighten them. Properly position

W1107, O-rings, and spotlessly clean waveguide seal in place, and secure W1107 to W1108 with four screws and lockwashers. The O-rings should be firmly seated in the waveguide choke flanges,

2. Secure W1107 to the magnetron with four screws and lockwashers.

3. Connect the two airhoses to W1107. Do not overtighten.

(2) *Removal and replacement of waveguide section W1108.*

(a) Removal of W1108.

1. Remove the four screws and lockwashers that secure W 1108 to W 1107. Remove the two O-rings and waveguide seal, noting position of seal.

2. Remove the four screws and lockwashers that secure W 1108 to W 1109. Remove the instruction plate and O-ring.

3. Remove W 1108 from the cabinet.

(b) Replacement of W1108.

1. Properly position W 1108 (choke joint at top), O-rings, and instruction plate in place, and secure to W 1109 with four screws and lockwashers.

2. With the waveguide seal spotlessly clean and properly positioned between the O-rings in the choke flanges of W 1108 and W 1107, secure W 1108 to W 1107 with four screws and lockwashers.

(3) *Removal and replacement of waveguide section W1109.*

(a) Removal of W1109.

1. Remove the airhose connected to the shutoff valve.

2. Remove the four screws and lockwashers that secure W1109 to W1108. Remove the instruction plate and O-ring.

3. Remove the four screws and lockwashers that secure W1109 to the cabinet. Remove the O-ring.

4. Remove W1109 from the cabinet.

5. Remove the emergency shutoff valve, pipe adapter, and elbow from W1109.

(b) Replacement of W1109.

1. Replace the pipe adapter, elbow, and shutoff valve on W1109, being careful not to overtighten them.

2. Position W1109 and the O-rings in place, and secure W1109 to the cabinet with four screws and lockwashers.

3. Position the instruction plate on the W1108 flange, and secure W1109 to W1108 with four screws and lockwashers.

4. Connect airhose to shutoff valve. Do not overtighten.

c. Removal and Replacement of Waveguide Sections in Receiver Compartment.

(1) *Removal and replacement of waveguide sections.* Removal and replacement of waveguide section W1502, ferrite isolator W1503, and waveguide section W1510 as a unit, plus the duplexer and its associated microwave assemblies, are described in TM 11-5840-208-20. Removal of certain waveguide sections within the receiver compartment requires the removal of one or more sections or assemblies to enable access to a particular section.

(2) *Removal and replacement of waveguide section W1501.*

(a) Removal.

1. Disconnect the coaxial cable connected to J4701 on the front of the stc assembly.

2. Remove the four screws from the flange connecting waveguide bend W1501 to ferrite isolator W 1503.

3. Remove the six screws that hold W1001 to the right hand wall of the receiver compartment, and remove W1501 from the compartment. Do not lose the O-ring.

(b) Replacement.

1. Insert the O-ring in the choke flange of W1501 and fasten the flange to the right sidewall of the receiver compartment with the six screws removed. in *(a)* 3 above.

2. Install the four screws into the choke flange joining the ferrite isolator to W1501. Check to see that the O-ring is in place.

3. Reconnect the coaxial cable to J4701 on the front of the stc assembly.

(3) *Removal and replacement of ferrite isolator* W1503.

(a) Removal.

1. Remove the ferrite isolator, flexible waveguide bend W 1502, and waveguide section W1510 as described in TM 11-5840-208-20.

2. Remove the four screws that connect W1502 to W1503 (W1510 still attached to other end of W1502).

(b) Replacement.

1. Replace and tighten the four screws that secure W1502 and W1510 to the ferrite isolator.

2. Replace the ferrite isolator, flexible waveguide bend W 1502, and waveguide section W1510 as described in TM 11-5840-208-20.

(4) *Removal and replacement of waveguide sections W1502 and W1510.*

(a) Removal.

1. Remove W1502 and W1510 as described in *(3)(a)l* above.

2. Remove the four screws that connect W1502 and W1510 on one end and W1503 on the other end.

(b) Replacement.

1. Reconnect W1510 to one end of W1502 and reconnect the other end of W1502 and W1503.

2. Replace the ferrite isolator, flexible waveguide bend W 1502, and waveguide section W1510 removed as a unit as described in *(3)(b)2* above.

d. Removal and Replacement of Flexible Waveguide Section W1512.

(1) *Removal.*

(a) Remove the duplexer and klystron motor assembly as described in TM 11-5840-208-20. Removal of the duplexer includes removal of ferrite isolator W1503, W1502, and W1510 as a unit .

(b) Remove the four screws that secure flexible waveguide W1512 to rigid waveguide W 1513 and the plate attached to the ceiling bracket at the rear of the receiver compartment. Check to see that the O-ring remains in the choke flange of W1513.

NOTE

It may be necessary to loosen the two screws that hold the sliding plate to the ceiling bracket. The other end of the sliding plate is secured to flexible waveguide W 1513.

(c) Remove flexible waveguide W1512 from the cabinet.

(2) *Replacement.*

CAUTION

To prevent possible damage to the magnetron, make sure that the sliding plate attached to the ceiling bracket is not positioned between the choke and plain flanges of waveguide sections W1513 and W1512.

(a) Position flexible waveguide W 1512, mating the plain flange of W1512 with the choke flange of W1513. Check to see that the O-ring is in the choke flange of W1513.

(b) Fasten the plate and flexible waveguide W1512 to rigid waveguide W1513 with the four screws removed in (1)(b) above.

(c) Tighten the screws in the end of the plate attached to the ceiling bracket if loosened during removal of W1512.

(d) Reposition the duplexer and klystron motor assembly in the cabinet as described in TM 11-5840-208-20.

e. Removal and Replacement of Waveguide Section W1513.

(1) *Removal.*

(a) Remove flexible waveguide W1512 as described in paragraph *3-24d(1).*

(b) Remove the screws, the washers, and the nuts that hold waveguide section W712 to W713 and W1513 at the outside rear of the receiver-transmitter group cabinet (fig. 3-163). Remove waveguide section W712 and the O-rings (fig. 2-16).

CAUTION

Waveguide section W1513 extends through the receiver-transmitter group cabinet wall. A cutout at the rear of the receiver compartment wall permits removal of W 1513 from the inside of the receiver. Be careful not to damage the waveguide during removal and replacement.

(c) Remove the six screws and nuts that secure the gasket and W1513 to the compartment wall. Remove W1513.

(2) *Replacement*

(a) Position W1513 in the receiver compartment, being careful to pass the end of the waveguide through the cutout in the rear wall. Check to see that the gasket is in place.

(b) Install the six screws and nuts that secure the gasket and W 1513 to the cabinet wall.

(c) Reposition waveguide section W712 between W713 and W1513 at the outside rear of the receiver-transmitter group cabinet and secure in place. Check to see that the O-rings are in place.

(d) Position flexible waveguide W1512 in place as described in paragraph *3-24d(2).*

f. Removal and Replacement of Waveguide Pressure Window.

(1) *General.* A circular waveguide pressure window is mounted between waveguiide section W745 and the scanner large endbell (fig. 2-16). This pressure window will rupture if it is not properly replaced.

(2) *Removal.*

(a) Remove the waveguide protective cover on the scanner large endbell.

(b) Remove the four screws that secure waveguide bend W745 (fig. 2-16) to the scanner waveguide section choke flange.

(c) Remove the four screws that secure W745 to waveguide bend W715. Be careful not to pull on the dehydrator airhose connected to W745. Remove the pressure window.

(3) *Replacement.*

CAUTION

Some of the replacement pressure windows are unmarked as to which side faces out. The glass-to-metal seal side of the pressure window is the side that has the most glass exposed. Do not touch the glass with the fingers and do not blow on the glass to clean it.

(a) Replace waveguide bend W745; be careful not to twist the airhose. Loosely couple W745 to W715.

(b) Position the waveguide pressure window

between W745 and the scanner waveguide section choke flange so that the glass-to-metal seal side (side that has the most glass exposed) is facing W745. Replace the four screws.

(c) Tighten the screws on both ends of W745.

(d) Replace the waveguide protective cover removed in *(2)(a)* above.

g. *Removal and Replacement of Waveguide Pressure Switch S1503.*

(1) *Removal.*

(a) Tag, unsolder, and disconnect the leads to S1503 (fig. 3-26).

(b) Unscrew and remove S1503 from the elbow in the air pressurization plumbing.

(2) *Replacement.*

(a) Screw the shaft of S1503 into the elbow in the air pressurization plumbing, being careful to prevent overtightening.

(b) Replace and solder the leads to S1503.

(c) Adjust S1503 in accordance with procedure in TM 11-5840-208-20.

h. Removal and Replacement of Waveguide Pressure Switch S1101.

(1) *Removal*

(a) Tag, unsolder, and disconnect the leads to S1101 (fig. 3-11).

(b) Unscrew and remove S1101 from the cross in the air pressurization plumbing.

(2) *Replacement.*

(a) Screw the shaft of S1101 into the cross in the air pressurization plumbing, being careful to prevent overtightening.

(b) Replace and solder the leads to S1101.

(c) Adjust S1101 in accordance with procedure in TM 11-5840-208-20.

3-25. Rf System Adjustment

a. General. With the exception of waveguide pressure switch S1101 and S1503 adjustments, and the local oscillator adjustments in the duplexer and klystron motor assembly (TM 11-5840-208-20), the echo box is the only other component of the rf system that requires adjustment in the field. This adjustment is necessary when the echo box frequency dial indication is not the true radar frequency as determined by use of external test equipment.

b. Adjustment of Tuned Cavity FR-111 MPQ-4A.

(1) Determine the true radar frequency with Spectrum Analyzer AN/UPM-58 or Radar Test Set AN/UPM-60A. Refer to TM 11-5099 or TM 11-6625-228-12.

(a) Tune FR-111/MPQ-4A for maximum deflection on relative power meter M1701, with tuning knob E1702.

(b) Note reading on frequency dial N1701.

(2) Remove the four screws at each end of waveguide section W744 that secure W744 to the echo box and flexible waveguide bend W743. Do not lose the O-ring (fig. 2-16 and 3-19).

(3) Remove the 10 screws that secure the front panel to the case and the 2 screws holding the internal waveguide on the left side of the case. All elements are mounted at the rear of the panel. Remove the front panel (fig. 3-21). Set frequency dial N1701 to the reading noted in (1) *(b)* above.

(4) Loosen the two setscrews in the hub of the dial (fig. 3-20).

(5) Rotate the dial until it indicates the exact radar frequency determined in (1) above. Hold the dial to prevent slippage.

(6) Tighten the two setscrews loosened in (4) above.

(7) Replace the echo box in the case and secure the front panel with the screws removed in (3) above.

(8) Position waveguide section W744 between the echo box and W743. Replace the O-ring in the choke flange of W744.

(9) Secure W744 to W743 and the echo box. Close the cover and snap the latches shut.

Section VI. RECEIVING SYSTEM TROUBLESHOOTING AND REPAIR

WARNING

Use caution when working in the receiver compartment as hazardous voltages are present on the terminal boards and on the waveguide around the Klystron.

3-26. Receiving System Troubleshooting Information

a. Reference Data. The following information will be helpful when troubleshooting the receiving system.

Reference	Data
Para 2-19a through *d*	Functioning of circuits in the receiving system.
Fig. FO-3 and 2-32 through 2-48	Receiving system, simplified schematic diagrams.
Fig. FO-22	ReceWer-Transmitter Group OA-1257/MPQ-4A, wiring diagram.
Fig. 3-37	Receiver Control C-2015/MPQ-4A, schematic diagram.
Fig. FO-25	Receiver control C-2016/MPQ-4A, schematic diagram (cent).
Fig. FO-24	Intermediate Frequency Amplifier AM-1538/MPQ-4A, schematic diagram.
Fig. 3-22	Receiver control C-2016/MPQ-4A, wave form diagram.
Fig. 3-23	Receiver Control C-2016/MPQ-4A, wave form diagram.
Fig. 3-24	Receiver Control C-2015/MPQ-4A, voltage and resistance diagram.
Fig. 3-25	Receiver Control C-2016/MPQ-4A, voltage and resistance diagram.
Fig. 3-26.	Receiver compartment, front view.

Reference	Data
Fig. 3-27	Receiver Control C-2015/MPQ-4A, top view.
Fig. 3-28	Receiver Control C-2015/MPQ-4A, bottom view,
Fig. 3-29, 3-30	Receiver Control C-2016/MPQ.4A, bottom view.
Fig. 3-31	Receiver Control C-2016/MPQ-4A, top view.
Fig. 3-32	Intermediate Frequency Amplifier AM-1538/MPQ-4A, top view.
Fig. 3-33, 3-34, 3-35 .	Intermediate Frequency Amplifier AM-1538/MPQ-4A, bottom view.
Fig. 3-36	Control-monitor, rear view.
Fig. 3-38	VIDEO TEST J1404, wave form diagram.
Fig. 3-46	Wave forms for stc output.
Fig. 3-47	Intermediate Frequency Amplifier AM-1538/MPQ-4A, voksge and resistance diagram.
Fig. 3-39	AFC OUTPUT J1405, wave form diagram.

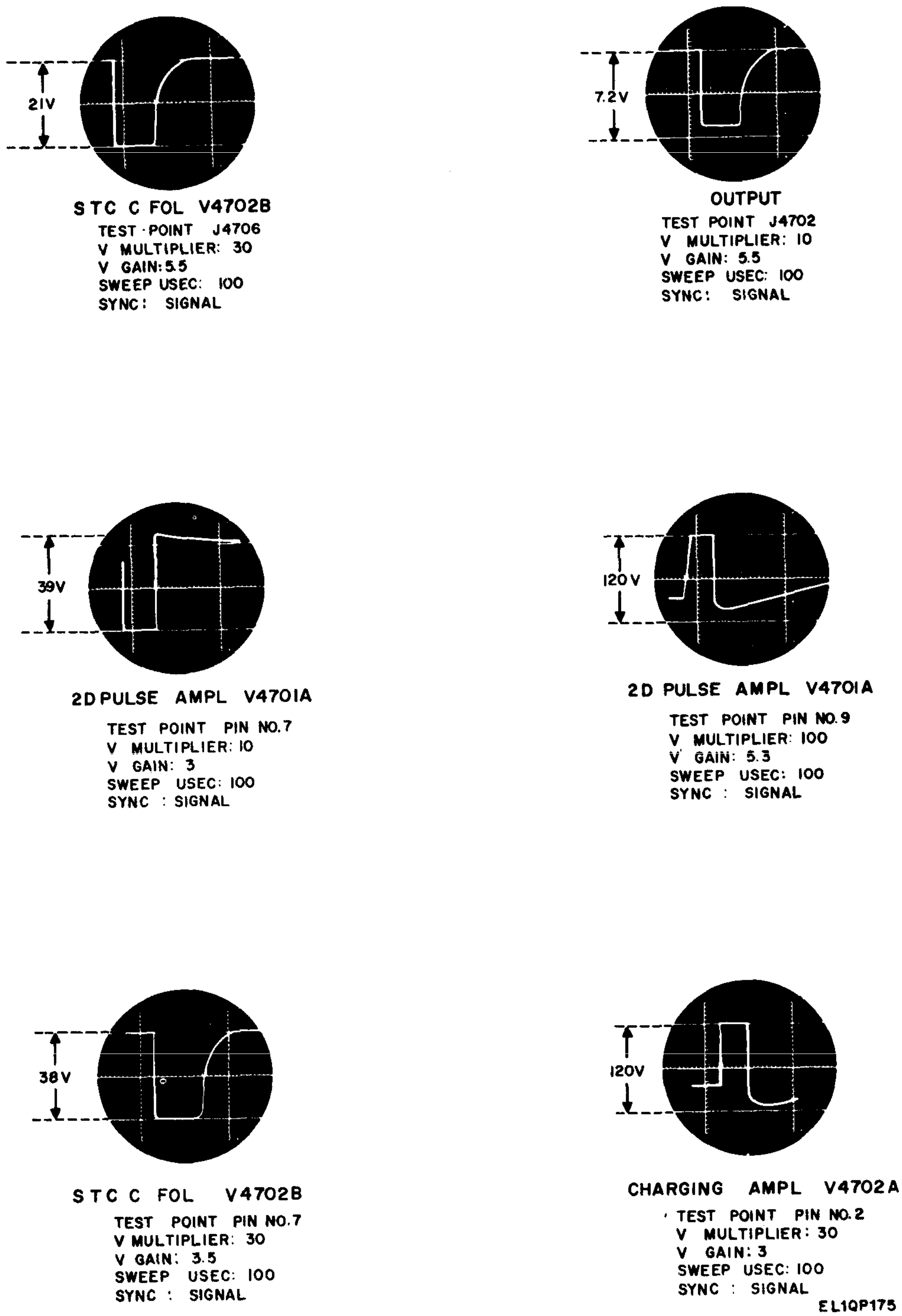


Figure 3-22. Receiver Control C-2015/MPQ-4A, waveform diagram.

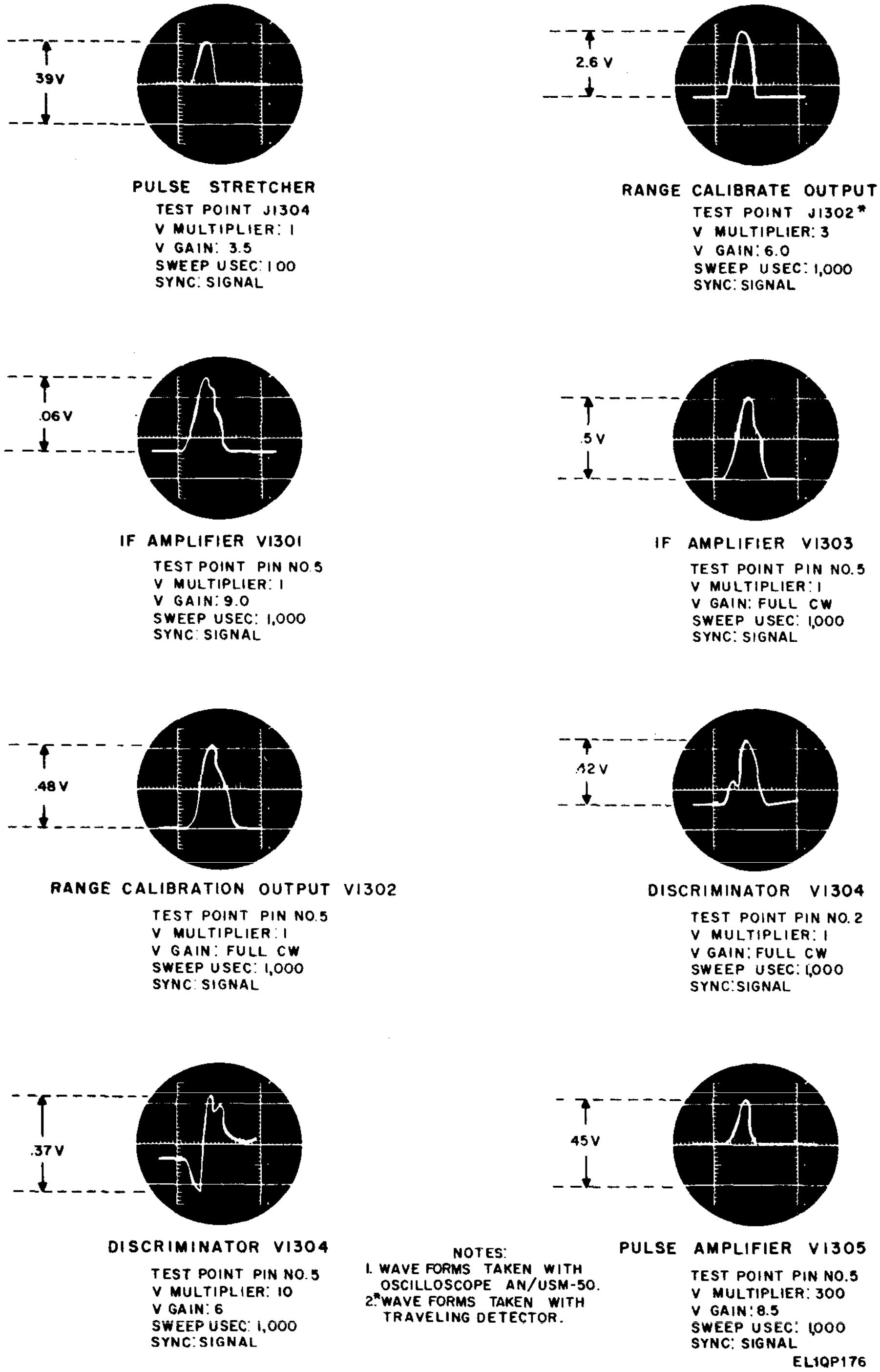
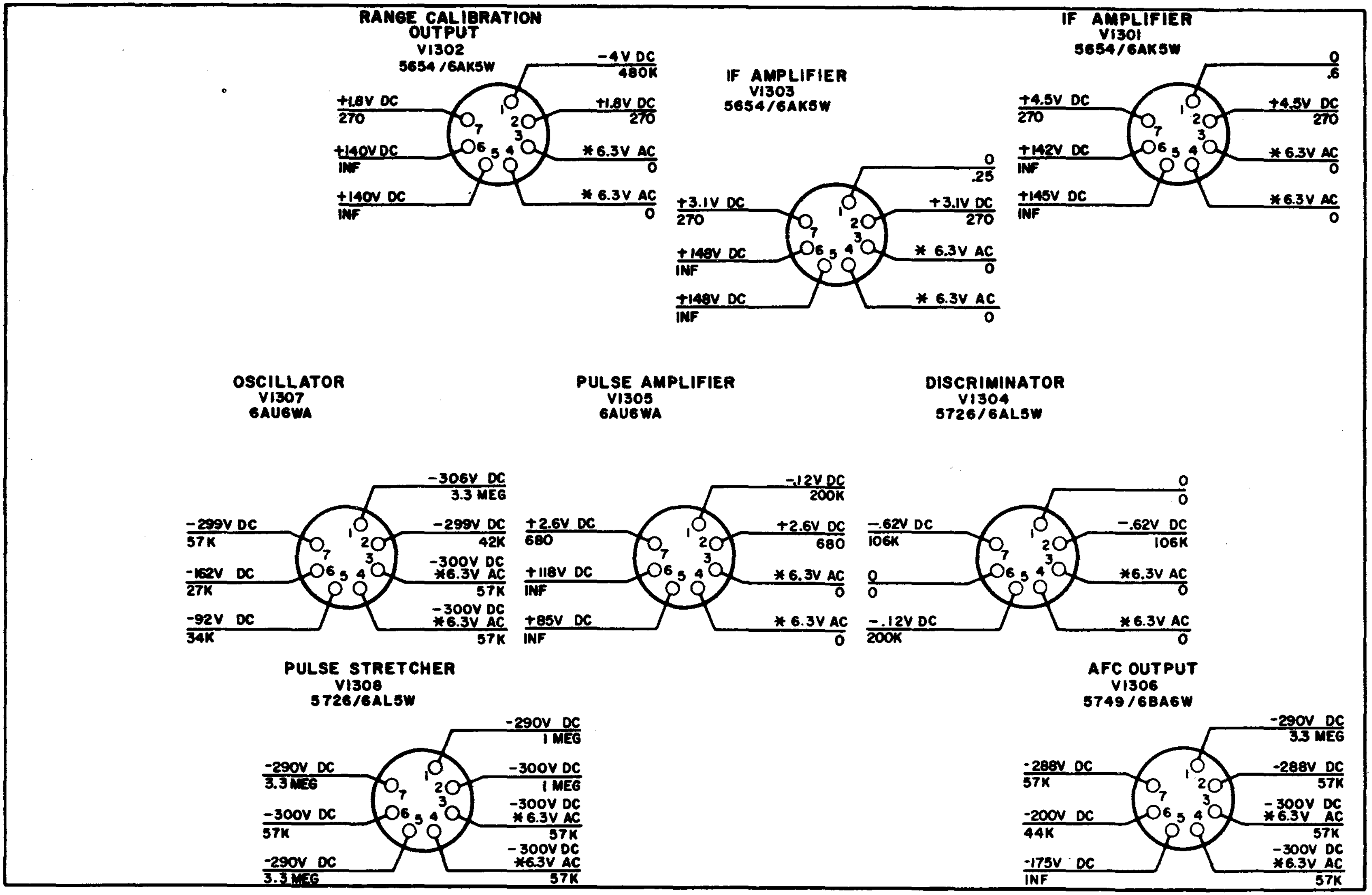


Figure 3-23. Receiver Control C-2016/MPQ-4A, waveform diagram.



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
4. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
5. K DENOTES THOUSAND, MEG DENOTES MILLION. INF DENOTES INFINITY

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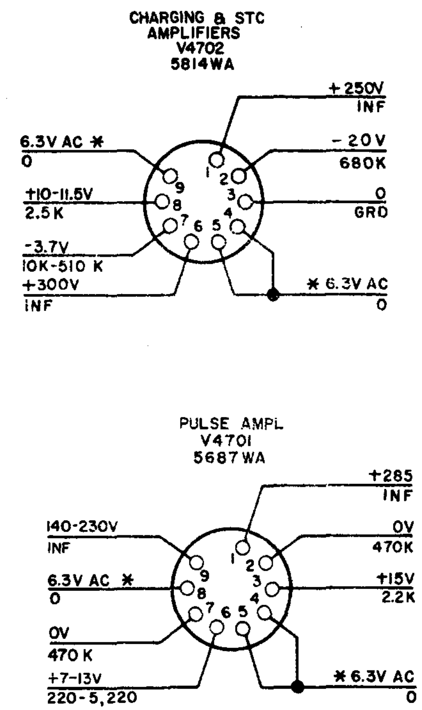
Figure 3-24. Receiver Control C-2015/MPQ-4A, voltage and resistance diagram.



NOTES:

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2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
4. * INDICATES MEASUREMENTS ACROSS FILAMENTS.

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Figure 3-25. Receiver Control C-2016/MPQ-4A, voltage and resistance diagram.

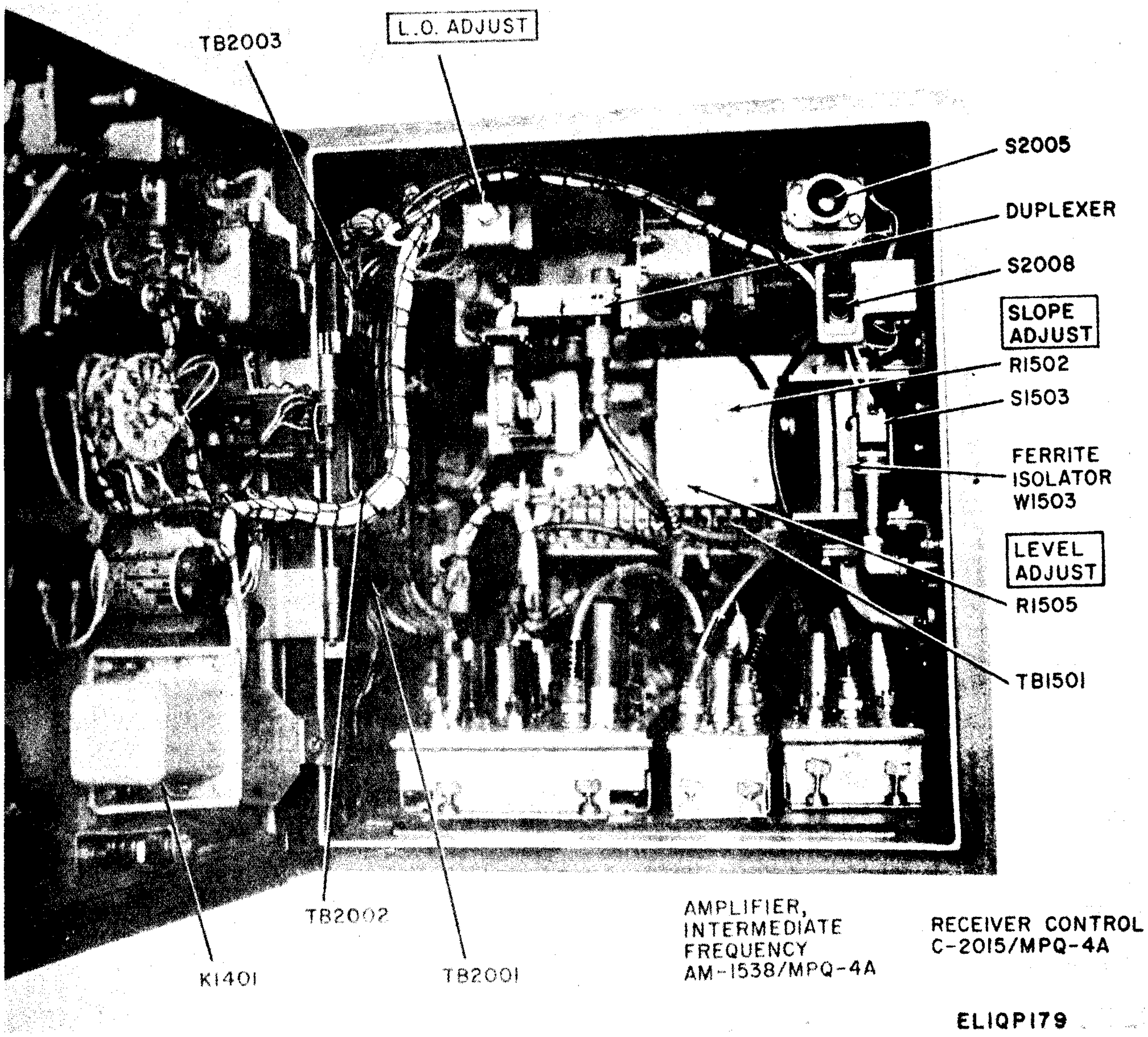


Figure 3-26. Reciever compartment, front view.

b. Receiving System Controls and Adjustments.

(1) Table 3-19 lists the receiving system controls for maintenance and operation.

(2) IF GAIN Potentiometer R109. This potentiometer, located on the front of Azimuth and Range Indicator IP-375/MPQ-4A (fig. 3-47), controls the gain of the receiver.

c. Receiving System Fuses. The fuses that protect circuits in the receiving system are given in table 3-20. The table lists the rating of each fuse, a blown-fuse indicator that lights when the fuse is blown, the circuit that each fuse protects, and a figure that shows the location of each fuse.

d. Normal Readings of Receiving System Panel Meters. Table 3-21 lists the meters that monitor all phases of operation of the receiving system, references a figure that shows the location of each meter, and gives the function of each meter.

e. Normal Indications at Receiving System Test Points. Table 3-22 lists the test points for testing the operation of circuits in the receiving system, references a figure that shows the physical location of each test point, and gives or references the normal indication at each test point.

f. Dc Resistances of Receiving System Transformers and Coils. Table 3-23 lists all transformer win dings and coils in the receiving system and gives the dc resistance of every winding.

Table 3-19. Receiving System Controls and Adjustments

Controls and adjustments	Location (fig.)	Function
Control-monitor panel		
TEST METER M1402 and TEST METER SELECTOR switch S1401.	3-16 3-36	Indicates crystal currents or low voltage power supply voltages. Switch positions are as follows: **Position — Function** XTAL 1 . . . . — Indicates current in if. crystal No. 1 (CR1501). XTAL 2 . . . . — Indicates current in if. crystal No. 2 (CR1502). AFC XTAL . . . . — Indicates current in if. crystal No. 3 (CR1503). +300V X100 . . . . — Indicates output voltage of plus 300-volt supply for afc and stc assemblies. +150V X50 . . . . — Indicates output voltage of +150-volt supply for afc and stc assemblies.
L.O. CAVITY switch S1402	3-16	RAISE or LOWER mechanical adjustment for varying frequency of local oscillator V1501.
A. F. C.-MANUAL switch S1403.	3-16	Selects either MANUAL or A.F.C. adjustments of local oscillator frequency.
Control-power supply panel		
TEST METER SELECTOR switch S651.	3-15	AFC STAL CUR position: switches the crystal circuit of the receiving system to be measured by TEST METER M652.
L.O. RAISE-LOWER switch S654	3-15	Operates the klystron drive motor to raise or lower the frequency of the local oscillator.
AFC-MANUAL switch S657.	3-15	AFC position: switches receiving system to aft. MANUAL position: switches receiving system for manual control of local oscillator frequency.
Receiver compartment		
SLOPE ADJUST potentiometer R1502 . .	3-26	Slope adjustment for repeller tracking potentiometer R1501.
LEVEL ADJUST potentiometer R1505 .	3-26	Zero range control for R1501.
L.O. ADJUST attenuator	3-26	Determines the amount of signal applied to the crystal mixers.

Table 3-20. Receiving System Fuses

Fuse	Rating		Blown-fuse indicator	Circuit protected (volts dc)	Location (fig.)
	Volts	Amp			
F1601 . .	250	0.125	I 1601	+300	3-4
F1602 . .	250	0.250	I 1602	+150	3-4
F1603 . .	250	0.062	I 1603	-300	3-4

Table 3-21. Normal Readings *of Receiving System Panel Meters*

Meter	Location (fig.)	Function
	3-16	Measures current of IF crystal No. 1 when TEST METER SELECTOR switch S1401 is in XTAL 1 position. (Normal indication 2 to 3.)
		Measures current of if. crystal No. 2 when S1401 is in XTAL 2 position. (Normal indication 2 to 3.)

Table 3-21. Normal Readings of Receiving System Panel Meters –Continued

Meter	Location (fig.)	Function
		Measures current of afc crystal when S1401 is in XTAL 3 position. (Normal reading 2 to 3.)
		Measures positive 300-volt dc supply to receiver when S1401 is in +300 VX100 position.
		Measures positive 150-volt dc supply to receiver when S1401 is in +150VX50 position.
		Measures negative 300-volt dc supply to receiver when S1401 is in – 300VX100 position.
TEST METER M652.	3-15	Measures afc crystal current when TEST

Table 3-21. Normal Readings of Receiving Systems Panel Meters—Continued

Meter	Location (fig.)	Function
		METER SELECTOR switch S651 is in the AFC XTAL CUR position. (Normal indication 2 to 3.)

Table 3-22. Normal Inch Indications at Receiving System Test Point

Test point	Location (fig.)	Normal indications
120 V 400 ~ J1403	**3-16**	**120 volts.**
VIDEO TEST jack J1404.	**3-16**	**Waveform (fig. 3-38).**
AFC OUTPUT jack J1405.	3-16	Waveform (fig. 3-39).

Table 3-23. Dc Resistances of Receiving System Troubleshooting and Coils

Transformer and coil	Location (fig.)	Terminals	Dc resistance (ohms)
If. amplifier			
Plate coil L1201	3-35	1-2	0.2
Neutralizing coil L1202	3-35	1-2	2.5
Decoupling choke L1203	3-34	1-2	1.2
Decoupling choke L1204	3-34	1-2	1.1
Decoupling choke L1205	3-34	1-2	1.2
Decoupling choke L1206	3-34	1-2	1.1
Decoupling choke L1207	3-33	1-2	1.2
Plate tuning L1208	3-33	1-2	0.3
Delay line inductor L1209	3-34	1-2	1.1
Delay line inductor L1210	3-34	1-2	2.5
Delay line inductor L1211	3-34	1-2	2.5
Delay line inductor L1212	3-34	1-2	2.5
Delay line inductor L1213	3-33	1-2	2.5
Delay line inductor L1214	3-33	1-2	1.1
Input coil L1215	3-35	1-2	0.1
Plate tuning coil L1216	3-35	1-2	0.2
Input coil L1217	3-35	1-2	0.2
Plate tuning coil L1218	3-35	1-2	0.2
Filament choke L1220	3-35	1-2	0.1
Filament choke L1221	3-35	1-2	0.1
Filament choke L1222	3-34	1-2	0.1

Table 3-23. Dc Resistances of Receiving System Troubleshooting and Coils—Continued

Transformer and coil	Location (fig.)	Terminals	Dc resistance (ohms)
If. amplifier–continued			
Filament choke L1223	3-34	1-2	0.1
Filament choke L1224	3-34	1-2	0.1
Filament choke L1225	3-34	1-2	0.1
Filament choke L1226	3-34	1-2	0.1
Filament choke L1227	3-33	1-2	0.1
Filament choke L1228.	3-33	1-2	0.1
Filament choke L1229.	3-33	1-2	0.1
IF choke L1231	3-35	1-2	3.5
IF choke L1232	3-35	1-2	3.5
Interstate transformer T1201.	3-34	1-2	0.4
		3-4	0.43
Interstage transformer T1202 . .	3-34	1-2	0.4
		3-4	0.43
Interstage transformer T1203. .	3-34	1-2	0.4
		3-4	0.43
Interstage transformer T1204 . .	3-34	1-2	0.4
		3-4	0.43
Interstage transformer T1205. .	3-34	1-2	0.4
		3-4	0.43
Interstage transformer T1206. .	3-33	1-2	0.4
		3-4	0.43
Crystal current filter Z1201. . . .	3-35	1-2	0.6
Crystal current filter Z1202. . . .	3-35	1-2	0.6
Detector filter Z1203.	3-33	1-2	0.6
Afc assembly			
Input transformer T1301	3-30	1-2	0.2
		3-4	
Input transformer T1302.	3-30	1-2	0.3
		3-4	0.3
Descriminator tuning L1301 . . .	3-29	1-2	0.4
Plate tuning L1302	3-29	1-2	
Plate tuning L1303	3-29	1-2	0.2
Filament choke L1304.	3-29	1-2	
Filament choke L1306	3-29	1-2	
Filament choke L1308	3-29	1-2	
Afc crystal current filter Z1301	3-30	1-2	0.6
Afc crystal current filter Z1302	3-30	1-2	0.6
Plate choke Z1303	3-30	1-2	0.6
Part of range calibrate output Z1304	3-30	1-2	
Range mark intensity filter Z1305.	3-30	1-2	0.6

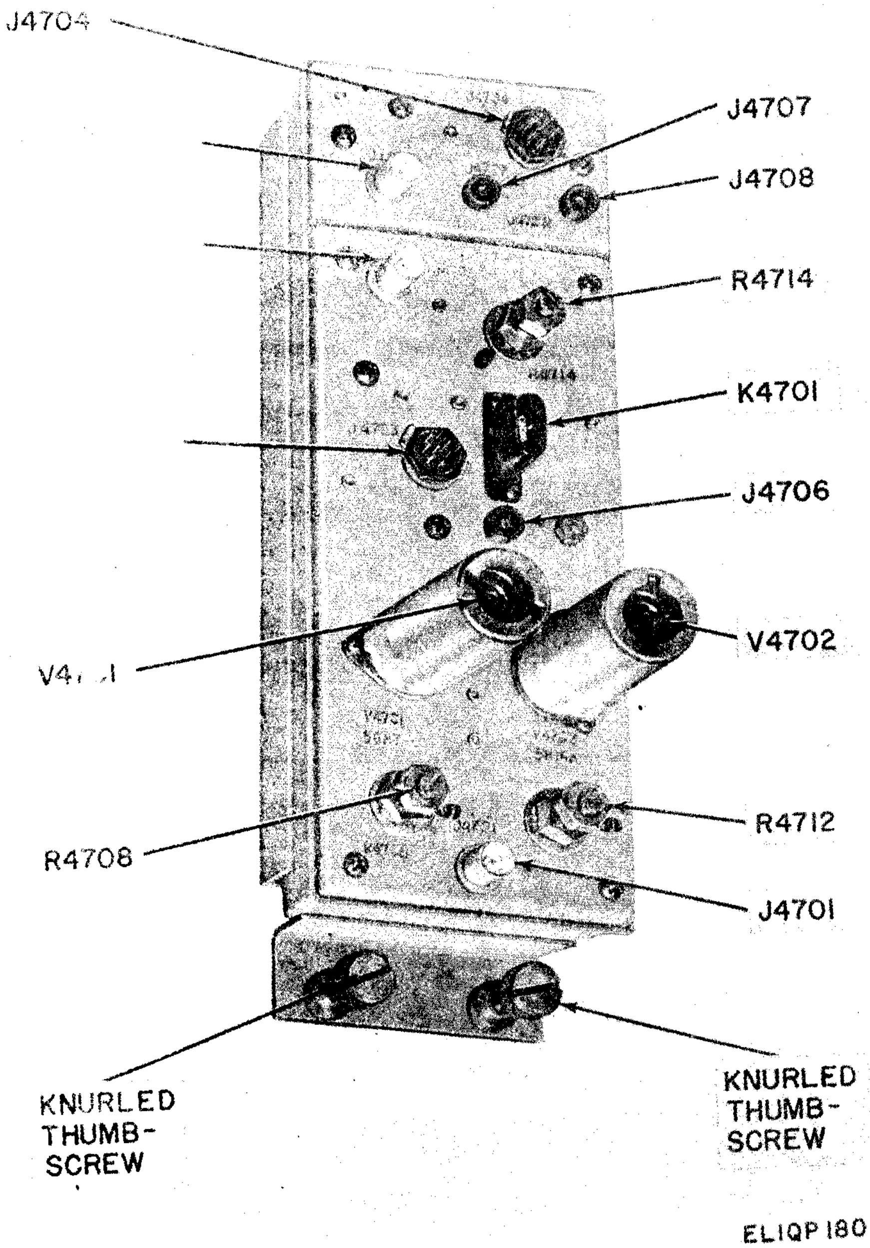


Figure 3-27. Receiver Control C-2015/MPQ-4A, top view.

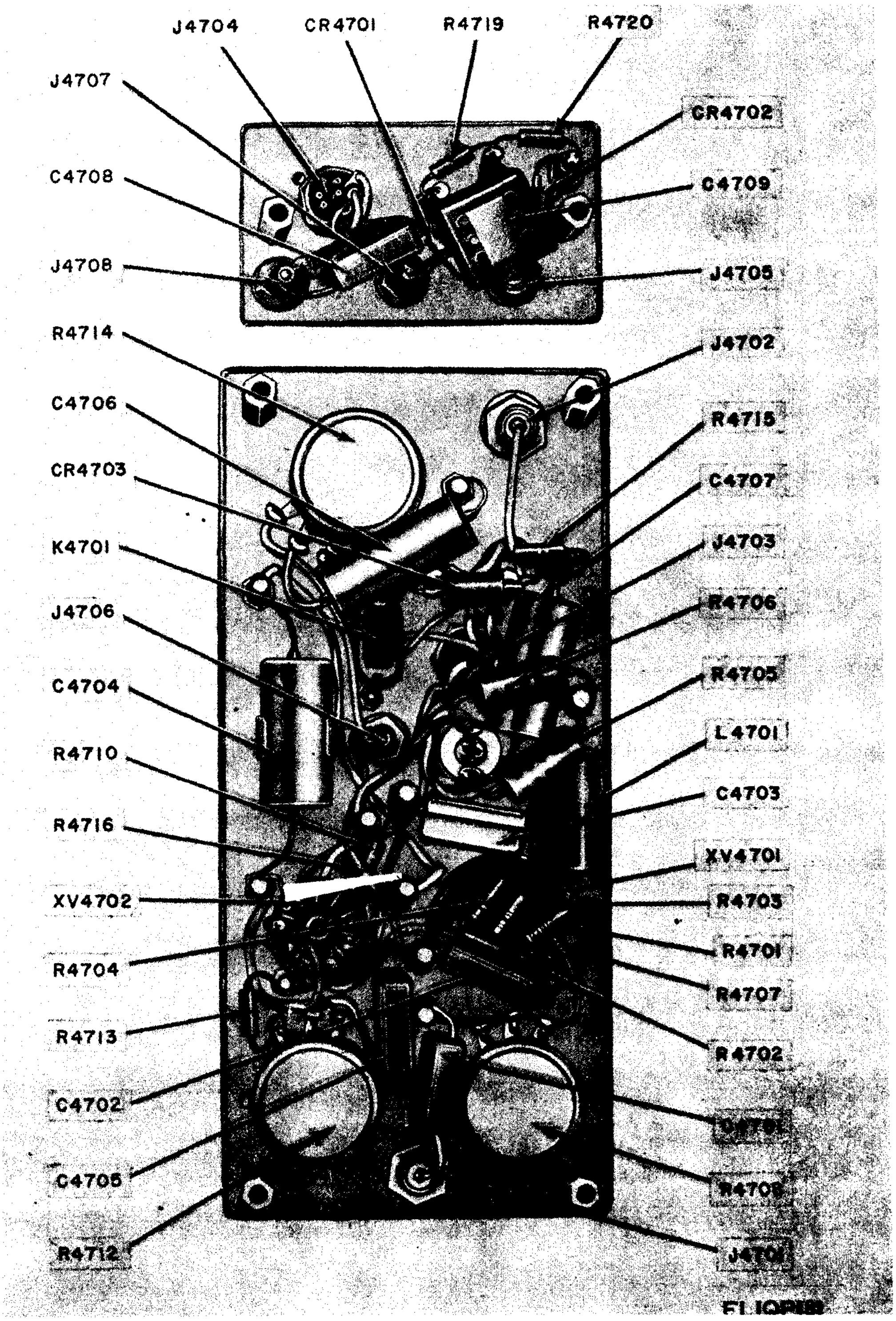


Figure 3-28. Receiver Control C-2015/MPQ-4A, bottom view.

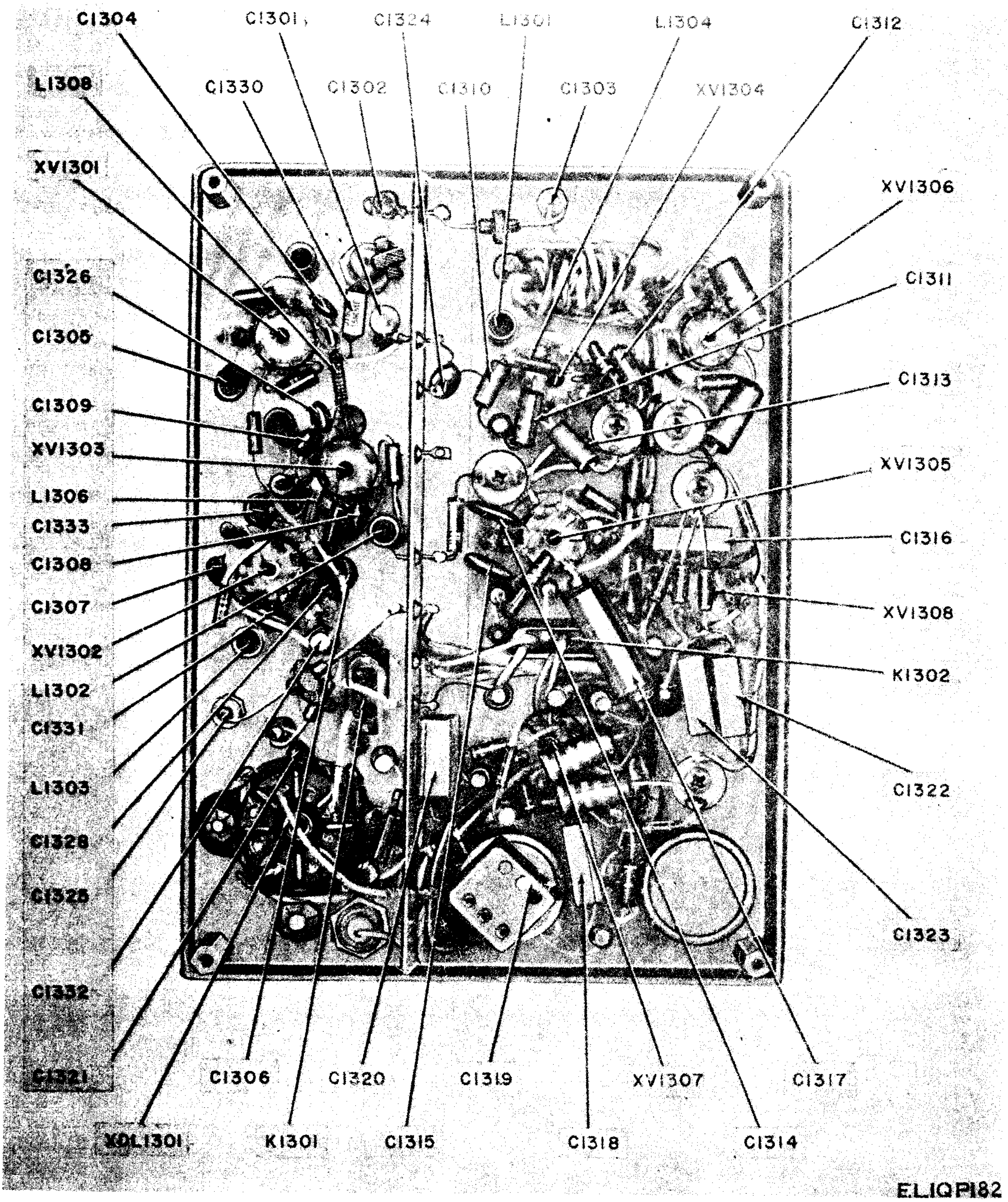


Figure 3-29. Receiver Control C-2016/MPQ-4A, bottom view, tube sockets and components.

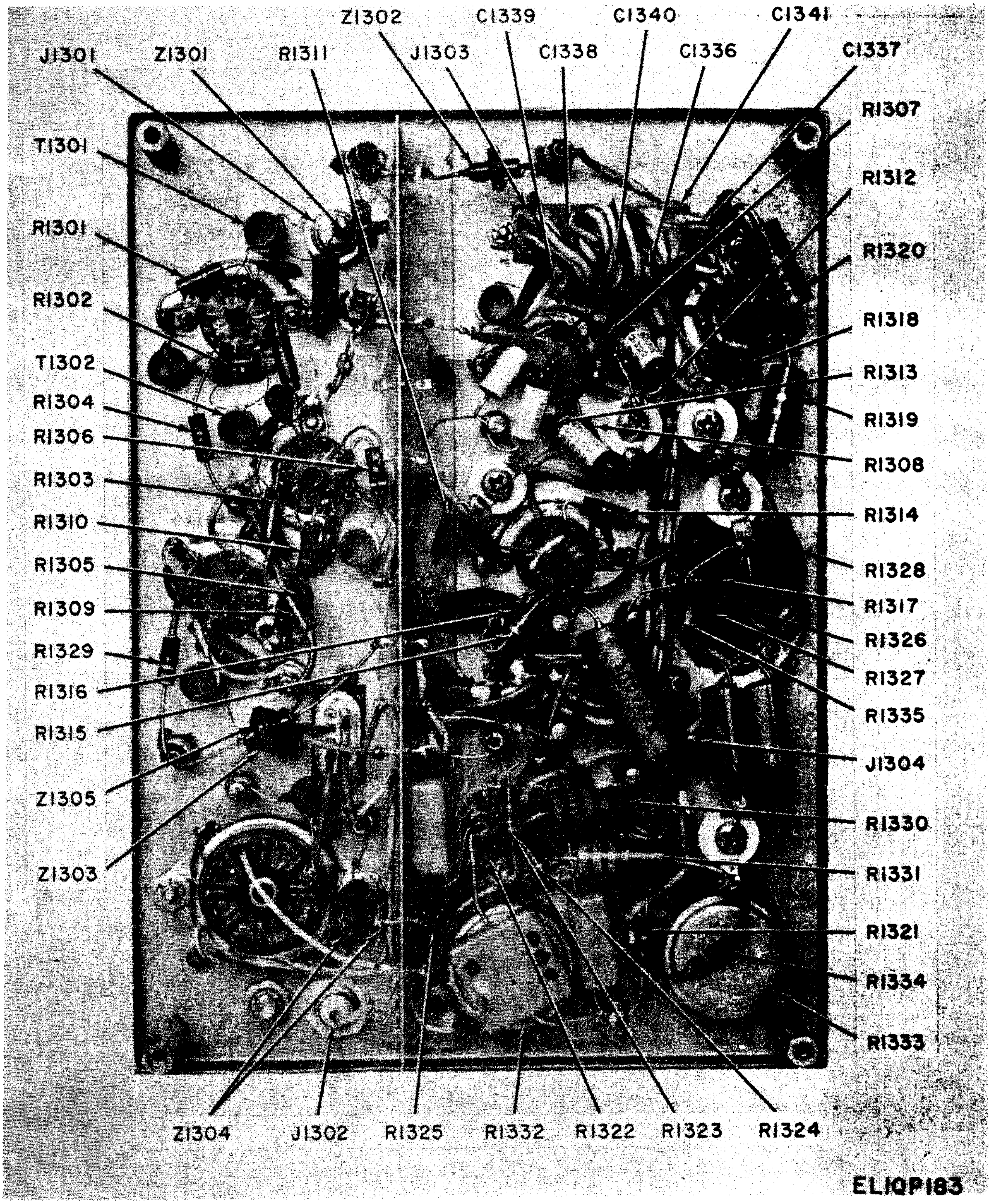


Figure 3-30. Receiver Control C-2016/MPQ-4A, bottom view, terminals and components.

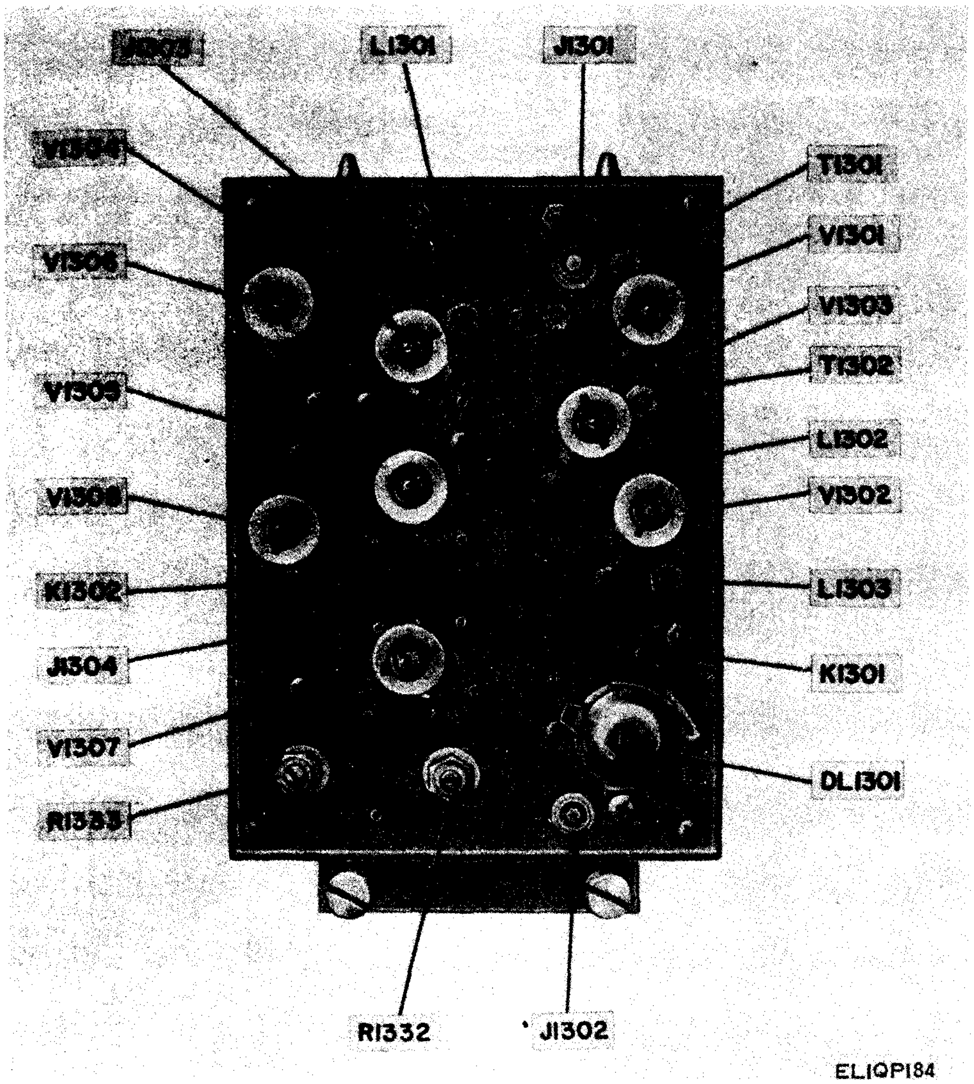


Figure 3-31. Receiver Control C-2016/MPQ-4A, top view.

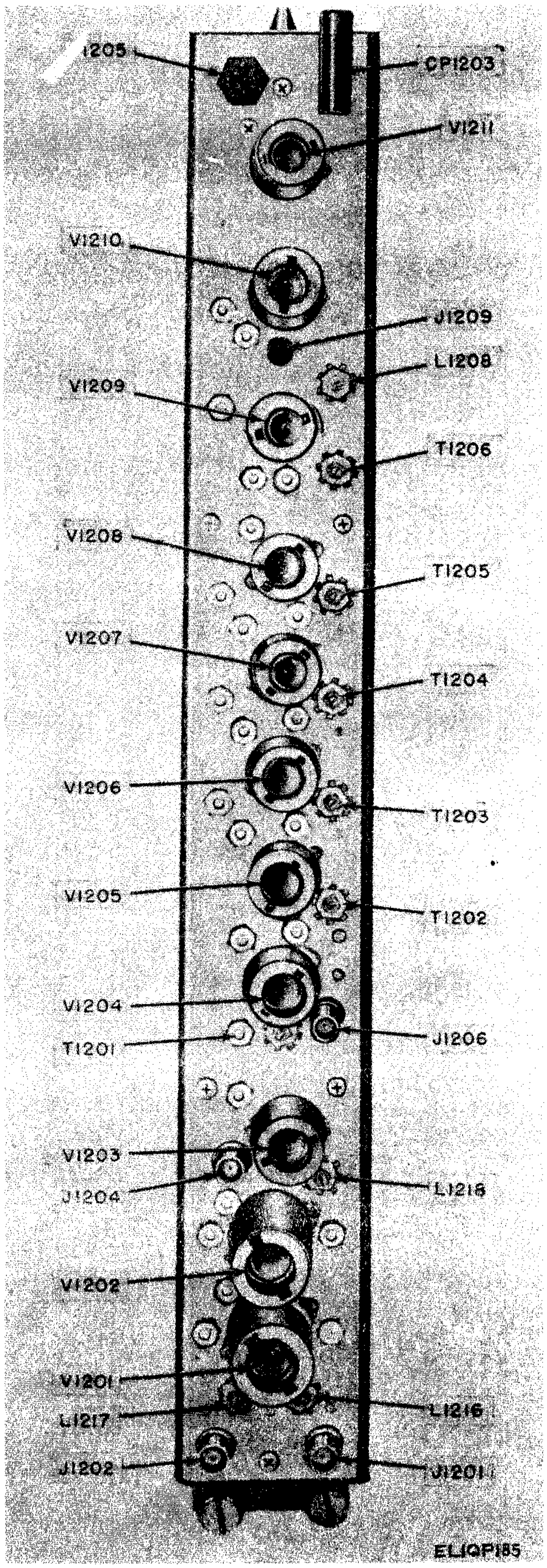


Figure 3-32. Intermediate Frequency Amplifier AM-1538/MPQ-4A, top view.

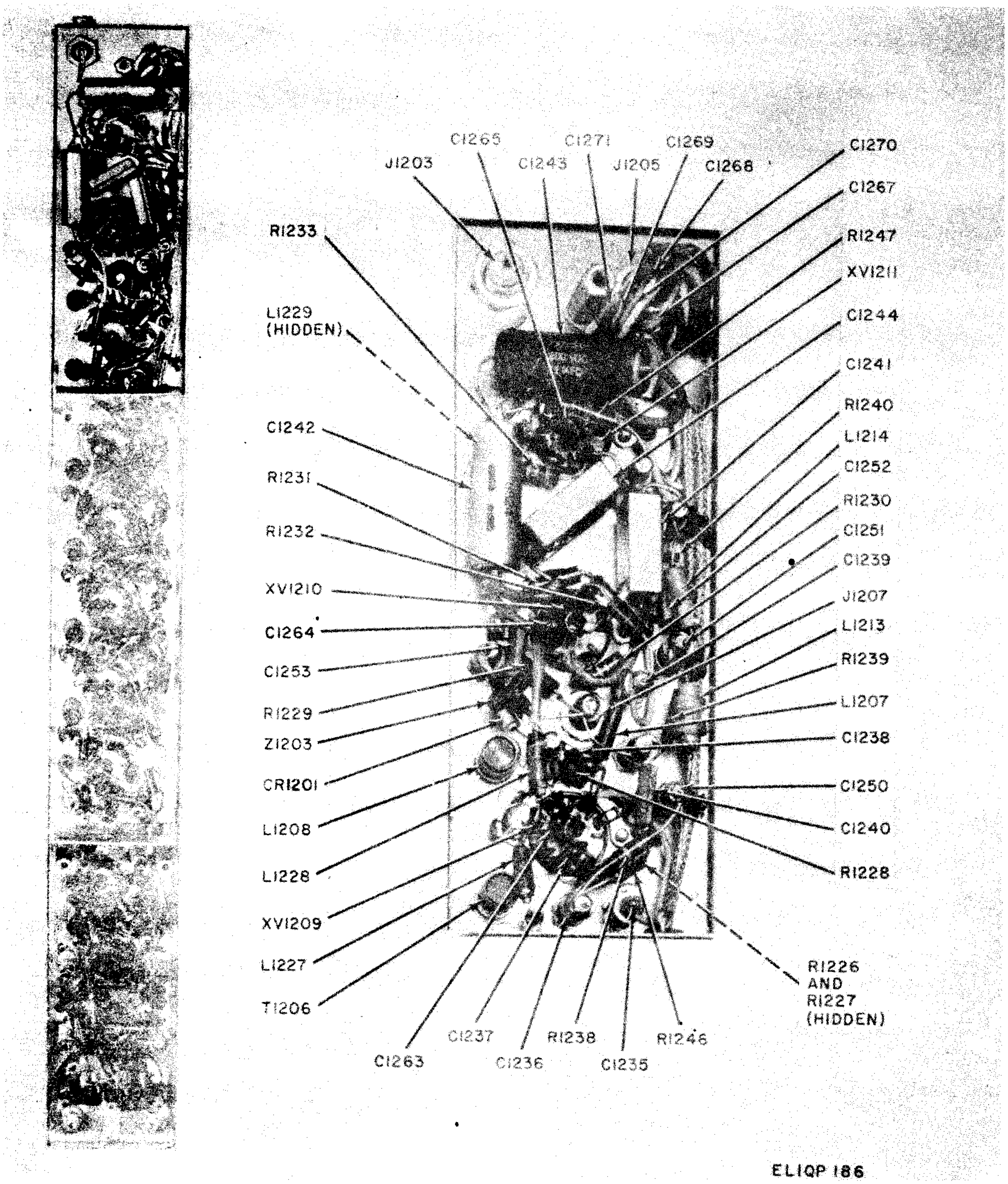


Figure 3-33. Intermediate Frequency Amplifier AM-1538/MPQ-4A, bottom view, (upper section).

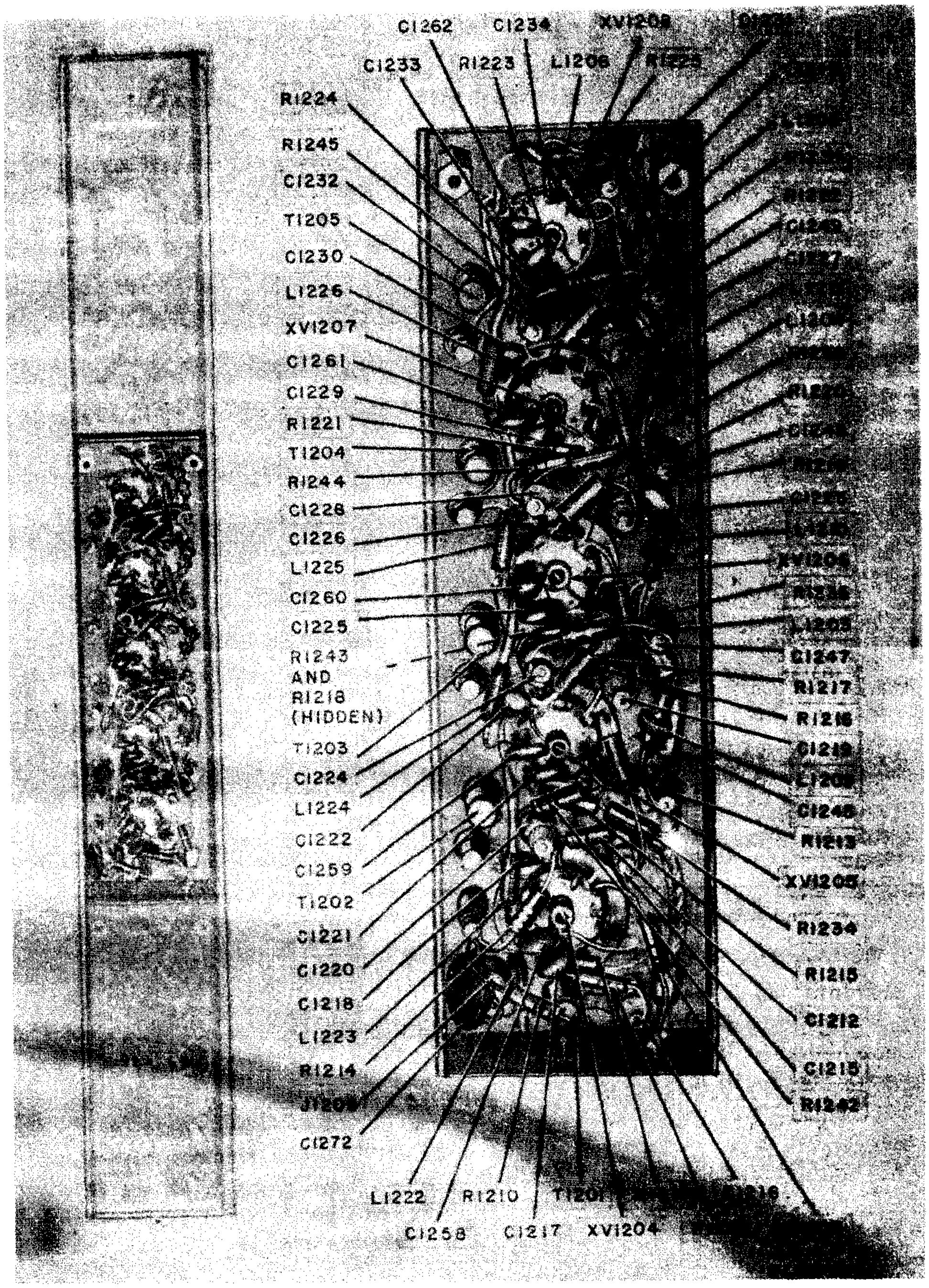


Figure 3-34. Intermediate Frequency Amplifier AM-1538/MPQ-4A bottom view (center section).

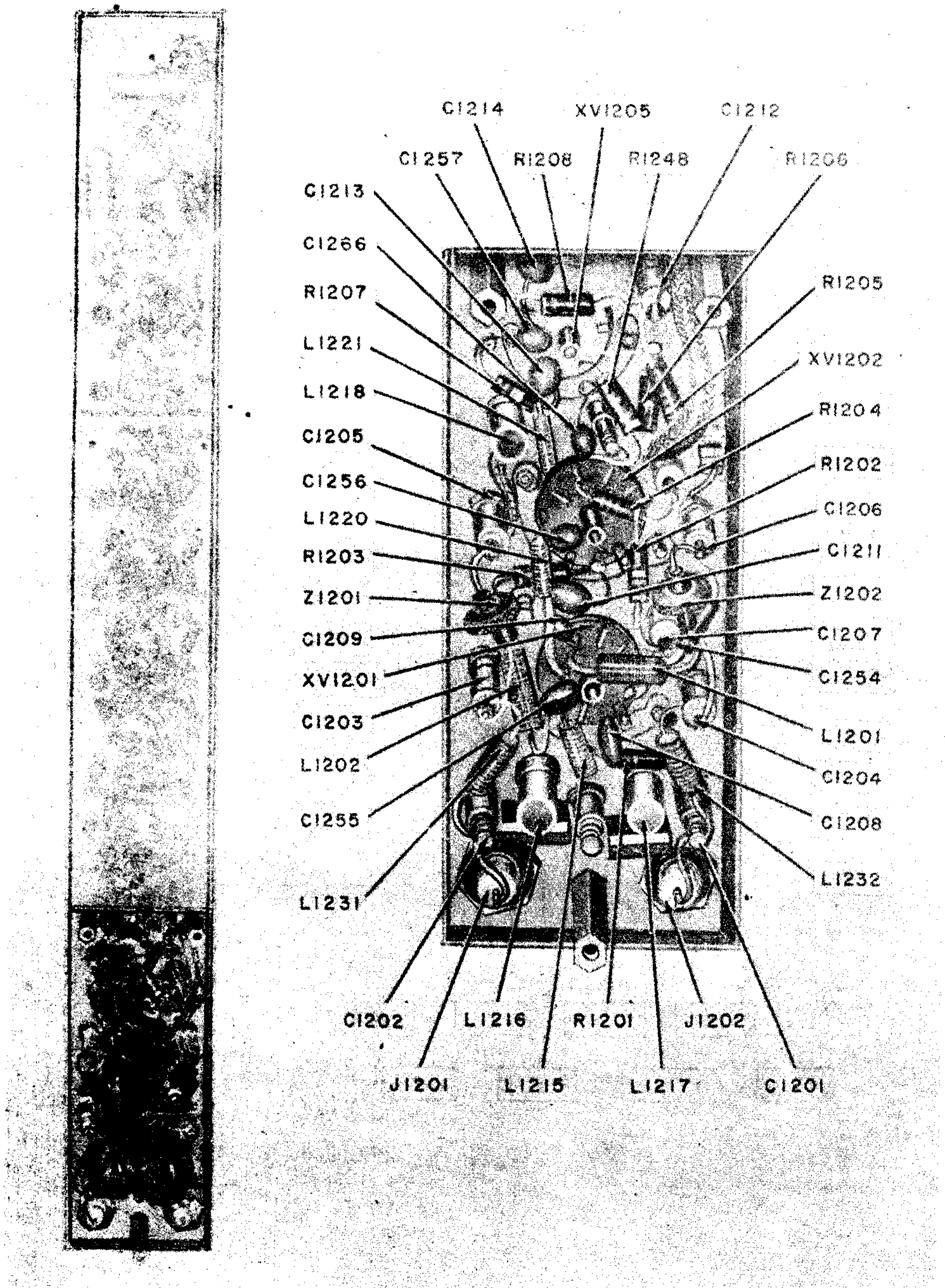


Figure 3-35. Intermediate Frequency Amplifier AM-1538/MPQ-4A bottom view (lower section).

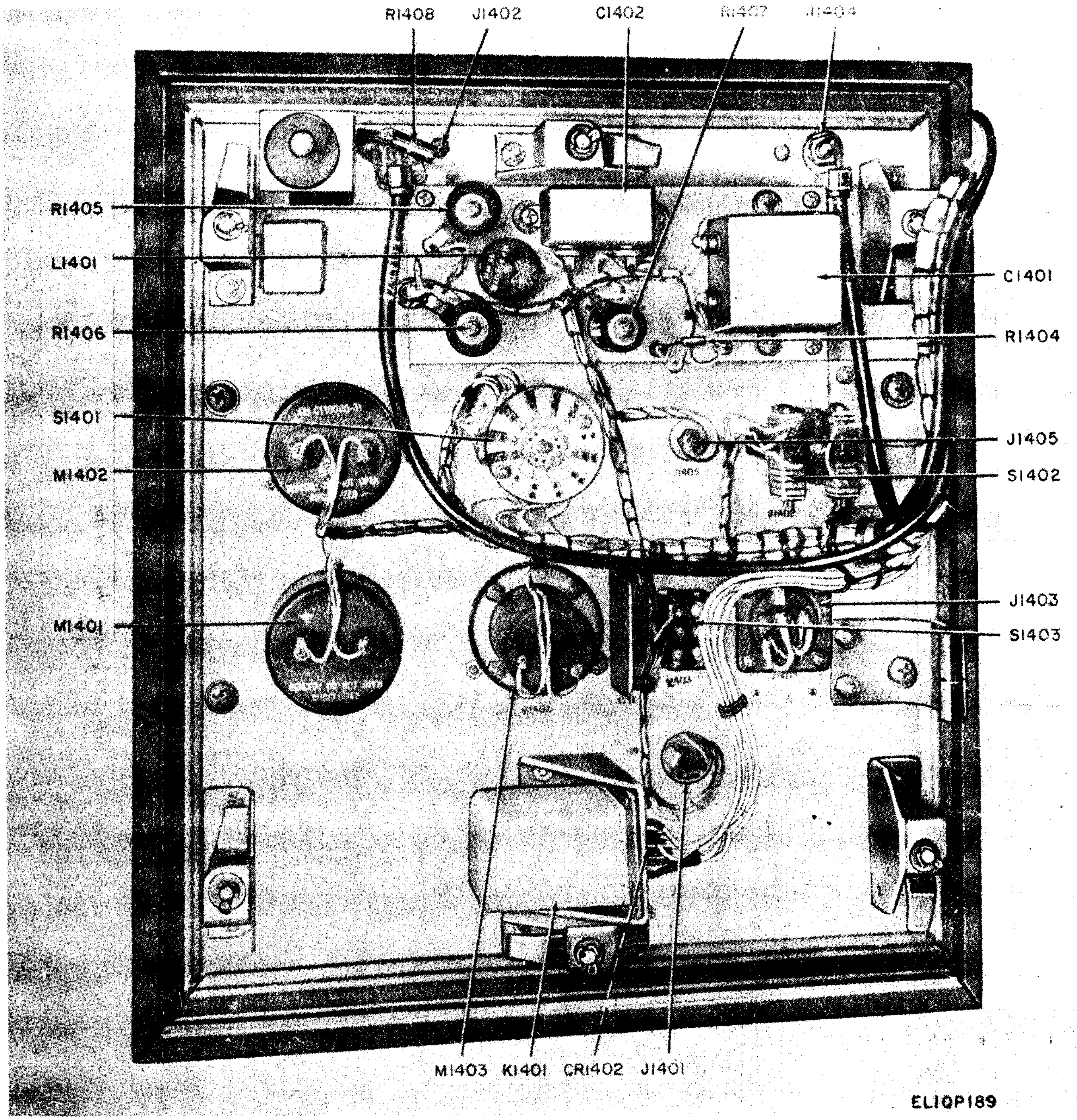


Figure 3-36. Control-monitor, rear view.

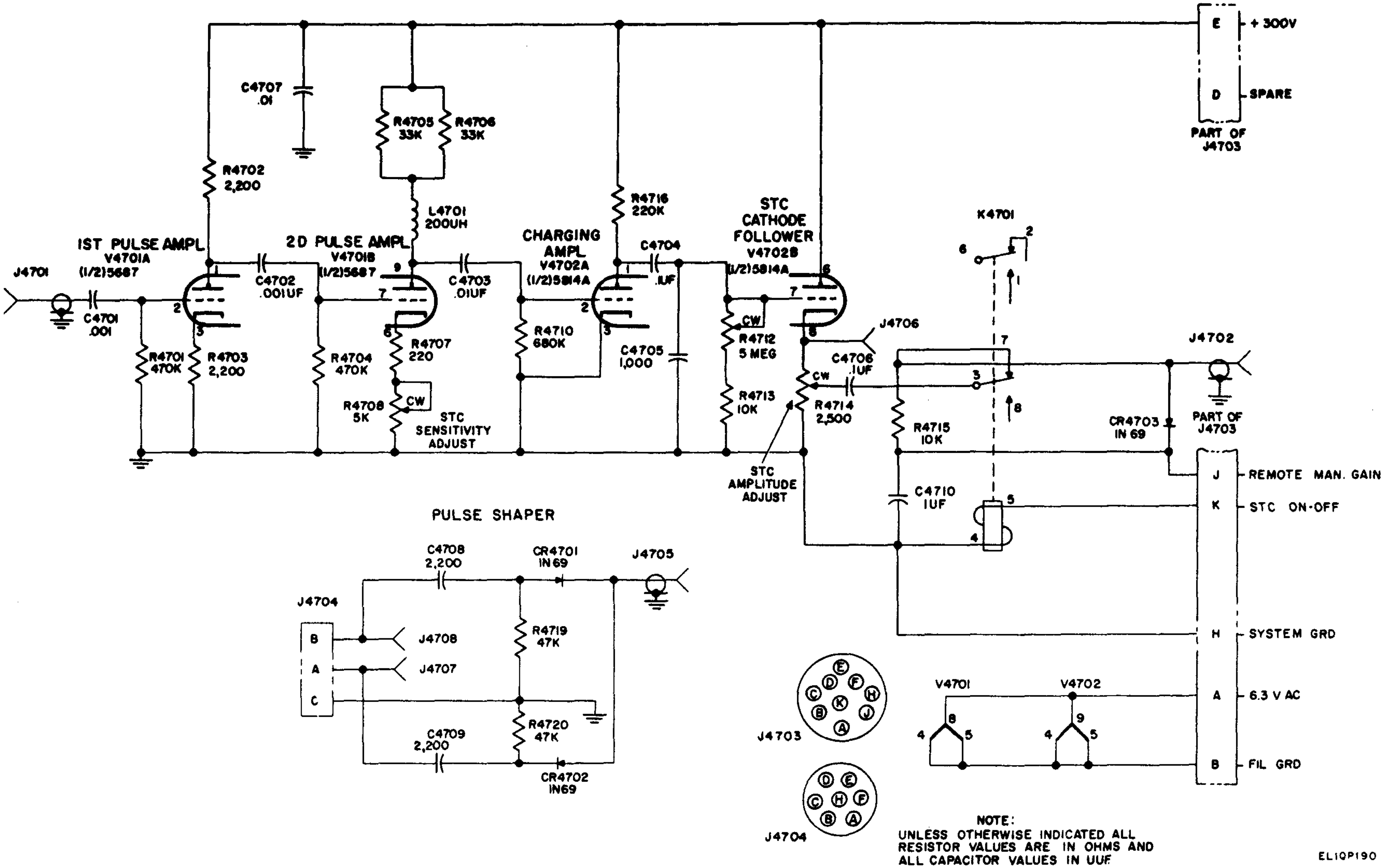


Figure 3-37. Receiver Control C-2015/MPQ-4A, schematic diagram.

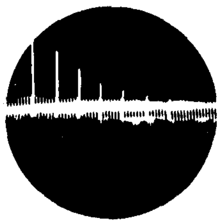


Figure 3-38. VIDEO TEST J1404 waveform diagram.

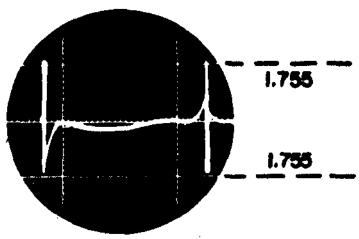


Figure 3-39. AFC OUTPUT J1405, waveform diagram.

3-27. Receiving System Troubleshooting

a. General. Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the receiving system.

(1) *Symptom troubleshooting* (table 3-25). Trouble that have been sectionalized to the receiving system usually can be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a specific channel, circuit, or stage. The symptoms given in table 3-25 consist of indications obtained on TEST METER M1402 with TEST METER SELECTOR switch S1401 in positions XTAL 1, XTAL 2, and AFC XTAL. To troubleshoot the receiving system, proceed as follows:

(a) Observe the indications obtained on M1402 and the B-scope.

(b) Compare the indications obtained with those listed in each of the symptoms.

(c) If the indications obtained correspond to those listed in a particular symptom, follow the procedure given in that particular symptom to isolate the trouble.

(d) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step. troubleshooting, table 3-26.

(2) Step-by-step troubleshooting table (table 3-26). The receiving system step-by-step troubleshooting table consists of a series of steps designed to evaluate all phases of operation of the receiving system. Use this table if the trouble cannot be isolated by symptom troubleshooting ((1) above). To troubleshoot the receiving system by using the step-by-step troubleshooting table, proceed as follows:

(a) Locate the test point given in step 1 of the table.

(b) Connect the test equipment and set its controls as directed in the test equipment column.

(c) Set the controls on the radar set as directed in the radar set controls column.

(d) Compare the indications obtained on the test equipment with the indications given or referenced in the normal indications column.

(e) If the indications obtained on the test equipment are normal, proceed either to the next step or as directed in the corrective measures column.

(f) If the indications obtained are abnormal, proceed as directed in the corrective measures column.

b. Test Equipment Required to Troubleshoot Receiving System. Table 3-24 lists the items of test equipment that are required to troubleshoot the receiving system.

Table 3-24. Test Equipment Required to Trouble Shoot Receiving System

Test equipment	Common name	Technical manual
Electronic Multimeter ME-26A/U.	Multimeter	TM 11-6625-200-15 and TM 11-6625-200-24P
Oscilloscope AN/USM-281C.	Oscilloscope	TM 11-6625-2658-14
Electron Tube Test Set TV-7/U . .	Tube tester	TM 11-6625-274-12

c. Preparation of System Components for Troubleshooting.

(1) *General.* When the radar set is installed properly, the receiving system is inaccessible for troubleshooting aligning, and testing.

WARNING

Before entering the receiver compartment, turn off high voltage and all power.

(2) *Receiver compartment.* To make the

receiver compartment accessible for troubleshooting, aligning, and/or testing, proceed as follows:

(a) Unscrew the six knurled thumbscrews on the front door of the receiver compartment (fig. 3-16); grasp both handles and pull the door out to engage the hinges; then, using the handle on the right side, open the door.

(b) Close shorting switch S2008 (fig. 3-26).

(c) Turn MAIN POWER switch S652 (fig. 3-15) to ON.

d. Preliminary Checks, Adjustments, and Control Settings. Before using the system troubleshooting tables check the cabling of the radar set (TM 11-5840-208-10). Set the A.F.C. -MANUAL switch on the control-monitor panel to the A.F.C. position.

Table 3-25. Receiving System Symptom Troubleshooting Table

Sympton	Probable cause	Corrective measures
No crystal current indication on TEST METER M1402.	Local oscillator not operating, afc unit.	Make voltage and resistance check of klystron tube circuits. Replace klyetron tube V1501. Check L.O. ADJUST R1505. (Should not require adjustment unless adjustment is accidentally modified.) Replace afc output tube V1306.
No afc crystal current indicatiom on TEST METER M1402. XTAL 1 and XTAL 2 have same indication.	CR1503	Replace crystal.
No indication on AFC OUTPUT jack J1405	Afc unit	Make voltage and resistance check of output tube V1306 (fig. 3-24) circuitry. Replace V1306.
No range calibration output. Normal AFC OUTPUT indication at J1405.	V1302	Make voltage and resistance check of V1302 (fig. 3-24).
All crystal currents (XTAL 1, XTAL 2, AFC XTAL on TEST METER SELECTOR switch S1401) do not fall between indications 2 and 9 on TEST METER M1402.	Setting of L.O. ADJUST	Adjust L.O. ADJUST for crystal indications all positions on M1402 between indication 2 and 3 of TEST METER SELECTOR switch S1401.
Afc crystal current on TEST METER M1402, but no sweep with transmitter turned off.	V1307	Make voltage and resistance checks at base of tube socket (fig. 3-24). Check waveforms (fig. 3-23).
No afc crystal current on TEST METER M1402 and no sweep with transmitter turned off.	V1306	Make voltage and resistance checks at base of tuba socket (fig. 3-24). Check waveforms (fig. 3-23).

Table 3-26. Receiving System Step-by-Step Troubleshooting Table

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1	VIDEO TEST J1404 (fig. 3-16).	Oscilloscope AN/USM-281C...	Set MAIN POWER switch S652 to ON.	Waveform (fig. 3-38)....	Troubleshoot the if. amplifier (para 3-30).
2	AFC OUTPUT J1405 (fig. 3-16).	Same as step 1	Same as step 1. Set AFC-MANUAL switch S657 to AFC.	Waveform (fig. 3-39)....	Troubleshoot the afc assembly (para 3-30).
3	Terminals 1 of TB2001 and ground (fig. 3-26).	Electronic Multimeter ME-26A/U. Set the multimeter controls to measure 300 volts dc.	Same as step 1.........	300 volts dc	Troubleshoot the dc power supply (para 3-48).
4	Terminal 4 of TB2001 and ground (fig. 3-26).	Set the multimeter controls to measure 150 volts dc.	Same as step 1.........	150 volts dc	Troubleshoot the dc power supply (para. 3-48)

3-28. Removal and Replacement of Parts in Receiving System

a. General. The receiving system consists of the crystal mixers, the local oscillator assembly, the if. amplifier, the afc amplifier, and the stc assembly. All components of the receiving system are located in the receiver compartment (fig. 3-26).

b. Removal and Replacement of TEST METER SELECTOR Switch S1401 (fig. 3-36).

(1) *Removal.*

WARNING

Before entering the receiver compartment, turn off high voltage and all power.

(a) Unscrew the six pawl fasteners on the front door of the receiver compartment; grasp both handles and pull the door out to engage the hinges; then, using the handle on the right side, open the door.

(b) Tag, unsolder, and disconnect leads on switch S1401,

(c) Loosen the setscrew that holds the knob in place on the front panel and remove it.

(d) Remove the hexagonal nut that holds S1401 in place and lift the switch from the door.

(2) *Replacement.*

(a) Place switch S1401 in place on the door and secure it with the hexagonal nut.

(b) Insert and tighten the setscrew which holds the knob in place on the front panel.

(c) Reconnect and solder the leads to switch S1401.

(d) Replace the front door of the receiver compartment and secure it with the six pawl fasteners ((1) *(a)* above).

c. Removal and Replacement of L. O. CAVITY Switch S1402 (fig. 3-36).

(1) *Removal.*

WARNING

Before entering the receiver compartment, turn off high voltage and all power.

(a) Unscrew the six pawl fasteners on the front door of the receiver compartment; grasp both handles and pull the door out to engage the hinges; then using the handle on the right side, open the door.

(b) Tag, unsolder, and disconnect the leads on S1402.

(c) Remove the rubber protector for S1402 on the front panel.

(d) Remove the hexagonal nut holding S1402 in place and lift the switch out of the door.

(2) *Replacement.*

(a) Place S1402 on the door and secure it with the hexagonal nut.

(b) Replace the rubber protector for S1402 on the front panel.

(c) Reconnect and solder the leads to S1402.

(d) Replace the front door of the receiver compartment and secure it with the six pawl fasteners ((1) *(a)* above).

d. Removal and Replacement of Duplexer and Klystron Motor Assembly. Removal and replacement of the duplexer and klystron motor assembly is covered under the procedure for replacement of klystron tube V1501, TM 11-5840-208-20.

e. Removal and Replacement of Klystron Drive Motor. Removal and replacement of the klystron drive motor requires the removal of the entire duplexer and klystron motor assembly from the receiver compartment. The procedures for this operation are contained in TM 11-5840-208-20.

(1) *Removal.*

(a) Remove the duplexer and klystron drive motor assembly as described in TM 11-5840-208-20.

(b) Tag and disconnect the drive motor leads from TB1501 (fig. 3-26).

(c) Push the actuator side of the klystron coupling against the coupling spring and rotate clockwise so that the pin rotates into its locked position.

(d) Loosen the setscrew in the collar (actuator side) of the coupling.

CAUTION

Do not allow the shaft and coupling to support the drive motor during and after removal of the four Phillips-head screws that hold the motor to the mounting bracket.

(e) Remove the four screws in the motor mounting plate; remove the motor, being careful to slide the coupling off the motor drive shaft.

(2) *Replacement.*

(a) Insert the motor drive shaft through the hole in the mounting bracket and carefully slide the actuator side of the coupling on the shaft. Do not tighten.

(b) Replace the four screws in the motor mounting plate. To insure proper alignment, do not tighten until all four screws have been replaced.

(c) Connect the leads of klystron drive motor B1501 to TB1501.

(d) Tighten the setscrew in the collar (actuator side) of the coupling. Do not couple to the klystron tuning screw (see note in *(e)* below).

(e) Align the drive motor shaft and klystron tuning screw.

NOTE

The klystron drive assembly requires adjustment when the klystron drive motor or the klystron tube is replaced. Coupling of the motor drive shaft with the klystron tuning screw cannot be performed in *(d)* above until the duplexer and the klystron drive motor assembly have been replaced in the receiver compartment (TM 11-5840-208-20). Use the control-monitor panel L. O. CAVITY, RAISE-LOWER switch to determine the position of the motor drive shaft before engaging the actuator side of the coupling to the klystron tuning screw coupling. Once the mechanical alignment has been performed, tune the klystron local oscillator (TM 11-5840-208-20).

f. Removal and Replacement of Klystron Tube V1501. Removal and replacement of klystron tube V1501 is described in TM 11-5840-208-20.

g. Removal and Replacement of Afc Assembly.

(1) *Removal.*

WARNING

Before entering the receiver compartment, turn off high voltage and all power.

(a) Unscrew the six pawl fasteners on the front door of the receiver compartment; grasp both handles and pull the door out to engage the hinges; then, using the handle of the right side, open the door.

(b) Disconnect cables from J1302 (fig. 3-31).

(c) Loosen the two screws from the front flange of the chassis (fig. 3-26).

(d) Pull the chassis out part way.

(e) Disconnect the harnessed cable from J1303 and the coaxial cable from J1301 and lift the chassis from the cabinet.

(2) *Replacement.*

(a) Place the chassis part way in the cabinet and reconnect the cables to J1303 and J1301.

(b) Put the chassis in its proper position in the cabinet. Engage the guide pins.

(c) Tighten the screws on the front flange of the chassis (fig. 3-26).

(d) Reconnect cable to J1302.

(e) Secure the front door of the receiver compartment with the six pawl fasteners.

h. Removal and Replacement of if. Amplifier.

(1) *Removal.*

WARNING

Before entering the receiver compartment, turn off high voltage and all power.

(a) Unscrew the six pawl fasteners on the front door of the receiver compartment; grasp both handles and pull the door out to engage the hinges; then, using the handle on the right side, open the door.

(b) Disconnect the cables from J1201 and J1202 (fig. 3-32)

(c) Loosen the screws from the front flange of the chassis (fig. 3-26).

(d) Pull the chassis forward part way and remove the cable from J1204 and J1206.

(e) Pull the chassis forward again and remove the cables from J1205 and T-connector CP1203.

(f) Pull and lift the chassis out of the receiver compartment.

(2) *Replacement.*

(a) Position the chassis part way into the compartment.

(b) Reconnect the cables to J1205 and T-connector CP1203. Slide the chassis to the rear again and reconnect the cables to J1204 and J1206.

(c) Tighten the screws on the front flange of the chassis.

(d) Reconnect the cables to J1201 and J1202,

(e) Secure the front door of the receiver compartment with the six pawl fasteners.

i. Removal and Replacement of Stc Assembly (fig. 3-26).

WARNING

Before entering the receiver compartment, turn off high voltage and all power.

(1) *Removal.*

(a) Unscrew the six pawl fasteners on the front door of the receiver compartment; grasp both handles and pull the door out to engage hinges; then, using the handle on the right side, open the door.

(b) Disconnect the cables from P4701 (fig. 3-27).

(c) Loosen the screws from the front flange of the chassis (fig. 3-26); slide the chassis partially forward and disconnect the harnessed cable behind the left-hand tube shield and the coaxial cable from J4702. Again slide the chassis forward and disconnect the coaxial and harnessed cables at the extreme rear of the chassis (pulse shaper). Slide the chassis out of the cabinet.

(2) *Replacement.*

(a) Reposition the stc assembly in the guide tracks of the receiver compartment.

(b) Slide the chassis part way in and reconnect harnessed cable plug P4704 to J4704 at the extreme rear of the chassis (pulse shaper).

(c) Reconnect coaxial cable plug P4705 to J4705. Again slide the chassis to the rear and reconnect harnessed cable plug P4703 to J4703 and coaxial cable plug P4701 to J4701. Check to see that the guide pins at the rear of the chassis are engaged.

(d) Tighten the screws on the front flange of the chassis.

(e) Secure the front door of the receiver compartment with the six pawl fasteners.

j. Receiving System Adjustment and Alignment. Procedures for adjusting and aligning the receiving system when the components of the radar set are interconnected are covered in TM 11-5840-208-20.

3-29. Receiving System Testing

a. General. This paragraph covers testing procedures for checking the serviceability of a repaired receiving system when components of the radar set are interconnected. Testing procedures designed to check the serviceability of the complete radar set are covered in section XII of this chapter.

b. Test Equipment Required. Table 3-27 lists the items of test equipment that are required to test the receiving system. Operating instructions for the listed test equipment are found in the referenced manuals.

c. Check of Receiver Operation.

(1) Place AFC-MANUAL switch S657 (fig. 3-25) in the MANUAL POSITION.

(2) Place A. F. C.-MANUAL switch S1403 (fig. 3-16) in the AFC position.

(3) Place TEST METER SELECTOR switch S1401 (fig. 3-16) in the AFC XTAL position.

(4) Operate L. O. RAISE-LOWER switch S654 (fig. 3-15) in the RAISE position and tune for maximum range markers on the crt. Two points will be found where the range markers are maximum. Choose the second point when S654 is in the RAISE position.

(5) Place AFC-MANUAL switch S657 in the AFC position.

(6) Check the crt presentation to see that the range markers are not brighter when S657 is in the MANUAL position than when it is in the AFC position. If the range markers are better when S657 is in MANUAL position, the klystron requires adjustment. (See klystron adjustment procedures TM 11-5840-208-20.)

Table 3-27. Test Equipment Required for Testing Receiving System

Test equipment	Common name	Technical manual
Oscilloscope AN/USM-281C.......	Oscilloscope	TM 11-6625-2658-14
Radar T'est Set AN/UPM-60A.....	Test set.	TM 11-6625-228-12

(7) Press STOP button S659; then press START button S658.

(8) Check to see whether the afc locks in every time the transmitter is turned off and on.

c. Receiver Sensitivity Check. The minimum discernible signal is a measure of the sensitivity of the receiving system. The sensitivity of the receiving system is checked by inserting a 1-milliwatt pulsed rf signal into Directional Coupler CU-399/MPQ-4A at a frequency within the radar frequency range. While observing the signal (pulse) on an oscilloscope, a known amount of attenuation is inserted until the pulse just disappears into the noise pattern (grass).

(1) Preliminary procedures and adjustments.

NOTE

The following procedure assumes local operation. In local operation, the control-indicator group is mounted on the radar trailer; however, the control-indicator group may be mounted on the remoting stand and placed at the left rear side of the radar trailer. This arrangement will afford use of the space vacated by the control-indicator group for mounting the test set and the oscilloscope.

(a) Rotate the antenna in azimuth until the front of the receiver-transmitter group is stopped directly over the curbside fender.

(b) Elevate the antenna so that LOWER BEAM ELEVATION counter M821 on the computer front panel indicates - 100 mils.

(c) Position the test set and the oscilloscope at the rear of the trailer and connect the power cables of each to the convenience outlets.

NOTE

Two convenience outlets are on the radar set. Receptacle J1003 is on the right side of the control-indicator cabinet, and receptacle J1403 is on the front of Control-Monitor C2102 MPQ-4A. Before connecting to J1403, open the front door of the receiver compartment and close shorting switch S2008.

(d) Perform the operating procedures for the oscilloscope as outlined in TM 11-6625-1703-15 and follow the starting procedure for the test set as outlined in TM 11-6625-228-12 which establishes the 1-milliwatt reference level of the rf output of the test set.

(e) Turn radar control-power supply MAIN POWER switch S652 to OFF.

(f) Disconnect waveguide section W743 from the bidirectional coupler and waveguide section W744 (fig. 2-16).

(g) Connect the test set flexible waveguide assembly between the rf connector on the front panel of the test set and the connector on the bidirectional coupler (fig. 3-40).

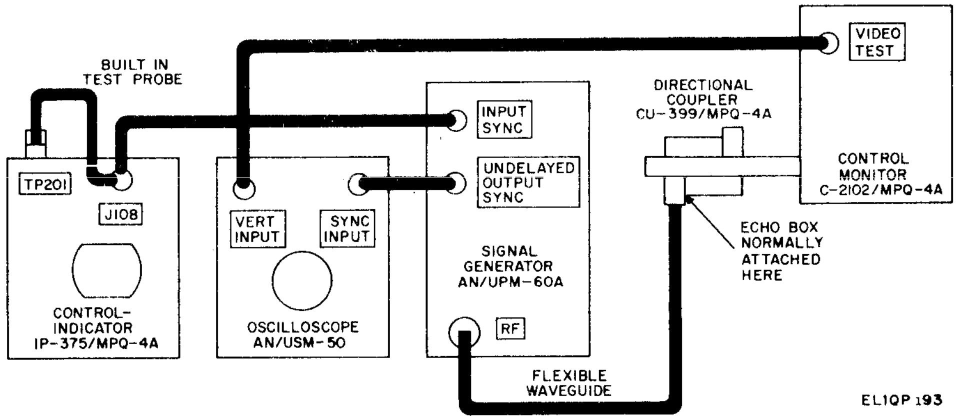


Figure 3-40. Receiver sensitivity measurement test setup.

(h) Connect a coaxial cable from VIDEO TEST jack J1404 on the front panel of the receiver control-monitor to the VERT INPUT jack on the oscilloscope.

(i) Connect a coaxial cable from the UN-DELAYED OUTPUT SYNC jack on the test set to the SYNC INPUT jack on the oscilloscope.

(j) Release the four pawl fasteners on the front panel of the radar azimuth and range indicator drawer and pull the drawer out to the stops. Close shorting switch S1004.

(k) Connect the built-in test probe (fig. 3-69) to TP201 (fig. 3-50).

(l) Connect a coaxial cable from EXT TEST jack J108 on the indicator (fig. 3-69) to the INPUT SYNC jack on the test set.

(2) *Procedure.*

CAUTION

Do not press START button S658 on the control-power supply after the 5-minute time delay following application of power to the radar set as the radiate condition of the transmitter will damage the test set.

(a) Turn radar control-power supply MAIN POWER switch S652 to ON.

(b) Operate the test set controls according to the starting procedure (TM 11-6625-228-12) and receiver sensitivity test instructions (TM 11-6625-228-12). Operate the controls on the oscilloscope according to the operating instructions given in TM 11-6625-2658-14.

NOTE

In the receiver sensitivity test instructions (TM 11-6625-228-12) regarding the setting of the MODULATION SELECTOR switch to the PULSE position, note that because the power monitor bridge measures average power when the MODULATION SELECTOR switch is at PULSE position, the meter needle (front panel) will drop and indicate low. This is normal. Do not change the setting of the POWER SET control as this would change the already established 1-milliwatt reference level.

(c) Set the test set controls and switches as follows:

1. MODULATION SELECTOR switch to PULSE.

2. PULSE WIDTH MICROSECONDS control to .25.

3. DELAY MULTIPLIER switch to X1.

4. SYNC SELECTOR switch to EXT POS.

5. FUNCTION SELECTOR switch to RECV.

(d) Adjust the test set DELAY MICROSECONDS control and the radar IF GAIN control (fig. 3-48) to present the test set pulse on the oscilloscope. Touch up the sweep controls on the oscilloscope to obtain the proper presentation (fig. 3-41).

Figure 3-41. Minimum discernible signal pulse.

(e) Adjust the test set OSCILLATOR TUNING control for maximum test set pulse and adjust the radar IF GAIN control so that the grass is about one-half the pulse amplitude.

NOTE

For maximum pulse amplitude, as seen on the oscilloscope, touch up the radar local oscillator tuning. Do not fire the transmitter.

(f) Determine the minimum discernible signal by increasing the setting of the test set ATTENUATOR control. Observe that the indication of attenuation appears on the outer, white scale of the POWER DBM dial. Increase the setting until the pulse, as seen on the oscilloscope, just disappears into the grass. As the pulse begins to disappear, increase the ATTENUATOR setting in 1 -db steps and vary the DELAY MICROSECONDS control slightly to permit discerning the pulse in the grass.

(g) Note the indication on the POWER DBM dial as the pulse disappears into the grass. This figure is the power output of the test set expressed in dbm (db below the reference level of 1-milliwatt). Add to this figure the attenuation losses introduced in coupling the rf output of the test set to the receiver through the bidirectional coupler. The total is the uncorrected minimum power level in db below 1-milliwatt (dbm) at the receiver input required to produce a minimum discernible signal indication. This total is a relative index of receiver sensitivity y. To obtain the absolute value, refer to the dbm correction curves supplied with the test set.

NOTE

The nominal and actual attenuation figures for the bidirectional coupler of the radar set appear on plates affixed to the CU-399/MPQ-4A.

3-30. Bench Servicing of Receiving System

a. General. This paragraph covers bench servicing of the receiving circuits in the receiver-transmitter. The following information will be helpful when bench servicing the receiving circuits in the receiving system.

Information	Reference
Receiver-transmitter group, schematic diagram	Fig. FO-22
Control-monitor, schematic diagram.	Fig. FO-26
If. amplifier, schematic diagram.	Fig. FO-24
Afc assembly, schematic diagram.	Fig. FO-25
Stc assembly, schematic diagram.	Fig. 3-37
Location of parts in receiver compartment.	Fig. 3-26
Location of parts in if. amplifier.	Fig. 3-32 through 3-35.
Location of parts in stc assembly.	Fig. 3-27 and 3-28.
Location of parts in afc assembly.	Fig. 3-29, 3-30 and 3-31.
Fuses	Table 3-18
Controls and adjustment.	Table 3-19
Stc assembly, waveform diagram	Fig. 3-22
Afc assembly, waveform diagram	Fig. 3-39
Stc assembly, voltage and resistance diagrams	Fig. 3-25
Afc assembly, voltage and resistance diagrams.	Fig. 3-24
Intermediate Frequency Amplifier AM-1538/MPQ-4A, voltage and resistance diagram.	Fig. 3-47

b. Checking for Short Circuits. To determine that no damage will result from applying power to the receiving system, perform a resistance check from the points specified in table 3-28, to the chassis ground with the chassis disconnected from the equipment. An indication less than the value shown indicates that a further check should be made to determine where the short circuit exists. Also make voltage and resistance checks.

c. Test Equipment Required. Table 3-29 lists the items of test equipment, cables and adapters that are required to bench service the receiving circuits in Receiver-Transmitter Group OA-1257/MPQ-4A. The cables and adapters are supplied with Test Facilities Kit MK-387/MPM-49.

Table 3-28. Short Circuit Checks of Receiving System

Check point	Resistance to ground
IF amplifier	
J1205A	0
J1205B	0.5
J1205C	Inf
J1205D	Inf
J1205E	5 meg
J1205F	Inf
J1205H	0
J1205J	0
J1205K	Inf
Stc assembly	
J4703A	Inf
J4703B	Inf
J4703C	Inf
J4703D	Inf
J4703E	Inf
J4703F	Inf
J4703H	0
J4703J	12K
J4703K	800
J4704A	Inf
J4704B	Inf
J4704C	0
J4704D	Inf
J4704E	Inf
J4704F	Inf
J4704H	Inf
Afc assembly	
J1301A	Inf
J1301B	Inf
J1301C	0
J1301D	Inf
J1301E	Inf
J1301F	0
J1301H	Inf
J1301J	Inf
J1301K	Inf
J1301L	Inf
J1301M	Inf
J1301N	Inf

Table 3-29. Test Equipment Required for Bench Servicing of Receiving System

Test equipment	Common name	Technical manual
Power Supply PP-1588/MPQ-4A[a]	Power supply.	
Control Power Supply C-2014/MPQ-4A[a]	Power supply.	
Interconnecting Box J-982/MPM-49A[a]	Junction box.	
Signal Generator SG-299/U	Pulse generator	TM 11-5134-15
Oscilloscope AN/USM-281C	Oscilloscope	TM 11-6625-2658-14
Electronic Multimeter ME-26/U	Vtvm (vacuum tube voltmeter	TM 11-6625-200-15
Electrical power cable assembly W2601.[a]		
RF cable assembly W2614.[a]		
RF cable assembly W2619.[a]		
Electrical power cable assembly W2608.[a]		
Electrical power cable assembly W2607.[a]		
RF cable assembly W2611.[a]		
RF cable assembly W2614.[a]		
RF cable cable assembly W2617.[a]		
Electrical power cable assembly W2610.[a]		
Electrical power cable assembly W2609.[a]		
Electrical power cable assembly W2606.[a]		
Electrical power cable assembly W2602.[a]		
Pulse Generator AN/PPM-1		TM 11-2678
Signal Generator TS-452C/U	Sweep generator	TM 11-6625-283-12
Motor-Generator PU-20C/C		TM 11-6125-200-10

[a]Pert of Test Facilities Kit MK-387/MPM-49

NOTE

When technical manual is not listed, refer to this manual.

d. Bench Servicing Connections for Afc Assembly. Follow the directions in (1) and (2) below to connect Receiver Control C-2016/MPQ-4A to bench service the afc assembly.

(1) Remove the afc assembly from the receiver compartment as described in paragraph 3-28 *g* (1).

(2) Connect the afc assembly and Signal Generator TS-452C/U to the junction box as shown in figure 3-42. All the cables that are required to make the connections are supplied with Test Facilities Kit MK-387/MPM-49.

(3) When the afc assembly is connected to the junction box as shown in figure 3-42, perform the following steps:

(a) Turn POWER switch S2601, on the junction box, to ON. POWER ON indicator lamp I2606 should light.

(b) Turn MAIN POWER switch S652 on Control-Power Supply C-2014/MPQ-4A to ON.

(c) Turn AFC POWER. switch S2606 on the junction box to ON.

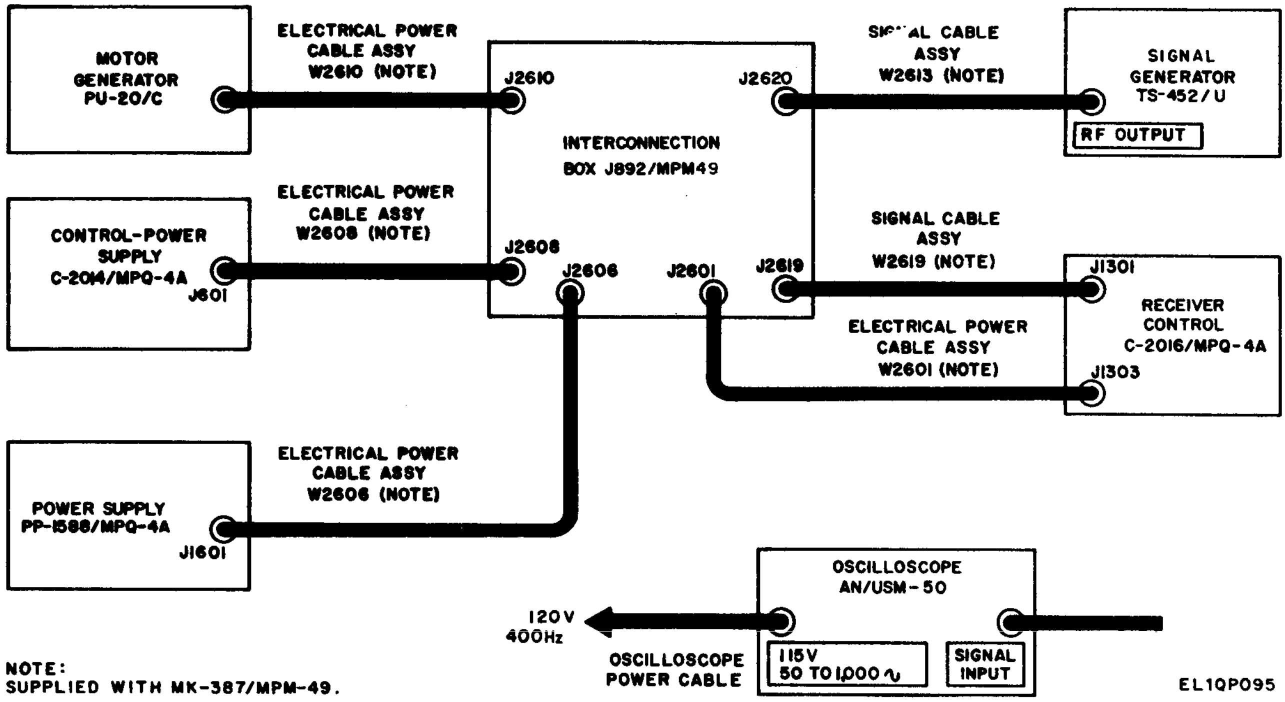


Figure 3-42. Bench test connections for afc assembly.

e. Bench Servicing Connections for Stc Assembly. Follow the directions in (1) and (2) below to connect Receiver Control C-2015/MPQ-4A to bench service the stc assembly.

(1) Remove the stc assembly horn the receiver compartment as discussed in paragraph 3-28 *i* (1).

(2) Connect the stc assembly to the junction box, the oscilloscope, and the pulse generator as shown in figure 3-43. All the cables that are required to make the connections are supplied with Test Facilities Kit MK-387/MPM-49.

(3) When the stc assembly is connected as shown in figure 3-43, perform the following steps:

(a) Turn POWER switch S2601, on the junction box, to ON. POWER ON indicator lamp I 2606 should light.

(b) Turn MAIN POWER switch S652 on Control-Power Supply C-2014/MPQ-4A to ON.

(c) Turn STC POWER switch S2605 on the junction box to ON.

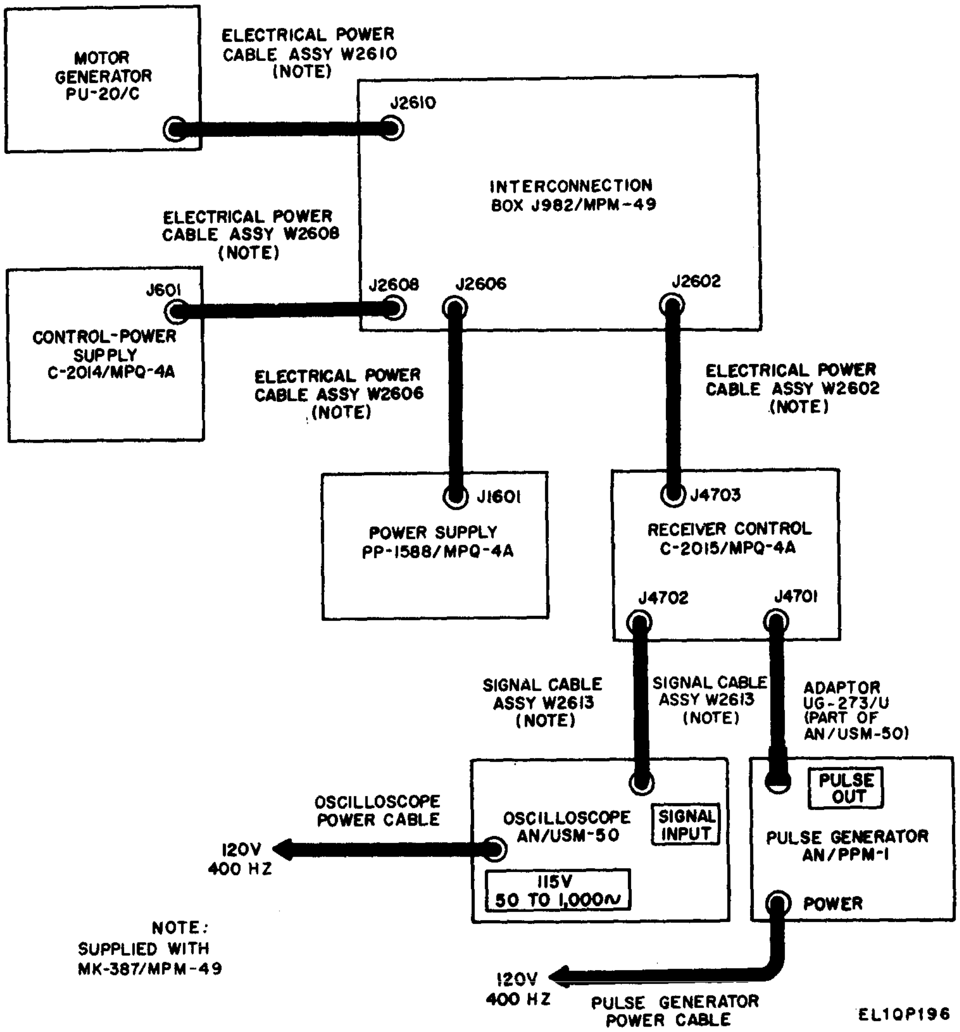


Figure 3-43. Bench test connections for stc assembly.

f. Bench Servicing Connections for if. Amplifier. Follow the directions in (1) and (2) below to connect Intermediate Frequency Amplifier AM-1538/MPQ-4A to bench service the if. amplifier.

(1) Remove the if. amplifier from the receiver cabinet as described in paragraph 3-28 *h* (1).

(2) Connect the if. amplifier to the junction box, the sweep generator, and the oscilloscope as shown in figure 3-44. All the cables that are required to make the connections are supplied with Test Facilities Kit MK-387/MPM-49.

(3) When the if. amplifier is connected to the test equipment as shown in figure 3-43, perform the following steps.

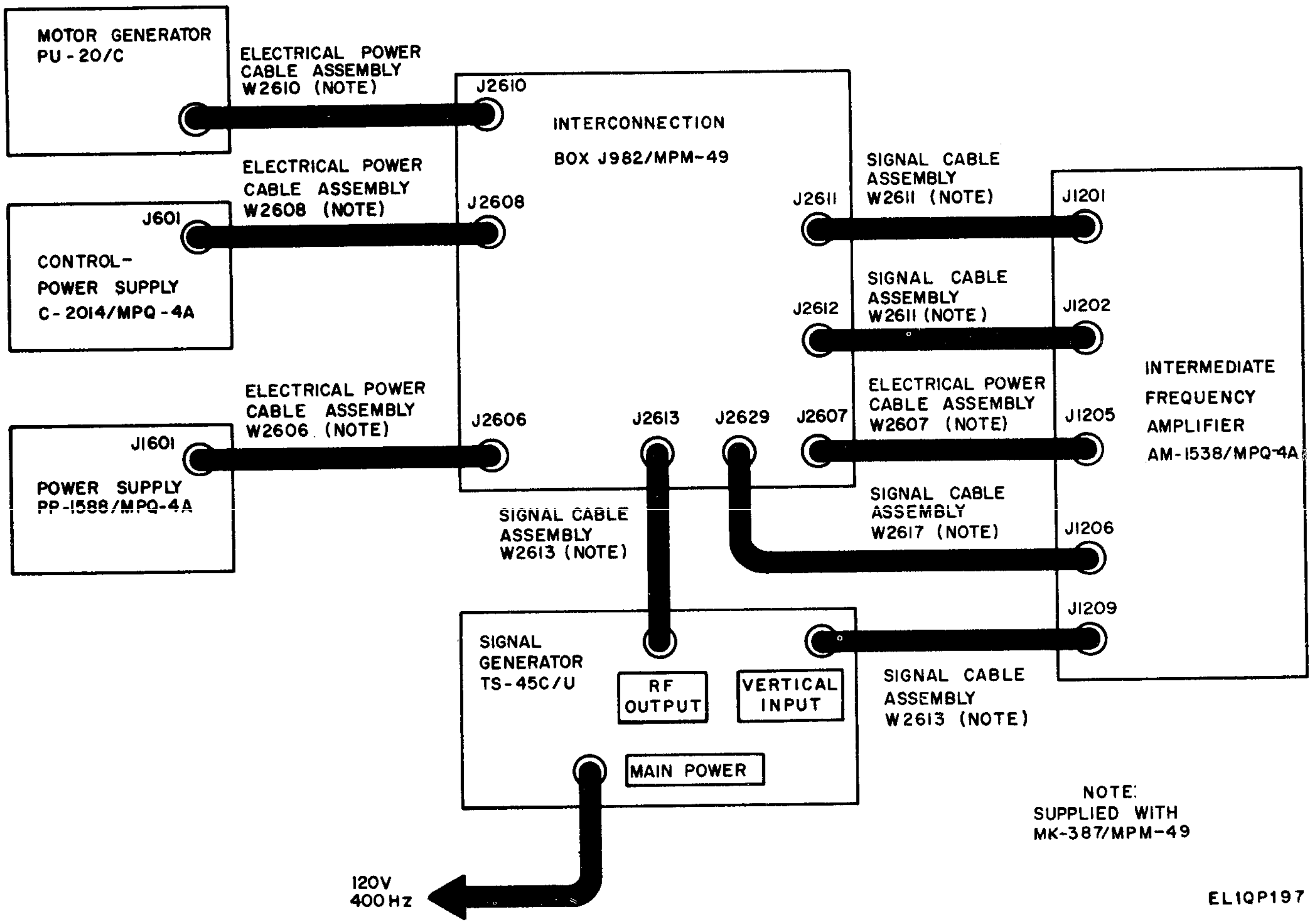


Figure 3-44. Bench test connections for if. amplifier.

(a) Turn POWER switch S2601 on the junction box to ON.

(b) Turn MAIN POWER switch on Control-Power Supply C-2014/MPQ-4A to ON.

(c) Turn if. switch S2607 to ON.

(4) If the stc assembly is being bench serviced with the if. amplifier, connect signal cable assembly W2617 between connector J1206 on the if. amplifier and connector J4702 on the stc assembly.

g. Bench Step-by-Step Troubleshooting Table. The bench step-by-step troubleshooting table consist of a series of steps designed to evaluate all phases of operation of each chassis of the receiving system. To troubleshoot the chassis receiving system using the step-by-step troubleshooting table, proceed as follows:

(1) Locate the test point given in step 1 of the table.

(2) Connect the test equipment listed in the test equipment column.

(3) Set the controls as directed in the *Controls* column.

(4) Compare the indications obtained on the test equipment with indications given or referenced in the normal indications column.

(5) If the indications obtained on the test equipment are normal, proceed either to the next step or as directed in the normal indications column.

(6) If the indications obtained are abnormal, proceed as directed in the corrective measures column.

Table 3-30. Bench Step-by-Step Troubleshooting Table for Receiving System

Step	Test point	Test equipment	Controls	Normal indications	Corrective measures
			If. amplifier		
1	J1203	Oscilloscope AN/USM-281C.	Refer to paragraph 3-30*f*	Waveform	Check V1211 and V1210; make voltage and resistance checks at base of tube sockets (fig. 3-47).
2	J1209	Same as step 1	Same as step 1	Waveform	Check CR1201, check V1209; make voltage and resistance checks at base of tube socket (fig. 3-47).
3	Pin 5 of V1209	Same as step 1	Same as step 1	Waveform	Check V1204 through V1209; make voltage and resistance checks at base of tube socket (fig. 3-47).
4	Pin 5 of V1203	Same as step 1	Same as step 1	Waveform	Check V1203, V1202, and V1201; make voltage and resistance checks at base of tube sockets (fig. 3-47) Check L1218, L1217, and L1216.
			Afc assembly		
1	Pin 5 of V1306	Oscilloscope AN/USM-281C	Refer to paragraph 3-30*d*	Sine wave	Check V1306, V1307, and V1308; make voltage and resistance checks at base of tube sockets (fig. 3-24).
2	J1304	Same as step 1	Same as step 1	Waveform (fig. 3-23).	Check V1305; make voltage and resistance measurements at base of tube socket (fig. 3-24).
3	Pin 5 of V1304	Same as step 1	Same as step 1	Waveform (fig. 3-23).	Check V1304; make voltage and resistance measurements at base of tube socket (fig. 3-24).
4	Pin 2 of V1304	Same as step 1	Same as step 1	Waveform (fig. 3-23).	Check L1301.
5	Pin 5 of V1302 or J1302.	Same as step 1	Same as step 1	Waveform (fig. 3-23)	Check V1302; make voltage and resistance measurements at base of tube socket (fig. 3-24). Check delay cell DL1301.
6	Pin 5 of V1301	Same as step 1	Same as step 1	Waveform (fig. 3-23)	Check V1301; make voltage and resistance measurements at base of tube socket (fig. 3-24). Check T1301.

Table 3-30. Bench Step-by-Step Troubleshooting Table for Receiving System—Continued

Step	Test point	Test equipment	Controls	Normal indications	Corrective measures
			Stc assembly		
1	J4702	Oscillsocope AN/USM-281C.	Refer to paragraph 3-30*e*	Waveform (fig. 3-22)	Check V4702; make voltage and resistance measurements at base of tube socket (fig. 3-25).
2	Pin 9 of V4701	Same as step 1	Same as step 1	Waveform (fig. 3-22)	Check V4701; make voltage and resistance measurements at base of tube socket (fig. 3-25).

h. Bench Alignment of Receiving System. The components of the receiving system can be aligned completely when connect ed for bench servicing (para 3-30 *d, e,* and *f*). Table 3-31 lists the adjustments that are required to completely align the receiving system and references a paragraph that contains detailed step-by-step directions for making each adjustment.

i. Alignment of if. Amplifier.

(1) Calibrate Oscilloscope AN/USM-281C for vertical amplitude.

(2) Connect the vertical input leads of the oscilloscope to pin 5 of V1203.

(3) Adjust L1216 through L1218 for a presentation on the oscilloscope similar to figure 3-45.

Table 3-31. Bench Alignment of Receiving System

Alignment	Procedure (para)
If. amplifier	3-30i
Afc assembly	3-30j
Stc assembly	3-30k

(4) Disconnect the oscilloscope test lead from V1203.

(5) Connect the oscilloscope test lead to J1209.

(6) Adjust T1201 through T1206, and L1208 until the response characteristic of the waveform on the indicator is the same as the characteristic shown in figure 3-45.

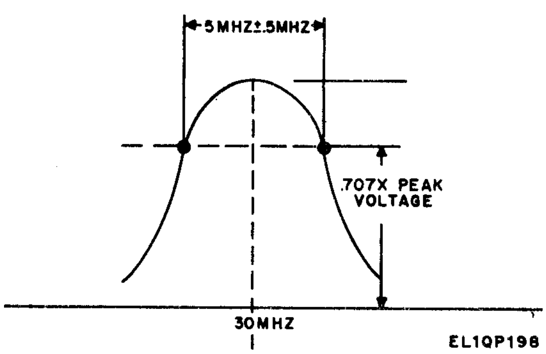


Figure 3-45. Idealized band-paw curve for if. amplifier.

(7) Measure the bandwidth of the overall response curve. The bad-width is the spread in megaHertz between the two points on the response curve which are 0.707 of the peak amplitude. Determine the frequency at the two points on the following curve which are 0.707 of the peak amplitude with a time mark generator and an oscilloscope. The measured bandwidth must be 5 magaHertz ±0.5 megaHertz.

(8) The frequency which falls midway between the two points located in (8) above must measure 30 mega Hertz ±0. 5 mega Hertz.

j. Alignment of Afc Assembly.

(1) With the proper oscillator coil inserted in the TS-452C/U sweep generator for checking a frequency response curve centered on 30 megaHertz, connect the rf detector cable supplied with the sweep generator between J1302 on the afc assembly and the INPUT jack on the TS-452C/U sweep generator.

(2) With the RANGE MARKS RELAY & STC switch on the junction box (fig. 3-174) turned on, check for a response curve on the sweep generator that is symmetrical, above and below 30 megaHertz. Adjust T1301, T1302, and L1303 as necessary, using an alignment tool, to correct the response curve.

(3) Disconnect the rf detector cable from the TS-452C/U and J1302, and remove V1308 (fig. 3-31) from the afc assembly.

NOTE

Use a test cable consisting of 3 feet of RG-59B/U coaxial cable with a UG-260B/U connector at one end and at the other end an alligator clip soldered to the braid and a test prod soldered to the center conductor.

