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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

FIELD AND DEPOT MAINTENANCE RADIO SET AN/TPS-1D



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RADIO SET AN/TPS–1D

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*** This manual supersedes so much of TM 11–1167, 1 February 1954, including C 1, 27 June 1955, as pertains to field and depot maintenance.**

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CHAPTER 1
INTRODUCTION

1. Scope

a. This manual covers field and depot maintenance of Radio Set AN/TPS–1D. Complete coverage for this equipment includes two other manuals as follows:

(1) Radio Set AN/TPS–1D, Operator's Manual (TM 11–1167–10).

(2) Radio Set AN/TPS–1D, Organizational Maintenance (TM 11–1167–20).

b. This manual covers theory, troubleshooting and repair, and disassembly and reassembly; it also contains an appendix and a glossary.

(1) The appendix contains a list of pertinent references.

(2) See SIG 7 & 8 AN/TPS–1D for maintenance parts information and for repair parts and special tool lists.

c. Forward all comments concerning this publication to Commanding Officer, United States Army Signal Publications Agency, Fort Monmouth, New Jersey.

2. Forms and Records

a. Unsatisfactory Equipment Report. Fill out and forward DA Form 468 (Unsatisfactory Equipment Report) to Commanding Officer, United States Army Signal Equipment Support Agency, Fort Monmouth, N. J., as prescribed in AR 700–38.

b. Damaged or Improper Shipment. Fill out and forward DD Form 6 (Report of Damaged or Improper Shipment) as prescribed in AR 700–58.

3. General Information

Radio Set AN/TPS–1D contains circuits that provide for the detection of airborne targets by either the normal radar method or the moving-target indication (mti) method of operation. The basic principles on which the operation of these circuits are based are given in paragraphs 17 through 22, TM 11–1167–10. For purposes of discussion and troubleshooting, the equipment is divided into eight functional systems, as follows: radio-frequency (RF), transmitting, receiving, signal comparing, indicating, antenna positioning, direct-current (dc) power supply, and alternating-current (ac) power distribution and control. The function and interrelation of these systems and a complete stage-by-stage block diagram analysis of the equipment are given in paragraphs 40 through 86, TM 11–1167–20. Additional information concerning the specific circuits which make up the eight functional systems of the equipment and the circuits employed in the various modes of operation of the equipment is given in paragraph 5 and additional mti principles are given in paragraph 4 of this manual.

a. Components are mentioned frequently in the manual by common names rather than by official nomenclature. The common names assigned to nomenclatured components are listed in paragraph 6, TM 11–1167–10.

b. Some Radio Set AN/TPS–1D equipments contain preferred type tubes. The substitution of preferred type tubes for older tubes is given in paragraph 33, TM 11–1167–20.

c. Reference designations which are assigned to each part indicate the type of part and the location of the part. The reference designation letters indicate the type of part, and the reference designation numbers indicate in which component the part is located. The reference designation numbers assigned to each major component are listed in paragraph 182. The parts of each functional system may be located by referring to the illustrations in the troubleshooting chapter for that system. In the chapters where many illustrations are used to call out parts, a chart which lists each part in the system and the figure on which the part can be located precedes the illustrations.

d. The letters CW on a symbol for a potentiometer indicates the position of the adjustable contact at the limit of clockwise travel viewed from the knob end or actuator end.

e. Equipment panel markings are capitalized in text and are boxed on illustrations.

f. Broken lines on illustrations represent mechanical connections and solid lines indicate electrical connections.

g. This manual covers the equipment as modified by the following Department of the Army Modification Work Orders.

Number	*Title*
MWO SIG 100	Modification of Radio Set AN/TPS–1D, Modification of Receiver-Transmitter RT–212/TPS–1D to Accommodate TR Tube Type 6322.
MWO SIG 11–1167–1	Modification of Radio Set AN/TPS–1D to Reduce Hum Pickup in the Local Oscillator.
MWO SIG 11–1167–2	Modification of Radio Set AN/TPS–1D to Improve Local Oscillator and Deletion of Automatic Frequency Control.
MWO SIG 11–1167–3	Modification of Radio Set AN/TPS–1D to Incorporate Manufacturing Changes.
MWO SIG 11–1167–4	Modification of Radio Set AN/TPS–1D and Radar Surveillance Central AN/GSS–1 to Provide an Oil Level Indicator in Antenna Base AB–221/TPS–1D.
MWO SIG 11–1167–5	Modification of Antenna Base AB–221/TPS–1D to Prevent Oil Leakage into the Motor Synchro Tray.
MWO SIG 11–1167–6	Modification of Radio Set AN/TPS–1D, Installation of Input Power Auto Transformer, Tune-up Mirror, and Replacement of Crystal Mixer.
MWO SIG 11–1167–7	Modification of Radio Set AN/TPS–1D, Installation of Pulse Delay Network MX–1606/GPX–17.
MWO SIG 11–1167–8	Modification of Radio Set AN/TPS–1D to Remove Pulse Thyratron Balancing Transformer from Radar Modulator MD–144/TPS–1D.

4. Mti Principles

As a normal search radar system, the AN/TPS–1D is similar in theory of operation to typical pulsed search type radar equipments. A serious limitation of the normal search type radar is that the returns from large stationary targets make it difficult or impossible to detect airborne targets flying over stationary targets when the returns appear in the same positions on the indicators. The inclusion of mti circuits in the AN/TPS–1D extends the capabilities of the equipment by making it possible to detect a moving target flying over a stationary target which returns considerably more echo signal. The mti circuitry makes this possible by substantially canceling the returns from stationary targets so that only the returns from moving targets and small amounts of residue clutter are displayed on the indicators. The AN/TPS–1D employs the pulse-to-pulse comparison method of mti. This method takes advantage of the fact that the RF echo signals returned from a stationary target have the same phase from pulse to pulse, while the echo signals returned from a moving target have a different phase from pulse to pulse because of *a change in position* of the moving target with respect to the radar antenna.

a. Phase Relationships. In all radar systems, the received RF signal voltage bears a definite phase relationship to the RF voltage of the corresponding transmitted signal. The phase relationship depends on the distance between the the radar antenna and the target. Fixed or stationary targets produce echoes with a fixed phase relationship from one receiving period to the next. Waveforms B and D, as compared with waveforms A and C, in figure 1 have the same phase relationship or phase change from one receiving period to the next. Moving targets produce echoes which have a different phase relationship from one receiving period to the next. Waveforms F and H, as compared with waveforms E and G, have different phase relationships from one receiving period to the next because of the change in position of the moving target from one pulse to the next. This principle makes it possible for the mti circuitry of the AN/TPS–1D to discriminate between fixed and moving targets.

b. Coherent Signal. The transmitted signal is created by pulsing a magnetron oscillator. The phase of the returning echoes cannot be compared with the phase of the magnetron oscillator because the magnetron does not oscillate during the receiving period. Instead, the comparison of phases is accomplished at the intermediate-frequency (IF) level. The mti circuitry includes a free-running 60-megacycle (mc) per second continuous oscillator, the coherent oscillator, or coho. A small portion of the output from the magnetron beats with the

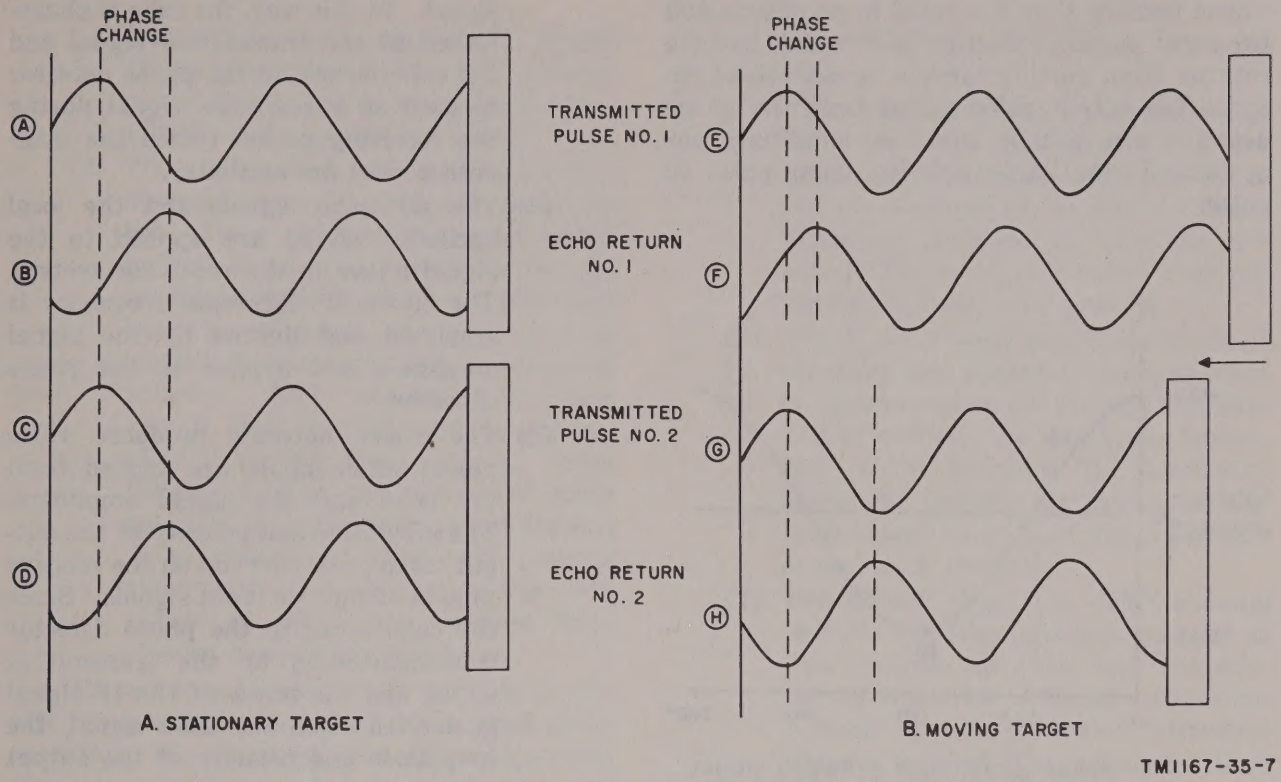


Figure 1. Phase relationships of transmitted and echo signals.

local oscillator and the difference frequency is applied to the coho so that the coho is phase-locked to the transmitted signal while the magnetron is oscillating. In this way, the phase of the coho is made to depend on the phase of the transmitted signal, and the coho is used as a reference during the receiving period. The returning echoes, which have a phase that depends on the phase of the transmitted signal and the distance to the target, beat with the local oscillator and produce a 60-mc IF signal. The IF echo signals and the coho reference signal are both applied to the phase detector.

c. Phase Detector. The phase detector produces video pulses, the amplitude and polarity of which depend on the relative phase relationship between the coho and IF signals. Figure 2 shows the output characteristics of the phase detector (a cosine wave). From the output curve, it can be seen that when the coho and echo signals are in phase, the video output pulses from the phase detector are maximum positive; and when the phase difference between the two is 180°, the video output pulses from the phase detector are maximum negative. The output from the phase detector varies between these limits, the actual polarity and amplitude of the output depending on the cosine of the angular difference between the coho and IF echo signals. The phase detector is the sensing device for the mti circuitry. The echo returns from a stationary target cause the same output from the phase detector from pulse to pulse. The echo returns from a moving target cause different outputs from the phase detector from pulse to pulse. This difference makes it possible to discriminate between stationary and moving targets. The outputs from the phase detector resulting from the returning signals (*a* above) are plotted on the output characteristic curve of the phase detector as points S, M, and M′. Point S represents the output from the phase detector that results from both echo returns from the stationary target. Points M and M′ represent the outputs from the phase detector that result from the returns from the moving target. The pulse-to-pulse comparison method of mti compares the video output pulses from the phase detector. The returns from stationary targets

cancel because they are equal in amplitude and the same polarity from pulse to pulse, but the returns from moving targets do not cancel because the output video pulses from the phase detector are neither equal in amplitude nor necessarily the same polarity from pulse to pulse.

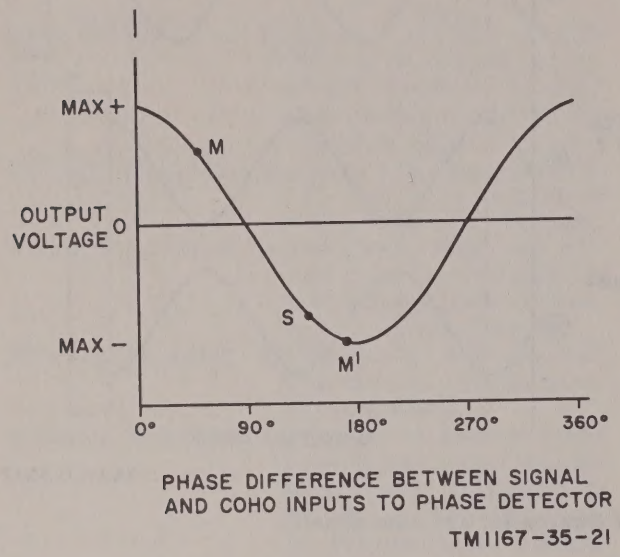


Figure 2. Phase detector output characteristic curve.

d. Cancellation Method. The method used to cancel the returns from stationary targets and provide mti signals is as follows (fig. 4):

(1) Pulsed RF oscillations are produced by the magnetron oscillator in the transmitting system and are applied to the RF system. The RF pulses are radiated by the antenna and, at the same time, a small portion of the magnetron signal is applied from the RF system to the coho mixer.

(2) The magnetron signal and the local oscillator signal are both applied to the coho mixer in the receiving system. The 60-mc IF difference frequency between the magnetron and local oscillator frequencies is detected by the coho mixer and applied to the coho. Each time the magnetron is pulsed, the input signal to the 60-mc continuous-wave (cw) coho synchronizes the coho so that its phase depends on the phase of the transmitted signal. In this way, the coho is phase-locked to the transmitted signal and the coho output to the phase detector is used as a reference signal during the receiving period (when the magnetron does not oscillate).

(3) The RF echo signals and the local oscillator signal are applied to the signal mixer in the receiving system. The 60-mc IF difference frequency is amplified and limited by the signal amplifiers and applied to the phase detector.

(4) The phase detector produces video pulses when inputs are applied from the coho and the signal amplifiers. The amplitude and polarity of the output video pulses depend on the relative phases of the two input signals. Since the coho input to the phase detector is synchronized by the transmitted signal and the phase of the IF signal is derived from the echo signal, the amplitude and polarity of the output video pulses from the phase detector depend on the distance to the target (*a* above).

(5) A 9-mc cw signal (carrier) is generated by the 9-mc carrier channel in the signal comparing system. All video pulses from the phase detector are applied to the 9-mc carrier so that the video information amplitude modulates the 9-mc carrier frequency. The modulated carrier is amplified and then applied to two channels: the delay channel and the nondelay channel.

(6) The delay channel delays the modulated 9-mc signal for a period of time exactly equal to the time between transmitted pulses. The signal is then amplified and detected (demodulated) by a negative detector.

(7) The nondelay channel amplifies the modulated 9-mc signal but does not delay it. The signal is amplified and then detected (demodulated) by a positive detector.

(8) The two video signals from the delay and nondelay channels are combined in opposite polarity so that the signals

from the same stationary target (from successive transmitted pulses) cancel because they are equal in amplitude and opposite in polarity.

(9) When compared, the returns from a moving target (from the same target but from successive transmitted pulses) do not cancel because the demodulated outputs from the delay and nondelay channels are not equal in amplitude nor necessarily opposite in polarity. The resultant difference signals from moving targets are applied to the mti video circuits. Since the mti video signals may be of either polarity, they are polarized in the mti video circuits so that only positive video pulses are applied to the indicators on which the returns from moving targets are displayed.

e. Circuit Requirements. In addition to circuit requirements necessary for normal radar operation, the following circuit requirements are necessary to accomplish satisfactory mti operation:

(1) Both the transmitter and local oscillator signals must be as free as possible from jitter, frequency modulation, and amplitude modulation. Dc is used for the filament supplies of both the magnetron and local oscillator tubes. Special consideration is given to the modulator pulse circuit to provide jitter-free operation.

(2) Arcing and magnetron frequency pulling by the RF transmission lines must be kept at a minimum. This is partially accomplished by careful design of the RF transmission lines.

(3) The pulse repetition rate or pulse timing must be exactly equal to the timing of the delay in the mercury delay line and associated signal circuits. This is accomplished in the signal comparing system by using the mercury delay line to establish the pulse repetition rate.

(4) The 60-mc reference signal must be synchronized by the transmitted signal. The coherent oscillator, which develops the 60-mc signal, is a stable 60-mc oscillator and it is phase-locked by attenuated pulses from the coho mixer.

(5) Amplitude variations of received signals must be minimized to afford maximum detection capability. The last three stages of the 60-mc IF amplifier are designed to limit the amplitude of echo signals before they are applied to the phase detector.

(6) The signal output amplitude levels of the delay and nondelay channels must be maintained to obtain best cancellation of clutter. An amplitude balancing circuit provides the necessary amplitude balance by automatically controlling the gain of the amplifiers in the delay channel.

(7) The outputs from the delay channel and the nondelay channel must be in time balance so that best cancellation of clutter is obtained. Provision is made for adjusting time balancing circuits so that the necessary time balance is obtained.

(8) A means must be provided for conveniently adjusting the mti circuits. A meter, a meter switch, and panel controls are included which provide a simple means of alining the circuits.

(9) The efficiency of the mti circuitry depends on the maintaining of close tolerances of the factors listed above.

f. Mti Operating Limitations. Employing the pulse-to-pulse comparison method of mti, the ability of the AN/TPS–1D to detect moving targets in areas free of clutter (returns from fixed targets) and its ability to differentiate between fixed and moving targets depend on a number of factors.

(1) If the moving target is in an area free of clutter, the main limiting factor is the speed of the moving target with respect to the pulse repetition rate and the RF wavelength of the equipment. The rate at which the target changes in slant range with respect to the radar set (radial velocity) affects the amplitude of the mti video signals developed by the mti circuitry. Theoretically, a target that moves an exact multiple of one-half of a wave-

length between transmitted pulses produces the same output from the phase detector from pulse to pulse, and the returns from any target for which this is true are canceled in the same manner as the returns from stationary targets. Targets moving at radial velocities equal to a multiple of one-half of a wavelength between transmitted pulses are said to be flying at *blind speeds*. Calculated on the basis of a wavelength of 23 centimeters (cm) and a pulse repetition rate of 400 pulses per second (pps), blind speeds occur at 89.4 knots and whole multiples thereof. Figure 3 shows the relationship of the amplitude of mti signals developed (before video limiting) versus the radial velocity of the target. Note that maximum mti video signals are developed at speeds of 44.7 knots removed from blind speeds. From the plot shown in figure 3 and the above discussion, it can be seen that against targets in areas free of clutter, mti performance is inherently poorer than the normal radar detection method which is not affected appreciably by the relative radial velocities of targets. The probability of a target maintaining an exact blind speed for any appreciable time is very remote, but the fact that mti performance depends to some extent on target velocities is significant.

(2) If the moving target is flying in a clutter area, the ability to detect the target depends on factors that have to do with the limitations of the mti circuits in cancelling the returns from fixed target signals. With the antenna at rest, the subclutter visibility (ability to detect moving targets in the presence of fixed targets) is limited at moving target signal levels of not more than 26 decibels (db) below that of clutter signals which are at or above the limit level of the 60-mc IF amplifier in the receiving system. As far as the radar circuits are concerned, subclutter visibility is principally determined by the stability of the local oscillator. Stability is defined by the degree of local oscillator amplitude or frequency change from one receiving period to the next. The rotation of the antenna produces the greatest limitation on the ability to detect moving targets in the presence of fixed targets. As the antenna rotates, the amplitude and phase of clutter signals change according to

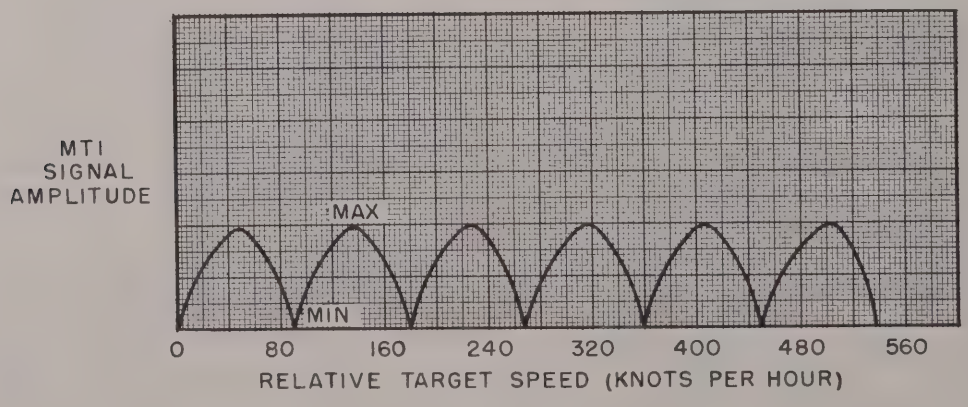


Figure 3. Mti signal versus target speed.

the shape of the antenna pattern and the RF phase distribution of the pattern. Even with slow antenna rotation, amplitude and phase changes of clutter signals can be sufficient to prevent complete cancellation of the clutter signals. In spite of the limitations of mti discussed above, mti makes it possible to detect moving targets over clutter areas where it is difficult or impossible to detect them with the normal radar method.

5. System Breakdown and Modes of Operation

The purpose of this paragraph is to establish what each functional system consists of, to discuss the relationship between systems and modes of operation, and to illustrate how switching of modes may frequently be used to sectionalize equipment troubles to a relatively small area in the equipment by observing the operation of the equipment in all modes of operation. The interrelationship between systems and a stage-by-stage block diagram discussion of the equipment are given in TM 11–1167–20. Higher echelon maintenance of the equipment requires a more comprehensive knowledge of the functions and technical operation of the functional systems and modes of operation of the equipment as well as general mti principles that pertain to the AN/TPS–1D. Refer to paragraph 4 for mti principles.

a. From a troubleshooting standpoint, the AN/TPS–1D may be operated in four different modes: normal, mti, coho adjust, and normal (internal trigger). The normal mode employs the conventional pulsed radar method of detecting and displaying the returns from stationary and moving targets on the radar indicators; the mti mode employs the pulse-to-pulse comparison method of mti to make it possible to substantially cancel the returns from stationary targets so that moving airborne targets flying over large stationary targets may be detected; the coho adjust mode is used when adjusting the equipment for proper mti operation (it is not used to search for targets); the normal (internal trigger) mode is used only for emergency operation. The normal (internal trigger) mode is used when the failure of external transmitter triggers, which are normally supplied from the signal comparing system, makes it necessary to trigger the transmitter internally from the transmitting system itself. The internal source is inherently less stable than the external source from the signal comparing system and, therefore, internal triggers cannot be used for mti operation. The frequency of the internal triggers may be varied over a range between 360 and 400 cycles per second (cps), providing an antijamming device against some types of jamming.

b. For purposes of discussion and troubleshooting, the equipment is divided into eight systems; transmitting, RF, receiving, signal comparing, indicating, antenna positioning, dc power supply, and ac power distribution and control.

c. The system breakdown is functional rather than physical. A system may be physically located in one or more component units of the equipment. The following is a list of the functional systems, the principal subassemblies or circuits of the system, and the common names of the component units in which they are located (fig. 38, TM 11–1167–20).

(1) The *transmitting system* consists of the trigger circuit (including the pulse delay network) and keyer assemblies in the modulator, and the pulse transformer, magnetron, and magnetron filament power supply circuits in the receiver-transmitter.

(2) The *RF system* consists of cavities assembly RF503, the keep-alive power supply, and the directional coupler in the receiver-transmitter, the antenna, and all RF transmission line components that feed the antenna.

(3) The *receiving system* consists of local oscillator and control circuits U501, signal mixer and harmonic filter Z509, IF preamplifier U221, coho mixer RF502, and coho preamplifier U502 assemblies in the receiver-transmitter, and coherent oscillator Z350 and 60-mc IF amplifier Z301 assemblies in the signal comparator.

(4) The *signal comparing system* consists of mti repetition rate trigger amplifier, video balancer and amplifier, nondelay amplifier Z2300, delay amplifier Z1300, and Pulse Delay Network

MX–1207/TPS–1D (2,500-microsecond delay line) assemblies, all of which are in the signal comparator.

(5) The *indicating system* consists of video amplifier circuits, ppi-scope sweep and display circuits, A-scope sweep and display circuits, fixed range marker circuits, variable range marker (strobe) circuits, video marker mixer circuits, and the indicator high-voltage power supply circuit, all of which are in the indicator.

(6) The *antenna positioning system* consists of the antenna servo amplifier assembly and antenna drive motor assembly (which includes all synchro components necessary to drive the ppi-scope and remote ppi-scope sweeps) in the antenna base, and the antenna rotate control mechanism and synchro receiver (B602) in the indicator.

(7) The *dc power supply system* consists of the unregulated +450-, and regulated +300-, +150-, and −150-volt dc power supplies, all of which are in the power supply unit.

(8) The *ac power distribution and control system* consists of the +27-volt dc power supply and the control chassis in the power supply, the distribution of +27 volts throughout the equipment, and all circuitry which control the application of 115 volts ac power to components which use 115 volts ac directly, such as transformers, blower motors, lamps, and heaters. Since they control the distribution of ac power and +27-volt dc control voltages, all fuses, blown fuse indicators, and interlocks are considered to be part of the ac power distribution and control system.

d. A functional block diagram of the equipment is shown in figure 4. The blocks with two shaded sides represent circuits which are used in all four modes of operation. The RF, antenna positioning, and dc power supply systems function the same in all modes of operation. The indicating system and ac power distribution and control system are shown with shaded blocks because the operational differences are minor in the different modes. The indicating system functions the same in all modes except for the presentations on the indicator screens, which are caused by circuitry outside of the indicating system. The operation of the ac power distribution and control system is different in different modes only in that distribution of +27 volts dc to relays is used in the mode switching circuitry. The operation of the transmitting, receiving, and signal comparing systems varies considerably, depending on the mode of operation in which the equipment is placed (see notes on fig. 4).

e. In the normal (internal trigger) mode, TRIGGER switch S152 on the modulator must be in the INTERNAL position. This mode (④, fig. 4) uses the least number of stages. Its operation is the same as the conventional pulsed radar which does not use mti. Proper operation in this mode indicates that the shaded blocks, the internal repetition rate multivibrator in the transmitting system, and the normal video circuits in the signal comparing system are all functioning properly.

f. All modes except the normal (internal trigger) mode require S152 to be in the EXTERNAL position. The normal mode (①, fig. 4) of operation differs from the normal (internal trigger) mode only in the source of triggers which trigger the transmitting system. When S152 is in the EXTERNAL position, the transmitting system is triggered by triggers produced by the external trigger generator circuits in the signal comparing system. These triggers are accurately timed by the trigger loop circuits in the signal comparing system. The accurate timing is not necessary for normal operation, but utilizing the external source of triggers for the normal mode makes it possible to switch from the normal to the mti mode of operation instantaneously from the indicator position without taking time to switch S152 to the EXTERNAL position where it must be for mti operation. If the equipment operates properly in the normal (internal trigger) mode but does not operate properly in the normal mode (which employs external triggers), the trouble must be in the external trigger generator or the trigger loop circuits in the signal comparing system.

g. The coho adjust mode (②, fig. 4) employs all the circuitry used in the normal mode, plus the coho mixer and coho circuits in the receiv-

ing system. The coho adjust mode is principally a mode in which adjustments of the coherent channel of the equipment are performed so that proper mti operation may be obtained. The coho adjust mode, however, may also be used to isolate trouble. If the equipment performs properly in the normal mode but not in the coho adjust mode, trouble must be in the coho mixer or coho circuits of the receiving system.

h. The mti mode (③, fig. 4) is used to detect moving airborne targets flying over stationary targets. It uses the pulse-to-pulse comparison method of mti (par. 4). The returns from fixed targets are substantially canceled in the signal comparing system so that only the returns from moving targets and small amounts of residue clutter, which it is beyond the capability of the equipment to cancel, are applied to the indicating system. In the mti mode, the receiving system circuitry differs from the normal mode in that the phase detector has a different video output signal because the phase detector has two inputs, one from the signal channel and one from the coho channel. The circuitry of the signal comparing system differs from the other modes of operation in that the video output from the phase detector is applied to the 9-mc carrier channel in the signal comparing system rather than the normal video circuits. The returns from stationary targets are canceled (par. 74), and pulses representing the returns from moving targets are applied from the mti video circuits to the indicating system. The mti mode uses all stages in the equipment except the normal video circuits in the signal comparing system and the internal repetition rate multivibrator in the transmitting system. If the equipment operates normally in the coho adjust mode but does not operate properly in the mti mode, the trouble is probably in the mti video circuits or the nondelay channel because these are the only circuits not common to both modes.

Figure 4. Modes of operation, functional block diagram.
(Contained in separate envelope)

CHAPTER 2

TRANSMITTING SYSTEM

Section I. GENERAL

6. General

The transmitting system produces pulses of RF energy at fixed intervals. The pulse width of the RF energy is accurately determined and set at 2 microseconds, and the time interval between pulses is approximately 2,500 microseconds. Peak power output of the transmitter is about 500 kilowatts (kw) and the RF is adjustable through a frequency range of 1,220 to 1,350 megacycles per second (mcs). The functional relationship of the transmitting system of the AN/TPS–1D and the physical location of the transmitting system components are covered in TM 11–1167–20.

7. Transmitting System, Block Diagram (fig. 5)

a. High-Voltage Power Supply and Control Circuits. The high-voltage power supply provides the transmitting system with operating power. The control circuits provide a means of applying input power and disconnecting the input power when abnormal loading conditions exist.

(1) Radiate relay K152 connects 115 volts ac to the high-voltage rectifier when RADIATE ON switch S616, located on the indicator, is depressed.

(2) Protective relay K151 operates and causes K152 to disconnect input power from the transmitting system when abnormal loading exists in the keyer or RF oscillator circuits.

(3) The high-voltage power supply functions as a full-wave rectifier. It provides a 5-kv (Kilovolt) dc output to charge pulse forming network Z161 in the keyer circuit.

b. Trigger Circuit. The function of the trigger circuit is to amplify and shape the waveforms which are applied as trigger pulses to the keyer circuits and to output jacks for identification friend or foe (iff) triggers and test equipment synchronizing pulses.

(1) TRIGGER switch S152, when in the EXTERNAL position, selects an accurately timed trigger pulse which is generated in the signal comparing system. When switched to the INTERNAL position, it enables internal repetition rate multivibrator V101 to operate by applying +300 volts.

(2) Internal repetition rate multivibrator V101 generates a rectangular voltage waveform which is differentiated and applied to blocking oscillator keyer V102A.

(3) Blocking oscillator keyer V102A can accept either a negative trigger voltage from an external source or a positive trigger voltage from internal repetition rate multivibrator V101. It produces an output which triggers blocking oscillator V1101A.

(4) Blocking oscillator V1101A is triggered and produces a narrow negative pulse that is coupled into diode clipper V1102A. An output is also provided for applying positive triggers to an iff set through iff PRE-TRIGGER jack J157.

(5) Diode clipper V1102A is connected to pass negative pulses to delay line Z1101. It prevents the positive voltage from V1101A from triggering blocking oscillator keyer V1101B.

(6) Delay line Z1101 is a shorted end artificial transmission line that has provisions for either 37- or 12.4-microsecond delay. The negative pulse which is applied, is reflected when it reaches the short circuit and the polarity is reversed. The resulting positive output is applied to blocking oscillator keyer V1101B.

(7) Delay line discharge diode V1102B conducts only when the delay line is discharging. It properly terminates the line and prevents reflections.

(8) Blocking oscillator keyer V1101B responds to the positive output pulse from the delay line, amplifies it, and triggers blocking oscillator V102B.

(9) When triggered, blocking oscillator V102B generates a high amplitude pulse which is coupled to cathode follower V103.

(10) Cathode follower V103 is a power amplifier stage and its output pulse is coupled through a low impedance coupling transformer into a coaxial line and then transferred to thyratron keyer V156.

c. Keyer Circuit. The keyer circuit utilizes the output of the high-voltage power supply (about 5 kv) to store energy. When it is triggered, a high-voltage pulse 2 microseconds wide is generated and applied to the rf oscillator circuits.

(1) Charging choke L151 is in series with the high-voltage power supply and pulse forming network Z161. It provides a means of charging Z161 to twice the supply voltage.

(2) Charging diodes V153 and V154 are parallel-connected. They are in series with charging choke L151 and pulse forming network Z161. They conduct while Z161 is charging to twice the supply voltage, and then stop conducting when Z161 is fully charged and isolate Z161 from the charging voltage source.

(3) Pulse forming network Z161, having charged to about 10 kv, is discharged when thyratron keyer tube V156 is triggered and provides a 5-kv pulse 2 microseconds wide across the primary of T502 in the rf oscillator circuits.

(4) Shunt diode V155 conducts at the end of the 2-microsecond discharge interval of Z161. Its conducting action clamps the charging voltage of Z161 to a slightly negative voltage to prevent thyratron keyer V156 from retriggering. When it conducts, it provides operating current for half of protective relay K151.

d. Rf Oscillator. The output of Z161 (5kv pulses, 2 microseconds wide and repeated at 2,500-microsecond intervals), is applied to pulse transformer T502. The pulse amplitude is stepped up to approximately 28.5 kv. It is applied to magnetron V502 which produces pulses of rf energy from approximately 1,220 to 1,350 megacycles for application to the rf assembly. The average magnetron current is constantly monitored by meter circuit M502.

Figure 5. Transmitting system, complete block diagram.
(Contained in separate envelope)

Section II. HIGH-VOLTAGE POWER SUPPLY AND CONTROL CIRCUITS

8. General

The high-voltage power supply and its associated control circuits are not grouped together physically but depend on one another to apply power to the transmitting system and protect against serious damage to system components when abnormal conditions occur. Distribution of input power (115 volts, 400 cycles) and the 27-volt dc power supply is shown in figures 229 and 231. The high-voltage power supply is shown in figure 210.

9. Radiate Relay K152
(fig. 6)

When the RADIATE ON button, located on the indicator, is depressed, a potential of +27 volts dc is applied to the field winding of radiate relay K152. When energized, the contacts of K152 pull in and complete the primary circuit of high-voltage transformer T151, applying 115 volts 400 cycles. The 27-volt supply bus for K152 is in series with interlock S153B and the normally closed contacts of protective relay K151. Relay K152 drops out and disconnects primary power to T151 when interlock S153B is opened or relay K151 becomes energized because of abnormal circuit operation in the transmitting system.

10. Protective Relay K151
(fig. 6)

a. Protective relay K151 has two separate windings and its contacts, 2 and 3, are normally closed in the de-energized condition. Its func-

tion is to remove +27 volts from the field winding of K152 when abnormal operating conditions occur in the transmitting system. The K151A winding is in the dc return leg of the high-voltage secondary of T151. When the high-voltage power supply is operating, approximately 3 percent of the supply current flows from the center tap of the high-voltage secondary winding through R153, K151A, and part of R168, to ground. The remaining 97 percent of the current flows through R152 to ground. Normally, the current through K151A would cause the relay to energize except that K151B is wound to produce a field which opposes the field of K151A so that one cancels the effect of the other. The current through K151B is derived from the conduction of shunt diode V155 (fig. 13). The shunt diode conducts each time the pulse forming network discharges and provides the operating current for K151B. The variable resistor connected in the return legs of K151 is used to balance the currents through the K151 windings. If an unbalanced condition exists and the currents of K151A and K151B are not equal, or at least within a tolerable range, then K151 operates and disconnects +27 volts from relay K152, which becomes open and primary power is disconnected from T151. When K151 operates, relay K405 located in the power supply, is also disabled, removing +27 volts from the bus. When contacts 2 and 3 of K151 drop back into their normally closed position, K152 will not operate because the +27-volt bus is open. To restore the high-voltage power supply to its operating condition, the RADIATE ON button located on the indicator panel must be depressed. For additional data on relays and ac control circuits, refer to chapter 8.

b. Protective relay K151 may operate for reasons listed below:

(1) Short or arcing in RF system.
(2) Shorted magnetron.
(3) Magnetron not oscillating.
(4) Intermittent oscillating magnetron.
(5) Mode changing of magnetron.
(6) Magnetron arcing or excessive sparking.
(7) Failure of magnetron filament supply.
(8) Open or shorted windings of pulse transformer.
(9) Failure of the shunt diode.
(10) Open winding of relay K151A or K151B.

11. High-Voltage Power Supply
(fig. 6)

The high-voltage power supply consists of high-voltage transformer T151 and rectifiers V151 and V152. The rectifiers are connected to function as a conventional full-wave rectifier circuit. The primary of T151 is tapped to provide a turns ratio between primary and secondary which can be selected to produce a secondary ac voltage ranging from 9,100 volts to 10,500 volts. The rectified output from rectifiers V151 and V152 is approximately 5,000 volts dc. Capacitor C153 is the high-voltage filter capacitor. Resistor R152 is a voltage dropping resistor and supplies a negative voltage source for the relay winding of K151A. A voltage drop is realized across R152 only when the keyer circuits are operating. The 6-megohm bleeder resistor (R151) is used to insure the discharging of capacitor C153 when power is disconnected from the system. Safety switch S151 makes contact and quickly discharges the high voltage across C153 when the modulator is removed from its case. Switch S151 is mechanically connected to interlock S153B and is used for the protection of maintenance personnel.

Section III. TRIGGER CIRCUIT

12. General
(fig. 210)

The trigger circuit is a separate chassis located in the modulator. TRIGGER switch S152, located on the front panel of the modulator, selects an external trigger pulse from the signal comparing system for accurate transmitter timing or enables a self-contained trigger generator which has a variable repetition rate control. A pulse delay network is included in the trigger circuit which provides iff pretrigger pulses. A delay line provides a time delay of either 37 or 12.4 microseconds for the trigger pulse to the thyratron keyer. The output of the trigger circuit is fed through a coaxial line which is part of the connecting

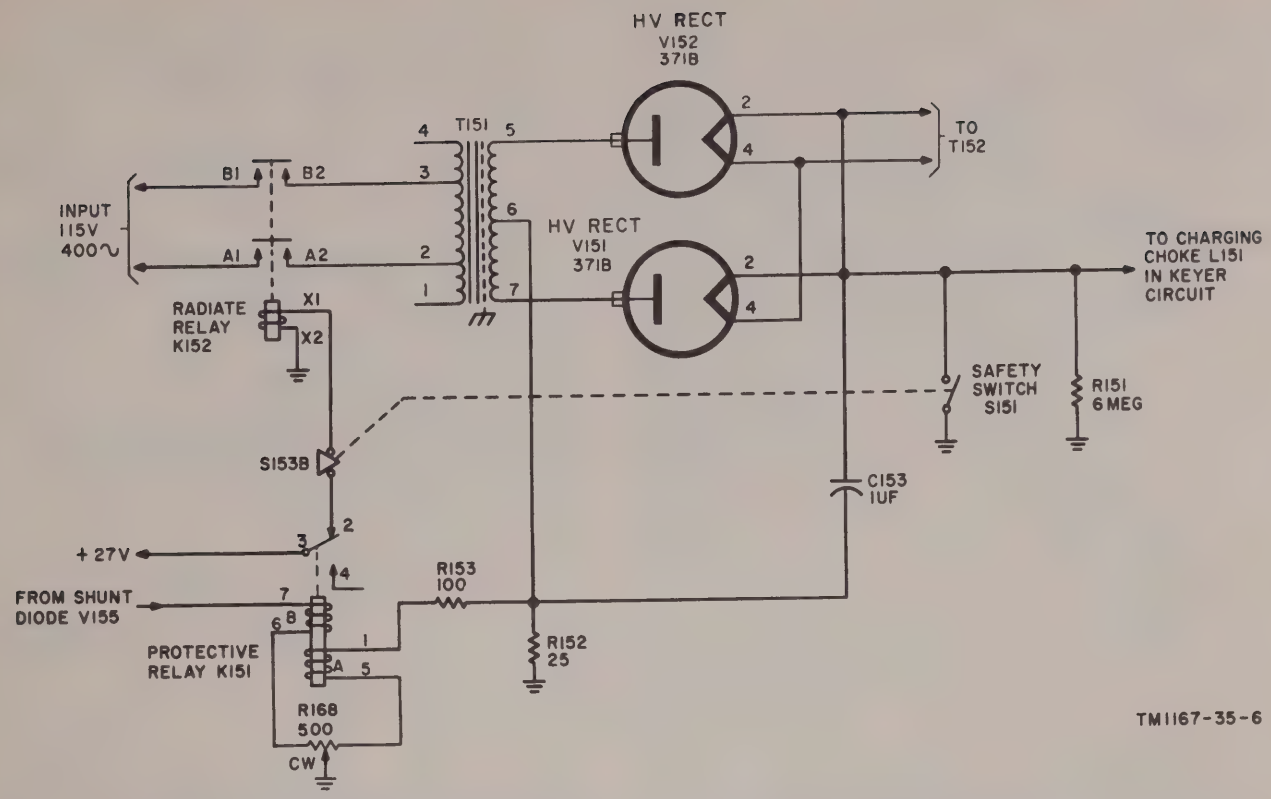


Figure 6. High-voltage power supply and control circuits, simplified schematic diagram.

harness and provides high amplitude triggers to the thyratron keyer located on the main chassis.

13. TRIGGER Switch S152
(fig. 7)

TRIGGER switch S152 is a double pole, double throw switch located on the front panel of the modulator. It connects an external trigger source into the trigger circuit when switched to the EXTERNAL position and provides operating voltage to the internal repetition rate multivibrator when switched to the INTERNAL position. The external trigger is an accurately timed pulse which is generated in the signal comparing system and is connected through EXT. TRIGGER INPUT jack J152 on the front panel of the modulator. The incoming external triggers are transferred from the switch through a coaxial line to the cathode of blocking oscillator keyer V102A. When in the INTERNAL position, S152 connects B+ to internal repetition rate multivibrator V101. In this position, the external trigger becomes disconnected from the trigger circuit and the pulse repetition frequency of the system is determined by V101. Capacitor C105A functions as a cathode bypass capacitor and is connected across the cathode resistor of V102A when S152 is switched to the INTERNAL position. Resistor R101 is connected in series with the B+ supply to V101 and functions as a decoupling resistor.

14. Internal Repetition Rate Multivibrator V101
(fig. 8)

a. Operation. Internal repetition rate multivibrator V101 is a plate-coupled multivibrator with the grid resistors returned to B+ to increase the output frequency stability. When B+ is applied through S152, multivibrator V101 is enabled to operate. Section B of V101 has an unbypassed cathode resistor (R109) which functions as the load. The properties of V101B will be degenerative and cause it to be driven toward cutoff, which results in a rising plate voltage. The rise will be exponential for a period of time and is determined by the time constant of C102, R104, and R105. The grid

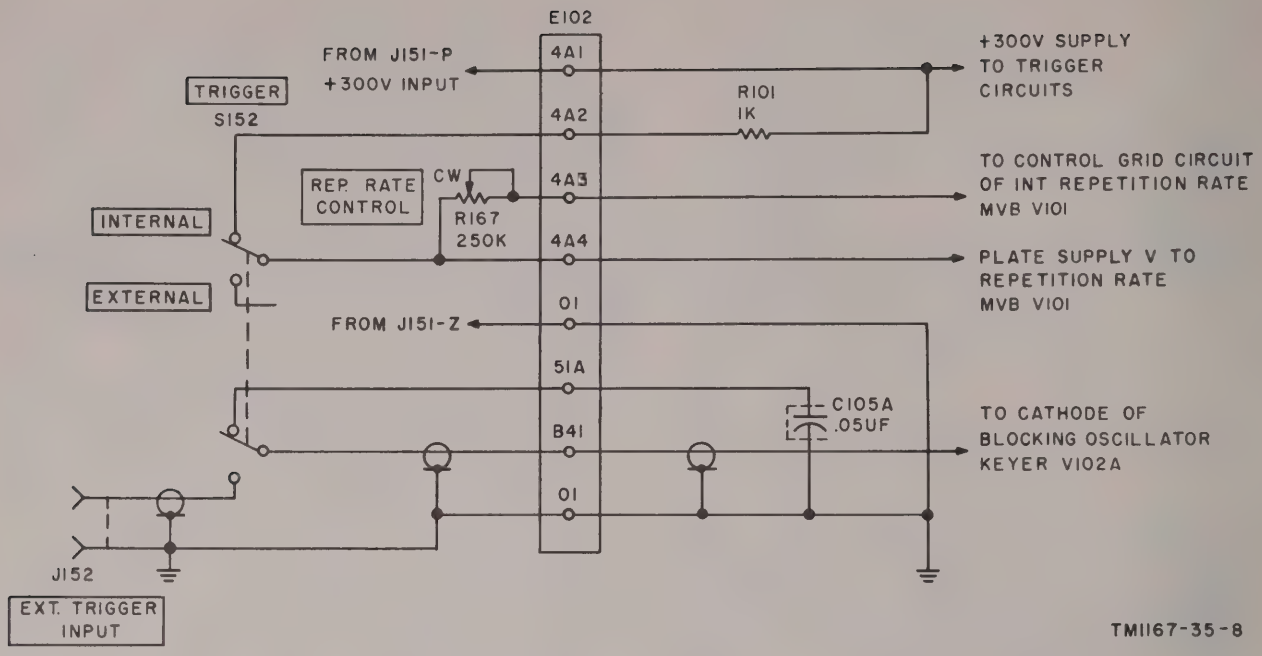


Figure 7. TRIGGER switch S152, simplified schematic diagram.

of V101A is driven slightly in the positive region because of the return of R106 to B+ and the charging of C102 through the grid to cathode circuit. Tube V101A is now in a state of heavy conduction and the voltage drop across R102 and R103 causes the plate voltage to drop to a very low value. Capacitor C103, affected by the drop in plate voltage, discharges through R107, R108, R110, and R167, causing the grid of V101B to be driven far below cutoff. The setting of R110, the coarse frequency adjustment, sets the limit of the frequency not to exceed 400 cycles. REP. RATE CONTROL R167 and the setting of R110 determines the time constant and, therefore, the length of time V101B will be cut off. If 400 cycles is exceeded, the magnetron average current will rise above normal values. The discharging characteristics of C103 through the grid resistors produce an exponential voltage rise at the grid of V101B. The voltage rise starts from the negative region far below cutoff (determined by the plate voltage change of V101A) and rises rapidly toward B+. The grid voltage goes through the cutoff level of the tube during a more linear part of the exponential rise in voltage, causing V101B to conduct. When V101B conducts, its plate voltage drops because of the voltage drop across R104 and R105. This dropping voltage causes C102 to start discharging through R106. The voltage at the grid of V101A drops and approaches cutoff. As cutoff is approached, the plate voltage of V101A rises because of a decreasing voltage drop across R102 and R103 plate load resistors. The rising plate voltage is coupled through C103 and causes the grid voltage of section B to rise slightly into the positive region. The action is regenerative and the heavy conduction of section B causes its plate voltage to drop sharply to a very low value; this change is coupled through coupling capacitor C102 to the grid of V101A. Section A is again driven far into the cutoff region and the length of time it is held below cutoff is determined by the time constant of C102 and R106. The plate voltage waveform of V101A can be observed at test point TP101.

b. Output. The variations of the tube current of section B develop a voltage waveform across cathode load resistor R109. The voltage waveform across R109 is coupled through and differentiated by C104 and R111. The short time constant of C104 and R111 (about 12.7 microseconds) produces very narrow differentiated pulses. These pulses (monitored at test point TP102) are applied to blocking oscillator keyer V102A.

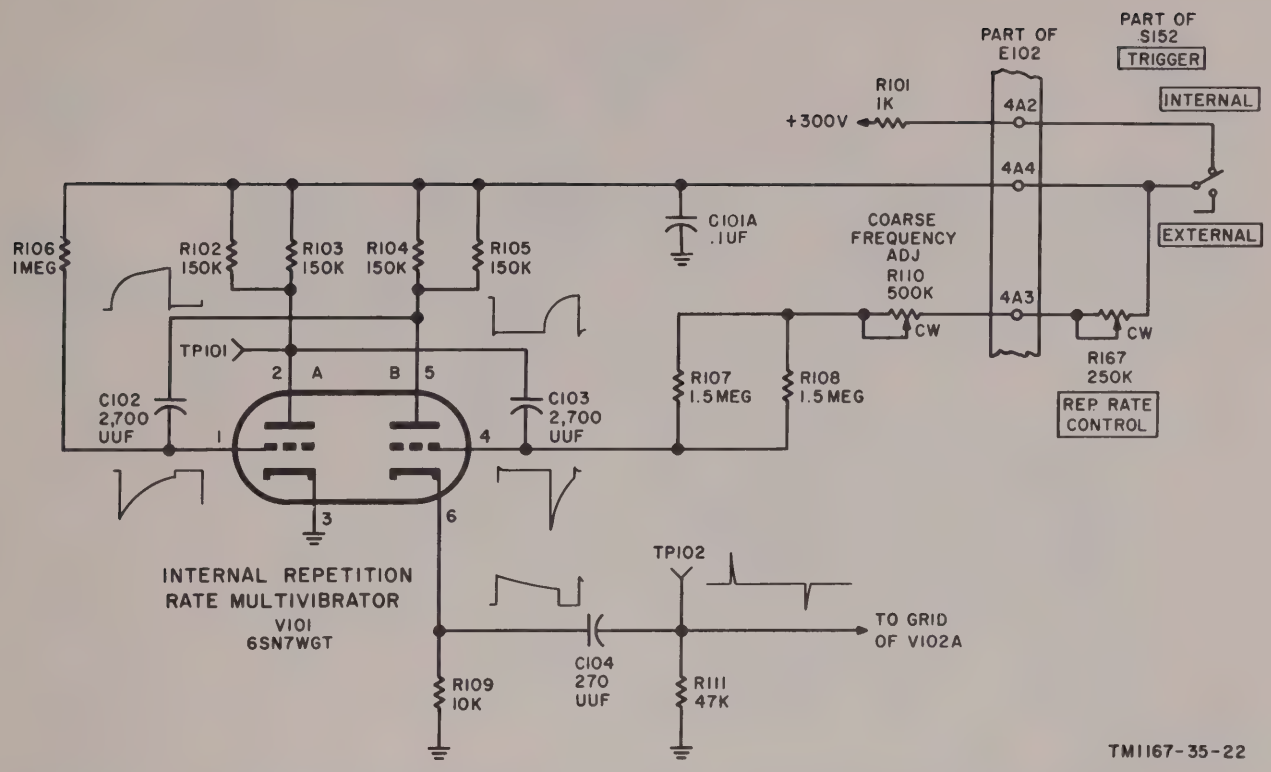


Figure 8. Internal repetition rate multivibrator, simplified schematic diagram.

15. Blocking Oscillator Keyer V102A (fig. 9)

a. Blocking oscillator keyer V102A is normally biased just below cutoff by fixed voltage divider resistors R113, R114, and R112. When the system is switched for internal operation, V102A receives the differentiated voltage waveform from the internal repetition rate multivibrator. The negative swing of the waveform does not affect the operation of the tube, since the grid is driven further into cutoff. The positive swing of the differentiated waveform brings V102A out of cutoff and causes heavy conduction. A negative pulse is generated in the plate circuit.

b. When the system is switched for external operation, the preceding multivibrator stage (V101) is disabled and the input to V102A is provided through the cathode circuit. An external trigger pulse originating in the signal comparing system is connected through EXT. INPUT TRIGGER jack J152 located on the front panel, through TRIGGER switch S152 to cathode resistor R112. Resistor R112 serves as part of the voltage divider forming the bias network for V102A and as a cathode resistor for the application of the external trigger pulse. The polarity of the external pulse is negative and drives the cathode voltage negative. The control grid remains essentially at the same static potential and, since the cathode is driven negative with reference to its static voltage, the bias of V102A reduces and causes the tube current to increase. The increase of plate current from a nonconducting state causes a negative pulse to be generated in the plate circuit. The plate of V102A and the plate of blocking oscillator V1101A in the following circuit (fig. 10) have a common plate load, and the waveform indicated is the combined effect of the amplified trigger pulse from V102A and operation of V1101A.

16. Blocking Oscillator V1101A (fig. 10)

a. Operation. Blocking oscillator V1101A is normally biased below cutoff by the fixed voltage divider which includes resistors R1101 and R1102 in the cathode. When the keyer in the preceding stage conducts, a magnetic field is generated by the common plate load winding (2–3) of transformer T1101. The grid wind-

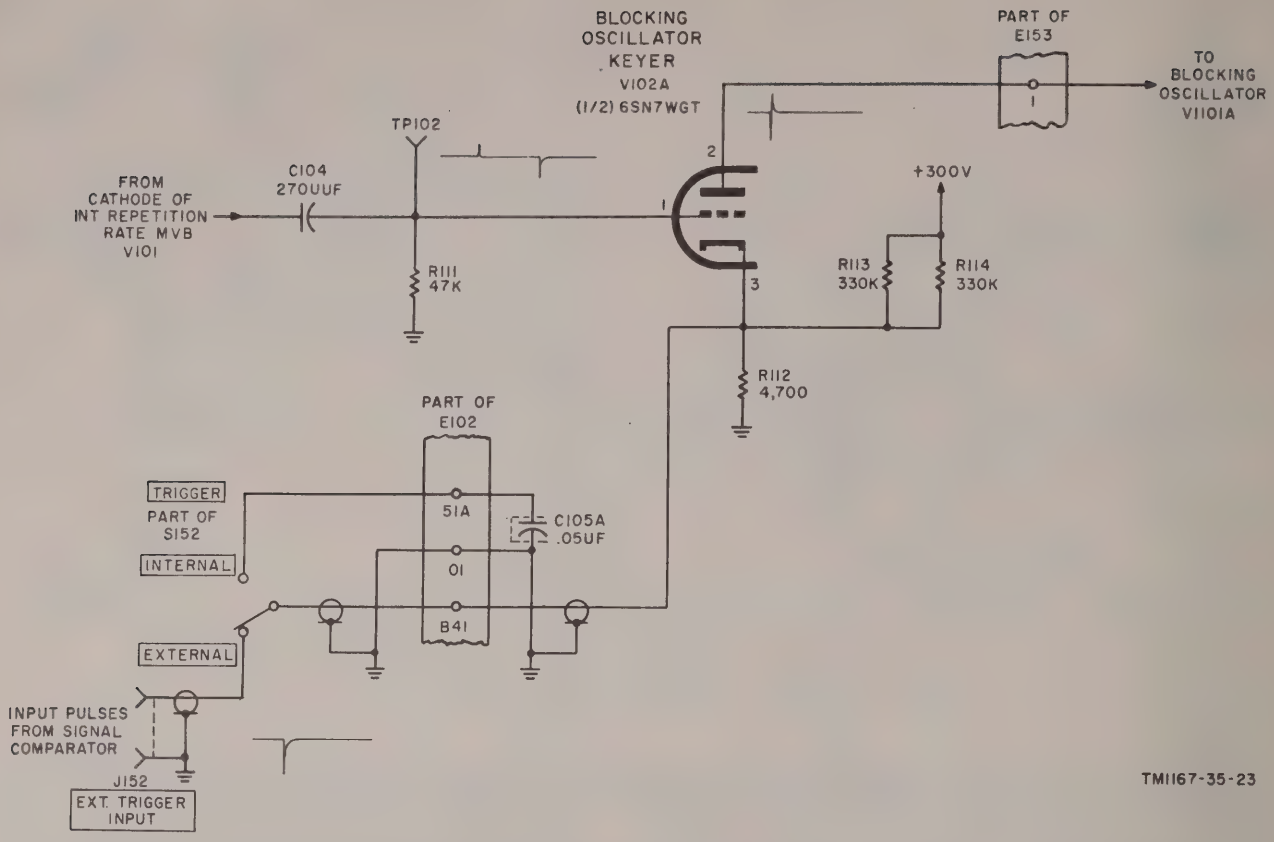


Figure 9. Blocking oscillator keyer V102A, simplified schematic diagram.

ing (1–6) is excited and a voltage is generated across the winding which causes the grid to be driven positive. Regenerative action in the blocking oscillator starts when V1101 starts to conduct. The plate current of V1101 increases and the magnetic field intensity of the plate winding increases, coupling a positive voltage to the control grid. When the tube current approaches saturation and the rate of change of current flowing through the tube is no longer increasing, the magnetic field of the plate winding is no longer changing and the induced grid voltage starts to drop. As the grid voltage drops, the tube current starts decreasing, thereby causing the magnetic field in the plate winding to collapse. The collapsing field of the plate winding induces a negative voltage into the grid winding and drives the grid into the cutoff region. Tube current stops flowing and the energy stored in the grid and plate windings is dissipated after a few cycles of oscillation. The tube remains at cutoff because of the fixed cathode bias, and the oscillations that follow after the stage functions are damped and maintained well below the cutoff level of the grid so that the stage does not become free running.

b. Output. The tube current during the operation of V1101A causes a positive pulse to develop across cathode resistor R1102. The positive pulse is coupled through coupling capacitor C1101 to load resistor R1103 and through a coaxial line to front panel jack J157 (IFF PRE-TRIGGER). The output pulse triggers iff equipment used with the radar set at a time interval prior to the transmitter firing. The time delay is determined by the delay line in the following circuits. The negative pulse developed in the plate circuit of V1101A is coupled to the following stage.

17. Diode Clipper V1102A
(fig. 11)

The negative pulse generated by blocking oscillator V1101A is coupled through capacitor C1103 and developed across R1105. Diode clipper V1102A is connected to conduct only when negative pulses are applied to the cathode

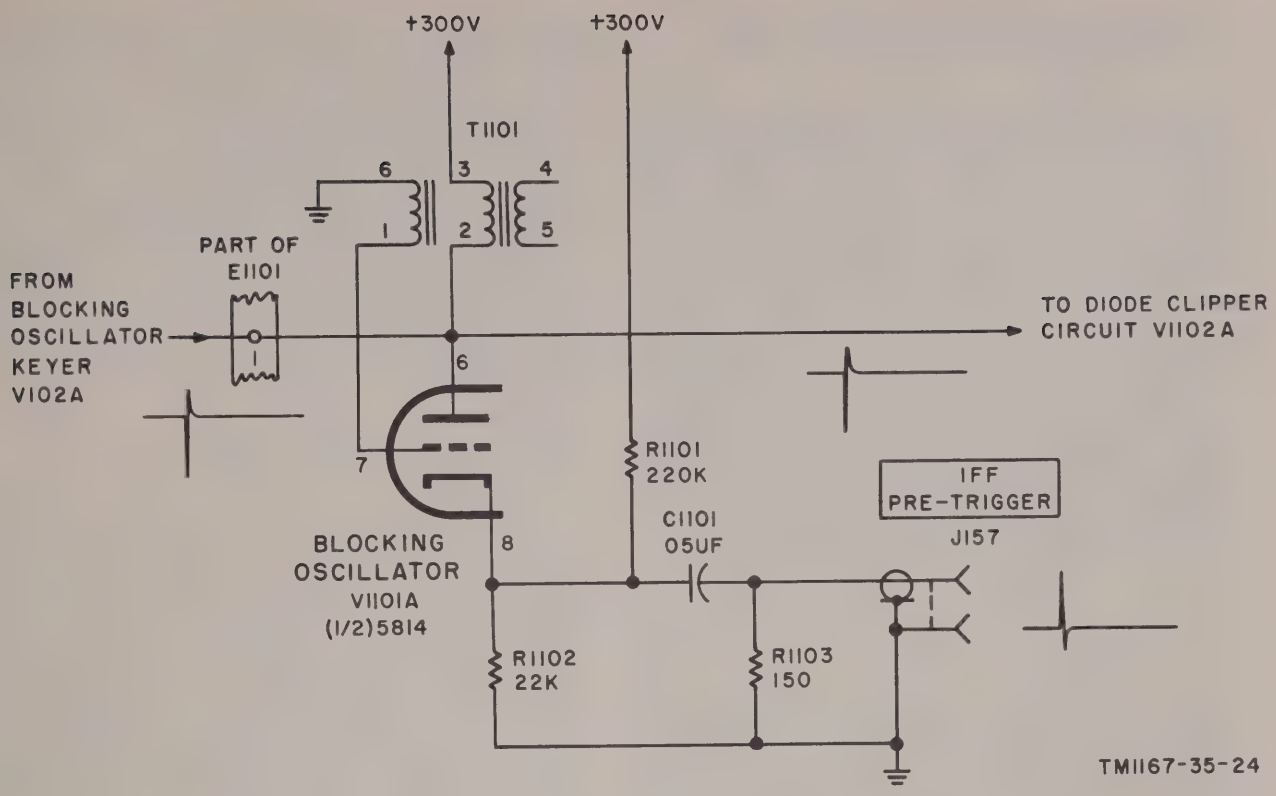


Figure 10. Blocking oscillator V1101A, simplified schematic diagram.

and becomes an open circuit to any positive voltage variations that follow the pulse. Only positive pulses can trigger blocking oscillator keyer V1101B which could be pretriggered except for the protection of the diode clipper. The diode clipper output provides a negative pulse that is applied to delay line Z1101.

18. Delay Line Z1101
(fig. 11)

Delay line Z1101 is designed to provide either 12.4 or 37 microseconds delay, depending on the requirements of the iff system used with the radar set. Microsecond delay switch S1101 is normally in the 12.4 position. The delay line is terminated at one end with a short circuit and, therefore, will reflect a voltage wave of opposite polarity to that which is applied. The negative pulse from the diode clipper enters the delay line between terminals 1 and 3. The negative pulse travels down the line to the short circuit. Since its energy is not dissipated by the short circuit, it is reflected, with a reversal of polarity (from the short circuit), to the input end of the line. It takes 6.2 microseconds for the pulse to travel down the line and another 6.2 microseconds to return from the shorted end to the input end. This results in a total time delay of 12.4 microseconds.

19. Delay Line Discharge Diode V1102B
(fig. 11)

The delay line discharge diode plate is connected across the input of the delay line and the cathode is grounded. The negative pulse that is first applied to the delay line encounters a high impedance through the diode and enters the delay line. The pulse returning out of the delay line has a positive polarity and causes the diode to conduct. Resistor R1106 (4.7K) and the resistance of the conducting diode are of the proper value to terminate the delay line and absorb the energy. This prevents the energy from reentering the line, causing additional reflections and distorting the waveform. The entire waveform includes a negative pulse followed by a positive pulse which was delayed 12.4 microseconds. The waveform is coupled through resistance-capacitance (RC) coupling network R1108 and C1104 and is applied to blocking oscillator keyer V1101B.

20. Blocking Oscillator Keyer V1101B (fig. 11)

Blocking oscillator keyer V1101B is biased below cutoff by the fixed cathode bias voltage determined by divider network R1109 and R1110. Capacitor C1106 is the cathode bypass capacitor. The negative pulse applied to the control grid has no effect on the tube since the grid is driven further into cutoff. Exactly 12.4 microseconds later, the positive return from the delay line causes the tube to come out of cutoff. The tube conducts and generates a negative pulse across the common plate load for tubes V1101B and V102B which is the plate winding (3–5) of transformer T102 (fig. 12). The negative pulse starts the blocking oscillator action of the following circuit.

21. Blocking Oscillator V102B (fig. 12)

Blocking oscillator V102B is normally biased below cutoff by the fixed cathode bias network consisting of voltage divider R115, R116, and R118, and cathode bypass capacitor C105B. When the negative pulse is generated in the common winding (3–5) of transformer T102, the blocking oscillator action starts. The operation of this circuit is similar to that described in paragraph 16 except for the method of pulse signal voltage takeoff. The third winding (2–4) of T102 develops a positive pulse as a result of the blocking oscillator action. When the functioning cycle of V102B is completed, it returns to the cutoff condition and awaits the next trigger from blocking oscillator keyer V1101B. Decoupling network R117 and C101B reduces the possibility of pulse variations generated in T102 from getting into the B+ lines. The pulse voltage across the output winding (2–4) can be observed with an oscilloscope at test point TP103. It is applied to cathode follower V103.

22. Cathode Follower V103 (fig. 12)

Cathode follower V103 is a pentode tube connected as a triode cathode follower circuit. Resistor R119 is the grid resistor and R120 is the grid limiting resistor. The bias for the stage is developed across cathode resistor R122. The positive pulse applied to the grid of V103 causes the tube to increase conduction. The function of grid limiting resistor R120 is to limit grid current and clip the positive peaks. The pulse is reproduced across cathode load resistor R122 and is coupled through capacitor C107 to the primary of coupling transformer T103. Test point TP104 is provided at this point to observe the pulse shape. Transformer T103 couples the pulse into a coaxial cable

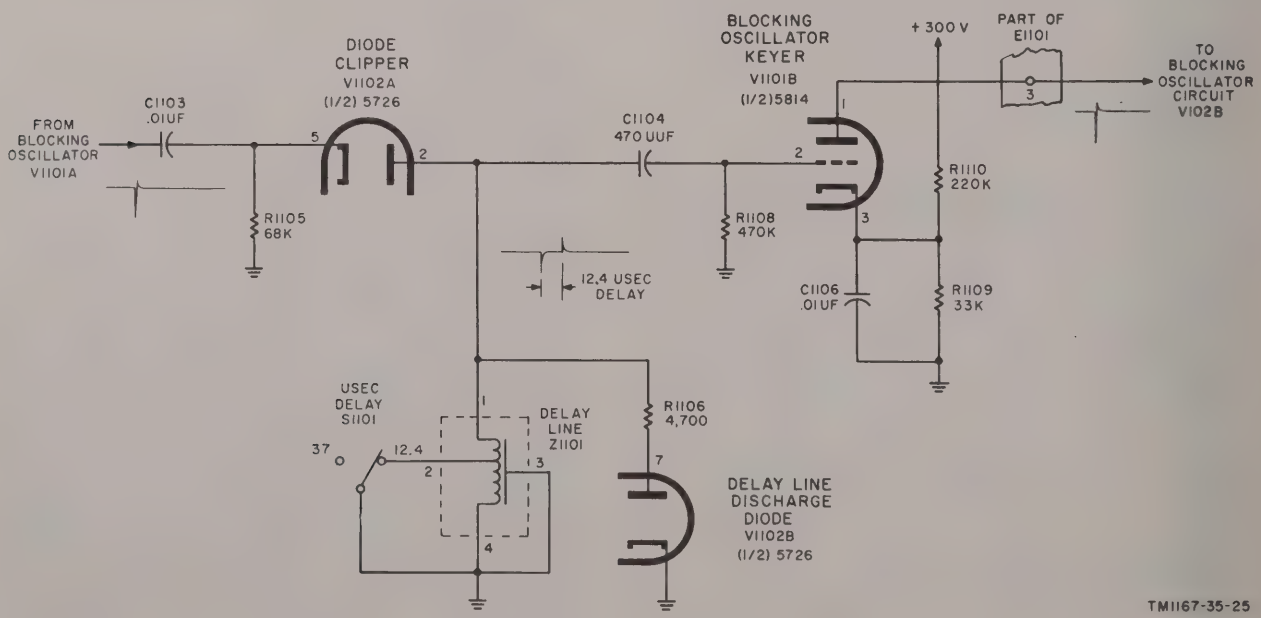


Figure 11. Pulse delay network, simplified schematic diagram.

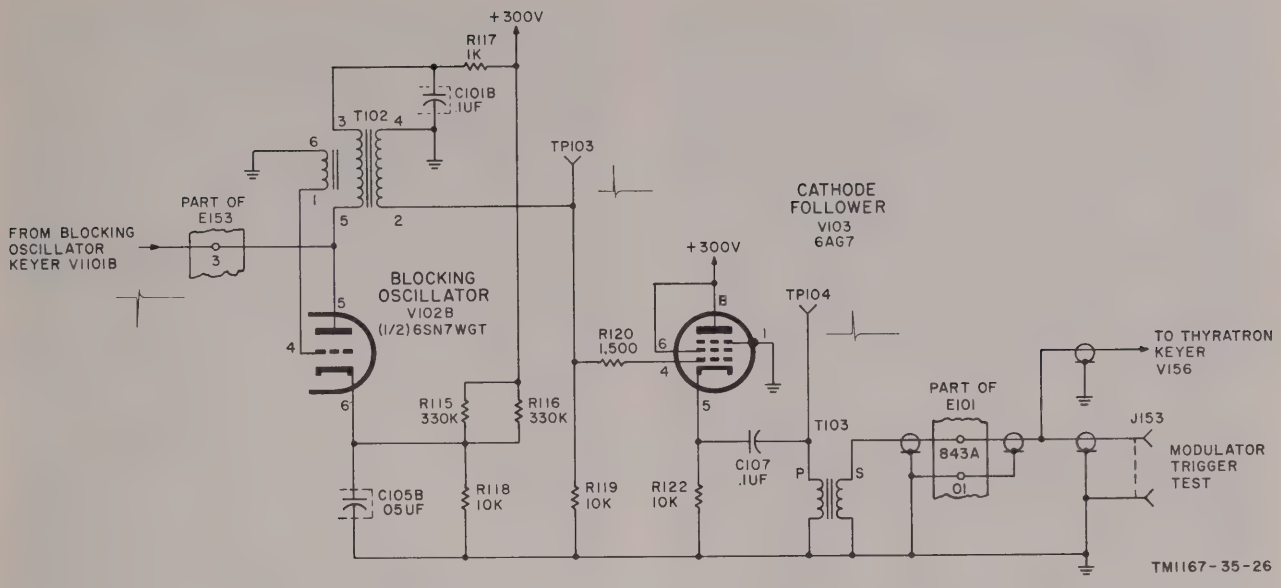


Figure 12. Trigger circuit output stages, simplified schematic diagram.

through terminal board E101. Test coaxial connector J153, located on the front panel of the modulator, may be used to monitor the trigger pulse or provide a trigger source for synchronizing test equipment. The trigger pulse is transferred through coaxial cable to the keyer circuits where it triggers thyratron keyer V156.

Section IV. KEYER CIRCUITS

23. General

The function of the keyer circuits is to provide a pulse 2 microseconds wide and of proper amplitude and power to excite the RF oscillator. Energy is stored by pulse forming network Z161 and is discharged by the thyratron. The complete functional block diagram is shown in figure 5.

24. Charging Choke L151 and Charging Diodes V153 and V154 (fig. 13)

a. Charging choke L151 forms a series-resonant circuit with the capacitance of pulse forming network Z161. The resonant frequency is approximately 200 cycles, which is one-half of the pulse repetition frequency of the set and twice the pulse repetition time. The circuit function is based on the principle of dc resonance charging which makes it possible for the capacitance of Z161 to charge to twice the supply voltage. The time required to attain this value of charge is one-half the period of the 200-cycle resonant frequency (within 2,500 microseconds), which is equal to the pulse repetition time of the set. The charging diodes (V153 and V154) conduct and present a low value of series resistance when Z161 is charging. When the maximum charge is reached, the diodes stop conducting and isolate Z161 from the power supply.

b. When Z161 is charging to the value of the supply voltage, the charging diodes (V153 and V154) conduct easily and the series current causes L151 to store energy in its magnetic field. The amount of energy in the magnetic field is about equal to the energy stored in the capacitance of Z161. When the charge on Z161 reaches the supply voltage value, the magnetic field around L151 collapses and forces current to continue to flow in the same direction. This action continues to charge the capacitance of Z161 in the same direction and Z161 charges to a value of nearly twice the supply voltage.

c. The charging diodes (V153 and V154) have their cathodes connected to Z161, which

is now charged to approximately 10 kv, and their plates connected to the 5-kv power supply, thus being rendered unable to conduct. Their function is to disconnect Z161 from the power supply when the maximum charge has been reached, enabling Z161 to retain its charge until the thyratron keyer tube functions.

d. In addition to dc resonance charging, an important function of the charging choke is to prevent damaging the thyratron or the power supply when Z161 is being discharged. When the thyratron is triggered, its resistance drops to a very low value to effectively discharge Z161. This also places the cathodes of the discharge diodes to very nearly ground potential through the thyratron. The 5-kv power supply would discharge through this circuit and the excessive currents could cause considerable damage. The inductive reactance of L151 during this short interval of time is very high and prevents any sizeable amount of current from flowing through the power supply.

25. Thyratron Keyer Tube V156
(fig. 13)

a. When pulse forming network Z161 has reached its full charge, the thyratron tube receives a trigger pulse which was generated in the trigger circuits. The plate voltage is approximately 10 kv because of the charge on Z161 and a trigger pulse in excess of 150 volts in amplitude is applied to the control grid across grid resistor R160. The thyratron is a thermally heated hydrogen gas tube (arc tube) and, when ionized, conducts very heavily, causing its resistance to drop to about 1 ohm. Its construction is such that the gas will not ionize under the influence of the plate voltage. A high amplitude positive pulse is required at the control grid to cause ionization between grid and cathode before the plate voltage has any influence on the gas. When the plate voltage does affect ionization, the conduction increases to a value of approximately 300 amperes in 1/10 microsecond or less. The thyratron will continue to conduct until the plate voltage drops to the de-ionization level. De-ionization of the thyratron is insured by causing the plate voltage to drop into the negative region (par. 26).

b. Rf choke L152 is a low value inductor (39 microhenries) and its purpose is to prevent damage to the thyratron because of excessive currents when it starts conducting. Before conducting, the plate circuit is at approximately 10-kv potential. The stray capacitances have also charged to the same potential. The stray capacitances consist of the wiring and cabled leads to Z161 that may be quite lengthy, the filament transformer of the charging diodes, and the filament transformer of the shunt diode. A considerable amount of energy is stored in these capacitances and, with the lead inductance of the plate wiring, a high-frequency oscillation can start when the thyratron starts conducting. The abrupt rate of rise of the oscillating current, combined with the normal discharge current of Z161, can reach excessive values which will exceed the plate dissipation rating of the thyratron and cause serious damage. Placing L152 in series with the plate lead of the thyratron introduces a high reactance at the start of the discharge time and lets the thyratron current build up to maximum value a little slower. This has a slight tendency to slope the leading edge of the pulse output but not to a degree that will cause any serious distortion to the wave shape. The slight slope of the leading edge of the pulse can improve the performance of the magnetron by allowing it to *ease* into oscillation as the pulse voltage level is reached. Too sharp a rise of the pulse voltage may pass the normal operating level before the magnetron starts to oscillate and cause it to oscillate in another mode or to arc.

26. Pulse Forming Network Z161
(fig. 13)

Pulse forming network Z161 is essentially an open-ended artificial transmission line. The inductive and capacitive arrangement of the network has a characteristic impedance of 16 ohms and the total delay (down and back interval) is 2 microseconds. When the network charges, it resonates with the charging choke (par. 24) and reaches its maximum charge in a period of less than 2,500 microseconds. When the thyratron is triggered, it represents a short circuit and the discharge path of Z161 is through the primary of pulse transformer T502 (fig. 14), through the thyratron, and L152. The impedance of the primary of T502 is purposely designed to be about 15 ohms or

less, depending on the reflected impedance of the magnetron, so that Z161 discharges into a slightly lower impedance. Since the characteristic impedance of Z161 is 16 ohms and the primary of T502 is 15 ohms or less, the 10-kv charge divides proportionally across these components and the amplitude of the pulse developed across the primary of T502 will be slightly less than 5 kv. When Z161 starts to discharge, a negative wave front travels from the input terminals to the open end of the line. Its amplitude is slightly greater than 5 kv. After the start of the discharging interval (1 microsecond later), the negative wave front reaches the end of the line. It encounters an open circuit and, therefore, reflects in phase with itself. During the return interval, the wave front is a value that will extend into the negative voltage region. Although the mismatch results in slightly less power output at the transmitter, it is of no serious proportion and is almost negligible. The advantage of the mismatch is that when the pulse is terminated the plate voltage presented to the thyratron drops well below the de-ionization level. If mismatch or improper tuning in the rf system occurs, the primary of T502 might present a higher impedance to Z161. This would cause the thyratron plate voltage to remain 100 volts or more positive after Z161 has discharged, and may cause re-ignition of the thyratron. De-ionization time of the thyratron normally takes about 5 microseconds. Purposely causing the waveform to terminate in the negative region insures that the thyratron extinguishes and also provides a means for the shunt diode to conduct and clamp the starting voltage of the resonant charging waveform to an exact level. This also insures that Z161 charges to the same value each period. The output pulse is coupled out of front panel jack J155. Resistors R157, R158, and R159 are connected as a divider to observe the Z161 charging waveform at TP151. Resistors R169 and R162 through R166 are connected as a divider to sample the output pulse waveform at a coaxial connection (J156) located on the front panel.

27. Shunt Diode V155
(fig. 13)

The shunt diode conducts at the end of each discharge interval of the pulse forming network and causes the charging waveform of

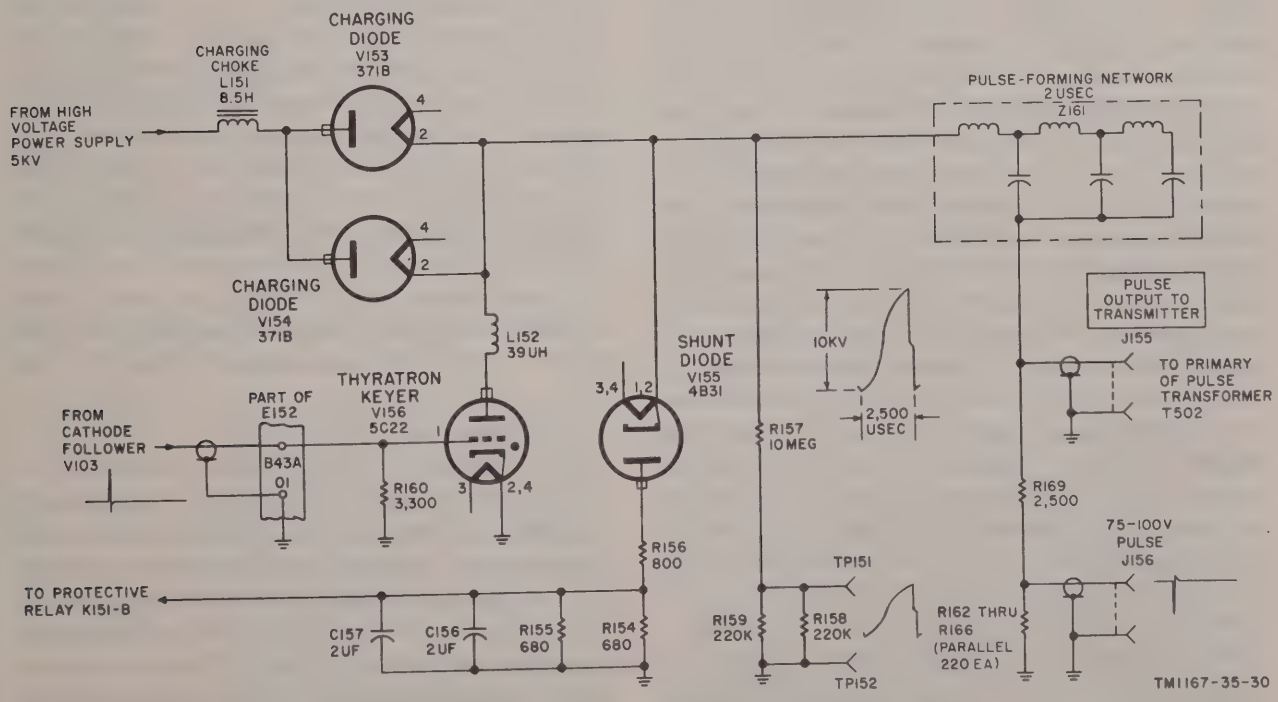


Figure 13. Keyer circuits, simplified schematic diagram.