(4) Connect the test cable prod to J1304 and the alligator clip to afc assembly chassis. Connect the UG-260B/U to the INPUT jack on the TS-452C/U.

(5) Check for a symmetrical discriminator response curve (low frequency positive curve being aym metrical to the high frequency negative curve) on the sweep generator with the crossover point at 30 megaHertz low-end peaking at 28.5 MHz ±0.25, and high-end peaking at 31.5 MHz ±0.25. Adjust L1301 and L1302 as necessary, using an alignment tool, to correct the response curve.

(6) Repeat the procedures given in (1) through (5) above.

(7) Remove the test cable; replace V1308.

k. Alignment of Stc Assembly.

(1) *General.* The output of the stc assembly is fed into the if. amplifier to reduce receiver sensitivity during a definite period of time so that strong signal returns from nearby targets will not block the receiver. The output of the stc assembly is a negative-going gate. The amplitude, risetime, and duration of the stc waveform are controlled by potentiometers R4708, R4712, and R4714.

(2) *Alignment procedures.*

(a) Connect the stc assembly as shown in figure 3-43.

(b) Adjust Pulse Generator AN/PPM-1 until the pulse at J4701 has an amplitude of 25 volts, a width of 0.8 microsecond, and a repetition rate of 5,000 pulses per second.

(c) Observe the waveform at pin 7 of V4701.

The waveform should be a negative pulse with an amplitude of 19 volts ±3 volts.

(d) Observe the waveform at pin 2 of V4702. The waveform should be a positive pulse which varies in amplitude from 8 volts to 35 volts ±5 volts when R4708 is varied.

(e) Observe the waveform at pin 1 of V4702. The waveform should be as shown in figure 3-46 without slipping.

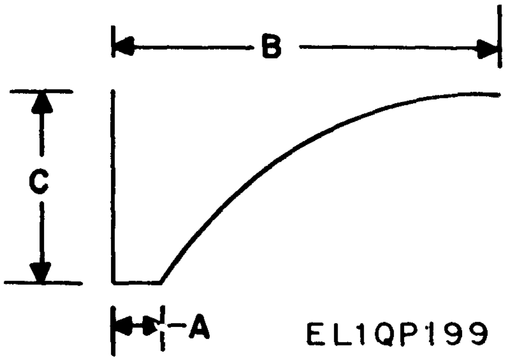


Figure 3-46. Waveform for stc output.

(f) Vary potentiometer R4708 throughout the entire range. The waveform observed in the procedure in *(e)* above should vary in amplitude from -15 volts ±5 volts to -65 volts ±10 volts.

(g) Observe the waveform at J4702.

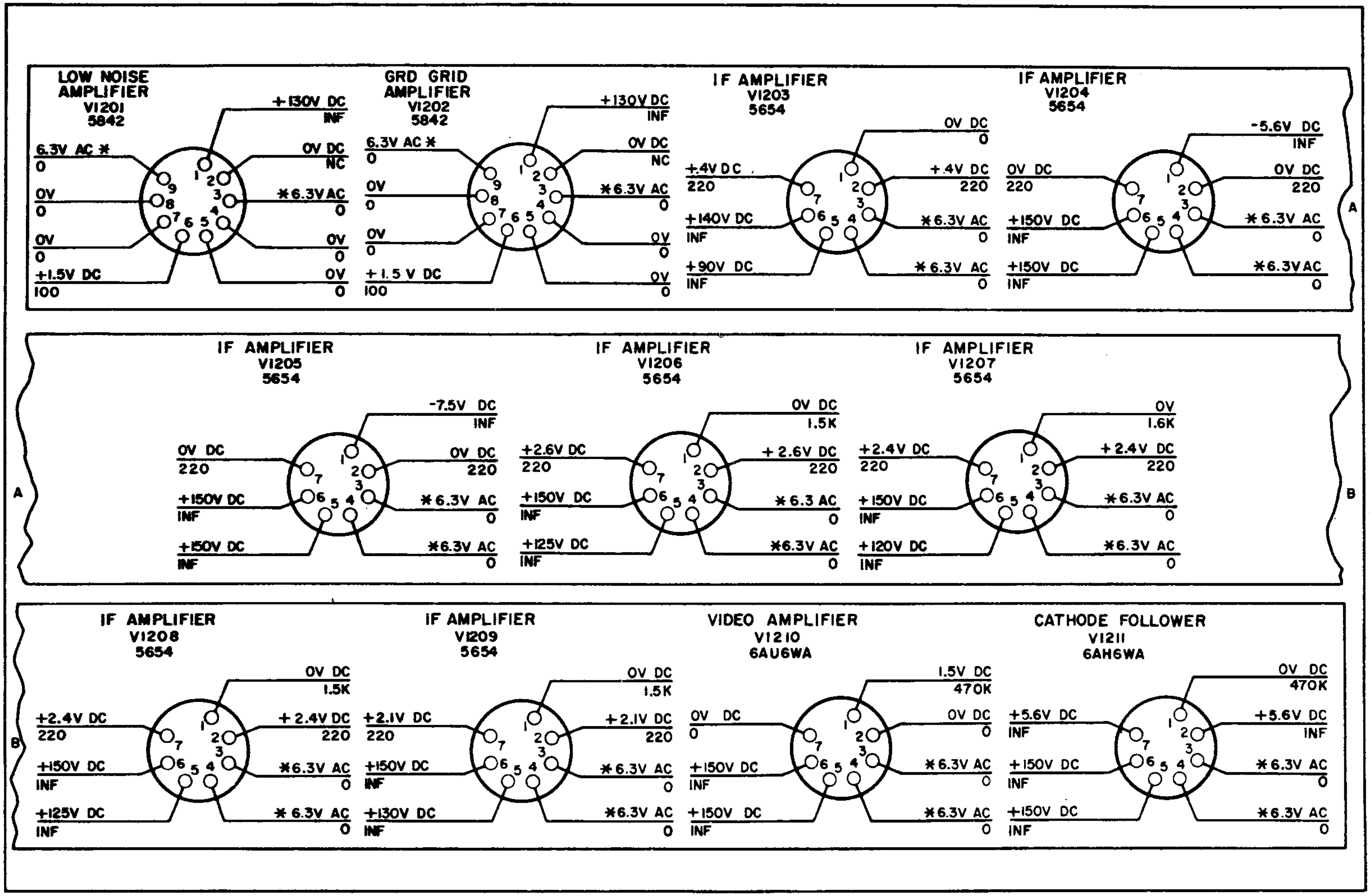
(h) Carefully adjust R4708 until the duration of A, figure 3-46 is 6 µsec.

(i) Adjust R4712 until the duration of the gate (B, fig. 3-48) is 48 µsec.

(j) Adjust R4714 until the amplitude (C, fig. 3-46) of the output waveform is -6 volts.

NOTE

When R4708 and/or R4712 is adjusted, the waveform will be changed slightly.



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSAND. MEG DENOTES MILLION. INF DENOTES INFINITY

EL1QP200

Figure 3-47. Intermediate Frequency Amplifier AM-1538/MPQ-4A, voltage and resistance diagram.

Section VII. SYNCHRONIZING AND INDICATING SYSTEMS TROUBLESHOOTING AND REPAIR

WARNING

Extremely dangerous voltages exist in Azimuth and Range Indicator IP-375/MPQ-4A. Fourteen thousand volts are applied to the anode of the B-scope and 440 volts are applied to the screen of the B-scope. When servicing the indicating system, observe the following precautions:

1. Do not make voltage measurements in the high voltage rectifier chassis.
2. Turn off the power and discharge the high voltage by grounding jack J162 before making resistance measurements in the high voltage rectifier chassis.

3-31. Synchronizing and Indicating Systems Troubleshooting Information

a. Reference Data. The following information will be helpful when troubleshooting the indicating and synchronizing systems:

Reference	Data
Fig. FO-4	Indicating system, block diagram.
Para 2-25	Functioning of circuits in the indicating system.
Para 2-22	Functioning of circuits in the synchronizing system.
Fig. 2-50 through 2-62, 2-64, 2-66, 2-67, 2-69 through 2-90	Synchronizing and indicating systems, simplified schematic diagrams.
Fig. FO-27	Azimuth and Range Indicator IP-375/MPQ-4A, schematic diagram.
Fig. 3-48	Azimuth and Range Indicator IP-375/MPQ-4A, front panel.
Fig. 3-49	Indicator, Azimuth and Range IP-375/MPQ-4A, rear panel.
Fig. 3-50, 3-51	Azimuth and Range Indicator IP-375/MPQ-4A, top view.
Fig. 3-52, 3-53	Azimuth and Range Indicator IP-375/MPQ-4A, bottom view.
Fig. 3-54	Long gate generator Z101, waveform diagram.
Fig. 3-55	Timing sweep generator Z102, waveform diagram.
Fig. 3-56	Trigger pickoff amplifiers Z107, Z108, and Z109, waveform diagram.
Fig. 3-57, 3-58	Azimuth synchronizer Z150, waveform diagram.
Fig. 3-59	Range sweep generator and driver Z144, waveform diagram.
Fig. 3-61	Azimuth sweep generator and driver Z145, waveform diagram.
Fig. 3-62	Video blanking Z146, waveform diagram.
Fig. 3-63	Modulator trigger generator Z147, waveform diagram.
Fig. 3-65	Video amplifier Z148, wave form diagram.
Fig. 3-66	Intensifier and short gate generator Z149, wave form diagram.
Fig. 3-67	Azimuth and Range Indicator IP-375/MPQ-4A, top-right view with panel up.
Fig. 3-68	Azimuth and Range Indicator IP-375/MPQ-4A, top-left view with panel up.
Fig. 3-69	Indicator beam centering adjustment and test probe.
Fig. 3-70	Azimuth and Range Indicator IP-375/MPQ-4A, bottom-right view with panel down.
Fig. 3-71	Azimuth and Range Indicator IP-375/MPQ-4A, bottom-left view with panel down.
Fig. 3-72	High voltage oscillator V161, wave form diagram.
Fig. 3-73	Video amplifier Z148, voltage and resistance diagram.
Fig. 3-74	Rsnga marker trigger pickoff amplifier Z109, voltage and resistance diagram.
Fig. 3-75	Azimuth sweep generator and driver Z145, voltage and resistance diagram.
Fig. 3-76	Azimuth synchronizer Z150, voltage and resistance diagram.
Fig. 3-77	Timing sweep generator Z102, voltage and resistance diagram.
Fig. 3-78	Long gate generator Z101, voltage and resistance diagram.
Fig. 3-79	Range sweep generator and driver Z144 subassembly, voltage and resistance diagram.
Fig. 3-80.	Range sweep generator and driver Z144, major voltage and resistance diagram.
Fig. 3-81	Intensifier and short gate generator Z149, voltage and resistance diagram.
Fig. 3-82	Modulator trigger generator Z147, voltage and resistance diagram.
Fig. 3-83	Range zero trigger pickoff amplifier Z107, voltage and resistance diagram.
Fig. 3-84.	Delay trigger pickoff amplifier Z108, voltage and resistance diagram.
Fig. 3-85.	Video blanking Z146, voltage and resistance diagram.
Fig. 3-86	Long gate generator Z101, bottom view.
Fig. 3-87	Timing sweep generator Z102, bottom view.
Fig. 3-88.	Trigger pickoff amplifiers Z107, Z108, and Z109, bottom view.
Fig. 3-89	Range sweep generator and driver Z144, bottom view.
Fig. 3-90	Azimuth sweep generator and driver Z145, bottom view.
Fig. 3-91	Video blanking Z146, bottom view.
Fig. 3-92	Modulator trigger generator Z147, bottom view.
Fig. 3-93	Video amplifier Z148, bottom view.

Reference	Data
Fig. 3-94	Intensifier and short gate generator Z149, bottom view.
Fig. 3-95	Azimuth synchronizer Z150, bottom view.
Fig. 3-96	Indicator drawer, voltage and resistance diagram.
Fig. 3-97	V231, waveform diagram.

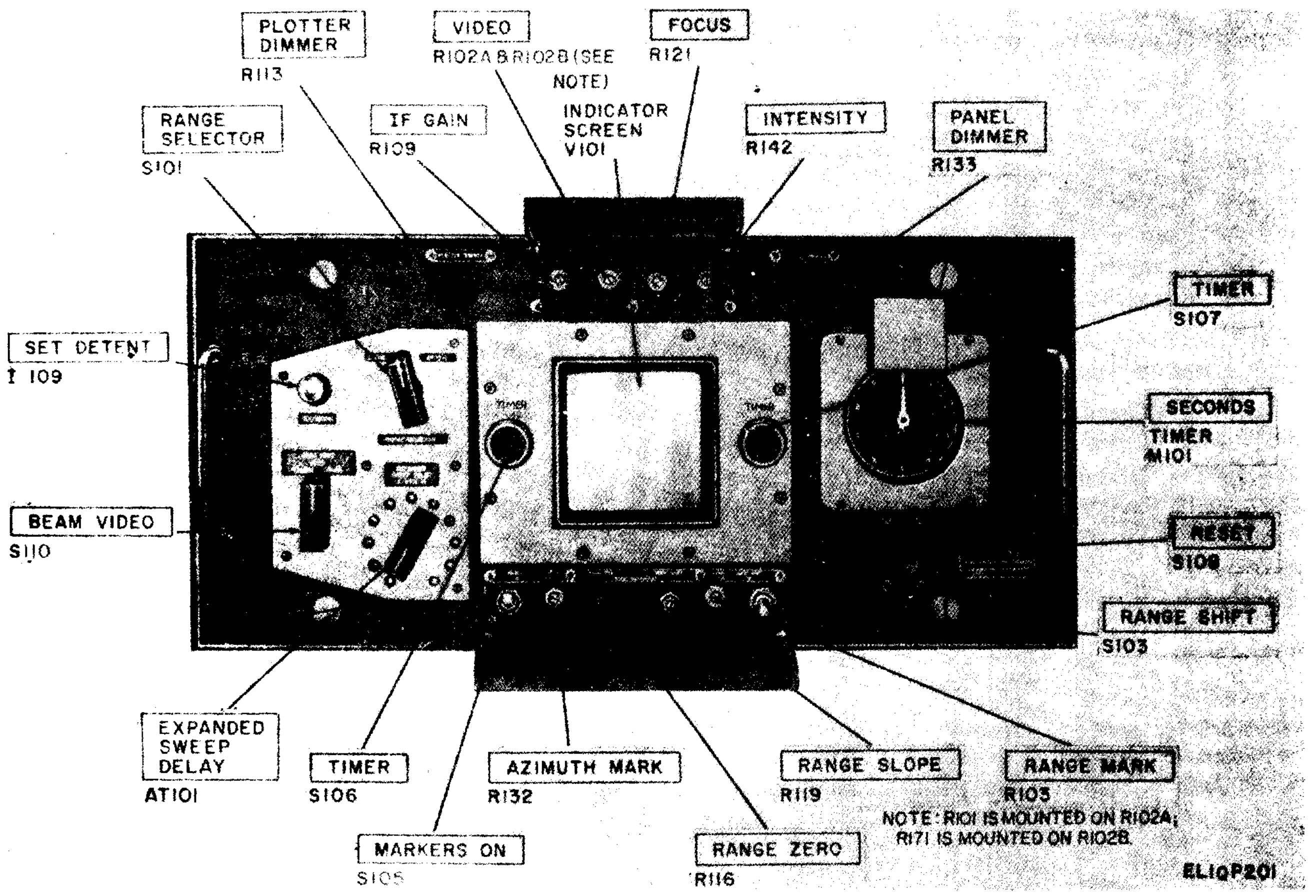


Figure 3-48. Indicator, Azimuth and Range Indicator IP-375/MPQ-4A, rear panel.

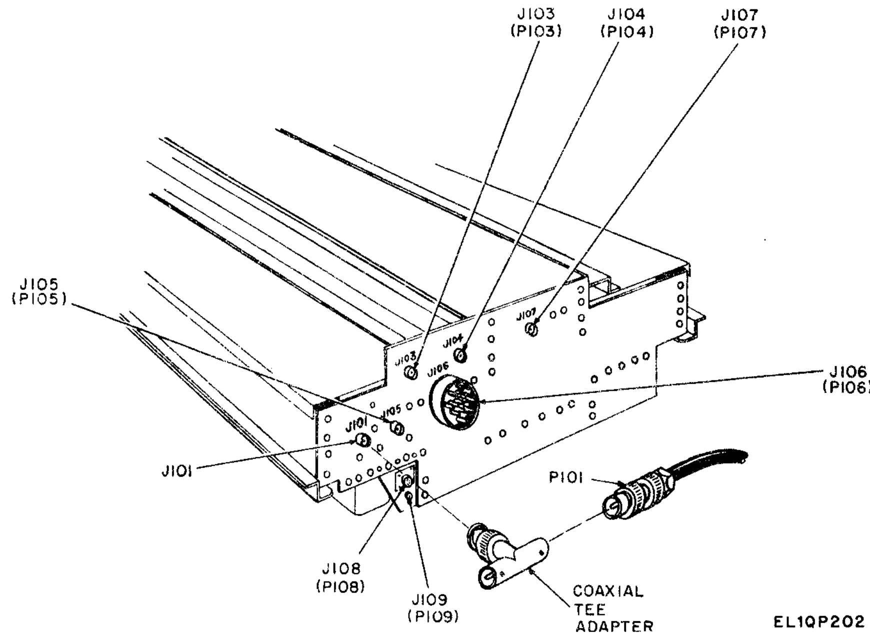


Figure 3-49. Azimuth and Range Indicator IP-375/MPQ-4A, front panel.

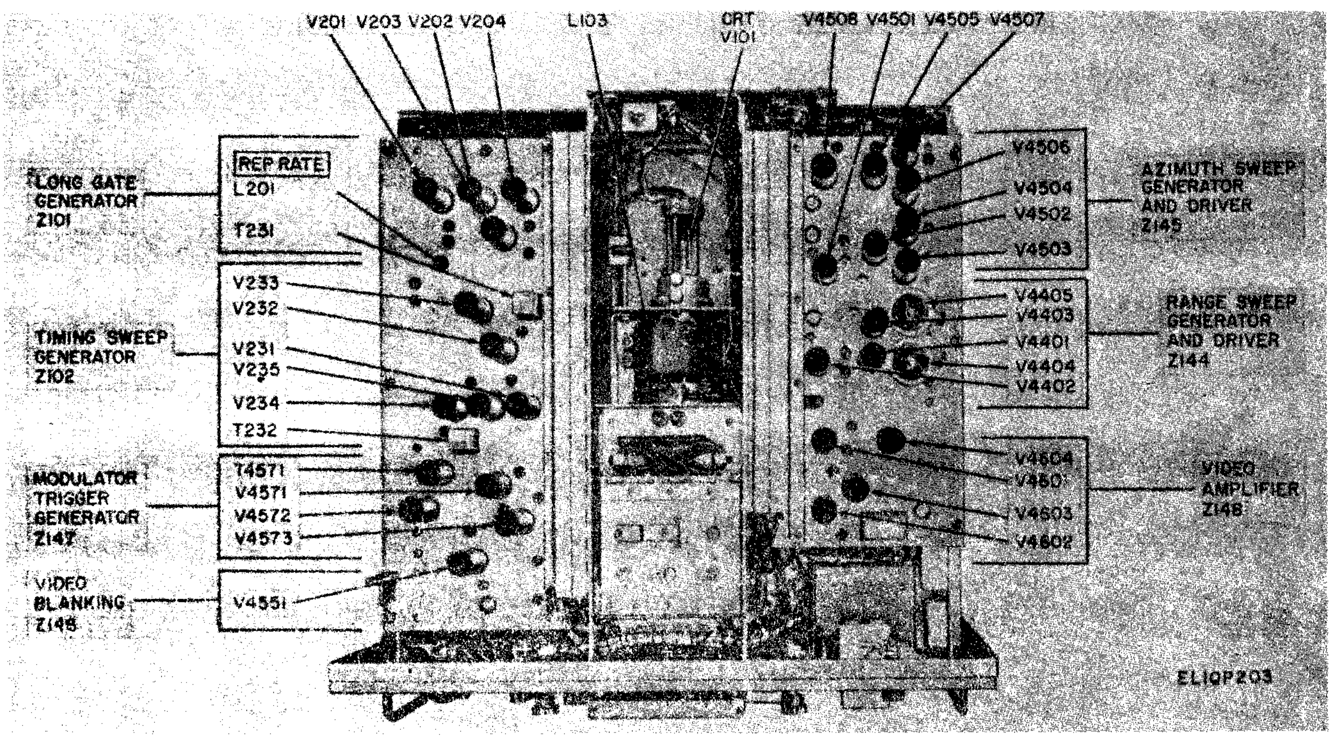


Figure 3-50. Azimuth and Range Indicator IP-375/MPQ-4A, top view, tube locations.

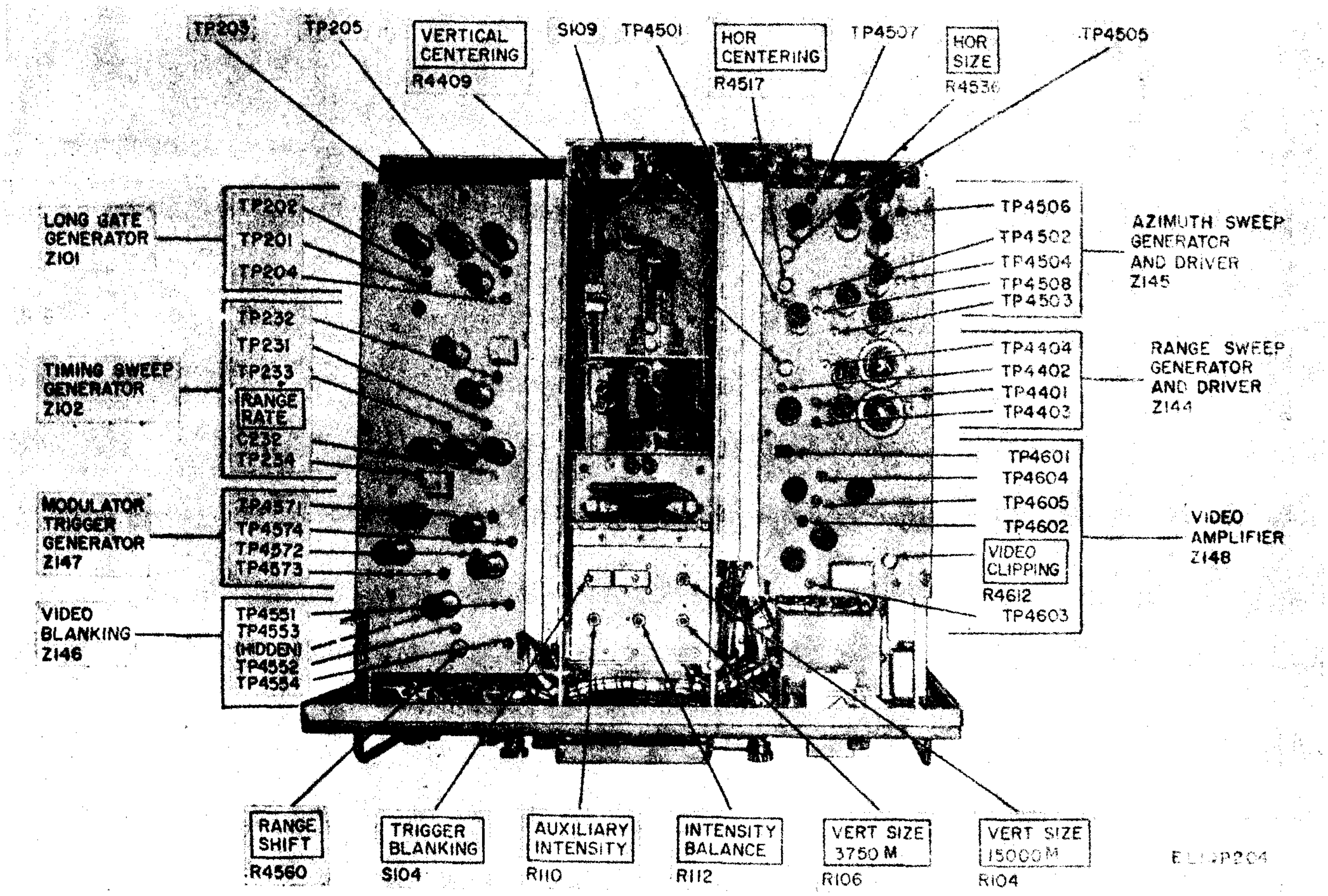


Figure 3-51. Azimuth and Range Indicator IP-375/MPQ-4A, top view, test points and controls.

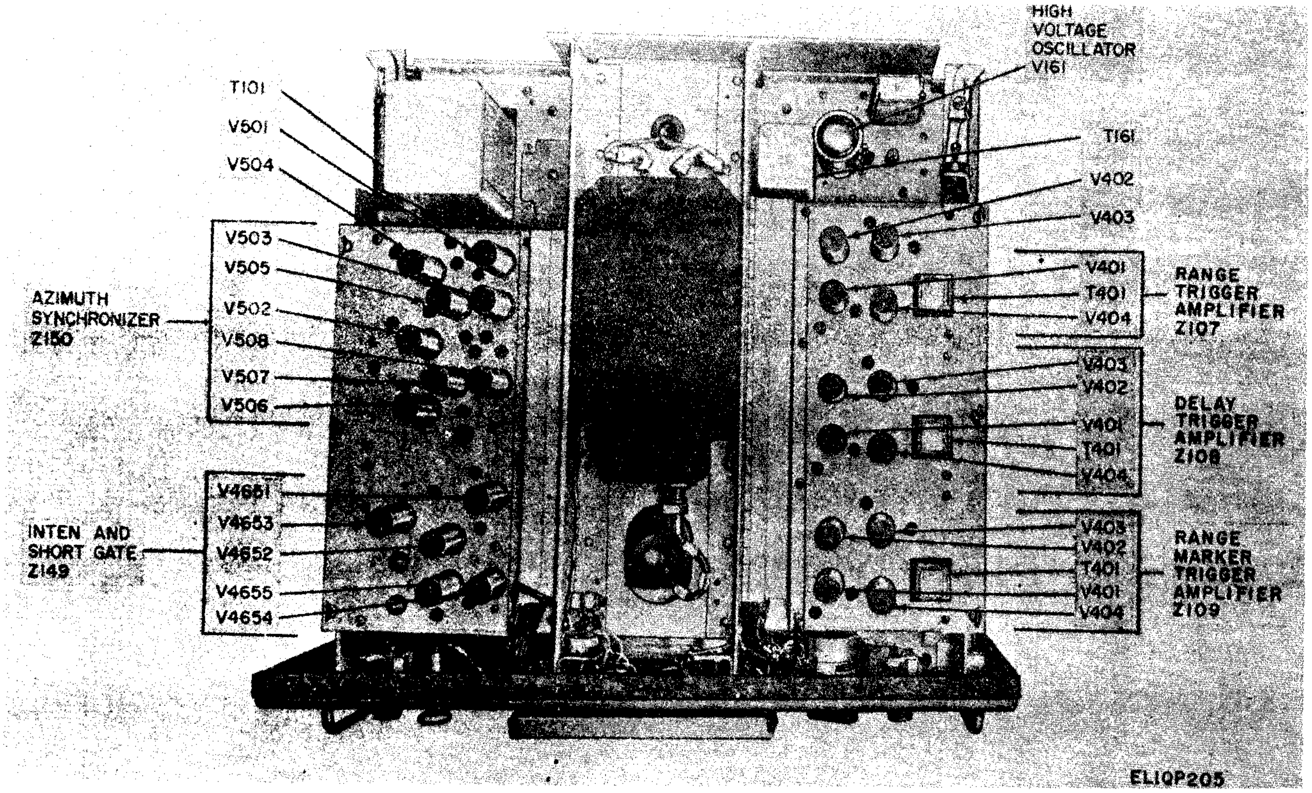


Figure 3-52. Azimuth and Range Indicator IP-375/MPQ-4A, bottom view, tube locations.

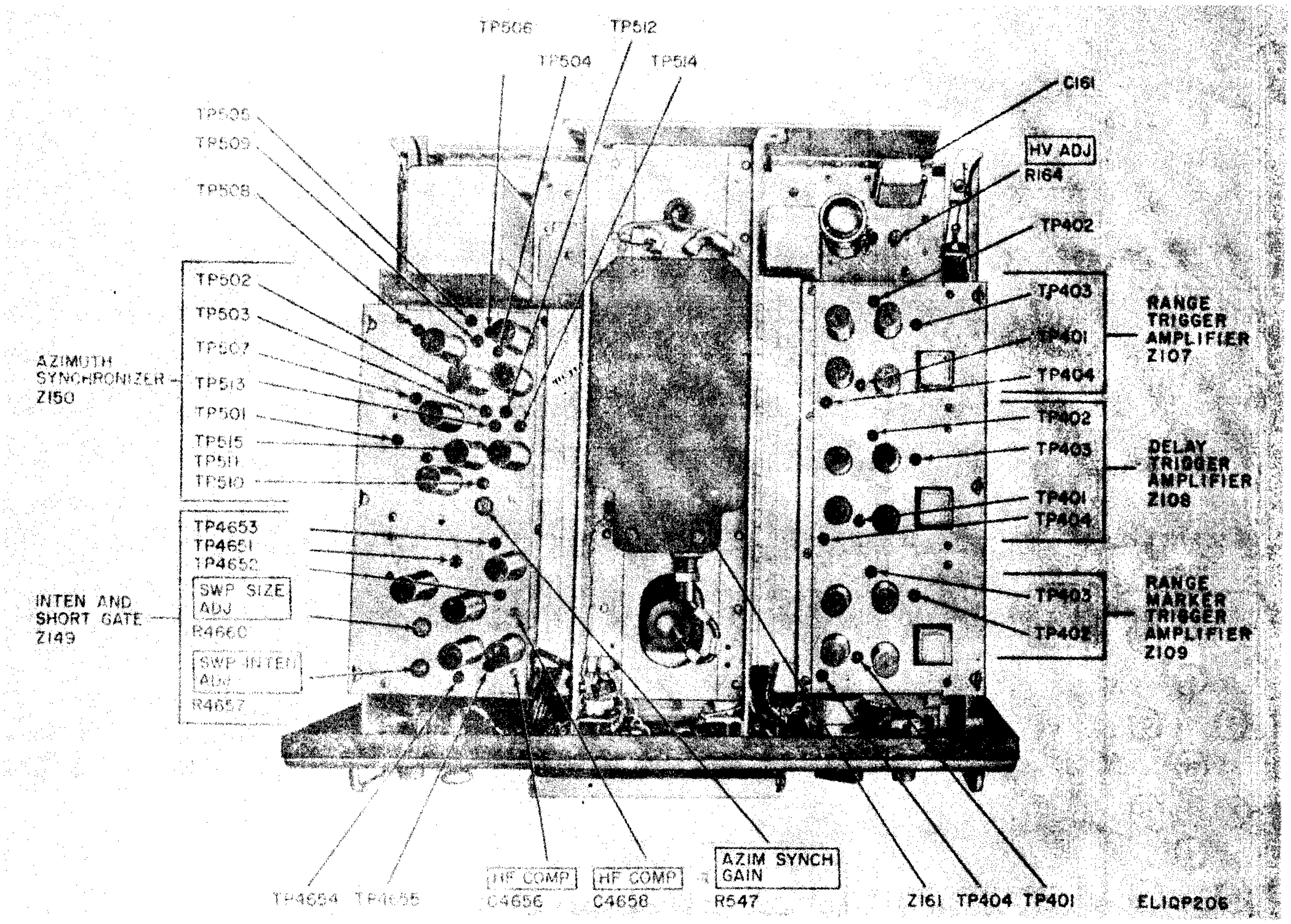
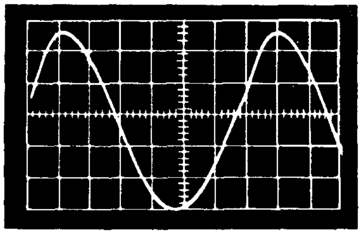
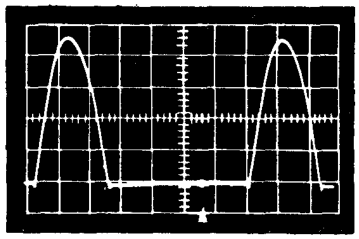


Figure 3-53. Azimuth and Range Indicator IP-375/MPQ-4A, bottom view, test points and controls.



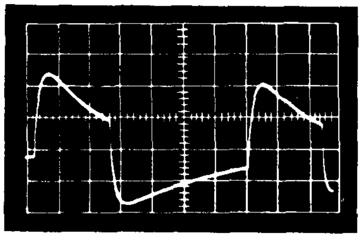
OSCILLATOR V201A

TEST POINT TP201
20 VOLTS/CM
20 MICROSECOND/CM



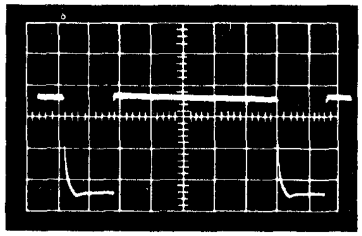
REGENERATIVE AMPLIFIER V201B

TEST POINT TP202
10 VOLTS/CM
20 MICROSECONDS/CM



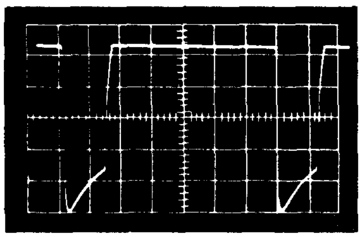
TRIGGER COUPLER V203A

TEST POINT TP203
10 VOLTS/CM
20 MICROSECONDS/CM



GATE CATHODE FOLLOWER V202B

TEST POINT TP204
5 VOLTS/CM
20 MICROSECONDS/CM

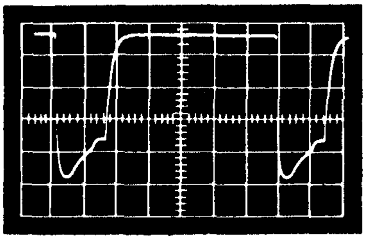


GATE GENERATOR V204B

TEST POINT TP205
20 VOLTS/CM
20 MICROSECONDS/CM

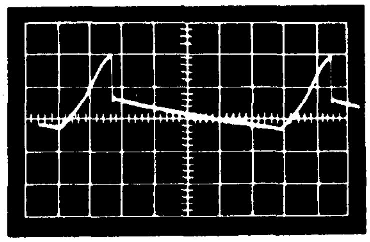
EL1QP207

Figure 3-54. Long gate generator Z101, waveform diagram.



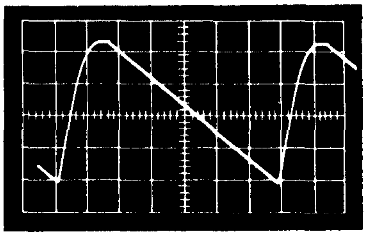
GATED MILLER SWEEP V231

TEST POINT TP231
10 VOLTS/CM
20 MICROSECONDS/CM



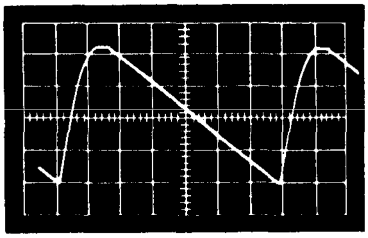
LINEAR AMPLIFIER V232

TEST POINT TP232
10 VOLTS/CM
20 MICROSECONDS/CM



LINEAR AMPLIFIER V232

TEST POINT TP233
50 VOLTS/CM
20 MICROSECONDS/CM

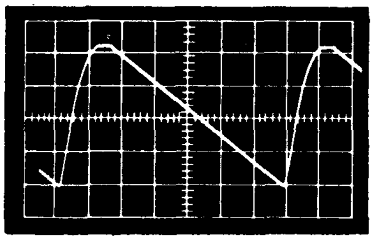


CATHODE FOLLOWER V235

TEST POINT TP234
50 VOLTS/CM
20 MICROSECONDS/CM

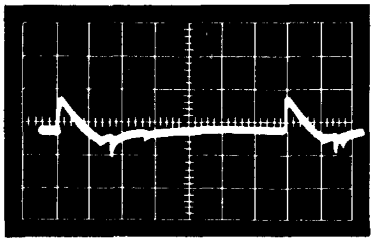
EL1QP208

Figure 3-55. Timing sweep generator Z102, waveform diagram.



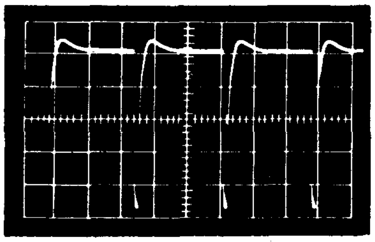
COMPARATOR TUBE V401

TEST POINT TP401
50 VOLTS/CM
20 MICROSECONDS/CM



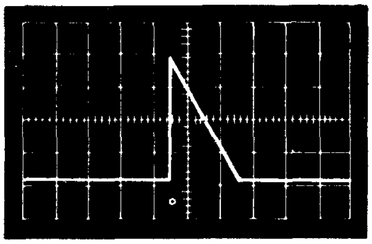
REGENERATIVE AMPLIFIER V401

TEST POINT TP402
10 VOLT/CM
20 MICROSECONDS/CM



REGENERATIVE AMPLIFIER V403

TEST POINT TP403
5 VOLTS/CM
50 MICROSECONDS/CM



BLOCKING OSCILLATOR V404

TEST POINT TP404
10 VOLTS/CM
20 MICROSECONDS/CM

EL1QP209

Figure 3-56. Trigger pickoff amplifiers Z107, Z108, and Z109, waveform diagram.

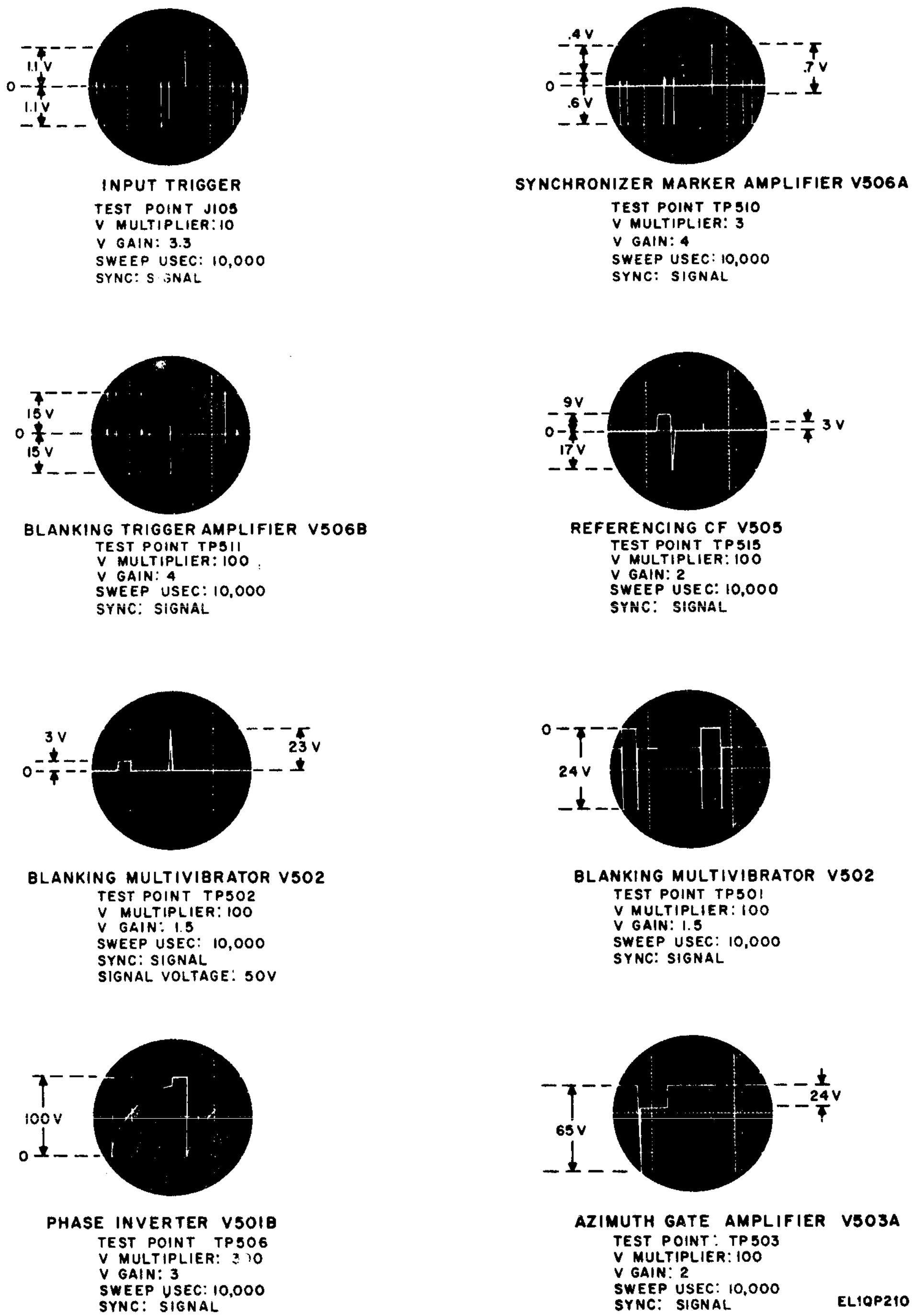


Figure 3-57. Azimuth synchronizer Z150, waveform diagram, J105, V501B, V502, V503A, V505, and V506.

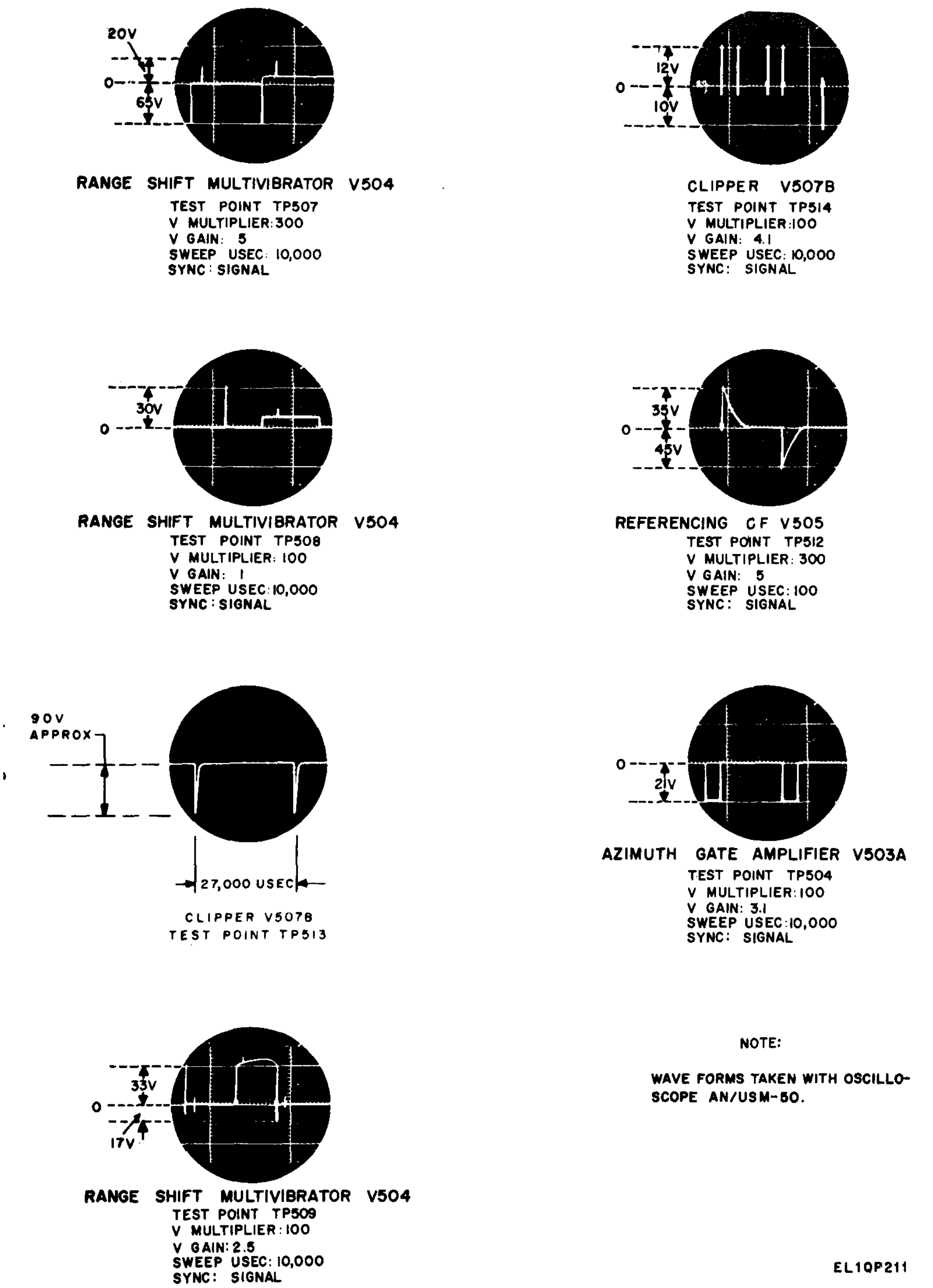
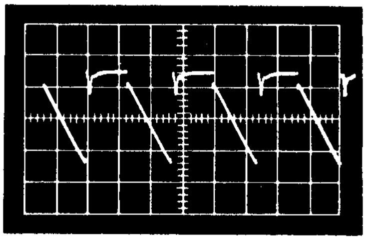
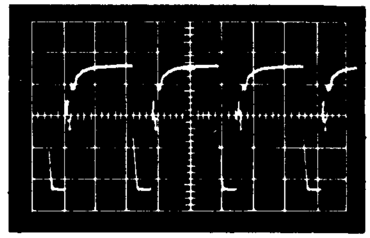


Figure 3-58. Azimuth synchronizer Z150, waveform diagram, V503A, V504, V505, and V507B.

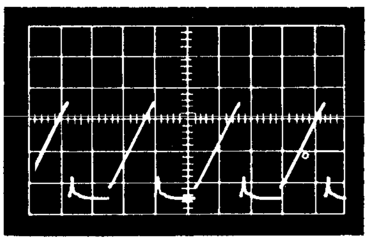


15,000 METER

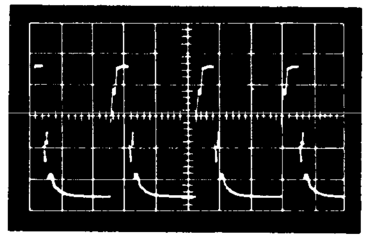


3,750 METER

RANGE SWEEP DRIVER V4404
TEST POINT TP4403
5 VOLTS/CM
50 MICROSECONDS/CM

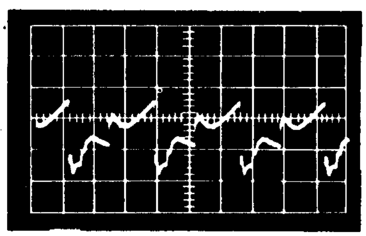


15,000 METER



3,750 METER

RANGE SWEEP DRIVER V4405
TEST POINT TP4404
5 VOLTS/CM
50 MICROSECONDS/CM



SWEEP GENERATOR V4401B
TEST POINT TP4401
.1 VOLT/CM
50 MICROSECONDS/CM

EL1QP212

Figure 3-59. Range sweep generator and driver Z144, waveform diagram.

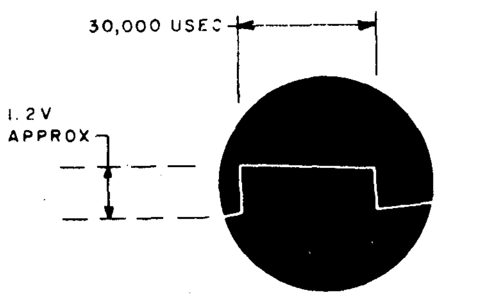


Figure 3-60. Voltage setting triode V4401A, testpoint TP4402, waveform diagram.

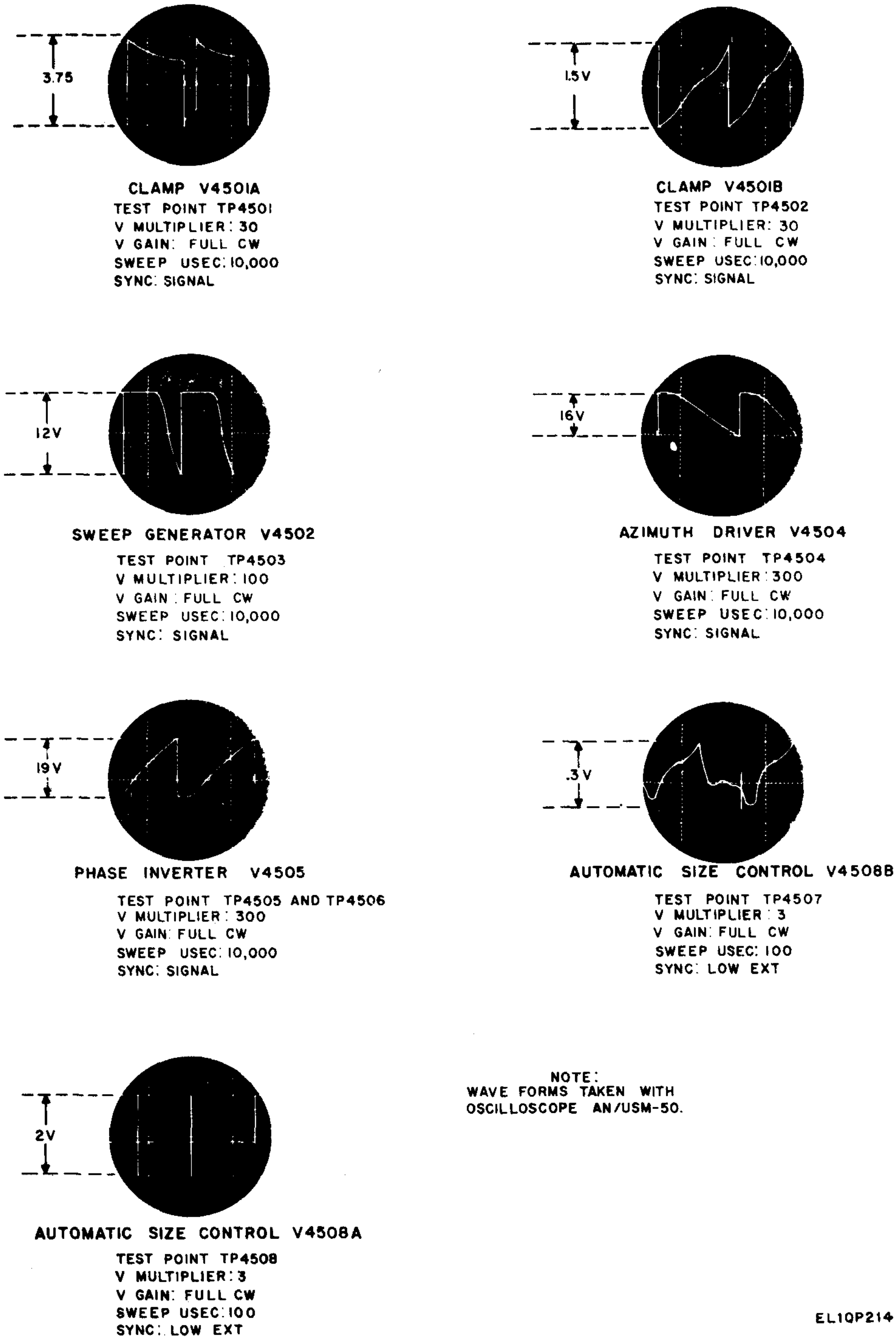


Figure 3-61. Azimuth sweep generator and driver Z145, waveform diagram.

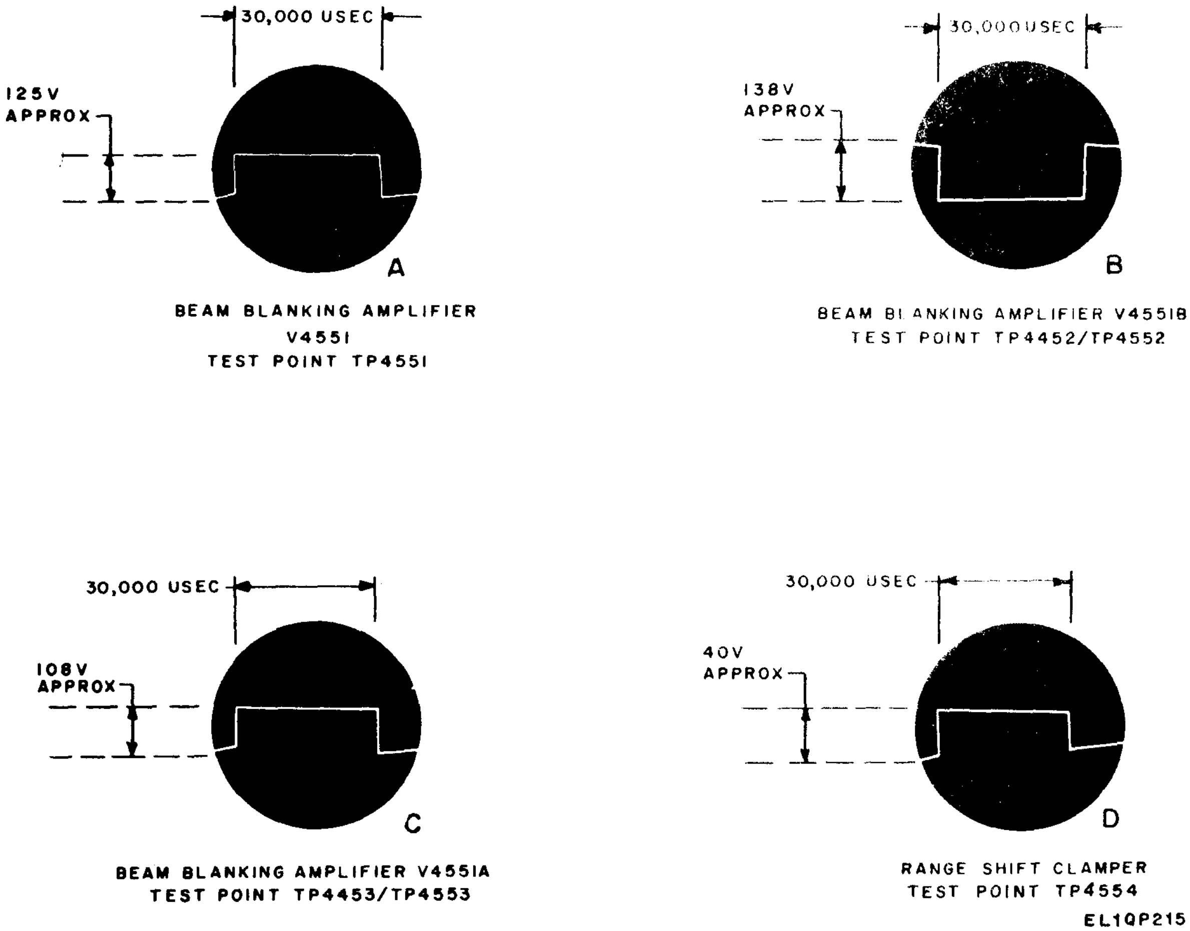


Figure 3-62. Video blanking Z146, waveform diagram.

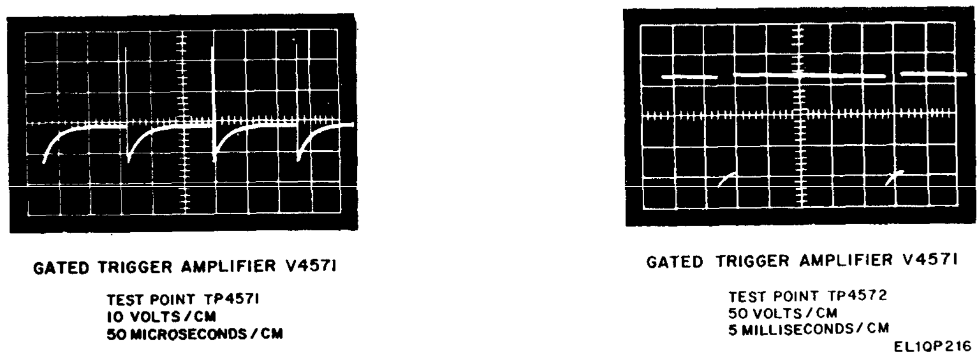


Figure 3-63. Modulator trigger generator Z147, waveform diagram.

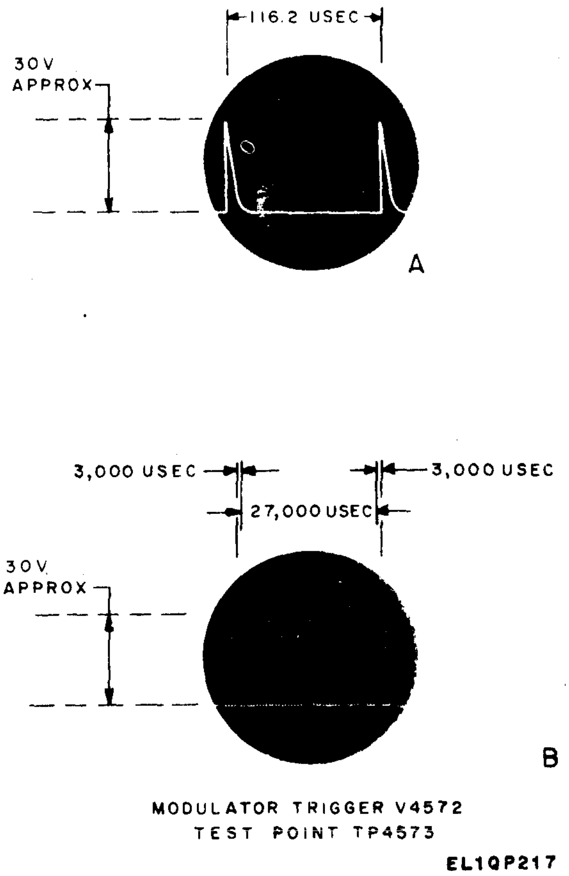


Figure 3-64. Modulator trigger V4572, test point TP 4573, waveform diagram.

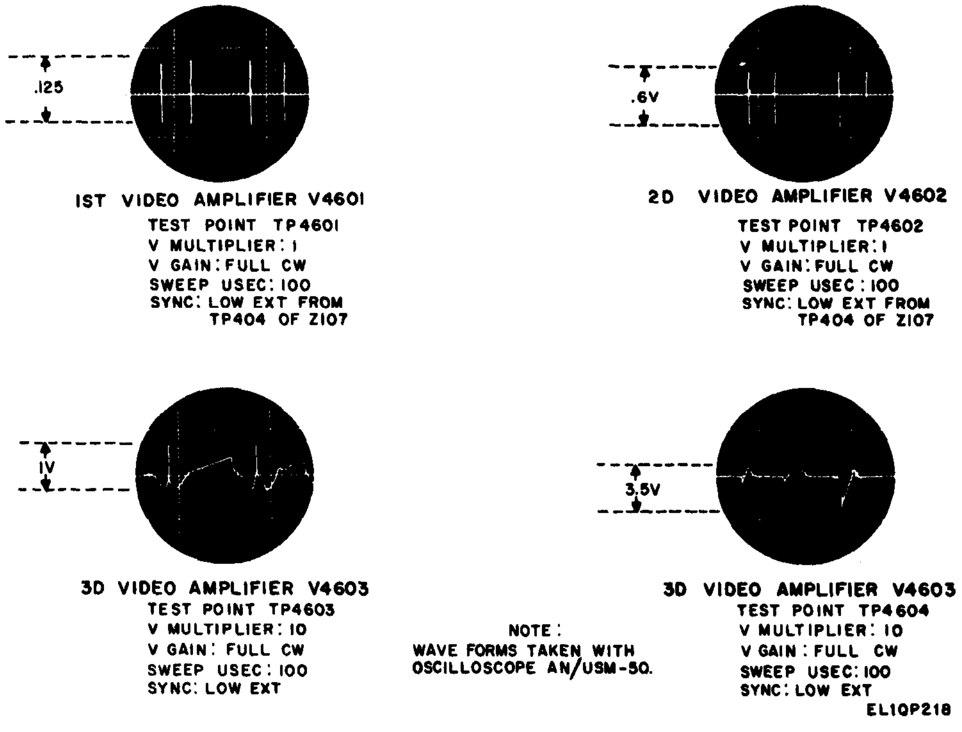


Figure 3-65. Video amplifier Z148, waveform diagram.

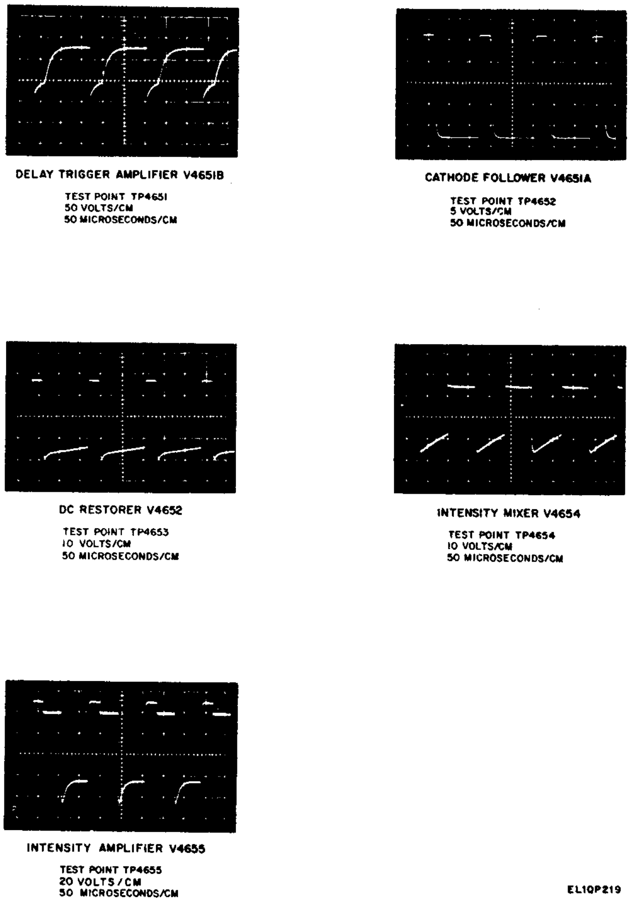


Figure 3-66. Intensifier and short gate generator Z149, waveform diagram.

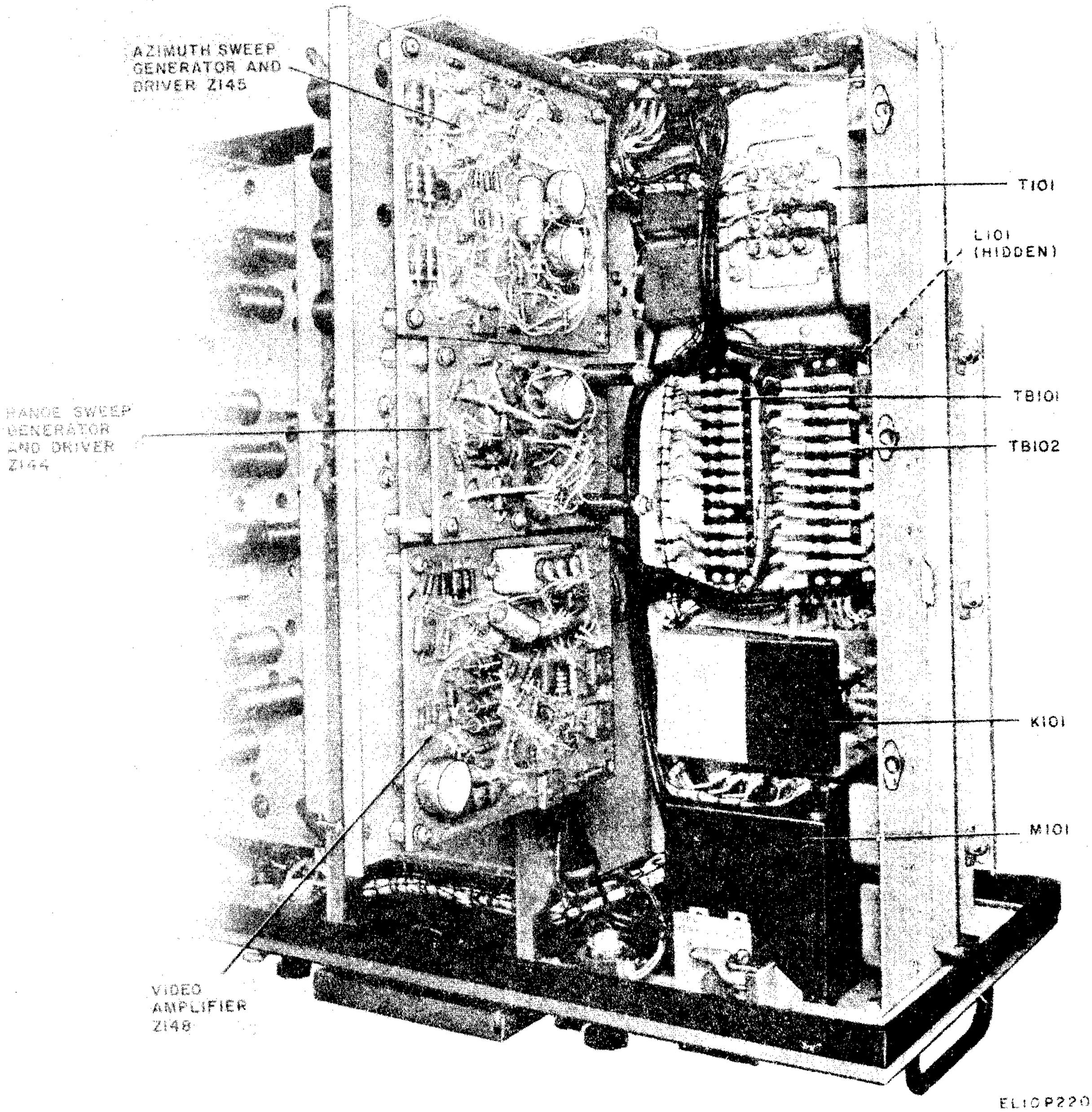


Figure 3-67. Azimuth and Range Indicator IP-375/MPQ-4A, top-right view with panel up.

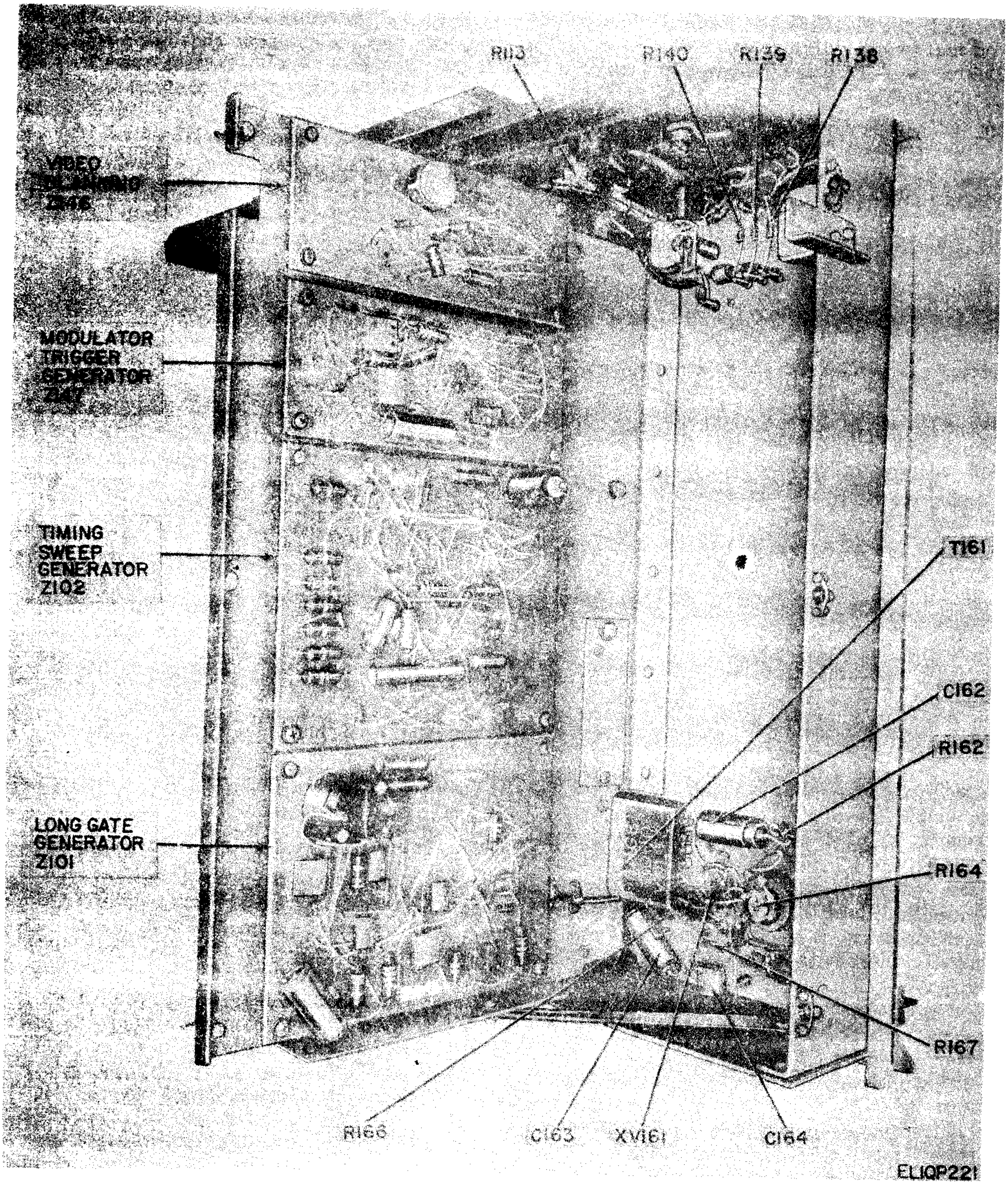


Figure 3-68. Azimuth and Range Indicator IP-375/MPQ-4A, top-left view with panel up.

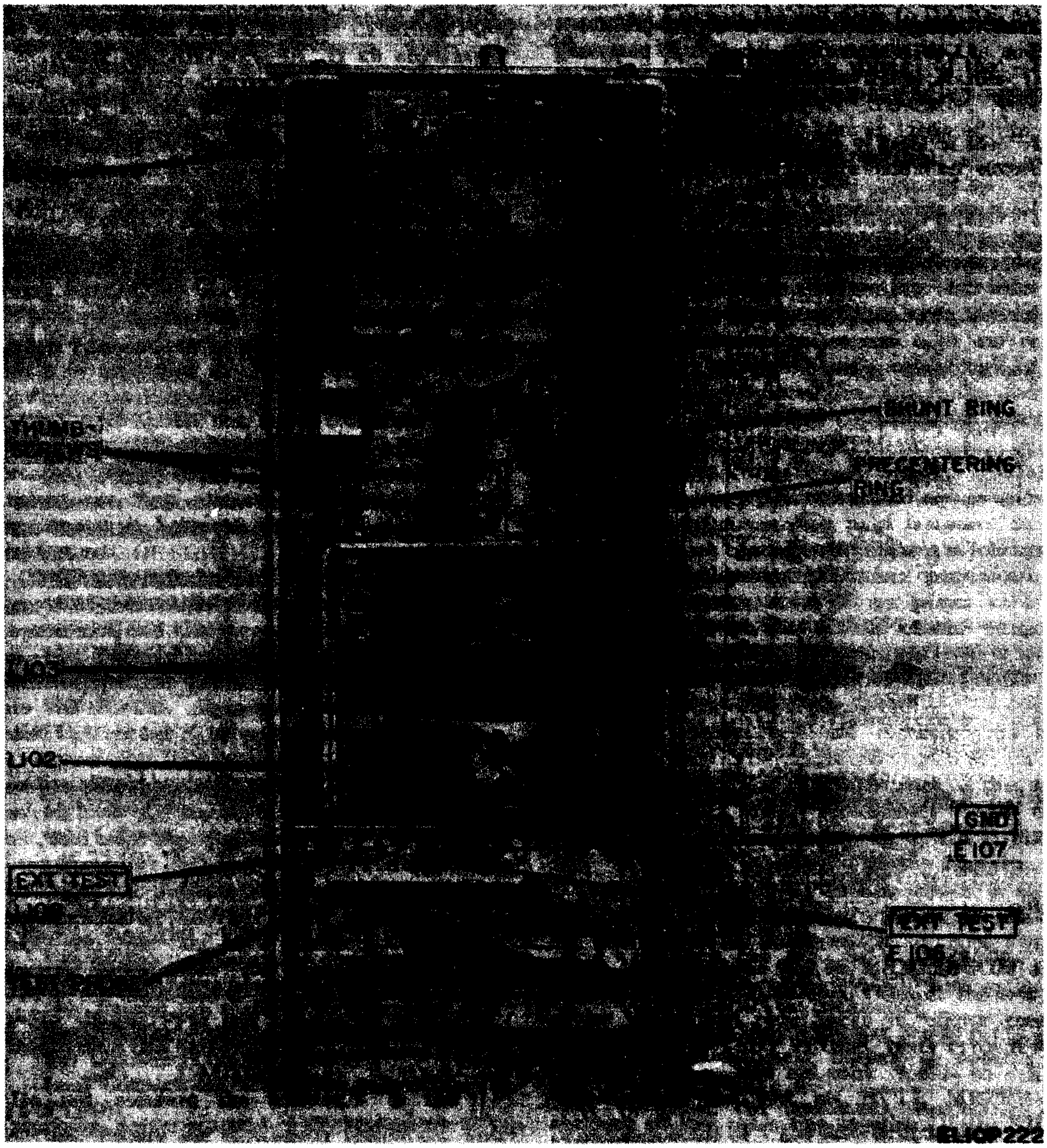


Figure 3-69. Indicator beam centering adjustment and test probe.

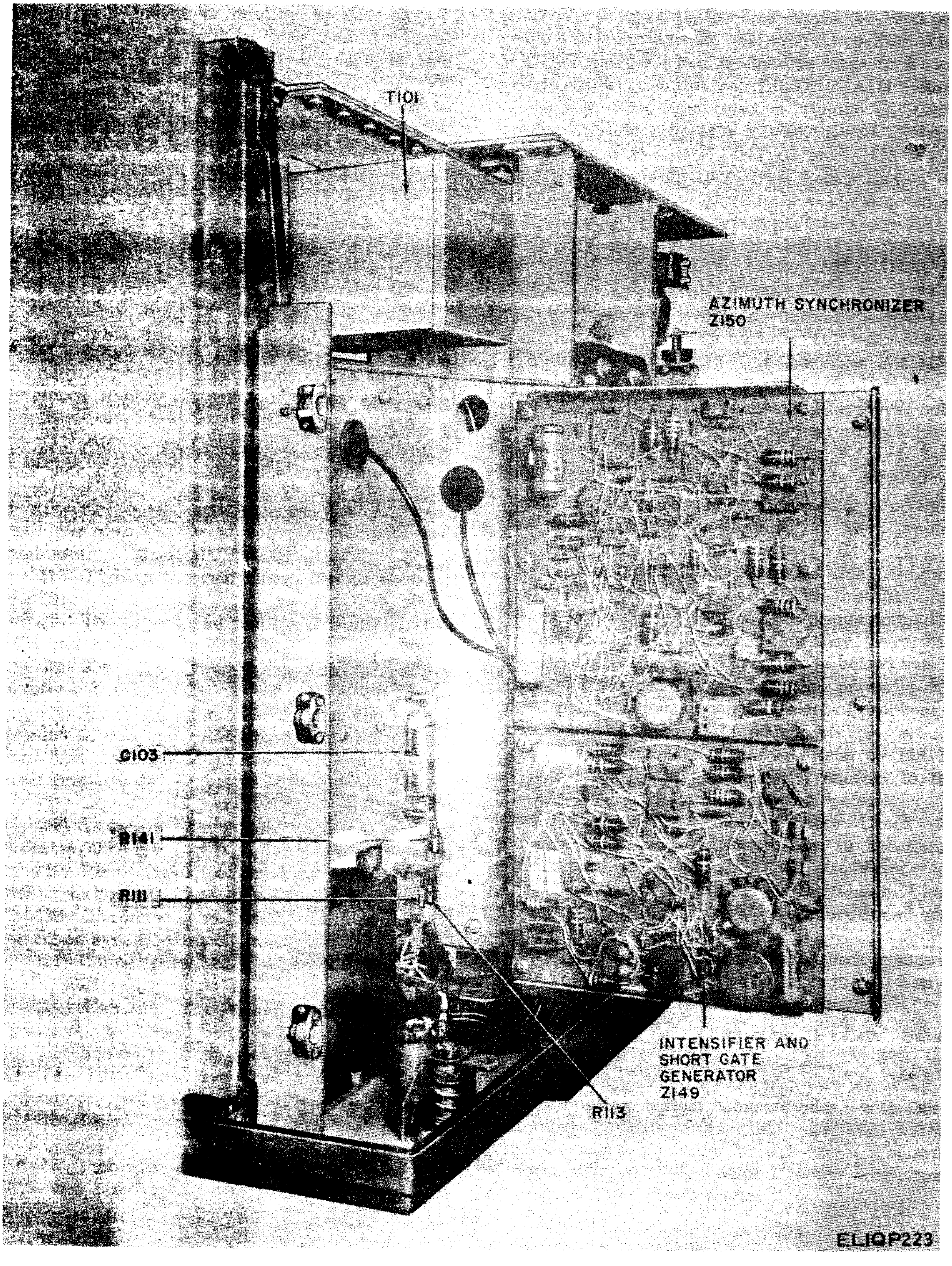


Figure 3-70. Azimuth and Range Indicator IP-375/MPQ-4A bottom-right view with panel down.

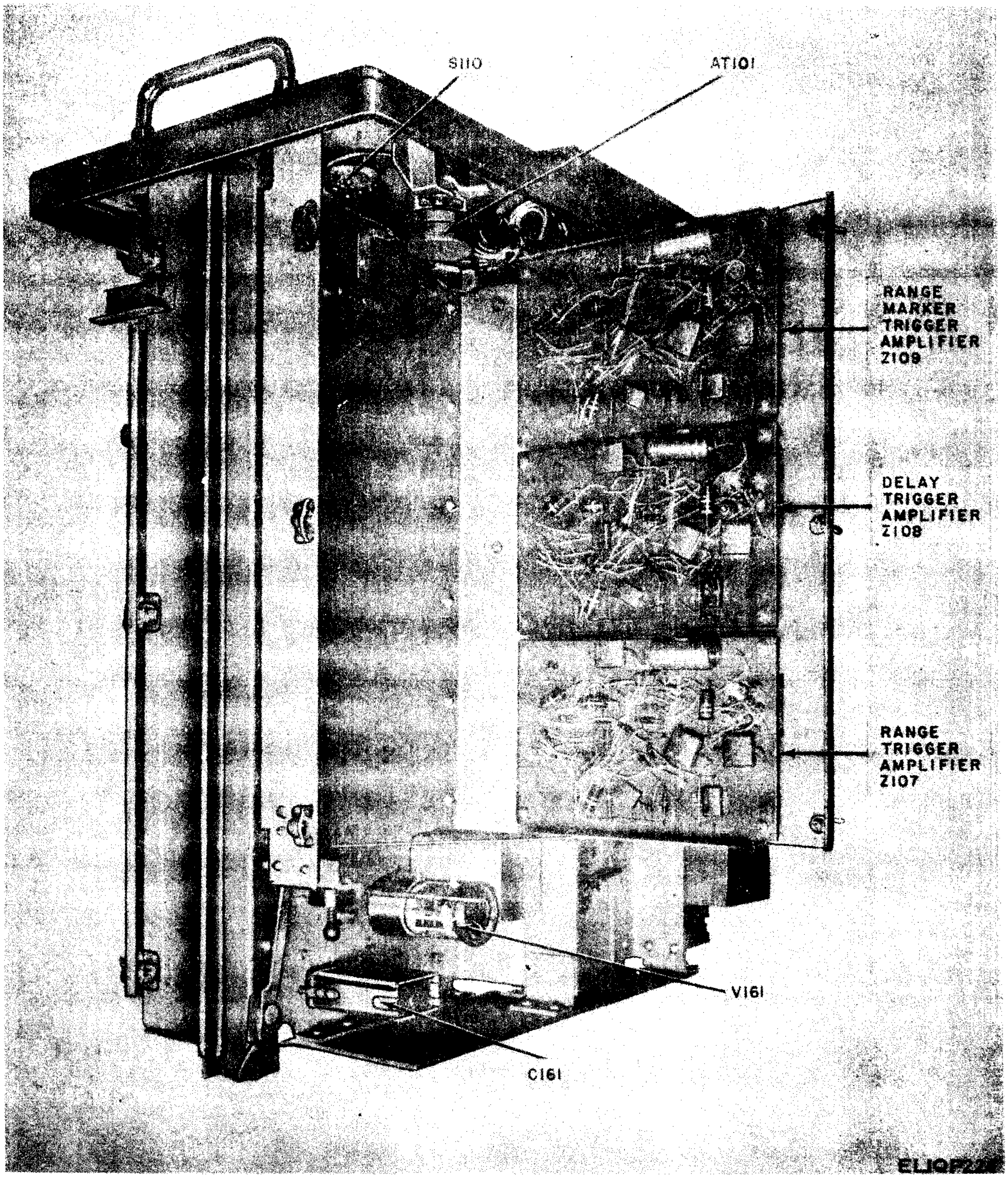


Figure 3-71. Azimuth and Range Indicator IP-375/MPQ-4A, bottom-left view with panel down.

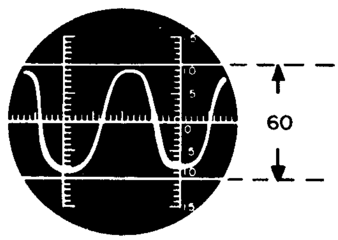
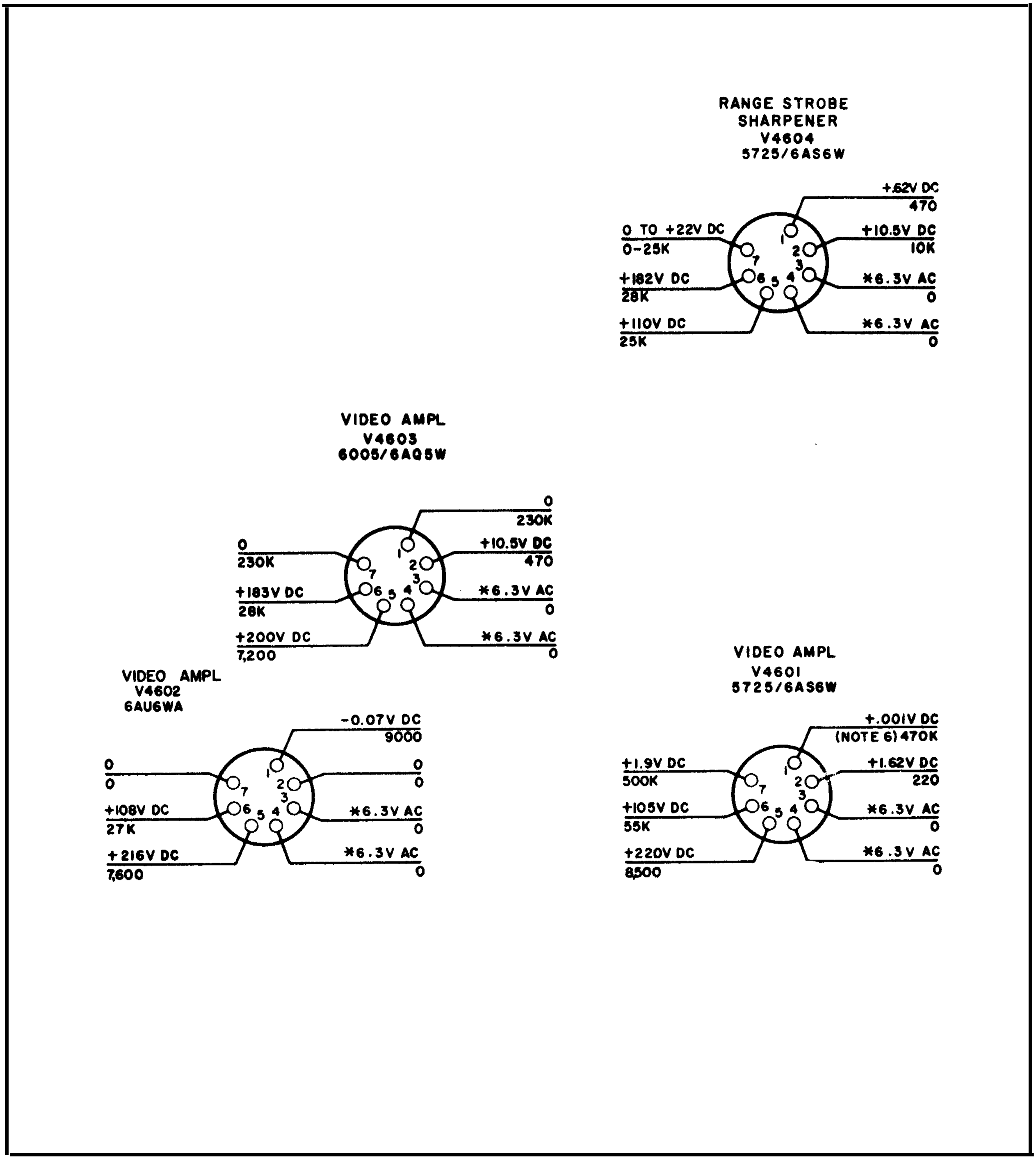


Figure 3-72. High voltage oscillator V161, waveform diagram.

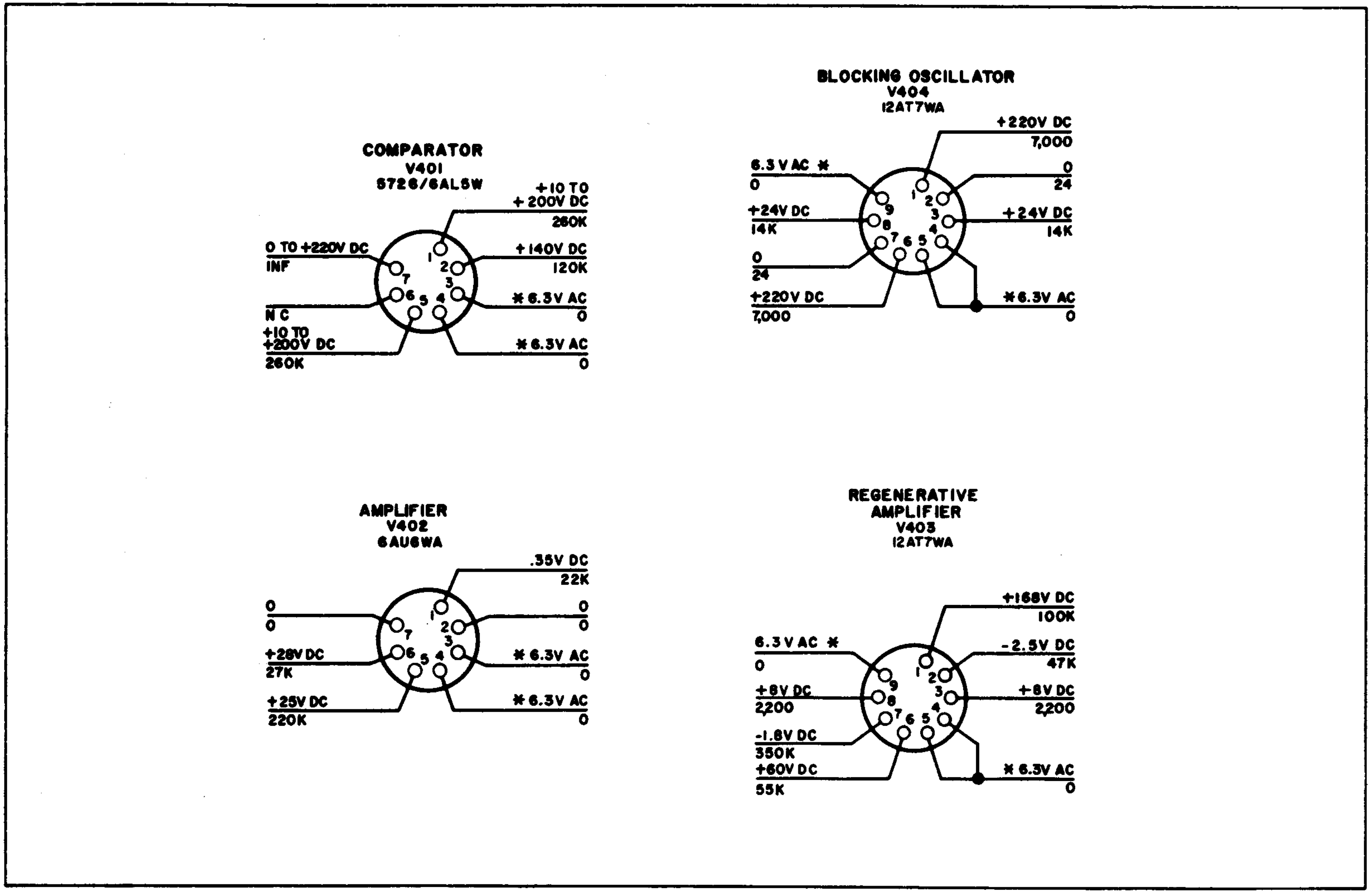


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. FOR RESISTANCE MEASUREMENTS ONLY.
4. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
5. K DENOTES THOUSAND, MEG DENOTES MILLION, INF DENOTES INFINITY.
6. RESISTANCE MEASUREMENT MADE WITH POSITIVE TEST LEAD OF OHMMETER

EL1QP226

Figure 3-73. Video amplifier Z148, voltage and resistance diagram.

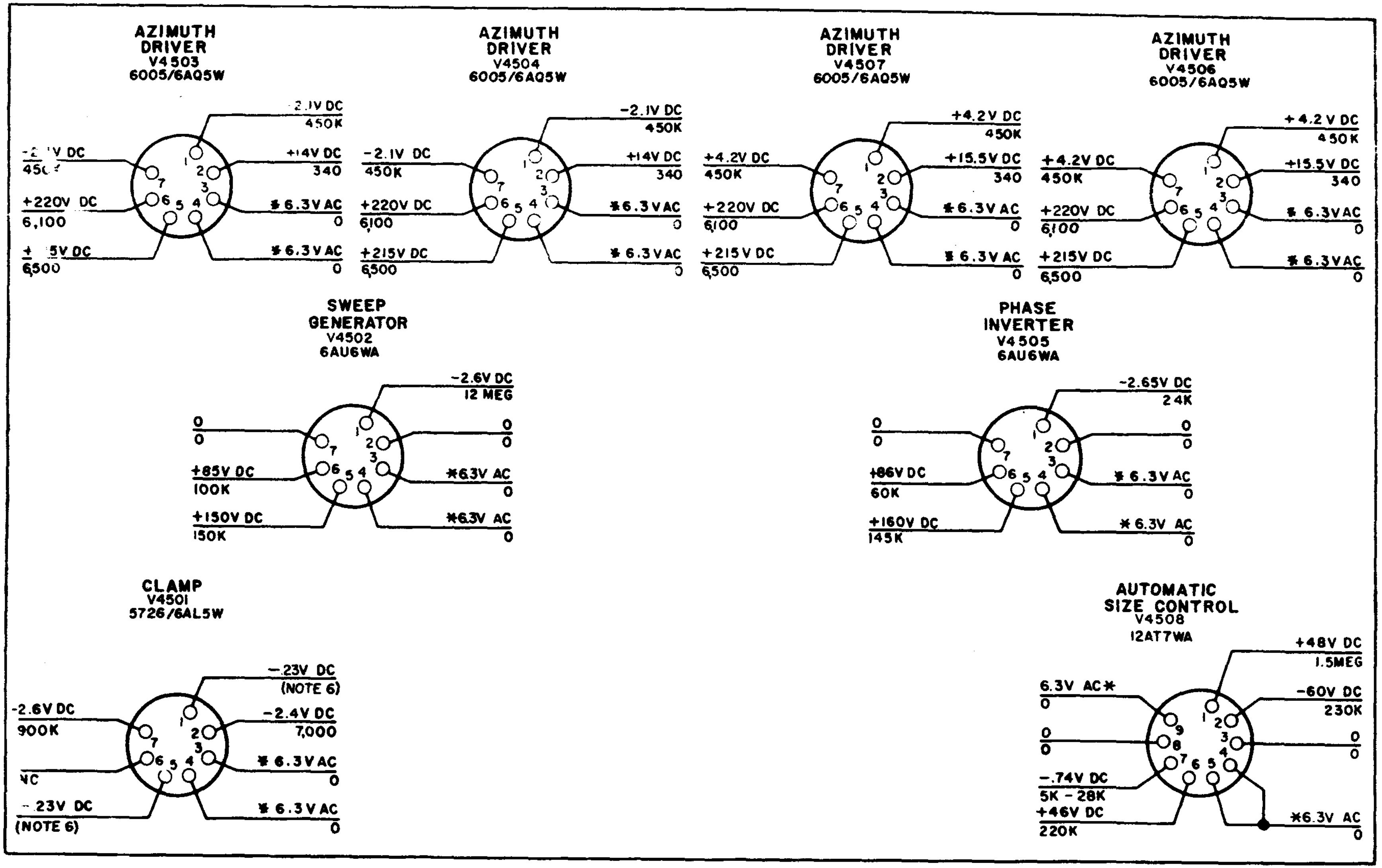


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED-TO GROUND WITH A 20,000 OHM PER VOLT METER.
2. VOLTAGE READING ABOVE THE LINE. RESISTANCE READING BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY DISCONNECT ALL EXTERNAL PLUGS.
5. ✱ INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSANDS, MEG DENOTES MILLION INF. DENOTES INFINITY.

EL1OP227

Figure 3-74. Range marker trigger pickoff amplifier Z109, voltage and resistance diagram.



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY. DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. 6,500 OR 220K - DEPENDING ON POLARITY OF METER LEADS AND CONDUCTION OF CRYSTRAL DIODE CR4501.

EL1QP228

Figure 3-75. Azimuth sweep generator and driver Z145, voltage and resistance diagram.

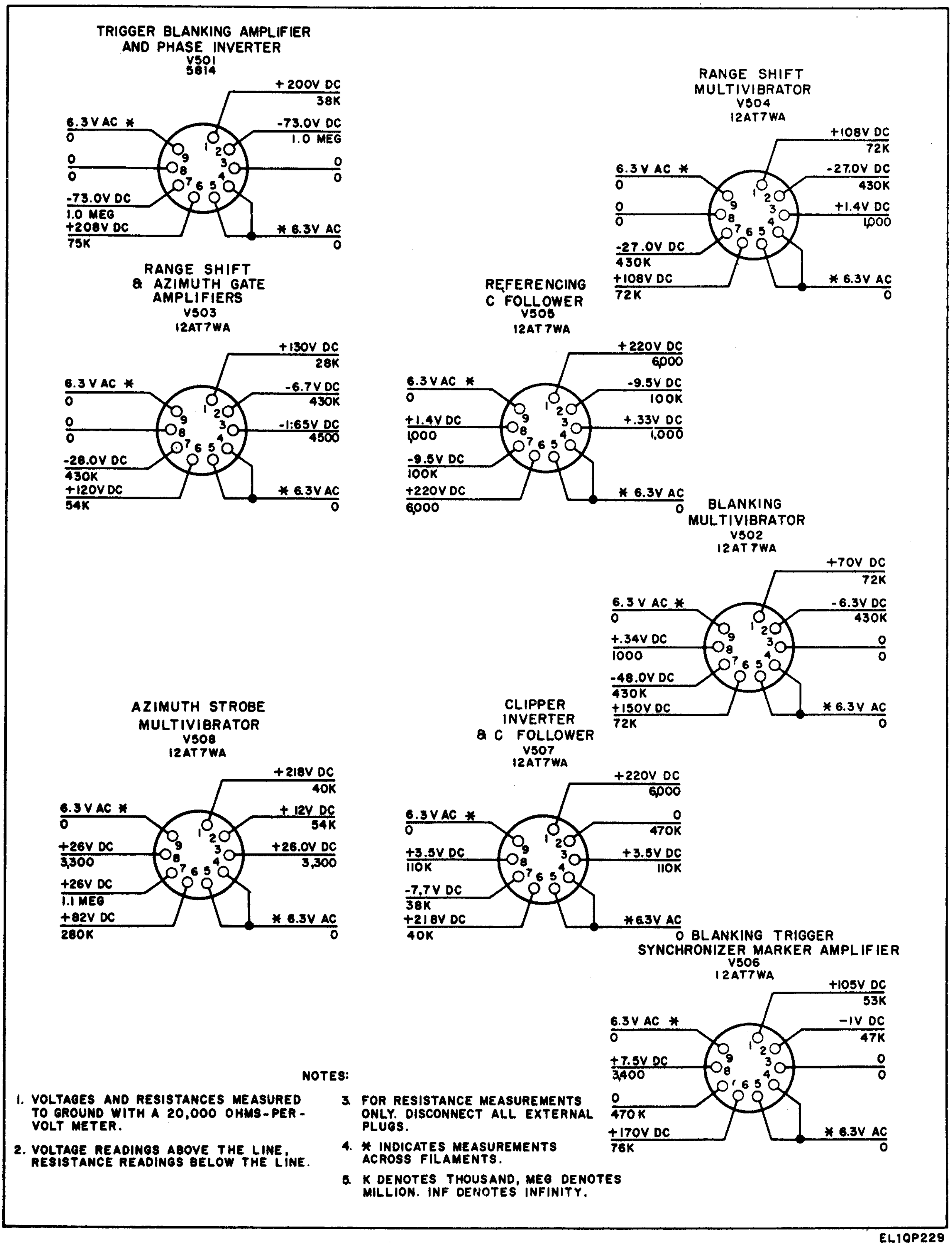
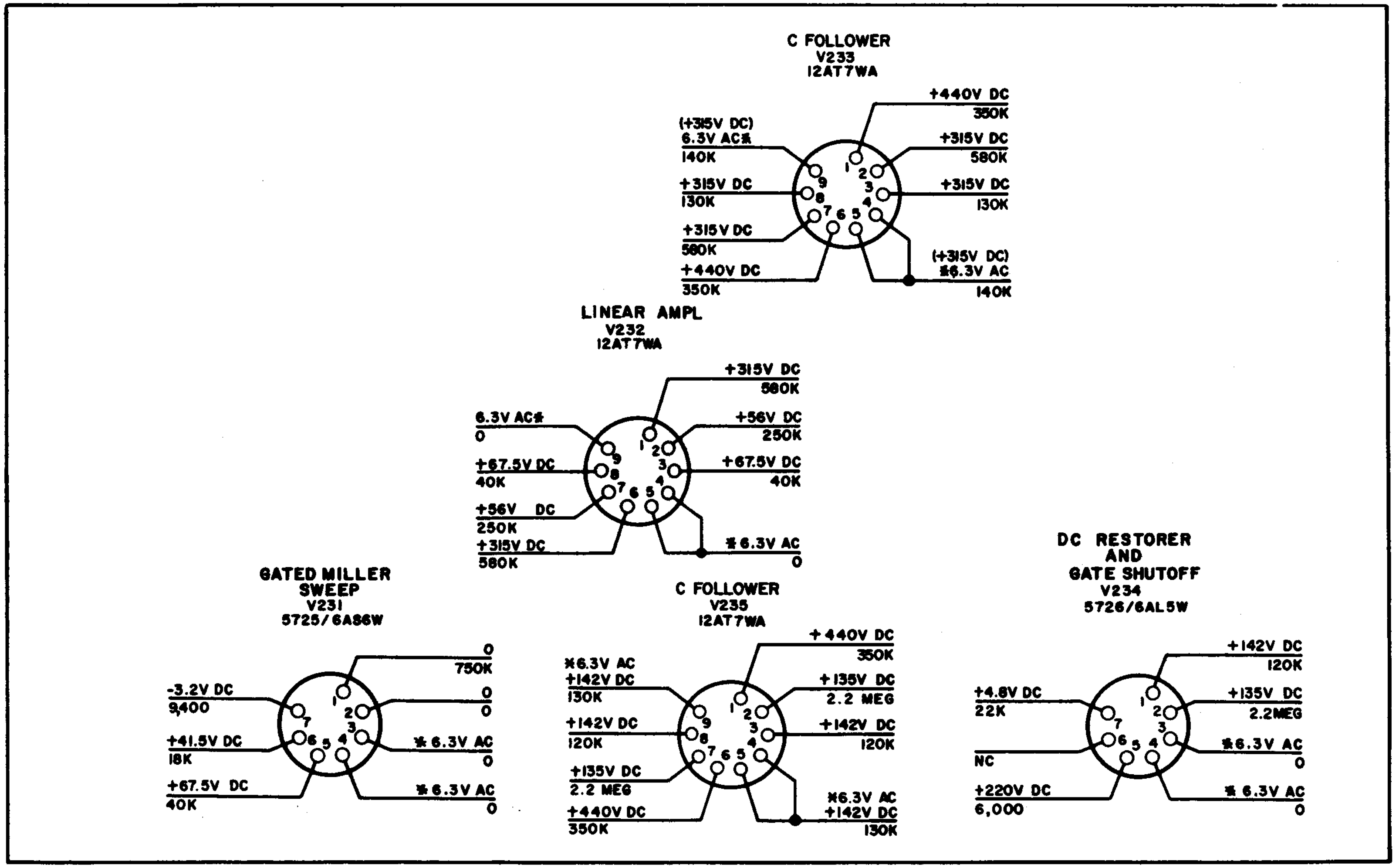


Figure 3-76. Azimuth synchronizer Z150, voltage and resistance diagram.

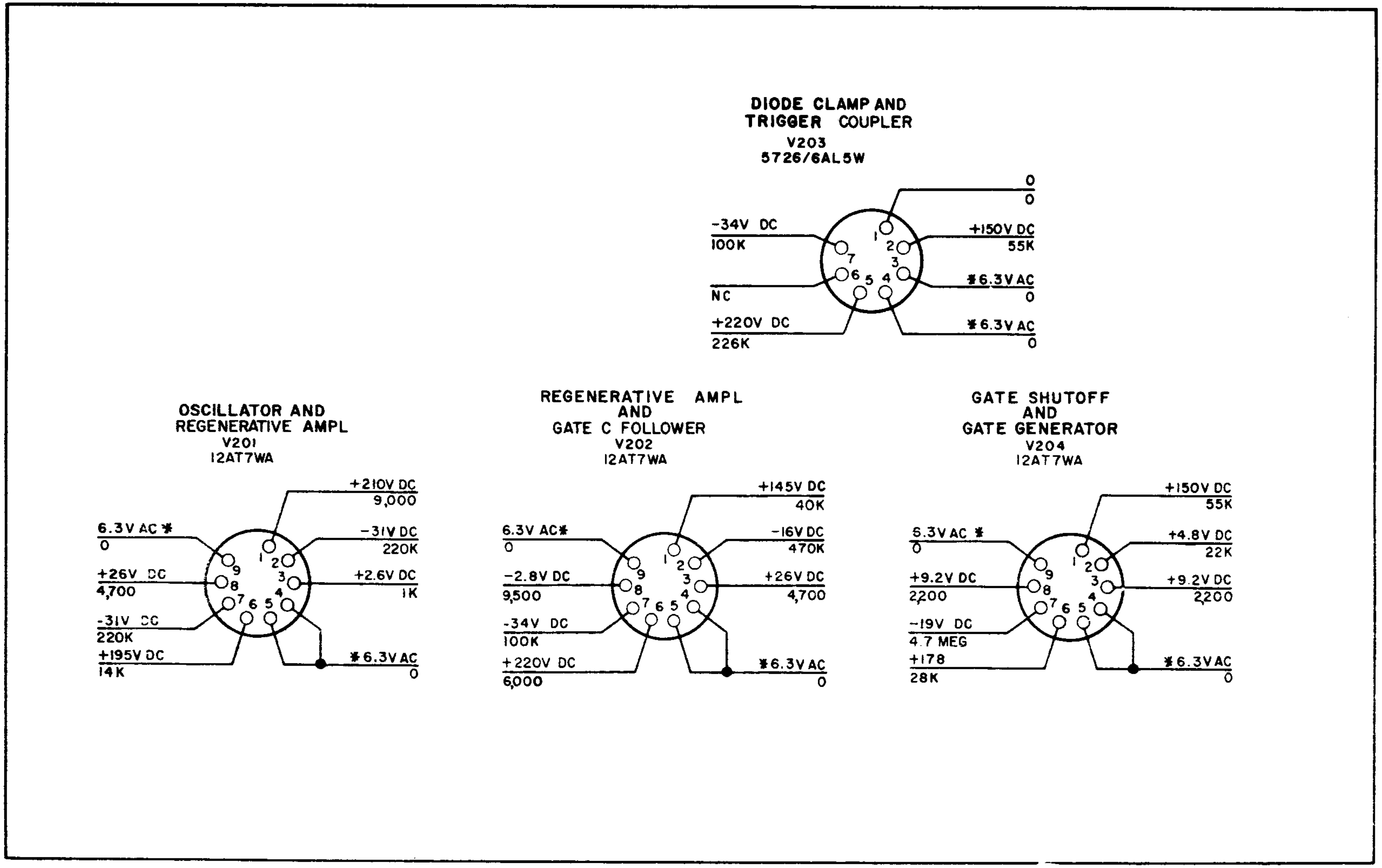


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY. DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSAND, MEG DENOTES MILLION. INF DENOTES INFINITY.

EL1QP230

Figure 3-77. Timing sweep generator Z102, voltage and resistance diagram.

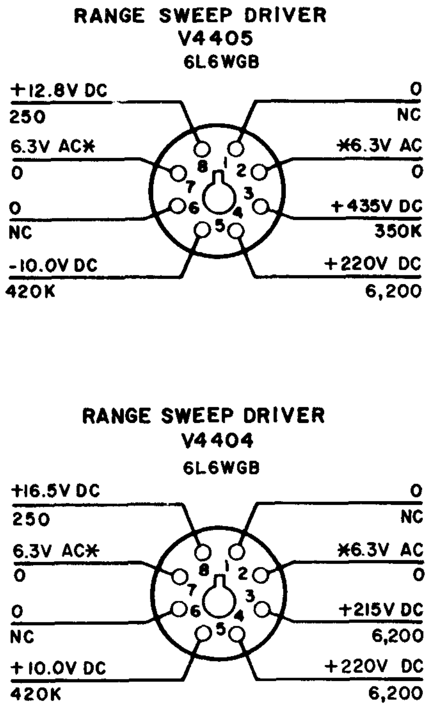


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSAND, MEG DENOTES MILLION. INF DENOTES INFINITY.

EL1QP231

Figure 3-78. Long gate generator Z101, voltage and resistance diagram.

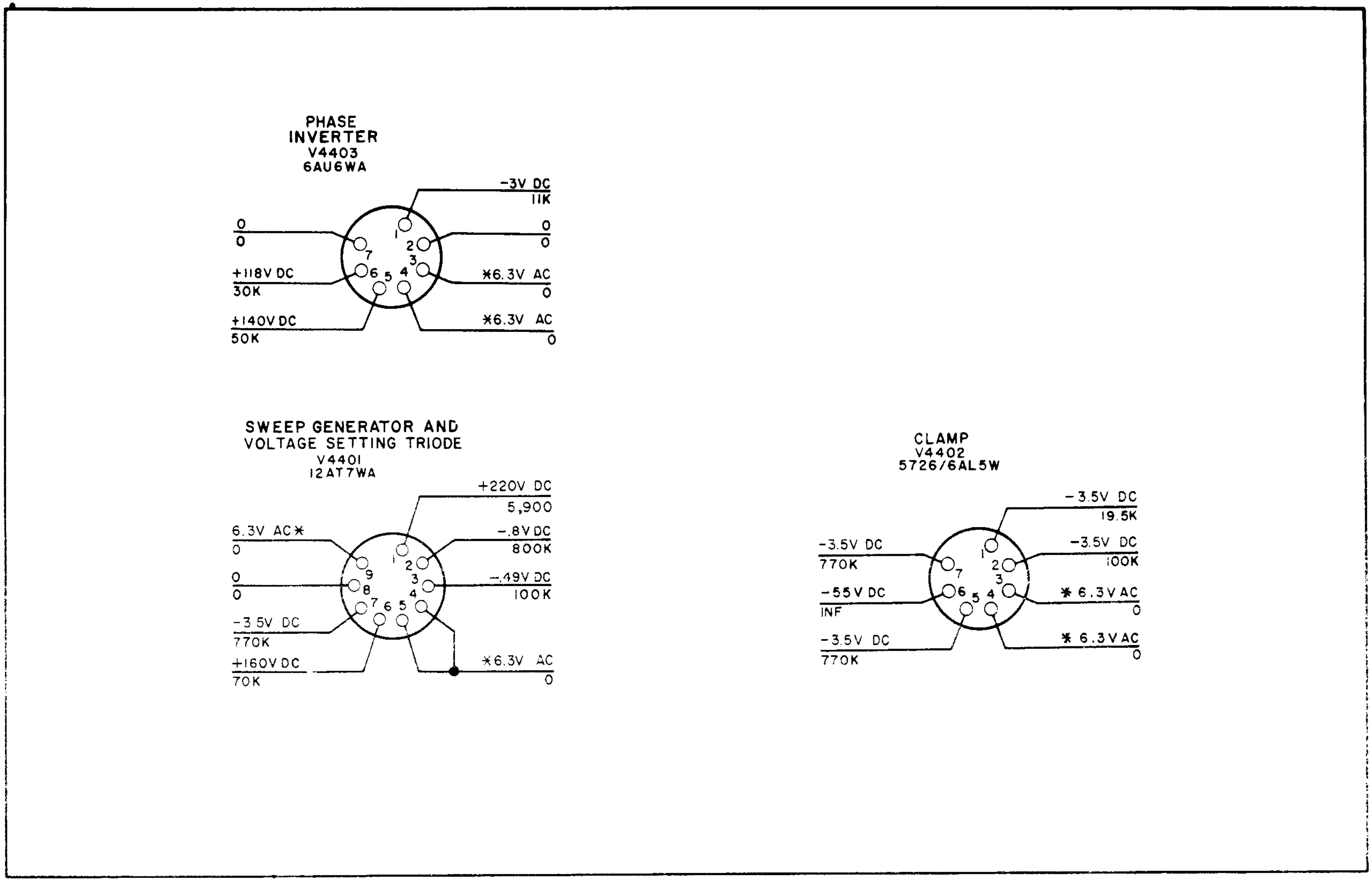


NOTES:

1. VOLTAGES AND RESISTANCE MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.

EL1QP232

Figure 3-79. Range sweep generator and driver Z144 subassembly, voltage and resistance diagram.

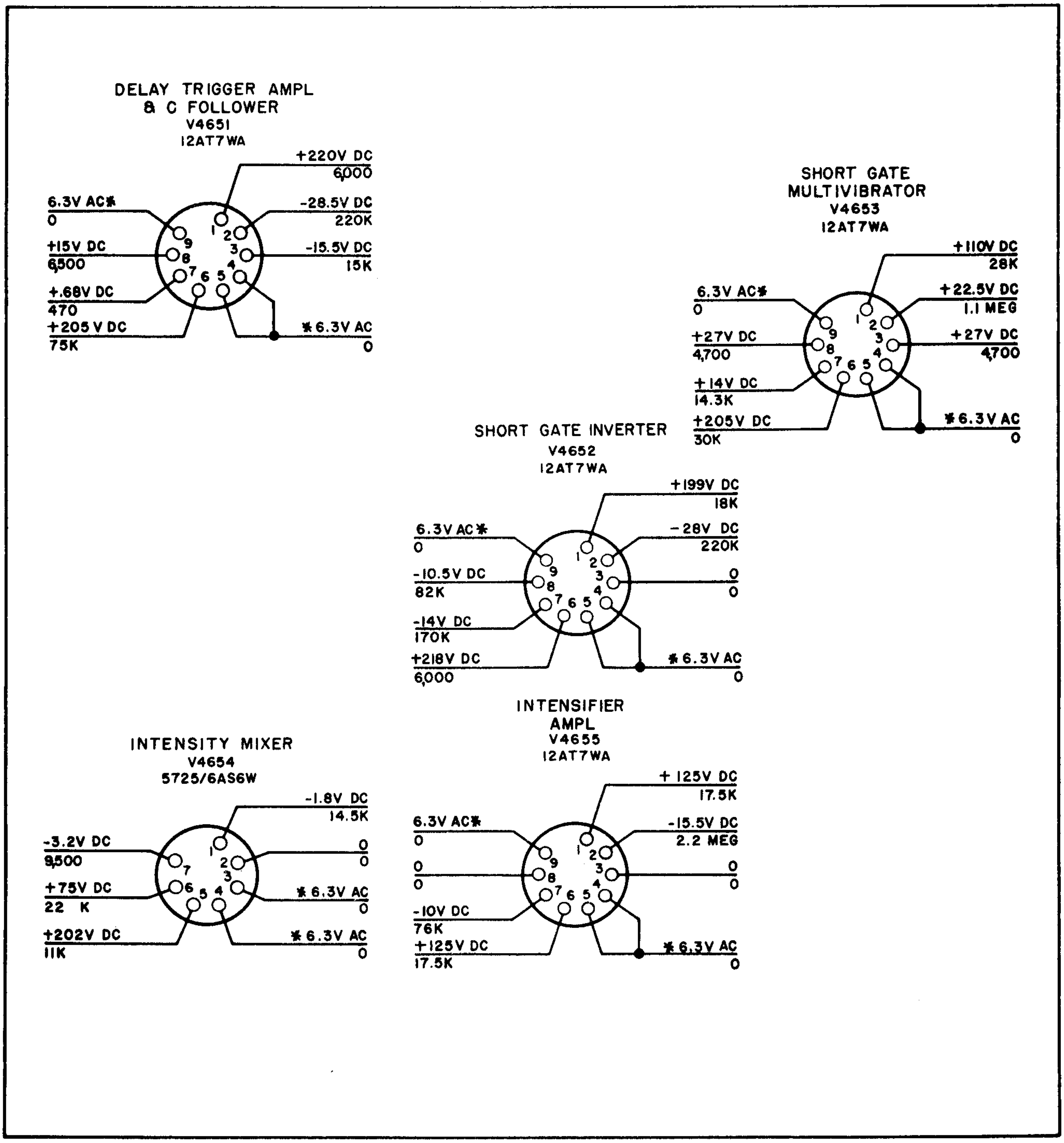


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
4. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
5. K DENOTES THOUSAND, MEG DENOTES MILLION, INF DENOTES INFINITY.

EL1QP233

Figure 3-80. Range sweep generator and driver Z144, major voltage and resistance diagram.

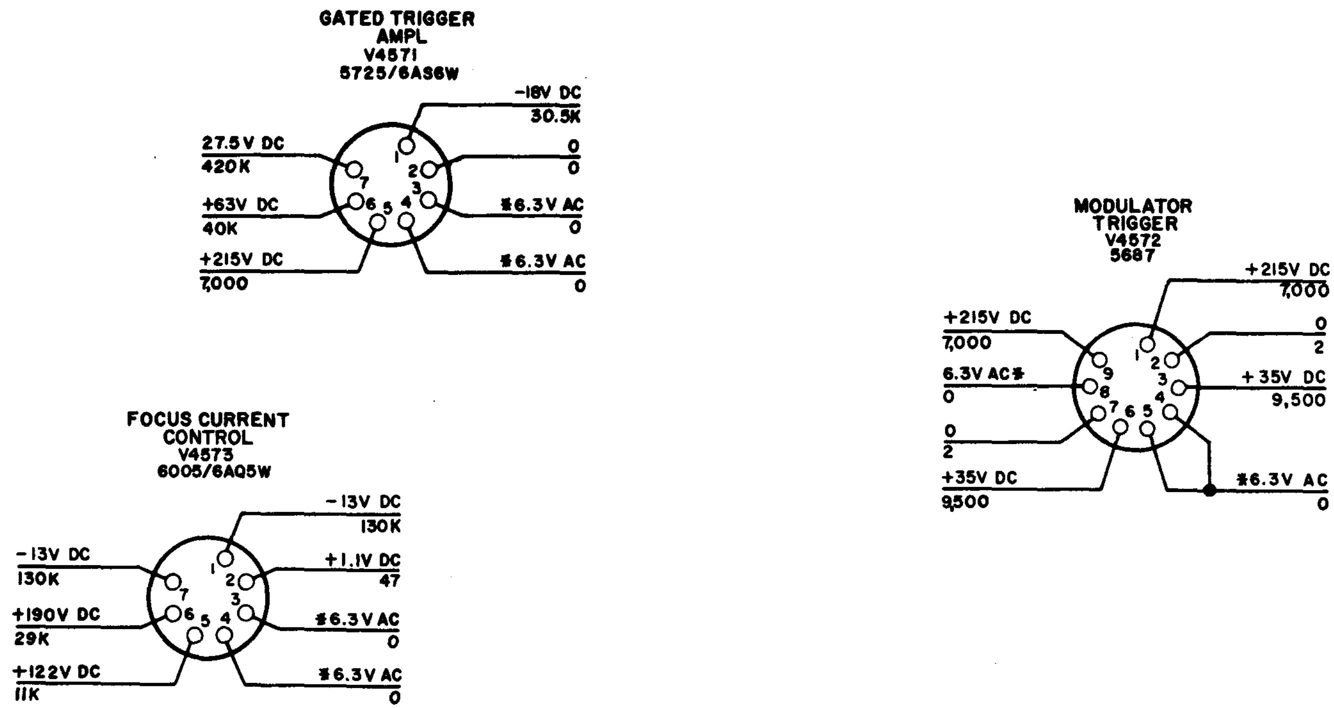


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
4. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
5. K DENOTES THOUSAND, MEG DENOTES MILLION, INF DENOTES INFINITY.

EL1QP234

Figure 3-81. Intensifier and short gate generator Z144, voltage and resistance diagram.

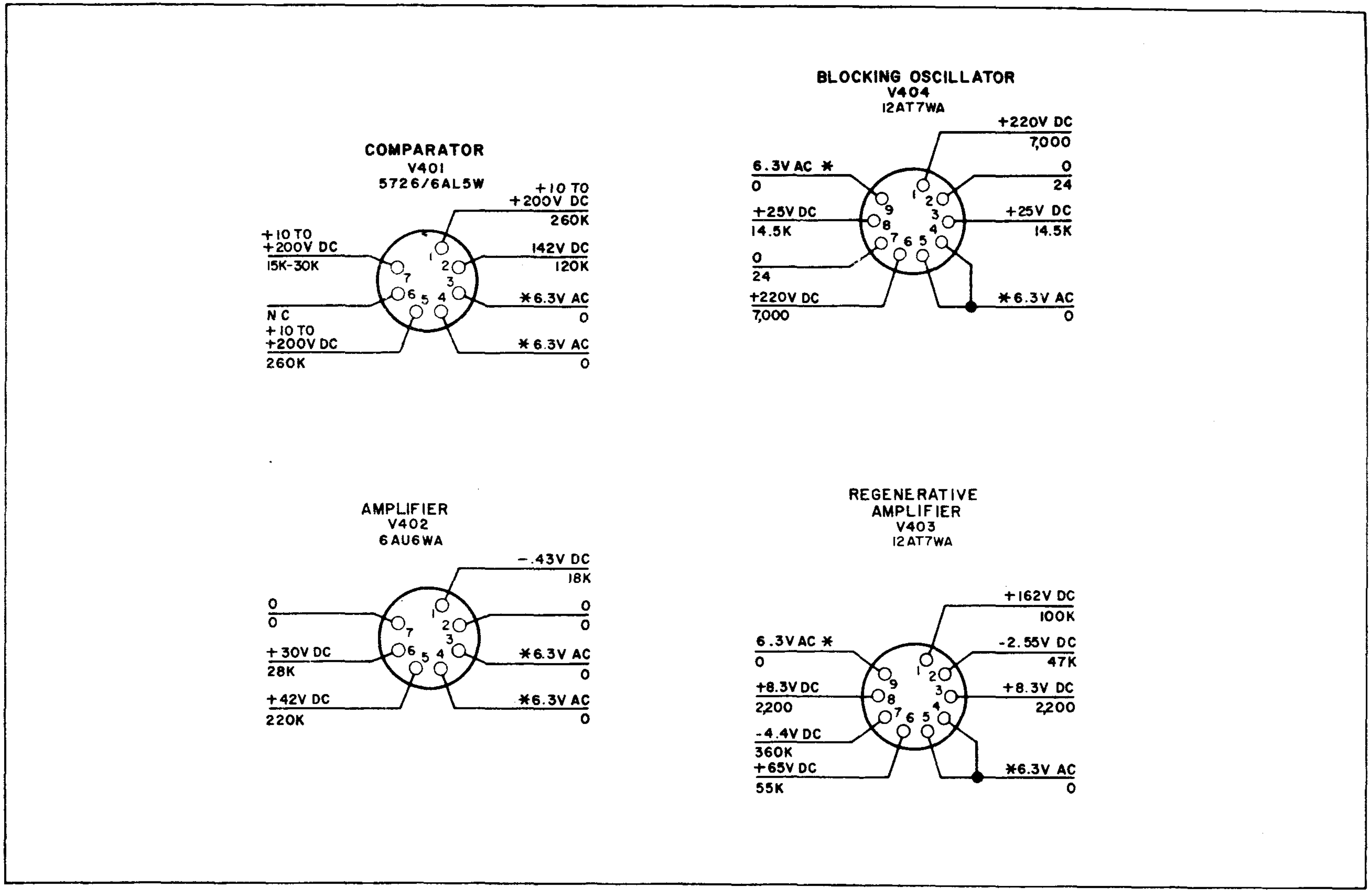


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUG.
4. * INDICATES MEASUREMENTS ACROSS FILAMENTS.

EL1QP235

Figure 3-82. Modulator trigger generator Z147, voltage and resistance diagram.

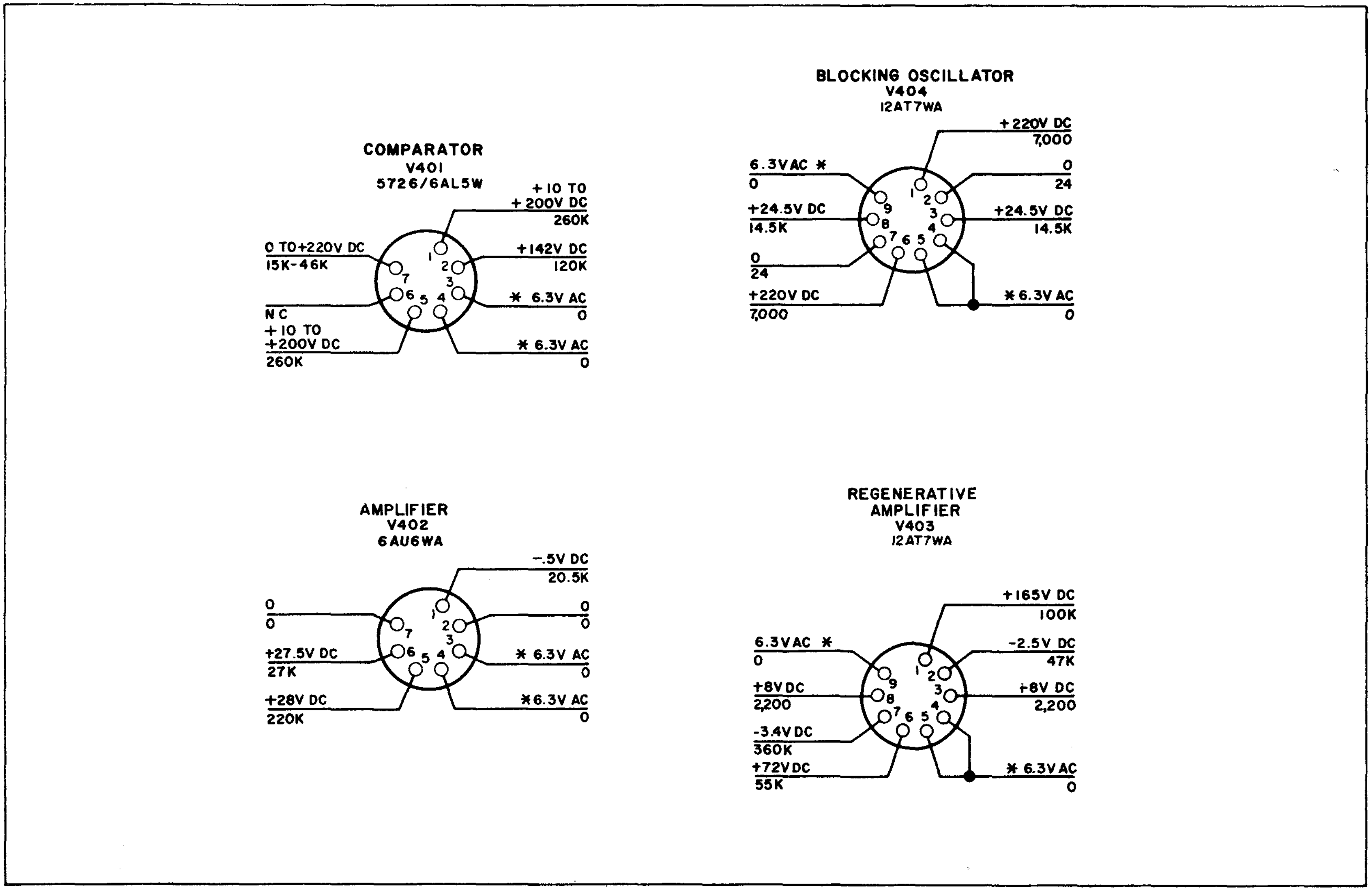


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED-TO GROUND WITH A 20,000 OHM PER VOLT METER.
2. VOLTAGE READING ABOVE THE LINE. RESISTANCE READING BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSANDS, MEG DENOTES MILLION INF. DENOTES INFINITY.

EL1OP236

Figure 3-83. Range zero trigger pickoff amplifier Z107, voltage and resistance diagram.

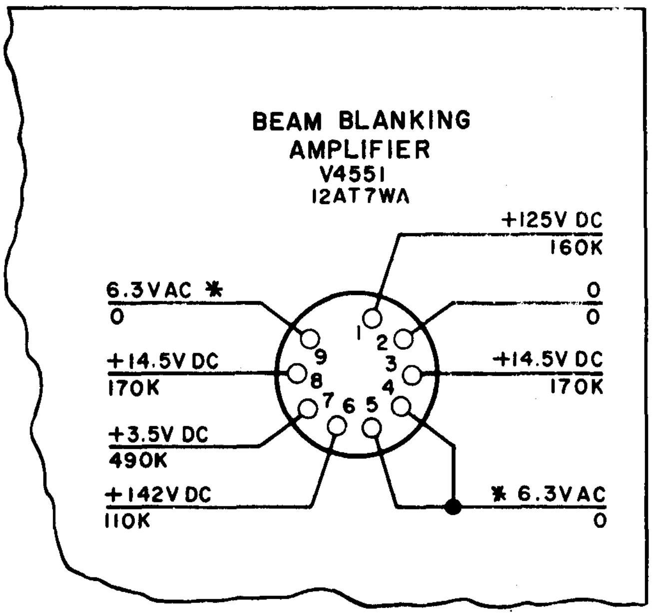


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM PER VOLT METER.
2. VOLTAGE READING ABOVE THE LINE. RESISTANCE READING BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSANDS, MEG DENOTES MILLION INF. DENOTES INFINITY.

EL1QP237

Figure 3-84. Delay trigger pickoff amplifier Z108, voltage and resistance diagram.



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.

EL1QP238

Figure 3-85. Video blanking Z146, voltage and resistance diagram.

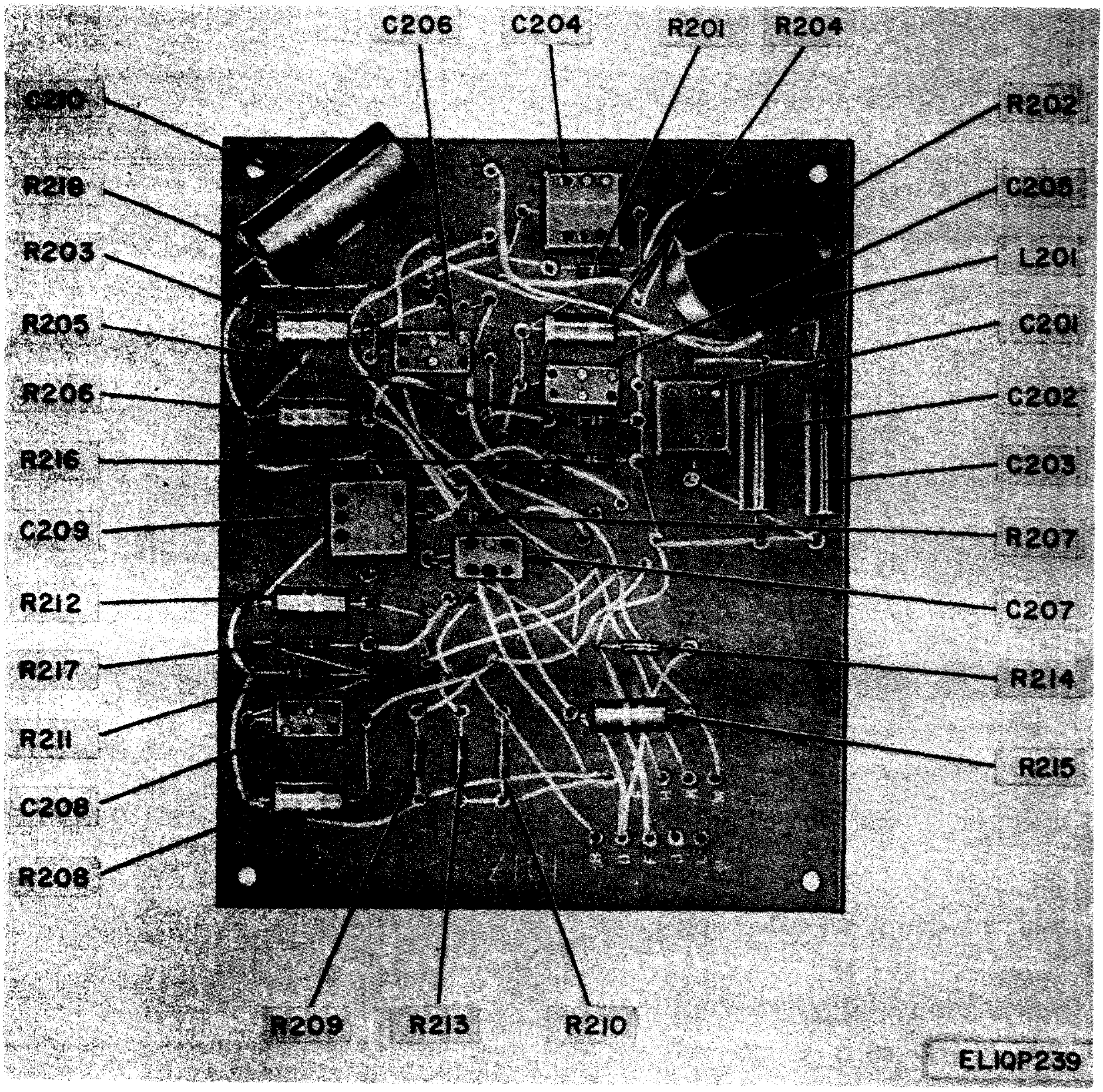


Figure 3-86. Long gate generator Z101, bottom view.

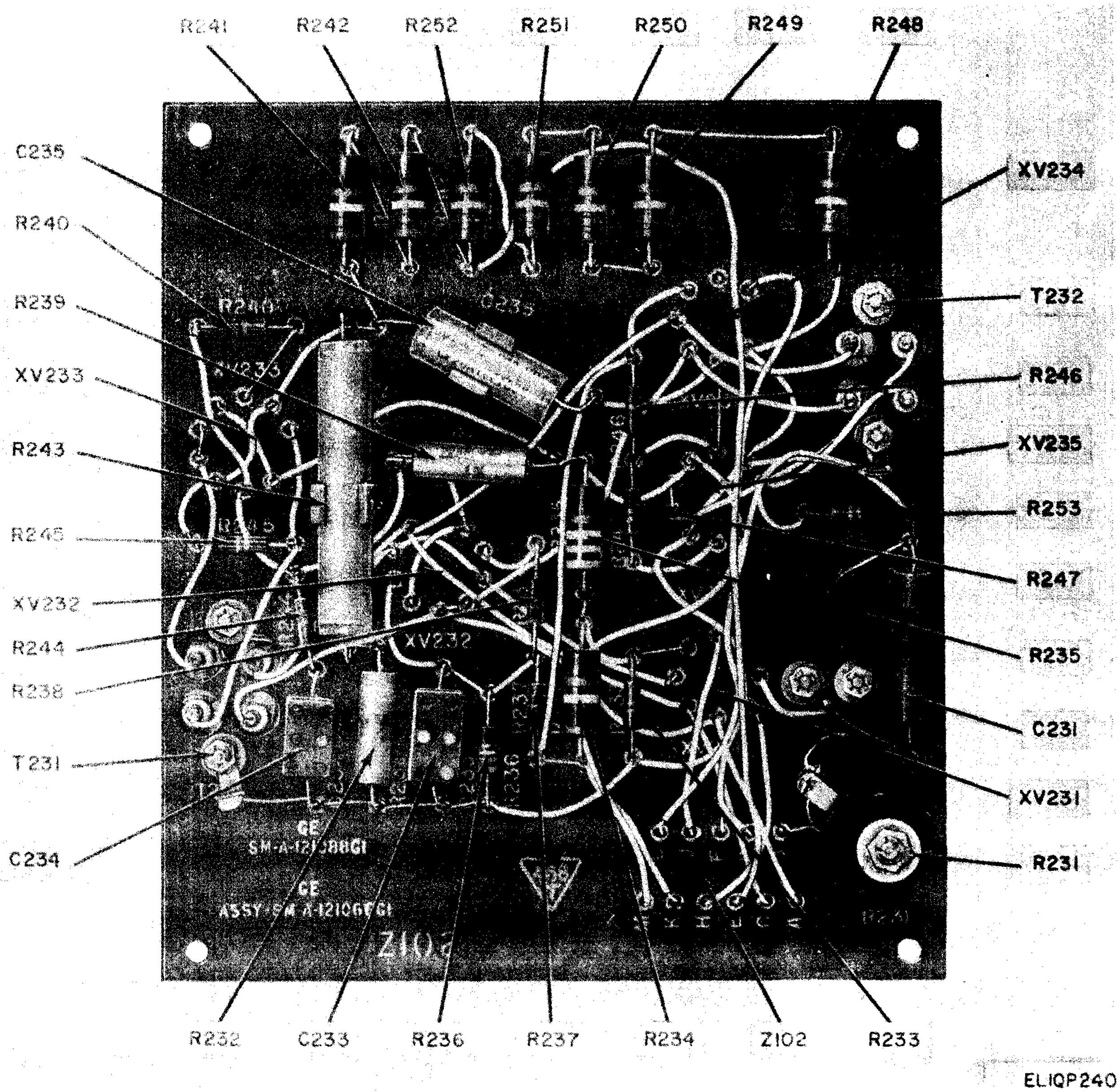


Figure 3-87. Timing sweep generator Z102, bottom view.

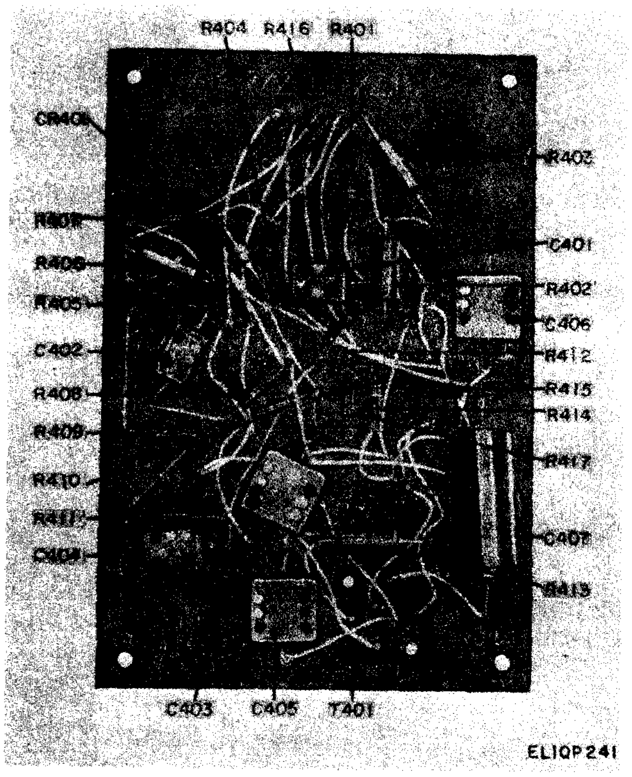


Figure 3-88. Trigger pickoff amplifiers Z107, Z108, and Z109, bottom view.

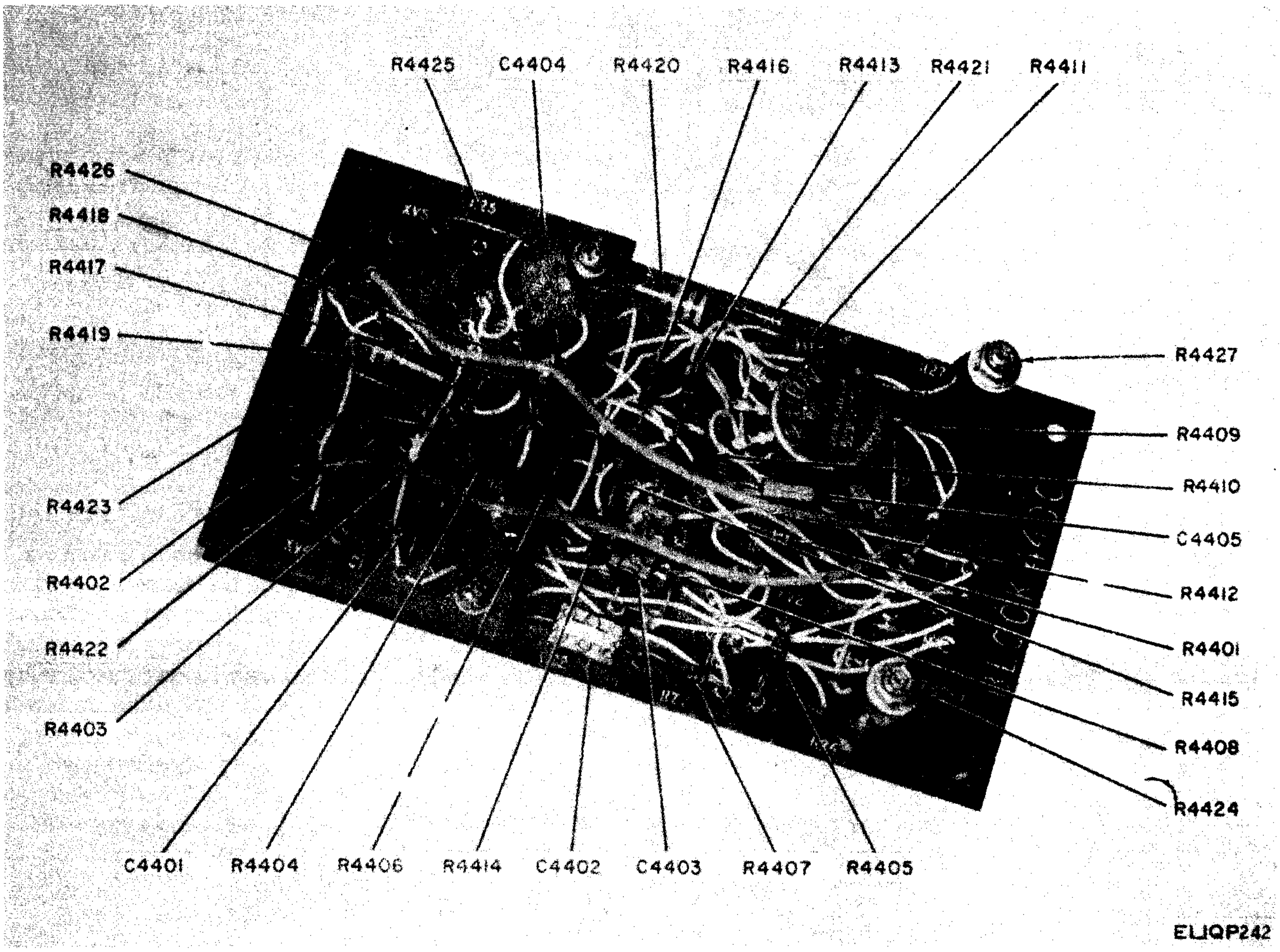


Figure 3-89. Range sweep generator and driver Z144, bottom view.

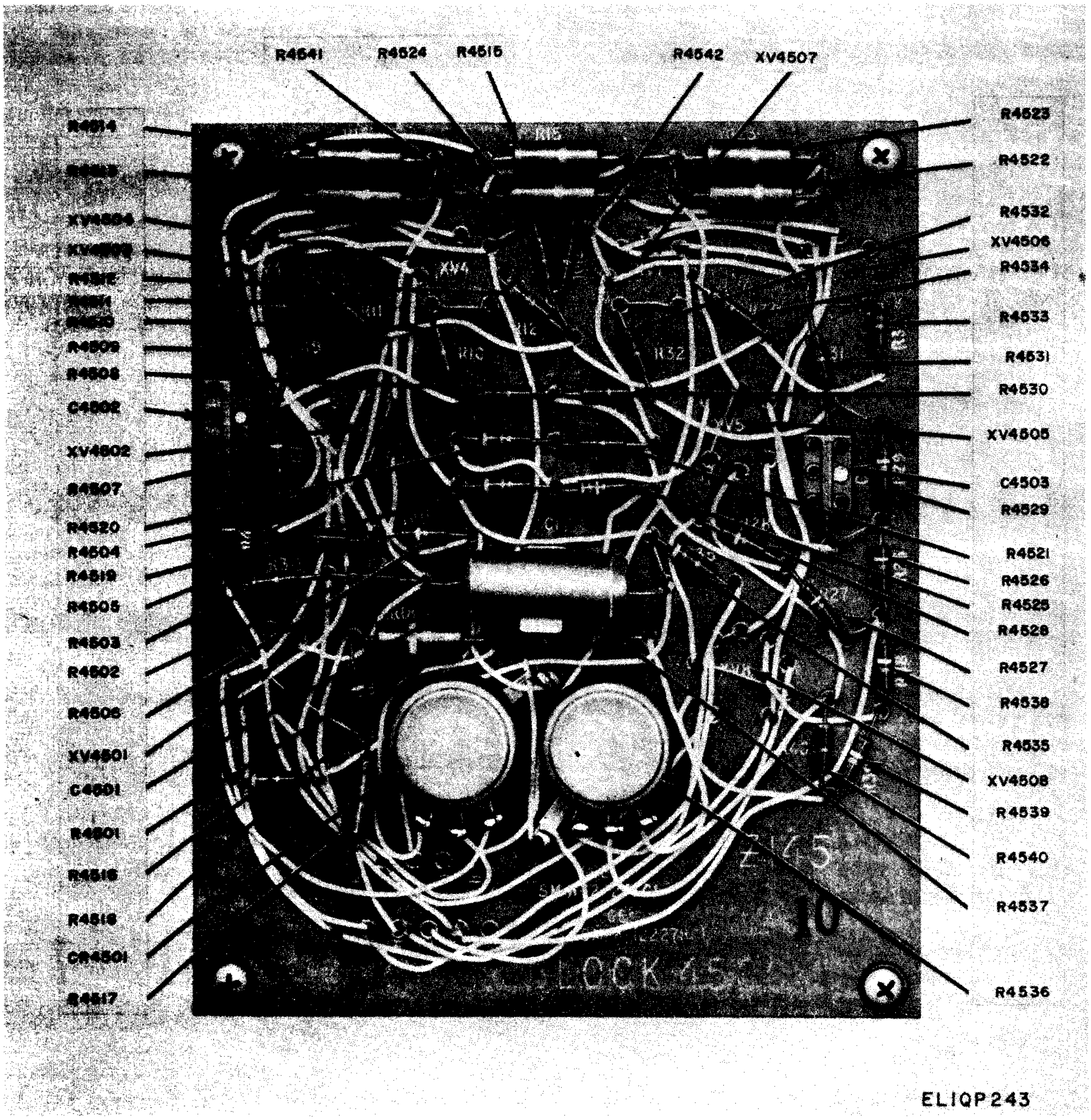


Figure 3-90. Azimuth sweep generator and driver Z145, bottom view.

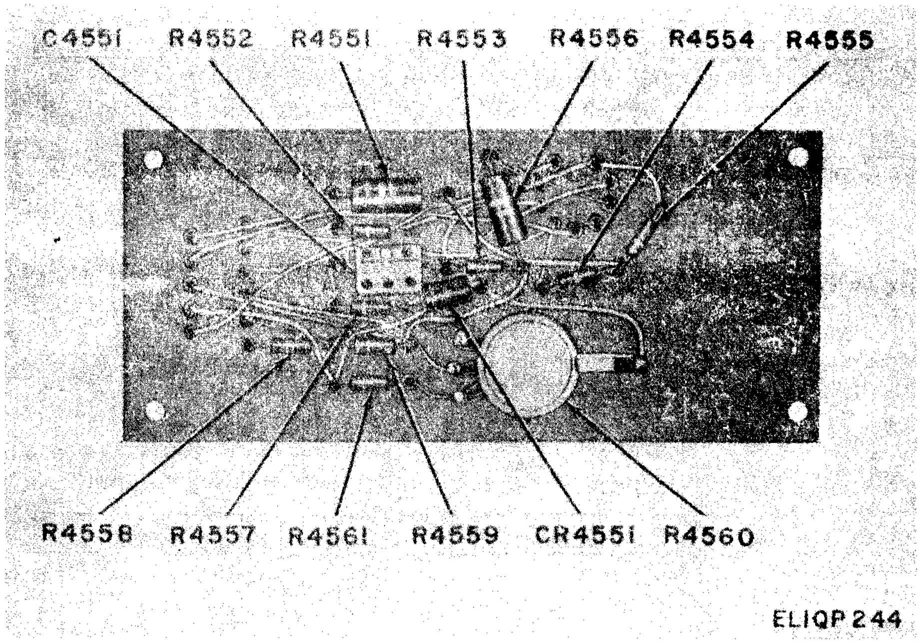


Figure 3-91. Video blanking B146, bottom view.

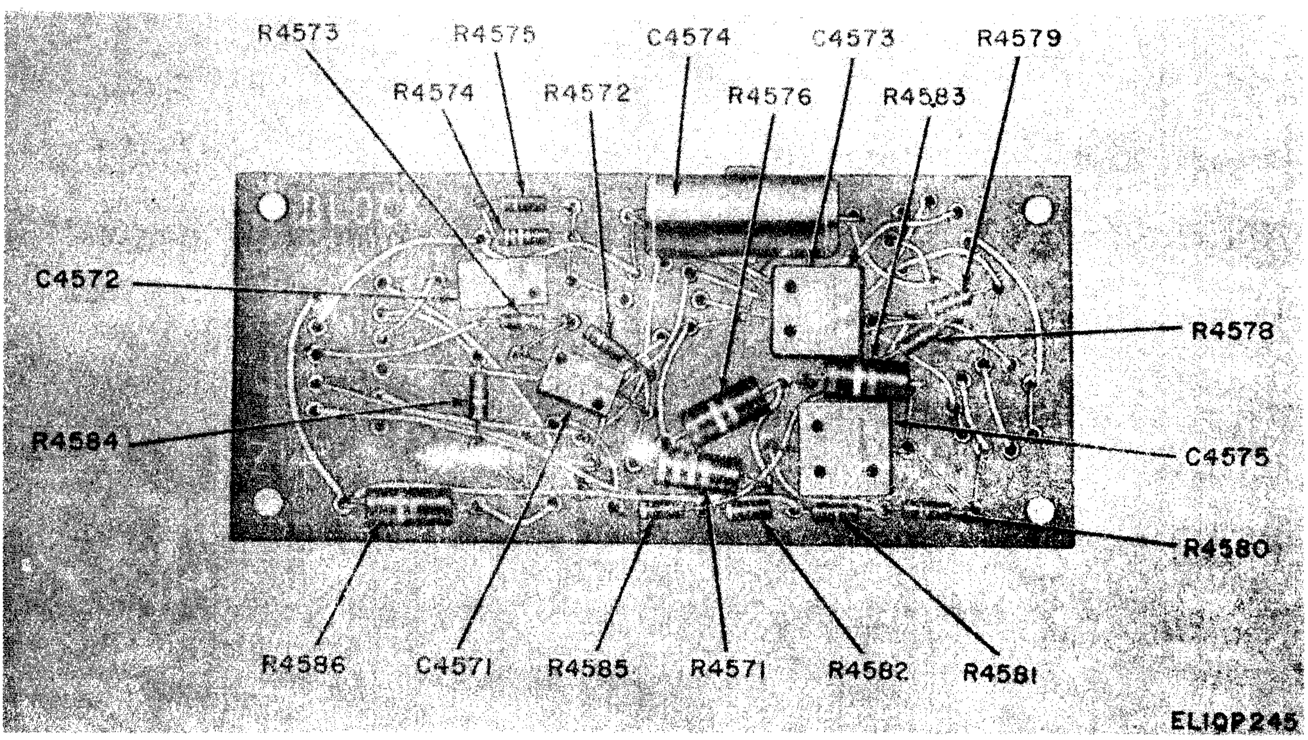


Figure 3-92. Modulator trigger generator Z147, bottom view.

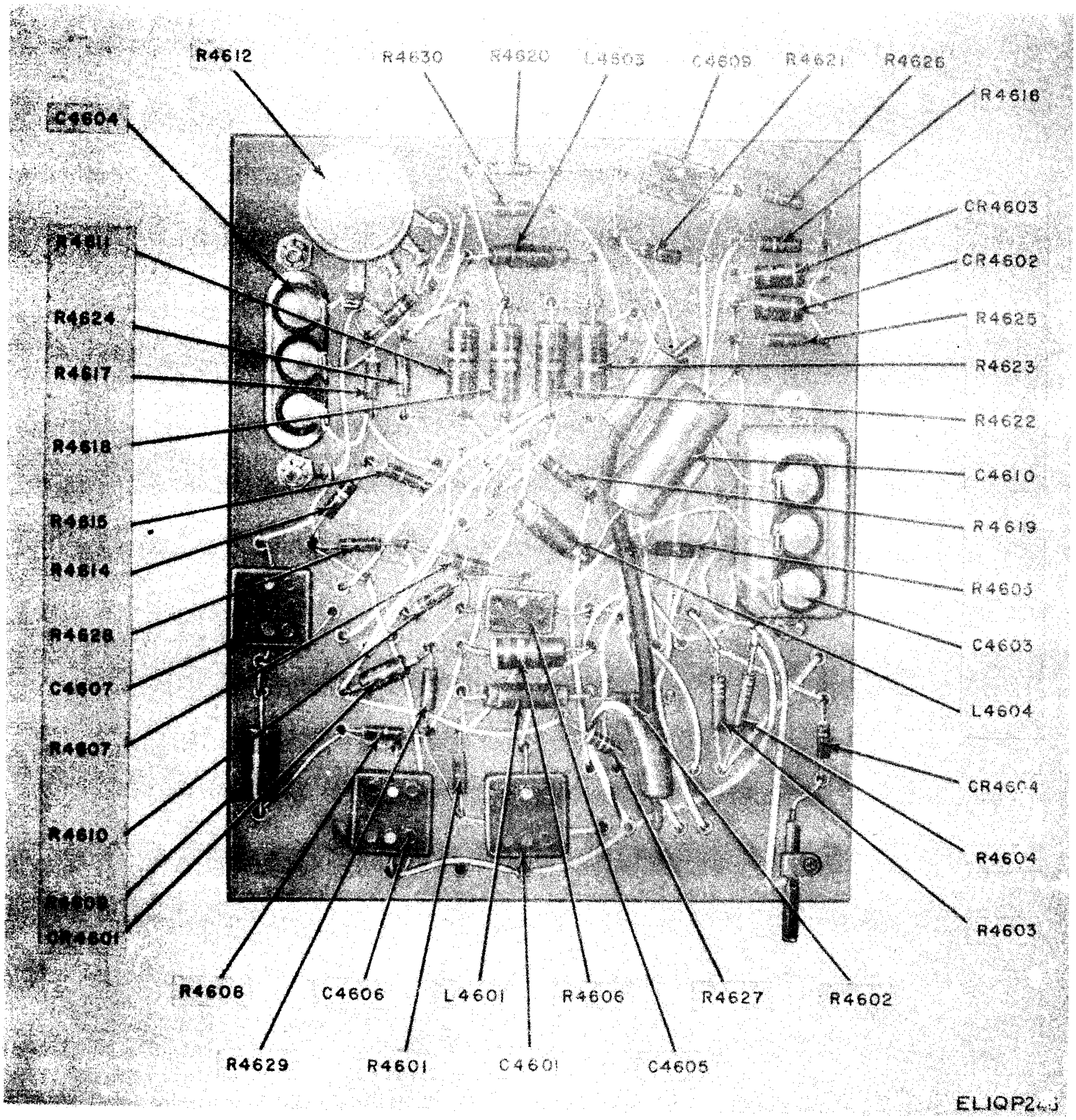


Figure 3-93. Video amplifier Z148, bottom view.

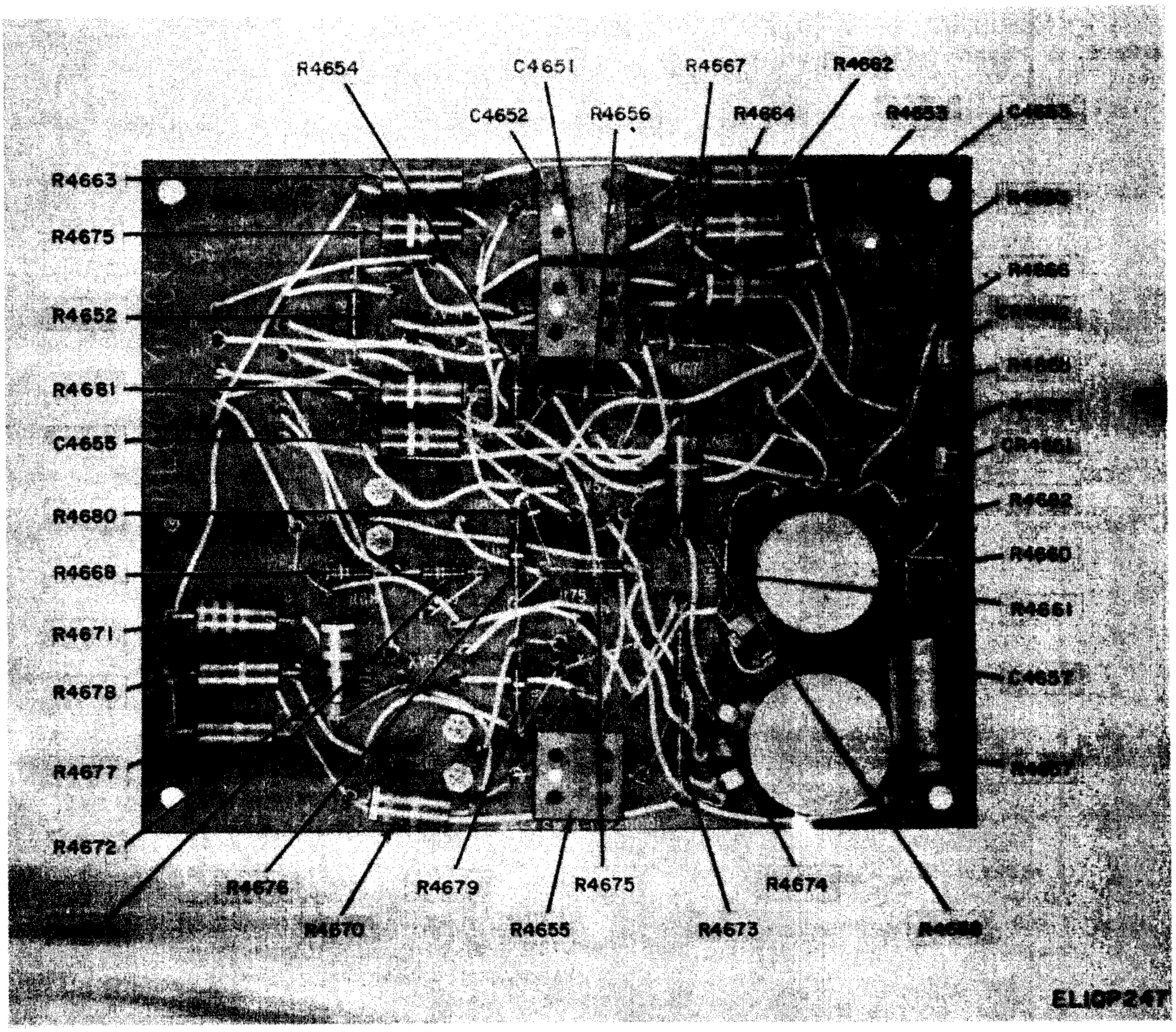


Figure 3-94. Intensifier and short gate generator Z149, bottom view.

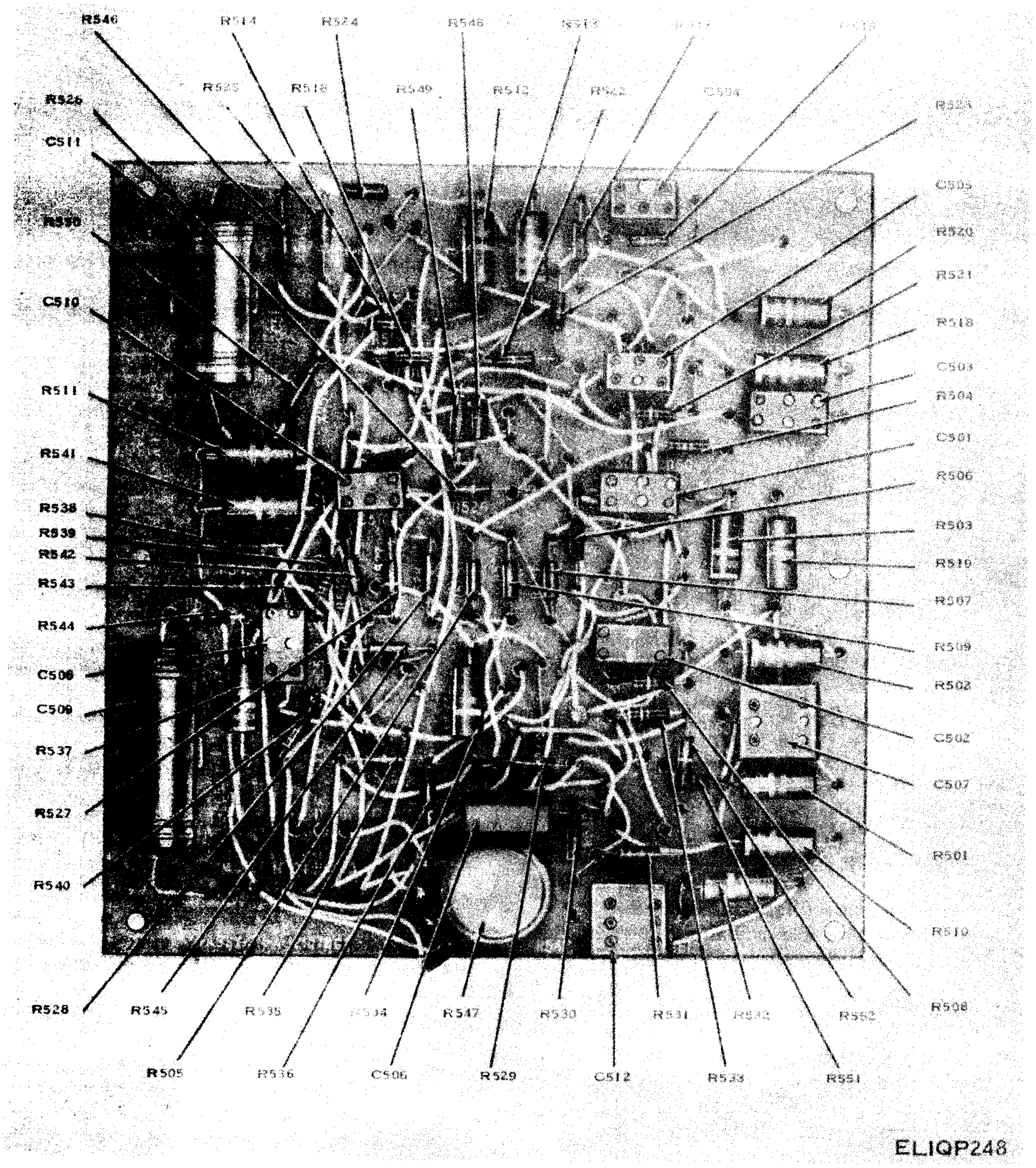
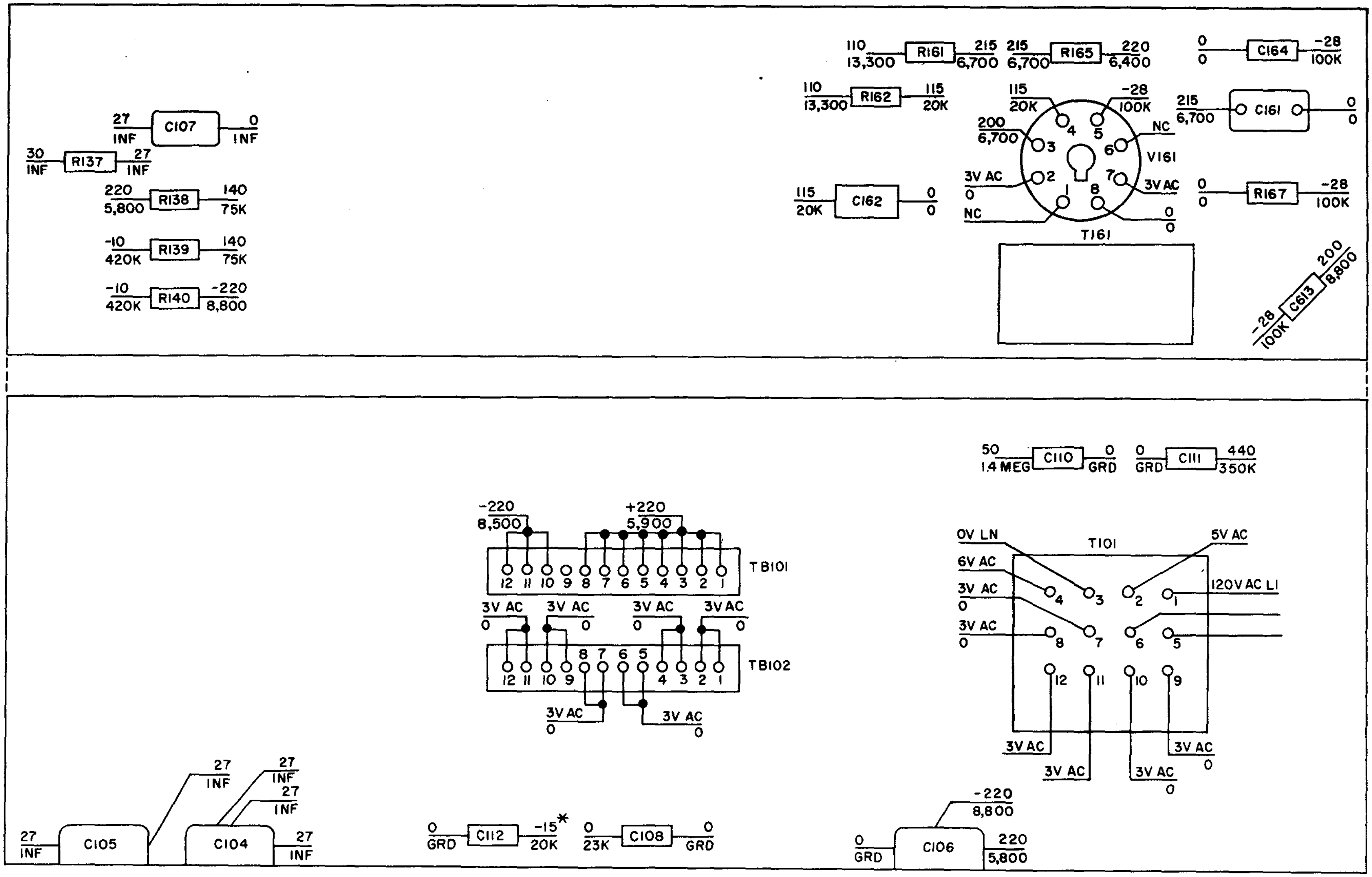


Figure 3-95. Azimuth synchronizer Z150, bottom view.

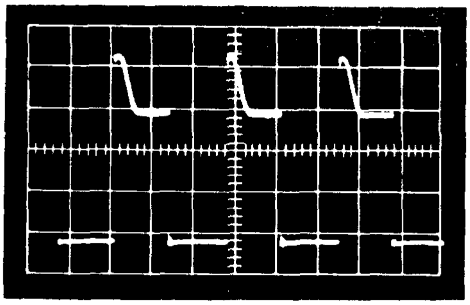


NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. * WITH R109 IN EXTREME COUNTERCLOCKWISE POSITION.
4. K DENOTES THOUSAND, MEG DENOTES MILLION. INF DENOTES INFINITY.

EL1QP249

Figure 3-96. Indicator drawer, voltage and resistance diagram.



GATED MILLER SWEEP V231

TEST POINT PIN I
.5 VOLT/CM
50 MICROSECONDS/CM
EL1QP250

Figure 3-97. Gated Miller sweep V231, waueform diagram.

b. Synchronizing and Indicating Systems Controls and Adjustments.

(1) Table 3-32 lists the controls and adjustments for operation and maintenance of the synchronizing and indicating systems.

(2) HV ADJ potentiometer R164 (fig. 3-52) is located in the left-rear section of the indicator. It is used to adjust the high voltage output of the high voltage oscillator tube.

c. Synchronizing and Indicating System Fuses. Table 3-33 lists the fuses that protect circuits in the synchronizing and indicating systems. The table lists the rating of each fuse, a blown-fuse indicator that lights when the fuse is blown, and the circuit that each fuse protects. Figure 3-3 shows the location of each fuse.

d. Normal Indications at Synchronizing and Indicating Systems Test Points. Table 3-34 lists the test points that are provided to test the operation of circuits in the synchronizing and indicating systems, references a figure that shows the physical location of each test point, and gives or references the normal indication at each test point.

e. Dc Resistances of Indicating and Synchronizing Systems Transformers and Coils. Table 3-35 lists the transformers and coils in the indicating system references a figure that shows the location of each, and gives the dc resistance of every winding.

Table 3-32. Synchronizing and Indicating Systems Controls and Adjustments

Controls and adjustments	Function
Indicator front panel (fig. 3-48)	
VIDEO adjustment R102.	Adjust video gain by varying the input voltage to video amplifier Z148.
RANGE MARK adjustment R103.	Adjusts rangemark intensity by adjusting the voltage applied to the suppressor grid of V4604.
IF GAIN adjustment R109.	Varies the sensitivy of the receiver.
PLOTTER DIMMER control R113.	Varies the brightness of plotter illumination by varying the voltage to lamps I 101, I 102, I 103, and I 104.
RANGE ZERO adjustment R116.	Adjusts the timing of modulator trigger pulse with respect to the start of the vertical sweep by changing the plate voltage of V401.
RANGE SLOPE adjustment R119.	Adjusts the slope of the timing sweep on the B-scope by changing the bias of V231.
FOCUS adjustment R121.	Adjusts the focus of the electron beam by varying the bias of V4513.
AZIMUTH MARK adjustment R132.	Adjusts the intensity of the azimuth mark by adjusting the voltage applied to V4652A.
PANEL DIMMER control R133.	Varies the illumination of the front panel control marking by varying the voltage to I 105, I 106, I 107, and I 108.
INTENSITY adjustment R142.	Adjusts the brightness of the screen by varying the grid bias of V4652A.
RANGE SELECTOR switch S101.	Sets the indicator for 15,000M or 3750M range.
RANGE SHIFT switch S103.	In ON position, displaces the upper beam from the lower beam by 750 meters for easy viewing of inflight target. In off position, the indicator functions as straight radar.
MARKERS ON switch S105.	Inserts 2,000-meter marks for range calibration.
TIMER switch S106....	Momentary pushbutton to start or stop SECONDS timer.
TIMER switch S107	Momentary pushbutton to start or stop SECONDS timer. Also reverses the beam video when S110 is in either LOWER or UPPER position.
RESET switch S108	Pushbutton used to return SECONDS timer to zero.

Table 3-32. Synchronizing and Indicating Systems Controls and Adjustments -Continued

Controls and adjustment	Function
Indicator front panel-Continued (fig. 3-48).	
BEAM VIDEO selector switch S110.	In UPPER position, selects the viedo from the upper beam for B-scope display. In LOWER position, selects the video from lower beam. In BOTH position, selects the video from both beams.
EXPANDED SWEEP DELAY switch AT101.	Places the center of the 3750M range anywhere on the 15000 M selector. Calibrated in 1500-meter steps. Uesd to select 3750-meter range sector for expansion.
SET DETENT indicator lamp I 109.	Indicates when computer controls are in the detent position.
SECONDS timer M101.	Indicates the time interval between the first and second actuations of switch S106 or S107.
Teat plate and test panel (fig. 3-51)	
TRIGGER BLANKING switch S104	Applies blanking pulses from azimuth synchronizer Z150 to the suppressor grid of V4571 in the OFF position. Removes the blanking pulses in the ON position.
VERT SIZE 15000M potentiometer R104	Adjusts the vertical size of indicator presentation when RANGE SELECTOR switch S101 is in the 15000M position by changing the length of sweep.
VERT SIZE 3750M potentiometer R106.	Adjusts the vertical size of indicator presentation when S101 is in the 3720M position by changing length of sweep.
AUXILIARY INTENSITY potentiometar R110.	Adjusts the intnesity of the raster on the B-scope by applying an intensifying voltage to the grid of the B-scope.
INTENSITY BALANCE potentiometer R112.	Adjusts the intensity of the scope presentation when S101 is in 3750 M position.
Trigger selector switch S109.	Applies trigger pulse from slave unit in SLAVE

Table 3-32. Synchronizing and Indicating Systems Controls and Adjustments-Continued

Controls and adjustments	**Function**
Test plate and test panel-Continued (fig. 3-51)	
	position. Applies trigger pulse from V202B to V203B in MASTER position.
Panel in upper left section of indicator (fig. 3-50)	
REP RATE adjustment L201.	Tunes the oscillator of long gate generator Z101 to establish repetition rate.
RANGE RATE adjustment C232.	Adjusts the range slope by changing the RC time constant of the grid of V231.
RANGE SHIFT potentiometer R4560.	Adjusts the shift of the upper beam presentation from the lower beam presentation when S103 is in ON position.
Panel in upper right section of indicator (fig. 3-50)	
HOR SIZE potentiometer R4536.	Adjusts the bias voltage applied to V4508A to adjust the horizontal size to the raster.
HOR CENTERING potentiometer R4517.	Adjusts the reference voltage of clamp tube V4501B to center the horizontal sweep.
VERTICAL CENTERING potentiometer R4409.	Adjusts the bias to V4401 B to center the vertical sweep.
VIDEO CLIPPING potentiometer R4612.	Adjuets the level of video clipping.
Panel in bottom right section of indicator (fig. 3-53)	
AZIM SYNCH GAIN potentiometer R547.	Adjusts the gain of the azimuth synchronizer by varying the input voltage.
SWP SIZE ADJ potentiometer R4660.	Adjusts the size of the sweep by varying the pulse width from the short gate multivibrator.
SWP INTEN ADJ potentiometer R4657.	Adjusts the output intensity by varying output voltage of R4652B.
HF COMP adjustment C4656.	Compensates for high frequency components of raster.
HF COMP adjustment C4658.	Compensates for high frequency components of band.

Table 3-33. Synchronizing and Indicating System Fuses

	Rating		**Blown-fuse indicator**	**protected**
	Volts	Amp		
F657	1,000	0.25	I 657	+440V dc circuits of crt V101 and Z102.
F658	250	0.5	I 658	+220V dc circuits of synchronizing and indicating systems.
F660	250	0.125	I 660	+220V dc circuits of synchronizing and indicating systems.
F661	250	5	I 661	+28V dc circuits of synchronizing and indicating systems.

Table 3-34. Normal Indications at Synchronizing and Indicating Systems Test Points

Test point	Location (fig.)	Normal indcation
		Long gate generator Z101
TP201	3-51	Oscillator ouptput (fig. 3-54)
TP202	3-51	Regenerative amplifier (fig. 3-54)
TP203	3-51	Trigger coupling input (fig. 3- (fig. 3-54)
TP204	3-51	Long gate (fig. 3-54)
TP205	3-51	Gate generator output (fig. 3-54)
		Timing sweep generator Z102
TP231	3-51	Gated miller sweep (fig. 3-55)
TP232	3-51	sweep voltage (fig. 3-55)
TP233	3-51	Cathode follower input (fig. 3-55)
TP234	3-51	Timing sweep voltage (fig. 3-55)
		Trigger pickoff amplifiers Z107, Z108, Z109
TP401	3-53	Timing sweep voltage (fig. 3-56)
TP402	3-53	Regenerative amplifier trigger (fig. 3-56) ....
TP403	3-53	Regenerative amplifier trigger (fig. 3-56)
TP404	3-53	Trigger pulse (fig. 3-56)
		Azimuth synchronizer Z150
J105	3-49	Azimuth triggers (on back of indicator drawer).
TP501	3-53	Blanking gate (fig. 3-57)
TP502	3-53	Blanking pulse (fig. 3-57)
TP503	3-53	Azimuth gate trigger (fig. 3-57)
TP504	3-53	Azimuth gate (fig. 3-58)
TP505	3-53	Range shift gate (same as TP 509).
TP506	3-53	Azimuth gate (fig. 3-57)
TP507	3-53	Range shift (fig. 3-58)
TP508	3-53	Range shift meet (fig. 3-58)
TP509	3-53	Range shift (fig. 3-58)
TP510	3-53	Azimuth marker input (fig. 3-57)
TP511	3-53	Blanking input (fig. 3-57)
TP512	3-53	Azimuth strobe output (fig. 3-57)
TP513	3-53	Azimuth strobe gate (fig. 3-57)
TP514	3-53	Inverter pulse (fig. 3-57)
TP515	3-53	Reset gate (fig. 3-57)
		Range sweep generator and driver Z144
TP4401	3-51	Sweep generator (fig. 3-59)
TP4401	3-51	Range shift gate (fig. 3-60)
TP4403	3-51	Range aweep voltage (fig. 3-59)
TP4404	3-51	Range sweep voltage (fig. 3-59)
		Azimuth sweap generator and driver Z145
TP4501	3-51	Azimuth gate (fig. 3-61)
TP4502	3-51	Azimuth sweep (fig. 3-61)
TP4503	3-51	Azimuth sweep voltage (fig. 3-61)
TP4504	3-51	Azimuth sweep (fig. 3-61)
TP4505	3-51	Azimuth sweep voltage (fig. 3-61)

Table 3-34. Normal Indications at Synchronizing and Indicating Systems Test Points — Continued

Test point	Location (fig.)	Normal indication
		Azimuth sweep generator and driver Z145-Continued
TP4506	3-51	Azimuth sweep (fig. 3-61)
TP4507	3-51	Azimuth sweep size voltage (fig. 3-61)
TP4508	3-51	Azimuth sweep size voltage (fig. 3-61)
		Video blanking Z146
TP4551	3-51	Range shift (fig. 3-62)
TP4552	3-51	Lower beam blanking gate (fig. 3-62)
TP4553	3-51	Upper beam blanking gate (fig. 3-62)
TP4554	3-51	Range shift voltage (fig. 3-62)
		Modulator trigger generator Z147
TP4571	3-51	Trigger input (fig. 3-63)
TP4572	3-51	Trigger blanking input (fig. 3-63)
TP4573	3-51	Modulator trigger pulse (fig. 3-63)
TP4574	3-51	Focus coil voltage (fig. 3-63)
		Video amplifier Z148
TP4601	3-51	Video input (fig. 3-65)
TP4602	3-51	Video (fig. 3-65)
TP4603.	3-51	Video (fig. 3-65)
TP4604	3-51	Video output (fig. 3-65)
TP4605	3-51	Range marker input (fig. 3-65)
		Short gate and intensifier Z149
TP4651.	3-52	Delay trigger pulse (fig. 3-66)
TP4652	3-52	Short gate (fig. 3-66)
TP4653	3-52	short gate (fig. 3-66)
TP4654.	3-52	Intensity voltage (fig. 3-66)
TP4655	3-52	Intensity output (fig. 3-66)
		High voltage oscillator V161
J161	3-53	Oscillator reganerative feedback (fig. 3-72).

Table 3-35. Dc Resistances of Indicating and Synchronizing Systems Transformers and Coils

Transformer or coil	Location (fig.)	Terminals	Dc resistance (ohms)
Filter coil L101	3-67	1-2	35.0
Range and azimuth sweep coil L102.	3-69	N1-D1	366
		N2-D2	220
		N3-D3	365
		N4-D4	220
Focus coil L103	3-69	1-2	2,600
Oscillator coil L201	3-88	1-2	112
		2-3	150
		1-3	280
High frequency compesation coil L4601.	3-93	1-2	1.8
High frequency compensation coil L4603.	3-93	1-2	2.0
High frequency compensation coil L4604.	3-93	1-2	2.0

Table 3-35. Dc Resistances of Indicating and Synchronizing Systems Transformers and Coils–Continued

Transformer or coil	Location (fig.)	Terminals	DC (ohms)
Filament Transformer T101.	3-52 and 3-67	1-2	0.5
		1-5	0.5
		2-3	0
		3-4	0
		4-5	0
		6-7	0
		6-8	0
		6-9	0
		6-10	0
		6-11	0
		6-12	0
High voltage oscillator transformer T161.	3-52 and 3-68	1-2	6.5
		2-3	28.0
		4-5	2,000
Filament isolation transformer T231.	3-50 and 3-87	1-2	0.8
		3-4	
Filament isolation transformer T232.	3-50 and 3-87	1-2	0.9
		3-4	
Blocking oscillator transformer T401.	3-52	1-2	23.8
		3-4	27.8
		5-6	27.8
Blocking oscillator Transformer T4571.	3-50	1-5	1.6
		2-6	1.9
		3-7	2.2

3-32. Synchronizing and Indicating Systems Troubleshooting

a. General. Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the indicating and synchronizing systems.

(1) *Symptom troubleshooting* (para 3-32 *d*). Troubles that have been sectionalized to the indicating and synchronizing systems can usually be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a section, circuit, or stage. The symptoms that are given in the table consist of indications obtained on the B-scope. To troubleshoot the indicating and synchronizing systems based on symptoms, proceed as follows:

(a) Observe the indications obtained on the B-scope.

(b) Compare the indications obtained with those listed in each of the symptoms.

(c) If the indications obtained correspond to those listed in a particular symptom, follow the procedure given in that particular paragraph to isolate the trouble.

(d) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleahooting table 3-37.

(2) *Step-by-step troubleshooting* (table 3-37). The indicating and synchronizing systems step-by-step troubleshooting table consists of a series of steps designed to evaluate all phases of operation of the indicating system. Use this table if the trouble cannot be isolated by symptom troubleshooting ((1) above). To troubleshoot the systems using the step-by-step troubleshooting table proceed as follows:

(a) Locate the test point given in step 1 of the table.

(b) Connect the test equipment and set its controls as directed in the test equipment column.

(c) Set the controls on the radar set as directed in the Radar set controls column.

(d) Compare the indications obtained on the test equipment with the indications given or referenced in the Normal indications column.

(e) If the indications obtained on the test equipment are normal, proceed to the next step or follow the directions in the Normal indications column.

(f) If the indications obtained are abnormal, proceed as directed in the corrective measures column.

b. Test Equipment Required to Troubleshoot Indicating and Synchronizing Systems. Table 3-36 lists the items of test equipment that are required to troubleshoot the systems.

c. Preparation of Synchronizing and Indicating Components for Troubleshooting. The indicator drawer is made accessible for troubleshooting, aligning, and/or testing by releasing the four indicator drawer latches and pulling the drawer out to its stop. Shorting switch S1004 must be closed. To make waveform tests, connect a cable from the SIGNAL INPUT connector of the oscilloscope to EXT TEST jack J108 on the indicator (fig. 3-69). Test connectors EXT TEST E106 and GND E107 are provided for connection to the probe with a banana plug-type connector. The test probe (fig. 3-69) may then be used for waveform measurements.

Table 3-36. Test Equipment Required to Troubleshoot Indicating and Synchronizing Systems

Test equipment	Common name	Technical manual
Multimeter TS-352B/U	Multimenter	TM 11-6625-366-15
Electronic Multimeter ME-26U.	Vtvm	TM 11-6625-200-15
Electron Tube Test Set	Tube tester	TM 11-6625-274-12
Oscilloscope AN/USM281C	Oscilloscope	TM 11-6625-2658-14

d. Synchronizing and Indicating Systems Symptom Troubleshooting. Extremely high voltages exist in the indicator drawer. Before making resistance measurements on the high voltage rectifier, discharge high voltage rectifier Z161 (fig. 3-53).

(1) *Symptom 1.* No raster or spot on screen.

(a) High voltage oscillator V161.

1. Observe waveform at J161 (fig. 3-72). If no indication is obtained, check the oscillator bias voltage at J161; then perform voltage and resistance checks on V161.

2. If an indication is obtained at j161, proceed to (b) below.

(b) First anode voltage V101. Check for presence of +440 volts dc at pin 10 of V101.

(c) High voltage rectifier Z161. Output voltage of Z161 cannot be measured at this maintenance category. Approximately 14,000 volts exists at the output of Z161.

(2) *Symptom 2.* Insufficient vertical deflection with RANGE SELECTOR switch S101 in 15000M position, but normal when S101 is in 3750M position.

(a) Long gate generator Z101. Check waveform at TP204 (fig. 3-54). If indication is abnormal, check long gate generator Z101. If indication is normal, proceed to *(b)* below.

(b) Range sweep generator and driver Z144.

1. Check waveforms at TP4403 and TP 4404 (fig. 3-59). If an abnormal indication is obtained, proceed to 2 below.

2. Check waveform at TP4401 (fig. 3-59). If an abnormal indication is obtained, proceed to 3 below.

3. Check VERT SIZE 15000M potentiometer R104.

(3) *Symptom 3.* Insufficient vertical deflection with RANGE SELECTOR switch S101 in 3750M position but normal when S101 is in 15000M position.

(a) Range sweep generator and driver Z144.

1. Check waveforms at TP4403 and TP4404 (fig. 3-59). If waveform is abnormal, proceed to *2* below.

2. Check waveform at TP4401. If waveform is abnormal, check Z144 and VERT SIZE 3750M potentiometer R106. If Z144 and R106 are normal, proceed to *(b)* below.

(b) Intensifier and short gate Z149.

1. Check waveform at TP4652 (fig. 3-66). If waveform is abnormal, proceed to *2* below.

2. Check waveform at TP4651. If waveform is abnormal, proceed to *(c)* below.

(c) Delay trigger pickoff amplifier Z108.

1. Check waveform at TP404 (fig. 3-56). If waveform is abnormal, proceed to *2* below.

2. Check waveform at TP401. If waveform is normal, check A108. If waveform is abnormal, proceed to *(d)* below.

(d) Timing sweep generator Z102.

1. Check waveform at TP234 (fig. 3-55). If waveform is abnormal, proceed to *2* below.

2. Check waveform at TP232. If waveform is normal, check Z102. If waveform is abnormal, check gated Miller sweep V231.

(4) *Symptom 4.* Insufficient vertical deflection with RANGE SELECTOR switch S101 in either position. Check waveform at TP204 (fig. 3-54) on long gate generator Z101.

(5) *Symptom 5.* Insufficient horizontal deflection.

(a) Azimuth sweep generator and driver Z145.

1. Check waveforms at TP4504 and TP4506 (fig. 3-61). If waveforms are abnormal, proceed to *2* below.

2. Check waveform at TP4503. If waveform is linear but not long enough, check automatic size amplifier V4508B. If waveform is abnormal, proceed to (b) below.

(b) Azimuth synchronizer Z150.

1. Check waveform at TP504 (fig. 3-58). If waveform is abnormal, proceed to *2* below.

2. Check waveform at TP501. If waveform is abnormal, proceed to *3* below.

3. Check waveform at TP510. If waveform is abnormal, check pulse shaper in the stc assembly.

(6) *Symptom 6.* Weak, or absence of video on crt with normal video at TP4602. Make voltage and resistance checks of third video amplifier V4603.

(7) *Symptom 7.* Normal video on crt but range strobe is absent.

(a) Video amplifier Z148. Check voltage at TP4605 (fig. 3-51). If voltage is normal, check V4604. If stage is normal, proceed to *(b)* below.

(b) Range trigger pickoff amplifier Z109.

1. Check waveform at TP404 (fig. 3-56). If waveform is abnormal, proceed to 2 below.

2. Check waveform at TP401. If waveform is normal, check amplifier V402, regenerative amplifier V403, and blocking oscillator V404. If waveform is abnormal, check range potentiometer in computer.

(8) *Symptom 8.* No intensified 3750 meter band when RANGE SELECTOR switch S101 is in 15000M position.

(a) Check waveform at TP4653 (fig. 3-66). If waveform is abnormal, check TP4651.

(b) If waveform at TP4651 is abnormal, check delay trigger pickoff amplifier Z108.

(9) *Symptom 9.* Azimuth strobe will not remain stationary.

(a) Check waveform at TP510 (fig. 3-57).

(b) Check servomotorr B3202.

Table 3-37. Synchronizing and Indicating System Step-by-Step Troubleshooting Table

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
			Video amplifier Z148		
1	TP4604	Oscilloscope AN/USM-281C.	MAIN POWER switch S652 to ON. Press START button S658.	Waveform (fig. 3-65).	Check waveform at TP4603 (fig. 3-65). If waveform at TP 4603 is normal, check V4603. Make voltage and resistance measurements at the tube socket base (fig. 3-73).
2	TP4603	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-65)	Rotate RANGE MARK potentiometer R103. The rangemarks on the waveform should be intensified. Rotate RANGE handwheel; the range marks should move. Check V4604. Make voltage and resistanc checks at the tube socket base (fig. 3-73) Check range marker trigger pickoff amplifier Z109 (step 4 below).
3	TP4601	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-65)	Check R101 and R102. Troubleshoot the receiving system (para 3-27*a*).
			Trigger pickoff amplifiers Z107, Z108, Z109		
4	TP404	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-56)	Check waveform at TP403. If waveform at TP403 is normal, check V404. Make voltage and resistance checks at tube socket base (fig. 3-74).
5	TP402	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-56)	Check V401. Make voltage and resistance measurements at tube socket base (fig. 3-74). Perform step 6 below.
6	TP401	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-56)	If waveform at TP401 is normal and waveform at TP402 is abnormal, check V401. Make voltage and resistance check at tube socket base (fig. 3-74) If V401 is normal, troubleshoot computing system (table 3-45). If waveform at TP401 is abnormal, proceed to step 14 below.

Table 3-37. Synchronizing and Indicating Systems Step-by-Step Troubleshooting Table—Continued

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
			Azimuth sweep generator and driver Z145		
7	TP4504 TP4506	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-61).	Check V4503, V4504, V4506, and V4507. Make voltage and resistance measurements at tube socket base (fig. 3-75). Perform step 8 below.
8	TP4503	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-61)	Check V4502. Make voltage and resistance measurements at tube socket base (fig. 3-75).
9	TP4501	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-61)	Check CR4501. Perform step 10.
			Azimuth synchronizer Z150		
10	TP504	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-57)	Check waveform at TP503 (fig. 3-57). If waveform at TP503 is normal, check V503B. Make voltage and resistance measurements at tube socket base (fig. 3-76). If waveform at TP503 is abnormal, perform step 11.
11	TP502	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-57)	Check waveform at TP501, (fig. 3-57). If waveform at TP501 is normal, proceed to step 12 below. If waveform at TP501 is abnormal, proceed to step 13 below.
12	TP515	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-57)	Check waveform at TP512 (fig. 3-58). If waveform at TP512 is normal, check V505. Make voltage and resistance measurements at base of tube socket (fig. 3-76) If waveform at TP512 is abnormal, proceed to step 13 below.
13	TP513	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-57)	Check waveform at TP511 (fig. 3-57). If waveform at TP511 is normal, check V507. Make voltage and resistance measurements at base of tube sockt (fig. 3-76). If waveform at TP511 is abnormal, proceed to step 14 below.

Table 3-37. Synchronizing and Indicating Systems Step-by-Step Troubleshooting Table—Continued

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
			Timing sweep generator Z102		
14	TP234	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-55)	Check V235. Make voltage and resistance measurements at base of tube socket (fig. 3-77).
15	TP233	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-55)	Check V233. Make voltage and resistance measurements at base of tube socket (Fig. 3-77).
16	TP232	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-55)	Check V231. Make voltage and resistance measurements at base of tube socket (fig. 3-77).
			Long gate generator Z101		
17	TP204	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-54)	Check V202A and V204A. Make voltage and resistance measurements at base of tube socket (fig. 3-78).
18	TP201	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-54)	Check V201. Make voltage and resistance measurements at base of tube socket (fig. 3-78).
			Modulator trigger generator Z147		
19	TP4573	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-63)	Check waveform at TP4571 (fig. 3-63). If waveform at TP4571 is normal check waveform at TP4572 (fig. 3-63). If waveform at TP4572 is normal, make voltage and resistance measurements at base of tube socket (fig. 3-82). If waveform at TP4572 is abnormal, perform step 10 above. If waveform at TP4571 is abnormal, check waveform at TP404 of Z107 (fig. 3-56). If waveform at TP404 of Z107 is abnormal, test Z107 as directed in steps 4, 5, and 6 above.

Table 3-37. Synchorinizing and Indicating Systems Step-by-Step Troubleshooting Table—Continued

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
			Range sweep generator and driver Z144		
20	TP4404 or TP4403	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-59)	Check waveform at TP4401 (fig. 3-59). If waveform at TP4401 is normal, make voltage and resistance measuements at base of tube socket (fig. 3-80).
			Intensifier and short gate generator Z149		
21	TP4652	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-66)	Check waveform at TP4653. If waveform is normal, make voltage and resistance measurements at base of tube socket (fig. 3-81). If waveform at TP4653 is abnormal, check waveform at TP 4651.
22	TP4651	Oscilloscope AN/USM-281C.	Same as step 1	Waveform (fig. 3-66)	If waveform is normal, make voltage and resistance measurements at base of tube socket (fig. 3-81). If wave form is abnormal, check waveform at TP404 of Z108. If waveform at TP404 of Z108 is abnormal, check Z108 in accordance with steps 4, 5, and 6 above.

3-33. Removal and Replacement of Parts in Synchronizing and Indicating Systems

a. General. All parts of the indicating system are contained in Azimuth and Range Indicator IP-375/MPQ-4A. Most parts of the synchronizing system are located in Azimuth and Range Indicator IP-375/MPQ-4A. Some parts (pulse shaper circuit) of the synchronizing system are located in Receiver Control C-2015/MPQ-4A in the receiver compartment of Receiver-Transmitter Group OA-1257/MPQ-4A, and the azimuth marker magnets and coils are located just inside the large end bell of Antenna AS-835/MPQ-4A.

WARNING

Extremely dangerous voltages exist in the indicator drawer. When removing or replacing parts, refer to each high voltage warning given for removal procedure.

b. Removal and Replacement of Cathode-Ray Tube V101. Removal and replacement of cathode. ray tube V101 is described in detail in TM 11-5840. 208-20.

c. Removal and Replacement of Filament Transformer T101 (fig. 3-67).

(1) *Removal.*

(a) Release the four indicator pawl fasteners and pull the drawer out.

(b) Unscrew the three cam-lock fasteners on the top-right hinged panel.

(c) Raise the hinged panel up until it locks in position.

(d) Tag, unsolder, and disconnect the leads on the standoff posts of T101,

(e) Unscrew the four locknuts which hold T101 to its mounting bracket.

(f) Remove T101 from the bottom-side of the indicator drawer.

(2) *Replacement.*

(a) Position T101 on the underside of the indicator drawer.

(b) Replace the four locknuts which hold T101 to its mounting bracket.

(c) Connect and solder the leads to the terminals of T101.

(d) Lower the hinged panel until it locks in position.

(e) Tighten the three cam-lock fasteners on the top-right hinged panel.

(f) Slide the indicator drawer in place and secure it with the four pawl fasteners.

d. Removal and Replacement of High Voltage Oscillator Transformer T161 (fig. 3-68).

WARNING

Since 2,000 volts may be present at terminals of T161, short terminal 1 of Z161 and J162 (high voltage output) with a shorting stick before proceeding.

(1) *Removal.*

(a) Repeat the procedure in *c* (1) *(a), (b)* and through *(c)* above.

(b) Unscrew the two Phillips-head screws which hold the cover plate on the mounting posts over T161.

(c) Tag, unsolder, and disconnect the leads on the standoff posts of T161.

(d) Unscrew the four nuts that hold T161 to the indicator main chassis.

(e) Remove T161 from the bottom of the indicator drawer.

(2) *Replacement.*

(a) Position T161 on the underside of the indicator drawer.

(b) Tighten the four nuts that hold T161 in position.

(c) Connect and solder the leads on the standoff posts of T161.

(d) Tighten the two Phillips-head screws that hold the cover plate on the mounting posts over T161.

(e) Repeat the procedure in *c* (2) *(d), (e),* and *(f)* above.

e. Removal and Replacement of Negative High Voltage Filter C161 (fig. 3-53).

(1) *Removal.*

(a) Release the four indicator pawl fasteners and pull the drawer out.

(b) Unscrew the three cam-lock fasteners on the top-left hinged panel.

(c) Raise the hinged panel up until it locks in position.

(d) Unscrew the two Phillips-head screws that hold the C161 mounting bracket to the indicator main chassis.

(e) Remove the mounting bracket.

(f) Tag, unsolder, and disconnect the leads to the terminals of C161.

(g) Remove C161 from the drawer.

(2) *Replacement.*

(a) Position C161 in the proper position in the drawer.

(b) Connect and solder the leads to the terminals of C161.

(c) Position the mounting bracket and secure it with the two Phillips-head screws.

(d) Lower the hinged panel until it locks into position and secure it with the three cam-lock fasteners.

(e) Slide the indicator drawer in place and secure it with the four pawl fasteners.

f. Removal and Replacement of High Voltage Rectifier Z161 (fig. 3-53).

(1) *Removal.*

WARNING

Approximately 14,000 volts exist at the

output of Z161 during normal operation. A residual charge exiete at output plug P162 end of cable W 161 and aquadag connector E161 after power has been removed. Be sure to discharge this residual charge by shorting the connectors to ground several times before touching the connector pine.

(a) Release the four indicator drawer pawl fastenera and pull the drawer out.

(b) Tag and disconnect the leads on Z161.

(c) Disconnect plug P162.

(d) Loosen the four screws holding Z161 in place and ~ it out of equipment.

(2) *Repkement.*

(a) Position Z161 in place in the indicator and secure it with the four screws.

(b) Connect plug P162.

(c) Connect the leads on Z161.

(d) Slide the indicator drawer in place and secure it **with the four pawl fasteners.**

g. *Removal and Replacement of Reluy K101 (fig. 3-67).*

(1) *Removal.*

(a) Release the four indicator pawl fasteners and pull the **drawer out.**

(b) Unscrew the three cam-lock fasteners on the top-right hinged panel and lift the panel.

(c) Tag and disconnect the leads on K101.

(d) Loosen **the four screws** holding K101 in place and lift out the relay.

(2) *Replacement.*

(a) Poeition K101 in its proper position and secure it with the four screws.

(b) Connect the leads on K101.

(c) Lower the panel in place and fasten it with the three cam-lock fasteners.

(d) Slide the **indicator drawer in place and secure it with four pawl fasteners.**

h. Removal and Replacement of Focus Cod L103 (fig. *3-50* and 3-69).

(1) *RemouaZ.*

(a) Tag, unsolder, and disconnect the leads to L103.

(b) Remove crt V101 as described in TM 11-5840-208-20.

(c) Loosen and remove the four Phillipe-head screws, **lockwashere, and flat washere from the focus coil.**

(d) Lift L103 from the chassis.

(2) Replacement.

(a) **Position** L103 on the chassis. Replace and **tighten the four Phillips-head screws, lock-washers, and flat washers.**

(b) Connect and solder the leads to L103.

(c) Replace the crt as described in **TM 11-**5840-208-20.

i. Removal and Replacement of Deflection Coil L102 (fig. 3-69).

(1) *Removal.*

(a) Remove crt V101 as described in TM 11-*5840-208-20.*

(b) Tag, unsolder, and disconnect the leads to L102.

(c) Loosen and remove the four Phillips-head screws, lockwashers, and flat washers from L102.

(d) Lift L102 from the chassis.

(e) Unsolder and disconnect resistors R143 through R150 from L102.

(2) *Replacement.*

(a) Connect and do not solder resistors R143 through R150 to L102.

(b) Place L102 in position and fasten it with the four Phillips-head screws, lockwashers, and flat washers.

(c) Connect and solder the leads to L102. Solder the resistors.

(d) Replace the crt as described in TM-11-5840-208-20.

3-34. Indicating and Synchronizing Systems Adjustment

a. General.

(1) This paragraph covers all the adjustments of the indicating and synchronizing systems when the components of the radar set are interconnected. All of the adjustment procedures in the indicating and synchronizing systems are performed on Azimuth and Range Indicator IP-375/MPQ-4A. The complete alignment and adjustment of the radar set are covered in section XII of this chapter.

(2) The following adjustments are covered in this paragraph:

(a) Long gate generator Z101 (*c* below).

(b) Timing sweep generator Z102 (pars 3-34 *e).*

(c) Delay trigger pickoff amplifier Z108 (para 3-34 *f).*

(d) Intensifier and short gate generator Z149 (para 3-34 *f).*

(e) Range sweep generator and driver Z144 (para 3-34 *d).*

(f) Azimuth synchronizer Z150 (para 3-34 *d).*

(g) Azimuth sweep generator and driver Z145 (para 3-34 *d).*

(h) Adjustment of precentering ring (para 3-34 *g).*

b. Test Equipment Required. Table 3-38 lists the items of test equipment that are required to align the synchronizing and indicating systems.

Table 3-38. Test Equipment Required for Alignment

Test equipment	Common name	Technical manual
Electronic Multimeter ME-26A/U	Vtvm	. . . . TM 11-6625-200-15
Electronic Counter, Digital Readout AN/USM-207	Electronic Counter	. . TM 11-6625-700-10
Oscilloscopes AN/USM-281C.	Oscilloscope	TM 11-6625-2658-14

c. Alignment of Long Gate Generator Z101.

(1) *General.* Adjustment of repetition rate coil L201 adjusts the repetition rate of the radar set. Repetition rate coil L201 controls the frequency of Hartley oscillator V201.

(2) *Procedure.*

(a) Connect a cable between the SIGNAL INPUT jack on oscilloscope AN/USM-281C and J108 (fig. 3-69) on the indicator.

(b) Insert the indicator test probe into TP201 (fig. 3-51).

(c) Adjust the oscilloscope to measure a 110-volt (peak-to-peak), 7,000-Hz input signal as described in TM 11-6625-1703-15. If the proper amplitude sine wave is obtained, regenerative amplifier V201 is operating properly.

(d) Disconnect the test probe from TP201.

(e) Connect the input lead of Electronic Counter AN/USM-207 to test point TP202.

(f) Set the counter for automatic operation with the display time out to the approximate midposition.

(g) Adjust REP RATE L201 on the counter for a count of 7000 Hz.

(h) Lock the tuning slug of REP RATE L201.

(i) Connect the test probe to test point TP204.

(j) Place RANGE SELECTOR switch S101 in the 15000M position.

(k) Check the oscilloscope presentation to make sure the amplitude of the positive gate present at TP204 is 14 volts minimum.

(l) Disconnect the test probe from TP204.

(m) Loosen the three cam-lock fasteners which hold the panel in place and lift the panel into its upright position.

(n) Check the following points with the test probe to determine if the long gate pulse observed in *(k)* above is present:

XZ102-J, XZ144-M, and pin 7 of V231.

Disconnect the oscilloscope.

Close and fasten the panels.

d. Alignment of Azimuth Synchronizer Z150, Azimuth Sweep Generator and Driver Z145, and Range Sweep Generator and Driver Z144.

(1) *General.* AZIM SYNCH GAIN potentiometer R547 adjusts the marker pulses from the antenna so that the synchronizing and indicating systems operate properly. VERTICAL CENTERING potentiometer R4409, VERT SIZE 15000M potentiometer R104, and VERT SIZE 3750M potentiometer R106 adjust the length of the vertical sweep on the crt. HOR CENTERING potentiometer R4517 and HOR SIZE potentiometer R4536 adjust the length of the horizontal sweep on the crt.

(2) *Procedures.*

(a) Unfasten the three cam-lock fasteners that hold the upper-right panel of the indicator and lift the panel.

(b) Connect the SIGNAL INPUT of the oscilloscope to J108. Insert the test probe in TP510.

(c) The presentation on the oscilloscope should indicate the presence of synchronizing pulses (fig. 3-57).

(d) Disconnect the test probe from TP510.

(e) Rotate AZIM SYNCH GAIN potentiometer R547 (fig. 3-53) fully counterclockwise.

(f) Connect the test probe to test point TP504.

(g) Rotate R547 clockwise until the proper waveform (fig. 3-58) is observed on the oscilloscope.

(h) Disconnect the test probe from TP504 and connect to TP506.

(i) Check to see that the waveform is correct.

(j) Rotate R547 clockwise until the waveform on the oscilloscope drops out of synchronization or the maximum rotation of R547 is reached.

(k) Set R547 to the approximate midpoint between a 0.3 and 0.4V waveform. The synchronizer should operate satisfactorily on pulses between the limits of 0.3 and 0.4 volt.

(l) Set the following controls (fig. 3-48 and 3-51) to their midpositions:

HOR CENTERING potentiometer R4517
HOR SIZE potentiometer R4536
VERTICAL CENTERING potentiometer. . R4409
VERT SIZE 15000M potentiometer R104
VERT SIZE 3750M potentiometer R106
RANGE ZERO potentiometer R116
RANGE SLOPE potentiometer R119
RANGE RATE adjustment C232

(m) Set the following controls (fig. 3-51 and 3-53) fully counterclockwise:

RANGE SHIFT potentiometer R4560
INTENSITY BALANCE potentiometer R112
SWP INTEN ADJ potentiometer R4657

(n) Set RANGE SELECTOR switch S101 in the 15000M position.

(o) Set RANGE SHIFT switch S103 to off.

(p) Turn INTENSITY adjustment R142 fully clockwise.

(q) slowly rotate AUXILIARY INTENSITY potentiometer R110 until the intensity of the trace is just visible.

(r) Adjust VERTICAL CENTERING potentiometer R4409 until the range sweep begins about 1/8 inch above the lower edge of the crt housing.

(s) Adjust VERT SIZE 15000M potentiometer R104 and VERT SIZE 3750M potentiometer R106 until the range sweep ends about 1/8 inch below the top edge of the crt housing. The vertical sweep length should be approximately 4½ inches long.

(t) Rotate HOR CENTERING potentiometer R4517 until the azimuth sweep begins about 1/8 inch to the right of the left edge of the crt housing.

(u) Adjust HOR SIZE potentiometer R4536 until the azimuth sweep ends about 1/8 inch to the left of the right side of the crt housing.

e. Alignment of Timing Sweep Generator Z102.

(1) *General.* RANGE SLOPE potentiometer R119 adjusts the slope of the sweep from gated miller sweep V231, and RANGE RATE capacitor C232 adjusts the rate of the sweep from V231.

(2) *Procedure.*

(a) Connect the test probe to test point TP234.

(b) Adjust the oscilloscope for an input frequency of 7,000 Hz.

(c) The wave form at TP234 should be a negative-going sawtooth of 210-volt magnitude beginning at +220 volts.

(d) Disconnect the test probe from TP234.

(e) Unfasten the three cam-lock fasteners that hold the panel and lift the panel upright.

(f) Connect the test probe to pin 1 of V231.

(g) Set the vertical gain of the oscilloscope to maximum.

(h) Adjust RANGE SLOPE potentiometer R119 to center of range and adjust RANGE RATE capacitor C232 until the waveform is a negative step of 2 volts with a width of 110 microseconds (fig. 3-97). The negative base, after the first microseconds, should be flat to within 0.2 volt.

(i) Disconnect the test probe.

(j) Close the panel and fasten the three cam-lock fasteners.

f. Alignment of Delay Trigger Pickoff Amplifier Z108 and Intensifier and Short Gate Generator Z149.

(1) General. SWP INTEN ADJ potentiometer R4657 is the plate load resistor for V4652B. Adjustment of R4657 varies the voltage applied to the grid of intensifier V4655. HF COMP capacitor C4658 sharpens the intensified portion of the sweep. HF COMP capacitor C4656 sharpens the start of the sweep on the crt. SWP SIZE ADJ potentiometer R4660 adjusts the duration of the short gate.

(2) *Procedures.* Connect a cable between the SIGNAL INPUT connector on Oscilloscope AN/USM-50 and EXT TEST connector J108.

(a) Connect the test probe to TP404 on delay trigger pickoff amplifier Z108.

(b) Observe the oscilloscope to determine that the proper waveform (fig. 3-56) is present at TP404.

(c) Disconnect the test probe from TP404.

(d) Set EXPANDED SWEEP DELAY switch AT101 to the 1.5 position.

(e) Rotate SWP INTEN ADJ potentiometer R4657 (fig. 3-53) slowly until a portion of the sweep on the crt is slightly brighter than the test of the sweep.

(f) Adjust FOCUS adjustment R121 for best overall focus.

(g) Place RANGE SELECTOR switch S101 in the 3750M position.

(h) Adjust INTENSITY BALANCE potentiometer R112 until the relative brightness of the presentation on the crt is the same as the presentation when S101 is in the 15000M position.

(i) Check the focus at both positions of S101.

(j) Place S101 in the 3750M position.

(k) Adjust HF COMP adjustment C4656 (fig. 3-53) until the best sweep start is obtained.

(l) Place S101 in the 15000M position.

(m) Adjust HF COMP adjustment C4658 until the intensified sector on the sweep is sharpest.

(n) Connect the test probe to test point TP4652.

(o) Adjust SWP SIZE ADJ potentiometer R4660 for a gate for approximately 30 microseconds.

(p) Disconnect the test probe,

(q) Rotate EXPANDED SWEEP DELAY switch AT101 from 0 to 15. The intensified 3,750 meter portion of the sweep should move upward in 1,500 meter jumps.

(r) Rotate AZIMUTH MARK adjustment R132. A vertical marker should be visible on two of the vertical sweeps.

(s) Place RANGE SHIFT switch S103 in the ON position. Note the position of the 3,760 meter intensified portion of the sweep.

(t) Adjust RANGE SHIFT R4560 until the jump between the two vertical sweeps is approximately 750 meters (approximately ½ inch).

(u) Rotate PLOTTER DIMMER control R113. The reflection plotter lights should become brighter when R113 is rotated clockwise.

(v) Rotate PANELDIMMER control R133. The intensity of the lights above the clock and behind the left-side control should vary.

(w) Check the stop and start of the clock with both TIMER switches S106 and S107. Press TIMER switch S106 or S107. The clock hand should move until either S106 or S107 is pressed.

(x) Place BEAM VIDEO selector switch S110 in either the UPPER or LOWER position.

(y) Press TIMER switch S106. The video presentation should switch from one beam to the other. (RANGE SHIFT switch S103 must be in the ON position.)

NOTE

The upper raster displays upper beam video and the lower raster displays lower beam video during range shift. No blanking should occur when BEAM VIDEO selector switch S110 is in the BOTH position.

g. Adjustment of Precentering Ring.

(1) *General.* The precentering ring adjustment is used to adjust the angle of the electron beam so that the beam passes through the center of the focus coil.

(2) *Procedures.*

(a) Loosen the two thumb-screws (fig. 3-69).

(b) Adjust the precentering ring until the raster is centered on the crt screen.

(c) Vary FOCUS potentiometer R121 from one extreme to the other. If the vertical and horizontal axes of the raster vary, adjust the shunt ring.

(d) Tighten the thumbscrews.

3-35. Indicating and Synchronizing Systems Testing

a. General. This paragraph covers testing procedures designed to check the serviceability of a repaired indicating system when the components of the radar set are interconnected. Testing procedures designed to check the serviceability of the complete radar set are covered in section XII of this chapter.

b. Test Equipment Required. Table 3-39 lists the items of test equipment that are required to check completely the serviceability of the indicating system.

c. Testing Procedures. The procedures contained in this paragraph are designed to check completely the serviceability of the indicator. The controls in table 3-40 should be rotated to their extreme counterclockwise positions.

(1) Turn MAIN POWER switch S652 ON.

(2) Check the presentation on the indicator tube. There should be no picture.

(3) Check the voltage at the points indicated in table 3-41.

Table 3-39. Test Equipment Required to Check the Serviceably of the Indicating System

Test equipment	Common name	Technical manual
Multimeter TS-352B/U	Multimeter	TM 11-6625-366-15
Electronic Counter, Digital Readout AN/USM-207	Electronic counter	TM 11-6625-700-10
Oscilloscope AN/USM-281C	Oscilloscope	TM 11-6625-2658-14

Table 3-40. Presetting for Controls

Control	Location (fig.)
HV ADJ potetiometer R164	3-53
AUXILIARY INTENSITY potentiometer R110	3-51
INTENSITY adjustment R142	3-48
VIDEO adjustment R102	3-48
AZIMUTH MARK adjustment R132	3-48
RANGE MARK adjustment R103	3-48

Table 3-41. Voltage Checks

Check point	Voltage	Location (fig.)
Z102 (pin M of XZ102)	+440 v dc	3-67
TB101-7	+220 v dc	3-67
TR101-12	–220 v dc	3-67
T101 (between terminals 1 and 3).	120 v ac	3-67
Between terminals 1 and 4 on M101 terminal board when RESET switch S108 is pressed.	+27 v dc	3-67

d. Testing.

(1) *Long gate generator Z101.*

(a) Set INTENSITY adjustment R142 to its extreme counterclockwise position.

(b) Set trigger selector switch S109 (fig. 3-69) to the MASTER position. This switch is located on the top-rear center section of the indicator cabinet.

(c) Turn MAIN POWER switch S652 ON.

(d) Rotate INTENSITY adjustment R142 clockwise. If a vertical trace appears, the gate generator is functioning.

(e) Remove V231 from the timing sweep generator. The vertical trace should lengthen.

(f) Replace V231. The trace should now shorten. This indicates that the cutoff is functioning.

(2) *Timing sweep generator Z102.*

(a) Set INTENSITY adjustment R142 and RANGE MARK adjustment R103 to their counterclockwise stop positions.

(b) Set RANGE SLOPE adjustment R119 to an approximate midway position.

(c) Rotate INTENSITY adjustment R142 clockwise until a raster is just visible.

(d) Rotate RANGE MARK adjustment R103 clockwise. An intensified horizontal trace should appear.

(e) Set RANGE SELECTOR switch S101 to 15000M.

(f) Rotate the LOWER BEAM RANGE handwheel on the computer throughout its range. The trace on the crt should move evenly throughout the vertical sweep range.

(3) *Range zero trigger pickoff amplifier Z107.*

(a) Set RANGE SELECTOR switch S101 to 15000M .

(b) Set INTENSITY adjustment R142 to give desired brightness.

(c) Set VIDEO adjustment R102 to its counterclockwise stop.

(d) Adjust RANGEMARK adjustment R103 so that a horizontal trace appears on the B-scope.

(e) Rotate RANGE ZERO potentiometer R116 continuously throughout the entire range and check to see that the range mark trace moves continuously and without any discrete jumps.

(4) *Intensifier and short gate generator Z149.*

(a) Set RANGE MARK adjustment R103, AZIMUTH MARK adjustment R132, and SWP INTEN ADJ adjustment R4657 to their counterclockwise stops.

(b) Set INTENSITY BALANCE adjustment R112 and INTENSITY adjustment R142 to their approximate midpositions.

(c) Set EXPANDED SWEEP DELAY switch AT101 to 4.5.

(d) A picture (square raster) should be seen on the B-scope.

(e) Turn SWP INTEN ADJ adjustment R4657 clockwise. The presentation should be a portion 25 percent brighter than the rest of the sweep.

(f) Rotate EXPANDED SWEEP DELAY switch AT101. The intensified portion should move upward in consistent jumps as the switch is stepped clockwise.

(g) Vary SWP SIZE ADJ adjustments R4660. The length of the intensified portion should increase with clockwise rotation.

(h) Set RANGE SELECTOR switch S101 to 3750M.

(i) Vary INTENSITY BALANCE adjustment R112. The sweep intensity should increase with clockwise rotation.

(j) Vary INTENSITY adjustment R142. Check to see that the intensity on the B-scope varies.

(k) Increase the gain of AZIMUTH MARK adjustment R132. A vertical line should appear.

(l) Connect the indicator test probe to test point TP4655.

(m) Connect a lead from the SYNC INPUT connector of Oscilloscope AN/USM-281C to jack J105 on the indicator.

(n) Adjust the oscilloscope for external synchronization as described in TM 11-6625-2658-14.

(o) The presentation on the oscilloscope should be intensity blanked during azimuth deadtime.

(p) Disconnect the oscilloscope from TP4655 and J105.

(5) *Modulator trigger generator Z147.*

(a) Set RANGE SELECTOR switch S101 to 3750M.

(b) Set EXPANDED SWEEP DELAY switch AT101 to 0.

(c) Vary INTENSITY adjustment R142 until a vertical sweep is visible.

(d) Connect the indicator test probe to J101.

(e) Connect TP503 (fig. 3-53) on the azimuth synchronizer, to ground momentarily. During the grounding, no pulse should appear at J101.

(f) Adjust FOCUS adjustment R121. (Raster lines should focus sharply at one position of adjustment.)

(6) *Range sweep generator Z144.*

(a) Set RANGE SELECTOR switch S101 to 15000M.

(b) Set RANGE SHIFT adjustment R4560, INTENSITY adjustment R142, and VIDEO adjustment R102 fully counterclockwise.

(c) Set VERTICAL CENTERING adjustment R4409 in its approximate rnidposition.

(d) Set VERT SIZE 15000M and VERT SIZE 3750M adjustments R104 and R106 in their approximate midpositions.

(e) Turn INTENSITY adjustment R142 clockwise so that a sweep is visible on the B-scope.

(f) Set VERTICAL CENTERING adjustment R4409 so that the range sweep begins ½ inch above the lower edge of the B-scope.

(g) Set VERT SIZE 15000M adjustment R104 for the 15,000-meter range so that the range sweep ends ½ inch below the top of the B-scope.

(h) Set VERT SIZE 3750M adjustment R106 to obtain the same sweep size on the 3750-meter range. This should result in total sweep lengths of approximately 4 inches.

(i) Set RANGE SHIFT switch S103 to ON.

(j) Advance RANGE SHIFT adjustment R4560 clockwise. Observe that the proper shift appears on the B-scope. At maximum setting on R4560, the shift on the B-scope should be approximately ¼ inch for the 15,000-meter range and 1 inch for the 3750-meter range.

(k) Return R4560 to its approximate midposition.

(7) *Video amplifier Z148.*

(a) Set INTENSITY adjustment R142 and RANGE MARK ADJUSTMENT R103 completely clockwise.

(b) Set VIDEO adjustment R102A and VIDEO CLIPPING adjustment R4612 completely clockwise.

(c) Set RANGE SELECTOR switch S101 to 15000M.

(d) Increase INTENSITY adjustment R142 until a sweep is barely visible.

(e) Connect a lead from TP404 of Z109 to J104.

(f) Rotate the LOWER BEAM RANGE handwheel of the computer. An intensified trace should appear on the B-scope and should vary in steps as the LOWER BEAM RANGE handwheel is varied.

(g) Increase the gain of RANGE MARK adjustment R103.

(h) An intensified trace should appear and should vary with the range setting of the LOWER BEAM RANGE handwheel of the computer.

(i) Check video blanking by shorting pin C to -220V. The trace on the B-scope should disappear.

(j) Increase the gain of VIDEO adjustment R102A until the trace blooms in the B-scope. Now turn VIDEO CLIPPING adjustment R4612 counterclockwise. The intensified trace should decrease in intensity.

(8) *Azimuth synchronizer Z150.*

(a) Set INTENSITY adjustment R142 and AZIMUTH MARK adjustment R132 fully counterclockwise.

(b) Rotate INTENSITY adjustment R142 clockwise so that a presentation is just visible on the B-scope.

(c) Set AZIM SYNCH GAIN adjustment R547 so that a normal azimuth sweep appeara on the B-scope.

(d) Rotate AZIMUTH MARK adjustment R132. A vertical marker should be visible on the B-scope. It should appear on about two of the vertical scan lines.

(e) Set RANGE SHIFT switch S103 to ON.

(f) Set RANGE SHIFT adjustment R4560 fully clockwise.

(g) Set RANGE SELECTOR switch S101 to 15000M. The amount of range shift on the B-scope should be approximately ¼ inch.

(h) Connect the SYNC INPUT lead of Oscilloscope AN/USM-281C to J105.

(i) Connect. the indicator test probe to J101.

(j) Adjust the oscilloscope as directed in TM 11-6625-2658-14.

(k) No triggers should appear on the oscilloscope during azimuth deadtime.

(9) *Azimuth sweep generator Z145.*

(a) Set HOR CENTERING adjustment R4517 and HOR SIZE adjustment R4536 in their approximate midpositions.

(b) Set INTENSITY adjustment R142 and VIDEO adjustment R102 fully counterclockwise.

(c) Rotate INTENSITY adjustment R142 clockwise so that a sweep is just visible on the B-scope.

(d) Set HOR CENTERING adjustment R4517 so that the left edge of the presentation begins about ½ inch inside the left edge of the B-scope.

(e) Set HOR SIZE adjustment R4536 so that the right edge of the presentation ends about ½ inch inside the right edge of the B-scope.

(10) *Video blanking Z146.*

(a) Set INTENSITY adjustment R142 fully counterclockwise.

(b) Set RANGE SELECTOR switch S101 to 1500M .

(c) Increase INTENSITY adjustment R142 until a raster is visible.

(d) By turning RANGE SHIFT switch S103 to the ON position, the raster associated with

the upper beam should be displaced upward on the B-scope. Varying RANGE SHIFT adjustment R4560 should cover a range of displacement from 1/16 inch to ¼ inch on the long range, and from the ¼ inch to 1 inch on the short range.

(e) Connect a lead from TP404 of Z109 to J104. With RANGE SHIFT switch S103 ON, turn BEAM VIDEO selector switch S110 through its three positions and check for the following:

BEAM VIDEO selector switch position	Video result
LOWER beam video	Trace on lower raster.
BOTH beam video	Double video trace.
UPPER beam video	Trace on upper raster.

Section VIII. COMPUTING SYSTEM TROUBLESHOOTING AND REPAIR

3-36. Computing System Troubleshooting information

a. Reference Data. The following information will be helpful when troubleshooting and/or repairing the computing system.

Reference	Data
Fig. FO-14	Computing system, data flow chart.
Para 2-26 and 2-27	Functioning of circuits in the computing system.
Fig. FO-29	Range subassembly, schematic diagram.
Fig. FO-30	Azimuth subassembly, schematic diagram.
Fig. 3-136	Time subassembly, schematic diagram.
Fig. 3-137	Height subassembly, schematic diagram.
Fig. 3-138	Elevation subassembly, schematic diagram.
Fig. FO-31	C-subassembly, schematic diagram.
Fig. FO-32	Coordinate subassemblies, schematic diagram.
Fig. FO-33	Booster and dual speed cutover amplifiers AR951, schematic diagram.
Fig. FO-34	Dual isolation amplifier AR901, schematic diagram.
Fig. FO-35	Dual eervoamplifiers AR926 through AR929, schematic diagram.
Fig. FO-36	Computer front panel assembly, schematic diagram.
Fig. FO-37	Computer chassis, schematic diagram.
Fig. 2-109	Elevation subassembly, simplified gearing diagram.
Fig. 2-117	Coordinate subassemblies, simplified gearing diagram.
Fig. FO-10	Azimuth subassembly, simplified gearing diagram.
Fig. 2-119	Height subassembly, simplified gearing diagram.
Fig. 2-116	C-subassembly, simplified gearing diagram.
Fig. 3-96	Radar Data Computer CP-319/MPQ-4A, front panel.
Fig. 3-99	Computer alignment potentiometer panel and test jacks.
Fig. 3-100	Radar Data Computer CP-319/MPQ-4A, bottom view of drawer.
Fig. 3-101	Partial left-side view of computer, showing beam separation dial and E_L adjustment.
Fig. 3-102	Radar Data Computer CP-319/MPQ-4A, drawer puller out, showing calibrated C-gears.
Fig. 3-103	Rear of computer front panel with mechanical subassemblies removed.
Fig. 3-104	Dual servoamplifier, top view.
Fig. 3-105	Coordinate subassembly, rear view.
Fig. 3-106	Range subassembly, rear view.
Fig. 3-107	Azimuth subassembly, left-side view.
Fig. 3-108	Booster and dual speed cutover amplifiers, top view.
Fig. 3-109	Computer chassis, lower decks, left-side view.
Fig. 3-110	Control- indicator cabinet, showing computer interlock switch S1006 and cabling connectors.
Fig. FO-19	Reference to transformer T861 and computer alignment potentiometers, schematic diagram.
Fig. 3-111	Computer drawer, showing mechanical subassemblies, top view.
Fig. 3-112	Calibrated C-gears.
Fig. 3-113	C-subassembly, front view.
Fig. 3-114	Dual isolation amplifier, top view.
Fig. 3-115	C-subassembly, right-side view.
Fig. 3-116	Coordinate subassembly, front view.
Fig. 3-117	Azimuth subassembly, front view.
Fig. 3-118	Azimuth subassembly, rear view.
Fig. 3-119	Azimuth subassembly, right-side view.
Fig. 3-120	Height subassembly, rear view.
Fig. 3-121	Height subassembly, front view.
Fig. 3-122	Range subassembly, left-side view.
Fig. 3-123	Range subassembly, front view.
Fig. 3-124	Range subassembly, right-side view.
Fig. 3-125	Time subassembly, front view.
Fig. 3-126	Time subassembly, right-side view.
Fig. 3-127	Time subassembly, left-side view.
Fig. 3-128	Elevation subassembly, front view.
Fig. 3-129	Elevation subassembly, left-side view.
Fig. 3-130	Dual servoamplifier, bottom view.
Fig. 3-131	Dual isolation amplifier, bottom view.
Fig. 3-132	Booster and dual speed cutover amplifier, bottom view.
Fig. 3-133	Dual isolation amplifier AR901, voltage and resistance diagram.

Referance	Data
Fig. 3-134	Dual servoamplifiers AR926 through AR929, voltage and resistance diagram.
Fig. 3-135	Booster and dual speed cutover amplifiers AR951, voltage and resistance diagram.
Fig. FO-7	Computing system, block diagram.
Fig. 2-110	Set detent and azimuth orient indicator lamp circuits.
Fig. 2-113...............	Range subassembly, simplified gearing diagram.
Fig. 2-114	Time potentiometer, simplified schematic diagram.

Reference	Data
Fig. 2-115	Time subassembly, simplified gearing diagram.
Fig. 2-118	Height section, schematic diagram.
Fig. FO-8	Elevation section, schematic diagram.
Fig. FO-9	Azimuth section, schematic diagram (sheet 1 of 2) .
Fig. FO-9	Azimuth section, schematic diagram (sheet 2 of 2).
Fig. FO-10	Range section, schematic diagram.
Fig. FO-12..........	C section, schematic diagram.
Fig. FO-13..........	Coordinate sections, schematic diagram.

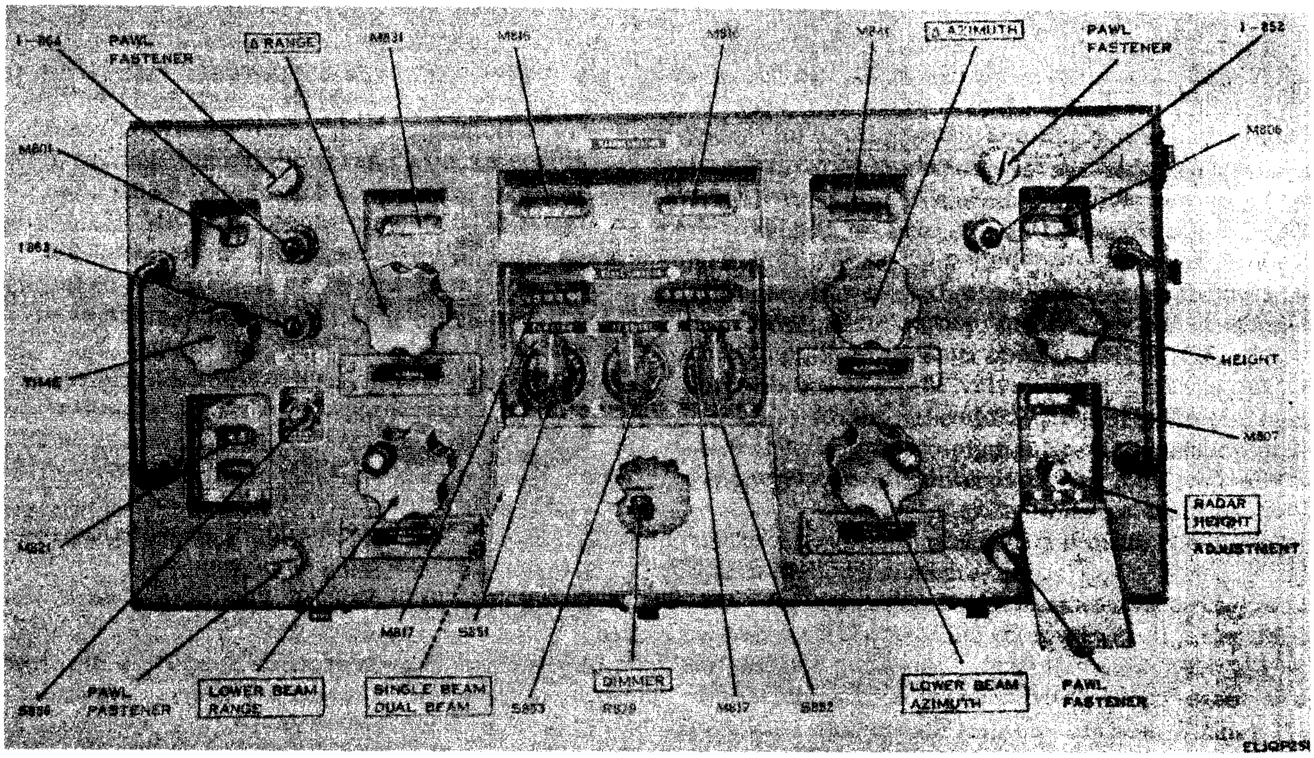


Figure 3-98. Radar Data Computer CP-319/MPQ4A, front panel,

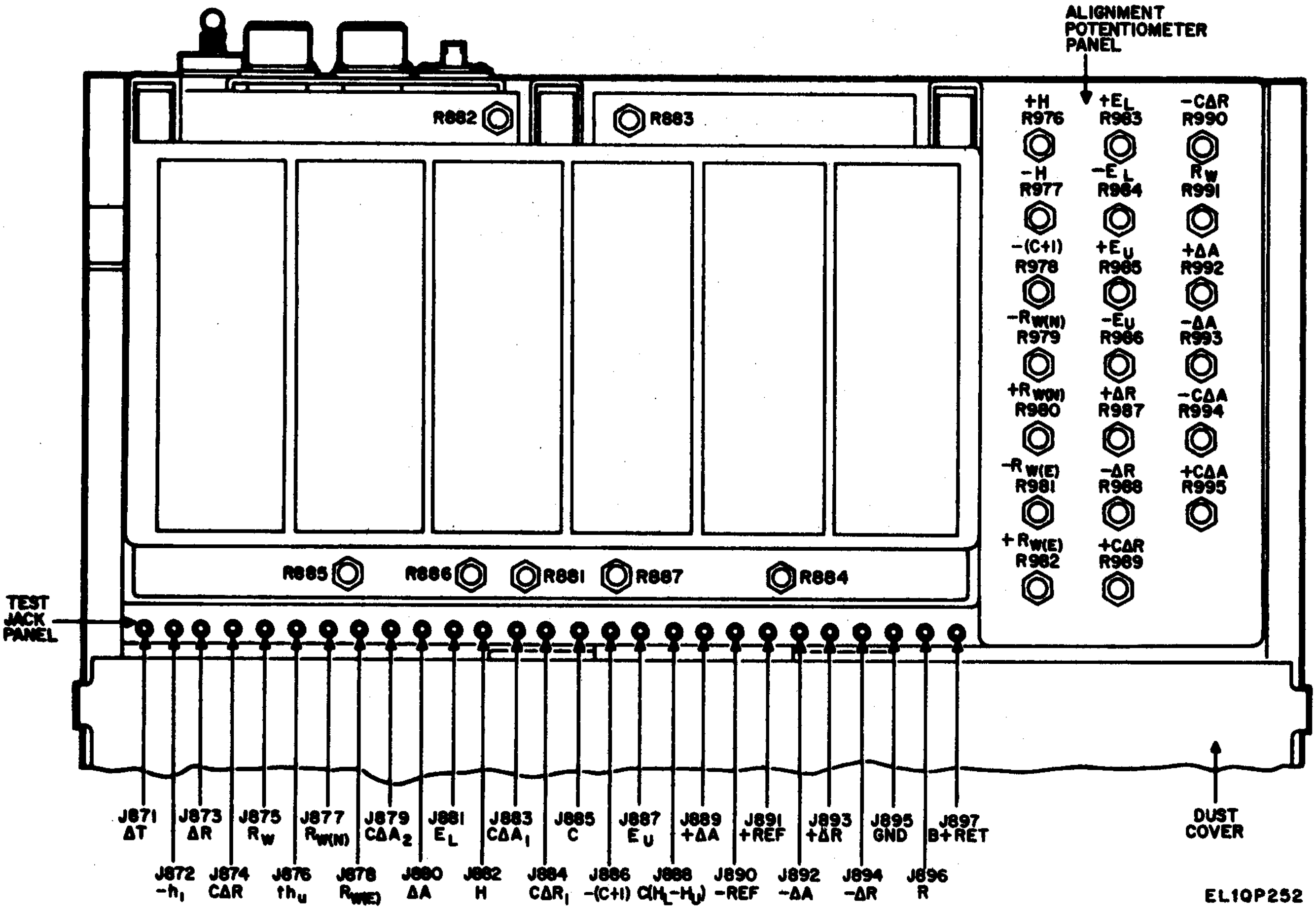


Figure 3-99. Computer alignment potentiometer panel and test jacks.

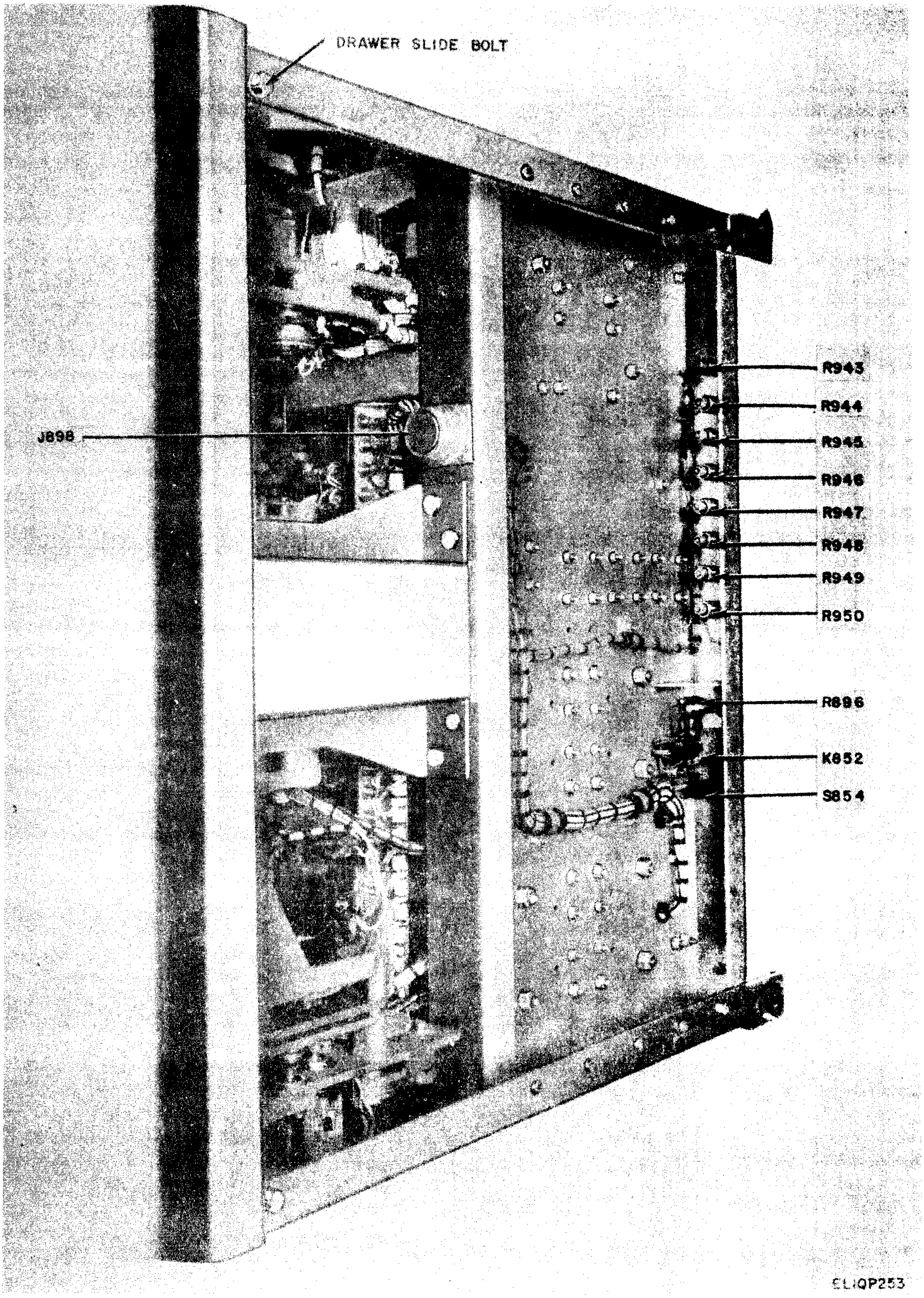


Figure 3-100. Radar Data Computer CP-319/MPQ-4A, bottom view of drawer.

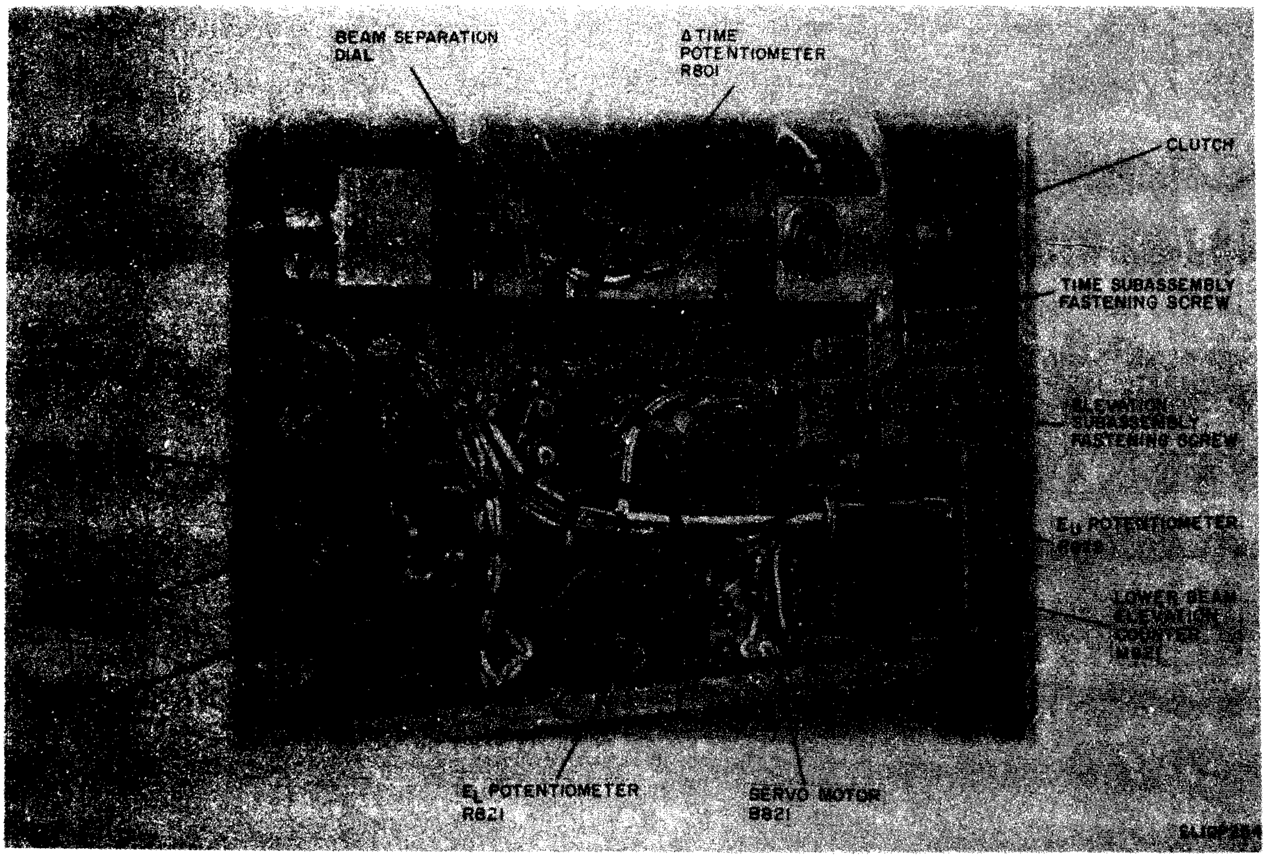


Figure 3-101. Partial left-side view of computer, showing beam separation dial and E_1 adjustment.

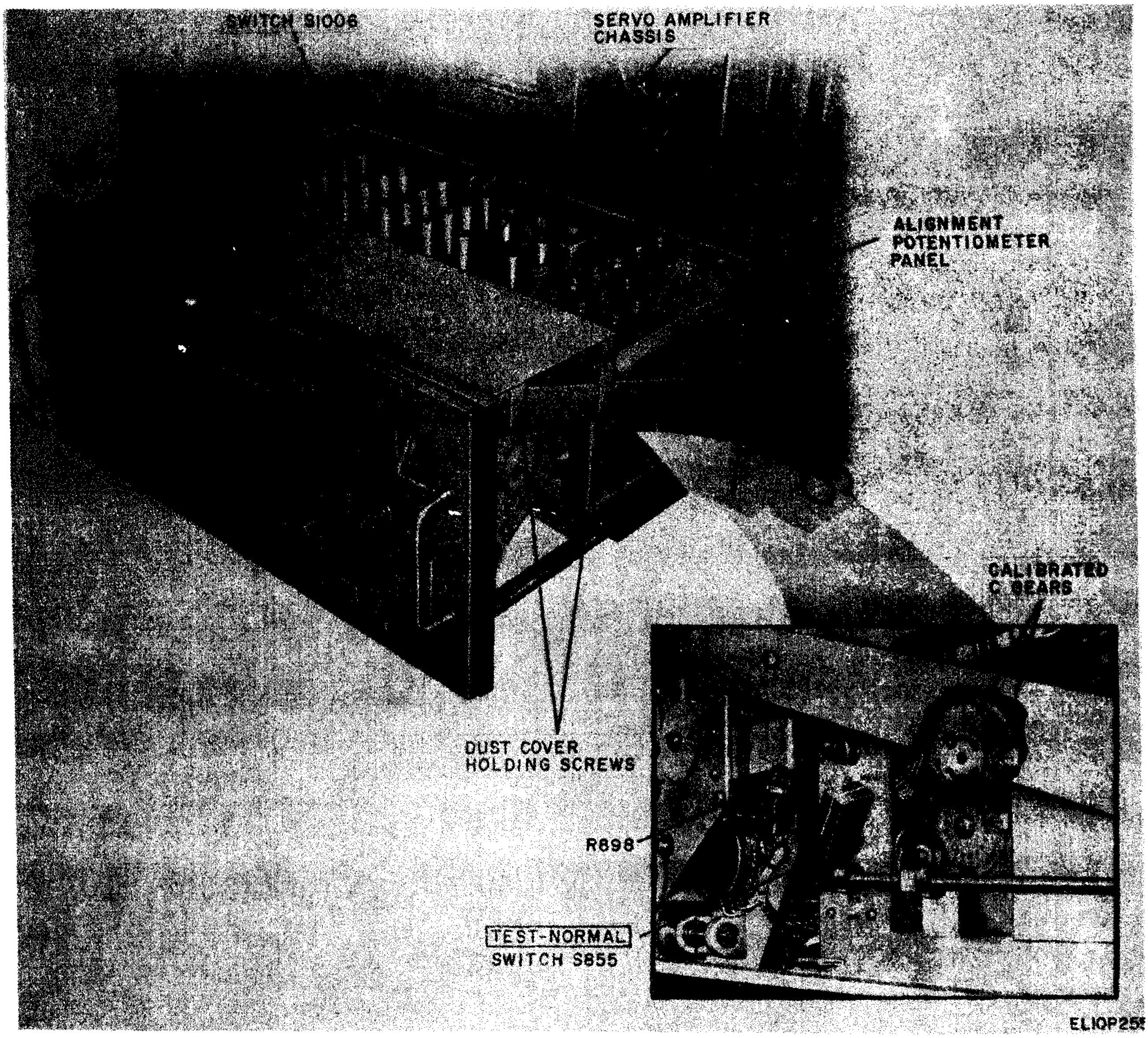


Figure 3-102. Radar Date Computer CP-319/MPQ-4A, drawer pulled out showing calibrated C gears.

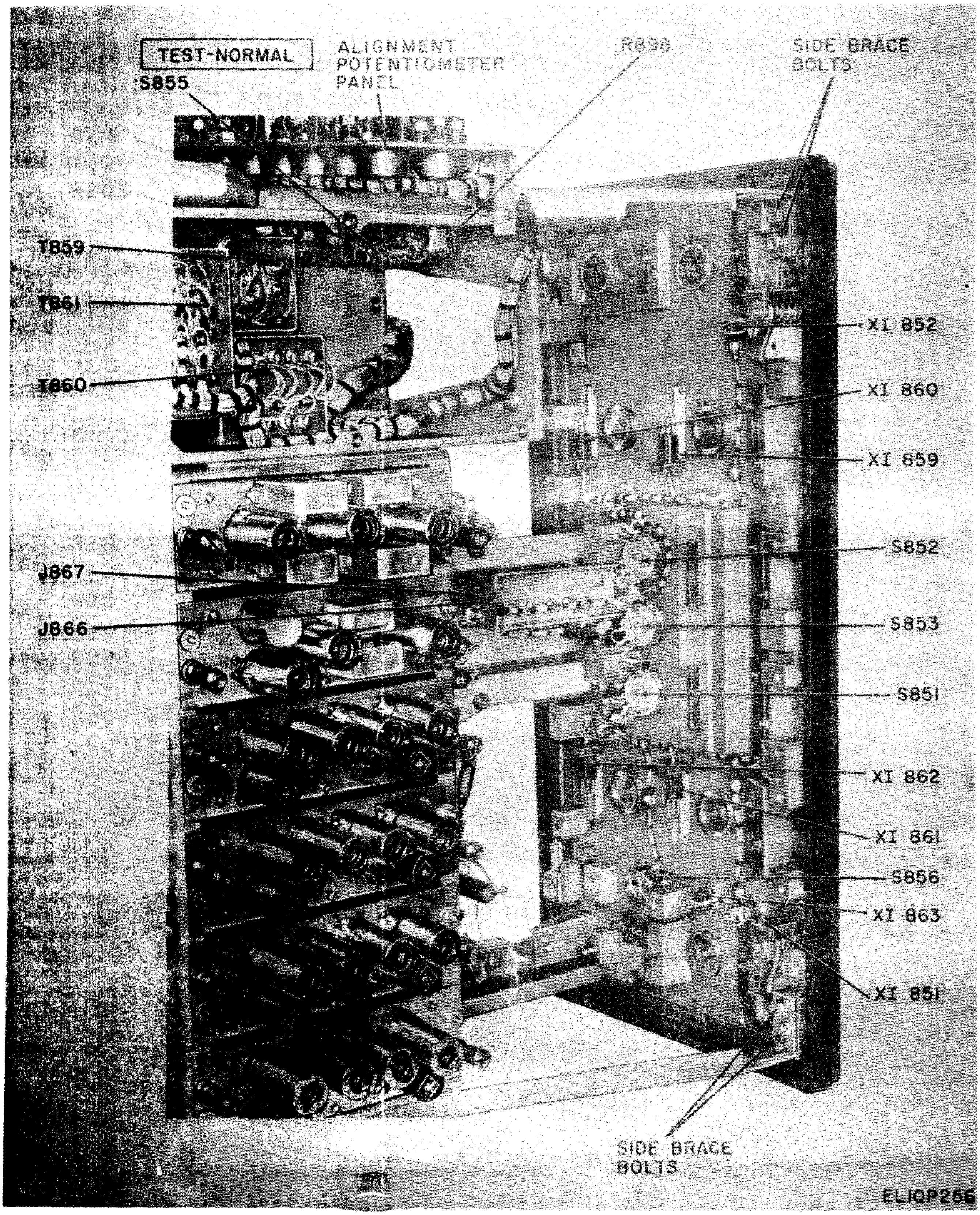


Figure 3-103. Rear of computer front panel with mechanical subassemblies removed.