Z161 to be clamped to the same value at the start of each charging cycle. Failure of the shunt diode could cause Z161 to charge to a higher voltage on each succeeding cycle and eventually cause breakdown of Z161. This is evident when at the end of the discharge interval the terminal voltage is of some negative value. This negative voltage would add to the 5-kv supply voltage and Z161 would then charge to a value greater than in the previous period. The discharge of Z161 would terminate the pulse still further in the negative region, and this action would become cumulative from period to period. The first effect experienced is that the magnetron will probably skip modes or become erratic and eventually a breakdown will occur. The protective relay (K151) operates if the shunt diode fails to function. When V155 conducts, it charges the RC network consisting of R154, R155, C156, and C157. The charge that accumulates across this network is used to supply operating voltage for protective relay K151B (par. 10). Resistor R156 serves as a current limiting resistor.

Section V. RF OSCILLATOR CIRCUITS

28. Pulse Transformer T502
(fig. 14)

The pulse transformer is specially designed to step up the pulse voltage to the magnetron about 1:6.2. The secondary windings are bifilar wound; this places both windings at equal potentials throughout, prevents breakdown between them during pulsing time, and allows the connecting of the cathode directly to the filament. The only potential difference between them is the dc filament voltage which is provided from a separate source. The primary winding has applied to it (through PULSE INPUT jack J505) a pulse amplitude a little less than 5 kv and 2 microseconds in duration. The pulse voltage is stepped up and the secondary (bifilar windings) applies a negative pulse to the magnetron cathode at approximately 29 kv. The primary has connected across it an RC network designed to remove the formation of a spike at the leading edge of the pulse. When the pulse is applied, the magnetron does not start to oscillate instantly and the load reflected into the primary is a very high impedance. Pulse forming network Z161 would discharge into this high impedance to develop an amplitude equal to the full charge (10 kv), causing the formation of an undesirable spike voltage. Resistor R509 and capacitor C509 present an impedance close to the impedance of Z161 at the instant the pulse is applied. The magnetron builds up to the operating level and the reflected impedance through T502 terminates Z161. Capacitor C509 charges very quickly through R509 and presents less loading to Z161 as the magnetron starts oscillating. The resulting effect is to present to Z161 an almost constant impedance by the loading of R509 and C509 which decreases as the loading of the magnetron increases. The effect of the RC network is nullified when C509 has charged. Resistor R508 is a terminal board made up of 12 one-megohm resistors in series and is a bleeder network connected across C509. The third winding on T151 is used to couple a trigger pulse, which has the same time relationship as the transmitter pulse, to the indicator through TRIGGER OUTPUT jack J506. Capacitor C504 is connected across the high side of the bifilar windings and C505 across the low side to maintain an equal potential between the windings and for filtering purposes. Safety gap E505 is a set of electrodes connected from the high side of the pulse transformer, to ground. The spacing of the gap is set at a little over 1 inch so that it arcs if the pulse voltage exceeds approximately 30 kv. The output pulse from the bifilar winding is of negative polarity and is connected through magnetron filament connector P516 to the cathode of the magnetron.

29. Magnetron V502
(fig. 14)

Magnetron V502 is an indirectly heated diode mounted between the poles of a powerful permanent magnet (E501). The diode is mounted so that the magnetic field of E501 will be perpendicular to the electric field that exists between the cathode and plate. For proper operation, the field intensity of the magnet should be 1,400 gauss ± 50. The cathode consists of

a thorium oxide coated cylinder with the surface exposed to the plates. The plates are constructed by stacking several die cast copper disks which have cavities between them. The cavities exhibit resonant qualities because of their inductive and capacitive properties. The plates are at ground potential and the oscillator is excited by application of a highly negative pulse to the cathode. The pulse amplitude is approximately 29 kv and the intense electric field causes the cathode to emit electrons. The electrons are accelerated by the electric field and they gain velocity and energy. The electrons cross the magnetic field at right angles and the interaction between the high velocity electrons and the magnetic field causes the electrons to be deflected. The deflected electrons form cycloid orbits, alternately speeding up in the direction of the plates and absorb energy from the dc electric field; then, in the process of the cycloid, are slowed down by the oscillating electric field across the gaps of the cavities and transfer energy to aid the oscillations in the cavities. The electron orbits eventually terminate when the electrons are collected by the plates. The cavities in the magnetron are alternately strapped to maintain frequency stability and to increase the efficiency of the oscillator. A loop is connected inside one of the cavities to couple the rf energy out of the cavity into a coaxial line. A method of tuning the magnetron is provided by the MAGNETRON TUNING control on the front panel of the receiver-transmitter. Tuning is accomplished by a metal diaphragm which is moved mechanically to change the electric field in the cavities (by changing the cavity size), thereby changing the resonant frequency.

30. Magnetron Overtemperature Thermostat S501 and Interlock S504B (fig. 14)

a. Magnetron overtemperature thermostat S501 is located near magnetron oscillator V502. When the heat radiated by V502 causes the temperature of S501 to rise to 85° C. (185° F.), the contacts open. The +27-volt supply is disconnected from the transmitter high-voltage relay holding circuits and the transmitter becomes disabled. To operate the transmitter, S501 must be manually reset. The reset button is located on the chassis near V502 and to reach it, the transmitter chassis must be pulled out of the case.

b. Interlock S504B opens when the transmitter chassis is removed from the case. When it opens, the +27-volt supply becomes disconnected and causes the same disabling condition on the transmitter as when S501 opens. When the transmitter chassis is properly replaced, S504B closes to restore continuity in the circuit.

c. Capacitors C514 and C515 are connected from the +27-volt supply lines to ground. Their function is to provide suppression of noise impulses and to prevent electrical disturbances from coupling from one chassis to another.

31. Meter Circuit M502 (fig. 14)

Meter M502 is a 0–100 milliampere (ma) meter connected in the dc return path of the magnetron. Its function is to provide a constant monitor of the average magnetron current. A normally operating magnetron conducts about 40 to 44 ma. Resistor R517 and capacitors C506, C507B, and C510 are connected as a filter network for the meter.

32. Magnetron Filament Supply Circuit (fig. 14)

The dc filament power for V502 is provided by T504, CR501, and the filter network. Transformer T504 has a multitapped primary which is adjusted for proper magnetron filament voltage. When power is first applied to the radar set, a time delay of approximately 5 minutes exists before operating power can be applied to the transmitting system. During this time, R516 is shorted by the contacts of radiate interlocking relay K405 located in the power supply chassis and the full 115 volts ac is applied to the primary of T504. This results in filament voltage for V502 of about 26 volts dc. After the 5-minute time delay, relay K401 cycles in, and the RADIATE ON button may then be depressed. Radiate interlocking relay K405 is energized and applies operating plate voltage to the transmitting system. One set of contacts of K405 opens to remove the short circuit across R156; this causes the magnetron filament voltage to drop to about 16 volts. The filament voltage is reduced because the cathode

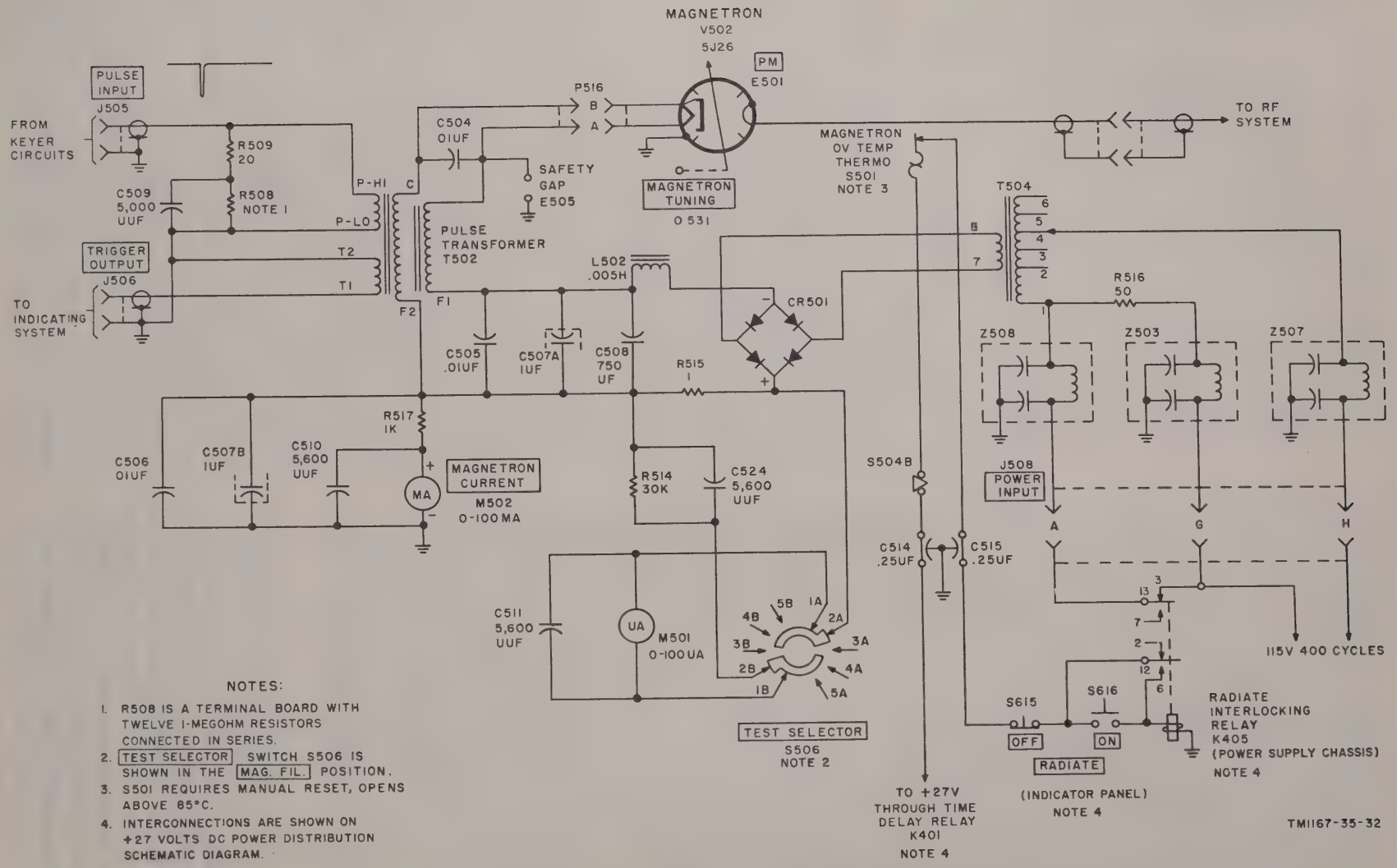


Figure 14. RF oscillator circuits, simplified schematic diagram.

is maintained at operating temperature because of the bombardment of returning electrons. A tapped connection is selected at the primary of T504 so that sufficient filament voltage is made available to the magnetron to compensate for variance in the supply voltage. The full-wave bridged selenium rectifier arrangement of CR501 provides a rectified dc output to the filament of V502. The supply voltage decreases with the aging of CR501, requiring the adjustment of T504. Inductor L502 and capacitors C508 and C507A make up the filament supply filter network. The filament current passes through R515, a 1-ohm resistor, and the voltage drop across it is measured by M501 through the appropriate contacts of TEST SELECTOR switch S506. Capacitor C511 is an RF bypass capacitor across M501. The value of R514 has a 1 percent tolerance and was selected so that normal operating magnetron filament current will give a red line reading on M501. Bypass capacitor C524 reduces the effect of RF currents that may be picked up by the wiring and cause erroneous indication of M501 and possible overheating of R514.

Section VI. MISCELLANEOUS CIRCUITS IN TRANSMITTING SYSTEM

33. Connector Plug Filter Networks Z151 Through Z159
(fig. 210)

a. Filter Networks Z151 and Z152. Interconnecting power cables to the keyer circuits require filter networks to suppress electrical noise that may cause instability in the unit. Filter networks Z151 and Z152 are in series with the 115-volt 400-cycle supply to high-voltage transformer T151. They are designed to provide at least 50–db attenuation to frequencies between 200 kc and 20 mc and are rated to pass a maximum of 27 amperes.

b. Filter Networks Z153 through Z159. The function of Z153 through Z159 is similar to that of Z151 and Z152. The difference is that the attenuation figure for these filters extends from 20 mc down to 100 kc and the maximum current rating is 7 amperes. Capacitors C159 through C171 serve as ac line filters.

34. Keyer Circuit Filament Supply
(fig. 210)

a. Filament transformer T152 receives primary power immediately when the radar set is turned on. Its function is to provide filament power to high-voltage rectifiers V151 and V152 and its rating is 5 volts at 20 amperes. A second winding provides filament power to charging diodes V153 and V154 and shunt diode V155. Its rating is 5 volts at 25 amperes.

b. Filament transformer T153 receives primary power immediately when the radar set is turned on. It provides filament power to thyratron keyer V156 and its rating is 6.3 volts at 20 amperes. The original design of T153 was to supply two thyratrons with filament power. A modification of the equipment (MWO 11–1167–8) resulted in a reduced load on T153 and an abnormally high filament voltage. It was therefore necessary to include R128, a 6.3-ohm 18-watt resistor, in series with the primary winding of T153 to reduce the filament voltage to a more normal value.

c. Filament transformer T101 is located on the trigger circuit chassis and receives primary power immediately when the radar set is turned on. One secondary winding provides filament power to tubes V101 and V102 and its rating is 6.3 volts at 1.2 amperes. The other winding provides filament power to tubes V1101, V1102, and V1103 and its rating is 6.3 volts at 2 amperes. One lead of the winding is connected to voltage divider R124, R125, and R126. This arrangement raises the filament winding to a dc potential of about 90 volts with reference to ground and reduces the possibility of filament-to-cathode arcing and possibly inducing a 400-cycle modulation component because of filament-to-cathode conduction.

35. Keyer Circuit Interlocks and High-Voltage Indicators
(fig. 210)

Interlocks S153A and S153B open when the modulator chassis is removed from its case. These interlocks protect personnel from dangerous high-voltage shock by disconnecting the power to high-voltage transformer T151. Interlock S153B, when opened, removes +27 volts

supplied to radiate relay K152, which releases and disconnects 115 volts 400 cycles from the primary of high-voltage transformer T151. Interlock S153A, when opened, removes the 115 volts 400 cycles applied to the *danger* high-voltage indicators I 151, I 152, and I 153, thus indicating whether or not the high voltage is on or off. The high-voltage indicator lamps are placed in the chassis at points where the danger from electric shock is likely.

36. Heaters HR151, HR152, and Blower Motor B151
(fig. 210)

a. Heaters HR151 and HR152 are each 150-watt elements and are operated by thermostatic switch S155. When the temperature drops to 0° C., S155 closes and 115 volts 400 cycles is applied to the heaters. When the temperature rises to above 15° C., S155 opens and disconnects heater power.

b. Blower motor B151 is controlled by thermostatic switch S154. When the temperature rises to 25° C. or greater, the contacts of S154 close and power is applied. The contacts of S154 open when the temperature drops to 10° C. or lower.

37. Filter Networks Z503, Z507, and Z508
(fig. 14)

Filter networks Z503, Z507, and Z508 function as electrical noise suppressors similar to those described in paragraph 33. They present 50–db attenuation at 50 mc and 150 mc, and are rated at a maximum of 4 amperes.

38. Blower Motor B501
(fig. 210)

Blower motor B501 is located in the receiver-transmitter chassis and has power applied to it when the radar set is turned on. Its function is to provide ventilation for the transmitting components which include magnetron V502.

CHAPTER 3
RF SYSTEM

Section I. GENERAL

39. General

The RF system conducts high power RF pulses from the magnetron to the antenna which radiates them. Target echoes are picked up by the antenna and conducted through the RF system to the receiving system input circuits.

40. Rf System, Block Diagram (fig. 15)

Pulsed RF energy from the transmitting system is conducted through a rigid coaxial assembly and interconnecting sections of coaxial transmission line to the antenna. Connected to the rigid coaxial assembly is a duplexer that couples energy from the coaxial line to the receiving system input circuits.

a. RF transmission line assembly RF501 is a section of rigid coaxial line. Pulsed RF output from the magnetron is coupled into it, and the energy is propagated along the line to the antenna. Some of the energy couples into the directional coupler, coho mixer assembly, and the duplexer.

b. The directional coupler accepts a fractional part of the transmitted pulse which is used to test and aline the receiver.

c. A fractional part of the transmitted signal is also coupled through an aperture (iris) and applied to the coho mixer assembly in the receiving system.

d. Duplexer assembly RF503 consists of pre-tr tube V503 contained in cavity A 516 and a transmit receive (tr) tube V504 contained in cavity A 517. The transmitted energy causes the electrodes in V503 and V504 to arc, which prevents the transmitted signal from getting into the receiving section and causing damage to the sensitive components. The low power received signals on the other hand, easily pass through the duplexer and into the receiver.

e. The keep-alive rectifier power supply (V501) provides a high voltage dc potential to tr tube V504 so that the arc is more easily formed during the transmitted pulse interval.

f. Shutter gate relay K501 engages a shutter gate located inside the cavity of A 517. The shutter gate serves to protect the signal crystal against locally operating radar transmitters when the set is not in use.

g. A series of interconnecting coaxial cables form the necessary transmission lines to couple the RF energy between the receiver-transmitter unit and the antenna base unit.

h. A rotating joint (RF752) is located in the antenna base unit. It provides for the transition from stationary to rotating transmission line sections. It also provides for the transmission of pulsed radar signals as well as iff signals.

i. At the antenna, the RF energy couples from a short radiator into a section of waveguide where it is matched to a horn type radiator and directed into the antenna reflector.

j. The iff antenna is a dipole with reflecting elements that are located in the mouth of the horn. It transmits and receives in the same direction that the radar signals propagate because it rotates with the radar antenna and directs its energy into the same antenna reflector.

k. The antenna reflector serves to focus the transmitted waves into a narrow beam which is radiated into space. The received echo signals are focused into a narrow beam and directed into the horn assembly where they are picked up and propagated to the receiver.

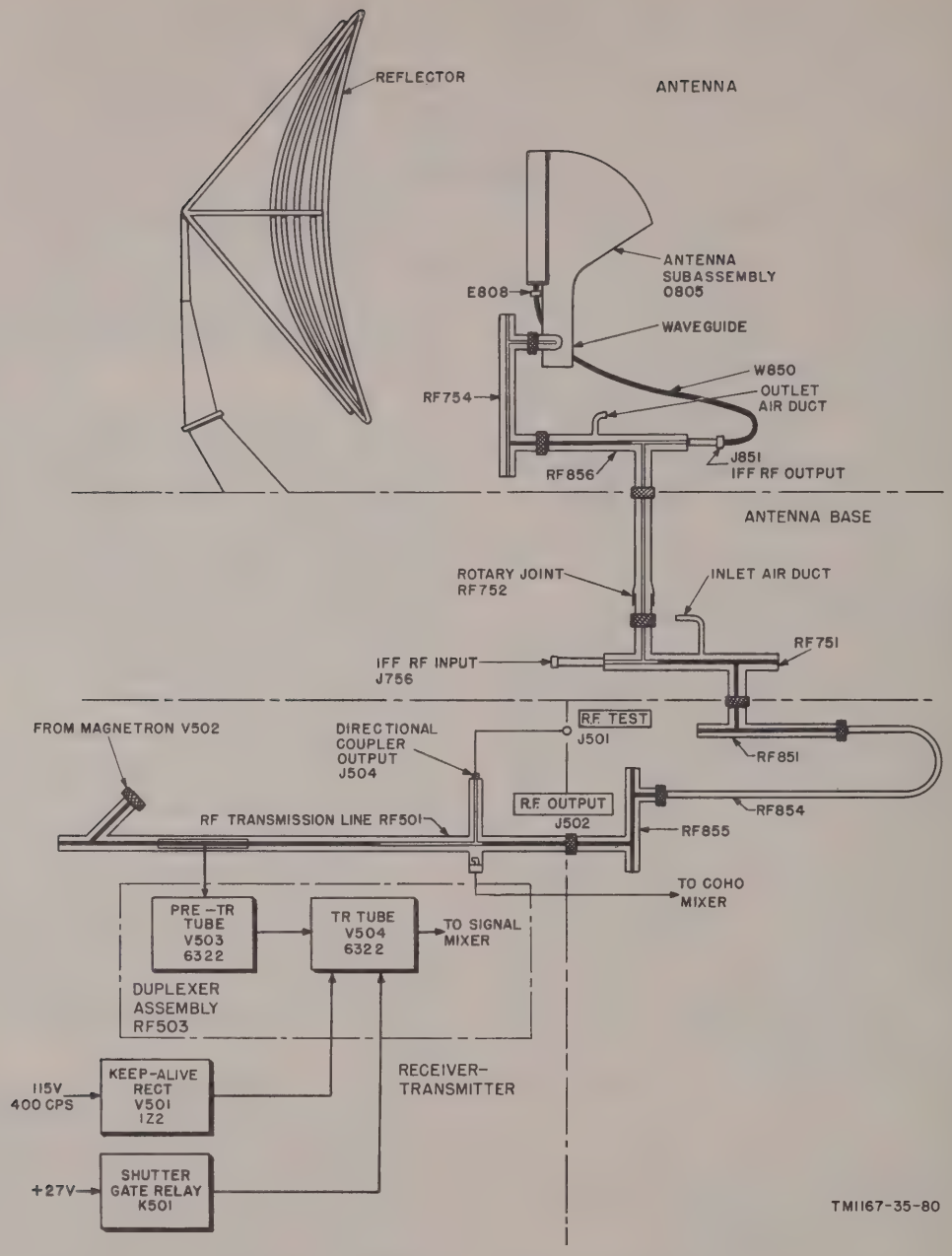


Figure 15. RF system, functional block diagram.

Section II. DUPLEXER AND RF TRANSMISSION LINE

41. Rf Transmission Line RF501 (fig. 16)

a. RF transmission line RF501 is a rigid coaxial transmission line section that couples the pulsed rf output of the magnetron to connecting transmission line sections which carry the rf energy to the antenna. The mechanical construction of RF501 is designed to propagate the transmitted and received signals with maximum efficiency. Air dielectric is used to obtain the required power handling requirements for the transmitted pulse and to keep line losses at a minimum. Rigid coaxial lines require a low-loss supporting device to accurately position and hold the center conductor properly centered at all times. One such device is the *stub support* (metallic insulator).

b. The stub support is a quarter wave length section of transmission line connected to extend away from the main line. The end furthest from the main line is purposely shorted between the center conductor and the outer conductor. The electrical short circuit forms a strong mechanical junction that enables the center conductor of the stub to support the center conductor of the main transmission line rigidly in place. Within the operating frequency band of the transmitter, the stub exhibits electrical characteristics equivalent to a quarter wave length. The electromagnetic energy propagating along the main line, encounters the junction where the stub connects. Some of the electromagnetic energy enters the stub and travels down towards the short circuit. When the electromagnetic energy reaches the short circuit, the electric field shorts and causes a high current which generates a magnetic field that adds to the magnetic field normally being propagated down the stub. The shorted end of the stub exhibits zero voltage and high current properties. The very low resistance of the short circuit at the end of the stub does not dissipate any measured amount of transmitted or received energy. The energy reflects and propagates back towards the main transmission line, causing the formation of a standing wave. At the junction to the main line, the standing wave exhibits a high impedance and the center conductor appears to be suspended by an extremely high resistance having practically no losses. Use of insulating materials to support the center conductor would introduce losses and the possibility of arc-over during the high power transmitted pulse.

c. The supporting stub located at the directional coupler junction also functions as a support for the center conductor of the main line of RF501. The diameter of the center conductor of the stub is larger than normal and one-quarter wave length long, which gives the stub wide-band characteristics. This is necessary for the stub to be effective over a wide frequency range.

d. A large open section located along RF501 is provided for connecting the duplexer assembly. The directional coupler is an integral part of RF501 as well as the coho coupling iris.

42. Directional Coupler
(fig. 16)

The directional coupler is a device that is used to measure RF power propagated along the transmission line in one direction only. When RF energy is traveling in the direction from the transmitter to the antenna, the directional coupler is excited and provides an output at R. F. TEST jack J501. RF energy traveling in the direction from the antenna to the receiver will not produce an output from the directional coupler.

a. The directional coupler is completely enclosed inside the center conductor of main transmission line section RF501. Along the length of the center conductor are two entrance slots spaced one-quarter of a wave length apart. The center conductor of the main line (RF501) serves as the outer conductor of the directional coupler and within it is another conductor that serves as the inner conductor. The transmitted energy propagated toward the antenna passes the first entrance slot and a fractional part of RF energy is coupled into it with no appreciable change in the phase relationship of the electric and magnetic fields. The RF energy continues to propagate in the same direction inside the inner coaxial line. The energies in both the inner and outer coaxial lines propagate at the same velocity. When they reach the second entrance slot additional energy is coupled from the outer coaxial line adding to the energy in the inner coaxial line and propagated to R. F. TEST jack J501. The sample of transmitter output at R. F. TEST jack J501 is used for test and alinement. The attenuation of the transmitted RF pulse through the directional coupler varies depending on the frequency and the individual component part.

b. The directional coupler output is applied to an echo box to test and aline the RF system. The sampled RF energy of the transmitter is coupled into the echo box and excites the echo box cavity. The RF energy is propagated from the echo box, through the directional coupler where it reenters into the main RF transmission line, and is directed toward the duplexer and receiving circuits.

c. Target echo energy is propagated in the opposite direction, from the antenna towards the receiver. Only a small amount of the RF energy couples from the main line (RF501)

into the entrance slots of the directional coupler. The major portion of the received energy continues propagating in the main line of RF501 and is coupled into the duplexer and receiver circuits. The energy in the directional coupler continues to propagate in the same direction and is absorbed and dissipated in the resistive material at the end of the inner line.

d. Received RF energy which tends to excite the inner line in the backward direction (towards J501) is cancelled. Cancellation occurs because the RF energy which couples into the second entrance slot must travel a distance of one-half wave length greater than the energy coupled into the first entrance slot. At the first entrance slot they coincide 180° out of phase, and therefore cancel.

e. The section that extends away from the main line to directional coupler output J501 functions as a supporting stub for the main line (par. 41*c*).

43. Coho Signal Coupling Iris
(fig. 16)

A small iris is located on the outer conductor of RF501 and has coupled into it a fraction of the transmitted signal. The iris is circular and its dimension is fixed to provide about 60-db attenuation. The electromagnetic fields propagating along RF501 pass the iris and couple through the opening into a small cavity which includes a pickup loop. The highly attenuated signal excites the loop and the energy is transferred to the coho mixer assembly through a coaxial line. Because the attenuation factor is so high (60 db), only the high-powered transmitter pulses couple enough energy to provide sufficient signal amplitude to affect the coho circuits in the receiving system.

44. Duplexer Assembly RF503
(fig. 17)

a. Duplexer assembly RF503 fits over the large opening (aperture) of RF501. Transmitted and received rf energy are coupled from RF501 into RF503. The tr switches connected within the cavities allow the use of a single antenna to transmit and receive. The duplexer assembly is adjusted by sliding it along the length of RF501. When transmitting, the magnetron presents a low impedance to the transmission line. Between transmitted pulses it presents a high impedance. During the receiving time interval the received energy develops standing waves on the line because of reflections from the magnetron. With standing waves formed on the line, a point of optimum pick-up is found by sliding the whole duplexer assembly back and forth. The duplexer assembly must be repositioned each time the magnetron is replaced because the nonconducting impedance varies between magnetrons. The position of the duplexer makes little difference to the transmitted signal.

b. When the transmitter is on, the high power RF pulse is propagated through RF501. As the energy passes the aperture, a portion of the transmitted pulse power is coupled into the duplexer and into the first cavity (A 516) which contains pre-tr tube V503. The energy excites the cavity and generates a standing wave. The pre-tr tube is located in the center of the cavity at a point of high electric field intensity which causes the electrodes to arc. The arc becomes a conducting path to the RF energy in the form of a short circuit for the duration of the transmitted pulse. During the arcing interval, the effective short circuit that is produced is reflected to the aperture which is one-half wave length away. The short circuit presented to the aperture prevents much of the transmitter power from entering the duplexer. Formation of the arc reduces the amount of power passing through the cavity to a value that can easily be handled by the following tr tube. Pre-tr tube V503 has no keep-alive voltage to aid in starting the arc since it is located at a point that receives more than enough rf power to insure arcing. A considerable amount of *leakage power* does get through pre-tr tube V503 and is picked up by a loop located inside the cavity (A 516). It is coupled to the following cavity (A 517) through a short length of coaxial line.

c. The gap between the electrodes of tr tube V503 does not break down and arc the instant that rf energy is applied. At the start of the RF pulse, a high voltage builds up before the arc takes place. This causes a spike of RF energy having enough power to cause serious damage to receiver components. The leakage power from pre-tr tube V503 is sufficiently high to cause damage to the signal mixer crystal. Therefore V503 functions to reduce the rf pow-

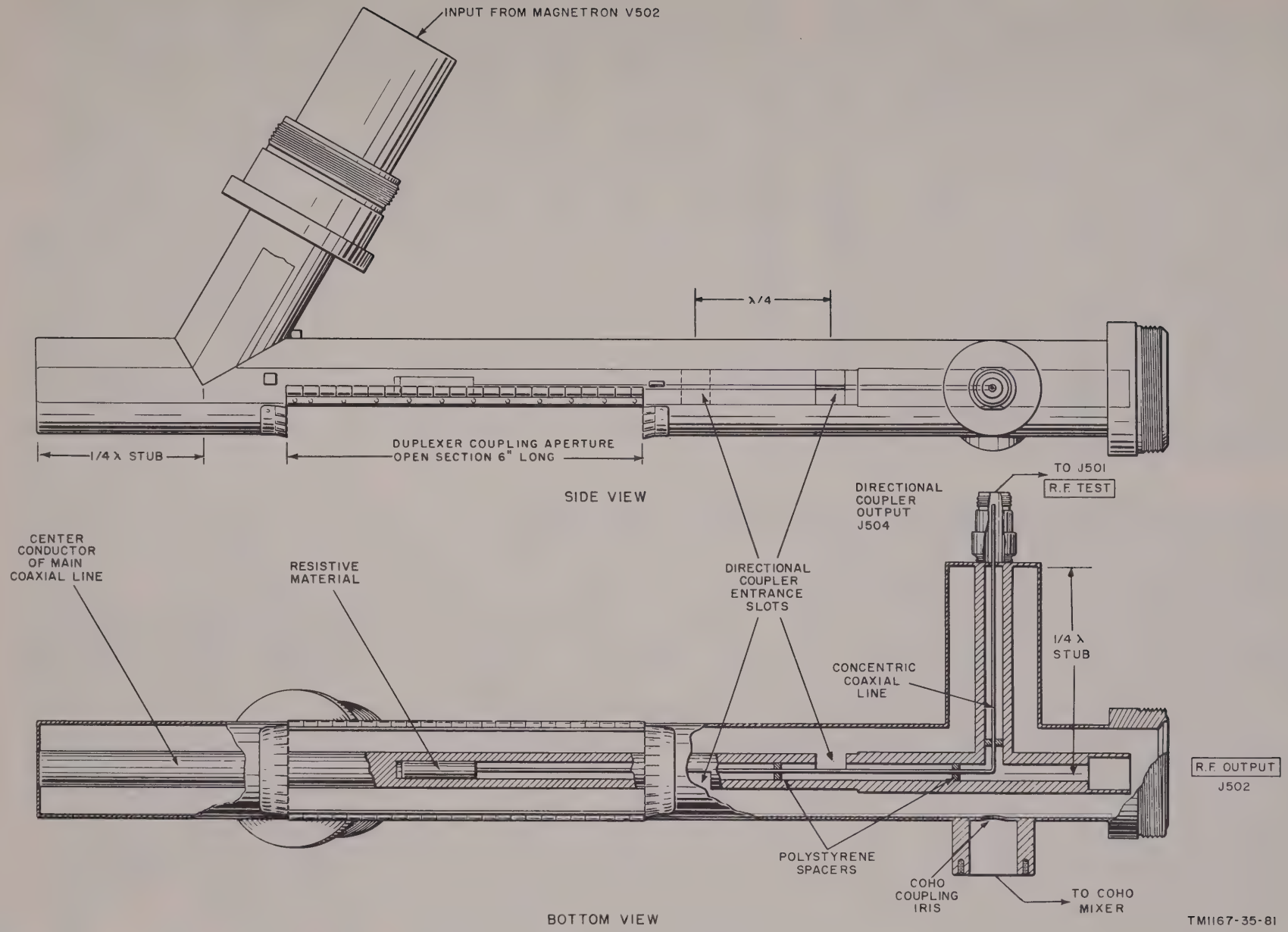


Figure 16. RF Transmission Line RF501, cutaway view.

er to a value which can be more efficiently attenuated by tr tube V504. To insure that the gap of V504 arcs more quickly, a keep-alive electrode is used. The keep-alive electrode is located near one of the gap electrodes of V504. A negative dc voltage is applied to maintain a steady glow discharge near the gap. Within the glow discharge, electrons move freely from the keep-alive electrode to the tr electrode and a few of them enter the tr gap. This effect causes the gap between the tr electrodes to become extremely sensitive to rf voltages and arcing takes place more rapidly, thereby reducing the spike amplitude to a tolerated value. The use of argon gas in both of the tr tubes helps to speed up the arc and improves receiver protection. After the transmitted pulse interval, the arc in both tubes continues for a short duration which blocks the receiver and renders it insensitive to close targets. A small amount of water vapor in the tr tube, aids in reducing receiver recovery time by causing the arc to extinguish more rapidly.

d. The RF power in the echo signals is not sufficient to cause the gaps in the pre-tr and tr tubes to arc. The received signals enter the pre-tr cavity (A 516) and when properly tuned, the cavity oscillates and presents a minimum of attenuation to the signal. A pickup loop couples the rf energy through a coaxial line to tr cavity A 517. When the tr cavity is excited the RF energy couples through another pickup loop into a coaxial line to the receiver mixer circuits. When placed within the cavities, V503 and V504 become a part of the cavity which can be tuned. Tuning the tr tubes is made by adjusting the knurled knob that extends from the center of V503 and V504. When the adjustment is made, the resonant qualities of the cavity are affected. The Q of the cavities is extremely high and careful adjustment is required to obtain maximum receiver sensitivity. The adjustment is best accomplished by tuning while observing the amplitude of an echo on the A-scope or observing the ringtime when using an echo box.

45. Keep-Alive Power Supply

(fig. 17)

The keep-alive voltage power supply consists of power transformer T501, rectifier tube V501, and associated resistors and capacitors that make up the filter network. Power is applied to the primary of T501 through noise filters Z503 and Z504. It has two secondary windings: one supplies filament voltage for V501 and the other supplies plate voltage. Rectifier tube V501 functions as a half-wave rectifier supplying high voltage and low current. Because the operating current is low, the series filter resistors are high in value. Resistors R505, R522, and R523 function as current limiters and series filter resistors. Capacitors C501 and C502 are the filter capacitors. Resistors R501, R502, R503, and R504 are connected in series and serve as the bleeder network. Capacitor C518 serves as an RF noise suppressor. The 1-megohm resistor which is a part of E506 and is located inside the cap that clips on to tr tube V504, functions as a current limiting resistor. The dc voltage applied to V504 is about 800 volts and has a negative polarity with reference to ground.

46. Shutter Gate Relay K501 and Shutter Gate

(fig. 17)

Shutter gate relay K501 functions to withdraw and insert a shutter gate into the tr cavity of V504 to block strong radar signals and protect the signal mixer crystal when the set is not operating. When the radar set is turned on and operating, received signals having sufficient power to cause damage to the crystal are reduced in power by the functioning of pre-tr V503 and tr V504. When the set is turned off, locally operating radar sets can radiate enough RF power to pass through the duplexer because keep-alive voltage is not present. The method of protection used is to employ the shutter gate located in the tr cavity at a point that will block RF energy. The shutter gate is shaped like a pin and is mechanically linked to the armature of K501. Five minutes after the equipment is turned on, K501 becomes energized and withdraws the pin from the cavity. The pin is held in the withdrawn position as long as the set is operating. When the set is turned off, K501 de-energizes and allows the pin to be reinserted into the cavity by spring return force. The field winding of K501 is in two parts and is tapped so that when power is to be applied, one of the windings is shorted by switching contacts. The current through

the starting winding is 3.7 amperes and develops a high starting torque for the armature. As the armature turns, it extracts the shutter gate pin and rotates a wafer switch that disconnects the short circuit across one of the field windings. When the additional winding becomes free of the short circuit, it adds in series with the starting winding. The additional winding has many more turns and smaller gage wire because its function is merely to hold the armature in the active position. The total current is about .105 amperes, and it is sufficient to overcome the force of the return spring and maintain the shutter gate in the extracted position. Resistor R526 and capacitor C523 are connected across the switch contacts to reduce arcing during the switching action.

47. Interconnecting Rf Coaxial Cables (fig. 18)

a. Rigid Coaxial Section RF855. The front panel on the receiver-transmitter includes R.F. OUTPUT jack J502 which is used to connect the transmitter output through additional coaxial RF transmission lines to the antenna and connect received signals from the antenna through the same lines into the receiver. Coaxial section RF855 connects to J502 and has a rigid outer conductor with an inner conductor which is centered in position by supporting stubs. Air dielectric is used to permit the handling of high power transmitter rf pulses and the received echoes with a minimum attenuation.

b. Rf Cable Assembly RF854. Flexible coaxial cable RF854 couples the RF energy between the location of the receiver-transmitter unit to the location of the antenna base unit. The dielectric is a flexible low-loss material that can withstand the high power transmitter pulses and the received signals with negligible attenuation, when the length is maintained at less than 50 feet.

c. RF Transmission Line Section RF851. Rigid coaxial line RF851 functions as a rigid coaxial line to flexible coaxial cable adapter. Flexible cable RF854 connects to one end of RF851 and the other end connects to the antenna base unit. It is a rigid section, and

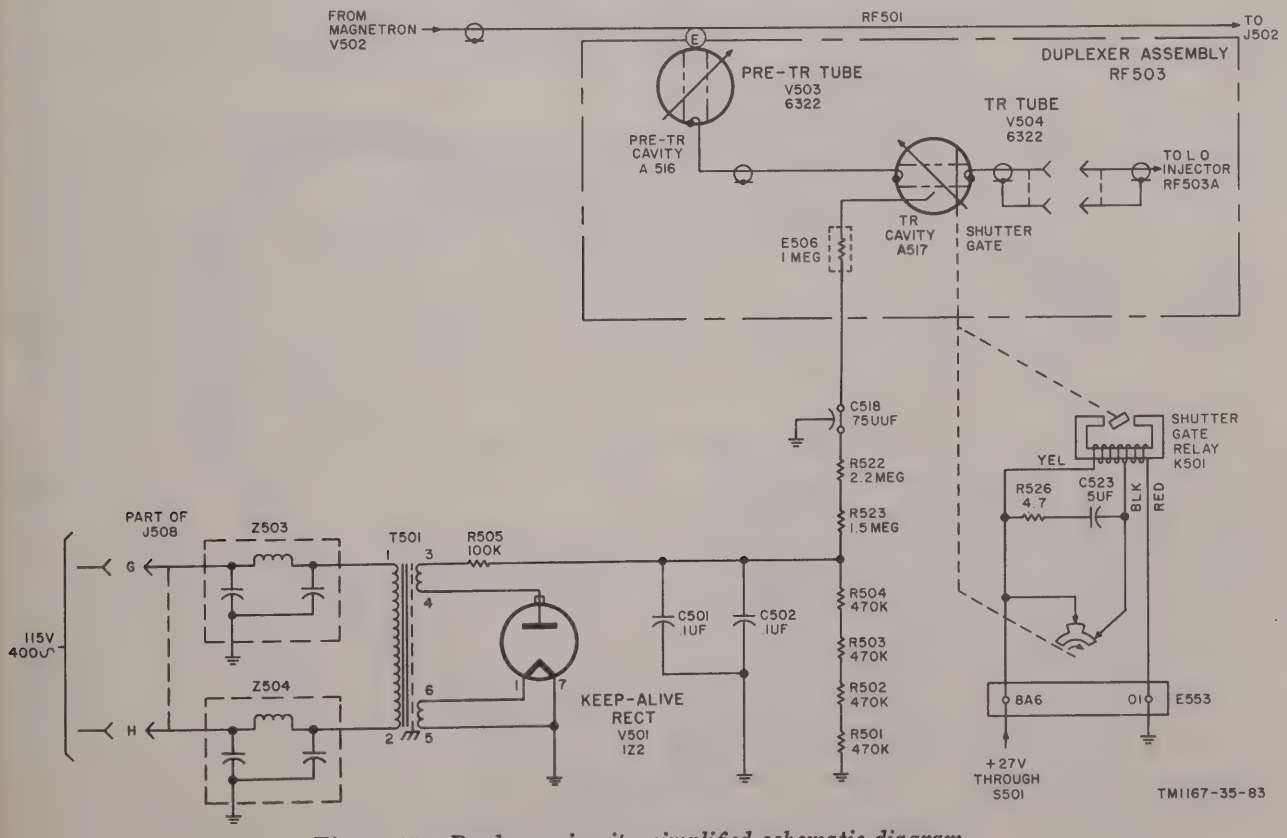


Figure 17. Duplexer circuits, simplified schematic diagram.

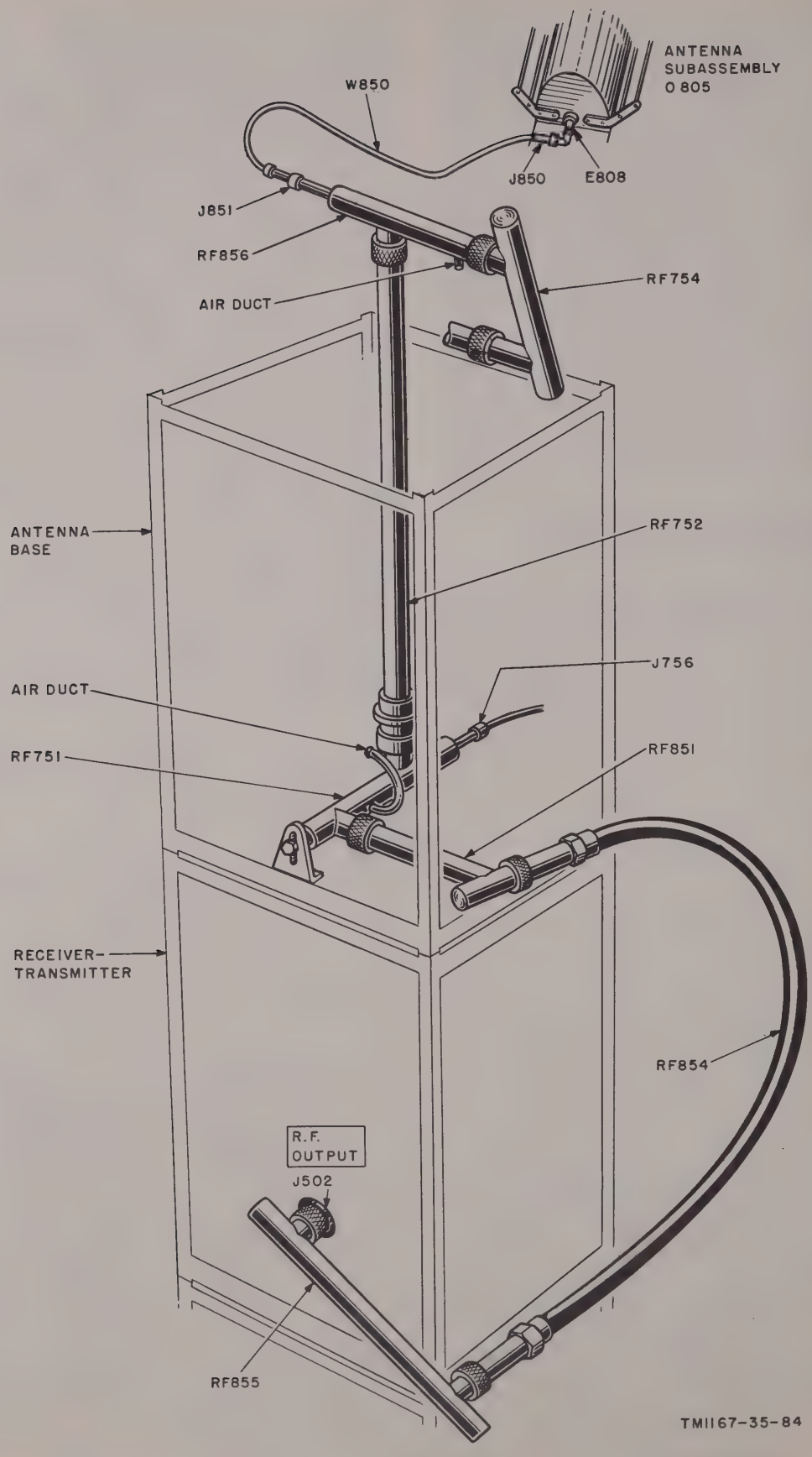


Figure 18. Interconnecting coaxial transmission line sections, pictorial diagram.

therefore the center conductor is centered by a supporting stub.

d. Rf Transmission Line Section RF751. Coaxial section RF751 (located in the antenna base unit) provides for the application of warm dry air into the RF lines, a coaxial connection to iff equipment, and a connection to the rotary joint. An air duct, that is part of the outer conductor of RF751, is located in the antenna base unit and is positioned so that warm air is forced into it by a blower in the servo amplifier case. The warm air circulates through RF751 and then up through rotary joint RF752 and leaves through another duct which is part of RF856 in the antenna unit. The warm air serves as a dehydrator which keeps the lines dry and reduces corrosion that may form because the rotary joint is not completely sealed. A part of RF751 is a concentric coaxial line. The inner line is used for iff signals which are applied to J756 and the outer line conducts the radar signals (fig. 15). The outer conductor of the inner coaxial line is the center conductor of the outer coaxial line and is held securely in place by supporting stubs at both ends of RF751. The inner section of coaxial line extends the length of the antenna base unit and its rotary connection is made with the center conductor of RF856 in the antenna section.

e. Rotary Joint RF752. Rotary joint RF752 is a section shaped like a sleeve that serves as the outer conductor and extends from the antenna section down through part of the antenna base unit. During antenna rotation, the upper sleeve of RF752 rotates with the antenna and makes contact to the stationary lower sleeve by spring contacts. The rotary joint permits the antenna to rotate in azimuth while the radar set remains stationary. Extending through the length of RF752 is the inner coaxial iff transmission line that makes a rotary connection with the center conductor of RF856. Surrounding RF752 is a shaft that serves as the spindle which is driven by the antenna drive motor (par. 152).

f. Rf Transmission Line Section RF856. Coaxial line section RF856 is a rigid section of line, part of which is a concentric coaxial line. The outer line conducts the radar signals to and from the antenna. The inner line terminates at jack J851 which provides for connection to the iff antenna. The outer conductor includes an air duct outlet for the forced air.

g. Rf Transmission Line Section RF754. Coaxial line section RF754 connects between RF856 and the antenna waveguide. It is a rigid coaxial line with an air dielectric and supporting stubs. Only radar signals are propagated through this section of line.

h. Rf Cable Assembly W850. Flexible coaxial line W850 connects jack J851 to the iff antenna. Jack J851 is located in the antenna section and terminates one end of the concentric coaxial transmission line RF856.

i. Coaxial Cable Adapters RF852 and RF853. When it is desired to operate the antenna over a distance greater than 50 feet from the transmitter, the attenuation of rf power through flexible coaxial cable RF854 becomes appreciable. At distances over 50 feet the use of air dielectric rigid coaxial lines is required. Accessory coaxial cable adapters RF852 and RF853 are necessary to make the rigid coaxial line connections at RF851 and RF855.

Section III. ANTENNA ASSEMBLY AS–548/TPS–1D

48. General
(fig. 19)

The complete antenna assembly includes antenna subassembly O 805, iff antenna E807, and antenna reflector sections E802 through E806 and E809. The method used to transfer the RF energy to and from the antenna assembly is common in microwave radar systems. The RF transmission lines couple the energy into the waveguide section of the antenna subassembly. The energy is propagated through a horn radiator and directed to the antenna reflector for propagation into space. The iff antenna is located in the nozzle of the horn radiator. Interaction between the iff and radar signals is not experienced because they are transverse polarized and operate in widely separated frequency bands.

49. Antenna Subassembly O 805
(figs. 20 and 21)

a. Waveguide Probe E801. The transmitted and received signals are coupled between the

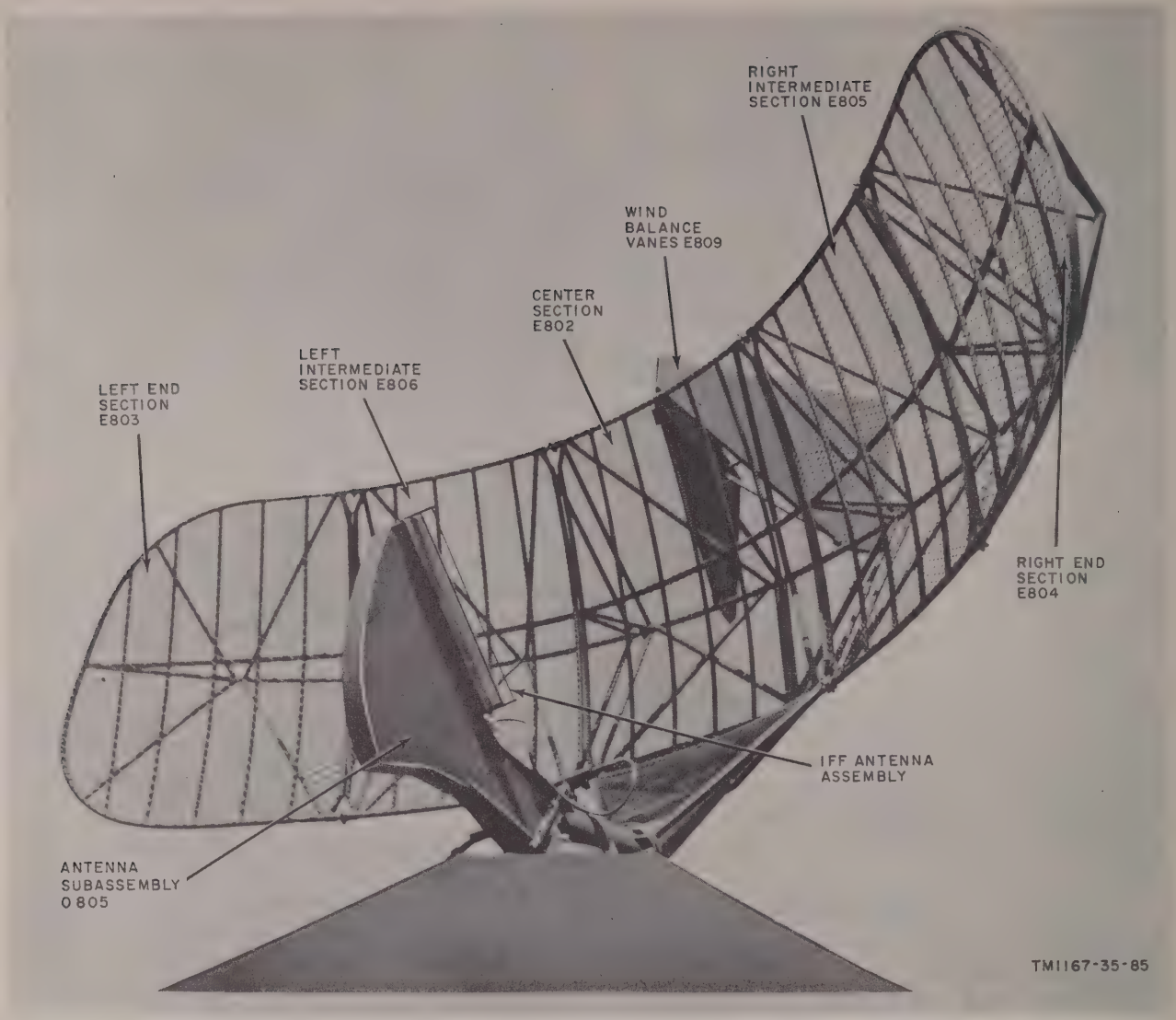


Figure 19. Antenna Assembly AS–548/TPS–1D.

waveguide assembly and the coaxial transmission line by waveguide probe E801. The center conductor of the coaxial transmission line extends into the wide dimension of the waveguide and functions as an antenna radiating element.

b. Waveguide and Horn Feed Assembly.

(1) The radiating energy from E801 propagates in all directions away from the radiating probe within the waveguide section. The position of E801 is located at a point where the reflecting RF fields from the shorted end of the waveguide return in phase with the forward propagating energy. An operating mode is generated and the RF energy is propagated in the direction of the horn feed assembly.

(2) Tuning plug O 809 is located a short distance from radiating probe E801. It is normally adjusted for optimum match between E801 and the waveguide assembly for maximum power transfer and to reduce standing waves on the transmission line. Standing waves are generated when a mismatched condition exists along the propagating path. This causes reflection of some RF energy back along the same path. The resultant of the incident energy added instantaneously to the reflected energy produces an

apparent stationary wave. The wave motion appears as though it is varying in amplitude only and the resultant electric fields are displaced from the magnetic fields by a quarter wave length. The peak magnitudes of the standing waves are greater than normal and are determined by the degree of mismatch. They can vary up to a maximum of twice the normal magnitude for 100 per cent reflection. When standing waves exist, the peak amplitudes of the electric fields can cause the dielectric to break down and form an arc. The excessive magnetic fields cause high currents through the conductors, and result in increased copper losses. Standing waves are measured by their standing wave ratio, which is derived by taking the ratio of the maximum to minimum field intensity on the transmission line. Tuning plug O 809 is inserted in the center of the wide dimension of the waveguide section and functions as a variable capacitive component. It is normally factory adjusted for optimum performance of the receiver-transmitter and minimum standing waves on the transmission lines.

(3) The horn feed follows the waveguide section. It matches the waveguide to space and directs the RF energy into the antenna reflector. The RF energy emanating from the horn is horizontally polarized.

(4) The mouth of the horn contains iff antenna dipole E807 and its corner type reflector assembly. The location of the iff antenna assembly does not have any effect on radar signals because of their transverse polarization.

50. Iff Antenna E807
(figs. 21 and 22)

a. The iff antenna is located in the mouth of

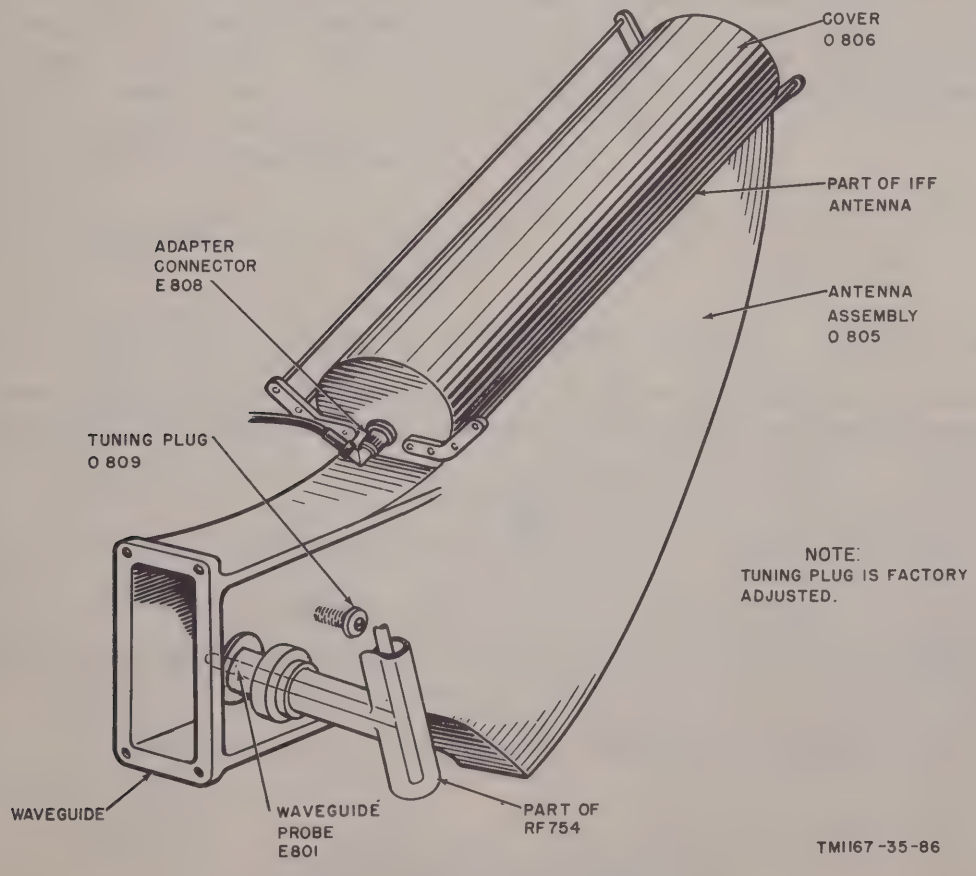


Figure 20. Antenna Subassembly O 805.

the horn of antenna subassembly O 805. It consists of a dipole radiator and eight reflectors. Four of the reflectors and the dipole are inclosed under fiberglas cover O 806. The remaining four reflectors are located outside the cover, forming a V-shaped reflector assembly. The RF connection is made to the iff antenna through coaxial connecting jack J850, which is a part of coaxial adapter E808. From E808, a rigid coaxial line extends through the length of the antenna assembly and has a stub supported center conductor. The center conductor extends one-quarter wavelength past the point where the dipole radiator feed line branches off. A mechanical joint (short circuit) is made at the end of the center conductor and provides the rigid supporting stub to position the center conductor of the coaxial line and the center conductor of the feed line. The center conductor of the feed line is connected to one leg of the dipole radiator through an insulated opening in the outer conductor and the other leg of the dipole radiator is connected to the outer conductor. The length of the feed line is made sufficiently long to include slots one-quarter wavelength long on opposite sides of the outer conductor. The slots serve as a balance transformer which converts the dipole from an unbalanced to a balanced dipole radiator.

b. The voltage standing wave ratio (fig. 22) indicates the degree of mismatch and reflections that exist on the iff transmission line within the operating frequency range. The standing wave ratio is an indication of how much energy is reflected because of mismatch; therefore the graph illustrates the optimum operating frequency band. A high degree of mismatch results in a large value standing wave figure and a perfect match yields a figure of 1. An operating frequency of operation is chosen which provides a figure as close to 1 as possible. The voltage standing wave ratio is merely a result of sampling the electric fields on the transmission line since it requires simple apparatus and is the most common method used.

51. Antenna Reflector Assembly E802 Through E806, and E809
(figs. 19 and 23)

a. The antenna reflector is a truncated parabolic reflector which provides a horizontal radiation pattern 4° wide and a vertical radiation pattern 12° wide. It is assembled from five separate lattice-metal sections (E802 through E806) and balance vanes E809. The wind balance vanes are solid, irregular shaped elements attached to the antenna reflector at a

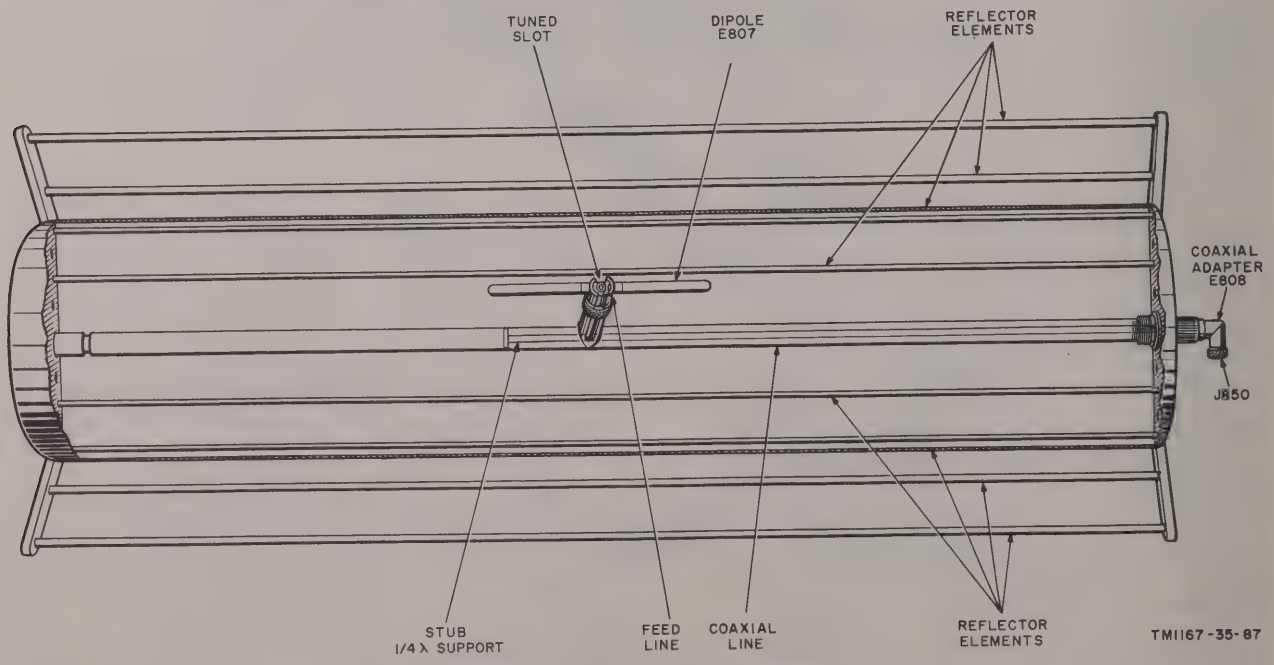


Figure 21. Iff antenna assembly.

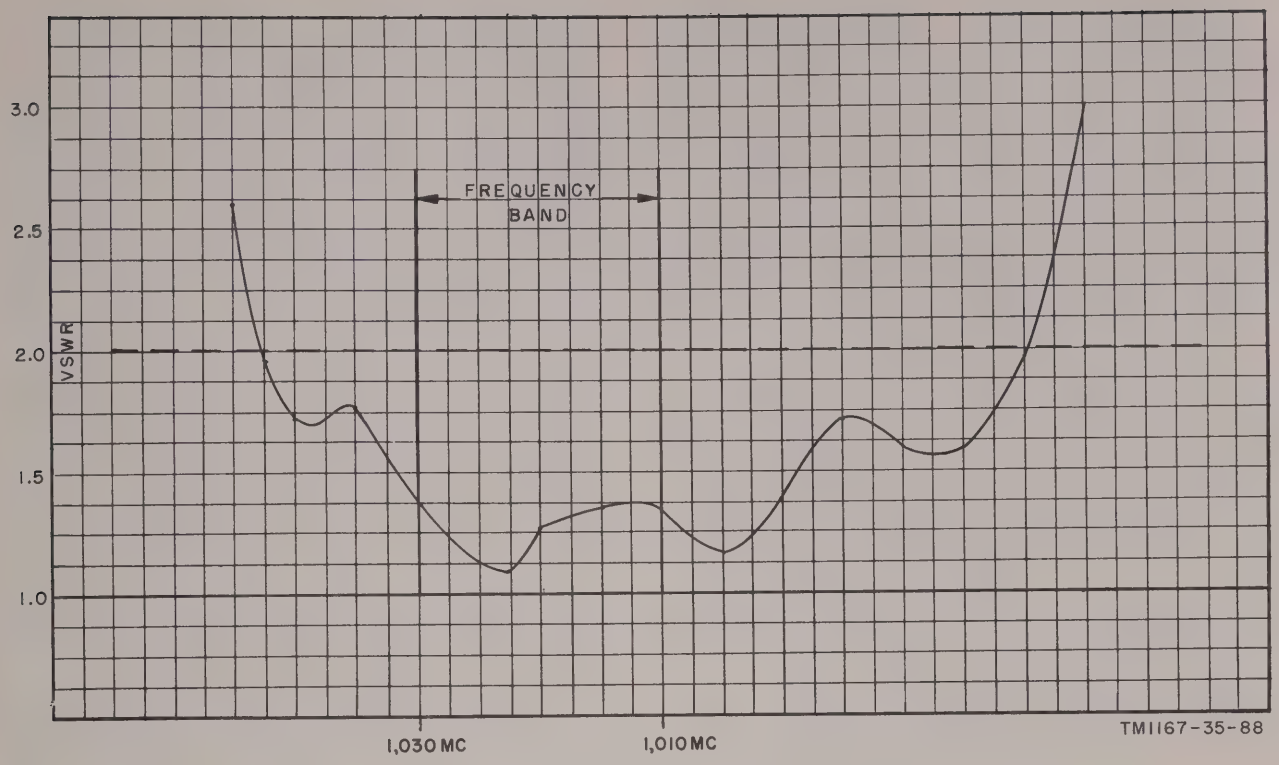


Figure 22. Iff antenna, voltage standing wave radio curve.

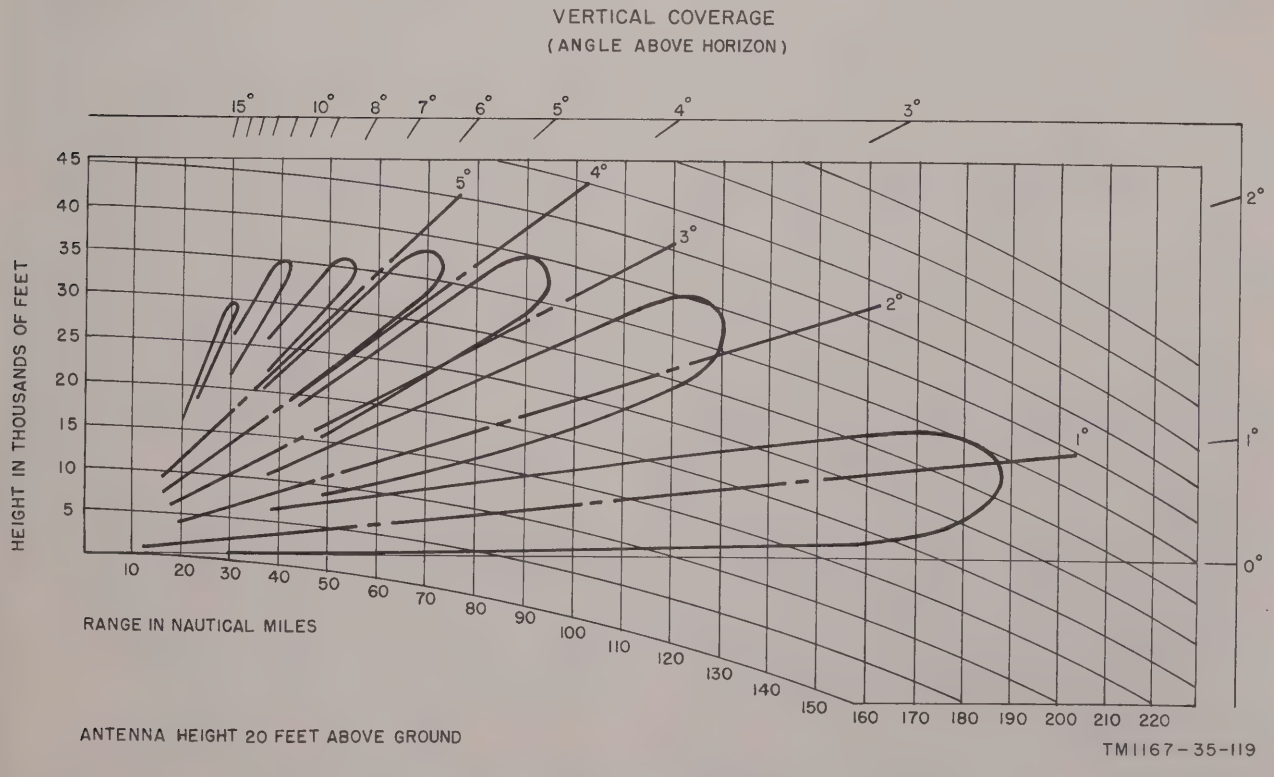


Figure 23. Vertical radiation pattern, typical characteristics.

predetermined position. They serve to equalize the effects of wind resistance, reducing abnormal strains and erratic rotation of the antenna.

b. The vertical radiation pattern contains several lobes with null points in between (fig. 23). The nulls are due to reflected ground waves adding to the prime wave out of phase, thereby resulting in cancellation. The lobes include energy from the ground waves which adds in phase to the prime wave, thereby reinforcing the signal. The illustration is for an antenna raised to a height of 20 feet above ground. The prime lobe axis is at 1°. Low flying aircraft under these conditions could remain undetected until quite close. The range is reduced by tilting the antenna to 0° or slightly below the horizon. This of course increases the return from ground clutter but the mti mode of operation virtually eliminates the effects of fixed targets.

CHAPTER 4
RECEIVING SYSTEM

Section I. GENERAL

52. General

The receiving system amplifies weak echo signals delivered by the antenna and provides video pulses of usable amplitude to the signal comparing system. Its function involves circuits for amplification and efficient demodulation of the RF signals. The receiver is a high gain superheterodyne type which receives RF signals in the 1,220 to 1,350 mc band and operates on an intermediate frequency of 60 megacycles. The echo signal power returning to the radar set may be in the order of micromicrowatts because of the distance to the targets and the scattering effect when reflecting from targets. The receiver must be sensitive enough to respond to weak signals and retain a certain amount of fidelity when reproducing the echo pulse shape. The primary factor in limiting the gain of the receiver is front end noise. Noise is generated in the rf components of the receiver, mainly the crystal mixer and the first intermediate frequency amplifier stages. Careful consideration of the noise factor is made during the design of the receiver but the effectiveness of the system depends largely on the capabilities of maintenance personnel. The limitations of the receiving system can be minimized if precautions are taken to properly measure receiver response and tune for optimum performance.

53. Receiving System, Block Diagram (fig. 24)

a. Local Oscillator and Control Circuits U501.

(1) The local oscillator tube (V505) is a disk-seal type lighthouse tube. It is located within a coaxial type tuning assembly and functions as a grounded-grid, tuned-plate tuned-cathode oscillator.

(2) The local oscillator is tuned by tuning motor B502, a dc motor that is controlled by L. O. MOTOR switch S613A on the indicator front panel.

b. Local Oscillator Injector RF503A. The local oscillator injector assembly accepts the echo signals from the tr cavities and the local oscillator output. The two signals are combined within the assembly and its output is applied to harmonic filter assembly Z509.

c. Harmonic Filter Z509.

(1) The harmonic filter is a device that permits the signal frequencies to pass with very little attenuation but it has a high attenuation factor for the harmonic frequencies.

(2) Signal mixer CR503 provides for the heterodyning of the local oscillator and received signal frequencies. The output is 60 megacycles and is applied to signal IF preamplifier U221.

d. Signal IF Preamplifier U221. The signal IF preamplifier contains three stages. The first stage (V232) is a low noise, neutralized cathode loaded amplifier feeding a grounded grid amplifier. The second stage (V224) is a conventional IF amplifier. The third stage (V225) connects to an impedance matching transformer and provides an output through a coaxial transmission line.

e. Signal IF Amplifiers. The signal IF amplifiers consist of tubes V301 through V306. Received signals are delivered from the preamplifier and amplified by the first three stages. The last three stages serve as limiter amplifiers.

f. Coho Mixer RF502. A highly attenuated sample of the transmitter signal pulse couples into RF502 through an iris on the main transmission line. The local oscillator output is also connected to RF502 where it heterodynes with the transmitter signal. The output of coho mixer crystal CR502, the 60-megacycle beat frequency, is applied to coho IF preamplifier V506.

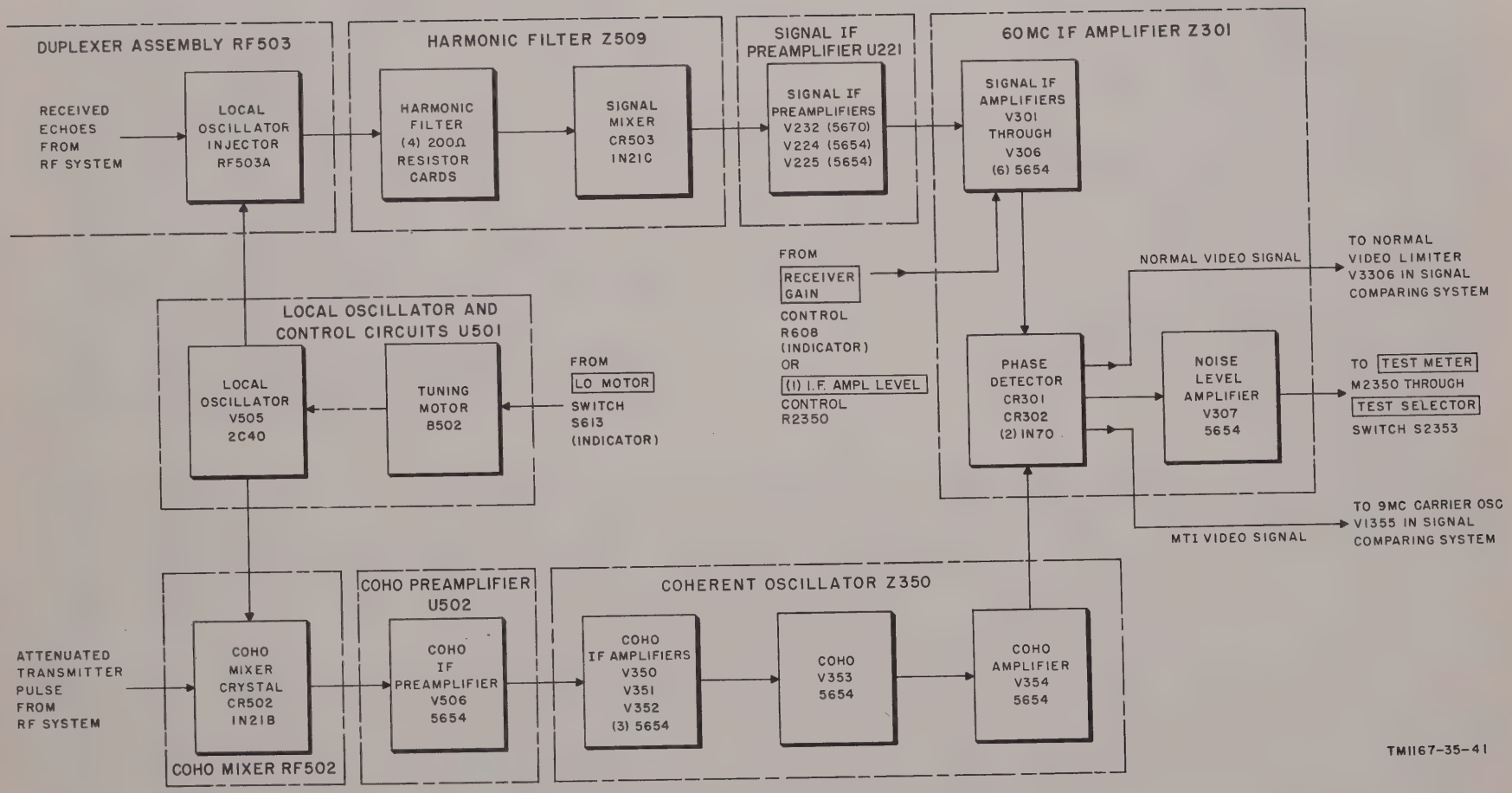


Figure 24. Receiving system, complete block diagram.

g. Coho Preamplifier U502. The coho preamplifier is a single stage 60-megacycle IF amplifier. Its output feeds a coaxial transmission line which transfers the signal to coherent oscillator Z350.

h. Coherent Oscillator Z350.

(1) The applied signal is amplified by the first three stages (V350, V351, and V352) and then applied to the coho (V353).

(2) The coho normally oscillates at 60 megacycles and is synchronized by the signal from the coho IF amplifiers. The coho thus becomes locked in relative phase to the frequency of the transmitted signal.

(3) The output of the coho is applied to coho amplifier V354 which is a 60-megacycle amplifier. The output of the amplifier is applied to the phase detector circuit (CR301 and CR302).

i. Phase Detector Circuit.

(1) The phase detector circuit includes diode rectifiers CR301 and CR302. It functions as a phase detector only when the radar set is operating in the mti mode. As a phase detector, it combines the continuous output of the coho and the received echos from the signal IF amplifier. The relative phase between the two signals is compared to determine the amplitude and polarity of the output video pulse.

(2) When operating in the normal mode, the coho is disabled and only the output of signal IF amplifier Z301 is applied. During operation in the normal mode, the detector functions as an amplitude modulation detector.

j. Noise Level Amplifier V307. The noise output from the phase detector is amplified by noise level amplifier V307 to obtain an indication of the overall gain of the receiving system. The noise is amplified, rectified, and filtered so that a dc voltage proportional to receiving system gain is applied to TEST METER M2350. The meter is then red-lined to obtain optimum overall receiving system gain by adjusting I. F. AMPL. LEVEL control R2350.

Section II. LOCAL OSCILLATOR AND CONTROL CIRCUITS

54. General

Local Oscillator Assembly Z511 is a metal cylinder which functions as the tuned circuit and contains local oscillator tube V505. The local oscillator tube is a lighthouse (disk-seal type) tube which provides a highly stable continuous frequency output. The operating frequency limits of V505 extend to about 3,000 megacycles and the tube easily operates through the 1,200 to 1,400 megacycle band determined by the tuning properties of Z511. The local oscillator frequency is changed by an adjustable ring-shaped plunger located inside Z511 and is moved by the action of a motor driven actuator. Tuning motor B502 is controlled by L.O. MOTOR switch S613A which is located on the front panel of the indicator unit.