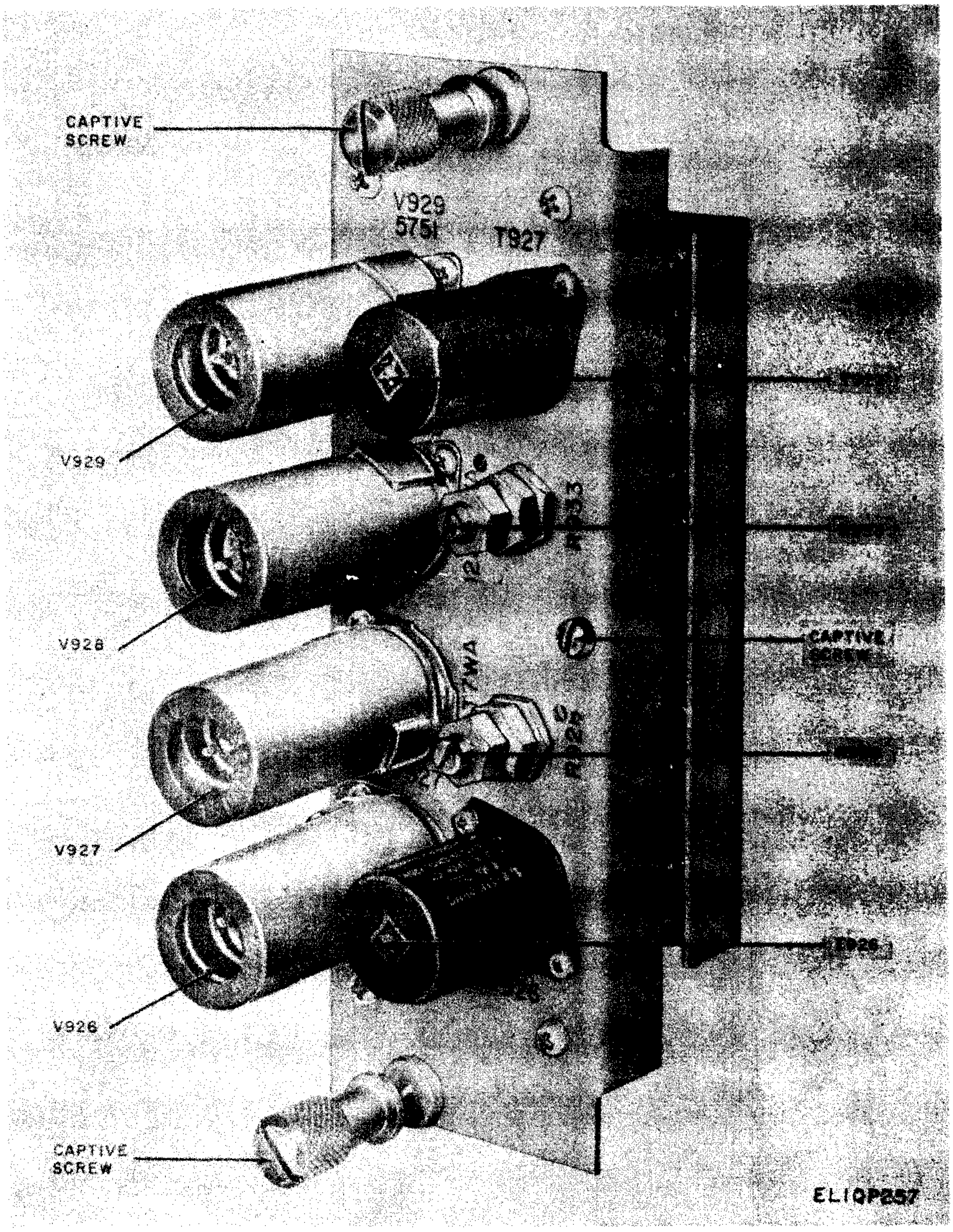


Figure 3-104. Dual servoamplifier, top view.

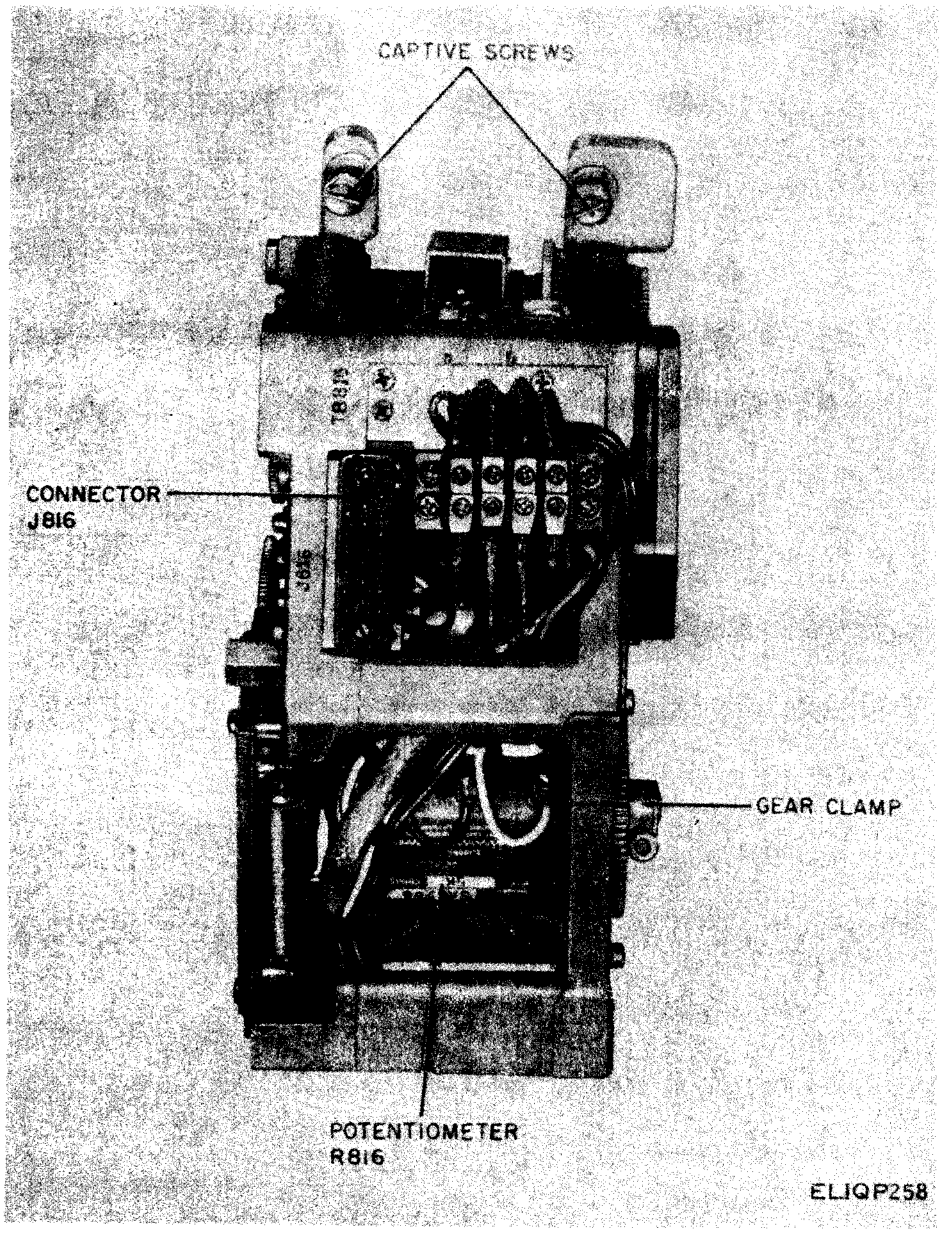


Figure 3-105. Coordinate subassembly, rear view

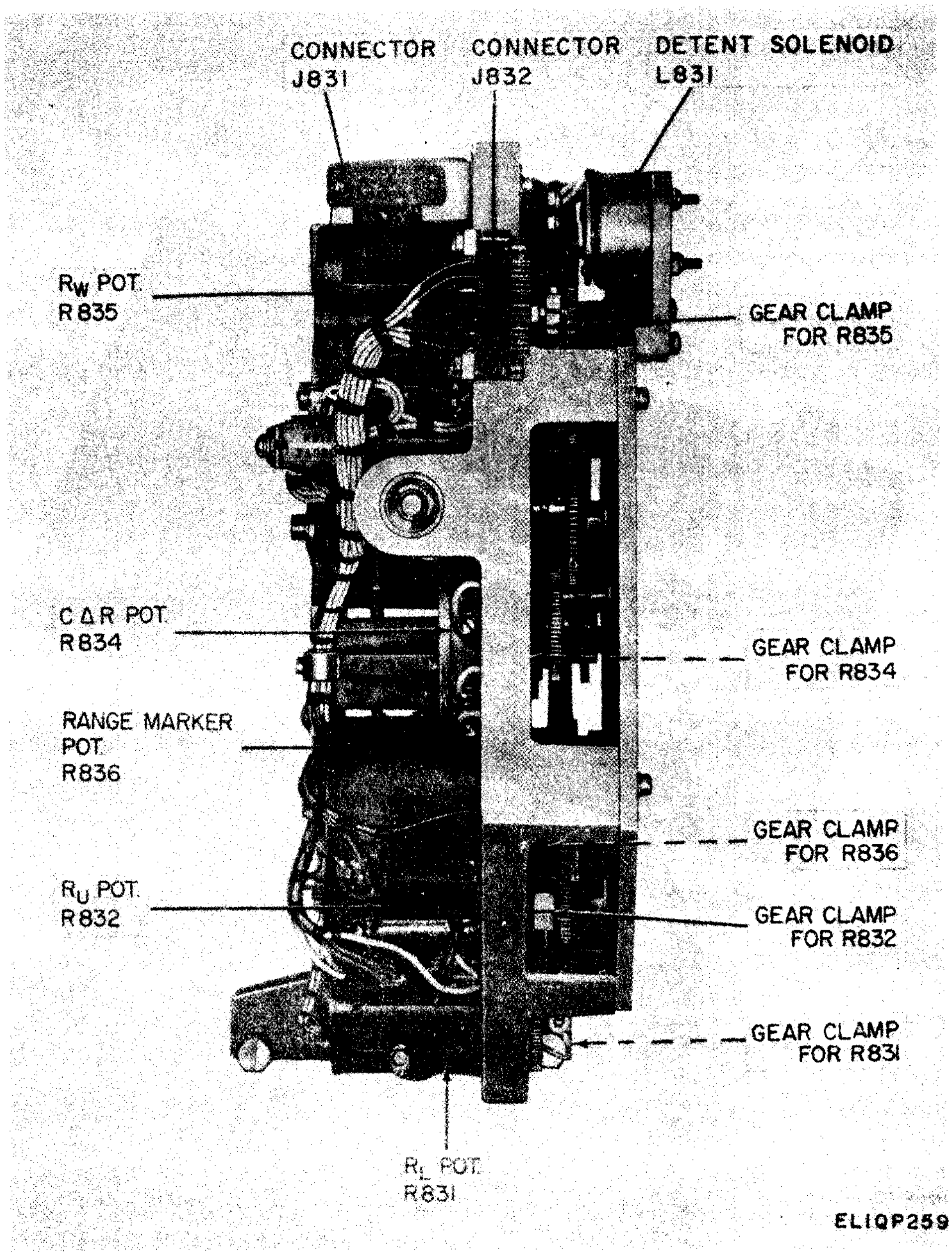


Figure 3-106. Range subassembly, rear view.

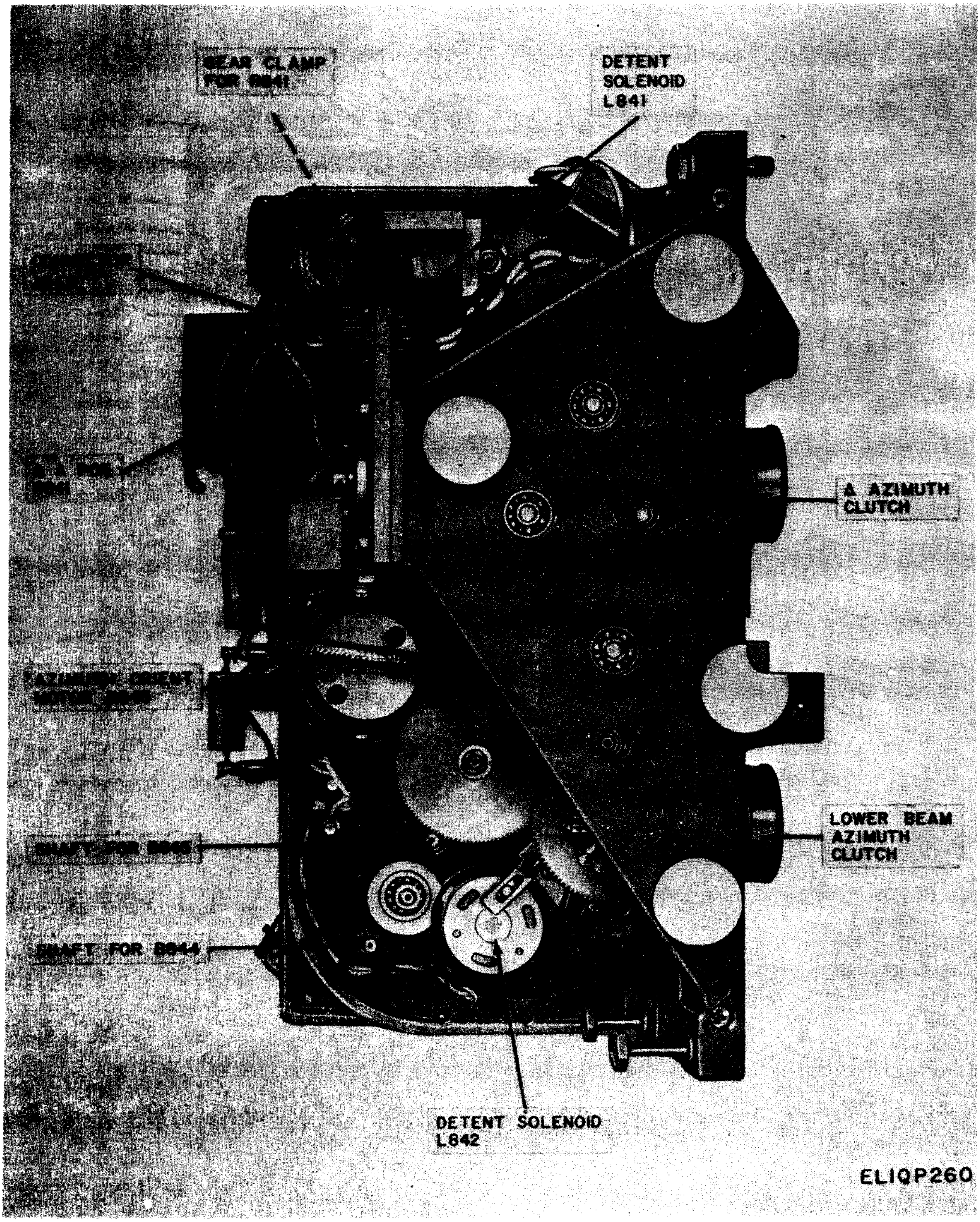


Figure 3-107. Azimuth subassembly, left-side view.

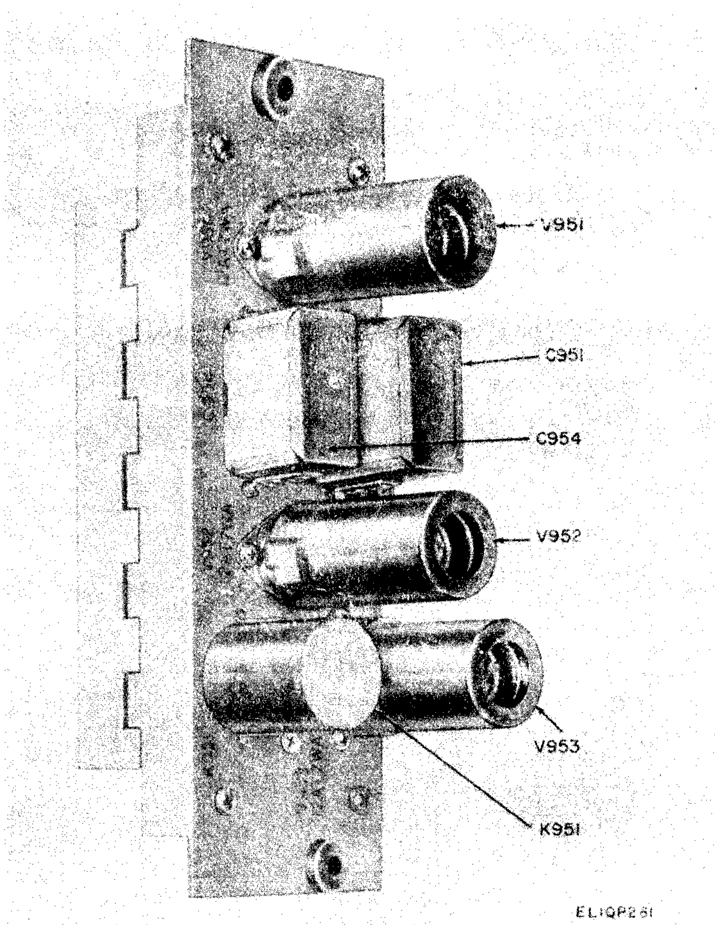


Figure 3-108. Booster and dual speed cutover amplifiers, top view.

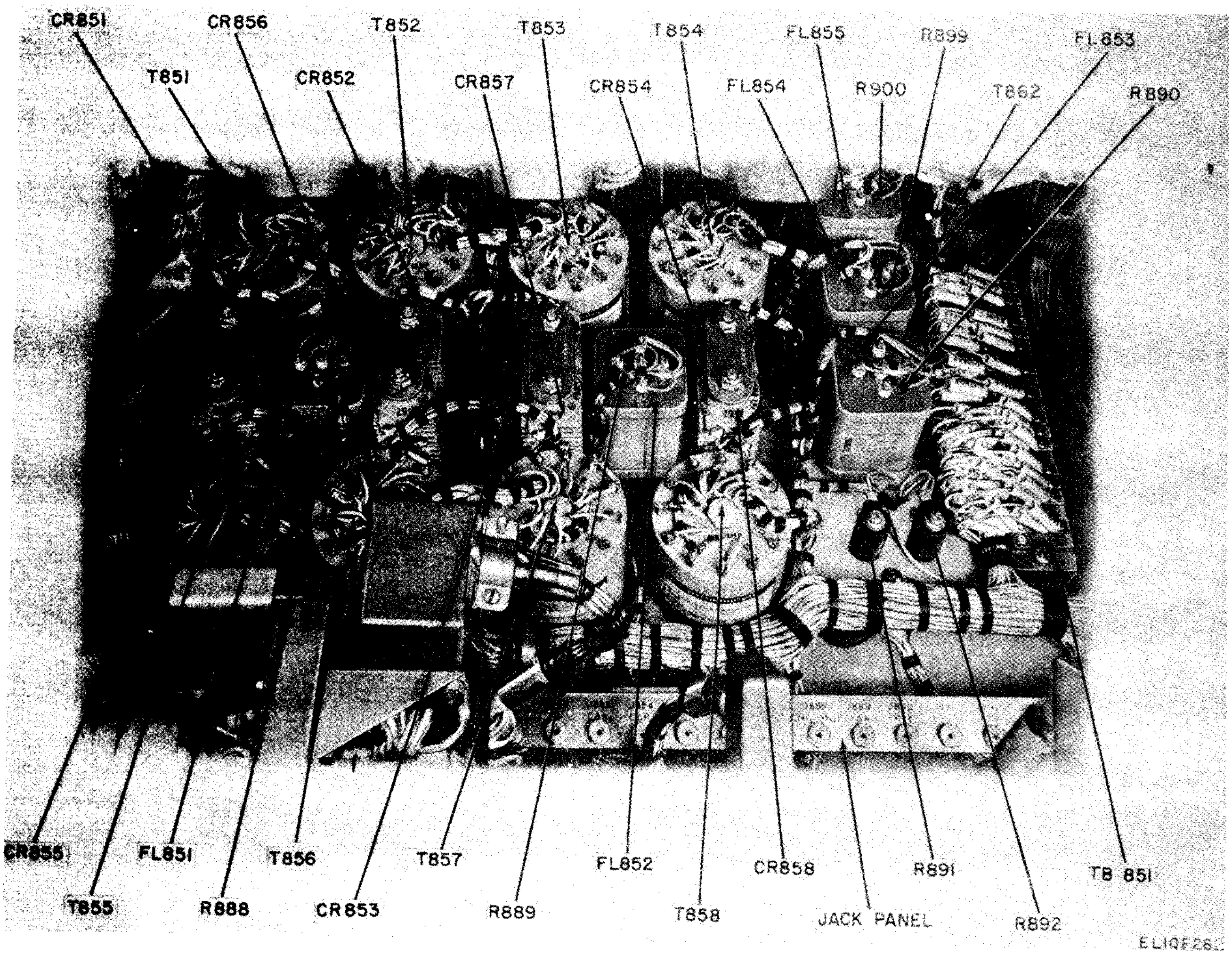


Figure 3-109. Computer chassis, lower deck, left-side view.

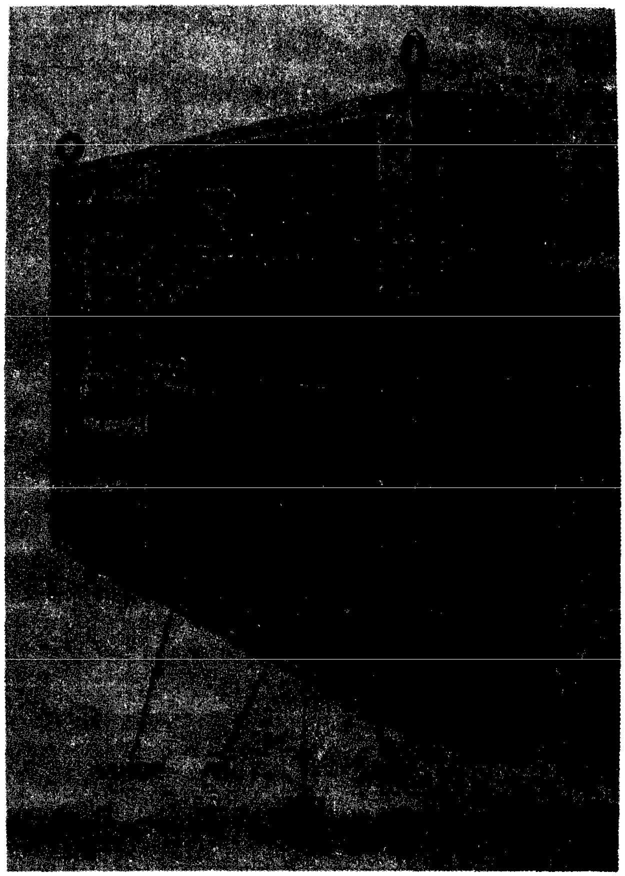


Figure 3-110. Control-indicator cabinet, showing computer interlock switch and cabling connectors.

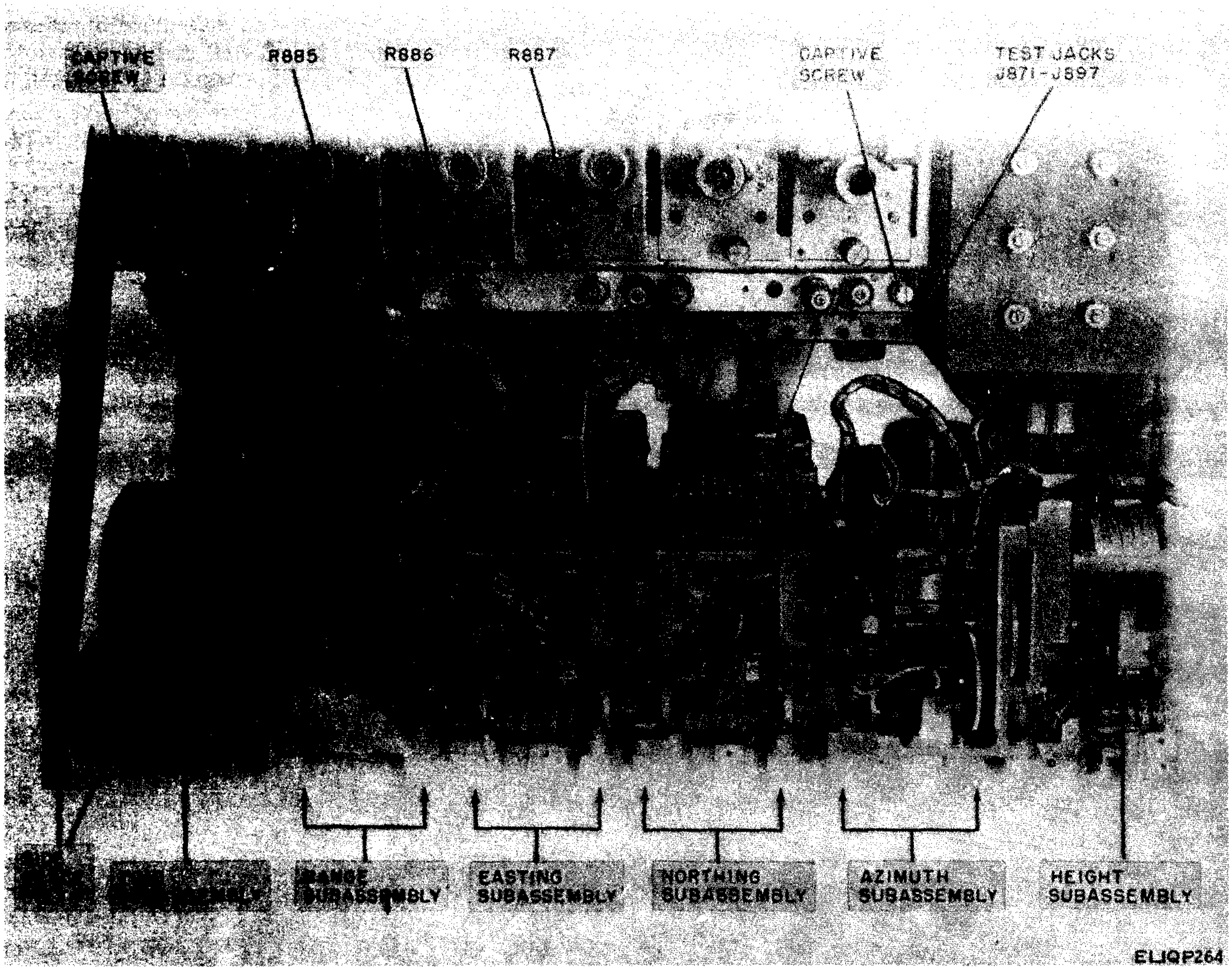


Figure 3-111. Computer drawer, showing mechanical subassemblies, top view.

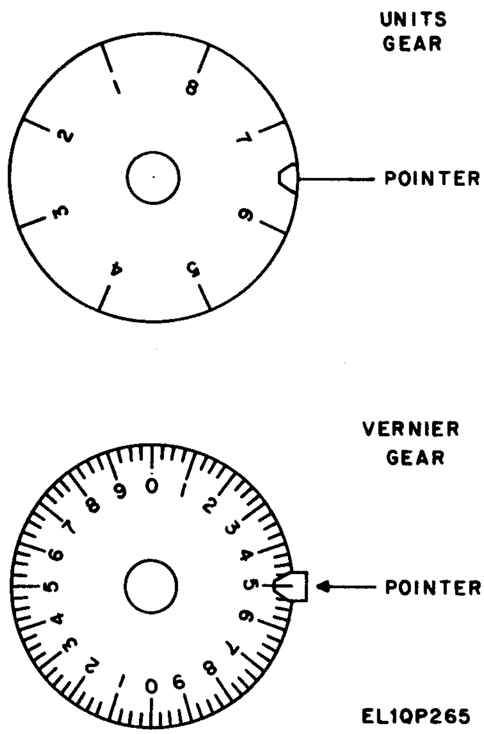


Figure 3-112. Calibrated C-gears.

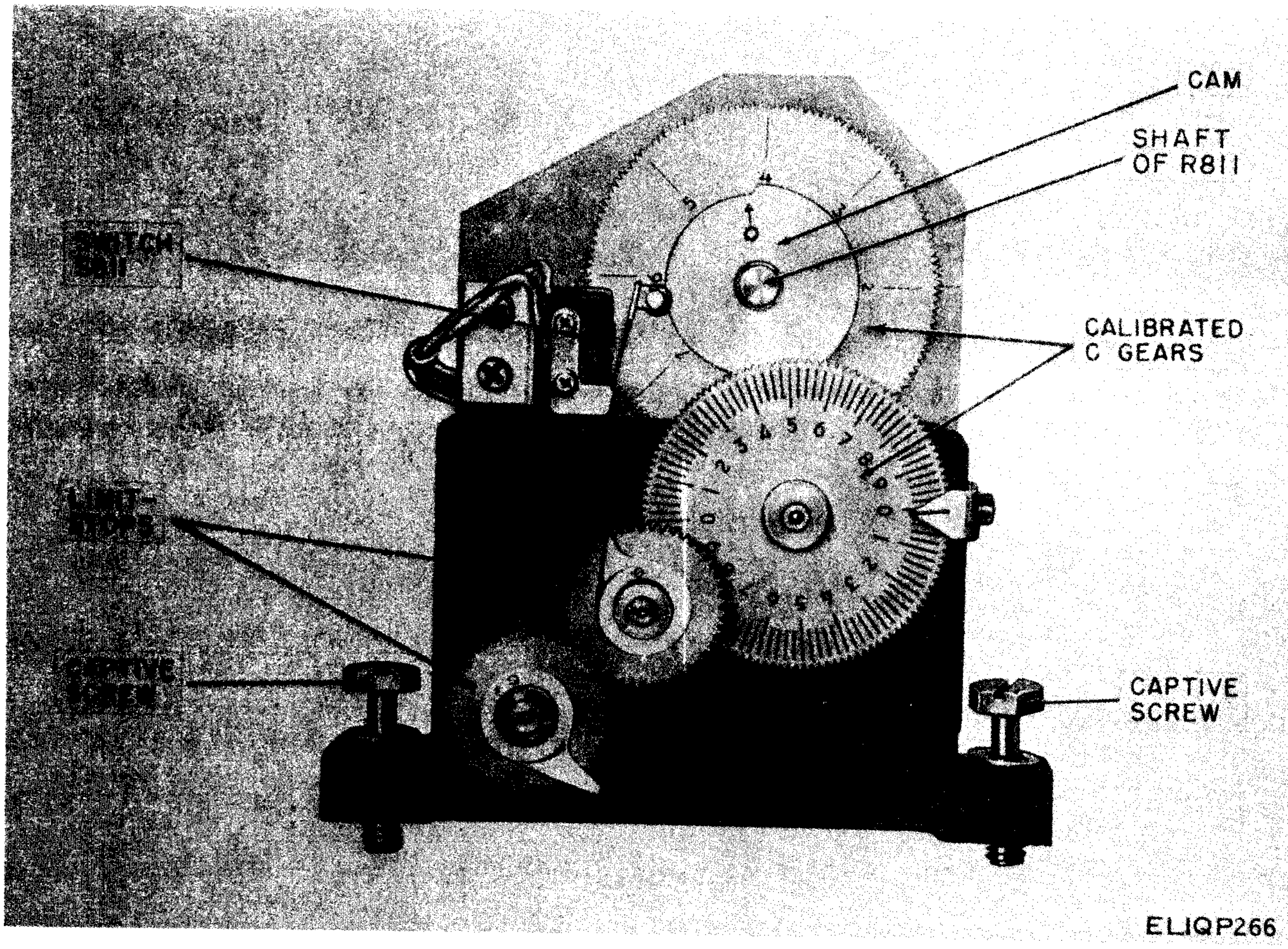


Figure 3-113. C subassembly, front view.

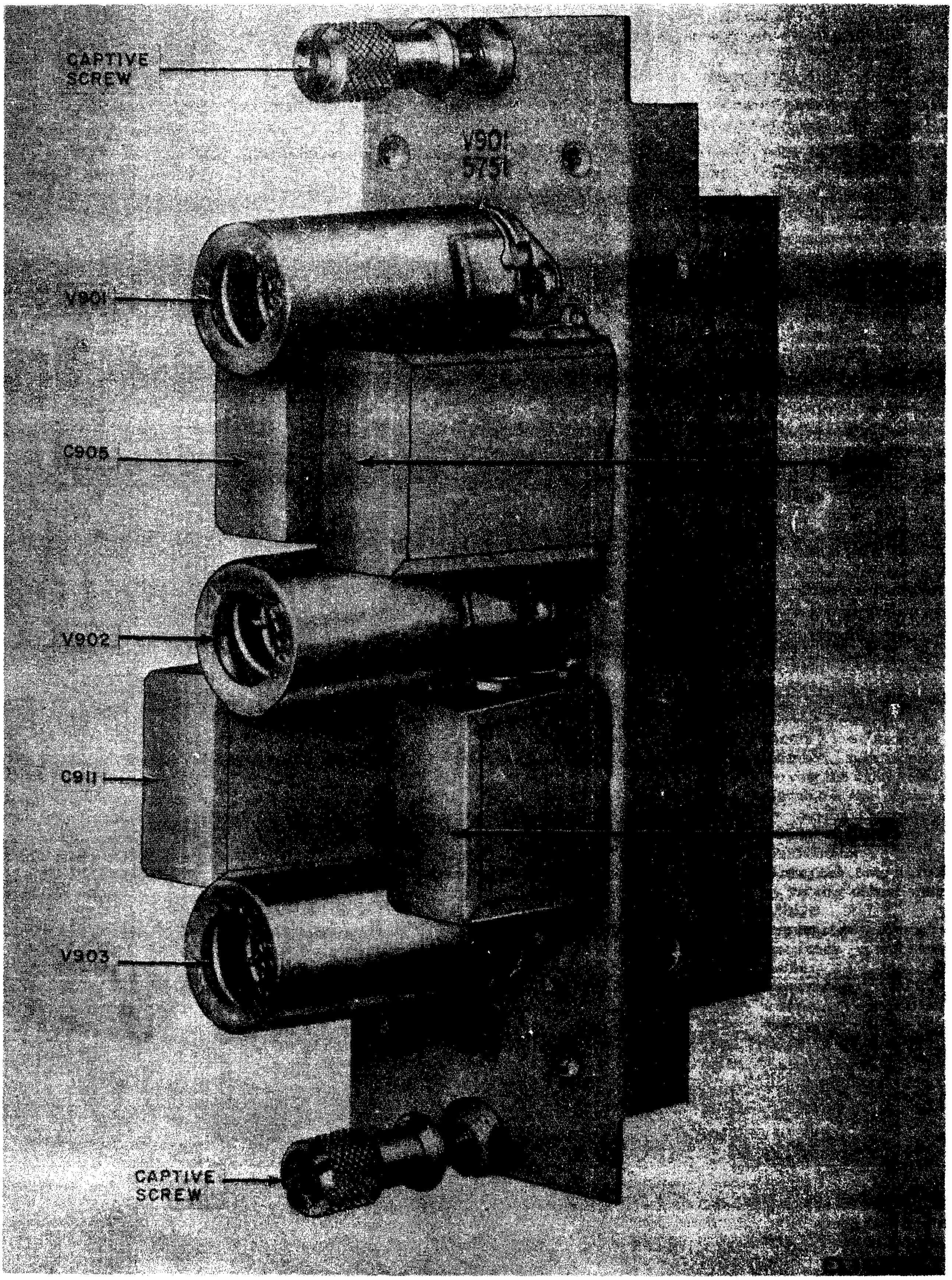


Figure 3-114. Dual isolation amplifier, top view.

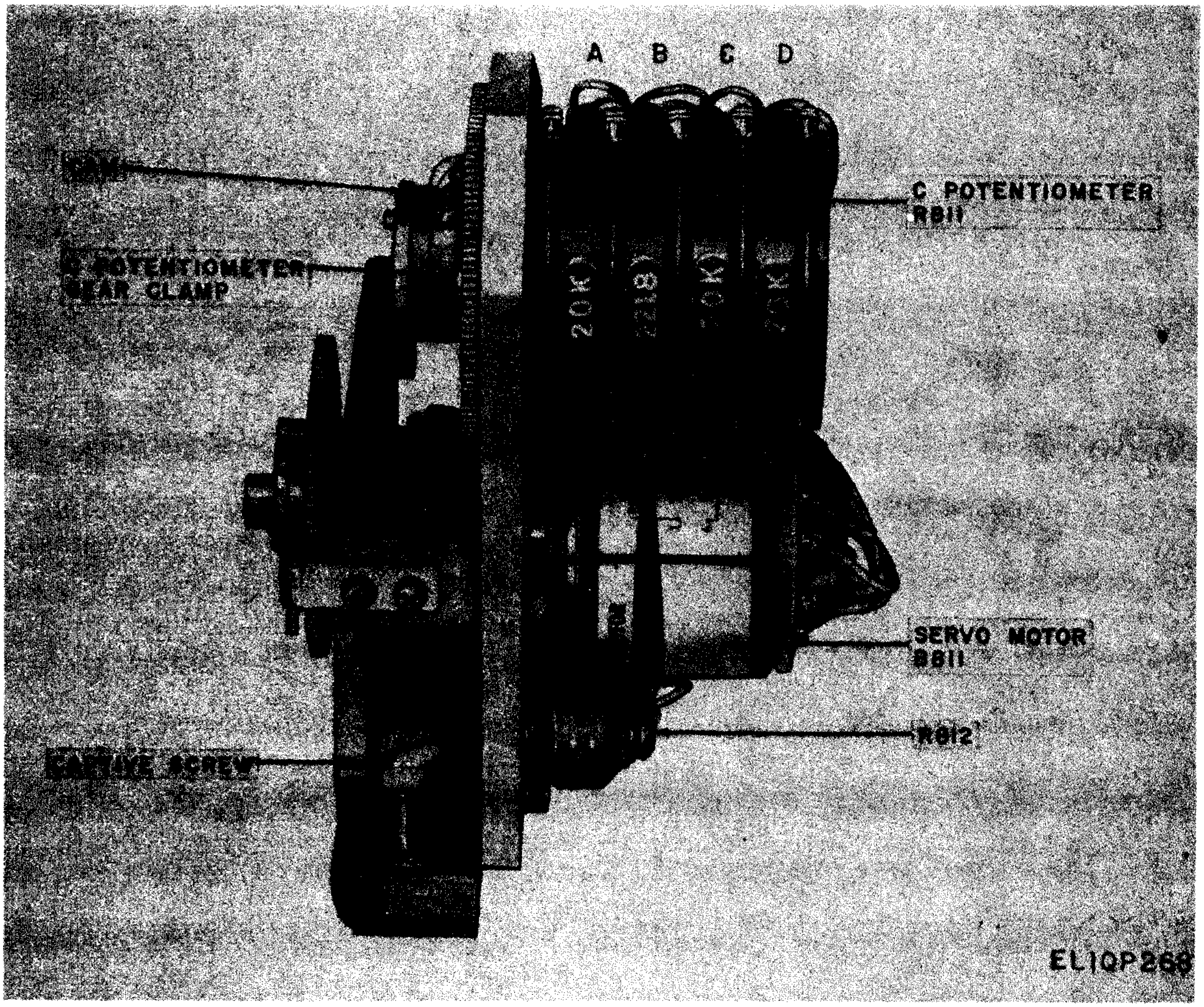


Figure 3-115. C subassembly, right-side view.

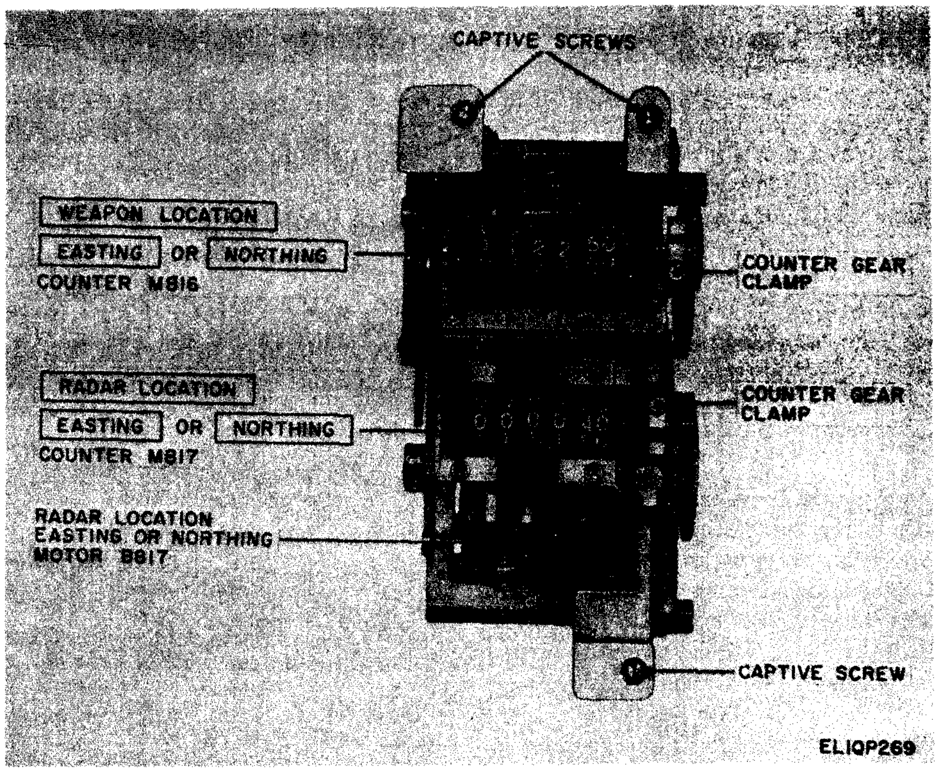


Figure 3-116. Coordinate subassembly, front view.

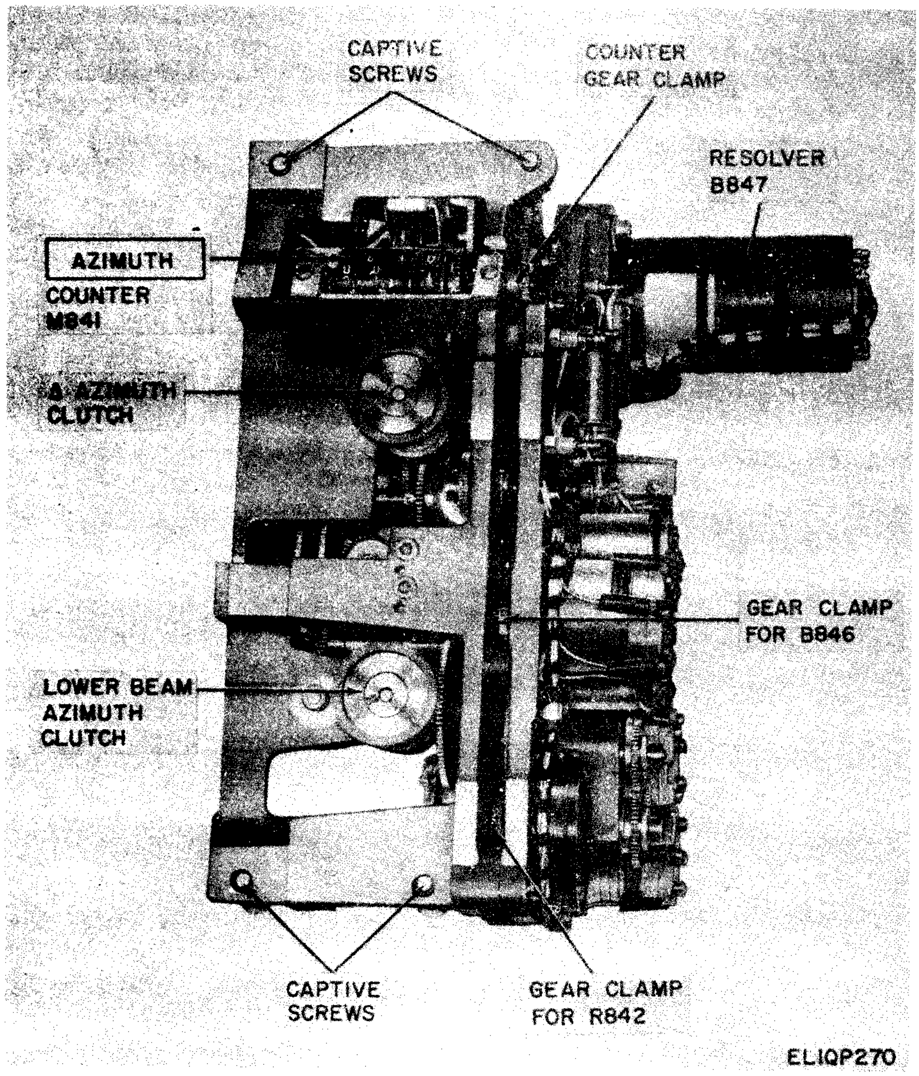


Figure 3-117. Azimuth subassembly, front view.

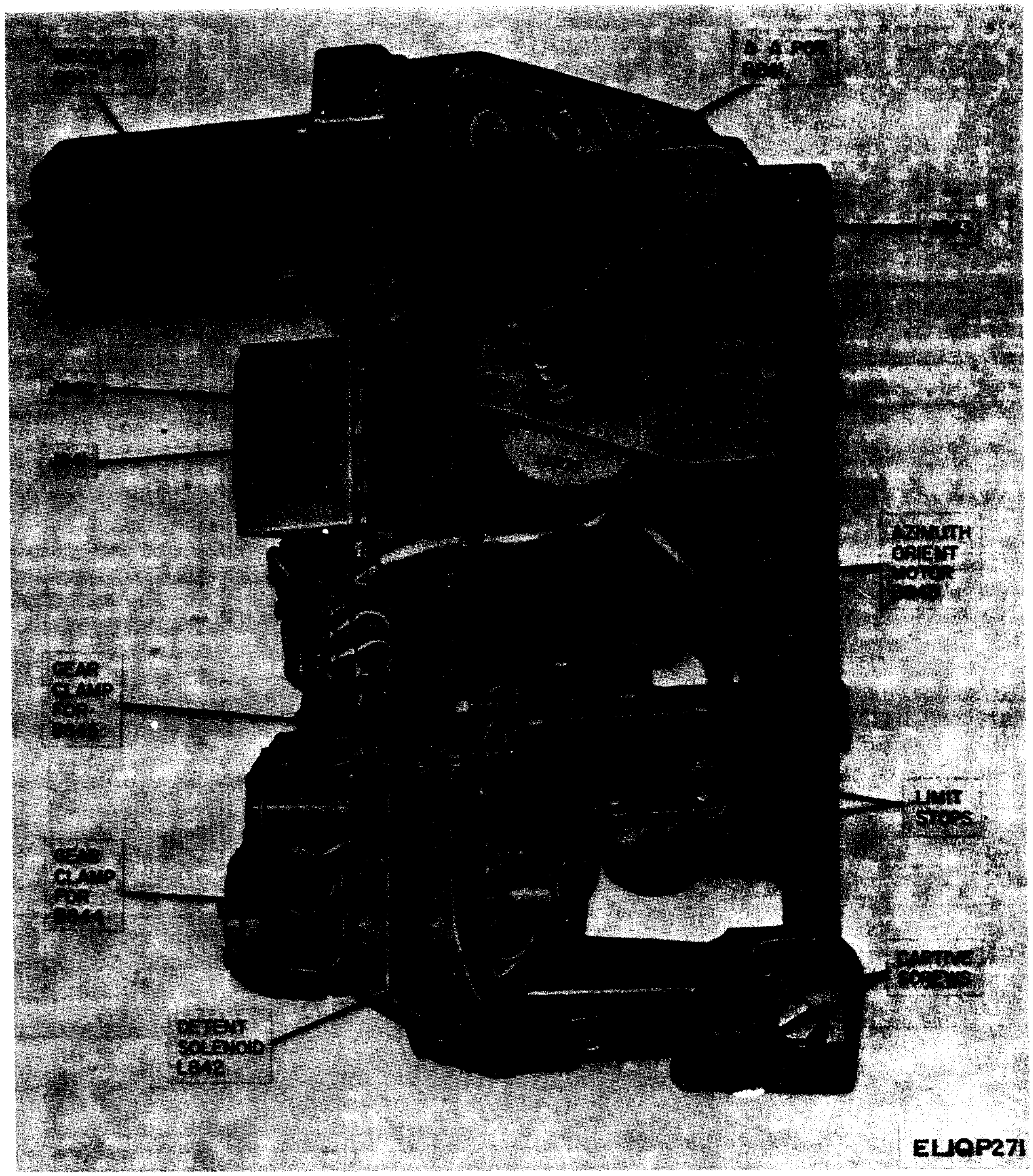


Figure 3-118. Azimuth subassembly, rear view.

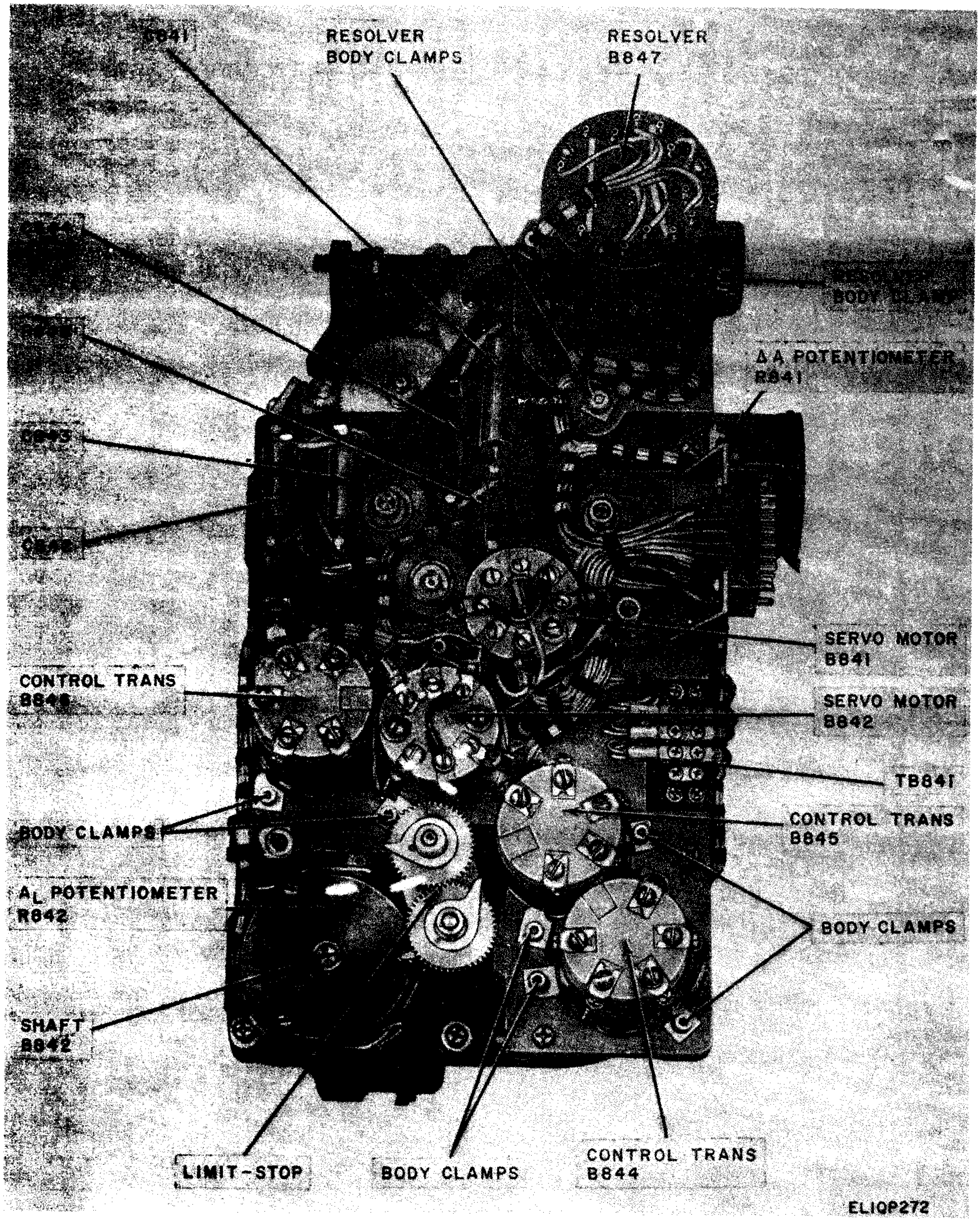


Figure 3-119 Azimuth subassembly, right-side view.

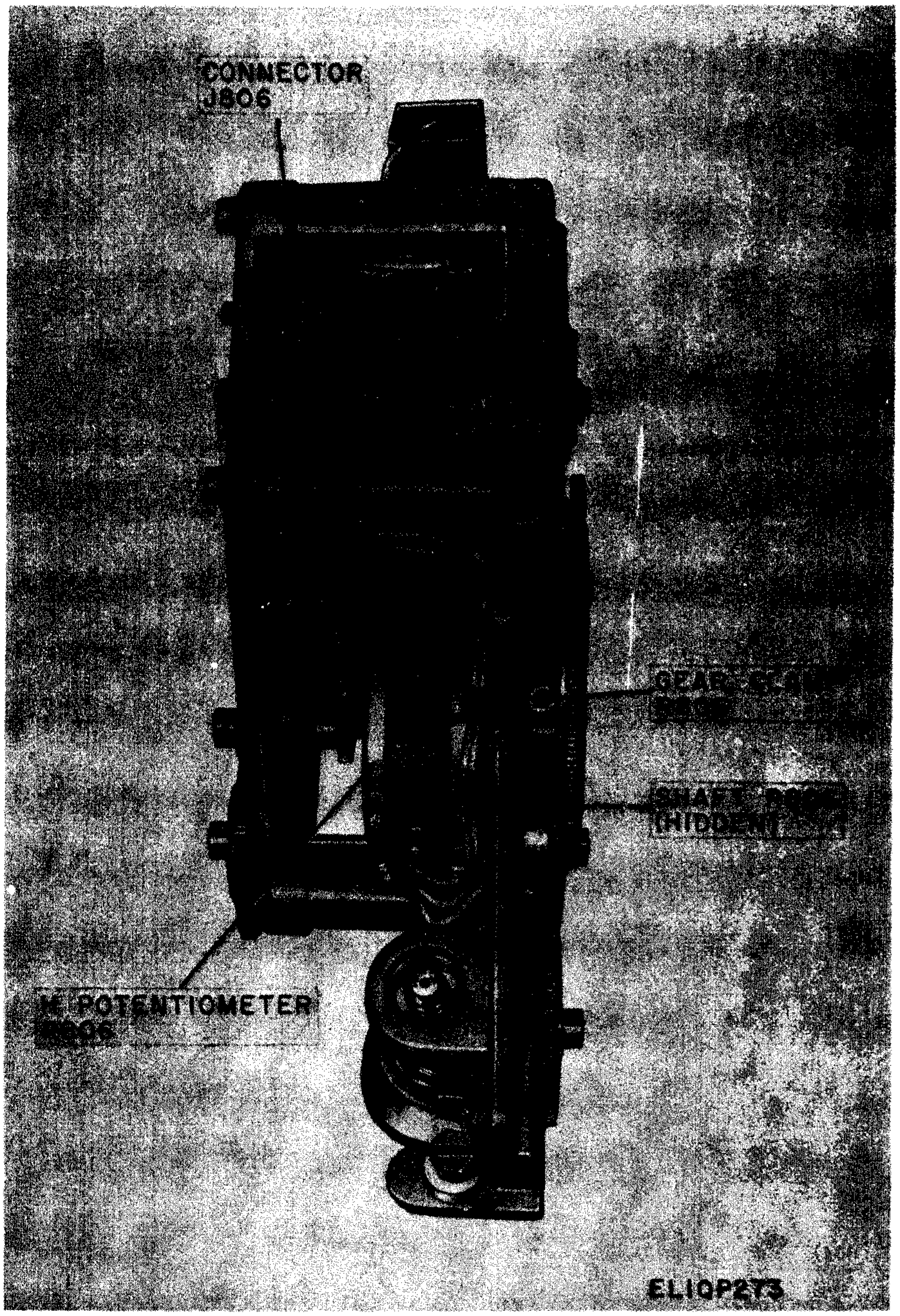


Figure 3-120. Height subassembly, rear view,

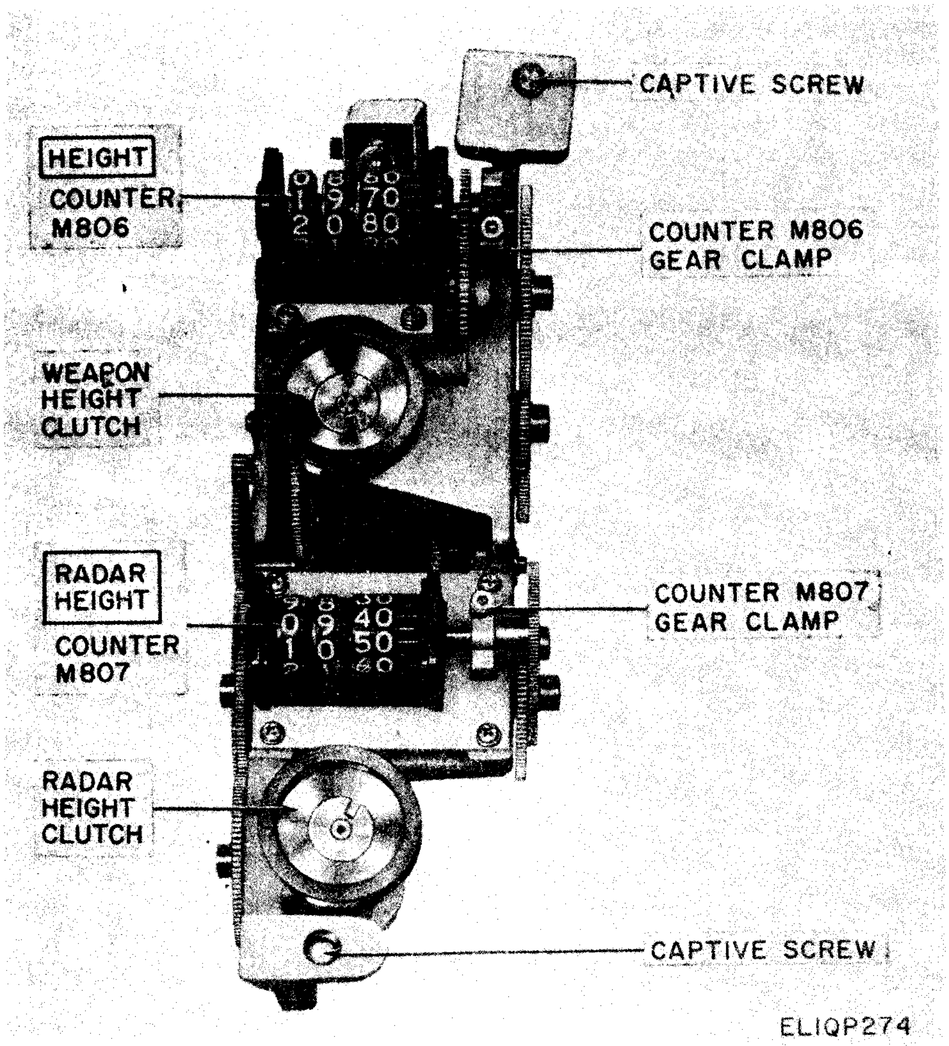


Figure 3-121. Height subassembly, front view,

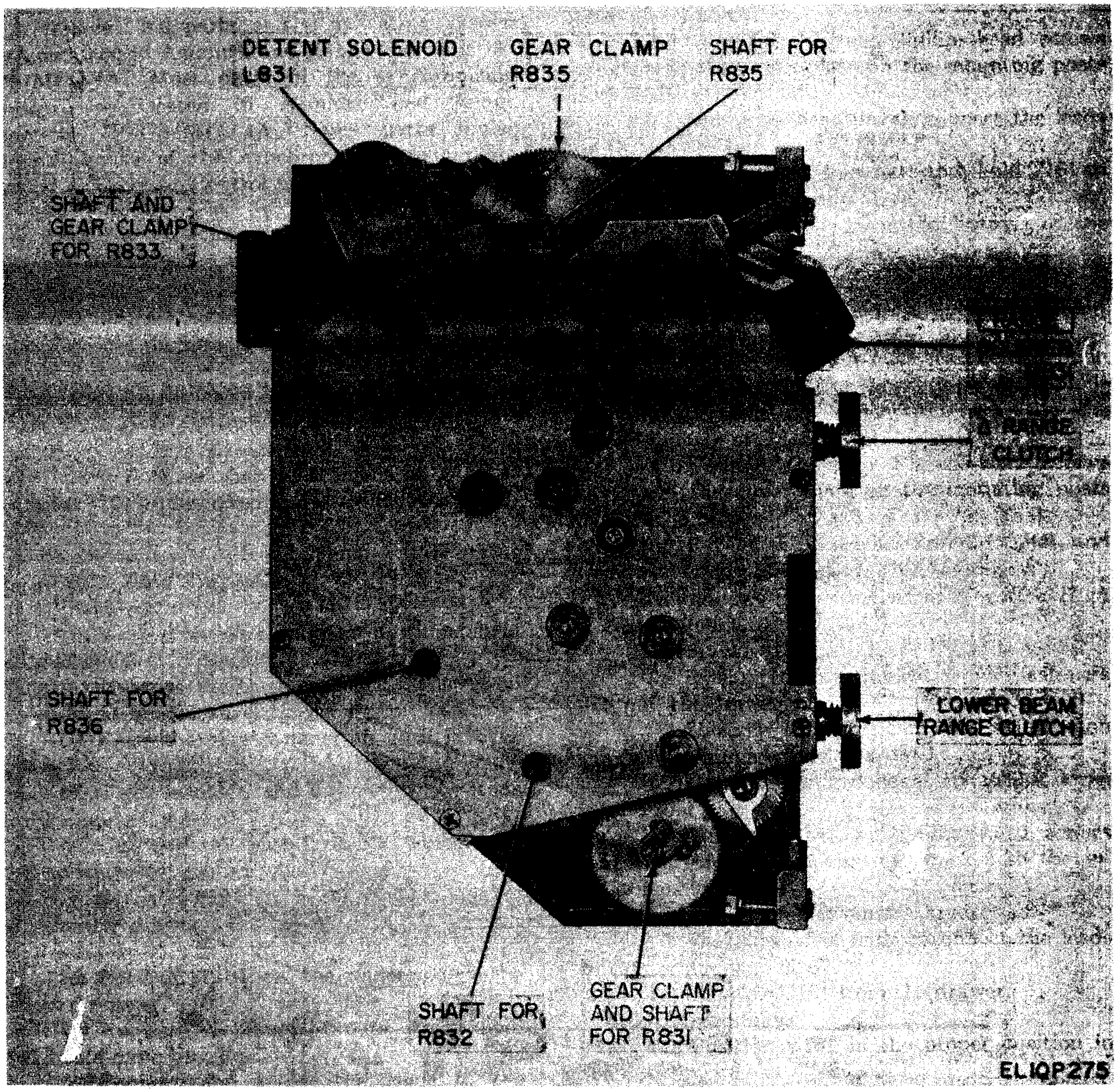


Figure 3-122. Range subassembly, left-side view.

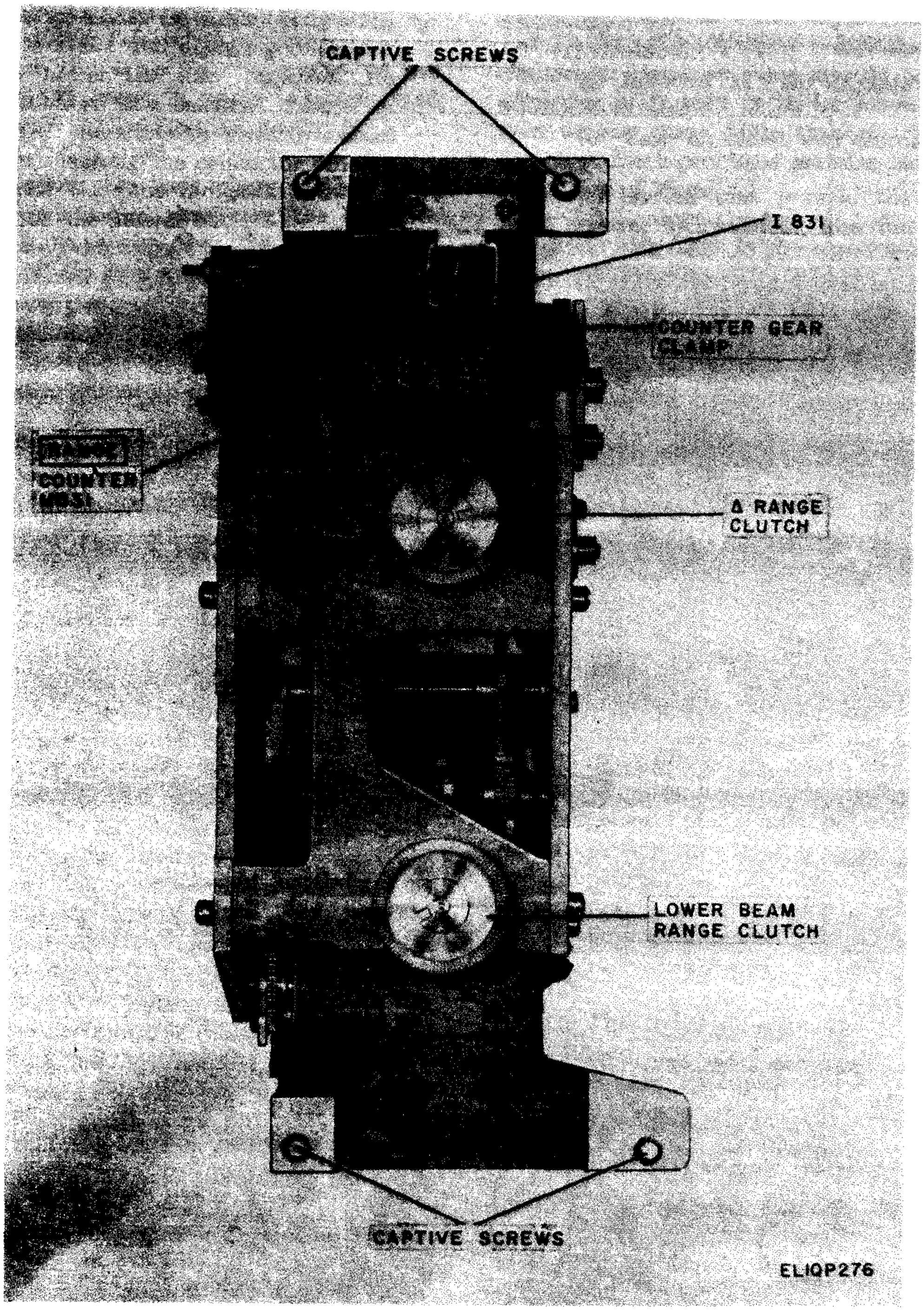


Figure 3-123. Range subassembly, front view.

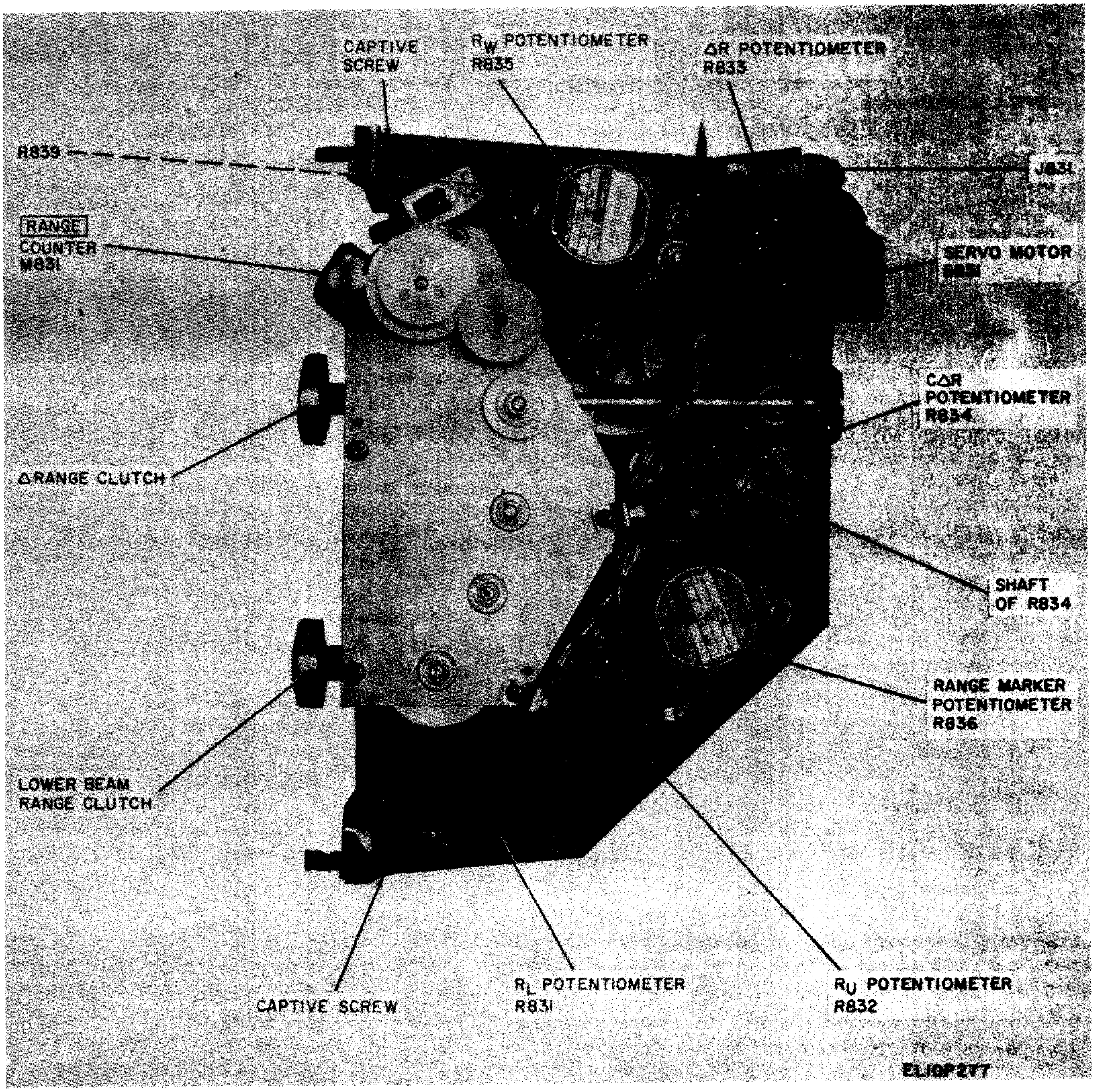


Figure 3-124. Range subassembly, right-side view.

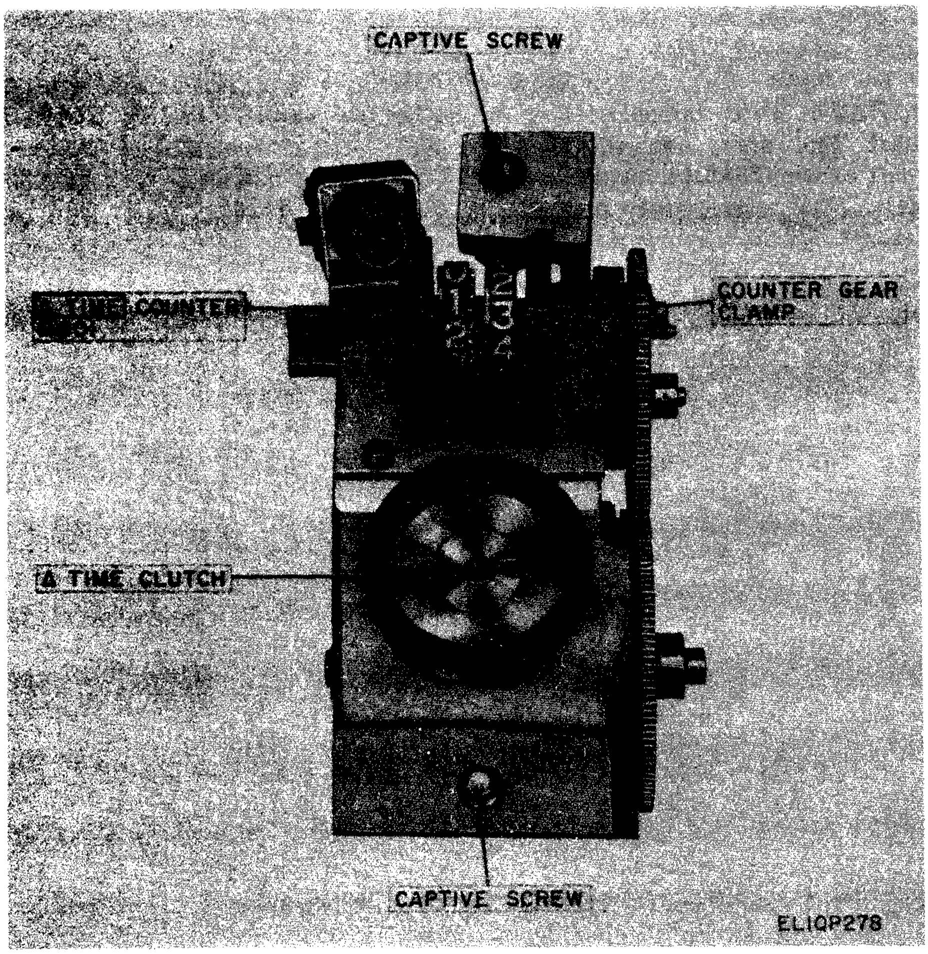


Figure 3-125. Time subassembly, front view.

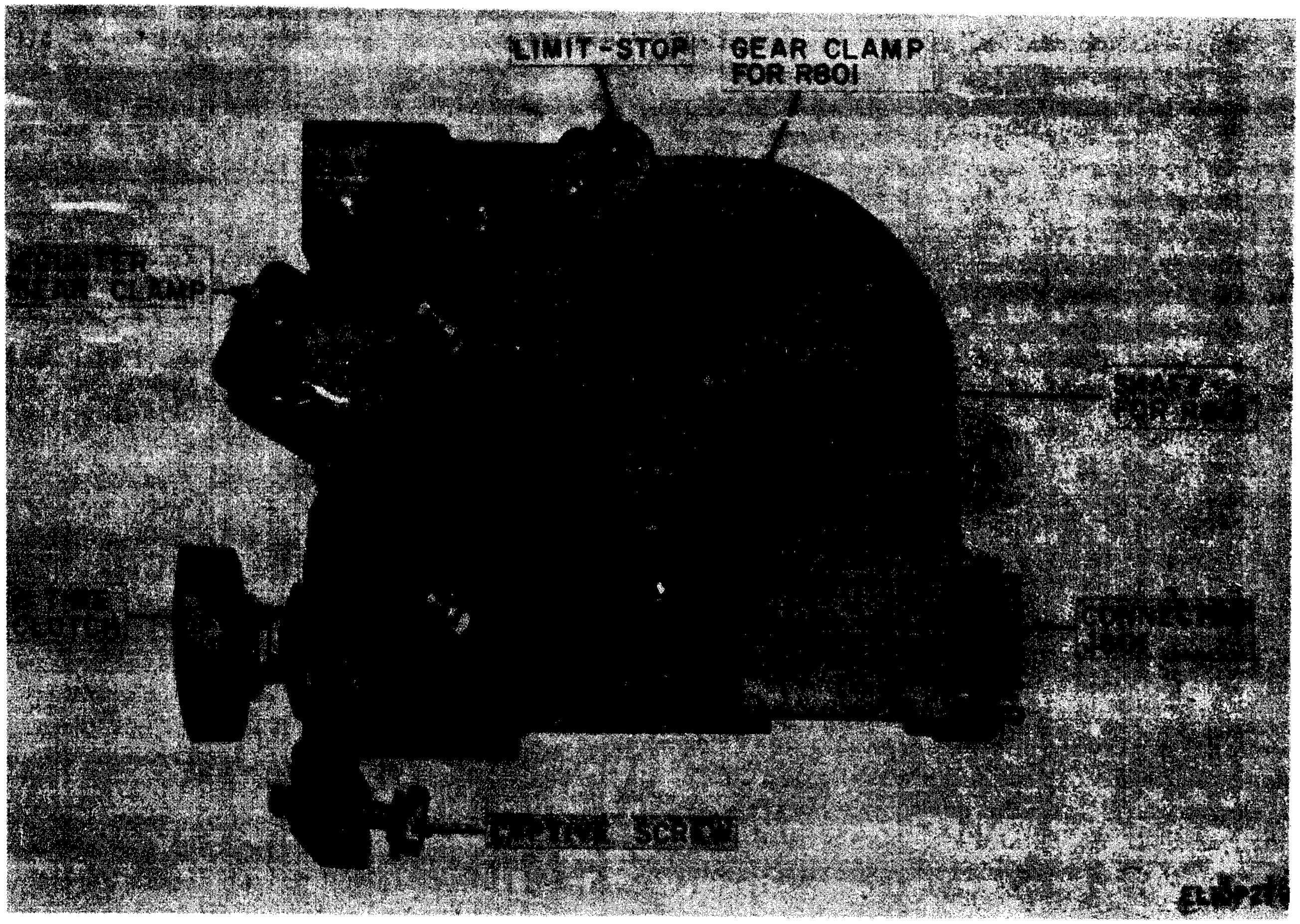


Figure 3-126. Time subassembly, right-side view.

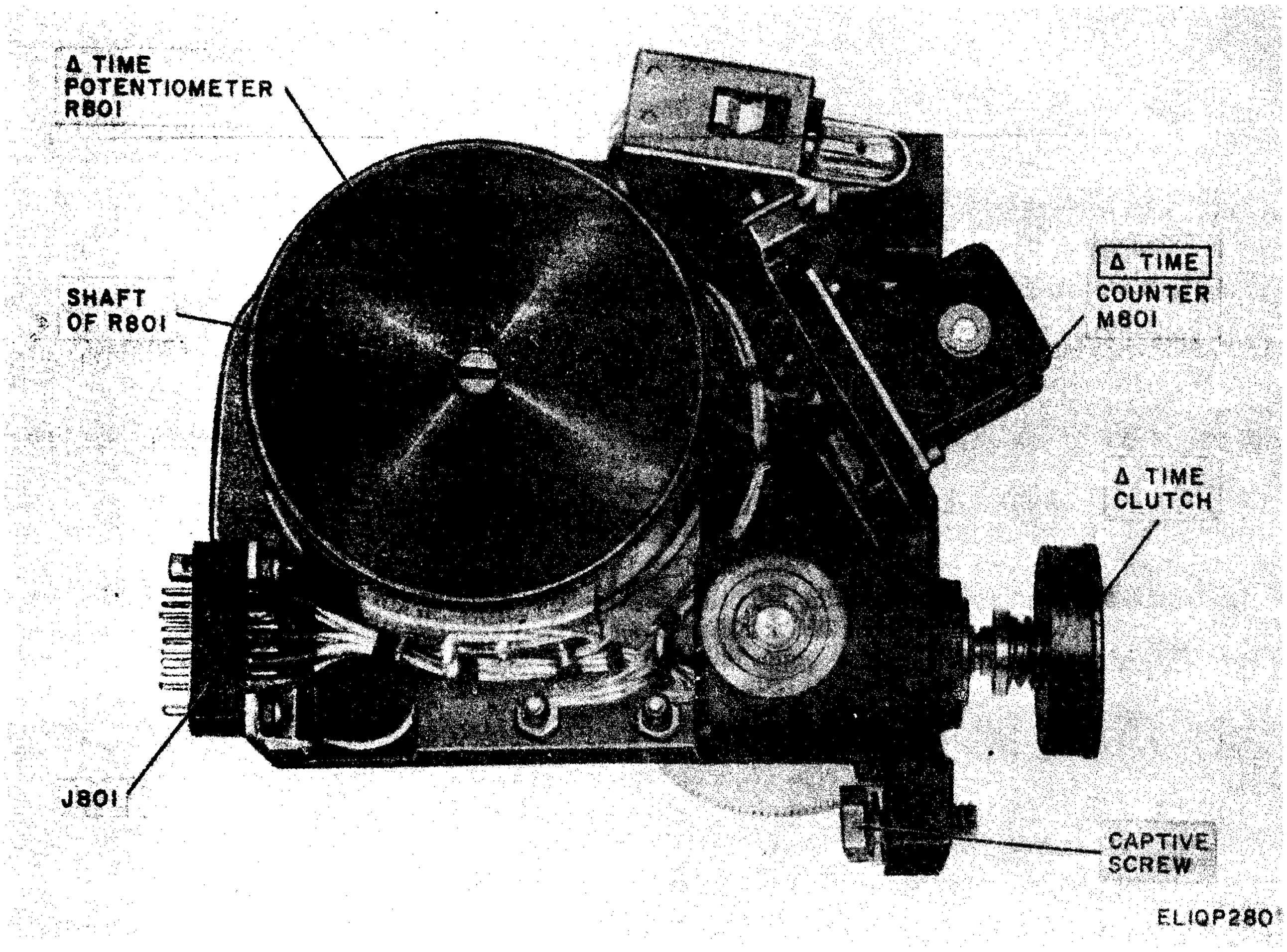


Figure 3-127. Time subassembly, left-side view.

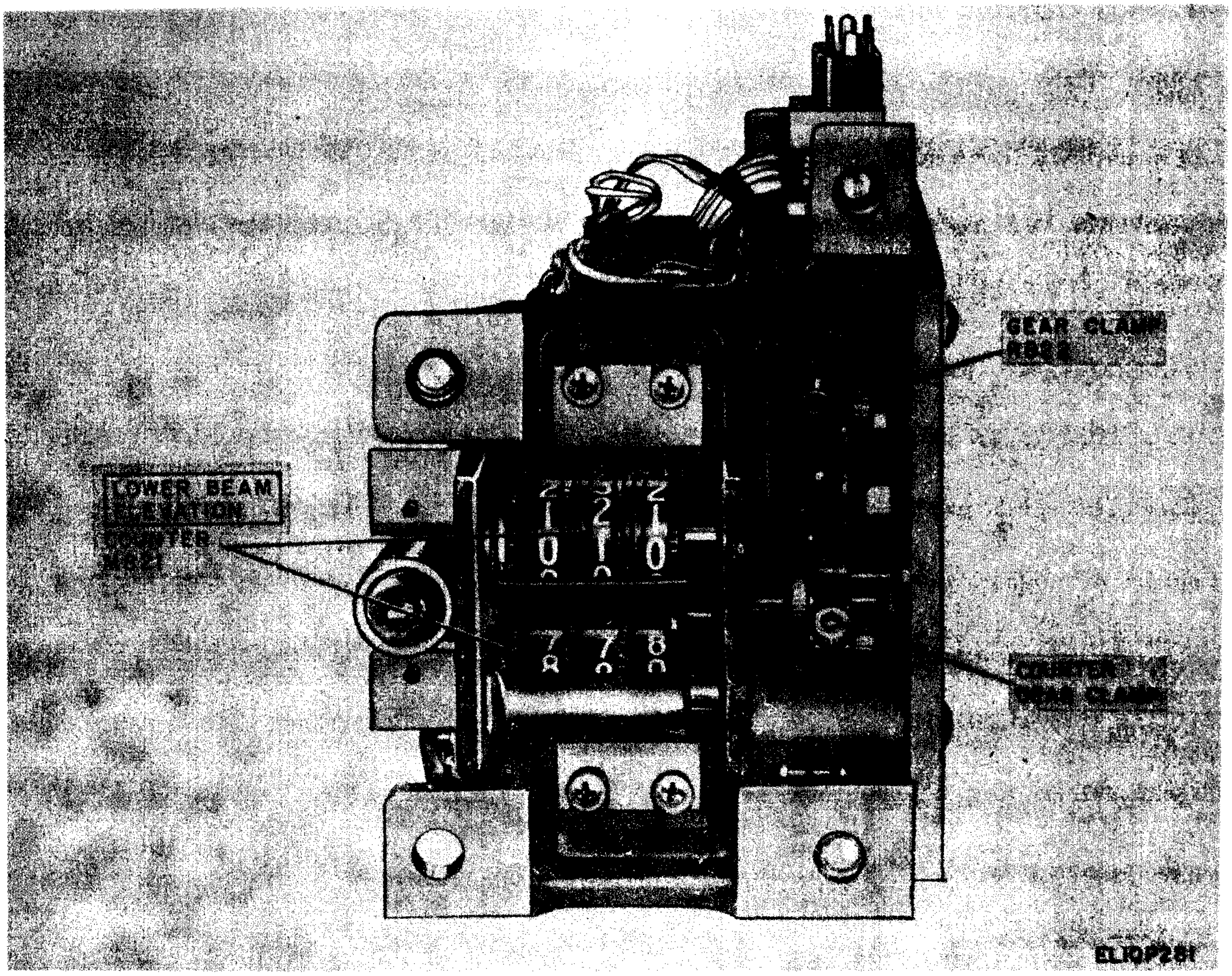


Figure 3-128. Elevation subassembly, front view.

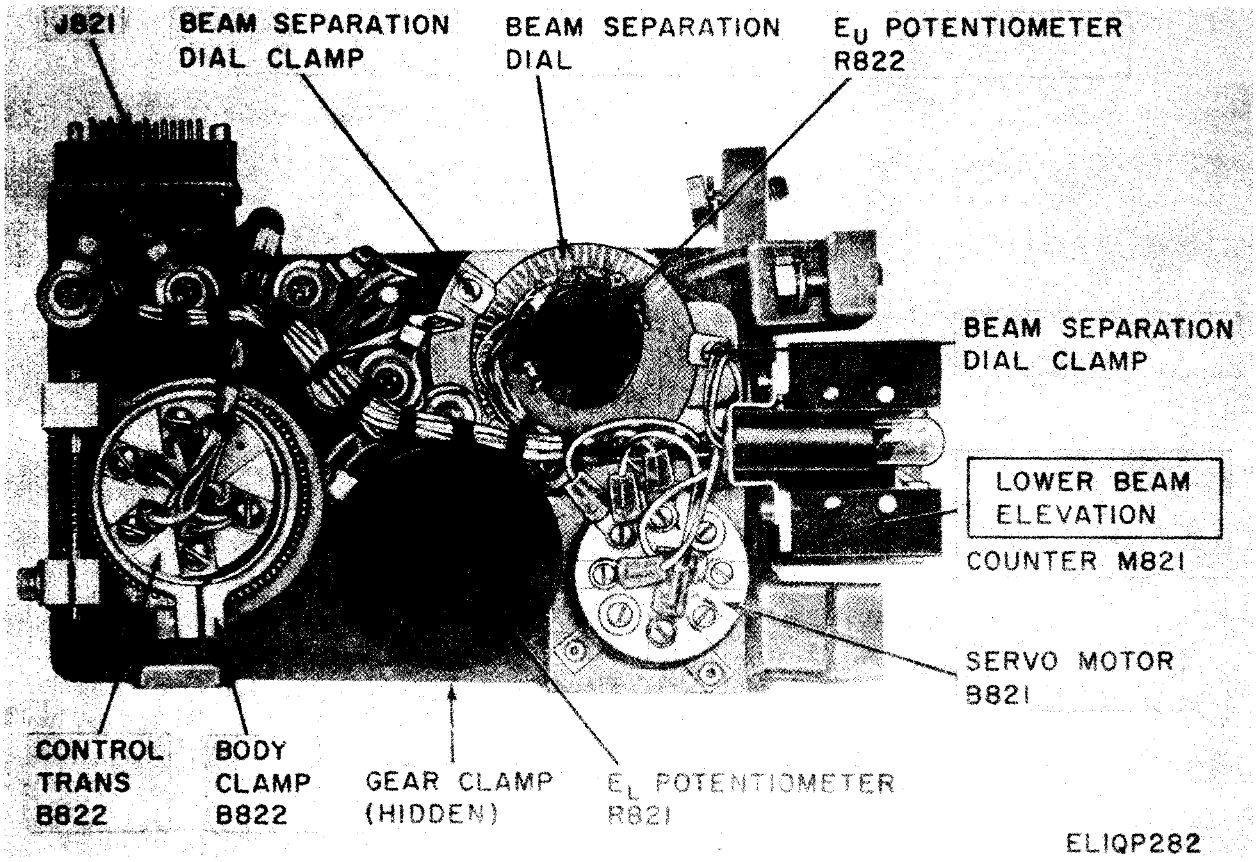


Figure 3-129. Elevation subassembly, left-side view.

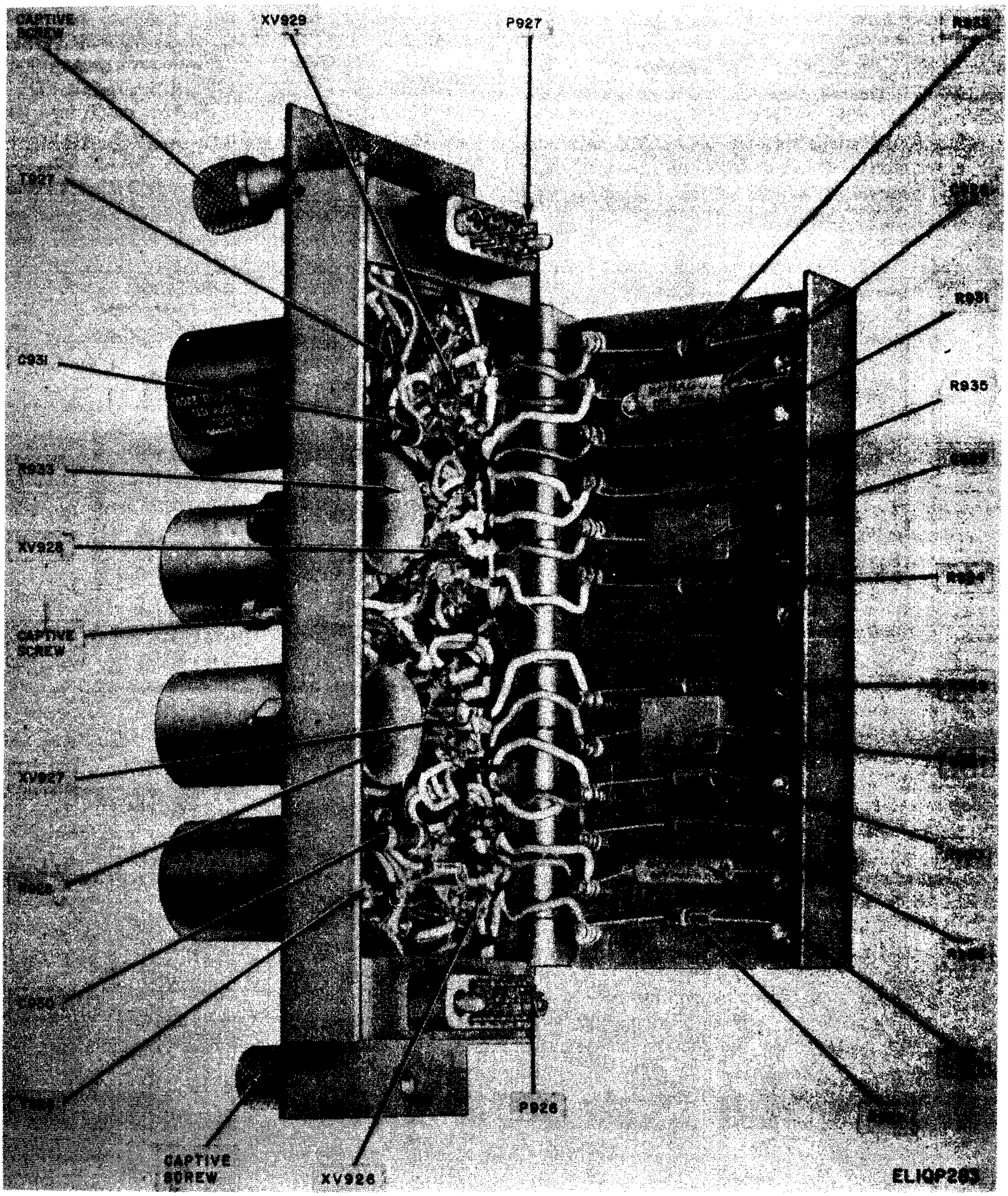


Figure 3-130. Dual servoamplifier, bottom view.

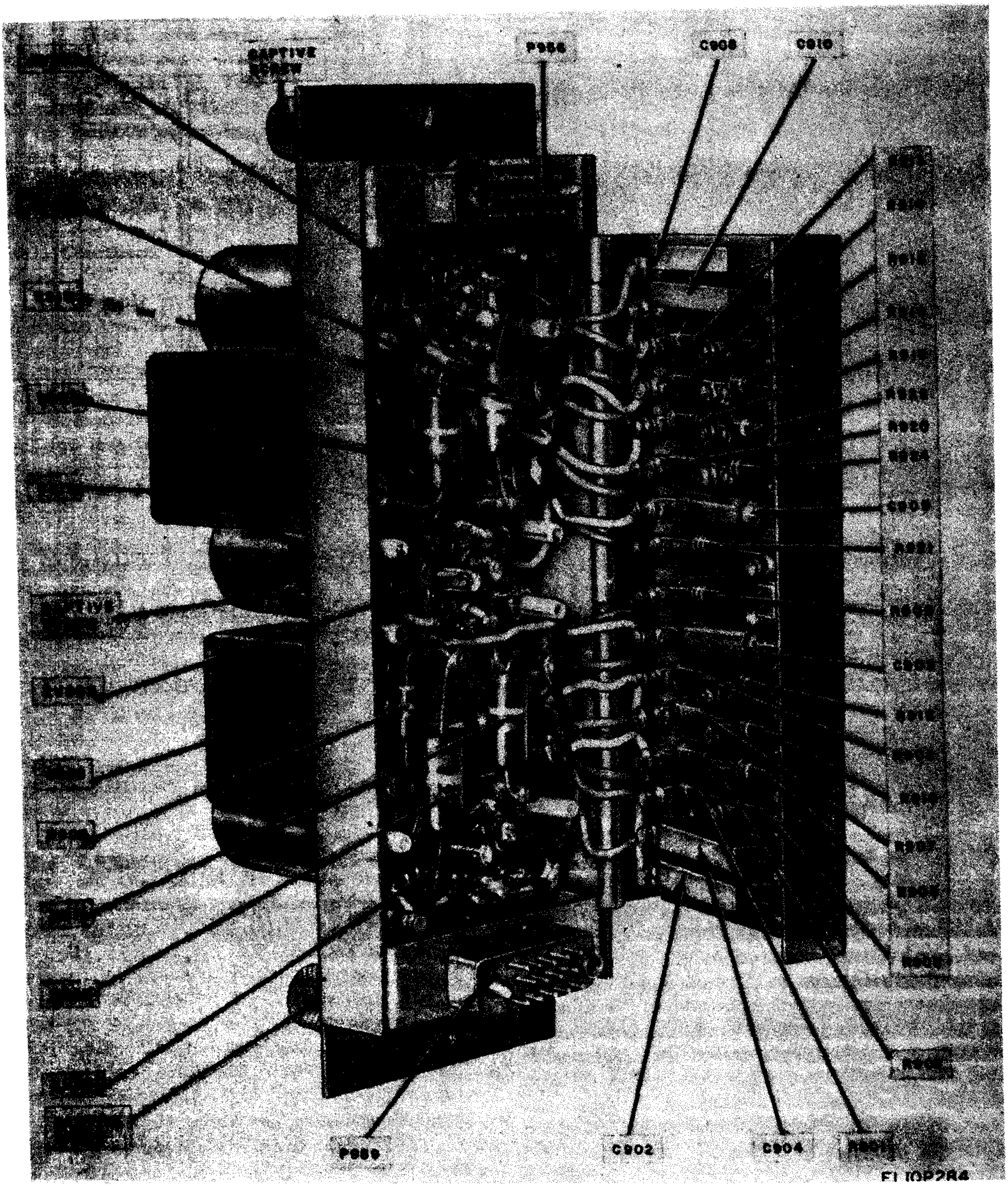


Figure 3-131. Dual isolation amplifier, bottom view.

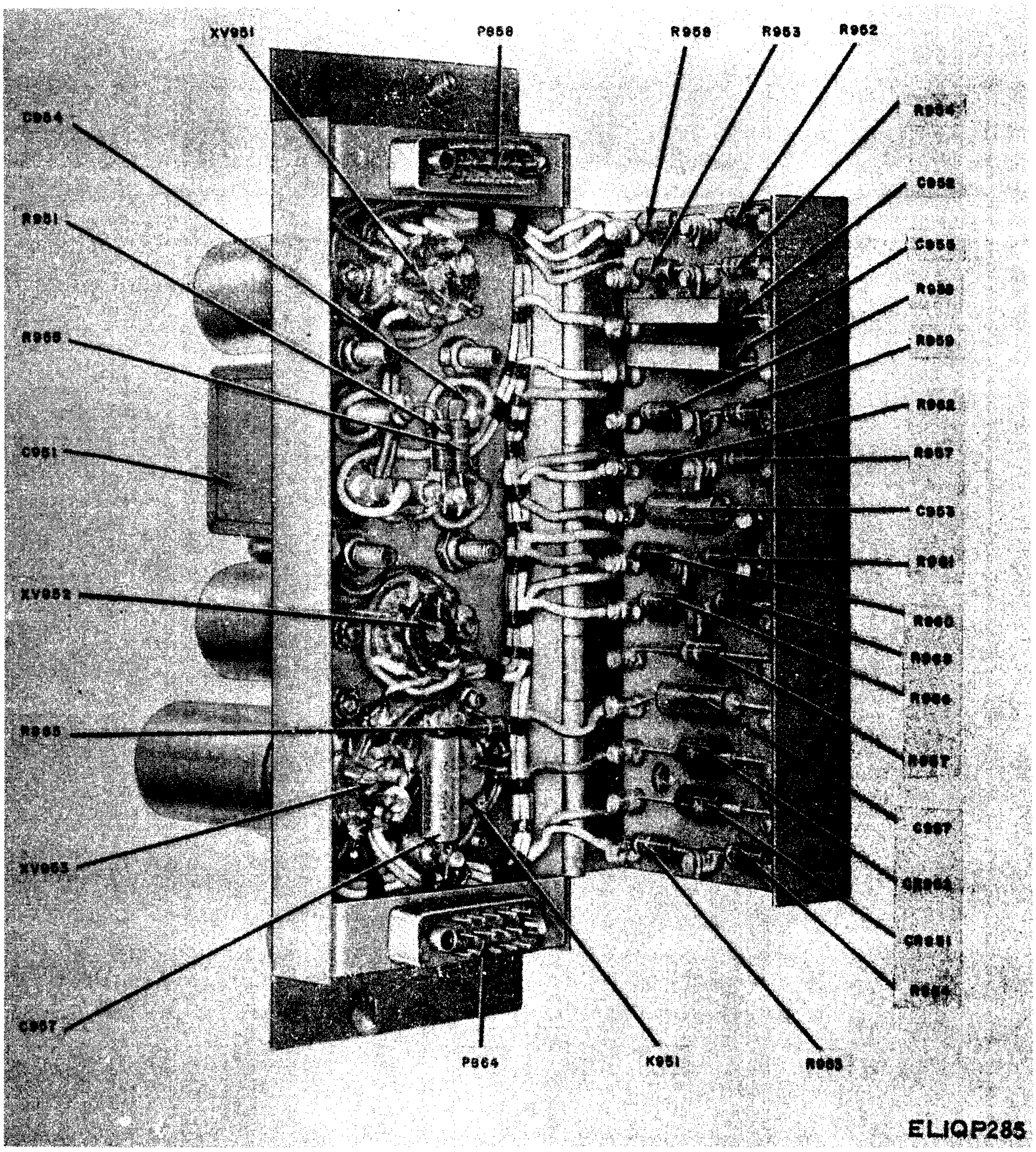
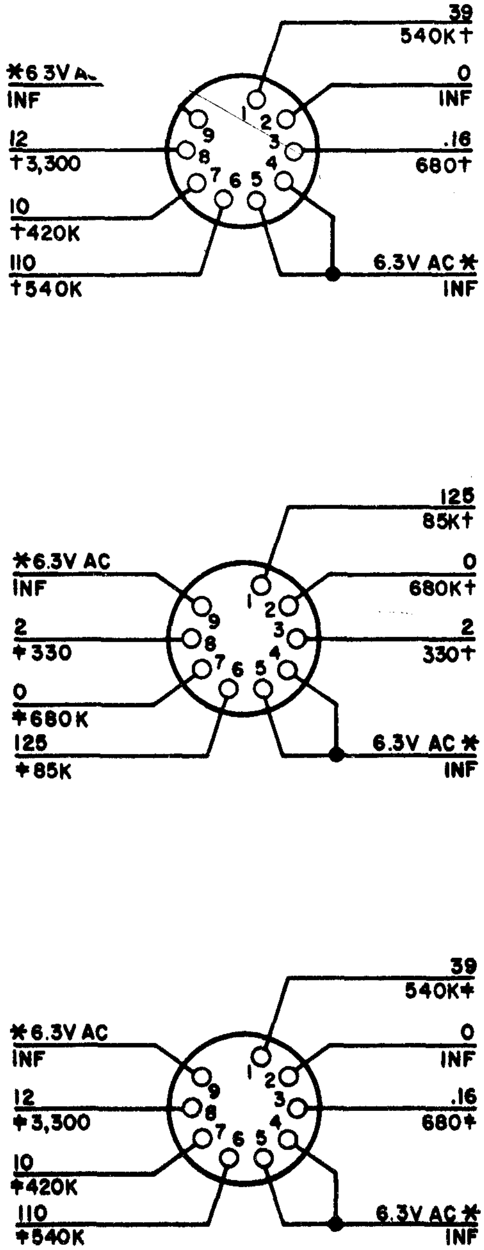


Figure 3-132. Booster and dual speed cutover amplifier, bottom view,



NOTES:

1. * INDICATES MEASUREMENTS BETWEEN FILAMENTS.

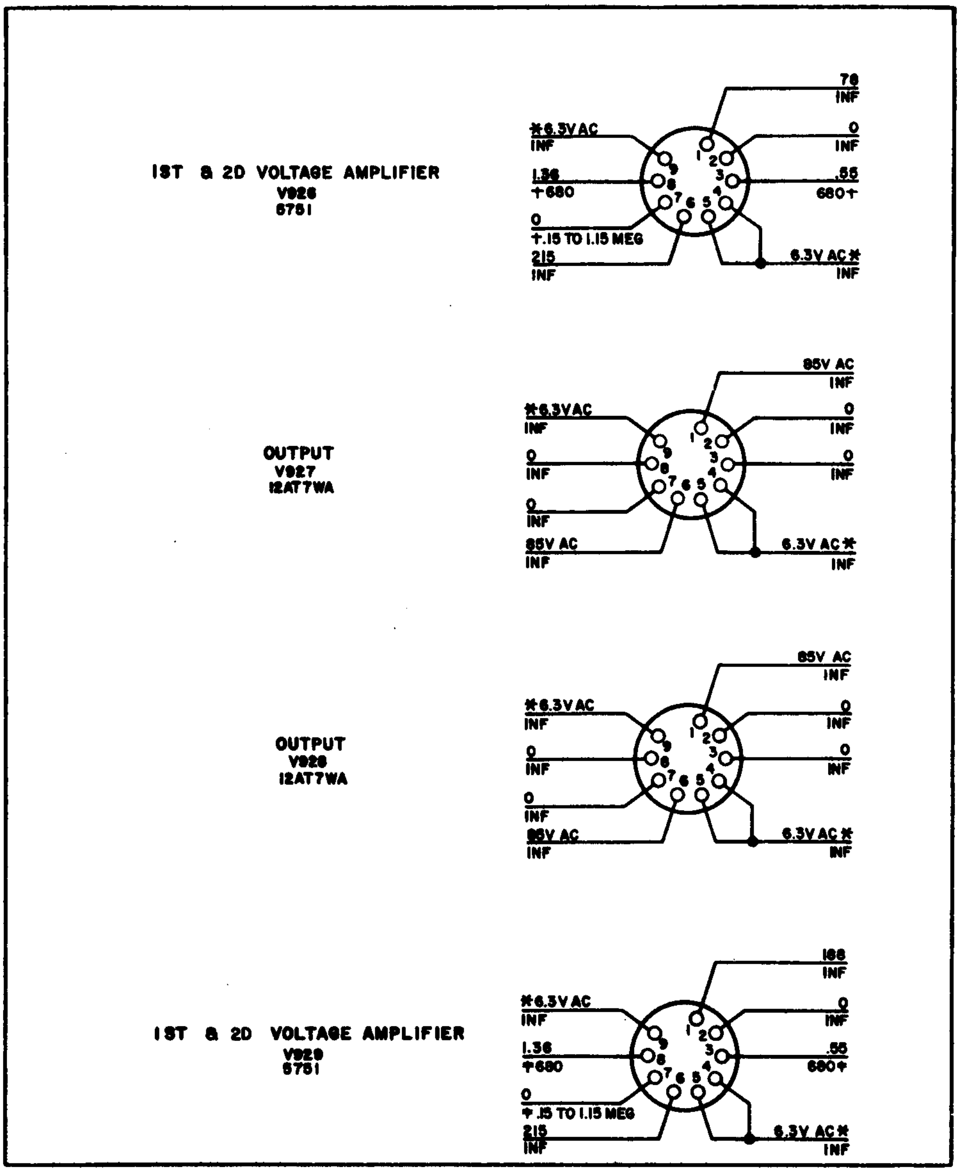
2. DC VOLTAGES MEASURED TO GROUND WITH A 20,000 OHMS-PER-VOLT METER UNLESS OTHERWISE INDICATED.

3. † INDICATES RESISTANCE MEASUREMENTS TO PIN R OF PLUG P865 WITH UNIT REMOVED FROM COMPUTER.

4. ✝ INDICATES RESISTANCE MEASUREMENTS TO PIN R OF PLUG P859 WITH UNIT REMOVED FROM COMPUTER.

EL1QP286

Figure 3-133. Dual isolation amplifier AR901, voltage and resistance diagram.

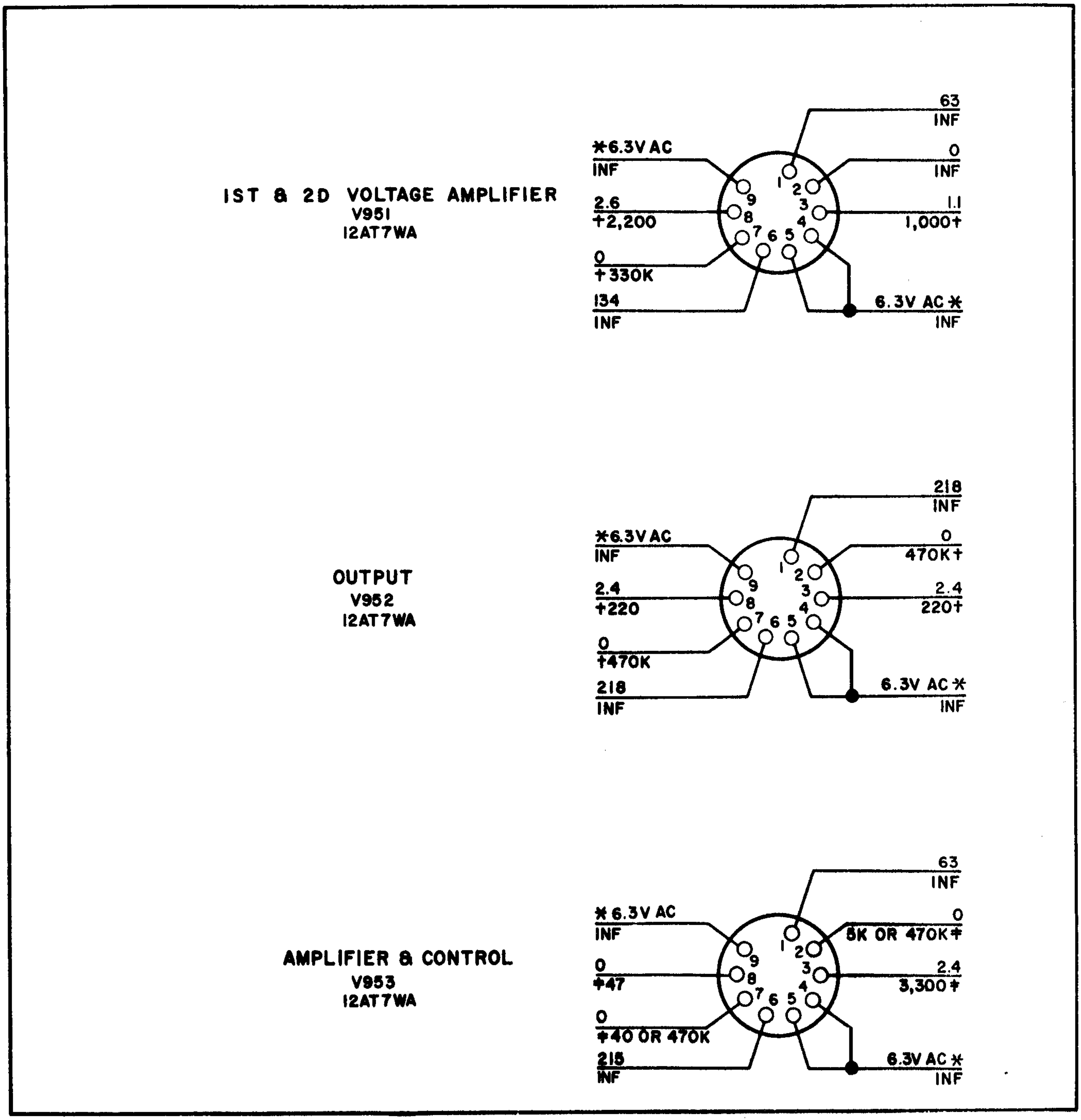


NOTES:

1. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
2. DC VOLTAGE MEASURED TO GROUND WITH 20,000 OHMS-PER-VOLT METER UNLESS OTHERWISE INDICATED.
3. + INDICATES RESISTANCE MEASUREMENTS TO PIN R OF PLUG P926 WITH UNIT REMOVED FROM COMPUTER.
4. + INDICATES RESISTANCE MEASUREMENTS TO PIN R OF PLUG P927 WITH UNIT REMOVED FROM COMPUTER.

EL1QP287

Figure 3-134. Duad servoamplifiers AR926 through AR929 voltage and resistance diagram.

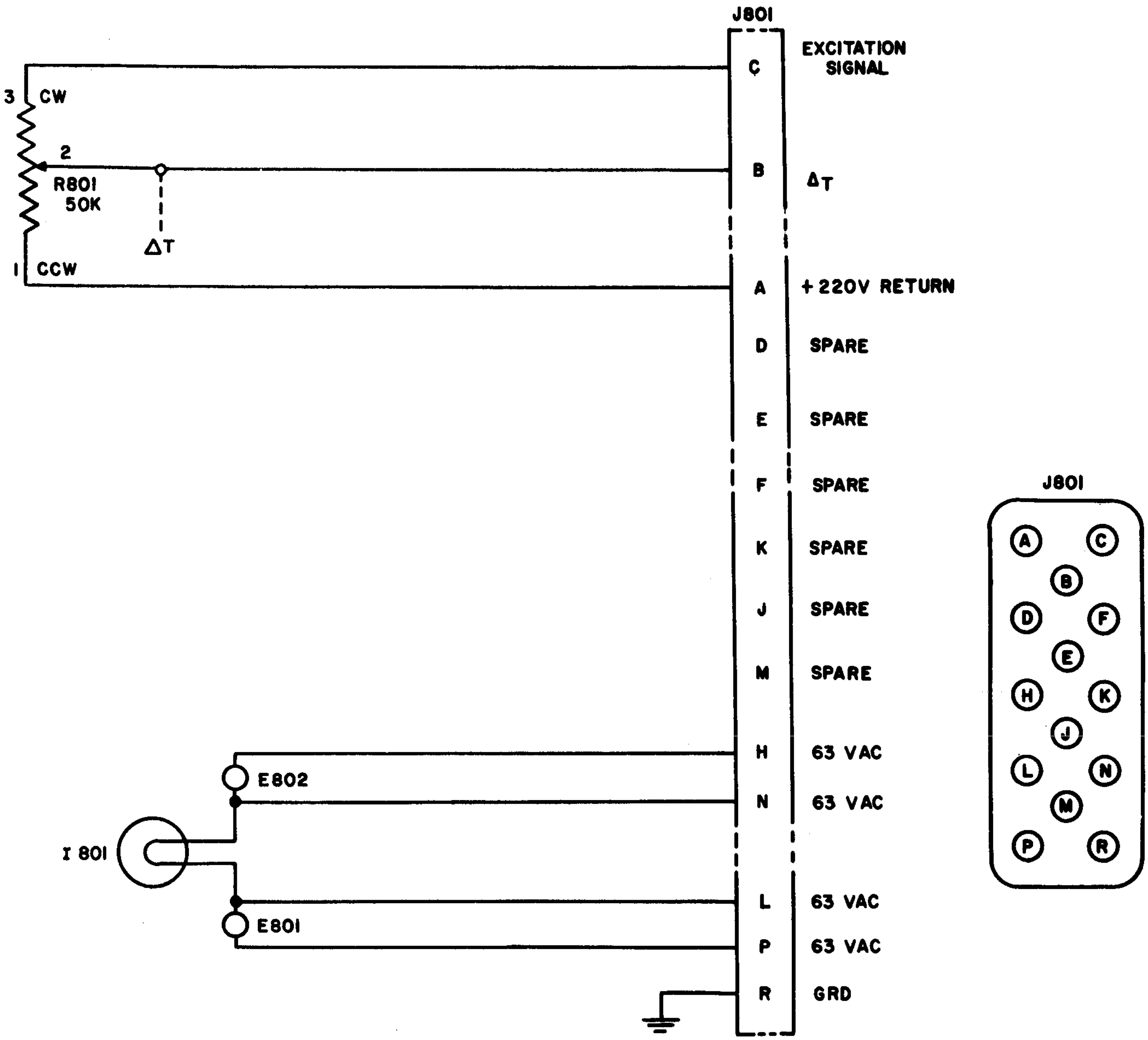


NOTES:

1. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
2. DC VOLTAGES MEASURED TO GROUND WITH A 20,000 OHMS-PER-VOLT METER UNLESS OTHERWISE INDICATED
3. + INDICATES RESISTANCE MEASUREMENTS TO PIN R OF PLUG P864 WITH UNIT REMOVED FROM COMPUTER.
4. + INDICATES RESISTANCE MEASUREMENTS TO PIN R OF PLUG P858 WITH UNIT REMOVED FROM COMPUTER.

EL1QP288

Figure 3-135. Booster and dual speed outover amplifers AR951, voltage and resistance diagram.

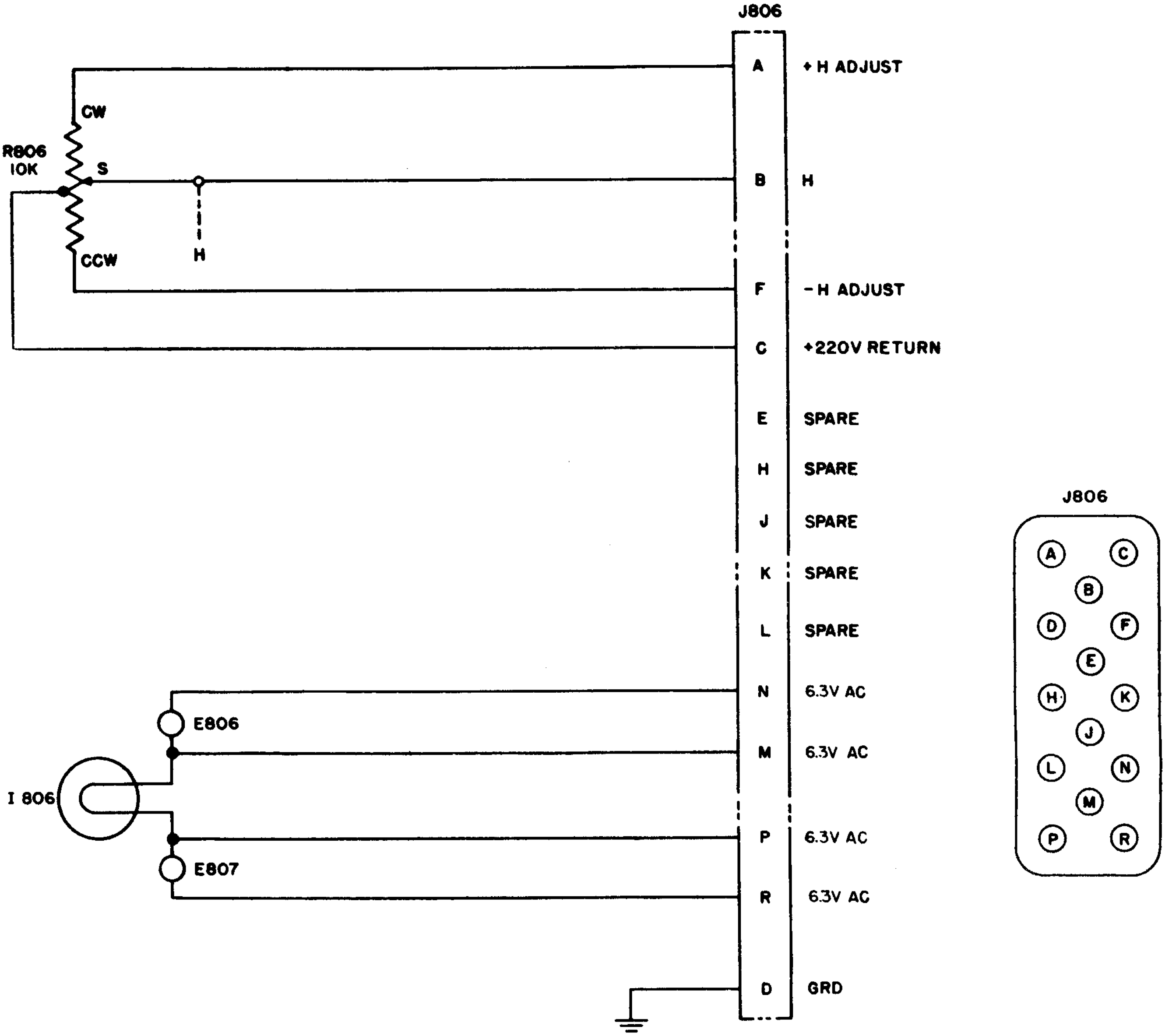


NOTES:

1. UNLESS OTHERWISE INDICATED RESISTANCES ARE IN OHMS.
2. ARROW INDICATES DIRECTION OF INCREASING FUNCTION.

EL1QP289

Figure 3-136. Time subasembly, schematic diagram.



NOTES :

1. UNLESS OTHERWISE INDICATED RESISTAWES ARE IN OHMS.
2. ARROW INDICATES DIRECTION OF INCREASING FUNCTION.

Figure 3-137. *Height subassembly, schematic diagram.*

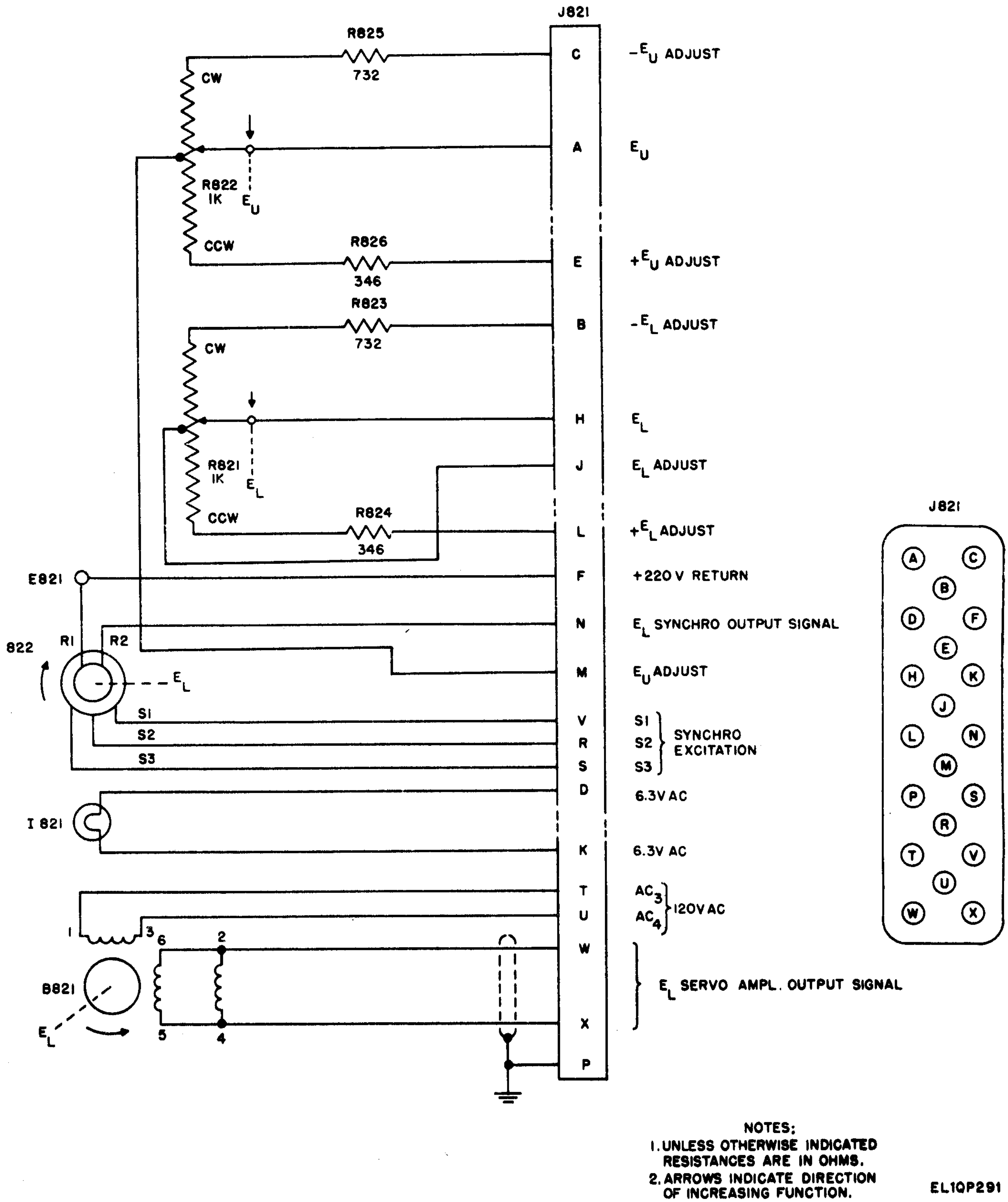


Figure 3-138. Elevation subassembly, schematic diagram.

b. Computing System Controls and Adjustments. Table 3-42 lists the controls and adjustments for operation and maintenance of the computing system.