55. Local Oscillator Assembly Z511 and LO V505

(fig. 25)

a. Local oscillator assembly Z511 is a metal cylinder which has two tuned sections with the local oscillator tube fitting in between the tuned sections. The external connections of the plate and grid elements extend into the three-quarter wave length section of an equivalent coaxial line and the cathode-to-grid portion fits into an approximately one-quarter wavelength section. The oscillator circuit is of the grounded grid type and utilizes tuned cathode and tuned plate sections which are basically coaxial lines. Feedback is accomplished by coupling loops located at points of maximum magnetic fields in both tuned sections. The grounded grid acts as a shield and effectively isolates the plate circuit from the cathode circuit with the coupling loop providing all the feedback. The cathode tuned circuit is physically shorter than a quarter wave length with the interelectrode capacity between grid and cathode of V505 providing the electrical properties to effectively lengthen the line. The short length of the cathode tuned circuit assumes the proportions of a resonant cavity. The plate tuned circuit is

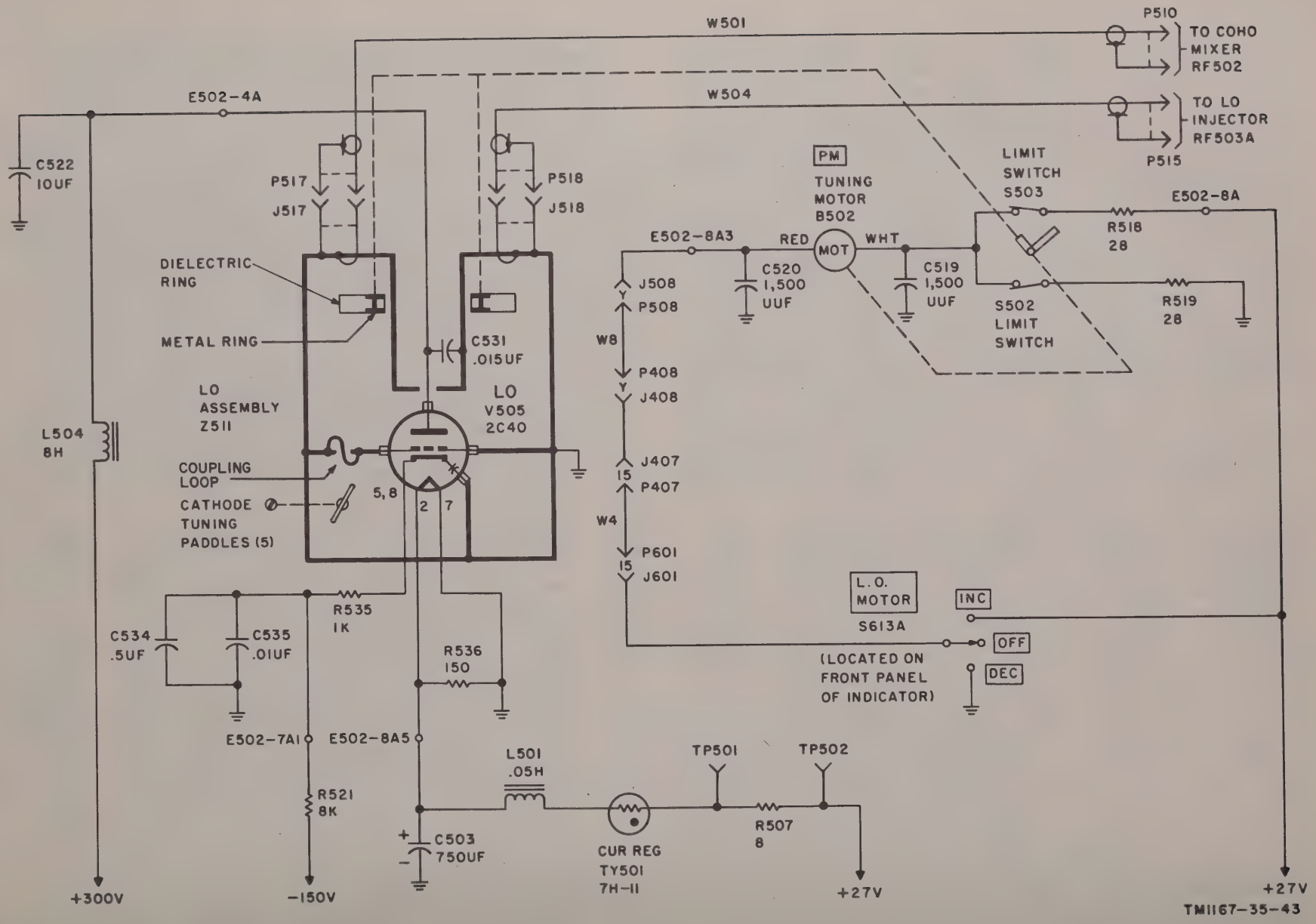


Figure 25. Local oscillator and control circuits, simplified schematic diagram.

somewhat shorter than a three-quarter wave length section with the plate to grid capacity making up the difference electrically. The isolation between the plate and cathode is by the grounded grid which provides excellent stability for the oscillator by virtually eliminating plate-to-cathode interelectrode capacitance. Two separate coupling loops located at the ground end of the plate tuned section provide outputs to the signal mixer and coho mixer assemblies.

b. The cathode tuned circuit has broadband characteristics and presents a negligible amount of phase shift in the feedback voltage throughout the frequency band. Tuning is accomplished by five adjustable paddles which are in the cathode tuned section of Z511. The paddles are located in the region of maximum magnetic field and affect the inductive component of the tuned circuit. Tuning the cathode section is required only after replacing V505 and is normally peaked to the center of the operating frequency band.

c. The plate tuned circuit is a high-Q three-quarter wave length section which is variable. The tuning adjustment of the plate circuit is operated by tuning motor B502 through gear reduction. A cam type actuator mechanism connected with the reduction gearing adjusts the position of a sliding ring which is mounted between the inner and outer conductors of the plate tuned line. The sliding ring is conconstructed of a metal inner ring surrounded by a dielectric material which prevents the metal portion from making electrical contact and shorting with Z511. Movement of the ring is similar to a plunger and affects both the electric and magnetic fields in the plate circuit, causing a change of the resonant frequency.

d. The metal portion of the ring is the equivalent of a shorted turn and therefore reduces the effective inductive reactance of the tuned circuit as the ring is moved towards the point of maximum magnetic field (away from the plate, towards the shorted end of the line) and the resonant frequency is raised. The dielectric portion of the ring affects the electric field. When the ring is moved toward the point of high electric field the capacitive reactance is decreased, causing the effective capacity to increase, and the resonant frequency is lowered.

e. Local oscillator tube V505 provides the amplification for the feedback voltage to sustain oscillation. Loop coupling is used to feedback regenerative energy from the plate tuned section to the cathode circuit. The loops are located at points of high magnetic field intensity. The tube elements are located at points of high electric field intensity and the mass of the elements themselves make up a part of the tuned circuit. The elements are very closely spaced to reduce the transit time within the tube. Interelectrode capacity between the elements is low, because of the small surface areas of the elements. The lead inductance of the elements is also minimized by providing large conducting surfaces which are disk-shaped and connect the tube elements to the circuit through multiple spring contacts. The cathode element is capacitively coupled to the outer cathode shell by a dielectric material. The cathode is heated and provides the tube current. The outer cathode shell which connects to the tuned circuit is effectively connected to the cathode element through the low capacitive reactance when the RF oscillations exist. To enable the cathode to respond to signal variations, it is raised above RF ground potential by R535, a 1,000-ohm resistor. Signal variations in the cathode circuit are amplified by the tube, which functions as a grounded grid amplifier and a fractional part is fed back from the plate circuit to the cathode by the coupling loop. Capacitor C531 provides the RF connection between the plate of V505 and Z511. The plate returns through a length of lead wire that has sufficient inductance to be an effective plate load at the RF frequency. The lead connects to terminal board E502 and at this point C522 and L504 form a filter network to the +300-volt supply. The cathode circuit returns through R521 and R535 to −150 volts. The voltage drop across these resistors because of tube current, places the cathode close to 0-volt dc with reference to ground. Capacitor C534 functions as a filter capacitor in conjunction with R521 which aids in maintaining a steady dc. Because of the distant location of C534, the resistance and inductance of its leads reduces the effective bypassing necessary at the junction of R531 and R535. It is therefore necessary to use a smaller capacitor, C535, as an RF bypass close to R531.

f. The filament supply for V505 is from the +27-volt power supply. Oscillator stability requires a constant temperature cathode and in turn a regulated power supply. Current regulator TY501 has a positive resistance coefficient. Normally the current through TY501 causes a voltage drop which provides the proper voltage and current for V505, providing that the +27-volt supply does not vary. A slight decrease in supply voltage causes the current through TY501 to decrease a fractional amount. The resistance of TY501 decreases and the voltage drop across it decreases; this results in an almost constant supply voltage to the filament of V505. A supply voltage rise would cause an opposite effect: the voltage rise causes the resistance of TY501 to increase and the higher voltage drop across TY501 causes the filament voltage of V505 to remain constant. Resistor R507 is a metering resistor with test points TP501 and TP502 connected at either end. The resistance of R507 is of the same value as the filament shunted by R536. The voltage drop measured across R507 is a direct indication of the voltage across the filament. The speed of response of TY501 is not sufficient to handle sudden fluctuations from the +27-volt supply and therefore requires the use of L501 and C503 as a filter network.

g. Output from the local oscillator is provided through two coaxial connections. Coupling loops located at points of high magnetic field intensity within Z511 pick up the generated local oscillator signals. One couples through J517 and cable W501 to coho mixer assembly RF502, and the other through J518 and cable W504 to local oscillator injector assembly RF503A.

56. Tuning Motor B502
(fig. 25)

Tuning motor B502 is controlled by L. O. MOTOR tuning switch S613A, located on the front panel of the indicator unit. The operator tunes the local oscillator by observing the ringtime on the A-scope when an echo box is connected to R.F. TEST jack J501 or by tuning for maximum target returns on the A-scope. Connection between tuning motor B502 and tuning switch S613A is made by interconnecting cables through the power supply unit. The operating voltage of B502 is approximately 6 volts. Limit switches S502 and S503 are normally closed until the actuator reaches either limit. When S613A is switched to the INC position, B502 is connected in parallel with R518. Approximately 21 volts is dropped across R519 and about 6 volts across the parallel connection of B502 and R518. The motor turns until the limit is reached, at which time, limit switch S502 is opened by the actuator which is connected to the motor shaft through the gear reduction. When S613A is switched to the DEC position, then B502 parallels R519 and the motor turns in the opposite direction. When the limit is reached, the actuator opens limit switch S503 so that power is disconnected and the motor stops turning. Tuning motor B502 does not operate when S613A is in the OFF position because the +27 volts dc supply is disconnected from the circuit. The actuator which is connected to B502 through the gear reduction also positions the tuning ring within Z511 when the tuning motor operates. Connected on either side of B502 are capacitors C519 and C520, which function as electrical noise filters when the motor is operating.

Section III. SIGNAL MIXER AND PREAMPLIFIER CIRCUITS

57. Local Oscillator Injector RF503A
(fig. 26)

a. Local oscillator injector RF503A is a rigid coaxial section of transmission line which combines the local oscillator signal with the received signals. The received signal input end connects directly to the output connector of tr cavity A 517. Received signals are picked up by a coupling loop in the tr cavity and propogate straight through the lower rigid coaxial line of RF503A to J514.

b. The local oscillator signal is coupled from J518 of Z511, through flexible coaxial cable W504 to local oscillator input J515 of RF503A. A disk type resistor R525 is located at coaxial junction of P515 and J515. The value of R525 is 50 ohms and its function is to terminate coaxial cable W504 and prevent reflections from

the tr cavity that may detune the local oscillator. When the tr tube in cavity A 517 arcs, it presents an electrical short circuit at the pick-up loop. The electrical length from the pick-up loop to J515 is an odd multiple of a quarter wave length and therefore will present a high impedance at J515. The high impedance is paralleled by R525 and the effect of the reflections is prevented from traveling back along coaxial cable W504 and being coupled into the tuned plate section of Z511. Without R525 the reflection could cause a reactance to be introduced into the tuned section, causing it to change frequency. Serious consequences would then result from instability, especially when operating in the mti mode. When the tr tube in cavity A 517 is not arcing, R525 functions simply as an attenuator for the local oscillator signal and for the fractional amount of RF signal that may couple from the main line. The output from the local oscillator is many times greater than necessary even though attenuated by R525. The local oscillator signal is coupled by a sliding contact sleeve to the coupling probe. The coupling adjustment on top of RF503A adjusts the degree of coupling of the local oscillator signal which is capacitively coupled from the coupling probe into the main line. The coupling adjustment is made while observing the TEST METER M501 when in the SIG position. The adjustment is made until the meter is at midposition (on the red line) which indicates that sufficient local oscillator power has been coupled into the main line so that signal mixer crystal CR503 can operate in the linear portion of its characteristic curve and thus provide the highest conversion efficiency.

c. The combined output of RF503A includes the signal frequency and the local oscillator frequency which is 60 megacycles higher than the signal frequency. The output of RF503A is provided through J514. Coaxial cable W503 connects the output of RF503A to harmonic filter assembly Z509 and signal crystal mixer CR503. The length of W503 is very important when considering the noise figure of the receiver. The noise generated in the receiver is a fixed amount, therefore every attempt is made to provide maximum signal input to the first stages of the IF amplifiers to obtain optimum performance. When the local oscillator and signal frequencies heterodyne at the signal mixer, a 60-megacycle signal component is generated. The local oscillator frequency is 60 megacycles above the signal frequency and it also heterodynes with the generated 60 megacycles, which results in an image frequency 60 megacycles higher than the local oscillator frequency. During this process, power is extracted from the 60-megacycle IF signal and results in a poorer receiver noise figure. The image signal frequency will travel back through Z509, W503, RF503A and into tr cavity A 517, where it reflects and travels back again to crystal mixer CR503. Again heterodyning action will take place between the local oscillator frequency and the image signal frequency (120 megacycles above the signal frequency) which results in a new 60-megacycle component. If the total distance traveled by the image signal causes the return to produce a new 60-megacycle component which is out of phase with the original 60-megacycle IF signal, an additional loss is experienced because of cancellation. The critical length between CR503 and A 517 causes the image frequency to return in phase so that its resulting 60 megacycles is reinforced instead of canceled.

d. The output of RF503A is from J514 through coaxial cable W503 to harmonic filter Z509 and includes the signal frequency and the local oscillator frequency.

58. Harmonic Filter Z509
(fig. 27)

a. Harmonic filter assembly Z509 includes a coaxial adapter (E558), harmonic filter (Z509), crystal holder (E527), signal crystal (CR503), and adapter (J512).

b. Coaxial adapter E558 serves to connect coaxial line W503 to the filter assembly because the connectors are of a different size and shape.

c. The actual filter assembly provides attenuation to the harmonic frequencies generated by the transmitter. The pre-tr and tr tubes (V503 and V504) operate efficiently enough to suppress the fundamental transmitter frequency but the additional rf power of the harmonic frequencies is capable of shortening the life of signal mixer CR503. The filter consists of two sections of waveguide connected against each other along the wide dimension. The signal input is into the center of the side dimension

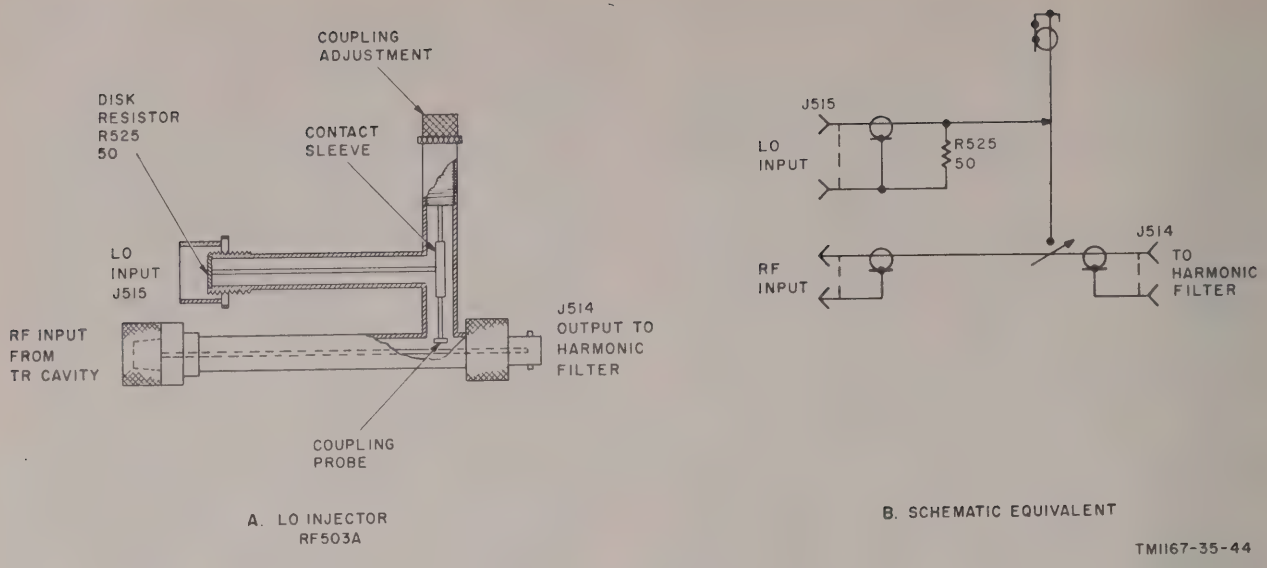


Figure 26. Local oscillator injector RF503A.

of the waveguides, with the center conductor of the input coaxial line passing through both waveguide sections at right angles to the direction of the propagation of the waveguides. The dimensions of the waveguides are specifically made to provide electrical characteristics so that received signal and the local oscillator frequency fall into the waveguide cutoff region. The harmonic frequencies on the other hand excite the waveguide and propagate from the center conductor of the coaxial line towards the ends of the waveguide where the energy is absorbed by resistor cards. This method provides at least 20 db attenuation to each of the harmonic frequencies while the signal and local oscillator frequencies pass virtually unaffected. Two matching disks are provided, one in each waveguide section. The matching disks are a part of the center conductor of the coaxial line and their size determines the impedance match through the waveguide section. The impedance match at the fundamental frequencies is nearly perfect, having a standing wave ratio of about 1.05 throughout the frequency range of 1,220 to 1,350 megacycles.

d. The signals that pass through the waveguide sections are fed into crystal holder E527. The center conductor of E527 is supported by a quarter wave stub at one end and has crystal CR503 connected to the other end. The local oscillator and signal frequencies heterodyne at CR503 and generate a 60-megacycle component signal.

e. The 60-megacycle signal is coupled through coaxial adapter J512 through coaxial line W502, to signal IF preamplifier chassis U221.

59. Signal IF Preamplifier U221
(figs. 29 and 30)

The signal IF preamplifier consists of three preamplifier stages located on a subchassis in the receiver-transmitter unit. The input stage is a low noise circuit which employs a dual triode. Provisions are also made to monitor the signal crystal current. The amplified signal from the low noise first preamplifier stage is applied to pentode amplifiers V224 and V225 for further amplification. The signal is amplified to a sufficient level so that it may be coupled through a coaxial line to 60-megacycle signal IF amplifier Z301 which is located in the signal comparator.

60. First Signal IF Preamplifier V232
(figs. 28 and 29)

a. The 60-megacycle output from signal mixer crystal CR503 is coupled into the IF preamplifier through J224. The rectified component of the RF which is derived from local oscillator power is conducted through the primary of T223 and the filter network consisting of L224, L225, C222, C223, and C224. The rectified and

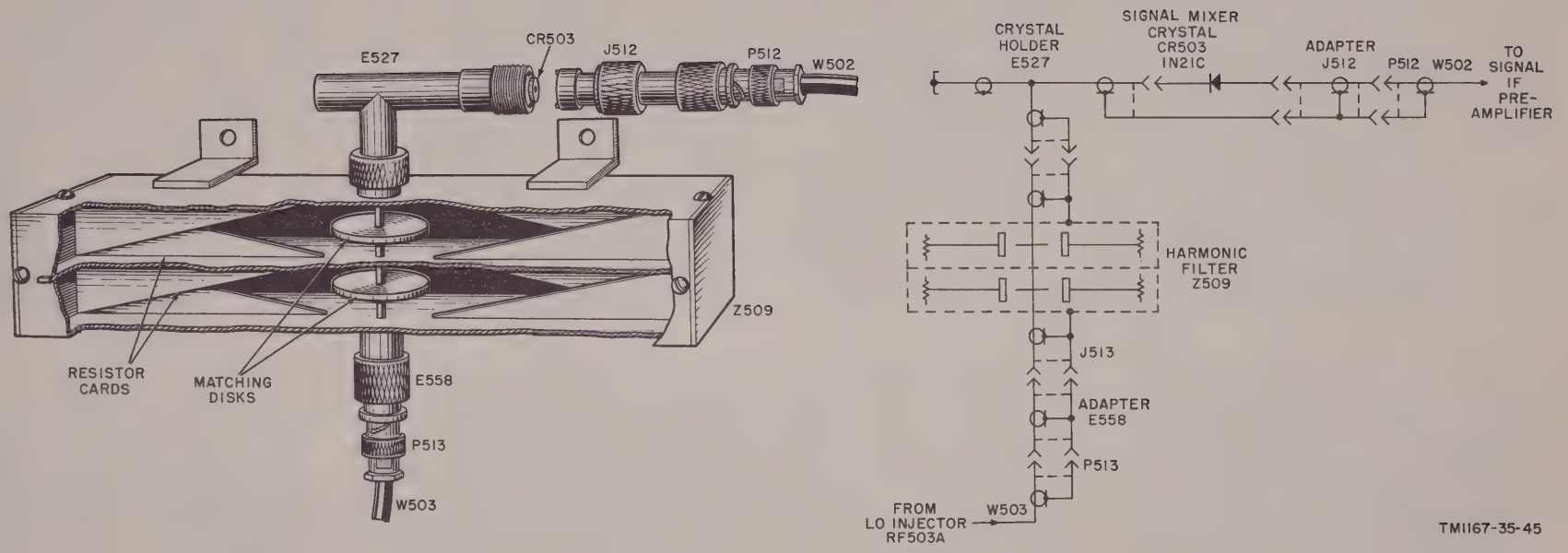


Figure 27. Harmonic filter assembly Z509.

filtered local oscillator power is then coupled through J225 and P225, through a shielded line to TEST SELECTOR S506. When S506 is in the SIG position, test meter M501 is connected in series with the crystal current loop and gives an indication that the local oscillator is functioning. Resistor R510 is rated at 100 ohms and has 1 percent tolerance. It functions as a meter shunt resistor so that the local oscillator power injected through RF503A will indicate a red line reading on M501. A dc return path for the crystal current is also provided by R510 when S506 is switched to another function. Capacitor C511 provides an RF bypass path to protect M501.

b. Usable reception of extremely weak signals depends on their being discernible above noise rather than upon the amplification provided by the receiving system. The noise contributed by the first and second vacuum tube amplifiers is most troublesome; therefore low noise triode-connected amplifiers are used rather than pentodes. First signal IF preamplifier V232 consists of a dual triode which functions as a cathode-loaded power amplifier and a grounded grid amplifier. This circuit arrangement provides for a low noise amplifier which has good stability. The 60-megacycle signal frequency is coupled through impedance-matching transformer T223. The secondary of T223 and the input grid to cathode capacitance (C_{gk}) form a resonant circuit at 60 megacycles. The first triode section of V232 functions as a cathode-loaded amplifier. Inductor L227 functions as the load impedance of the first section and the input network for the second section. The common cathode bias network consists of R259 and C225 and is an effective short circuit at 60 megacycles. The grid to plate capacitance (C_{gp}) provides a feedback path that may cause the stage to oscillate. Examination of the equivalent circuit (fig. 28) shows a triode amplifier which has an inductive load impedance (L227). When an inductive load is used, the C_{gp} feedback causes a negative resistance effect in the amplifier (regenerative feedback) and therefore the stage could oscillate. Neutralizing inductor L245 is connected in parallel with C_{gp} so that at the operating frequency, the inductive reactance of L245 cancels the capacitive reactance of C_{gp}. The amplified signal across L227 is divided across two resonant circuits, L245 and C_{gp}, and T223 secondary and C_{gk}, which are equivalent to a resistive voltage divider. The feedback is degenerative and opposes the input signal, therefore the gain of the first section is reduced to near unity. This circuit arrangement provides excellent stability for the amplifier and maintains a condition of minimum noise. The use of resistive components in the signal carrying channels is avoided because of additional noise generated.

c. The second triode section of V232 operates as a grounded grid amplifier. The grounded control grid functions as a shield which reduces feedback. The signal developed by the first triode section appears across L227 and drives the second triode section. Plate load impedance Z221 consists of L229 shunted by R228 to broaden the bandpass of the stage. Resistor R261 and capacitor C229 function as a decoupling network. Capacitor C228 provides an rf ground for the plate of the first triode section and R260 with C228 function as a de-

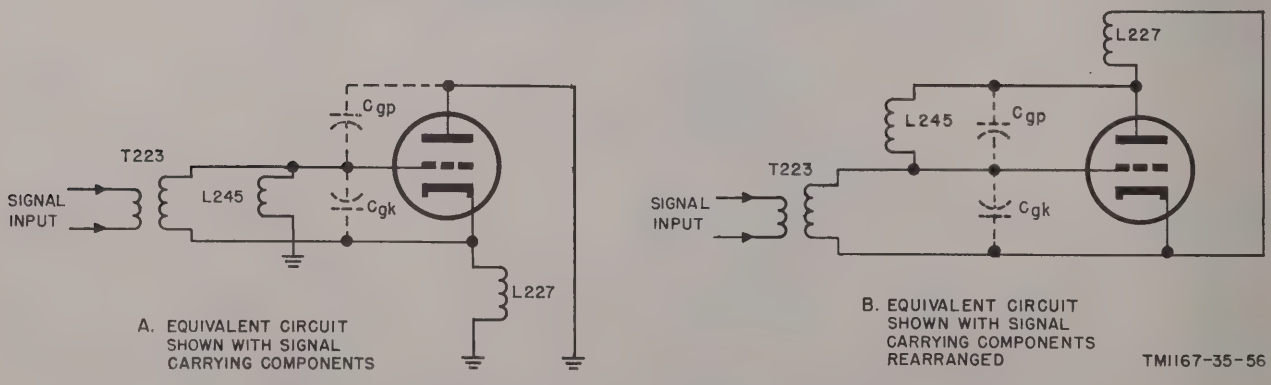


Figure 28. Neutralized signal IF preamplifier V232, equivalent circuits.

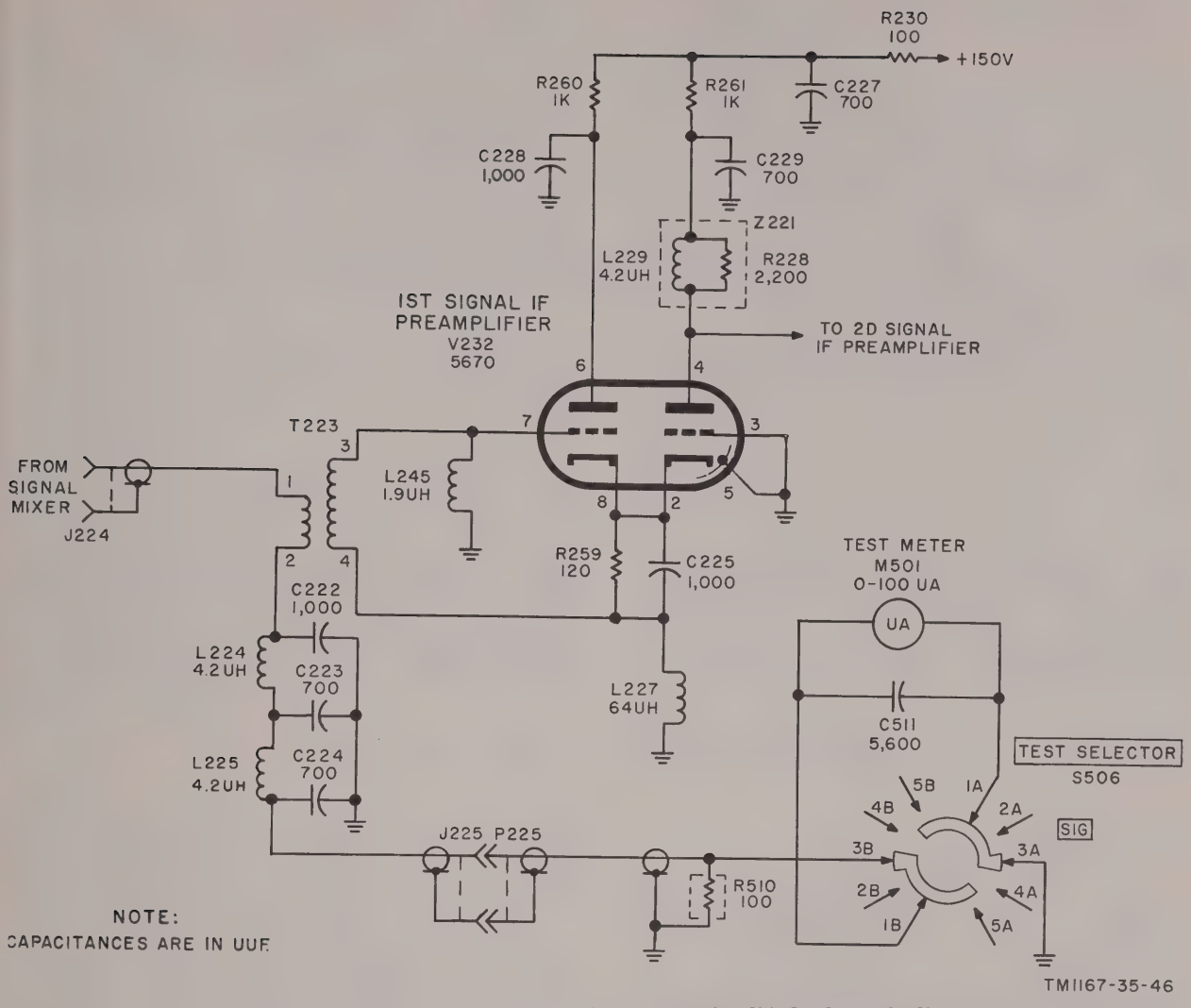


Figure 29. First signal IF preamplifier V232, simplified schematic diagram.

coupling network. Resistor R230 and capacitor C227 function as a decoupling network which isolates V232 from the +150-volt supply. The signal output from V232 is applied to the second signal IF preamplifier V224.

61. Second and Third Signal IF Preamplifiers V224 and V225

(fig. 30)

a. The output from the first preamplifier stage is applied through coupling capacitor C230 to the grid of V224. The input network includes L230 which tunes with the distributed capacity to 60 megacycles. Tube V224 is a high gain pentode operated as a conventional IF amplifier. The amplified signal is developed across plate load Z222 which consists of L231 and R232. The plate load tunes to 60 megacycles with less gain and broader bandwidth by the use of R232. Cathode bias is obtained by the use of C231 and R231. The output of V224 is coupled through C235 to the grid of V225.

b. Inductor L232 and the distributed capacitance due to the physical layout of components, form a parallel resonant circuit at 60 mc. The 60-megacycle signal is amplified by 3d signal IF amplifier V225 and the amplified signal is developed across the primary of plate transformer T222. Additional loading is provided by R236 to increase the bandpass. The output is taken from the secondary of T222 and coupled through coaxial connections J227 and

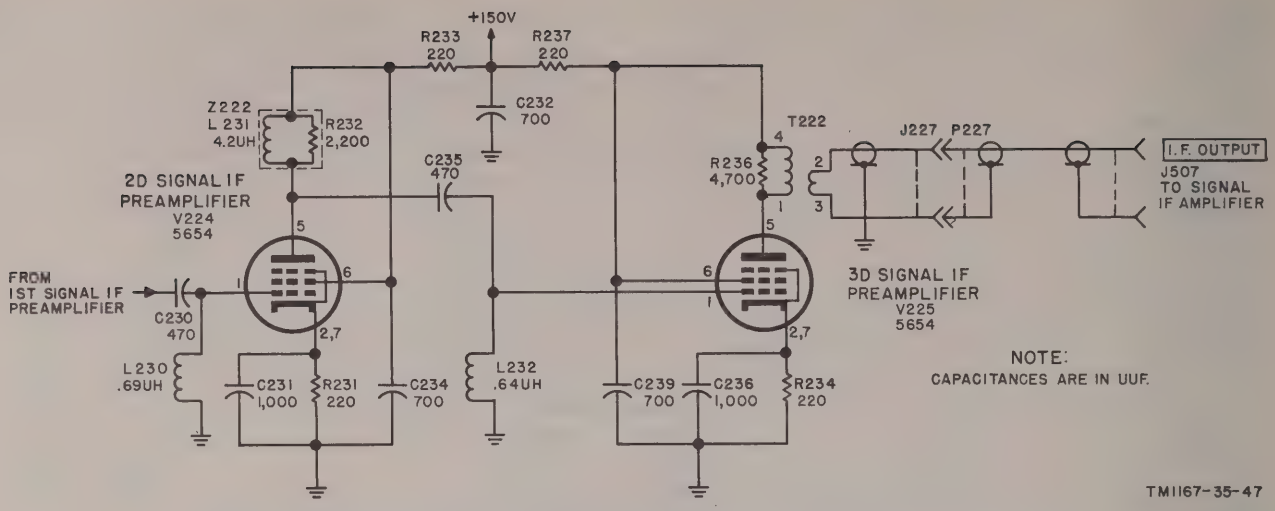


Figure 30. Second and third signal IF preamplifiers, simplified schematic diagram.

P227, to the I.F. OUTPUT connector J507. From J507 the 60-megacycle IF signal is coupled through a coaxial cable to the signal IF amplifier stages in the signal comparator. The cathode bias network consists of C236 and R234. Isolation between the stages and from the +150-volt supply line is accomplished by the use of R233, R237, C232, C234, and C239.

Section IV. SIGNAL IF AMPLIFIER CIRCUITS

62. General
(figs. 31 and 32)

The 60-megacycle IF signal frequency from preamplifier U221 is coupled from J507 on the front panel of the receiver-transmitter to J306 on the front panel of the signal comparator. A coaxial cable carries the signal from J306 to J307, the input to Z301. Six stages are included in Z301 (three amplifiers and three limiter amplifiers) for proper phase detection when operating in the mti mode. The 60-megacycle IF amplifier has a resultant bandpass approximately 1 megacycle wide, which can be varied through a range of 5 megacycles centered around the IF carrier frequency. The amplifier includes five fixed tuned stages that have a nominal center frequency of 60 megacycles.

63. First, Second and Third Signal IF Amplifiers
(figs. 31 and 220)

a. First Signal IF Amplifier V301. The 60-megacycle signal is transferred through a coaxial line from J307 to the input of V301. The 47-ohm resistor (R301) terminates the coaxial line. Capacitor C302 couples the signal into V301. The grid returns through grid resistor R332 to a bias supply derived from the −150-volt power supply and a variable voltage divider which is illustrated in figure 220. The bias supply filter network consists of C303, C314, C342, R303, and R311. The signal is amplified by V301 and the output signal is developed across plate load L302 which tunes to approximately 60 megacycles. Capacitors C301, C309, and C313 function as screen grid bypass capacitors and are physically located close to the tube socket to reduce the effect of wiring lead inductance. Cathode bias for all three stages is derived by the individual RC networks consisting of C307 and R302, C310 and R306, and C315 and R308.

b. Second Signal IF Amplifier V302. Capacitor C308 couples the signal into the second signal IF amplifier (V302) input circuit. The band pass of second signal IF amplifier is approximately 1 megacycle and is tunable through a range of about 5 megacycles centered around 60 megacycles. The 60-megacycle IF amplifier Z301 has a normal bandpass of 5 megacycles, limited only by the tuned circuit of V302. The

grid circuit of V302 includes L301, C306, and variable capacitor C305. The input tuned circuit of V302 has a high Q compared to the other stages and this produces the 1-megacycle response. Capacitor C305 is normally adjusted for maximum received signal. Because of the high Q tuned grid circuit, there is a possibility of the circuit oscillating. This possibility is suppressed by the addition of R304 in series with the control grid. The amplified signal is developed across plate load resistor R305 and applied to third signal IF amplifier V303.

c. Third Signal IF Amplifier V303. The signal is applied through C312 to the grid of third signal IF amplifier V303. The input circuit is tuned to a nominal 60-megacycle frequency by L303 and the distributed capacitance. The gain of V303 is varied by adjusting the bias supply voltage. The amplified signal is developed across plate load R307. Resistor R309 provides isolation between the first two amplifier stages and the other circuits of Z301 which use the same supply voltage. The amplified signal is applied to fourth signal IF amplifier V304.

64. Fourth, Fifth, and Sixth Signal IF Amplifiers
(fig. 32)

a. The need for limiting the received signals is necessary because all signals vary in amplitude from pulse to pulse. The amplitude variations may be due to various factors such as moving components on a stationary target and antenna movement. Strong ground clutter returns at varying amplitudes due to antenna motion and gives a false indication of target motion. The fourth, fifth, and sixth signal IF amplifiers function as limiters to reduce the false indications caused by very strong clutter signals. Some clutter signals return without sufficient amplitude to go into the limiting region and they may give undesirable results. The effect of the varying amplitudes of the echo from pulse to pulse will be more readily apparent when analyzing the function of the phase detector.

b. The control grid circuits of the limiter stages return to individual voltage dividers which provide approximately +50 volts. The

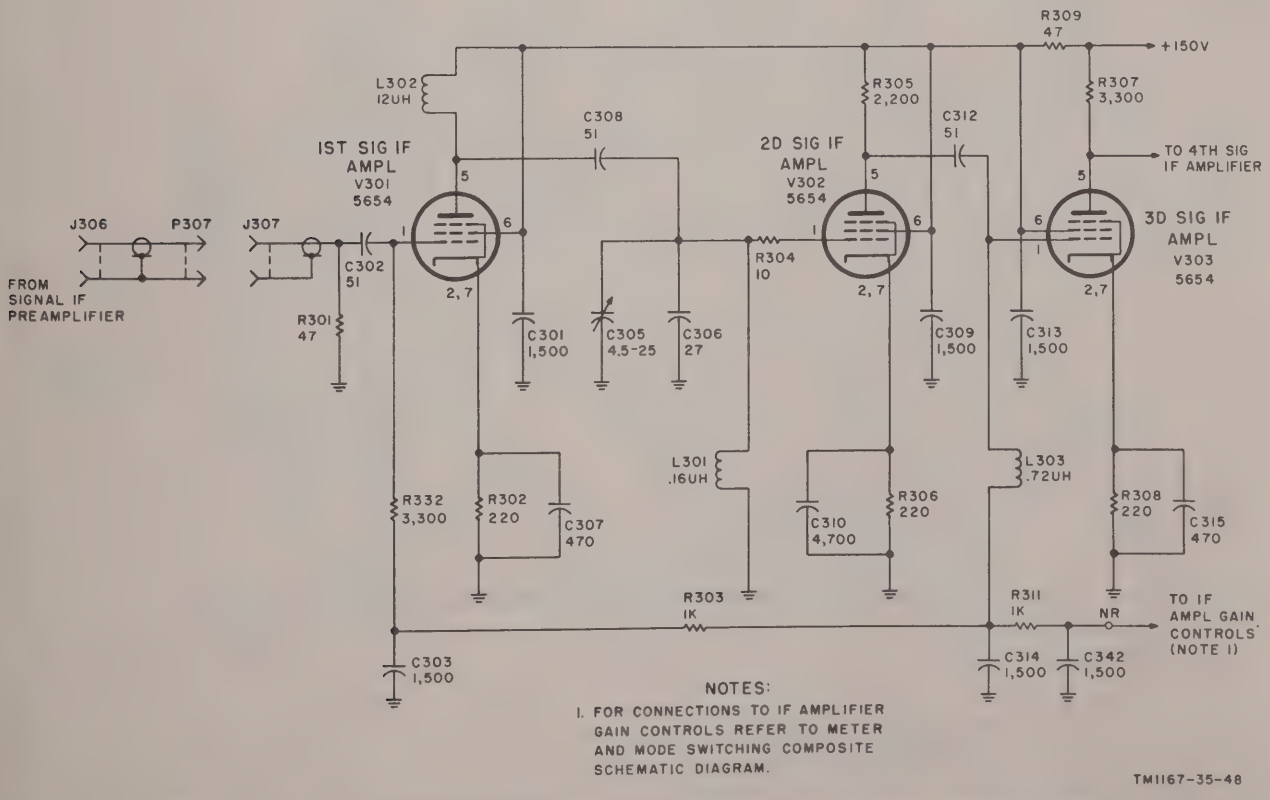


Figure 31. First, second, and third signal IF amplifiers, simplified schematic diagram.

cathode bias networks develop sufficient voltage to maintain the tubes with a small amount of bias. The voltage drop across the plate load and cathode resistors of V304 and V305 causes the cathode-to-plate voltage to be about 75 volts, while the cathode-to-screen-grid voltage is about 100 volts. The plate of V306 returns to +150 volts through the primary of T301 in the phase detector circuit which results in a cathode-to-plate voltage of 100 volts. The static voltage conditions cause saturation and cutoff limiting with the application of a 3-volt peak-to-peak signal voltage to any of the three limiter stages.

c. The control grid of V304 returns to a +50-volt point through voltage divider R312 and R310. Capacitor C318 functions to bypass RF. Cathode bias is developed by the use of R314 and C320. Capacitor C319 functions as the screen grid bypass. Similar networks are also provided for V305 and V306.

d. The signal from third signal IF amplifier V303 is applied through C317 to the control grid of V304. Inductor L304 and the distributed capacitance are tuned to the IF carrier. Resistor R313 functions as the plate load. Identical components are used for fifth signal IF amplifier V305. The output of V305 is coupled through C327 to the grid of V306. The function of V306 is similar to the previous stages, with the difference being a larger value of L306 in the grid circuit. This is necessary to tune to the correct frequency because the input capacitance is less than the previous stages. The input capacitance is in part determined by the feedback through the tube plate-to-grid capacitance as a result of the plate load impedance. Although not as critical when using a pentode amplifier, the input capacitance decreases with a decrease in plate load impedance. In the case of V306, the plate load consists of R321 and the primary of T301 and C332, which provides a lower plate load impedance than V304 and V305 resulting in less input capacitance.

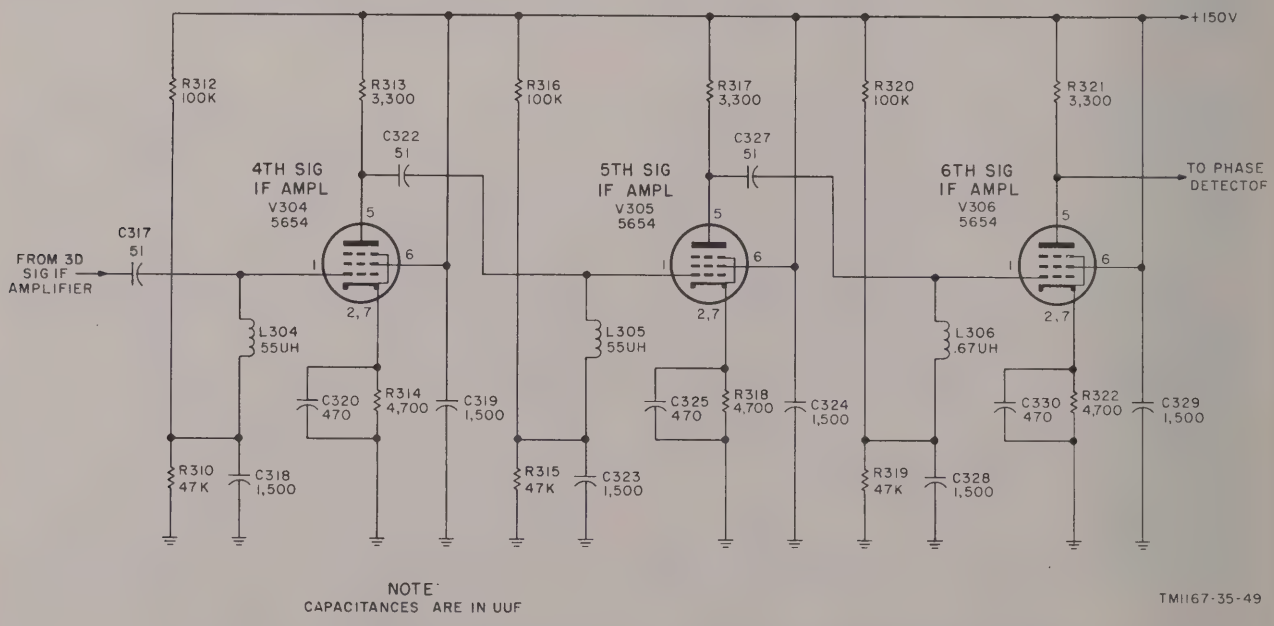


Figure 32. Fourth, fifth and sixth signal IF amplifiers, simplified schematic diagram.

Section V. COHO MIXER AND PREAMPLIFIER CIRCUITS

65. Coho Mixer Assembly RF502 (fig. 33)

a. Coho Mixer Assembly RF502 is an irregularly shaped coaxial assembly that provides for combining the transmitter signal pulses with the local oscillator signal. It is broadly tuned and responds well throughout the operating frequency band.

b. The transmitter pulses are coupled through a small aperture in the wall of the outer conductor of RF501 and are attenuated about 60 db. The energy enters into a small cavity and excites the pick-up loop of RF502.

c. The local oscillator signal which is 60 megacycles higher than the transmitter frequency is coupled through flexible coaxial cable W501 to J510. A 50-ohm disk type resistor fits between P510 and J510 and is used to terminate the coaxial cable, thereby reducing reflections back toward the local oscillator. The energy is fed through a short length of rigid coaxial section of RF502 and applied through a contact sleeve to the center conductor of the coupling probe. The coupling adjustment positions the coupling probe for the degree of coupling desired. The local oscillator energy is capacitively coupled and combines with transmitter pulse energy.

d. Both transmitter and local oscillator signals propagate towards crystal mixer CR502. A quarter wavelength supporting stub (metallic insulator) is employed which provides a rigid support and maintains the inner conductor properly centered.

e. Coho mixer CR502 is inserted at the output end of RF502 and is in series with the center conductor of the coaxial lines.

f. Coaxial adapter J511 connects to RF502 and holds CR502 securely in place. The other end of J511 connects with P511 on coaxial cable W507.

g. The output of CR502 is 60 megacycles, the result of heterodyning the transmitter and local oscillator frequencies. Coaxial cable W507 couples the 60-megacycle frequency into coho IF preamplifier U502.

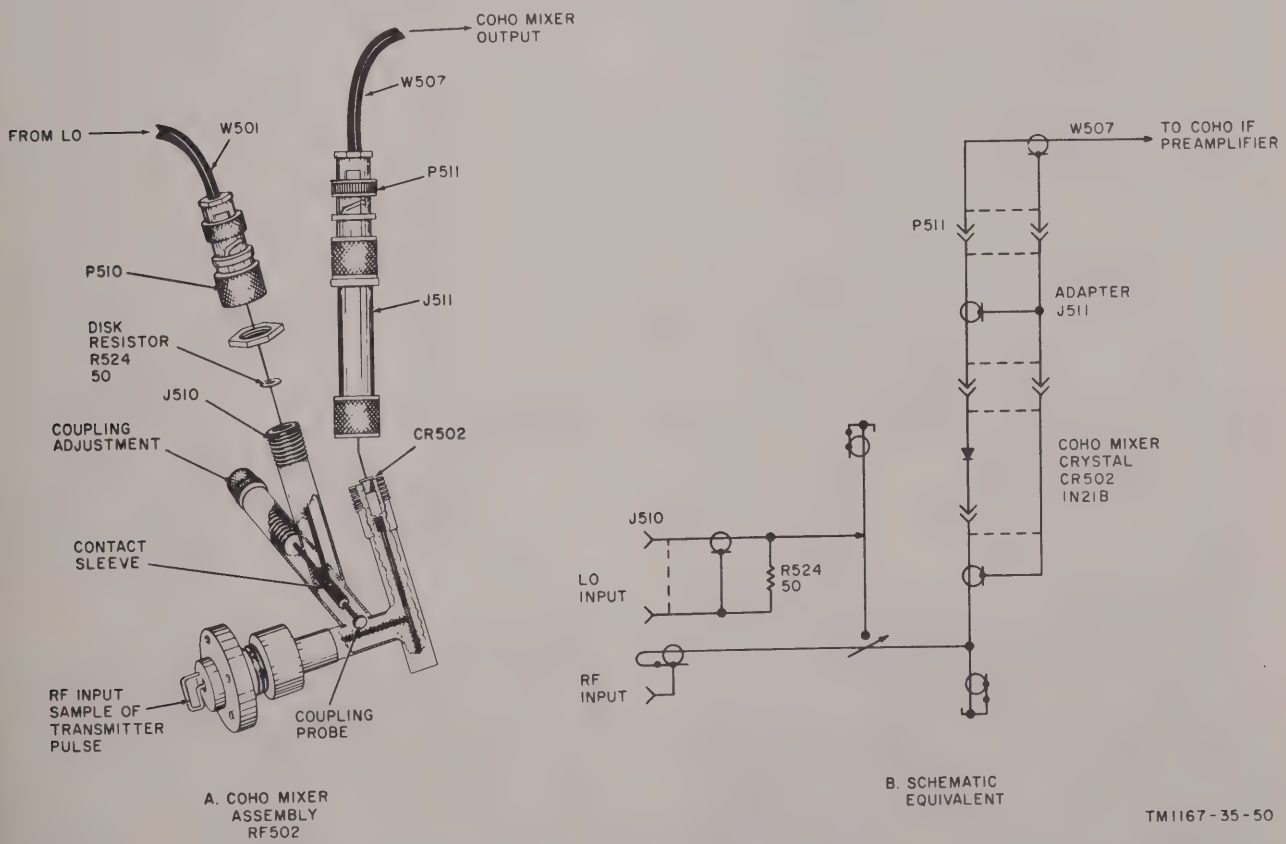


Figure 33. Coho mixer assembly RF502.

66. Coho Preamplifier U502
(fig. 34)

Coho preamplifier U502 consists of a single stage 60-megacycle amplifier located on a subchassis in the receiver-transmitter unit. The 60-megacycle signal is amplified to well above the noise level so that it can be more easily applied through a coaxial cable to coherent oscillator Z350 which is located in the signal comparator.

a. The output from coho mixer crystal CR502 is a pulsed 60-megacycle signal frequency and a rectified dc component resulting from the continuous output of the local oscillator. The crystal current is filtered by L507, C526, C532, and C513. TUNING METER M601 located on the front panel of the indicator unit provides a constant monitor of the coho crystal current which is applied through interconnecting cables from the receiver-transmitter unit through the power supply unit to the indicator unit. A center (red line) reading of M601 indicates the correct amount of local oscillator power applied to the mixer. Resistor R450 serves as the meter shunt for M601 and is located in the power supply unit. Capacitor C603 serves as the meter bypass.

b. Test meter M501 which is located on the front panel of the receiver-transmitter unit provides an indication of the coho crystal current when TEST SELECTOR S506 is switched to the COHO position.

c. The pulsed 60-megacycle signal from coho mixer CR502 is coupled through a coaxial line

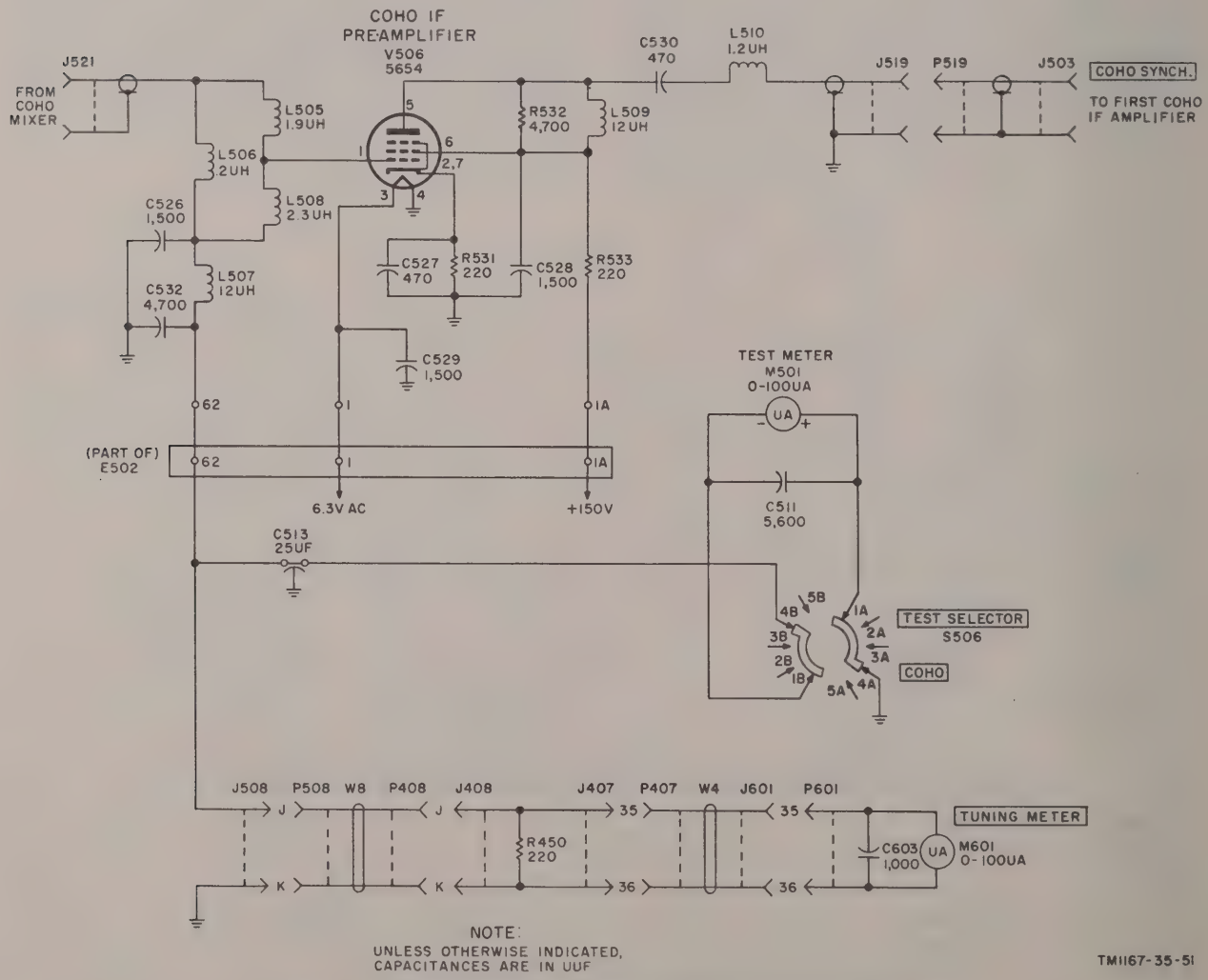


Figure 34. Coho preamplifier U502, simplified schematic diagram.

to J521, the input jack to coho IF preamplifier V506. The input circuit of V506 is a self inductance coupled pi network that consists of L506, L505, and L508. This type of input circuit arrangement introduces some attenuation but has the added advantage of providing the stage with an improved noise figure and an almost flat bandpass approximately 5 megacycles wide. The plate load consists of L509 which tunes with the distributed capacitance and is shunted by damping resistor R532 to maintain proper bandwidth. The screen grid is bypassed by C528 which also functions as part of a decoupling network with R533. Cathode bias is provided by R531 which is bypassed by C527. Capacitor C529 bypasses the filament supply line of V506.

d. The amplified signal is coupled through C530 which blocks the dc from the output circuits. Inductor L510 tunes to 60 megacycles with the distributed capacitances of the circuit and the input capacitances of the coaxial line. A short length of coaxial line carries the signal from J519 on the subchassis to COHO SYNC jack J503 on the front panel of the receiver-transmitter unit.

Section VI. COHERENT OSCILLATOR Z350

67. General

The signal from the coho IF preamplifier is a 60-megacycle frequency, 2 microseconds in duration, and is recurrent at 2,500 microsecond intervals. The signal exactly represents the phase of the transmitted RF pulses, it is used to synchronize (phase lock) coherent oscillator V353 at 2,500 microsecond intervals. The output of the coho is a 60-megacycle continuous wave which is maintained in a reference phase relative to transmitter RF frequency. The coho 60-megacycle reference frequency is required for the phase detector circuit to produce an indication of a moving target when operating in the mti mode. The coho functions only when OPERATION SELECTOR switch S2354 is in either MTI or COHO ADJUST positions. When in the NORMAL position, the coho (V353) is disabled by removing the screen grid voltage through the action of mode selector relay K3301 located in the video balancer and amplifier circuits of the signal comparator unit.

68. First, Second, and Third Coho IF Amplifiers

(fig. 35)

a. First Coho IF Amplifier. The 60-megacycle pulses from the coho preamplifier subchassis in the receiver-transmitter unit are coupled through a coaxial cable to J304 on the front panel of the signal comparator unit. A short coaxial cable carries the signal to subchassis Z350 which contains the coho and the amplifiers. The coaxial cable is terminated by R350 which matches the coaxial line and prevents reflections. The cathode of the first coho IF amplifier returns through a variable voltage divider network which consists mainly of R351 and COHO SYNC adjustment R2355. Capacitor C370 and L350 function as a filter network. When R2355 is in the full counterclockwise position, the cathode of V350 returns to a +10-volt source which will cause the tube to cut off. Varying R2355 will cause V350 to conduct and the stage gain will be adjustable. When R2355 is in the full clockwise position, cathode bias resistor R352 is returned to dc ground potential and V350 operates with maximum gain. The function of COHO SYNC adjustment R2355 is to control the amplitude of the synchronizing signal voltage which is applied to V353, the coherent oscillator. Capacitor C351 is the cathode bypass capacitor and C350 functions to bypass the screen grid. Very little amplification is realized by V350 and serves merely as a means of controlling the amplitude of the signals and to transfer them from J350 to the following stage. The signal developed across plate load R353 is coupled through C352 to the following stage.

b. Second Coho IF Amplifier. The applied signal to V351 is developed across L351 which tunes to 60 megacycles with the input circuit capacitance. Resistor R355 and C354 make up the cathode bias network and C353 is the screen grid bypass capacitor. The amplified signal developed across R354 is coupled through C355 to the following stage.

c. Third Coho IF Amplifier. The signal is amplified by V352 with L352 being tuned to the

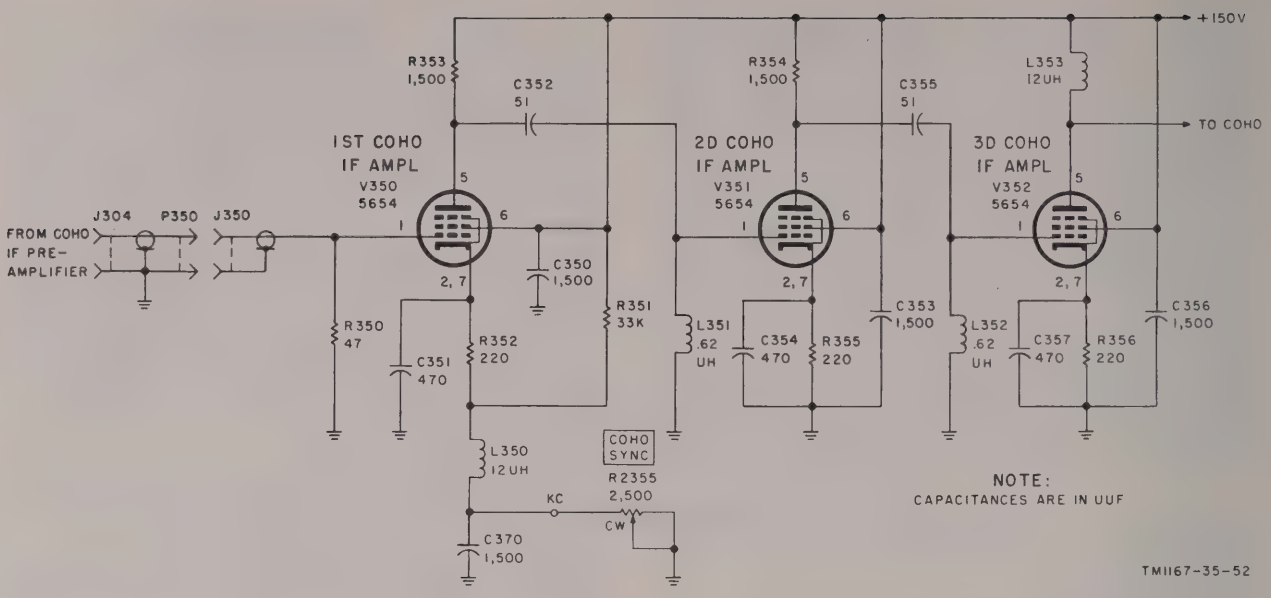


Figure 35. First, second, and third coho IF amplifiers, simplified schematic diagram.

applied frequency by the distributed capacitances of the input circuit. The amplified signal of V352 is developed across plate load impedance L353 and is applied to the coho as a synchronizing voltage. Resistor R356 and C357 serve as the cathode bias network and C356 bypasses the screen grid.

69. Coho V353 and Coho Amplifier V354 (fig. 36)

a. Coho V353. The coho is a stable 60-megacycle electron-coupled oscillator which is synchronized by the applied 60-megacycle pulses (2 microseconds in duration and occurring at 2,500 microsecond intervals). Its output is continuous and is amplified and applied to the phase detector. The synchronizing signal is coupled into the circuit through C359. The grid leak bias network consists of C362 and R357. The tuned circuit consists of L354, C360, C361 and additional capacitive components which are the grid to cathode capacitance of V353 and the capacitance existing across L355, from the cathode to ground. These two additional capacitive components form a capacitive voltage divider across the tuned circuit which gives rise to a Colpitts type oscillator. Inductor L355 has across it a total capacitance of about 1.8 micromicrofarad ($\mu\mu$f) and it resonates to a frequency lower than 60 megacycles. At the operating frequency of 60 megacycles, the cathode circuit appears capacitive since the capacitive reactance across L354 is less than the inductive reactance. The tuned circuit which includes L354 is a high Q tank having a high C to L ratio. Feedback is provided by the capacitive divider grid to cathode and cathode to ground capacitances. The cathode to ground capacitance charges during the positive alternations when V353 conducts and during the negative alternation replenishes the energy in the grid tank circuit. During the positive alternations, grid current flows and charges the grid leak bias network which provides continuous operating bias for the oscillator. Capacitor C361 is variable so that the 60-megacycle oscillator frequency may be selected. Slight drift that may occur between the transmitter synchronizing pulse intervals is negligible and the coho is easily brought back in phase. The dc return path for V353 is provided through L355. Capacitor C364 functions as the oscillator ac plate return as well as the screen grid bypass. COHO LEVEL control R2351 selects the value of dc voltage applied to the screen grid and therefore the magnitude of the oscillator output. The dc supply voltage is obtained through mode selector relay K3301 and is applied only when the OPERATION SELECTOR switch S2354 is in the MTI or COHO ADJUST position. COHO LEVEL control R2351 is adjusted

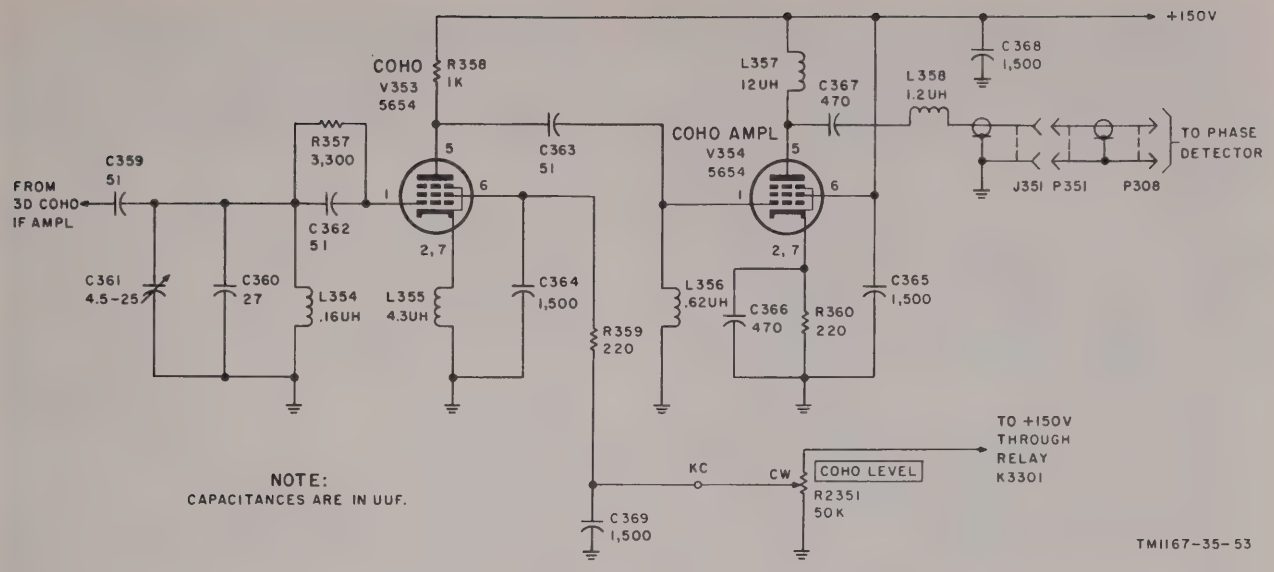


Figure 36. Coho and coho amplifier, simplified schematic diagram.

for a red line reading of TEST METER M2350 which indicates the proper output level of coherent oscillator Z350. Resistor R359 and C369 provide filtering of the screen grid voltage supply. The 60-megacycle signal is electron-coupled through V353 and is developed across R358 the plate load.

b. Coho Amplifier V354. The output of V353 is a cw 60-megacycle signal that requires some additional amplification because it has to be coupled through a coaxial line to the phase detector. Coho amplifier V354 serves as a buffer amplifier for V353. The signal is coupled into V354 through C363. The grid circuit is tuned by L356 and the input capacitance. Cathode bias is employed and R360 is bypassed by C366. The screen grid bypass capacitor is C365 and the +150-volt line is bypassed by C368. The amplified signal is generated across plate load L357 and coupled through C367 and L358 to J351 the coaxial output jack. Inductor L358 serves to introduce inductive reactance to cancel the capacitive input of the coaxial line. The coaxial line couples the signal to the phase detector circuit and the line is terminated by a 100-ohm resistor (fig. 37). The input to the coaxial line at J351 appears as a very low impedance, which would load the output of V353 very heavily and therefore the requirement for the additional stage.

Section VII. PHASE DETECTOR

70. General

The phase detector is required when operating in the mti mode to produce an indication of moving targets. The echo signals from the signal IF amplifier are combined with the coherent oscillator signal and the phase difference between the two frequencies is detected. Moving targets cause a phase displacement of the RF from pulse to pulse and therefore the amplitude and polarity of the detected video pulse will vary. Stationary targets cause the succeeding echo returns to have the same RF phase difference between the IF signal and the coherent oscillator signal. The resulting video pulses have a relatively constant amplitude and the same polarity. When operating in the normal mode, the coherent oscillator is disabled and only a part of the detector circuit is active so that it functions as an amplitude modulation (am) detector. When operating in the normal mode, the detector provides only negative video pulses to the video amplifier stages.

71. Phase Detector
(figs. 37 and 38)

a. The pulses from the signal IF amplifier are coupled through the primary of T301 to the secondary. The primary is a low Q tuned cir-

cuit that is tuned by C332 and responds to a wide frequency band centered around 60 megacycles. The secondary is tuned by C333 and the bandpass is broadened by R323. The coho signal is coupled through J308 and appears across R324 which functions to terminate the coaxial line. It is applied to the center tap of the secondary and is rectified by CR301 and CR302. The rectified output of CR301 charges C334 negative with reference to ground and that voltage is divided across R325 and R326. The rectified output of CR302 charges C335 positive with reference to ground and that voltage is divided across R327 and R326. Resistor R326 is common to both voltages developed by the coho signal. Since the voltages are of equal value but opposite polarity, the resultant voltage drop across R326 is zero. When the 60-megacycle signal IF voltage is introduced into the secondary of T301, half of the secondary voltage will aid the coho voltage while the other half will oppose. The net effect will be either a positive or a negative voltage developed across R326 depending on the instantaneous polarities of the coho and the signal voltages. For the phase detector to function properly, it is desired that the amplitudes of the applied coho and the signal voltages be approximately equal. This is accomplished by setting the COHO LEVEL R2351 and the IF AMP LEVEL R2350 for a center (red line) reading on TEST METER M2350 (fig. 220).

b. Consider the instantaneous coho voltage across R324 to be positive with reference to ground. If the instantaneous signal voltage across the secondary of T301 is negative at the CR301 end and positive on the other end, then the coho and signal voltages would be aiding so that CR302 will conduct and increase the charge on C335. The coho voltage would be opposing the signal voltage so that conduction through CR301 is decreased and the charge across C334 is reduced. The resulting voltage drop across R326 will have an average positive value with reference to ground. If this phase between the coho and signal frequencies is maintained, the polarity across R326 will remain positive. The maximum voltage developed across R326 will be when the coho and signal voltages are exactly in phase. If the instantaneous coho voltage across R325 is negative with reference to ground and the instantaneous signal voltage across the secondary of T301 is negative at the CR301 end, the resulting voltage across R326 will be negative. The coho and signal voltage will be aiding so that CR301 increases conduction and increases the charge on C334 while they oppose, so that CR302 decreases conduction and also decreases the charge on C335. The signal frequency consists of 2-microsecond pulses at 60 megacycles; therefore, the comparison at the phase detector will produce 2-microsecond video pulses which will have an amplitude and polarity depending on the relative phase between the coho and signal frequencies. A condition will exist when the two voltages are displaced either 90° or 270° so that equal magnitudes of charge will accumulate across C334 and C335. The charges will be of opposite polarity so that the resulting voltage developed across R326 is zero. A moving target will produce return signals that have a different phase from pulse to pulse; therefore the amplitude and polarity of the video pulse across R326 will change from pulse to pulse. The successive changes are compared in the video balancer and amplifier circuits and mti video pulses are provided for the indicator. Stationary targets always produce the same phase displacement from pulse to pulse and the comparison in the video balancer and amplifier circuit results in cancellation. The video pulses developed across R326 are coupled to 9-megacycle carrier oscillator V1355 for further processing to provide mti indications.

c. When in the normal mode of operation, the coherent oscillator is disabled. The signal pulses coupled through T301 are rectified by CR301 and normal video is developed across R325 and R326 with C334 being the filter capacitor. During application of the 60-megacycle signal pulses, CR302 also conducts, charging C335 positive and develops a positive video pulse across R327 and R326. The voltages across R326 cancel, and thus make the available video pulse voltage only that which is developed across R325. The negative video pulses are coupled through a shielded cable to normal video limiter V3306.

d. When the coho is enabled to operate, CR301 provides a rectified output which is applied through voltage divider R2358 and R2363 through TEST SELECTOR switch S2353 to

TEST METER M2350. The voltage divider is fixed at a value calculated to produce a center (red line) reading on M2350 when the coho output amplitude is of the correct value.

e. When the coho is disabled, the noise which is generated in the signal IF amplifiers is applied to an amplifier which raises the level to provide an indication on a meter.

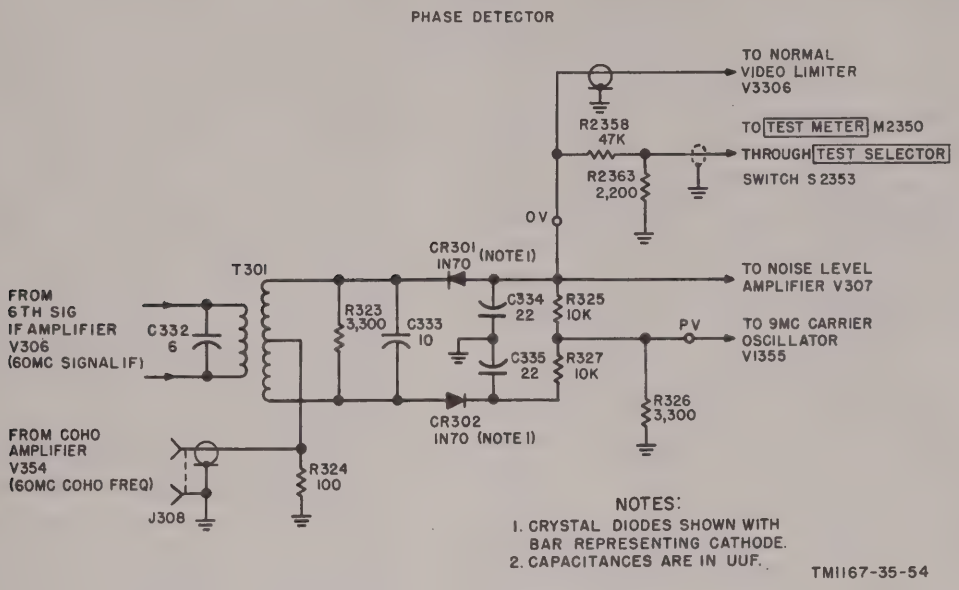


Figure 37. Phase detector, simplified schematic diagram.

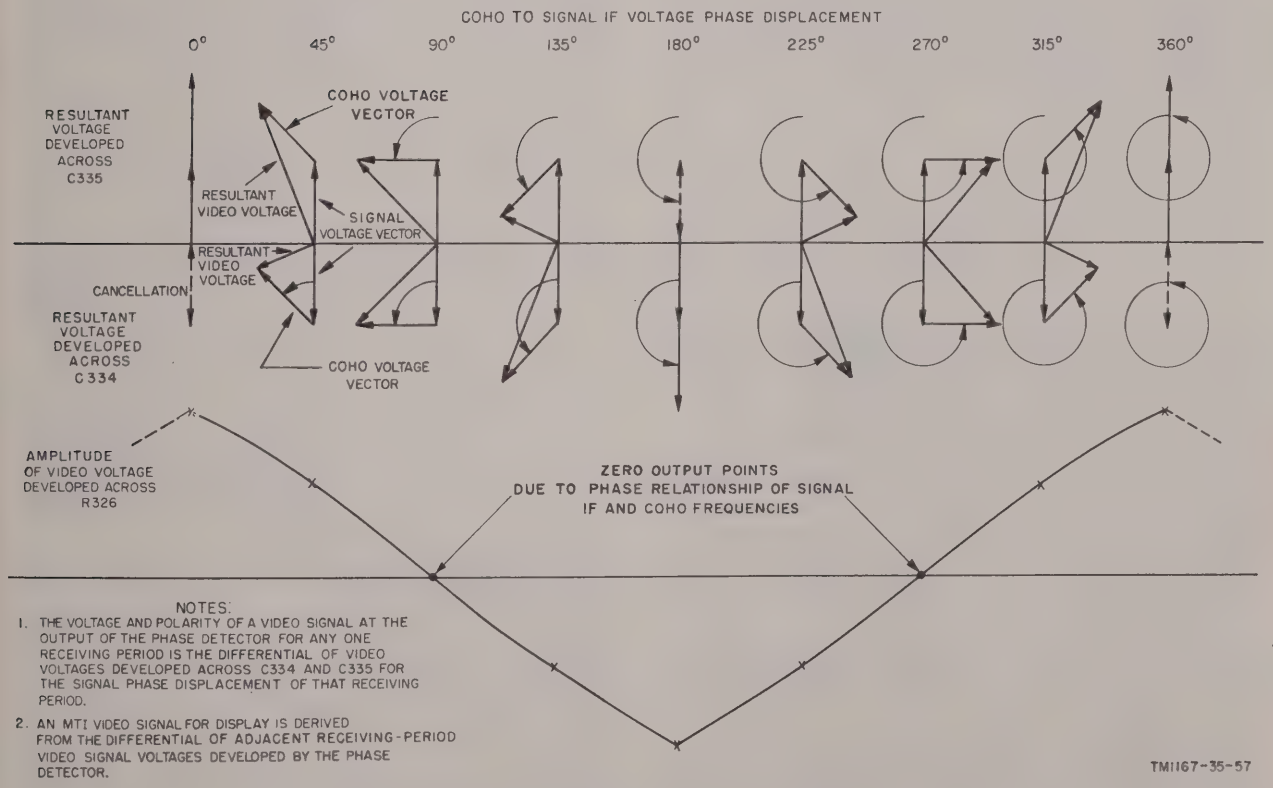


Figure 38. Phase detector vector analysis.

72. Noise Level Amplifier V307 (fig. 39)

a. The gain of 60-megacycle IF amplifier Z301 is adjusted by observing the indication of the relative noise level. The noise generated in the mixer and first few IF stages limits receiver sensitivity. A condition of too much IF amplifier gain will raise the noise to saturation level so that received signals would show no indication. A condition of too little gain would not only bring the receiver noise down to a very low level but medium power and weak echo signals would not respond. The proper gain of the IF amplifier has been calculated so that the noise level received from the phase detector is amplified and then rectified and applied through a voltage dropping resistance to a meter which has a marked scale. Setting the IF gain control for center (red line) reading of the meter (with the transmitter off) automatically sets the gain for optimum. Besides adjusting the gain for the proper noise level, the average received signal amplitude is correct for application to the phase detector.

b. The noise impulses from the phase detector circuit are coupled through L307, which functions to isolate the input circuit capacity of V307 from the phase detector and also provides for series peaking, because the noise impulses are usually high-frequency video. Series peaking is accomplished through the series resonance voltage rise across the input capacitance of V307. Cathode bias is employed and derived from R330 and C337. The screen bypass capacitor is C336. The +150-volt supply line is bypassed by C340. The amplified noise impulses develop across plate load resistor R329 and are coupled through C339 to the rectifier. Shunt rectifier CR303 conducts during positive alternations and presents a high impedance during the negative alternations. An average negative voltage is generated which is filtered by R331 and C341. When the TEST SELECTOR S2353 is in the (1) I.F. AMPL LEVEL position, TEST METER M2350 indicates the voltage across C341. To obtain an indication on M2350, the OPERATION SELECTOR switch S2354 must be in the NORMAL position. When S2354 is in any other position except NORMAL, it short-circuits C341 and there is no indication on M2350. The stage gain of V307 and the losses of the coupling and filter network are set so that M2350 will indicate a center (red line) reading when the signal IF amplifier gain is properly adjusted.

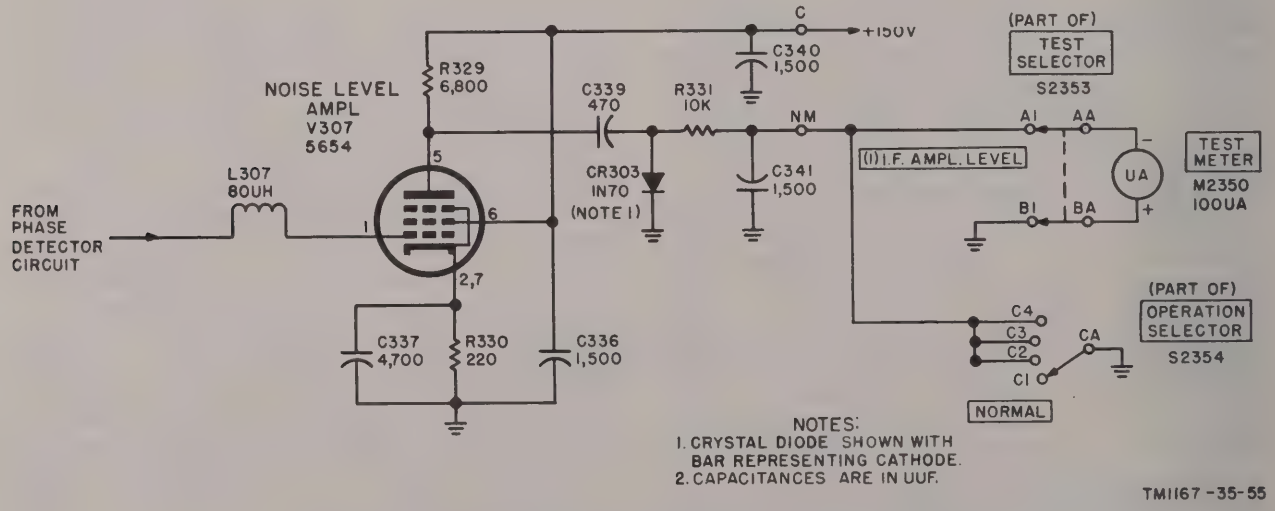


Figure 39. Noise level amplifier, simplified schematic diagram.

CHAPTER 5
SIGNAL COMPARING SYSTEM

Section I. GENERAL

73. General

The signal comparing system makes moving-target indication (mti) possible in the mti mode of operation of the equipment. Video pulses representing both fixed and moving targets are applied to the signal comparing system from the phase detector in the receiving system.

a. The principal function of the signal comparing system is to cancel echoes from fixed targets (ground clutter) in the mti mode of operation so that only video pulses representing moving targets are applied to the indicating system. For the radar operator to detect relatively small moving aircraft targets flying over terrain that causes relatively strong clutter patterns to appear on the indicators, the returns from fixed targets must be substantially cancelled. The efficiency of an mti system can be described in terms of subclutter visibility in units of decibels. If an equipment using mti makes it possible to detect a moving-target signal which is 30 db weaker than the signal from the fixed target it is flying over, the subclutter visibility rating of the equipment is 30 db.

b. The signal comparing system makes subclutter visibility possible by cancelling signals returned from fixed targets. Cancellation is accomplished by circuitry that delays the echoes from a transmitted pulse and compares them with the echoes from the following transmitted pulse. The echo pulses from the first transmitted pulse are delayed for a length of time equal to the pulse repetition time of the equipment. Inverted echo pulses from the following transmitted pulse (which are not delayed) are then compared with the delayed pulses so that the returns from fixed targets cancel and the returns from moving targets do not. Cancellation of fixed target signals is made possible because the returns from a fixed target (from the same target but from successive transmitted pulses) appear as pulses of equal amplitude and of the same polarity in the successive input video signals to the signal comparing system. The returns from a moving target (from the same target but from successive transmitted pulses) vary in amplitude and polarity in the successive input video signals because the phase of the signals returning from a moving target changes with respect to the transmitted signals and therefore with respect to the coherent input to the phase detector which has the same phase as the transmitted signal.

c. An important function of the signal comparing system is to establish the pulse repetition time of the equipment in all modes of operation except the normal (internal trigger) mode. To cancel clutter signals and provide maximum subclutter visibility, signal returns from a transmitted pulse must be delayed the exact time between transmitted pulses before they are used to cancel the signal returns from the following transmitted pulse. One way of accomplishing this would be to trigger the transmitting system independently of the signal comparing system and then adjust the amount of delay that takes place in the signal comparing system. This method is undesirable because it would be difficult to establish a stable pulse repetition time and it would also be difficult to adjust the time delay of the mercury delay line in the signal comparing system. The stability requirements are taken care of by having the signal comparing system develop transmitter triggers which depend on the amount of time delay that takes place in the signal comparing system.

d. The only *signal* input to the signal comparing system is from the phase detector in the receiving system. The type of input and its application depend on the mode of operation of

the equipment. In the normal mode, the phase detector operates as a conventional second detector, and negative video pulses representing both fixed and moving targets are applied to the signal comparing system. The normal video pulses do not go through the comparison and cancellation circuits. They are amplified and applied to the indicating system and to Azimuth and Range Indicator IP–345/TPS–1D (remote ppi) as positive video pulses. In the mti mode, a coherent signal is applied to the phase detector so that the input to the signal comparing system consists of bipolar video pulses representing fixed and moving targets. After comparison of received signals and cancellation of fixed target returns, positive video pulses representing moving targets are applied to the indicating system and the remote ppi. Relays which are actuated by a master mode selector switch disable some and enable other stages to operate in the signal comparing system so that the proper type of video pulses are applied to the indicators for the chosen mode of operation.

e. Three *signal* outputs are taken from the signal comparing system in all modes of operation. Positive video pulses are applied to the indicating system and to the remote ppi. Negative trigger pulses are applied to the transmitting system but they are not used in the normal (internal trigger) mode of operation.

f. All ac and dc potentials necessary to operate the stages of the signal comparing system are applied from the power supply.

g. Except for two potentiometers, the entire signal comparing system is located within the signal comparator (Signal Comparator CM–36/TPS–1D). MTI BALANCE potentiometer R2618, RECEIVER AMPL BALANCE potentiometer R2627, and one switch (OPERATION) are located on the front panel of the indicator. These remote controls have corresponding controls on the front of the signal comparator.

h. The relationship of the signal comparing system to other functional systems of the AN/TPS–1D is covered in TM 11–1167–20.

74. Simplified Block Diagram (fig. 40)

a. The signal comparing system consists of seven subsystems (channels or circuit groups):

(1) 9-mc carrier channel.
(2) Delay channel.
(3) Nondelay channel.
(4) Video circuits.
(5) Amplitude balancing circuits.
(6) Time balancing circuits.
(7) Trigger generator circuits.

b. In the mti mode of operation, the video input to the signal comparing system amplitude modulates a gated 9-mc oscillator in the 9-mc carrier channel. (Waveform A represents the pulse returns from one transmitted pulse, and waveform C represents the pulse returns from the following transmitted pulse approximately 2,500-microseconds later.)

c. The output from the 9-mc carrier channel is applied to the delay and nondelay channels (waveform B from one transmitted pulse and waveform D from the following transmitted pulse). The input to the delay channel (waveform B) is delayed by the delay channel and becomes waveform F for comparison purposes. The input to the nondelay channel (waveform D) is not delayed by the nondelay channel and becomes waveform E for comparison purposes. The output from the delay channel is a negative envelope which results from demodulating the 9-mc carrier. It consists of the video information (waveform A) riding on a negative dc level that is determined by the peak amplitude of the alternations of the 9-mc carrier output from the delay amplifier. The output from the nondelay channel is a positive envelope which results from demodulating the 9-mc carrier. It consists of the video information (waveform C) riding on a positive dc level that is determined by the peak amplitude of alternations of the 9-mc carrier output from the nondelay amplifier.

d. The negative envelope from the delay channel (waveform F) which contains video information from waveform A is compared with the positive envelope from the nondelay channel (waveform E) which contains information from waveform C so that the algebraic sum of the two signals is developed at the comparison point. Since the fixed target returns are equal in amplitude and opposite in polarity they cancel and do not appear in the outputs to the indicating system. The carrier envelopes (dc components) also cancel because they are equal in magnitude and opposite in polarity. The echo pulses from moving targets do not

cancel, because they are not necessarily equal in amplitude or opposite in polarity, the amplitude and polarity depending on the radial velocity of the moving target. The moving-target signals are amplified and polarized by the video circuits and are applied to the indicating system and the remote ppi as positive video pulses.

e. To obtain maximum cancellation of clutter signals, the fixed target pulse outputs from the delay channel and nondelay channel must have essentially the same amplitude and must appear simultaneously at the comparison point. The amplitude requirement for cancellation is taken care of by the amplitude balancing circuits and the time requirement by the time balancing circuits.

f. In the mti mode, the time between transmitted pulses depends on the amount of time delay in a trigger loop within the signal comparing system. This timing is accomplished by synchronizing a free-running multivibrator that gates the 9-mc carrier oscillator in the 9-mc carrier channel. The multivibrator also gates the trigger generator circuit which produces negative pulses and applies them to the transmitting system.

g. The seven subsystems of the signal comparing system are discussed in paragraphs 75 through 81.

75. 9-mc Carrier Channel
(fig. 40)

The 9-mc carrier channel provides a carrier frequency upon which the input video pulses can be carried most efficiently through the mercury delay line. The 9-mc frequency is used to obtain the required amplitude and bandwidth through the delay line.

a. A pentagrid-type tube is used as a gated 9-mc carrier oscillator (V1355). It is gated to develop triggers using the delay line as a timing device. It oscillates while the V1354 half of the carrier gate multivibrator is beyond cutoff (waveform T). The 9-mc oscillations occur from 10 microseconds before the transmitter fires (to prevent the returning echo pulses from affecting the timing of the transmitter triggers) until approximately 2,140 microseconds after the transmitter fires (waveform V). The oscillations are interrupted in order to use the envelope of the demodulated 9-mc oscillations for timing purposes.

b. Video pulses from the receiving system (waveforms A and C) are applied to the injector grid of V1355 so that the pulses amplitude modulate the 9-mc carrier. The modulated carrier is amplified by 9-mc amplifier V1356 and by 9-mc output amplifier V1357 (waveforms B and D) before being applied to the delay and nondelay channels. The output signal of V1357 is applied directly to the delay line in the delay channel. The same output signal is applied to the nondelay amplifier, but it is attenuated approximately 60 db so that the signal input voltages to the delay and nondelay amplifiers are more nearly equal.

c. The carrier gate multivibrator is a free-running multivibrator which is adjusted to have a natural frequency slightly lower than the pulse repetition frequency of the equipment, (natural period which is longer than the pulse repetition time or pulse interval of the equipment). The multivibrator is synchronized by trigger pulses obtained from a trigger loop within the signal comparing system. The trigger loop consists of the carrier gate multivibrator, the 9-mc oscillator, the 9-mc amplifiers, the delay channel (except for the 1.9-microsecond delay line), and the time balancing circuits which adjust the amount of delay of the trigger pulses that synchronize the carrier gate multivibrator. In effect, the carrier gate multivibrator synchronizes itself through the trigger loop so that its period is equal to the sum of all the delays in the trigger loop (slightly more than 2,500 microseconds).

d. An output is also taken from the V1353B half of the carrier gate multivibrator (waveform W) to the trigger generator. The trigger generator develops negative triggers, which occur 10 microseconds after the 9-mc oscillations begin, and applies them to the transmitting system. These triggers time the start of the transmitted pulses.

76. Delay Channel
(fig. 40)

The delay channel delays, amplifies, and demodulates the modulated 9-mc carrier.

a. The input modulated 9-mc carrier (waveform B) is delayed 2,500 microseconds by mercury delay line W2350 so that the negative output envelope from the delay channel can be compared with the positive output envelope

from the nondelay channel. A 9-mc carrier frequency is used because the delay line operates most efficiently at this frequency. Because the delay line attenuates the signal voltage approximately 60 db, amplifiers V1301 through V1305 are necessary to raise the level of the 9-mc signals so that efficient detection can be accomplished by delay amplifier detector V1306.

b. The gain of delay amplifiers V1301 through V1304 is controlled automatically by an amplitude balancing bias from the amplitude balancing circuits so that the amplitude of the output negative envelope from the delay channel (waveform F) is equal to the amplitude of the output positive envelope from the nondelay channel (waveform E).

c. The output from delay amplifier detector V1306 is applied to two circuits. The negative envelope which results from demodulating the modulated 9-mc carrier (waveform N) is part of the trigger loop signal. The negative envelope is also applied to the comparison point (waveform F) through 1.9-microsecond delay line W2351. The 1.9-microsecond delay line compensates for the inherent time delays which affect the timing of waveform E which is compared with waveform F at the comparison point. These inherent time delays are the delays in the trigger loop (outside of the delay channel) and in the nondelay channel. Time balance between waveforms E and F is accomplished by delaying waveform F an additional 1.9 microseconds and then adjusting the time delay of the time balancing circuits so that the total of all the delays affecting waveform E is equal to 1.9 microseconds.

77. Nondelay Channel
(fig. 40)

a. The nondelay channel is identical to the delay channel except for the following features:

(1) It contains no delay lines.
(2) Its gain is not controlled automatically.
(3) Its detector is a positive detector.
(4) The input signal is attenuated to compensate for the attenuation of the delay line in the delay channel.

b. The nondelay amplifier attenuates and amplifies the modulated 9-mc carrier signal (waveform D) so that the output signal (waveform E) is a positive envelope equal in amplitude and in time balance with the negative envelope from the delay channel (waveform F). This is done so that the returns from fixed targets cancel across the comparison point components and only moving targets are passed on to the video circuits.

c. The nondelay channel is the only subsystem in the signal comparing system which cannot affect the operation of the equipment in the normal mode of operation of the equipment. The nondelay channel is used only when the equipment is in the mti mode.

78. Video Circuits
(fig. 40)

The video circuits limit and amplify signals in all modes of operation of the equipment. Video information is sent from the video circuits to the indicating system and to the remote ppi.

a. In the normal mode, the phase detector operates as a conventional second detector. Negative pulses from both fixed and moving targets are applied to normal video limiter V3306 from the phase detector in the receiving system (waveform K). The screen and plate circuits of V3306 are common to the screen and plate circuits of mti video limiter V3305 so that either normal or mti video can appear in the common plate circuit. A relay actuated by a mode selector switch disables either V3305 or V3306 depending on the mode of operation selected. Normal video signals are amplified and inverted by V3306, and mti video signals are amplified and inverted by V3305. Strong video signals cause limiting in the common plate circuit of V3305 and V3306.

b. The input to video cathode follower V3307 is either normal video (waveform L) or mti video (waveform J), depending on the mode of operation. The cathode follower stage acts as a power amplifier and matches the low impedance of the coaxial cable which carries the positive video information (waveform L or J) to the indicating system. Video cathode follower V3308 does the same for video sent to the remote ppi.

c. In the mti mode, a positive envelope (waveform E) is applied to the comparison point from the nondelay channel and a negative envelope (waveform F) is applied from the delay channel. With proper operation of the

signal comparing system, the envelopes (dc components) that result from demodulating the 9-mc carrier, cancel, and the positive and negative fixed clutter targets cancel (waveform G), so that they are not applied to mti video amplifier V3303. Since the returns from moving targets are not necessarily of equal strength and opposite polarity when applied to the comparison point, the output pulses from the comparison point are either positive or negative depending on the polarity and amplitude of the demodulated video pulses. The bipolar video pulses representing moving targets are amplified by mti video amplifier V3303 and applied to video polarizer V3304 (waveform H).

d. Both positive and negative video pulses are applied to video polarizer V3304, but the operation of the circuit is such that all inputs appear as negative pulses in the output signal (waveform I). This polarization is necessary when the manner in which video information is applied to a ppi scope is considered. If the video pulses remained bipolar, some would cause intensified spots on the ppi screen, but the opposite polarity pulses would cause dark areas on the screen and remain undetected.

e. The negative video pulses from V3304 are amplified and limited by mti video limiter V3305 (waveform J) before being applied to cathode followers V3307 and V3308. In the mti mode, the operation of V3305 is the same as it is for V3306 in the normal mode. The cathode followers operate the same in either mode of operation.

f. The output cathode followers are the only stages in the signal comparing system that affect the operation of the equipment in all modes of operation.

79. Amplitude Balancing Circuits (fig. 40)

The amplitude balancing circuits develop a bias voltage which controls the gain of four delay amplifier stages in the delay channel to equalize the output amplitudes from the delay and nondelay channels. The closer the amplitudes are balanced the better the cancellation of fixed targets.

a. The amplitude balancing circuits are actuated by a difference in the dc components of the signals developed across the comparison point components. They are not affected significantly by the video (ac component) differences. Amplitude balance dc amplifier V3301, in conjunction with reference tubes V3300 and V3302, operates as a two stage dc amplifier which has a constant dc in its output circuit when there is no dc applied to the input circuit. The amplitude balance potentiometer (R2354 in the signal comparator or R2627 on the indicator) adjusts the average balancing bias applied to the delay channel. It is adjusted to make the amplitude of the negative envelope from the delay channel essentially equal to the amplitude of the positive envelope from the nondelay channel.

b. When an unbalance in the output levels from the delay and nondelay channels occurs, the comparison point components operate as a sensing device. The dc potential difference between the two output levels is applied to V3301 which amplifies the difference. This amplitude difference is the amplitude balancing bias. It is applied to the delay channel to change the gain of the delay channel and essentially equalize the output amplitude of the two channels. Actually the output amplitudes cannot be perfectly balanced by the circuit. For example, if the emission of fifth nondelay amplifier V2305 falls off slightly during operation of the equipment, the positive dc component to the comparison point decreases and a net negative dc difference potential (error voltage) is applied to V3301. This dc error voltage is amplified by V3301 and applied to the delay channel as a negative correction bias which decreases the gain of the delay channel until the output amplitude level of the delay channel is reduced to a slightly higher level than the output from the nondelay channel. The slight difference (error voltage) is necessary to *hold* the output of the delay channel essentially equal to the lower output from the nondelay channel which results from the decreased gain of V2305.

80. Time Balancing Circuits (fig. 40)

The time balancing circuits are used to obtain a variable time delay so that the time of the output of the nondelay channel (waveform E) can be made to coincide in time with the output from the delay channel (waveform F) at the comparison point. This time balance is neces-

sary to obtain maximum cancellation of fixed targets and maximum subclutter visibility.

a. Two factors are compensated for by the time balancing circuits: The inherent time delays in the delay and nondelay channels are not necessarily equal; and time delays not common to the delay channel occur in the nondelay channel because the output of delay amplifier detector V1306 is used to start the timing of the next transmitted pulse.

b. Time balance is accomplished by delaying the output from the delay amplifier detector an additional 1.9 microseconds before it is applied to the comparison point. The variable time delay of the time balancing circuits is then adjusted so that the total of all the time delays in the time balancing circuits, the 9-mc carrier channel, and the nondelay channel is equal to 1.9 microseconds (the delay of W2351).

c. The carrier gate multivibrator is a free-running multivibrator. When the V1354 half cuts off, 9-mc carrier oscillator V1355 begins to oscillate. These oscillations are amplified by V1356 and V1357, travel down the 2,500 microsecond delay line, and are amplified again by delay amplifiers V1301 through V1305. The negative envelope of the 9-mc oscillations is detected by delay amplifier detector V1306 so that the time of the start of the negative gate from V3306 (waveform N) corresponds to 2,500 microseconds after the 9-mc oscillations begin (plus any small inherent time delays picked up in the 9-mc carrier channel and the delay channel). The demodulated negative envelope (waveform N) input to the time balancing circuits is differentiated (waveform O) and applied to slope generator V1350. The operation of V1350 is similar to that of a sweep generator. The input cuts off the stage and a capacitor in the plate circuit charges while the tube is beyond cutoff. This action produces a sharp rise in voltage at the output (waveform P) which is in turn differentiated (waveform Q) and applied to pickoff amplifier V1351. The cathode of V1351 returns to a voltage divider so that mti balance potentiometer R2356 (or R2618 on the indicator) controls the time when V1351 goes into conduction. A small time delay (from 1 to 3 microseconds) is obtained by operating V1351 beyond cutoff so that the start of the input signal to the grid (waveform Q) does not cause conduction. The setting of R2618 establishes the time balancing bias which controls the time of conduction of V1351. When V1351 goes into conduction, a negative trigger is developed and applied to the V1354 half of the carrier gate multivibrator (waveform S). Approximately 350 microseconds before the development of the negative trigger, the natural timing of the multivibrator causes the V1354 half of the multivibrator to go back into conduction (waveform T) so that the negative trigger causes the V1354 half to go back into cutoff before it would naturally do so. The loop of the signal path from the time that the V1354 half of the carrier gate multivibrator cuts off until it cuts off again is called the trigger loop. This trigger loop establishes the overall timing of the carrier gate multivibrator and therefore the time between transmitter pulses.

d. By providing a variable time delay in the portion of the trigger loop which is not common to the delay channel, the time balancing circuits make it possible to adjust the output from the nondelay channel so that it is in time balance with the output from the delay channel. This occurs when R2356 (or R2618) is adjusted so that all of the time delays affecting the timing of the output from the nondelay channel are equal to 1.9 microseconds, the time delay of W2351.

81. Trigger Generator Circuits
(fig. 40)

The trigger generator circuits produce negative pulses which depend on the timing of the trigger loop and apply them to the transmitting system as external transmitter triggers. The output triggers (waveform Z) take place 10 microseconds after the 9-mc carrier oscillator starts to oscillate. This 10-microsecond time delay allows time for the 9-mc oscillations to stabilize before the video pulses start arriving. The 10-microsecond time delay also insures that the carrier gate is triggered by the leading edge of the delayed carrier gate with no influence from received signals.

a. Trigger generator V1353A is a shock-excited oscillator which is gated by the output from the V1353B half of the carrier gate multivibrator (waveform W). The trigger generator produces a critically damped sine wave

(waveform X) which has a period of 20 microseconds. The first positive swing in voltage causes an output from trigger amplifier V1352. Because a bias network in its cathode circuit then holds the stage sufficiently beyond cutoff (waveform Y), the second and subsequent positive alternations do not raise the tube above cutoff.

b. The leading edge of the first positive alternation from the trigger generator causes a negative pulse to be developed in the output circuit (waveform Z). The output negative triggers appear 10 microseconds after the start of the negative gate input to V1353A because the first negative (10-microsecond duration) alternation does not affect the operation of trigger amplifier V1352. The output negative triggers are applied to the transmitting system as transmitter triggers in the mti mode of operation. In the normal (external trigger) mode of operation of the equipment, the output negative triggers also determine the time that the transmitter fires. This is automatically the case when the OPERATION selector switch on the indicator unit is changed from MTI to NORMAL, unless an additional switch is thrown so that the transmitter is triggered internally.

Figure 40. Signal comparing system, block diagram.
(Contained in separate envelope)

Section II. 9-MC CARRIER CHANNEL CIRCUITS

82. General
(fig. 219)

The 9-mc carrier channel circuits produce gated 9-mc oscillation which are used to carry video information through the delay and nondelay channels and at the same time establish the pulse repetition frequency of the equipment. The 9-mc signal provides a carrier which is modulated by the input video pulses from the phase detector so that the video information can be carried down mercury delay line W2350 in the delay channel. The oscillations are gated or interrupted so that the start of the oscillations (which is also delayed in the delay channel) can be used to initiate timing pulses which make the pulse repetition time of the equipment depend on the amount of delay in the signal comparing system.

a. The carrier gate channel includes carrier gate multivibrator, V1353B and V1354, 9-mc carrier oscillator V1355, 9-mc amplifier V1356, and 9-mc output amplifier V1357. All 9-mc carrier channel stages are located in the mti repetition rate trigger amplifier.

b. Bipolar video pulses are applied to the injector grid (pin 7) of 9-mc carrier oscillator V1355 from the junction of resistors R325 and R327 in the phase detector circuit of the receiving system. These video pulses amplitude modulate the 9-mc oscillations produced by V1355. The modulated 9-mc carrier is amplified by 9-mc amplifier V1356 and 9-mc output amplifier V1357 before being applied to the delay channel (the voltage across R1385 and R1380), to the nondelay channel (the attenuated voltage across R13580), and to test meter M2350 after being attenuated by R1381 and R1382, rectified by CR1350, and filtered by C1385 and R1383.

c. Negative trigger pulses are applied to the grid of the V1354 half of the carrier gate multivibrator from the plate circuit of V1351 in the time balancing circuits. These pulses synchronize the free-running carrier gate multivibrator so that the period of the multivibrator (which has a longer natural period) is forced to be equal to the time delays in the delay channel (approximately 2,500 plus 1.9 microseconds). Two outputs are taken from the carrier gate multivibrator. The V1354 half gates the 9-mc oscillator. The V1353B half gates trigger generator V1353A which is a shock-excited oscillator that produces transmitter triggers.

83. Carrier Gate Multivibrator
(figs. 41 and 42)

The carrier gate multivibrator is a synchronized plate-coupled, free-running multivibrator which is used to gate 9-mc carrier oscillator V1355 and the trigger generator circuits. The cathode, control grid, and screen grid of V1354 operate as one triode section of the multivibrator; the cathode (pin 3), control grid (pin 2), and plate (pin 1) of dual triode V1353 operate as the other triode section of the multivibrator. Both control grids of the multivi-

brator are returned to +150 volts to increase the accuracy of the circuit timing.

a. With no synchronizing pulses applied from pick-off amplifier V1351, the multivibrator oscillates at a frequency determined by the time constants of the coupling circuits between the two sections and the size of the plate load resistors (waveform A). A change in voltage at the plate of V1353B is coupled to the control grid of V1354 by the discharge of C1365 through R1364 in series with part of potentiometer R1365. A change in voltage at the screen grid of V1354 is coupled to the control grid of V1353B by the discharge of C1366 through grid resistor R1362. The grid time constants are equal, for all practical purposes, but the natural period of the multivibrator is asymmetrical because of the difference in the size of the plate load resistors. Resistor R1361 (33K) is considerably larger than R1363 (4,700 ohms). When the V1353B section fires (T_1 in waveform A) a greater change in voltage occurs at the plate of V1353B than at the screen grid of V1354 when the V1354 section fires (T_2 in waveform A). As a result, when the V1353B section fires, the V1354 section is held beyond cutoff by the discharge of C1365 for a longer period of time than the V1354B section is held cutoff by the discharge of C1366 when the V1354 section fires. The operation of the multivibrator is asymmetrical, with the time between T_2 and T_4 fixed by the circuit values, and the time between T_1 and T_2 varied by the setting of carrier gate length potentiometer R1365.

b. When the control grid of V1354 is driven beyond cutoff, plate current through V1354, as well as the screen current, cuts off. The 9-mc carrier gate oscillator (V1355) begins to oscillate when the V1354 section of the carrier gate multivibrator cuts off (time T_1 in waveform A). The start of the 9-mc oscillations (time T_1) is delayed around the trigger loop (through the 9-mc amplifiers, mercury delay line, delay amplifiers, delay amplifier detector, and time balancing circuit) so that a negative trigger pulse (time T_3) is developed by pick-off amplifier V1351. While the 9-mc oscillations are being delayed in the trigger loop, the V1354 section of the carrier gate multivibrator goes back into conduction at time T_2. At time T_3, the negative trigger pulse (waveform B) from

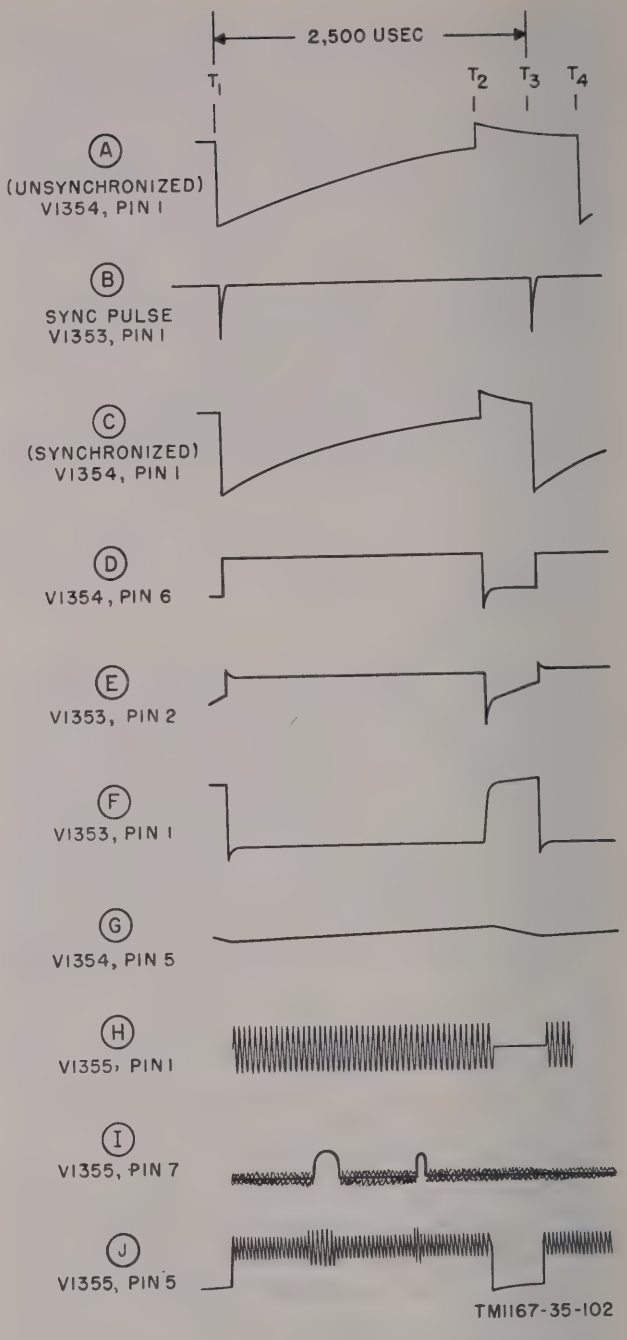


Figure 41. 9-mc carrier channel, waveforms.

V1351 is applied to the grid of V1354 and causes the V1354 section to go back into cutoff before the discharge of C1366 (which normally times the phase of the multivibrator action between T_2 and T_4) allows the V1353B section to go back into conduction. When the V1353B section goes back into conduction, the V1354 section cuts off. The synchronizing pulse

which occurs at T_3 forces the natural period of the multivibrator to be reduced to a time equal to the amount of time delay in the trigger loop (waveforms C, D, E, and F). When V1354 goes back into cutoff at time T_3 (which is equivalent to T_1 again), the circuit operation is repeated. In this manner, the carrier gate multivibrator synchronizes itself by means of the trigger loop.

c. Carrier gate length potentiometer R1365 is a very important chassis adjustment and must be adjusted properly to obtain mti. If R1365 is misadjusted so that the time between T_1 and T_2 (waveform A) is longer than 2,500 microseconds, the delayed negative sync pulses have no effect on V1354 because it is still beyond cutoff when the negative pulses arrive. In this case, the carrier gate multivibrator continues to oscillate at its natural frequency and the pulse repetition time of the equipment is not stable enough for effective mti operation. The negative sync pulses are also ineffective if R1365 is misadjusted so that the time between T_1 and T_4 is less than 2,500 microseconds. With proper adjustment of R1365, the time between T_1 and T_2 is approximately 2,150 microseconds. This insures that the natural period of the multivibrator is longer than the delay in the trigger loop and that the delayed trigger pulses synchronize the multivibrator because they are applied to the control grid of V1354 while V1354 is conducting.

d. Filter network R1367 and C1386 isolates the 9-mc oscillations that appear in the plate circuit of V1354 from other circuits supplied by +150 volts and at the same time does not drop the +150-volt supply potential to the multivibrator appreciably. Resistor R1366 and capacitor C1367B decouple the multivibrator from the +150-volt supply. Inductor L1355 and capacitor C1370 are functionally part of 9-mc carrier oscillator V1355.

e. Two outputs are taken from the carrier gate multivibrator. The V1354 section gates 9-mc carrier oscillator V1355 because the 9-mc oscillator can oscillate only when the V1354 is cutoff. The V1353B section (waveform D) gates trigger generator V1353A in the trigger generator circuits to initiate the timing of the transmitter trigger pulses.

84. 9-mc Carrier Oscillator
(figs. 42 and 43)

The 9-mc carrier oscillator (V1355) is gated by the carrier gate multivibrator. It produces gated 9-mc oscillations which are modulated by the input video to the signal comparing system. The modulated 9-mc carrier is then amplified and applied to the delay and nondelay channels

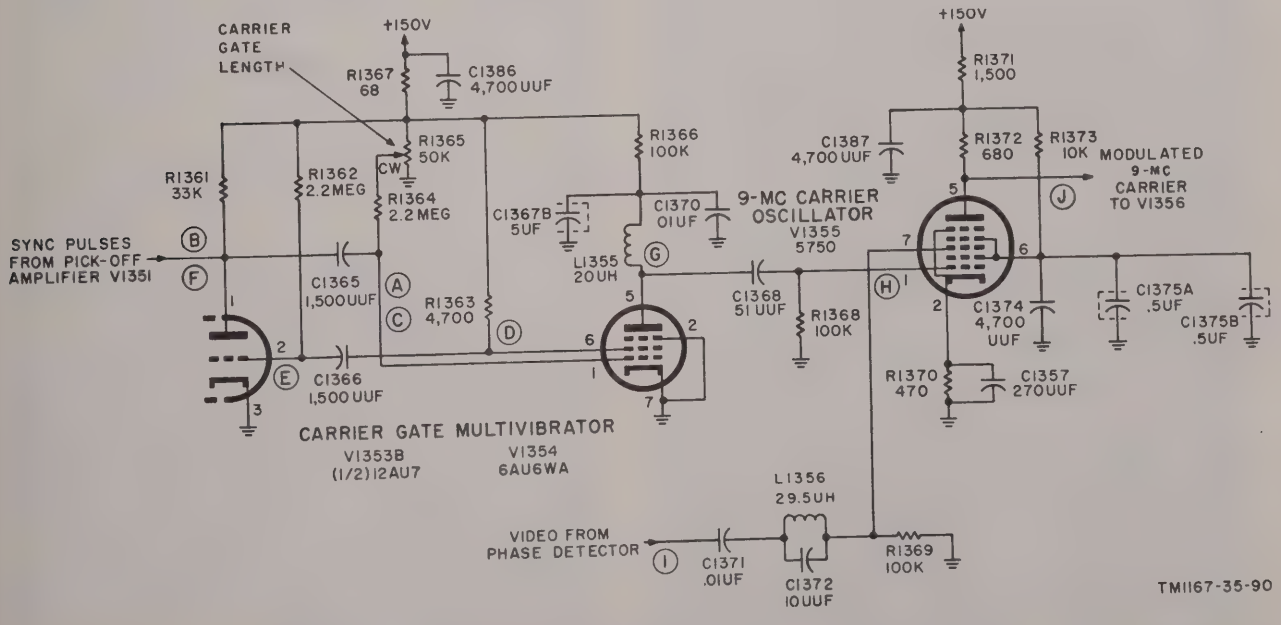


Figure 42. Carrier gate oscillators, simplified schematic diagram.

to make cancellation of the returns from fixed targets possible.

a. A pentagrid converter type tube (5750) is used in the gated 9-mc carrier oscillator circuit. The cathode, control grid (pin 1), and screen grid (pin 6) are used in a grounded-plate Colpitts oscillator circuit, and the modulating signal is applied to the injector grid (pin 7). The 9-mc oscillations are gated by placing the tank circuit inductance of the oscillator (L1355) in the plate circuit of the V1354 section of the carrier gate multivibrator.

b. Bypass capacitor C1370 (.01 microfarad (μf)) is physically close to one end of L1355 and holds this end of L1355 very close to ac ground (the capacitive reactance of C1370 being only 5 ohms at 9 mc). Decoupling capacitor C1367B (.5 μf) is considerably larger than C1370 and is in parallel with C1370. The larger capacitor cannot hold the end of L1355 to which they are both connected close enough to ac ground, because it is physically located far enough from L1355 to make the ac resistance of its connection to L1355 relatively high at 9 mc.

c. The 9-mc oscillations are gated by grounding and ungrounding the plate of the V1354 end of L1355. When the V1354 section of the carrier gate multivibrator conducts, the low dc resistance of the heavily conducting tube effectively grounds the end of L1355 that connects to the plate of V1354. The 9-mc oscillator cannot function with both ends of L1355 close to ground potential at 9 mc. When the V1354 section of the carrier gate multivibrator is beyond cutoff, the end of L1355 which is near the plate of V1355 is no longer grounded and the 9-mc oscillations take place. The timing waveforms of the carrier gate multivibrator and the 9-mc oscillator are shown in figure 41.

d. The 9-mc oscillator section of V1355 is a Colpitts-type oscillator. This is evident when the circuit is drawn to show the split capacitances characteristic of the Colpitts oscillator (fig. 43). The screen grid of V1355 acts as the plate of the oscillator. Resistor R1373 drops the average plate voltage to +90 volts and bypass capacitor C1374 places the plate at ac ground because its capacitive reactance is only 4 ohms at 9 mc. Capacitance C_o represents the plate-to-cathode capacitance of V1354 and the stray wiring reactances. Capacitance C_I represents the grid-to-cathode capacitance of V1355. Parallel RC network R1370 and C1357 provides sufficient cathode bias to operate the tube in its linear region. The tank circuit, which determines the frequency of oscillation, consists of L1355 in parallel with C_o, with both of these components in parallel with C1368, C_I and C1357.

e. When the V1354 section of the carrier gate multivibrator cuts off, the top of the tank circuit is ungrounded and the tank circuit begins to oscillate at 9 mc. To sustain oscillations, feedback into the tank circuit is necessary to make up for losses in the tank circuit. Feedback is provided by the current through the triode tube section which flows through C1357. The voltage across C_I controls the amount of feed-back current, and the reactance of C1357 controls the phase of the feedback current. The resulting feed-back current into the tank circuit causes the 9-mc oscillations to be sustained as long as the V1354 section of the carrier gate multivibrator remains cutoff.

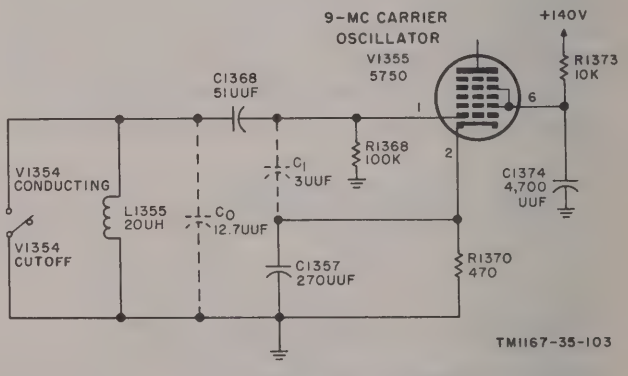


Figure 43. 9-mc carrier oscillator, equivalent circuit.

f. Decoupling network R1371 and C1387 isolates the 9-mc signal from the +150-volt power supply. In addition to C1374, which is physically close to the screen grid and places the screen grid at ac ground potential (for proper 9-mc oscillator operation), C1375A and C1375B are connected from the screen grid of V1355 to ground. The large capacitors (.5 μf) are bathtub-type capacitors and cannot be placed close enough to V1355 to keep their lead reactance sufficiently low at 9 mc. The large capacitors function as a conventional 1-μf screen bypass

capacitor, which prevents the dc voltage at the screen grid from changing appreciably when video pulses are applied to the injector grid.

g. The input video pulses from the phase detector are applied through coupling capacitor C1371 and a parallel resonant circuit (L1356 and C1372) and are developed across injector grid resistor R1369. The parallel resonant circuit is tuned to 9 mc and does not affect the video pulses appreciably. Its high impedance to 9 mc prevents 9-mc signals from the oscillator section of V1355 from feeding back to the phase detector. The video pulses developed at the injector grid amplitude modulate the 9-mc oscillations (30 percent) so that the amplitude of the 9-mc oscillations appearing in the plate circuit is increased during the application of positive video pulses and decreased during the application of negative video pulses. The amplitude of the output-modulated 9-mc oscillations is very small (approximately .5 volt) because of the small value of plate load resistor R1372 (680 ohms). This is necessary to maintain the wide bandwidth necessary for the video information. The output-modulated 9-mc oscillations are applied from the plate of 9-mc carrier oscillator V1355 to 9-mc amplifier V1356.

85. 9-mc Amplifiers
(fig. 44)

The 9-mc amplifier (V1356) and 9-mc output amplifier (V1357) together amplify the modulated 9-mc carrier output from the 9-mc carrier oscillator approximately 25 times before the modulated 9-mc carrier is applied to networks which apply the signal to the delay channel, the nondelay channel, and test meter M2350.

a. The 9-mc amplifier (V1356) is a low-gain, wide band tuned-grid amplifier. Fixed bias and cathode bias are used to operate the tube in its linear region. Current through voltage divider R2352 (DELAY LINE INPUT) and R1377 as well as plate current flow through R2352 and cathode resistor R1375 establishes the cathode at a nominal value of +5 volts with respect to ground. Since the grid is grounded from a dc standpoint, bias for the stage is 5 volts. Bypass capacitors C1377 and C1379 prevent the ac signal from affecting the dc bias. The gain of the stage is held low by keeping the value of plate load resistor R1374 low (2,200 ohms) to maintain a wide bandwidth so that video information is not lost.

b. The modulated 9-mc carrier is coupled from the 9-mc carrier oscillator to the grid circuit of V1356 by coupling capacitor C1373. The 9-mc signal is developed at the grid of V1356 across the high impedance of the parallel resonant circuit consisting of L1358 and the grid-to-cathode interelectrode capacitance of the tube. A modulated 9-mc signal in the order of 2.5 volts peak-to-peak is developed in the plate circuit and coupled to 9-mc output amplifier V1357 by C1378.

c. The gain of V1356 is controlled by the setting of R2352. Varying this potentiometer changes the bias of V1356 which in turn changes the gain of the stage. Although its name (DELAY LINE INPUT) does not indicate it, R2352 actually controls the amplitude of all three outputs from the 9-mc carrier channel because the signal is amplified a fixed amount by V1357 before being applied to the delay line in the delay channel, the nondelay channel, and test meter M2350.

d. The 9-mc output amplifier (V1357) is a low-gain, wide band tuned-grid power amplifier. A power amplifier is necessary because the output from V1357 is applied to several low impedance circuits.

e. Cathode bias (5 volts) is developed across cathode resistor R1378 and maintained by cathode bypass capacitor C1383. The modulated 9-mc input signal to V1357 is developed across L1360 which forms a parallel resonant circuit with the input capacitance of the tube. The output signal is developed across plate load L1362. The gain of the stage is decreased to approximately 5 by the loading of R1379 (3,300 ohms) and the low impedance circuits to which the output-modulated 9-mc signal is applied. The stage gain is made low to maintain the necessary wide bandwidth. Filter network C1382, R1376, and C1386 isolates the 9-mc signal frequency from the +150-volt supply to prevent interaction with other stages operating at 9 mc because of the common plate supply potential.

f. The output from V1357 is coupled to the output circuits by coupling capacitor C1381. Inductances L1363 and L1365 lower the impedance of the signal circuit to feed signal voltages to the 2,500-microsecond mercury delay line through a 90-ohm coaxial cable (RG–62/U). In addition to being applied to

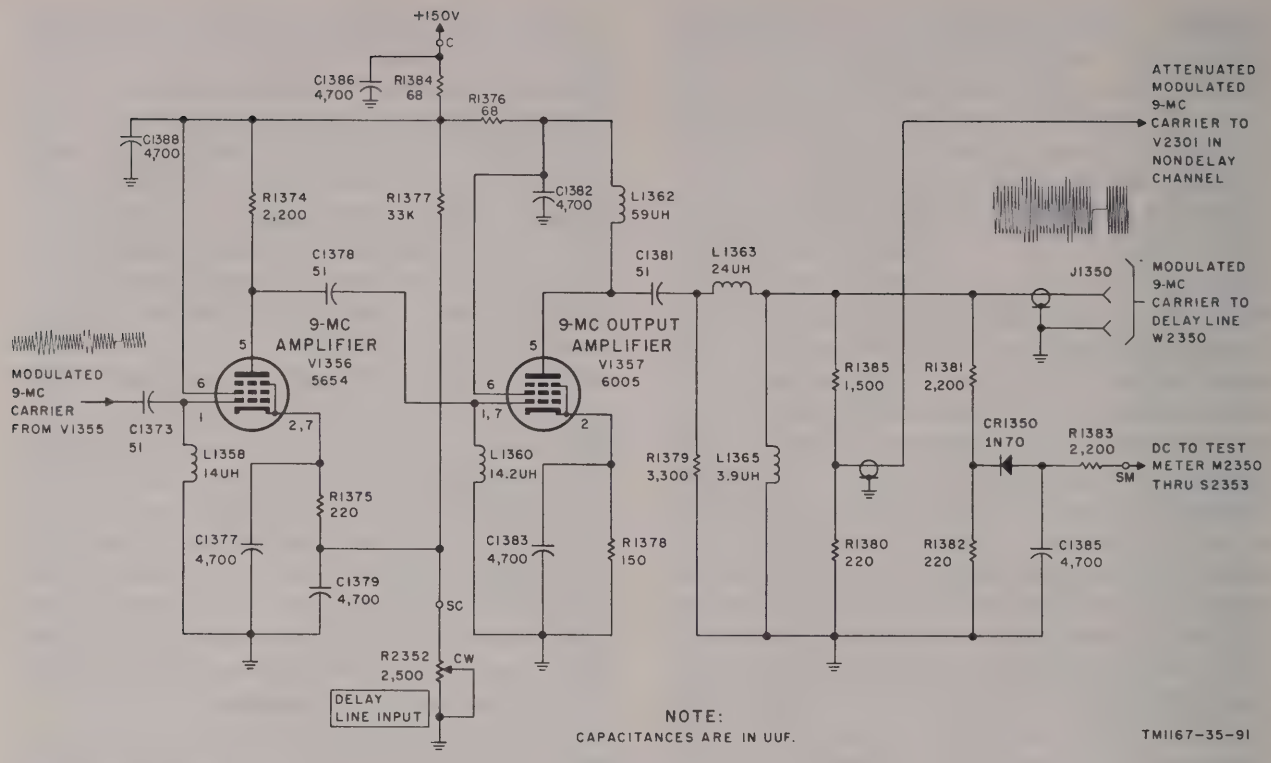


Figure 44. 9-mc amplifiers, simplified schematic diagram.

the mercury delay line in the delay channel, the voltage across L1365 is applied to the nondelay channel and to test meter M2350 to provide an indication of the level of the modulated 9-mc carrier signal input to the delay line.

g. The voltage divider, R1385 and R1380, further decreases the impedance of the signal circuit to feed signal voltages to the nondelay channel through a 73-ohm coaxial cable (RG–59/U). In addition to impedance matching considerations, R1385 and R1380 are part of an attenuation network which includes the 68-ohm resistor (R2301) which terminates the coaxial cable carrying the attenuated 9-mc carrier signal to the nondelay channel. The total voltage attenuation is such that the signal at the junction of R1385 and R1380 is approximately 29.5 db below the signal voltage across L1365. The signal input to the nondelay channel is further attenuated in the nondelay channel to compensate for the attenuation of the mercury delay line and make the signal inputs to the delay and nondelay amplifiers more nearly equal.

h. Voltage divider R1381 and R1382 decreases the level of the 9-mc signal so that a red-line indication is obtained on test meter M2350 when the input to the mercury delay line is correct. Crystal diode CR1350 functions as a half-wave rectifier and filter network C1385 and R1383 filters the 9-mc signal so that a negative dc voltage proportional to the peak amplitude of the 9-mc signal is applied to the meter.

Section III. DELAY CHANNEL CIRCUITS

86. General
(fig. 219)

The delay channel delays the information returned from one transmitted pulse for a time equal to the time between transmitted pulses so that the returns from one transmitted pulse can be used to cancel the fixed target returns from the following transmitted pulse.

a. The delay channel consists of 2,500-microsecond delay line W2350, delay amplifier Z1300, resistor R2357, and 1.9-microsecond delay line W2351.

b. There are two signal inputs to the delay channel: The modulated 9-mc carrier signal from the output circuit of V1357 in the 9-mc carrier channel; and the amplitude balancing bias from C3301B in the amplitude balancing circuits.

c. Three outputs are taken from the delay channel. The modulated 9-mc carrier signal is delayed and attenuated by 2,500-microsecond delay line W2350, amplified by five delay amplifier stages, demodulated by the delay amplifier detector, delayed an additional 1.9 microseconds by W2351, and applied to the comparison point components as a negative envelope of the carrier and video information. An output is taken from the delay amplifier detector and applied to V1350 in the time balancing circuits. This output is part of the trigger loop signal which times the transmitted pulses in the mti mode of operation. The third output from the delay channel is also taken from the delay amplifier detector. It is applied to TEST METER M2350 through TEST SELECTOR switch S2353 to provide an indication of the output amplitude level from the delay amplifier for adjustment of mti operation.

d. Plus 150 volts dc is applied to the delay channel from the power supply system through power line filter Z2351. Filament voltage (6.3 volts ac) is applied from filament transformer T2350. The filament circuit of each stage of the nondelay amplifier is isolated from other stages (from a 9-mc standpoint) by LC filter networks to prevent 9-mc feedback between stages due to the interelectrode capacitance between cathode and filament. Capacitors C1304, C1308, C1317, C1321, C1323, C1325, and C1330 offer a low impedance to a 9-mc signal. Rf chokes L1304, L1306, L1308, L1810, and L1316 present a considerably higher impedance to 9 mc than the bypass capacitors.

87. 2,500-Microsecond Delay Line
(figs. 45 and 46)

The 2,500-microsecond mercury delay line is the heart of the pulse-to-pulse comparison method of mti. The delay line provides the necessary time delay between transmitted pulses and is also used as the principal timing device to produce pulses to trigger the transmitting system. Because the signal comparing system generates pulses to trigger the transmitter, the length of the delay line is not critical. However, to achieve maximum cancellation of the returns from fixed targets and maximum subclutter visibility, the distortion of the signal traveling down the delay line must be held to a minimum.

a. The long delay (2,500 microseconds) and wide bandwidth (3 mc) of the delay line are obtained by using two piezoelectric quartz crystals as transducers and the relatively slow velocity of transmission of mechanical vibrations through a liquid. A quartz crystal is a high Q device with a narrow bandwidth and cannot be used to transmit microsecond pulses efficiently. The delay line, therefore, is operated at 9 mc. The crystals are 13-mc, fundamental X-cut crystals operating in thickness vibration. The 13-mc crystals produce maximum transfer of energy for the 9-mc signal frequency, and the resultant attenuation of the delay line is approximately 60 db.

b. Direct mercury-to-crystal contact is used both at the input and output of the delay line; the mercury is the ground side of the electrical input and output circuits. Mercury rather than some other liquid is used because the mercury loads the crystals and reduces the Q to maintain a wide bandwidth. Insulated plates on the opposite sides of the crystals are used as electrical connections at the input and output of the delay line.

c. When the 9-mc input alternating voltage is applied across the input transmitting quartz crystal, the thickness of the crystal changes at a 9-mc rate because of the peizoelectric effect. The mechanical vibrations of the crystal cause ultrasonic waves to travel through the mercury. At the other end of the delay line, the mechanical waves cause the receiving quartz crystal to vibrate at a 9-mc rate, and a 9-mc voltage is developed across the faces of the crystal. In this manner, the modulated 9-mc signals from the 9-mc carrier channel are delayed by a length of time depending on the velocity of the mechanical vibrations and the length of the delay line.

d. The delay line assembly is hermetically sealed and has an expansion chamber in one side of the tank to compensate for temperature variations. Heater HR2350, which is mounted inside the assembly, closes at −30°C., to prevent the temperature of the mercury from falling to the freezing point (−39°C.). No attempt is

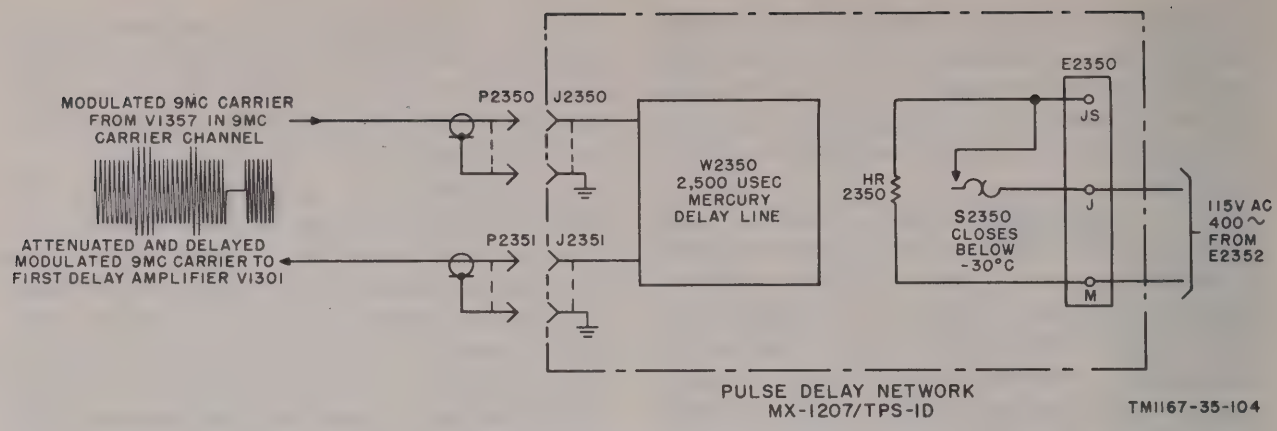


Figure 45. Pulse delay network, simplified schematic diagram.

made to hold the mercury at a specific temperature because the operation of the equipment does not require an exact time delay. Within the assembly, the delay line is mounted on specially designed shock mounts to prevent damage to the delay line during transport.

e. The mechanical vibrations travel through mercury at the speed of sound which is 4,700 feet per second at 20°C. Since this corresponds to a delay of 17.6 microseconds per inch, it would take a column of mercury approximately 142 inches (almost 12 feet) to obtain a 2,500-microsecond delay for a pulse repetition frequency of 400 cps. For physical compactness the line is, in effect, folded into 16 direct paths. This is accomplished by reflecting the mechanical vibrations back and forth progressively along the opposite sides of the mercury container. This results in a compact tank measuring 3 by 9.5 by 11.25 inches.

f. The reflectors consist of circular surfaces $\frac{5}{8}$ inch in diameter, arranged on two opposing sides of the tank. They are formed in the sidewalls of the tank by cutting $\frac{1}{8}$-inch grooves around these circular surfaces. To obtain maximum reflection capabilities (nearly 100 percent), the reflecting surfaces are made rough by sandblasting. A smooth reflecting surface has a tendency to absorb the mechanical vibrations because of the good contact it makes with the mercury. Almost total reflection is obtained because of the presence of a trapped air pocket in the sandblasted face of the reflector and the mercury. Since air is a nearly perfect acoustic mismatch to mercury and has very high attenuation at 9 mc, it gives practically total reflection from the mercury-air interface. This action is very similar to radio transmission line termination.

g. The output from the mercury delay line is applied to the delay amplifier.

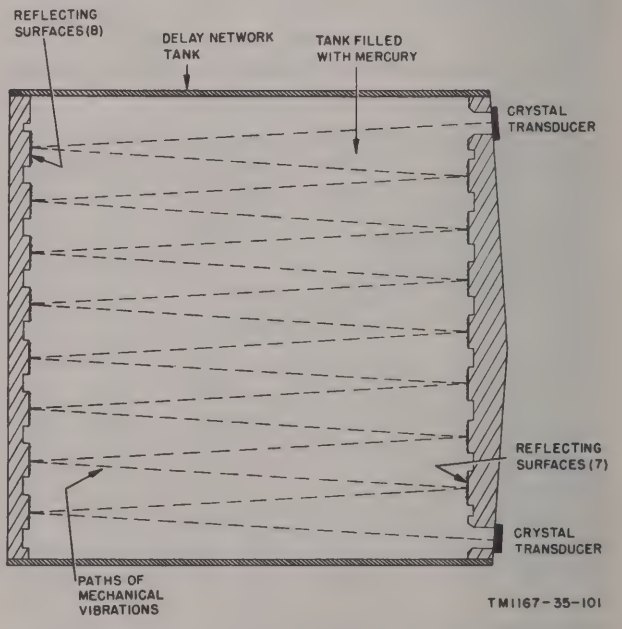


Figure 46. 2,500 mercury delay line, equivalent circuit.

88. Delay Amplifiers V1301 through V1304 (fig. 47)

An attenuated modulated 9-mc carrier signal is applied to the delay amplifiers from the 2,500-microsecond mercury delay line. The delay amplifiers increase the amplitude of the modulated 9-mc carrier signal so that the video information can be detected efficiently. The

gain of the first four delay amplifiers is controlled automatically by a bias voltage from the amplitude balancing circuits so that the amplitude of the output from the delay channel is equal to the amplitude of the output from the nondelay channel.

a. Inductor L1301 and resistor R1302 match the low impedance of the coaxial cable which connects to J1301 and carries the modulated 9-mc carrier signal from the mercury delay line. Inductor L1302 forms a series resonant circuit with the input capacitance of V1301. The Q of the tank circuit is kept low by the low resistance of R1302 (1K) and grid resistor R1301 (10K) to maintain a wide bandwidth. This input arrangement provides for impedance matching without appreciable loss of the video information which is carried by the 9-mc carrier frequency.

b. First delay amplifier V1301 is a sharp cutoff high transconductance type tube (5654). The stage operates as a single-tuned, low gain, wide band 9-mc amplifier. The resistance of plate load resistor R1304 is low (1,500 ohms) to maintain the necessary wide bandwidth. From an ac standpoint, R1304 is in parallel with inductor L1301 which forms a parallel resonant circuit with the interstage shunt capacitances (the output capacitance of V1301, the stray wiring capacitance, and the input capacitance of V1302). The flow of normal plate and screen currents through cathode resistor R1305 develops approximately 1 volt of cathode bias. Cathode bypass capacitor C1302 prevents the input signal from affecting the cathode bias during circuit operation. The operating point of the tube is also affected by the automatic amplitude balancing bias which is applied to the control grid from the amplitude balancing circuits. The gain of the stage is changed by changing the operating point which in turn varies the transconductance of the tube.

c. The second, third, and fourth delay amplifiers are identical except that the plate load resistor of the fourth delay amplifier (R1316) is lower (1K) because the fourth delay amplifier output circuit is coupled to a different type tube (6005). All of the amplifiers are synchronous tuned to a center frequency of 9 mc. Four voltage amplifiers are necessary because of the low gain of each stage.

d. Several precautions are taken to prevent feedback between stages to maintain the proper overall gain and bandwidth. Resistors R1303, R1307, R1311, and R1315, in conjunction with

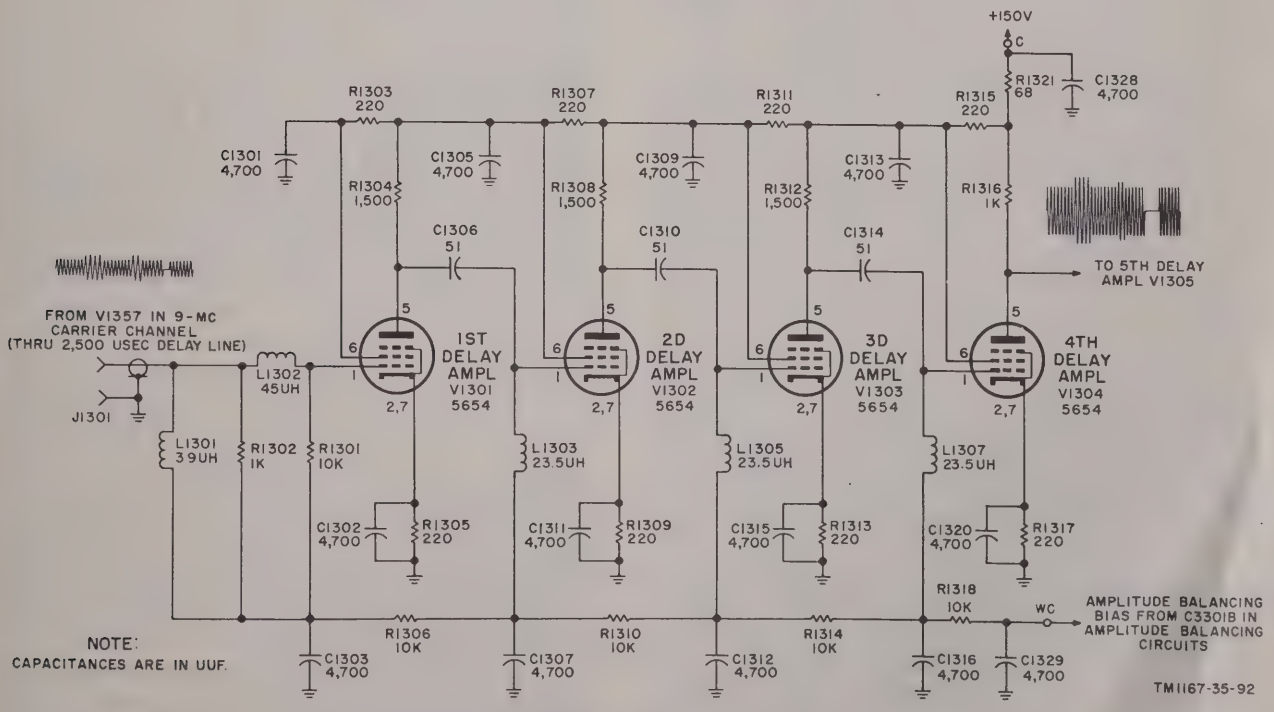


Figure 47. Delay amplifiers, simplified schematic diagrams.

capacitors C1301, C1305, C1309, and C1313, prevent interaction due to the common +150-volt plate and screen supply potential. The capacitors also function as screen bypass capacitors. Resistors R1306, R1310, R1314, and R1318, in conjunction with capacitors C1303, C1307, C1312, C1316, and C1329, prevent interaction between stages due to the common amplitude balancing bias potential which is applied to all four control grids. Filter network C1328 and R1321 prevents signals from other circuits operating at 9 mc from entering the delay amplifier from the +150-volt supply.

e. The amplified 9-mc carrier signal from V1354 is applied to fifth delay amplifier V1305.

89. Fifth Delay Amplifier and Delay Amplifier Detector
(fig. 48)

Fifth delay amplifier V1305 is a beam power type tube (6005) which is used as a 9-mc power amplifier. The power amplifier is necessary to drive the low impedance delay amplifier detector and the load on the detector. Delay amplifier detector V1306 is a dual diode type tube (5726) which is used as a full-wave negative detector. The modulated 9-mc carrier signal is demodulated (rectified and filtered) by the delay amplifier detector so that the output from the circuit is the negative envelope of the modulated 9-mc carrier signal.

a. Fifth delay amplifier V1305 is a single-tuned, low gain, wide band 9-mc power amplifier. The normal flow of plate and screen currents develop approximately 4.5 volts of cathode bias across cathode resistor R1320 to operate the tube in its linear region. Cathode bypass capacitor C1322 offers a very low impedance to the 9-mc signal and prevents it from changing the operating point of the tube. The modulated 9-mc carrier signal from V1304 is coupled to the grid circuit by C1319. Inductor L1309 is tuned to 9 mc with the output capacitance of the fourth delay amplifier, the stray interstage wiring capacitances, and the input capacitance of V1305. Because a 6005 type tube has a higher input capacitance than a 5654 type tube, L1309 is considerably smaller than the grid inductors of the second, third, and fourth delay amplifiers. The amplified 9-mc signal is developed across plate load resistor R1319 (3,300 ohms) in parallel with the primary of interstage coupling transformer T1301. Filter network R1321 and C1328 prevents 9-mc signals from other circuits supplied by +150 volts from appearing in the plate circuit of V1305.

b. Transformer T1301 couples the amplified 9-mc carrier signal to the input of delay amplifier detector V1306. The secondary of T1301 is tuned to 9 mc by C1324. The Q of the tuned circuit is decreased by shunt resistor R1322 to maintain the necessary wide bandwidth. The 9-mc oscillations in the tank circuit cause the diode sections to conduct alternately so that the signal appearing at the plates of the diodes is a pulsating dc voltage with a ripple frequency twice the applied frequency. The full-wave detector makes it easier for pi filter C1326, L1312, and C1327 to smooth out the ripple frequency and at the same time not filter out the video pulses which modulate the 9-mc carrier signal. The output of the filter is a negative envelope of the modulated 9-mc carrier signal. The negative pedestal portion of the output envelope (the dc component) is directly proportional to the peak amplitude of the 9-mc input to the detector.

c. The negative output level from the pi filter (dc component or pedestal) is compared with the positive output level from a similar filter in the nondelay channel so that the difference between the two dc levels is developed at the comparison point in the video circuits. If the two levels are equal, they cancel along with the returns from fixed targets, and only the differences in amplitudes of the moving-target video pulses riding on the envelopes are passed on to the succeeding video circuits. If the positive pedestal from the nondelay channel is not equal to the negative pedestal from the delay channel, the difference of the dc levels is applied to the amplitude balancing circuits. The amplitude balancing circuits cause a change in the amplitude balancing bias which is applied to the first four delay amplifiers. The change in bias changes the gain of the delay amplifiers so that the negative pedestal from the delay amplifier detector is made very nearly equal in amplitude to the positive pedestal from the nondelay channel.

d. The negative envelope output from the delay amplifier detector is applied to three circuits. An output is applied through current

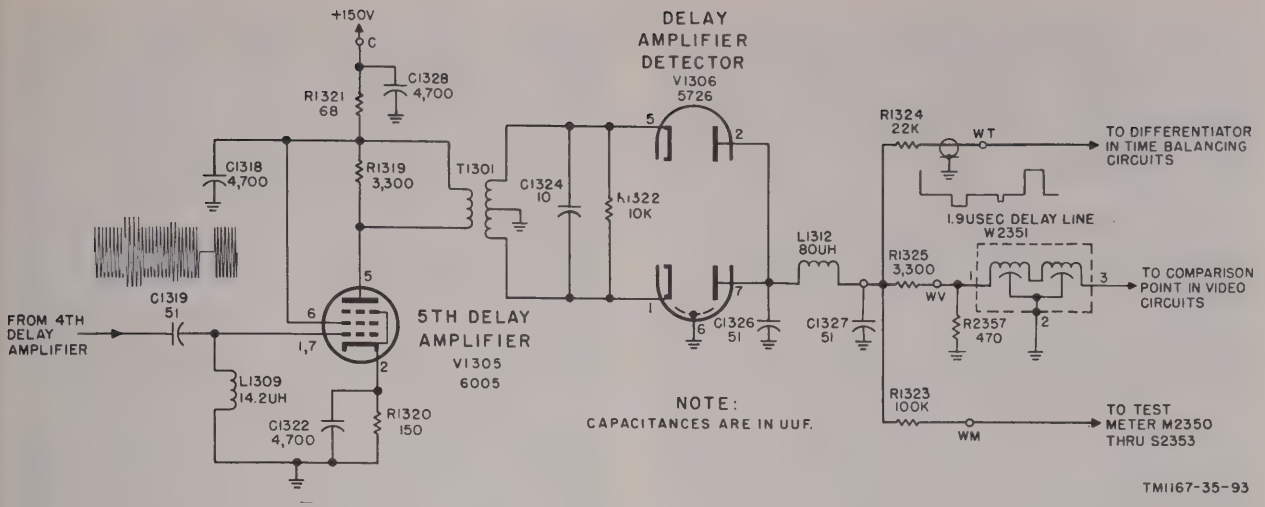


Figure 48. Fifth delay amplifier and delay amplifier detector, simplified schematic diagram.

limiting resistor R1323 and test selector switch S2353 to test meter M2350 as a dc voltage to indicate the output level from the delay amplifier. The negative output envelope is also part of the trigger loop signal. It is applied through isolating resistor R1324 and the time balancing circuits to the 9-mc carrier gate channel to synchronize the carrier gate multivibrator. A third output from the delay amplifier detector is applied through isolating resistor R1325 and 1.9-microsecond delay line W2351 to the comparison point in the video circuits.

e. The negative envelope is applied through W2351 because it is impossible for the positive envelope from the nondelay amplifier detector to appear at the comparison point at the same time that the negative envelope appears at the output of the delay amplifier detector, because the trigger loop times the start of the following transmitted pulse and there are inherent time delays in the trigger loop. Time balance between the positive and negative envelopes that are applied to the comparison point is accomplished by delaying the negative envelope for 1.9 microseconds before it is applied to the comparison point, and then adjusting the amount of time delay in the time balancing circuits so that the sum of all the time delays affecting the positive envelope output from the nondelay channel is equal to 1.9 microseconds.

f. The frequency-versus-impedance characteristic of W2351 is nonlinear. Attenuator R1325 (3,300 ohms) and R2357 (470 ohms) prevents irregular loading of the delay amplifier detector. The attenuator isolates the detector from its load so that the load has less effect on the operation of the detector.

Section IV. NONDELAY CHANNEL CIRCUITS

90. General
(fig. 219)

In the mti pulse-to-pulse comparison system, the returns from one transmitted pulse are delayed and compared with the returns from the following transmitted pulse. A positive output envelope from the nondelay channel is compared with the negative output envelope from the delay channel (which carries the delayed returns from the previous transmitted pulse) in order to cancel the returns from fixed targets and provide mti. To provide maximum cancellation of the returns from fixed targets, the positive output envelope from the nondelay channel must be equal in amplitude, opposite in polarity, and coincident in time with the negative envelope from the delay channel. The nondelay channel is similar to the delay channel except that the nondelay channel input circuits attenuate the input 9-mc carrier signal (to balance the attenuation of the modulated 9-mc carrier signal as it travels

down the mercury delay line in the delay channel), its gain is controlled manually (rather than automatically by an amplitude balancing bias), its detector is a positive detector (rather than a negative detector), and it contains no delay lines.

a. The nondelay channel consists of the nondelay amplifier, resistors R2364 and R3301, and NONDELAY AMPL. OUT potentiometer R2353.

b. The only input to the nondelay channel is the modulated 9-mc carrier signal from the output circuit of V1357 in the 9-mc carrier signal channel. The nondelay amplifier attenuates, amplifies, and demodulates the modulated 9-mc carrier signal.

c. Two outputs are taken from the nondelay amplifier detector in the nondelay channel. An output is applied to TEST METER M2350 through TEST SELECTOR switch S2353 to provide an indication of the output amplitude level from the nondelay amplifier for adjustment of mti operation. The other output from the nondelay amplifier detector is applied to the comparison point in the input circuit of V3303 in the video circuits.

d. Plus 150 volts dc is applied to the nondelay channel from the power supply system through power line filter Z2351. Filament voltage for all stages (6.3 volts ac) is applied from filament transformer T2350. The filament circuit of each stage of the nondelay amplifier is isolated from the rest of the stages (from a 9-mc standpoint) by LC filter networks to prevent the 9-mc signals from feeding from one stage to another caused by the interelectrode capacitance between cathode and filament. Capacitors C2306, C2311, C2316, C2321, C2324, C2326, and C2331 offer a low impedance to a 9-mc signal. RF chokes L2302, L2304, L2306, L2308, and L2309 offer a considerably higher impedance than the bypass capacitors.

91. Nondelay Amplifiers V2301 Through V2304

(fig. 49)

A modulated 9-mc carrier signal is applied to the nondelay amplifiers from the 9-mc carrier channel. The nondelay amplifiers increase the amplitude of the modulated 9-mc signal so that the video information can be detected efficiently. The gain of the first four nondelay amplifiers is controlled manually by voltage divider R2364 and R2353 (NONDELAY AMPL. OUT) between −150 volts and ground.

a. Resistor R2301 (68 ohms) matches the low impedance of the coaxial cable which connects to J2301 and carries the modulated 9-mc carrier signal from the 9-mc carrier channel. Resistor R2301 is also part of an attenuator network which includes R1380 in parallel with R2301 and both resistors in series with R1385 (fig. 44). Because of the attenuator network, the amplitude of the voltage across R2301 is approximately 29.5 db less than the voltage applied to the attenuator network. The voltage across R2301 is applied to attenuator network R2302 (33K) and R2303 (100 ohms). The amplitude of the voltage across R2303 is approximately 30.5 db less than the voltage across R2301. The total voltage attenuation of approximately 60 db by both attenuators compensates for the approximately 60-db voltage loss in the mercury delay line in the delay channel. In this manner, the amplitudes of the inputs to the nondelay amplifier and the delay amplifier are made approximately equal.

b. The output amplitudes of the nondelay channel and the delay channel are maintained nearly equal by proper adjustment of R2353 which controls the gain of the nondelay amplifier, and the amplitude balancing circuits which automatically control the gain of the delay amplifier.

c. First nondelay amplifier V2301 is a sharp cutoff high transconductance type tube (5654). The stage operates as a single-tuned, low gain wide band 9-mc amplifier. Inductor L2311 forms a series resonant circuit with the input capacitance of V2301. The Q of the tank circuit is kept low by the low resistance of R2303 (100 ohms) and grid resistor R2304 (10K) to maintain a wide bandwidth. Capacitor C2301 isolates the dc bias voltage applied to the control grid from the input circuits. The resistance of plate load resistor R2306 is low (1,500 ohms) in order to maintain the necessary wide bandwidth. From an ac standpoint, R2306 is in parallel with inductor L2301 which forms a parallel resonant circuit with the interstage shunt capacitances (the output capacitance of V2301, the stray wiring capacitance, and the input capacitance of V2302). The flow of normal plate and screen currents through

cathode resistor R2307 develops approximately 1 volt of cathode bias. Cathode bypass capacitor C2304 prevents the input signal from affecting the cathode bias during circuit operation. The operating point of the tube is also affected by the fixed bias which is applied to the control grid from voltage divider R2364 and R2353 (NONDELAY AMPL. OUT) between −150 volts and ground. The gain of the stage is adjusted by changing the operating point which in turn varies the transconductance of the tube.

d. The second, third, and fourth nondelay amplifiers are identical except that the plate load resistor of the fourth delay amplifier (R2318) is lower (1K) because the fourth nondelay amplifier output circuit is coupled to a different type tube (6005). All of the amplifiers are synchronous tuned to a center frequency of 9 mc. Four voltage amplifiers are necessary because of the low gain of each stage.

e. Several precautions are taken to prevent feedback between stages to maintain the proper overall gain and bandwidth. Resistors R2305, R2309, R2313, and R2317, in conjunction with capacitors C2302, C2307, C2312, and C2317, prevent interaction due to the common +150 volts plate and screen supply potential. The capacitors also function as screen bypass capacitors. Resistors R2308, R2312, R2316, and R2320, in conjunction with capacitors C2303, C2308, C2313, C2318, and C2330, prevent interaction between stages due to the common grid bias potential which is applied to all four control grids. Filter network C2329 and R2323 prevents signals from other circuits operating at 9 mc from entering the nondelay amplifier from the +150-volt supply.

f. The amplified modulated 9-mc carrier signal from V2304 is applied to fifth nondelay amplifier V2305.

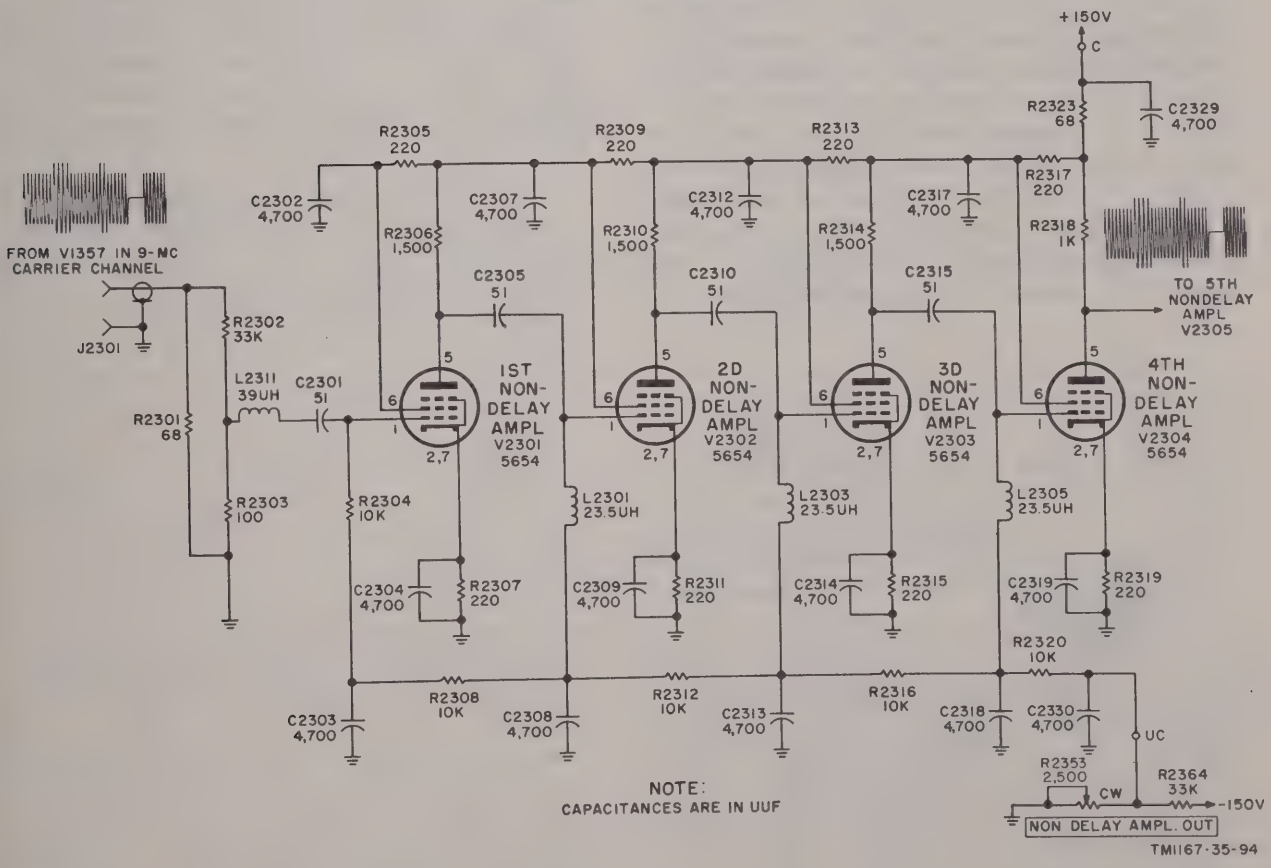


Figure 49. Nondelay amplifiers, simplified schematic diagram.