(1) *Alignment potentiometer panel.* Resistors R976 through R995, the alignment potentiometers, are mounted on a panel (fig. 3-99) in the upper right-rear section of the computer drawer. These resistors are used to set the voltage across the computing potentiometers to precise analog values. For details of their functions, refer to TM 11-5840-208-20.

Table 3-42. Computing System Controls and Adjustments

Controls and adjustments	Location (fig.)	Function
Front panal controls		
Δ time handwheel	3-98	Used to set the time interval between upper and lower beam echoes into the computer. Rotation of the handwheel poeitions the shaft of Δ T potentiometer R801 to a position corresponding to mechanical analog Δ T.
Δ TIME counter M801.	3-98	Indicates the time interval (in seconds) between upper and lower beam echoes when the Δ time handwheel is rotated.
LOWER BEAM ELEVATION counter M821.	3-98	Indicates in mile the elevation of the lower beam of the radar eat.
SINGLE BEAM indicator lamp 1864.	3-98	Lights when SINGLE BEAM-DUAL BEAM switch S857 is set to SINGLE BEAM.
SINGLE BEAM-DUAL BEAM switch S857.	3-98	witches computer to process inputs derived from either single beam or duel beam indicator presentations. The SINGLE BEAM position is used to make computations from polar coordinate data obtained from single beam presentations that are Characteristics of low-angle trajectory projectiles that intercept only the radar beam. The DUAL BEAM position is used to make computations from polar coordinate data obtained from a normal dual beam indicator presentation when high angle trajectory projectiles intercept both upper and lower radar beams.
AXIMUTH ORIENT indicator lamp I 863.	3-98	Lights when detent ewitch S856 is in AZIMUTH ORIENT position
Detent switch S856	3-98	Energizes lower beam azimuth solenoid L842 in AZIMUTH ORIENT poeition to allow placing LOWER BEAM AZIMUTH handwheel in detent. Releases solenoids L842, L841, and L831 in OFF position. In OFF and AZMIMUTH ORIENT **positions,** Δ RANGE **and** Δ AZIMUTH handwheels may be in detent. Energizes solenoids L831 and L841 in DETENT RELEASE position so **that** Δ RANGE **and** Δ AZIMUTH handwheels may be moved from detent.
Δ RANGE handwheel.	3-98	set the range of the upper beam intercept into the computer and moves the range strobe line on the indicator.
RANGE counter M831.	3-98	Indicates lower beam range and **Δ range in** meters when positioned by LOWER BEAM RANGE and Δ RANGE handwheels.
LOWER BEAM RANGE handwheel.	3-98	Used to eat the range of the lower beam intercept point into the computer by moving the range strobe line on the indicator to bisect the lower beam echo.
RADAR LOCATION EASTING switch S851.	3-98	Controls slewing motor B817 to drive RADAR LOCATION EASTING counter M817 which adds on a differential to produce the correct weapon easting. S851 is used in installation and alignment.

Table 3-42. Computing system Controls and Adjustments - Continued

Controls and adjustments	Location (fig.)	Function
Front panel controls - Continued		
RADAR LOCATION EASTING counter M817.	3-98	Mechanically driven by slewing motor B817 to indicate radar location in map coordinates.
RADAR LOCATION AZ ORIENT switch S853.	3-98	Controls slewing motor B843 which sets the desired azimuth indication into the counter at the initial radar orientation.
RADAR LOCATION NORTHING switch S852.	3-98	Controls slewing motor B817 which drives RADAR LOCATION NORTHING counter M817 and adde on a differential for the correct weepon northing. S852 is used in installation and alignment.
RADAR LOCATION NORTHING counter M817.	3-98	Mechanically driven by slewing motor B817 to indicate radar location in map coordinates.
WEAPON LOCATION EASTING counter M816.	3-98	Indicates weapon location in map coordinates,
WEAPON LOCATION NORTHING counter M816.	3-98	Indicates weapon location in map coordinates.
AZIMUTH counter M841.	3-98	Mechanically driven by LOWER BEAM AZIMUTH hand. wheels and slewing motor B843 to indicate the azimuth to the weapon,
Δ AZIMUTH hand. Wheel.	3-98	Sets the azimuth of the upper beam intercept into the computer. The Δ AZIMUTH handwheel is set in end out of the detent position during operation. The azimuth to the upper beam intercept is determined when the azimuth strobe line bisects the upper echo,
LOWER BEAM AZIMUTH handwheel,	3-98	Used to set the azimuth of the lower beam intercept point into the computer, By moving the handwheel, the azimuth from the radar to the lower beam intercept is determined when the azimuth strobe on the indicator bisects the lower beam intercept.

Table 3-42. Computing system Controls and Adjustments - Continued

Controls and adjustments	Location (fig.)	Function
Front panel controls-Continued		
DOUBTFUL SOLUTION indicator lamp 852 .	3-98	Lights when values of height and time eet into the computer are such that C is greater than 3.8.
Weapon HEIGHT counter M806.		Indicates the height of the weapon in meters above sea level when the height of the radar adjustment is combined with the height of weapon adjustment.
Weapon height hand wheel.	3-98	Mechanically positions the weapon height counter in conjunction with the radar adjustment to produce weapon height.
RADAR HEIGHT counter M807.	3-98	Indicates height of radar above sea level when RADAR HEIGHT adjustment is rotated.
RADAR HEIGHT adjustment,	3-98	Sets the height of the radar aet into the computer end positions a differential to add with the weapon height. This control is adjusted during installation and alignment.
DIMMER control R879.	3-98	Controls brightness of panel lights.
Servoamplifi er chassis (fig. 3-99)		
Balance control R882,		**Balances C Δ** R servoamplifier AR928B by applying a small voltage to the input from transformer T862.
Balance control R883.		**Balances C Δ** A servoamplifier AR929B by applying a small voltage to the input from transformer T862.
Balance control R885.		Balances C servoamplifier AR927A by applying a small voltage to the input from tmnformer T862.
Balance control R886.		Balances casting servoamplifier AR928A by applying a bias voltage to the cathodes of the output tubes of the ser. voamplifiers,
Balance control R887.		Balances northing servoamplifier AR929A by applying a- bias voltage to the cathodes of the output tubes of the ser. voamplifiers.
Left side of computer drawer (fig. 3-101)		
E adjustment L		Sets mechanical analog E_L into the computer by moving the stator (body) of control transformer B882. This adjustment is made

Table 3-42. Computing system Controls and Adjustments - Continued

Controls and adjustments	Function
Left side of computer drawer (fig. 3-101) - Continued	
E adjustment L-Continued	during alignment to adjust for any difference between the computer lower beam elevation counter and the antenna elevation counter.
Beam reparation dial.	Adds the proper value to mechanical analog EL on potentiometer R822 to produce analog E_{υ}. For computer alignment and beam separation dief is set to 35; otherwise, the diaf is set to the value indicated on the beam separation plate (fig. 4, TM 11-5840-208-10) for normal operation
Right side of omputer drawer (fig. 3-101)	
TEST NORMAL switch S855.	Used during teat to switch the C-section to a position of C = 1.
Potentiometer R898.	Adjusted to obtain a calibrated C-gears indication of 1.00 with TEST-NORMAL switch S855 in the TEST poeition by establishing a reference voltage input to C servoamplifier AR927AA.
Calibrated C gears	Used to indicate the value of C for each value of range, azimuth and elevation. The gears are rotated for correct value of C during alignment.

(2) *Servoamplifier subassemblies.* Controls R928 and R933 located on the dual servoamplifier subassemblies (fig. 3-104) are gain control potentiometers.

(3) *Rear of computer drawer.* Switch S854 is located on the rear of the computer drawer (fig. 3-100). The switch applies 115 volts ac to the magnetic amplifiers through relay K852.

c. Test Jacks. The computer has no test jacks for use in locating troubles. The test jacks, located in the bottom front of the computer drawer between the mechanical subassemblies and the servoamplifiers are used in aligning the various computer circuits.

d. Dc Resistance of Computing System Transformers and Coils. Table 3-43 lists the transformers and coils in the computing system, references a figure that shows the location of each, and gives the in-circuit dc resistance of every winding.

Table 3-43. Dc Resistance of Computing System Transformers and Coils

Transformer or coil	Location (fig.)	Terminals	Dc resistance (ohms)
T859	3-103	1-2	11
		3-4	4
T860	3-103	1-4	2.3
		2-4	2.2
		3-4	2.1
		5-6	0
		5-7	0
		6-7	0
		8-9	0
T926-T927	3-104	1-2	1,100
		3-4	2,000
		3-5	4,600
		4-5	2,400
L816	3-105	Pine D and J of J816	11
L831	3-106	Pine W and X of J832	8
L841	3-107	Pina F and J of J843	8
L842	3-107	Pina E and J of J843	8
K951	3-108	Pin 6 of V853 and Pin C of P858.	8K
T851-T858[a]	3-109	8-10	100
		7-9	100
		1-6	16

[a]Resistance may vary because of internal resistors for correcting core characteristics (para 2-47g(4)).

Table 3-43. Dc Resistance of Computing System Transformers and Coils - Continued

Transformer or coil	Location (fig.)	Terminals	Dc resistance (ohms)
T851-T858	3-109	4-6	16
		2-5	17
		3-5	17
		2-3	35
		1-4	35
T861	3-103	1-2	6.5
		3-14	1.7
		4-14	1.7
		5-14	1.7
		6-14	0.2
		7-14	1.0
		8-14	1.0
		9-14	1.5
		10-14	1.6
		11-14	0.2
		12-14	0.1
		13-14	0.1
		15-14	0.1
		16-14	1.0
		17-14	1.0
		18-14	0.2
		19-14	0.1
		20-14	0.1
		21-14	1.6
		22-14	1.6
		23-14	1.8
		24-14	1.8
		25-14	1.9
T862	3-108	2-3	13
		2-4	25
		3-4	13
		6-7	0.3
K852	3-100	A-H	S00K

a Resistance may vary because of internal resistors for correcting core characteristics (para 2-47g(4)).

3-37. Computing System Troubleshooting

a. General. Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the computing system.

(1) *Symptom troubleshooting table* (table 3-45). Troubles that have been sectionalized to the computing system can usually be isolated rapidly by following a procedure based on symptoms that localize the trouble to either a subassembly, a circuit, or a stage. The symptoms given in the table consist of indications obtained on the indicator and on the counters of the computer front panel. To troubleshoot the computer by using the symptom troubleshooting table, proceed as follows:

(a) Observe the symptoms obtained on the indicator and on the counters of the computer front panel.

(b) Compare the indications obtained with those listed in the symptom column.

(c) If the indications obtained correspond to those listed for a particular symptom, follow the procedure given in the probable trouble column to isolate the trouble.

(d) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleshooting table (table 3-46).

(2) *Step-by-step troubleshooting table* (table 3-46). The computing system step-by-step troubleshooting table consists of a series of steps designed to evaluate all phases of operation of the computing system. To troubleshoot the computing system by using the step-by-step troubleshooting table, proceed as follows:

(a) Locate the test point given in step 1 of the table.

(b) Connect the test equipment and set the controls on the test equipment as directed in the test equipment column.

(c) Set the controls on the computer as directed in the computer controls column.

(d) Compare the indications obtained on

the test equipment with the indications given or referenced in the normal indications column.

(e) If the indications obtained on the test equipment are normal, proceed either to the next step or as directed in the normal indications column.

(f) If the indications obtained are abnormal, proceed as directed in the corrective measures column.

b. Test Equipment Required, Table 3-44 lists items of test equipment that are required to troubleshoot the computing system.

Table 3-44. Test Equipment Required to Troubleshoot the Computing System

Test equipment	Common name	Technical manuel
Multimeter TS-952B/U.	Multimeter	TM 11-6625-366-15
Electronic Multi-Meter ME-26B/U.	Vacuum tube voltmeter.	TM 11-6625-200-15
Electron Tube Set Teet TV-7D/U.	Tube tester	TM 11-6625-274-12

c. Preparation of Computing System Components for Troubleshooting. The components of the computing system are readily accessible when the computer drawer is pulled out. Power must be applied to the computing system by closing switch S1006, located inside the control-indicator cabinet in the left-front of the computer compartment (fig. 3-110). The servoamplifier subassemblies are mounted on a servoamplifier chassis in the top-rear section of the computer drawer. To remove any of the amplifier subassemblies, unscrew the front and back captive screws and lift out the amplifiers. The nagnetic amplifiers occupy the section under the servo amplifier chassis. To reach this section, loosen two screws on the front corners of the servoamplifier chassis and lift the chassis back on the hinges (fig. 3-109 and 3-111).

CAUTION

Do not measure the resistance of the precision potentiometers with Multimeter TS-352B/U. The resulting current through the potentiometers may damage them.

Table 3-45. Computing System Symptom Troubleshooting Table

Symptom	Probable cause	Corrective measure
Indication on AZIMUTH counter M841 dose not change when antenna is rotated in azimuth.	*a.* Servoamplifier AR926B.	*a.* Substitute another servoamplifier for AR926B. If the symptom disappears, troubleshoot the servoamplifier (para 3-42c).
	b. Dual speed cutover amplifier AR951B.	*b.* Rotate antenna in azimuth with the azimuth handwheel If the symptom disappears, troubleshoot dual speed cutover amplifier AR951B (para 3-42c).
	c. Servomotor B841.	*c.* Check servomoter B841.
	d. Control transformer B844.	*d.* Check control transformer B844.
AZIMUTH counter M841 records changes in only one direction when antenns rotates.	Selenium rectifier CR851	Check selenium rectifier for an open circuit.
AZIMUTH counter M841 records changes in only one direction **when Δ** AZIMUTH handwheel is rotated.	selenium rectifier CR854	Check CR854 for open circuit.
Azimuth strobe line on indicator does not move when LOWER BEAM AZIMUTH OR **Δ AZIMUTH** handwheels are rotated.	*a.* Servo amplifier AR926A.	*a.* Substitute another servoamplifier for AR926A. If the symptom disappears, troubelshoot the servoamplifier (para 3-42c).
	b. Control transformer B846,	*b.* Check B846.
	c. Servometer B3202.	*c.* Troubleshoot B3202.
Azimuth strobe line on indicator oscillates (changes position).	Servoamplifier AR926A	Adjust R928 on AR926A. If symptom does not disappear, substitute another servoamplifier for AR926A. If symptom still does not disappear, zero servomotor B3202,

Table 3-45. *Computing System Symptom Troubleshooting Table-Continued*

Symptom	Probable cause	Corrective measure
LOWER BEAM ELEVATION counter M821 records changes in elevation in only one direction.	Selenium rectifier CR852	Check selenium rectifier for open circuit .
RANGE counter M831 records changes in only one direction when Δ RANGE handwheel is rotated.	Selenium rectifier CR853	Check selenium rectifier for open circuit .
RANGE counter M831 moves slowly	Selenium rectifier CR853	Check selium rectifier for short.
WEAPON LOCATION EASTING or WEAPON LOCATION NORTHING counter M816 records changes in only one direction.	Selenium rectifiers CR857 or CR858.	Check selenium rectifiers for open circuits.
Gear train chatter or hunting	Misalignment of computer	Adjust associated gain potentiometer R298 and R933; align computer (para 3-49). Check sarvoamplifier, associated with gear train that chatters, by substitution. **NOTE** If a new amplifier is substituted for the existing amplifier, be sure to edjust the associated gain potentiometer on the new amplifier. Check to see if radiation from Z161 (fig. 3-52) is causing the gear chatter. To make this check, provide shielding by placing a sheet of metalized cloth over the servoamplifier chassis end closing the computer drawer, using care to prevent en electrical short; or temporarily remove V161 (fig. 3-52). If gear chatter disappears, check Z161 by substitution (para 3-*33f*) .

d. Troubleshooting by Substitution. Troubles suspected in the servoamplifiere or coordinate subassemblies can be isolated quickly by substitution. The four dial servoamplifiere in the computer are identical and may be easily changed ((1) below). The two coordinate subassemblies are identical ((2) below).

(1) *Servoamplifier.* Trouble can be isolated to a defective amplifier by substituting another servoamplifier (fig. 3-104). The four servoamplifier subassemblies located on the servoamplifier chassis, are directly interchangeable and reversible.

(2) *Northing and casting subassemblies.* To eliminate either of the mechanical coordinate subassemblies (easting or northing) as a possible source of trouble, reverse the connectors and check to see whether the mechanical subassembly performs satisfactorily. For example, if WEAPON LOCATION EASTING Counter M816 goes to the limit stop, the possible trouble could be defective servoamplifier AR928A, defective magnetic amplifier T851, or defective servomotor B816. Disconnect NORTHING connector P817 from the northing subassembly and EASTING connector P816 from the casting subassembly. Connect NORTHING connector P817 to the casting subassembly and observe the counter. If the counter goes to the limit stop, then the mechanical subassembly can be eliminated as the cause of the trouble.

Table 3-46. *Computing System Step-by-Step Troubleshooting Table*

Step	Computer controls	Normal indications	Corrective measures
1	**Rotate** Δ RANGE or LOWER BEAM RANGE handwheel.	Indication on RANGE counter changes. Range strobe line on indicator moves.	Troubleshooting servoamplifier AR928B (para *3-42c)* or servomotor B831.
2	**Rotate** Δ AZIMUTH or LOWER BEAM AZIMUTH handwheel	Indication on AZIMUTH counter changes. Azimuth strobe line on indicator moves.	Troubleshoot servoamplifier AR929B (para *3-42c).*

Table 3-46. Computing System Step-by-Step Troubleshooting Tabk - Continued

Step	Computer controls	Normal indications	Corrective measures
3	Operate RADAR LOCATION EASTING switch S851 .	RADAR LOCATION EASTING counter M817 indication should change	Troubleshoot switch or motor B817.
4	Operate RADAR LOCATION NORTHING switch S852.	RADAR LOCATION NORTHING counter M817 indication should change.	Troubleshoot switch or motor B817.
5	Rotate RADAR LOCATION AZ ORIENT switch S853.	Indication on AZIMUTH counter M841 should change.	Troubleshoot switch S853 or motor B843.
6	Radar antenna changed in elevation; computer controls in operating position.	LOWER BEAM ELEVATION counter M821 changes with change in elevation.	Troubleshoot servoamplifier AR927B (para *3-42c)* and control transformer B822,

3-38. Removal and Replacement of Parts in Computing System

a. General.

CAUTION

Be careful when removing and replacing parts to prevent damaging computer parts, such as synchro resolvers, synchro control transformers, and helipots, which are of precision manufacture and require careful handling. Such parts are found in the mechanical subassemblies which are the plug-in compartments in the front section of computer drawer (fig. 3-111).

(1) To remove any of the eight mechanical subaesemblies in the front section of the computer, remove the dust cover (fig. 3-102).

(2) To remove any of the six amplifiers at the top rear of the drawer, loosen the two captive screws, one at each end of the chassis, and lift the amplifier.

(3) To remove any of the parts at the rear of the front panel, remove the dust cover and the mechanical subassemblies.

(4) Removal and replacement of some parts will require uncabling the computer drawer and removing the drawer from the cabinet.

b. Removal and Replacement of Alignment Potentiometers R976 through R995.

(1) *Removal.*

(a) Remove the four screws from the dust cover (fig. 3-102).

(b) Remove the duet cover.

(c) Remove the six screws from the potentiometer panel (fig. 3-99).

(d) Lift the panel. The backs of the potentiometers are now accessible.

(e) Unsolder, disconnect, and tag the leads from the defective potentiometer.

(f) Remove the nut and the lockwasher from the shaft end of the potentiometer.

(g) Remove the defective potentiometer.

(2) *Replacement.*

(a) Replace the lockwasher and the nut.

(b) Connect and solder the leads removed from the defective potentiometer. Be sure that the leads are connected to the correct terminals.

(c) Replace the potentiometer panel and the six screws.

(d) Replace the dust cover and fasten it with the four screws.

(e) When replacing one of the potentiometers (R976 through R995) at the right-rear of the computer drawer, aline the circuit controlled by that particular potentiometer as described in paragraph 3-39.

c. Removal and Replacement of Magnetic Amplifiers T851 through T858.

(1) *Removal.*

(a) Remove the dust cover by unscrewing the four screws (fig. 3-102).

(b) Loosen the two captive screws at the front comers of the servoamplifier chassis (fig. 3-111).

(c) Lift the front of the hinged servoamplifier chassis and swing it back:

(d) Unsolder, disconnect, and tag the leads.

(e) Remove the nut from the bottom of the magnetic amplifier and remove the magnetic amplifier.

(2) *Replacement.*

(a) Install the replacement magnetic amplifier. Install and tighten the nut on the bottom of the magnetic amplifier.

(b) Connect and solder the leads. Make sure that the wires are connected to the proper terminals.

(c) Carefully position the hinged servoamplifier chassis in place and fasten the two captive screws.

(d) Replace the dust cover and fasten it with the four screws.

d. Removal and Replacement of Selenium Rectifiers CR851 through CR858 (fig. 3-109).

(1) *Removal.*

(a) Remove the dust cover and lift the hinged servoamplifier chassis as described in paragraph *3-38a.*

(b) Unsolder, disconnect, and tag the leads to the rectifier being removed.

(c) Remove the nut and washer from the top of the rectifier.

(d) Remove the nut and washer from the adjoining rectifier. Remove the bracket.

(e) Remove the nut and washer from the bottom of the rectifier.

(f) Remove the defective rectifier.

(2) *Replacement.*

(a) Install the replacement rectifier.

(b) Install the washer and nut on the bottom of the replacement rectifier.

(c) Install the bracket between the top of the replacement rectifier and the top of the adjoining rectifier.

(d) Replace the washer and nut on the adjoining rectifier. Tighten the nut.

(e) Install the washer and the nut on the top of the replacement rectifier. Tighten the nut.

(f) Connect and solder the leads to the rectifier. Make sure that the leads are connected to the proper terminals.

(g) Carefully position the hinged servoamplifier chassis in place and fasten it with the two captive screws.

(h) Replace the dust cover and fasten it with the four screws.

e. Removal and Replacement of Autotransformer T859, Filament Transformer TWO, and Reference Transformer T861.

(1) *Removal.*

(a) Remove the four screws that hold the dust cover; remove the dust cover (fig. 3-102).

(b) Remove the six screws from the potentiometer panel at the right-rear corner of the computer drawer.

(c) Lift the potentiometer panel and lay it to one side. The tops of the transformers are now accessible.

(d) Unsolder, disconnect, and tag the leads of the transformer being replaced.

(e) Remove the four nuts and washers. Remove the transformer.

(2) *Replacement.*

(a) Install the replacement transformer with the four nuts and washers., Tighten the nuts securely.

(b) Connect and solder the leads to the transformer. Be sure that the leads are connected to the correct terminals of the transformer.

(c) Position the potentiometer panel and fasten it with the six screws.

(d) Replace the dust cover and fasten it with the four screws.

f. Removal and Replacement of Damping Filters FL851 through FL855.

(1) *Removal.*

(a) Remove the dust cover by removing the four screws (fig. 3-102).

(b) Remove the two captive screws in the front comers of the hinged servoamplifier chassis.

(c) Lift the front of the servoamplifier chassis and swing it back to expose the five resonant damping filters located in the bottom-rear section of the computer drawer (fig. 3-109).

(d) Unsolder, disconnect, and tag the wires of the filter removed and remove the resistor connected to the filter terminals.

(e) Remove the four secrews from the bottom of the filter.

(f) Lift the filter out of the computer drawer.

(2) *Replacement.*

(a) Install the replacement filter.

(b) Replace and tighten the screws on the bottom of the filter.

(c) Connect and solder the wires to the filter. Connect and solder the resistor to the terminals. Make sure that the wires are connected to the proper terminals of the filter.

(d) Lower the hinged servoamplifier chassis in place and fasten it with the two captive screws.

(e) Replace the dust cover and fasten it with the four screws.

g. Removal and Replacement of Potentiometers R882, R883, R885, R886, and R887.

(1) *Removal.*

(a) Remove the four screws from the dust cover. Remove the dust cover (fig. 3-102).

(b) Remove the two captive screws from the front corners of the hinged servoamplifier chassis (fig. 3-111).

(c) Lift the front of the servoamplifier chassis. The potentiometer backs are now exposed.

(d) Unsolder, disconnect, and tag the wires to the potentiometer being removed.

(e) Remove the nut from the shaft of the potentiometer and withdraw the potentiometer from the chassis.

(2) *Replacement.*

(a) Install the potentiometer in its proper position.

(b) Fasten it in place with the nut.

(c) Connect and solder the wires to the potentiometer. Make sure the wires are connected to the proper terminals.

(d) Lower the servoamplifier chassis in place and fasten it with the two captive screws.

(e) Replace the dust cover and fasten with the four screws.

h. Removal and Replacement of Relay K852.

(1) *Removal*

(a) Uncable the computer and remove the computer drawer from the cabinet.

(b) Carefully turn the computer drawer on its side.

(c) Unsolder, tag, and disconnect the leads to the relay (fig. 3-100).

(d) From the rear of the computer, remove the two screws that hold the relay.

(e) Remove the relay.

(2) *Replacement.*

(a) Fasten the replacement relay in position with the two screws.

(b) Connect and solder the leads to the replacement relay. Make sure that the replacement relay is connected in the same manner as the defective relay.

(c) Replace the computer drawer in the cabinet and fasten the cables.

i. Removal and Replacement of Resistors R943 through R950 and R896.

(1) *Removal.*

(a) Uncable the computer and remove the computer drawer from the cabinet.

(b) Carefully turn the computer drawer on its side.

(c) Unsolder, tag, and disconnect the leads to the defective resistor (fig. 3-100).

(d) Remove the screw that holds the defective resistor.

(e) Remove the resistor.

(2) *Replacement.*

(a) Fasten the replacement resistor in position with a screw, washer, and standoff terminal.

(b) Connect and solder the leads to the resistor.

(c) Return computer drawer to the cabinet and fasten the cables.

j. Removal and Replacement of Switch S854 (fig. 3-100).

(1) *Removal.*

(a) Uncable the computer and remove the computer drawer from the cabinet.

(b) Carefully turn the computer drawer on its side.

(c) Unsolder, tag, and remove the leads to the switch.

(d) unscrew the nut that holds the switch and remove the switch.

(2) *Replacement.*

(a) Fasten the switch in position with the nut.

(b) Connect and solder the leads to the switch.

(c) Return the computer drawer to the cabinet and fasten the cables.

k. Removal and Replacement of Transformer T862.

(1) *Removal.*

(a) Remove the two captive screws from the front of the servoamplifier chassis (fig. 3-111).

(b) Lift the hinged servoamplifier chassis out of the way.

(c) Unsolder, tag, and disconnect the leads to the transformer.

(d) Remove the screws, washers, and standoff insulator from the transformer.

(e) Remove the transformer.

(2) *Replacement.*

(a) Fasten the replacement transformer in position with the screws and washers.

(b) Connect and solder the leads to the transformer.

(c) Fasten the servoamplifier chassis in place with the two captive screws.

1. *Removal and Replcement of Detent Switch S856.*

(1) *Removal.*

(a) Remove the dust cover by removing the four screws (fig. 3-102).

(b) Disconnect connectors J806, J811, J841, J842, J843, J817, J816, J831, J832, J821, J801, J866, and J867 from the mechanical subassemblies.

(c) Remove the mechanical subassemblies as described in *p* below.

(d) Remove the four bolts and lockwashers that hold the side braces to the front panel (fig. 3-103).

(e) Remove the bolt and lockwasher that attach the front panel to the right drawer slide (fig. 3-100).

(f) Remove the bolt and lockwasher that attach the front panel to the left drawer slide (fig. 3-100).

(g) Remove the three bolts and lockwashers that attach the chassis mounting bracket to the front panel.

(h) Detach the front panel from the computer drawer and lay it face down on the bench.

(i) Unsolder, tag, and disconnect the leads to the switch.

(j) Remove the seal nut from the switch.

(k) Remove the switch (fig. 3-100).

(2) *Replacement.*

(a) Place the replacement switch in position and fasten it with the seal nut. Make sure that the keyway washer is in place.

(b) Connect and solder the leads to the switch. Make sure that the leads are connected to the proper terminals.

(c) Hold the front panel in place and replace

the three bolts and lockwashers that attach the bracket to the computer front panel.

(d) Replace the bolt and lockwasher in the right drawer slide.

(e) Replace the bolt and lockwasher in the left drawer slide.

(f) Replace the four bolts and lockwashers that attach the side braces to the front panel. Tighten the bolts.

(g) Replace the mechanical subassemblies as described in *p* below.

(h) Connect the connectors that were removed.

(i) Replace the dust cover and fasten in place with the four screws.

m. Removal and Replacement of Switches S851, S852, and S853.

(1) *Removal.*

(a) Remove the four screws from the dust cover; then remove the dust cover.

(b) Remove the front panel of the computer *(l(1) (b)* through *(h)* above).

(c) Tag, unsolder, and disconnect the leads to the switch (fig. 3-103).

(d) Loosen the setscrew and remove the knob from the switch shaft.

(e) Remove the nut from the shaft of the switch.

(f) Remove the switch (fig. 3-103),

(2) *Replacement.*

(a) Place the switch in position and fasten the nut securely.

(b) Replace the knob on the switch shaft and tighten the set screws.

(c) Connect and solder the leads to the switch. Make surte that the leads are connected to the proper terminals.

(d) Replace the front panel *(l(2) (c)* through *(h)* above).

(e) Replace the dust cover and fasten it in place with the four screws.

n. Removal and Replacement of DIMMER Potentiometer R879.

(1) *Removal.*

(a) Remove the dust cover by removing the four screws (fig. 3-102).

(b) Remove the computer front panel (para *3-38l(1) (b)-(h)).*

(c) Tag, unsolder, and disconnect the leads to the potentiometer.

(d) Loosen the setscrew and remove the knob from the shaft of the potentiometer.

(e) Remove the seal nut.

(f) Remove the potentiometer.

(2) *Replacement.*

(a) Mount the replacement potentiometer in place and fasten it with the seal nut.

(b) Replace the knob and fasten the set-screw.

(c) Connect and solder the leads to the potentiometer.

(d) Replace the front panel as described in *(l(2) (c)* through *(h)* above).

(e) Replace the dust cover and fasten it in place with the four screws.

o. Removal and Replacement of Resistors R873 through R878.

(1) *Removal*

(a) Remove the four screws (fig. 3-102) from the dust cover. Remove the dust cover.

(b) Remove the computer front panel *(l(1) (b)* through *(h)* above).

(c) Tag, unsolder, and disconnect the leads to the resistor,

(d) Remove the resistor by removing the screw.

(2) Replacement.

(a) Fasten the replacement resistor in place with the screw.

(b) Connect and solder the leads to the resistor.

(c) Replace the front panel *(l(2) (c)* through *(h)* above).

(d) Replace the dust cover and fasten it with the four screws.

p. Removal and Replacement of Mechanical Subassemblies. The mechanical subassemblies of the computer are the plug-in components in the front section of the computer drawer (fig. 3-111).

(1) *Removal of elevation subassembly.* The elevation subassembly is in the lower-left front section of the computer drawer, underneath the time subassembly (fig. 3-101).

(a) Disconnect connector P821 from connector J821.

(b) Remove the time subassembly as described in (3) below.

(c) Loosen the four captive screws that hold the subassembly in place.

(d) Carefully remove the elevation subassembly from the panel,

(2) *Replacement of elevation subassembly.*

(a) Carefully place the elevation subassembly in position.

(b) Tighten the four captive screws.

(c) Reconnect connector P821 to connector J821.

(d) Replace the time subassembly as described in (4) below.

(3) *Removal of time subassembly.*

(a) Disconnect connector P801 from connector J801.

(b) Loosen the two captive screws that hold the time subassembly to the front panel.

(c) Carefully remove the time subassembly.

(4) *Replacement of time subassembly.*

(a) Place the time subassembly in position and fasten the two captive screws.

(b) Reconnect connector P801 to connector J801.

(5) *Removal of range subassembly.*

(a) Disconnect connectors P831 and P832 from connectors J831 and J832.

(b) Loosen the four captive screws that hold the range subassembly to the front panel (fig. 3-123).

(c) Remove the four Phillips-head screws and lockwashers that hold the **Δ RANGE name** plate on the front panel (fig. 3-98).

(d) Carefully pull the **Δ RANGE nameplate** and lamp assembly I 861 out until the lamp assembly is outside the panel.

(e) Carefully remove the range subassembly from the computer drawer.

(6) *Replacement of range subassembly.*

(a) Position the range subassembly in the computer drawer.

(b) Tighten the four captive screws that hold the range subassembly to the front panel.

(c) Replace lamp I 861 and the **Δ RANGE** nameplate. Replace the four Phillips-head screws and lockwashers. Tighten the screws.

(d) Reconnect connectors P831 and P832 to connectors J831 and J832.

(7) *Removal of easting subassembly.*

(a) Disconnect connector P816 from the connector J816.

(b) Loosen the thres captive screws that hold the subassembly in place.

(c) Remove the casting subassembly.

(8) *Replacement of casting subassembly.*

(a) Position the easting subassembly in place and tighten the three captive screws.

(b) Connect connector P816 to connector J816.

(9) *Removal of northing subassembly.*

(a) Disconnect connector P817 from connector J816.

(b) Loosen the three captive screws that hold the northing subassembly in place (fig. 3-111).

(c) Carefully remove the northing subassembly.

(10) *Replacement of northing subassembly.*

(a) Carefully position the northing subassembly in place and tighten the three captive screws.

(b) Connect connector P817 to connector J816.

(11) *Removal of azimuth subassembly.*

(a) Disconnect connectors P841, P842, and P843 from J841, J842, and J843.

(b) Loosen the four captive screws that hold the azimuth subassembly in place.

(c) Carefully remove the azimuth subassembly from the computer drawer.

(12) *Replacement of azimuth subassembly.*

(a) Carefully position the azimuth subassembly in place and tighten the four captive screws.

(b) Connect connectors P841, P842, and P843 to connectors J841, J842, J843.

(13) *Removal of height subassembly.*

(a) Remove the two Phillips-head screws that hold weapon height lamp assembly 1806 and drape the lampholder (harnessed wires attached) over to the left of the height subassembly.

(b) Disconnect connector P806 from connector J806.

(c) Loosen the two captive screws that hold the subassembly in place.

(d) Carefully remove the height subassembly from the computer drawer.

(14) *Replacement of height subassembly.*

(a) Carefully position the height subassembly in place and tighten the two captive screws.

(b) Connect connector P806 to connector J806.

(c) Replace lamp assembly 1806 on the height subassembly with two Phillips-head screws removed in (13) *(a)* above.

(15) *Removal of C-subassembly.* The C subassembly is in the right-center section of the computer drawer underneath the potentiometer panel (fig. 3-102).

(a) Remove the six Phillips-head screws from the potentiometer panel.

(b) Lift the potentiometer panel and lay it to one side.

(c) Disconnect connector P811 from connector J811.

(d) Loosen the two captive screws that hold the C-subassembly in place.

(e) Carefully lift the C-subassembly out of the computer drawer.

(16) *Replacement of C-subassembly.*

(a) Lower the C-subassembly into position and tighten the two captive screws that hold it in place.

(b) Position the potentiometer panel in place and fasten with the six Phillips-head screws.

(c) Connect connector P811 to connector J811.

3-39. Computing System Electrical Alignment

a. General. The computing potentiometer checks and alignment procedures in this section apply only to Radar Data Computer CP-319/MPQ-4A in Radar Set AN/MPQ-4A. If an alignment cannot be satisfactorily completed on a subassembly, it may be necessary to perform the mechanical alignment (para 3-40) on a given assembly.

b. Alignment.

(1) The electrical end mechanical alignment procedures contained in this paragraph and paregraph 3-40 allow for checking, adjusting, and aligning each of the mechanical subassemblies. A test point is connected to the slider of each computer potentiometer and alignment potentiometer is connected to one or both ends of the computing potentiometer (fig. FO-18).

(2) The computer test set is connected to the teat jacks at the potentiometer slider and to the reference voltage jacks. The alignment potentiometers are then rotated until the computing potentiometer is balanced and a null is indicated onthe test set.

(3) The test jacks are in the bottom compartment of the computer, between the mechanical subassemblies and the eervoamplifier chassis (fig. 3-99). The electrical connections of the test jacks and the alignment potentiometers are shown in figure FO-19. The alignment potentiometers are located on the top-right rear section of the computer drawer (fig. 3-99).

c. Test Equipment Required. The following items of test equipment are required to check adjust, and align the computer.

(1) Computer Teat Set TS-909/PPM is a null indicating device used for checking, adjusting, and aligning the CP-319/MPQ-4A, and aids in isolating troubles that have been localized to the computer. Instructions for operating the TS-909/PPM are contained in TM 11-1223. Computer Test Set TS-909/PPM will be referred to as test set throughout this paragraph.

CAUTION

Do not measure the resistance of the precision potentiometers with Multimeter TS-352/U. The resulting current through the potentiometers may damage them.

(2) Multimeter TS-352/U is used during alignment. Instructions for operating the TS-352/U are contained in TM 11-6625-366-15. Multimeter TS-362B/U will be referred to as multimeter through this paragraph.

(3) Test Facilities Kit MK-387/MPM-49 furnishes ac and dc operating voltages, interconnecting points, and switching between the computer and the test equipment for bench servicing end testing.

(4) Simulator, Antenna Position SM-154/MPQ-4A is a source of signals, normally generated by Radar Set AN/MPQ-4A, and is required when bench-servicing Radar Data Computer CP-319/MPQ-4A. Simulator, Antenna Position SM-154/MPQ-4A is referred to as simulator throughout this paragraph.

NOTE

Any necessary mechanical alignment of subassemblies can be accomplished by using the radar set as a substitute for the simulator, and duplicating antenna simulator control settinga with actual antenna information. When a procedure requires removal and remoting of mechanical subassemblies, the cables and adapters required are supplied with Test Facilities Kit MK-387/MPM-49.

d. Alignment Procedures.

(1) *Preliminary procedures and adjustments.*

(a) Loosen the four pawl fasteners on the computer front panel and slide the computer drawer out until the catches lock.

(b) Connect the test set power cable to receptacle J898 in the bottom of the computer drawer (fig. 3-100).

(c) Close shorting switch S1006 inside the control-indicator cabinet (fig. 3-110).

(d) Connect test set black ground lead W4605 to the GND jack, J895 (fig. 3-99) on the computer drawer. Use of a cable such as that used for W4603 or W4604 (commonly used with multimeters) is recommended (fig. 2, TM 11-1223).

(e) Turn Control-Power Supply C-2014/MPQ-4A MAIN POWER switch S652 to ON. After a 30-second warmup period, set the test set MAIN POWER switch to ON.

(f) Adjust the test set BRIDGE ADJ dials (fig. 4, TM 11-1223) to zero. Connect the test set cables to the test panel jacks as follows: coaxial cable W4602 to TEST PROBE, black cable W4603 to -REF VOLT, and red cable W4604 to +REF VOLT. Zero the test set NULL METER by shorting ail test cable tips together. If the NULL METER does not indicate zero, do not proceed. Refer to TM 11-1223. Reconnect test set black ground lead W4605 to GND jack J895.

(g) Place detent switch S856 in the OFF (center) position.

(h) Rotate the **ΔRANGE and Δ AZIMUTH** handwheels until the detente engage.

(i) Adjust gain potentiometers R928 and R933 (fig. 3-104) on the servo channels individually fully clockwise. After adjusting each potentiometer

to its maximum position, check its associated gear train for gear chatter or hunting. If gear chatter exists, turn the adjustment potentiometer counterclockwise in small increments until gear chatter stops.

(j) Follow the instruction in TM 11-1223 to operate Computer Test Set TS-909/PPM.

NOTE

Each gain, balance, and alignment potentiometer in the computer is locked by a locknut on the potentiometer shaft. To adjust the potentiometers, first loosen the locknuts. After adjustment has been made to a potentiometer, continue by holding the screwdriver on the potentiometer while fingertightening the locknut and observing the TS-909/PPM NULL METER for correct indication (zero or null).

(2) *Height potentiometer R806 check and alignment.*

(a) Connect the test set red test lead W6404 -REF jack J890 (fig. 3-99) in the computer.

(b) Connect test set black test lead W4603 to B + RET jack J897 in the computer.

(c) Connect test set coaxial test probe W4602 to H jack J882 in the computer.

(d) Set weapon HEIGHT counter and RADAR HEIGHT counter to 1000.

(e) Set the test set BRIDGE ADJ potentiometer to 0000, and turn the weapon HEIGHT handwheel until the test set NULL METER indicates zero. Both HEIGHT counters, M806 and M807, must indicate 1000 ±2.5 meters. If they do not, adjust the shaft of H potentiometer R806 as indicated below,

(f) Remove the height subassembly from the computer drawer (para 3-38p(13)). Be sure to remove power from the computer.

(g) Connect the height subassembly to the computer with remoting cable W2627, CX-4465 (3 ft 4 in.), supplied with Test Facilities Kit MK-387/MPM-49.

(h) Place a strip of masking tape over both radar height and weapon height gears on the right side of the height subassembly (fig. 3-139) to hold them immovable. Reapply power to the computer.

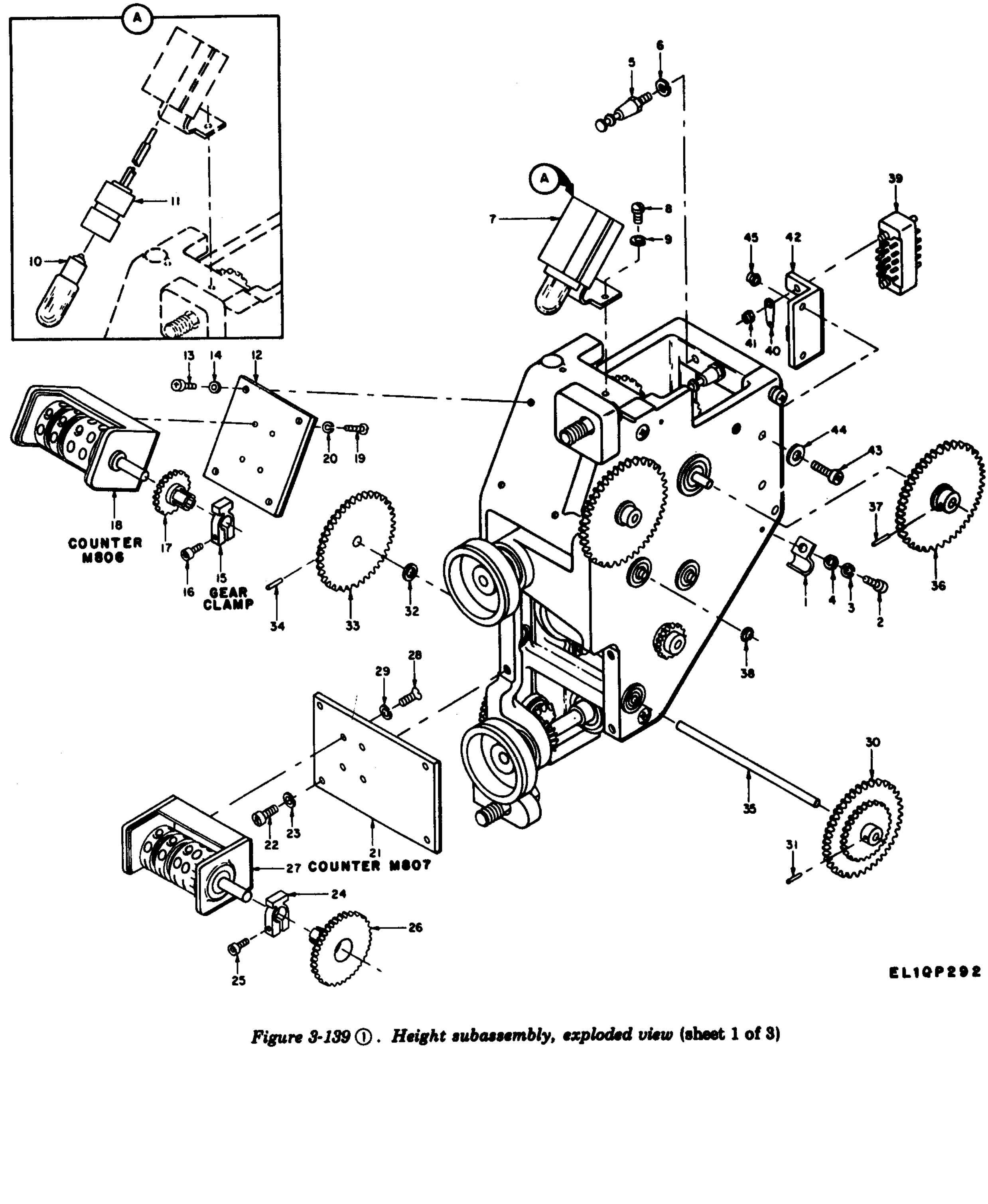


Figure 3-139 ①. *Height subassembly, exploded view* (sheet 1 of 3)

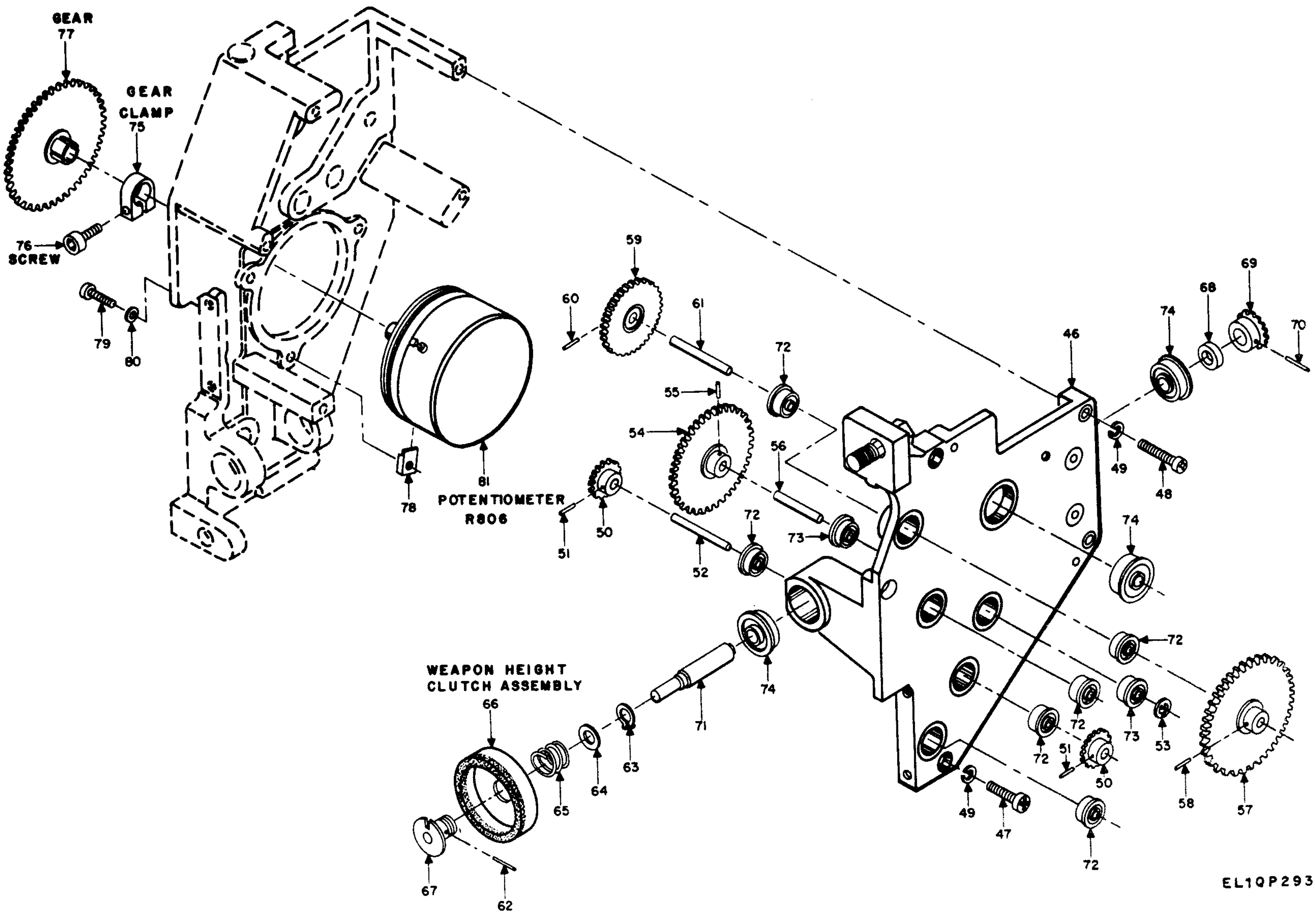


Figure 3-139 ②. *Height subassembly, exploded view* (sheet 2 of 3).

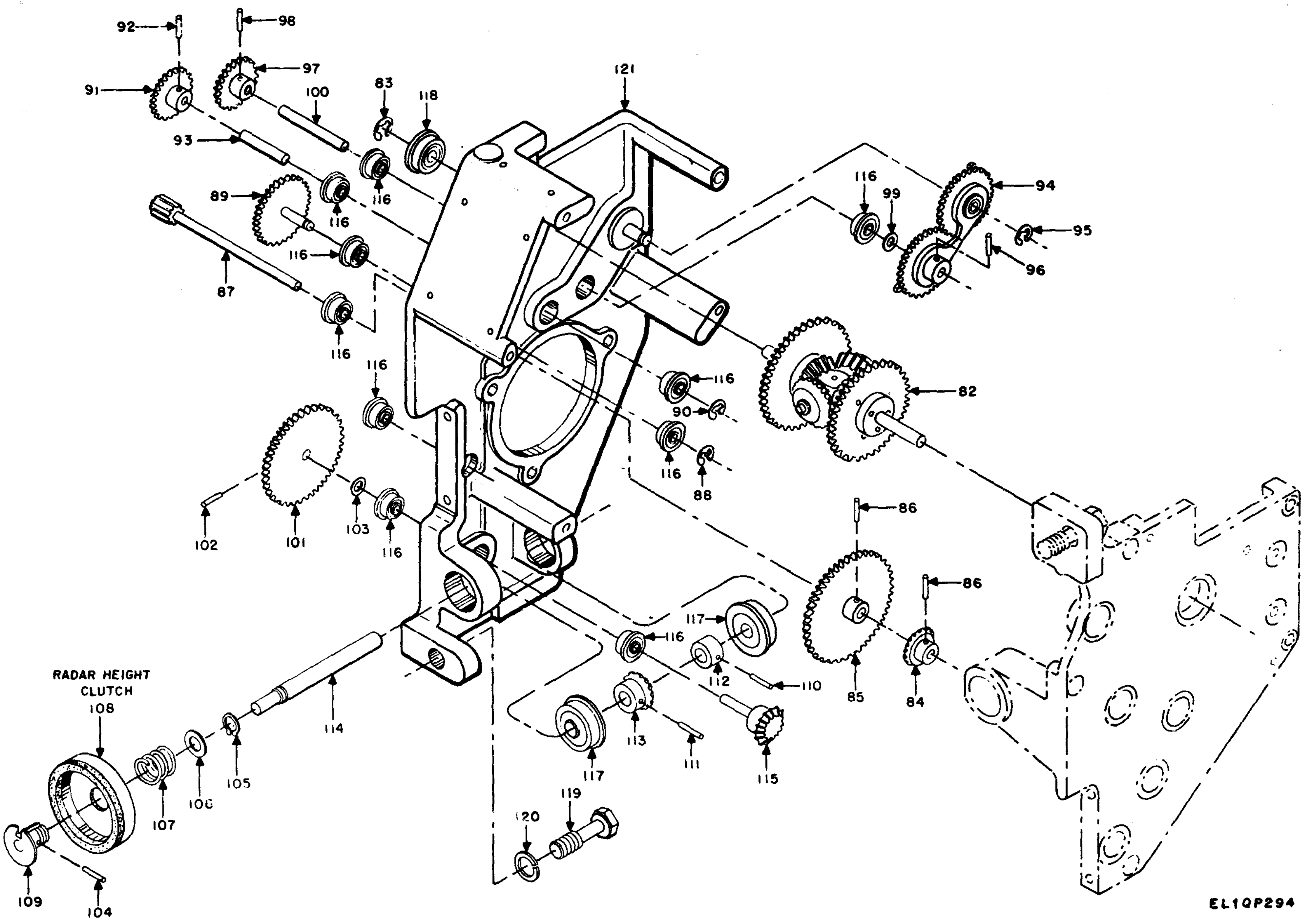


Figure 3-139 ③. Height subassembly, exploded view (sheet 3 of 3).

(i) Loosen the large gear clamp on the left side of the height subassembly (75, 76, and 77, fig. 3-139, sheet 2) with a 1/8-inch Allen wrench.

(j) Adjust the screw in the center of the gear (77, fig. 3-139, sheet 2) which is the shaft of R806, while observing the test set NULL METER for a null.

(k) Retighten the gear clamp with a 1/8-inch Allen wrench while observing the test set NULL METER to insure that the meter needle does not move off the zero point.

(l) Remove power from the computer and disconnect remoting cable W2627.

(m) Remove the masking tape and replace the height subassembly into the computer (para 3-38p(14)).

(n) Reapply power to the computer. If satisfactory results are not obtained after performing the above, begin alignment from (a) above.

(o) Set the BRIDGE ADJ potentiometer to 0357.

(p) Rotate the weapon height handwheel on the computer fron panel until the indication on the weapon HEIGHT counter is 542.5.

(q) Adjust potentiometer R976, at the right rear of the alignment potentiometer panel (fig. 3-99), until the NULL METER indicates zero.

(r) Disconnect red test lead W4604 from -REF jack J890 and connect it to +REF jack J891.

(s) Rotate the weapon height handwheel on the computer front panel until the weapon HEIGHT counter indicates 1457.5.

(t) Adjust potentiometer R977 on the alignment potentiometer panel (fig. 3-99) until the NULL METER on the test set indicates zero.

(u) Disconnect the teat leads.

(3) *Elevation potentiometer check and alignment.*

(a) Set the radar antenna to 0° elevation by operating ELEVATION switch S655 on Control. Power supply C-2014/MPQ-4A.

(b) Set the computer LOWER BEAM ELEVATION counter to 000 by adjusting the worm gear on control transformer B822. The worm gear E_L WORM GEAR, fig. 3-101) which mechanically adjusts the body of the control transformer, can be adjusted with a screwdriver from underneath the drawer. Note that the worm gear is held in place by a 1/2-inch machine screw. To adjust the worm gear, first loosen the screw, then retighten upon adjustment.

(c) Set the beam separation dial (fig. 3-101) to 35 mils during the alignment of the computer. Loosen the three 1/4-inch machine screws, adjust to *exactly* 35 mile, and retighten. The beam separation dial must be reset to the reading called for on the antenna beam separation plate (fig. 4, TM 11-5640-208-10) upon completion of computer alignment. However, reset may be postponed if the computer alignment is to be followed by system field testing (para 3-41a through *e*), as computer accuracy check problems are also based on a beam separation of 35 roils.

(d) Connect the test set red test lead W4604 to– REF jack J890 in the computer.

(e) Connect test set black test lead W4603 to B + RET jack J897.

(f) Connect test set coaxial probe W4602 to E_L jack J881 in the computer.

(g) Elevate the radar set antenna to +50 roils by operating ELEVATION switch S655 on the control-power supply.

(h) Set the test set BRIDGE ADJ potentiometer to 1593.

(i) Adjust potentiometer R983 on the alignment potentiometer panel until the test set NULL METER indicates zero.

(j) Disconnect the red test lead and the coaxial test probe from the test jacks.

(k) Connect the test set red test lead to + REF jack J891 in the computer.

(l) Connect the test set coaxial test probe to E_u jack J887 in the computer.

(m) Set the BRIDGE ADJ potentiometer to 2716.

(n) Adjust potentiometer R985 on the alignment potentiometer panel until an indication of zero is obtained on the test set NULL METER.

(o) Operate control-power supply ELEVATION switch S655 until the radar set antenna is at an elevation of - 50 mils.

(p) Disconnect the test set red test lead from +REF jack J891 and connect to it - REF jack J890.

(q) Set the BRIDGE ADJ potentiometer to 0472.

(r) Adjust potentiometer R986 on the alignment potentiometer panel until the test set NULL METER indicates zero.

(s) Disconnect the red test lead and the coaxial teat probe from the test jacks.

(t) Connect the test set red test lead to +REF jack J891 in the computer.

(u) Connect the teat set coaxial test probe to E_L jack J881 in the computer.

(v) Set the test set BRIDGE ADJ potentiometer to 1593.

(w) Adjust potentiometer R984 on the alignment potentiometer panel until the NULL METER indicates zero.

(x) Disconnect the black test lead, red teat lead, and coaxial teat probe from the test jacks.

(4) *Check and alignment of C-potentiometer R811.*

(a) Connect the test set red test lead to - REF jack J890 in the computer.

(b) Connect the test set black test lead to B + RET jack J897 in the computer.

(c) Connect the test set coaxial test probe to C + 1 jack J886 in the computer.

(d) Turn TEST-NORMAL switch S855 to NORMAL (fig. 3-102).

(e) Operate control-power supply ELEVATION switch S655 until the radar antenna is at an elevation of +50 roils.

(f) **Rotate Δ** Time and/or weapon HEIGHT handwheel until the DOUBTFUL SOLUTION lamp lights. The indication on the calibrated C gears (fig. 3-102) must be between 3.60 and 3.88; if it is not, adjust the cam as indicated below; otherwise proceed to *(g)* below.

NOTE

The two calibrated C-gears (fig. 3-102) on the C-subassembly are used during alignment to indicate the value of C for different values of range, azimuth, elevation, and time. The upper gear shows the value of C in whole units, 0-8; the lower, or vernier gear, shows the decimal value of C from 0.00 to 0.99. The gears in figure 3-112 show the value of C to be 6.50. The upper gear is mounted above and behind the vernier gear on the C-subassembly (fig. 3-102).

CAUTION

Remove power from the computer; be careful when removing and replacing the alignment potentiometer panel so as not to short the potentiometers to the terminals of transfer T861 below the alignment potentiometer panel.

(g) Remove the C-subassembly from the computer drawer (para 3-38p(15)).

(h) Check the C-gears for proper mesh alignment by rotating the units C-gear and hub (fig. 3-140) toward zero until the lower limit stop is reached. With the lower limit stops touching, the calibrated C-gears should indicate a value of 0.00.

NOTE

To determine the correct end of the trough of the cam, refer to figure 3-113. The correct end of the trough shows below and to the left of number 4 on the unite C-dial. When both C-dials are set to indicate 0.00, the roller on the micro-switch (S811) spring rests on the zero point of the cam. If the C-gears do not indicate 0.00 upon releasing hand pressure on the gears (limit stops may separate slightly), this could be caused by microswitch spring tension against the cam and does not necessarily indicate a malfunction. Any value other than 0.00 (taking the foregoing statement into consideration) indicates improper meshing of gears in the gear train, or a sheared or missing gear pin. Refer to a higher category of maintenance.

(i) Loosen the gear clamp (25, fig. 3-140) on the shaft of C-potentiometer R811 which is held in place by a 5/8-inch machine screw (26, fig. 3-140).

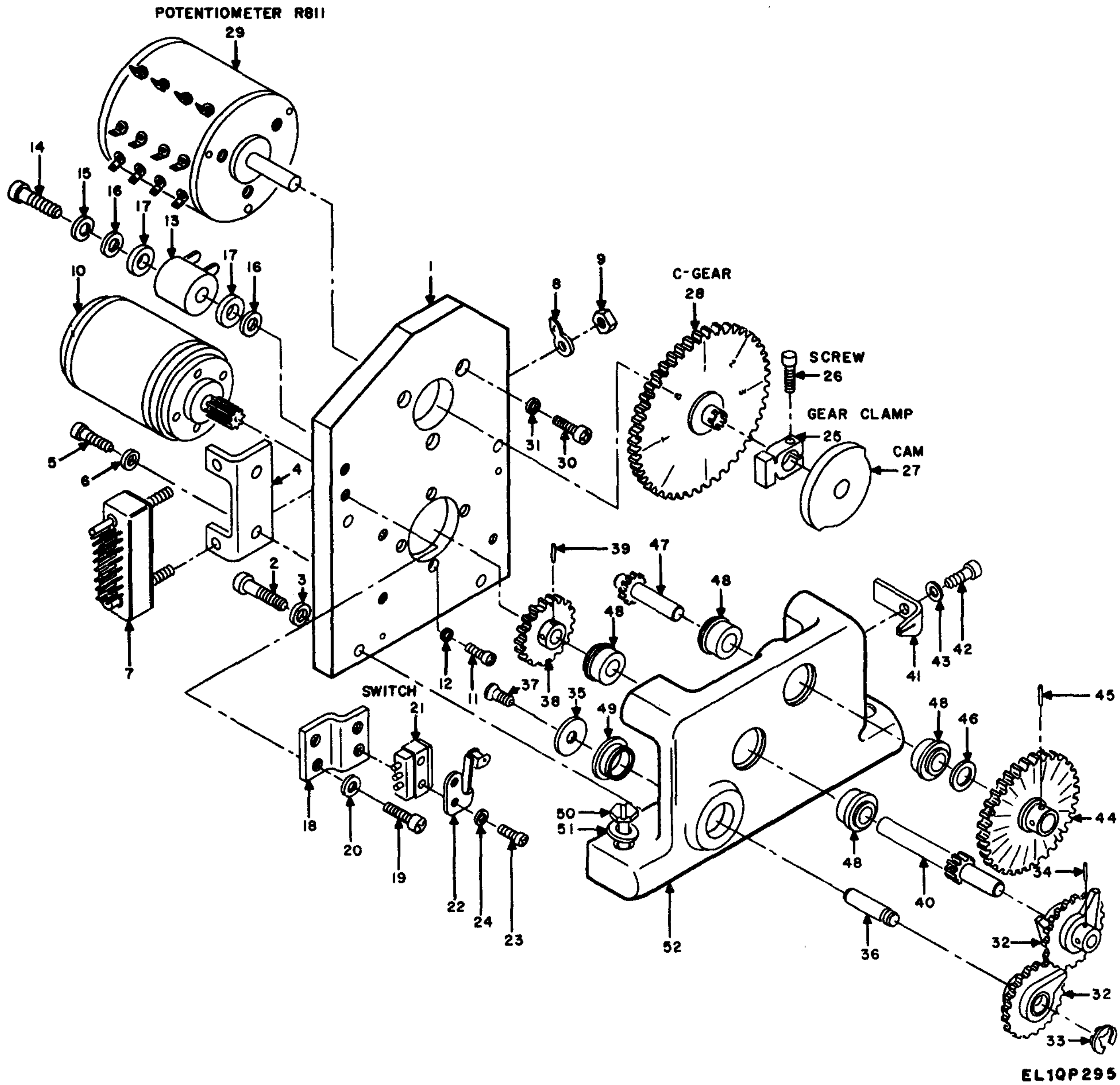


Figure 3-140. C-subassembly, exploded view.

(j) Adjust the position of the cam (27, fig. 3-140) on the shaft of C-potentiometer R811 so that microswitch S811 is-in the open position between 3.60 and 3.88 indication on the C-dials. An accurate determination of this can be made by connecting a multimeter (ohms function) directly across the switch terminals.

(k) Tighten the gear clamp on the shaft of C-potentiometer R811.

CAUTION

Do not apply power until the hookup as shown in figure 3-141 is completed.

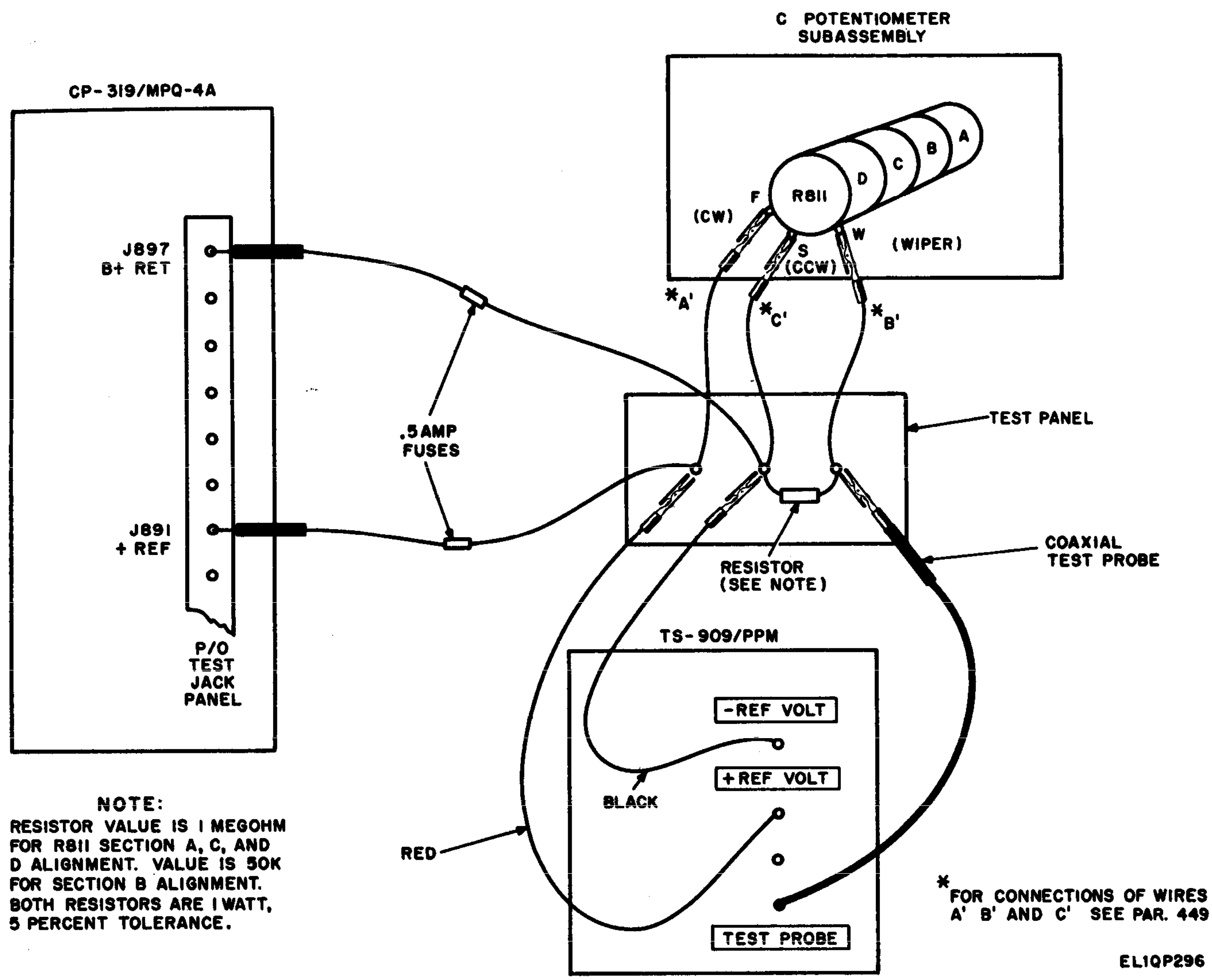


Figure 3-141. Bench test connections for computer C-subassembly.

(l) Connect the C-subassembly as shown in figure 3-141. Upon completion of the hookup reapply power and rotate the C-dials to accurately indicate the settings shown in table 3-47 by rotating the vernier c-dial.

(m) Adjust the test eet BRIDGE ADJ dials to zero the NULL METER at each *of the C-dial* settings in the chart and record the BRIDGE ADJ dial indications obtained for each section of C-potentiometer R811. If the desired results are not obtained (BRIDGE ADJ dial indication columns), continue as follows.

CAUTION

Avoid changing the position of the cam on the c-potentiometer shaft *((i)* and *(j)* above) when loosening the gear clamp to make the following adjustments.

Table 3-47. Bench Testing C-Subassembly

ITEM	C dial settings	TS 909/ PPM BRIDGE ADJ dial indication	
		R811 Sections A, C, and D[a]	R811 Section B[a]
1	1.00	1270	2256
2	3.00	3814	4511
3	5.00	6356	6767
4	7.00	8898	9022

[a]Maximum limits: BRIDGE ADJ dial indications for sections A, C, D, and B must be within ±25 of values listed.

(n) Loosen the gear clamp on the shaft of C-potentiometer R811 (25 end 26, fig. 3-140).

(o) With a screwdriver, adjuet the shaft of the C-potentiometer so that the test set BRIDGE ADJ dial indications differ as little as possible from the values given in table 3-47 *((l)* above) (tolerance of ±25). Retighten the gear clamp.

(p) Repeat the procedures given in *(1)* through (o) above for each shaft adjustment until results (BRIDGE ADJ dial indication columns) are within tolerance.

(q) Remove power from the computer and disconnect all leads shown in figure 3-141.

CAUTION

Be extremely careful when replacing the alignment potentiometer panel over the terminals of reference transformer T861.

(r) Replace the C-subassembly in the computer (para *3-38p(16))*.

(s) Reapply power to the computer and turn the TEST-NORMAL switch to TEST. C-dials must indicate 1.00; if they do not, adjust potentiometer R898 (fig. 3-102) while observing the C-dials for 1.00.

NOTE

If the cam adjustment *((f)* through *(k)* above) was necessary, repeat the procedures given in *(a)* through *(f)* above; disregard *(g)* through *(r)* above; follow up *(f)* with *(s)* above.

(t) Adjust the test set BRIDGE ADJ for a zero indication on the NULL METER.

(u) BRIDGE ADJ dials must indicate between 2554 and 2564; if they do not, adjust -(C+1) potentiometer R978.

(v) Disconnect all test set test leads, except the black GROUND lead, from the computer,

(w) Set detent switch S856 to the DETENT RELEASE (down) position.

(x) Rotate the Δ AZIMUTH handwheel in one direction until the end of travel is reached.

(y) Connect the test set red lead to **C Δ jack J880, the —REF VOLT black lead to B+ RET jack J897, and the coaxial test probe to C Δ A_1 jack J883 in the computer.**

(z) Adjust the test set BRIDGE ADJ dials for a zero indication on the NULL METER. BRIDGE ADJ dials must indicate between 1220 and 1320 when the NULL METER indicates zero,

(aa) Rotate the Δ RANGE handwheel in one direction until the end of travel is reached.

(ab) Disconnect the test set red lead **from Δ A jack J880 and connect it to Δ R jack J873: disconnect the coaxial test probe from C Δ A_1 jack J883 and connect it to C Δ R_1 jack** J884.

(ac) Adjust the test set BRIDGE ADJ dials for a zero indication on the NULL METER. BRIDGE ADJ dials must indicate between 1220 and 1320 when the NULL METER indicates zero.

(ad) Disconnect all test set test leads, except the black GROUND lead from the computer,

(ae) Set detent switch S856 to the OFF **(center) position and rotate the Δ RANGE and Δ AZIMUTH handwheels to their detent** positions.

(af) Adjust the radar height control until RADAR HEIGHT counter M807 indicates 1000 meters.

(ag) Rotate the weapon height handwheel until weapon HEIGHT M806 indicates 1000 meters.

(ah) Operate control-power supply ELEVATION switch S655 until computer LOWER BEAM ELEVATION counter M821 indicates +35 mils.

(ai) Rotate the Δ TIME handwheel until Δ TIME counter M801 indicates 0.0 second.

(aj) Turn TEST-NORMAL switch S855 to NORMAL.

(ak) Observe the calibrated C-dials. C-dials must indicate 1.00; if they do not, adjust balance potentiometer R885 (fig. 3-99) while observing the C-dials for 1.00.

(al) While observing the calibrated C-dials, check for oscillations at upper range settinge as the LOWER BEAM RANGE handwheel is rotated to run range out to 15,000 meters. If there are no oscillations, proceed to (an) below. If there are oscillations, adjust gain potentiometer R928 or R933 on C-servoamplifier AR927A to reduce gain, and just eliminate oscillations. Then run range down to 2,000 meters, and check gain setting by twisting the C-dial off 1.00 with the index finger and releasing. There should be sufficient torque to permit the C-dial to return to the same indication without hesitation or creeping. If not, slightly increase gain to obtain sufficient torque.

(am) Turn TEST-NORMAL switch to TEST. C-dials must indicate 1.00; if they do not, adjust R898 *((s)* above) while observing the C-dials. Return the TEST-NORMAL switch to NORMAL.

(an) Operate control-power supply ELEVATION switch S655 until computer LOWER BEAM ELEVATION counter M821 indicates +70 roils.

(ao) Observe the C-dials. C-dials must indicate 2.00; if they do not, slightly adjust R983 ((3) *(i)* above) for half the difference; then adjust R985 ((3) *(n)* above) for the remaining difference.

(up) Operate control-power supply ELEVATION switch S655 until computer LOWER BEAM ELEVATION counter M821 indicates +105 roils.

(aq) Observe the C-dials. C-dials must indicate 3.00 ±0.06; if they do not, slightly adjust C-eervoamplifier gain potentiometer R933 or R928 on AR927A (*(al)* above).

(ar) Turn the TEST-NORMAL switch to TEST and observe the C-dials. C-dials must indicate 1.00; if they do not, carefully readjust potentiometer R898 ((s) above) while observing the c-dials.

NOTE

If the requirements described in *(aj)* through *(ar)* above cannot be met, repeat the procedures given in (3) *(a)* through *(x)* above in its entirety.

(5) *Δ Azimtuh potentiometer R841 check and alignment.*

(a) Connect the test set red test lead to +REF jack J891 in the computer.

(b) Connect the test set black test lead to B +RET jack J897.

(c) Connect the coaxial test probe to Δ A jack J880.

(d) Adjust the test set BRIDGE ADJ dials to 0000. If the test set NULL METER indicates zero when the Δ AZIMUTH handwheel is in detent, Δ A potentiometer R841 is mechanically aligned. Check to see that the TEST-NORMAL switch is set to TEST.

NOTE

If the NULL METER does not indicate zero, but is slightly off zero to the left or right, keep in mind that the Δ AZIMUTH handwheel is in detent. Observe the NULL METER while applying *slight* hand pressure to the Δ AZIMUTH handwheel while it is still engaged in detent. This action should correct the off-zero condition of the NULL METER. The foregoing is caused by the mechanical detent and gear train mechanical tolerances. If the condition and corrective action described above do not correct the off-zero condition of the NULL METER, mechanical alignment of R841 is required. Refer to paragraph 3-40 for procedure.

(e) Disconnect the test set red test lead and connect it to + Δ A jack J889.

(f) Set the BRIDGE ADJ potentiometer to 5000.

(g) Place detent switch S856 in the DETENT RELEASE position.

(h) Rotate the Δ AZIMUTH handwheel clockwise until the NULL METER on the test set indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(i) Disconnect the test set red test lead and connect it to + REF jack J891.

(j) Set the test set BRIDGE ADJ potentiometer to 3372.

(k) Adjust potentiometer R992 on the alignment potentiometer panel until the NULL METER indicates zero.

(l) Disconnect the red test lead from + REF jack J891 and connect it to — Δ A jack J892.

(m) Set the BRIDGE ADJ potentiometer on the test set to 5000.

(n) Rotate the Δ AZIMUTH handwheel counterclockwise until the NULL METER on the test set indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with cars the null can be obtained.

(o) Disconnect the red test lead from jack — Δ A J892 and connect it to -REF jack J890.

(p) Set the BRIDGE ADJ potentiometer on the test set to 3372.

(q) Adjust .potentiometer R993 on the alignment potentiometer panel until the NULL METER on the test set indicates zero.

(r) Disconnect the three test leads from the computer.

(6) *C Δ A potentiometer R842 check and alignment.*

(a) Connect the test set red lead to -REF jack J890 in the computer.

(b) Connect the test set black test lead to B+ RET jack in the computer and connect the coaxial test probe to C Δ A_1 jack J879 (fig. 3-99).

(c) Set detent switch S856 to the OFF position. Check to see that the Δ AZIMUTH handwheel on the computer front panel is in the detent position.

(d) Set the test set BRIDGE ADJ potentiometer to 0000.

(e) Adjust balance potentiometer R883, on the rear of the servoamplifier chassis (fig. 3-98), until the teat set NULL METER indicates zero. If a zero indication cannot be reached, reduce the gain of servoamplifier AR929B by adjusting R933 (fig. 3-104) a small amount. Repeat until a zero indication is reached.

(f) Record the indication on the AZIMUTH counter. This indication will be used in the procedure in *(m)* and *(r)* below.

(g) Disconnect the red test lead from -REF jack J890 and connect it to + Δ A jack J889.

h) Disconnect the coaxial test probe from

C Δ A, jack J879 and connect it to Δ A jack J880.

(i) Set the BRIDGE ADJ potentiometer to 5000.

(j) Set detent switch S856, on the computer front panel, to DETENT RELEASE (down position).

(k) Rotate the Δ AZIMUTH handwheel clockwise until the NULL METER indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(l) Remove the red test lead and coaxial test probe.

(m) Adjust -C Δ A potentiometer R994 on the alignment potentiometer panel until the indication on the AZIMUTH counter is 35 mils less than the indication noted in *(f)* above.

(n) Connect the red test led to - Δ A jack J892.

(o) Connect the test set coaxial teat probe to Δ A jack J880 in the computer; test set BRIDGE ADJ dials set to 5000.

(p) Rotate the Δ AZIMUTH handwheel on the computer front panel counterclockwise until the NULL METER indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(q) Disconnect the three test leads (+REF VOLT red lead, -REF VOLT black lead and coaxial test probe) from the computer.

(r) Adjust +C Δ A potentiometer R995 on the alignment potentiometer panel (fig. 3-99) until the AZIMUTH counter indicates 35 mils more than the indication noted in *(f)* above.

(7) Δ *Range potentiometer R833 check and alignment.*

(a) Connect the test set red test lead to -REF jack J890 in the computer.

(b) Connect the black test lead to B +RET jack J897.

(c) Connect the coaxial test probe to Δ R jack J873.

(d) Adjust the test set BRIDGE ADJ dials to 0000. Set detent switch S856 to the OFF position. If the test set NULL METER indicates zero when the Δ RANGE handwheel is in detent, Δ R potentiometer R833 is mechanically aligned. Check to see that the TEST-NORMAL switch is in TEST.

NOTE

If the NULL METER does not indicate zero, but is slightly off zero to the left or right, keep in mind that the Δ RANGE handwheel is in detent. Observe the NULL METER while applying *slight* hand pressure to the Δ RANGE handwheel while it is still engaged in detent. The action should correct the off-zero condition of the NULL METER. The foregoing is caused by the mechanical detent and gear train mechanical tolerances. If the condition and corrective action described above do not correct the off-zero condition of the NULL METER, mechanical alignment of R833 is required. Refer to paragraphs **3-40*g*** for procedure.

(e) Disconnect the red test lead from -REF jack J890 and connect it to + Δ R jack J893.

(f) Set the BRIDGE ADJ potentiometer to 5000.

(g) Place detent switch S856 on the computer front panel in the DETENT RELEASE position.

(h) Rotate the Δ RANGE handwheel clockwise until the NULL METER on the test set indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(i) Disconnect the red test lead from + Δ R jack J893 and connect it to +REF jack J891.

(j) Set the BRIDGE ADJ potentiometer on the test set to 3372.

(k) Adjust + Δ R potentiometer R987 on the alignment potentiometer panel until the NULL METER on test set indicates zero.

(l) Disconnect the red test lead from +REF jack J891 and connect it to - Δ R jack J894.

(m) Set the BRIDGE ADJ potentiometer on the test set to 5000.

(n) Rotate the Δ RANGE handwheel on the computer front panel counterclockwise until the NULL METER on the test set indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(o) Disconnect the red test lead from - Δ R jack J894 and connect it to -REF jack J890.

(p) Set the BRIDGE ADJ potentiometer on the teat set to 3372.

(q) Adjust - Δ R potentiometer R988 on the alignment potentiometer panel until the NULL METER on the test set indicates zero.

(r) Disconnect the coaxial test probe from the computer test jack J873.

(s) Place detent switch S856 in the OFF position.

(8) *C Δ**R** R potentiometer R834 check and alignment.*

(a) Connect the coaxial test probe to **CΔR₂** jack J874.

(b) Rotate the Δ RANGE handwheel until it engages in detent. Rotate the LOWER BEAM RANGE handwheel to set the RANGE counter to 07500 meters.

(c) Set the BRIDGE ADJ potentiometer to 0000.

(d) Adjust C Δ R balance potentiometer R882 (fig. 3-99) to rear of AR928B until the test set NULL METER indicates zero. If a zero indication cannot be obtained at first attempt, reduce the gain of C Δ R servoamplifier AR928B by adjusting R933 (fig. 3-104) a *small* amount.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained. Note that the test set NULL METER needle may drift slightly off zero after adjustment. The drift is caused by the Δ R detent cam and is acceptable.

(e) Record the indication on the RANGE counter on the computer front panel. This indication will be used in the procedures in *(1)* and *(p)* below.

NOTE

RANGE counter M831 indication should be approximately 07500 meters.

(f) Disconnect the red test lead from -REF jack J890 and connect it to + Δ R jack J893.

(g) Disconnect the coaxial test probe from C Δ R, jack J874 and connect it to Δ R jack 3873.

(h) Set the BRIDGE ADJ potentiometer to 5000.

(i) Set detent switch S856 to DETENT RELEASE (down).

(j) Rotate the Δ RANGE handwheel clockwise until the NULL METER indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(k) Remove the red test lead and coaxial teet probe from the computer jacks.

(l) Adjust +C Δ R potentiometer R989 on the alignment potentiometer panel until the weapon RANGE counter indication is 450 meters less than the indication noted in *(e)* above.

(m) Connect the test set red test lead to - Δ R jack J894 and the coaxial test probe to Δ R jack J873 in the computer; BRIDGE ADJ potentiometer setting remains at 5000.

(n) Rotate the Δ RANGE handwheel counterclockwise until the NULL METER indicates zero.

NOTE

Some difficulty may be encountered in obtaining a null; however, with care the null can be obtained.

(o) Remove the red test lead and coaxial test prove from the computer jacks.

(p) Adjust -C Δ R potentiometer R990 on the alignment potentiometer panel until the indication on the weapon RANGE counter is +450 meters more than the indication noted in *(e)* above.

(q) Return detent switch S856 to the OFF position and rotate the Δ R and Δ A handwheels to their detent positions.

(9) *Alignment of weapon range potentiometer R835.*

(a) Connect the test set red test lead to +REF jack J891 in the computer.

(b) Connect the black test lead to B + RET jack J897.

(c) Connect the coaxial test probe to Rw jack 3875.

(d) Set the test set BRIDGE ADJ potentiometer to 2857.

(e) Rotate the LOWER BEAM RANGE handwheel on the computer front panel until the weapon RANGE counter indicates 7500 meters.

(f) Adjust Rw potentiometer R991 on the alignment potentiometer panel until the test set NULL METER indicates zero.

(g) Disconnect the test set red lead and coaxial test probe from computer test jacks J891 and J875.

(10) Δ *Time potentiometer R801 check and alignment.*

(a) Turn TEST-NORMAL switch S855 to TEST while observing the C dials. C-dials must indicate 1.00.

(b) Rotate the Δ TIME handwheel on the front panel until A TIME counter M801 indicates 4.0 seconds (fig. 3-98 and 3-125).

(c) Connect the test set red lead to -(C + 1) jack J886.

(d) Connect the test set coaxial test probe to Δ T jack J871.

(e) Adjust the test set BRIDGE ADJ dials until the test set NULL METER indicates zero. The indication on the BRIDGE ADJ dials must be between 4494 and 4544 to be acceptable.

NOTE

If the Δ TIME counter digits do not fall in at the center of the front panel window, a *slight* rocking back and forth of the Δ TIME handwheel and/or resetting of the Δ TIME handwheel to 4.0 seconds with a consequent readjustment of the BRIDGE ADJ dials will allow for a correct dial indication. This is due to differences in the A TIME subassembly castings and computer front panel window placement.

(f) Return the A TIME counter indication to 0.0 second with A TIME handwheel.

(g) Remove power from the test set and the computer.

(h) Disconnect all test set test leads and test set power cable CX-3382/U (W4601) from the computer.

(11) *Coordinate subassemblies check and alignment.*

(a) Reapply power to the computer. Check to determine that detent switch S856 is in the OFF position and that the A RANGE and Δ AZIMUTH handwheels are engaged in their detent positions.

(b) Rotate the LOWER BEAM RANGE handwheel until the RANGE counter indicates 07500 meters.

(c) Place detent switch S856 at AZIMUTH ORIENT and detent the LOWER BEAM AZIMUTH handwheel.

(d) Return the detent switch to the OFF position.

(e) Uee RADAR LOCATION EASTING switch S851 and RADAR LOCATION NORTHING switch S852 to set the RADAR LOCATION EASTING AND RADAR LOCATION NORTHING counters (M817) to 000000 (fig. 3-98).

(f) Use RADAR LOCATION AZ ORIENT switch S853 to set the AZIMUTH counter to 0000.0 mil.

NOTE

An alternate method of setting the required data into the AZIMUTH counter may be used to perform the procedures given in (f) above and *(i)*, *(2)*, and (o) below. Use the RADAR LOCATION AZ ORIENT switch to set the AZIMUTH counter near the required indication. Touch up with the LOWER BEAM AZIMUTH handwheel.

(g) Adjust balance potentiometer R886 (fig. 3-99 on the front of the servoamplifier chassis until the WEAPON LOCATION EASTING counter indicates 000000. If indication cannot be obtained, slightly adjust gain of servoamplifier AR928A.

(h) Adjust + Rw (N) potentiometer R980 on the alignment potentiometer panel until the WEAPON LOCATION NORTHING counter indicates 007500.

(i) Use RADAR LOCATION AZ ORIENT switch S853 and the LOWER BEAM AZIMUTH handwheel and set the AZIMUTH counter to 1,600 roils.

(j) Adjust balance potentiometer R887 (fig. 3-99), on the front of the servoamplifier chassis, until the WEAPON LOCATION NORTHING counter indicates 000000. If indication cannot be obtained, slightly adjust gain of servoamplifier AR929A.

(k) Adjust + Rw (E) potentiometer R982 on the alignment potentiometer panel until the WEAPON LOCATION EASTING counter indicates 007500.

(l) Use RADAR LOCATION AZ ORIENT switch S853 and the LOWER BEAM AZIMUTH handwheel and set the AZIMUTH counter to 3,200 roils.

(m) Observe the WEAPON LOCATION EASTING counter to see if the indication has changed from 000000. If the indication has varied from 000000, adjust potentiometer R886 until the error is halved (*(e)* above).

(n) Adjust – Rw (N) potentiometer R979 until the WEAPON LOCATION NORTHING counter indicates 992500.

(o) Use RADAR LOCATION AZ ORIENT switch S853 and the LOWER BEAM AZIMUTH handwheel and set the AZIMUTH counter to 4,800 roils.

(p) Observe the WEAPON LOCATION NORTHING counter to see if the indication has changed from 000000. If the indication has varied, adjust potentiometer R887 until the error is halved (*(j)* above).

(q) Adjust – Rw(E) potentiometer R981 until the WEAPON LOCATION EASTING counter indicates 992500.

3-40. Computing System MechanicalAlignment

a. General. This paragraph covers detailed instructions for the mechanical alignment of computer subassemblies after repair or in conjunction with the electrical alignment (para 3-39 *d)* when necessary. After any mechanical subassembly of the computer has been mechanically aligned, a complete electrical alignment is required. Complete mechanical alignment is unnecessary if only one or two of the subassemblies have been repaired.

b. Test Equipment Required. Table 3-48 lists the items of test equipment that are required for mechanical alignment of the computer:

c. Mechanical Alignment of C-Subassembly (fig. 3-140).

(1) Remove the C-subassembly from the computer drawer (para 3-38 *p* (15)).

(2) Loosen the gear clamp (25) on the shaft of potentiometer R811 (29).

(3) Check the C-gears for proper mesh alignment, rotate the units C-gear (gear and hub (28) toward zero until the lower limit stop is reached. With the lower limit stops touching, the calibrated C-gears should indicate a value of 0.00. Any value other than 0.00 indicates improper meshing of gears in the gear train during assembly, or a sheared or missing gear pin. Refer to higher category of maintenance.

(4) Set the cam (27) on the shaft of R811 so that the switch (21) is in the open position when the calibrated C-gears are rotated from 0.00 to 3.80. Rotate the calibrated C-gears and see that the microswitch is closed for values of C from 3.80 to 7.74. (The point at which the microswitch opens can be determined very accurately by connecting the multimeter (ohms function) directly across the switch terminals.)

Table 3-48. Test Equipment Required for Mechanical Alignment of Computing System

Test equipment	Common name	Function
Computer Test Set TS-909/PPM.		Computer alignment indications.
Oscilloscope AN/USM-281C.	Oscilloscope	Observe waveforms.
Multimeter TS-352B/U.	Multimeter	Measures voltages.
Voltmeter, Electronic AN/USM-98.		Precision voltage measurement.
Remoting cables and adapters.[a]	Cables	Connections.

[a]The cables and adapters are supplied with Test Facilities Kit MK-387/MPM-49.

(5) Connect J811 on C-subassembly P811 in the computer drawer with remoting cable W2628. Turn the POWER switch on the TS-909/PPM to ON.

(6) Remove amplifier AR927 (second from left) from the computer and apply power to the computer.

(7) Connect the red lead from the +REF VOLT connector on TS-909/PPM to +REF jack J891 in the computer drawer.

(8) Connect the lead from the -REF VOLT connector on the TS-909/PPM to B +REF jack J897 in the computer.

(9) Connect the TEST PROBE lead on the TS-909/PPM to C-jack J885.

(10) Set the computer TEST-NORMAL switch to TEST.

(11) Set the BRIDGE ADJ potentiometer on the TS-909/PPM to 1128.

(12) Rotate the calibrated C-gears to an indication of 4.00.

(13) While holding the calibrated C-gears at 4.00, turn the shaft of R811 until the NULL METER on the TS-909/PPM indicates zero.

(14) Tighten the gear clamp. Set the C-gears to an indication of 4.00 and check to see that the NULL METER still indicates zero.

(15) Rotate the C-gears to an indication of 6.00 and adjust the BRIDGE ADJ potentiometer on the TS-909/PPM for a zero indication on the NULL METER (should null at approximately 1692). Write down the exact BRIDGE ADJ setting.

(16) Rotate the C-gears to an indication of 2.00 and adjust the BRIDGE ADJ potentiometer for a zero NULL METER indication (approximately 0564). Write down the exact BRIDGE ADJ setting.

(17) Add the exact BRIDGE ADJ setting in (15) above to the exact BRIDGE ADJ setting in (16) above. Divide the figure obtained by 2. If the answer is between 1105 and 1150, the C-subassembly is properly aligned. If the answer is not between 1100 and 1150, proceed as follows:

(a) Set the BRIDGE ADJ potentiometer on the TS-909/PPM to the calculated value obtained above.

(b) Loosen the gear clamp.

(c) Repeat the procedure given in (12), (13) and (14) above.

(18) Remove power from the computer and replace the C subassembly (para **3-38*p*(** and AR927 in the computer drawer.

(19) Align the entire computer (para **3-39*a*** through ***d*)**.

d. Mechanical Alignment of Coordinate Subassemblies (fig. 3-142). Both the northing and casting subassemblies are aligned the same way; therefore, the alignment of only one subassembly is discussed.

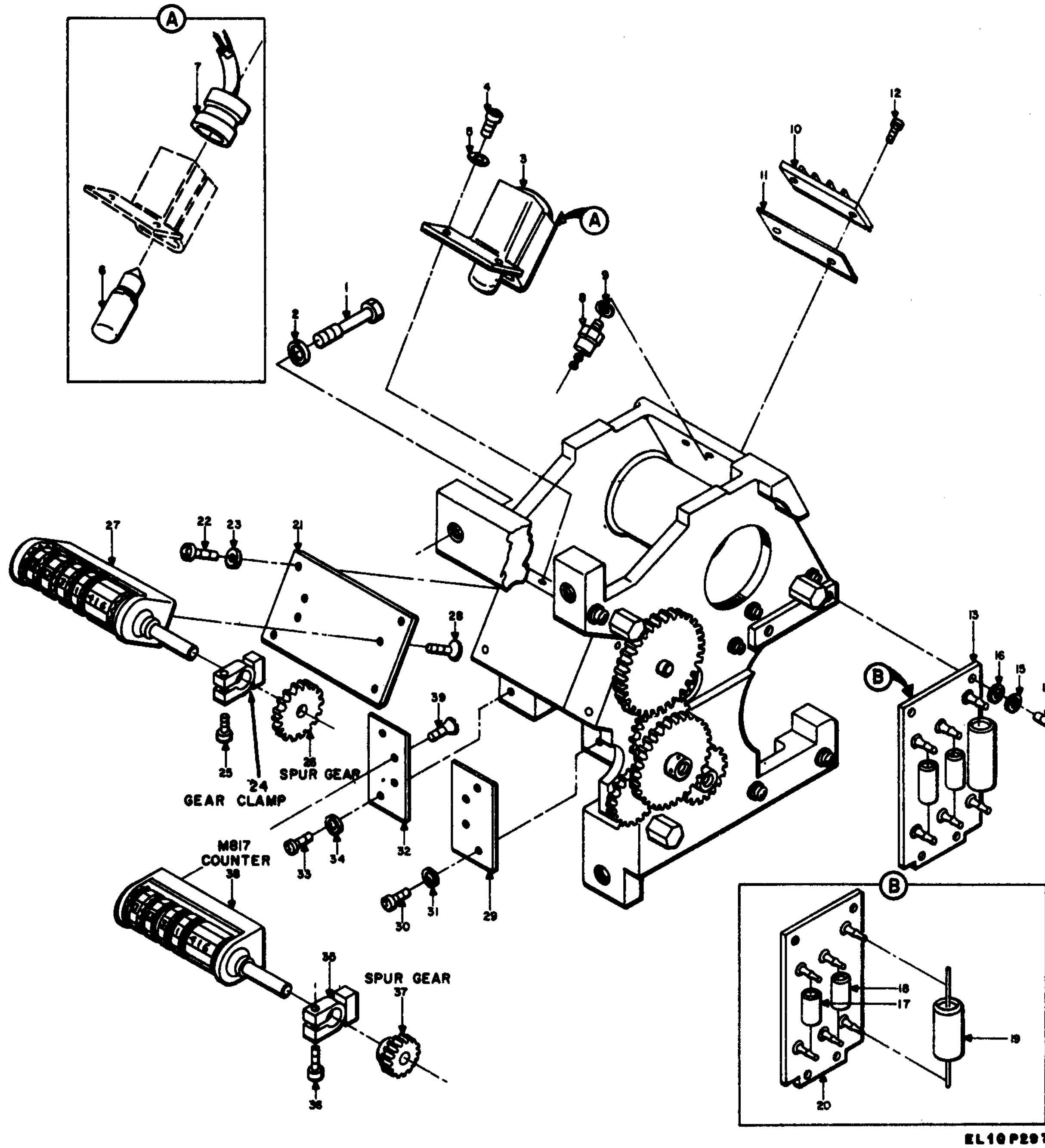


Figure 3-142 ①. *Coordinate subassembly, exploded view* (sheet 1 of 2).

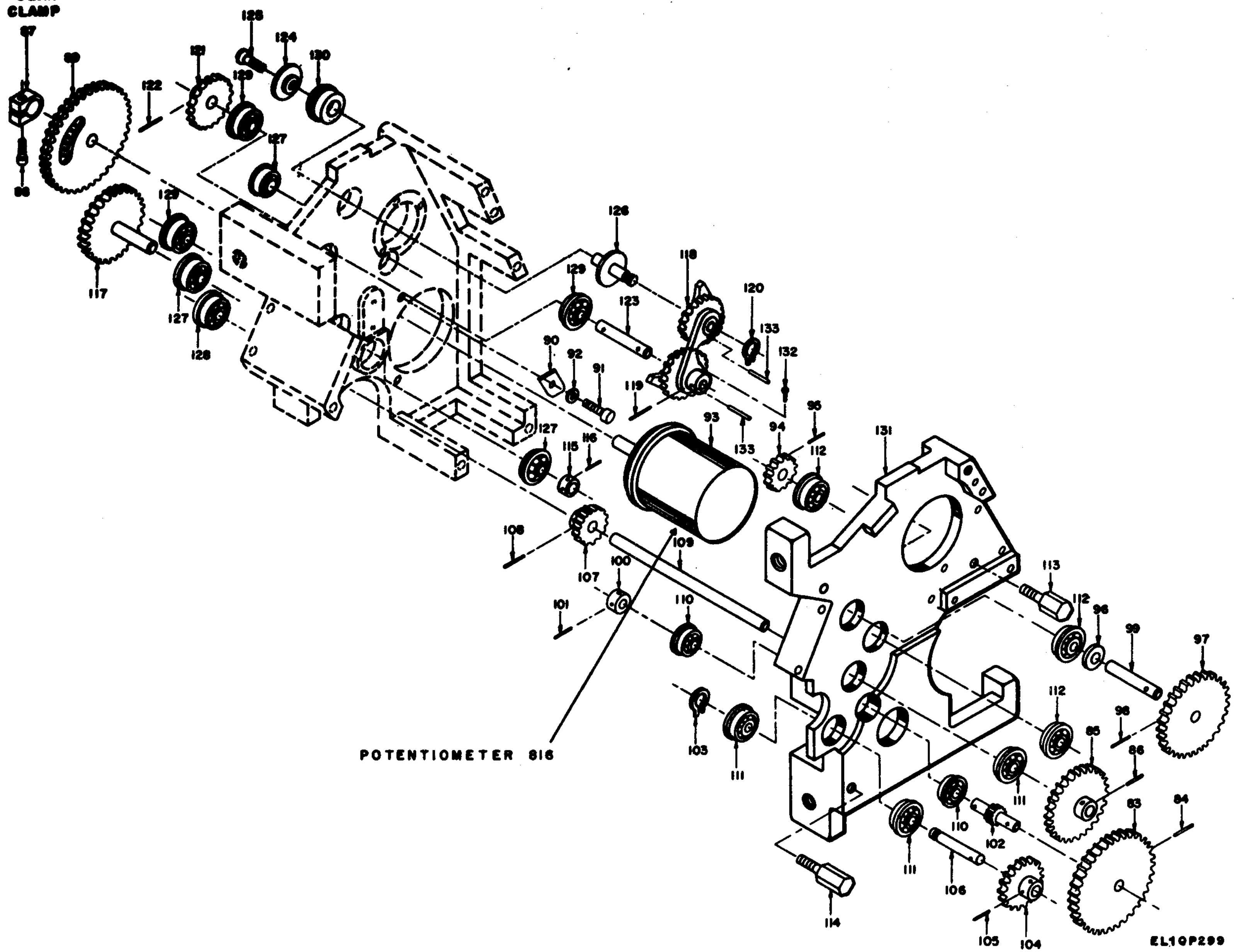


Figure 3-142 ②. *Coordinate subassembly, exploded view* (sheet 2 of 2).

(1) Remove the coordinate subassembly from the computer drawer (para 3-38 *p* (7) or (9)).

(2) Loosen the gear clamp (87) on potentiometer R816 (93).

(3) Rotate the spur gear (37) on counter M817 (38) by hand until the counter indicates 000000.

(4) Rotate the spur gear (26) on counter M816 (27) clockwise until the limit stop is reached.

(5) Loosen the gear clamp (24) on counter M816.

(6) Rotate the countershaft by hand until the counter indicates 016355.

(7) Tighten the gear clamp (24) on counter M816.

(8) Rotate the spur gear (26) on countershaft M816 until the counter indicates 000000. (Both counters should now indicate 000000.)

(9) Place a strip of masking tape over the counters and attach the ends of the tape to the frame of the subassembly. (Both counters should now be held in the 000000 position by the tape.)

(10) Connect the coordinate subassembly to the computer with remoting cable W2628.

(11) Apply power to the computer.

(12) Connect the oscilloscope signal input lead to jack J877 (northing subassembly) or J878 (casting subassembly). Connect the oscilloscope ground lead to B + RET jack J897.

(13) Adjust the sweep of the oscilloscope to display 2 cycles of the 400-Hertz input. Adjust the vertical gain for an amplitude great enough for a good presentation.

(14) Rotate the shaft of potentiometer R816 (93) until the oscilloscope presentation is minimum.

(15) Tighten the potentiometer gear clamp (87).

(16) Disconnect the oscilloscope leads from the computer.

(17) Turn off the computer power.

(18) Disconnect remoting cable W2628.

(19) Remove the tape from the counters.

(20) Replace the coordinate subassembly in the computer (para 3-38 *p* (8) or (10)) and align the computer (para 3-39 *a* through *d*).

e. Mechanical Alignment of Azimuth Subassembly (fig. 3-143 and 3-144).

(1) Remove-the azimuth subassembly from the computer drawer (para 3-38 *p* (11)).

(2) Loosen the gear clamp (8, fig. 3-143) on potentiometer R841 (12).

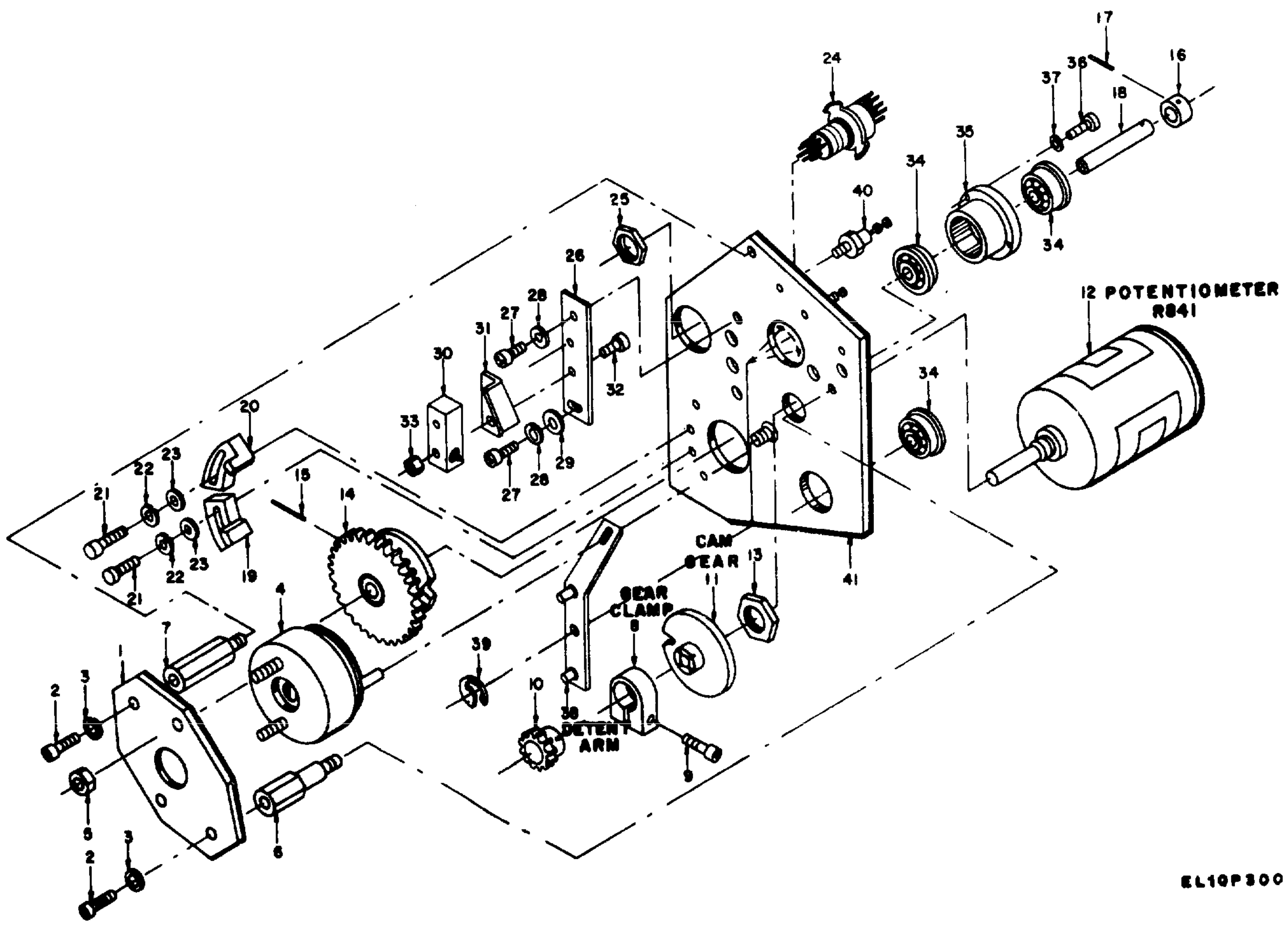


Figure 3-143. Delta A potentiometer assembly, exploded view.

(3) Loosen the gear clamp (82, fig. 3-144) on potentiometer R842 (85).

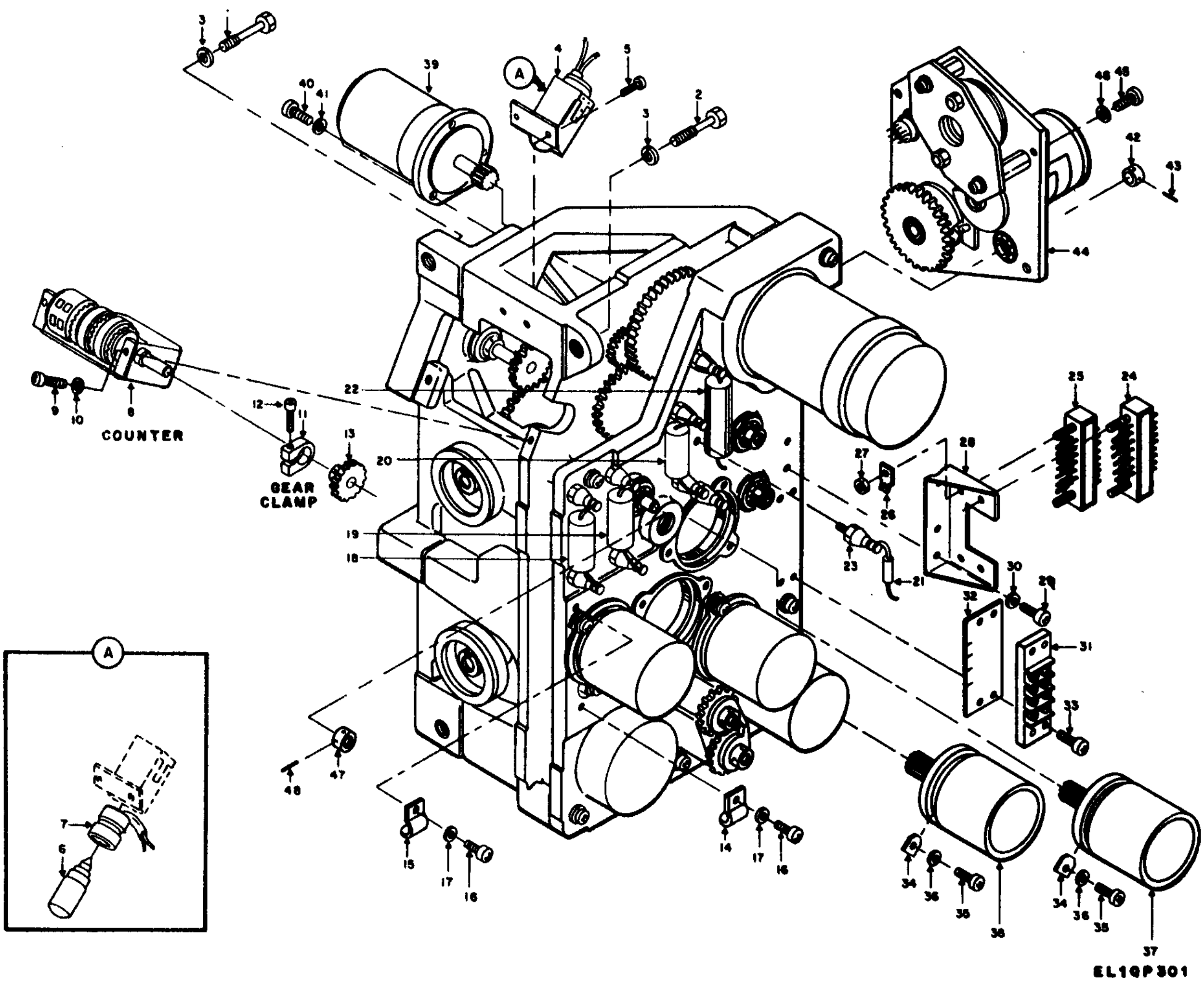


Figure 3-144 ①. Azimuth subassembly, exploded view **(sheet 1 of 4).**

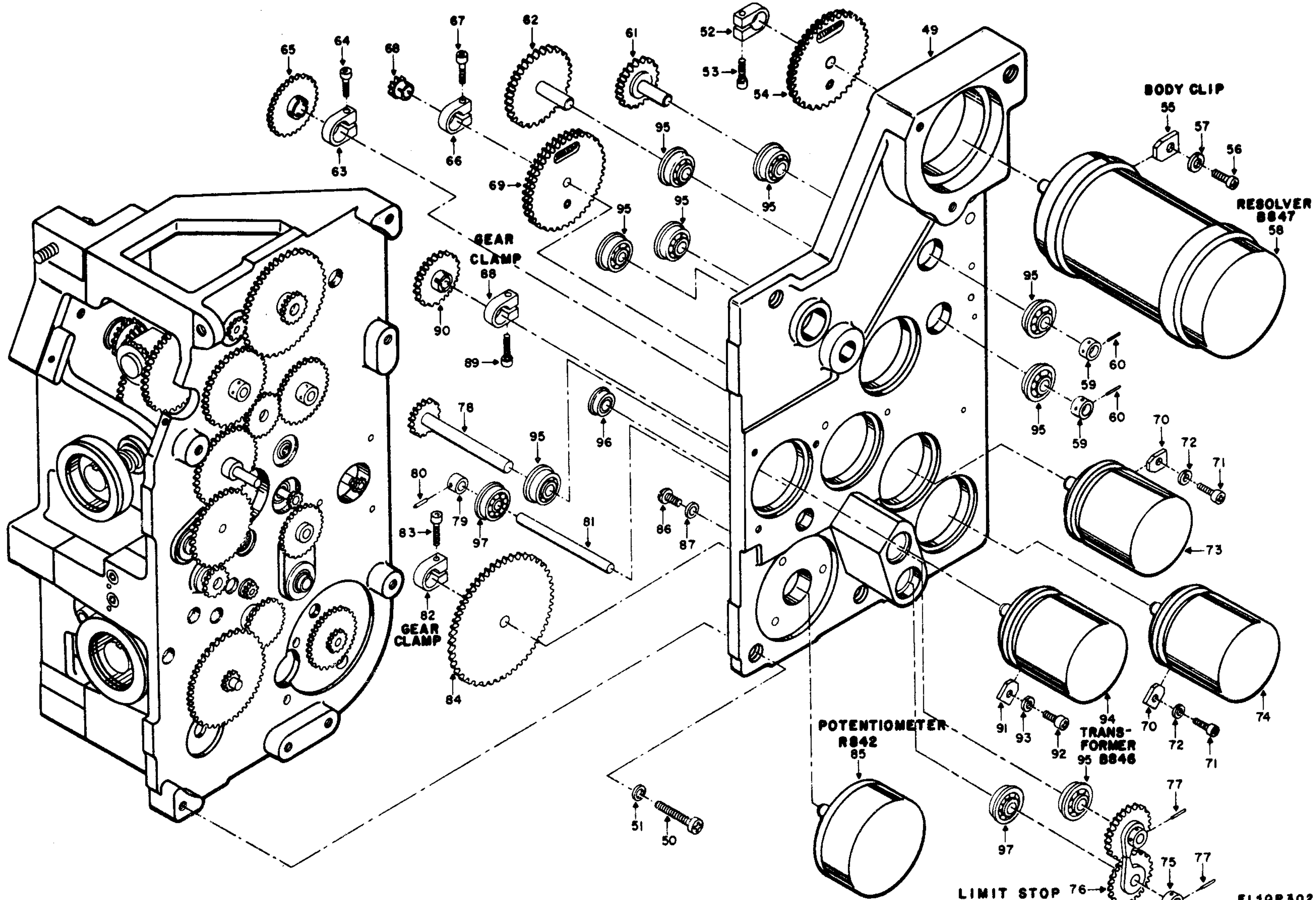


Figure 3-144②. Azimuth subassembly, exploded view (sheet 2 of 4).

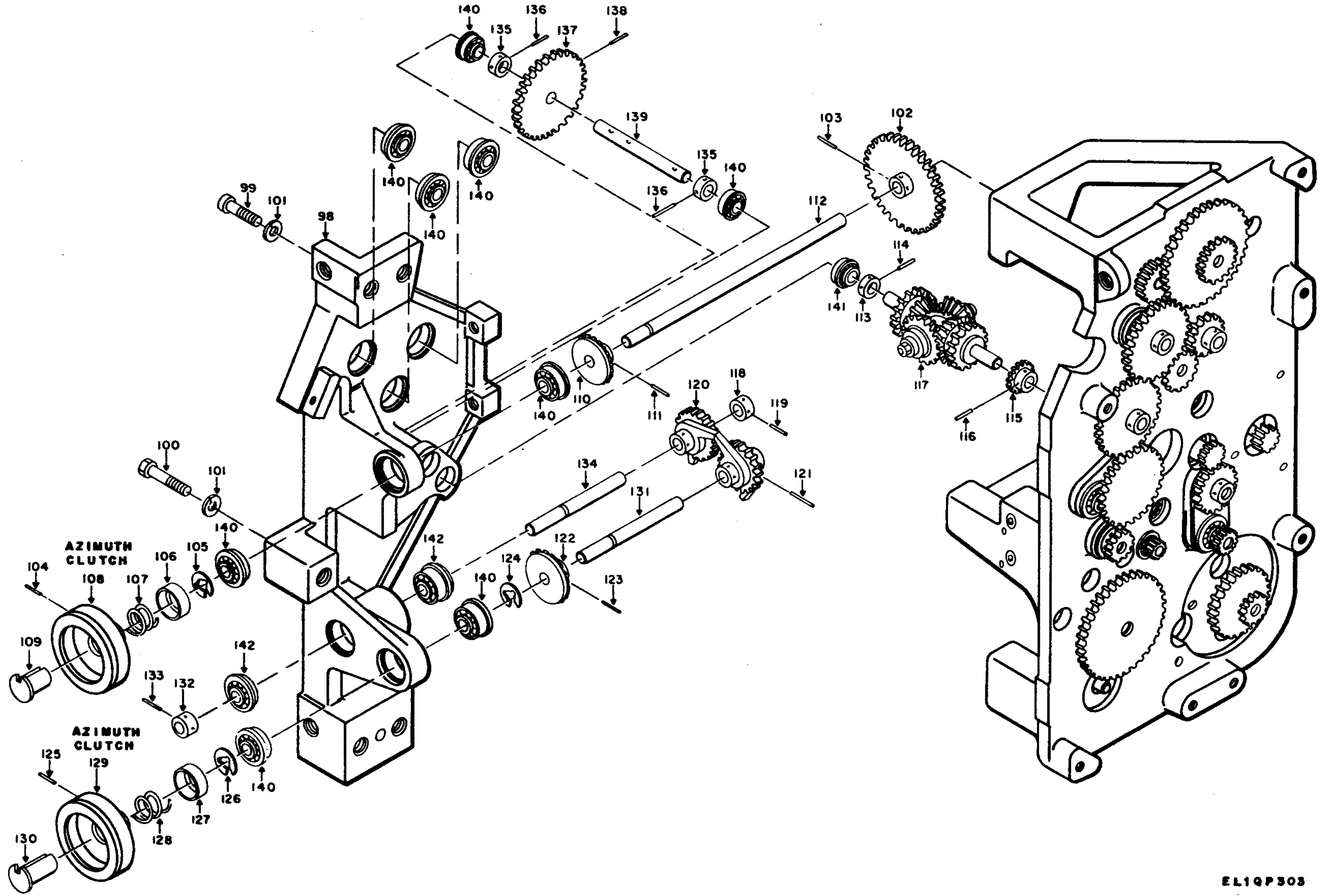


Figure 3-144③ . Azimuth subassembly, exploded view (sheet 3 of 4).

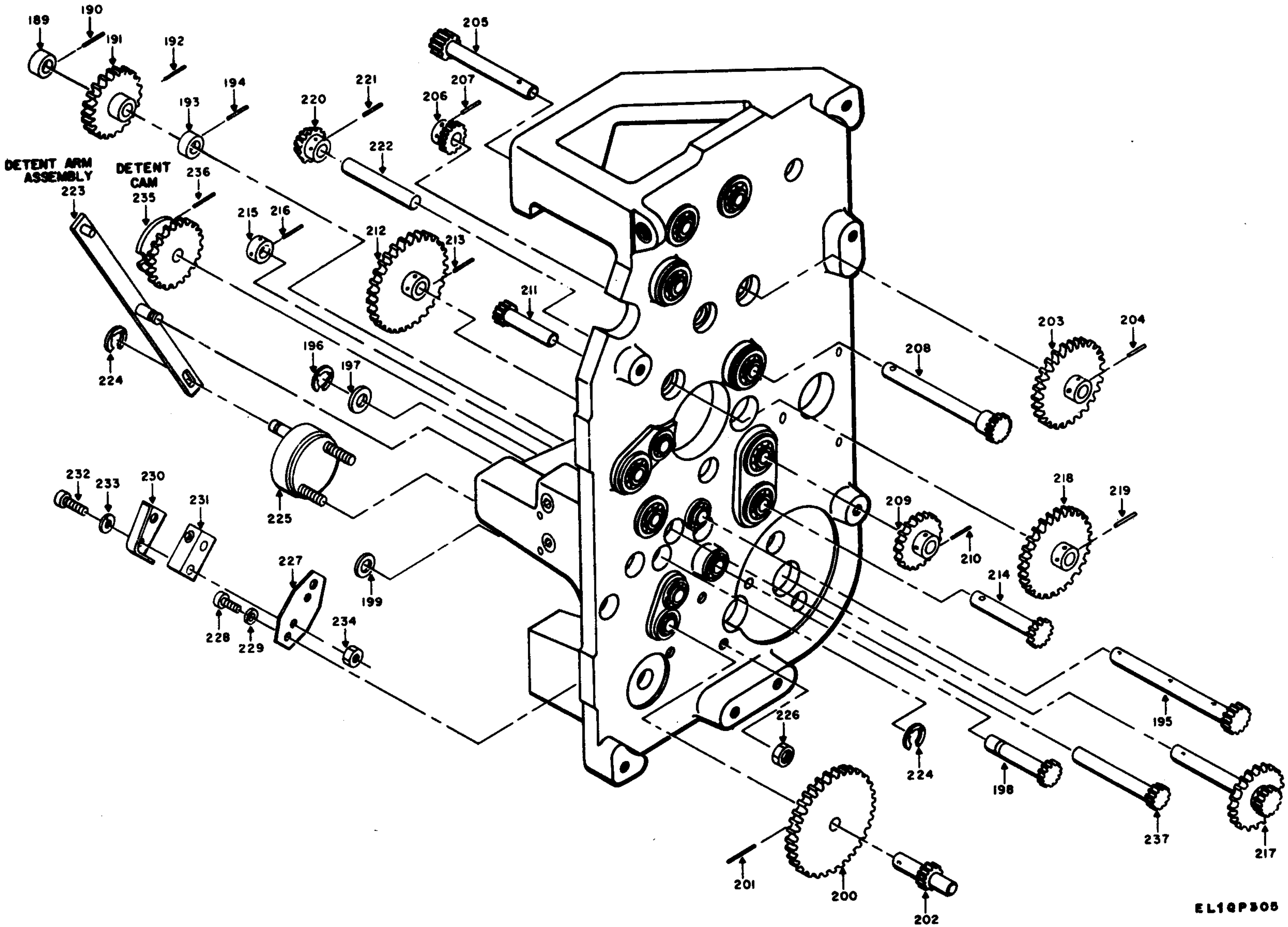


Figure 3-144. ④. *Azimuth subassembly, exploded view* (sheet 4 of 4).

(4) Place the azimuth subassembly in an upright position and rotate the Δ azimuth clutch MP-8-47-1 (108) until the detent arm assembly (38, fig. 3-143) engages the cam notch on the cam gear (11).

(5) Connect the azimuth subassembly to connectors J841, J842, and J843 in the computer; use two W2628 cables, and one W26246 cable. Apply power.

(6) Connect the SIGNAL INPUT lead of the oscilloscope to Δ A jack J880 in the computer. Connect the oscilloscope GND lead to B+RET jack J897.

(7) Set the sweep of the oscilloscope to display 2 cycles of the 400-Hertz voltage present. Set the VERTICAL GAIN to give a reasonable amplitude.

(8) Rotate the shaft of R841 (12) until the amplitude of the oscilloscope trace is minimum.

(9) Tighten the gear clamp (8) on the shaft of potentiometer R841.

(10) Place detent switch S856 on the computer front panel in the AZIMUTH ORIENT position.

(11) Rotate the lower beam azimuth clutch (129, fig. 3-144) until the detent arm assembly (223) engages detent cam (235).

(12) Loosen the gear clamp (11) on AZIMUTH counter M841 (8).

(13) Rotate the countershaft until the AZIMUTH counter indicates 0000 mils.

(14) Fasten the counter in the zero position with masking tape.

(15) Fasten the lower beam azimuth clutch in position with masking tape. Be sure that the clutch is immovable.

(16) Place the detent switch (front panel) in the OFF position.

(17) Rotate the limit stop (76) to either end of travel.

(18) Rotate the limit stop in the opposite direction 17.5 turns, noting the position of the limit-stop tip and counting turns.

(19) Fasten the limit stop in position with masking tape.

(20) Disconnect the test lead from Δ A jack 880 and connect it to C Δ A2 jack J879.

(21) Adjust the oscilloscope (7) above).

(22) Rotate the shaft of potentiometer R842 (85) until the amplitude of the oscilloscope trace is minimum.

(23) Tighten the gear clamp (82) of potentiometer R842.

(24) Loosen the gear clamp (88) on control transformer synchro B846.

(25) Turn the shaft of control transformer synchro B846 (94) until the azimuth strobe indicator on the antenna simulator indicates zero.

NOTE

If the radar is being used during mechanical alignment instead of the antenna simulator, substitute the following procedures for those in (25) above.

(a) Connect Oscilloscope AN/USM-281C signal input lead to test point TP511 in the indicator. Connect GND connection to a ground in the indicator.

(b) Set the sync control for external signal control.

(c) Adjust the oscilloscope to display the lower beam azimuth sweeptime. (Lower beam sweeptime is the period between the deadtime stop pulse and the following deadtime start pulse, with the azimuth strobe pulse somewhere between the stop and start pulses.)

(d) Expand the sweep until the dead time stop pulse is on the extreme left of the tube display and the deadtime start pulse is on the extreme right side of the tube display.

(e) Turn the shaft of control transformer synchro B846 (94) until the azimuth strobe pulse is at the exact center point in time between the stop and start pulses.

(26) Tighten the gear clamp (88) on control transformer synchro B846.

(27) On the C-2014/MPQ-4A Control Power Supply, adjust the antenna azimuth switch for a zero indication on the counter.

(28) Tighten the gear clamp (11) on AZIMUTH counter M841.