92. Fifth Nondelay Amplifier and Nondelay Amplifier Detector
(fig. 50)

Fifth nondelay amplifier V2305 is a beam power type tube (6005) which is used as a 9-mc power amplifier. The power amplifier is necessary to drive the low impedance nondelay amplifier detector and the load on the detector. Nondelay amplifier detector V2306 is a dual diode type tube (5726) which is used as a full-wave positive detector. The modulated 9-mc carrier signal is demodulated (rectified and filtered) by the nondelay amplifier detector so that the output from the circuit is the positive envelope of the modulated 9-mc carrier signal.

a. Fifth nondelay amplifier V2305 is a single-tuned, low gain, wide band power amplifier. The normal flow of plate and screen currents develop approximately 4.5 volts of cathode bias across cathode resistor R2322 to operate the tube in its linear region. Cathode bypass capacitor C2323 offers a very low impedance to the 9-mc signal and prevents it from changing the operating point of the tube. The modulated 9-mc carrier signal from V2304 is coupled to the grid circuit by C2320. Inductor L2307 is tuned to 9 mc with the output capacitance of the fourth nondelay amplifier, the stray interstage wiring capacitances, and the input capacitance of V2305. Because of the higher input capacitance of a 6005 type tube as compared with a 5654 type tube, L2307 is considerably smaller than the grid inductors of the second, third, and fourth nondelay amplifiers. The amplified 9-mc signal is developed across plate load resistor R2321 (3,300 ohms) in parallel with the primary of interstage coupling transformer T2301. Filter network R2323 and C2329 prevents 9-mc signals from other circuits supplied by +150 volts from appearing in the plate circuit of V2305.

b. Transformer T2301 couples the amplified 9-mc carrier signal to the input of nondelay amplifier detector V2306. The secondary of T2301 is tuned to 9 mc by C2325. The Q of the tuned circuit is decreased by shunt resistor R2324 to maintain the necessary wide bandwidth. The 9-mc oscillations in the tank circuit cause the diode sections to conduct alternately so that the signal appearing at the plates of the diodes is a pulsating dc voltage with a ripple frequency twice the applied frequency. The full-wave detector makes it easier for pi filter C2327, L2310, and C2328 to smooth out the ripple frequency and at the same time not filter out the video pulses which modulate the 9-mc carrier signal. The output of the filter is a positive envelope of the modulated 9-mc carrier signal. The positive pedestal portion of the output envelope (the dc component) is directly proportional to the amplitude of the 9-mc input to the detector.

c. The filtered positive envelope output from the nondelay amplifier detector is applied to two circuits. An output is applied through current limiting resistor R2325 and test selector

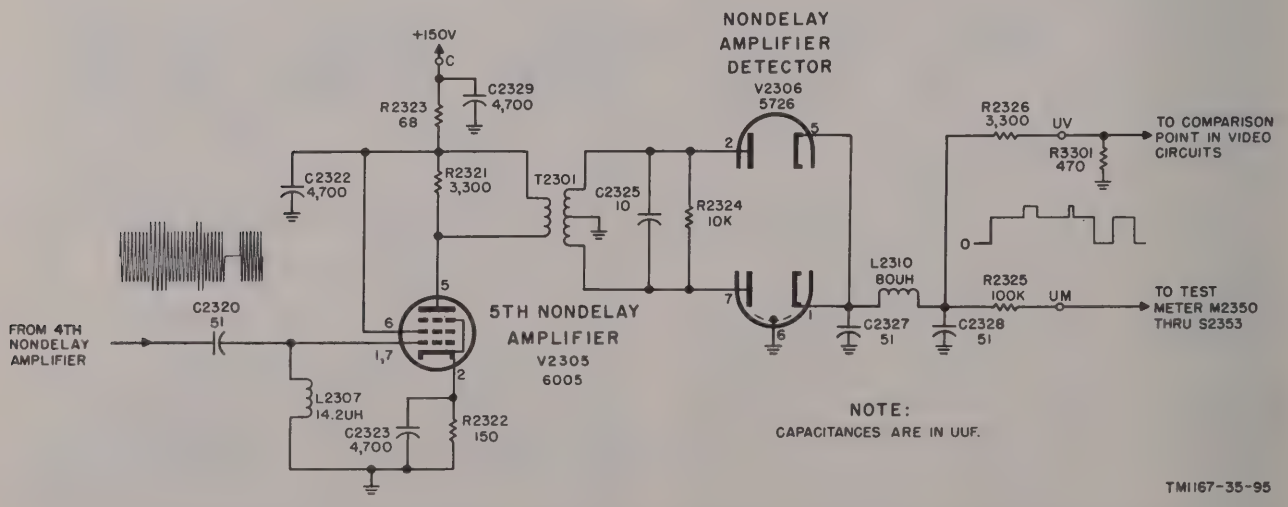


Figure 50. Fifth nondelay amplifier and nondelay amplifier detector, simplified schematic diagram.

switch S2353 to test meter M2350 as a dc voltage to indicate the output level from the nondelay amplifier. Potentiometer R2353 (NONDELAY AMPL. OUT) is adjusted to obtain an output level from the nondelay amplifier detector which produces a red-line indication of M2353. The amplitude balancing circuits then maintain the output level from the delay amplifier so that the negative output envelope from the delay channel is equal to the positive output envelope from the nondelay channel.

d. The output from the nondelay amplifier detector is also applied through isolating resistor R2326 to the comparison point in the video circuits. Attenuator R2326 and R3301 is necessary to balance the loss that takes place through a similar attenuator in the delay channel.

Section V. VIDEO CIRCUITS

93. General
(fig. 219)

The video circuits amplify and limit video pulses in all modes of operation of the equipment before the video pulses are applied to the indicating system and the remote ppi.

a. The video circuits include mti video amplifier V3303 (and the comparison point components in its input circuit), video polarizer V3304 (which includes crystal diodes CR3300 and CR3301), mti video limiter V3305, normal video limiter V3306, video cathode follower V3307, remote video cathode follower V3308, video relay K3300, part of mode selector relay K3301, part of OPERATION SELECTOR switch S2354, and OPERATION switch S601 (located on the indicator).

b. In the normal and coho adjust modes of operation, negative video pulses representing both fixed and moving targets are applied to normal video limiter V3306 from crystal diode CR301 in the receiving system. The pulses are amplified or limited (depending on the input amplitude of each pulse) and applied to cathode followers V3307 and V3308 as positive video pulses.

c. In the mti mode of operation, a positive envelope carrying bipolar video information from the nondelay channel and a delayed negative envelope carrying bipolar video information from the delay channel are applied to the comparison point in the input circuit of V3303. As a result of comparing (or algebraically adding) the opposite polarity envelopes across the comparison point components, the returns from fixed targets are cancelled and only pulses representing moving targets are applied to and amplified by V3303. The bipolar video pulses from V3303 are polarized by V3304 so that all video pulses applied to V3305 are negative. The pulses are amplified or limited (depending on the input amplitude of each pulse) and applied to cathode followers V3307 and V3308 as positive video pulses.

d. The selection of either normal, coho adjust, or mti video is accomplished by mode selector switches and relays.

e. Three outputs are taken from the video circuits. Video information is applied to the indicating system from video cathode follower V3307. The same video information is applied to the remote ppi from remote video cathode follower V3308. A dc voltage which represents the difference in levels of the inputs to the comparison point is taken from across capacitor C3311 and applied to V3301 in the amplitude balancing circuits.

94. Comparison Point Components and Mti Video Amplifier V3303
(fig. 51)

The positive envelope (which carries bipolar video information) from the nondelay channel and the delayed negative envelope (which carries bipolar video information from the previous transmitted pulse) from the delay channel are added algebraically across the comparison point components in the input circuit of mti video amplifier V3303. The dc carrier levels and the returns from fixed targets are equal in magnitude and opposite in polarity and therefore cancel and are not applied to V3303. Since the returns from a moving target generally have different amplitudes, the resultant of the returns from two successive transmitted pulses is applied to V3303.

a. The input network provides isolation between the two signal input circuits and also

compensates for W2351 being in the delay channel. Resistors R3301 and R2357 are part of attenuators in their respective channels. The video pulses (or instantaneous differences between the two input signals) are developed at the grid of V3303. If the magnitudes of the input envelopes (the dc components) are not equal, a net dc voltage is developed across C3311, with the polarity depending on which envelope is larger. The video pulses riding on the envelopes (or pedestals) have negligible effect on the voltage across C3311, which is the output to the amplitude balancing circuits, because the integrated signal voltage developed across C3311 is negligible.

b. The normal flow of plate and screen currents through cathode resistor R3307 and potentiometer R3306 establishes the normal cathode potential. The control grid is normally very close to ground potential so that the cathode potential establishes the operating point of the tube. The tube is operated in its linear region so that either positive or negative input pulses receive the same amplification. Cathode bypass capacitor C3301A prevents degeneration across R3307 during circuit operation. Decoupling resistor R3335 establishes the normal screen and plate supply potential at +130 volts. Decoupling capacitors C3300A and C3300B prevent degeneration during circuit operation.

c. When the input pulses are applied, part of the input signal is purposely cancelled because of the degeneration across unbypassed potentiometer R3306 (mti video gain). The stage gain is controlled by varying the amount of degeneration that takes place across the portion of R3306 that remains in the circuit. The amplified positive and negative video pulses are developed across plate load resistor R3305 and applied to video polarizer V3304.

95. Video Polarizer V3304 (fig. 52)

The pulse-to-pulse method of mti causes the resultant video pulses at the comparison point to be either positive or negative in polarity. Before being applied to the indicators, the information must be polarized so that all of the video pulses have the same polarity. Video

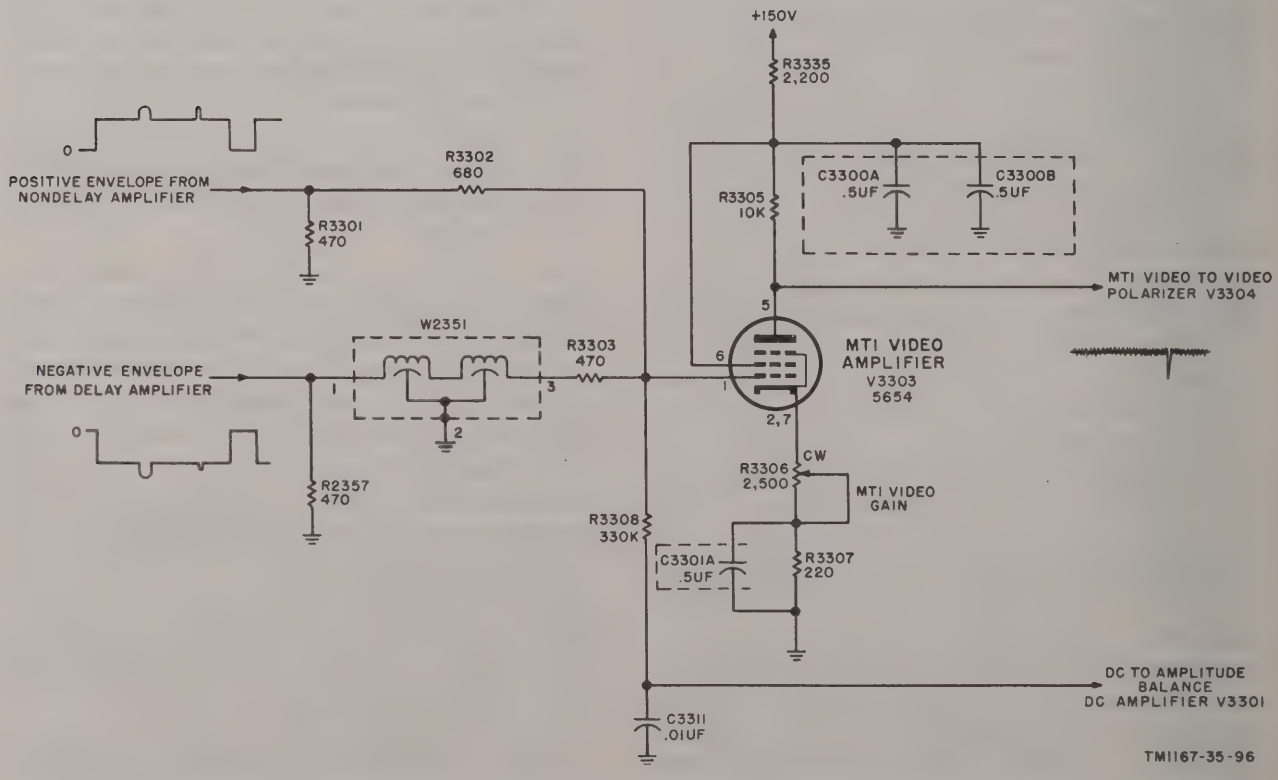


Figure 51. Comparison point and mti video amplifier, simplified schematic diagram.

polarizer V3304 functions so that the output pulses are all negative regardless of the polarity of the input pulses. Polarization is accomplished by operating V3304 so that an input pulse of either polarity causes both positive and negative pulses to be applied to crystal diodes CR3300 and CR3301. The crystal diodes are connected so that only negative pulses appear in the output of the circuit.

a. The 5654 pentode type tube is connected as a triode in the video polarizer circuit. The screen grid is retuned to the plate through parasitic suppressor resistor R3328 (220 ohms). Two equal load resistors are used in the stage, R3318 in the cathode circuit, and R3315 in the plate circuit. The normal flow of plate current through V3304 develops approximately .6 volt of cathode bias across cathode resistor R3317 and approximately 28 volts across load resistor R3318. Grid resistor R3318 is returned to the junction of R3317 and R3318 (rather than ground) so that the normal grid potential is also 28 volts and only the voltage developed across R3317 establishes the operating point of the tube.

b. Operation of the video polarizer stage depends on the fact that the forward resistance (against the arrowhead in the symbol) is less than one thousand ohms and the backward resistance (in the direction of the arrowhead in the symbol) is several hundred thousand ohms.

c. Video signals are coupled from V3303 by C3302 and are developed across grid resistor R3316. When a positive video pulse is applied to the grid of V3304 a positive pulse is developed across R3318 and coupled across R3319 by coupling capacitor C3304. The positive voltage developed across R3319 causes very little current flow through R3321 because of the high backward resistance of CR3301. At the same time that the positive input pulse causes a positive pulse to be developed across R3318 it causes a negative pulse to be developed at the plate of V3304. The negative pulse is coupled from the plate of V3304 to R3320 by coupling capacitor C3303. The negative voltage developed across R3320 causes a relatively large current to flow through the forward resistance of CR3300 and therefore a resultant current through load resistor R3321. As a result, when a positive pulse is applied to the input of V3304, a negative pulse is developed across R3321 because CR3300 conducts more than CR3301.

d. When a negative pulse is applied to the input of V3304, the negative pulse developed across R3318 causes CR3301 to conduct more than the positive pulse developed at the plate of V3304, causes CR3300 to conduct, and again a negative pulse is developed across load resistor R3321.

e. The polarized (all negative) video pulses developed across load resistor R3321 are applied to mti video limiter V3305.

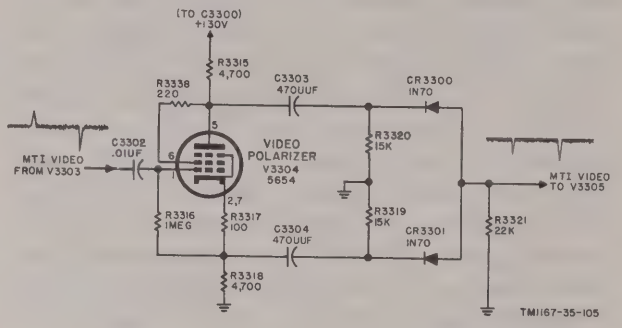


Figure 52. Video polarizer, simplified schematic diagram.

96. Video Limiters
(fig. 53)

Mti video limiter V3305 and normal video limiter V3306 amplify weak video pulses, amplify and limit strong video pulses (depending on the individual amplitudes of the input pulses from the video polarizer), and apply the proper video information to the output cathode followers. The limiter circuits are controlled by switches and relays so that one or the other stage is operative depending on the mode of operation of the equipment.

a. If OPERATION SELECTOR switch S2354 is in the NORMAL position, of if S2354 is in the REMOTE position and OPERATION switch S601 (on the indicator unit) is in the NORM position, the ground circuits of mode selector relay K3301 and video relay K3300 are completed and both relays are energized. The contacts of K3300 disable mti video limiter V3305 by opening its cathode circuit and the contacts of K3301 enable normal video limiter V3306 by grounding its cathode.

b. Normal video limiter V3306 is operated with zero bias since the input pulses are all negative in the normal mode of operation. The cathode is grounded through the contacts of K3301 and the control grid is returned to ground through grid resistor R2323. The screen and plate circuits of V3306 and V3305 are common. The normal flow of screen current through V3306 has two paths: It flows through R3322 to +150 volts and also through the forward resistance of crystal diode CR3302, plate load resistors R3324, R3326, and R3330, and decoupling resistor R3327 to +150 volts. The flow of screen grid current through screen grid dropping resistor R3322 drops the normal screen grid potential to approximately +55 volts. With the screen grid potential very low, the normal flow of plate current through V3306 is reduced to less than 1 ma. The flow of plate current through R3324, R3326, R3330, and R3327 (in addition to the screen grid current that flows through these resistors) drops the normal plate potential to approximately 40 volts. Because of the high backward resistance of CR3302, no appreciable plate current flows through R3322.

c. Negative video pulses representing fixed and moving targets are coupled from the receiving system by coupling capacitor C3306. The input negative pulses are amplified by V3306 so that positive pulses are developed in the plate circuit. Any input pulse large enough to cause the plate potential to rise above the screen grid potential (+55 volts) causes crystal diode CR3302 to conduct in its forward direction. Limiting takes place because the flow of screen grid current through the plate load resistors holds down the plate potential of V3306. While the stage is operated as a limiter for strong input pulses, weak input pulses receive normal amplification. Screen bypass capacitor C3305A prevents degeneration by preventing the screen grid potential from varying during the application of video pulses. The video pulses are decoupled from the +150-volt supply by R3327 and C3305B.

d. Because of limiting in the plate circuits of V3305 and V3306, the maximum amplitude of the positive pulses at the common plates of the limiter stages is approximately 15 volts in any mode of operation of the equipment. The plate load of V3306 is tapped so that smaller maximum amplitude pulses (approximately 6 volts) are coupled to V3307 by coupling capacitor C3307 and even smaller maximum amplitude pulses (approximately 3 volts) are coupled to V3308 by coupling capacitor C3308.

e. If OPERATION SELECTOR switch S2354 is placed in the COHO ADJUST position (or if S2354 is placed in the REMOTE position and OPERATION switch S601 is placed in the COHO. ADJ. position), K3301 remains energized but K3300 deenergizes because its ground circuit is opened. Mti video limiter V3305 remains disabled and normal video limiter V3306 continues to operate in the same manner except that cathode bias network R3336 and C3309 is placed in the cathode circuit. The cathode bias shifts the operating point of the tube so that both positive and negative input pulses to V3306 can be amplified. The operating point is shifted because in the coho adjust mode of operation the coherent oscillator in the receiving system is enabled by other contacts of K3301 and both negative and positive pulses are applied to V3306. If the operating point of V3306 were not shifted away from the zero bias operating point, very small positive input pulses would drive the tube into the plate current saturation and the positive pulses would not be reproduced.

f. If OPERATION SELECTOR switch S2354 is placed in the MTI position (or if S2354 is placed in the REMOTE position and OPERATION switch S601 is placed in the MTI position), the ground circuits of both K3300 and K3301 are opened and both relays deenergize. Mti video limiter V3305 is made operative by grounding its cathode and normal video limiter V3306 is disabled by opening its cathode circuit. Except for the fact that negative mti video pulses are coupled (by C3310) to V3305 from video polarizer V3304, the operation of V3305 is identical with that of V3306 in the normal mode of operation.

97. Video Cathode Followers
(fig. 54)

In all modes of operation, video is applied to video cathode follower V3307 from the common plate circuits of the video limiters. The stage operates as a power amplifier and matches the impedance of the coaxial cable which connects to J303 and carries video information to the

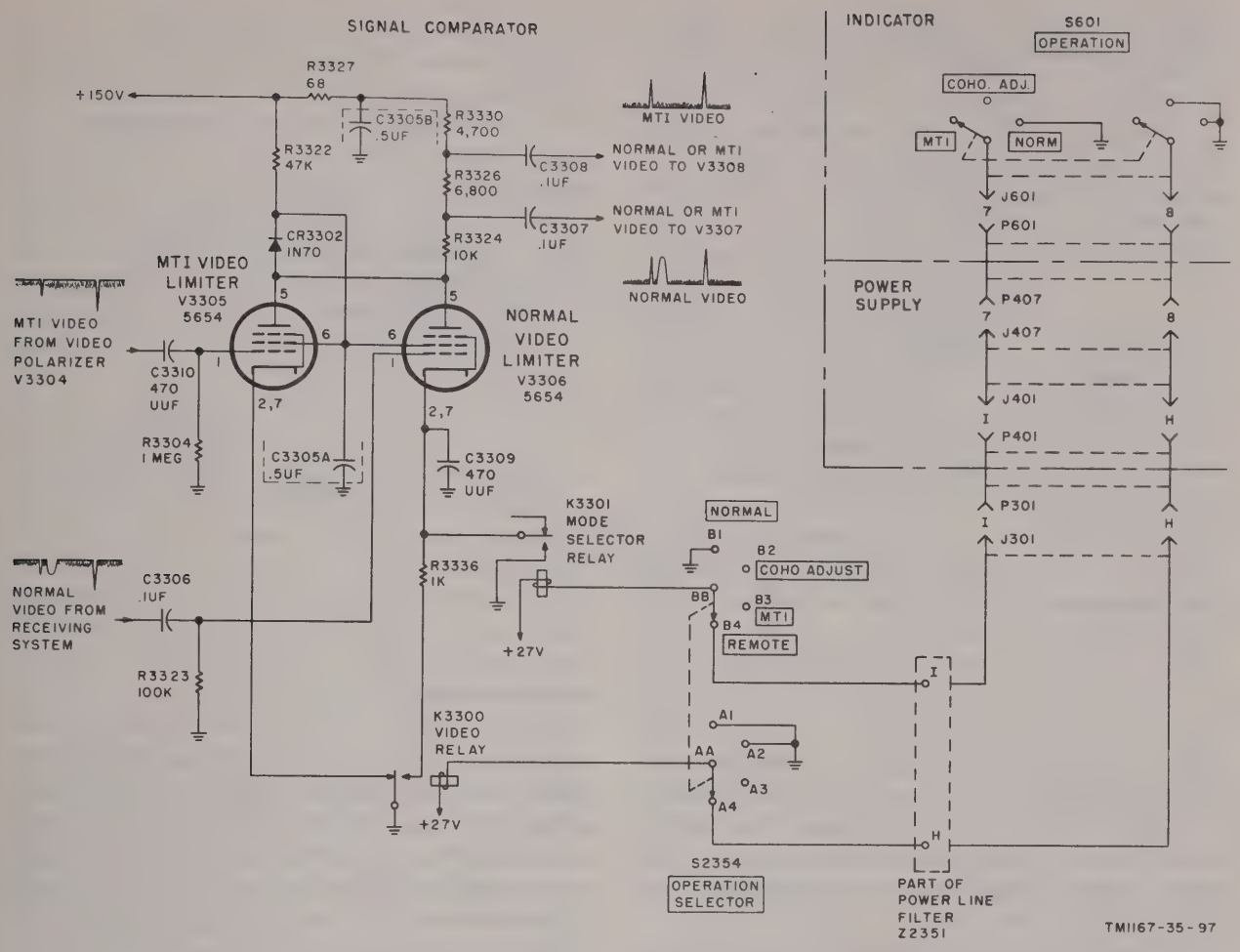


Figure 53. Video limiters, simplified schematic diagram.

indicating system. Remote video cathode follower V3308 does the same for the video that is applied to the remote ppi unit.

a. Both fixed and cathode bias are used in the V3307 circuit. Voltage divider R3334 and R3333 between −150 volts and ground establishes the grid potential at −2.2 volts. Cathode bias (approximately 3.7 volts) is developed across cathode resistors R3337 and R3328 by the normal flow of plate current. Both types of bias are used to establish the operating point of the tube, because the amount of resistance in the cathode circuit affects the output impedance of the stage. The stage is operated as a triode with the plate returned to +150 volts and the screen also returned to +150 volts except for small parasitic suppressor resistor R3329 (68 ohms) and small decoupling resistor R3327 (68 ohms). Capacitor C3305B, in conjunction with R3327, decouples video pulses from the +150-volt supply.

b. The input positive video pulses from the video limiters are developed across grid resistors R3325 and R3333 and are developed at the cathode with slightly reduced amplitude. The amplitude of the positive video pulses applied to the indicating system is further reduced because the pulses are taken from the junction of R3328 and R3337. This is done to match the impedance of the coaxial cable which connects to J303 and carries the video information to the indicating system.

c. Remote video cathode follower V3308 operates the same as V3307 except that the input positive pulses are smaller in amplitude and the cathode circuit of V3308 is completed

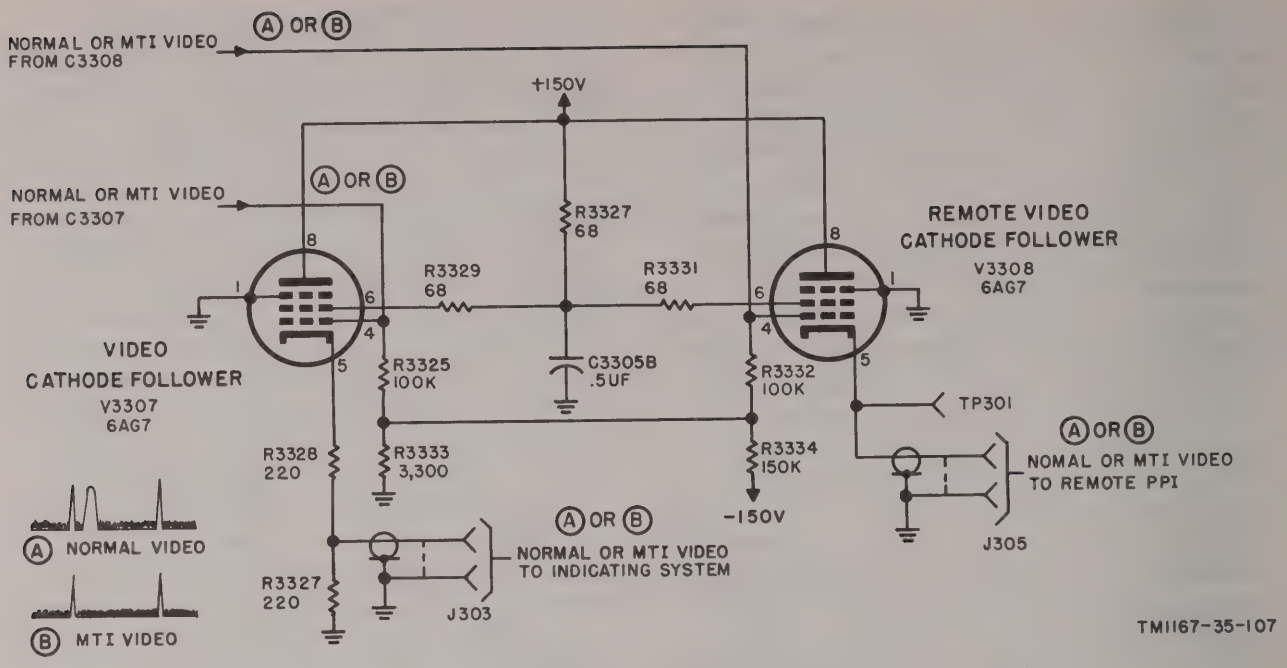


Figure 54. Video cathode followers, simplified schematic diagram.

in the remote indicator unit by approximately 75 ohms of resistance to ground. The cathode of V3308 is left open in the signal comparing system so that no power is drawn from the power supply when the remote ppi unit is not used.

d. Cathode follower V3307 will operate (but improperly) if R3327 were to become open because there is a resistor in the indicator (R672) which is in parallel with R3327. Remote video cathode follower V3308 cannot operate unless its cathode circuit is completed by a terminating resistor; therefore no video can be seen at test point TP301 unless a remote ppi unit is used or unless some other termination is provided from J305 to ground.

Section VI. AMPLITUDE BALANCING CIRCUITS

98. General
(fig. 219)

In the pulse-to-pulse comparison method of mti used in the AN/TPS–1D, the amplitude of the returns from one transmitted pulse are compared with the returns from the following transmitted pulse so that the returns from fixed targets cancel and only the returns from moving targets are displayed on the indicators. To obtain maximum cancellation of the returns from fixed targets, the amplitude of the returns from fixed targets (and the dc components) from the nondelay channel and delay channel must be equal at the comparison point. The amplitude balancing circuits are adjusted so that these two inputs are equal initially; then the amplitude balancing circuits automatically adjust the gain of the delay amplifier during operation to maintain the inputs to the comparison point equal in amplitude.

a. The amplitude balancing circuits consist of amplitude balancing dc amplifier V3301, voltage reference tubes V3300 and V3302, part of OPERATION SELECTOR switch S2354, AMPL. BALANCE R2354, and RECEIVER AMPL. BALANCE R2627 on the indicator unit.

b. The only signal input to the amplitude balancing circuits is a dc voltage which represents the difference in magnitude of the dc components from the delay and nondelay channels. It is applied to the amplitude balancing circuits from C3311, one of the comparison point components, in the input circuit of V3303 in the video circuits.

c. The only output from the amplitude balancing circuit is the amplitude balancing bias which is applied from C3301B to the first four delay amplifiers in the delay channel.

d. Regulated +150 and −150 volts dc are applied from the power supply through power line filter Z2351. Filament voltage (6.3 volts ac) is applied to V3301 from filament transformer T2350. Voltage reference tubes V3300 and V3302 are cold cathode type gas tubes and therefore do not require filament voltage.

99. Amplitude Balancing Circuits (fig. 55)

A dc voltage which is the difference between the dc components of the output from the delay and nondelay channels is applied to the amplitude balancing circuits. Amplitude balancing dc amplifier V3301, in conjunction with voltage reference tubes V3300 and V3302, amplifies the difference and produces a bias for the delay amplifier which automatically adjusts the gain of the delay amplifier so that the input difference voltage is minimized.

a. Voltage reference tubes V3300 and V3302 are OB2 type miniature voltage regulator tubes. They are used in the circuit to provide reference voltages. Operated within their current ratings the voltage across them remains a constant 108 volts regardless of changes in the voltages applied to them. During circuit operation, V3300 holds the cathode of V3301B at a constant +42 volts and V3302 holds the R3314 and R3313 junction 108 volts below the voltage at the plate of V3301B.

b. Voltage reference tubes V3300 and V3302 and both sections of V3301 normally conduct. With R2354 in its midposition, the flow of normal plate current through plate load resistors R3309 and R2354 (AMPL. BALANCE) drops the plate potential of V3301A (pin 1) and the grid potential of V3301B (pin 7) to +40 volts. The normal flow of plate current through V3301B and V3302 drops the plate voltage of V3301B (pin 6) to +105 volts. The normal flow of current through V3300 establishes the voltage at the cathode of V3301B (pin 8) at a constant reference potential of +42 volts. These currents develop a bias of 2 volts for V3301B so that the tube is operated in its linear region. With these normal conditions, the flow of plate current from −150 volts dc through R3314, V3302, and R3312 (in addition to the normal plate current of V3301B through R3312) to +150 volts dc makes the junction of R3314 and R3313 equal to approximately −3 volts. The voltage at the junction of R3314 and R3313 is the normal bias potential for the delay amplifiers because there is no current flow to or from the delay amplifiers.

c. If the nondelay channel and delay channel are working normally and all component values are exact, the midposition setting of R2354 produces an output bias voltage from the amplitude balancing circuits which causes the output amplitude from the delay channel to be equal to the output amplitude from the nondelay channel and the input to V3301A is zero. Since an exact balance in the two channels is not likely, assume that the gain of one of the amplifier stages in the nondelay channel (V2303) is less than its comparable amplifier in the delay channel (V1303). This results in the output dc component from the nondelay channel to be less positive and a resultant negative voltage is developed across C3311 and applied to V3301A.

d. A negative going dc input voltage to the grid of V3301A causes plate current flow through V3301A to decrease and its plate voltage and the voltage at the grid of V3301B to increase. The cathode of V3301B is held at a constant potential by V3300 so that the positive going potential at the grid of V3301B causes plate current through V3301B to increase and the voltage at the plate of V3301B decreases. Since the voltage across V3302 is a constant 108 volts, a decrease in voltage at the plate of V3301B causes the voltage at the junction of R3314 and R3313 to become more negative and the output amplitude balancing bias to the delay amplifiers becomes more negative. This causes the gain of the delay channel to reduce to the point where its output dc component is slightly more than the output dc component from the nondelay channel.

e. The operation of the amplitude balancing circuits is similar to that of a closed loop servo system. The comparison point (the sensing device) develops an error voltage, V3301 amplifies the error (the difference between the dc components from the delay and nondelay channels), and the amplitude balancing bias (the

followup signal) is applied to the delay amplifier to adjust its gain and equalize the inputs to the comparison point. As in a closed loop servo system, the error is not completely canceled out during circuit operation. The more the error signal (the input to V3301A) is amplified, the closer the inputs to the comparison point can be equalized. But a very small difference (the error voltage) is necessary to change the amplitude balancing bias and to maintain it changed from the perfect balance values and hold the dc component output from the delay channel changed.

f. The amplitude balancing circuit responds only to the differences in the average levels (or the dc components) to the comparison point. Filter capacitor C3301B is too large (.5 μf) to respond to short time duration differences in the input to the comparison point. The long time constant of C3301B and R3313 also compensates for the approximately 350 microseconds out of 2,500 microseconds that there is no input to the amplitude balancing circuit because the 9-mc carrier oscillator is gated. An instantaneous amplitude balancing circuit is not desirable because it would minimize the differences in amplitudes of the returns from moving targets and make subclutter visibility poor.

g. In normal alinement of the signal comparing system for proper mti operation, the gain of the nondelay channel is adjusted for a red-line indication; then R2354 is adjusted so that the amplitude balancing circuit makes the output from the delay channel also give a red-line indication. This adjusts the amplitude balancing circuits and the delay channel so that the amplitude balancing circuits maintain the inputs to the comparison point essentially equal during circuit operation.

h. When OPERATION SELECTOR switch S2354 is in REMOTE position, R2627 (RECEIVER AMPL. BALANCE), which is located on the indicator unit, takes the place of R2354 so that the operator can make this adjustment on the front panel of the indicator.

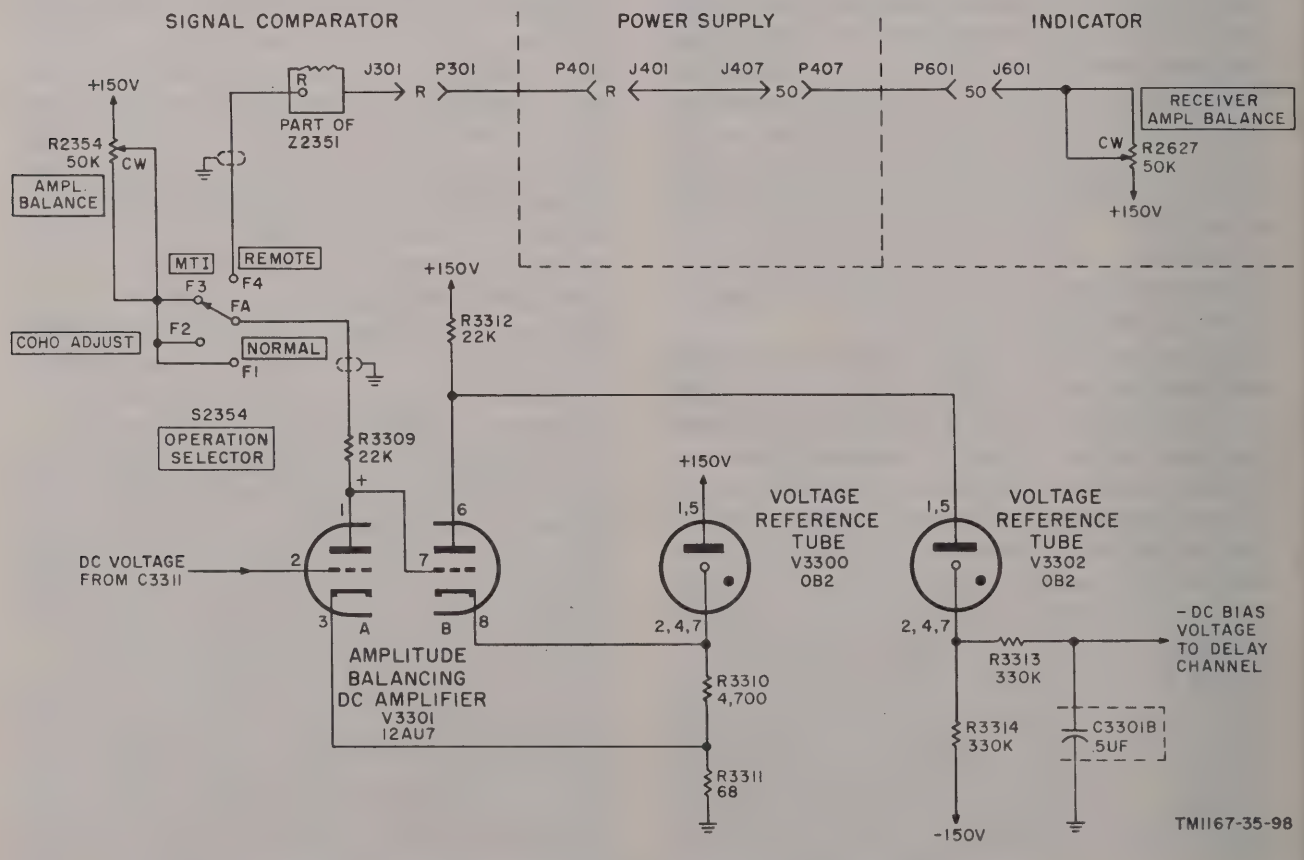


Figure 55. Amplitude balancing circuits, simplified schematic diagram.

Section VII. TIME BALANCING CIRCUITS

100. General
(fig. 219)

In the pulse-to-pulse comparison method of mti used in the AN/TPS–1D, the returns from one transmitted pulse are compared with the returns from the following transmitted pulse so that the returns from fixed targets cancel and only the returns from moving targets are displayed on the indicators. Time delays not common to the delay channel result from the fact that the output of the delay amplifier detector is used to start the timing of the next transmitted pulse. To obtain maximum cancellation of the returns from fixed targets, the inputs to the comparison point must exactly coincide in time. The time balancing circuits are used to obtain a variable time delay so that the signal comparing system can be adjusted to obtain the necessary time balance between the inputs to the comparison point. Time balance is accomplished by delaying the output from the delay amplifier detector an additional 1.9 microseconds before it is applied to the comparison point, and then the variable time delay of the time balancing circuits is adjusted so that the total of all the time delays affecting the timing of the output from the nondelay channel is equal to 1.9 microseconds.

a. The time balancing circuits consist of slope generator V1350, pick-off amplifier V1351, part of OPERATION SELECTOR switch S2354, R2356 (MTI BALANCE), and R2618 (MTI BALANCE) on the indicator.

b. The input to the time balancing circuits is the negative envelope from the delay amplifier detector (WT). It is applied from the delay amplifier detector to the grid of slope generator V1350.

c. The output from the time balancing circuits is a negative pulse which is applied to the grid of the V1354 section of the carrier gate multivibrator to synchronize the multivibrator.

d. Regulated +150 volts dc is applied from the power supply through power line filter Z2351. Filament voltage for V1350 and V1351 is applied from filament transformer T2350.

101. Time Balancing Circuits
(fig. 56)

A negative envelope from the delay amplifier detector is applied to the time balancing circuits. The time balancing stages, slope generator V1350 and pick-off amplifier V1351, produce a negative trigger which is used to synchronize the carrier gate multivibrator. The output negative trigger pulse is variable from the time equal to the start of the negative input envelope to approximately 3 microseconds after the start of the negative input envelope. This variable time delay is used to obtain an exact time balance between the two inputs to the comparison point.

a. Slope generator V1350 is operated with zero bias. The normal flow of screen grid current through screen dropping resistor R1351 establishes the screen grid potential at +68 volts. The normal flow of plate current through plate load resistor R1352 holds the plate voltage at +10 volts and the capacitances between plate and ground (C1353 and the associated tube and circuit shunt capacitances) are normally charged to +10 volts.

b. The input negative envelope (waveform A) is coupled from the delay amplifier detector by coupling capacitor C1350 and differentiated across grid resistor R1350 (waveform B). The time constant of R1350 and C1350 is short (90 μsec) as compared to the relatively long duration of the negative going portion of the input signal (2,150 μsec) so that the negative going voltage at the grid is a peaked wave which returns to zero in approximately 450 microseconds. When the input voltage swings positive, the grid becomes positive with respect to the cathode so that the positive voltage developed at the grid is a sharp positive peak which is narrower and smaller in amplitude than the negative peak because the low cathode-to-grid impedance is in parallel with R1350 during the application of the positive going portion of the input. The positive going portions of waveforms A and B do not affect the timing of the time balancing circuits.

c. With V1350 operated with the screen voltage low, the cutoff potential for the tube is also low (the dotted line in waveform B),

and the extreme negative portion of the differentiated peak applied to the grid cuts off V1350 and holds it cutoff for approximately 60 microseconds. While the tube is beyond cutoff the operation of the stage is similar to a sawtooth generator. When plate current through V1350 ends, the capacitances from the plate of V1350 to ground start to charge exponentially toward +150 volts. The first portion of the exponential change is fairly linear; and this sloping voltage is coupled across grid resistor R1353 by coupling capacitor C1354 (270 $\mu\mu$f) to trigger pick-off amplifier V1351 into conduction. Once V1351 is triggered into conduction (from 0 to 3 microseconds after V1350 cut off) and the grid of V1351 rises above its cathode potential, the charge of C1354 slows down the charge of the capacitances from the plate of V1350 to ground. The resultant waveform at the plate of V1350 (waveform C) is an exponential rise from approximately +10 volts to approximately +130 volts during the 60 microseconds that V1350 is held beyond cutoff. When the input to V1350 rises above the cutoff potential of V1350 (the dotted line), the tube goes back into conduction and the capacitances in the plate circuit discharge to the normal conditions when they are all charged to +10 volts. Screen bypass capacitor C1352 prevents degeneration by holding the screen grid potential close to +68 volts during the time that V1350 is beyond cutoff.

d. Pick-off amplifier V1351 is operated so that it can be used to obtain a variable time delay of from 0 to approximately 3 microseconds. With OPERATION SELECTOR switch S2354 in the NORMAL, COHO ADJUST, or MTI position, voltage divider R2356 (MTI BALANCE), R1355, R1354, and R1367 between ground and +150 volts establishes the cathode potential of V1351 at approximately +20 volts positive with respect to ground. The screen grid is returned to +150 volts. The control grid is normally at ground potential so that V1351 is normally beyond cutoff. Plate load resistor R1361 is also the plate load resistor of the V1353B half of the carrier gate multivibrator. For this reason, although V1351 is normally beyond cutoff and only conducts for a few microseconds during circuit operation, the plate voltage of V1351 normally measures approximately +57 volts because of current flow through R1361 from the multivibrator.

e. The circuit conditions just previous to the development of the variable trigger pulse in the plate circuit of V1351 are such that V1350 conducts heavily, V1351 is beyond cutoff, the V1353B section of the carrier gate multivibrator is beyond cutoff, and the V1354 section of the carrier gate multivibrator is conducting. The sloping rise in voltage at the plate of V1350 (waveform C), which begins when the negative input envelope is applied to V1350, is coupled to the control grid of V1351 (waveform D). At some point along the sloping rise, the positive going voltage overcomes the bias established by the setting of R2356, and causes plate current to flow through plate load resistor R1361. The pulse of current through R1361 causes a decrease in potential at the plate of V1351 which is coupled to the V1354 section of the carrier gate multivibrator and causes V1354 to cut off and reverse the conducting conditions in the multivibrator at an exact time, depending on the setting of R2356 (MTI BALANCE). The greater the resistance of potentiometer R2356, the more positive the cathode of V1351 is and the more positive the grid of V1351 must become before V1351 conducts; therefore the greater the amount of time delay between the time of the start of the negative input to V1350 and of the negative pulse of current through R1361 which synchronizes the carrier gate multivibrator. It is possible to vary the resistance of R2356 from 0 to 50K to vary the time delay produced by the time balancing circuits from 0 to approximately 3 microseconds. When OPERATION SELECTOR switch S2354 is in the REMOTE position, R2618 (MTI BALANCE) on the indicator serves the same purpose as R2356 but from the operating position.

f. Once conduction of V1351 triggers the carrier gate multivibrator, the timing of the multivibrator is independent of further operation of V1351 until 2,500 microseconds plus 0 to 3 microseconds later. Soon after plate current starts to flow through V1351, the continuing rising potential at the grid of V1351 causes grid current to flow and the relatively fast time constant charge of C1354 differentiates the positive input from the slope generator to produce waveform D at the grid of V1351.

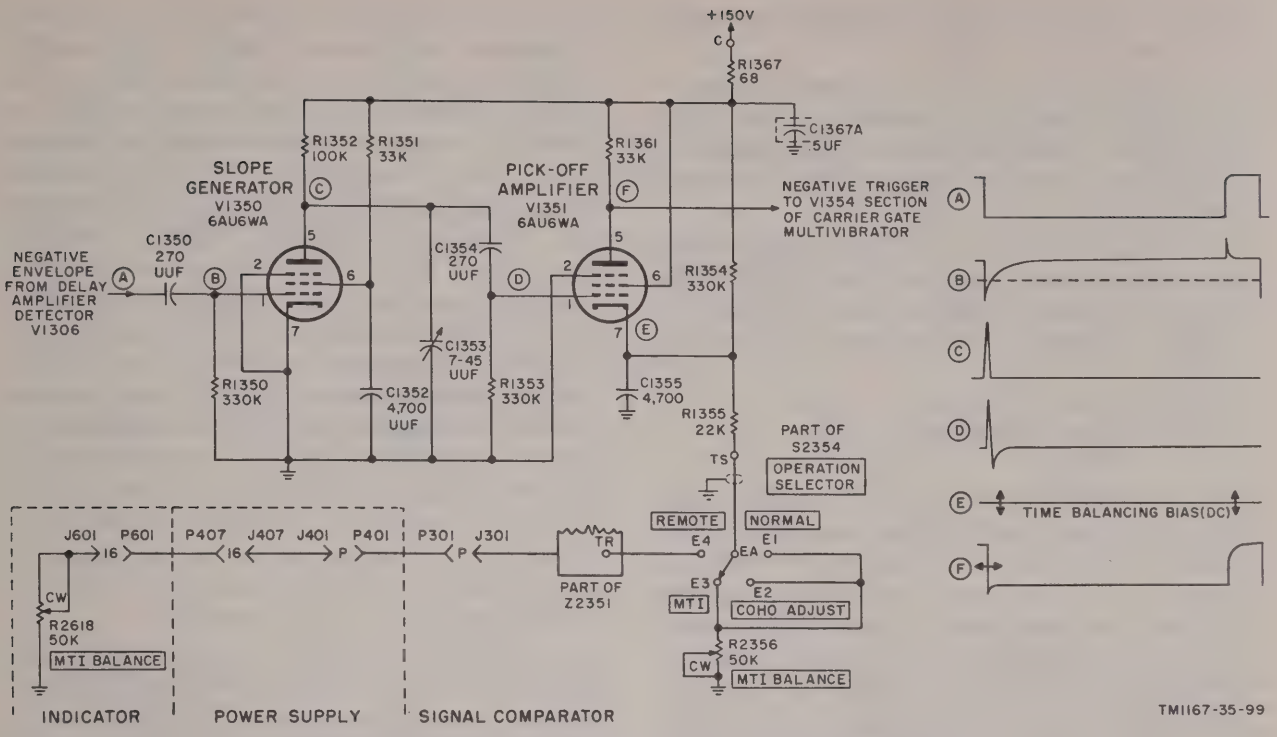


Figure 56. Time balancing circuit, simplified schematic diagram.

Cathode bypass capacitor C1355 prevents degeneration during the timing of the variable delay portion of the operation of V1351 by preventing the ac component of current from changing the cathode bias potential established by the dc current through the voltage divider in the cathode circuit. Decoupling network R1367 and C1367A smooths out the pulses of current drawn from the +150-volt power supply so that no interaction occurs between stages operated from the common +150-volt supply potential.

g. The output negative pulse from the plate of pick-off amplifier V1351 cannot be observed because the plate waveform of the V1353B section of the carrier gate multivibrator appears at the plate of V1351 (waveform F). If the carrier gate multivibrator is disabled in an effort to observe the negative trigger pulse, the 9-mc carrier oscillator will not oscillate and there is no delayed negative envelope input to V1350 so that the negative trigger cannot be developed by V1351. This illustrates the interdependency of the circuits in the trigger loop and the relatively large number of stages that affect the generation of the trigger pulses applied to the transmitting system.

Section VIII. TRIGGER GENERATOR CIRCUITS

102. General
(fig. 219)

The pulse-to-pulse comparison method of mti requires a very stable pulse repetition frequency. To obtain the necessary stability, the signal comparing system develops accurate trigger pulses to time the transmitting system. In the signal comparing system, the frequency of the carrier gate multivibrator is controlled by the trigger loop and the multivibrator gates the trigger generator circuits. The trigger generator circuits apply negative trigger pulses to the transmitting system 10 microseconds after the 9-mc carrier oscillator is gated into oscillation.

a. The trigger generator circuits consist of trigger generator V1353A and trigger amplifier V1352.

b. The only signal input to the trigger circuits is a gating voltage from the plate (pin 1)

of the V1353B section of the carrier gate multivibrator.

c. The output from the trigger generator circuits is a series of negative pulses which are applied from J302 in the output circuit of V1352 to the trigger circuits in the transmitting system.

d. Regulated +150 volts dc is applied from the power supply through power line filter Z2351. Filament voltage for V1353A and V1352 is applied from filament transformer T2350.

103. Trigger Generator Circuits (fig. 57)

The trigger generator circuits are gated by the carrier gate multivibrator and produce negative output triggers which occur 10 microseconds after the gated 9-mc carrier oscillator is gated into oscillation. The negative output triggers are applied to the trigger circuits to trigger the transmitting system in all modes of operation except the normal (internal trigger) mode. Trigger generator V1353A is operated as a shock-excited oscillator to provide the necessary 10 microseconds delay; trigger amplifier V1352 is operated as a cutoff limiter so that only one negative pulse is produced each time a gate is applied to the trigger generator circuits (each time the 9-mc carrier oscillator is gated into oscillation).

a. The plate of trigger generator V1353A is returned to +150 volts dc through decoupling resistor R1267 (68 ohms) so that the plate potential is normally +150 volts. The plate potential remains at +150 volts during circuit operation because the load for the stage is in the cathode circuit. The grid is returned to ground through grid resistor R1359. The normal flow of plate current is limited by cathode bias developed across cathode resistor R1360 (2,200 ohms) and the dc resistance of L1352 (108 ohms). The normal flow of plate current through L1352 creates a magnetic field about the inductor in the tank circuit.

b. The input gating voltage (waveform A) from the carrier gate multivibrator is coupled to the grid of V1353A by coupling capacitor C1361. When the input negative swing in voltage is developed across grid resistor R1359 (waveform B) at time T_2, the tube is rapidly driven beyond cutoff and the tank circuit in the cathode circuit is shocked into oscillation. When the tube current cuts off, the inductor maintains current flow through itself in the same direction. The field about L1352 collapses, inducing a voltage across the inductor which is negative at the grid of the V1352 end of the tank circuit with respect to the ground end. This induced voltage, which is the output voltage from the circuit (waveform D), maintains current flow through the inductor and since the current cannot flow through the tube, it flows around the tank circuit and charges tank capacitor C1363. Once shocked into oscillation, the tank circuit continues to oscillate at a frequency which depends on the size of L1352 and C1363. The tank circuit components oscillate at a frequency of 50 kilocycles (kc). This makes the period of oscillation 20 microseconds and the duration of one alternation equal to 10 microseconds.

c. The trigger circuits must produce only one negative trigger each time they are gated. If more than one is produced, multiple triggering of the transmitting system results and circuitry in the transmitting system automatically turns off the transmitter. Several features in the trigger generator circuits prevent multiple triggering. The oscillations in the tank circuit are critically damped and trigger amplifier V1352 is operated as a cutoff limiter so that only the first positive swing in voltage at the grid of V1352 (the voltage across the tank circuit) causes plate current to flow through V1352. The oscillations in the tank circuit are critically damped by the input circuit of V1352. During the first positive swing in voltage, the grid potential rises above the cathode potential of V1352 and the flow of grid current loads down the tank circuit. This results in the second positive alternation being smaller in amplitude so that it does not cause plate current to flow. The oscillations in the tank become critically damped. The second positive swing in voltage across the tank does not rise above the cathode potential of V1352, and the oscillations then damp out more gradually because only the dc resistance of L1352 causes further damping. The lower amplitude oscillations are too small to cause multiple output trigger from the trigger generator circuits, because they do not cause plate current to flow through V1352.

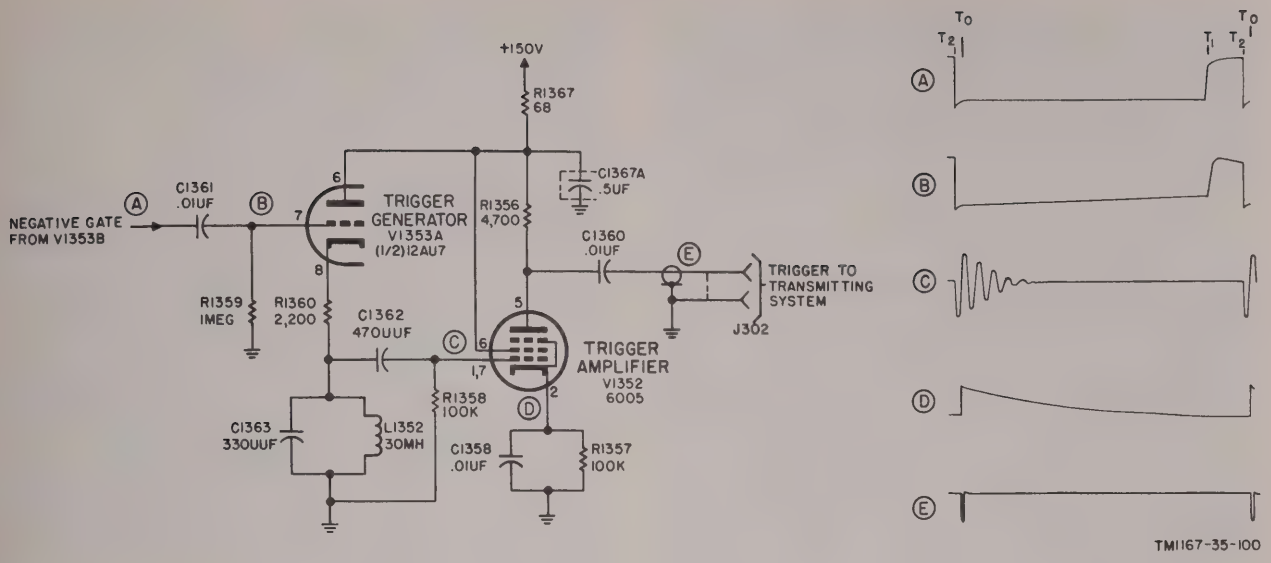


Figure 57. Trigger generator circuits, simplified schematic diagram.

d. With no input to trigger amplifier V1352, the operating point of V1352 is established close to cutoff by the high resistance of cathode resistor R1357 (100K). A large cathode resistor and cathode bypass capacitor are used so that the input signal causes additional bias to be developed to operate the tube beyond cutoff during circuit operation. When the tank circuit is shocked into oscillation, the first negative alternation has no effect on V1352 because the stage is already beyond cutoff. The first positive alternation raises the grid above cutoff and the flow of plate current through V1352 develops a negative pulse at the plate of V1352 10 microseconds after the trigger generator circuits are gated by the carrier gate multivibrator. The first positive alternation also raises the grid above the cathode potential so that grid current flows and charges C1358. When the amplitude of the first positive alternation falls below the cathode potential (the voltage across C1358), grid current stops flowing and the long time constant discharge of C1358 (waveform D) holds the cathode sufficiently positive so that V1352 remains beyond cutoff until the tank circuit is shocked into oscillation again at time T_2. Decoupling network R1367 and C1367A prevents interaction between stages through the common +150-volt supply potential.

e. Negative output trigger pulses from the trigger generator circuits are coupled from the plate of V1352 to J302 by coupling capacitor C1360. The negative trigger pulses occur at the same frequency as the frequency of the carrier gate multivibrator but they occur 10 microseconds after the carrier gate multivibrator gates the 9-mc carrier oscillator and trigger generator V1353A. The output negative pulses are applied from J302 to the trigger circuits in the modulator of the transmitting system where they establish the timing of the transmitted pulses in all modes of operation except the normal (internal trigger) mode.

Section IX. MISCELLANEOUS CIRCUITS

104. General
(fig. 219)

All of the signal comparing system stages are located in Signal Comparator CM–36/TPS–1D (signal comparator). The only parts in the signal comparing system which are not located in the signal comparator are R2618 (MTI BALANCE) and R2627 (RECEIVER AMPL. BALANCE) which are operated adjustments on the indicator. These two potentiometers are in the signal comparing system circuitry only when OPERATION SELECTOR

switch S2354 is in the REMOTE position. In any other position of S2354, the operation of the signal comparing system is independent of all units except for the power supply. Within the signal comparator considerable interdependency exists between the signal comparing system and the receiving system.

a. Two major subassemblies of the receiving system are located in the signal comparator: 60-mc IF amplifier Z301 and coherent oscillator Z350. In addition, TEST METER M2350, TEST SELECTOR S2353, OPERATION SELECTOR S2354, and mode selector relay K3301 are necessary for the operation of the receiving and signal comparing systems independently. The effect of these subassemblies and parts on the operation of the receiving system are discussed in chapter 4.

b. Some parts in the signal comparator affect the operation of the receiving system as well as the signal comparing system only because units of the receiving system are located in the signal comparator. These parts are discussed in paragraph 105.

105. Miscellaneous Circuit Functioning (fig. 219)

The parts discussed in this section affect the operation of the signal comparing system as a whole rather than the operation of individual subsystems or channels. All of these parts except Z2350 also affect the operation of the receiving system.

a. When main POWER switch S602 on the indicator is thrown ON, power is applied to the primary of filament transformer T2350 through terminals A and B of power line filter Z2351. The 115-volt, 400-cycle source is stepped down to 6.3 volts and applied from T2350 to all vacuum tubes in the signal comparator except voltage reference tubes V3300 and V3302.

b. The internal temperature of the signal comparator is kept between 25° C. (77° F.) and 0° C. (32° F.) by blower motor B2350 and heater HR2351. When the internal temperature reaches 25° C., high temperature thermostat S2352 closes and power is applied from terminals A and B of Z2351 to the windings of blower motor B2350. Capacitor C2350 (1 μf) is not part of the motor assembly but is necessary to the operation of the motor. Blower motor B2350 is a two-phase induction motor which is operated from a single-phase supply. Capacitor C2350 is a phase-splitting capacitor which is placed in series with one of the stator coils to make the current through the two stator coils 90° out of phase to satisfy the requirement that the fields about the stators of a two-phase motor must be approximately 90° out of phase. A fan on the rotor shaft circulates air through the unit. When the internal temperature drops to 10° C., S2352 opens and power is removed from the motor. Because the fan of the blower motor is exposed and presents a hazard to personnel working inside the unit, interlock S2355 opens when the unit is pulled from its case. When S2355 opens, power is removed from the blower motor. Ventilation is not necessary when the unit is pulled from its case.

c. When the internal temperature of the signal comparator drops to 0° C., low temperature thermostat S2351 closes and power is applied from terminals J and M on Z2351 through terminals A and B of P/J2354 to strip space heater HR2351. The 150-watt heater increases the internal temperature of the unit until it reaches 15° C. At this time, S2351 opens and power is removed from the heater.

d. Power line filter Z2351 contains a number of capacitor and inductor type filters which prevent high frequency noise variations from entering the signal comparator from the interconnections of the power supply to which J301 connects.

e. Sections A, B, E, and F of OPERATION SELECTOR switch S2354 affect the operation of the signal comparing system. Section A actuates video relay K3300. Section B actuates mode selector relay K3301. The manner in which the switches and relays change the modes of operation is discussed in paragraph 96. Section E of S2354 controls whether R2356 or R2618 (on the indicator) is used to adjust the time balancing circuits. Section F controls whether R2354 or R2627 (on the indicator) is used to adjust the amplitude balancing circuits.

f. TEST METER M2350 is a 0- to 100-microampere dc meter which is used in adjusting and troubleshooting the signal comparing system and the receiving system. TEST SELECTOR switch S2353 is a two pole, six position rotary switch which makes it possible to mon-

itor five different circuits and to remove M2350 from the monitored circuits in the sixth position. Three circuits in the signal comparing system are monitored. The level of the input signal to the mercury delay line is monitored when S2353 is in the third position (DELAY LINE INPUT). In this position, R2352 is adjusted to obtain a red-line indication on M2350 to establish the correct input level to the delay and nondelay channels. The level of the output from the nondelay channel is monitored when S2353 is in the fourth position (NONDELAY AMPL. OUT.) In this position, R2353 is adjusted to obtain a red-line indication on M2350 to establish the optimum output level from the nondelay channel to the comparison point. The level of the output from the delay channel is monitored when S2353 is in the fifth position (AMPL. BALANCE). In this position, R2354 is adjusted to obtain a red-line indication on M2350 to establish the output level from the delay channel to the comparison point equal to the level of the output from the nondelay channel to the comparison point. Adjustment of R2354 affects the amplitude balancing circuits which in turn make the amplitude of the output signal from the delay channel equal to the output from the nondelay channel at the comparison point.

g. In addition to being used for alinement of the signal comparing system, M2350 and S2353 are used in localizing trouble within the signal comparing system and the receiving system. Once the equipment is adjusted for proper operation, an abnormal reading on M2350 indicates trouble in the monitored circuit.

h. Mercury delay line test unit Z2350 is a test attenuator which is mounted on clips in the signal comparator. It is substituted in place of the mercury delay line when it is suspected that the attenuation of the mercury delay line is too high. The nominal voltage attenuation of Z2350 is 65 db, which is also the nominal attenuation of mercury delay line W2350.

CHAPTER 6
INDICATING SYSTEM

Section I. GENERAL

106. General

a. The indicating system, located entirely within Azimuth-Range Indicator IP–141/TPS–1D, displays video pulses that represent the positions of targets in either the normal or mti mode of operation. Targets are displayed on a 7-inch ppi scope and a 5-inch A-scope.

b. The ppi scope displays slant range and azimuth as polar coordinates on a long persistence screen. Either 5, 10, or 25-mile range markers which appear as concentric circles on the ppi may be selected for measuring range. A radial sweep, which can be seen through a transparent illuminated scale calibrated in degrees of azimuth or mills, indicates azimuth as it is made to follow antenna rotation. The ppi scope detects targets in all directions; thus, the antenna is rotated continuously when viewing this scope. The long persistence of the screen stores information until the antenna returns to a particular reference azimuth. In this way a radar map of the area is presented with the radar site at the center. In the mti mode of operation, only moving targets are displayed.

c. Each scope has its own gating circuits, sweep circuits, and range selector switch. The ranges are 20, 40, 80, and 160 nautical miles. The A-scope range selector switch has an additional position for viewing any expanded 10-mile segment of range between approximately 15 miles and 160 miles. The position of the range strobe (seen only on the ppi scope) determines the start of the 10-mile expanded segment of range appearing on the A-scope.

d. The A-scope displays slant range along a particular azimuth on a short persistence screen to obtain more accurate range information and better range resolution on specific targets already detected on the ppi scope. Five and 25-mile range markers or 10-mile range markers appear as sharp pips for range measurement. To detect targets on the A-scope, the antenna must be positioned so that the target is in the antenna beam. This scope is also used when adjusting the radar system.

e. The indicating system functions only when the RADIATE switch is in the ON position because the indicator trigger is obtained from a winding on pulse transformer T502 in the receiver-transmitter. Without an indicator trigger, both scopes are normally blank because no trigger is applied to the sweep and unblanking circuits.

f. In addition to the indicator trigger, the only other *signal* inputs into the indicating system are positive video pulses from the signal comparing system and positive IFF video pulses from the associated IFF equipment. These three coaxial inputs and all other inputs come from the interconnections within the power supply unit.

g. While there are no *signal* outputs from the indicating system, all controls necessary to operate the complete equipment are located on the front panel of the indicator.

h. All ac and dc potentials necessary to operate the indicating system come from the power supply unit except for +5,000, +1,500, +700, and −1,500 volts dc potentials, which are produced in the indicator high-voltage power supply.

i. The relationship of the indicating system with respect to other functional systems of the AN/TPS–1D is discussed in the block diagram analysis in TM 11–1167–20.

Figure 58. Indicating system, block diagram.
Contained in separate envelope.

107. Simplified Block Diagram

a. The indicating system (fig. 58) can be logically broken down into six subsystems as follows:

(1) Ppi sweep circuits.
(2) Fixed range marker circuits.
(3) Range strobe generator.
(4) A-scope sweep circuits.
(5) Video circuits.
(6) Indicator high-voltage power supply.

b. These subsystems are blocked in with dotted lines and are discussed in paragraphs 108 through 113.

108. Ppi Sweep Circuits
(fig. 58)

The ppi sweep circuits generate and display a sharp, intensified, radial sweep, which extends from the center of the ppi screen outward. To have the beam move linearly from the axis of the tube (when the transmitter fires) to the outer edge of the screen (at a time which depends on the setting of the ppi sweep range selector switch), the ppi sweep circuits must generate a sweep voltage which will cause a linear change in current through the deflection coil. This linear change in current causes the strength of the magnetic field about the deflection coil to increase linearly and thus deflect the beam linearly. This sweep provides a linear time base upon which targets are displayed. As the antenna is rotated, the antenna drive motor also drives a synchro transmitter. Stator information is sent from the antenna positioning system to the indicating system. Synchro receiver B602, in the indicating system, drives the deflection coil (yoke) so that the ppi sweep always indicates the azimuth to which the antenna is pointing.

a. Ppi-gate multivibrator V603 is triggered by the indicator trigger. It provides a negative gate to ppi-sweep generator V605 while providing a positive gate to the control grid of the ppi scope to allow beam current to flow. The time duration of the gate is 20, 40, 80, or 160 miles, depending on the position of a range selector switch. Ppi-gate clamper V604A clamps the grid voltage of V603B to the same potential for all sweep ranges.

b. Ppi-sweep generator V605 produces a positive sawtooth voltage which is amplified by sweep voltage amplifiers V606A and V606B. Since changes in *current* are necessary to deflect the beam, ppi sweep power amplifier V608 controls the changes in current. Feedback from V608 to V606A makes the deflection coil current through V608 uniformly proportional to the input sawtooth voltage to V606A. Ppi-sweep clamper V607A insures that the sweep starts at the same point on the screen regardless of the sweep range being used.

c. Ppi focus current regulator V610 uses the constant current characteristics of a pentode to maintain focus current constant. This is necessary because focus current is supplied by an unregulated +450-volt dc supply voltage.

109. Fixed Range Marker Circuits
(fig. 58)

a. The fixed range marker circuits generate range markers for both the ppi and the A-scope. Normally, 5-mile range markers are displayed on the 20- and 40-mile sweep ranges, and 25-mile range markers on the longer 80- and 160-mile sweep ranges. A soldered link connection may be changed to provide 10-mile range markers on all sweep ranges instead of 5- and 25-mile markers.

b. Marker gate multivibrator V614 is triggered by the indicator trigger. Its negative going output shock excites 16-kc gated oscillator V615. The oscillator produces a slightly damped continuous 16.38-kc sine wave as long as the output from V614 is negative (slightly more than 160 miles). When the output of V614 swings positive, the sine wave oscillations are quickly damped out. The first negative swing of the 16.38-kc oscillation corresponds to the time of the indicator trigger, which in turn corresponds to the time when the transmitter fires. The negative swings occur every 61 microseconds, which corresponds to 10,000 yards or approximately 5 nautical miles of radar range.

c. Limiter-peaker V616A employs grid limiting and cutoff limiting to produce sharp positive going leading edges which correspond to 0, 5, 10, 15, etc. miles of radar range. The sharp positive leading edges are applied to 5-mile blocking oscillator keyer V616B and appear at the grid of 5-mile blocking oscillator V167A to trip this biased single-swing blocking oscillator every 5 miles. The output waveform shown for V616B is determined principally by reflections from the blocking oscillator transformer associated with V617A.

d. Narrow (under 2 microseconds) negative pulses are taken from the plate circuit of

V617A in the 20 and 40 positions of PPI RANGE SELECTOR switch S606, amplified by ppi video-marker mixer V602, and applied to the cathode of ppi scope V609. On the screen they appear as intensified concentric circles every 5 miles.

e. Narrow positive pulses are taken from the cathode circuit of V617A in the 20, 40, and EXP positions of A RANGE SELECTOR switch S609. They are amplified by A video-marker mixer V619 and A-video amplifier V612B and applied to the vertical upper deflection plate of the A-scope to produce sharp positive 5-mile range markers.

f. Narrow positive pulses are also taken from the cathode circuit of V617A and applied through 25-mile blocking oscillator keyer V617B to the grid of 25-mile blocking oscillator V618B so that every fifth positive pulse triggers V618B. The output waveform shown for V617B results from the action of V618B. Marker clamper V618A permits the application of bias to the grid of V618B without affecting the timing of the stage. When the range selector switches are in the 80- or 160-mile position, 25-mile range marks are taken from V618B and applied to the scopes the same as the 5-mile markers are applied.

110. Range Strobe Generator
(fig. 58)

a. In the EXP position of A RANGE SELECTOR switch S609, the range strobe generator circuits determine at what range the 10-mile sweep on the A-scope starts, and also generate a pulse which is applied to the ppi scope to indicate the starting point of the expanded sweep on the A-scope.

b. Range strobe multivibrator V621 is triggered by the indicator trigger. Its output is a negative going gate which starts when the transmitter fires and ends at a time which depends on the setting of the RANGE STROBE control on the front panel of the indicator unit. As this potentiometer is varied, the timing of the multivibrator is affected so that the trailing edge of the negative gate is varied. The output of V621 passes through differentiator R686 and C646 so that the trailing edge of the negative gate becomes a positive trigger. This voltage is applied to strobe blocking oscillator keyer V613A which in turn triggers strobe blocking oscillator V613B. The output of V613B is a narrow negative going pulse which is amplified by iff video-strobe mixer V601, and appears as a negative pulse at the cathode of the ppi scope. This produces an intensified spot on the ppi screen, which indicates the position of the strobe.

c. When A RANGE SELECTOR switch S609A is in the EXP position, the positive trigger from differentiator R686 and C646 also triggers A-gate multivibrator V622. In this case, the outputs of V622 are a negative 10-mile gate to A-sweep generator V623 and a positive 10-mile unblanking gate to the control grid of the A-scope to allow beam current to flow during sweep time. The 10-mile sweep voltage produced by V623 is amplified by V624 and applied to the deflection plates of the A-scope to produce an expanded time base.

111. A-Scope Sweep Circuits
(fig. 58)

a. The A-scope differs from the ppi scope in the manner in which information is displayed. The A-scope uses position (or deflection) modulation, while the ppi scope uses intensity (or grid) modulation. Another significant difference is that to obtain a sweep, the A-scope uses electrostatic deflection, which requires sawtooth voltages applied to deflection plates, and the ppi scope uses magnetic deflection, which requires a sawtooth of *current* through the deflection coil. The beam current of the A-scope is held beyond cutoff until an unblanking gate allows beam current to flow.

b. Stages V622 through V625 and V604B generate a horizontal sweep which appears on the screen of the A-scope. A-gate multivibrator V622 is triggered by the indicator trigger when A RANGE SELECTOR switch S609A is in the 20-, 40-, 80-, or 160-mile position. The multivibrator produces positive and negative gates of corresponding time durations. A-gate clamper V604B clamps the grid voltage of V622B to the same potential for all sweep ranges. The A-scope sweep waveforms are shown for expanded sweep conditions. With S609 in a position other than EXP, the waveforms differ only in that they start at zero time and vary in time duration. The positive output is applied to the control grid of A-scope V625 to unblank it, while the negative output

gate is applied to A-sweep generator V623 to hold it beyond cutoff during the time that the sweep is being formed. The output of V623 is a positive sawtooth voltage which is applied to A paraphase amplifier V624.

c. The paraphase amplifier (V624) is a cathode-coupled paraphase amplifier (one input produces two outputs). The two outputs are applied to the horizontal deflection plates of A-scope V625 to provide the necessary sawtooth voltages to produce a horizontal time base by means of electrostatic deflection.

112. Video Circuits
(fig. 58)

a. In either the normal or mti modes of operation of the equipment, radar video information comes from the signal comparing system to video amplifier V611 in the indicating system. Video amplifier V611 amplifies the radar video pulses and applies them to video cathode follower V612A. Two outputs are taken from V612A. Positive video pulses go to the A-video-maker mixer V619. The output of V619 is a composite negative signal consisting of range markers and radar video pulses. A-video amplifier V612B amplifies the composite signal before it is applied to the vertical upper deflection plate of the A-scope.

b. Positive radar video pulses are also taken from V612A and are applied to ppi video-marker mixer V602. This stage also receives range markers so that its output is a composite signal. In addition to radar video information and range markers appearing in the output of V602, iff video pulses and the strobe marker which are mixed in iff video-strobe mixer V601 also appear in the composite video signal at the plate of V602. Amplifiers V601 and V602 have a common plate load. In this way, radar video pulses, range markers, iff video pulses, and the range strobe marker all appear at the cathode of the ppi scope as negative pulses, which intensity modulate the beam so that intensified spots appear on the screen to display all four types of information. Ppi-video clamper V607B clamps the signals applied to the cathode of the ppi scope all negative so that weak targets following strong ones are not lost.

c. With ANTI JAM switch S607 in the OFF position, the antijam circuit, consisting of C624 and L603 and video negative limiter CR601, has very little effect on the video signals that are coupled from V611 to V612A.

d. When the ANTI JAM switch is in the ON position, the coupling between V611 and V612A becomes a high pass filter. Any long pulses of jamming or clutter are differentiated so that only the leading edges of the long pulses are reproduced. Crystal diode CR601 removes the negative overshoot that occurs at the trailing edge of the long positive pulse when it is differentiated.

113. Indicator High-Voltage Power Supply
(fig. 58)

Indicator high-voltage rectifier V626 is a half-wave rectifier used to supply necessary high voltages to operate the ppi scope and A-scope. Rectifier V626 supplies +5,000 volts dc to the aquadag and +700 volts dc to the first anode of the ppi scope. It also supplies +1,500 volts dc to the second anode (and aquadag) of the A-scope as well as various potentials between −1,500 volts dc and ground to the grid, cathode, and first anode circuits of the A-scope.

Section II. PPI SWEEP CIRCUITS

114. General
(fig. 224)

a. When the transmitter fires, a large positive pulse (indicator trigger) is taken from the T1–T2 winding of pulse transformer T502 (fig. 212). It leaves the transmitting system from J506, is carried through the interconnections of the power supply in a coaxial cable, and enters the indicating system in a coaxial cable within the cable that connects to J601.

b. The coaxial cable which carries the indicator trigger is terminated in its characteristic impedance by resistors R680 (68 ohms) and R681 (10 ohms). Loading of the pulse transformer is reduced by taking the indicator trigger from the junction of R680 and R681. A reduced amplitude indicator trigger is taken from the top of R681 to ground and coupled to four places by—

(1) C643 to range strobe multivibrator V614.
(2) C627 to marker gate multivibrator V621.
(3) C643 in series with C647 when S609A is in the 20-, 40-, 80-, or 160-mile position to A-gate multivibrator V622.
(4) C609 to ppi-gate multivibrator V603.

c. The ppi-sweep circuits produce the necessary unblanking, positioning, and deflection voltages to produce a time base on the screen of ppi scope V609. The ppi-sweep circuits consist of ppi-gate multivibrator V603, ppi-gate clamper V604A, ppi-sweep generator V605, ppi-sweep amplifier V606, ppi-sweep clamper V607A, ppi-sweep power amplifier V608, and deflection coil L601.

115. Ppi-Gate Multivibrator (fig. 59)

Ppi-gate multivibrator V603 is t cathode-coupled, one-shot multivibrator circuit which is triggered by the indicator trigger when the transmitter fires. It produces a positive unblanking gate for the ppi scope and a negative gate for ppi-sweep generator V605. Ppi-gate clamper V604A is a negative clamper (or disconnect diode) which permits the application of reference bias to the B section of V603 during its conduction period. It disconnects the bias network during the cutoff period so the bias network does not affect the timing of the multivibrator.

a. Both grids of V603 are returned to +300 volts. The grid of the B section returns to +300 volts through its grid resistors R627 and R626 so that grid current and plate current normally flow through the B section. The grid resistors are very large with respect to the dc resistance from cathode to grid so that the grid is normally slightly positive with respect to the cathode. The flow of plate current through the B section makes the common cathode of the multivibrator 80 volts positive with respect to ground. The voltage divider consisting of R623 and R619 places the grid of the A section a +51 volts with respect to ground. With the grid of the A section 29 volts negative with respect to its cathode, the A section is normally cut off and the plate potential is +300 volts. Thus, the pretrigger conditions are such that the B section conducts heavily and the A section is beyond cutoff until the indicator trigger trips the multivibrator.

b. The indicator trigger is coupled from the junction of R680 and R681 by C609 and is developed across grid resistor R623 to bring the A section of V603 out of cutoff. When plate current starts to flow through the A section, a rapid regenerative action characteristics of a multivibrator, and independent of the input trigger, begins. Current flow through plate load resistor R620 causes the plate voltage to decrease. This decrease causes C610 (in the 20 position of S606A) to begin to discharge through R627 and R622. This discharge current, in addition to the grid current already flowing, causes the grid of the B section to become less positive with respect to its cathode so that the plate current flow through the B section decreases. The decrease in plate current causes the common cathode to become less positive with respect to the grid of the A section and results in a further increase in plate current through the A section. As the plate potential decreases, C610 must adjust to a greater change and its increased discharge current causes a further decrease in the plate current flow through the B section. This rapid regenerative action continues until the A section conducts heavily and the B section cuts off. This action occurs so rapidly that when the indicator trigger appears at the grid of the A section, the A section fires (or its plate current increases rapidly) and the B section cuts off (or its plate current rapidly decreases to zero).

c. When the A section of V603 fires, the plate potential decreases 110 volts so that the capacitor C610 must discharge exponentially. Its discharge path is through S606A, R627, R626, the +300-volt power supply to ground, R624 and R625 in parallel, and the cathode-to-plate dc resistance of the A section. While C610 discharges, it holds the B section beyond cutoff. The length of time that the B section remains cut off depends on the setting of PPI GATE potentiometer R626, which controls the discharge time constant of C610. In the 20 position of S606A and with proper adjustment of R626, the B section is held cut off for a time equivalent to 20 miles of radar range and the output gates of V603 are both equal to 20 miles. If PPI RANGE SELECTOR switch S606A is

changed to the 40 position, capacitor C611 is added in parallel with C610 to increase the time constant of the coupling between the A and B sections of the tube and thus increase the time duration of the output gates. In the same manner as S606A is switched to the 80 and 160 positions, the additional capacitance added to the coupling circuit increases the length of the output gates to 80 miles and 160 miles.

d. When the discharge current of the selected capacitors in the coupling circuit between the A and B sections of V603 decreases to the point that it can no longer develop enough voltage to hold the B section cut off (time T_{20} in the output waveform), a second rapid regenerative action restores the circuit to the pretrigger conditions. Flow of current through the B section causes the cathode potential to rise, which in turn causes the common cathode to go more positive with respect to the grid of the A section (the grid of the A section having returned to a fixed 51 volts after the narrow indicator trigger ended). As the common cathode rises in potential, plate current through the A section decreases and its plate potential rises. The rapid switch over to pretrigger conditions is aided because as the plate of the A section rises in potential, whatever capacitors are in the coupling circuit between the tube sections must recharge to the pretrigger condition. This charge current causes the grid of the B section to go more positive, which further increases the plate current through the B section. This regenerative action rapidly returns the circuit to its pretrigger conditions. The charge path of the capacitors in the coupling circuit is through R620, through the +300-volt power supply to ground, and to the grid of the B section in two parallel paths. One path is through R624 and R625 in parallel and both in series with the dc resistance from cathode to grid of the B section. The other path from ground to the grid of the B section is through R632 and the dc resistance of V604A. In all switch positions of S606A, ppi-gate clamper V604A insures rapid circuit recovery to the pretrigger conditions by clamping the potential at grid 7 of V603 negative with respect to the cathode potential of V604A (+73 volts).

e. When the A section cuts off (time T_{20}), the coupling capacitors recharge and remain so until the next indicator trigger. In the 160 position of S606A, ppi-gate clamper V604A insures that the circuit recovery (recharge of the coupling capacitors) is complete before the next indicator trigger. Without the V604A charge current for the coupling capacitors, there would be just enough time for the capacitors to charge when the prf of the system is 400 pps.

f. Ppi-gate clamper V604A affects the operation of V603 in several ways. During pretrigger conditions, current through V604A flows through resistors R627 and R626 and the grid current of the B section of the multivibrator. This diode current is an important factor in determining the pretrigger (static) conditions as well as the operating (dynamic) conditions. The bias network consisting of R628 through R632 places the cathode of V604A at +73 volts with respect to ground. Since the voltage across the conducting diode cannot be very great, the plate of the diode and grid of the B section are normally slightly positive with respect to +73 volts.

g. When the A section of V603 fires (time T_0), V604A cuts off and disconnects the R628 through R632 bias network from the B section grid circuit so that the bias network will not be a low resistance path for the discharge of the coupling capacitors. If this disconnecting diode were *not* between the bias network and the grid, the coupling capacitors would discharge much faster (with R628 through R631 in parallel with R627 and R626) and make the output gates considerably narrower. Ppi-gate clamper V604A effectively clamps the B section grid voltage all negative with respect to the +73 volts at the cathode of V604A regardless of the size coupling capacitor used between the sections of V603.

h. Two outputs are taken from V603. A positive gate unblanks the ppi scope while the negative gate is applied to ppi-sweep generator V605.