(29) Disconnect and tag the leads to terminals 1, 4, 5, and 8 of resolver B847 (58).

(30) Connect a shorting wire between terminals 2 and 4 of B847.

(31) Connect the leads of the multimeter to terminals 6 and 8 of B847.

(32) Connect the signal input lead of Oscilloscope AN/USM-281C to terminal 1 of B847 and connect the ground return to terminal 5 of B847.

(33) Adjust the oscilloscope for an input of 400 Hz and the multimeter to measure 250 volts ac.

(34) Loosen the body clips (55) of B847.

(35) Turn the body of B847 until the reading on the multimeter and the amplitude of the signal on the oscilloscope are minimum.

(36) Tighten the body clips of B847.

(37) Disconnect the oscilloscope and multimeter leads.

(38) Remove the shorting wire between terminals 2 and 4 of B847.

(39) Connect the leads to terminals 1, 4, 5, and 8 of B847.

(40) Disconnect cables W2628 and W2626 from the azimuth subassembly and computer drawer.

(41) Remove the masking tape from AZIMTUH counter M841 and the two clutches.

(42) Replace the azimuth subassembly (para **3-38*p*(12))** and align the computer (para **3-39*a*** through ***d*).**

NOTE

If the height subassembly requires mechanical alignment, do not replace the azimuth subassembly in the computer drawer until the height subassembly has been aligned.

f. Mechanical Alignment of Height Subassembly (fig. 3-139).

(1) Remove the height subassembly from the computer (para **3-38*p*(13)).**

(2) Loosen the gear clamp (75) on the shaft of potentiometer R806 (81).

(3) Turn the RADAR HEIGHT clutch (108) until counter M087 (27) indicates 0000.

(4) Place a strip of masking tape over the counter to hold it immovable.

(5) Rotate the weapon height clutch assembly (66) fully clockwise.

(6) Loosen the gear clamp (15) on the shaft of counter M806 (18).

(7) Turn the countershaft until counter M806 indicates 0900.

(8) Tighten the gear clamp (15).

(9) Rotate the weapon height clutch assembly (66) fully counterclockwise. The WEAPON HEIGHT counter M806 (18) should indicate 9100.

(10) Connect the height subassembly to the computer with cable W2627. Apply power to the computer.

(11) Connect the signal input cable of Oscilloscope AN/USM-281C to H-jack J882; connect the ground return to B+RET jack J897.

(12) Adjust the sweep of the oscilloscope to display 2 cycles of 400 Hz, and adjust the vertical gain for a good vertical display.

(13) Rotate the weapon height clutch assembly (66) until M806(18) indicates 0000.

(14) Place a strip of masking tape over the counter to hold it immovable.

(15) Rotate the shaft of potentiometer R806 (81) until the oscilloscope presentation amplitude is minimum.

(16) Tighten the gear clamp (75) on the shaft of potentiometer R806.

(17) Disconnect the oscilloscope test leads and cable W2627.

(18) Remove the masking tape from the counters.

(19) Replace the height subassembly (para 3-**38*p*(14))** and align the computer (para **3-39*a*** through ***d*).**

g. Mechanical Alignment of Range Subassembly (fig. 3-145).

(1) Remove the range subassembly from the computer (para **3-38*p*(5)).**

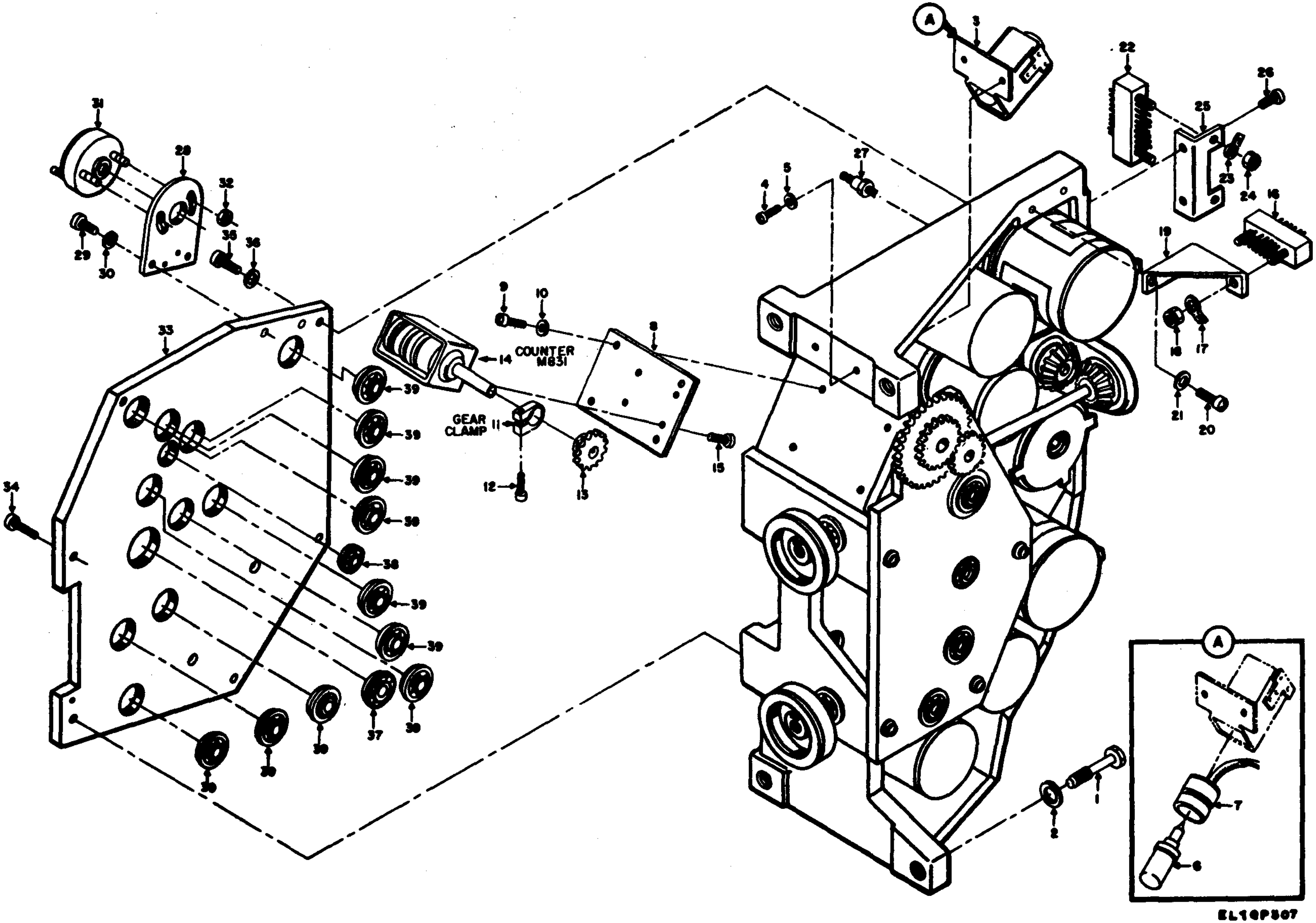


Figure 3-145①. Range subassembly, exploded view (sheet 1 of 3).

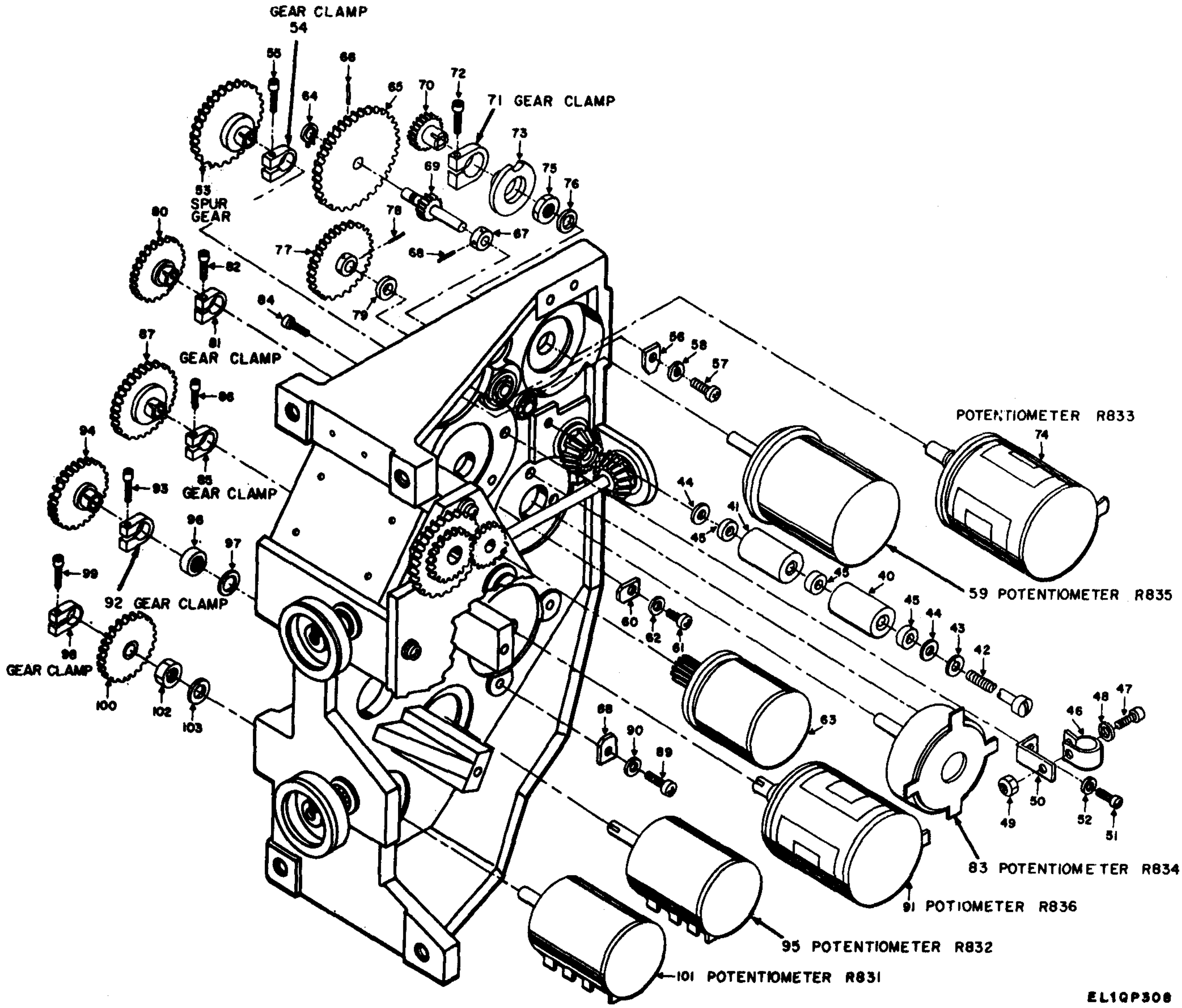


Figure 3-145 ②. *Range subassembly, exploded view* (sheet 2 of 3).

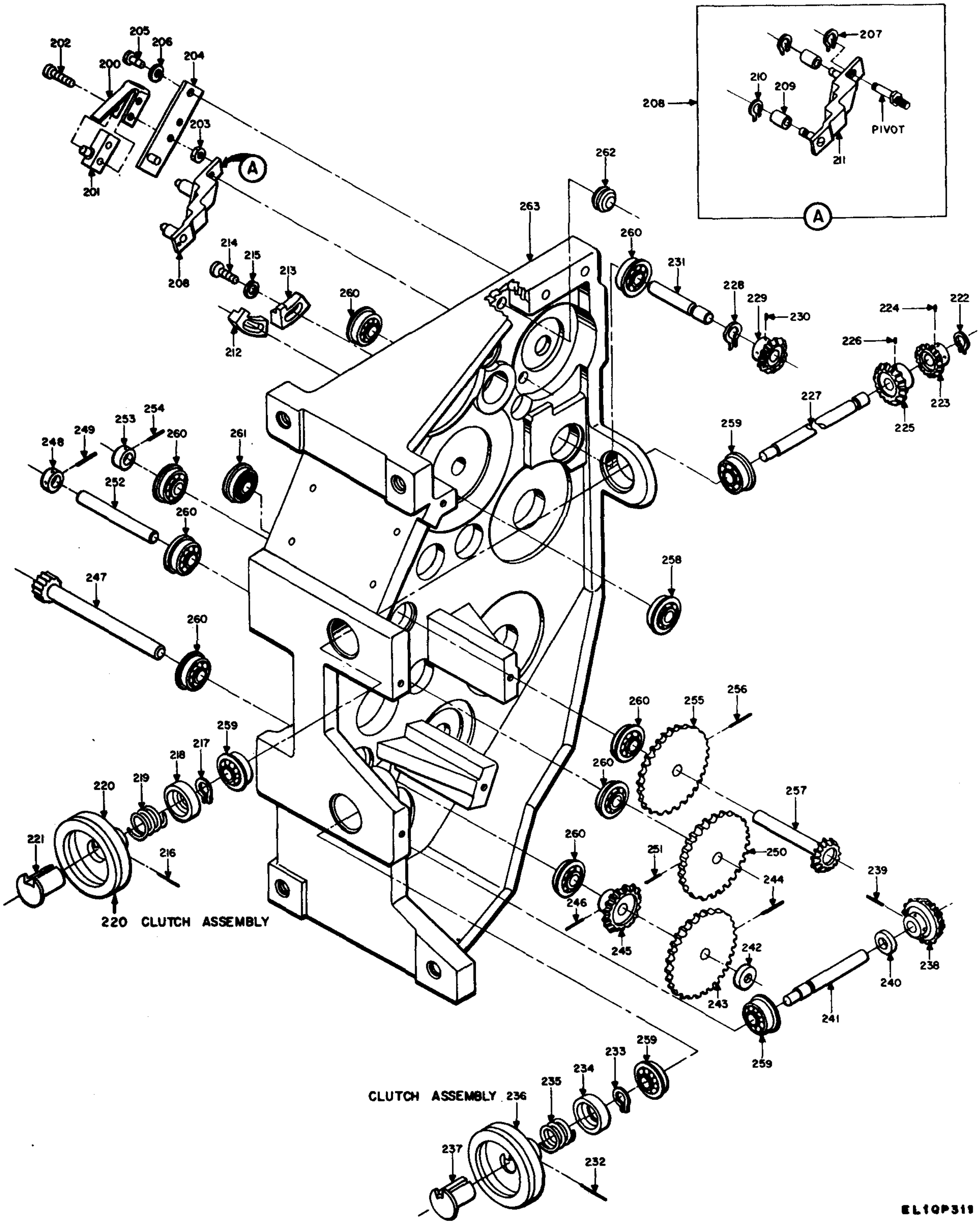


***Figure 3-145* ③. *Range subassembly, exploded view* (sheet 3 of 3).**

(2) Loosen the gear clamps on potentiometer R831 through R836 as indicated:

Potentiometer	Legend No.	Gear clamp legend No.
R831	101	98
R832	95	92
R833	74	71
R834	83	81
R835	59	54
R836	91	85

(3) Rotate the lower beam range clutch assembly (236) fully counterclockwise.

(4) Rotate the spur gear (53) on the shaft of R835 (59) fully counterclockwise.

(5) Loosen the gear clamp (11) on counter M831 (14).

(6) Rotate the countershaft by hand until the counter indicates 00225.

(7) Tighten the gear clamp (11) on the countershaft.

(8) Rotate the spur gear (53) on the shaft of variable resistor R835 (59) fully clockwise. Counter M831 (14) should now indicate 16365.

(9) Rotate the Δ range clutch assembly (220) until the detent engages.

(10) Connect the range subassembly to the computer; use one W2628 cable and one W2627 cable. Apply power to the computer.

(11) Connect Oscilloscope AN/USM-281C signal input lead to Δ R jack J873. Connect the ground return to B+RET jack J897.

(12) Adjust the oscilloscope to present 2 cycles of the 400 Hz signal having an amplitude of about 2 inches.

(13) Check to see that the Δ range is still in detent.

(14) Turn the shaft of potentiometer R833 (74) until the amplitude of the oscilloscope presentation is minimum.

(15) Tighten the gear clamp (71) on the shaft of R833.

(16) Disconnect the oscilloscope signal input lead from jack J873 and connect it to C Δ R jack J874.

(17) With the spur gear (53) on the shaft of R835 (59) held fully counterclockwise, turn the lower beam range clutch assembly (236) clockwise until it stops. While holding the clutch assembly in this position, turn the counter to indicate 02457.

NOTE

When the shaft of potentiometer R834 is released, the amplitude of the oscilloscope presentation should stay at a minimum. If the amplitude of the oscilloscope presentation increases when the shaft is released, it indicates binding between the spur gear (80) and the potentiometer shaft. If binding occurs, gently tap the gear while holding the potentiometer shaft at the minimum signal level.

(18) The signal amplitude on the oscilloscope should be at a minimum. If not, proceed as follows: with the, gear train in the above position, turn the shaft of potentiometer R834 (83) so that the oscilloscope signal amplitude is at a minimum (at maximum gain). Tighten the gear clamp (81) on the shaft of R834.

(19) Disconnect the oscilloscope leads.

(20) Rotate the lower beam range clutch assembly (236) until weapon RANGE counter M831 (14) indicates 08250. (Δ range remains in detent.)

(21) Connect the TS-909/PPM to the computer. Connect the +REF VOLT lead to +REF jack J891 in the computer. Connect the -REF VOLT lead to B+RET jack J897 in the computer. Connect the TEST PROBE lead to R_w jack J875 in the computer.

(22) Rotate the shaft of potentiometer R835 (59) fully clockwise. Adjust BRIDGE ADJ (TS-909/PPM) potentiometer for a zero NULL METER indication. Write down the exact BRIDGE ADJ setting.

(23) Rotate the shaft of potentiometer R835 fully counterclockwise. Adjust BRIDGE ADJ potentiometer for a zero NULL METER indication. Write down the exact BRIDGE ADJ setting.

(24) Add the exact BRIDGE ADJ setting noted in (22) above to the exact BRIDGE ADJ setting noted in (23) above. Divide the sum ((22) and (23)) above by 2.

(25) Set the resultant figure noted in (24) above on the BRIDG ADJ potentiometer.

(26) Rotate the shaft of potentiometer R835 for a zero indication on the NULL METER of the TS-909/PPM.

(27) Tighten the gear clamp (54) on potentiometer R835.

(28) Remove the TEST PROBE lead from jack J875 and connect it to CHB jack J876.

(29) Set antenna elevation to +150 mils.

(30) Rotate the shaft of potentiometer R832 (95) fully clockwise. Adjust BRIDGE ADJ potentiometer for a zero NULL METER indication. Write down the exact BRIDGE ADJ setting.

(31) Rotate the shaft of potentiometer R832 fully counterclockwise. Adjust BRIDGE ADJ potentiometer for a zero NULL METER indication. Wirte down the exact BRIDGE ADJ setting.

(32) Add the exact BRIDGE ADJ setting noted in (30) above to the exact BRIDGE ADJ setting noted in (31) above. Divide the sum by 2.

(33) Set the BRIDGE ADJ potentiometer to the figure noted in (32) above.

(34) Rotate the shaft of poteniometer R832 for a zero indication on the NULL METER.

(35) Tighten the gear clamp (92) on potentiometer R832.

(36) Remove the TEST PROBE from jack J876 and connect it to CH_L jack J872. Remove the red test lead from computer test jack J891 (+REF) and connect to computer test jack J890 (-REF).

(37) Rotate the shaft of potentiometer R831 (101) fully clockwise. Adjust BRIDGE ADJ potentiometer for a zero NULL METER indication. Write down the exact BRIDGE ADJ setting.

(38) Rotate the shaft of the potentiometer R831 fully counterclockwise. Adjust BRIDGE ADJ potentiometer for a zero NULL METER indication. Write down the exact BRIDGE ADJ setting.

(39) Add the exact BRIDGE ADJ setting noted in (37) above to the exact BRIDGE ADJ setting noted in (38) above. Divide the sum of (37) and (38) by 2.

(40) Set the BRIDGE ADJ potentiometer to the figure noted in (39) above.

(41) Rotate the shaft of potentiometer R831 for a zero indication on the NULL METER.

(42) Tighten the gear clamp (98) on potentiometer R831.

(43) Disconnect the test leads of the TS-909/PPM.

(44) Connect the AN/USM-98 test lead to jack J851. Connect the ground return to B+RET jack J897.

(45) Adjust the AN/USM-98 to measure voltage on the 0-500-volt scale.

(46) Rotate the shaft of potentiometer R836 fully counterclockwise. Write down the exact voltage indication on the AN/USM-98.

(47) Rotate the shift of potentiometer R836 fully counterclockwise. Write down the exact voltage indication on the AN/USM-98.

(48) Add the exact voltage noted in (46) above to the exact voltage noted in (47) above. Divide the sum of (46) and (47) by 2.

(49) Rotate the shaft of potentiometer R836 for an exact voltage indication on the AN/USM-98 equal to the calculated voltage from (48) above.

(50) Tighten the gear clamp (85) on the shaft of potentiometer R836.

(51) Turn the computer power off. Disconnect the test leads and remoting cables.

(52) Replace the range subassembly in the computer (para **3-38*p*(7))** and perform a complete electrical alignment of the computer (para **3-39*a*** through ***d*)**.

h. Mechanical Alignment of Time Subassembly (fig. 3-146)

(1) Remove the time subassembly from the computer (para **3-38*p*(4))**.

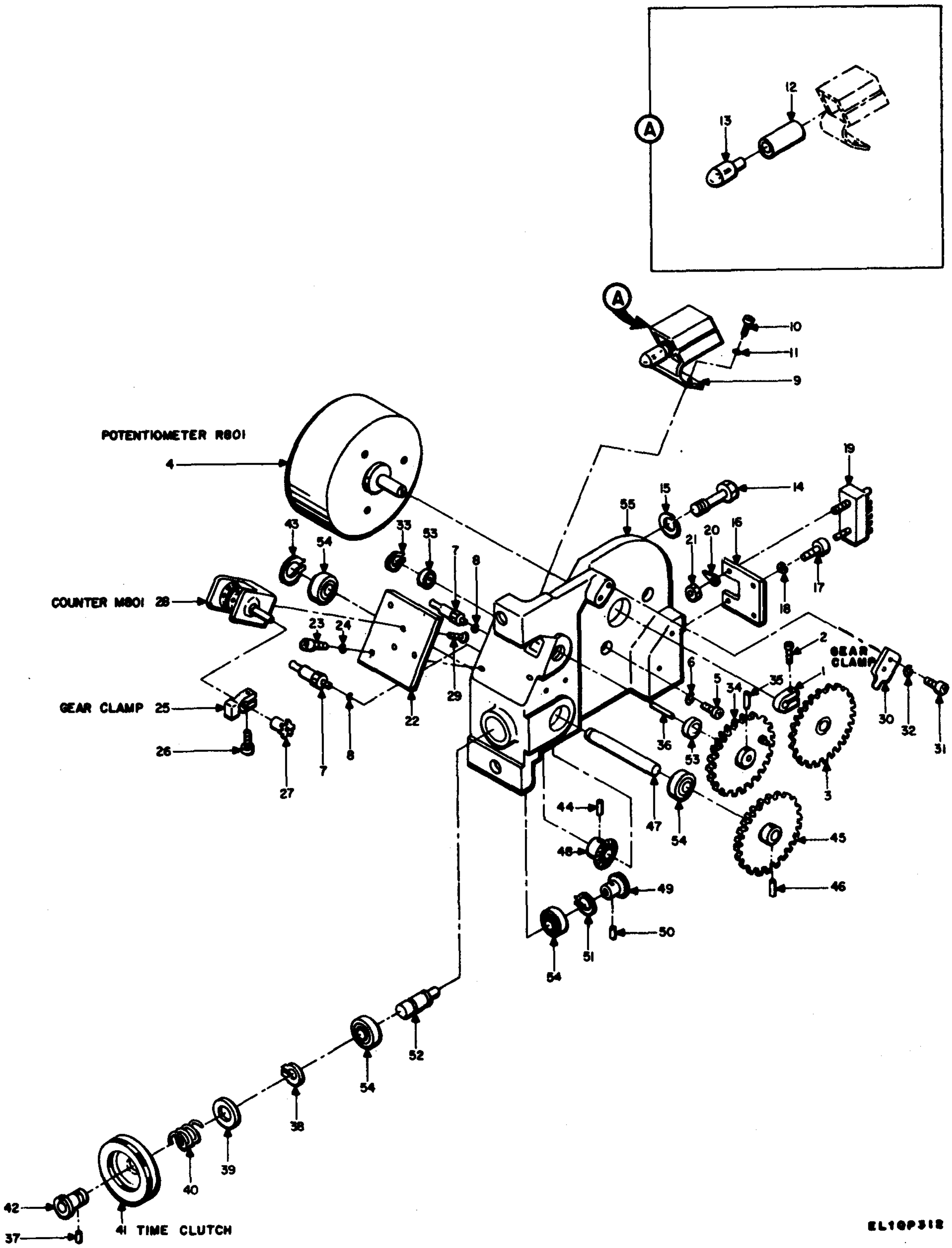


Figure 3-146. Time subassembly, exploded view.

(2) Rotate the Δ time clutch (41) fully counterclockwise.

(3) Loosen the gear clamp (25) of counter M801 (28).

(4) Rotate counter M801 until it indicates 0.0.

(5) Tighten the counter gear clamp (25).

(6) Connect the time subassembly to the computer with a W2627 cable.

(7) Place the TEST-NORMAL switch (right side of computer drawer) in the TEST position.

(8) Connect Computer Test Set TS-909/PPM to the computer test jacks as follows: +REF VOLT lead to +REF jack J891; -REF VOLT lead to -REF jack J890; TEST PROBE to Δ T jack J871.

(9) Apply power to the computer.

(10) Set the BRIDGE ADJ potentiometer on the TS-909/PPM to 5000.

(11) Loosen the gear clamp (1) on the shaft of potentiometer R801 (4).

(12) Rotate the shaft of potentiometer R801 fully counterclockwise until the NULL METER just indicates zero (counter M801 indicates 0.0 ((4) above).

(13) Tighten the gear clamp (1) on R801.

(14) Rotate the Δ time clutch until counter M801 indicates 6.0.

(15) Set the BRIDGE ADJ potentiometer until the NULL METER indicates zero.

(16) Write down the BRIDGE ADJ setting.

(17) Subtract the BRIDGE ADJ setting (it will be less than 5000) from 5000.

(18) Divide the difference figure ((17) above) by 4.

(19) Subtract the answer ((18) above) from 5000. Set the BRIDGE ADJ potentiometer to this figure.

(20) Rotate the Δ time clutch until counter M801 indicates 3.0.

(21) The NULL METER should indicate zero. If the NULL METER does not indicate zero, rotate the BRIDGE ADJ potentiometer 25 divisions above and then 25 divisions below the setting made in (19) above. The NULL METER should indicate zero within this range.

(22) Disconnect the test leads and remoting cable.

(23) Replace the time subassembly in the computer drawer **(3-38*p*(4))** and realign the computer (para **3-39*a*** through ***d*)**.

i. Mechanical Alignment of Elevation Subassembly (fig. 3-147).

(1) Remove the elevation subassembly from the computer (para **3-38*p*(1**

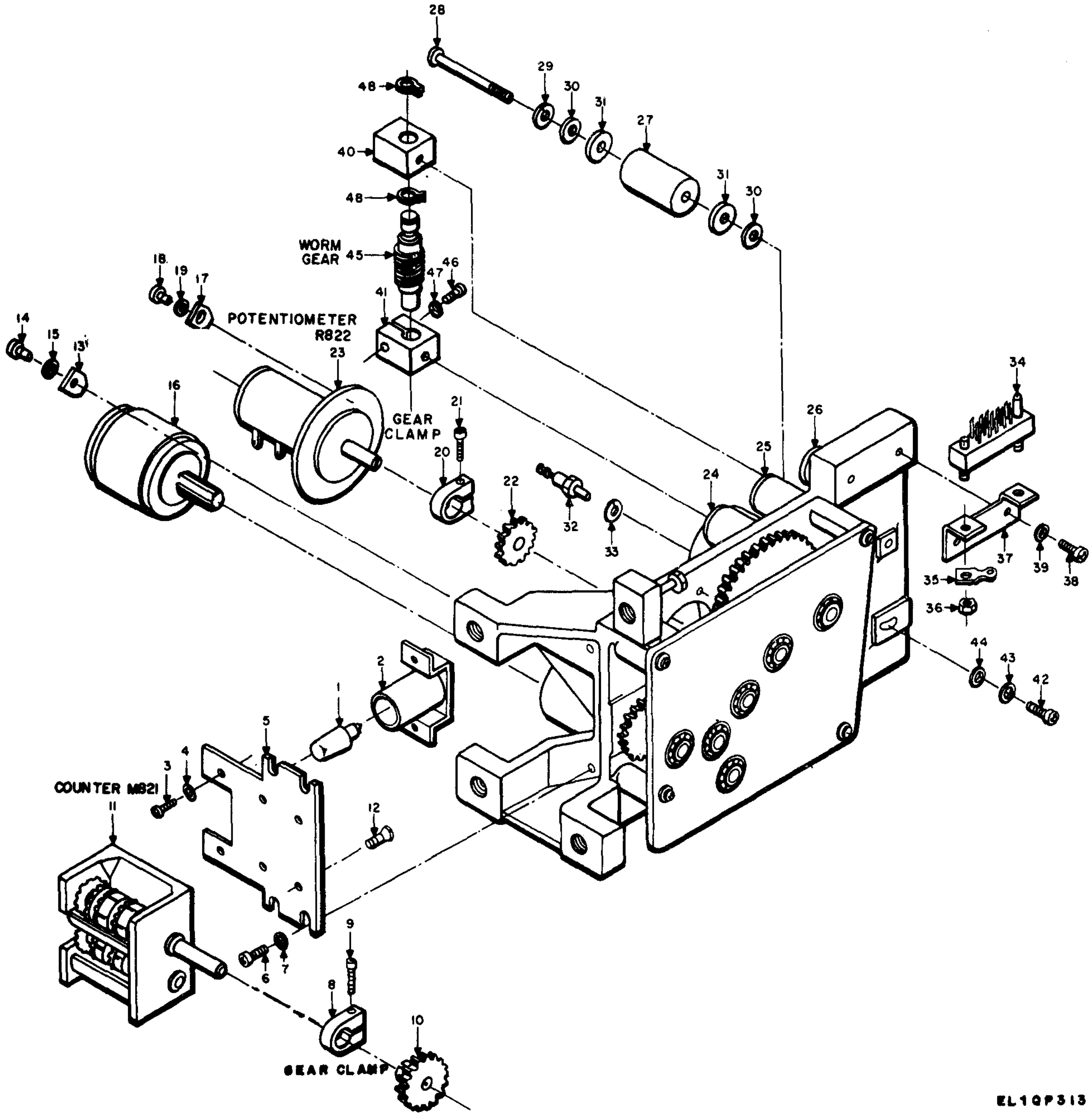


Figure 3-147 ①. Elevation subassembly, exploded view (sheet 1 of 2).

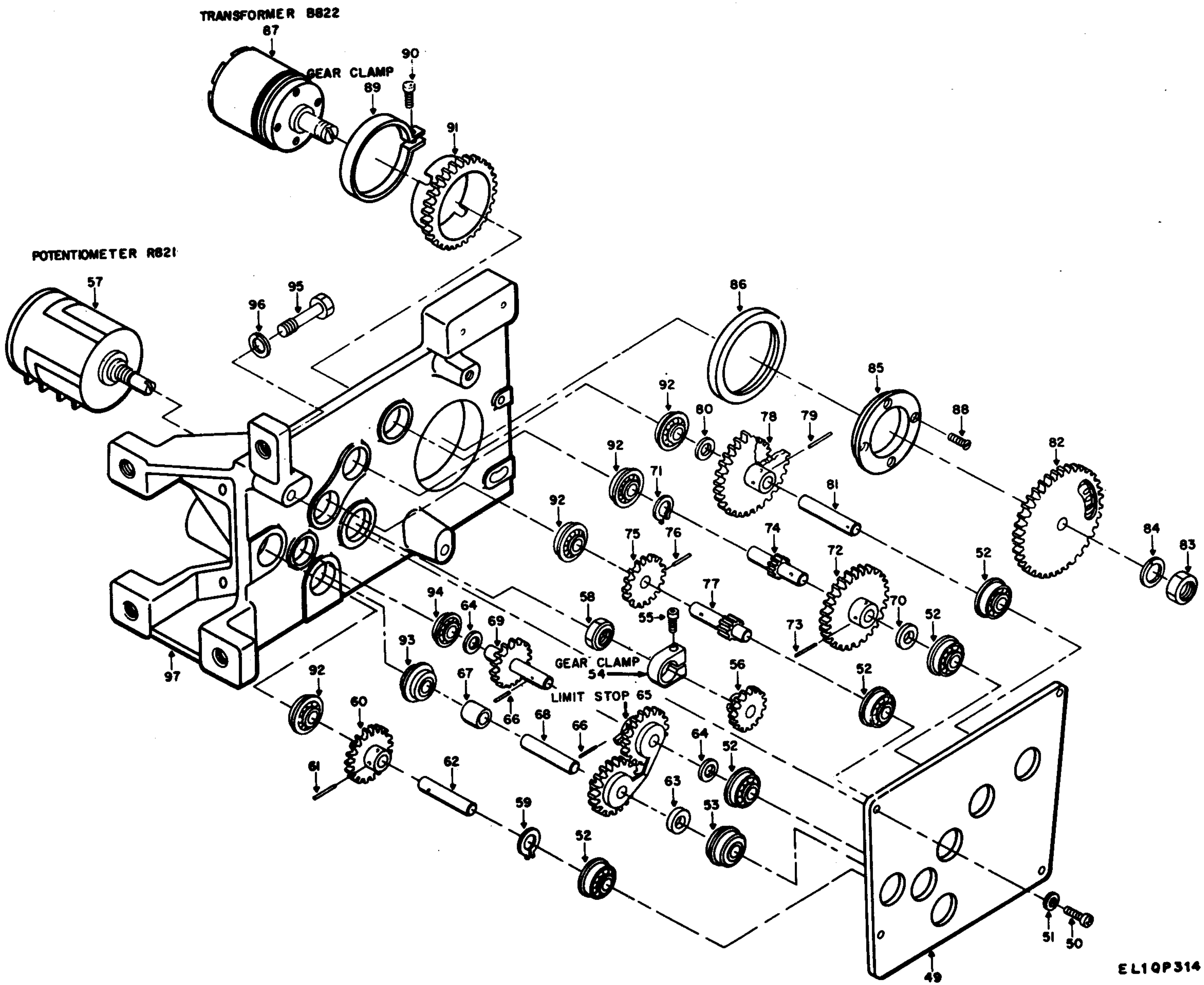


Figure 3-147 ②. *Elevation subassembly, exploded view* (sheet 2 of 2).

(2) Loosen the gear clamps (54 and 20) on potentiometers R821 (57) and R822 (23).

(3) Rotate the shaft of counter M821 (11) clockwise until the limit stop (65) engages.

(4) Loosen the gear clamp (8) on counter M821.

(5) Hold the gear train at the clockwise limit. stop and rotate the upper counter to 200.

(6) Tighten the counter gear clamp (8).

(7) Set the beam separation dial at 35 (para 3-39 *d* (3)).

(8) Connect the elevation subassembly to the computer with a W2628 cable.

(9) Connect the signal input lead of Oscilloscope AN/USM-281C to EL jack J881 and the ground lead to B + RET jack J897. Apply power to the computer.

(10) Adjust the oscilloscope for an input frequency of 400 Hz and an approximate 2-inch amplitude display.

(11) Rotate the gear train until the counter indicates 000.

(12) Hold the gear train so that the counter remains at 000 and rotate the shaft of R821 (57) until the oscilloscope presentation amplitude is minimum.

(13) Tighten the gear clamp (64) on the shaft of R821.

(14) Disconnect the test lead from EL jack J881 and connect it to EU jack J887.

(15) Turn the gear train until the lower counter indicates 035.

(16) Hold the gear train so that the counter remains at 035 and rotate the shaft of R822 (23) until the oscilloscope presentation amplitude is minimum.

(17) Tighten the gear clamp (20) or R822.

(18) Turn the gear train until the counter indicates 000.

(19) Place a strip of masking tape over the counter to hold at 000.

(20) Disconnect and tag the leads to R1, R2, and S2 on synchro control transformer B822 (87).

(21) Connect a shorting wire between R2 and S3 on B822.

(22) Connect the test leads from the oscilloscope to R1 and S1 of B822.

(23) Loosen the body gear clamp (89) of B822.

(24) Turn the body of B822 until the oscilloscope presentation amplitude is minimum.

(25) Tighten the body gear clamp (89) of B822.

(26) Disconnect the oscilloscope leads *from* B822 and remove the shorting wire between R2 and S3.

(27) Reconnect the lead to S2 of B822.

(28) **Disconnect** the lead to S3 of B822 and connect a shorting wire between S1 and S3.

(29) Connect the oscilloscope leads to R1 and R2 of B822.

(30) Turn the worm gear (45) of B822 until the oscilloscope presentation amplitude is minimum.

(31) Disconnect cable W2628 and the oscilloscope test leads.

(32) Reconnect the leads of R1, R2, and S3 of B822.

(33) Remove the masking tape from the counter.

(34) Replace the elevation subassembly in the computer (para 3-38 *p* (2)) and electrically align the computer (para 3-39 *a* through *d*).

3-41. Computing System Testing

a. General.

(1) This paragraph covers testing procedures for checking the serviceability of a repaired computing system when the components of the radar set are interconnected. Testing procedures for checking the serviceability of the complete radar set are covered in paragraph 3-63.

(2) The testing procedures in this paragraph are divided into three parts. The first part is a voltage check *(c* below) on the various computing potentiometers to insure that they have been properly aligned. The second part *(d* below) verifies that the potentiometers function properly. The third part (e below) consists of a set of problems to check the overall computer accuracy.

b. Test Equipment Required. Refer to TM 11-5840-208-20, for test equipment required to test the serviceability of the computing system.

c. *Potentiometer Voltage Check.* Check the various computing potentiometers in accordance with procedures given in TM 11-5840-208-20.

d. Check of Computer Functioning. Check computing functioning in accordance with procedures in TM 11-5840-208-20.

e. Computer Accuracy Check. Check computer accuracy in accordance with procedures given in TM 11-5840-208-20.

3-42. Servicing of Computing System Subassemblies

a. General. This paragraph covers servicing of the computing system subassemblies, with servo amplifiers, isolation amplifiers, and the booster and dual speed cutover amplifier. The following information will be helpful when performing maintenance on the computer.

Information	Location (Fig. No.)
Dual servoamplifiers AR926 through AR929, schematic diagram.	FO-34
Dual isolation amplifier AR901, schematic diagram.	FO-33
Booster and dual speed cutover amplifiers AR951, schematic diagram.	FO-32
Voltage and resistance diagrams	3-133, 3-134, and 3-135
Dual servo amplifier, bottom view ..	3-130
Dual isolation amplifier, bottom view	3-131
Booster and dual speed cutover amplifier, bottom view.	3-132

b. Test Equipment Required. Table 3-49 lists items of test equipment that are required to test the computing system subassemblies.

c. Checking for Short Circuits. To prevent damage which would result from applying power to a shorted amplifier, perform a resistance check from the points specified to the chassis ground with the chassis disconnected from the equipment. A reading less than the value shown indicates that a further check should be made to determine where the short circuit exists. Make voltage and resistance checks (fig. 3-133, 3-134, and 3-135).

Table 3-49. Test Equipment Required to Test Computing System Subassemblies

Test equipment	Common name	Technical manual
Multimeter TS-352B/U.	Multimeter	TN 11-6625-366-15
Multimeter ME-26A/U.	Vtvm	TM 11-6625-200-15

Table 3-50. Resistance Checks for Short Circuits

Check point	Terminal	Resistance to ground
P926 and P927 servo amplifiers AR926 through AR929.	A	Inf
	B	Inf
	C	Inf
	D	Inf
	E	Inf
	F	Inf
	H	Inf
	J	Inf
	K	Inf
	L	Inf
	M	Inf
	N	Inf
	P	O
	R	Inf
P869 and P858 booster and dual speed cutover amplifier AR951.	A	Inf
	B	Inf
	C	Inf
	D	Inf
	E	Inf
	F	Inf
	H	Inf
	J	Inf
	K	Inf
	L	Inf
	M	Inf
	N	Inf
	P	O
	R	Inf
P859 and P865 dual isolation amplifier AR901.	A	Inf
	B	Inf
	C	Inf
	D	Inf
	E	Inf
	F	Inf
	H	Inf
	J	Inf
	K	Inf
	L	Inf
	M	Inf

Table 3-50. Resistance Checks for Short Circuits - Continued

Check point	terminal	Resistance to ground
	N	Inf
	P	O
	R	Inf

d. Removal and Replacement of Parts.

(1) *Amplifiers.* To remove the servoamplifiers, isolation amplifier, booster amplifier, and dual speed cutover amplifier from the servoamplifier chassis in the computer drawer, unscrew two captive screws on each amplifier and lift the amplifier from the chassis. To reach the parts in the amplifier subassemblies, loosen a captive screw on the top of each chassis (fig. 3-104, 3-108, and 3-114). Fold back the bottom covers of the subassemblies to reach each part for removal or replacement, and for resistance measurements.

(2) *Mechanical Subassemblies.* To remove the mechanical subassemblies from the computer drawer, loosen the captive screws attached to the subassembly and lift the subassembly out of the drawer. Removal and replacement of mechanical subassemblies are discussed in paragraph 3-38p.

3-43. Computer Single Beam-Dual Beam Mode

a *General.* This paragraph covers the adjustment and taking procedure of the single beam-dual beam mode of operation of the computer. Weapon location coordinate data for projectile with low angle trajectories that intercept only the lower beam (dual beam operation) is an added facility to improve the operational capability of the radar set.

b. Test Equipment Required. Refer to TM 11-

5840-208-20 for test equipment required to adjust and test the serviceability of the computing system for the single beam mode of operation.

c. Adjustment of Single Beam Potentiometers R881 and R884. Adjust single beam potentiometers R881 and R884 in accordance with the procedures in TM 11-5840-208-20. A SINGLE BEAM-DUAL BEAM switch (fig. 3-98) facilitates selection of the correct mode of operation to permit adjustment of R881 and R884 (fig. 3-148) and fig. 3-149).

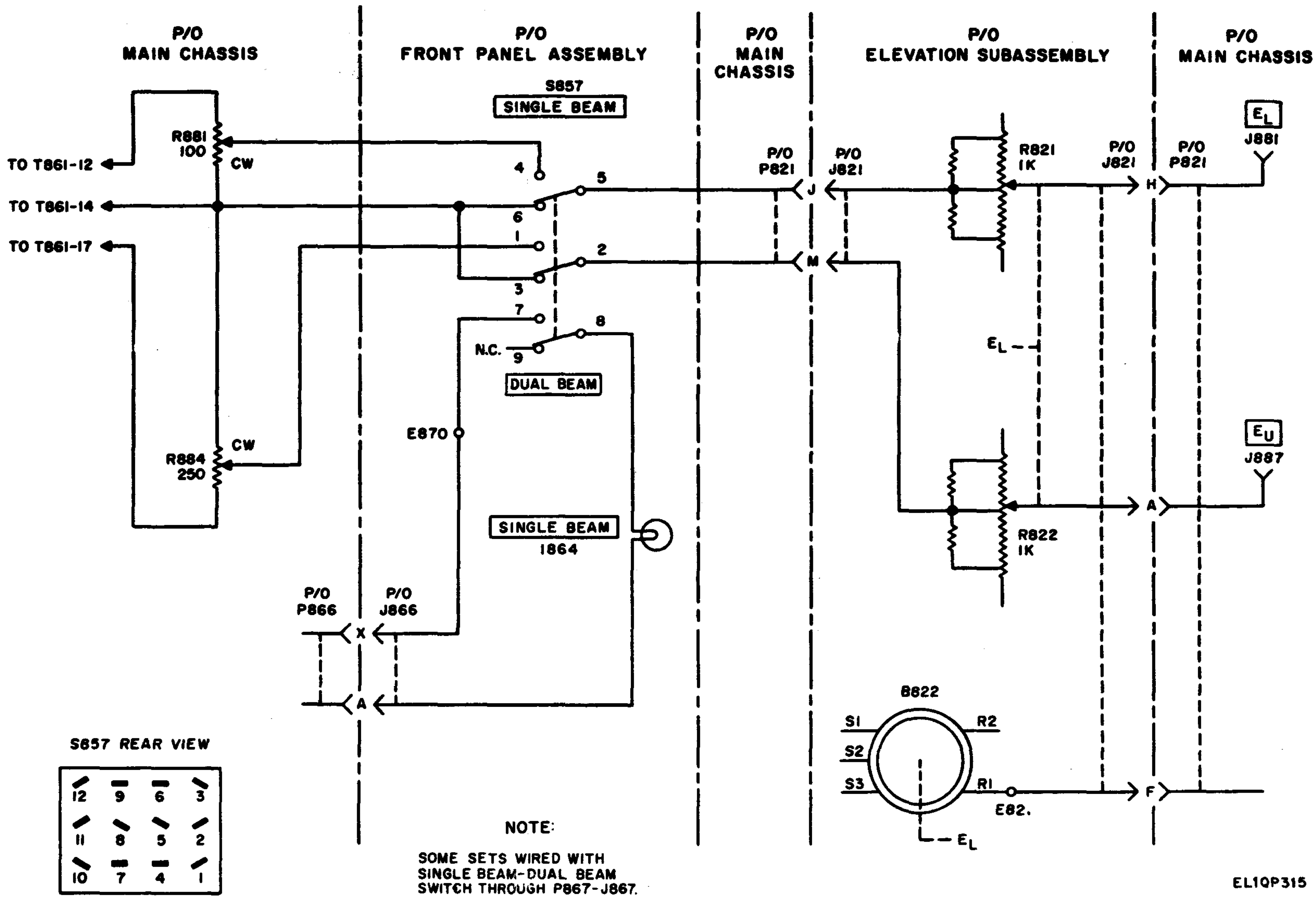


Figure 3-148. Radar Data Computer CP-319/MPQ-4A, partial schematic diagram, including single beam-dual beam switching and adjustment potentiomters less P867 and J867 wiring.

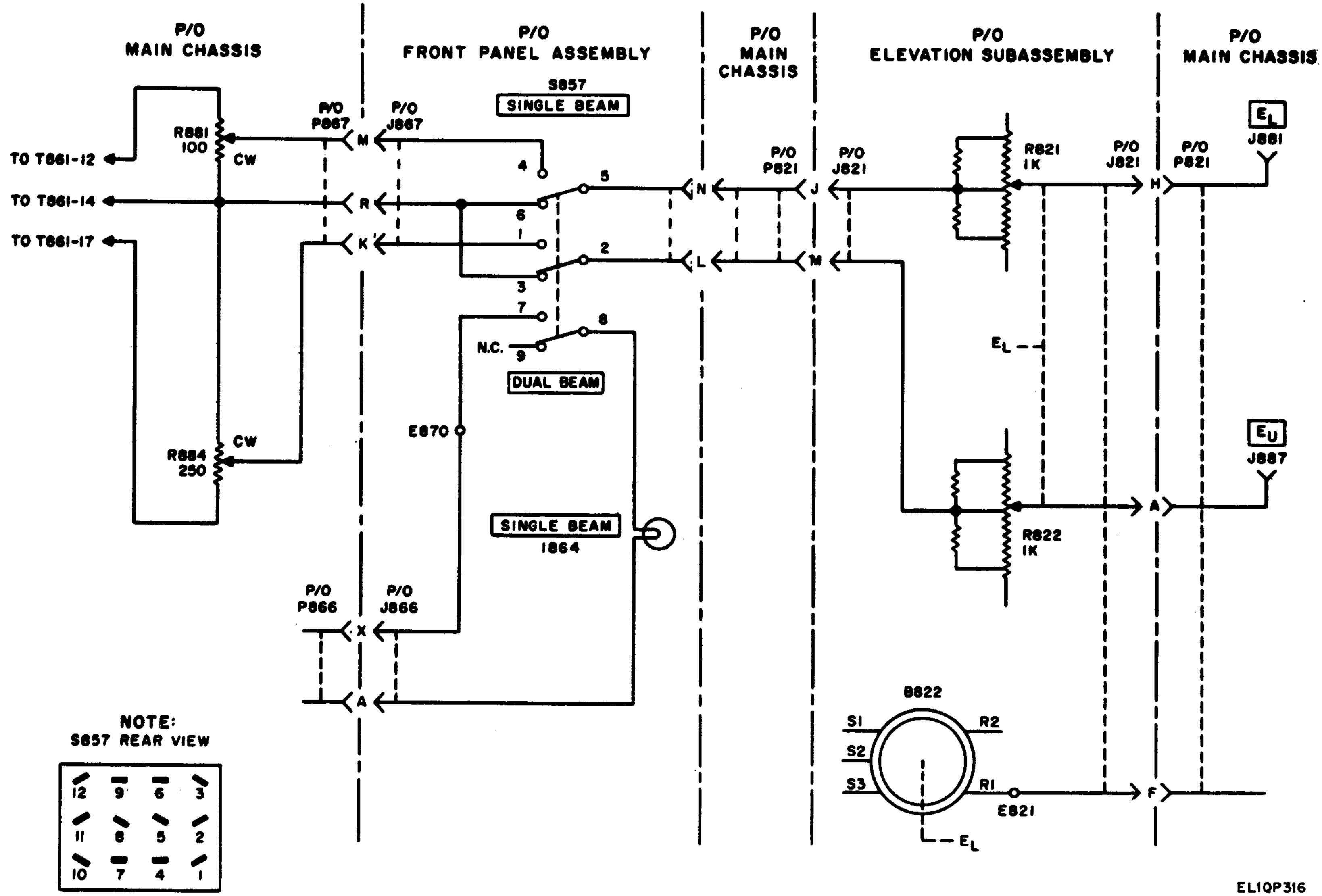


Figure 3-149. Radar Data Computer CP-319/MPQ-4A, partial schematic diagram, including single beam-dual beam switching adjustment potentiometers, and P867-P867 wiring.

Section IX. ANTENNA POSITIONING SYSTEM TROUBLESHOOTING AND REPAIR

3-44. Antenna Positioning System Troubleshooting Information

a. Reference Data. The following information will be helpful when troubleshooting the antenna positioning system.

Reference	Information
FO-38	Antenna assembly, schematic diagram
Para 2-38, 2-39, and 2-40	Functioning of circuits in the antenna positioning system.
Fig. 3-150	Azimuth stowlock S3002
Fig. 3-151	Antenna azimuth handwheel
Fig. 3-152	Antenna azimuth counter
Fig. 3-165	Antenna Group OA-1258/MPQ-4A, showing dehydrator.

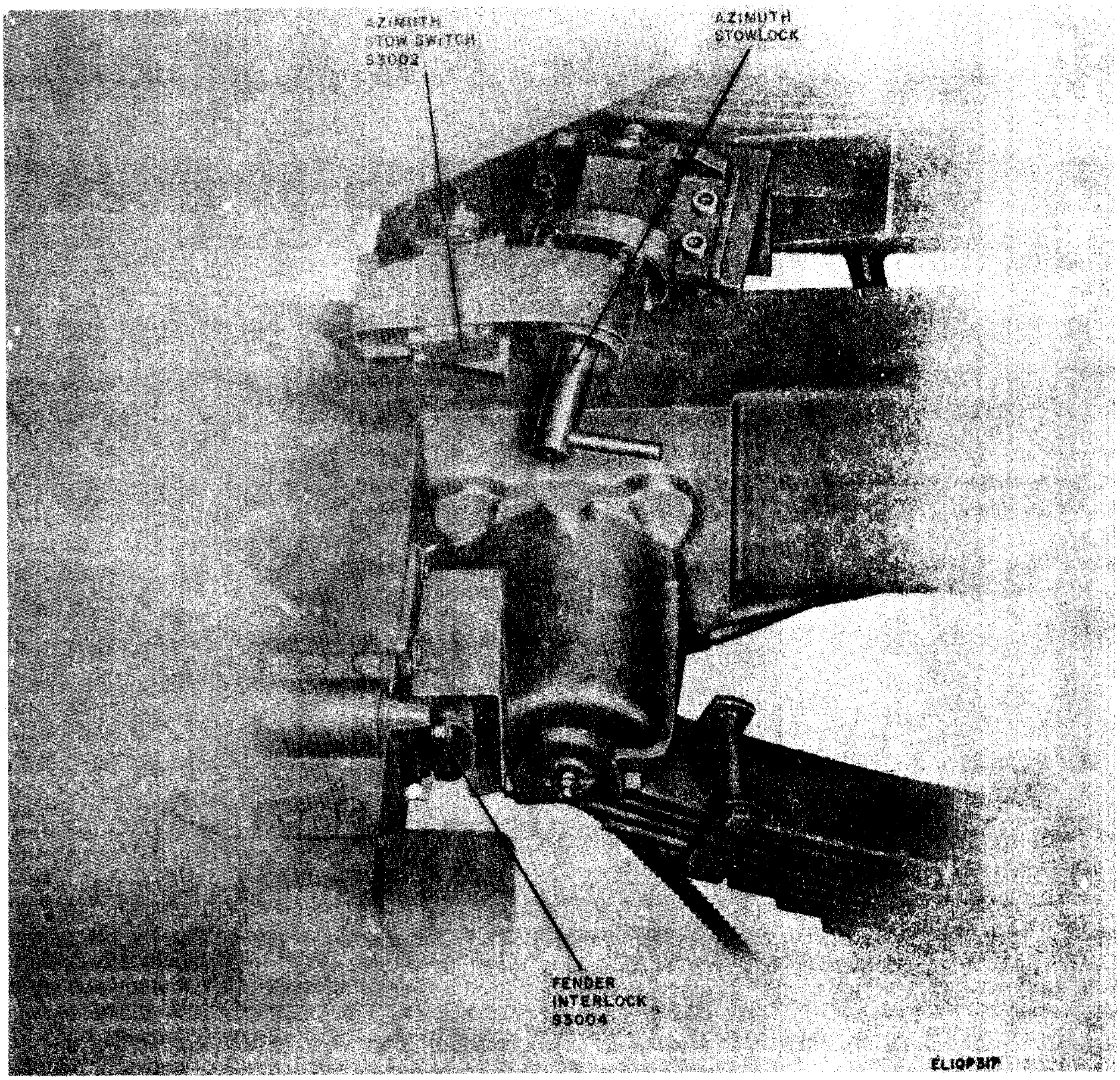


Figure 3-150. Azimuth stowlock S3002.

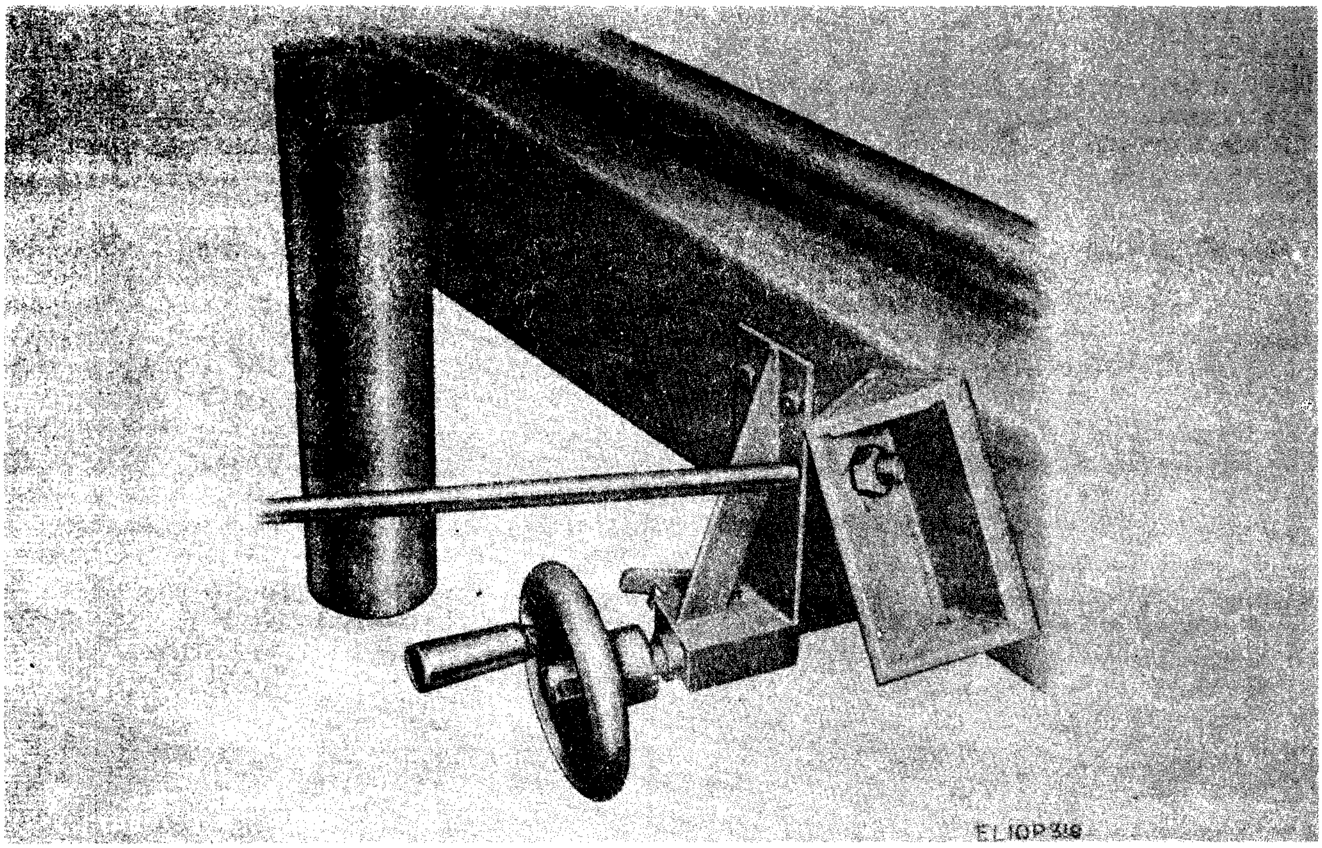


Figure 3-151. Antenna azimuth handwheel.

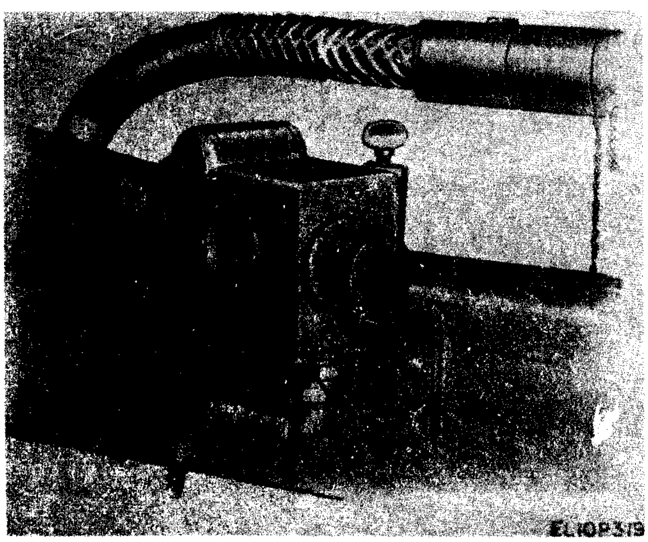


Figure 3-152. Antenna azimuth counter.

b. Antenna Positioning System Controls and Adjustments. Table 3-51 lists the controls and adjustments that are functional parts of the antenna positioning system.

c. Dc Resistance Coils. Table 3-52 lists the coils in the antenna positioning system, references a figure that shows the location of each, and gives the resistance of each winding.

Table 3-51. Antenna Positioning System Controls and Adjustments

Controls and adjustments	Location (fig.)	Function
Azimuth stowlock and azimuth stowlock switch S3002.	3-150	Locks pedestal and opens azimuth drive circuit when engaged.
Azimuth handwheel	3-151	Drives pedestal manually.
Azimuth counter	3-152	Mechanically indicates azimuth angle in mils.
Elevation counter	3-165	Mechanically indicates elevation angle in mils.
Azimuth counter illumination potentiometer R3001.	. . . . . .	Controls illumination of azimuth counter illumination lamp I 3001.
Azimuth counter illumination lamp I 3001.	. . . . . .	Illuminates azimuth counter.

Table 3-51. Antenna Positioning System Controls and Adjustments - Continued

Controls and adjustments	Location (fig.)	Function
Elevation counter illumination potentiometer R3002.	......	Controls illumination of elevation counter illumination lamp I 3002.
Elevation counter illumination lamp I 3002.	......	Illuminates elevation counter.
Azimuth counter reset ..	3-150	Zeros azimuth counter
ELEVATION switch S655.	3-104	Energizes elevation drive motor on antenna.
AZIMUTH switch S656	3-104	Energizes azimuth drive motor.

Table 3-52. Location and Dc Resistance of Coils

Coil	Location (fig.)	Dc resistance (ohms)
Fixed marker coil L3201	2-60	19 [a]
Adjustable coil L3202	2-60	19 [a]
Marker coil L3203	2-60	38

[a] These coils are measured in parallel. An indication of 38 ohms indicates that one of the coils is open.

3-45. Antenna Positioning System Troubleshooting

a. General.

(1) A troubleshooting procedures is provided to assist in isolating trouble that has been sectionalized to the antenna positioning system.

(2) Troubles that have been sectionalized to the antenna positioning system can usually be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a circuit. The symptoms which are given in paragraph 3-45c are based on indications obtained on the azimuth and elevation counters and by visually observing the operation of the antenna. To troubleshoot the antenna positioning system based on symptons, proceed as follows:

(a) Visually observe the indications on the azimuth and elevation counters on the antenna.

(b) Compare the indications obtained with those listed in each of the symptoms.

(c) If the indications correspond to those listed in a particular symptom, follow the procedure under that particular symptom to isolate the trouble.

b. Test Equipment Required. Table 3-53 lists the items of test equipment are required to troubleshoot the antenna positioning system.

Table 3-53. Test Equipment Required to Troubleshoot the Antenna Positioning System

Test equipment	Common name	Technical manual
Multimeter TS-352B/U.	Multimeter	TM 11-6625-366-15
Ohmmeter ZM-21A/U	Megger	TM 11-2050.

c. Symptom Troubleshooting.

(1) *Symptom 1.* Scanner motor B3201 is inoperative.

(a) Check scanner motor circuit for worn or damaged slipring brushes.

(b) Check relay K3003 for normal operation.

(c) Disconnect B3201 and measure the resistances at the terminals of J3201. The normal indications are given in paragraph 3-56c.

(2) *Symptom 2.* Antenna does not move in elevation.

(a) If elevation motor is operating but the antenna is not actuated, check the gearing.

(b) If elevation motor is inoperative, check the limit switches by measuring between terminals D and F, and E and F of J3012. Refer to paragrpah 3-46c for indications. Check relays K1501 and K1502.

(3) *Symptom 3.* Antenna does not move in azimuth.

(a) Azimuth drive motor B3003 operating but not driving pedestal. Check azimuth gear train.

(b) If azimuth drive motor is inoperative, check relays K3001 and K3002 and measure azimuth drive motor circuit (para 3-46c).

3-46. Testing Antenna Positioning System

a. General. This paragraph covers testing procedures to check the serviceability of an antenna positioning system.

b. Test Equipment Required. Table 3-54 lists the test equipment required to completely test the serviceability of the antenna positioning system.

c. Checking for Short Circuits.

(1) Table 3-55 lists the normal resistance between terminals of the various jacks and plugs in the antenna positioning system.

(2) A voltage of 28 volts dc must be applied between pins 6 and 43 of J3010. The positive side of the voltage source is applied to pin 6. The same check should be made with 28 volts dc applied between pins 51 and 43. Positive voltage is applied to pin 51.

(3) The check in (2) above is to test the continuity through the sliprings. The antenna should be rotated by hand through 360° for each check.

(4) This measurement is made through the coil of K3003.

(5) Apply 28 volts dc between pin 43 of J3010 and Pin A of J3018 when checking scanner circuitry.

(6) All ungrounded circuits should be checked with the megger.

NOTE

Do not use the megger across the illuminating lamps nor across diodes CR3001 and CR3002.

Table 3-54. Test Equipment Reqired for Field Testing Antenna Positioning System

Test equipment	Common name	Technical manual
Multimeter TS-352B/JU	Multimeter	TM 11-6626-366-15
Electronic Counter, Digital Readout AN/USM-207	Electronic counter	TM 11-6625-700-10
Ohmmeter ZM-21A/U	Megger	TM 11-2050

Table 3-55. Checks for Short Circuits

Check point	Resistance (ohms)
J3203:	
A to B	150
A to C	150
A to D	Inf
D to G	70
E to F	110
E to H	Inf
H to I	36
J3202:	
A to C	19
A to B	Inf
B to C	38
J3201:	
A to B	2
A to C	2
B to C	2
J3207:	
A to B	0
J3012:	
A to B	8
A to C	8
B to C	8
D to F	0
E to F	0
D to F[a]	Inf
E to F[b]	Inf
J3205:	
A to B	30 to 0 (Control knob moving clockwise)
J3204:	
A to B	140
J3909 - B to J3205 - B	Inf (Control knob at OFF) 110 to 130 (Control knob moving clockwise)
J3204 - A to J3205 - A	0
J3021:	
A to B	75 (Level Illumination control at OFF)
TB3004:	
1 to 2	147
1 to 3	147
2 to 3	147
4 to 5	147
4 to 6	147
5 to 6	147
7 to 8	34
J3010:	
41 to 32	5
41 to 47	5
32 to 47	5 (See (2) above)

Table 3-55. Checks for Short Circuits - Continued

Check point From	Check point To	Resistance (ohms)
J3016:		
A to B		(Counter illumination control at OFF)
J3010	J3008	(See (3) above).
32	E	
47	F	
21	A	
22	B	
20	C	
35	I	
34	H	
36	G	
41	D	
J3010	J3013	(See (3) above).
41	A	
36	B	
16	C	
17	D	
15	E	
J3010	J3002	(See (3) above).
40	A	
14	B	
9	C	
8	D	
30	E	
J3010	J3002	
24	G	
44	H	
45	J	
23	L	
28	M	
19	N	
1	P	
J3010	J3033	(See (3) above).
50	A	
49	B	
46	C	
J3010	J3001	(See (3) above).
41	F	
32	K	
37	C	
47	N	
52	D	
36	B	
43	H	
42	A	
31	P	
18	J	
39	G	

Table 3-55. Check for Short Circuits - Continued

Check point From	To	Resistance (ohms)
J3010		
A	J3004	(see (3) above).
B	J3006	
C	J3005	
D	J3007	
J3010	J3018	(See (4) above).
43	A	
42	B	
J3010	J3011	(See (5) above).
41	A	
32	B	
47	C	

[a]With antenna raised to maximum elevation.
[b]With antenna lowered to minimum elevation.

d. Operational Check of Antenna Positioning System.

(1) Operate ELEVATION switch S655 in the RAISE and LOWER positions. Determine if the antenna will raise and lower through the required limits.

(2) Operate AZIMUTH switch S656 and determine if the antenna will rotate through 6,400 mils of azimuth in either direction.

(3) See that the scanner motor is running smoothly.

e. Measuring Scanner Speed.

(1) Connect Electronic Counter AN/USM-207 between pins A and C of J3202.

(2) When the scanner has reached operating speed, measure the pulses per second with the frequency meter.

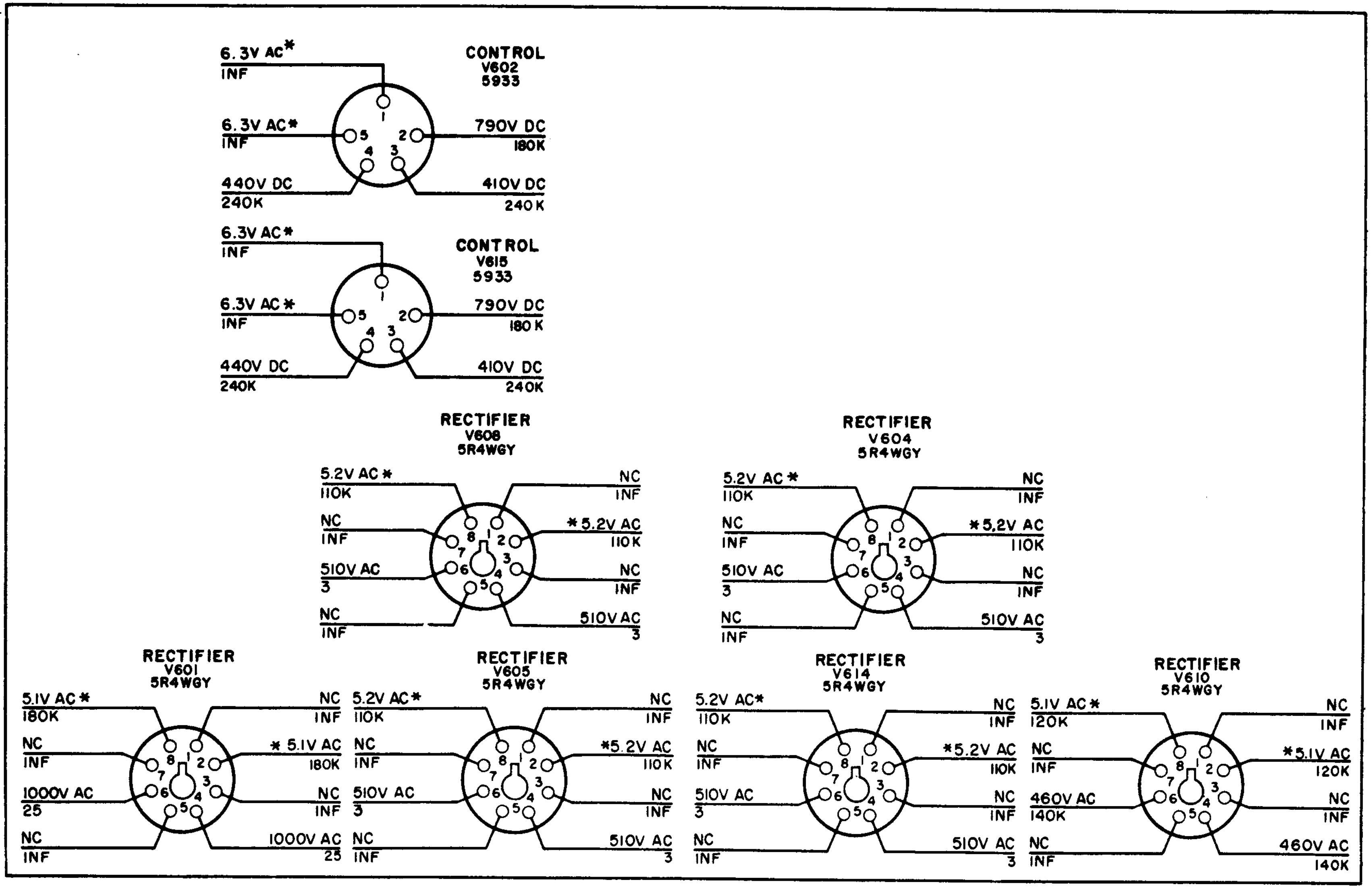
(3) The scanner rotor speed should be 1,020 rpm (revolutions per minute) ±60 rpm. The frequency meter will indicate 68 Hertz ±4 Hertz.

Section X. DC POWER SUPPLIES TROUBLESHOOTING AND REPAIR

3-47. Dc Power Supplies Troubleshooting Information

a. Reference Data. The following information will be helpful when troubleshooting the dc power supplies.

Reference	Data
Fig. FO-38	Control-Power Supply C-2014/MPQ-4A, schematic diagram.
Fig. FO-39	Power Supply PP-1588/MPQ-4A, schematic diagram.
Para 2-41 through 2-44b(6)	Theory of circuits in dc power supplies.
Fig. 3-153	Control-Power Supply C-2014/MPQ-4A, stationary chassis, voltage and resistance diagram.
Fig. FO-20	Power Supply PP-1588/MPQ-4A, voltage and resistance diagram.
Fig. 3-154	Control-Power Supply C-2014/MPQ-4A, hinged chassis, voltage snd resistance diagram.
Fig. 3-155	Power Supply PP-1588/MPQ-4A, top view.
Fig 3-156	Power Supply PP-1588/MPQ-4A, bottom view.
Fig. 3-157	Control-Power Supply C-2014/MPQ-4A, underside view of stationary chassis.
Fig. 3-158	Control-Power Supply C-2014/MPQ-4A, underside view of hinged chassis.
Fig. 3-159	Control-Power Supply C-2014/MPQ-4A, top-side view of hinged chassis.



NOTES:

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES READINGS TAKEN BETWEEN PINS.
6. K DENOTES THOUSANDS, MEG DENOTES MILLION, INF DENOTES INFINITY.

EL1QP320

Figure 3-153. Control-Power Supply C-2014/MPQ-4A, stationary charge, voltage and resistance diagram.

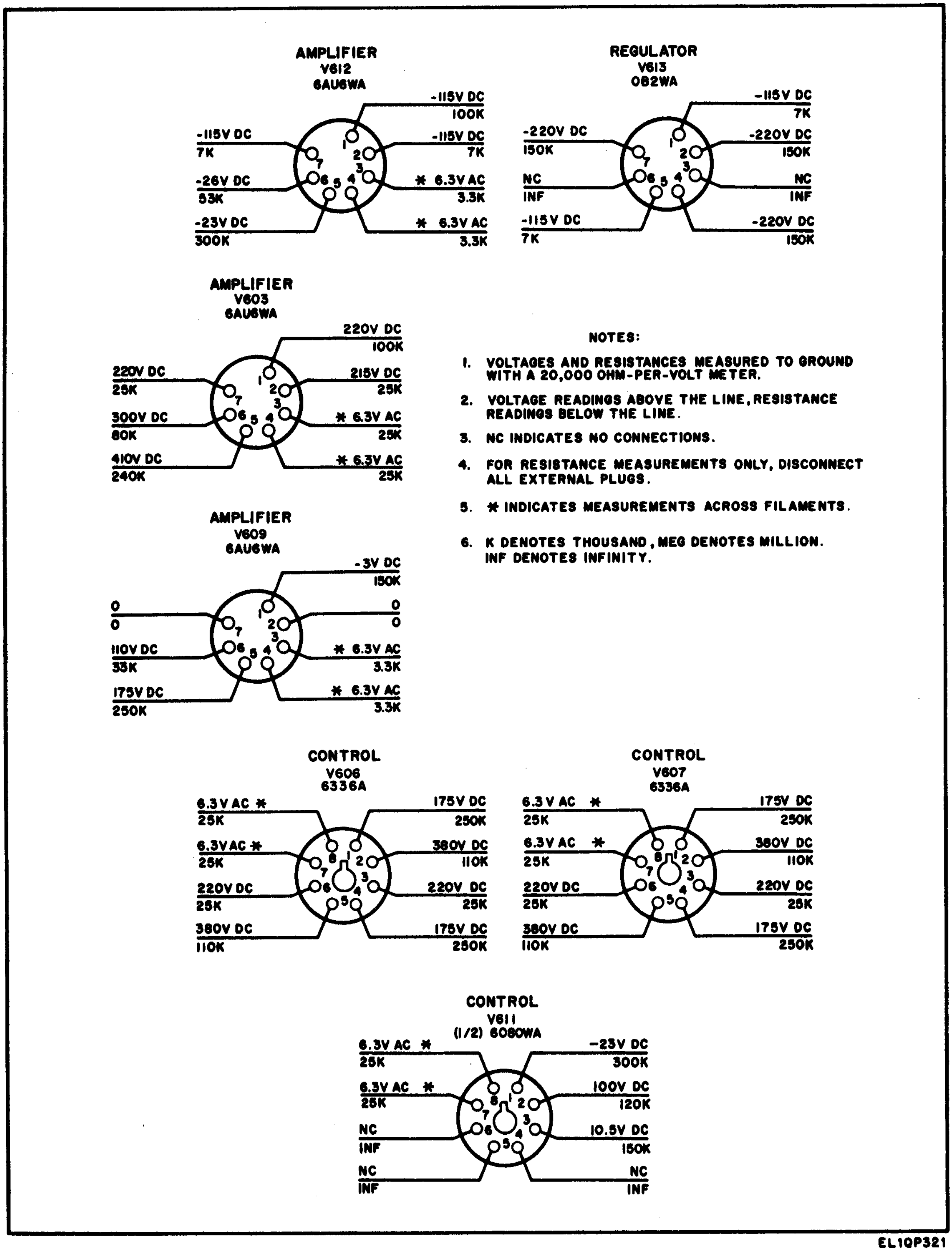


Figure 3-154. Control-Power Supply C-2014/MPQ-4A, hinged chassis, voltage and resistance diagram.

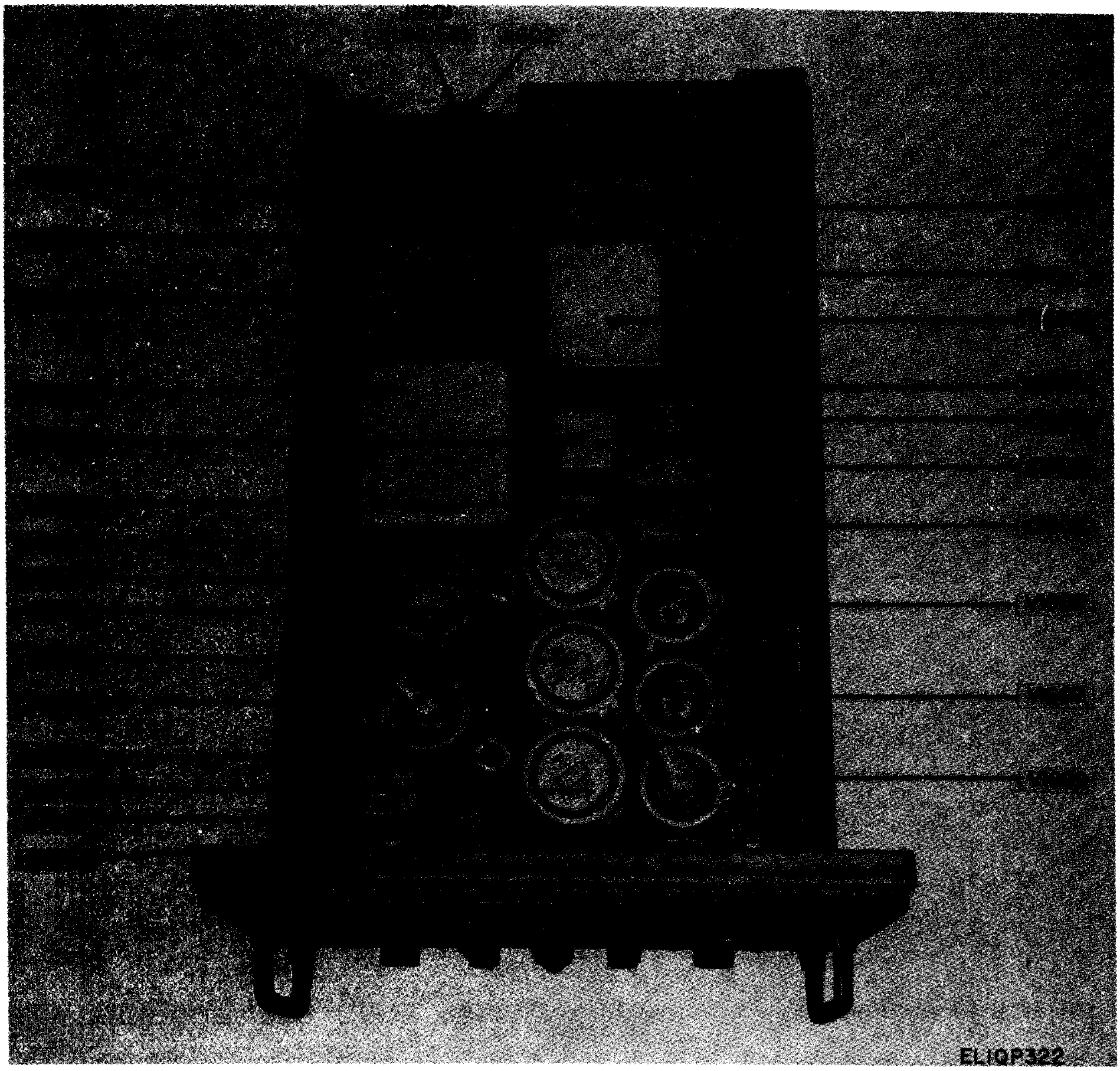


Figure 3-155. Power Supply PP-1588/MPQ-4A, top view.

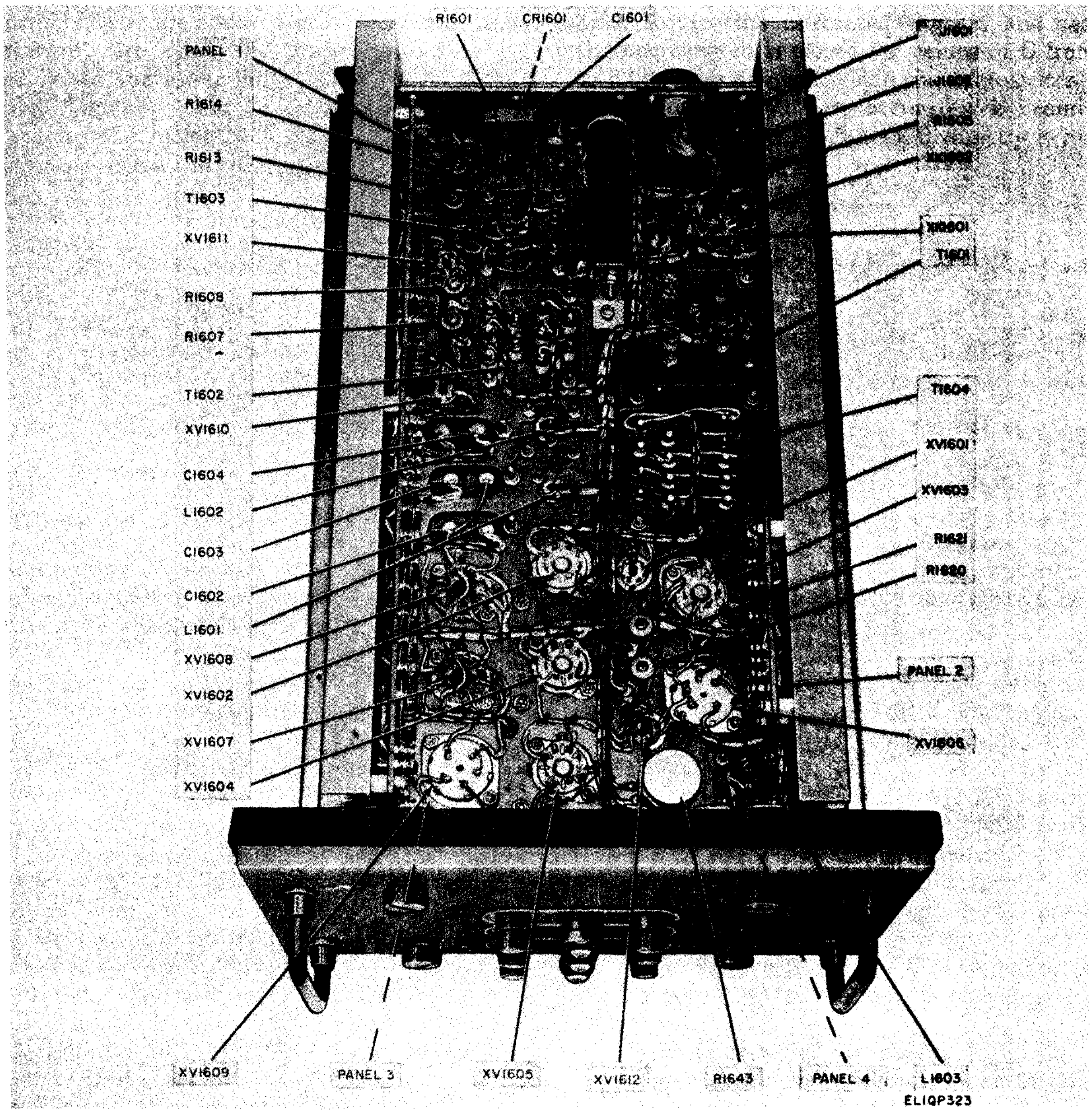


Figure 3-156. Power Supply PP-1588/MPQ-4A, bottom view.

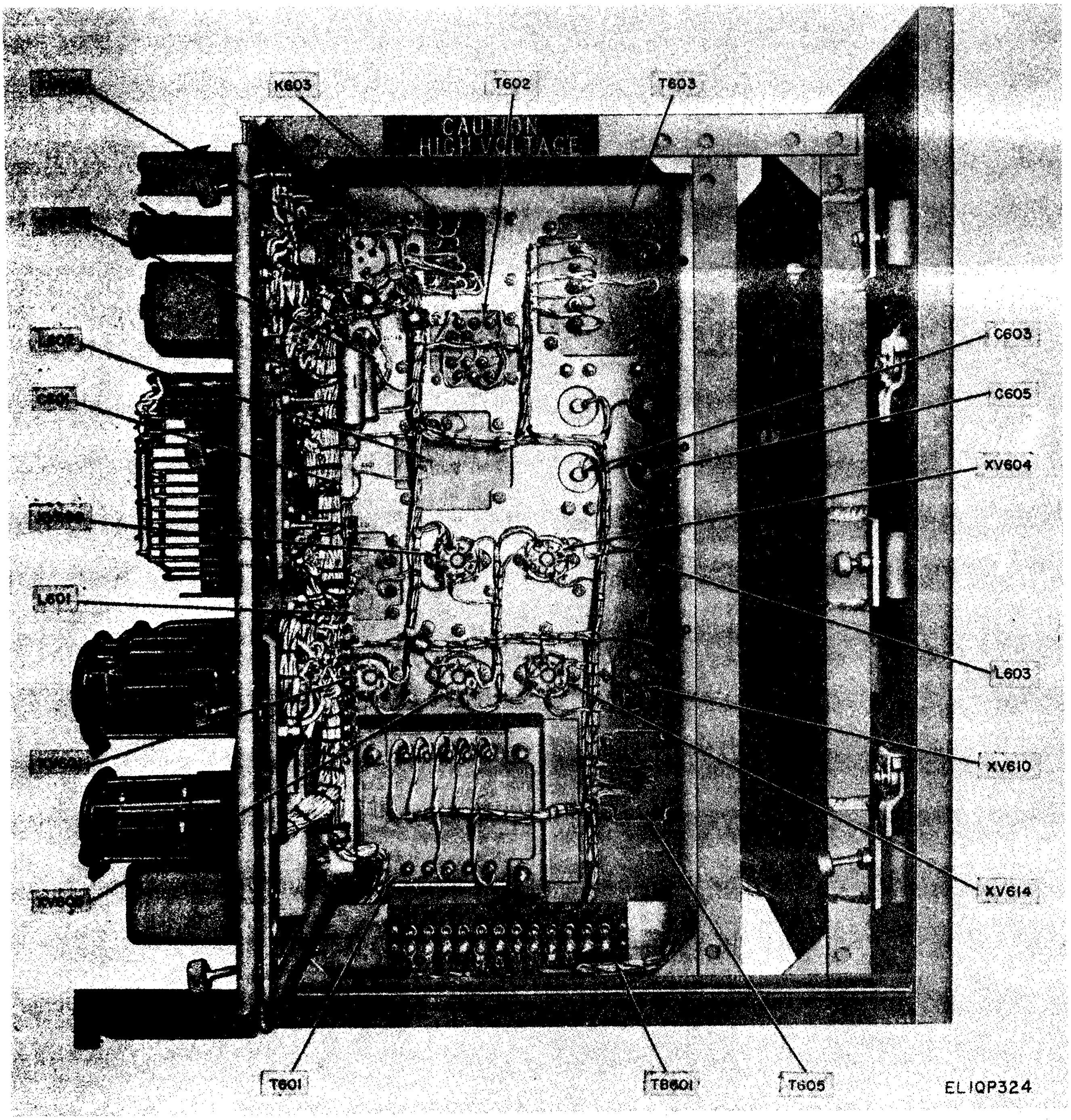


Figure 3-157. Control-Power Supply C-2014/MPQ-4A, undersize view of stationary chassis.

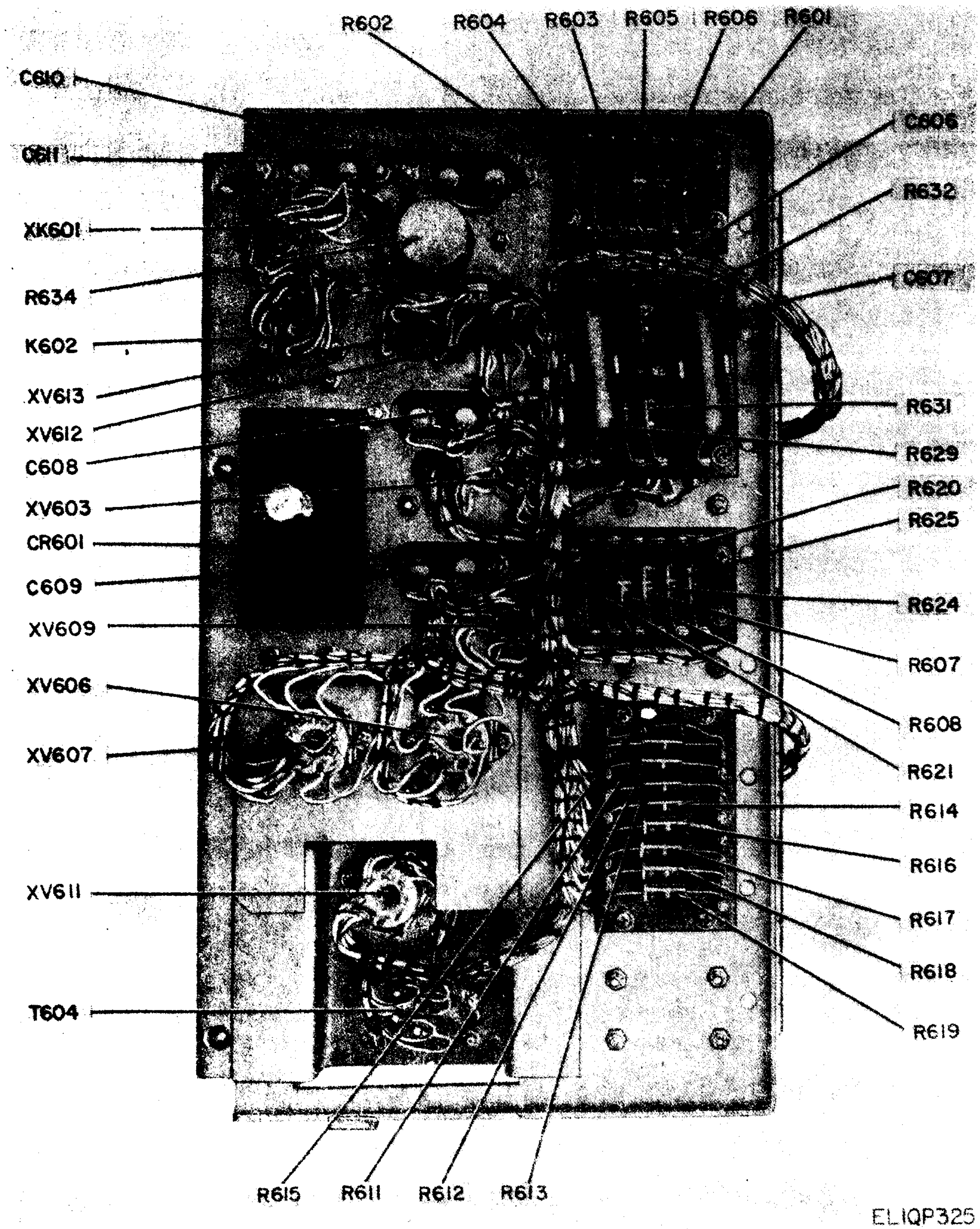


Figure 3-158. Control-Power Supply C-2014/MPQ-4A, underside view of hinged chassis.

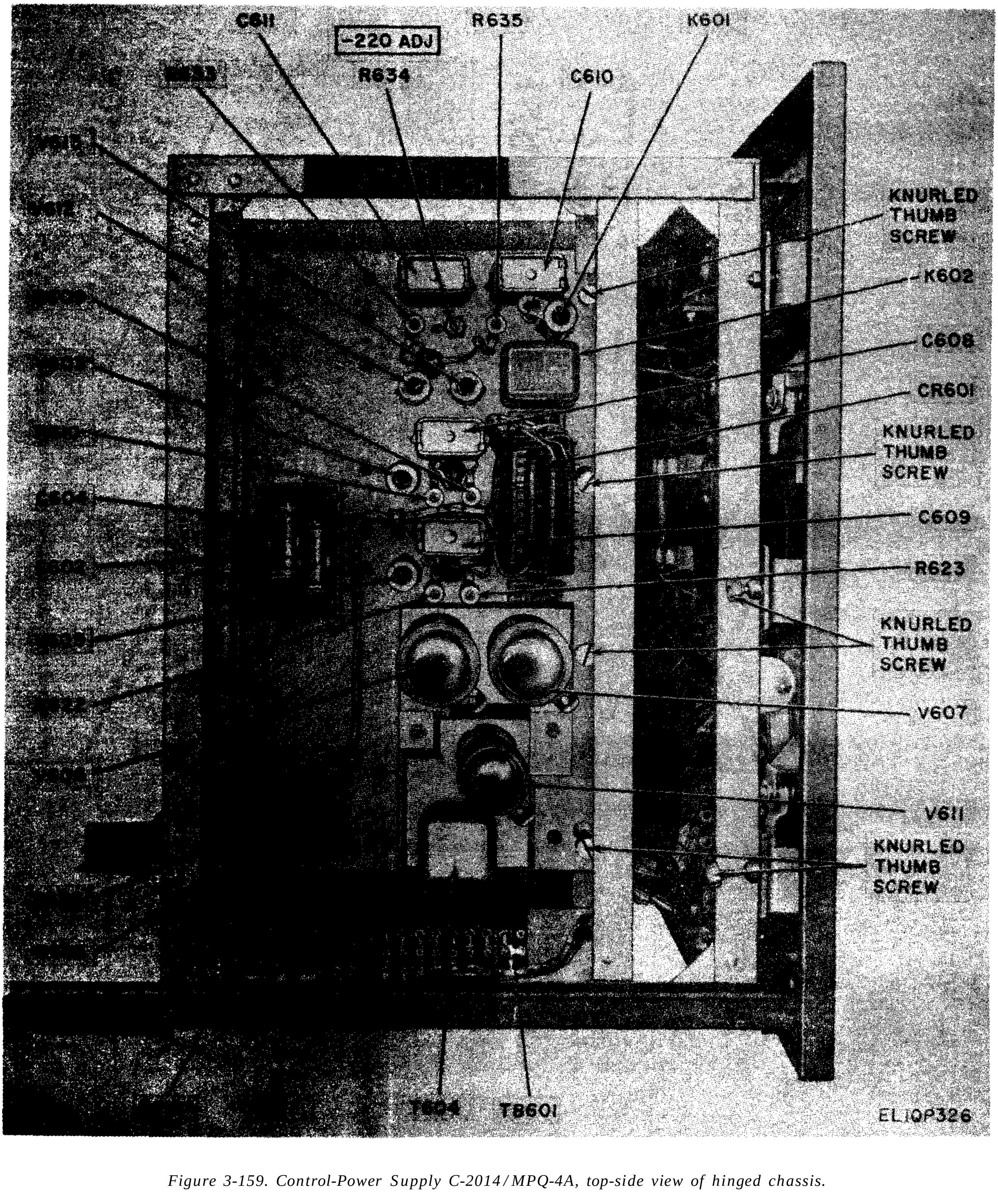


Figure 3-159. Control-Power Supply C-2014/MPQ-4A, top-side view of hinged chassis.

b. Controls and Adjustments.

(1) *Control-Power Supply C-2014/MPQ-4A.* The only control for Control-Power Supply C-2014/MPQ-4A is TEST METER SELECTOR switch S651 (fig. 3-15). This switch connects TEST METER M652 across the dc circuits to measure the output voltages.

(2) *Power Supply PP-1588/MPQ-4A.* TEST

METER SELECTOR switch S1401 (fig. 3-16) connects TEST METER M1402 across the dc circuits to measure the output voltages.

c. Dc Power Supplies Fuses.

(1) *Control-Power Supply C-2014/MPQ-4A.* Table 3-56 lists the fuses in the control-power supply. The table lists the rating of each fuse, a blown-fuse indicator, the circuit that each fuse protects, and a figure that shows the location of each fuse.

(2) *Power Supply PP-1588/MPQ-4A.* Table 3-57 lists the fuses located in the low voltage power supply. It also lists the rating of each fuse, a blown-fuse indicator, and the circuit that each fuse protects.

Table 3-56. Location of Fuses in Control-Power Supply

Fuse	Rating		Blown-fuse indicator	Circuit protected	Location (fig.)
	Volts	Amp			
F657	1,000	0.25	I 657	440 vdc in indicator	3-7
F658	250	0.5	I 658	+220 vdc in indicator	3-15
F659	250	0.25	I 659	+220 vdc in computer	3-15
F660	250	0.125	I 660	-220 vdc in indicator	3-15
F661	250	5	I 665	28 vdc	3-15

Table 3-57. Location of Fuses in the Low-Voltage Power Supply

Fuse	Rating		Blown-fuse indicator	Circuit protected
	Volts	Amp		
F1601	250	0.125	I 1601	+300 vdc
F1602	250	0.250	I 1602	+150 vdc
F1603	250	0.062	I 1603	-300 vdc

d. Normal Indications of Dc Power supplies Panel Meters. Table 3-58 lists the meters that monitor the operation of the dc power supplies, reference a figure that shows the location of each meter, and give the function of each meter.

e. Resistance of Power Supplies Transformers and Coils. Table 3-59 lists the transformers and coils in the dc power supplies, references a figure that shows the location of each, and gives the dc resistance of windings.

Table 3-58. Dc Power Supplies Panel Meters Normal Indications

Meter	Location (fig.)	Function
Control-Power Supply C-2014/MPQ-4A		
TEST METER M652	3-15	Indicates the dc output voltages of the +440-volt, +220-volt, +28 volt, and −220-volt dc supplies when switched across the outputs by TEST METER SELECTOR switch S651 (para 3-47*b*(1)).
Control-monitor		
TEST METER M1402.	3-16	Indicates the dc output voltages of the +300-volt, +150-volt, and −300-volt dc supplies when switched across the outputs by TEST METER SELECTOR switch S1401 (para 3-47*b*(2)).

Table 3-59. Resistance of Power Supplies Transformers and Coils

Transformer or coil	Location (fig.)	Terminals	Dc resistance (ohms)
Control-Power Supply C-2014/ MPQ-4A			
Plate transformer T601 for +400-volt and +220-volt circuits	3-157	1 and 3	2
Filament transformer T602	3-157	1 and 3	0.2
		8 and 9	0
		10 and 11	0
		12 and 13	0
Filament transformer T603	3-157	1 and 3	0.2
		14 and 15	0
		16 and 17	0
		17 and 18	0
Filament transformer T604	3-158	1 and 3	0.3
		6 and 7	0
		8 and 9	0.1
		9 and 10	0.1
Plate transformer T605 for -200-volt circuit	3-157	1 and 2	0.4
		1 and 3	0.2
		6 and 7	250
		7 and 8	250
Reactor L601, +400-volt circuit	3-157		37
Reactor L602, +220-volt circuit	3-157		16
Reactor L603, -220-volt circuit	3-157		220
Power Supply PP-1588/MPQ-4A			
Rectifier filament transformer T1601	3-156	1 and 2	0.6
		3 and 4	0
		5 and 6	0
		7 and 8	0
		9 and 10	0
Filamemt transformer T1602	3-156	1 and 2	1.6
		3 and 4	0
		5 and 6	0
		7 and 8	0
		9 and 10	0.4
Filament transformer T1603 for afc assembly end if. amplifier	3-156	1 and 3	1.6
		8 and 10	0
		11 and 12	0
		13 and 14	0
Plate transformer T1604 for regulated supplies	3-156	1 and 2	0.5
		4 and 5	130
		17 and 18	300
		14 and 16	20
		6 and 8	350
+450-volt filter L1601	3-156		300
580-volt filter L1602	3-156		200
260-volt filter L1603	3-156		40

3-48. Dc Power Supplies Troubleshooting

a General. Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the power supplies.

(1) *Symptom troubleshooting (e and f below)*. Troubles that have been sectionalized to the power supplies can usually be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a channel, circuit, or stage. The symptoms given in *e* below consist of indications obtained on TEST METER M652 for troubles in Control-Power Supply C-2014/MPQ-4A, or TEST METER M1402 for troubles in Power Supply PP-1588/MPQ-4A.

(a) Observe the indications obtained on the test meters.

(b) Compare the indications obtained with those listed in each of the symptoms.

(c) If the indications obtained correspond to those listed in a particular symptom, follow the procedure given in that particular subparagraph to isolate the trouble.

(d) If the trouble cannot be related by symptom troubleshooting, refer to the step-by-step troubleshooting table 3-61.

(2) *Step-by-step troubleshooting* (table 3-61). The step-by-step troubleshooting table for the power supplies consists of a series of steps to evaluate all

phases of operation of the power supplies. Use this table if the trouble cannot be isolated by symptom troubleshooting in (1) above. To troubleshoot the power supplies by using the step by step troubleshooting table, proceed as follows:

(a) Locate the test point given in step 1 of the table.

(b) Connect the test equipment and set the control on the test equipment as directed in the test equipment column.

(c) Set the controls on the radar set as directed in the radar set controls column.

(d) Compare the indications obtained on the test equipment with the indications given or referenced in the normal indications column.

(e) If the indications obtained on the test equipment are normal, proceed either to the next step, or as directed in the normal indication column.

(f) If the indications obtained are abnormal, proceed as directed in the corrective measures column.

b. Test Equipment Required. Table 3-60 lists the items of test equipment that are required to troubleshoot the power supplies.

Table 3-60. Test Equipment Required to Troubleshoot Power Supplies

Test equipment	Common name	Technical manual
Multimeter TS-352B/U	Multimeter	TM 11-6625-366-15
Electron Tube Test Set TV-7/U.	Tube tester	TM 11-6625-274-12

c. Preparation for Troubleshooting. When the radar set is installed properly, the power supplies are inaccessible for troubleshooting, aligning, or testing. Follow the procedures given in (2) and (3) below when troubleshooting, aligning, and/or testing the power supplies.

WARNING

Be extremely careful when making voltage measurements in the power supplies. Voltages in excess of 700 volts are present.

(1) *Control-Power Supply C-2014/MPQ-4A.* To reach the power supply, proceed as follows:

(a) Loosen the six pawl fasteners on the front of the control panel (fig. 3-15), grasp the handles, and pull out.

(b) Close interlock shorting switch S1002 located on the right-side of the control-power supply compartment of the control-indicator cabinet.

(c) Loosen the captive screws that hold the left chassis of the power supply in position and swing the chassis back as shown in figure 3-159.

(d) Loosen the captive screws that hold the front panel in position and carefully drop the panel forward as shown in figure 3-7.

(2) *Power Supply PP-1588/MPQ-4A.* To reach the low voltage power supply, proceed as follows:

(a) Loosen the four pawl fasteners on the front of the low voltage power supply drawer and pull the drawer out.

(b) Close interlock switch S2009 located in the upper right corner of the cabinet.

d. Preliminary Checks, Adjustments, and Control Settings. Before beginning any troubleshooting procedure, make sure that the components of the radar set are properly cabled. Check the indications on TEST METER M652 (para 3-47 *b* (1)) and TEST METER M1402 (para 3-471 *b* (2)) for each position of TEST METER SELECTOR switch S651 and TEST METER SELECTOR switch S1401.

e. Control-Power Supply C-2014/MPQ-4A Symptom Troubleshooting.

(1) *Symptom 1.* Abnormal indication on M652 when TEST METER SELECTOR switch S651 is in the +440V position.

(a) If the indication is low, check regulator tubes V602, V603 and V615.

(b) If the indication is zero, check C601 (fig. 3-157) or V601.

(2) *Symptom 2.* Abnormal indication on M652 when TEST METER SELECTOR switch S651 is in the +220V position.

(a) If the indication is low, check regulator tubes V606, V607, and V609 (fig. 3-159).

(b) If the indication is zero, check C603 (fig. 3-157) or rectifier tubes V604, V605, V608, or V614.

(3) *Symptom 3.* Zero or low indication on M652 when TEST METER SELECTOR S651 is in the 28V position. Check rectifier CR601 (fig. 3-158).

(4) *Symptom 4.* Abnormal indication on M652 when TEST METER SELECTOR switch S651 is in the -220V position.

(a) If indication is low, check V611, V612, or V613.

(b) If indication is zero, check C605, L603 (fig. 3-157), or V610.

f. Power Supply PP-1588/MPQ-4A Symptom Troubleshooting.

(1) *Symptom 1.* Abnormal indication on M1402 when TEST METER SELECTOR switch S1401 is in the +300V position.

(a) If indication is low, check V1606, V1610, R1605, R1607, R1608, or R1641.

(b) If indication is zero, check C1602, L1602 (fig. 3-156), or V1602.

(2) *Symptom 2.* Abnormal indication on M1402 when TEST METER SELECTOR switch S1401 is in the +150V position.

(a) If indication is low, check V1607, V1608, or V1611.

(b) If indication is zero, check C1603, L1603 (fig. 3-156), or V1603 and V1604.

(3) *Symptom 3.* Abnormal indication on M1402 when TEST METER SELECTOR switch S1401 is in the -300V position.

(a) If indication is low, check V1601, V1609, or V1612.

(b) If indication is zero, check V1604, L1601 (fig. 3-156), or V1605.

Table 3-61. Step-by-Step Troubleshooting for Dc Power Supplies

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
		Control-Power Supply C-2014/MPQ-4A			
1	Terminals 9 and 10 of TB601 (fig. 3-157).	Multimeter TS-352B/U controls set to measure 28 volts dc.	MAIN POWER switch S652 in ON position.	I 666 lights 28 volts dc ±2 volts	Check C611. Troubleshoot CR601 and/or T603.
2	Terminals 7 and 3 of TB1003 (fig. 3-6).	Multimeter controls set to measure 440 volts dc.	Same as step 1	+440 volts dc	Troubleshoot +440-volt rectifier circuit (fig. FO-39) if there is no voltage. If voltage indication is low proceed to step 3.
3	Terminals 8 and 3 of TB1003 (fig. 3-6).	Multimeter controls set to measure 220 volts dc.	Same as step 1	+220 volts dc	If indication is zero, troubleshoot +200-volt rectifier circuit (fig. FO-39). If voltage indication is low, proceed to step 4.
4	Terminals 1 and 3 of TB1003 (fig. 3-6).	Multimeter controls set to measure 220 volts dc.	Same as step 1	−220 volts dc	Troubleshoot −220-volt rectifier (fig. FO-38).
		Power-Supply PP-1588/MPQ-4A			
1	Terminals 1 of TB2001 and 7 of TB2002 (fig. 3-26).	Multimeter TS-352B/U controls set to measure 300 v.	MAIN POWER switch S652 in ON position, START button S658 depressed.	+300 vdc	If indication is zero, troubleshoot the +300-volt rectifier (fig. FO-39). If indication is low, proceed to step 2.
2	Terminals 4 of TB2001 and 7 of TB2002 (fig. 3-26).	Multimeter controls set to measure 150 vdc.	Same as step 1	+150 vdc	If indication is zero, troubleshoot the +150-volt rectifier (fig. FO-39). If indication is low proceed to step 3.
3	Terminals 12 and 7 of TB2002 (fig. 3-26).	Multimeter controls set to measure 300 vdc.	Same as step 1	−300 vdc	If indication is zero, troubleshoot the −300-volt rectifier (fig. FO-39). If indication is low, adjust R1643 as described in paragraph 3-50d). If adjustment of R1643 has no control over low reading, troubleshoot regulator circuit.
4	Terminals A of J1602 and D of J1601 (fig. 3-156).	Multimeter controls set to measure +700 vdc.	Same as step 1	+ 630 vdc	Troubleshoot keep-alive rectifier CR1601 (fig. FO-39).

3-49. Removal and Replacement of Parts in DC Power Supplies

a. General. Control-Power Supply C-2014/MPQ-4A consists of all parts in the low voltage power supply and on the control panel of the control-indicator group. Power Supply PP-1588/MPQ-4A consists of all parts in the low voltage power supply for the receiver-transmitter.

b. Removal and Replacement of Capacitors C601, C603, C605, C608, C609, C610, and/or C611 (fig. 3-157 and 3-158).

(1) *Removal.*

(a) Loosen the four pawl fasteners on the control panel and pull out the drawer.

(b) Loosen the captive screws on the chassis on the left side of the power supply and swing out to the left.

(c) Tag, unsolder, and disconnect the leads to the terminals on the capacitor that is to be replaced.

(d) Loosen the two nuts on the mounting brackets that hold the capacitor in position.

(e) Move the mounting brackets aside and remove the capacitor from the power supply.

(2) *Replacement.*

(a) Place the capacitor in position.

(b) Replace and tighten the nuts that hold the capacitor in place.

(c) Connect and solder the leads to the capacitor.

(d) Swing the chassis in place and fasten the captive screws.

(e) Slide the drawer in place and fasten the four pawl fasteners.

c. Removal and Replacement of Transformers T601, T602, T603, T604, T605; Chokes L601, L602, L603; and Relays K602 and K603 (fig. 3-157 and 3-158).

(1) *Removal.*

(a) Perform procedures in *b* (1) *(a)* and *(b)* above.

(b) Tag, unsolder, and disconnect the leads to the terminals on the part that is to be replaced.

(c) Unscrew the four nuts on the mounting bolts that hold the part to the shelf.

(d) Remove the part.

(2) *Replacement.*

(a) Position the part in place.

(b) Replace the nuts which hold the part in place.

(c) Connect and solder the leads to the part.

(d) Perform procedures in *(2)(d)* and *(e)* above.

d. Removal and Replacement of Parts in Power Supply PP-1588/MPQ4A. The parts of Power Supply PP-1588/MPQ-4A are mounted on a slide-out chassis. Normal procedures should be followed for removal and replacement of parts similar to those contained in Control-Power Supply C-2014/MPQ-4A (*b* and *c* above). Several parts peculiar to the PP-1588/MPQ-4A require special handling instructions as described in (1) and (2) below.

(1) *Removal.*

(a) Loosen the four pawl fasteners on the front panel and pull the drawer out until the drawer slides lock.

(b) Release the two clips on the left and right ends of selenium rectifier CR1601 (fig. 3-155 and 3-156).

NOTE

One end of selenium rectifier CR1601 has a red band, or dot, on one end to indicate correct position of the rectifier. Note also the painted red dot on the chassis to the left of the left-hand retainer clip which holds CR1601.

(2) *Replacement.*

CAUTION

To avoid damaging selenium rectifier CR1601, be careful to note that the end has the painted red band, or dot, is inserted into the retainer clip which has the painted red dot on the chassis to the left of the clip.

(a) Position the rectifier cartridge over the open clips and press down on the end caps on the cartridge. This action forces the clips to partially close.

(b) Push the clips toward the center of the cartridge and press down to insure they are engaged.

(c) Release the drawer slide lock and slide the drawer in place. Fasten the four pawl fasteners.

3-50. Adjustment of Dc Power Supplies

a. General.

(1) This section covers the adjustments necessary for proper operation of the dc power supplies. The adjustments for Control-Power Supply C-2014/MPQ-4A are located on the hinged chassis which is on the left side of the control-power supply drawer. The adjustment for Power Supply PP-1588/MPQ-4A is located inside the power supply drawer.

(2) The adjustments to the low voltage power supplies are made to establish the level of the negative voltages. The negative voltages are then used as the reference level for the positive voltages of the power supplies.

b. Test Equipment Required. Multimeter TS-352B/U, commonly referred to as multimeter, is the only item of test equipment required to adjust the power supplies. Instructions for operating the multimeter are contained in TM 11-6625-366-15.

c. Adjustment of Control-Power Supply C-2014/MPQ-4A.

(1) *General.* The -220V ADJ potentiometer, R634, adjusts the bias on the grid of amplifier tube

V612. Amplifier tube V612, in conjunction with regulator tubes V611 and V613, keeps the output of -220 volt rectifier at -220 volts dc.

(2) *Procedure.*

(a) Adjust R634 (fig. 3-159) to the extreme clockwise position. Connect the multimeter between terminals 1 and 3 of TB1003 (fig. 3-6). Multimeter controls must be set to measure -220 volts dc.

(c) Record the multimeter indication. The minimum indication should be -225 volts.

(d) Disconnect the multimeter.

(e) Connect the multimeter to terminals 8 and 3 of TB1003, (fig. 3-6). Multimeter controls must be set to measure +220 volts dc.

(f) Record the multimeter indication. The minimum indication should be +225 volts dc.

(g) Disconnect the multimeter.

(h) Connect the multimeter to terminals 7 and 3 of TB1003 (fig. 3-6). Set the multimeter controls to measure +450 volts dc.

(i) Record the multimeter indication. The minimum indication should be +450 volts dc.

(j) Adjust R634 to the extreme counterclockwise position.

(k) Connect the multimeter between terminals 7 and 3 of TB1003. Record the indication on the multimeter. The maximum indication should be +430 volts dc.

(l) Disconnect the multimeter.

(m) Connect the multimeter to terminals 8 and 3 of TB1003. Set the multimeter controls to measure +220 volts dc.

(n) Record the multimeter indication. The maximum indicator should be +215 volts dc.

(o) Disconnect the multimeter.

(p) Connect the multimeter to terminals 1 and 3 of TB1003. The multimeter should be adjusted to measure a negative voltage.

(q) Record the multitimeter indication. The maximum indication should be -215 volts dc.

(r) Adjust R634 until the voltage at terminals 1 and 3 of TB1003 is -220 volts dc.

(s) Rotate TEST METER SELECTOR switch S651 to the -220V position.

(t) Compare the indication on TEST METER M652 with the indication on the multimeter. The indication on M652 should be within ±8 volts of the indication on the multimeter.

(u) Disconnect the multimeter.

(v) Connect the multimeter to terminals 8 and 3 of TB1003.

(w) Record the multimeter indication. The indication should be +220 volts dc ±3 volts.

(x) Rotate S651 to the ±220V position.

(y) Compare the reading on TEST METER M652 with the indication on the multimeter. The indication on M652 should be within ±8 volts of the indication on the multimeter.

(z) Disconnect the multimeter.

(aa) Connect the multimeter to terminals 7 and 3 of TB1003.

(ab) Record the multimeter indication. The indication should be +440 volts dc ±5 volts.

(ac) Rotate S651 to the +440V position.

(ad) Compare the indication on M652 with the indication on the multimeter. The indication on M652 must be within ±8 volts of the indication on the multimeter.

(ae) Disconnect the multimeter.

d. Adjustment of Power Supply PP-1588/MPQ-4A.

(1) *General.* The -300V adjust potentiometer, R1643 (fig. 3-155), adjusts the bias on the grid of amplifier tube V1612. Amplifier tube V1612, in conjunction with regulator tubes V1601 and V1609, keeps the output of the -300-volt rectifier at -300 volts dc.

(2) *Procedure.*

(a) Adjust R1643 to the extreme clockwise position.

(b) Connect the multimeter to terminals 1 of TB2001 and 7 of TB2002 (fig. 3-26). Set the multimeter controls to measure +300 volts dc.

(c) Record the multimeter indication. The minimum indicator should be +310 volts dc.

(d) Disconnect the multimeter.

(e) Connect the multimeter to terminals 12 and 7 of TB2002 (fig. 3-26). Set the multimeter controls to measure -300 volts dc.

(f) Record the multimeter indication. The minimum indication should be -310 volts dc.

(g) Disconnect the multimeter.

(h) Connect the multimeter to terminals 4 of TB2001 (fig. 3-26) and 7 of TB2002. Set the multimeter controls to measure +150 volts dc.

(i) Record the multimeter indication. The minimum indication should be +155 volts dc.

(j) Adjust R1643 to the extreme counterclockwise position.

(k) Record the multimeter indication. The maximum indication should be +145 volts dc.

(l) Disconnect the multimeter.

(m) Connect the multimeter to terminals 1 of TB2001 and 7 of TB2002. Set the multimeter controls to indicate +300 volts dc.

(n) Record the multimeter indication. The maximum indication should be +290 volts dc.

(o) Disconnect the multimeter.

(p) Connect the multimeter to terminals 12 and 7 of TB2002. Set the multimeter controls to measure -300 volts dc.

(q) Record the multimeter indication. The maximum indication should be -290 volts dc.

(r) Adjust R1643 until the indication on the multimeter is -300 volts dc.

(s) Place TEST METER SELECTOR switch S1401 in the -300V position.

(t) Compare the indication on TEST METER M1402 with the indication on the multimeter. The indication should not differ by more than ±5 volts.

(u) Disconnect the multimeter.

(v) Connect the multimeter to terminals 1 of TB2001 and 7 of TB2002. Set the multimeter controls to measure +300 volts dc.

(w) Place S1401 in the +300V position.

(x) Compare the indication on M1402 with the multimeter indication. The two indications should not differ by more than ±5 volts.

(y) Disconnect the multimeter.

(z) Connect the multimeter to terminals 4 of TB2001 and 7 of TB2002. Set the multimeter controls to measure +150 volts dc.

(aa) Place S1401 in the +150V position.

(ab) Compare the indication on M1402 with the multimeter indication. The two indications should not differ by more than ±5 volts.

(ac) Disconnect the multimeter.

3-51. Testing Dc Power Supplies

a. *General.* This paragraph covers testing procedures to check the serviceability of a repaired power supply when the components of the radar set are interconnected. Bench testing of the power supply circuits is covered in paragraph 3-52h. Testing procedures designed to check the serviceability of the complete radar set are covered in paragraphs 3-59 and 3-60.

b. *Test Equipment Required.* Multimeter TS-352B/U, commonly called multimeter, is the only item of test equipment required to test the dc power supplies. Instructions for operating the multimeter are contained in TM 11-6625-366-15.

c. *Testing Power Supplies.* The voltages from the control-power supply may be tested from the terminal boards located on the left side of the control-indicator cabinet (fig. 3-6). The voltages of the receiver-transmitter low voltage power supply may be tested from terminal boards located on the left side of the receiver compartment (fig. 3-26).

(1) *Control Power Supply C-2014/MPQ-4A.*

(a) Open the control-power supply drawer as described in paragraph 3-49 *b* (1) *(a)* and *(b).*

(b) Close shorting switch S1002.

(c) Remove the cover over the terminal boards by removing the 16 screws.

(d) Turn MAIN POWER switch S652 to ON.

(e) Connect the multimeter to terminals 7 and 3 of TB1003 (fig. 3-6). Set the multimeter controls to measure +440 volts dc.

(f) Record the multimeter indication. The multimeter should indicate +440 volts dc to ±5 volts.

(g) Disconnect the multimeter.

(h) Connect the multimeter to terminals 8 and 3 of TB1003. Set the multimeter controls to measure +220 volts dc.

(i) Record the multimeter indication. The indication should be +220 volts dc ±3 volts.

(j) Disconnect the multimeter.

(k) Connect the multimeter to terminals 1 and 3 of TB1003. Set the multimeter controls to measure -220 volts dc.

(l) Record the multimeter indication. The indication should be -220 volts dc ±3 volts.

(m) Disconnect the multimeter.

(n) Connect the multimeter to terminals 9 and 10 of TB601 (fig. 3-157). Set the multimeter controls to measure 28 volts dc.

(o) Record the multimeter indication. The indication should be 28 volts dc ±2 volts.

(p) Press START button S658.

(q) Disconnect the multimeter.

(r) Connect the multimeter to terminals 2 of TB1006 and 6 of TB1001.

(s) Record the multimeter indication. The indication should be 28 volts dc ±2 volts.

(t) Press STOP button S659. The multimeter indication should be zero.

(u) Press START button S658. The multimeter indication should be 28 volts dc.

(v) Disconnect the multimeter.

(w) Connect the multimeter to terminals 5 of TB1006 and 6 of TB1001. Set the multimeter controls to measure 28 volts dc.

(x) Place ELEVATION switch S655 in the LOWER position.

(y) Record the multimeter indication. The multimeter should indicate 28 volts dc ±2 volts.

(z) Disconnect the multimeter.

(aa) Connect the multimeter to terminals 1 of TB1006 and 6 of TB1001. Set the multimeter controls to measure 28 volts dc.

(ab) Record the multimeter indication. The multimeter should indicate 28 volts dc ±2 volts.

(ac) Place S655 in the RAISE position.

(ad) Disconnect the multimeter.

(ae) Connect the multimeter to terminals 7 of TB1005 and 6 of TB1001. Set the multimeter controls to measure 28 volts dc.

(af) Place AZIMUTH switch S656 in the CCW position.

(ag) Record the indication of the

multimeter. The indication on the multimeter should be 28 volts dc.

(ah) Disconnect the multimeter.

(ai) Connect the multimeter to terminals 8 of TB1005 and 6 of TB1001. Set the multimeter controls to measure 28 volts dc.

(aj) Place S656 in the CW position.

(k) Record the indication on the multimeter. The indication should be 28 volts dc ±2 volts.

(al) Disconnect the multimeter.

(am) Connect the multimeter to terminals 9 of TB1006 and 6 of TB1001. Set the multimeter controls to measure 28 volts dc.

(an) Place AFC-MANUAL switch S657 in the AFC position.

(ao) Record the multimeter indication. The indication should be 28 volts dc ±2 volts.

(ap) Disconnect the multimeter.

(aq) Connect the multimeter to terminals 5 of TB1005 and 6 of TB1002. Set the multimeter controls to measure 150 volts ac.

(ar) Check to see if the multimeter indication is between the limits of 125 to 145 volts.

(as) Rotate MAGNETRON POWER control T651 clockwise.

(at) Observe the multimeter to see if the voltage indication decreases approximately 1 volt ac.

(au) Disconnect the multimeter.

(av) Replace the cover over the terminal boards by replacing the 16 holding screws.

(aw) Close the drawer and fasten the four pawl fasteners.

(2) *Power Supply PP-1588/MPQ-4A.*

(a) Open the control-monitor panel by loosening the pawl fasteners and swinging the panel out.

(b) Close interlock switch S2008.

(c) Connect the multimeter to terminals 12 and 7 of TB2002 (fig. 3-26). Set the multimeter controls to measure -300 volts dc.

(d) Record the multimeter indication. The indication should be -300 volts dc ±5 volts.

(e) Disconnect the multimeter.

(f) Connect the multimeter to terminals 1 of TB2001 and 7 of TB2002. Set the multimeter controls to measure +300 volts dc.

(g) Record the multimeter indication. The indication should be +300 volts dc ±5 volts.

(h) Disconnect the multimeter.

(i) Connect the multimeter to terminals 4 of TB2001 and 7 of TB2002. Set the multimeter controls to measure +150 volts dc.

(j) Record the multimeter indication. The indication should be +150 volts dc ±5 volts.

(k) Disconnect the multimeter.

(l) Close the panel and fasten the pawl fasteners.

3-52. Bench Servicing of Dc Power Supplies

a. General. This paragraph covers bench servicing of the dc power supplies. The following information will be helpful when bench servicing the dc power supplies.

Information	Location
Control-Power Supply C-2014/MPQ-4A, schematic diagram.	Fig. FO-38
Power supply PP-1588/MPQ-4A, schematic diagram.	Fig. FO-39
Panel meters	Para 3-47*b*
Fuses	Para 3-47*c*

b. Test Equipment Required. Table 3-62 lists the items of test equipment and cables that are required to bench service the dc power supplies. The cables and adapters are supplied with Test Facilities Kit MK-387/MP M-49.

c. Checking for Short Circuits. To determine that no damage will result from applying power to the dc power supplies, perform a resistance check from the points listed in table 3-63, to the chassis ground with the chassis disconnected from the equipment. An indication less than the value shown indicates that a further check should be made to determine where the short circuit exists. Also make voltage and resistance checks.

d. Bench Servicing Connections. Follow the directions in (1) or (2) below to connect Control-Power Supply C-2014/MPQ-4A or Power Supply PP-1588/MPQ-4A to bench service the dc power supplies.

Table 3-62. Test Equipment Required for Bench Servicing Dc Power Supplies

Test equipment	Common name	Technical manual
Multimeter TS-352B/U.	Multimeter	TM 11-6625-366-15
Electronic Multimeter ME-26A/U	Vtvm	TM 11-6625-200-15
Voltmeter, Electronic ME-30A/U	Voltmeter	TM 11-6625-320-12
Variable Power Transformer TF-171/USM.	Variac	
Interconnecting Box J-982/MPM-49	Junction box	

Table 3-62. Test Equipment Required for Bench Servicing Dc Power Supplies - Continued

Test equipment	Common name	Technical manual
Motor Generator PU-20C/C.	PU-20C/C	TM 11-6125-200-10
Electrical Dummy Load DA-205/MPQ-4A	None	
Electrical power cable assembly W2610.	None	
Electrical power cable assembly W2615.	None	
Electrical power cable assembly W2616.	None	
Electrical Dummy Load DA-206/MPQ-4A		
Electrical power cable assembly W2618.	None	
Electrical power cable assembly W2620.	None	
Electrical power cable assembly W2629.	None	
Electrical power cable assembly W2631.	None	

NOTE

The junction box and power cable assemblies are covered in TM 11-6625-520-15.

Table 3-63. Checks for Short Circuits

Check point	Resistance to ground	Check point	Resistance to ground
Control-Power Supply C-2014/MPQ-4A			
J601A	Inf	J601Y	Inf
J601B	Inf	J601Z	50
J601C	Inf	J601a	Inf
J601D	160	J601b	Inf
J601E	Inf	J601c	Inf
J601F	Inf	J601d	Inf
J601G	Inf	J601e	Inf
J601H	0	J601f	0
J601I	160	J601g	Inf
J601J	Inf	J601h	Inf
J601K	Inf	J601i	Inf
J601L	Inf	J601j	Inf
J601M	Inf	J601k	Inf
J601N	Inf	J601l	Inf
J601O	Inf	J601m	Inf
J601P	140K	J601n	Inf
J601Q	Inf	J601o	22K
J601R	0	J601p	Inf
J601S	Inf	J601q	Inf
J601T	200K	J601r	150
J601U	Inf	J601s	Inf
J601V	50	J601t	Inf
J601W	Inf	J601u	Inf
J601X	Inf		
Power Supply PP-1588/MPQ-4A			
J1601A	Inf	J1601M	Inf
J1601B	Inf	J1601N	Inf
J1601C	Inf	J1601P	Inf
J1601D	0	J1601R	30K
J1601E	27K	J1601S	0
J1601F	27K	J1601T	Inf
J1601G	Inf	J1601U	Inf
J1601H	Inf	J1601V	Inf
J1601J	Inf		
J1601K	Inf	J1602A	5 MEG
J1601L	800	J1602B	5 MEG

(1) *Control-Power Supply C-2014/MPQ-4A.*

(a) Disconnect all cables that connect Control-Power Suply C-2014/MPQ-4A (part of Test Facilities Kit MK-387/MPM-49) to Interconnecting Box J-982/MPM-49.

(b) Connect Control-Power Supply C-2014/MPQ-4A to be bench serviced to Interconnecting Box J-982/MPM-49 and Electrical Dummy Load DA-206/MPQ-4A as shown in figure 3-160.

(2) *Power Supply PP-1588/MPQ-4A.*

(a) Disconnect all cables that connect power Supply PP-1588/MPQ-4A (part of Test Facilities Kit MK-387/MPM-49) to Interconnecting Box J-982/MPM-49.

(b) Connect Power Supply PP-1588/MPQ-4A to be bench serviced to Interconnecting Box J-982/MPM-49 and Dummy Load DA-205/MPQ-4A as shown in figure 3-160.

(3) *Interconnecting Box J-982/MPM-49 controls.* When the dc power supplies are connected as shown in figure 3-160, turn POWER switch S2601 to ON.

e. Bench Troubleshooting Dc Power Supplies.

(1) Connect the dc power supplies for bench servicing (*d* above).

(2) Use troubleshooting table 3-64 to troubleshoot the power supplies.

Table 3-64. Troubleshooting Tables for Dc Power Supplies

Step	Test point	Test equipment	Control-power supply controls	Normal indications	Corrective measures
			Control-Power Supply C-2014/PG-4A		
1	Terminals 1 and 9 of TB601	Multimeter TS-352B/U, controls set to measure 440 volts dc. TEST METER SELECTOR switch S651 in 440V position.	MAIN POWER switch S652 at ON. MAIN POWER switch S2602 on J982/MPM-49 at ON.	+440 volts dc. TEST METER M652 indicates +440 volts dc.	Check rectifier V601 if no voltage. Check capacitor C601. Make voltage and resistance checks (fig. 3-153 and 3-154). If indication is normal proceed to step 2.
2	Terminals 3 and 9 of TB601.	Multimeter controls set to measure 220 volts dc. TEST METER SELECTOR switch S651 in 220V position.	Same as step 1	+220 volts dc. TEST METER M652 indicates +220 volts dc.	If indication is normal, proceed to step 3. If indication is zero, check C603 or L602. If indication is low, adjust R634; if R634 does not affect voltage, make voltage and resistance checks (fig. 3-153 and 3-154).
3	Terminals 2 and 9 of TB601,	Multimeter controls set to measure —220 volts dc. TEST METER SELECTOR switch S651 in —220V position.	Same as step 1	—220 volts dc. TEST METER M652 indicates —220 volts dc.	If indication is normal, proceed to step 4. If indication is zero, check L603, C605, or V610. If indicationis low check R627 or V612. Make voltage and resistance checks (fig. 3-153 and 3-154).
4	Terminals 10 and 9 of TB601.	Multimeter controls set to measure 28 volts dc. TEST METER SELECTOR switch S651 in 27V position.	Same as step 1	+28 volts dc. TEST METER M652 indicates +28 volts dc.	If reading is zero, check C611 or CR601. Make voltage and resistance checks.
			Power Supply PP-1588/MPQ-4A		
1	Pin 4 of V1606	Multimeter TS-352B/U controls set to measure 300 volts dc.		+300 volts dc	If indication is normal, proceed to step 2. If indication is low, check V1610 or adjust R1643; if indication is still low, proceed to step 2. If indication is zero, check V1602, L1602, or C1602. Make voltage and resistance checks (fig. FO-20).
2	Pin 2 or 7 of V1601	Multimeter controls set to measure —300 volts dc.		—300 volts dc	If indication is low, check V1601 or V1612. Adjust R1643; if no effect, check V1609.

Table 3-64. Troubleshooting Tables for Dc Power Supplies—Continued

Step	Test point	Test equipment	Control-power supply controls	Normal indications	Corrective measures
	Power Supply PP-1588/MPQ-4A—Continued				
					If indication is zero, check V1605, L1601, C1604, and R1602. Make voltage and resistance checks (fig. FO-20).
3	Pin 3 or 6 of V1607 or V1608.	Multimeter controls set to measure 150 volts dc.		+150 volts dc	If indication is low, check V1611. If indication is zero, check V1603, V1604, L1603, or C1603. Make voltage and resistance checks (fig. FO-20).
4	Pin A or B of J1602.	Multimeter controls set to measure 700 volts dc.		+700 volts dc	Check C1601, R1601, or CR1601.

f. Removal and Replacement of Parts. The removal and replacement of parts in the dc power supplies are descrbed in paragraph 3-49b, *c*, and *d*.

g. *Bench Adjustment of Power Supplies.*

(1) *Adjusment of Control-Power Supply C-2014/MPQ-4A.*

(a) Adjust -200V ADJ potentiometer R634 (fig. 3-159) to the extreme clockwise position.

(b) Connect Multimeter TS-352B/U between terminals 2 and 9 of TB601 (fig. 3-157). Multimeter controls should be set to measure dc voltages in excess of -220 volts.

(c) Record the multimeter indication. The minimum indication should be -225 volts dc.

(d) Disconnect the multimeter.

(e) Connect the multimeter to terminals 3 and 9 of TB601 (fig. 3-157). Multimeter controls must be set to measure +200 volts dc.

(f) Record the multimeter indication. The minimum indication should be +220 volts dc.

(g) Disconnect the multimeter.

(h) Connect the multimeter to terminals 1 and 9 of TB601 (fig. 3-157). Set the multimeter controls to measure +500 volts dc.

(i) Record the multimeter indication. The minimum indication should be +450 volts dc.

(j) Adjust R634 (fig. 3-159) to the extreme counterclockwise position.

(k) Record the indication on the multimeter. The multimeter is connected between terminals 1 and 9 of TB601 (fig. 3-157). The maximum indication should be +430 volts dc.

(l) Disconnect the multimeter.

(m) Connect the multimeter to terminals 3 and 9 of TB601 (fig. 3-157).

(n) Record the multimeter indication. The maximum indication should be +215 volts dc.

(o) Disconnect the multimeter.

(p) Connect the multimeter between terminals 2 and 9 of TB601 (fig. 3-157). The multimeter controls should be adjusted to measure a negative dc voltage.

(q) Record the multimeter indication. The maximum indication should be -215 volts dc.

(r) Adjust R634 (fig. 3-159) until the voltage measured between terminals 2 and 9 of TB601 (fig. 3-157) is -220 volts dc ±3 volts.

(s) Rotate TEST METER SELECTOR switch S651 to the -220V position.

(t) Compare the indication on TEST METER M652 with the indication on the multimeter. The indication on M652 must be within ±8 volts of the multimeter reading.

(u) Disconnect the multimeter.

(v) Connect the multimeter to terminals 3 and 9 of TB601 (fig. 3-157). Multimeter controls are adjusted to measure positive dc voltage.

(w) Record the multimeter indication. The indication must be +220 volts dc ± volts.

(x) Rotate S651 to the +220V position.

(y) Compare the indication on TEST METER M652 with the multimeter indication. The reading on M652 must be within ±8 volts of the multimeter indication.

(z) Disconnect the multimeter.

(aa) Connect the multimeter to terminals 1 and 9 of TB601 (fig. 3-157).

(ab) Record the indication on the multimeter. the multimeter indication must be +440 volts dc ±5 volts.

(ac) Rotate S651 to the +440V position.

(ad) Compare the indication on M652 with the indication on the multimeter. The indication on M652 must be within ±8 volts of the multimeter indication.

(ae) Disconnect the multimeter.

(2) Adjustment of Power Supply PP-1588/MPQ-4A.

(a) Adjust -300V ADJ potentiometer R1643 (fig. 3-155) to the extreme clockwise position.

(b) Connect Multimeter TS-352B/U to pins F and D of J1601 (fig. 3-155). Set the multimeter controls to measure +500 volts dc.

(c) Record the multimeter indication. The minimum indication should be +310 volts dc.

(d) Disconnect the multimeter.

(e) Connect the multimeter to pins L and D of J1601 (fig. 3-155). Set the multimeter controls to measure a negative dc voltage.

(f) Record the multimeter indication. The minimum indication should be -310 volts dc.

(g) Disconnect the multimeter.

(h) Connect the multimeter to pins R and D of J1601 (fig. 3-155). Set the multimeter controls to measure a positive dc voltage.

(i) Record the multimeter indication. The minimum indication should be +155 volts dc.

(j) Adjust R1643 (fig. 3-155) to the extreme counterclockwise position.

(h) Record the multimeter indication. The maximum indication should be +145 volts dc.

(l) Disconnect the multimeter.

(m) Connect the multimeter to pins F and D of J1601.

(n) Record the multimeter indication. The maximum indication should be +290 volts dc.

(o) Disconnect the multimeter.

(p) Connect the multimeter to pins L and D of J1601 (fig. 3-155). Set the multimeter controls to measure a negative dc voltage.

(q) Record the multimeter indication. The maximum indication should be -290 volts dc.

(r) Adjust R1643 (fig. 3-155) until the multimeter indicates -300 volts dc.

h. Bench Testing Procedures.

(1) *General.* The procedures in this paragraph are designed to completely test the serviceability of a repaired power supply.

(2) *Serviceability test of Control-Power Supply C-2014/MPQ-4A.*

(a) Connect the control-power supply to Interconnecting Box J-982/MPM-49 and the variac as shown in figure 3-160.

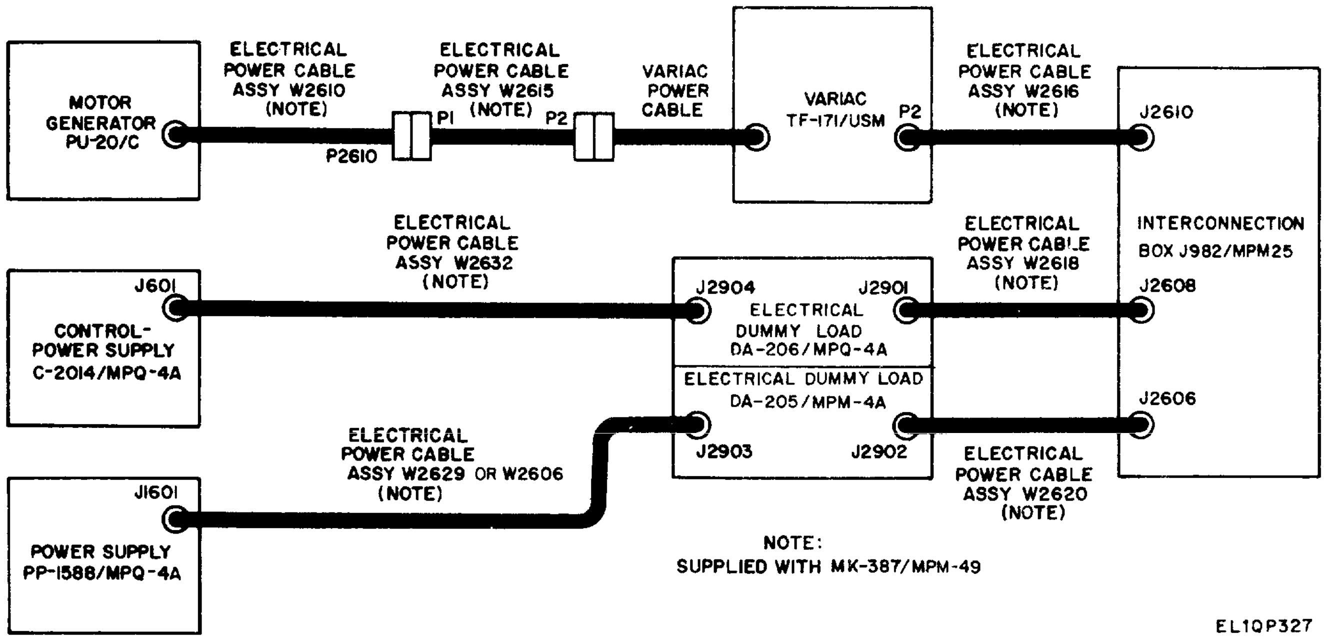


Figure 3-160. Bench test connections for dc supplies

(b) Adjust the variac until the input voltage measures 125-volts ac ± 3 volts.

(c) Turn MAIN POWER switch S652 to ON. MAIN POWER ON & INTLK CLOSED indicator lamp I 666 should light.

(d) Check the operation of the blown-fuse indicators as follows:

1. Remove fuse F651 and check to see that I 651 lights.

2. Remove fuse F652 and check to see that I 652 lights.

3. Remove fuse F653 and check to see that I 653 lights.

4. Remove fuse F654 and check to see that I 654 lights.

5. Remove fuse F655 and check to see that I 655 lights.

6. Remove fuse F656 and check to see that I 656 lights.

(e) Turn MAIN POWER switch S652 to OFF.

(f) Wait 3 minutes.

(g) Turn MAIN POWER switch S652 to the ON position.

(h) Measure the time required for relay K601 to close after the step in *(g)* above has been accomplished, Relay K601 can be heard when it closes. The closing time should be 30 seconds ± 7 seconds.

(i) Measure the time required for relay K603 to close after the step in *(h)* above has been performed, Relay K603 can be heard when it closes. The closing time should be 5 minutes ± 30 seconds. READY indicator lamp I 663 should light.

(j) Set the multimeter control to measure ac volts and plug the test lead into the 250 volt jack. Connect the multimeter test leads to terminals 2 and 3 of T651.

(k) Check to see that the multimeter indication is within the range of 125 to 145 volts, with the MAGNETRON POWER control set to maximum counterclockwise.

(l) Rotate MAGNETRON POWER control T651 clockwise.

(m) Check to see that the multimeter indication decreases to approximately 1 volt ac as T651 is rotated clockwise.

(n) Disconnect the multimeter.

(o) Set the multimeter control to measure –dc volts and plug the test lead into the 250 volt jack. Connect the multimeter test leads to terminals 2 and 9 of TB601 (fig. 3-157).

(p) Check to see that the multimeter in. dication is – 220±3 volts dc.

(q) Place TEST METER SELECTOR switch S651 in the -220V position.

(r) Compare the indication on TEST METER M652 with the indication on the multimeter. The two indications must be within ±8 volts.

(s) Disconnect the multimeter.

(t) Connect the multimeter to terminals 3 and 9 of TB601 (fig. 3-157).

(u) Check to see that the multimeter indicates +220 volts dc.

(v) Place S651 in the +220V position.

(w) Compare the indication on M652 with the multimeter indication. The two indications should be within ±8 volts of each other.

(x) Disconnect the multimeter.

(y) Connect the multimeter to terminals 1 and 9 of TB601. Set the multimeter controls to indicate +440 volts dc.

(z) Check to see that the multimeter indicates +440 volts dc.

(aa) Place S651 in the +440V position.

(ab) Compare the indication on M652 with the multimeter indication. The indication on M652 should be within ±8 volts of the multimeter indication.

(ac) Switch the load switch on Electrical Dummy Load DA-206/MPQ-4A to the 25 percent over position.

(ad) Record the multimeter indication. The indication should be +440 volts dc ±5 volts.

(ae) Switch the load switch on DA-206/MPQ-4A to the 25 percent under position.

(af) Record the multimeter indication. The indication should be ±440 volts dc ±5 volts.

(ag) Disconnect the multimeter.

(ah) Connect the multimeter to terminals 3 and 9 of TB601 (fig. 3-157). Set the multimeter controls to measure +220 volts dc.

(ai) Record the indication of the multimeter. The reading should be +220 volts dc ±3 volts.

(aj) Switch the load switch on DA-206/MPQ-4A to the 25 percent over position.

(ak) Record the multimeter indication. The indication should be +220 volts dc ±3 volts.

(al) Disconnect the multimeter.

(am) Connect the multimeter to terminals 2 and 9 of TB601.

(an) Record the multimeter indication. The indication should be -220 volts dc ±3 volts.

(ao) Switch the *load* switch on DA-206/MPQ-4A to the 25 percent under position.

(ap) Record the indication on the multimeter. The indication should be -220 volts dc ±3 volts.

(aq) Switch the *load* switch on DA-206/MPQ-4A to the normal position.

(ar) Disconnect the multimeter.

(as) Connect the voltmeter to DA 206/MPQ-4A.

(at) Check the ripple voltage of the -220-volt supply. The ripple voltage should not exceed 15 millivolts rms.

(au) Check the ripple voltage of the +220-volt supply. The ripple voltage should not exceed 15 millivolts rms.

(av) Check the ripple voltage of the +440-volt supply. The ripple voltage should not exceed 15 millivolts rms.

(aw) Disconnect the voltmeter.

(ax) Turn MAIN POWER switch S652 to OFF position.

(ay) Disconnect the control-power supply from the junction box.

(3) *Serviceability test for Power Supply PP-1588/MPQ-4A.*

(a) Connect the power supply to Interconnecting Box J-982/MPM-49 as shown in figure 3-160 and turn the power on.

(b) Check blown-fuse indicators as follows:

1. Remove fuse F1601 and check to see if I 1601 lights. Replace the fuse.

2. Remove the fuse F1602 and check to see if I 1602 lights. Replace the fuse.

3. Remove the F1603 and check to see if I 1603 lights. Replace the fuse.

(c) Connect Multimeter TS-352B/U to pins F and D of J1601 (fig. 3-156). Set the multimeter controls to measure +300 volts dc.

(d) Check the multimeter indication. The indication should be +300 volts dc ±5 volts.

(e) Disconnect the multimeter.

(f) Connect the multimeter to pins L and D of J1601 (fig. 3-156). Set the multimeter controls to measure -300 volts dc.

(g) Check the multimeter indication. The indication should be -300 volts ±5 volts.

(h) Disconnect the multimeter.

(i) Connect the multimeter to pins R and D of J1601. Set the multimeter controls to measure 150 volts dc.

(j) Check the multimeter indication. The indication should be +150 volts dc ±3 volts.

(k) Disconnect the multimeter.

(l) Disconnect the power supply from J-982/MPM-49.

Section XI. VENTILATING AND DEHYDRATING SYSTEMS TROUBLESHOOTING AND REPAIR

3-53. Ventilating and Dehydrating Systems Troubleshooting Information

a. Reference Data. The following information will be helpful when troubleshooting the ventilating and dehydrating systems.

Reference	Information
Fig. 2-146	Receiver-transmitter blower, partial schematic diagram.
Fig. 2-147	Shelter blowers, simplified schematic diagram.
Fig. 2-148	Dehydrator, Desiccant, Electrical HD-264/MPQ-4A, schematic diagram.
Fig. 2-149	Dehydrator, Desiccant, Electrical HD-264A/MPQ-4A schematic diagram.
Fig. 2-150	Dehydrator, functional diagram.
Fig. 3-161	Blower B1101 showing location and mounting
Fig. 3-162	Blower B1001 showing location and mounting.
Fig. 3-163	Receiver-transmitter cabinet showing blowers.
Fig. 3-164	Control-indicator cabinet showing blowers and exhaust vent.
Fig. 3-165	Antenna Group OA-1258/MPQ-4A, showing dehydrator.
Fig. 3-166	Receiver-transmitter cabinet showing exhaust vent.
Fig. 3-167	Electrical Equipment Shelter S-134/MPQ-4A, schematic diagram.
Fig. 3-168	Electrical Equipment Shelter S-134A/MPQ-4A, schematic diagram.
Fig. FO-41	Control-Indicator Group OA-1256/MPQ-4A, interconnecting diagram.

b. Normal Indications of Panel Meters. Air pressure gage on the dehydrator is the only meter in the ventilating system. It indicates the air pressure within the dehydrator and waveguide. The normal indication is approximately 16 pounds per square inch.

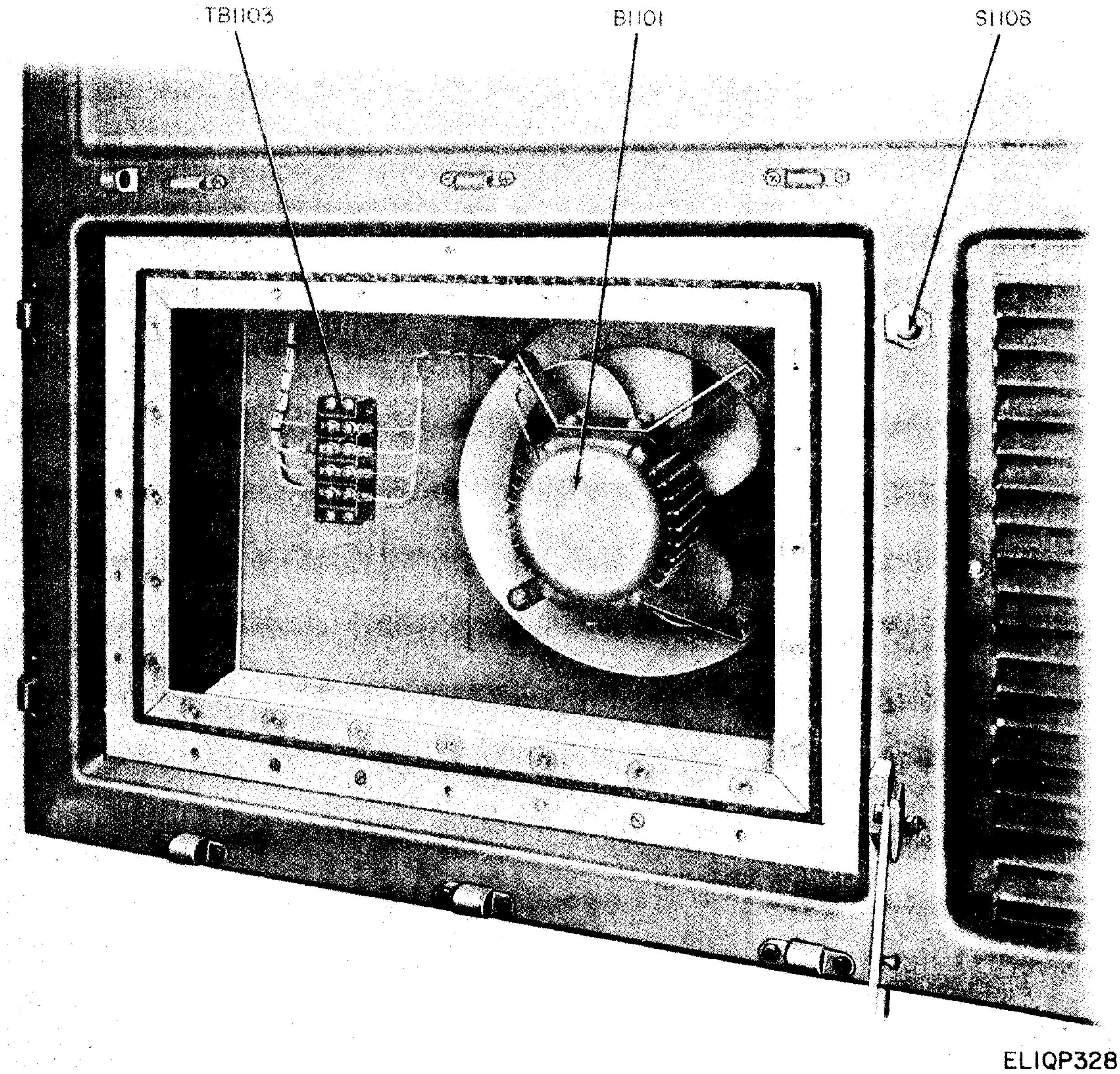


Figure 3-161. Blower B1101 showing location and mounting.

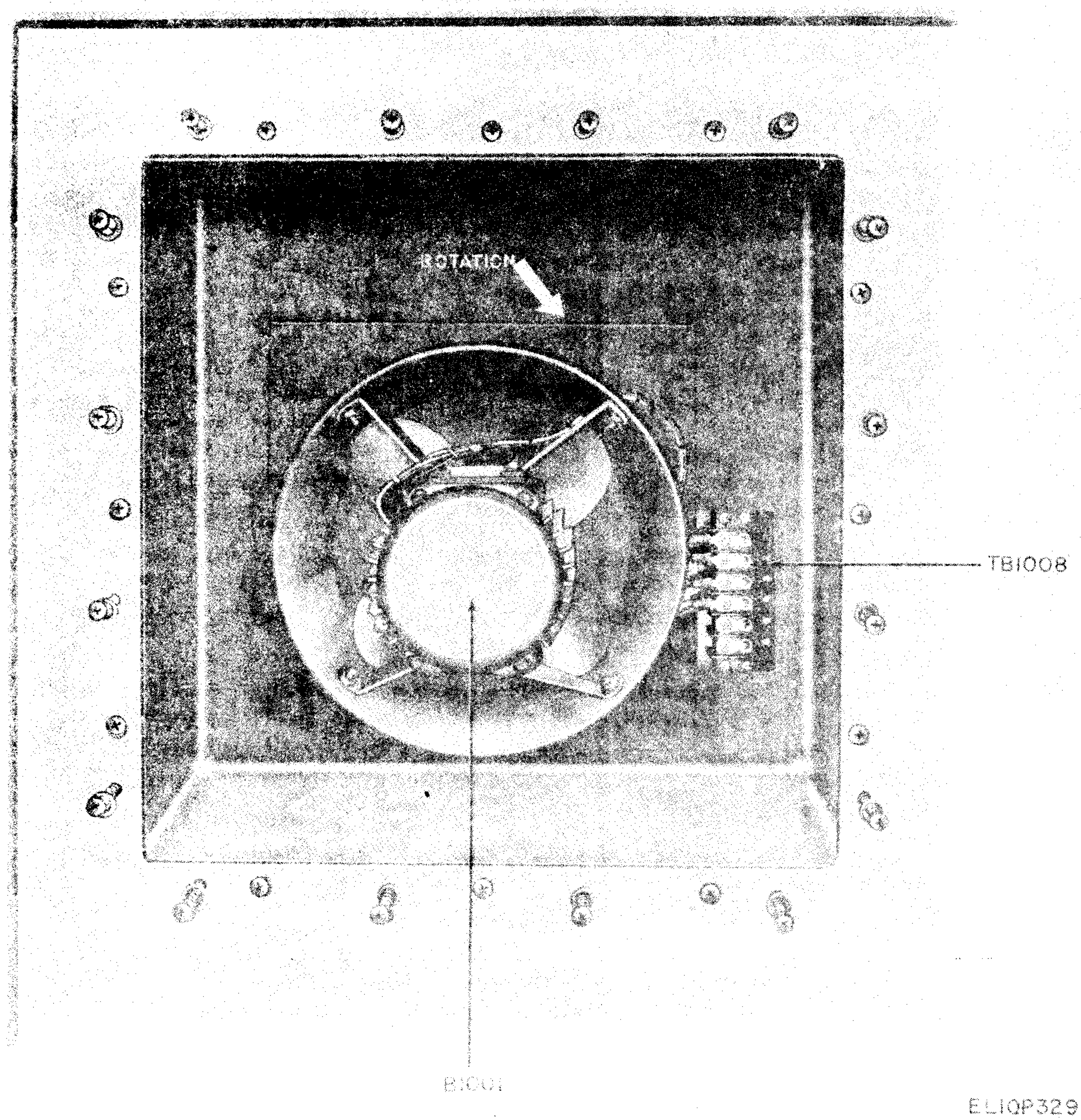


Figure 3-162. Blower B1001 showing location and mounting.

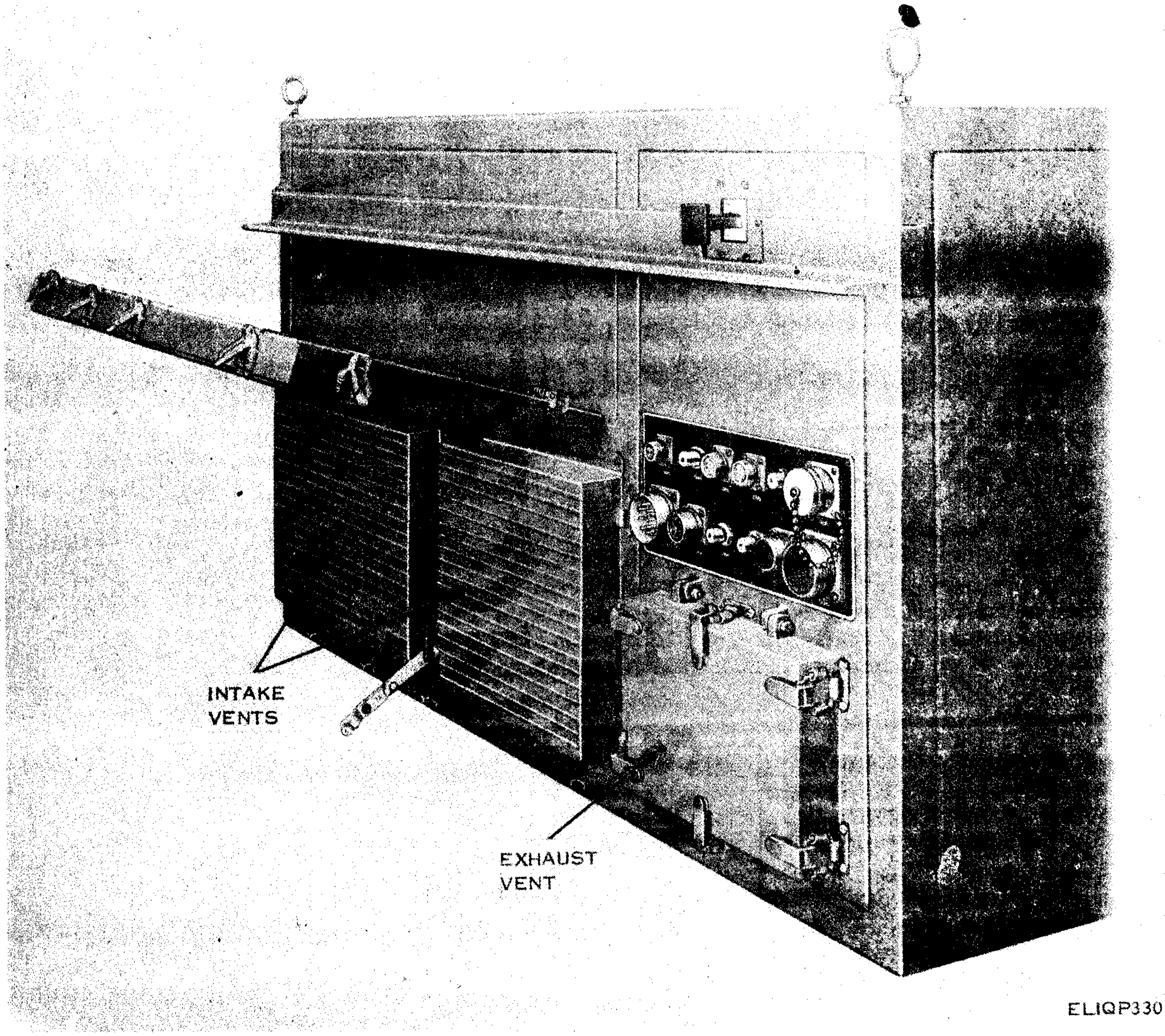


Figure 3-163. Receiver-transmitter cabinet showing blowers.

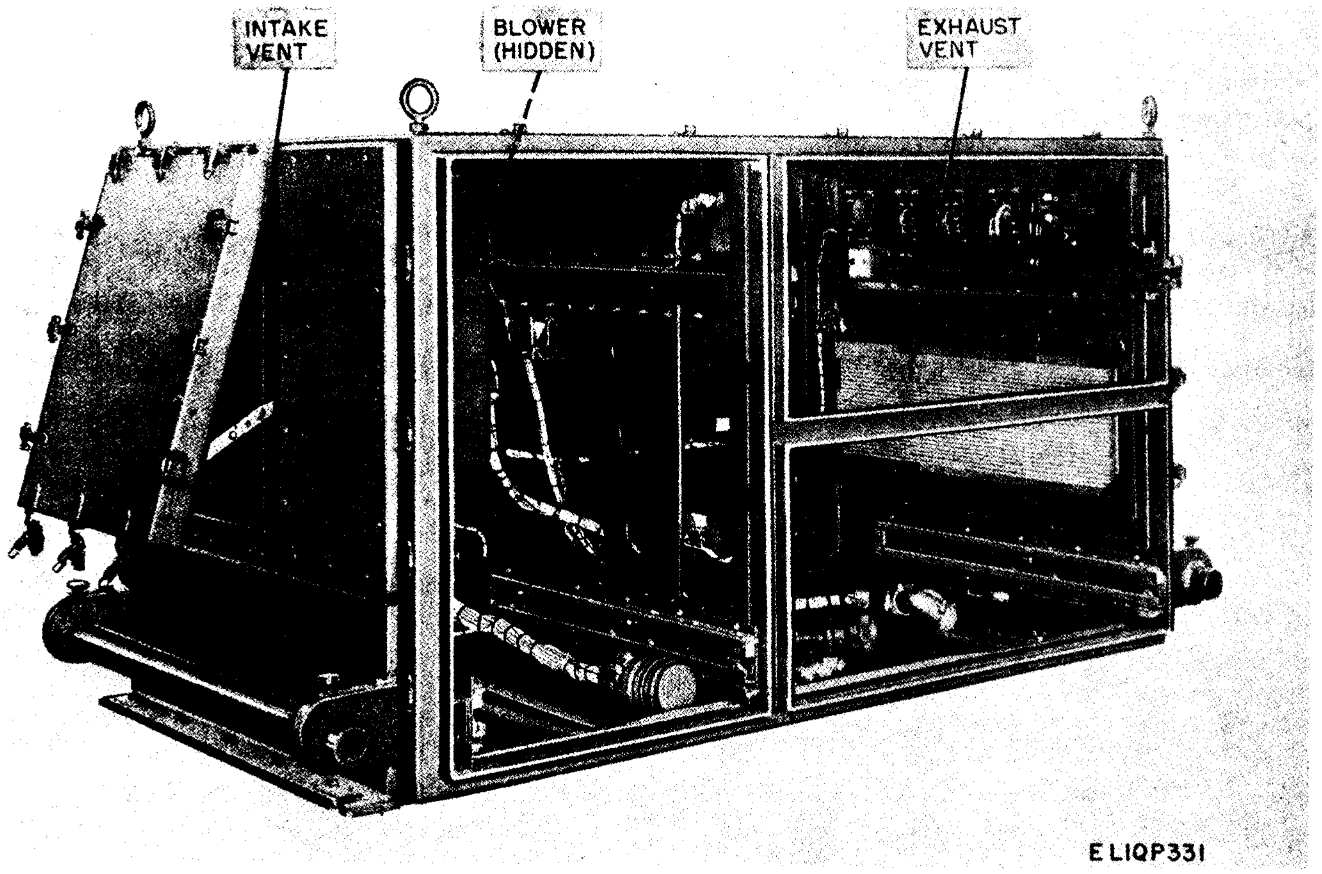


Figure 3-164. Control-indicator cabinet showing blowers and exhaust vent.

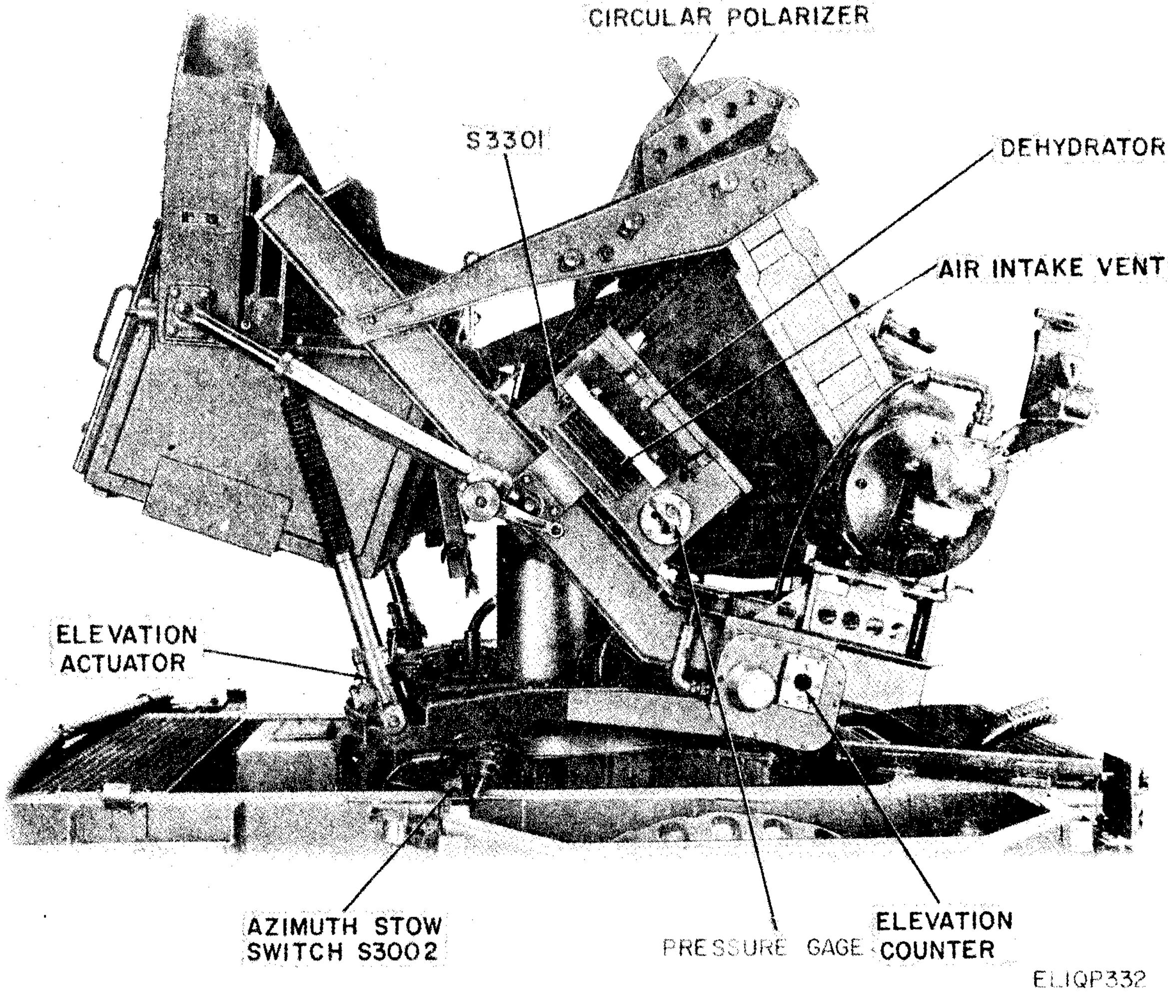


Figure 3-165. Antenna Group OA-1258/MPQ-4A, showing dehydrator.

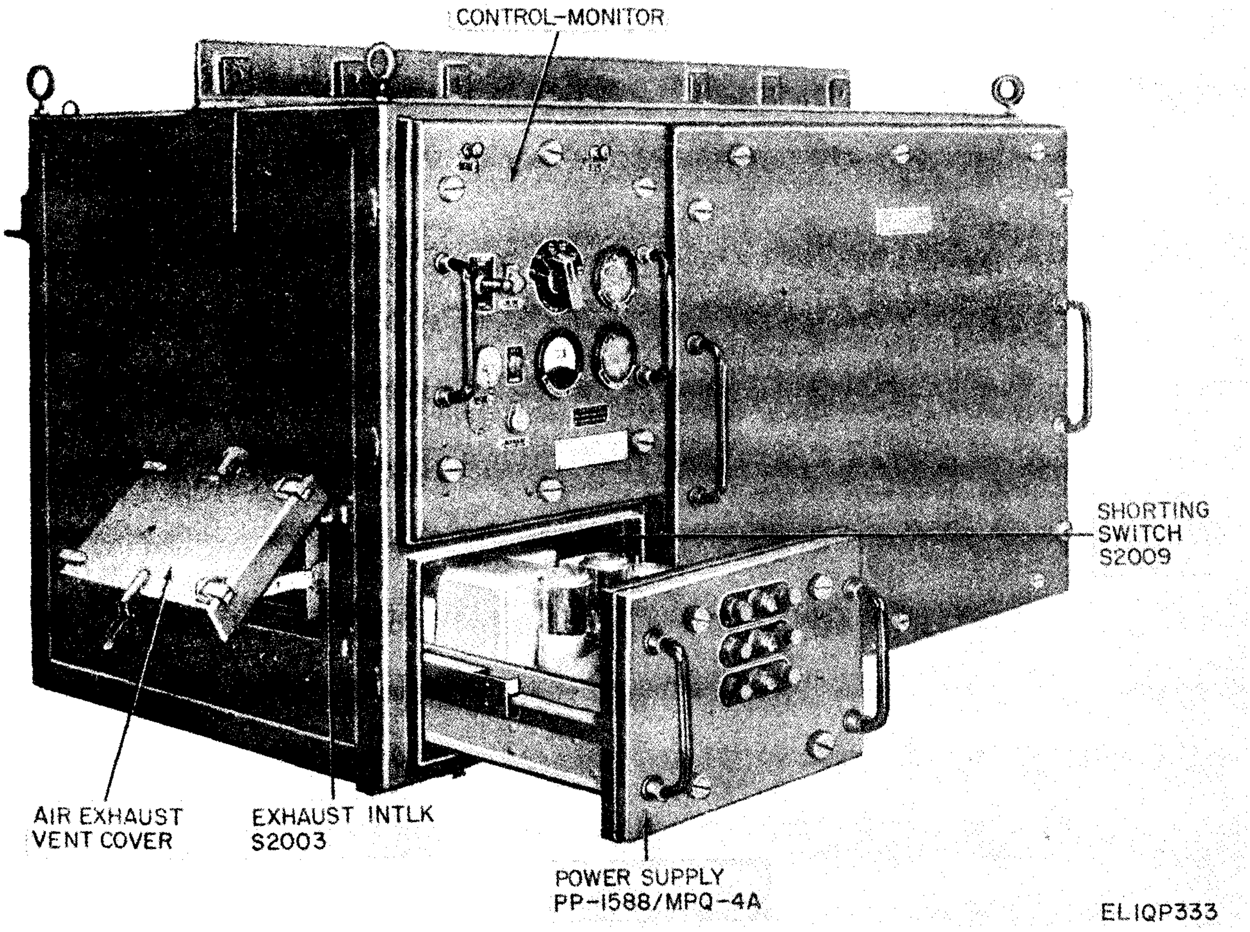


Figure 3-166. Receiver-transmitter cabinet showing exhaust vent.

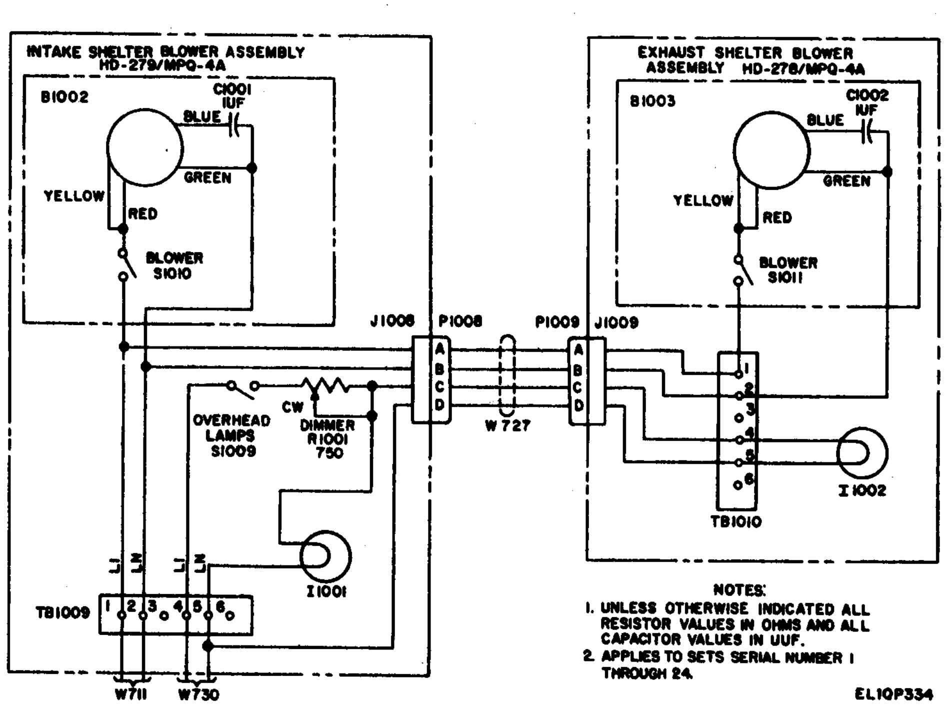


Figure 3-167. Electrical Equipment Shelter S-134/MPQ-4A. schematic diagram

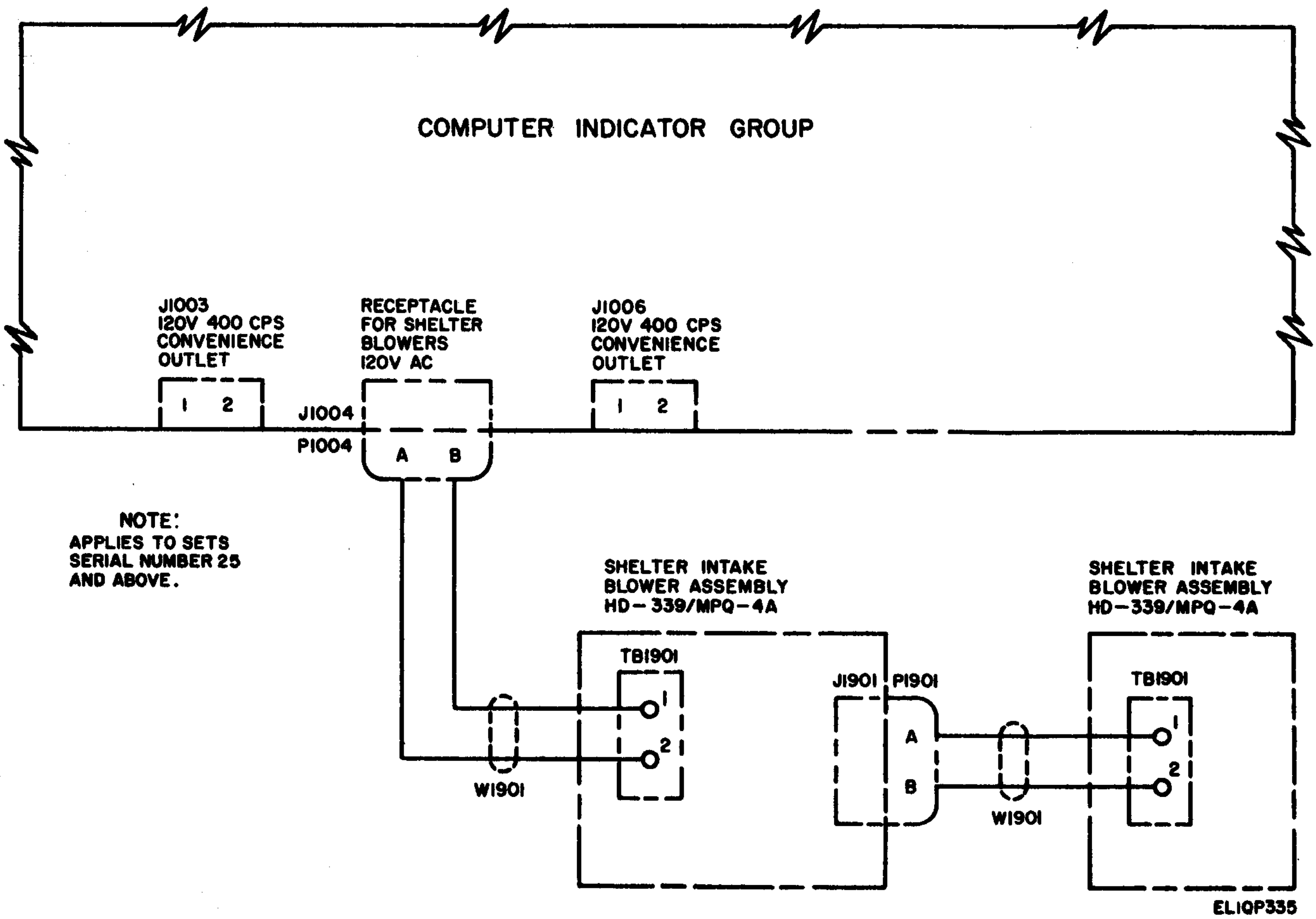


Figure 3-168. Electrical Equipment Shelter S-134A/MPQ-4A, schematic diagram.

3-54. Ventilating and Dehydrating Systems Troubleshooting

a. General. Two troubleshooting methods are provided to assist in isolating trouble that has been sectionalized to the ventilating and dehydrating systems.

(1) *Symptom Troubleshooting (c below).* Troubles that have been sectionalized to the ventilating and dehydrating systems can usually be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a stage. To troubleshoot the systems based on a symptoms, proceed as follows:

(a) Observe the indications obtained on air pressure gage.

(b) Compare the indications obtained with those listed in each of the symptoms.

(c) If the indications obtained correspond to those listed in a particular symptom, follow the procedure given in that particular paragraph to isolate the trouble.

(d) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleshooting table 3-65.

(2) *Step-by-step troubleshooting* (table 3-65). The ventilating system step-by-step troubleshooting table consists of a series of steps to evaluate all phases of operation of the ventilating system. Use this table if the trouble cannot be isolated by symptom troubleshooting ((1) above). To troubleshoot the ventilating system by using the step-by-step troubleshooting table, proceed as follows:

(a) Locate the test point given in step 1 of the table.

(b) Connect the test equipment and set the controls on the test equipment as directed in the test equipment column.

(c) Set the controls on the radar set as directed in the radar set controls column.

(d) Compare the indications obtained on the test equipment with the indications which are given or referenced in the normal indications column.

(e) If the indications obtained on the test equipment are normal, proceed either to the next step or as directed in the normal indications column.

(f) If the indications obtained are abnormal, proceed as directed in the corrective measures column.

b. Test Equipment Required. Multimeter TS-352B/U, commonly called multimeter, is the only item of test equipment required to troubleshoot the ventilating system. Instructions for operating Multimeter TS-352B/U are contained in TM 11-6625-366-15.

c. Ventilating and Dehydrating Systems Symptom Troubleshooting.

(1) *Symptom 1.* Motor B3301 does not run when MAIN POWER switch S652 is switched to ON. Check dehydrator pushbutton switch S3301. Check dehydrator fuses or circuit breaker setting. Check dehydrator control relay K1401, including relay activation circuitry (fig. FO-16 and FO-17).

(2) *Symptom 2.* The indication on air pressure gage is low.

(a) Remove waveguide pressurizing tube and place a cap over the dehydrator bulkhead fitting. If the pressure builds up, troubleshoot the waveguide.

(b) If pressure is still low, troubleshoot the dehydrator.

(3) *Symptom 3.* No indication on air pressure gage M3301.

(a) Remove the waveguide pressurizing tube and place a cap over the bulkhead fitting on the dehydrator.

(b) If the pressure builds up, troubleshoot the waveguide.

(c) If no indication is obtained, troubleshoot the dehydrator.

Table 3-65. Troubleshooting Table for Ventilating and Dehydrating Systems

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1	Terminals No. 1 and No. 7, TB3301.	Multimeter TS352B/U controls set to measure 115 volts ac.	MAIN POWER switch S652 to ON.	120 volts ac.	Check connector J3301 or cabling.
2	Terminals No. 2 and No. 7, TB3301.	Same as step 1.	Same as step 1.	120 volts ac.	Same as step 1.
3	Terminals No. 3 and No. 7, TB3301.	Same as step 1.	Same as step 1.	120 volts ac.	Same as step 1.
4	Terminals No. 4 and No. 7, TB3301.	Same as step 1.	Same as step 1. Dehydrator panel open.	120 volts ac.	Check switch.
5	Terminals No. 5 and No. 7, TB3301.	Same as step 1.	Same as step 4.	120 volts ac.	Same as step 4.
6	Terminals No. 6 and No. 7, TB3301.	Same as step 1.	Same as step 4.	120 volts ac.	Same as step 4.
7	Terminals No. 1 and No. 4, TB3302 (HD-264/MPQ-4A only).	Same as step 1.	Same as step 4.	120 volts ac.	Check circuit breaker CB3301.
8	Terminals No. 2 and No. 4, TB3302 (HD-264A/MPQ-4A only).	Same as step 1.	Same as step 4.	120 volts ac.	Check circuit breaker CB3301.
9	Terminals No. 3 and No. 4, TB3302 (HD-264A/MPQ-4A only).	Same as step 1.	Same as step 4.	120 volts ac.	Check circuit breaker CB3301.

3-55. Removal and Replacement of Parts of Ventilating and Dehydrating Systems

a. General. The ventilating system consists of two blowers mounted in the receiver-transmitter cabinet, one blower mounted in the control-indicator cabinet, and the dehydrating system.

b. Removal and Replacement of Magnetron Blower B1102 (fig. 3-11).

(1) *Removal.*

(a) Remove magnetron V1105 (para 3-20e)

(b) Remove the magnetron holding bracket by loosening the two nuts.

(c) Tag, disconnect, and remove the leads to terminal board TB1104.

(d) Unscrew and remove the screws, lockwashers, and nuts that hold the blower in place.

(e) Remove the blower.

(2) *Replacement.*

(a) Position the blower in place.

(b) Replace and tighten the screws, lockwashers, and nuts that hold the blower in place.

(c) Replace the magnetron holding bracket and tighten the screws.

(d) Replace the magnetron (para 3-20 *e*).

c. Removal and Replacement of Blower B1101 (fig. 3-161). Blower B1101 is located in the right rear section of the modulator-transmitter compartment. Access to the blower is gained from the rear of the receiver-transmitter cabinet.

(1) *Removal.*

(a) Loosen the latches that hold the rear intake vent of the receiver-transmitter cabinet.

(b) Loosen and remove the screw and nut that secure the latch to the vent cover.

(c) Loosen and remove the two screws and nuts that hold the vent cover.

(d) Remove the vent cover.

(e) Loosen and remove the eight screws that hold the lower cover in place.

(f) Remove the lower cover.

(g) Remove the air filter.

(h) Loosen and remove the 24 screws that hold the retainer in place.

(i) Remove the retainer.

(j) Tag and disconnect the four leads from terminal board TB1103.

(k) Loosen and remove the four screws and nuts from the blower plate.

(l) Remove the blower and the plate.

(m) Loosen and remove the eight screws and nuts that attach the blower to the blower plate.

(2) *Replacement.*

(a) Position the blower on the plate.

(b) Replace and tighten the eight screws and bolts that hold the blower and the plate.

(c) Position the blower and plate inside the blower compartment.

(d) Replace and tighten the four screws and nuts that hold the plate in place.

(e) Connect the four blower leads to TB1103.

(f) Position the retainer in place.

(g) Replace and tighten the 24 screws that hold the retainer in place.

(h) Replace the air filter.

(i) Position the lower cover over the filter and fasten in place with the eight holding screws.

(j) Position the vent cover in place and replace the two screws and nuts at the top corners.

(k) Fasten the latch to the vent cover with a screw and nut.

d. Removal and Replacement of Blower B1001 (fig. 3-162). Blower B1001 is located in the control-indicator cabinet behind the control-power supply drawer. Access to the blower compartment can be gained through an opening on the rear of the cabinet.

(1) *Removal.*

(a) Loosen the pawl fasteners on the front of the control-power supply and pull the drawer out.

(b) Remove the cable from J601.

(c) Remove the control-power supply drawer from the cabinet.

(d) Loosen and remove the 16 Phillips-head screws that hold the cover of the blower compartment. This cover is located on the rear of the control-indicator cabinet.

(e) Remove the cover.

(f) Disconnect the four blower leads from terminal board TB1008 (fig. 3-162).

(g) Loosen and remove the four Phillips-head screws that hold the blower plate to the back wall of the cabinet. Access to the nuts on the end of the four screws is obtained from the inside of the cabinet.

(h) Remove the blower and plate from the blower compartment.

(i) Loosen and remove the screws and nuts that attach the blower to the plate.

(j) Remove the blower from the plate.

(2) *Replacement.*

(a) Position the blower on the ((1) *(j)* above).

(b) Attach the blower to the plate with the screws and nuts removed as instructed in ((1) *(i)* above).

(c) Position the blower and plate in the blower compartment and attach them with the four Phillips-head screws and nuts.

(d) Connect the four blower leads to TB1008.

(e) Position the cover over the blower compartment and attach it with the 16 Phillips-head screws.

(f) Replace the control-power supply drawer in the cabinet.

(g) Connect the cable to J601.

(h) Slide the control-power drawer in and fasten the pawl fasteners.

3-56. Testing Ventilating and Dehydrating Systems

a. General. This paragraph covers testing procedures designed to check the serviceability of a repaired ventilating system.

b. Testing Procedures.

(1) *Receiver-transmitter cabinet* (fig. 3-163).

(a) Turn MAIN POWER switch S652 to ON.

(b) Close the intake vents at the rear of the cabinet.

(c) Open the intake vent and check to see if air is being drawn in by each blower.

(d) Close the exhaust vent (fig. 3-166).

(e) Open the exhaust vent and check to see if air is being blown out of the cabinet.

(2) *Control-indicator cabinet* (fig. 3-164).

(a) Close the intake air vent on the side of the cabinet.

(b) Open the vent and check to see if air is being drawn into the cabinet.

(c) Close the exhaust vent on the right side of the cabinet.

(d) Open the vent and check to see if air is being blown out of the cabinet.

(3) *Dehydrator* (fig. 3-165).

(a) Open the vent on the front of the dehydrator.

(b) Open the purge valve on the right side of the dehydrator, and check to see that the dehydrator compressor operates when air pressure drops to 14 psi ±1. Close the purge valve, and check to see that the compressor shuts off when pressure builds up to 16 psi on the air pressure gage.

(c) After releasing the compressed air, attach test pressure gage with adapter to the air outlet on the dehydrator. Check to see that the dehydrator pressure gage indicates the same as the test gage within ±1 psi, when pressure builds up.

(d) Check the crystals in the front panel dry air indicator on the dehydrator to see the crystals are blue.

3-57. Maintenance of Dehydrator

a. General. This paragraph covers maintenance of the dehydrator when it is disconnected from the other components of the radar set. The following figures will be helpful when performing maintenance on the dehydrator.

(1) Dehydrator, simplified schematic diagram, figures 2-148 and 2-149.

(2) Dehydrator, functional diagram, figures 2-150.

b. Dehydrator Symptom Troubleshooting Table.

(1) *Symptom 1.* Pressure gage (fig. 2-150) indicates low pressure (cap on bulkhead fitting).

(a) Use a brush and apply a soapy solution to all fittings, and check for air leaks. When tests are complete, clean fittings with dry cloth to remove soapy solution. Tighten any leaky fittings.

(b) If the 20-pound pressure relief valve is open and pressure gage indicates low pressure, check for a restriction in the drying (desiccant) chambers, connecting hoses, needle valve, and connecting ball check valve.

(c) If the 20-pound pressure relief valve is closed, it is an indication of defective compressor components.

(2) *Symptom 2.* Pressure gage indicates high pressure (approximately 20 psi with cap removed from bulkhead fitting).

(a) Check to see if the line fitter is clogged.

(b) Check to see if the output adapter is clogged.

(3) *Symptom 3.* Pressure gage shows no indication of pressure (cap on bulkhead fitting).

(a) Check for loose fittings.

(b) Check for a broken airhose.

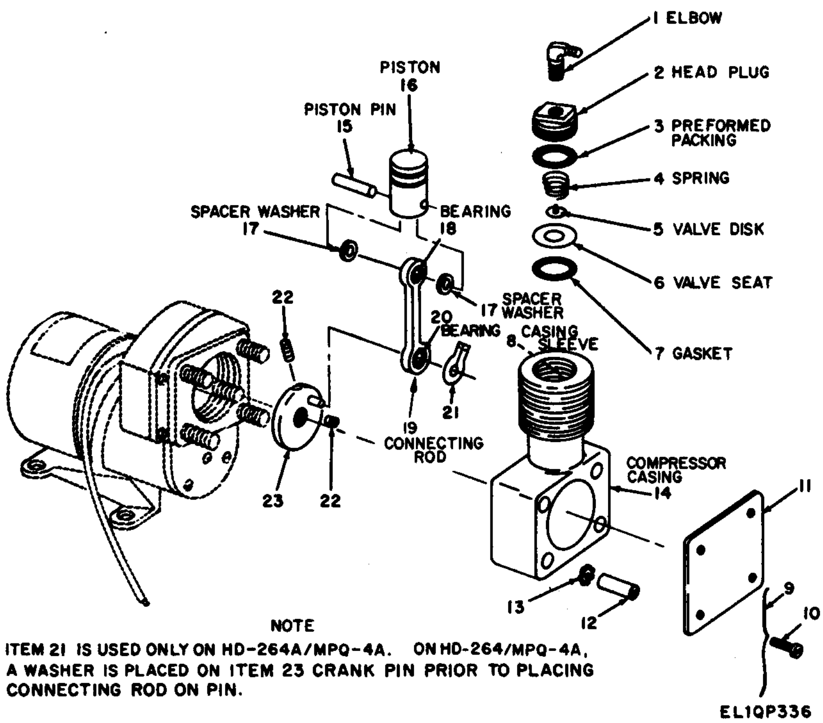


Figure 3-169. Dehydrator, disassembly and reassembly.

c. Disassembly and Reassembly of Compressor Components (fig. 3-169).

(1) *Disassembly.*

(a) Remove motor and compressor assembly A5, and separate as described in TM 11-5840-208-20. Disassemble compressor A5A1 as follows:

CAUTION

Bearings (18 and 20) are pressed into place and should not be removed. The piston pin (15) is staked in place and requires care when removing to prevent damage to the piston.

(b) Separate piston (16), spacer washers (17), and connecting rod (19), by removing piston pin (15).

CAUTION

Casing sleeve (8) is pressed into place and should not be removed.

(c) Remove elbow (1), head plug (2), preformed packing (3), spring (4), valve disk (5), valve seat (6), and gasket (7) from top of compressor casing (14).

(2) *Assembly.*

(a) Install gasket (7), valve seat (6), valve disk (5), spring (4), preformed packing (3), head plug (2), and elbow (1) in top of compressor casing (14).

NOTE

Be certain that the pin on valve disk (5) faces upward and is cantered as seen through opening in head plug.

(b) Assemble connecting rod (19), spacer washers (17), piston (16) and piston pin (15).

(c) Assemble and replace motor and compressor assembly A5 as described in TM 11-5840-208-20.

Section XII. COMPLETE ALIGNMENT AND TESTING OF RADAR SET AN/MPQ-4A

3-58. Introduction

The information in this section is to be used as a guide to completely test and/or align Radar Set AN/MPQ-4A. Complete testing and/or alignment are required when the radar set has been either out of operation for a prolonged period or extensively repaired.

3-59. Radar Set AN/MPQ-4A, Complete Alignment

Table 3-66 lists the alignment and adjustment procedures for completely aligning Radar Set AN/MPQ-4A. Step-by-step directions for performing the procedures listed in the Alignment or adjustment column are contained in the paragraphs listed in the procedure column. To align the set completely, perform the procedures in the order listed in table 3-66.

3-60. Test Equipment Required for Boresighting

Table 3-67 contains a list of components of Electronic Equipment Maintenance Kit MK-399/MPQ-4A required to boresight the radar set.

3-61. Boresighting Radar Set AN/MPQ-4A

a. General. Radar Set AN/MPQ-4A is boresighted to align the azimuth counters and azimuth strobe line in the center of the lower beam.

Table 3-66. Alignment and Adjustment Procedures

Alignment or adjustment	Procedure (para No.)
Line frequency and line voltage adjustment	TM 5-5274
Transmitting system	3-21 *a* through *d*
Rf system	3-25 *a* and *b*
Receiving system	3-28 *j*
Synchronizing and indicating system	3-34 *a* through *g*
Computing system	3-39 and 3-40
Dc power supplies	3-50 *a* through *d*
Boresighting and azimuth linearity	3-61
Alignment of upper and lower beams	3-62

Table 3-67. Test Equipment Required for Boresighting

Component	Common name
Electronic Equipment Maintenance Kit MK-399/MPQ-4A, consisting of:	Boresighting kit
Antenna Group OA-1967/MPQ-4A	Antenna.
Frequency Mixer State CV-662/G . . .	Mixer.
Waveguide Probe RF-74/U	Crystal detector.
Flexible Waveguide CG-539/U (24 in.).	None.
Cable Assemblies:	
CG-426G/U (2 ft)	
CG-426G/U (6 ft)	
CG-1657/U (6 ft)	
CG-1658/U (4 ft)	
CG-1658/U (12 ft)	
Radio Frequency Amplifier AM-1881/U.	Amplifier.
Oscilloscope AN/USM-281	Oscilloscope.

b. Boresighting Procedure.

(1) Mount the antenna tripod, alignment target, and parabolic reflector as shown in figure 3-170.

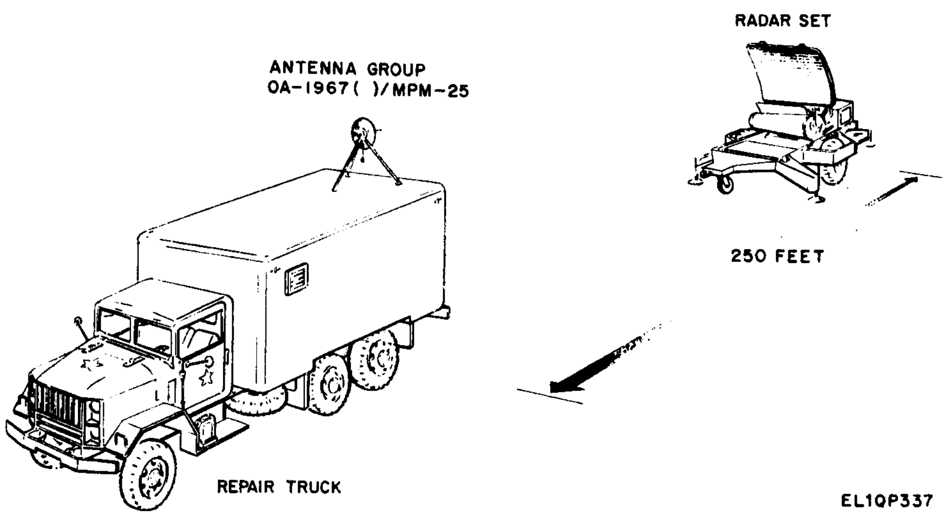


Figure 3-170. Location of equipment for boresighting.

(2) Connect Radar Test Set AN/UPM-60A to the reflector feed assembly.

(3) Disconnect waveguide section W715 from waveguide section W745 at the radar scanner.

(4) Connect the crystal detector, amplifier, mixer, and the oscilloscope at the radar set position as shown in figure 3-171.

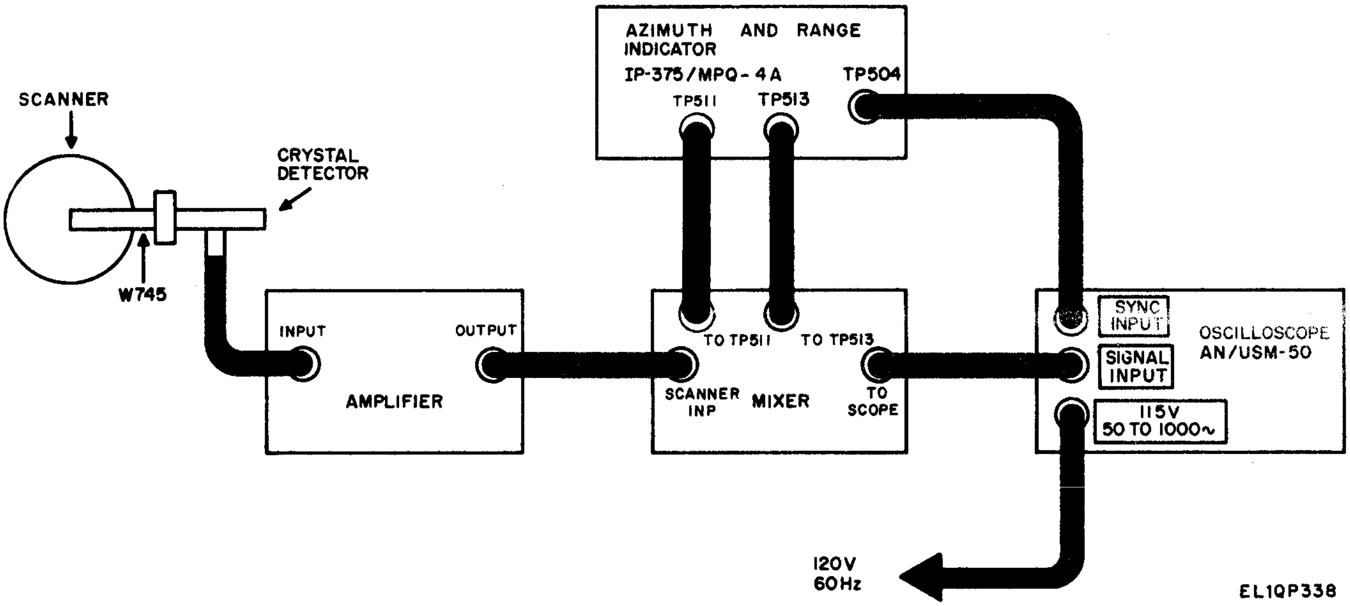


Figure 3-171. Test connections for boresighting.

(5) Turn MAIN POWER switch S652 to ON.

(6) Set the oscilloscope for external trigger, 4-volt-per-centimeter vertical deflection sensitivity, and 5,000-microeeccmd-per-centimeter sweep speed.

(7) Make sure the radar set is level.

(8) Center the target on the antenna tripod (fig. 3-170) in the radar telescope crosshairs.

(9) Adjust Radar Test Set AN/UPM-60A to transmit a frequency of 16,000 megaHertz CW at a power output of 2 milliwatts.

(10) Set the GAIN switch on the amplifier to 40 db.

(11) Set the mixer to the trigger position, and adjust the oscilloscope for one full scan presentation (two trigger pairs visible, one pair at one end of the sweep and the other pair at the other end of the sweep).

(12) Switch the mixer to the scanner position.

(13) Use the AZIMUTH and ELEVATION controls on the radar set to position the crosshair of the telescope to the exact center of the target on the antenna tripod.

(14) While the oscilloscope at the radar position is being observed, adjust the position of the parabolic reflector shown in figure 3-170 in both azimuth and elevation to peak the signal on the oscilloscope.

(15) Peak the signal on the oscilloscope with the crystal detector.

(16) Set the GAIN switch on the amplifier to either 20 db or 40 db, whichever will allow the strobe pulse to be clearly seen on the oscilloscope.

NOTE

Gain control at mixer may also be used for this purpose.

(17) Observe that the azimuth strobe line bisects the pulse envelope on the oscilloscope as shown in figure 3-172. If the strobe line does not bisect the pulse envelope, rotate the body of azimuth strobe synchro B3203 (fig. 3-173) until the pulse envelope is bisected.

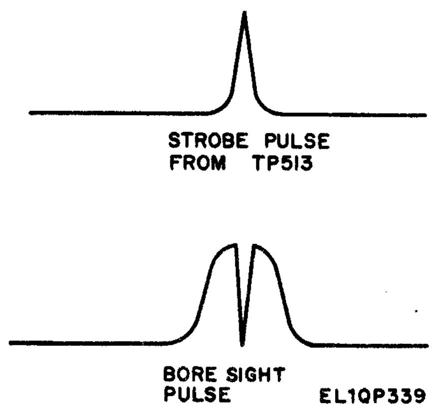


Figure 3-172. Boresighting waveforms.

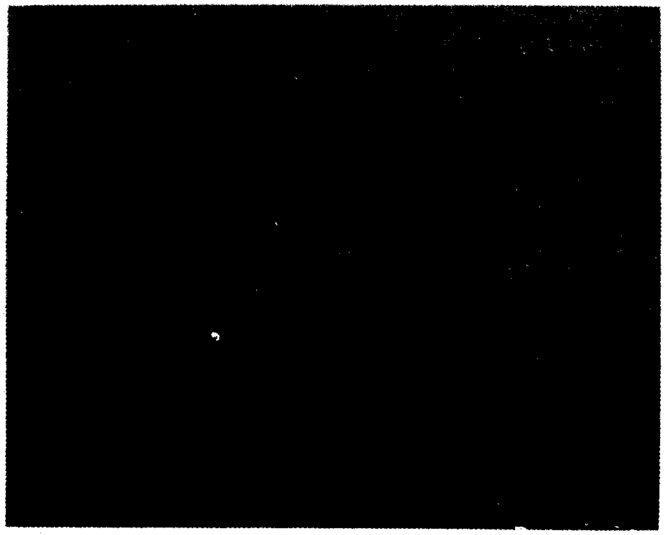


Figure 3-173. Azimuth marker servo and movable coil.

c. Azimuth Linearity.

(1) Rotate the LOWER BEAM AZIMUTH and Δ AZIMUTH handwheels on the computer to the detent positions.

(2) Record the indication of AZIMUTH counter M841.

(3) Rotate the antenna azimuth handwheel (fig. 3-151) until the transmitted pulse moves to the extreme left of the oscilloscope face.

(4) Rotate the LOWER BEAM AZIMUTH handwheel until the azimuth strobe bisects the transmitted pulse.

(5) Record indication of AZIMUTH counter M841.

(6) Place the LOWER BEAM AZIMUTH handwheel in the detent position.

(7) Rotate the azimuth handwheel (fig. 3-151) until the indication on AZIMUTH counter M841 is changed by 45 mils.

(8) Rotate the LOWER BEAM AZIMUTH handwheel until the azimuth strobe pulse bisects the transmitted pulse.

(9) Record the indication of AZIMUTH counter M841.

(10) Rotate the LOWER BEAM AZIMUTH handwheel to the detent position.

(11) Perform procedures in (7) through (10) above until the azimuth strobe reaches the right edge of the oscilloscope.

3-62. Alignment of Upper and Lower Beams

a. General. The azimuth strobe line should bisect the upper and lower beam target echoes without moving the azimuth handwheels on the computer.

b. Procedure.

(1) Rotate the Δ RANGE and Δ AZIMUTH handwheels to the detent positions.

(2) Point the radar antenna at the radar test set as shown in figure 313.

(3) Rotate the LOWER BEAM AZIMUTH hand wheel until the azimuth strobe line bisects the lower beam echo.

(4) Actuate ELEVATION switch S655 until the target transmitter echo appears on the upper beam presentation.

(5) If the azimuth strobe line bisects the echo on the upper beam, the equipment is adjusted. If the azimuth strobe line does not bisect the echo, perform the procedure in (6) through (11) below.

(6) Turn MAIN POWER switch S652 to OFF and wait until the scanner motor stops.

CAUTION

Be extremely careful not to permit dust or dirt to enter the scanner once the large endbell cover is removed as damage to the barrier teeth will result.

WARNING

Because of the dynamic balance characteristic of the scanner rotor (approximately 600 pounds) the rotor will continue to rotate long after power has been removed. Allow approximately 5 to 7 minutes before removal of the endbell, as this presents a hazard to personnel, and any dust in the area would be drawn into the rotating scanner.

(7) Remove the large end bell from the scanner.

(8) Loosen the two screws that hold upper marker coil L3202 (fig. 2-60) in place and move the coil to the right or left. Moving coil L3202 changes the start time of the azimuth sweep on the indicator during upper beam; this changes the sweep position on the indicator and the position of the upper beam information presentation. Be sure to tighten the screws that hold marker coil L302 in place before turning the MAIN POWER switch to ON.

WARNING

The scanner rotor operates at 1,020 revolutions per minute. Do not attempt to adjust the position of marker coil L3202 while the scanner rotor is rotating.

(9) Turn MAIN POWER switch S652 to ON.

(10) Repeat the procedures in (1) through (8) above until the azimuth strobe line bisects both beam echoes.

(11) Replace the end bell on the scanner.

3-63. Testing Radar Set AN/MPQ-4A

Table 3-68 lists the procedures for testing the operation of Radar Set AN/MPQ-4A. Step-by-step directions for performing the procedures listed in the Test column are contained in the paragraphs listed in the Procedure column. Perform the procedures in the order listed in table 3-68.

3-64. Complete Systems Test

a. General. The teat procedures detailed in *b* through *n* below provide a thorough check of the radar set.

b. Voltage Check. Rotate TEST METER SELECTOR switch S651 to all positions. Record all voltages in a test data chart similar to the chart below. All voltages except the 28VDC should be within ±5 volts. The 28VDC should read between 26 end 30 volts.

TEST METER SELECTOR switch position	Reading	Accuracy
+440V		
+220V		
– 28V		
–220V		

c. Elevation Controls.

(1) operate ELEVATION switch S 655 and elevate the antenna to the upper limit stop.

(2) The indications of the antenna and computer elevation counters should be a minimum of +200 mile.

(3) Run the antenna to the lower limit stop.

Table 3-68. Procedures for Testing Operation of Radar Set AN/MPQ-4A

Test	Procedure (para No.)
Power unit output	TM 5-5274
Synchronixing and indicating systems outputs.	3-35 *d*
Dc power supply outputs	3-51 *c*
Voltage check	3-64 *b*
Elevation control	3-64 *c*
Azimuth control	3-64 *d*
Strobe lines	3-64 *e*
Detent light	3-64 *f*
Stc	3-64 *g*
Radiate test	3-64 *h*
Afc	3-64 *i*
Range mark intensity and calibration	3-64 *j*
Ringtime and frequency	3-64 *k*
Intensity balance	3-64 *l*
Range shift	3-64 *m*
Video blanking	3-64 *n*
Elevation counters	3-65

(4) The indication of the antenna and computer elevation counters should be a minimum of -100 mile.

(5) The minimum total excursion of the antenna should be - 100 mile to +200 roils. If these limits cannot be met, adjust the elevation drive as directed in paragraph *3-46d*.

d. Azimuth Control.

(1) Operate AZIMUTH switch S656.

(2) Observe that the antenna rotatee in the direction indicated by the switch position.

(3) Observe that the computer AZIMUTH counter follows the motion of the antenna.

e. Strobe Lines. Operate the LOWER BEAM AZIMUTH end LOWER BEAM RANGE handwheels on the computer and see that the indicator strobe lines move in the direction indicated below:

control	Direction	strobe line direction
LOWER BEAM AZIMUTH	Cw	Right.
LOWER BEAM AZIMUTH	Ccw	Left.
LOWER BEAM RANGE	Cw	Up.
LOWER BEAM RANGE	Ccw	Down.

f. Detent Light. Move the computer handwheels out of detent. SET DETENT light I 109 on the indicator should glow. The light should go out when the hand wheels are moved into detent.

g. *Stc.*

(1) Set MARKERS ON switch S105 on the indicator to OFF.

(2) Adjust R4708 and R4712 on the stc chassis until the noise on the indicator screen is removed for the first 3,000 meters of range.

h. Radiate Test.

(1) After the READY light begins to glow, press START button S658.

(2) RADIATE light I 662 should glow.

(3) Adjust MAGNETRON POWER control T651 for a current of 18 ma.

i. Aft.

(1) Set MARKERS ON switch S105 to ON.

(2) Set AFC-MANUAL switch S657 to MANUAL.

(3) Tune the local oscillator with L. O. RAISE-LOWER switch S654 until range-marks appear on the indicator. Tune for maximum brilliance of the markers.

(4) Set switch S657 to AFC.

(5) If the markers remain at maximum brilliance, the afc is locked on. If the markers are not maximum, klystron adjustment is required. (Sss TM 11-5840-208-10.)

j. Rangemark Intensity and Calibration.

(1) Adjust R1333 (fig. 3-31) until the 14,000-meter marker is barely visible.

(2) Adjust the range handwheels on the computer until the RANGE counter indicates 2,000 meters.

(3) Adjust RANGE ZERO control R116 on

the indicator until the range strobe line is exactly on the 2,000-meter marker.

(4) Rotate the range handwheel until the counter indicates 14,000 meters.

(5) Adjust RANGE SLOPE control R119 until the strobe is exactly on the marker.

(6) Repeat the procedures given in (2) through (5) above until the strobe line is always on the marker. If trouble is encountered, RANGE RATE control C232 (fig. 3-50) may be adjusted.

k. Ringtime and Frequency. Check ringtime and frequency as described in TM 11-5840-208-10.

l. Intensity Balance.

(1) Rotate RANGE SELECTOR switch S101 to 15,000M.

(2) Adjust VIDEO potentiometer R102 and IF GAIN potentiometer R109 so that no noise is visible on the indicator screen.

(3) Adjust INTENSITY control R142 so that the raster is barely visible on the screen.

(4) Rotate S101 between the 3750M and 15000M positions.

(5) Adjust INTENSITY BALANCE potentiometer R112 until the intensity is the same for both positions of S101.

m. Range Shift.

(1) Adjust the VIDEO and IF GAIN controls until full noise is visible on the screen.

(2) Set RANGE SHIFT switch to ON.

(3) Move the range strobe line between the upper beam and lower beam displacement and check the range with the RANGE counter on the computer. The range should be checked on both the 15000-meter and 3,750-meter ranges and must be 750 meters ±150 meters.

(4) If the range displacement is not correct, adjust RANGE SHIFT potentiometer R4560 (fig. 3-51).

n. Video Blanking.

(1) Point the antenna toward a tall vertical target, such as a water tower, that will give a return from both upper and lower beams simultaneously .

(2) Set BEAM VIDEO switch S110 to LOWER BEAM. Only the return from the lower beam should remain on the screen.

(3) Press the TIMER button. Only the return from the upper beam should be shown on the screen.

(4) Press the TIMER button. The lower beam presentation should appear.

(5) Set the BEAM VIDEO switch to UPPER BEAM.

(6) Repeat the procedures in (3) and (4) above. The video presentations should be revereed.

(7) Set BEAM VIDEO switch to BOTH. The TIMER button should have no effect on the video presentation.

3-65. Elevation Counters.

a. *General.* Indications on LOWER BEAM ELEVATION counter M821 and the antenna elevation counter (fig. 3-165) are compared so that the amount of error can be recorded.

b. Procedure.

(1) Depress the antenna to - 100 mile.

(2) Record the indication of LOWER BEAM ELEVATION counter M821 and the antenna elevation counter in a test data chart (*c* below).

(3) Elevate the antenna 10 mile.

(4) Record the indication of LOWER BEAM ELEVATION counter M821 and the antenna elevation counter in the test data chart (*c* below).

(5) Perform the procedures given in (3) and (4) above at 10-mil intervals until the maximum elevation is reached.

(6) Depress the antenna 10 mils.

(7) Record the indications of M821 and the antenna elevation counter in the test data chart (*c* below).

(8) Perform the procedures in (5) and (6) above at 10-mil intervals until the maximum antenna depression is reached.

c. Test Data Chart. The chart below lists the antenna elevations and gives a comparison between the two elevation counters.

Antenna elevation	LOWER BEAM ELEVATION counter M821	Antenna elevation counter
- 100		
- 90		
- 80		
- 70		
- 60		
- 50		
- 40		
- 30		
- 20		
- 10		
0		
+ 10		
+ 20		
+ 30		
+ 40		
+ 50		
+ 60		
+ 70		
+ 80		
+ 90		
+ 100		
+110		
+ 120		
+ 130		
+ 140		
+ 150		
+ 160		

Antenna elevation	LOWER BEAM ELEVATION counter M821	Antenna elevation counter	Antenna elevation	LOWER BEAM ELEVATION counter M821	Antenna elevation counter
+ 170			+ 8 0		
+ 180			+ 50		
+ 190			+ 40		
+200			+ 30		
+ 190			+ 20		
+ 180			+ 10		
+ 170			0		
+ 160			– 10		
+ 150			– 20		
+ 140			– 30		
+ 130			– 4 0		
+ 120			– 50		
+ 110			– 8 0		
+ 100			– 70		
+ 9 0			– 80		
+ 8 0			– 9 0		
+ 70			– 100		

Section XIII. TEST FACILITIES KIT MK-387/MPM-49 TROUBLESHOOTING AND REPAIR

3-66. Test Facilities Kit MK-387/MPM-49 troubleshooting and repair information

For troubleshooting and repair information of the Test Facilities Kit MK-387/MPM-49, refer to TM 11-6625-520-15.

APPENDIX A
REFERENCES

DA Pam 310-4	Indexes of Technical Publications Technical Manuals, Technical Bulletins, Supply Manuals (Types 7, 8, and 9), Supply Bulletins, and Lubrication Orders.
DA Pam 310-7	U.S. Army Equipment Index of Modification Work Orders.
SC 5180-91-CL-S21	Tool Kit, Electronic Equipment TK-100/G. (NSN 5180-00-605-0079).
TB 9-6625-975-35	Calibration Procedure for Ohmmeters I-48, I-48B, ZM-21A/U and ZM-21B/U. (Winslow Model 5G1000), and Biddle Models 7676-1,7679-1, and 7679-R.
TB 11-6125-217-12/1	Operator and Organizational Peventive Maintenance Services for Motor Generator PU-335/MPM-25.
TM 9-2330-213-14	Operator's, Organizational, Direct Support and General SuPPOrt Maintenance Manual (including Repair Parts and Special Tools Lists): Chassis, Trailer 1½-ton, 2-wheel, M103A1 (FSN 2330-835-8629), M103A2 (2330-049-8050), M103A3 and M103A3C (2330-141-8052), M103A4 (2330-141-8051), M103A4C (2330-542-2182); Trailer, Cargo: M104 (2330-754-0509), M104A1 (2330-835-8630), M105A1 (2330-835-8631), M105A2 (2330-141-8050), M105A2C (2330-542-5689); Trailer, Tank, Water: 1½-ton, 2-wheel, 400 gallon, M107A1 (2330-835-8633), M107A2 (2330-141-8049), M107A2C (2330-542-5688) and Trailer, Van, Shop, Folding Sides: 1 Vz-ton, 2-wheel, M448 (2330-631-5692).
TM 9-2330-234-15	Operator's, Organizational, Direct Support and General Support Maintenance Manual: (Including Repair Parts and Special Tools List): Chassis, Trailer 2½-Ton, 2-Wheel, M454 (2330-709-5847).
TM 11-1223	Computer Test Set TS-909/PPM Including Repair Parts and Special Tool Lists.
TM 11-1242	Crystal Rectifer Test Seta TS-268/U, TS-268A/U, TS-268B/U, TS-268C/U, TS-268D/U, and TS-268E/U.
TM 11-2050	Test set I-48-B and Ohmmeter ZM-21A/U.
TM 11-5099	Spectrum Analyzer AN/UPM-58.
TM 11-5840-208-ESC	Equipment Serviceability Criteria for Radar Set AN/MPQ-4A.
TM 11-5840-208-10	Operator's Manual for Radar Set AN/MPQ-4A (NSN 5840-00-543-0759).
TM 11-5840-208-20	Organizational Maintenance Manual: Radar Set, AN/MPQ-4A (NSN 5840-00-543-0759).
TM 11-5840-208-35P	Direct Support, General SupPOrt, and Depot Maintenance Repair Parts and Special Tools Lists Radar Set AN/MPQ-4A.
TM 11-5950-203-14P	Operator's, Organizational, Direct Support, and General Support Maintenance Repair Parts and Special Tools Lists (Including Depot Maintenance Repair Parts and Special Tools): Variable Power Transformer TF-171A/USM (FSN 5950-503-0632).
TM 11-6125-200-10	Operator's Manual Motor Generators PU-20/C, PU-20A/C, PU-20B/C, PU-20C/C, and PU-33/C.
TM 11-6125-217-14P	Operator's, Organizational, Direct Support, and General Support Maintenance Repair Parts and Special Tools Lists (Including Depot Maintenance Repair Parts and Special Tools): Motor Generator PU-335/MPM-25, FSN 6125-823-2257.
TM 11-6625-200-15	Operator's, Organizational, DS, GS, and Depot Maintenance Manual: Multimeters ME-26A/U, ME-26B/U, ME-26C/U, and ME-26D/U. (NSN 6625-00-646-9409).
TM 11-6625-218-12	Organizational Maintenance Manual: Frequency Meter AN/TSM-16.
TM 11-6625-228-12	Operation and Organizational Maintenance Radar Test Set AN/UPM-60A. (NSN 6625-00-569-0266).
TM 11-6625-228-20P	Organizational Maintenance Repair Parts and Special Tools List Test Sets, Radar AN/UPM-60 and AN/UPM-60A.
TM 11-6625-228-35	Field and Depot Maintenance Radar Test Set AN/UPM-60A.

TM 11-6625-237-14	Operator's, Organizational, Direct Support, and General Support Maintenance Manual for Generators, Puke AN/PPM-1 (NSN 6625-00-503-0661) and AN/PPM-1A (NSN 6625-00-503-3621).
TM 11-6625-258-14	Operator's, Organizational, Direct Support, and General Support Maintenance Manual: Signal Generator SG-299/U (NSN 6625-00-624-3516), SG-299A/U (NSN 6625-00-897-0060), SG-299B/U (NSN 6625-00-808-5584), SG-299C/U (NSN 6625-00-916-8541), SG-299D/U (NSN 6625-00-765-6656) , and SG-299E/U.
TM 11-6625-274-12	Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV-7/U, TV-7A/U, TV-7B/U, and TV-7D/U.
TM 11-6625-283-12	Operator and Organizational Maintenance Manual: Signal Generators TS-452B/U and TS-452C/U.
TM 11-6625-316-12	Operator's and Organizational Maintenance Manual: Test Sets, Electron Tube TV-2/U, TV-2A/U, TV-2B/U, and TV-2C/U.
TM 11-6625-320-12	Operator and Organizational Maintenance: Voltmeter, Meter ME-30A/U and Voltmeters, Electronic ME-30B/U, ME-30C/U, and ME-30E/U.
TM 11-6625-353-12	Operator and Organizational Maintenance Manual: Amplifiers, Radio Frequency AM-1881/U and AM-3026/U.
TM 11-6625-366-15	Operator's, Organizational, DS, GS, and Depot Maintenance Manual: Multimeter TS-352B/U.
TM 11-6625-393-12	Operator and Organizational Maintenance Manual: Test Sets, Radar AN/UPM-96.
TM 11-6625-404-12	Operator and Organizational Maintenance Manual: Test Set, Electron Tube TV-13A/U.
TM 11-6625-520-15	Operator's, Organizational, Direct Support, General Support, and Depot Maintenance Manual Including Repair Parts and Special Tools Lists: Maintenance Kit, Electronic Equipment MK-673/MPQ-4A (NSN 6625-00-064-6013).
TM 11-6625-541-12	Operator and Organizational Maintenance Manual: Simulator, Antenna Position SM-154/MPQ-4A. (NSN 6625-00-064-6010).
TM 11-6625-700-10	Operator's Manual: Digital Readout, Electronic Counter AN/USM-207. (NSN 6625-00-911-6368).
TM 11-6625-2658-14	Operator's, Organizational, Direct Support and General Support Maintenance Manual for Osciloscope AN/USM-281C (NSN 6625-00-106-9622).

GLOSSARY

A_L	Lower beam horizontal angle
A_U	Upper beam horizontal angle
ΔA	Delta azimuth
A_W	Weapon azimuth
A_Z	Antenna azimuth
C	A term used in azimuth and range computations.
E_L	Lower beam elevation
E_U	Upper beam elevation
H	Height
H_R	Radar height
H_W	Weapon height
h_L	Height of lower beam
h_U	Height of upper beam
R_L	Lower beam range
R_L	Ground range to lower beam intercept
R_U	Upper beam range
R_U	Ground range to upper beam intercept
R_W	Weapon range
ΔR	Delta range
$R_{W(E)}$	Weapon range casting
$R_{W(N)}$	Weapon range northing
Stc	Sensitivity time control
T	Time
ΔT	Delta time
Vswr	Voltage standing wave ratio
B,O,	Angles
$\cong$	Approximate equals

Analog computer. A computer in which voltages or shaft rotations are used as analogs of numbers.

Analog voltage. A voltage used in computing a problem which represents a number.

Azimuth scan. The area in a horizontal plane covered by one rotation of the scanner.

Azimuth strobe. Movable marker appearing on the indicator. Used to set exact azimuth of an echo into the computer.

Beam separation. The angle at the antenna made by the upper and lower beams.

Data. Any information regarding azimuth, elevation, and range used in computing the problem.

Dead time. A period during which the transmitter is blanked and the barrier teeth in the scanner pass each other without danger of arcing.

Duplexer. High-speed electronic switch which disconnects the receiver during transmit time and couples the receiver to the antenna when the transmitter is inoperative.

Electrical analog. Analog voltage.

Ferrite isolator. A device which allows energy to pass in one direction with little or no attenuation but greatly attenuates energy trying to pass in the opposite direction.

Lin-log amplifier. An amplifier having a high gain with little or no signal input. As signal strength exceeds a given value, the gain of the amplifier decreases at a logarithmic rate.

Mechanical analog. A shaft rotation which represents a number.

Pulse stretcher. An electronic circuit which operates as a voltage level holding circuit, (A given voltage level input of short duration will establish the output voltage level for a long period of time.)

Range., marker. Movable range mark controlled by the range hand wheel on the computer. Also called range strobe.

Range marks. Fixed range marks appearing on the indicator. Used to calibrate the range marker strobe.

Range strobe, (See Range marker.)

Scanner. The portion of the antenna group that causes the transmitted beam to be split into upper and lower beams for transmission and also causes each beam to sweep 25° in azimuth.

Sensitivity time control. A means of electronically controlling the gain of a receiving system so that gain is at minimum, at minimum range, and will increase to maximum gain at some predetermined range.

Slotted waveguide. A section of waveguide with slots cut into the wide side.

Tooth barrier. A device for directing the energy within the scanner in the proper direction.

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ARNG: State AG (3); Units-Same as Active Army except allowance is one (1) copy for each unit.

USAR: None.

For explanation of abbreviations used, see 310-50.

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL MANUALS

SOMETHING WRONG WITH THIS MANUAL?

THEN. . .JOT DOWN THE DOPE ABOUT IT ON THIS FORM, TEAR IT OUT, FOLD IT AND DROP IT IN THE MAIL!

FROM: (YOUR UNIT'S COMPLETE ADDRESS)
Commander
Stateside Army Depot
ATTN: AMSTA-US
Stateside, N.J. 07703

DATE 10 July 1975

PUBLICATION NUMBER	DATE	TITLE
TM 11-5840-340-12	23 Jan 74	Radar Set AN/[illegible]C-76

BE EXACT. . .PIN-POINT WHERE IT IS

PAGE NO.	PARAGRAPH	FIGURE NO.	TABLE NO.	IN THIS SPACE TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT:
2-25	2-28			Recommend that the installation antenna alignment procedure be changed throughout to specify a 2° IFF antenna lag rather than 1°. REASON: Experience has shown that with only a 1° lag, the antenna servo system is too sensitive to wind gusting in excess of [illegible] knots, and has a tendency to rapidly accelerate and decelerate as it hunts, causing strain to the drive train. Hunting is minimized by adjusting the lag to 2° without degradation of operation.
3-10	3-3		3-1	Item 5, Function column. Change "2 db" to "3db." REASON: The adjustment procedure for the TRANS POWER FAULT indicator calls for a 3 db (500 watts) adjustment to light the TRANS POWER FAULT indicator.
5-6	5-8			Add new step f.1 to read, "Replace cover plate removed in step e.1, above." REASON: To replace the cover plate.
		F03		Zone C 3. On J1-2, change "+24 VDC to "+5 VDC." REASON: This is the output line of the 5 VDC power supply. + 24 VDC is the input voltage.

SAMPLE

TEAR ALONG DOTTED LINE

TYPED NAME, GRADE OR TITLE, AND TELEPHONE NUMBER
SSG I. M. DeSpiritof 999-1776

SIGN HERE: SSG I.M. DeSpiritof

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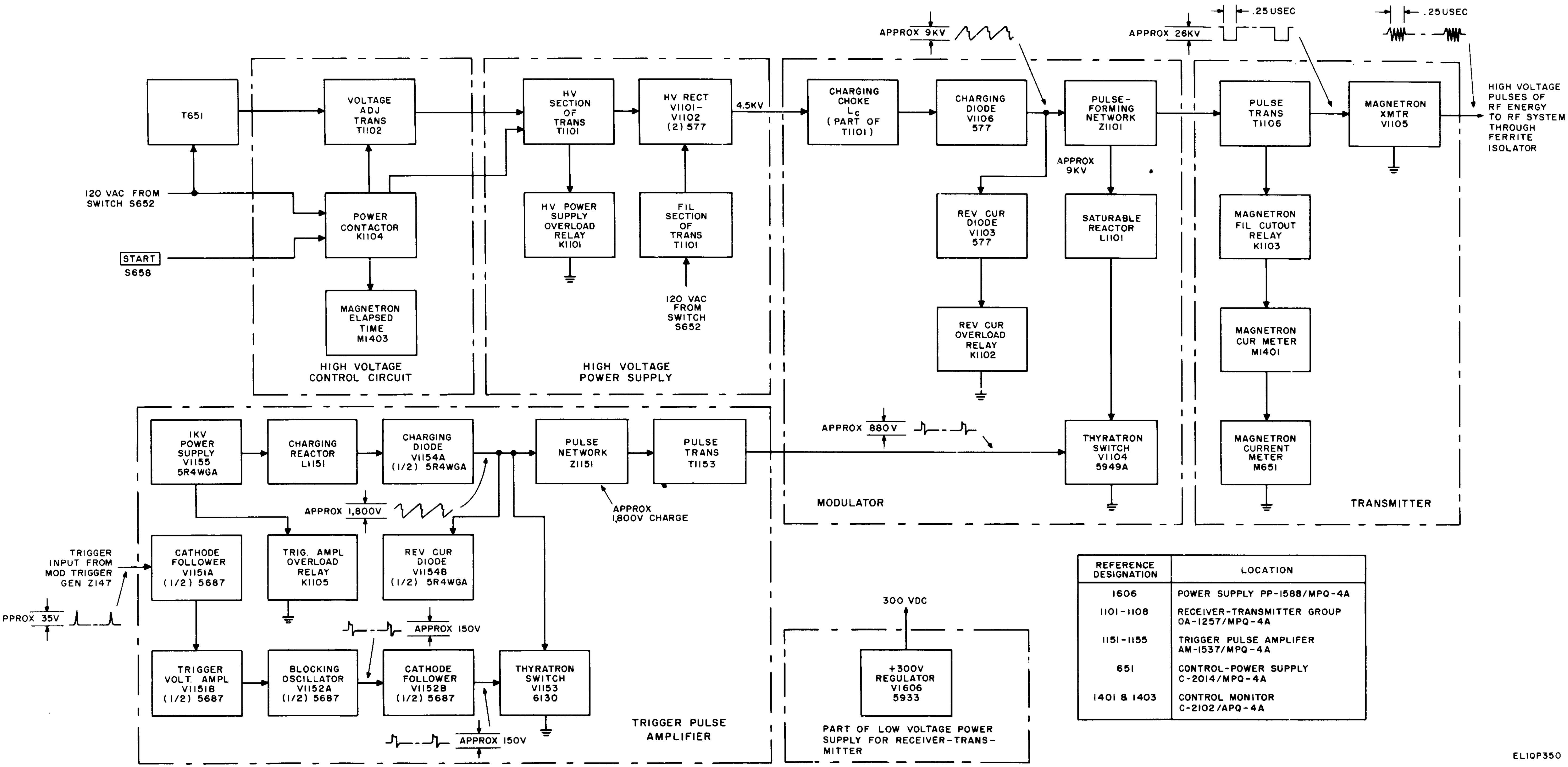
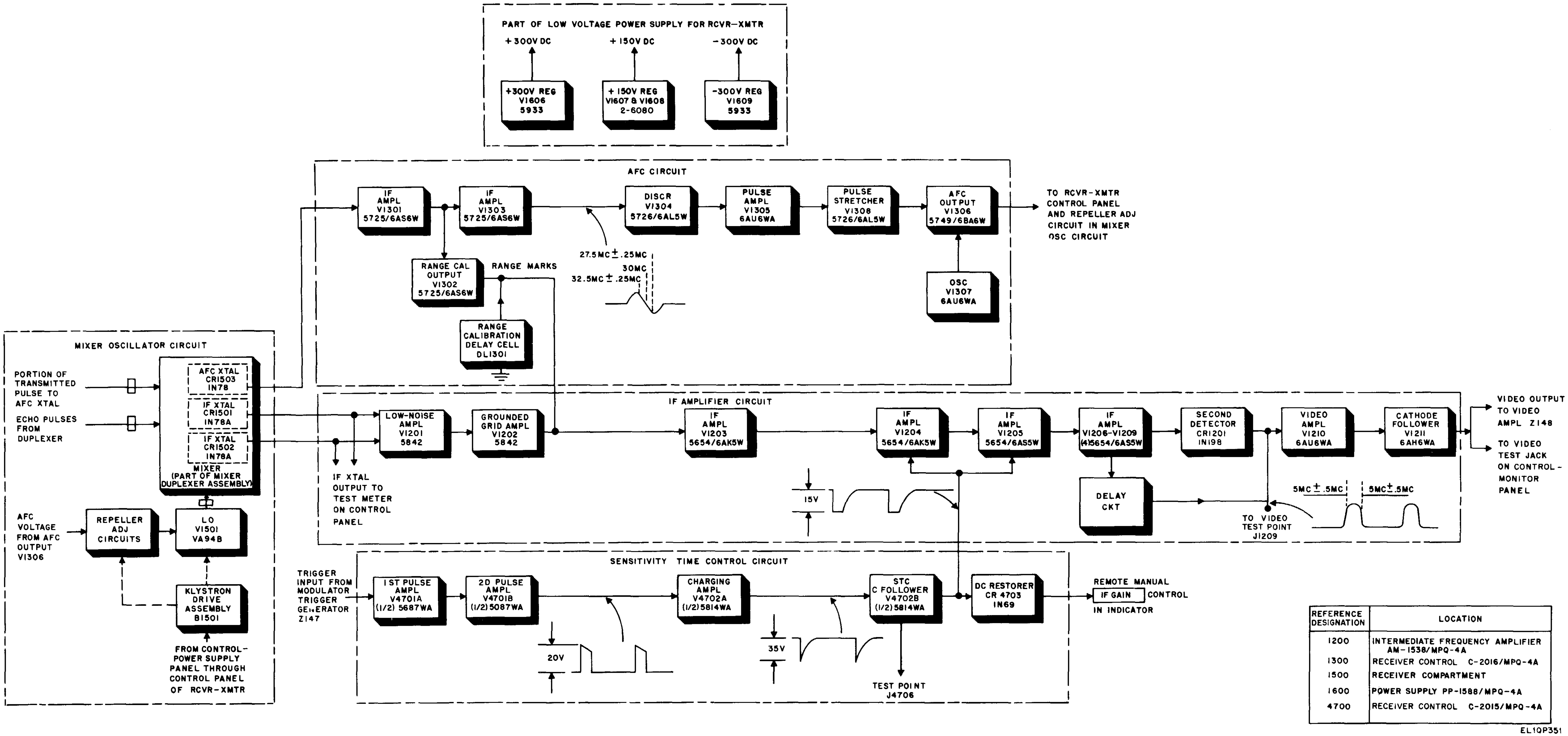
Figure FO-1①. Radar Set AN/MPQ-4A, block diagram (sheet 1 of 2)

Figure FO-1(3). Radar Set AN/MPQ-4A, block diagram (sheet 2 of 2).



REFERENCE DESIGNATION	LOCATION
1606	POWER SUPPLY PP-1588/MPQ-4A
1101-1108	RECEIVER-TRANSMITTER GROUP OA-1257/MPQ-4A
1151-1155	TRIGGER PULSE AMPLIFER AM-1537/MPQ-4A
651	CONTROL-POWER SUPPLY C-2014/MPQ-4A
1401 & 1403	CONTROL MONITOR C-2102/APQ-4A

Figure FO-2. Transmitting system, black diagram.



REFERENCE DESIGNATION	LOCATION
1200	INTERMEDIATE FREQUENCY AMPLIFIER AM-1538/MPQ-4A
1300	RECEIVER CONTROL C-2016/MPQ-4A
1500	RECEIVER COMPARTMENT
1600	POWER SUPPLY PP-1588/MPQ-4A
4700	RECEIVER CONTROL C-2015/MPQ-4A

Figure FO-3. Receiving system, block diagram.

Figure FO-4. Synchronizing and indicating systems, block diagram.

Figure FO-5. Timing sweep generator Z102.

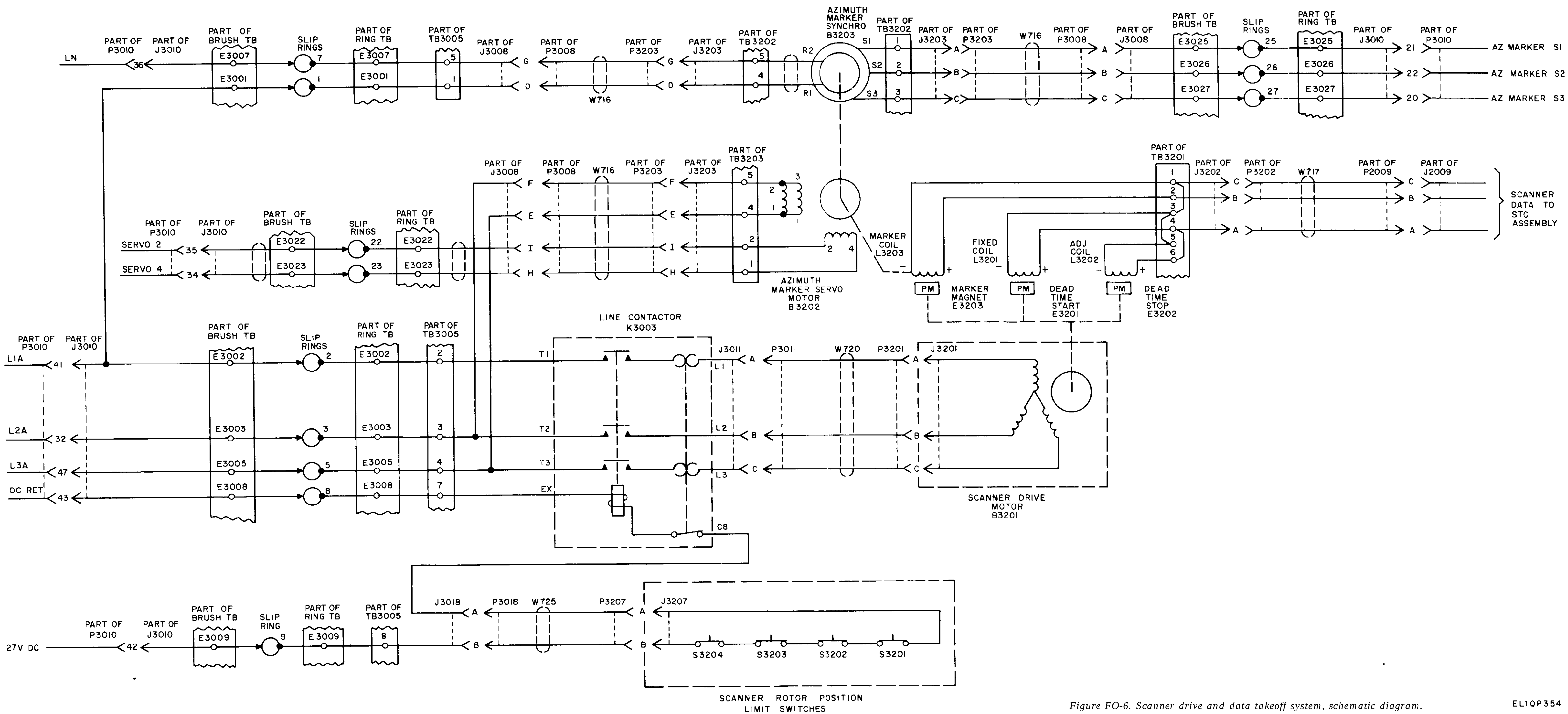


Figure FO-6. Scanner drive and data takeoff system, schematic diagram.

EL1QP354

Figure FO-7. Computing system, block diagram.

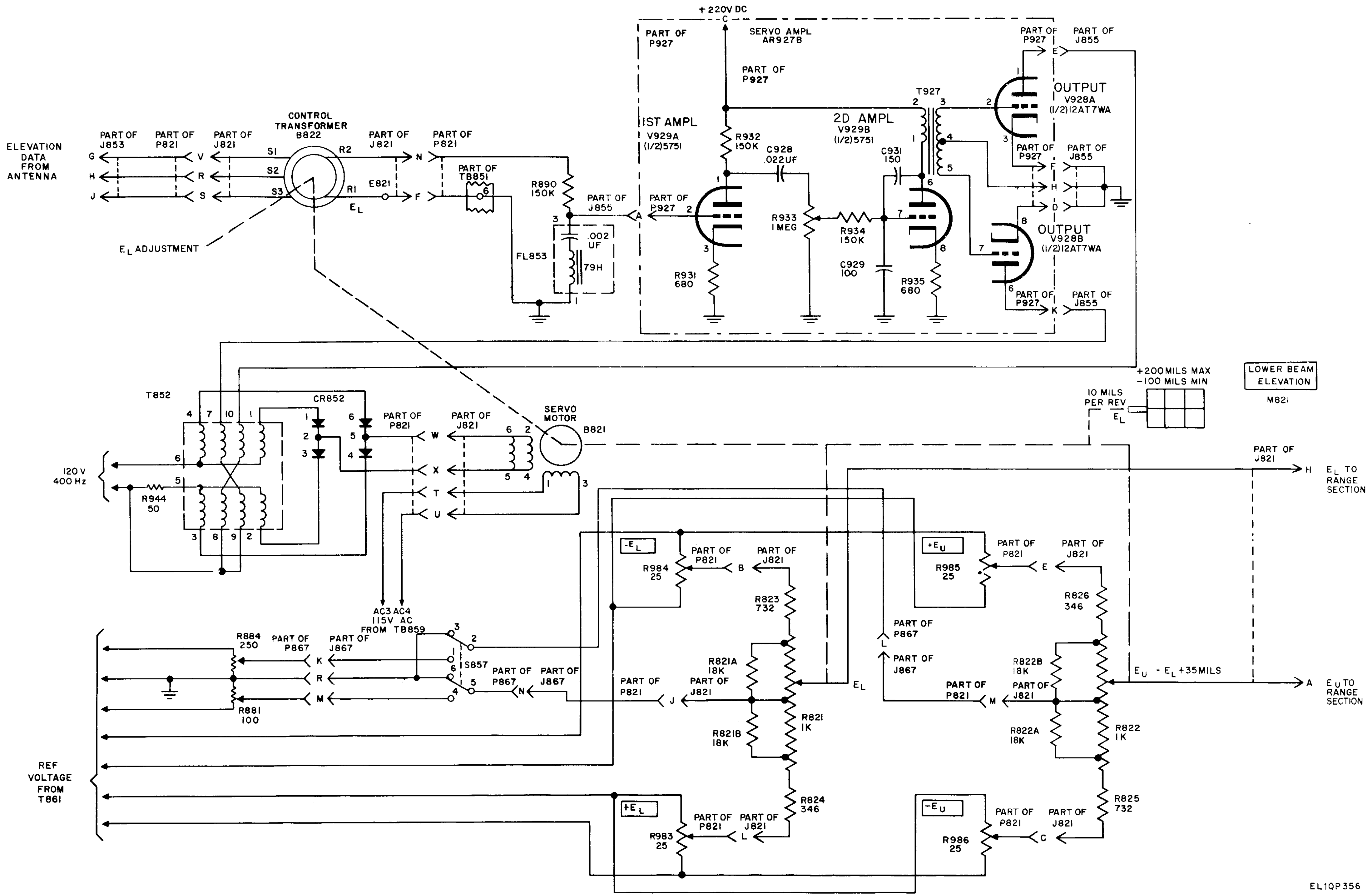


Figure FO-8. Elevation section, schematic diagram.

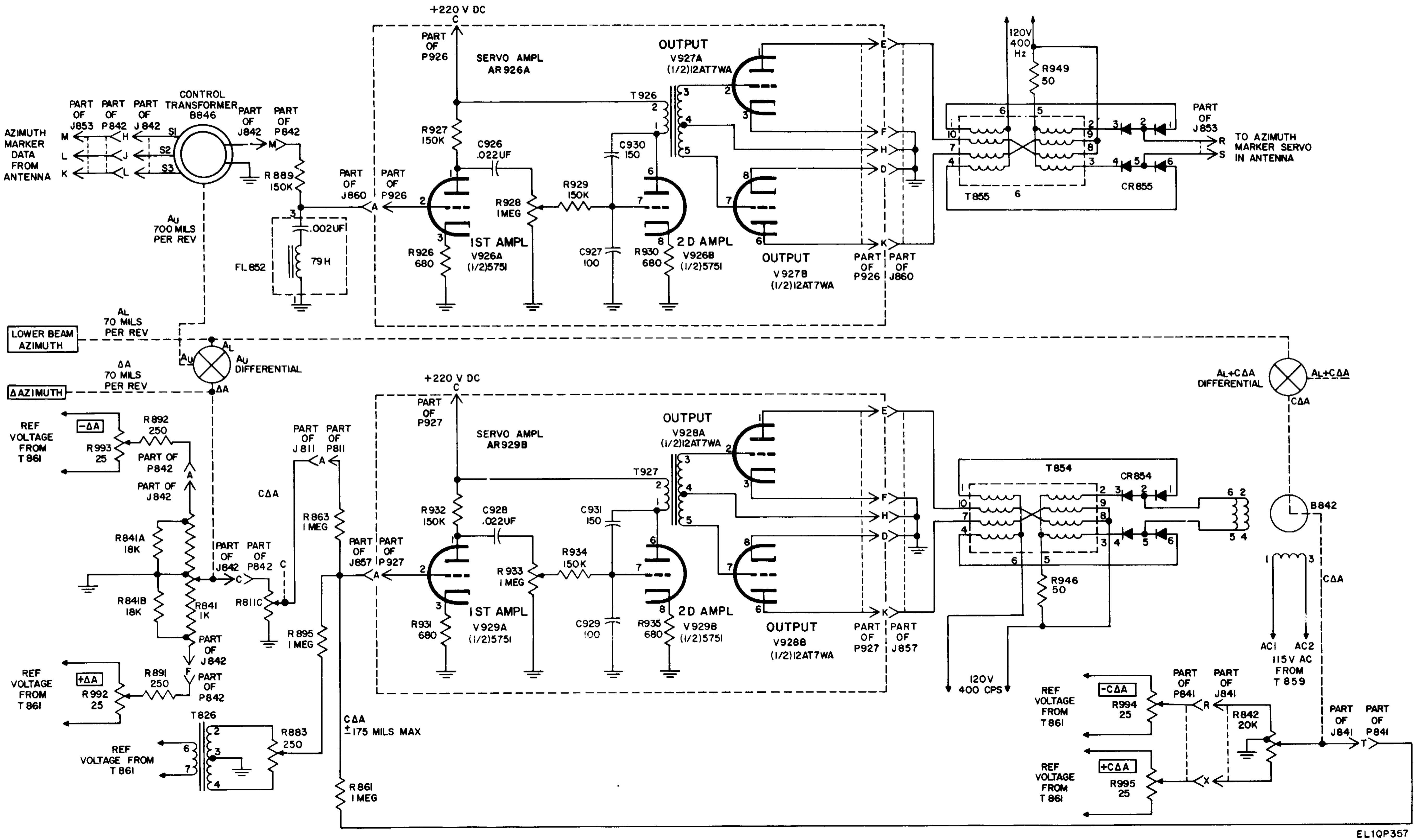


Figure FO-9 ①. Azimuth section, schematic diagram (sheet 1 of 2).

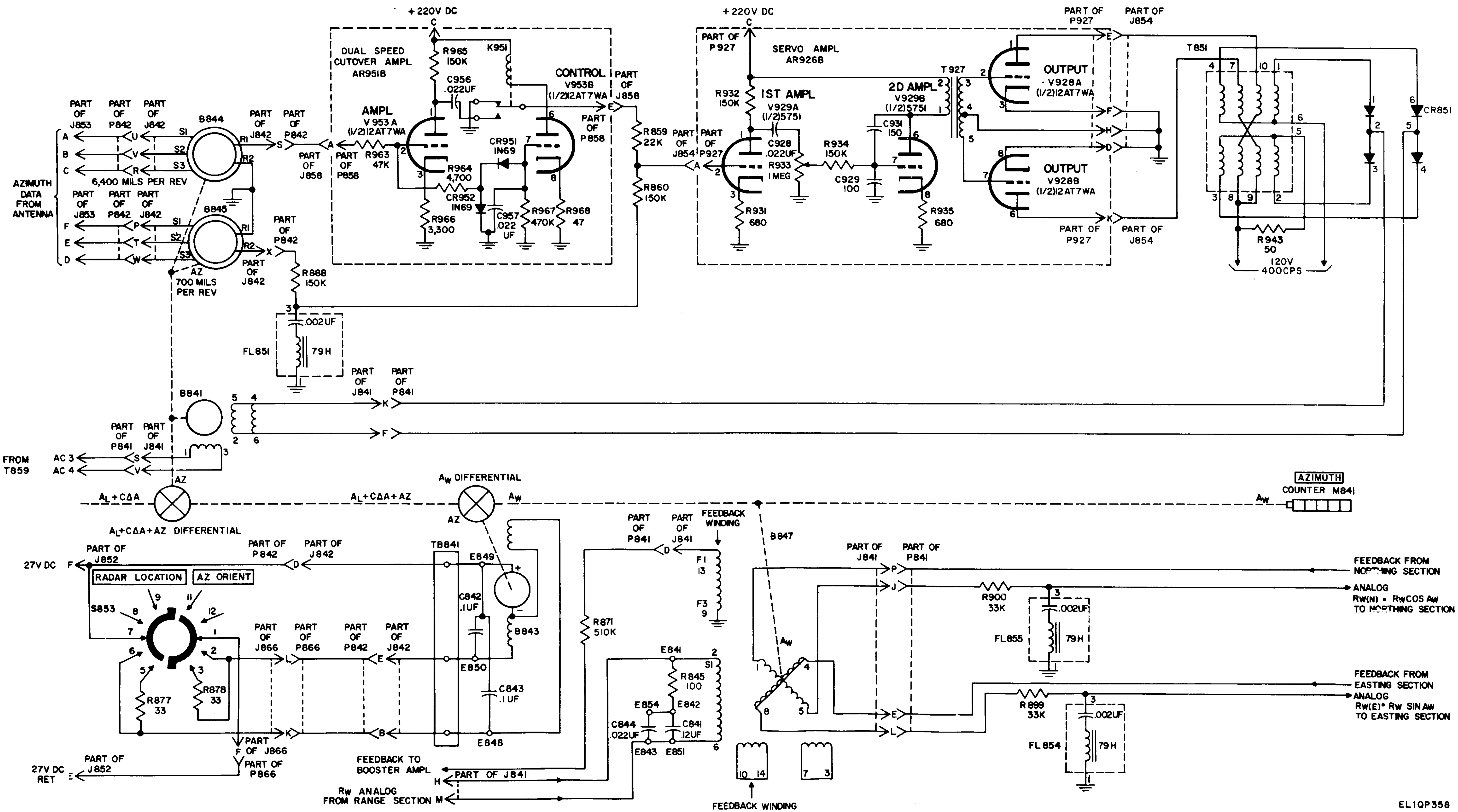


Figure FO-9 ②. Azimuth section, schematic diagram (sheet 2 of 2).