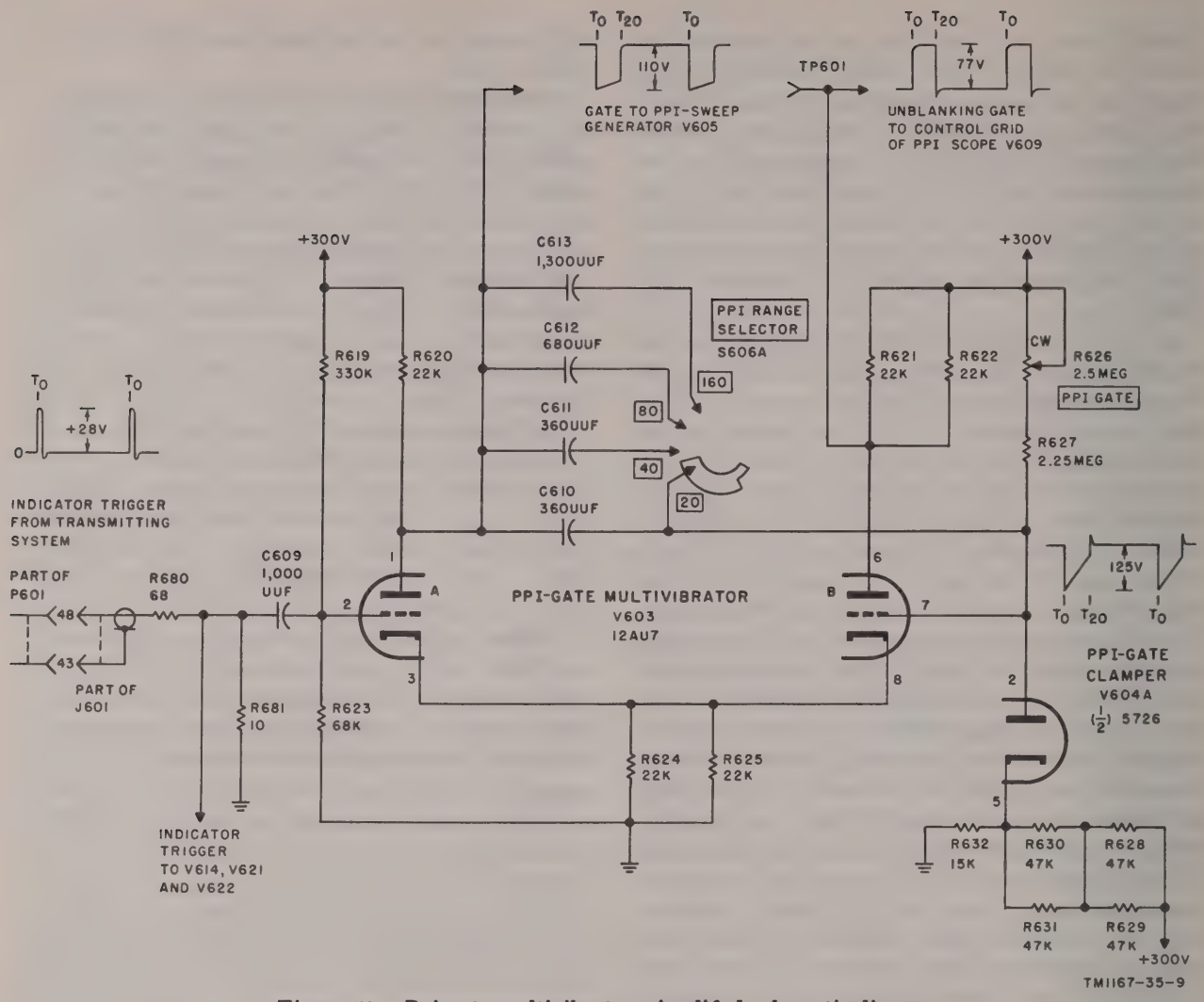


Figure 59. Ppi-gate multivibrator, simplified schematic diagram.

116. Ppi-Sweep Generator V605 (fig. 60)

Ppi-sweep generator V605 receives a negative gate from the ppi-gate multivibrator and produces a sawtooth voltage which is applied to the ppi-sweep amplifiers.

a. The static (no indicator trigger) conditions are such that the grid and cathode are at ground potential and the screen is held at +85 volts by current through screen dropping resistors R635, R636, and R637. The tube conducts lightly because plate load resistor R634 is large (2.2 megohms). Because the zero bias dc plate resistance of the tube is very small compared to the plate load resistor, the plate voltage is normally close to 1 volt and C618 is charged to this potential.

b. When the negative gate is coupled from V603 by C614, it is developed across grid resistor R633 and the tube cuts off. As soon as plate current ends, the plate potential would normally rise to +300 volts except that the voltage at the plate can only rise as fast as C618 will charge through R634. The only immediate effect caused by the start of the negative gate is that the charge current of C618 replaces the tube current that was previously flowing and holding the plate voltage down. As long as the negative gate holds the tube cut off (approximately 247 microseconds in the 20 position of S606B), C618 charges exponentially toward +300 volts. Since the time constant of C618 and R634 is very long compared with the duration of the negative

gate, C618 charges for only .11 time constant so that for all practical purposes, the rise in voltage is linear during the gate. The rise is to 34 volts if the negative gate is exactly 20 miles. The actual amplitude of the sawtooth developed in the plate circuit is affected by the setting of PPI GATE potentiometer R626 (fig. 59), which determines the electrical length of the sweeps appearing on the ppi scope. When the negative gate ends, C618 quickly discharges through the low resistance of the tube and the voltage at the plate remains at +1 volt until the next negative gate begins.

c. When S606B is switched to the 40 position, C617 is added in parallel with C618. This doubles the charge time constant of the combined capacitance so that it will charge to the same potential during the gate which is twice as long. This makes the physical length of the 40-mile sweep the same as the 20-mile sweep on the ppi scope. Similarly, in the 80 position of S606B, C616 is added in parallel with C617 and C618 to maintain the physical length the same when the electrical length of the sweep is changed to 80 miles. In the 160 position of S606B, parallel capacitors C615, C616, and C618 make up the sweep capacitance.

d. In all four switch positions, the output of V605 is a sawtooth voltage of almost the same amplitude but the slope of the rise changes so that it takes more time for the sawtooth voltage to rise to the required amplitude. The output of V605 is coupled to ppi-sweep voltage amplifier V606.

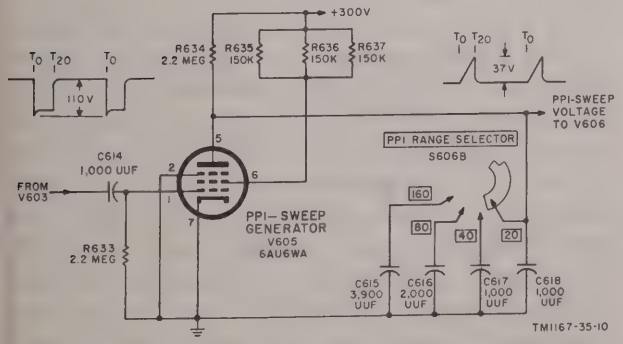


Figure 60. Ppi-sweep generator, simplified schematic diagram.

117. Ppi-Sweep Amplifiers (fig. 61)

Ppi-sweep amplifier V606 and ppi-sweep power amplifier V608 produce a linear change in current through deflection coil L601 so that the beam of the ppi scope moves linearly from the center of the screen to the outer edge of the screen. A sawtooth voltage is applied from the ppi-sweep generator through both sections of V606, which act as voltage amplifiers, to ppi-power amplifier V608 which controls the current through deflection coil L601. There is a feedback from V608 back to V606A which makes it possible for the sawtooth voltage applied to the grid of V606A to cause a linear change in current through the deflection coil. Positive ppi-sweep clamper V607A makes the sweep start at the same point and extend for the same physical length as the sweep range is changed.

a. Both V606A and V606B normally conduct. The flow of V606A plate current through the cathode resistors of V608 (R651 and R648, R649, and R650) and the cathode resistor of V606A (R641) develops sufficient bias (approximately 2 volts) to operate the tube in its linear region. In a similar manner, cathode bias is developed across cathode resistor R642 to operate V606B in its linear region. Voltage dividers R644, R645, and R646, between −150 volts and ground, establishes the plate of V607A and therefore the grid of V608 at −63 volts. With the cathode of V608 close to ground potential and the grid at −63 volts, V608 is normally cut off and no current flows through deflection coil L601.

b. To have the ppi-scope beam move outward linearly, the ppi-sweep amplifiers must cause the current through deflection coil L601 to increase linearly (as a sawtooth). Normally, a trapezoidal voltage must be applied to a deflection coil to cause a sawtooth current to flow through both the inductance and the resistance of the coil. A trapezoidal voltage consists of a vertical jump in voltage followed by a sloping rise in voltage. The peak-to-peak amplitudes of all four ppi-sweep voltages are kept the same to keep the physical length the same for all four electrical sweep lengths. For the slow 160-mile sweep, the amplitude of the jump voltage amplitude needs to be small as compared to the amplitude of the sloping rise.

For the faster 20-mile sweep, the amplitude of the jump voltage needs to be larger as compared to the amplitude of the sloping rise. The use of a feedback amplifier compensates for the nonlinear characteristics of the tube that drives the deflection coil.

c. When the positive going input sawtooth is applied to V606A, plate current through V606A increases, plate current through V606B decreases, and the voltage at the plate of V606B rises. The rise in V606B plate voltage is coupled to the grid of V608 and this positive going voltage raises the grid of V608 above cutoff and plate current starts to flow to V608 and the deflection coil. As current through V608 increases, a voltage proportional to its plate current (current feedback) is applied to the cathode circuit of V606A. The sawtooth voltage developed at the cathode of V608 causes the cathode of V606A to go positive with respect to its grid. This feedback is highly degenerative to the sawtooth applied to the grid of V606A. The result is that the gain of V606A is considerably less than one (approximately .1) because of the feedback. When the circuit first goes into operation at time T_0, the feedback is not immediately effective because of the inherent time delays in the loop from the grid of V606A through V606A, V606B, V608, and back to the cathode of V606A. Before the negative feedback is fully effective, the higher gain characteristics of V606A result in a slight, but rapid, decrease in voltage at the plate of V606A. Without feedback, the gain of V606A would be so great that plate voltage would rapidly decrease and the stage would quickly saturate because of the large input waveform. The rapid decrease in the voltage at the plate of V606A is amplified by V606B and is important for proper circuit operation. Since V608 is normally operated beyond cutoff, the rapid change in voltage raises the grid of V608 above cutoff very close to time T_0 and into the more linear operating region of the tube.

d. The feedback to V606A and the resulting gain characteristics of the stage produce a distorted small negative-going sawtooth voltage at the plate of V606A. This voltage is amplified by V606B, which has a gain of approximately 20. The resulting amplified positive going distorted sawtooth voltage is coupled to the grid of ppi-power amplifier V608. This driving voltage resembles a trapezoidal voltage except that there is no clear-cut jump voltage and no clear-cut beginning to the sloping rise. The driving voltage causes the plate current of V608, which is the current through the deflection coil, to be *uniformly proportional to the sawtooth input to V606A.*

e. Damping resistor R657 (10K) decreases the amplitude of the positive spike in voltage that takes place at the end of sweep time when the input to V608 suddenly swings negative. When current through the tube is interrupted, the field about the deflection coil collapses to keep current flowing in the same direction. By furnishing a path for the continuing current, R657 limits the positive spike to approximately 340 volts. Resistor R640 is the plate load of V606B. Resistor R639 and capacitor C619A decouple the sweep amplifiers from other circuits supplied by +450 volts. The physical length of the sweep on the ppi scope is adjusted by varying PPI SWEEP LENGTH potentiometer R651. By affecting the gain of V608 and the amplitude of the feedback to V606A, the setting of R651 establishes the maximum current that flows through the deflection coil.

f. Ppi-gate clamper V607A is necessary because four different electrical sweep lengths are displayed on the ppi scope. The sharp rise of the driving voltage applied to V608 is the highest in amplitude for the fastest sweep (20-mile) because the slope of the rise of the input to V606A is the greatest and more amplification by V606A takes place before the current feedback becomes effective. By clamping the sweep voltage for the four sweep ranges all positive with respect to −63 volts, the amount of the rapid rise in voltage at the grid of V608 that appears above cutoff is automatically adjusted by the ppi-sweep amplifiers so that the required smaller sharp rise in voltage appears above cutoff as the sweep range is increased. The charge time constant of C620 is long during sweep time when the V608 driving voltage is coupled from the plate of V606B to the grid of V608. At the end of sweep time, V607A conducts so that C620 does not have to discharge through the high resistance of R647 (330K). In this way, C620 discharges quickly

to the same level regardless of the sweep range used. In all sweep ranges, the grid of V608 starts to go positive from the potential established by the voltage divider in the plate circuit of V607A.

g. The ppi-sweep circuits produce magnetic fields around the windings of deflection coil L601 which are proportional to current through the sweep-power amplifier. A magnetic field also exists around the electron stream itself (electrons in motion create this field). Interaction between the magnetic field around the electron stream and the magnetic fields around the deflection coil deflects the electron stream away from the area where the two fields aid and toward the area where the magnetic fields oppose one another (fig. 61). As the current through the deflection coil increases, the strength of the magnetic fields around the deflection coil increases and causes the electron stream to be deflected farther from the center of the cathode ray tube. Thus, the interaction between the fields produces a sweep which is always perpendicular to the magnetic fields around the deflection coil. Electrical contact from the plate of V608 through the deflection coil to +450 volts is maintained by slip rings so that the deflection coil yoke assembly may be rotated. The entire yoke assembly is rotated by a synchro receiver so that the sweep follows antenna rotation. Rotation of the yoke causes the magnetic fields around the deflection coil to rotate and because the sweep must always be perpendicular to these fields, the sweep rotates as the yoke rotates. The result is that a radial sweep (or time base), which always points to the same azimuth as the antenna, is produced on the screen of the ppi scope.

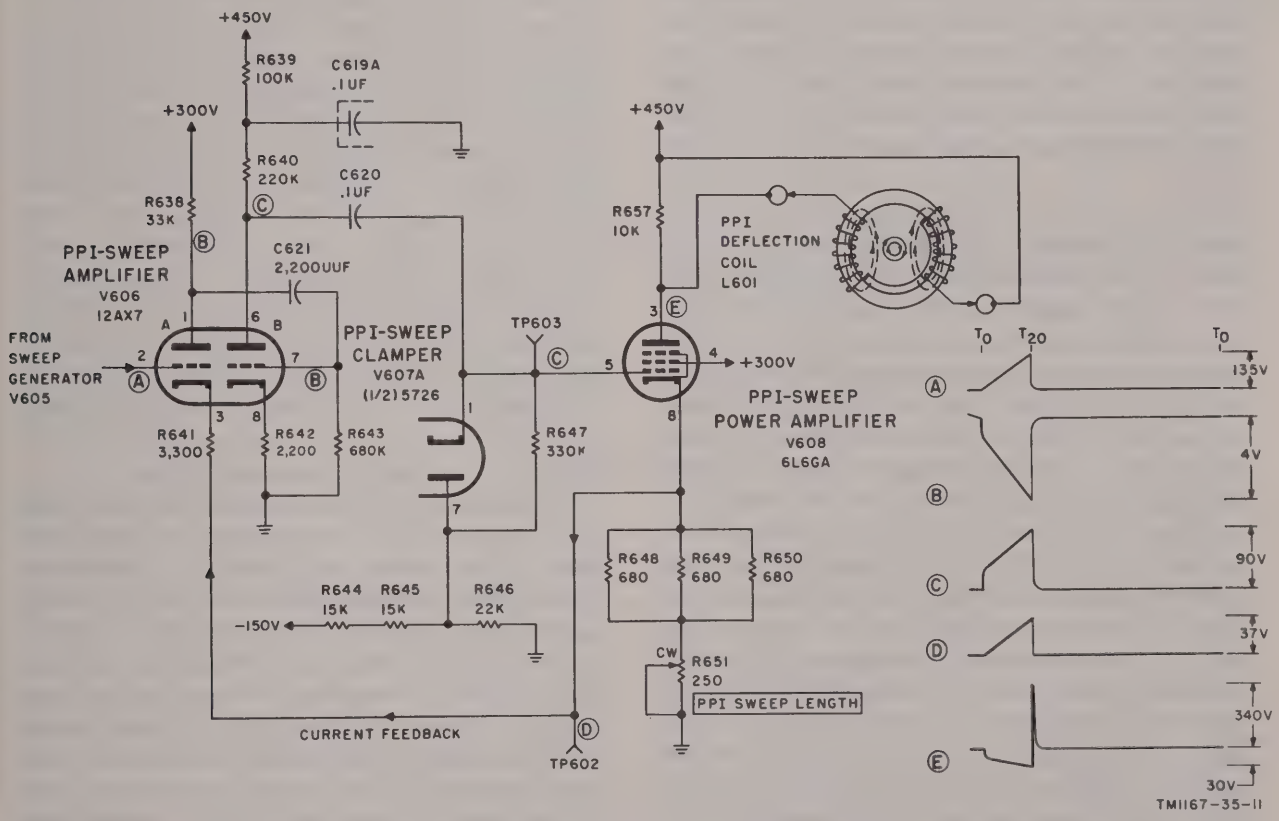


Figure 61. Ppi-sweep amplifiers, simplified schematic diagram.

118. General
(fig. 224)

The ppi-display circuits intensify fixed range markers, the variable range strobe, radar video, and iff video information on the screen of ppi scope V609. The ppi-display circuits also include ppi-focus current regulator V610, ppi video V607B, and associated voltage dividers which establish necessary dc operating potentials.

a. Fixed range markers, the variable range strobe, and both radar and iff video are applied from the common plate load of iff video-strobe mixer V601 and ppi video-marker mixer V602. All four types of information appear as negative pulses at the common plates of V601 and V602 and are coupled across R658 by C606. The negative pulses intensity modulate the cathode ray tube beam and cause intensified spots to appear on the screen. The ppi unblanking gate is applied from plate 6 of ppi-gate multivibrator V603 through parallel RC networks R656 and C622 to the control grid of V609.

b. Synchro stator information is applied from the antenna positioning system. The drive motor, which causes the antenna to rotate, is also geared to the rotor of a synchro transmitter which is excited by 115 volts, 400 cycles. As the synchro transmitter rotor is turned, the currents induced in the stator windings of the synchro transmitter flow through the stator windings of synchro receiver B602 through terminals 37, 38, and 41 of J601. The resulting fields induced about the stator windings cause the rotor of B602 to turn. The rotor of B602 is geared to the ppi deflection coil so that the ppi sweep rotates as the antenna rotates. A mechanical adjustment (AZIMUTH) is used to orient the ppi sweep to the antenna position. Microswitch S612 is part of an automatic synchronizing device (located in the antenna positioning system) which prevents the synchro receiver rotor from taking an incorrect position because a 24-speed synchro system is used to make the ppi sweep follow the position of the antenna (par. 154).

c. Plus 5,000 volts dc is applied from the indicator high-voltage power supply to the aquadag of V609 and +700 volts dc is applied from the same source to the first anode. Unregulated +450 volts dc and regulated +300 volts dc are applied to the circuit from the dc power supply system.

119. Ppi-Display Circuit Functioning
(fig. 62)

Ppi scope V609 is a 7BP7A type cathode ray tube that uses magnetic deflection to create a time base, intensity (grid) modulation to display information, and magnetic focusing to make the presentation sharp.

a. The cathode ray tube electron beam is controlled by the difference in potential between the control grid and the emitting cathode. Normally, the grid is held at +133 volts by voltage dividers R653 (in the 20 position of S606C), R655, and R656 between ground and the +225 volts normally present at plate 6 of ppi-gate multivibrator V603 before the unblanking gate is developed. The cathode is normally held at approximately +230 volts by voltage divider R661, R660B, R659, and R660A between ground and +300 volts. Maintenance adjustment COARSE INTENSITY potentiometer R660 establishes the range over which front panel INTENSITY control R659 can vary the normal cathode potential. With the first anode operated at +700 volts and the aquadag at +5,000 volts, the grid is normally operated sufficiently negative with respect to the cathode (approximately 100 volts) so that no beam current flows until the positive going unblanking gate is applied to the control grid.

b. When the positive unblanking gate is applied (at time T_o), the control grid of V609 rises above cutoff and beam current flows through the cathode ray tube during sweep time. The intensity potentiometers are normally adjusted so that the unblanking gate just brings the tube out of cutoff so that the negative pulses applied to the cathode cause noticeable increases in intensity. Capacitor C622 (62 $\mu\mu$f) is placed across R656 for high-frequency compensation so that the leading edge of the fast positive rise in the unblanking voltage is reproduced at the control grid of V609.

c. Four different electrical sweep lengths are displayed on the ppi scope. As the beam of a cathode ray tube moves across the screen

slower, the intensity of the trace increases because more electrons strike the screen per unit of time. Wafer switch sections S606C, R654, R653, R652, and the short from the 160 position of the switch to ground are used to compensate for this. When the sweep range is changed from the 20 position to the 40 position, R653 (10K) replaces R654 (15K) in the grid circuit so that the unblanking gate does not cause the control grid to rise as much above cutoff. The same type of compensation takes place as the sweep range is changed to 80 and 160 miles because less beam current is necessary to obtain the same screen intensity as the sweep is made slower.

d. The aquadag, which acts as the second anode of the tube, is operated approximately 5,000 volts positive with respect to the cathode. This difference in potential establishes an electric field which accelerates the electron stream toward the phosphorescent screen. If this were the only force acting upon the beam, the electrons would travel down the axis of the cathode ray tube and strike the center of the screen. The ppi-sweep circuits generate a sweep voltage which results in a second force that deflects the electron stream away from the axis of the tube during sweep time. The resultant of these two forces determines where the beam strikes the screen. Electrons emitted from the phosphorescent screen due to secondary emission are attracted to the positive aquadag and returned to the electron stream through the power supply.

e. The electrons emitted by the relatively large cathode surface are accelerated toward the center of the screen. However, they tend to diverge and strike the screen over a wider area than desired. Focusing the beam on the screen is accomplished by creating a magnetic field of sufficient strength to cause the electrons to converge at a focal point on the screen. The strength of the magnetic field about focus coil L602 determines where the various electrons making up the beam strike the screen. The strength of the field in turn depends on the amount of current flowing through the focus coil. The path of current is from ground through R671, R670, V610, R664, R663, and the focus coil to +450 volts. While most of the current is through smaller resistors R663 (3,100 ohms) and R664 (3,100 ohms), some of the focus current flows through the larger positioning potentiometers R662 (25K) and R665 (25K), which are in parallel with R663 and R664. Ppi-focus current regulator V610 controls the amount of current that flows through the focus coil. The control grid is grounded and the screen grid returns to regulated +300 volts through screen dropping resistors R666 through R669 (15K total). The flow of screen current through the screen dropping resistors holds the screen at approximately +205 volts. Since the control grid is grounded, the amount of plate current that flows through V610 (and therefore the focus coil) is controlled by the setting of FOCUS potentiometer R671 which controls the amount of cathode bias. Once R671 is adjusted to give proper focus current, this value is maintained even though the focus coil is returned to an unregulated +450 volts. This is due to the constant current characteristics of a pentode and the degenerative cathode circuit of V610. In the region in which the tube is operated the screen and cathode potentials control plate current which is almost independent of plate voltage. Any tendency for plate current to change is reduced by a change in the potential across the unbypassed cathode resistance. Resistor R670 protects the circuit from excessive current if the resistance of R671 is adjusted to zero.

f. Positioning of the ppi presentation is facilitated by the fact that the ppi-sweep driver is operated beyond cutoff. Before sweep time, there are no fields about the deflection coil so that if the gun structure of the tube and the yoke assembly are perfectly centered, the beam would normally strike the center of the screen when current starts to flow through the deflection coil. However, mechanical imperfections make a positioning system necessary. Positioning is accomplished magnetically by two coils which are a part of focus coil assembly L602. The electromagnetic fields of these coils influence the path of the cathode ray tube beam at right angles to each other. Part of the focus coil current flows through PPI CENTERING potentiometers R662 and R665. If all factors affecting the positioning of the beam are balanced so that the beam is centered, the potentials at the wiper arms of R662 and R665 are equal to the potential at the junction of R663 and R664 and no current flows through

the positioning coils. In this ideal case no positioning force is necessary. When necessary, ppi centering is accomplished by changing the magnitude and direction of current through R662, which positions the beam vertically or R665 which positions the beam horizontally. This is done by changing the potential of the wiper arm of the applicable positioning potentiometer with respect to the potential at the junction of R663 and R664.

g. As the ppi sweep is rotated, a circular intensified area is created upon which polar coordinate (slant range and azimuth) information is displayed. The information is coupled by C606 from the common plate load of iff video-strobe mixer V601 and ppi video-marker mixer V602 across R658 so that all four types of information appear as negative pulses at the cathode of V609. Capacitor C619B prevents the video pulses from appearing across the average intensity controlling voltage divider from the bottom of R658 to ground. Capacitor C619B is large enough (.1 μf) so that the voltage across it does not change appreciably during the application of the short duration negative pulses. In this way, the negative pulses are developed at the top of R658 (and the cathode of V609) with respect to the fixed dc potential established by the intensity potentiometers. With proper intensity adjustment, the unblanking gate just raises the grid above cutoff. The applied negative pulses cause beam current to increase and the intensity of the spots on the screen to increase amounts which depends on the amplitude of the negative pulses. The negative video pulses also cause pulses of first anode current. By supplying these pulses C623 (.5 μf) prevents degeneration by preventing the pulses of current from flowing through dropping resistor R673. With the antenna and sweep rotating, range markers and the strobe appear as concentric circles and video pulses appear as narrow arcs (blips) because the targets only appear at particular azimuths.

h. Ppi-video clamper V607B maintains the operating point of V609 by clamping the input composite video all negative with respect to

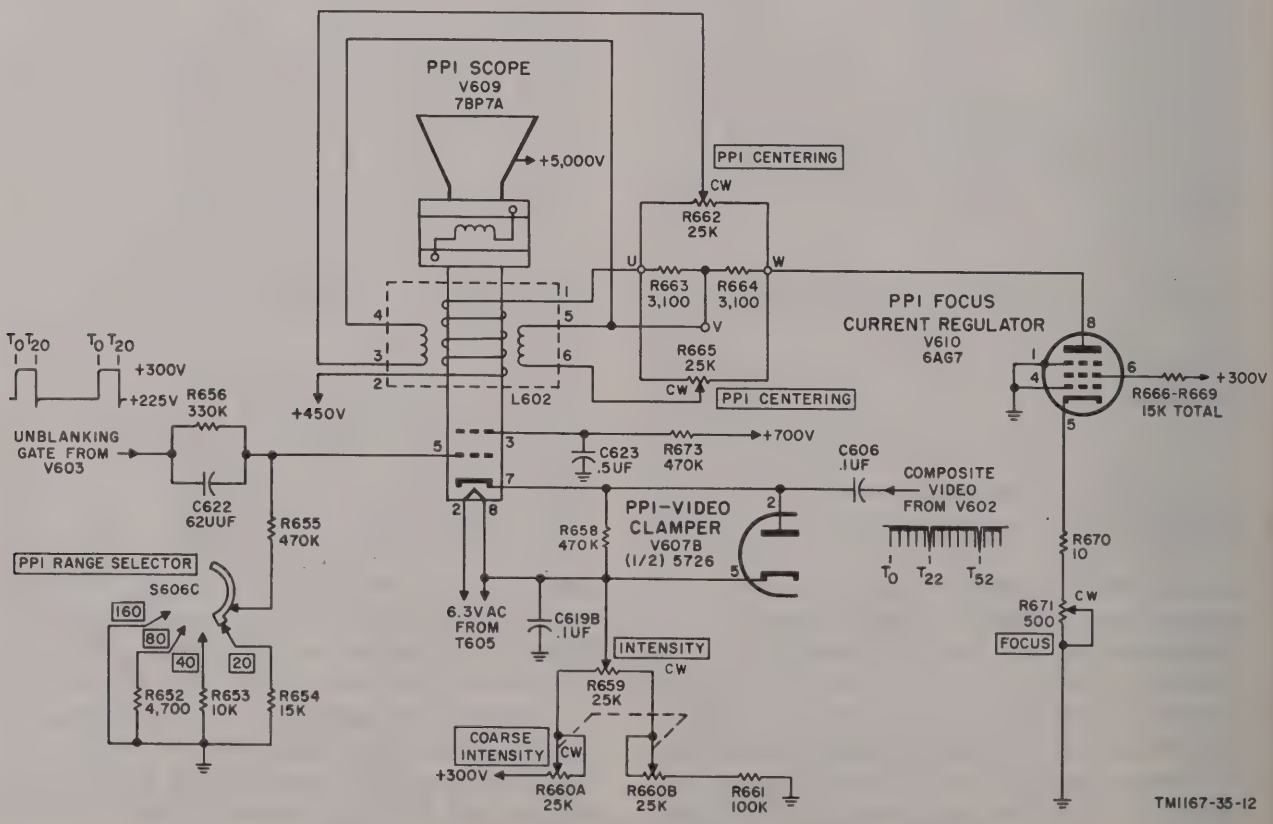


Figure 62. Ppi-display circuits, simplified schematic diagram.

the potential at the wiper arm of R659. The video pattern changes as the antenna rotates because there are different returns from different azimuths. This is especially true in the normal mode of operation because ground clutter is also displayed. If the video were not clamped, a weak target following strong ground clutter may remain unobserved. When a strong target is displayed, coupling capacitor C606 discharges through R658. Since the average current through a coupling capacitor is zero, at the end of the relatively long negative pulse, C606 regains whatever charge it loses. If V607B were not used or if it were to become defective, the recharge current of C606 up through R658 would cause the cathode of V609 to go positive with respect to the normal operating potential at the wiper arm of R659. In the case of a long negative pulse, this would cause the cathode potential of V609 to rise above the point where V609 cuts off and cause V609 to remain cutoff long enough to cause the loss of weak targets which follow. The clamper prevents this by conducting when C606 recharges. Since the resistance of the conducting diode is very low compared with the resistance of R658, C606 recharges quickly at the end of all negative pulses and the next negative pulse is developed from the level at which clamping takes place (the potential at the wiper arm of R659).

Section IV. FIXED RANGE MARKER CIRCUITS

120. General
(fig. 224)

Marker gate multivibrator V614, 16-kc gated oscillator V615, limiter-peaker V616A, 5-mile blocking oscillator keyer V616B, 5-mile blocking oscillator V617A, 25-mile blocking oscillator keyer V617B, 25-mile blocking oscillator V618B, and marker clamper V618A make up the fixed range marker circuitry.

a. The fixed range markers are triggered by the indicator trigger when the transmitter fires and normally produce 5- and 25-mile range markers for the ppi scope and A-scope. Four outputs are taken from the fixed range marker channel: negative 5-mile markers, positive 5-mile markers, negative 25-mile markers, and positive 25-mile markers.

b. The type of range marker that will appear on the ppi scope and A-scope depends on the position of, PPI RANGE SELECTOR switch S606, RANGE MARKS MILES switch S608, and A RANGE SELECTOR S609, and three soldered link connections. Normally, the links are connected as shown in figure 224 so that 5- and 25-mile range markers are produced. All discussions on the range marker circuitry assume that the links are in this position. The links (which actually consist of three hookup wire soldered leads) can also be placed in the dotted line positions shown in figure 224. In this case, only 10-mile range markers are produced and they are displayed on all sweep ranges.

c. When RANGE MARKS MILES switch S608 is in the OFF position, no fixed range markers are displayed on the scopes. When it is in the TEST position, both 5- and 25-mile range markers are displayed on both scopes, in the 80- and 160-sweep range positions.

d. When S608 is in the ON position, whether 5- or 25-mile range markers are displayed on the scopes depends on the positions of the respective range selector switches. When S606 is in the 20 or 40 positions, 5-mile markers are displayed on the ppi scope. When S606 is in the 80 or 160 position, 25-mile markers are displayed on the ppi scope. When S609 is in the 20, 40, or EXP position, 5-mile markers are displayed on the A-scope. When S609 is in the 80 or 160 mile position, 25-mile markers are displayed on the A-scope.

121. Marker Gate Multivibrator
(fig. 63)

Marker gate multivibrator V614 is a cathode-coupled, one-shot multivibrator which is triggered by the indicator trigger so that the range markers are synchronized with each sweep. It produces a negative gate which actuates the fixed range marker circuits and determines how many range markers are produced.

a. The grid of the B section of V614 returns to +300 volts through grid resistor R697 so

that slightly more than zero bias grid current and plate current normally flow through the B section. The flow of B section current through R698 and R699 makes the common cathode 75 volts positive with respect to ground. Voltage divider R690 and R689 between ground and +300 volts holds the grid of the A section at +51 volts with respect to ground. With the grid of the A section 24 volts negative with respect to its cathode, the A section is normally beyond cutoff and its plate at +270 volts.

b. Currents through most of the stages in the fixed range marker channel cause an average voltage drop of 30 volts across decoupling resistors R1601, R1602, R1603, and R1604. Decoupling capacitor C630B takes on an average charge of 270 volts. Since C630B is large (1 μf), it can supply pulses of current through the marker circuits and then recharge slowly. The voltage across C630B never changes more than a few volts during circuit operation, so that for all practical purposes C630B acts as a 270-volt battery and is B+ for the stages it decouples. In this way, the decoupling network reduces interaction with other circuits of the system which are operated from the +300-volt supply.

c. When the indicator trigger is coupled into the marker circuit by coupling capacitor C627, the flow of additional current up through R690 raises the grid of the A section above cutoff, and the A section fires. The flow of plate current through plate load resistors R692 and R691 causes the potential at the plate of the A section to drop and C628 to begin to discharge. The discharge of C628 cuts off the B section, allowing the A section to continue to conduct after the indicator trigger ends. The length of time that the B section remains beyond cutoff is determined by the time constant of the discharge of C628 (which is fixed), and the amount of the change in voltage at the plate of the A section when the A section fires (which is controlled by the setting of MARKER GATE potentiometer R691).

d. When the A section fires, R698 and R699, the dc plate resistance of the A section, R692, and R691 make up a voltage divider between ground and +270 volts. The setting of MARKER GATE potentiometer R691 determines how far below +270 volts the plate voltage of the A section drops at time T_o. For example, if the wiper arm of R691 is moved counterclockwise so that more of the resistance of the potentiometer is shorted out, when the A section fires, the plate current flow through the smaller plate load resistance causes less voltage drop at the plate. In this case, it will take less time for the discharge current of C628 to diminish to the point where it can no longer hold the B section beyond cutoff. It takes a capacitor the same length of time to *completely* adjust to any value of voltage change but in this case, the B section goes back into conduction and C628 must then recharge to the pretrigger voltage across it before C628 completely adjusts to the change in potential at the plate of the A section. MARKER GATE potentiometer R691 is adjusted so that the discharge current of C628 holds the B section beyond cutoff for a time equivalent to slightly more than 160 miles, so that the output gate width is just enough to include the 160-mile range marker.

e. When the discharge current of C628 diminishes to the point (T_{160}) where it can no longer hold the B section beyond cutoff, the circuit rapidly returns to the pretrigger conditions. The B section fires and the resulting voltage drop across the common cathode resistors causes the A section to cutoff and remain beyond cutoff until the next indicator trigger.

f. The circuit operation of V614 is the same if RANGE MARKS MILES switch S608 is switched from the ON to the TEST position. In the OFF position, the +300 volts is removed from the voltage divider in the grid circuit of the A section. The grid is then at ground potential during the pretrigger time. With the grid 75 volts negative with respect to the cathode, which is held at +75 volts by current through the B section, the 28-volt positive indicator trigger is insufficient in amplitude to bring the A section into conduction. The result is that the potential at the plate of the A section remains at +270 volts and there is no output gate from V614. Without this output gate, the succeeding stages remain inoperative and no fixed range markers are displayed on the indicators.

g. The output of marker gate multivibrator V614 controls the conduction of the following stage, 16-kc gated oscillator V615.

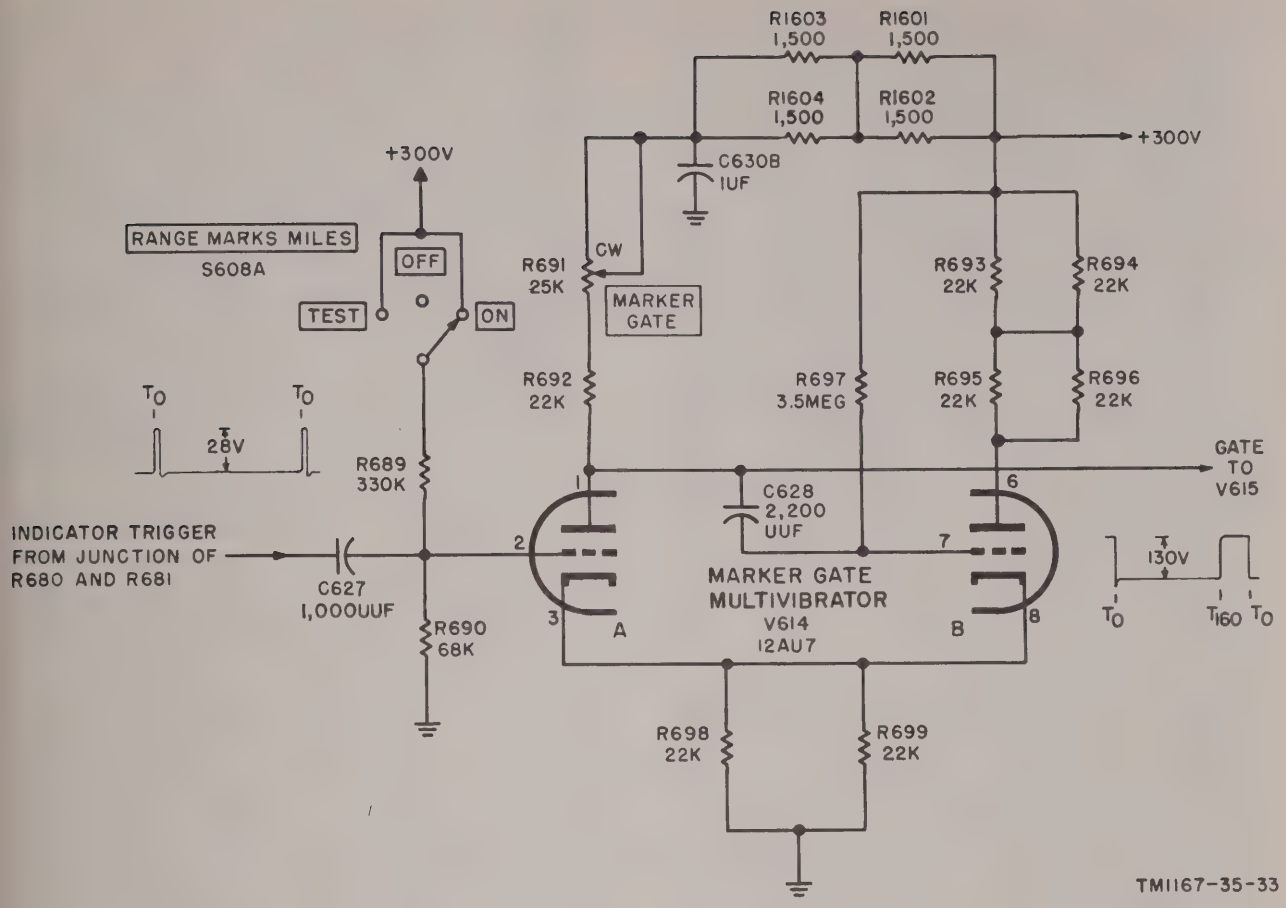


Figure 63. Marker gate multivibrator, simplified schematic diagram.

122. Gated Oscillator, 16-Kc
(fig. 64)

The 16-kc gated oscillator is made up of the two 12AU7 triode sections of V615. The A section is a shock-excited oscillator and the B section is a cathode follower which provides feedback into the tank circuit to produce a continuous 16.38-kc sine wave during the negative 160-mile gate from the marker gate multivibrator. The period of one sine wave of the output voltage is 61 microseconds which corresponds to 10,000 yards (approximately 5 miles) of radar range. The sine waves produced by V614 are converted into range markers by the succeeding stages.

a. The pregate conditions of the circuit are such that the A section conducts heavily (9.1 ma) and the B section conducts lightly (.9 ma). These two currents flowing through R1610 make the top of R1610 and therefore the grid of the A section +10 volts with respect to ground. The flow of both plate currents through the coil in tank circuit Z601 makes the cathode of the A section and the grid of the B section +12 volts. The flow of B section plate current through cathode resistor R1611 establishes the cathode of the B section at +29 volts. With this arrangement, the A section conducts heavily with 2 volts bias, and the B section conducts lightly with 17 volts bias. Flow of plate current through the A section plate load resistors R1606, R1607, R1608, and R1609 leaves the plate of the A section normally at +133 volts. The load of the cathode follower B section is in the cathode circuit (the S to T section of the tank coil and R1611); therefore, the plate of the B section remains constant at +270 volts.

b. Considering the operation of the A section and ignoring the B section temporarily, the A section operates as a shock-excited oscillator. Before the negative portion of the input gate

is applied, the normal flow of A section plate current through the tank inductor creates a strong, but stationary, magnetic field about the inductor. The only voltage across the tank circuit is the 2-volt drop across the dc resistance of the inductor (210 ohms).

c. When the negative gate is coupled in by C629 and developed across grid resistor R1605, the grid of V615A is suddenly driven beyond cutoff and plate current stops abruptly. An inductor opposes any change in current; therefore, the field about the inductor collapses. The collapsing field induces a voltage which is + at the S end and − at the F end of the inductor. This induced counter electromotive force causes current to continue to flow through the inductor in the same direction as it was previously flowing. Since the grid of the tube is driven well beyond cutoff and the current cannot flow through the tube, current flows from the lower plate of the tank capacitor into the upper plate, charging the capacitor. Once shocked by the sudden interruption of plate current, the energy originally stored in the magnetic field about the inductor is transferred to an electrostatic field across the capacitor. When the field has completely collapsed, the capacitor starts to discharge (from F to S through the inductor) and builds up an opposing field about the inductor, which tends to hold back the discharge of the capacitor. This oscillation continues sinusoidally but the losses in the circuit, due principally to the dc resistance of the inductor, cause the sine wave that is developed to gradually damp out. The frequency of oscillation depends on the size of the capacitor and inductor and is independent of the frequency of the input gate. The value of the inductance and therefore the frequency of oscillation is screwdriver adjusted to 16.4 kc by changing the depth of the core in the inductor. The amplitude of the initial oscillations and the degree of damping of the sine wave output taken from the top of the tank circuit depends on the Q of the tank circuit which is relatively low (32).

d. The B section of V615 is a cathode follower that decreases the amount of damping in the tank circuit by providing feedback into the tank circuit to replenish some of the energy lost due to tank circuit losses. The flow of plate current through the B section is from ground through bypass capacitor C631, the tank coil from S to T, R1611, and the tube to B plus. By determining the value of the peak current that flows through the B section and therefore through the tank inductor from S to T, the potential across the top of the inductor (F to T) and the size of R1611 determine how much of the loss in the tank circuit is compensated. Resistor R1611 is made large enough to limit the current through V615B so that the feedback does not quite make up for tank circuit losses. A 16.38-kc sine wave, which gradually decreases in amplitude from approximately 150-volts peak to peak at T_0 to 140 volts at T_{160} is taken from the top of the tank circuit during the negative input gate.

e. Parallel RC network R1610 and C631 makes the value of R1611 less critical. The time constant of the network is such that the dc voltage at the bottom of the tank (and therefore the dc voltage at the top of the tank and the grid to which the sine wave is applied) decreases exponentially to compensate for the fact that the amplitude of the sine wave output decreases exponentially. If this were not done, the range markers developed by succeeding stages would gradually become farther apart because of the gradual increase in the time it would take the decreasing output amplitude to drive V616A to cutoff.

f. When the input to the A section of V615 swings positive (T_{160}), the A section goes back into conduction and the current through the A section quickly damps out the tank oscillations. When the A section conducts, the flow of grid current in parallel with the current through R1605 causes C629 to charge quickly to the positive input voltage. When the input gate goes negative, grid current stops flowing and C629 can only discharge with a long time constant through the high resistance of R1605 (1 megohm). In this way, grid leak bias is developed to operate the grid well beyond cutoff (−68 volts). This is necessary because the oscillations in the tank circuit cause the cathode to swing highly negative with respect to ground. Without grid leak bias, the signal voltage would not be great enough to hold the A section cutoff during the entire 160-mile negative input gate. The action that takes place in the grid circuit of V614A is grid clamping.

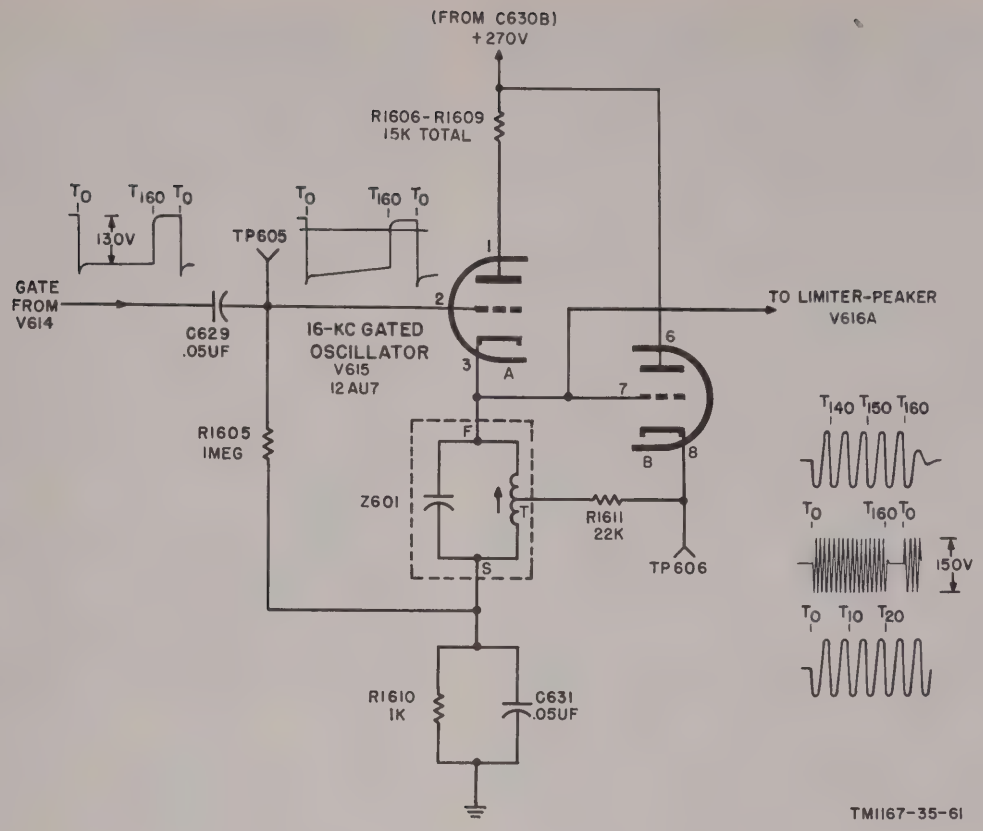


Figure 64. Gated oscillator, 16-kc, simplified schematic diagram.

g. The output of the 16-kc gated oscillator is taken from the common cathode of V615 and is directly coupled to limiter-peaker V616A. The waveform consists of 32 complete sine waves (starting with a negative alternation) and one critically damped sine wave, the leading edge of which becomes the 160-mile range marker.

123. Marker Circuits, 5-Mile (fig. 65)

The negative leading edges of the 16-kc sine wave produced by the 16-kc gated oscillator are converted into sharp positive peaks by limiter-peaker V616A. These positive peaks are applied through 5-mile blocking oscillator keyer V616B, which acts as a buffer stage, to single-swing 5-mile blocking oscillator V617A. The 5-mile blocking oscillator produces narrow range marker pulses which are applied to the ppi mixer circuit, the A-scope mixer circuit, and the 25-mile range marker circuit.

a. The bias on limiter-peaker V616A is normally 10 volts (grid +12 and cathode +22) so that approximately 6.7 ma plate current normally flows and creates a magnetic field about peaking coil L604. Because high frequencies must be reproduced in the plate circuit, a small plate load resistor is used (3,300 ohms). Since the input signal swings considerably positive, two methods are used to protect the tube from excessive current flow during circuit operation. Grid limiting is provided by R1612 in the grid circuit. Degeneration occurs across cathode resistor R1614 because cathode bypass capacitor C632 is too small (330 $\mu\mu$f) to bypass the sine waves of current through V616A.

b. With its grid normally at ground potential, blocking oscillator keyer V616B is held beyond cutoff by the flow of plate current through V616A which holds the common cathode at +22 volts. While cathode bypass capacitor C632 is too small to bypass V616A current, it effectively bypasses the narrow pulse current that flows through V616B during circuit operation.

c. With the range marker link connection in the B to C position, voltage divider R1623 and

R1622 holds the grid of 5-mile blocking oscillator V617A at −27 volts to produce 5- and 25-mile range markers on the indicators. With the cathode at ground potential, V617A is normally beyond cutoff. Capacitor C635 is normally charged to the bias potential of −26 volts and prevents stray triggering of the blocking oscillator.

d. Both V616A and V616B help the 5-mile blocking oscillator go into conduction as soon as possible as the 16-kc input sine wave swings negative (at 0, 5, 10, 15, etc., miles). When the input to V616A swings negative, it cuts off plate current. The field about peaking coil L604 collapses to keep current flowing through the inductor in the same direction. Because the flow of plate current is cutoff abruptly, the collapsing field causes a sharp positive rise in voltage at the plate of V616A. This rise in voltage is coupled across grid resistor R1615 by coupling capacitor C633. The rise in voltage at the grid of V616B causes it to conduct. Plate current flow through V616B causes a magnetic field to expand about the 5–6 winding of T602. This field induces a voltage across the 2–7 winding which is positive at the grid and raises the grid of V617A above the −26 volt bias reference. As soon as the induced voltage raises the grid above cutoff and some plate current begins to flow, a rapid regenerative action begins, which is characteristic of a blocking oscillator and independent of the input. To make the resulting range markers as accurate as possible, the action from the time V616A cuts off until the 5-mile blocking oscillator fires is almost instantaneous.

e. The degree of coupling between the plate winding of T602 (3–8) and the grid winding (2–7) is very close to unity. When plate current starts to flow through V617A, the plate voltage decreases and transformer action causes the grid (terminal 2 of the transformer) to go positive with respect to terminal 7. This causes a further increase in plate current, which causes the plate potential to decrease further and the grid potential to become even more positive. Since the grid has far more control over plate current than the plate potential has during this portion of the cycle, the grid potential is rapidly raised above the cathode potential and grid current starts to flow. The regenerative action continues with the plate current increasing, the plate voltage decreasing, the grid potential increasing, and the flow of grid current charging C635. The result is that with the grid becoming highly positive with respect to the cathode, the operation of the tube is moved into a very nonlinear region and the grid does not have as much control over plate current. As the grid continues going positive and the plate potential decreases, an equilibrium point is reached where the decrease in plate voltage has as much effect in decreasing plate current as the increase in grid voltage has in increasing it. Thus, there is no further increase in plate current, no voltage induced in the grid winding, and the regenerative action ends.

f. At the equilibrium point, there is no further increase in plate current, a stationary magnetic field exists about the plate winding because of plate current flow, no voltage is induced in the grid winding, a stationary magnetic field exists about the grid winding because of the flow of grid current, and the regenerative action ends. The circuit cannot remain in this equilibrium condition. With no further voltage induced across the grid winding, grid current tends to stop flowing. This causes the field about the grid winding to collapse and induces a counter electromotive force which is positive at the grid end of the grid winding, which keeps grid current flowing. Grid current cannot stop flowing until the field about the grid winding collapses. However, in this process, the grid becomes slightly less positive. While still in the nonlinear operating region of the tube, the decrease in grid voltage causes a decrease in plate current which in turn causes the field about the plate winding to start to collapse. The collapse of the field about the plate winding induces a voltage across the grid winding which is negative at the grid end of the grid winding. This induced voltage opposes the cemf due to the collapsing field about the grid winding and causes a further decrease in grid current. The action continues relatively slow with the grid becoming less positive, plate current decreasing, and the plate voltage rising.

g. As the grid becomes less positive, the tube is again operated in the more linear region where the grid has considerably more effect on plate current than the plate voltage and a

second rapid regenerative action occurs. Because of the gain of the tube in the linear region and the close transformer coupling between the increasing plate voltage and the decreasing grid voltage, the original field built up about the grid winding moves in all the way. Now the collapsing field about the plate winding induces a voltage across the grid winding which is negative at the grid end. This causes the grid to go negative with respect to the cathode, grid current to stop flowing, and the charge of C635 ends. Since C635 has a path through which to discharge and starts to discharge, the induced voltage across the grid winding due to the collapse of the field about the plate winding and the capacitor discharge both cause the grid to go negative with respect to the cathode. With the grid rapidly going negative, the result is that the change in grid current is almost instantaneous from the time grid current stops flowing until plate current stops flowing because of the second rapid regenerative action.

h. The length of time that plate current flows through V617A is principally determined by the characteristics of blocking oscillator transformer T602. In this case, the time (pulse width) is approximately 1.8 microseconds, and during this time a positive pulse of voltage is developed across cathode resistor R1621, and a negative pulse of voltage is developed across R2622 in the plate circuit. These pulses are the outputs taken from V617A.

i. When the plate current of V617A is cutoff by the second rapid regenerative action of the single-swing blocking oscillator, the change in plate current is so fast that ringing takes place between the plate winding (3–8) and its distributed capacitance. However, only one large positive swing in voltage (which raises the plate potential above the +270 volts plate supply potential) takes place at the plate of V617A because 5-mile blocking oscillator keyer V616B conducts heavily during this time and loads the plate winding. If the ringing does continue for a few cycles, the exponential discharge of C635 holds the grid well beyond cutoff so that the ringing could not cause V617A to go into conduction again. The time constant of the discharge of C635 is such (10

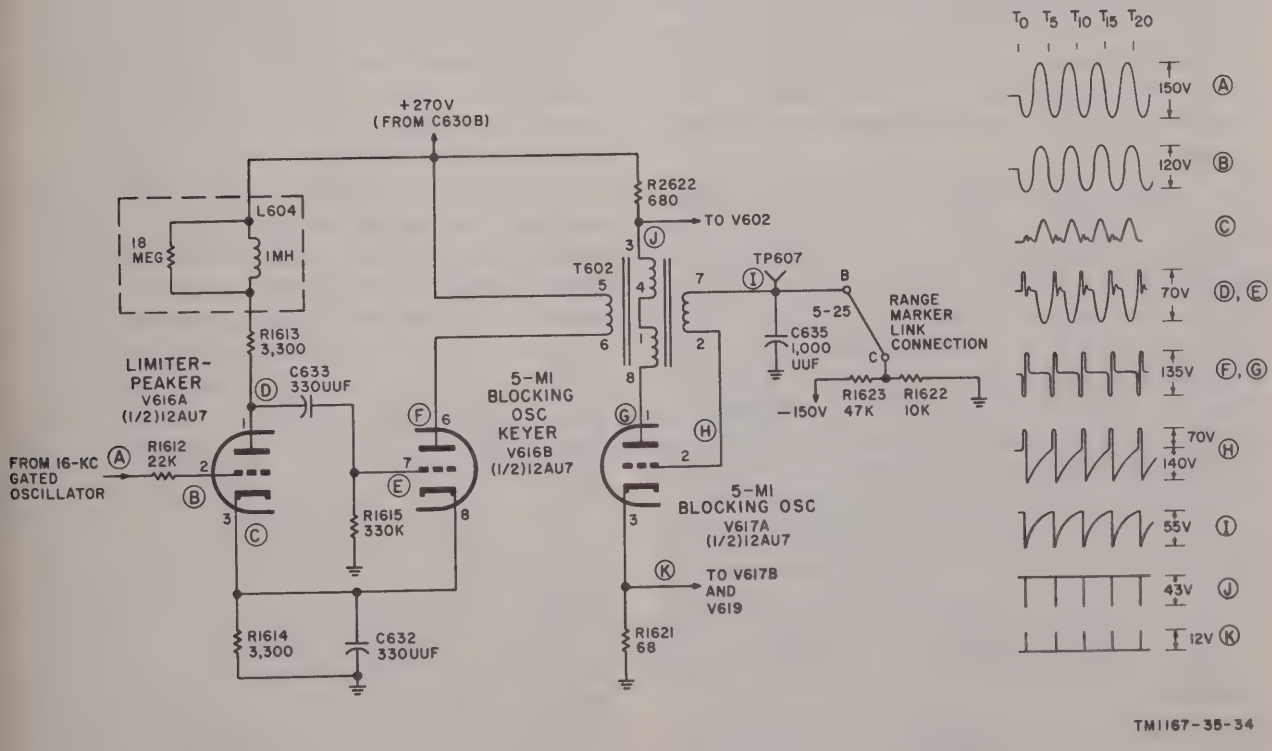


Figure 65. Five-mile marker circuits, simplified schematic diagram.

microseconds) that the circuit recovers completely during the 61 microseconds between range markers.

j. While plate current flows through 5-mile blocking oscillator V617A, negative pulses are developed across R2622. These pulses are applied through marker selector switches to ppi video-marker mixer V602. At the same time, positive pulses are developed across cathode resistor R1621. These pulses are applied directly to 25-mile blocking oscillator keyer V617B and through marker selector switches to A video-marker mixer V619.

124. Marker Circuits, 25-Mile (fig. 66)

The 5-mile range markers produced by the 5-mile blocking oscillator are used to produce 25-mile range markers. This is done by applying the 5-mile markers through 25-mile blocking oscillator keyer V617B so that every fifth 5-mile range marker triggers 25-mile blocking oscillator V618B into conduction. Marker clamper V618A permits the application of bias to V618B and at the same time, disconnects bias network R1624 and R1625 during a phase of circuit operation.

a. The 25-mile blocking oscillator keyer (V617B) is operated so that it normally conducts. The flow of plate current (5.2 ma) through cathode resistor R1626 (2,200) establishes the cathode 11.5 volts positive with respect to its grid, which is normally at ground potential.

b. The 25-mile blocking oscillator (V618B) is normally held beyond cutoff by the voltage divider in its grid circuit. The grid of marker clamper V618A is connected to its plate so that this triode section is operated as a diode. The plate returns to +300 volts through the grid resistors of the 25-mile blocking oscillator, R1619, R1630, and R1618, so that V618A normally conducts. Current through V618A flows from −150 volts through R1624, in parallel with current from ground through R1625. The normal plate current through V618A establishes the plate of V618A and therefore the grid of 25-mile blocking oscillator at approximately −33 volts if potentiometer R1618 (BO. ADJ.) is adjusted to obtain 25-mile range markers.

c. The pulse which occurs at time T_0 triggers V618B into conduction. From this time until grid current stops flowing, the circuit operation is the same as for 5-mile blocking oscillator keyer V616B and 5-mile blocking oscillator V617A (par. 123). The difference between the two blocking oscillator circuits is that the RC time constant in the grid circuit of V618B is much longer so that V618B is not triggered every 5 miles.

d. The flow of grid current during the single-swing blocking oscillator action charges C637 so that the ungrounded plate becomes considerably negative with respect to ground. When grid current stops flowing, C637 discharges through R1619, R1630, R1618, and the +300-volt power supply to ground. Its discharge current makes the plate of V618A negative with respect to its cathode so that marker clamper V618A cuts off and disconnects the voltage divider tied to its cathode (R1624 and R1625) from the circuit. The discharge of C637 holds V618A cutoff and V618B sufficiently beyond cutoff so that the next four 5-mile range markers are insufficient in amplitude to bring V618B into conduction. The time constant of the discharge of C637 is adjusted by changing the resistance of potentiometer R1618 (BO. ADJ.) so that the 5-mile marker occurring at time T_{25} raises the grid of V618B above cutoff and every fifth 5-mile marker triggers the 25-mile blocking oscillator. Thus V618B acts as a frequency divider and produces range markers one-fifth as often as 5-mile blocking oscillator V617A.

e. The grid of V618B is returned to +300 volts to stabilize the timing of the circuit. The discharge of C637 holds both V618B and V618A cutoff. Once V618A cuts off, C637 starts to charge so that its upper plate would be 300 volts positive with respect to ground. The 5-mile marker, which brings the blocking into conduction, interrupts this charge so that the top of C637 never becomes positive with respect to ground, but because C637 tries to charge to +300 volts makes its actual discharge time a more linear change and therefore the grid potential a sharper rise upon which the proper 5-mile range marker rides. In this way, circuit variations have less effect on the timing of the firing of V618B when the proper 5-mile marker triggers it. Potentiometer R1618 is adjusted to give 25-mile range markers approx-

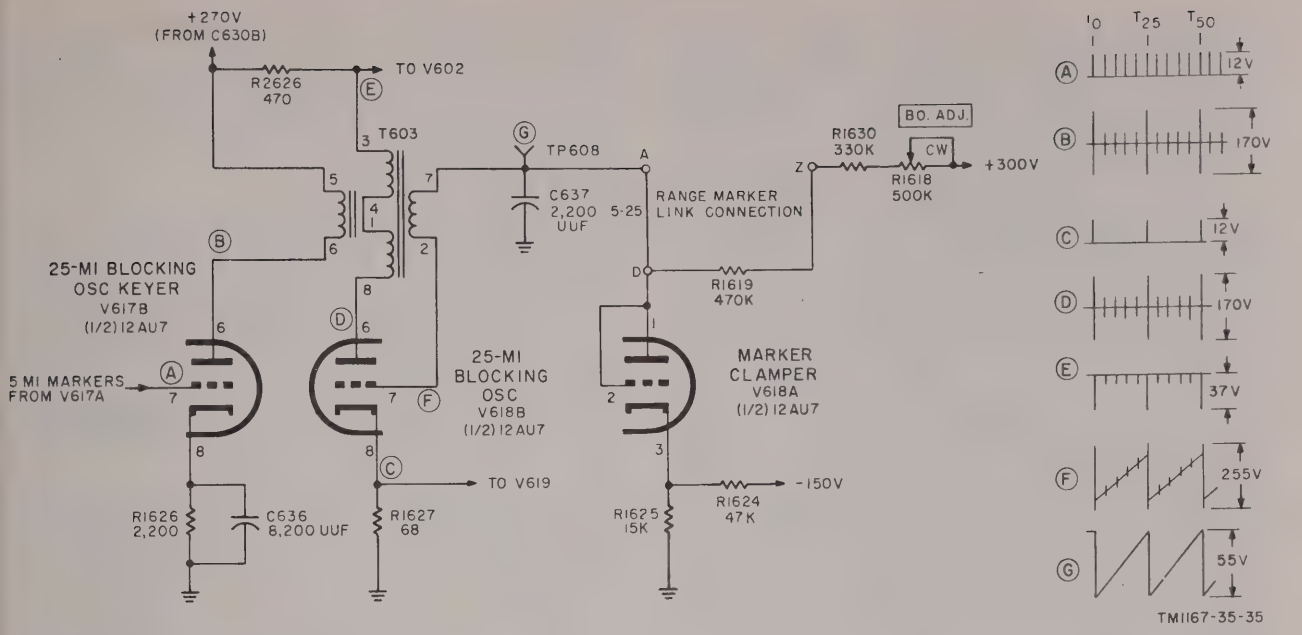


Figure 66. Marker circuits, 25-mile, simplified schematic diagram.

imately halfway between the points where the setting of R1618 would produce 20-mile markers and where the setting of R1618 would produce 30-mile markers. This arrangement (with the grid of V618B returned to +300 volts) gives maximum stability and maximum range for circuit variations and still produces 25-mile range markers.

f. Two outputs are taken from 25-mile blocking oscillator V618B. Negative pulses are taken from the plate circuit and applied through marker selector switches to ppi video-marker mixer V602. Positive pulses are taken from the cathode circuit and applied through marker selector switches to A video-marker mixer V619.

Section V. STROBE GENERATOR CIRCUITS

125. General
(fig. 224)

Range strobe multivibrator V621, strobe blocking oscillator keyer V613A, and strobe blocking oscillator V613B make up the variable strobe generator circuitry.

a. Range strobe multivibrator V621 is triggered by the indicator trigger and produces a variable time delay from approximately 10 to 150 miles later than the indicator trigger. Two outputs are taken from V621. One is applied to A gate multivibrator V622 when A RANGE SELECTOR S609 is in the EXP position to trigger the start of the expanded 10-mile sweep on the A-scope. The other is applied through strobe blocking oscillator keyer V613A to trigger strobe blocking oscillator V613B.

b. The strobe blocking oscillator produces a narrow negative pulse, which is applied through video-marker mixer V602 to the ppi scope to indicate the range at which the expanded sweep on the A-scope starts. This arrangement makes it possible to select a target on the ppi scope, vary RANGE STROBE potentiometer R1657 until the strobe is seen just preceding the selected target, and then observe the selected target on the expanded 10-mile sweep on the A-scope. This is possible, because the strobe on the ppi scope and the start of the expanded sweep on the A-scope move simultaneously in time.

126. Range Strobe Multivibrator
(fig. 67)

Range strobe multivibrator V621 is a cathode-coupled, one-shot multivibrator, which is

triggered by the indicator trigger, and produces a variable time delay. The output of V621 determines where the strobe appears on the ppi scope and at what range the expanded sweep on the A-scope begins.

a. Both grids of V621 are returned to +300 volts. Voltage divider R1658, R1657, and R1659 establishes the grid of the B section at +61 volts. Grid current through the B section helps establish this potential since both grid current and plate current normally flow through the B section. The flow of B section grid and plate currents through cathode resistors R1654 and R1656 establishes the common cathode of the multivibrator at +60 volts. Voltage divider R1653 and R1647 hold the grid of the A section at +38 volts. With the grid of the A section normally 22 volts negative with respect to its cathode, the A section is normally beyond cutoff. The pretrigger conditions are such that the B section conducts heavily with its plate at +100 volts and the A section is beyond cutoff with its plate at +270 volts.

b. The flow of four currents (the two voltage divider currents and the grid and plate currents through the B section) through decoupling resistor R1652 causes an average voltage drop of 30 volts across R1652 and results in decoupling capacitor C644 taking on an average charge of +270 volts. Capacitor C644 is large (.5 μf) and can supply pulses of current through the multivibrator and then recharge slowly. Since the voltage across C644 does not change more than a few volts during circuit operation, the 270 volts across C644 is B+ for the stage. Thus decoupling network R1652 and C644 reduces interaction between circuits operated from the same power source.

c. When the indicator trigger is coupled in by C643 and developed across grid resistor R1653, the grid of the A section rises above cutoff and the A section fires. The drop in potential at the plate (105 volts) causes C645 to discharge through the grid resistors so that the grid of the B section is rapidly driven beyond cutoff. The amount of the change in voltage at the plate of the A section when the A section fires and the time constant of the discharge of C645 determine how long the B section remains beyond cutoff. When the discharge current of C645 diminishes to the point where it can no longer hold the B section beyond cutoff, the B section fires and the circuit rapidly returns to the pretrigger conditions with the B section conducting heavily and the flow of B section current through the common cathode resistances, holding the A section beyond cutoff.

d. At the time of the indicator trigger (T_0), the waveform at the plate of the A section drops and remains low as long as the B section remains beyond cutoff. When the discharge of C645 can no longer hold the B section beyond cutoff, the circuit returns to the pretrigger conditions (T_{52}) and the voltage at the plate of the A section rapidly returns to +270 volts.

e. The length of the negative output gate from V621 depends on the setting of two potentiometers, strobe limit potentiometer R1655 (STROBE LIM) and RANGE STROBE potentiometer R1657. When the A section fires, common cathode resistors R1654 and R1656, the dc plate resistance of the A section, R1655, and R1648 make up a voltage divider between ground and +270 volts. The setting of R1655 determines how far below +270 volts the plate voltage of the A section drops at time T_0. For example, if the wiper arm of R1655 is moved toward the plate of the tube, less of the resistance of R1655 is shorted out and the current through the A section will cause a greater voltage drop across the greater plate load resistance. A greater voltage drop takes place at the plate of the A section, and with all other circuit values constant, it will take longer for the discharge current of C645 to diminish to the point where it cannot hold the B section beyond cutoff. It takes a capacitor the same length of time to *completely* adjust to any change in voltage, but in this case, C645 starts to recharge rather than continue to discharge. The B section goes back into conduction, the multivibrator rapidly switches so that the B section conducts heavily, and the A section cuts off and C645 must recharge to its pretrigger state. In this way, the setting of R1655 establishes the maximum length of time that V621 can be held beyond cutoff by establishing the amount of decrease in plate voltage at the plate of V621A when V621L is triggered into conduction.

f. The discharge current of C645 flows through R1657 and then in two paths from the wiper arm of R1657. One is through R1659

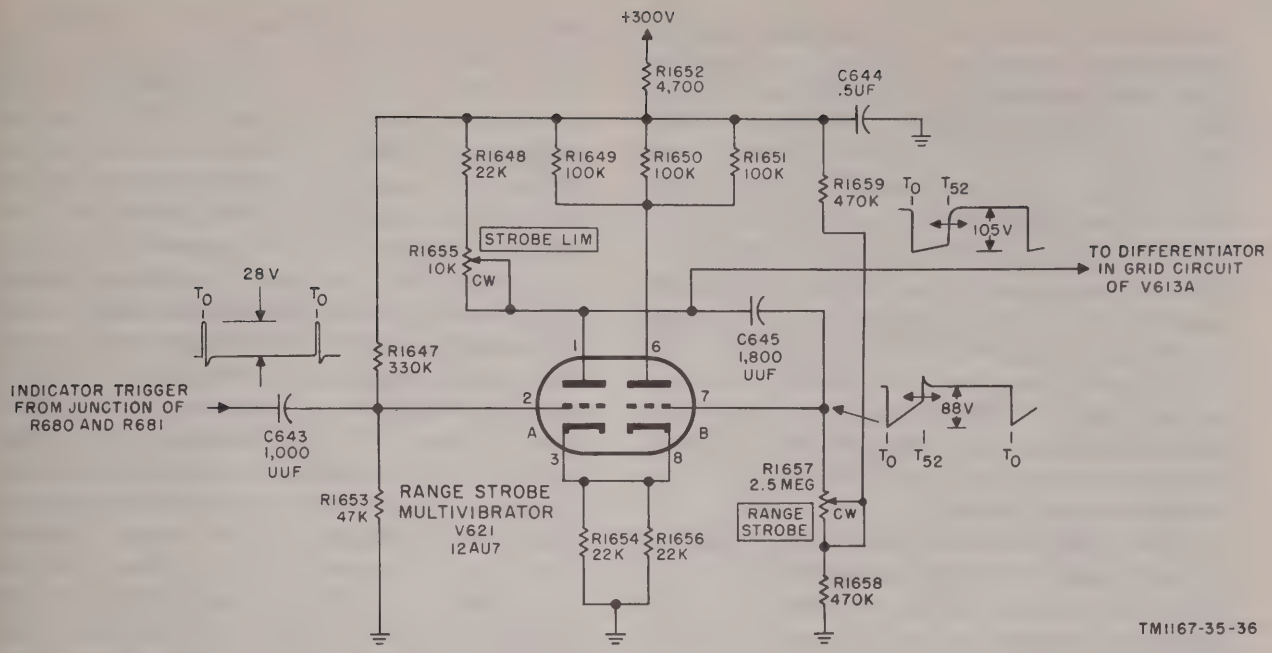


Figure 67. Range strobe multivibrator, simplified schematic diagram.

into C644 and from C644 to ground. The other is through R1658 to ground. The discharge path of C645 is completed from ground through R1654 and R1655 and the dc plate resistance of the A section. Resistors R1655 and R1657 limit the time the discharge of C645 holds the B section beyond cutoff. With the RANGE STROBE potentiometer set for maximum strobe position (maximum resistance), strobe limit potentiometer R1655 is adjusted to make the position of the strobe equal to 150 miles on the ppi scope. This adjusts the length of time that the A section of V621 remains conducting (and the B section remains beyond cutoff) to a time equivalent to 150 miles. Then, as the resistance of R1657 is decreased, the range of the strobe decreases until the resistance of R1657 is zero. At this time, the strobe is at its minimum range between 10 and 15 miles, depending upon exact circuit values.

g. A negative output gate is taken from the plate of V621A (pin 1). The variable time of the positive rise (T_{52}, with the conditions shown) of the output waveform is used in subsequent circuits to make the strobe on the ppi scope and the start of the expanded sweep on the A-scope occur from approximately 10 miles to 150 miles. The negative output gate is applied to strobe blocking oscillator keyer V613A.

127. Strobe Keyer and Blocking Oscillator (fig. 68)

Strobe blocking oscillator keyer V613A serves as a buffer stage between two oscillators, multivibrator V621, and strobe blocking oscillator V613B, and also damps out ringing which takes place in blocking oscillator transformer T601 during circuit operation. Strobe blocking oscillator V613B is a single-swing blocking oscillator which is used to generate a narrow pulse that appears as a strobe marker on the ppi scope. Each stage is a section of a 12AU7 medium mu dual triode.

a. Both cathodes of V613 are grounded and both grids are normally held at −27 volts by voltage divider R688 and R687 between −150 volts and ground. With 270 volts plate supply potential being supplied by decoupling capacitor C630B (fig. 63), cutoff for both tube sections is approximately −20 volts. Both tube sections are normally beyond cutoff and both plate potentials are normally equal to +270 volts. Capacitor C626, which is in parallel with R687, is normally charged to the bias

potential of −27 volts. It prevents stray triggering of the blocking oscillator by any sudden changes in voltage which might appear between R687 and R688, by holding this point at −27 volts.

b. The negative gate which is applied from strobe multivibrator V621 is differentiated by the short time constant of C646 and R686. The voltage appearing at TP604 is a sharp negative peak which corresponds in time to the indicator trigger and a sharp positive peak which corresponds in time to the variable trailing edge of the negative input gate. The variable positive peak leaves the strobe generator circuitry at this point to trigger the A-scope expanded sweep.

c. The sharp positive peak is also applied to the strobe blocking oscillator keyer. It raises the grid of V613A above cutoff and allows plate current to flow through the keyer. The surge of plate current through the 5–6 winding of T601 (which is the plate load for V613A) causes a magnetic field to expand and cut the 2–7 winding of T601. The voltage induced in the 2–7 winding raises the grid of V613B above the −27 volt bias reference. Almost instantaneously, the grid rises above −20 volts, plate current begins to flow through V613B, and normal single-swing blocking oscillator action results. Circuit operation is identical with that which takes place in 5-mile blocking oscillator V617A (par. 123).

d. The pulse of current that flows through V613B flows through R685 and develops a narrow negative pulse (1.8 microseconds) across R685. This negative pulse is applied through C625 and R584 to the cathode of iff video-marker mixer V601 and appears as a large negative pulse on the cathode of the ppi scope to make an intensified variable strobe marker appear on the screen of the ppi scope. The amplitude of the negative pulse taken from the plate circuit of V613B is controlled by strobe intensity potentiometer R685 (STROBE INT.). The pulse is amplified by a fixed amount in succeeding stages so that R685 controls the intensity of the strobe with respect to other information displayed on the ppi screen.

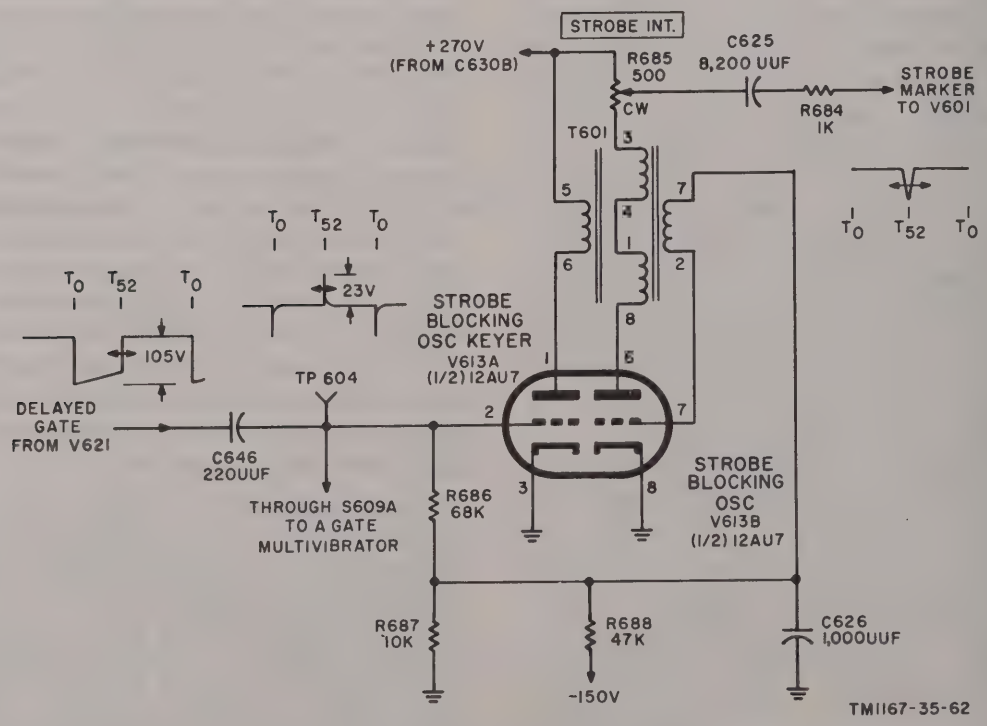


Figure 68. Strobe keyer and blocking oscillator, simplified schematic diagram.

128. General
(fig. 224)

The A-scope sweep circuits produce the necessary unblanking, positioning, and deflection voltages to produce a time base on the screen of A-scope V625. The A-scope sweep circuits consist of A-gate multivibrator V622 which produces the necessary gates, A-gate clamper V604B which operates in conjunction with the multivibrator for producing gates of various time durations, A-sweep generator V623 which produces a linear sawtooth voltage, and A paraphase amplifier V624 which produces positive and negative going sawtooth voltages to provide push-pull deflection of the beam of the A-scope.

a. The A-scope sweep circuits are actuated by the indicator trigger when A RANGE SELECTOR switch S609 is in the 20, 40, 80, or 160 position. In these positions, the time base on the A-scope starts at zero and extends for a corresponding range.

b. The sweep may also be delayed and started from between approximately 10 and 150 miles when S609A is in the EXP position. In this case, an expanded sweep of 10 miles duration appears on the A-scope. The start is triggered by the output of range strobe multivibrator V621.

129. A-Gate Multivibrator V622
(fig. 69)

A-gate multivibrator V622 is a cathode-coupled, one-shot multivibrator circuit which produces the unblanking and sweep gates for the A-scope. When S609A is in the 20, 40, 80, or 160 position, the indicator trigger is coupled from the junction of R680 and R681 by C643 (through S609A) in series with C647 to trip the multivibrator. In these four positions of S609A, the circuit values are virtually identical with those of ppi-gate multivibrator V603 and ppi-gate clamper V604A (par. 115).

a. In the EXP position of S609A, A-gate

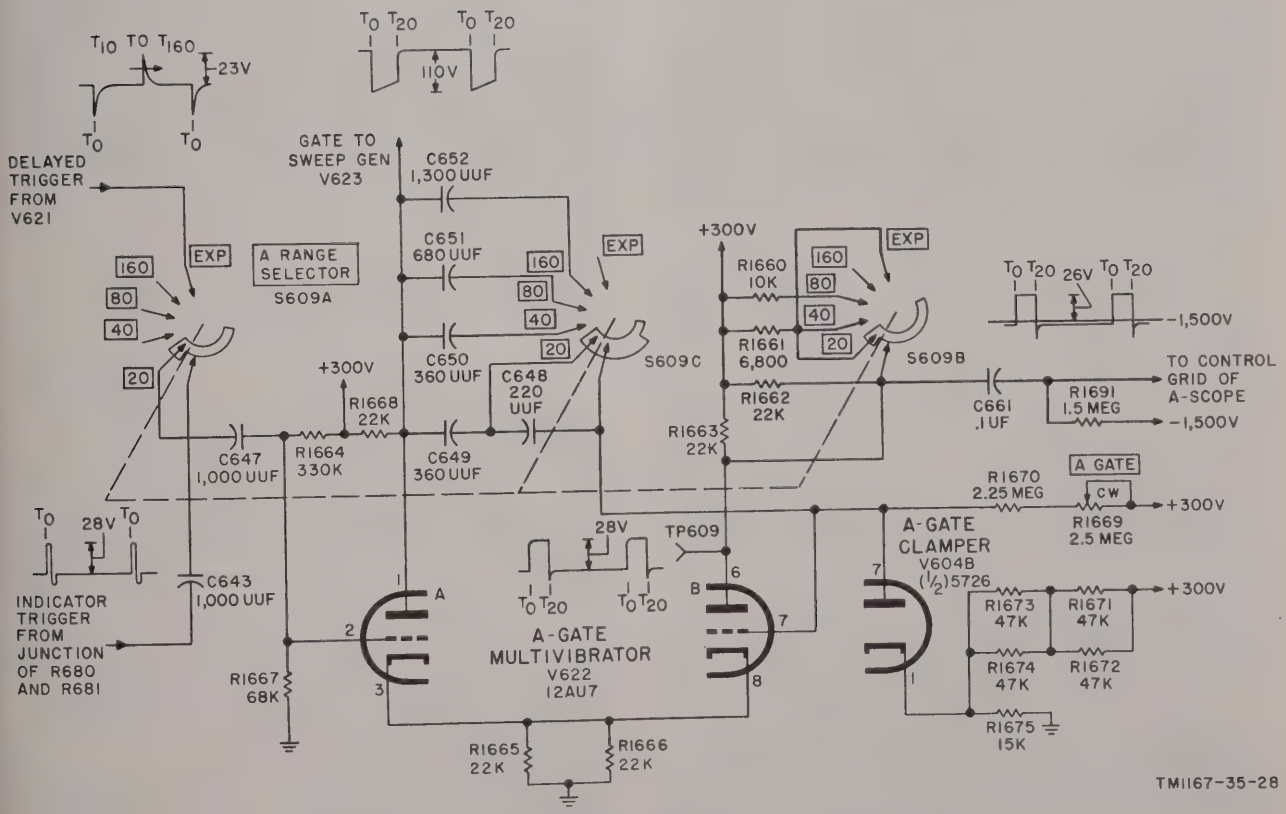


Figure 69. A-gate multivibrator, simplified schematic diagram.

multivibrator V622 is not actuated by the indicator trigger. Instead, the indicator trigger trips range strobe multivibrator V621, which develops a delayed trigger which in turn trips V622. The coupling from the A section to the B section of V622 consists of C649, C651, and C652 all in parallel and in series with C648 (C650 dropping out of the circuit in the EXP position of S609A). The effective capacitance in the coupling circuit is 210 $\mu\mu$f, which makes the output gates of the multivibrator 10 miles. The negative output gate is applied to A-sweep generator V623 to hold it beyond cutoff during expanded sweep time.

b. The B section plate circuit of V622 differs from the B section plate circuit of V603 in that the size of the plate load resistence of V622 is changed by S609B. However, this does not affect the *timing* of the multivibrator. It is done to adjust the amplitude of the positive output unblanking voltage that is coupled to the control grid of the A-scope to maintain the same intensity on the screen as the sweep speed is changed.

c. Since the control grid of A-scope V625 is operated at −1,500 volts dc, C661 is necessary to keep this large negative potential from the multivibrator plate. Because the coupling capacitor is used, resistors R1660, R1661, R1662, and R1663 are used in the plate circuit of the B section of V622. In the position of S609B that is shown in figure 69 the multivibrator circuitry is the same in the EXP, 20, and 40 positions. Resistors R1661, R1662, and R1663 make up the plate load of the B section of the multivibrator. In coupling the unblanking gate through C661 and across R1691, the coupling circuit determines how far positive (and negative) the grid of the A-scope goes with respect to the −1,500-volt reference.

d. In displaying various sweep speeds on a cathode ray tube, the slower the beam moves, the less positive the control grid needs to be (with respect to the cathode) to obtain a constant trace illumination, because the slower the beam is deflected, the greater the number of hits on the screen per unit of time. Waveforms A, B, and C of figure 70 show how the grid of V625 goes less positive as the unblanking gate width increases (sweep speed decreases) from EXP to 20 to 40. This results from the natural action of the coupling circuit, which makes the area above the −1,500-reference equal to the area below the reference.

e. A problem that results from the action of the coupling circuit is that as the sweep speed is changed to 80 and if no compensation in the unblanking amplitude is made, the grid of the A-scope will not go positive enough to maintain the proper intensity even though the sweep speed is decreased (waveform D). This is compensated for by increasing the plate load resistance of the B section of V622 to increase the amplitude of the voltage at the plate

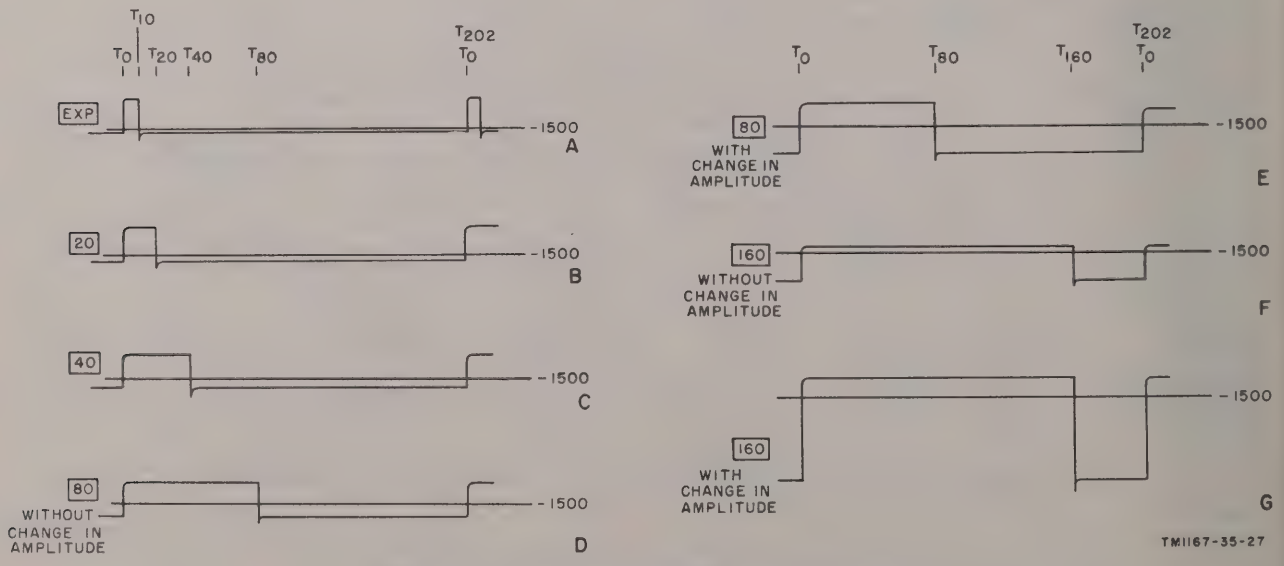


Figure 70. A-scope unblanking gate waveforms.

of V622B (waveform E). Resistor R1660 (10K) is substituted for R1661 (6,800 ohms), making the total plate load resistance of V622B higher when S609 is switched from the 40 to the 80 position. The plate load resistance, the dc resistance of the tube, and the cathode resistance make up a voltage divider between +300 volts and ground. If the plate load resistance is made larger, when the B section fires a greater share of the +300 volts appears across the load resistance and causes the plate voltage to drop to a lower potential. When the tube goes back into cutoff, a larger rise in potential takes place and the positive gate becomes greater in amplitude.

f. In the same way and for the same reasons, in the 160 position of S609B, the plate load resistance in the B section is increased by eliminating R1660 (waveforms F and G).

130. A-Sweep Generator (fig. 71)

A-sweep generator V623 produces a sawtooth voltage which is applied to A paraphase amplifier V624 which in turn produces push-pull voltages to form a time base between the horizontal deflection of A-scope V625.

a. The static (no indicator trigger) conditions are such that the grid and cathode are at ground potential and the screen is held at +80 volts by the flow of screen current through screen dropping resistors R1679, R1680, and R1681. The tube conducts very lightly because plate load resistors R1677 and R1676 are large. Because the zero bias dc plate resistance of the tube is very small compared to the plate load resistance, the plate voltage is approximately .5 volt and C657 is charged to this potential.

b. When the negative gate is coupled in by C653 and developed across grid resistor R1678, the tube cuts off. As soon as plate current ends, the plate potential would normally rise to +300 volts but the voltage at the plate can only rise as fast as C618 will charge through R1677 and R1676. The only immediate effect caused by the start of the negative gate is that the charge current of C657 replaces the plate current which previously held the plate voltage down. As long as the negative gate holds the tube beyond cutoff (247 microseconds in the 20 position of S609D), C657 charges exponentially toward +300 volts. Since the time constant of C657 and the plate resistance is very long compared with the duration of the negative gate, C657 charges for only .027 of a time constant (with R1676 at midrange); therefore, the rise in voltage at the plate is linear during the gate. The rise is to 9 volts if the negative gate is exactly 20 miles. The actual amplitude of the sawtooth voltage developed in the plate circuit is principally determined by the setting of A-scope SWEEP LENGTH potentiometer R1676. This potentiometer varies the *physical* length of the sweep on the A-scope by varying the amplitude of the output sawtooth of V623 from 6 to 15 volts. The linearity of the sawtooth is not affected by this control because the maximum that C637 can charge (with R1676 equal to zero) is 5 percent of the applied voltage and the rise would still be linear if C647 charged as high as 10 percent of the 300-volt change in voltage that takes place when the tube cuts off.

c. When the negative gate ends, C657 quickly discharges through the low resistance of the tube and the voltage at the plate remains at .5 volt until the next negative gate begins.

d. To have the 40-mile range sweep on the A-scope maintain the same physical length when the electrical length is changed to 40 miles by S609, C656 is added in parallel with C657 to double the charge time constant of the combined capacitance so that it will take twice as long for the combined capacitance to charge to the same potential during the gate which is twice as long. Similarly, in the 80 and 160 positions of S609, C655 and C654 are added in parallel to maintain the physical length when the electrical sweep length is changed to 80 and 160 miles respectively.

e. Capacitor C658 is shorted out in the 20, 40, 80, and 160 positions of S609. In the EXP position, the short is removed so that C658 becomes in series with C657, C655, and C654, which are all in parallel. The total capacitance from plate to ground becomes 935 $\mu\mu$f or approximately half of what it is in the 20 position. Since the gate time is also decreased to half by S609, the amplitude of the sawtooth remains approximately the same.

f. In all five switch positions of S609, the output of V623 is a sawtooth voltage of almost the same amplitude but the slope of the rise

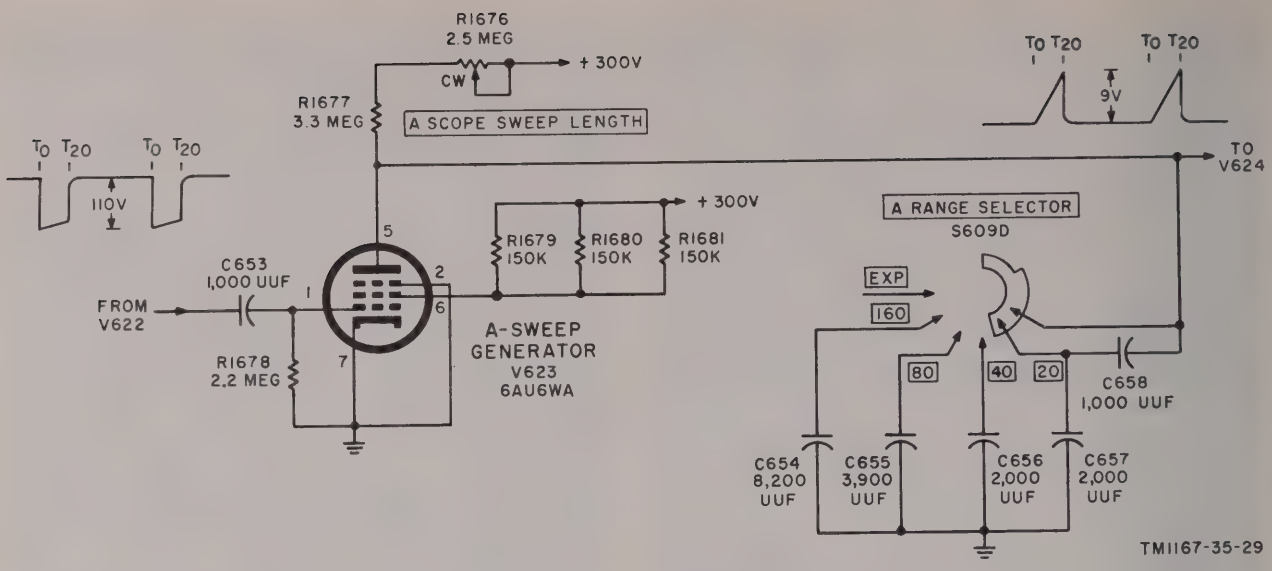


Figure 71. A-sweep generator, simplified schematic diagram.

changes so that it takes different times for the sawtooth to rise to the required amplitude. The output of V623 is applied to A paraphase amplifier V624.

131. Paraphase Amplifier V624 (fig. 72)

A paraphase amplifier V624 is a high mu twin triode operated as a cathode-coupled paraphase amplifier. The linear sawtooth voltage from the A-sweep generator is amplified by V624 and sawtooth voltages of opposite polarity are taken from the plates to provide for push-pull horizontal deflection of the A-scope.

a. Voltage divider R1688 and R1687 establishes the grid potential of the B section close to the cathode potential and therefore determines how much plate current normally flows through the B section. Parallel cathode resistors R1685 and R1686 (132K total resistance) are returned to −150 volts. The large cathode resistance is necessary to obtain balanced output voltages. Because of the degeneration that results across the large unbypassed cathode resistance, the plate supply potential for the stage is increased to 450 volts between −150 and +300 to obtain sufficiently large output sawtooth voltages to drive the horizontal deflection plates of V625.

b. Current through the common cathode resistance establishes the cathode of the A section at +2 volts. Since the grid of the A section is very close to ground, the operating point of the A section (−2 volts) limits the current flow through the A section to considerably less than the normal current through the B section. This normal unbalance in the static tube currents through equal plate load resistors R1682 and R1683 results in the plate of the A section being more positive (+230) than the plate of the B section (+100). Since these potentials are dc coupled to the horizontal deflection plates of V625, the left deflection plate is 130 volts more positive than the right deflection plate. The electric field between the deflection plates causes the cathode ray tube beam to be at the extreme left of the screen before the input sawtooth is applied. The start of the sweep is positioned to the left side of the A-scope so that it can move from left to right as the time base is formed.

c. As the input sawtooth voltage goes positive, plate current through the A section increases. The potential at the top of R1685 and R1686 becomes more positive with respect to the grid of the B section and causes plate current through the B section to decrease. Since the A section is the driving section and the B section the driven section of the paraphase amplifier, there must be a net increase in current up through R1685 and R1686. This means that the change in current through the A section slightly exceeds the change in current through the B section, with the difference in currents (the net increase in IR drops across R1685 and R1686) providing the drive for the

B section. In this way, the cathode coupling between the tube sections causes the voltage at the plate of the B section to rise as the voltage at the plate of the A section decreases. This action continues during the positive rise in voltage at the grid of the A section and the output sawtooth voltages cause push-pull horizontal deflection of the beam of V625. When the input sawtooth goes negative, the tube section currents quickly return to their normal values and the cathode ray tube beam is rapidly deflected to its starting position.

d. The fall time of the input sawtooth waveform is very rapid and the sawtooth contains higher order harmonics. Resistor R2623 prevents ringing of the lead inductance and stray capacitance in the grid circuit.

e. One-half of the 12AX7 tube is operated close to zero bias and the other is operated at −2 volts (for horizontal positioning); therefore, R1684 is placed in the cathode circuit of the B section as a degenerative compensation because the transconductance of the B section is higher. In this way, the current changes through the equal plate load resistors develop closely balanced output voltages. If the tube sections were operated at the same point, R1684 would not be necessary, but then the sweep would start from the center of the screen of V625.

f. The static grid potential of the B section of V624 is established by the setting of horizontal centering (HORIZ CENTER) potentiometer R1687. The grid potential determines the static dc potentials at the plates of V624 and therefore at the horizontal deflection plates. The sawtooth voltage input to the A section and the gain of V624 determine the ac swing in voltages at the plates. Varying R1687 varies the references about which the ac variations take place and therefore varies the positioning of the entire sweep on the screen of the A-scope.

g. Capacitors C659 (1.5 to 7 μμf) and C660 (5 μμf) balance the capacitance between the horizontal deflection plates and the vertical upper deflection plate. Capacitor C659 is adjustable to compensate for variations in wiring the

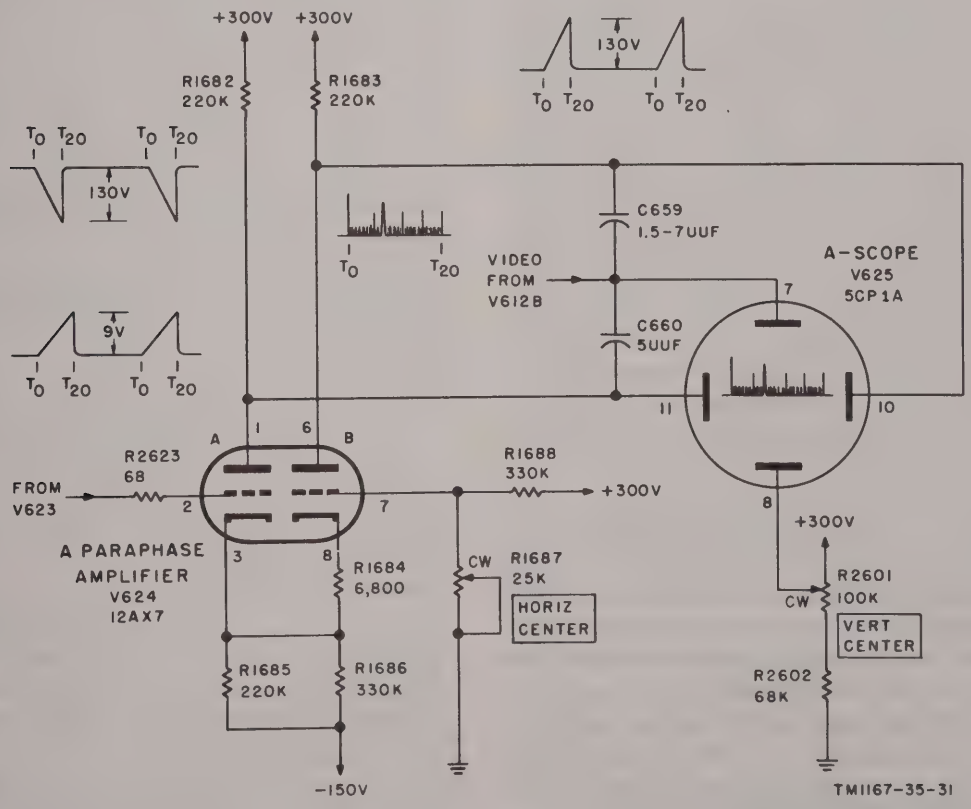


Figure 72. A paraphase amplifier, simplified schematic diagram.

deflection plates and for variations in the cathode ray tube characteristics. If the two pairs of deflection plates are unbalanced, the vertical deflection will not be at right angles to the base line trace so that video and marker signals will appear to lean to one side.

Section VII. A-SCOPE DISPLAY CIRCUITS

132. General
(fig. 224)

a. The A-scope display circuits display range markers and radar video information on the screen of cathode ray tube V625. The display circuits also include potentiometers and voltage dividers to establish the correct dc operating potentials for the cathode ray tube elements.

b. Minus 1,500 volts and positive 1,500 volts are applied to the A-scope from the indicator high-voltage power supply. An unblanking gate (from V622) and push-pull sweep voltages (from V624) are applied from the A-scope sweep circuits. Positive video pulses are applied to the vertical upper deflection plate from V612B in the video circuits.

133. A-Scope Display Circuit Functioning
(fig. 73)

A-scope V625 is a 5CP1A-type cathode ray tube which employs electrostatic deflection (position modulation) to display information and electrostatic focusing to make the presentation sharp.

a. Voltage divider R1692 through R1698 between −1,500 volts and ground establishes the dc operating potentials for the control grid (−1,500 volts), cathode (−1,460 to −1,350 volts) and first anode (−1,150 to −850 volts). Test point TP611 (−430 volts) is used to give a low level indication of the potentials along the voltage divider. Voltage divider R1690 and R1689 establishes the second anode potential between +225 and +300 volts. A +1,500-volt potential is applied to the aquadag coating within the bulb of the cathode ray tube from the indicator high-voltage power supply.

b. The cathode ray tube electron beam is controlled by the difference in potential between the control grid and the emitting cathode. Normally, the cathode is operated sufficiently positive with respect to the control grid (beyond cutoff) to prevent any beam current from flowing. During sweep time, an unblanking gate from A-scope gate multivibrator V622 raises the grid above cutoff and allows beam current to flow. The first anode, second anode, and aquadag, which are progressively more positive with respect to the cathode, accelerate the beam through the deflection plates to the phosphoresent screen. If the accelerating potentials were the only force acting on the beam, the beam would travel down the axis of the cathode ray tube and strike the center of the screen.

c. The A-scope sweep circuits generate sweep voltages which result in a second force that deflects the electron stream horizontally from the axis of the tube. Large positive pulses are applied from A-scope video amplifier V612B to the vertical upper deflection plate to attract the beam upward while range markers and video information are displayed. Thus the actual position of the beam as it strikes the screen is the resultant of three forces. The first anode, second anode, and aquadag accelerate the beam along the axis of the tube while the deflection plates cause the electron beam to move in the plane of the phosphorescent screen.

d. Vertical centering of the sweep is accomplished by varying the dc potential between the vertical lower deflection plate and the vertical upper deflection plate. Voltage divider R2602 and R2601, the vertical centering (VERT CENTER) potentiometer, makes it possible to vary the potential of the vertical lower deflection plate between +133 and +300 volts.

e. The amount of illumination of the trace on the screen is determined by the number of electrons that strike the screen. This is varied by INTENSITY control R1693, which controls the bias of the cathode ray tube. Cathode bypass capacitor C662 prevents degeneration when the unblanking gate is applied to the control grid. The filament of the tube is connected to the cathode to prevent breakdown between the filament and the cathode, which is operated approximately −1,400 volts with respect to ground.

f. Focus of the electron beam so that it strikes the focal point on the screen is affected

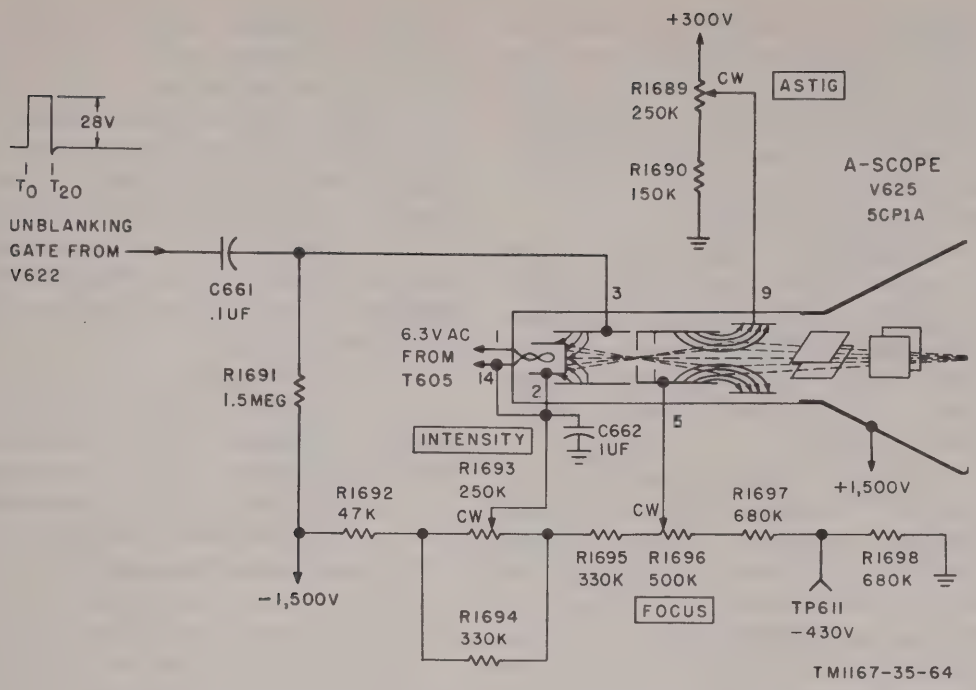


Figure 73. A-scope display circuits, simplified schematic diagram.

by two electrostatic fields: the field between the control grid and cathode and the field between the first and second anodes. For this reason there may be interaction between the INTENSITY and the FOCUS controls. The predominant factor affecting whether or not the beam reaches the focal point on the screen is the electrostatic field configuration between the first and second anode. Focusing is based on the principle that electrons are accelerated along electrostatic lines of force. FOCUS potentiometer R1696 adjusts the potential of the first anode with respect to the second anode so that the field configuration between the two anodes causes the electron beam to be in focus when it strikes the screen.

g. Astigmatism or elongation of the cathode ray tube electron beam, is caused by the average potential on one pair of deflection plates being different from the average potential on the other pair of deflection plates. Control R1689 (ASTIG) corrects astigmatism by making the second anode potential equal to the average voltage on the vertical deflection plates. (The vertical deflection plates are closest to the second anode.) Thus, the beam spot is made as round as possible. Then FOCUS control R1696, which affects both horizontal and vertical focus planes equally, is used to adjust the electrostatic field between the first and second anodes so that the beam reaches the screen of the tube at the correct focal point.

Section VIII. VIDEO AMPLIFIER CIRCUITS

134. General
(fig. 224)

The video amplifier circuits amplify the video pulses that are applied from the signal comparing system and range markers that are generated in the indicating system into sufficiently large pulses to display the position of targets of the ppi scope and the A-scope. Fixed range markers, the variable strobe marker, and iff video are mixed with the radar video pulses so that they are also displayed on the ppi scope. Fixed range markers are mixed with the radar video so that they are displayed on the A-scope.

a. In either the NORMAL or MTI mode of operation, radar video information leaves the

signal comparing system from coaxial connector J303 (fig. 219, sheet 1), and enters the power supply at J415 (fig. 233, sheet 1). The video signal pulses are carried from J407 in the power supply in a coaxial cable within the multiconductor cable which enters the indicator on terminal 47 of J601 (fig. 224).

b. The input positive video pulses are amplified by grounded grid video amplifier V611 and video cathode follower V612A, which are common amplifiers for both ppi and A video. Video is taken from the wiper arms of independent gain control potentiometers in the cathode circuit of V612A.

c. Positive video pulses are applied from the cathode circuit of V612A to ppi video-marker mixer V602 and then to the cathode of ppi-scope V609 as negative video pulses. Positive video pulses are also applied to A video-marker mixer V619, are amplified by A-video amplifier V612B, and applied to the vertical upper deflection plate of A-scope V625.

d. The amplitudes of the video pulses given in the stage analyses which follow were obtained by feeding an RF pulse into the directional coupler from a signal generator. With both video gain controls adjusted for maximum gain, the attenuator on the signal generator was adjusted to obtain a saturated pulse on the A-scope.

135. Common Video Amplifiers (fig. 74)

Video amplifier V611 and video cathode follower V612A are called common video amplifiers because they amplify video pulses that are applied to both the ppi scope and the A-scope. Outputs are taken from the cathode circuit of V612A to separate ppi and A-video amplifier channels.

a. The screen grid of V601 is connected to the plate so that the tube is operated as a triode. The stage is operated as a grounded grid amplifier. The normal flow of plate current through V611 develops sufficient cathode bias to operate the tube in its linear region. This bias voltage is developed across R672 (4,700) in parallel with R3337 (220) in the cathode circuit of cathode follower V3307 in the signal comparing system. Operation of V611 depends upon its cathode circuit being connected to the cathode circuit of V3307 which drives it. Proper transfer of power requires that the coaxial cable which carries video pulses to the indicating system be matched at both ends. The low input impedance of the grounded grid amplifier matches the impedance of the coaxial cable at the indicating system end. Decoupling network R675, R676, and C630A prevents the video pulses appearing in the plate circuit from affecting other stages supplied by +300 volts. Resistor R678 is the plate load for V611.

b. When a positive pulse is applied to the cathode of V611, it causes the cathode to go positive with respect to the grounded grid so that plate current decreases and the plate potential rises. No polarity inversion takes place through the grounded grid amplifier. The gain of the stage is approximately 11.

c. Video pulses are coupled from the plate circuit of V611 to the grid of V612A in a manner which depends upon the position of ANTI JAM switch S607. With S607 in the OFF position, video pulses are coupled from the plate circuit of V611 to the grid of V612A by the long time constant of C624 (.1 μf) and R679 (680K). The L603, R674, and CR601 components have very little effect on circuit operation so that video pulses of short or long duration are coupled to the grid of video cathode follower V612A.

d. To reproduce a pulse, the high frequencies must be reproduced in order to produce the rapid rise and fall of the pulse and the low frequencies must be reproduced in order to produce the top or constant amplitude portion of the pulse. A pulse can be differentiated by a high-pass filter which passes only high frequencies.

e. When S607 is in the ON position, R679 is shorted out, C624 and L603 make up a high-pass filter, and wide pulses of low-frequency jamming or extended ground clutter returns are differentiated. Capacitor C624 (.1 μf) and inductor L603 (17 mh) make up an ac voltage divider to the various frequencies making up a pulse. The low-frequency components in the input pulse do not appear across L603 due to its low reactance as compared to the high reactance of C624 at low frequency. At 400 cycles, the reactance of L603 is 43 ohms as compared to 4,000 ohms for C624. The high-frequency components in the input pulse appear

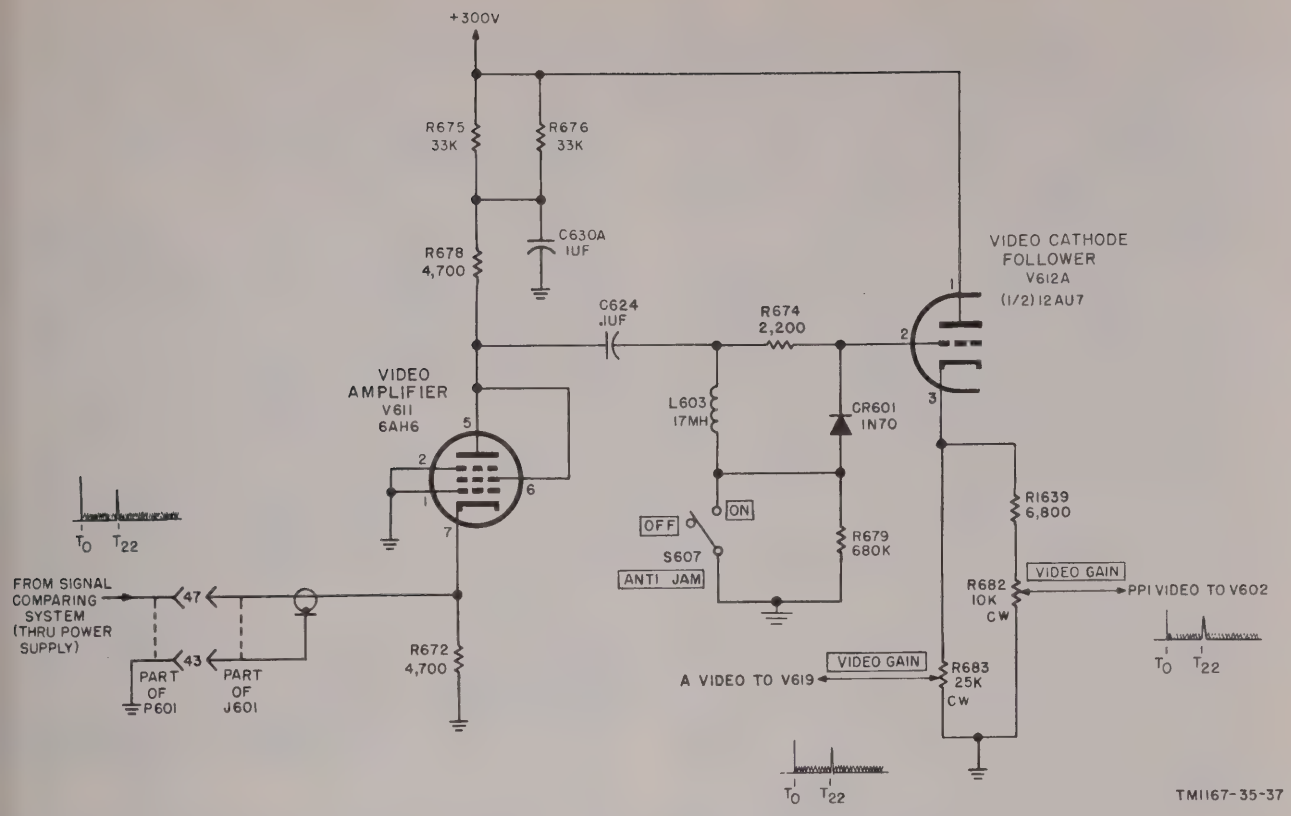


Figure 74. Common video amplifiers, simplified schematic diagram.

across L603 due to its high reactance as compared to the low reactance of C624 at high frequencies. At 1 megacycle, the reactance of L603 is 107K as compared to 1.6 ohms for C624; therefore, only the leading edges of the positive pulses coupled from V611 to V612A are reproduced across L603. In the case of pulses equal to the pulse width of the equipment (2 microseconds), this does not cause much loss and they are effectively coupled to V612A. However, only the leading edge of long duration pulses are coupled to V612A.

f. Crystal diode CR601 limits the negative overshoots which result from differentiating the positive pulses. The crystal diode has a low forward resistance (approximately 500 ohms from the grid of V612A to ground) and a high backward resistance (approximately 700K from ground to the grid of V612A). Resistor R674 and crystal diode CR601 operate as a parallel diode limiter circuit between the top of L603 and the grid of V612A. Positive pulses are not affected and appear across the high backward resistance of CR601 which acts as the grid resistor for V612A. Only a small portion of the negative overshoots appear across the forward resistance of the crystal diode because most of the negative pulse is developed across series limiting resistor R674 and does not appear as input to V612A.

g. Video cathode follower V612A has a high input impedance and a low output impedance. While it has a gain of less than 1 (approximately .9), it has good high-frequency response and provides a convenient method of controlling the amplitude of the video pulses that are applied to the ppi and A-video channels. Video to the A-video channel is taken from the wiper arm of VIDEO GAIN potentiometer R683. Video to the ppi channel is taken from the wiper arm of VIDEO GAIN potentiometer R682.

136. Ppi Video Mixers
(fig. 75)

Ppi video-marker mixer V602 and iff video-strobe mixer V601 mix four different types of video information (ppi video, fixed range

markers, iff video, and the variable strobe marker) to obtain one composite video signal which combines all four. The composite video signal is made up of negative pulses that are taken from the common plates of V601 and V602 and coupled to the cathode of ppi scope V609, which displays them as intensified spots on the screen.

a. Iff video-strobe mixer V601 is a sharp cutoff 6AH6 pentode-type tube. Cathode bias for the stage is developed across cathode resistor R612 by the normal flow of plate current and screen grid current. The flow of screen current through screen dropping resistor R1613 establishes the screen at +125 volts. Screen bypass capacitor C605A prevents degeneration when a signal is applied to either the grid or cathode by preventing the pulses of increased screen current from flowing through R1613.

b. Positive iff video pulses from the associated iff equipment are carried from the power supply in a coaxial cable within the multiconductor cable that connects to J601. Parallel resistors R601 and R610 terminate the coaxial cable in its characteristic impedance. A portion of the available iff video signal is taken from the wiper arm of IFF VIDEO gain potentiometer R610 and coupled by C604 across grid resistor R611. Parasitic suppressor R2625 prevents the sharp iff pulse transients from shocking the stray capacitance and lead inductance into oscillation.

c. The mixing of the two signals is accomplished by having both input signals cause an increase in plate current. Both the positive iff video signals which are applied to the control grid, and the negative strobe marker which is applied to the cathode, cause plate current to increase so that both types of signals appear as negative pulses in the common plate circuit of V601 and V602.

d. The operation of ppi video-marker mixer V602 is similar to V601, except there is more resistance in the cathode circuit (R615 and R1617) and the screen dropping resistor is smaller (100K) so that the screen grid is operated at +180 volts. These differences are necessary because of the wide range of amplitudes of the ppi video pulses. The stage is operated to give higher amplification to the weak video targets and at the same time limit the amplitude of the strong video signals and the range markers by having the tops of the strong signals drive the tube into the nonlinear operating region. This prevents excessively large negative pulses from appearing in the plate circuit and therefore the cathode circuit of the ppi scope where they could cause burns in the screen of the ppi scope.

e. Positive video pulses are coupled from the ppi gain potentiometer in the cathode circuit of V612A by C607 and developed across grid resistor R614. The positive going video pulses cause pulses of increased plate current across the common plate load resistors (R616 and R617) so that ppi video also appears in the composite video signal as negative pulses.

f. The fourth type of information included in the composite video signal at the plates of V601 and V602 is the fixed range markers that are displayed on the ppi scope. Whether range markers are displayed or not and whether 5-mile or 25-mile range markers or both are displayed depends upon the position of RANGE MARKS MILES switch S608 and the D and E wafer sections of PPI RANGE SELECTOR switch S606.

g. In the OFF position of S608, the A section of S608 prevents any fixed range markers from being generated (fig. 63). In the ON position of S608, 5-mile markers are displayed on the ppi scope when S606 is in the 20 or 40 position. Negative 5-mile markers are coupled from the plate circuit of the 5-mile blocking oscillator by C634. They are developed across a portion of 5–10 MILE MARKER INT potentiometer R1617 which is in the cathode circuit of V602. The position of the wiper arm of R1617 determines the amplitude of the negative 5-mile marker pulses that appear at the cathode of V602 and therefore the amplitude of the negative 5-mile marker pulses that appear in the composite video signal. Isolating resistor R1616 prevents loading of V617A when the wiper arm of R1617 is placed close to ground. With the switch conditions described, the 25-mile markers are grounded through the E wafer section of S608.

h. With S608 in the ON position and S606 in the 80 or 160 position, 25-mile markers are applied to V602 the same as the 5-mile markers are applied in the 20 and 40 positions. In this case, the 5-mile markers are grounded by the E wafer section of S606 so that the load on

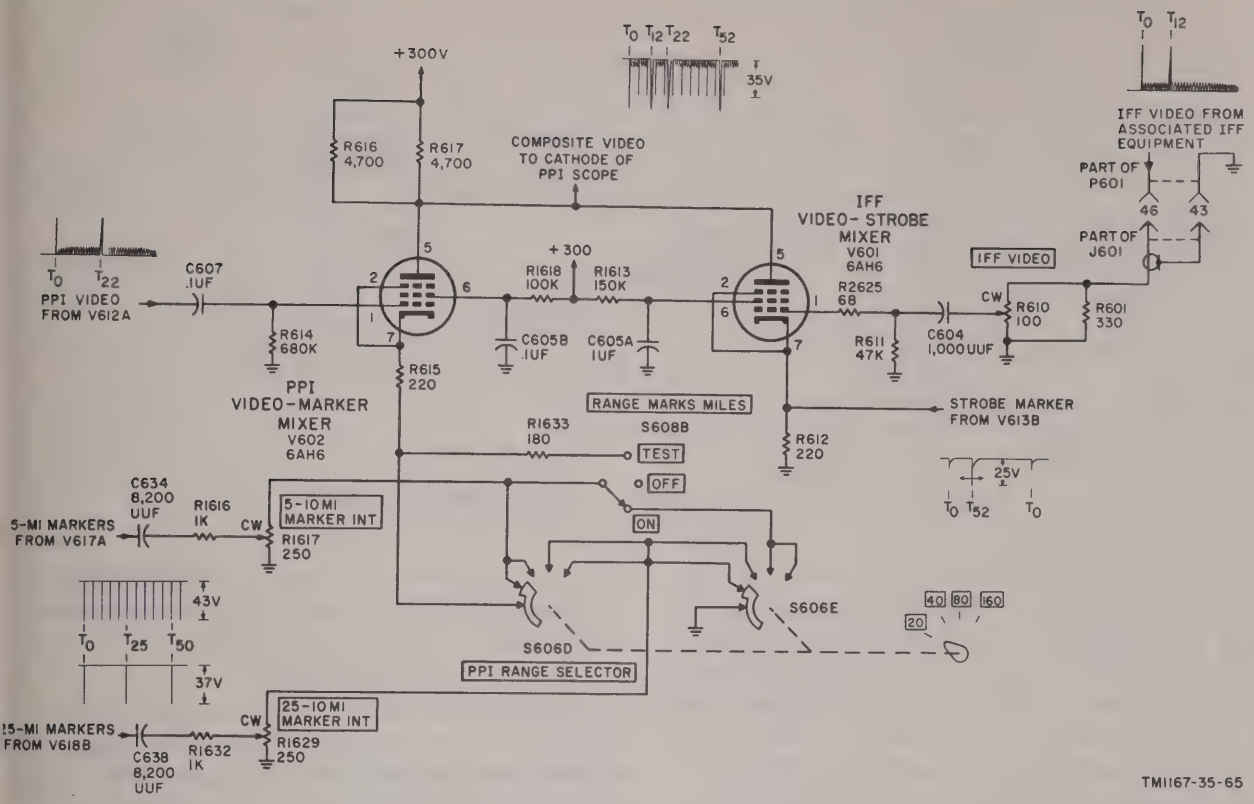


Figure 75. Ppi video mixers, simplified schematic diagram.

5-mile blocking oscillator V617A is not changed radically.

i. With S608 in the TEST position, both 5- and 25-mile markers appear in the ppi composite video signal when S606 is in the 80 or 160 position. In this case, R1633 is added in the cathode circuit of V602 to compensate for R1617 and R1629 being in parallel. The added resistance in the cathode circuit prevents a change in the amount of cathode bias developed and therefore prevents the operating point of the tube from changing too much.

137. A Video-Marker Mixer (fig. 76)

A video-marker mixer V619 is a medium μ twin triode which is used to mix the A video pulses and the fixed range markers before they are amplified and applied to the A-scope.

a. Both amplifier sections of V619 normally conduct. Both grids are operated at ground potential and approximately 9 volts cathode bias is developed across common cathode resistor R1638. A video-marker mixer V619 combines the inputs to the grid circuits into a composite video signal. Mixing takes place across common plate load resistor R1636. The gain of each tube section is approximately two because of the relatively small plate load and the relatively large unbypassed cathode resistor.

b. Positive video pulses are coupled from the gain potentiometer in the cathode circuit of V612A by coupling capacitor C639 and developed across grid resistor R1635. The positive video pulses are applied to the pin 2 grid, and positive fixed range markers are applied to the pin 7 grid, so that both appear as negative pulses in the plate circuit. Whether range markers appear in the composite signal or not, and whether the markers are 5 or 25 markers or both, depends upon the position of RANGE MARKS MILES switch S608 and the E and F wafer sections of A RANGE SELECTOR switch S609.

c. In the OFF position of S608, the A section of S608 (fig. 63) prevents any fixed range markers from being generated. In the ON position of S608, 5-mile markers are displayed

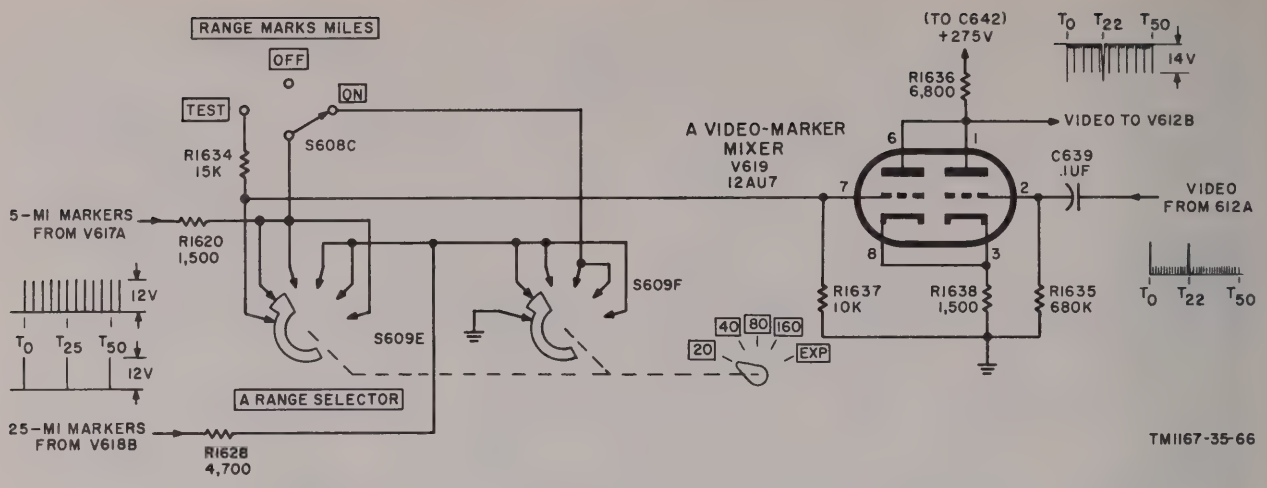


Figure 76. A video-marker mixer, simplified schematic diagram.

on the A-scope when S609 is in the 20, 40, or EXP position. The 5-mile markers are applied from the cathode circuit of the 5-mile blocking oscillator through isolating resistor R1620 and the E section of S609. They are developed across grid resistor R1637 and appear in the composite video signal as negative pulses.

d. In the ON position of S608, 25-mile markers are displayed on the A-scope when S609 is in the 80 or 160 position. Positive 25-mile markers are applied from the cathode circuit of the 25-mile blocking oscillator through isolating resistor R1628 and the E section of S609. They are developed across R1637 and appear in the composite video signal as negative pulses.

e. In the TEST position of S608, both 5- and 25-mile markers are displayed on the A-scope when S609 is in the 80 or 160 position. In this case, R1634 (15K) forms a voltage divider with R1637 (10K) so that the amplitude of the 5-mile markers is reduced. This is done so that the 25-mile markers stand out as larger amplitude markers on the A-scope. Negative video and range markers are applied from the common plates of V619 to A video amplifier V612B.

138. A-Video Amplifier and Clamper (fig. 77)

A-video amplifier V612B amplifies the composite A video that is applied from the A video-marker mixer and also operates as a cutoff limiter which establishes the maximum amplitude of strong targets on the A-scope. A-video clamper V620A clamps the input negative video all negative with respect to ground to insure that weak targets which follow strong ones receive proper amplification.

a. The normal flow of plate current through V612B (10 ma) develops 5 volts bias across cathode resistor R1641 so that the tube is operated in its linear region. Cathode bypass capacitor C641 is large enough to bypass narrow video pulses but small enough (1,000 $\mu\mu$f) so that desirable degeneration takes place when long duration pulses are applied. The normal flow of plate current to +300 volts also causes a voltage drop of 50 volts across decoupling resistors R1642, R1643, and R1646 (5K total) so that decoupling capacitor C642 (2 μf) is normally charged to +250 volts. Since the voltage across C642 is effectively B+ for the stage, the dynamic transfer curve for the stage is such that cutoff is −15 volts. The normal flow of plate current through plate load resistors R1644 and R1645 (6K total) causes a voltage drop of approximately 60 volts so that the plate potential is normally 190 volts. With these static conditions, the maximum positive swing that can take place at the plate of V612B is 60 volts. This is when large amplitude negative video pulses and range markers drive the stage into cutoff.

b. The negative composite video signal is coupled from V619 by C640 and developed across grid resistor R1640. The positive composite video signal developed at the plate of V612B is applied directly to the vertical upper deflection plate of A-scope V625. There the

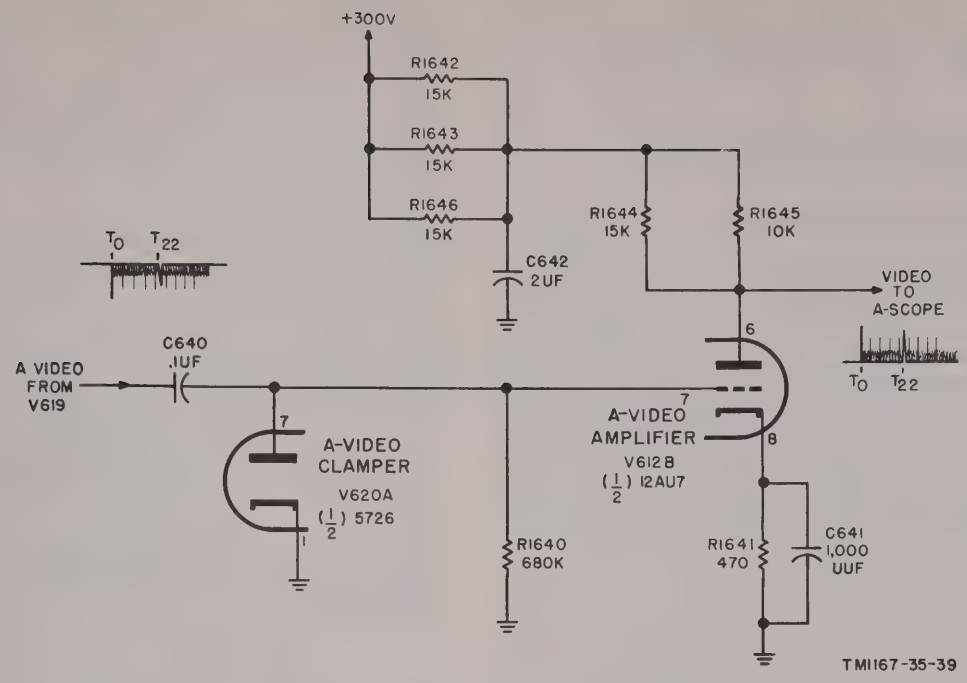


Figure 77. A-video amplifier and clamper, simplified schematic diagram.

individual target video pulses and range marker pulses appear as sharp positive pulses above the time base on the A-scope screen.

c. A-video clamper V620A has no effect on circuit operation while the input video signal swings negative. The negative swing in voltage that causes C640 to discharge through R1640 in order to develop the pulse at the grid of V612B causes V620A to cut off. An individual pulse of 2 microseconds duration does not cause C640 to discharge very much because of its large size (.1 μf). However, when pulses of longer duration are applied, C640 may have time to discharge enough so that its recharge at the end of the pulse becomes a problem. When the negative pulse ends, V620A conducts and provides C640 with a fast time constant recharge path. This is necessary so that the recharge current of C640 does not drive the grid positive with respect to ground. If V620A were not in the circuit or if it were to become defective, a long pulse could cause the grid of V612B to go positive for a period of time while C640 recharges. During this time, a weak negative pulse could not be developed at the grid of V612B and therefore would not be observed on the A-scope.

Section IX. INDICATOR HIGH-VOLTAGE POWER SUPPLY

139. General
(fig. 224)

The indicator high-voltage power supply provides high-voltage potentials to operate the cathode ray tubes. Minus 1,500 volts is applied to the voltage divider that furnishes normal operating potentials for the grid, filament, cathode, and first anode of the A-scope. Plus 700 volts is applied to the first anode of the ppi scope, +1,500 volts is applied to the aquadag of the A-scope, and +5,000 volts is applied to the aquadag of the ppi scope.

a. Power is applied to the primary of high-voltage transformer T604 through terminals 26 and 27 of J601. Indicator lamp I 610 lights when primary power is applied to the indicator high-voltage power supply to indicate that high voltage may be present in the indicator. Resistor R2620 (180K) is placed in series with I 610 to obtain long life operation of the glow lamp, because it requires only 65 volts ac to ionize.

b. For power to be applied to T604, three interlocks (or their interlock defeats) must be

closed. These interlocks are S603 in the indicator, S504A in the receiver-transmitter, and S402 in the power supply (fig. 229, sheet 1).

140. High-Voltage Rectifier V626
(fig. 78)

The indicator high-voltage power supply consists of half-wave rectifier V626 and filter and voltage divider networks to provide high voltage dc potentials to the A-scope and ppi scope. Since the load on the power supply is the small beam currents through the cathode ray tubes and the high resistance voltage divider in the cathode circuit of the A-scope and the input ac frequency is 400 cycles, the power supply is a simple half-wave rectifier with small filter capacitors.

a. During the circled conditions, the plate of the rectifier tube is negative with respect to the cathode so that the tube cannot conduct. During the uncircled conditions, V626 conducts and C665 and C666 charge to the peak voltage across the plate winding of T604 through V626 and R2615. At the same time, C667 charges through filter resistor R2616, and capacitor C668 charges through R2616 and R2624. Resistor R2615 protects V626 from the initial charge current through C665 and C666 and does not affect circuit operation after the first few uncircled positive sine wave alternations. Since the load on all potentials is very small, V626 only conducts when the uncircled voltage across T604 exceeds the voltage across C666 and C665. These pulses of current through V626 replenish the small charge lost by the filter capacitors each cycle while V626 is cut off. Capacitor C666 furnishes the −1,500 volt load current, C665 furnishes the +700- and +1,500-volt load current, and C667 and C668 furnish the +5,000-volt load current.

b. Voltage divider R2603 through R2614, in parallel with the potential across C665, establishes the necessary +700- and +1,500-volt potentials. The voltage across R2603 provides a low potential means of checking all of the high-voltage potentials supplied by the power supply. If the voltage at TP612 is approximately +300 volts, the high-voltage power supply is operating properly.

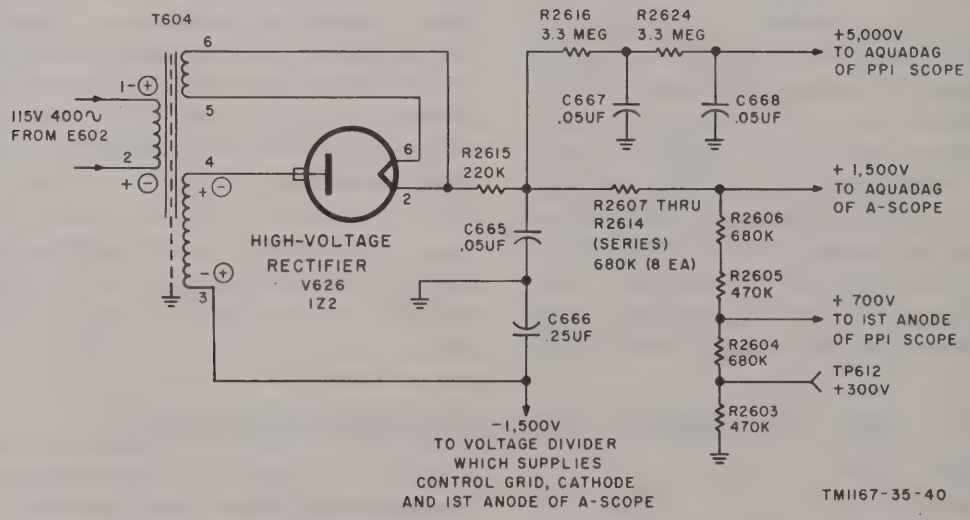


Figure 78. Indicator high-voltage power supply, simplified schematic diagram.

Section X. MISCELLANEOUS CIRCUITS

141. General
(fig. 224)

a. All controls necessary to operate the equipment are located on Azimuth-Range Indicator IP–141/TPS–1D unit. Many components located physically on the indicator unit are functionally part of other systems and are therefore described in the chapters covering the system. For example, POWER ON switch S602 is part of the power distribution system

and TUNING METER M601 is part of the receiving system.

b. A tabulation of the component parts located on the indicator unit but which are functionally part of a system other than the indicating system follows:

Symbol reference designation	System	Theory chapter	Trouble-shooting chapter
J602	Antenna positioning	7	17
M601	Receiving	4	14
R608	Receiving	4	14
R609	Antenna positioning	7	17
R2618	Signal comparing	5	15
R2619	Antenna positioning	7	17
R2627	Signal comparing	5	15
S601	Signal comparing	5	15
S602	Power distribution	8	11
S612	Antenna positioning	7	17
S613	Receiving	4	14
S615	Transmitting	2	12
S616	Transmitting	2	12
S617	Antenna positioning	7	17
S618	Antenna positioning	7	17

142. Miscellaneous Components (fig. 224)

Some component parts affect the operation of the indicating system as a whole rather than the individual subsystems described in the preceding sections.

a. Convenience servicing outlet J603 provides 115-volt, 400-cycle power for auxiliary equipment, such as a vacuum tube voltmeter or soldering iron, regardless of the position of main power switch S602.

b. When the main power switch is thrown on, power is applied to the primary of filament transformer T605. The 3–4 secondary winding furnishes 6.3-volt ac filament voltage to all tubes in the indicating system except V609, V625, and V626. Filament voltage for the cathode ray tubes is applied from separate secondary windings of T605 and filament voltage for the high-voltage rectifier is supplied by a filament winding on high-voltage transformer T604. In addition to supplying filament voltage to 23 tubes in the indicating system, the 3–4 winding of T605 also furnishes power for POWER ON indicator lights I 609 and I 601 through I 608 in series with DIMMER potentiometer R2617. The eight illuminating lights are placed every 45° around the ppi scope so that they illuminate the azimuth scale. The amount of illumination is controlled by R2617.

c. The internal temperature of the indicator unit is kept between 25° C. (77° F.) and 0° C. (32° F.) by blower motor B601 and heater HR601. When the internal temperature reaches 25° C., high temperature thermostat S610 closes and power is applied through terminals 28 and 27 of J601 to the windings of blower motor B601. Capacitor C664 (1 μf) is not a part of the motor assembly but it is necessary to operate the motor. Blower motor B601 is a two-phase induction motor which is operated from a single-phase supply. Capacitor C664 is a phase-splitting capacitor which is placed in series with one of the stator coils to make the current through the two stator coils 90° because the fields about the stators of a two-phase motor must be approximately 90° out of phase. A fan on the rotor shaft circulates air through the unit. When the internal temperature drops to 10° C., S610 opens and power is removed from the motor.

d. When the internal temperature of the indicator unit drops to 0° C., low temperature thermostat S611 closes and power is applied through terminals 19 and 11 of J601 to strip space heater HR601. The 150-watt heater increases the internal temperature of the indicator unit until it reaches 15° C. At this time, S611 opens and power is removed from the heater.

e. Electrical noise suppressors Z602 through Z606 are ppi-type filters which prevent high-frequency random noise variations from being carried into the indicator unit from the interconnections of the power supply.

f. Capacitors C601 and C602 provide additional filtering of the +300- and +450-volt potentials which enter terminals 39 and 30 on J601.

CHAPTER 7
ANTENNA POSITIONING SYSTEM

Section I. GENERAL

143. General

a. The primary purpose of the antenna positioning system is to drive the antenna in azimuth only, through 360° rotation. The antenna can rotate either in a clockwise (cw) or counterclockwise (ccw) direction and the speed of rotation is adjustable between 0 and 15 rpm.

b. The antenna positioning system consists of the following major assemblies:

(1) Antenna rotate control mechanism.
(2) Servo amplifier chassis.
(3) Antenna drive assembly.

c. All of the components in the antenna positioning system are located in Antenna Base AB–221/TPS–1D with the exception of the antenna rotate control mechanism which is located in Azimuth-Range Indicator IP–141 TPS–1D.

d. The overall circuit relationship of the antenna positioning system is shown in the antenna positioning system composite schematic diagram (fig. 227).

e. The relationship of the antenna positioning system with reference to other functional systems of the radar set is covered in TM 11–1167–2D.

144. Antenna Positioning System Block Diagram Discussion
(fig. 79)

The antenna positioning system is an open loop servo system which functions to rotate the antenna. Feedback in the servo amplifier is used to maintain the antenna rotating at a constant rate of speed as dictated by the setting of ANTENNA ROTATE control R609. Both voltage and current feedback are used for rotation speed stability.

a. ANTENNA ROTATE Control Circuit. ANTENNA ROTATE control R609 is located at the indicator so that the operator may observe the indicator scopes while controlling the speed and direction of antenna rotation. When adjusted for either direction of antenna rotation, it controls the value of bias applied to control tube V703A in the servo amplifier, which in turn affects the speed of antenna drive motor B751. It also causes motor control relays K701 and K702 in the servo amplifier to function and allow the antenna drive motor to turn in the desired direction.

b. Servo Amplifier Chassis. All of the components that supply power to operate antenna drive motor B751 are located in the servo amplifier chassis. Bridge rectifier CR701 supplies the antenna drive motor with a constant source of field current. Control rectifiers V701 and V702 supply current for the armature of B751 through relays K701 and K702. The direction of rotation of B751 is controlled by the action of K701 and dynamic braking is accomplished by K702. The amount of armature current supplied by the control rectifiers is determined by the value of bias developed by the combined action of the RC integrator networks, discharge diode V705A, transformer T701, and control tube V703A. Plate supply voltage for V701 and V702 is provided by transformer T704 through T703. Transformer T703 samples the average plate current of V701 and V702 and applies it to full-wave rectifier V704. Full-wave rectifier V704 provides two outputs. A sample of the rectified current combines with a sample of the output voltage of V701 and V702 and the resultant is fed back to control tube V703A to provide speed stability of antenna drive motor B751. The other output of V704 is applied to temporary overload V703B, which functions when an overload condition exists, to override the effect of control tube V703A, causing the antenna motor armature supply current to be

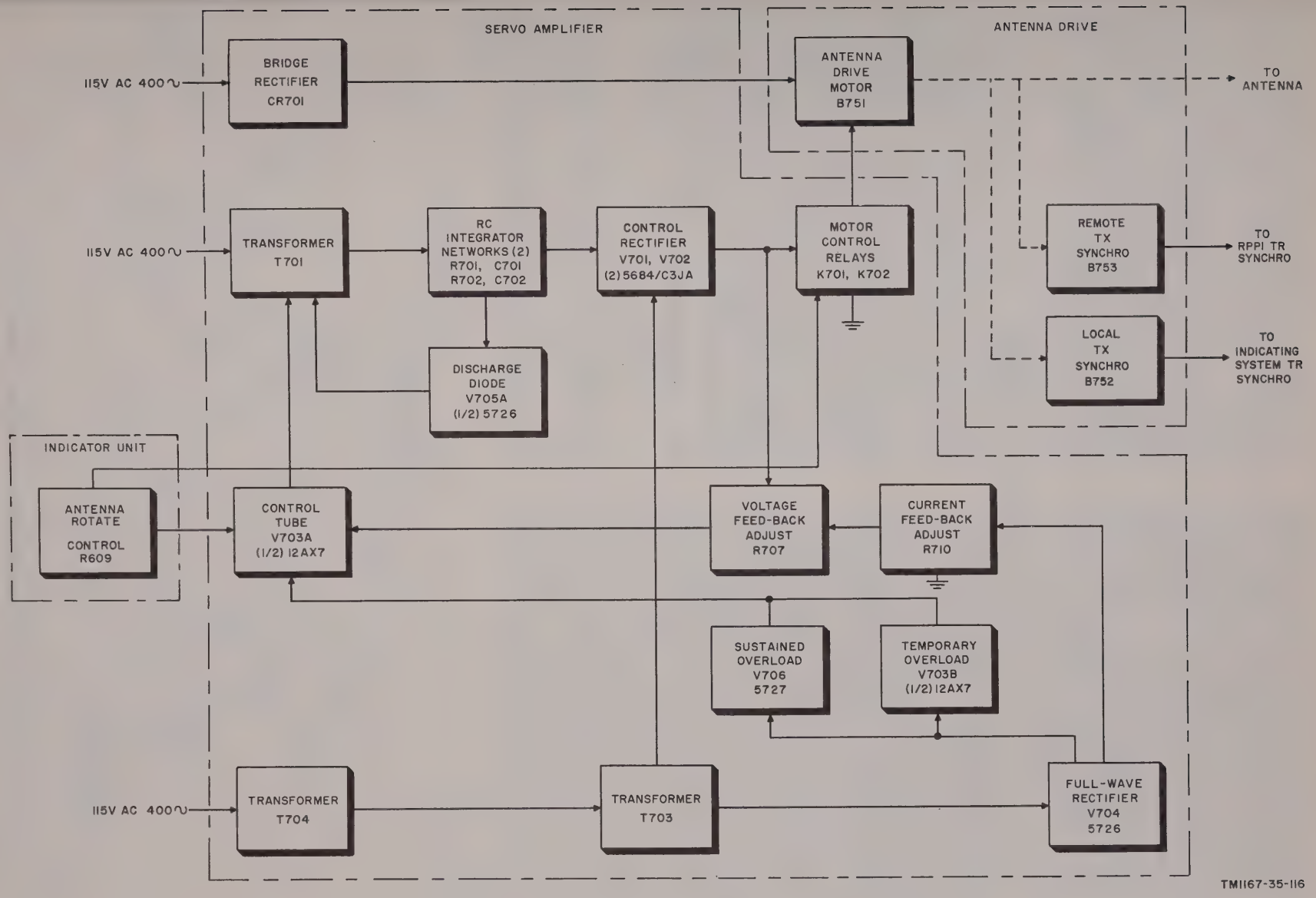


Figure 79. Antenna positioning system, complete block diagram.

reduced momentarily. If the output of V704 is excessive for a sustained time interval, sustained overload V706 functions to disable the effect of control tube V703A and causes the antenna drive motor armature to stop rotating.

c. Antenna Drive Assembly. A constant field supply current that is obtained from bridge rectifier CR701 is applied to antenna drive motor B751. The armature current which is variable in amplitude and polarity is provided by control rectifiers V701 and V702 through motor control relays K701 and K702. Antenna motor B751 drives the antenna through a gear reduction of 119:1. Two synchro transmitters (B752 and B753) are driven by B751 through gear reduction. Antenna position information is provided by B752 to the indicator for ppi operation. The other synchro, B753, provides similar information to a remote ppi installation.

Section II. SERVO AMPLIFIER

145. ANTENNA ROTATE Control Mechanism (figs. 80 and 82)

ANTENNA ROTATE control R609 is a potentiometer with the center tap grounded. Both ends are connected together and return through R2619 to +150 volts. The control shaft of R609 is mechanically connected to cams O 1601 and O 1606 which operate switches S617 and S618. When R609 is in the center position, braking cam O 1601 closes microswitch S617 and causes braking relay K702 to become energized; this disconnects the armature of the antenna drive motor from the control rectifiers. Moving the arm of R609 in either direction away from center (by rotating the hand wheel) causes S617 to open, deenergizes K702, and applies power to the armature of the antenna drive motor. Reversing cam O 1606 opens microswitch S618 for clockwise rotation and closes it for counterclockwise rotation of the antenna by deenergizing and energizing K701 which reverses the armature connection of the antenna drive motor. When the arm of R609 is moved in either direction away from center position, a positive voltage from zero to a maximum of +150 volts may be selected for application to the cathode of control tube V703A as bias voltage. Adjustment of R2619 sets the maximum limits of bias voltage that may be selected by R609.

146. Bridge Rectifier CR701 and Protective Circuits (fig. 81)

a. Bridge rectifier CR701 is a bridge connected full-wave rectifier. It is of the selenium type and converts the 115 volts, 400 cycles into approximately 95 volts dc. Its

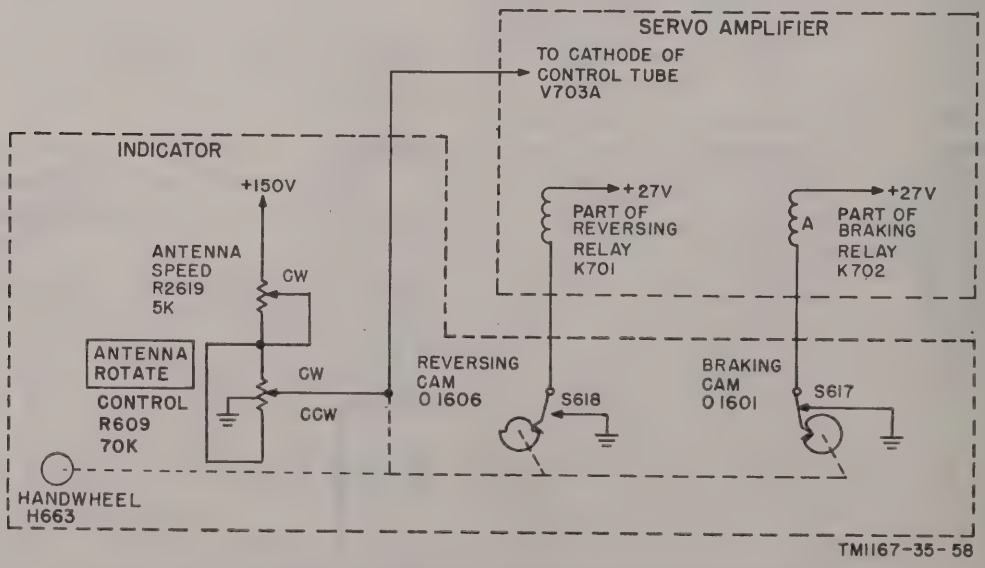


Figure 80. Antenna rotate control, simplified schematic diagram.

main purpose is to provide a constant source of current for the field winding of antenna drive motor B751.

b. Thermostatic switch S754 is normally closed, and opens when the temperature drops below −34° C. It is in series with the 115 volts, 400 cycles which supplies power through T704 and T703 to the control rectifier plates. If the temperature in the antenna base drops below −34° C., S754 opens and disables the power applied to the control rectifiers. Extreme freezing temperatures can cause the oil in the antenna drive assembly to become sluggish and stiff, placing an overload on the antenna drive motor that may cause severe damage to the components.

c. Part of safety switch S753 and interlock S701 are in series with the ac power applied to the control rectifiers. Personnel working on the antenna can disable the antenna drive motor by switching S753 to the OFF position. Interlock S701 disables the antenna drive motor by disconnecting the ac power when the servo amplifier chassis is removed.

d. Protective relay K703 and the field windings of B751 are energized by CR701. If the dc supply source drops to less than 70 volts, K703 deenergizes and disables the power supplied to B751 armature. Failure of the field supply source eliminates the counter electromotive force (cemf) generated by the armature. This could cause the armature current of B751 to exceed rated values which in turn would cause serious damage to the motor since the armature current would be limited only by the dc resistance of the armature.

e. Plate voltage relay K705 is energized by the +27-volt supply that is delayed through the 5-minute time-delay relay. Its function insures that the tubes in the servo amplifier have been adequately warmed up before being placed into service. When energized, K705 completes the input circuit which applies ac power to T704 and subsequently to the control rectifiers.

f. Capacitors C716 and C717 function to suppress noise generated by control rectifiers V701 and V702.

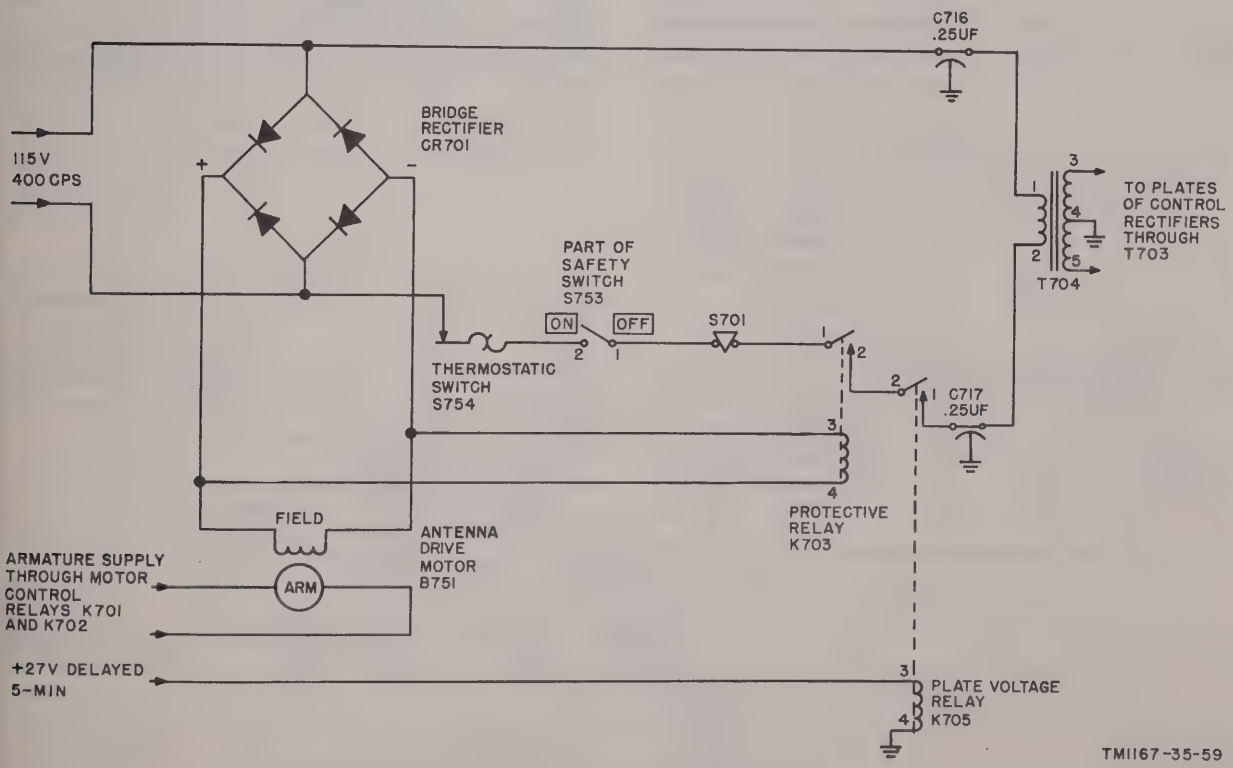


Figure 81. Bridge rectifier CR701 and protection circuits, simplified schematic diagram.

g. Transformer T704 provides ac power to the plates of control rectifiers V701 and V702 through T703. The voltage supplied to the plates of V701 and V702 is approximately 300 volts, 400 cycles when measured from either plate to ground.