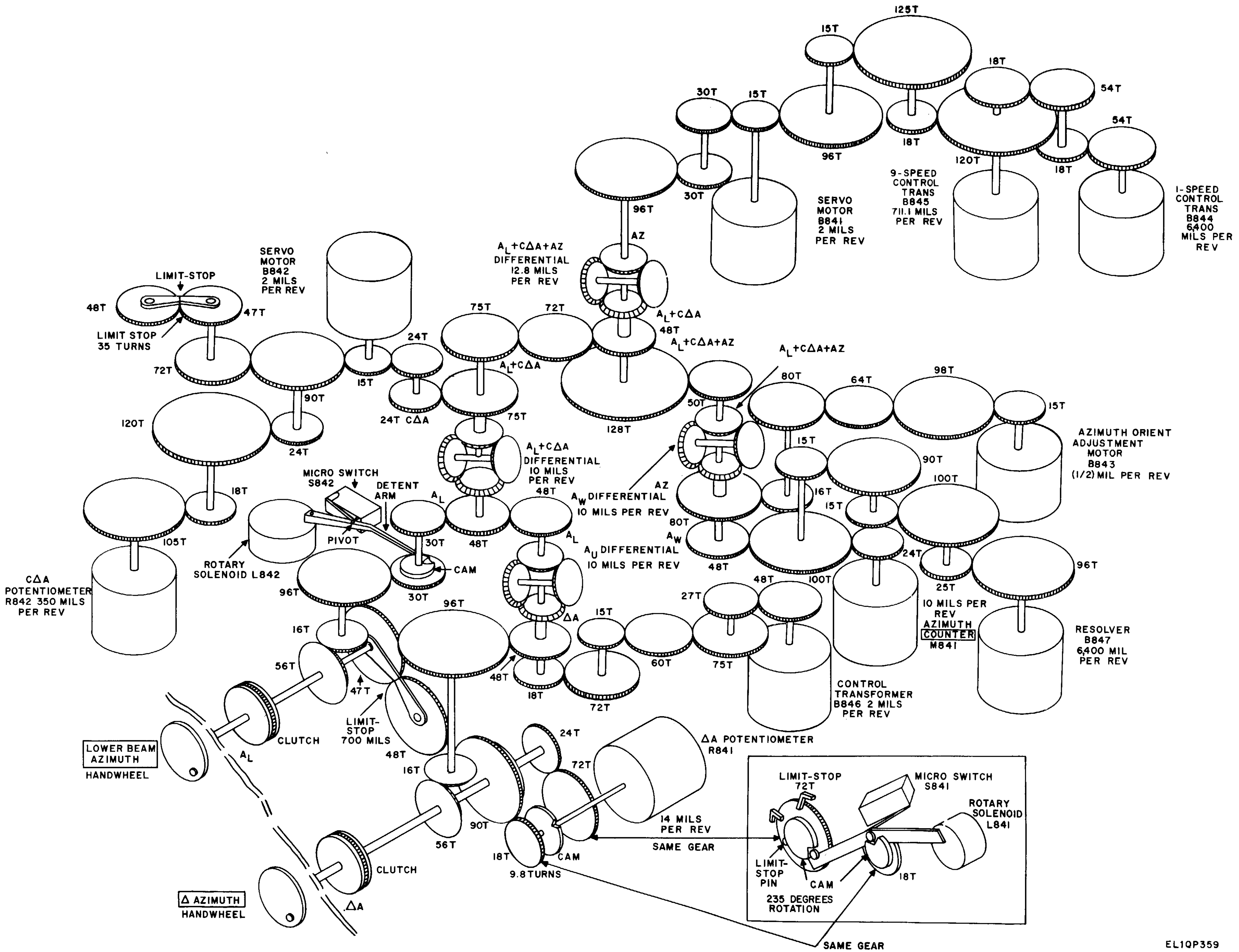


Figure FO-10. Azimuth subassembly.

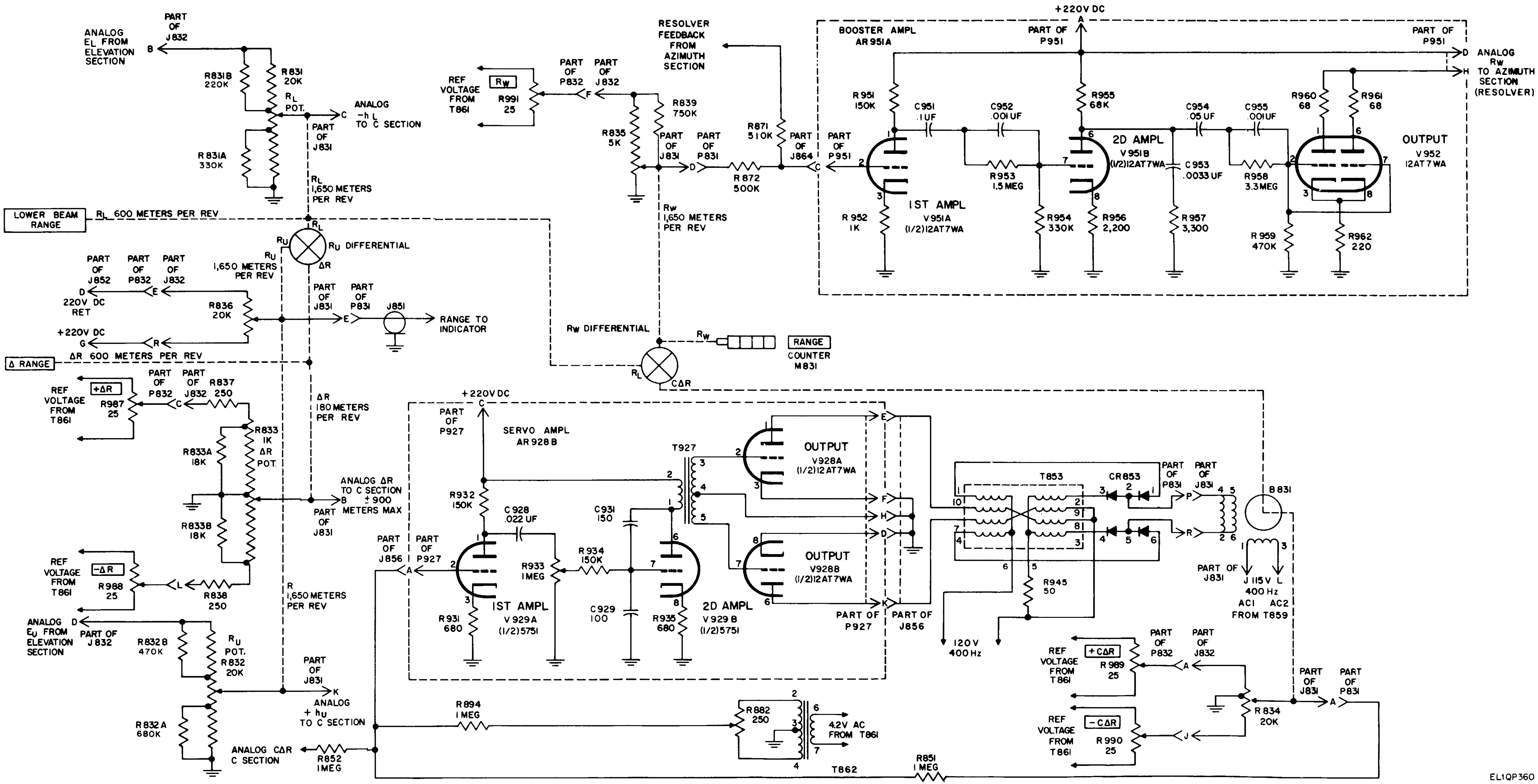


Figure FO-11. Range section schematic diagram.

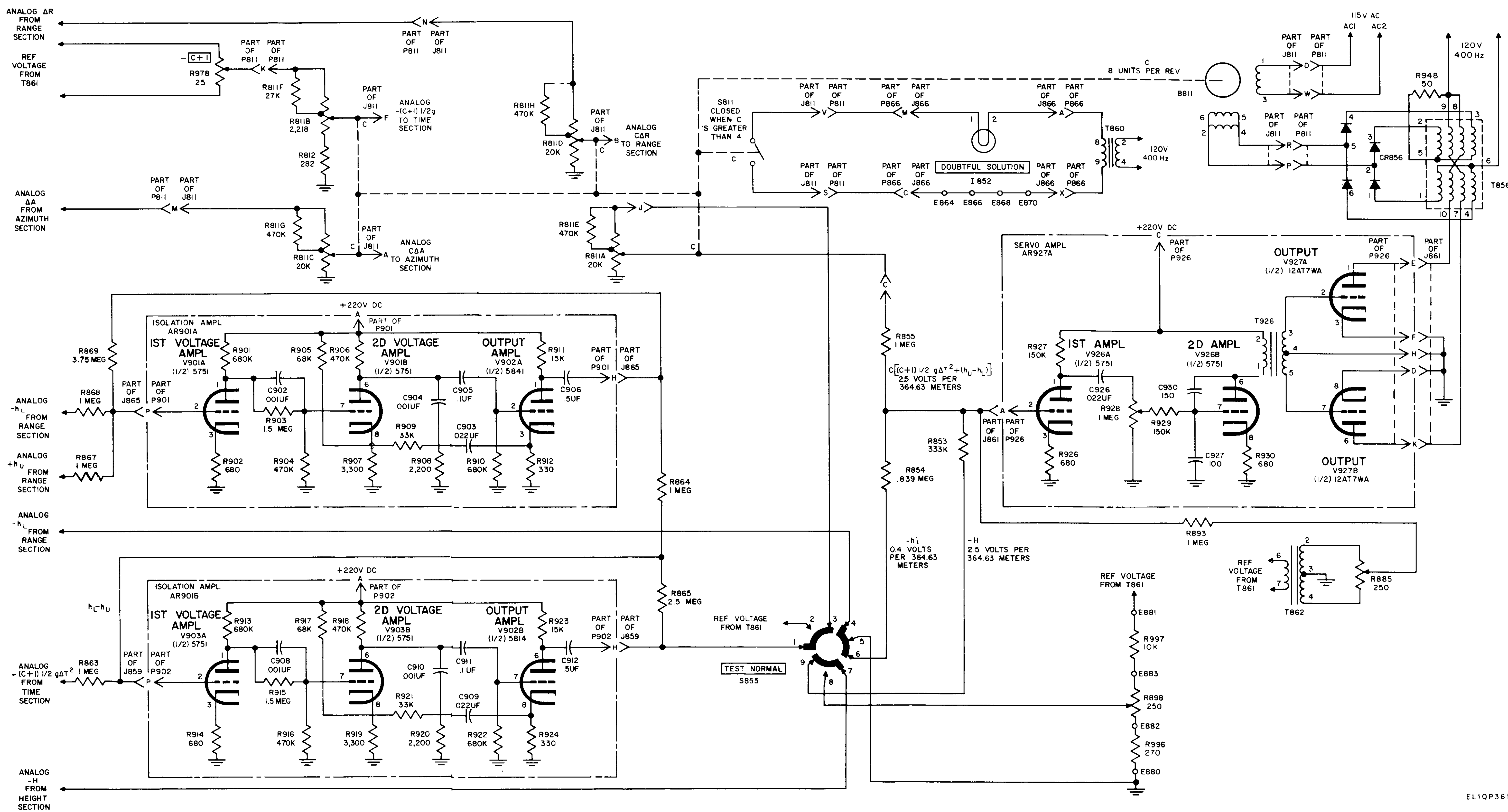


Figure FO-12. C section, schematic diagram.

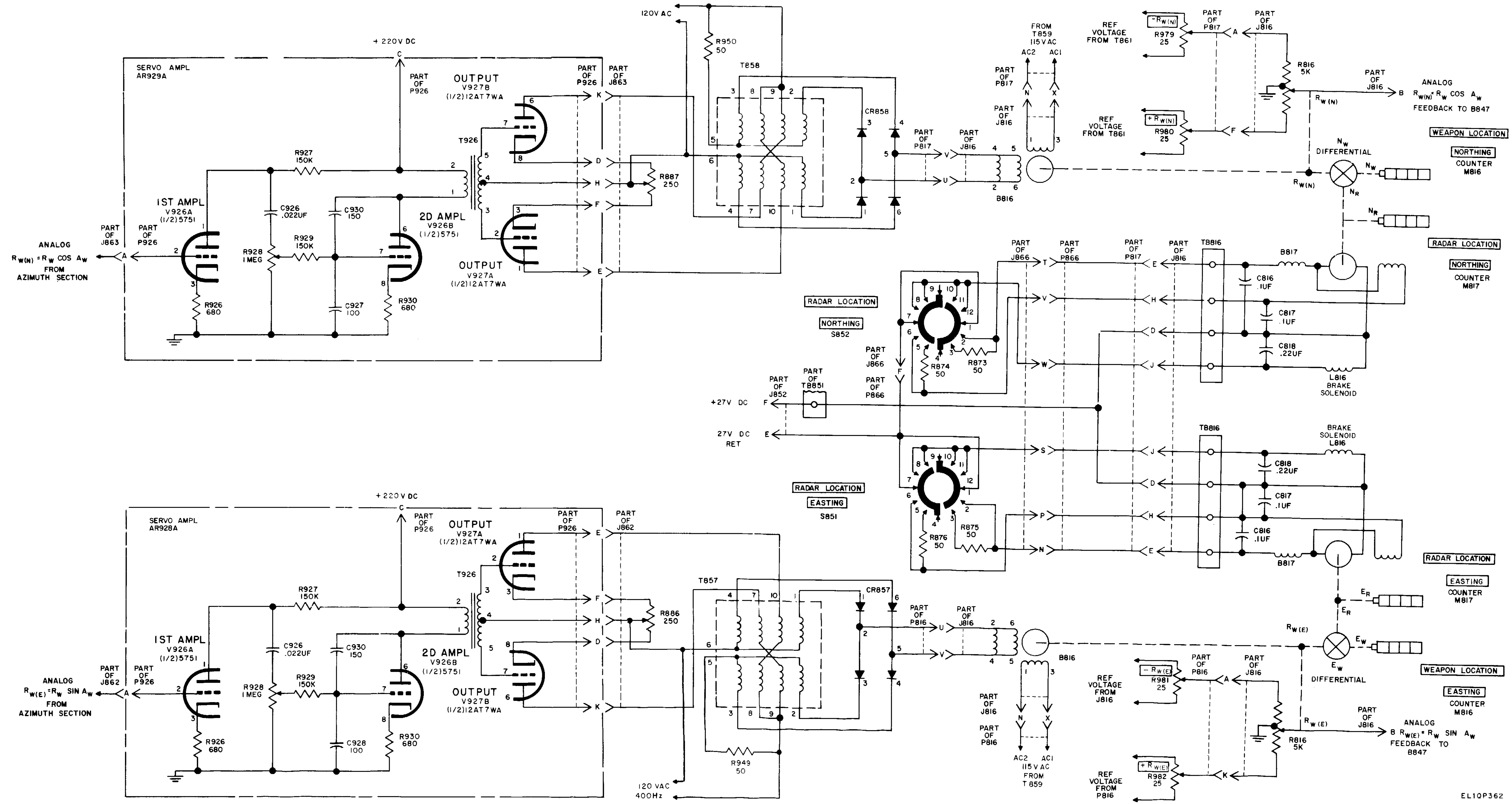


Figure FO-13. Coordinate sections, schematic diagram.

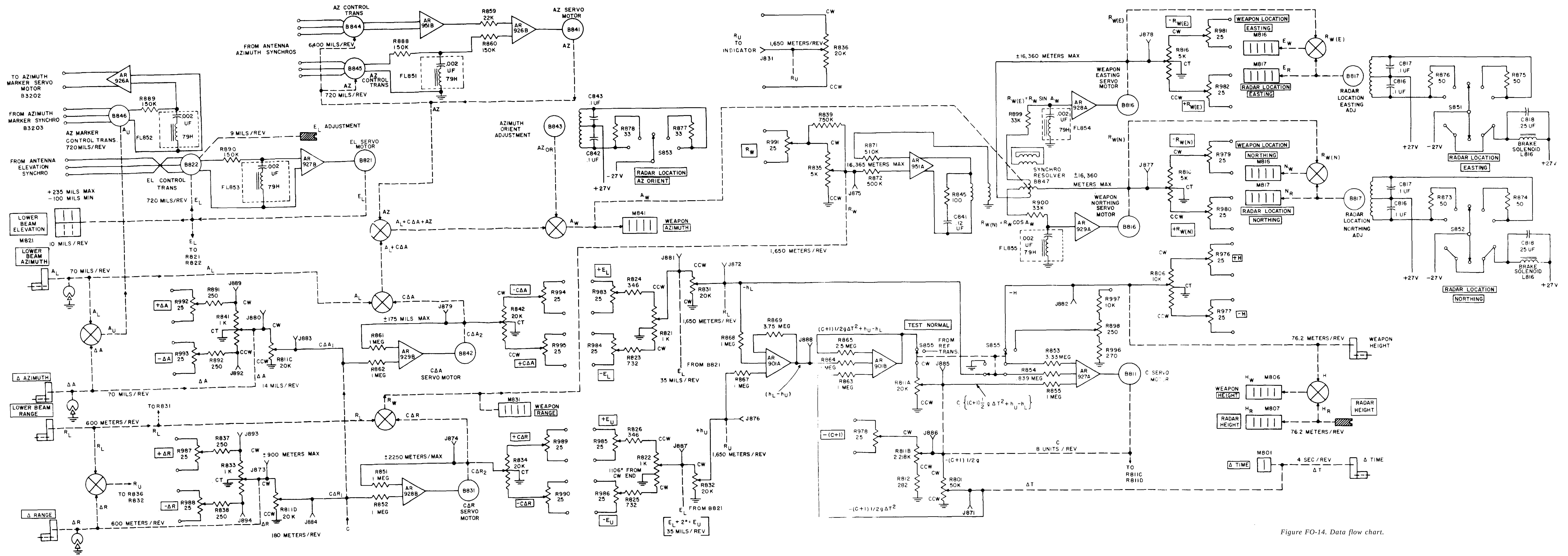


Figure FO-14. Data flow chart.

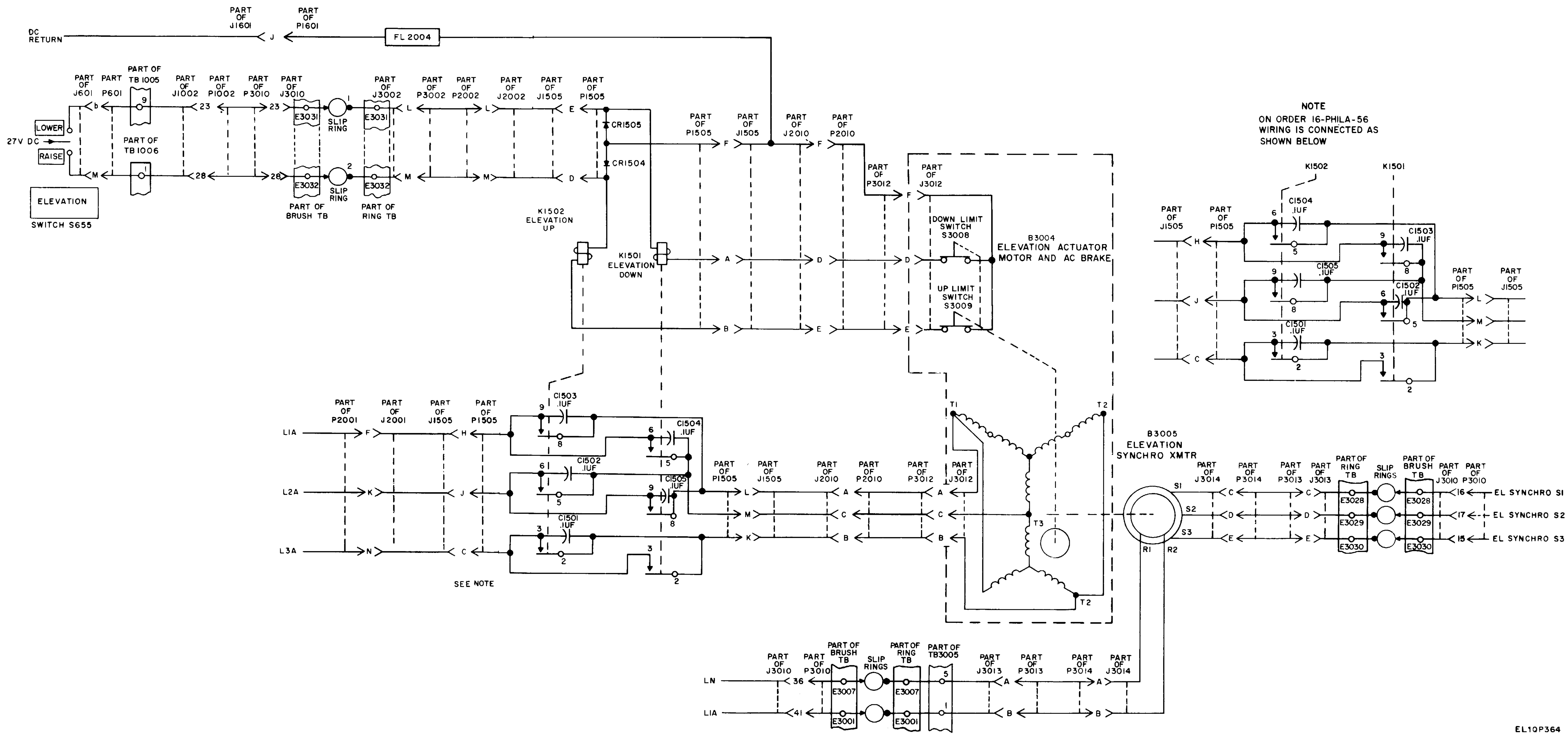


Figure FO-15. Elevation actuator motor B3004 and elevation data transmitter, schematic diagram.

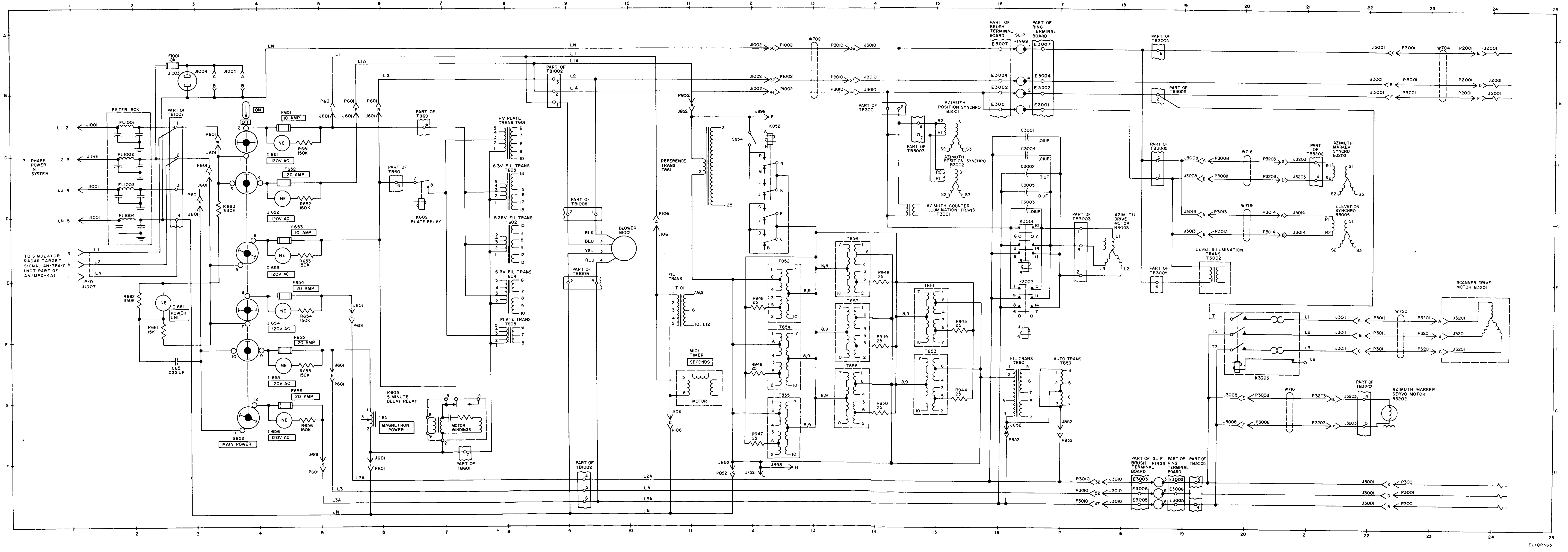


Figure FO-16 ①. *Ac power distribution diagram* (sheet 1 of 2).

Figure FO-16 (2). Ac power distribution diagram (sheet 2 of 2).

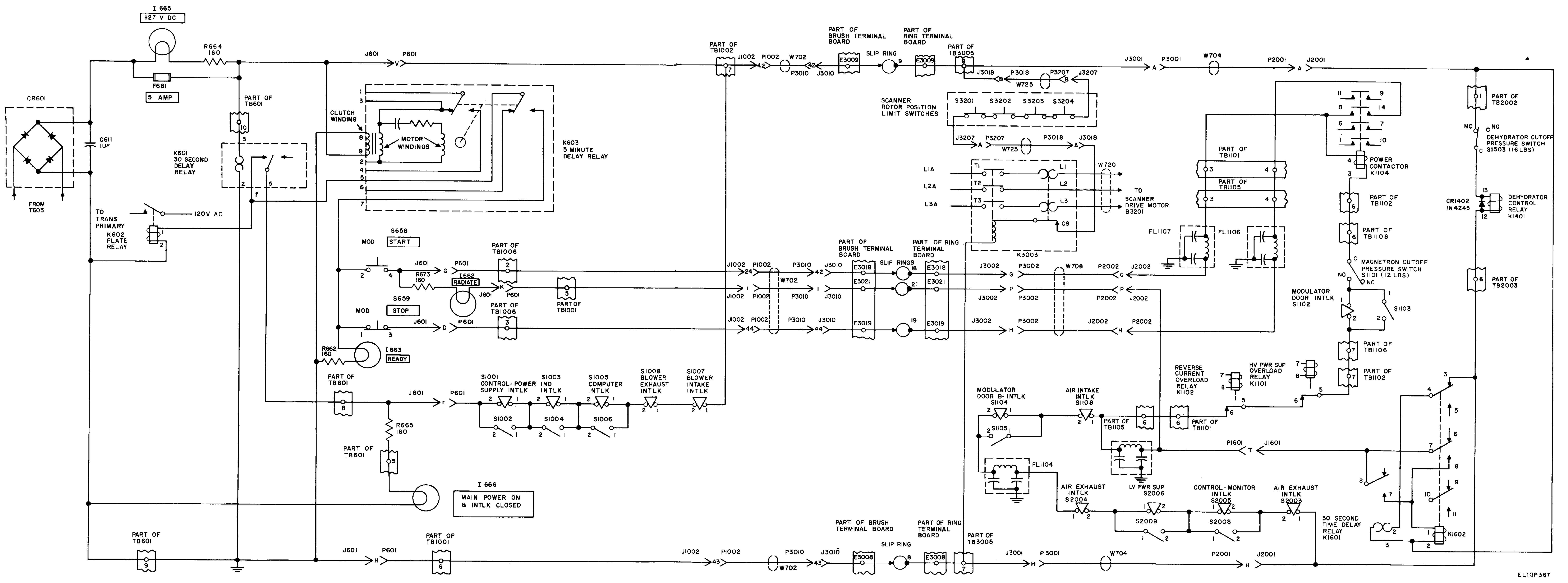
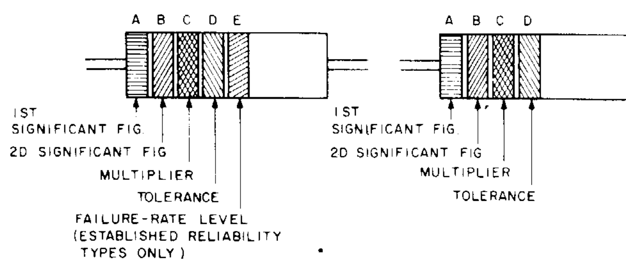
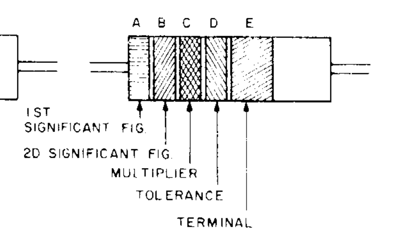


Figure FO-17. Dc control circuits diagram.

Figure FO-18. Reference transformer T861 and computer alignment potentiometers, schematic diagram.



COLOR CODE MARKING FOR COMPOSITION TYPE RESISTORS.



COLOR-CODE MARKING FOR FILM-TYPE RESISTORS.

TABLE 1
COLOR CODE FOR COMPOSITION TYPE AND FILM TYPE RESISTORS.

BAND A		BAND B		BAND C		BAND D		BAND E		
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)	COLOR	FAILURE RATE LEVEL	TERM.
BLACK	0	BLACK	0	BLACK	1			BROWN	M=1.0	
BROWN	1	BROWN	1	BROWN	10			RED	P=0.1	
RED	2	RED	2	RED	100			ORANGE	R=0.01	
ORANGE	3	ORANGE	3	ORANGE	1,000			YELLOW	S=0.001	
YELLOW	4	YELLOW	4	YELLOW	10,000	SILVER	±10 (COMP. TYPE ONLY)	WHITE		SOLD-ERABLE
GREEN	5	GREEN	5	GREEN	100,000	GOLD	±5			
BLUE	6	BLUE	6	BLUE	1,000,000	RED	±2 (NOT APPLICABLE TO ESTABLISHED RELIABILITY).			
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7							
GRAY	8	GRAY	8	SILVER	0.01					
WHITE	9	WHITE	9	GOLD	0.1					

BAND A — THE FIRST SIGNIFICANT FIGURE OF THE RESISTANCE VALUE (BANDS A THRU D SHALL BE OF EQUAL WIDTH)

BAND B — THE SECOND SIGNIFICANT FIGURE OF THE RESISTANCE VALUE.

BAND C — THE MULTIPLIER (THE MULTIPLIER IS THE FACTOR BY WHICH THE TWO SIGNIFICANT FIGURES ARE MULTIPLIED TO YIELD THE NOMINAL RESISTANCE VALUE.)

BAND D — THE RESISTANCE TOLERANCE.

BAND E — WHEN USED ON COMPOSITION RESISTORS, BAND E INDICATES ESTABLISHED RELIABILITY FAILURE-RATE LEVEL (PERCENT FAILURE PER 1,000 HOURS) ON FILM RESISTORS, THIS BAND SHALL BE APPROXIMATELY 1-1/2 TIMES THE WIDTH OF OTHER BANDS, AND INDICATES TYPE OF TERMINAL

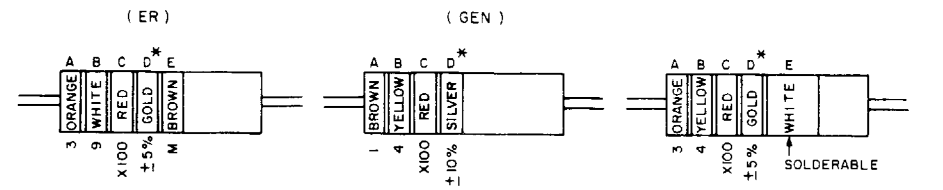
RESISTANCES IDENTIFIED BY NUMBERS AND LETTERS
(THESE ARE NOT COLOR CODED)

SOME RESISTORS ARE IDENTIFIED BY THREE OR FOUR DIGIT ALPHA NUMERIC DESIGNATORS. THE LETTER R IS USED IN PLACE OF A DECIMAL POINT WHEN FRACTIONAL VALUES OF AN OHM ARE EXPRESSED. FOR EXAMPLE:

2R7 = 2.7 OHMS   10R0 = 10.0 OHMS

FOR WIRE-WOUND-TYPE RESISTORS COLOR CODING IS NOT USED, IDENTIFICATION MARKING IS SPECIFIED IN EACH OF THE APPLICABLE SPECIFICATIONS.

EXAMPLES OF COLOR CODING



NOMINAL RESISTANCE 3,900 OHMS
RESISTANCE TOLERANCE ±5%
FAILURE RATE LEVEL M

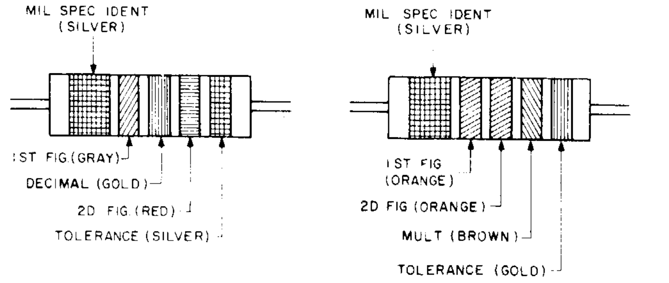
NOMINAL RESISTANCE 1,400 OHMS
RESISTANCE TOLERANCE ±10%

NOMINAL RESISTANCE 3,400 OHMS
RESISTANCE TOLERANCE ±5%
TERMINAL SOLDERABLE

COMPOSITION-TYPE RESISTORS   FILM-TYPE RESISTORS

* IF BAND D IS OMITTED, THE RESISTOR TOLERANCE IS ± 20% AND THE RESISTOR IS NOT MIL-STD

A. COLOR CODE MARKING FOR MILITARY STANDARD RESISTORS.



(A) 8.2UH ± 10%   (B) 330UH ± 5%

COLOR CODING FOR TUBULAR ENCAPSULATED R.F CHOKES. AT A, AN EXAMPLE OF OF THE CODING FOR AN 8.2UH CHOKE IS GIVEN. AT B, THE COLOR BANDS FOR A 330UH INDUCTOR ARE ILLUSTRATED

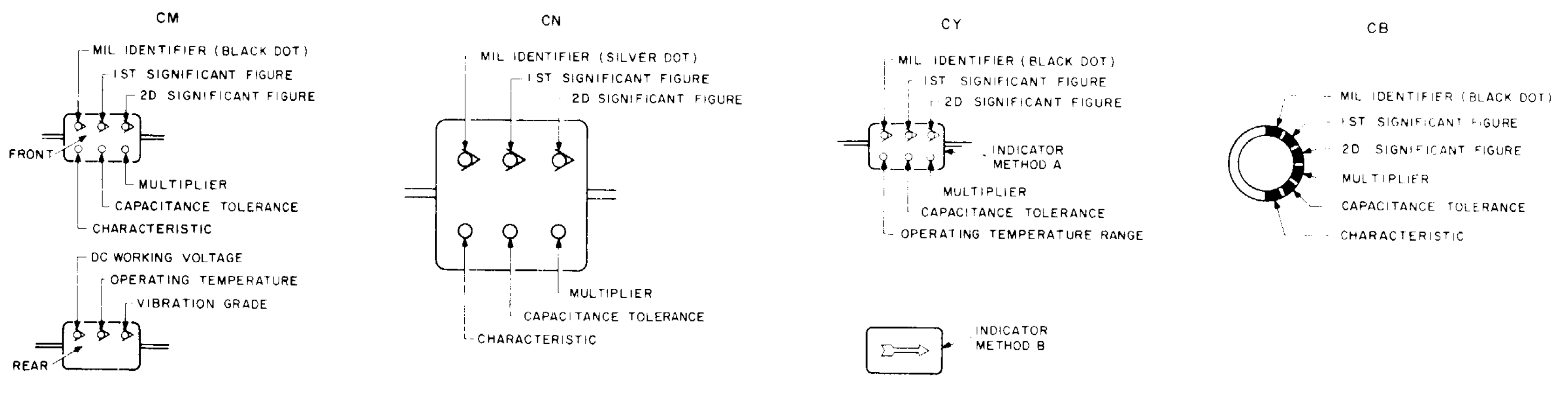
TABLE 2
COLOR CODING FOR TUBULAR ENCAPSULATED R.F CHOKES.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	INDUCTANCE TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	1
RED	2	100	2
ORANGE	3	1,000	3
YELLOW	4		
GREEN	5		
BLUE	6		
VIOLET	7		
GRAY	8		
WHITE	9		
NONE			20
SILVER			10
GOLD	DECIMAL POINT		5

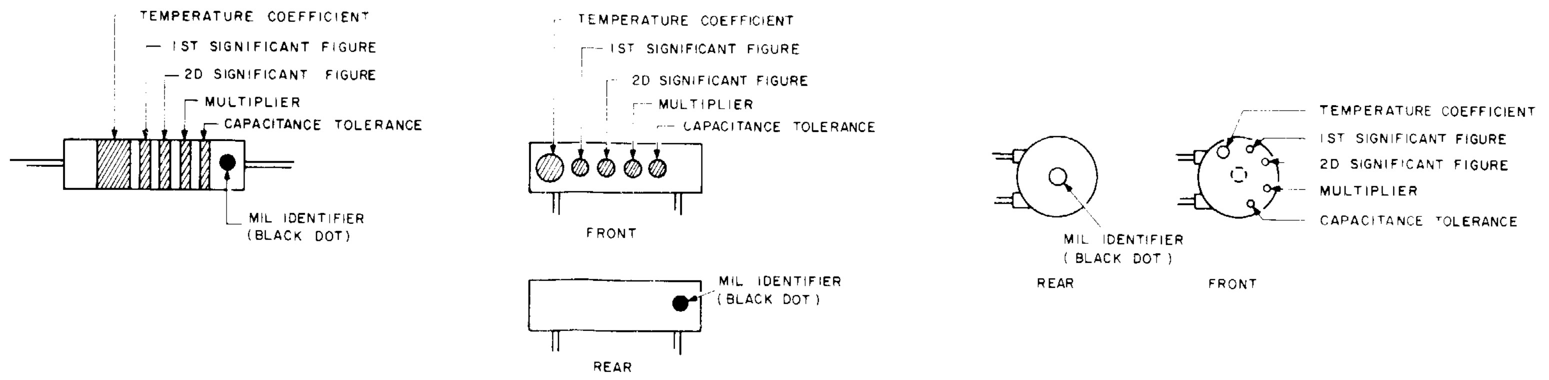
MULTIPLIER IS THE FACTOR BY WHICH THE TWO COLOR FIGURES ARE MULTIPLIED TO OBTAIN THE INDUCTANCE VALUE OF THE CHOKE COIL.

B. COLOR CODE MARKING FOR MILITARY STANDARD INDUCTORS.

CAPACITORS, FIXED, VARIOUS-DIELECTRICS, STYLES CM, CN, CY, AND CB



MICA-DIELECTRIC   PAPER-DIELECTRIC   GLASS-DIELECTRIC, GLASS CASE   MICA, BUTTON TYPE



AXIAL LEAD   RADIAL LEAD   DISK-TYPE

TABLE 3 — FOR USE WITH STYLES CM, CN, CY AND CB.

COLOR	MIL ID	1ST SIG FIG.	2D SIG FIG	MULTIPLIER	CAPACITANCE TOLERANCE				CHARACTERISTIC [2]			DC WORKING VOLTAGE	OPERATING TEMP RANGE	VIBRATION GRADE
					CM	CN	CY	CB	CM	CN	CB	CM	CY, CM	CM
BLACK	CM, CY CB	0	0	1			±20%	±20%		A			$-55°$ TO $+70°C$	10-55 HZ
BROWN		1	1	10					B	E	B			
RED		2	2	100	±2%		±2%	±2%	C				$-55°$ TO $+85°C$	
ORANGE		3	3	1,000		±30%			D		D	300		
YELLOW		4	4	10,000					E				$-55°$ TO $+125°C$	10-2,000HZ
GREEN		5	5		±5%				F			500		
BLUE		6	6										$-55°$ TO $+150°C$	
PURPLE (VIOLET)		7	7											
GRAY		8	8											
WHITE		9	9											
GOLD				0.1			±5%	±5%						
SILVER	CN			0.01	±10%	±10%	±10%	±10%						

TABLE 4 — TEMPERATURE COMPENSATING, STYLE CC.

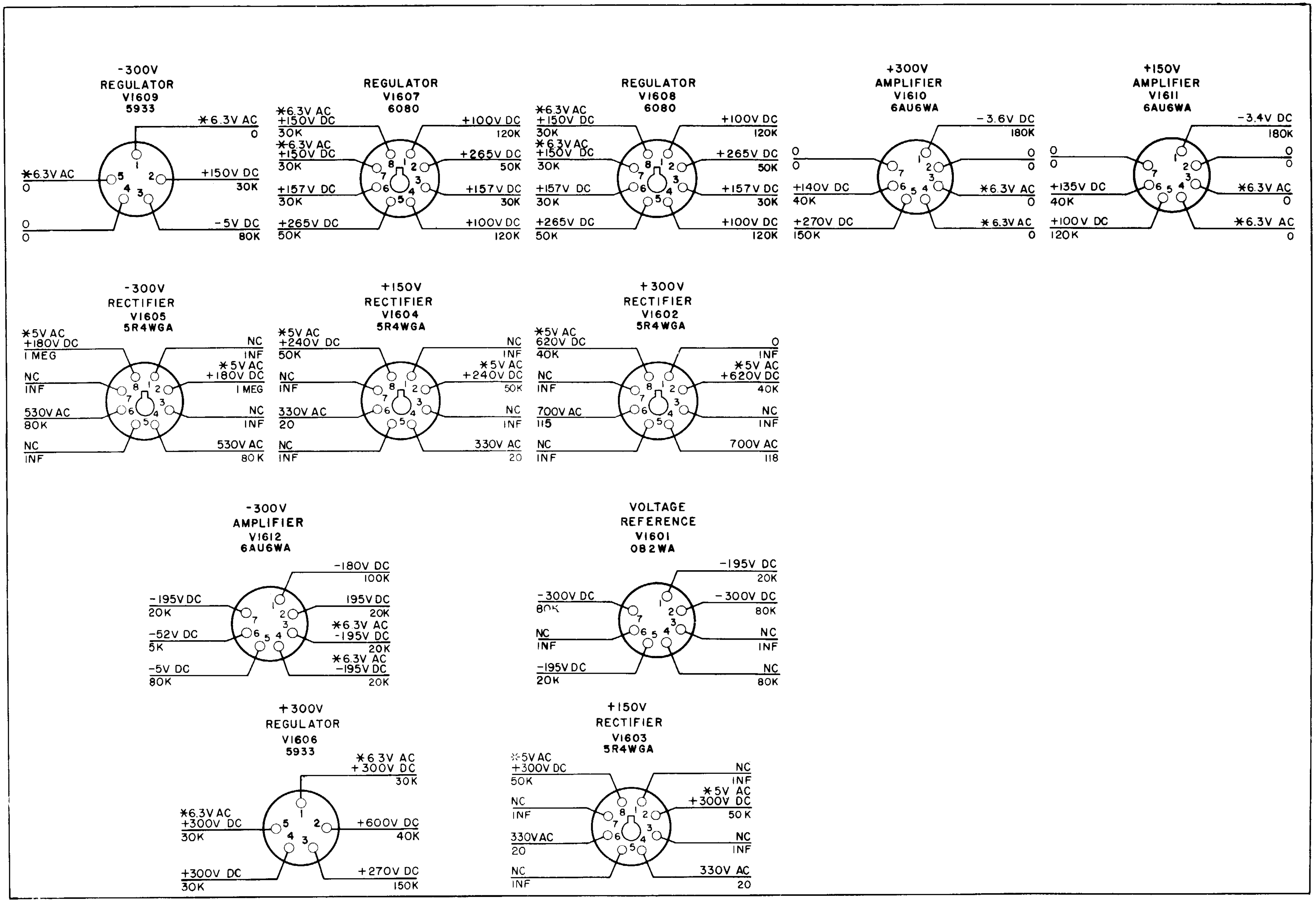
COLOR	TEMPERATURE COEFFICIENT [4]	1ST SIG FIG.	2D SIG FIG.	MULTIPLIER [1]	CAPACITANCE TOLERANCE		MIL ID
					CAPACITANCES OVER 10 UUF	CAPACITANCES 10 UUF OR LESS	
BLACK	0	0	0	1		± 2.0 UUF	CC
BROWN	−30	1	1	10	± 1%		
RED	−80	2	2	100	±2 %	± 0.25 UUF	
ORANGE	−150	3	3	1,000			
YELLOW	−220	4	4				
GREEN	−330	5	5		± 5 %	± 0.5 UUF	
BLUE	−470	6	6				
PURPLE (VIOLET)	−750	7	7				
GRAY		8	8	0.01*			
WHITE		9	9	0.1*	± 10%		
GOLD	+100			0.1		± 1.0 UUF	
SILVER				0.01			

1. THE MULTIPLIER IS THE NUMBER BY WHICH THE TWO SIGNIFICANT (SIG) FIGURES ARE MULTIPLIED TO OBTAIN THE CAPACITANCE IN UUF.
2. LETTERS INDICATE THE CHARACTERISTICS DESIGNATED IN APPLICABLE SPECIFICATIONS: MIL-C-5, MIL-C-25D, MIL-C-11272B, AND MIL-C-10950C RESPECTIVELY.
3. LETTERS INDICATE THE TEMPERATURE RANGE AND VOLTAGE-TEMPERATURE LIMITS DESIGNATED IN MIL-C-11015D.
4. TEMPERATURE COEFFICIENT IN PARTS PER MILLION PER DEGREE CENTIGRADE.

* OPTIONAL CODING WHERE METALLIC PIGMENTS ARE UNDESIRABLE.

C. COLOR CODE MARKING FOR MILITARY STANDARD CAPACITORS

Figure FO-19. Color code marking for MIL-STD resistors, capacitors, and inductors.



NOTES

1. VOLTAGES AND RESISTANCES MEASURED TO GROUND WITH A 20,000 OHM-PER-VOLT METER.
2. VOLTAGE READINGS ABOVE THE LINE, RESISTANCE READINGS BELOW THE LINE.
3. NC INDICATES NO CONNECTIONS.
4. FOR RESISTANCE MEASUREMENTS ONLY, DISCONNECT ALL EXTERNAL PLUGS.
5. * INDICATES MEASUREMENTS ACROSS FILAMENTS.
6. K DENOTES THOUSAND, MEG DENOTES MILLION, INF DENOTES INFINITY.

EL1QP371

Figure FO-20. Power Supply PP-1588/MPQ-4A, voltage and resistance.

Figure FO-21. Radar Set AN/MPQ-4A, intercabling diagram.

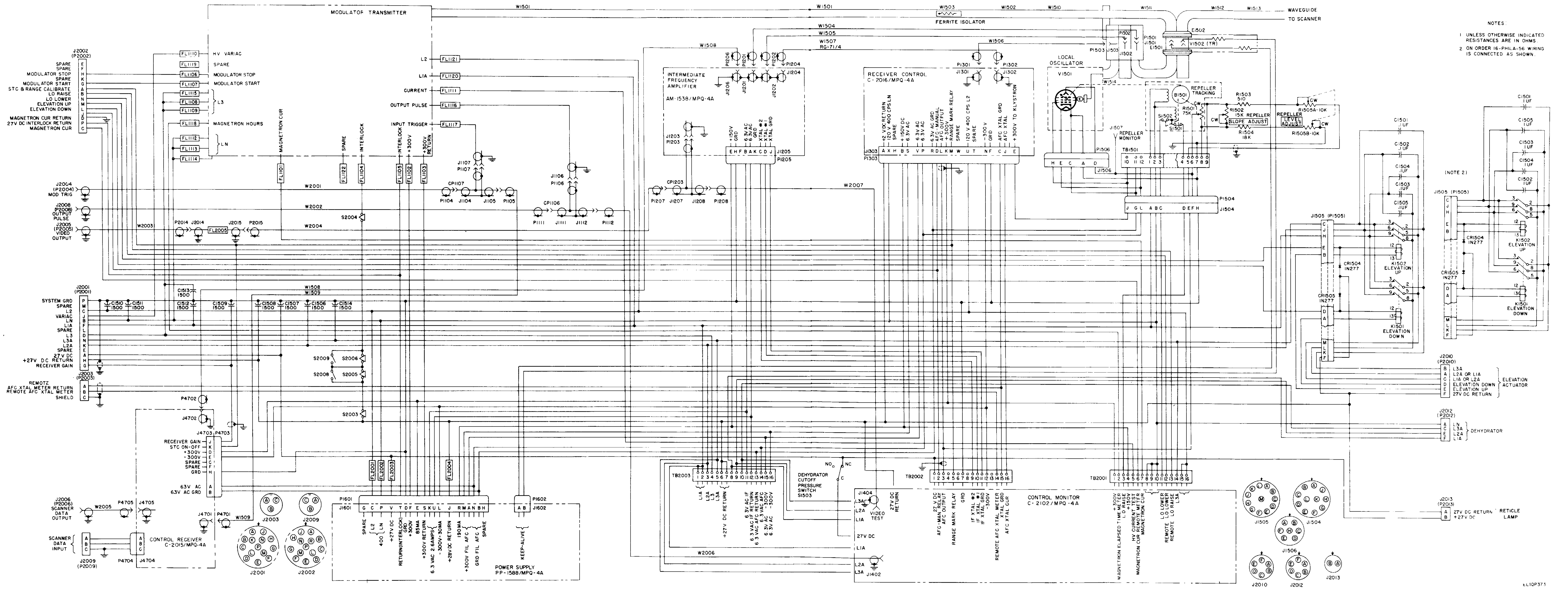


Figure FO-22. Receiver-Transmitter Group OA-1257/MPQ-4A, schematic diagram.

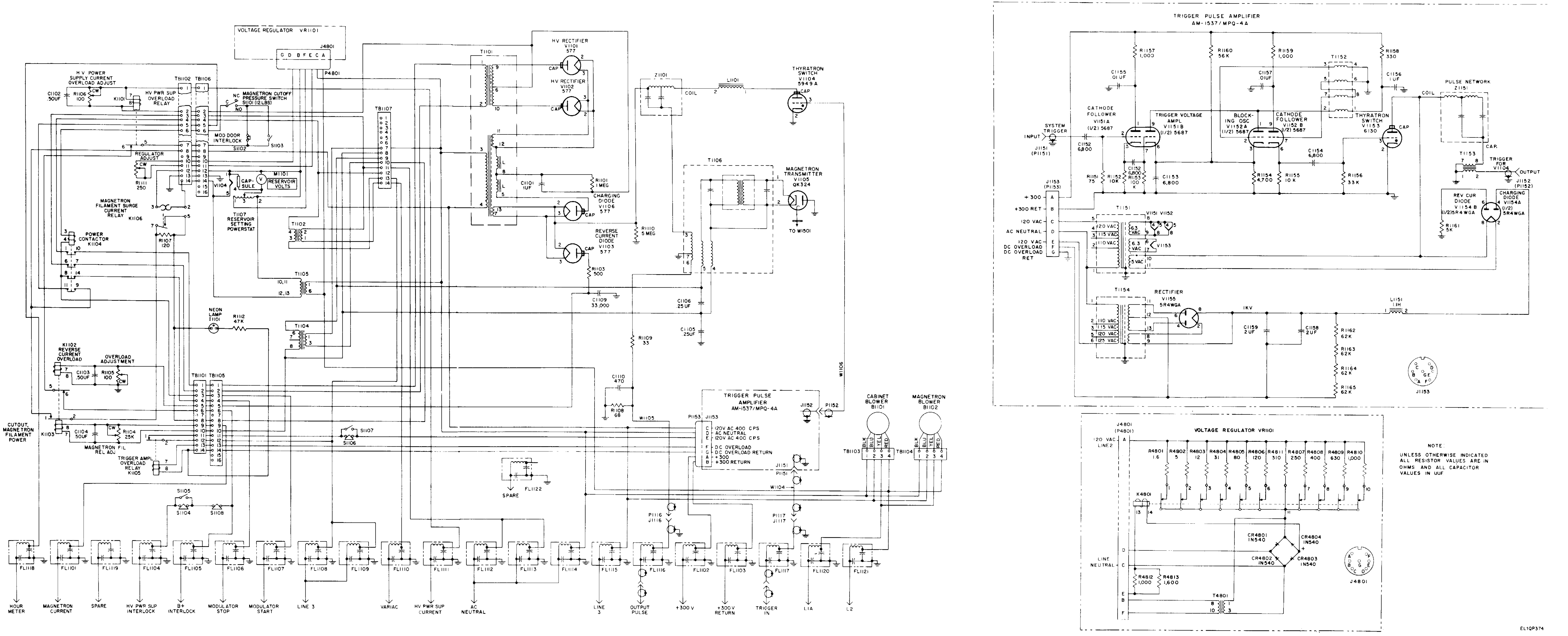


Figure FO-23. Modulator-transmitter, schematic diagram.

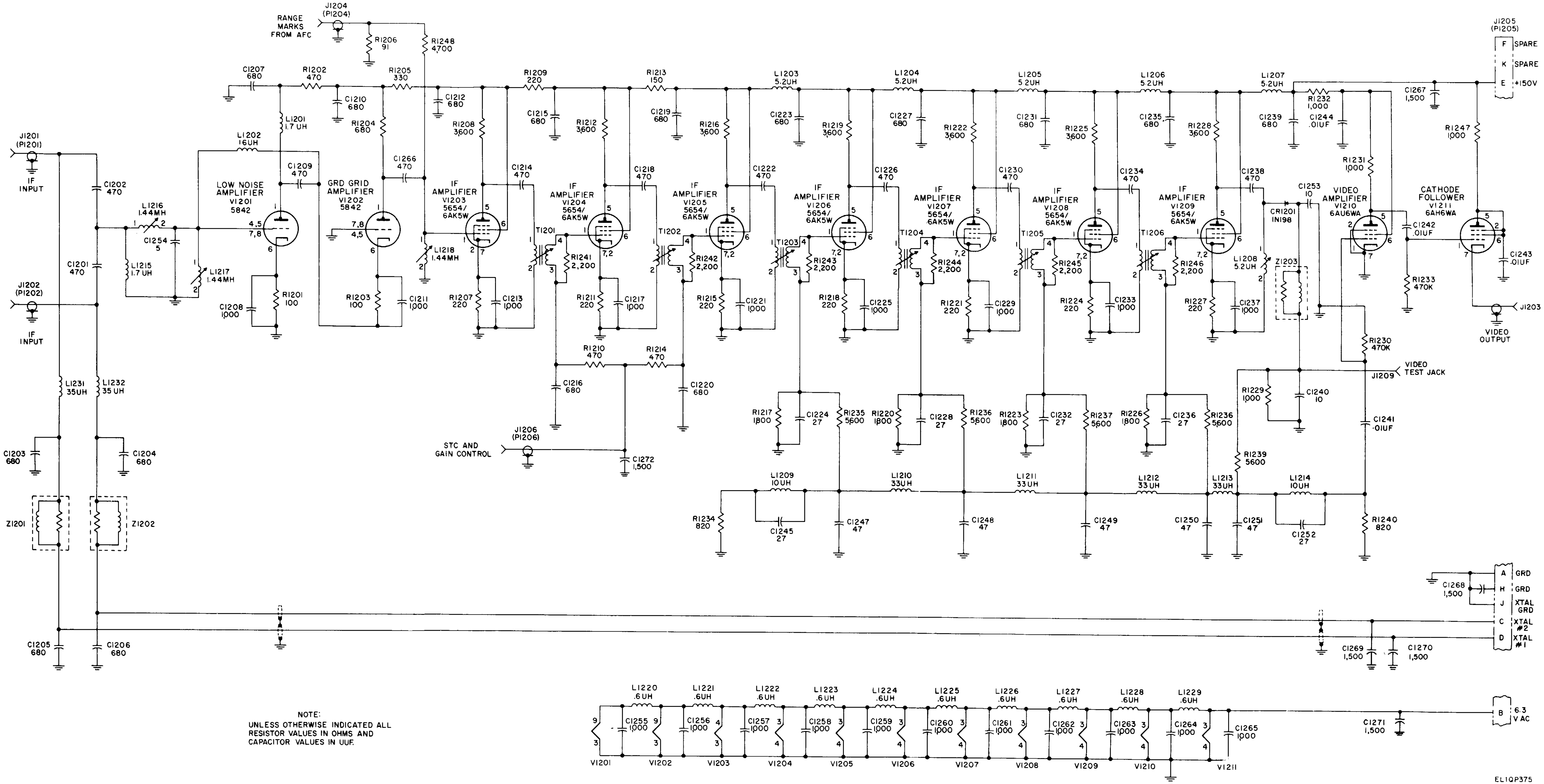


Figure FO-24. Intermediate Frequency Amplifier AM-1538/MPQ-4A, schematic diagram.

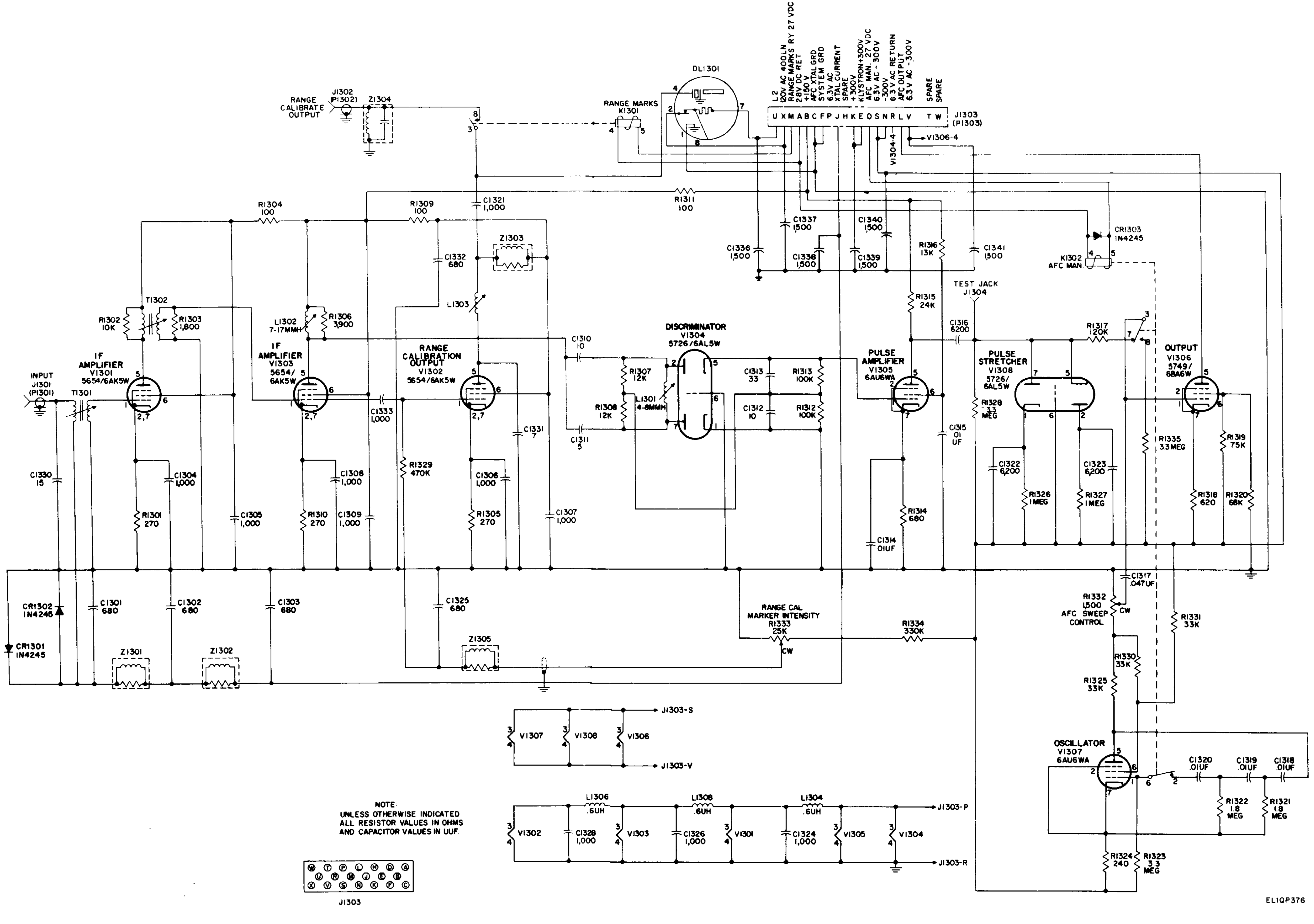


Figure FO-25. Receiver-Control C-2016/MPQ-4A, schematic diagram.

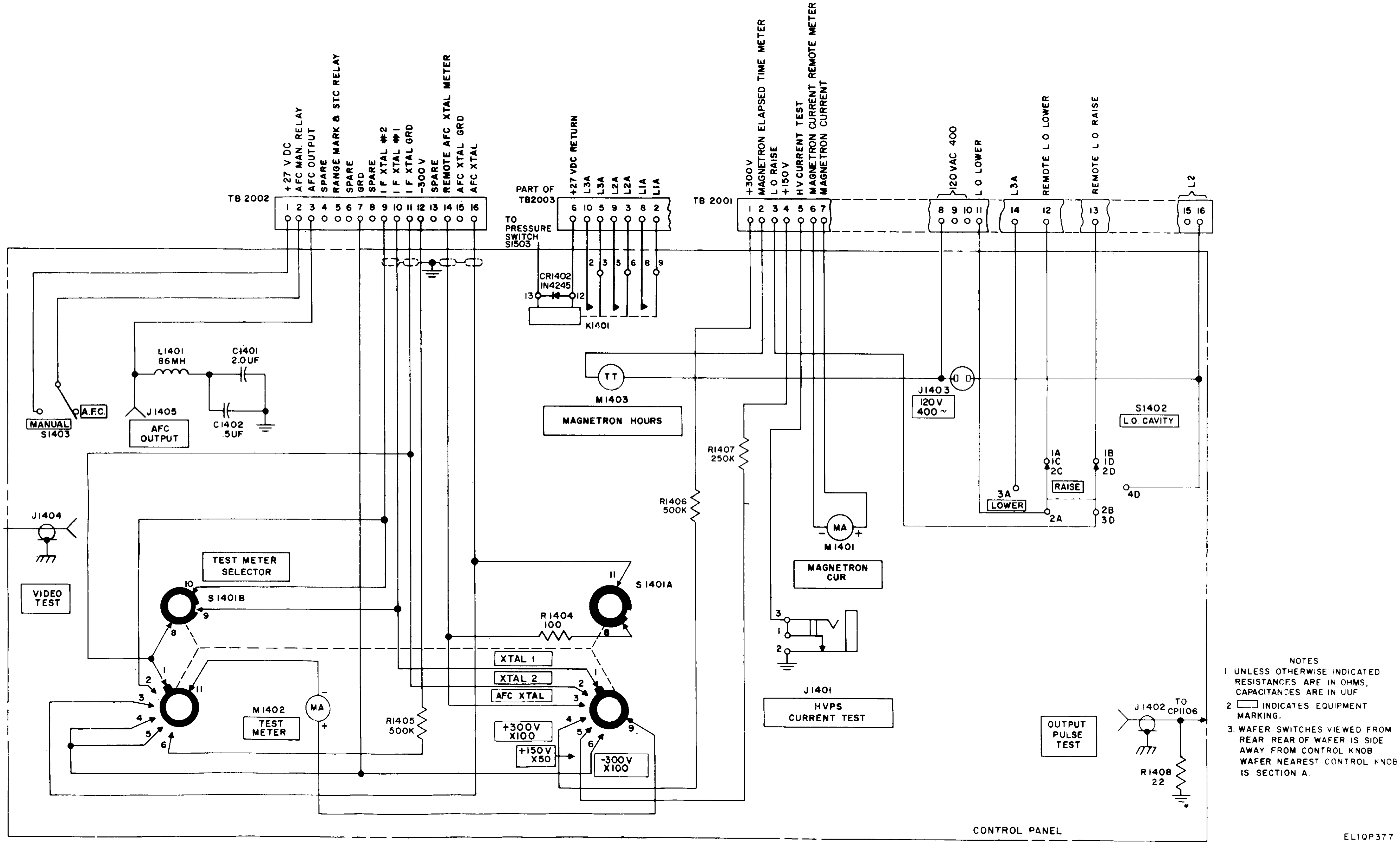


Figure FO-26. Control-Monitor C-2102/MPQ-4A, schematic diagram.

Figure FO-27 (1). Indicator, Azimuth and Range IP-375/MPQ-4A, schematic diagram (sheet 1 of 2).

Figure FO-27 (3). Indicator, Azimuth and Range IP-375/MPQ-4A, schematic diagram (sheet 2 of 2).

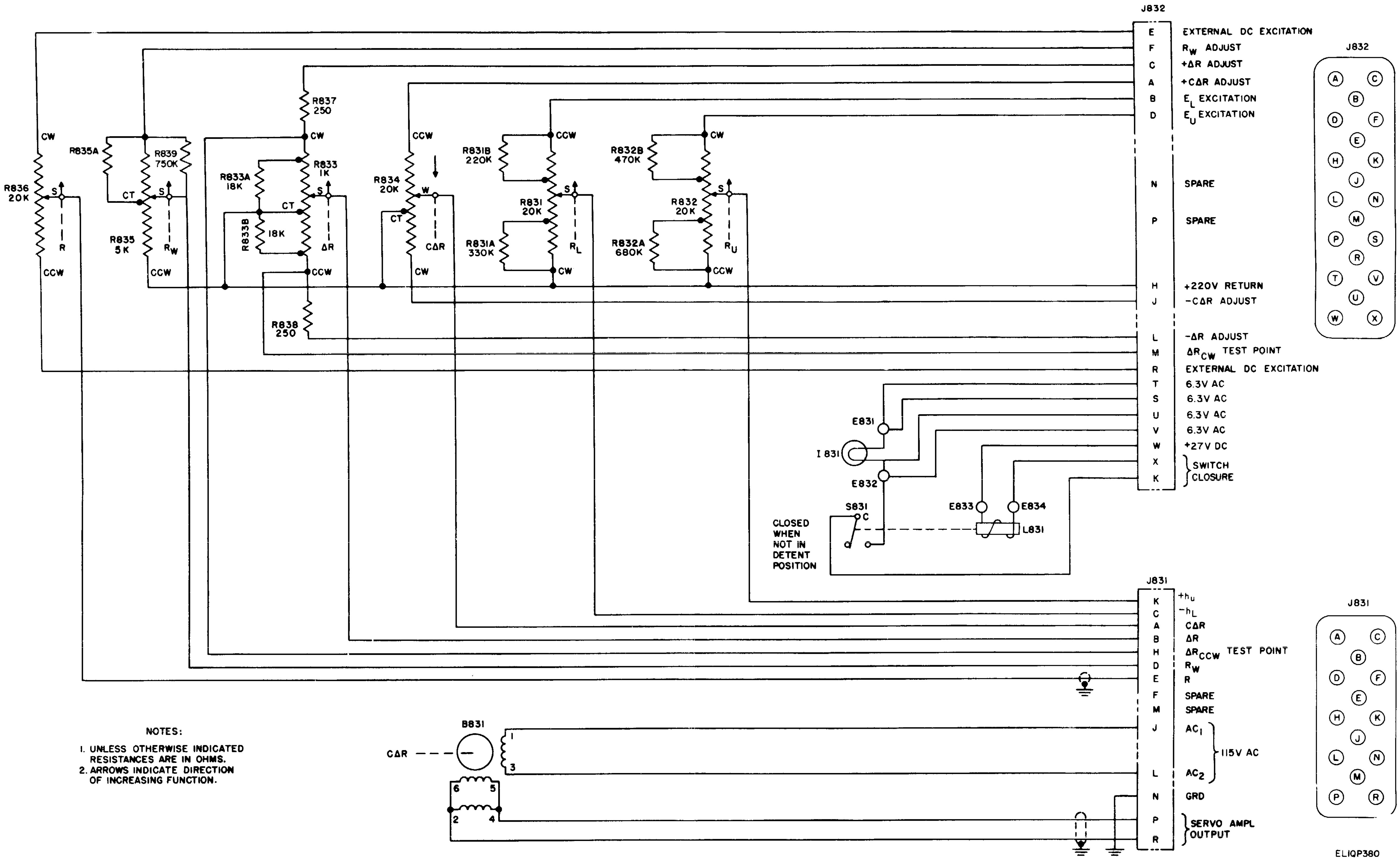


Figure FO-28. Range assembly, schematic diagram.

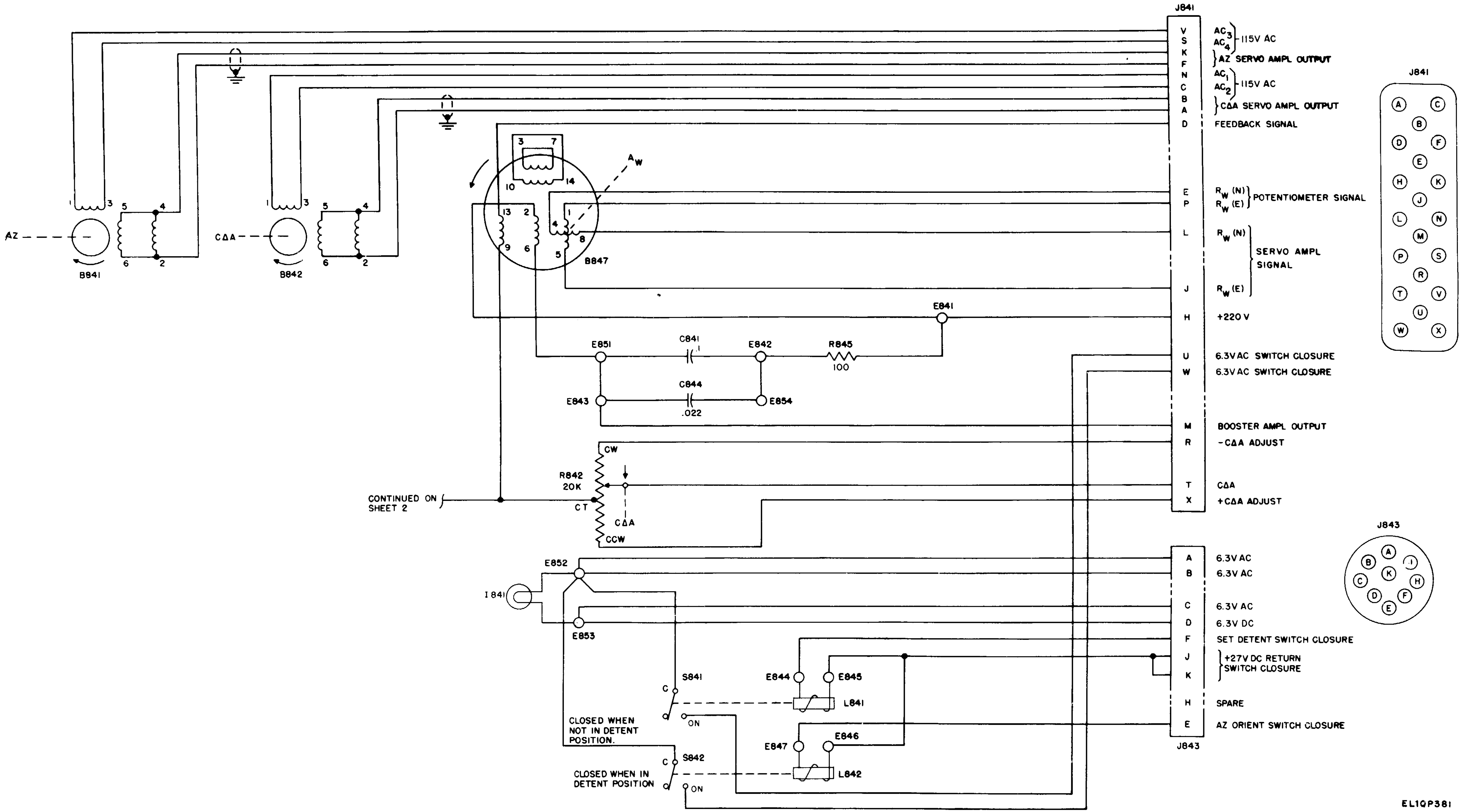
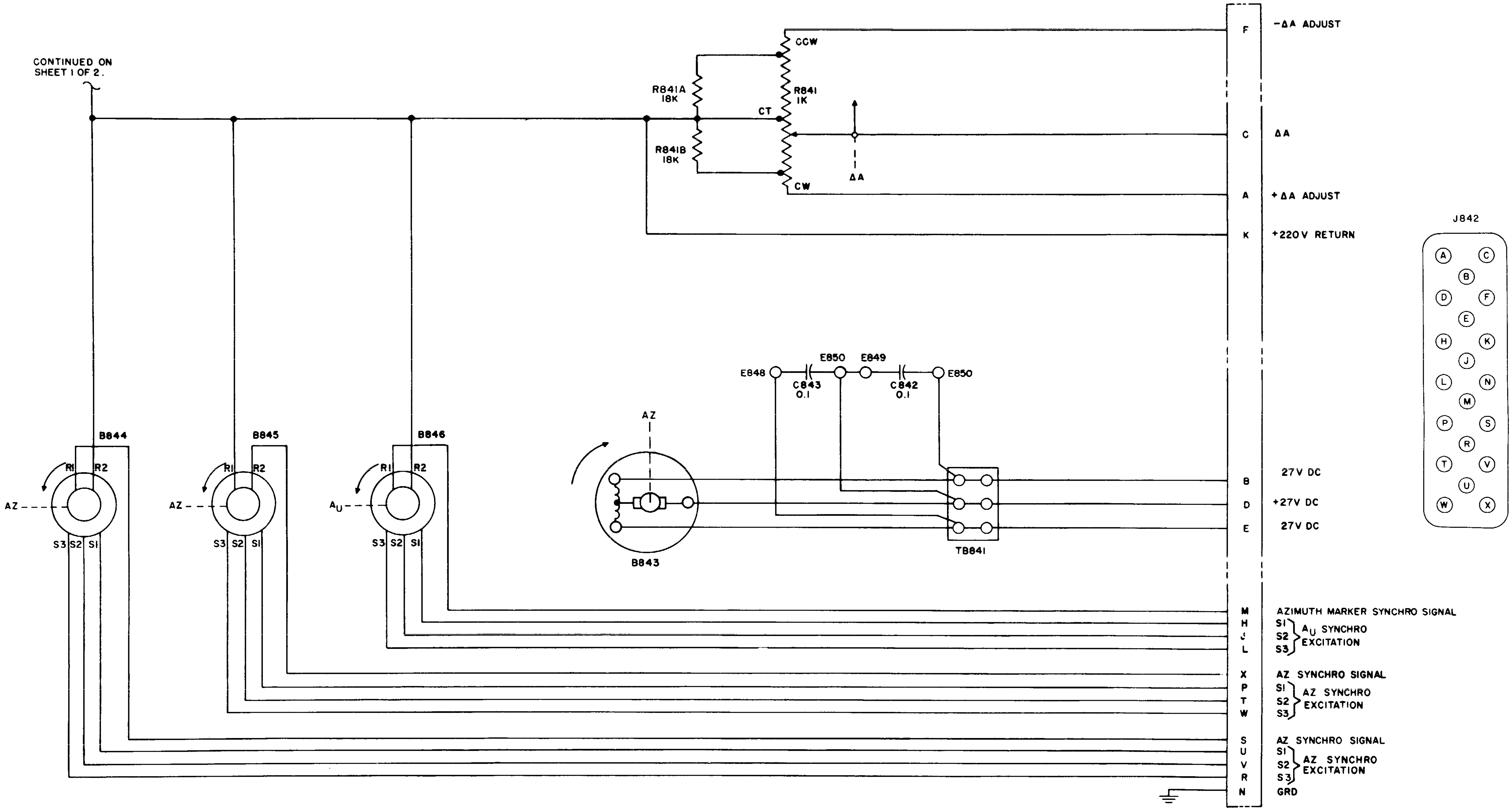


Figure FO-29(1). Azimuth subassembly, schematic diagram (sheet 1 of 2).



NOTES:

1. UNLESS OTHERWISE INDICATED RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. ARROWS INDICATE DIRECTION OF INCREASING FUNCTION.

EL1QP382

Figure FO-29 ②. Azimuth subassembly, schematic diagram (sheet 2 of 2).

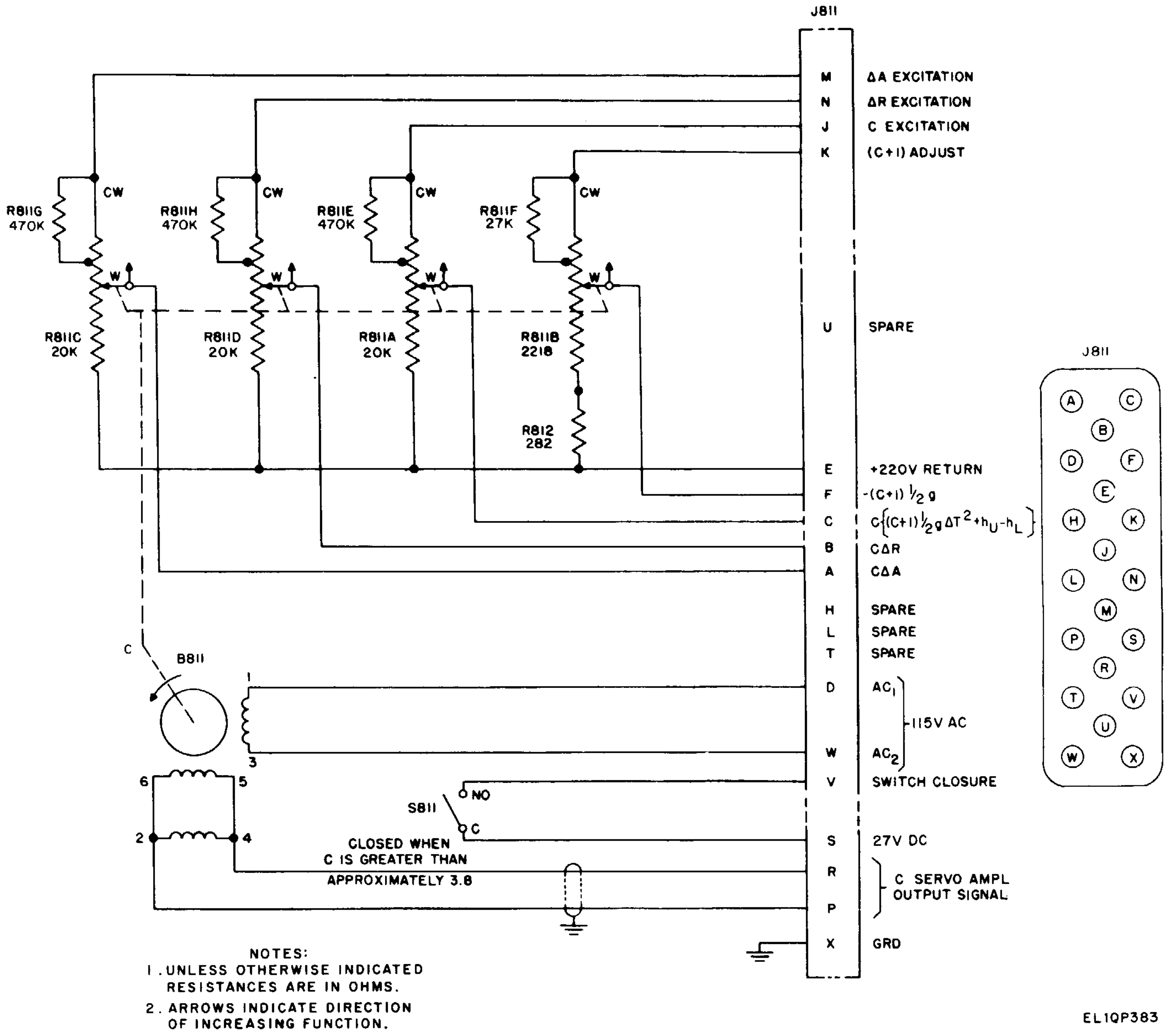
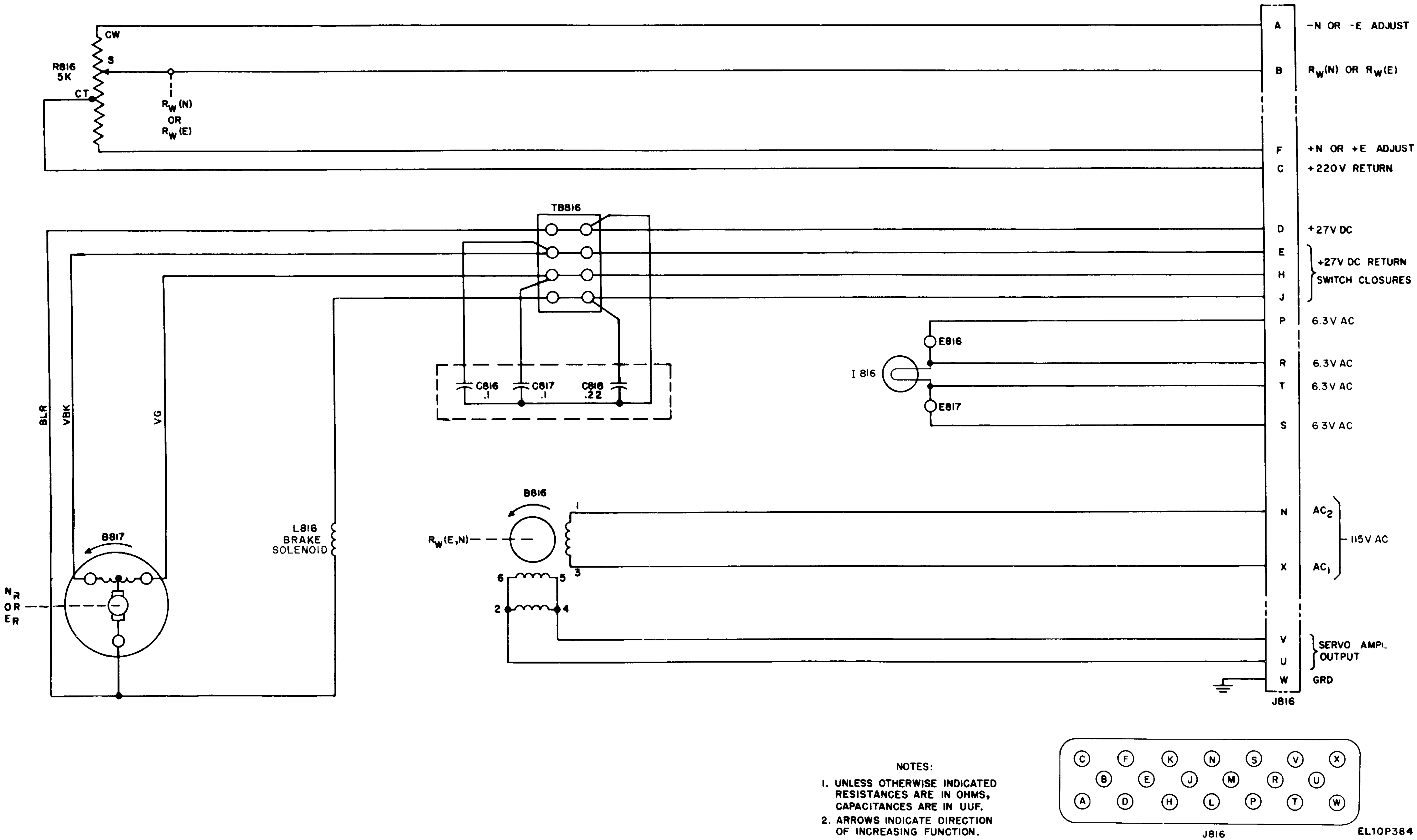


Figure FO-30. C-subassembly, schematic diagram.



NOTES:

1. UNLESS OTHERWISE INDICATED RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. ARROWS INDICATE DIRECTION OF INCREASING FUNCTION.

Figure FO-31. Coordinate subassemblies, schematic diagram.

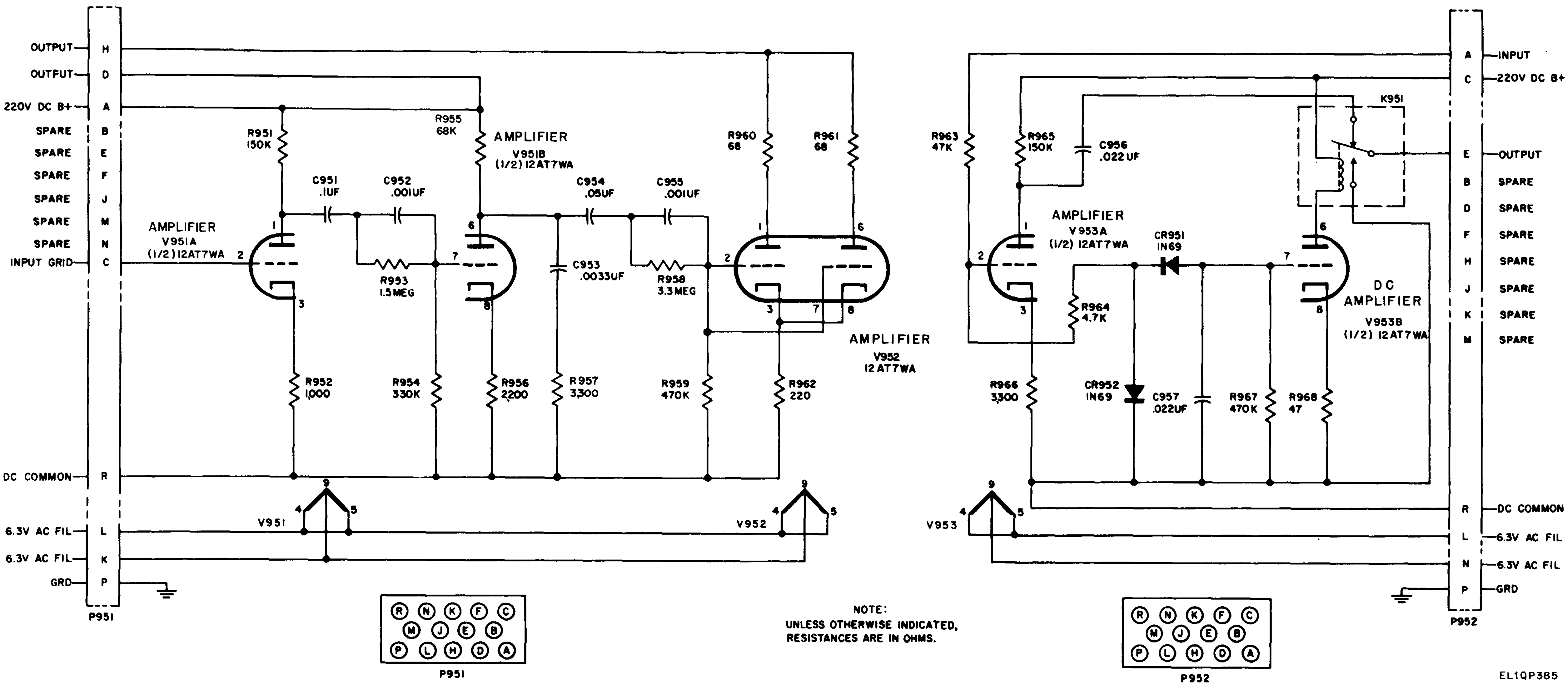
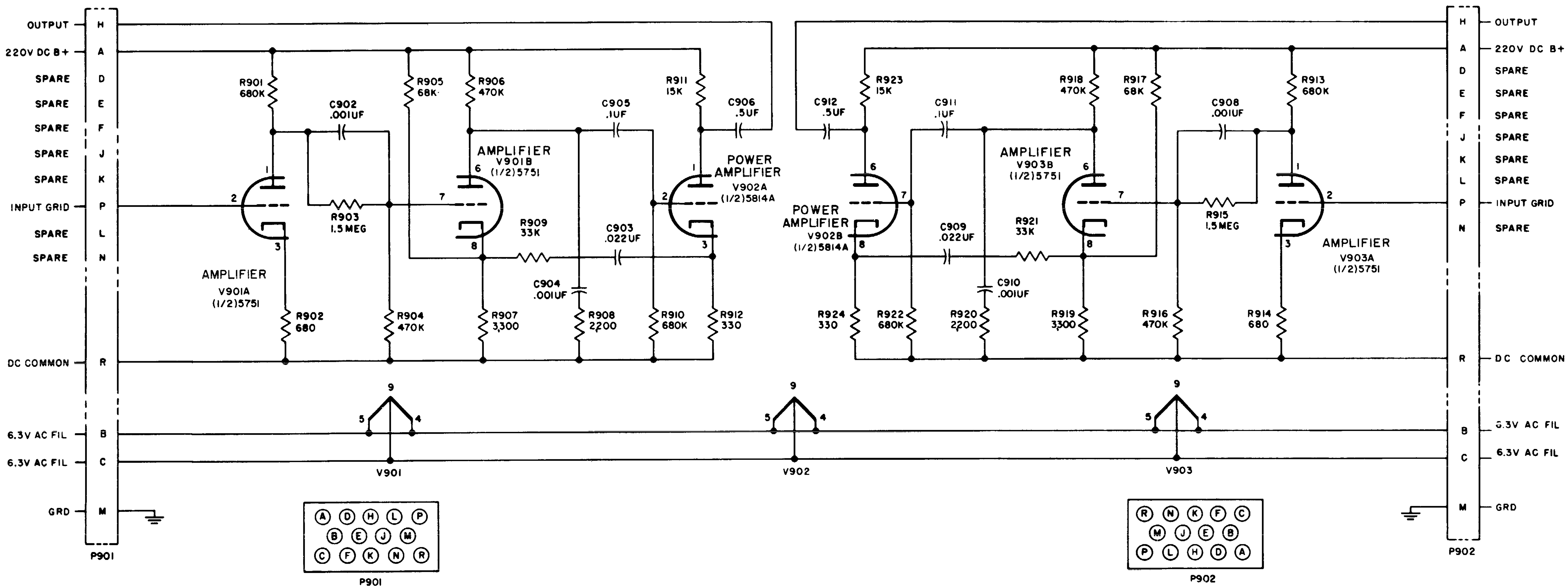
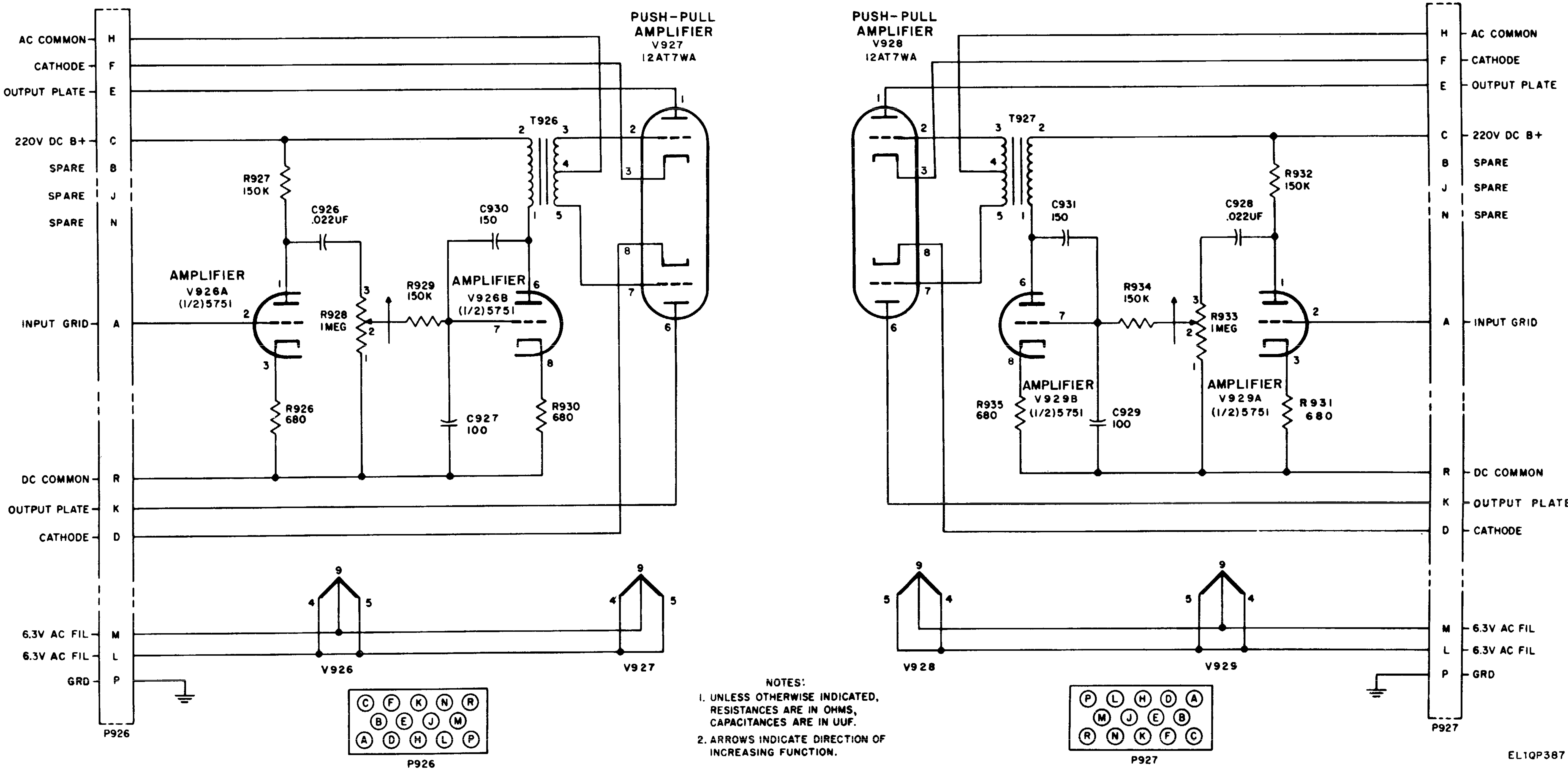


Figure FO-32. Booster and dual speed cutover amplifier AR951, schematic diagram.



NOTE:
UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS.

Figure FO-33. Dual isolation amplifier AR901, schematic diagram.



NOTES:
1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. ARROWS INDICATE DIRECTION OF INCREASING FUNCTION.

Figure FO-34. Dual servo amplifier AR926 through AR929, schematic diagram.

NOTES:

1. UNLESS OTHERWISE INDICATED RESISTANCES ARE IN OHMS.
2. WAFER SWITCHES SHOWN IN NORMAL POSITION.
3. SINGLE BEAM LAMP I864 CONNECTS TO E870 THROUGH PART OF SINGLE BEAM-DUAL BEAM SWITCH S857. SEE FIGURES 294.10 AND 294.11 FOR DETAILS.
4. IN SOME SETS PINS K, L, M, N, R, CONNECT TO SINGLE BEAM-DUAL BEAM SWITCH S857. SEE FIGURES 294.10 AND 294.11 FOR DETAILS.
5. CONNECTIONS TO EXTERNAL COMPONENTS ON MAIN CHASSIS BY-PASS PINS K, L, M, N, R, IN SOME SETS, OTHERWISE PINS K, L, M, N, R, CONNECT TO SINGLE BEAM-DUAL BEAM SWITCH S857.

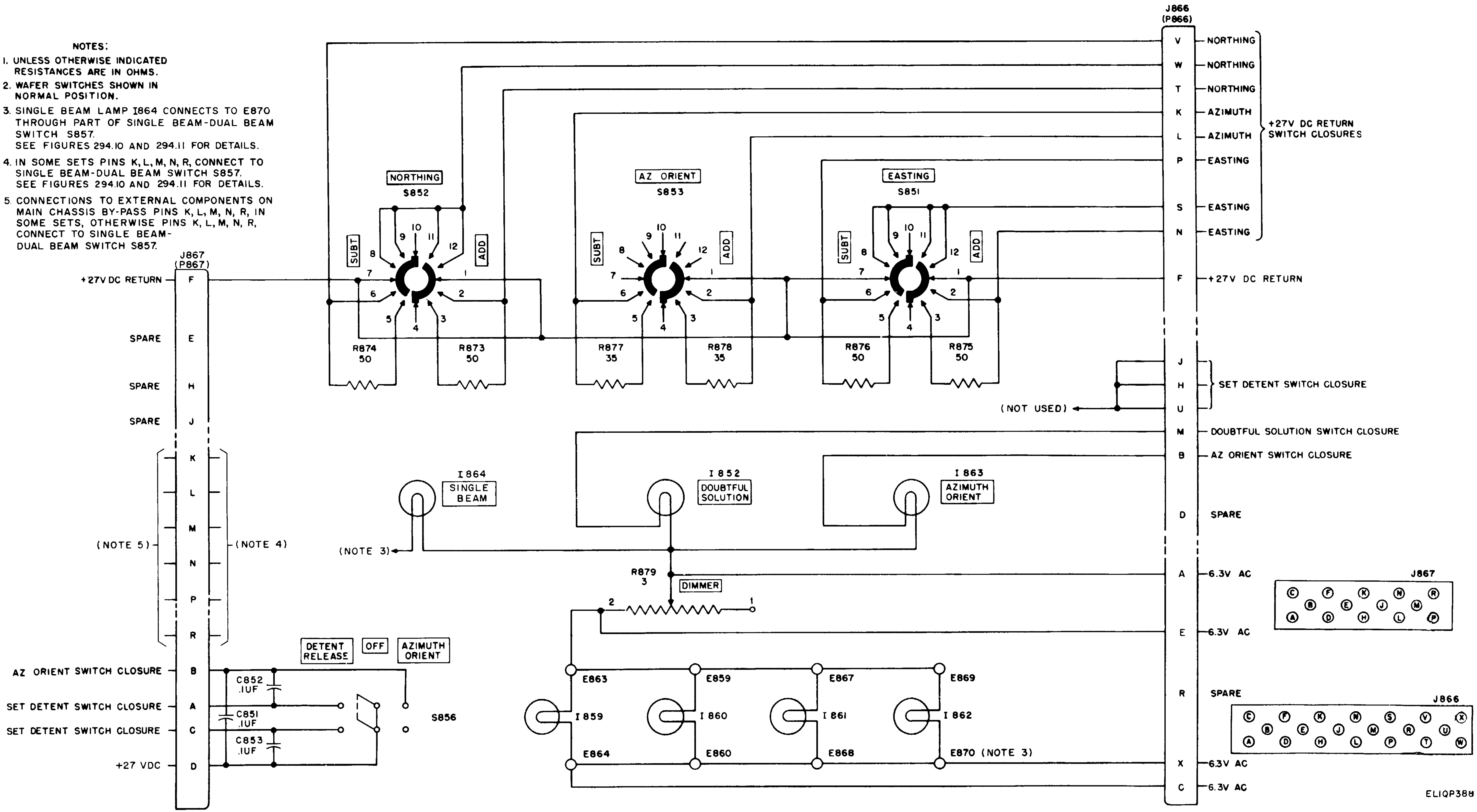


Figure FO-35. Computer front panel assembly, schematic diagram.

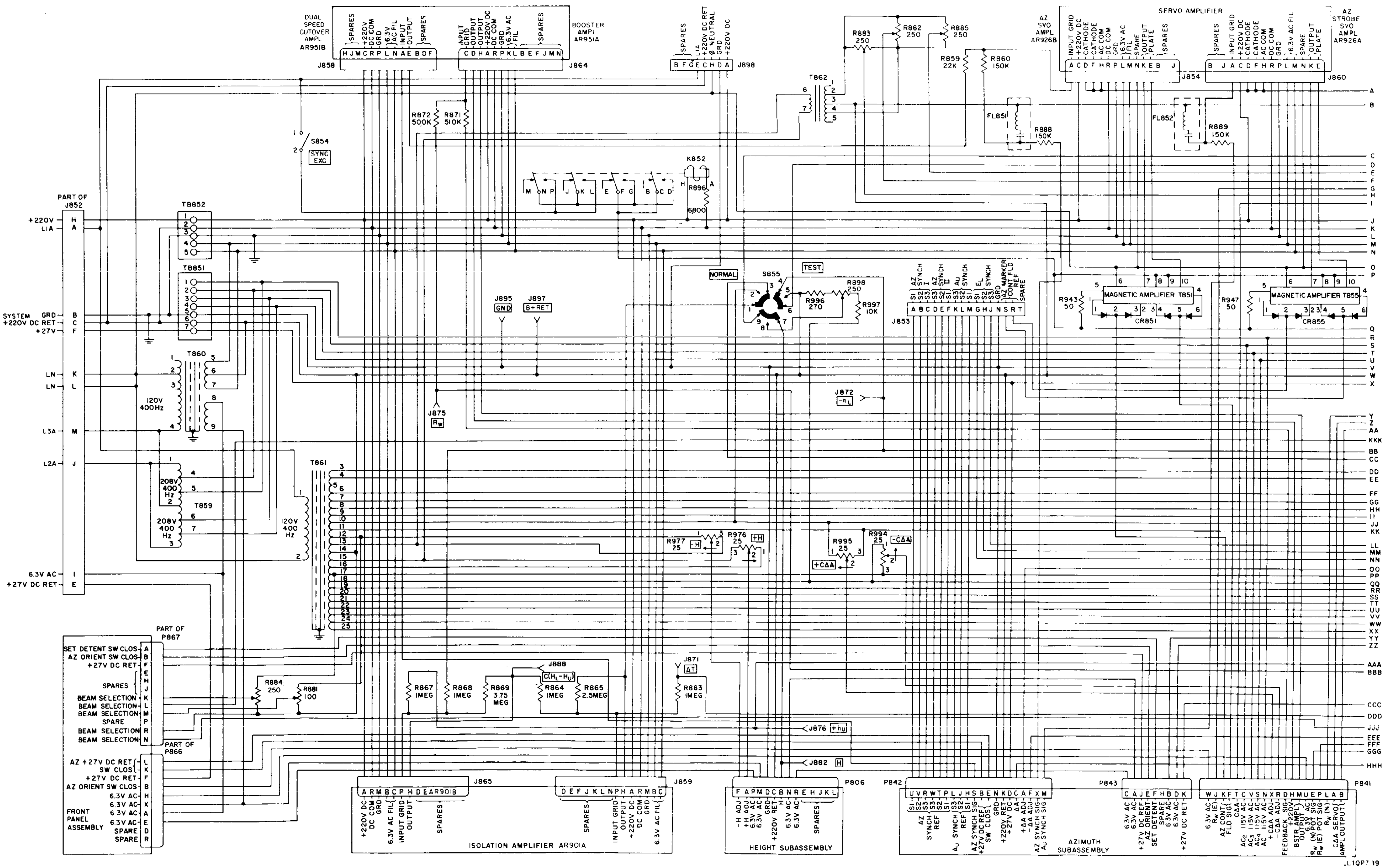


Figure FO-36 (1). Computer chassis, schematic diagram (sheet 1 of 2).

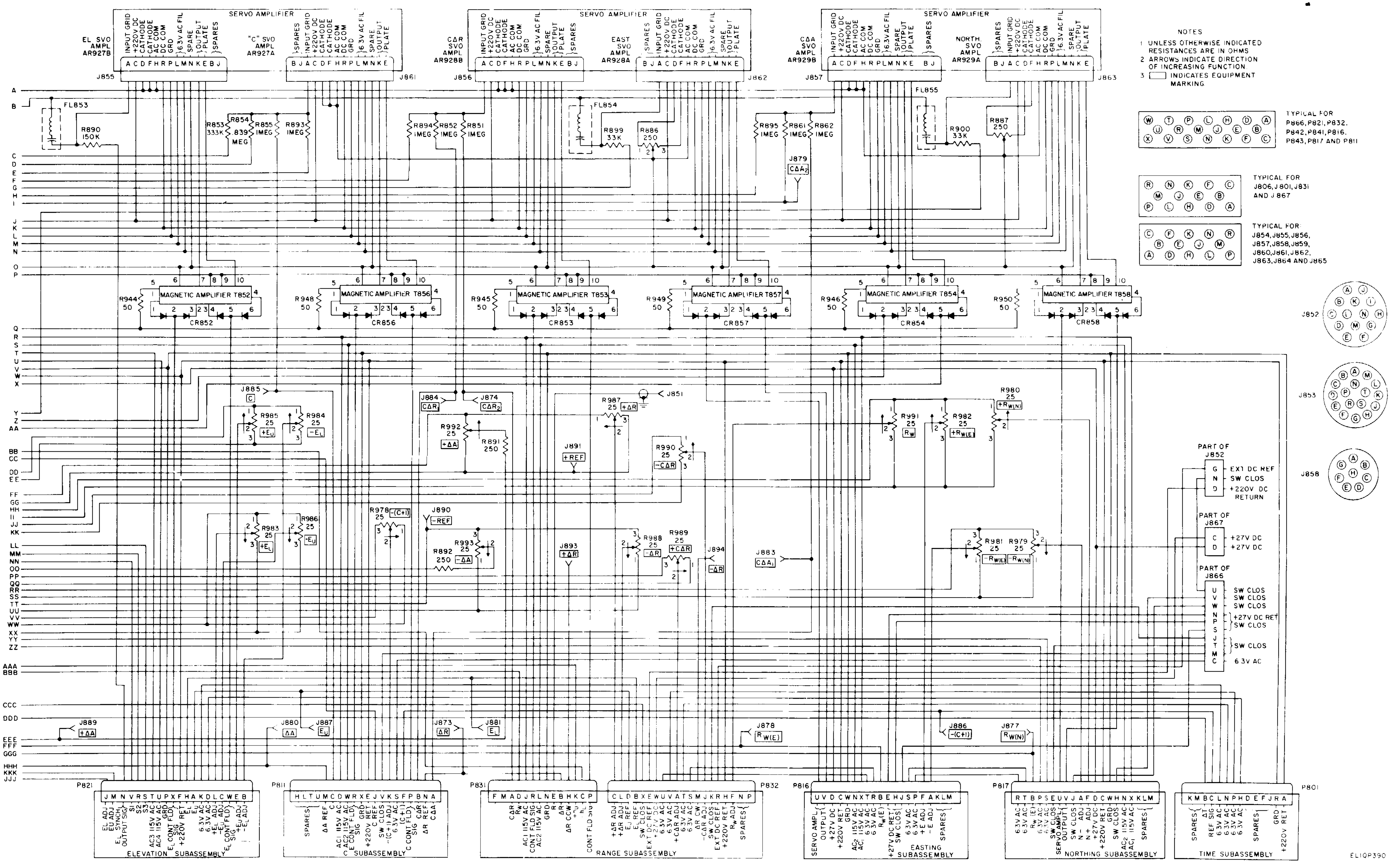


Figure FO-36 (2). Computer chassis, schematic diagram (sheet 2 of 2).

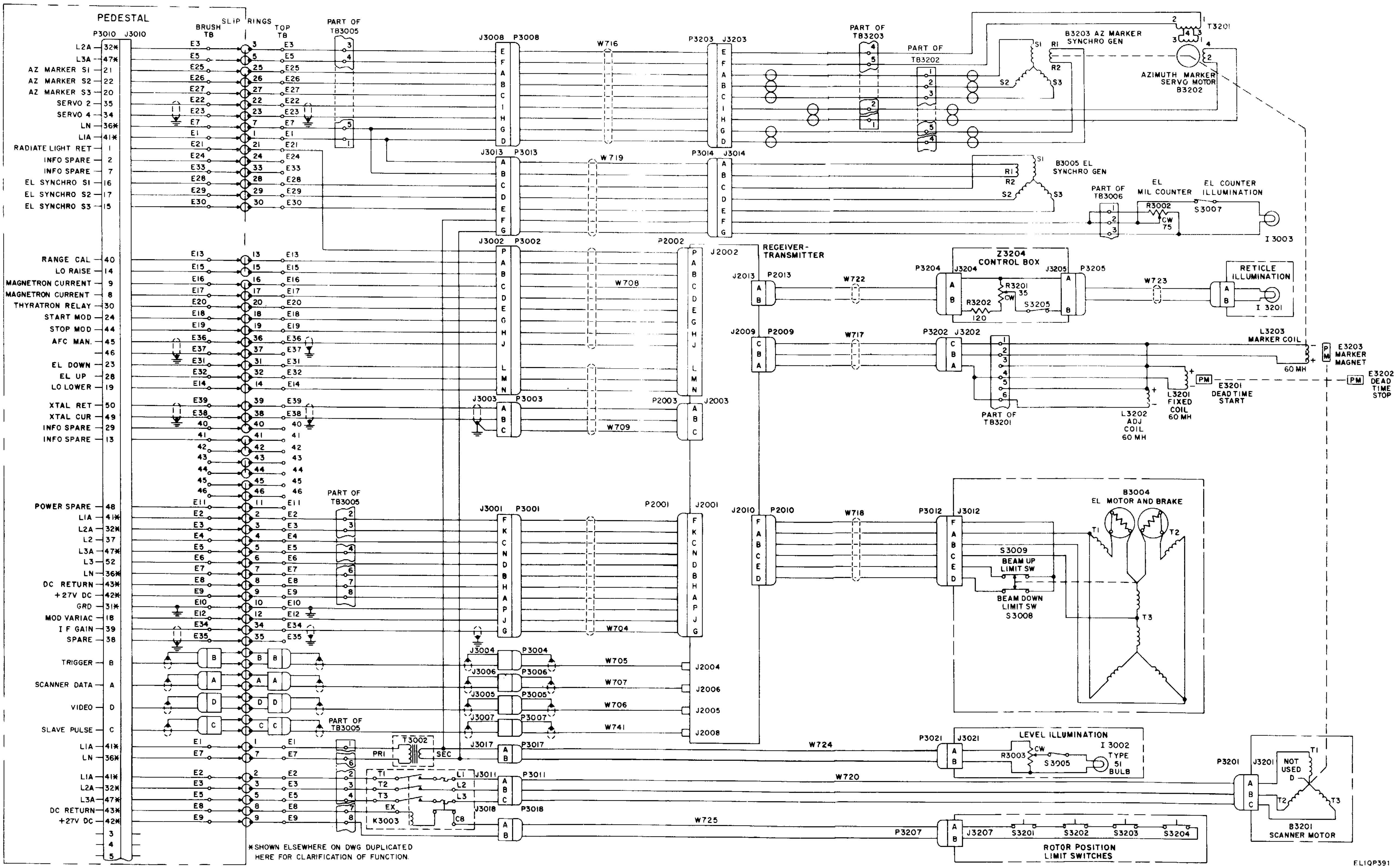


Figure FO-37 ①. *Antenna assembly* (sheet 1 of 2).

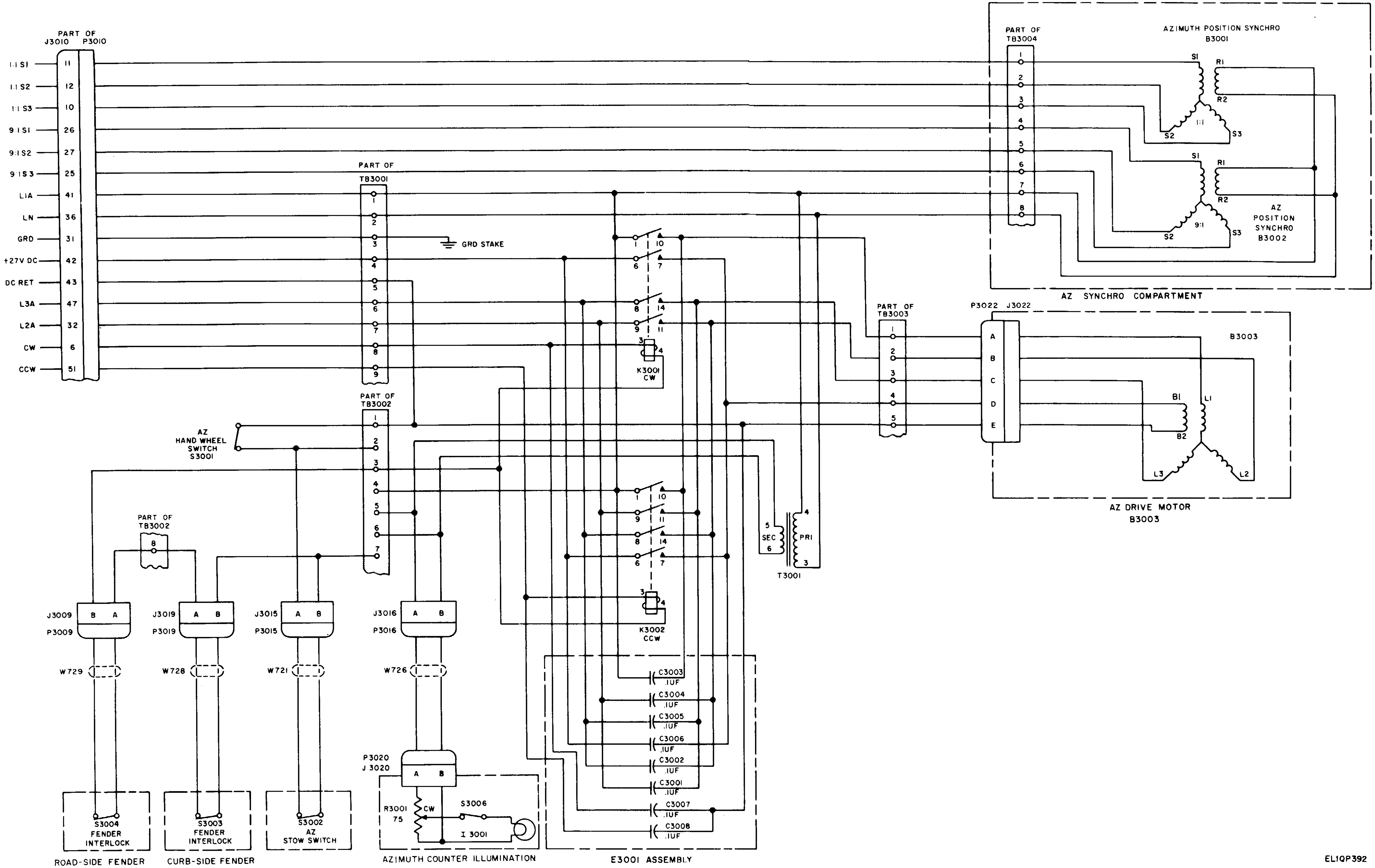


Figure FO-37 (2). Antenna assembly (sheet 2 of 2).

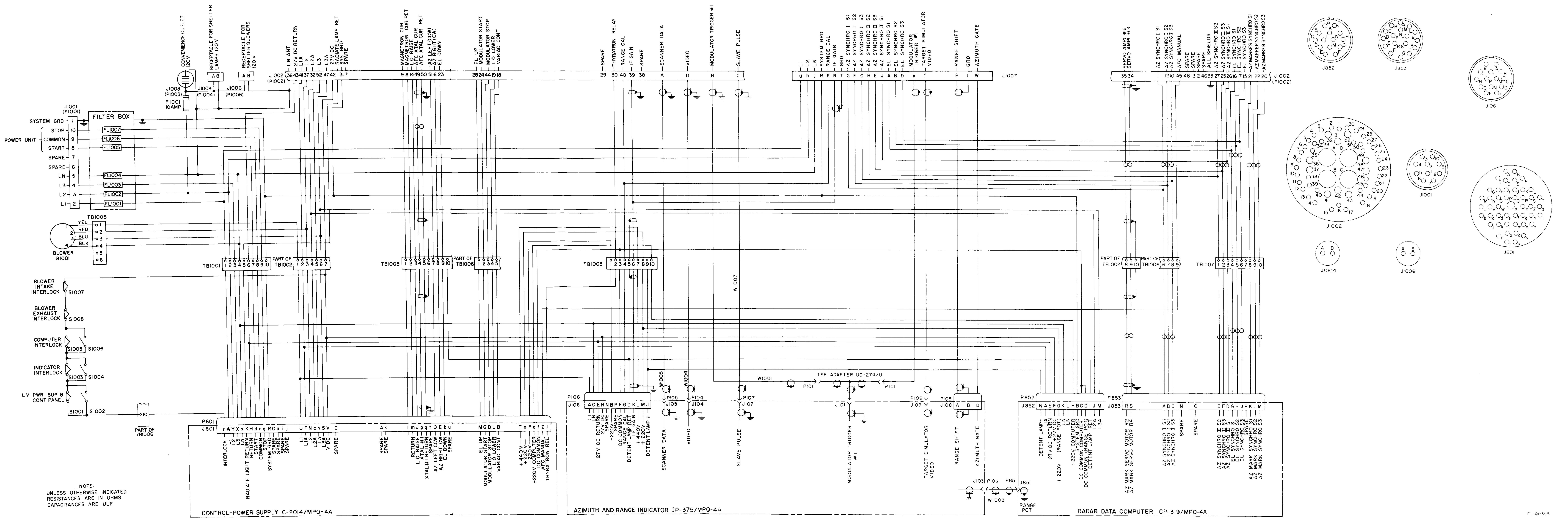


Figure FO-40. Control-Indicator Goup OA-1256/MPQ-4A, interconntcting diagram

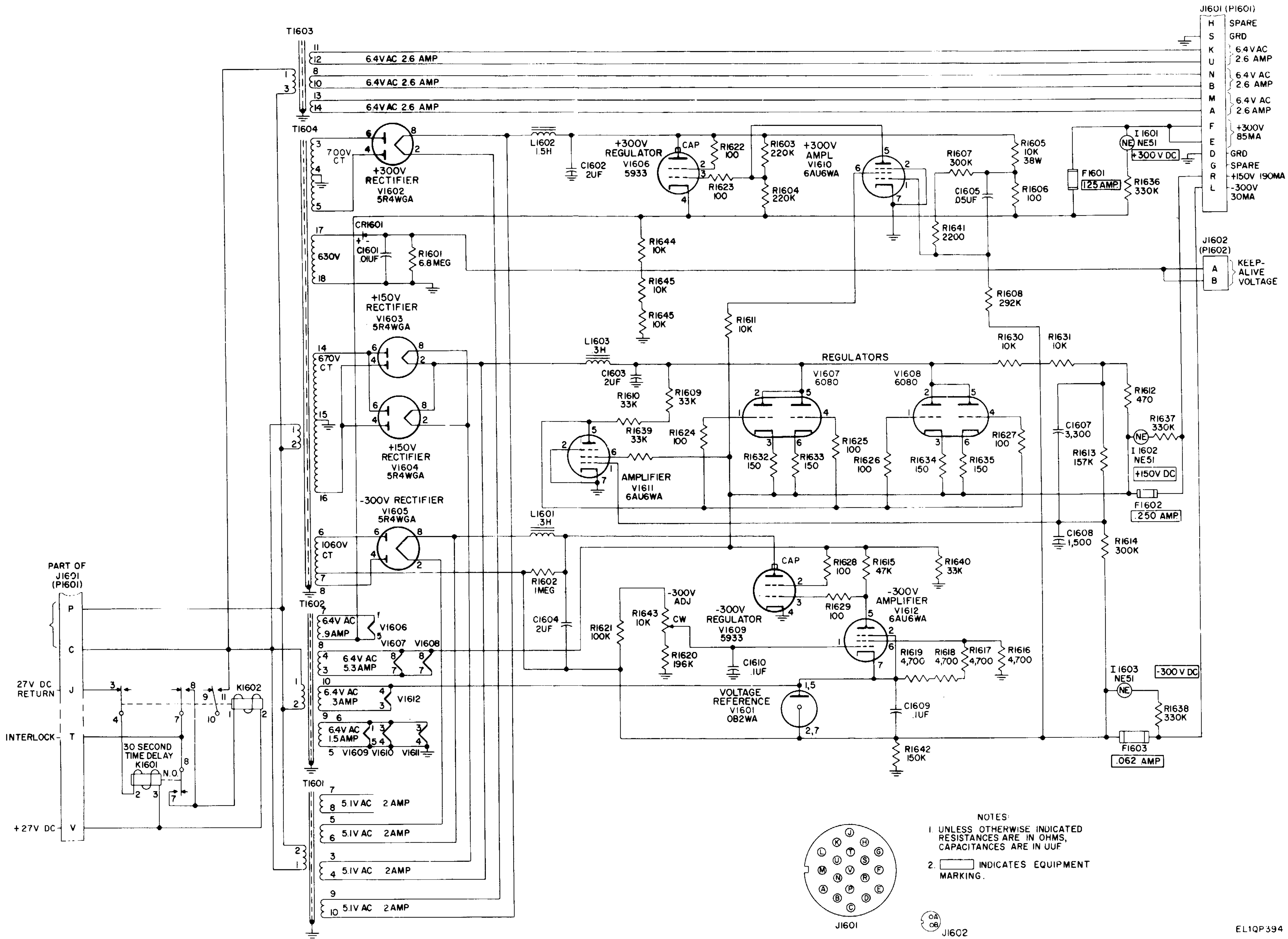


Figure FO-39. Power Supply PP-1588/MPQ-4A, schematic diagram.

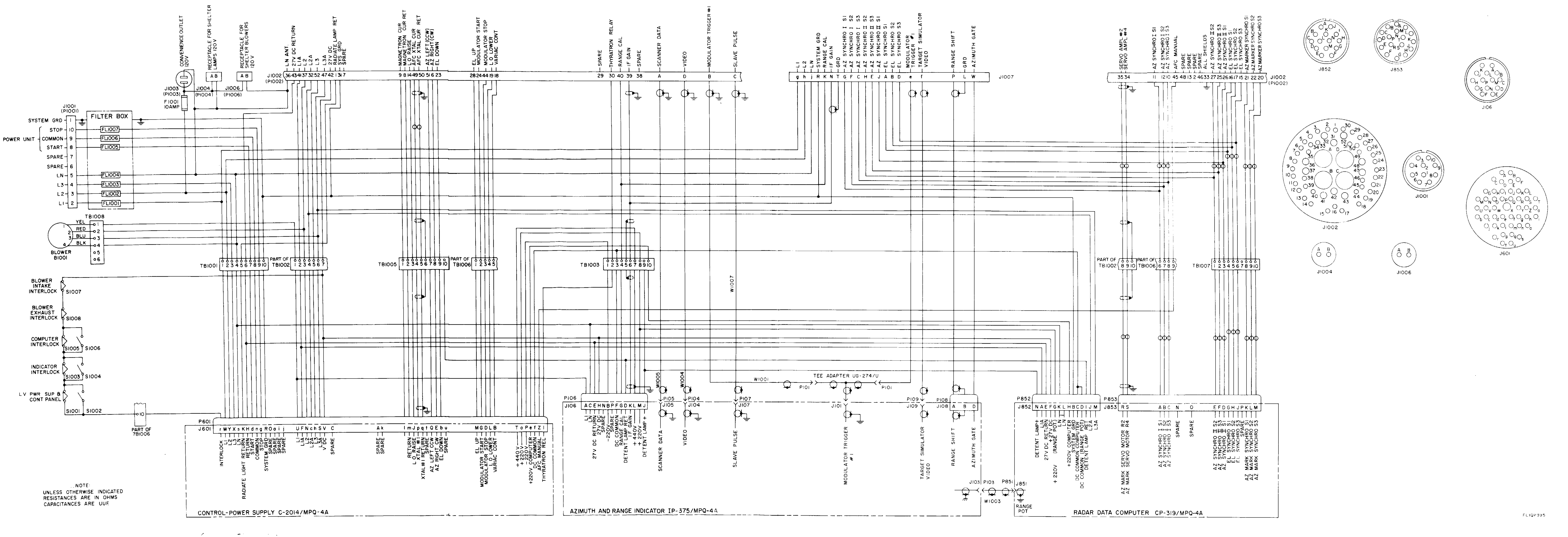


Figure FO-40. Control-Indicator Goup OA-1256/MPQ-4A, interconntcting diagram.