147. Control Rectifiers and Motor Control Relays

(fig. 82)

a. Control rectifiers V701 and V702 function as a controlled output full-wave rectifier power supply which has the armature of antenna drive motor B751 serving as the load. Power is applied through transformer T704 and T703 resulting in a peak plate voltage approximately 425 volts. The bias control voltage applied to the grids of V701 and V702 determines whether they will be cut off or conducting. The bias control voltage also determines the amount of average current through the armature of B751 and therefore the motor speed. Capacitors C713, C714, and C715 function as noise suppressors for the plate and cathode circuits of V701 and V702. When V701 and V702 start conducting, the voltage across the tubes drops to about 12 volts. Current limiting resistors R727 and R728 prevent the starting surge current from reaching excessive values. Capacitors C709 and C710 function as filter capacitors to filter the 800-cycle ripple frequency.

b. Reversing relay K701 functions as a double-pole, double-throw switch and determines the direction of current flow through the armature of B751. It is energized by the action of reversing cam O 1606 which is located in the indicator and mechanically connected to the shaft of ANTENNA ROTATE control R609.

c. Braking relay K702A (voltage coil) functions to disconnect the antenna drive motor armature from the control rectifiers, only when ANTENNA ROTATE control R609 is in the zero position. At this time, braking cam O 1601 closes S617 which energizes K702A (voltage coil). Contacts 2 and 7 open, disconnecting the armature from the control rectifiers. Contacts 1 and 7 close, connecting K702B (holding coil) and R719 across the armature to function as a dynamic brake. If the armature current were reversed while the antenna drive motor was still rotating, the torque developed could cause serious damage to the antenna drive components. The dynamic braking action caused by the shunt connection of K702B and R719 prevents this by providing a conducting path for the current generated

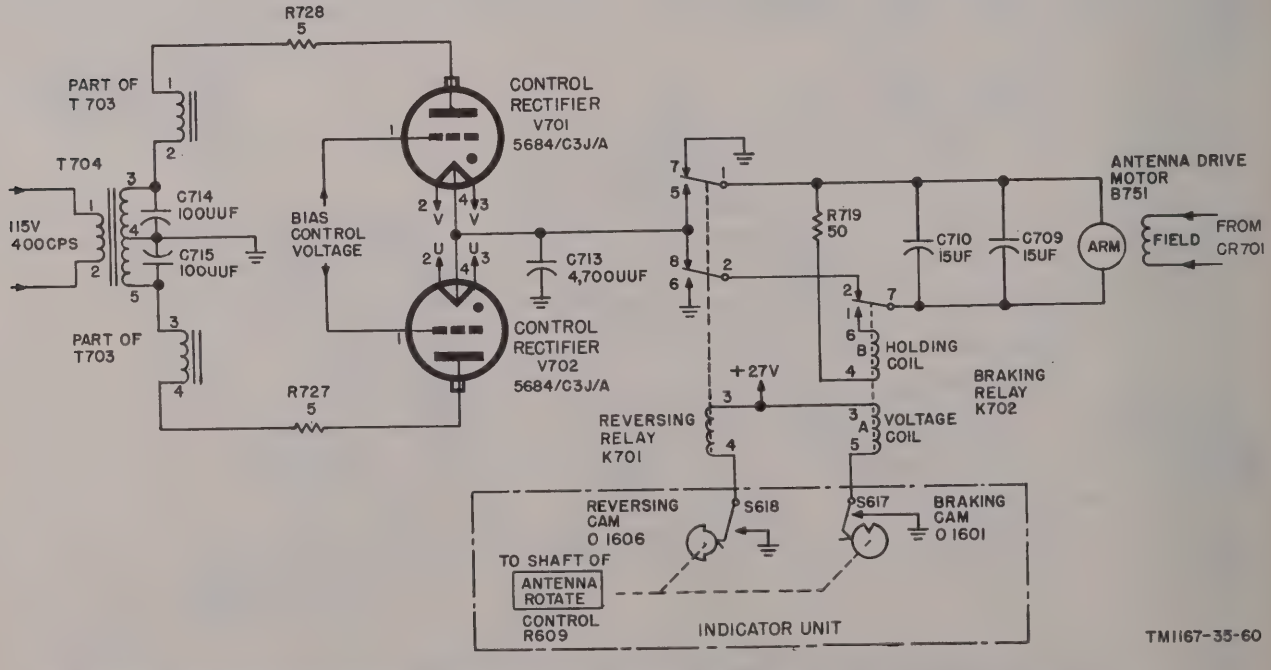


Figure 82. Control rectifiers V701, V702 and motor control relays K701, K702, simplified schematic diagram.

by the counter electromotive force of the rotating armature. The current in turn produces a magnetic flux about the armature which opposes the field flux and forces the motor to slow down. The faster the armature rotation, the greater will be the force generated to slow it down. The current passing through K702B holds relay contacts 1 and 7 closed until the motor slows down. When the armature speed decreases to a safe value, the current drops sufficiently to allow the holding coil to release. If the ANTENNA ROTATE control passes the zero position and is reset for rotation in the opposite direction while the antenna is still rotating, the armature would not be connected to the control rectifiers again until the antenna is almost at a standstill so that the power could be safely applied. Resistor R719 limits the current and determines the amount of dynamic braking action.

148. Control Rectifier Bias Supply Network
(figs. 83 and 227)

The average current supplied to the antenna drive motor by the control rectifiers is primarily determined by the dc bias level applied to the grids of V701 and V702. The bias voltage is generated by the action of control tube V703A functioning as a variable resistance rectifier and discharge diode V705A which provides a constant rate discharge path of the RC bias network.

a. Charging the Bias Network. Transformer T701 supplies approximately 225 volts, 400 cycles to the network. When terminal 4 of T701 is positive, V703A conducts charging capacitor C701. The charging path starting from the most negative point is from terminal 3 of T701, through R701, C701, R705, R706, R707, R708, R709, R710, R609, V703A to terminal 4 of T701. Capacitor C701 charges with the polarity negative at the junction of R701 and C701. The charge on C701 provides the bias for V701. The dc voltage across C701 is effectively in parallel with C702 and after several cycles, the charge on both capacitors adjusts to an almost equal value with the charge on C702 providing the bias for V702. When ANTENNA ROTATE control R609 is adjusted in either direction away from the grounded center position, a positive voltage is applied to the cathode of V703A which increases the bias. An increase in bias causes the plate resistance to increase and when V703A conducts to permit charging C701 and C702, its conductance is less allowing less charge to accumulate which results in less bias for V701 and V702. When R609 is in the center position, a minimum bias is applied to V703A which reduces its plate resistance and causes a maximum bias to be generated and applied to V701 and V702.

b. Discharging the Bias Network. Discharge diodes V705A, R720, and thyratron bias control R721 serve as the discharge path for C701 and

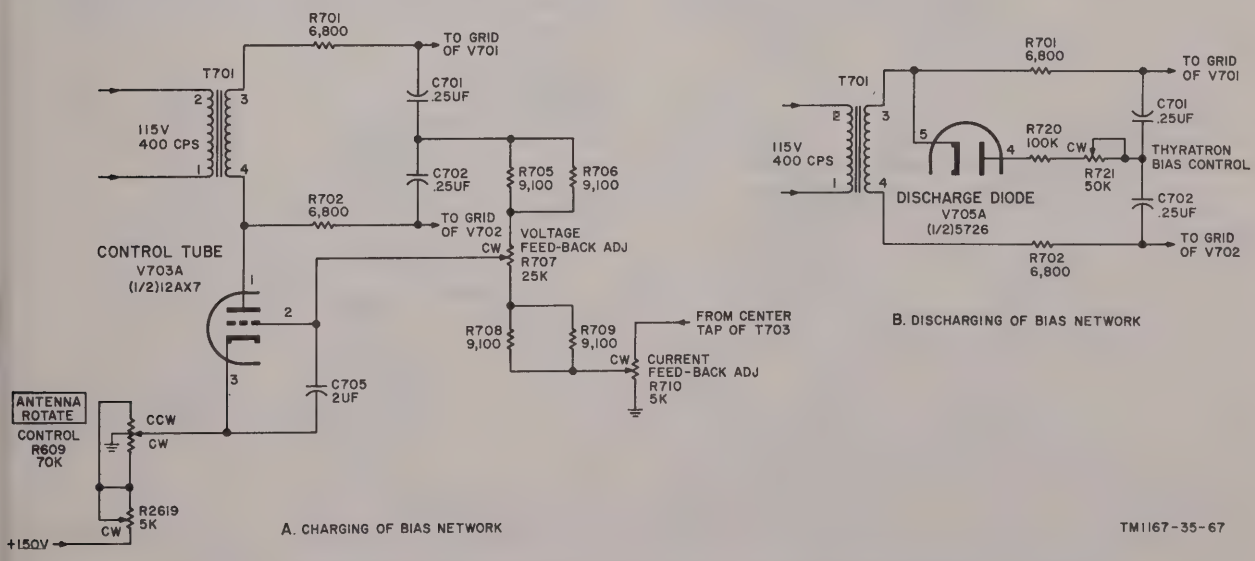


Figure 83. Control tube V703A and discharge diode V705A, simplified schematic diagram.

C702. Since the average charge across C701 and C702 must be able to drop rapidly to a lower value when V703A conducts less, a discharge path is provided for the capacitors. The discharging time constant is made adjustable by setting thyratron bias control R721. The average bias is established by adjusting R721 so that V701 and V702 are just cutoff when R609 is in the center position. When R609 is moved in either direction away from center, the circuit functions to cause a reduction of the bias to V701 and V702 so that they start conducting. Moving R609 further away from center position causes V701 and V702 to

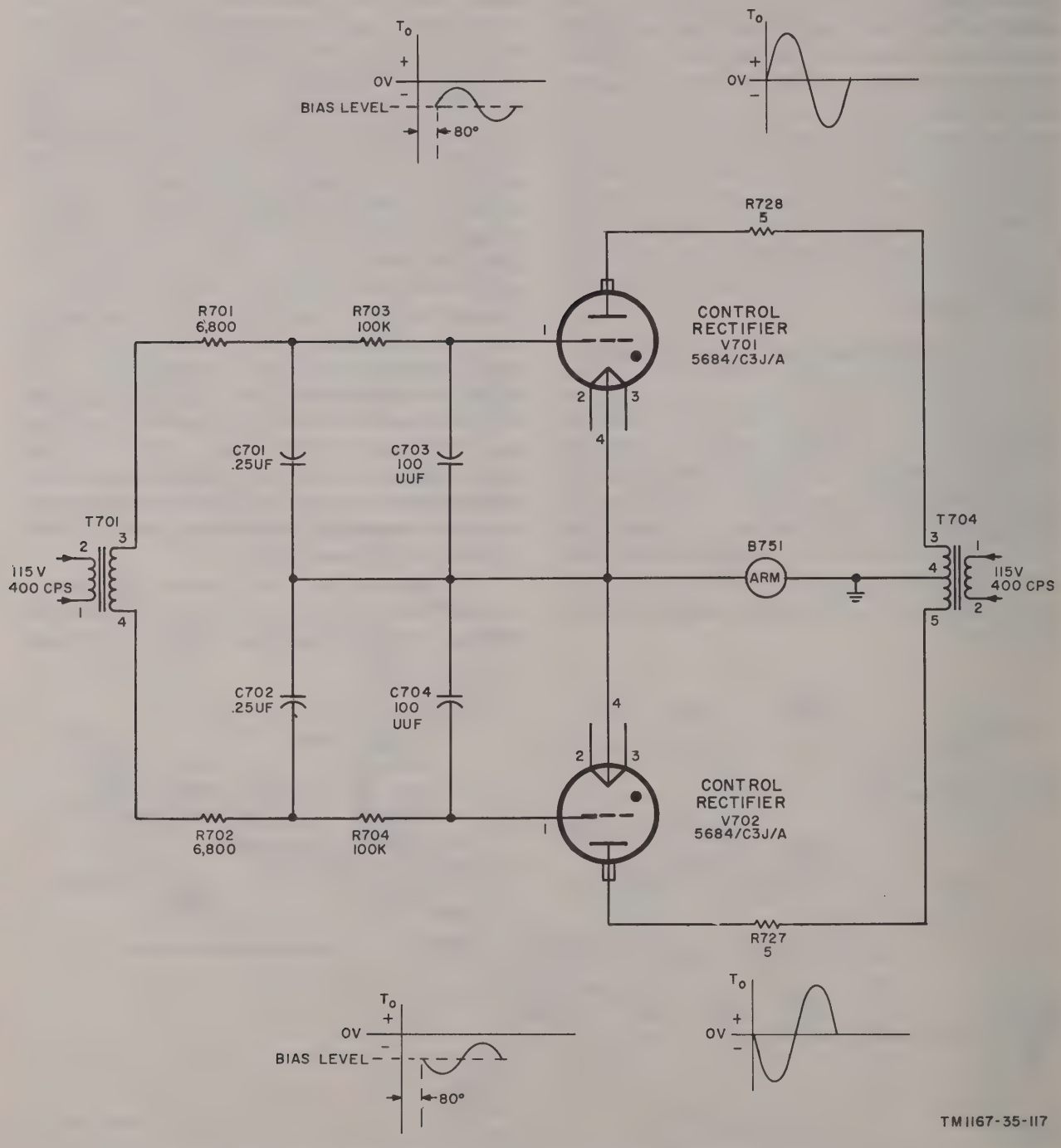


Figure 84. RC integrator network, simplified schematic diagram.

increase conduction and supply a greater value of average current to the armature of B751.

149. Control Rectifier Ignition Voltage Control Network
(figs. 84 and 85)

When the control rectifiers start conducting, they go into a state of full conduction almost immediately. It is therefore undesirable to operate them with dc applied to the plates. Transformer T704 supplies approximately 300 volts at 400 cycles to the plates of the control rectifiers which causes them to conduct alternately in push-pull. The control grids have applied to them a bias voltage upon which is superimposed a 400-cycle voltage provided by transformer T701. The 400-cycle grid voltage is shifted in phase approximately 80°. Only when the grid voltage reaches the ignition potential will the tube conduct. Varying the bias voltage will cause the tube to conduct over varied portions of an alternation and therefore the amount of current supplied to the antenna motor is controlled and variable.

a. RC Integrator Network. Transformer T701 provides the input power to generate the charge on capacitors C701 and C702. The 400-cycle voltage is also phase shifted by R701 and C701, lagging the applied voltage approximately 80°. Resistors R702 and C702 have a similar function. When the control rectifiers go into conduction, noise pulses generated are attenuated by filter networks R703, C703, and R704, C704. The relationship of phase shifted grid voltage waveforms and the corresponding plate voltages applied are shown in the simplified schematic diagram (fig. 85).

b. Control Rectifier Ignition Voltage. Thyratron type control rectifiers V701 and V702 must ionize before heavy conduction can take place. The applied bias voltage prevents the 400-cycle plate voltage from causing ionization. The grid voltage has control over the ionizing potential only. Deionization requires that the ac plate voltage drop to the extinction potential of the tube. The 400-cycle voltage at the grids can be raised or lowered by adjusting the bias voltage. When the antenna is stationary, the bias level extends into the negative region to a value that prevents the 400-cycle voltage peaks from reaching the ignition potential. Reducing the bias will allow the 400-cycle grid voltage to trigger the control rectifier which will conduct heavily until the plate supply voltage drops to the de-ionization voltage level. Further reducing the bias voltage will cause the 400-cycle grid voltage to trigger sooner and the tube will conduct over a greater period during the alternation. Since the control rectifiers are connected so that they may conduct during opposite half cycles, the output current has an 800-cycle ripple frequency which is smoothed by filtering and an average value of dc is applied to the motor armature. The value of average current is proportional to the percentage conduction of the control rectifiers during each alternation.

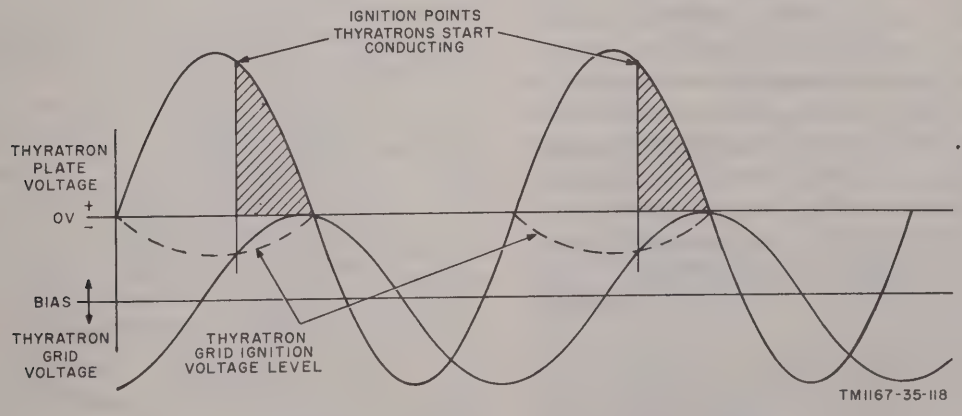


Figure 85. Control rectifier ignition voltage.

150. Voltage and Current Feedback (fig. 86)

The bias applied to V703A controls the value of plate resistance which in turn determines the amount of charge on C701 and C702 which in turn provides the bias for V701 and V702. Feedback is applied to V703A in the form of samples of the voltage and current of the armature of B751. Use of feedback keeps the antenna rotating at a constant speed when varying loads are applied. During rotation, gusts of wind will at times oppose or aid the antenna and thus change the load on the armature of B751. This will cause the cemf to vary and in turn affect the armature current. Counter electromotive force is proportional to the speed of rotation of the armature of B751.

a. Voltage Feedback. The source of voltage feedback is the output voltage supplied by control rectifiers V701 and V702 and applied to the armature of B751. The total armature voltage is divided by R705, R706, R707, R708, R709, and a part of R710. Voltage feedback adjustment R707 selects a proportional amount of the voltage across the armature which is applied to the grid of V703A. Capacitor C705 serves to filter any abrupt variations of the voltage applied to the grid. The polarity of the voltage feedback is positive with reference to ground.

b. Current Feedback. Transformer T704 is the source that supplies power to control rectifiers V701 and V702. Transformer T703 has two primary windings that are connected in series with T704 and the control rectifiers so that samples of the output current of V701 and V702 may be taken. When the control rectifiers conduct, the samples which are proportional to the current supplied, are applied to full-wave rectifier V704. The center tapped secondary of T703 provides a negative output voltage which is filtered by C707. Current feedback adjustment R710 selects a portion of the voltage across R710 and applies it to the grid return of V703A. The positive output of V704 provides voltages for the overload circuits (par. 151).

c. Operation. When the ANTENNA ROTATE control is adjusted for antenna rotation, an increment of bias is applied to control tube V703A which causes an increase in its plate resistance. The bias on control rectifiers V701 and V702 decreases, causing them to conduct which in turn causes antenna drive motor B751 to rotate. The voltage applied to the armature of B751 is also across the voltage divider networks R705 through R710 and a portion is selected and applied to the control grid of V703A. The rotating speed of the armature generates a cemf, and the difference between the voltage applied to the armature and the cemf determines the value of armature current. The armature current which is conducted by V701 and V702 is sampled by the primary windings of T703 and rectified by full-wave rectifier V704. The resulting negative voltage is generated across R710 and a portion selected and applied as a part of the grid voltage to V703A. The armature attains a speed of rotation which causes the voltage feedback combined with the current feedback voltage to reach a balanced condition with the bias initially applied by R609 to V703A. The bias network to V701 and V702 adjusts to a value which supplied the demand of B751 and the system stabilized to the operating conditions. Variations in antenna loading because of wind resistance cause automatic compensation by virtue of the current and voltage feedback to maintain a constant speed of rotation.

(1) When a load is placed on the motor causing it to slow down, the cemf across the armature decreases. The potential difference between the applied voltage and the cemf becomes greater and causes an increase in current. The increase in current causes the negative voltage across R710 to increase and the bias on V703A also increases. The bias network of V701 and V702 charges less because of an increased plate resistance of V703A which results in less bias and increased conduction of V701 and V702. The increased current demand causes the applied voltage to drop slightly but the cemf drops a greater amount and results in increased armature current. When V701 and V702 conduct more, the applied voltage and the current through the armature increases. The action of the combined feedback voltages brings the motor back to proper speed. A balance is reached

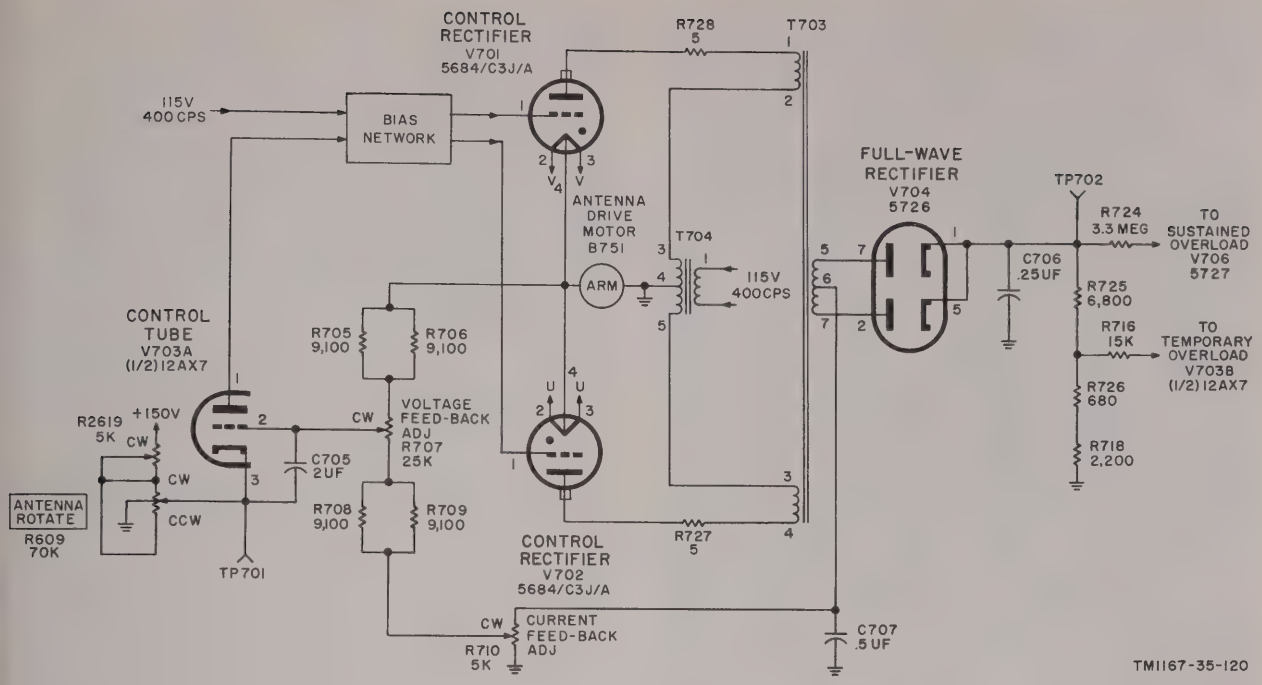


Figure 86. Voltage and current feedback, equivalent circuit.

between the voltage supplied by R609 and the feedback voltages to V703A so that V701 and V702 will provide sufficient voltage and current as demanded by the load.

(2) When the loading is reduced, the motor speed tends to increase, causing the cemf to increase. The armature current decreases and the resulting voltage across R710 decreases. The grid of V703A becomes less negative which allows the bias network to charge to a higher value and reduce the conduction of V701 and V702. The output voltage and current of V701 and V702 decreases, resulting in a reduced speed of B751. The speed becomes adjusted to a value which causes the voltage and current feedback voltages to balance with the bias selected by R609 and applied to V703A.

d. Adjustment. The voltage feedback provided by R707 is proportional to the voltage applied to the armature of B751. It is adjusted when the antenna is rotating at a high speed under no external load conditions until the antenna rpm corresponds with the rpm indicator dial located on the indicator. The current feedback voltage across R710 is proportional to the current through B751. The voltage provided by R710 is regenerative and is adjusted with the antenna rotating at a slow speed. The proper adjustment is for maximum feedback without producing an oscillating condition as indicated by the pulsating of V701 and V702.

151. Overload Circuits
(figs. 87 and 227)

When an overload condition occurs which tends to slow down or stop antenna rotation, it may cause serious damage to the electrical components. Protective circuits are provided which function to reduce or completely cut off condition of V701 and V702. Temporary overloads cause V703B to function while sustained overloads of 4 seconds or more will cause V706 to function.

a. Temporary Overload. Temporary overload tube V703B is connected essentially in parallel with control tube V703A. When V703B is made to conduct, it parallels V703A and the charge on C701 and C702 increases,

raising the bias on V701 and V702. The increased bias will cause antenna drive motor B751 to slow down and limit the armature current peaks to 6 to 10 amperes. Temporary overloading causes the armature current of B751 to increase, which is sampled by T703 and rectified by V704. The output voltage of V704 is filtered by C706 and appears across voltage dividers R725, R726, and R718. The voltage at the junction of R725 and R726 is coupled through isolating resistor R716 to the control grid of V703B. Clamper tube V705B in the grid circuit of V703B functions to hold the static grid voltage sufficiently positive with reference to ground so that the output voltage provided by V704 will not cause V703B to conduct unless the overload condition exists. The conducting path for V705B is from ground through R718, R726, R716, V705B, R713, R714, R712, R711 to +150 volts. The potential difference between the plate and cathode of V705B is about ½ volt. The cathode of V703B is maintained at a more positive potential than the control grid because of the connection to the voltage divider which includes R711 through R715. The resulting bias on V703B is approximately 9 volts which holds the tube normally below cutoff. Cutoff for V703B is about −3 volts between grid and cathode. When an overload causes the voltage applied to the grid to rise above its static value, V705B stops conducting and the grid voltage rises approaching the cutoff value of the tube (−3 volts). As the positive going grid voltage rises above cutoff, V703B conducts and the bias on V701 and V702 increases because of the increased charge of C701 and C702 through V703B. The armature current of B751 is reduced by the decreased conduction of V701 and V702, and the output voltage of V704 decreases which will result in V703B to stop conducting.

b. Sustained Overload. A sustained overload on the antenna which results in excessive armature current will cause sustained overload tube V706 to conduct. Tube V706 is of the tetrode thyratron type gas tube. The cathode potential is selected by the setting of overload adjust potentiometer R717 which is part of the voltage divider including R722 and R723. An approximate voltage setting is 80 volts. The control grid returns to the output of full-wave rectifiers V704 through R724 and from grid to ground through C712. The time constant of R724 and C712 is 3 seconds which will require an overloading condition to be sustained for several seconds in order that V706 is made to conduct. The plate of V706 is connected to the plate of control tube V703A and when V706 conducts, it causes C701 and C702 to charge to a value which will cut off conduction of control rectifiers V701 and V702. When the armature current source is cut off, the antenna stops rotating and V706 continues to conduct at a 400-cycle rate maintaining a high value of bias on V701 and V702 (approximately −48 volts). Conduction through V706 occurs during the positive extremes of the 400-cycle voltage applied by T701. During the conducting interval of V706, the charge on C701 and C702 increases, with V706 conducting sufficiently to make up the voltage difference caused by the constant rate of discharge of C701 and C702 through V705A. With the armature current at zero, there is no longer an output from V704 and the voltage at TP702 drops to approximately +4 volts. The charge on C712, however, must be maintained near +80 volts so that the grid to cathode potential of V706 allows ionization and to conduct during the positive peaks of the ac plate voltage. The charge on C172 is maintained near +80 volts by the control grid located in an area of ionized gas and at a potential level between the cathode and plate potentials. When the ac plate voltage reaches the deionization potential V706 cuts off and C712 discharges (at a 3-second time constant rate) a fractional amount. The discharging time interval is approximately 2,000 microseconds and the amount of discharge so small that it is difficult to measure. It therefore requires very little additional recharging during the conducting time of V706 to maintain the control grid at a potential that will allow V706 to ionize easily when the plate voltage rises to the peak value of the applied ac voltage. To cause V706 to stop conducting completely, the ANTENNA ROTATE control is brought back to 0 rpm. When this is done, the bias on control tube V703A decreases, causing the tube to conduct and additional charge builds up on C701 and C702. Since the ac voltage peaks which caused V706 to conduct are superimposed on the negative dc voltage level, when C701 and C702 accumulate additional charge, the ac

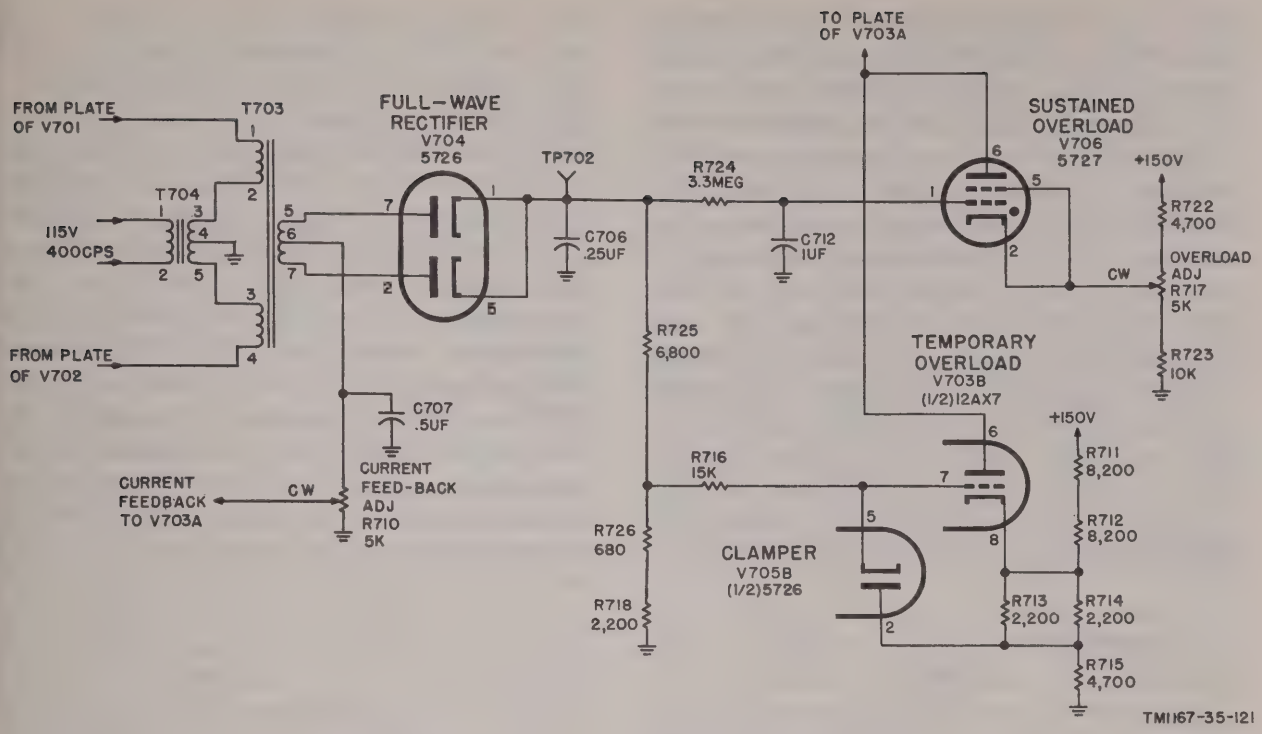


Figure 87. Overload circuits, simplified schematic diagram.

voltage peaks no longer extend far enough into the positive region and V706 does not ionize. If V706 does not conduct, C712 discharges and the control grid voltage drops to a value which will prevent ionization when the plate voltage rises.

Section III. ANTENNA DRIVE ASSEMBLY

152. Antenna Drive Motor B751
(fig. 228)

Antenna drive motor B751 is located in the antenna base which is a part of the antenna pedestal. The motor is a $\frac{1}{10}$ horsepower dc shunt-wound type with the field and armature separately excited. The field winding receives a constant source of dc from rectifier CR701. The armature is connected as the load for control rectifiers V701 and V702. The antenna speed is determined by the amount of current supplied to the armature and the direction of rotation selected by the action of reversing relay K701. The antenna drive motor is mechanically connected through gear reduction to the antenna spindle shaft and two transmitting synchros. One revolution of the antenna is produced by 119 revolutions of B751 through the gear reduction.

153. Synchro Components
(figs. 88 and 228)

a. The two synchros in the antenna base unit are synchro transmitters B752 and B753. Remote synchro transmitter B753 functions as a 60-cycle synchro data transmitter and its electrical data is used only with a remote ppi. It is mechanically connected with the antenna drive assembly and provides 1:1 antenna rotation data. Local synchro transmitter B752 functions as a 400-cycle synchro data transmitter for local ppi information. One revolution of the antenna causes 24 revolutions of the rotor of B752. Local synchro receiver B602 located in the indicator receives the data from B752, and drives the ppi yoke assembly at a 24:1 ratio. The ppi yoke is synchronized with the antenna rotation.

b. Torque receivers and transmitters (syn-

chros) are identical electrically. A synchro has three stator windings which are usually wye connected and placed physically 120° apart. The rotor is a single winding which functions as the primary of a transformer. Applied to the rotor of B752 is 115 volts, 400 cycles. The stator windings have induced into them a voltage the polarity and amplitude of which is determined by the instantaneous position of the rotor. When the rotor of B752 is in the position as indicated in figure 88, the rotor induces voltages into the stator windings. The stator windings of B752 are connected in parallel with B602 and the same voltages appear across them. Since the rotor of B602 also connects to the same 115-volt, 400-cycle source, the magnetic fields generated across the stators of B602 force the alinement of the rotor to be the same as in B752. Clockwise rotation of B752 rotor as indicated in figure 88 shows the voltages induced in S2 and S3 with no voltage induced in S1 since the coupling between the rotor and S1 is minimum. The S1 and S2 windings of B602 are connected in parallel with S3 and S2, respectively, of B752, and generate a magnetic field which causes the rotor to turn and aline itself with the same magnetic field configuration as was setup in B752. The rotor of B602 rotates in the opposite direction as that of B752. This is necessary because of the arrangement of the gear reduction in the antenna base and the yoke drive assembly so that the resulting rotation of the antenna and deflection yoke are in the same direction.

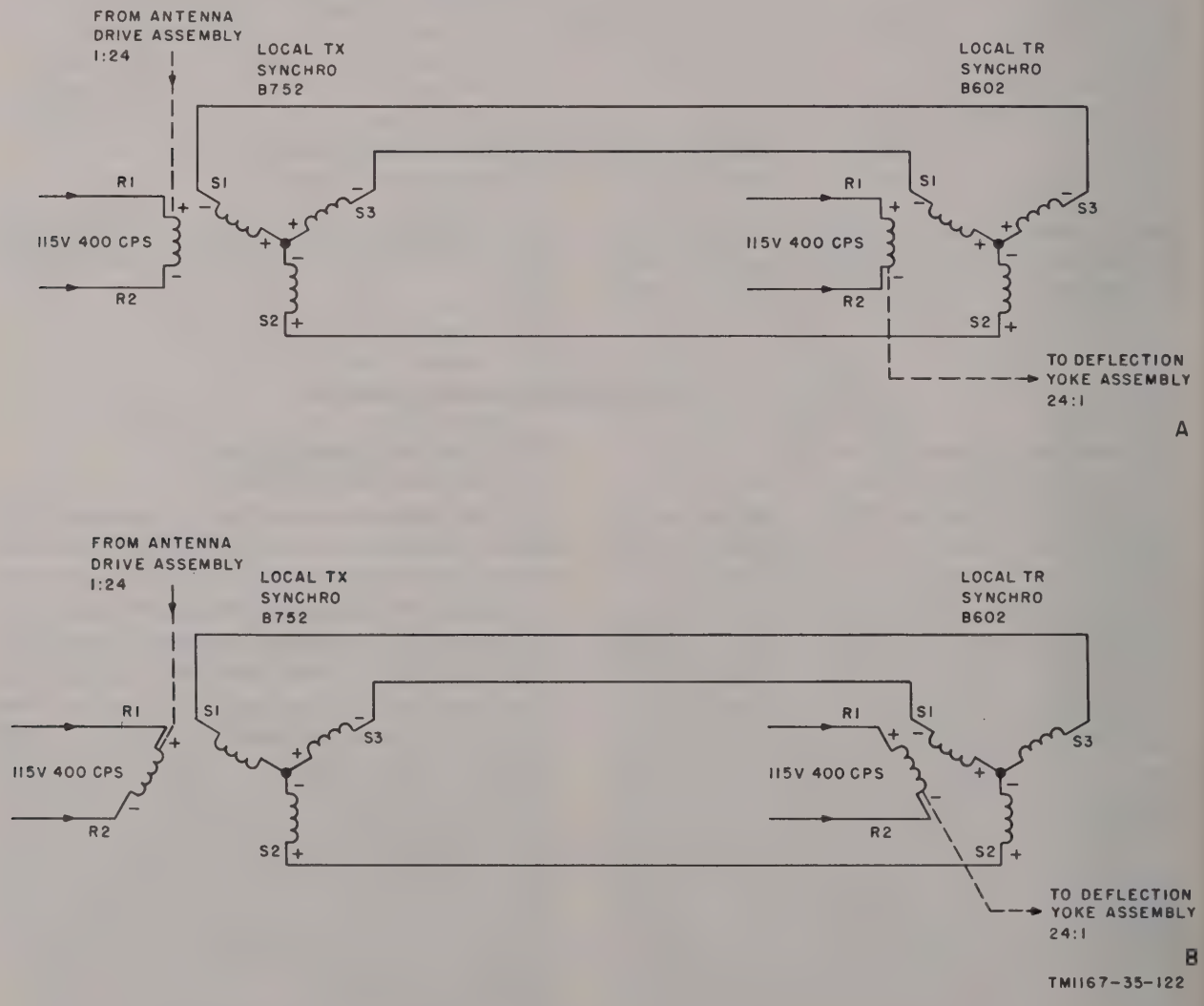


Figure 88. Synchro equivalent circuit.

154. Synchro Self-Zeroing Circuit
(figs. 89 and 227)

a. The 24-speed synchros used to synchronize the rotation of the deflection yoke assembly with the antenna rotation have 24 possible locking points spaced 15° apart. To prevent B602 from locking to one of the 23 false points, a one-speed cam and switch zeroing circuit is used. The circuit includes synchro relay K704, two synchronizing switches, S612 (normally open) and S756 (normally closed), transmitter zero cam (part of B753), and receiver zero cam (part of the deflection yoke assembly).

b. When B752 and B602 are properly alined, synchro relay K704 is never allowed to energize because synchronizing switches S756 and S612 function to maintain an open circuit. If a condition occurs that would cause B602 to become misalined, S756 will be closed when S612 closes. This will cause K704 to energize and apply zeroing voltage to B602. The zeroing voltage is derived from the tapped primary winding of transformer T702. When K702 becomes energized, stator windings S1 and S3 of B602 are connected together to one side of the applied zeroing voltage and S2 is connected to the other. The rotor of B602 stops rotating and remains alined with the stator field at the zeroing reference position. The transmitter zero cam continues to rotate with antenna rotation and when S756 is open, K704 releases connecting the stators of B752 and B602 in parallel. The rotor of B602 will start rotating and remain synchronized with the rotation of B752. Once during 24 revolutions of B752 and B602, the synchronizing switches S756 and S612 will simultaneously open and close to prevent K704 from becoming energized. The actuating cam which opens S756 is approximately 12° wide and the cam which closes S612 is somewhat less than 12° wide to insure that K704 will not energize at an improper time. When the synchros are electrically alined, an adjustment can be made to aline the ppi sweep of the indicator to be in the same direction as the antenna by setting the AZIMUTH control which is located on the front panel of the indicator.

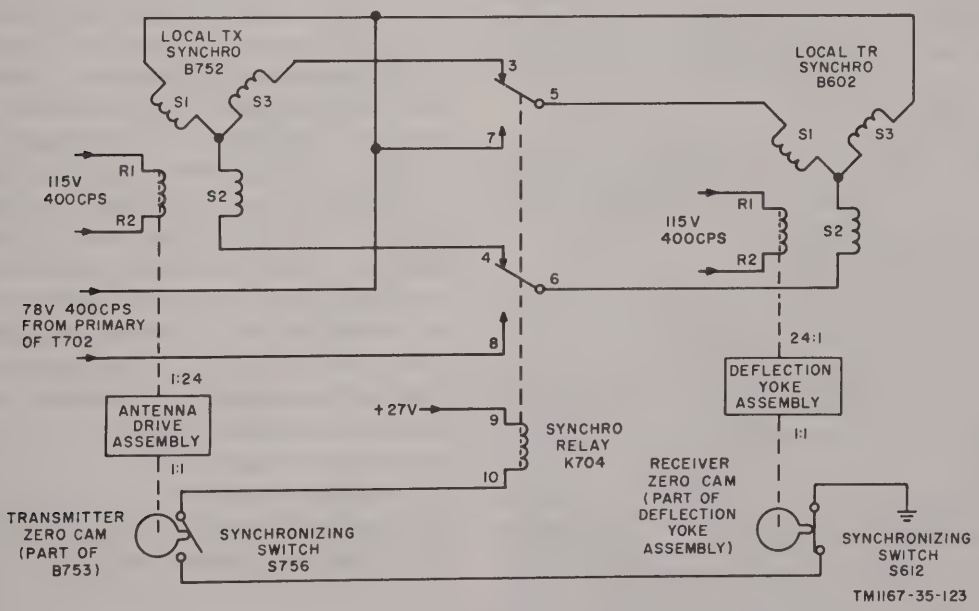


Figure 89. Synchro self-synchronizing circuit, simplified schematic diagram.

CHAPTER 8
AC POWER DISTRIBUTION AND CONTROL SYSTEM

Section I. GENERAL

155. General

The ac power distribution and control system includes all circuits and parts that function to distribute and control the application of 115-volt, single-phase, 400-cycle, ac power to and within the component units of the entire equipment. The ac power distribution and control system is principally concerned with the distribution of power to parts which require 115 volts directly, such as the primaries of transformers, heaters, blower motors, synchro-rotors, relays, and indicating lamps. It is also concerned with fuses, relays, and switches which affect the application of ac power to these component parts.

a. Much of the distribution of power through the equipment is controlled by relays which are actuated by +27 volts dc and for this reason the complete distribution of +27 volts dc is included in the ac power distribution and control system.

b. The distribution of unregulated +450 volts dc and regulated +300, +150, and −150 volts dc is covered in the dc power supplies system, paragraph 168.

c. The power supply serves as a junction box for the radar sets. All power to the equipment is applied to the power supply and all power leaving the equipment is applied from the power supply. In addition, all ac and dc power distribution between component units of the equipment is through interconnections within the power supply. All 115-volt, 400-cycle power supplied to the equipment from gasoline driven Power Unit PU–107/U (or a substitute source) is applied to J405 (POWER IN SYSTEM) and J404 (POWER IN HEATERS). When a remote ppi is used with the equipment, 115-volt, 60-cycle power is applied from the remote ppi through the interconnecting cable which connects to J412 (SYNCHRO DATA TO RPPI).

d. Power to associated iff equipment may be applied from J411 (IFF POWER). Power is available for other auxiliary equipment such as test equipment and soldering iron from convenience outlets on the power supply, the indicator, and the antenna base.

e. The following schematic diagrams are used in following the distribution of power through the equipment:

(1) Figure 229, ac power distribution, schematic diagram.
(2) Figure 230, heater power distribution, schematic diagram.
(3) Figure 231,+27-volt dc power distribution, schematic diagram.

156. Power Receptacles and Metering (fig. 229)

When power is applied to J405 (Zone C1 on fig. 229) from the primary source of power, a limited amount of power is distributed regardless of whether or not main power contactor K402 (E4) is energized. Voltmeter M401 should indicate 115 volts and frequency meter M403 should indicate 400 cycles when power is applied from the primary source. Power is also applied to convenience servicing outlets J409, J603, and J754 through the normally closed contacts of K405 and fuse F416 (6.25 amp). This is done so that soldering and measurements requiring power to be removed from the remainder of the equipment may be performed.

a. Fuse F416 is a virtual short circuit around blown fuse indicator I 416; it prevents the lamp from glowing as long as the fuse is good. When the fuse burns out, the flow of current through the lamp causes it to glow to provide an indication that the fuse should be replaced. Blown fuse indicator socket XI 416 contains a built-in 68K current limiting resistor because of the very low current rating of I 416 (.0003 ampere). All of the fuses in the power distribution system have the same type of

blown fuse indicator lamps and operate in the same manner.

b. If F416 burns out, resistor R444 (68K) is placed in shunt with the servicing outlets to furnish a path of current through blown fuse indicator I 416 when no power is being drawn from the convenience outlets.

c. Radiate interlock relay K405 energizes when the transmitter is turned on. Contacts 8 and 14 of K405 substitute F401 (1.6 ampere) in place of F416 (6.25 ampere) so that too much power cannot be drawn from the servicing outlets while the transmitter is drawing power from the primary source.

157. Main Power Contactor Relay K402 (fig. 229)

Except for the circuits discussed in paragraph 156, no power can be distributed through the equipment unless main contactor K402 (E4) is energized.

a. Relay K402 is a double-pole, single-throw dc relay with contacts in series with each side of the line that furnishes 115-volt, 400-cycle ac power throughout the equipment. Selenium rectifier CR402 is used to rectify the voltage applied to the coil of K402 and C407 filters the voltage so that the dc relay does not chatter with pulsating dc applied to it.

b. When system POWER switch S602 (B–3) is placed in the ON position, power is applied to K402 through F402 (1.6 ampere), the relay energizes, contact is made between A2 and A1 and B2 and B1 and power is immediately made available to many circuits throughout the equipment through fuses F412 (60 ampere) and F413 (60 ampere).

Section II. AC POWER DISTRIBUTION

158. General

Undelayed 115 volts ac is distributed throughout the equipment and delayed 115 volts ac is applied to the modulator and the antenna base.

a. Most circuits requiring 115-volt, 400-cycle ac power receive power immediately when main contactor K402 is energized (undelayed 115 volts). To provide time for filaments to warm up, the application of 115 volts, 400 cycles is delayed approximately 5 minutes before it is applied to some circuits (delayed 115 volts).

b. To provide the protective 5-minute time delay, the undelayed 115 volts power is applied to the +27-volt dc power supply. Some circuits requiring +27-volt dc power receive power immediately (undelayed +27 volts). One such circuit is the 5-minute time delay circuit discussed in paragraph 164. Five minutes after the undelayed 115-volt ac power is applied to the time-delay circuit, the delayed +27-volt dc power is used to energize dc relays which cause delayed 115-volt ac power to be applied to the equipment.

159. Undelayed Ac Power Distribution (fig. 229)

When system POWER switch S602 (C–3) is closed, main power contactor relay K402 energizes and undelayed 115-volt ac power is immediately applied through the closed contacts of K402 and fuses F412 and F413 (A–4 and E–4) to the circuits described in *a* through *m* below.

a. Power is applied to output receptacle J411 (C–5) which furnishes 115 volts, 400 cycles to the associated iff equipment.

b. Power is applied through F405 (A–5) and filter Z2351 to the primary of filament transformer T2350 (C–5). The secondary of T2350 furnishes 6.3 volts ac to the filaments of all vacuum tubes in the signal comparator.

c. Power is also applied through F405 and Z2351 to blower motor B2350 when high temperature thermostat S2352 closes and safety interlock S2355 is closed. Interlock S2355 removes power from B2350 when the signal comparator is pulled out of its case because the fan on the motor presents a hazard to personnel working in the unit.

d. Power is applied through F410 (A–8), filter capacitors C159 and C171, and LC filter components Z153 and Z154 to the primaries of filament transformers T101 (C–10), T152 (C–8), and T153 (C–9) in the modulator. Two circuits are supplied power in parallel with the three filament transformers. Power is supplied to blower motor B151 (C–7) when high temperature thermostat S154 closes. Power is also applied to modulator high-voltage warning

lights I 151, I 152, and I 153 through interlock S153A. Interlock S153A opens when the modulator is pulled out of its case. If the manual interlock defeat is closed, the three warning lights glow as a warning to personnel that high voltage may be present in the chassis. If interlock S153A is opened, interlock S153B also opens and removes ac power to the high-voltage power supply in the modulator by interrupting the distribution of delayed +27 volts dc to relays which must be energized to apply power to the high-voltage circuit.

e. Power is applied through F409 (A–13) to the primary of filament transformer T401 (D–13) and blower motor B401 (C–13) in the power supply.

f. Power is also applied through F409, Z501 (B–14), S504A, Z502, S603 (B–18), and S402B to the primary of plate supply transformer T402 (C–19) and from terminal 1703–E401 (B–19) through F407 to the primary of indicator high-voltage transformer T604 (C–20). The secondaries of plate transformer T402 supply power to the rectifiers and voltage regulator circuits which supply +450, +300, +150, and −150 volts dc to stages throughout the equipment. None of the systems of the equipment can function properly unless power is applied to T402. Note that if any of the three interlocks (S504A on the receiver transmitter, S603 on the indicator, or S402B on the power supply) are open, power is not supplied to the primary of R402 and the equipment cannot function. Interlocks S504A and S603 have built-in interlock defeats and interlock S402B can be defeated by closing S404B (INTERLOCK SHORTING SWITCH). Power is also supplied through F409 to interlock S402A (B–13) and current limiting resistor R445 to high-voltage warning light I 417 and through Z501, S504, and Z507 to high-voltage warning lights I 501 and I 502 through current limiting resistors R506 and R520. High-voltage warning light I 610 (B–21) and its current limiting resistor R2620 are in parallel with the primary of T604 so that I 610 glows when power is applied to T604. Indicator high-voltage transformer T604 supplies plate voltage to the indicator high-voltage power supply which furnishes high-voltage potentials to the cathode-ray tube circuits.

g. Power is applied through F403 (A–16) to preamplifier filament transformer T503 (C–18).

h. Power is also applied through F403 and Z503 and Z507 to the primary of keep-alive power supply transformer T501 in parallel with blower motor B501. Power is also applied through F403 to the primary of magnetron filament transformer T504. The method of applying power to T504 and the amount of power that is applied depends on whether or not radiate interlock relay K405 is energized. When the radar *is not* radiating, 115 volts is applied to the primary of T504 through Z508 and Z507. The normally closed contacts of K405 provide a short circuit around resistor R516 (50 ohms). When the radar set *is* radiating, K405 energizes and power is then applied through Z503, R516, and Z507 to the primary of magnetron filament transformer T504, decreasing the voltage applied to the primary and the secondary of the transformer (par. 32).

i. Power is applied through F404 (A–21) and through filters Z605 and Z606 to the primary of filament transformer T605 in parallel with the rotor of synchro receiver B602. When high temperature thermostat S610 closes, power is also applied to blower motor B601 (C–22).

j. With safety switch S753 (B–22) on the antenna base in the ON position, power is also applied through F404 to the rotor of synchro transmitter B753.

k. Power is applied through F406 (A–23) to blower motor B702 (D–24), the primary of thyratron grid transformer T701 (C–24), the primary of filament transformer T702, dry-disk rectifier CR701 (C–25), and the primary of +27-volt dc supply transformer T403 (B–22). The output of CR701 furnishes 95 volts dc to the field winding of antenna drive motor B751 and also to protective relay K703 which opens the thyratron plate transformer circuit (C–28) so that no current can flow through the armature of B751 in the event that field excitation is not available. The secondary of transformer T403 supplied plate voltage to the +27-volt dc power supply which furnishes undelayed +27 volts dc to some control relays and to the 5-minute time delay circuit (par. 164). The delayed +27-volt dc output from the 5-minute time delay circuit furnishes power to relays

that control the distribution of delayed 115 volts ac power. The contacts of three such relays are shown on the ac power distribution schematic diagram; K405 (A–2 and A–16), K152 (E–10), and K705 (C–28).

l. When S401 (SWITCH ANT. BLOWER) is in the ON position (B–23), power is also applied through F406 to tent ventilator blower motor B755 (C–23).

m. When high temperature thermostat S703 closes, power is also applied through F406 to blower motor B701 (C–26).

160. Delayed Ac Power Distribution (fig. 229)

Five minutes after system POWER switch S602 (C–3) is closed and the undelayed 115 volts ac is distributed through the equipment, dc relays energized by delayed +27 volts dc make delayed 115 volts ac available for two circuits which require time for filaments of vacuum tubes to warm up before plate voltages are applied. Delayed 115 volts ac is supplied to the servo amplifier in the antenna positioning system (antenna base) and to the high-voltage power supply in the transmitting system (modulator). Power distribution to both circuits can only take place after the 5-minute time-delay circuit in the power supply makes delayed +27 volts dc available.

a. Power is applied through F408 (A–26) through normally closed low temperature thermostat switch S754 to the primary of thyratron plate transformer T704 (D–26) if the contacts of S753, S701, K703, and K705 are closed. The contacts of interlock switch S701 close when the servo amplifier chassis is in its case (or its interlock defeat is closed). The contacts of K703 close if field excitation is available for antenna drive motor B751. The contacts of K705 close when delayed +27 volts dc is applied to plate voltage relay K705. The contacts of S753 (safety switch) must be manually placed in the ON position for the antenna to be rotated (par. 146). Normally closed thermostat S754 opens and prevents rotation of the antenna if the temperature of the antenna base falls below −34° C. This prevents damage to the antenna drive motor at very low temperatures.

b. Delayed 115 volts ac is applied to the high-voltage power supply in the modulator. Power is applied through F411 (A–11), J420 (MAGNETRON AGING JACK) and P420, bypass capacitors C170, C166, and C165, and filters Z151 and Z152 to the primary of high-voltage transformer T151 (D–11) when radiate relay K152 is energized. The complete circuit through which K152 is energized by delayed +27 volts dc is shown on figure 231 and is discussed in paragraph 165*h*. Shorting plug P420 is connected to J420 so that the circuit is completed to the primary of T151 during normal operation. When the magnetron is replaced it may be aged by removing P420 and substituting a plug which connects to a variac so that the voltage applied to the primary of T151 can be increased to normal in steps.

161. Fuses and Interlocks

The distribution of 115-volt ac power is controlled by fuses that are located on the front panel of the power supply and interlocks which are located on individual units.

a. All fuses have blown fuse indicators which operate as described in paragraph 156*a*. The blown fuse indicators have the same symbol reference designation number as the fuses. Time lag fuses are used in circuits which may be subject to momentary current surges. A complete list of fuses, their ratings, and the circuits they protect is given in paragraph 207*a*.

b. Different types of interlocks are used in the equipment to protect personnel against injury from voltages greater than 500 volts. There is considerable interrelationship between the interlocks in the various units. For example, figure 229 shows that if interlock S603 on the indicator is open, power is not applied to the primary of plate transformer T402 and therefore none of the systems functions properly because T402 supplies power to the unregulated +450-volt dc, and the regulated +300-, +150-, and −150-volt dc power supplies. A complete list of interlocks, their operation, function, and disabling (or defeating) procedures is given in paragraph 207*b*.

Section III. DISTRIBUTION OF +27-VOLT DC POWER

162. General

Delayed +27 volts dc is distributed throughout the equipment to control relays. The +27-volt dc power supply also furnishes power to the local oscillator filament, the local oscillator tuning motor, and the OPERATING HOURS meter.

a. Undelayed 115 volts ac is applied to the primary of 27-volt dc supply transformer T403 (par. 159*k*) in the +27-volt dc power supply. The +27-volt dc power supply produces undelayed +27 volts dc and applies it to the 5-minute time delay circuit. All relays in the equipment except protective relay K151 in the transmitting system, protective relay K703 in the antenna positioning system, and main power contactor relay K402 (par. 157) are energized by delayed +27 volts dc.

b. The distribution of undelayed 115 volts dc to the +27-volt dc power supply, the 5-minute time-delay circuit, and the entire distribution of +27 volts dc are shown in figure 231.

163. Plus 27-Volt Dc Power Supply (fig. 231)

The +27-volt dc power supply is located in the power supply but is considered to be part of the power distribution and control system because its output is used to energize relays which control the distribution of power throughout the equipment.

a. When POWER switch S602 is placed in the ON position, power is applied to the primary of +27-volt dc supply transformer T403 through the closed contacts of main power contactor K402, system power fuses F412 and F413 and fuse F406. Step-down transformer T403 applies approximately 37 volts ac to dry-disk rectifier CR401 which is connected in a full-wave bridge rectifier circuit. Choke input filter L403 and C403 filters the pulsating dc output from CR401 and provides +27 volts to terminal E401–8A. Bleeder resistor R404 loads the power supply so that the +27-volt output voltage does not vary much with changes in the remainder of the load on the power supply.

b. The output from the +27-volt dc power supply (undelayed +27 volts dc) is applied to three circuits: the filament of local oscillator tube V505 (par. 55*f*), local oscillator tuning motor B502 when L.O. MOTOR switch S613 is in the DEC position (par. 56), and to the 5-minute time-delay circuit.

164. Five-Minute Time-Delay Circuit (fig. 231)

Undelayed +27 volts dc is applied from the +27-volt dc power supply to the 5-minute time-delay circuit which consists of 5-minute time-delay relay K401 and slave relay K403.

a. Five-minute time-delay relay K401 consists of a 6-volt dc motor that drives three cams which in turn actuate three microswitches. The motor has a permanent magnet field so that when current flows through the armature of the motor, the armature turns and its output shaft (through reduction gears) drives the three cams at a rate of $\frac{1}{5}$ rpm. With 6 volts applied to the armature the cams make 1 complete revolution in 5 minutes.

b. When undelayed +27 volts is applied to the circuit, current flows from ground, through the armature of K401, through a portion of R443, through the normally closed contacts of switch No. 1 (1 and 9), through the normally closed contacts of slave relay K403 (3 and 1) to +27 volts dc. Time-delay adjustment R443 controls the amount of current through the armature of the motor and therefore the speed of rotation of the armature and the three cams. The resistor is normally adjusted to provide a total time-delay of 5 minutes (the length of time for 1 complete revolution of the cams).

c. Five seconds after the motor of K401 starts to rotate, cam No. 1 closes contacts 1 and 8 so that current through the armature of the motor and R443 flows directly to +27 volts. At the same time cam No. 2 closes contacts 2 and 6. This sets up the circuit for energizing K403 with the delayed +27-volt dc circuit being kept open.

d. Five seconds later (a total of 10 seconds after the motor starts to rotate) cam No. 3 closes contacts 3 and 5 so that +27 volts is applied through contacts 3 and 5 of switch No. 3 and contacts 6 and 2 of switch No. 2 to the coil of slave relay K403. This causes K403 to energize. When K403 energizes, contacts 1 and 5 of K403 close and the undelayed +27 volts

holds K403 energized directly through the holding contacts (1 and 5) of K403.

e. Ten seconds later (a total of 20 seconds after the motor of K401 starts to rotate), cam No. 3 opens contacts 3 and 5 of switch No. 3 so that contact 3 again makes with contact 4 and removes the path of +27 volts (which previously flowed through switch number 3) through the coil of K403. Relay K403 is now able to hold itself energized through its own closed holding contacts (1 and 5).

f. Approximately 4 minutes and 40 seconds later, cam No. 1 causes contact 1 to make with contact 9 again and cam No. 2 causes contact No. 2 to make with contact 7 again. At this time (approximately 5 minutes after the motor of K501 starts to rotate, the exact amount of time depending on the setting of R443) switch No. 1 removes power from K401 and the armature of its motor stops turning. At the same time, switch No. 2 connects delayed +27 volts dc to its load. Delayed +27 volts is applied from the output of the +27-volt power supply through contacts 1 and 5 of K403 and through contacts 2 and 7 of switch No. 2 to terminal E404–8A7 from which delayed +27 volts dc is distributed.

g. Under normal operating conditions, once the delayed +27 volts dc is made available to the system, it remains available until K403 deenergizes. This can only occur if ac power is removed from the primary of T403 and normally this can only be accomplished by placing POWER switch S602 in the OFF position. Many abnormal conditions, such as a trouble in the +27-volt dc power supply or power distribution to T403, can also cause K403 to deenergize resulting in removal of delayed +27 volts dc. If K403 should become deenergized, it is necessary for 5-minute time-delay relay K401 to run through its complete cycle again before K403 can become energized again and distribute delayed +27 volts dc to the system.

165. Distribution of Delayed +27 Volts Dc (fig. 231)

Approximately 5 minutes after system POWER switch S602 is placed in the ON position, +27 volts dc is made available by the 5-minute time-delay circuit and delayed +27-volt dc power is applied to the circuits described in *a* through *h*, below.

a. Power is applied to plate voltage relay K705 in the antenna positioning system. The contacts of K705 complete the circuit for the application of ac power to the primary of thyratron plate transformer T704, making it possible for the antenna to be rotated (par. 160*a*).

b. Power is applied to the voltage coil of braking relay K702 when breaking cam S617 completes the ground return circuit of K702 (par. 147).

c. Power is applied to reversing relay K701 when reversing cam S618 completes the ground return circuit of K701 (par. 147).

d. Power is applied to synchro relay K704 when synchro transmitter zero cam S756 and synchro receiver zero cam S612 complete the ground return circuit of K704 (par. 154).

e. Power is applied to video relay K3300 and mode selector relay K3301 depending upon whether or not their ground return circuits are completed by OPERATION SELECTOR switch S2354 or OPERATION switch S601 (par. 96).

f. Power is applied through interlock S504B and normally closed magnetron overtemperature thermostat S501 to shutter gate relay K501. When K501 energizes it removes a shorting pin from tr tube V504A allowing the receiver to accept signals. The pin protects the signal crystal mixer from damage caused by signals from other radiating sources when the equipment is off and there is no keep-alive voltage (par. 46).

g. Power is also applied through S504B and S501 to the local oscillator tuning motor when L.O. MOTOR switch S613 is in the INC position. Undelayed +27 volts dc is applied to the motor when S613 is in the DEC position (par. 56).

h. When RADIATE ON switch S616 is pressed, power is also applied through S504B and S501, and through S616, the normally closed contacts of K151, and S153B to energize radiate relay K152, radiate interlock relay K405, and M402 (OPERATING HOURS). When K405 energizes, contacts 6 and 12 close and act as holding contacts across S616. This is necessary because S616 is spring-loaded and

opens as soon as physical pressure is removed. Two other sets of contacts of K405 close ac power distribution circuits (fig. 229). When K152 energizes its contacts apply ac power to the primary of modulator high-voltage transformer T151 (par. 160). Meter M402 measures the number of hours the transmitter radiates. Since the transmitter is normally on, the reading on M402 closely approximates the total number of hours the equipment is used. The normally closed contacts of K151 open in the event of an overload in the transmitting system. If K151 energizes, its contacts open and cause K152 and K405 to deenergize. Both K152 and K405 must be energized for the equipment to radiate. The equipment stops radiating if interlocks S504B, or S153B are opened or if RADIATE OFF switch S615 is pressed.

Section IV. HEATER CIRCUITS

166. General

Power to heat the components of the equipment is furnished directly from the primary source of power. Approximately 2.5 kw of the capacity of the primary source of power is reserved for power to the heaters.

a. All heaters except HR751 and HR2350 are 150-watt space heaters that are controlled by low-temperature thermostats which are normally open, close at 0° C, and open again after the temperature of the component is raised above 15° C.

b. Heater HR751 is a 1,000-watt heater in the antenna drive motor gear case within the antenna base. Its thermostat (S751) closes at 0° C. and remains closed as long as the temperature of the gear case remains below 0° C. The heater prevents overloading of the antenna drive motor by preventing the oil in the gear-case from becoming too stiff.

c. Heater HR 2350 is a 250-watt heater within the mercury delay line subassembly within the signal comparator. Its thermostat (S2350) closes when the temperature of the subassembly falls below −30° C. and remains closed as long as the temperature within the mercury delay line subassembly remains below −30° C. Mercury remains in a liquid state down to approximately −39° C. This heater prevents the mercury in the delay line from freezing.

d. A complete list of the heaters used in the equipment, the units in which they are located, their ratings, the thermostats used with each heater, and the illustrations upon which they may be located is given below.

Heater	Component (heated)	Rating (watts)	Thermostat	Location (fig. No.)	
				Heater	Thermostat
HR151	Modulator	150	S155	110	106
HR152	Modulator	150	S155	110	106
HR401	Power supply	150	S403	177	179
HR501	Receiver-transmitter	150	S505	103	123
HR502	Receiver-transmitter	150	S505	123	123
HR601	Indicator	150	S611	149	156
HR701	Antenna base	150	S702	165	164
HR751	Antenna drive motor gear case	1,000	S751	188	168
HR752	Antenna base	150	S751	167	168
HR2350	Delay line assembly	250	S2350	195	195
HR2351	Signal comparator	150	S2351	201	143

167. Heater Circuit Functioning
(fig. 230)

Power to all heaters in the equipment is applied from the primary source of power to J404 (POWER IN HEATERS) on the front panel of the power supply. From J404, 115 volts ac, 400 cycles, is applied through F414 and F415 (30 amp each) to the circuits described in *a* through *f*, below.

a. Power is applied through filters Z159 and Z158 to heater HR151 in parallel with HR152 when thermostat S155 closes.

b. When thermostat S403 closes, power is applied to heater HR401.

c. Power is applied to heater HR501 in parallel with HR502 when thermostat S505 closes.

d. When thermostat S611 closes, power is applied to heater HR601.

e. Heater power is applied to heaters HR701, HR751, and HR752 when their respective thermostats close (S702, S751, and S752) and if safety switch S753 is in the ON position.

f. Heater power is applied through line filter Z2351 to heaters HR2350 when thermostat S2350 closes, and to heater HR2351 when thermostat S2351 closes.

CHAPTER 9
DC POWER SUPPLY SYSTEM

168. General

a. The dc power supply system receives 115-volt, 400-cycle power from the power distribution and control system and provides dc operating potentials for the entire equipment. The potentials furnished by the dc power supply system are:

(1) Unregulated +450 volts to the indicating system.
(2) Regulated +300 volts to the indicating, receiving, and transmitting systems.
(3) Regulated +150 volts to the antenna positioning, indicating, receiving, and signal comparing systems.
(4) Regulated −150 volts to the indicating, receiving, and signal comparing systems.

b. A +27-volt power supply and a relay control chassis are also located in the power supply. They are considered to be part of the ac power distribution and control system because their primary function is to control the distribution of ac power to the equipment.

c. Power Supply PP–674/TPS–1D serves as a junction box for the entire equipment. All interconnections between units of the equipment are made through interconnections within the power supply. Figure 233 (sheet 1) shows all of the internal interconnections of the power supply. Figure 233 (sheet 2) is a complete schematic diagram of the power supply (dc power supplies) and control chassis. Figure 207 shows all of the external cabling from the power supply to all other units of the equipment.

169. Dc Power Supply System, Block Diagram (fig. 90)

The dc power supply system furnishes plate supply potentials to most of the stages and bias potentials to many of the stages in the equipment. Therefore the dc power supply system incorporates a protective feature which prevents the application of plate supply potentials when bias potentials are absent because of trouble in the negative portion of the dc power supply system.

a. Power is applied to filament transformer T401 and plate transformer T402 from the ac power distribution and control system. Filament transformer T401 furnishes filament power to positive rectifiers V401 through V405 and to negative rectifier V406. Plate transformer T402 furnishes different values of stepped up ac potentials to all three rectifier circuits which are operated as conventional full-wave rectifier circuits. Each rectifier has a choke input-type filter associated with it to smooth out the 800-cycle ripple frequency. Parallel rectifier tubes are used in the positive power supplies due to the larger load currents furnished by them.

b. Rectifiers V404 and V405 furnish unregulated +450 volts to the ppi sweep amplifiers and the ppi focus current regulator because the relatively large currents required by these circuits cannot be handled by the indicator high-voltage power supply. Plus 450 volts is also applied to the +300-volt regulator circuit which consists of series regulators V414, V415, and V416 and control tube V417. The output from the +300-volt regulator is applied to many stages in the indicating, receiving, and transmitting systems.

c. The +300-volt regulator circuit regulates for changes in the line voltage applied from the ac power distribution and control system as well as for changes in load current which would normally cause a change in output voltage. Either tendency for the output regulated +300 volts to change causes the input to control tube V417 to change. The control tube acts as a dc amplifier and causes the bias on series regulator tubes V414, V415, and V416 to vary. The change in bias causes the dc resistance of the series regulator tubes to vary so that the

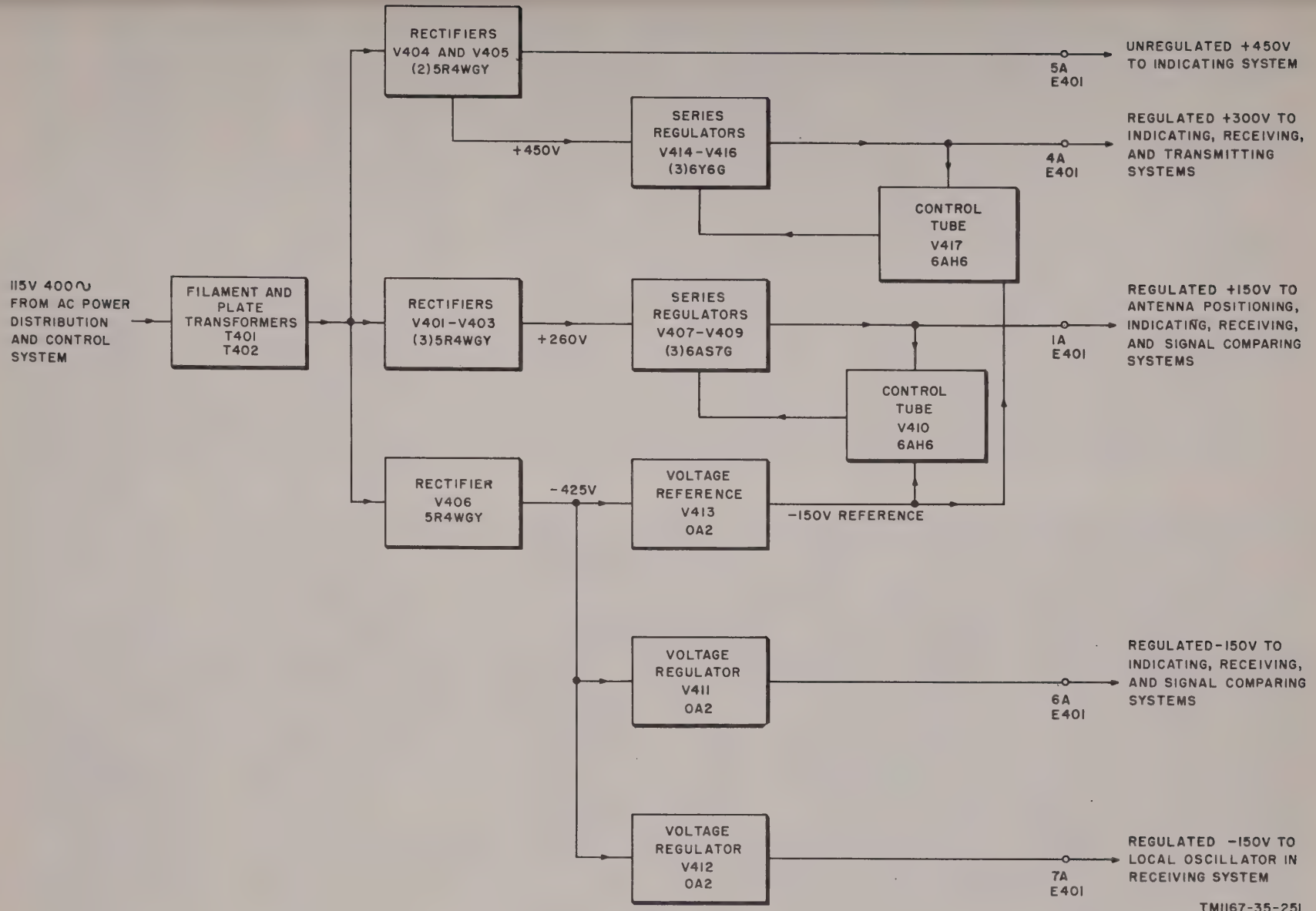


Figure 90. Dc power supply system, block diagram.

change in voltage across the series regulator tubes allows the output voltage to remain very close to +300 volts.

d. Positive rectifiers V401 through V403 apply approximately +260 volts to the +150-volt regulator which consists of series regulators V407, V408, and V409 and control tube V410. The +150-volt regulator functions in the same manner as the +300-volt regulator so that the regulated +150-volt output to the antenna positioning, indicating, receiving, and signal comparing systems is held very close to +150 volts.

e. Negative rectifier V406 furnishes unregulated −425 volts to voltage regulators V411 and V412 and to voltage reference tube V413. All three stages operate as shunt regulators, their output voltage being regulated at −150 volts. The output from V411 (regulated −150 volts) is applied to the indicating, receiving, and signal comparing systems where it is used for establishing bias potentials. The output from V412 is applied to the receiving system where it is used as B for the local oscillator stage.

f. The output from voltage reference tube V413 is applied to the +150- and +300-volt regulator circuits where it is used to maintain a constant reference voltage for proper operation of the voltage regulator circuits. This arrangement provides for protection of the equipment by preventing the application of normal B+ potentials when the negative rectifier circuit becomes inoperative and bias potentials are lost. If there is no output from negative rectifier V406, the normal regulated +300-volt output (4A) is reduced to approximately +100 volts and the normal regulated +150-volt output (1A) is reduced to approximately +100 volts.

170. Positive Rectifiers
(fig. 91)

The positive rectifiers receive 115-volt, 400-cycle power from the power distribution and control system when system POWER switch S602 is placed in the ON position. Two outputs are taken from the positive rectifiers, unregulated +260 volts is applied to the +150-volt regulator circuit and unregulated +450 volts is applied to the indicating system and to the +300-volt regulator circuit.

a. Both positive rectifier circuits receive plate potentials from the same secondary winding on T402; 670 volts rms is applied from terminals 5 and 7 to the +150 rectifier circuit, and 1,060 volts rms is applied from terminals 4 and 8 to the +450 rectifier circuit.

b. The rectifier circuits differ only in load considerations. Three 5R4WGY full-wave rectifier type tubes are used in parallel in the +150-volt rectifier circuit (V401, V402, and V403) to handle the larger load drawn from the +150-volt rectifier circuit and a larger filter capacitor (C405) and smaller choke

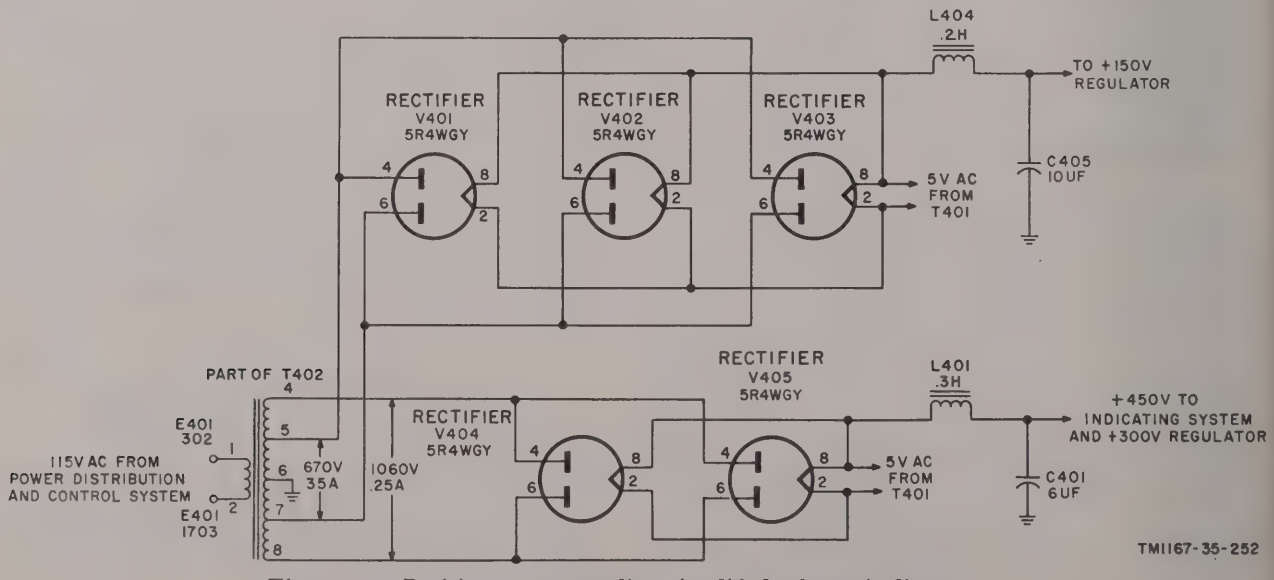


Figure 91. Positive power supplies, simplified schematic diagram.

(L404) are used in its filter to handle the larger current drain.

c. Both rectifier circuits are conventional full-wave rectifier circuits and apply pulsating dc with a ripple frequency of 800 cycles to choke input-type filters which smooth the ripple amplitude to a tolerable level. The filtering requirements are reduced because both outputs are applied to voltage regulator circuits which provide further filtering of the ripple amplitude. The unregulated +450-volt output is applied to a few stages where the output ripple amplitude does not affect circuit operation.

171. Voltage Regulators, Equivalent Circuit (fig. 92)

The voltage regulator circuit shown in figure 92 can be used to show the operation of both the series and shunt regulator circuits used in the dc power supply system.

a. The regulator circuit shown maintains its output voltage virtually constant if a change in the unregulated voltage applied to the regulator circuit (which results from changes in the line voltage or the rectifier circuit) or if a change in load drawn from the power supply (which also tends to make the unregulated voltage change) occurs.

b. Voltage reference tube V4 is an OA2 type glow-discharge voltage regulator tube operated as a shunt regulator. Operated within its current rating (5 to 30 ma) the voltage across it remains a constant 150 volts in spite of considerable variation in the value of the unregulated input voltage. Changes in the unregulated input voltage appear across series resistor R4. If the unregulated input voltage increases, further ionization of V4 causes an increased current to flow through R4. Increased current through R4 causes an increased voltage drop across R4 so that the voltage across V4 remains 150 volts. If the unregulated input voltage decreases, the degree of ionization of V4 also decreases and causes less voltage drop across R4, which in turn allows the voltage across V4 to remain very close to 150 volts. Thus the voltage from the junction of R4 and R7 to ground is held at a constant −150 volts. This potential is used as a constant reference voltage for the series regulator circuit (V2 and V3).

c. An unregulated dc voltage is produced by the conventional full-wave rectifier and choke input filter consisting of T1, V1, L1, and C1. This unregulated dc voltage appears across C1 and is applied to the voltage regulator circuit. The dc plate resistance (R_p) of series regulator tube V2 forms a voltage divider with R8 so that the voltage across V2 plus the voltage across R8 always equals the unregulated voltage across C1. The voltage regulator circuit maintains the voltage across R8 very close to 150 volts by controlling the voltage across V2 by varying its dc plate resistance. The dc plate resistance of a vacuum tube depends upon its bias. Its dc resistance can be varied from infinity (when the control grid is sufficiently negative with respect to the cathode to hold the tube beyond cutoff) to close to zero (when the control grid is highly positive with respect to the cathode so that plate current saturation occurs). While the dc resistance of V2 is not changed to these extreme values in this circuit, its dc resistance is varied by controlling the difference in potential between the control grid and cathode.

d. The cathode of control tube V3 is returned to ground. Voltage divider R1 and R2 (between the unregulated input potential and ground) establishes the screen grid potential of V3 sufficiently positive so that V3 normally conducts. The amount of conduction of V3 depends primarily upon the potential at the control grid of V3 with respect to the grounded cathode. This potential is established by voltage divider R5, R6, and R7 between regulated +150 volts and the reference potential of regulated −150 volts. The plate current through V3 flows through plate load resistor R3 and causes the plate potential of V3 to vary and the control grid of V2 to vary with respect to its cathode. The difference in potential between the control grid and cathode of V3 controls the dc plate resistance of series regulator tube V2 and the regulated output voltage. Potentiometer R6 is normally adjusted so that the regulated output voltage is +150 volts with respect to ground.

e. An increase in the input line voltage causes the unregulated voltage across C1 to rise. This rise must be distributed between V2 and R8. The function of the voltage regulator circuit is to make virtually all of the rise appear across V2 and virtually none of the rise to appear across R8. As the line voltage starts

to rise, the output voltage from the voltage regulator starts to rise also. The increase in potential at the top of R5 with respect to the −150 volts reference potential causes the control grid of V3 to go positive with respect to its cathode. The resulting increased current flow through V3 and R3 causes the potential at the plate of V3 to decrease. The control grid of V2 is directly coupled to the plate of V3 so that the decrease in potential at the plate of V3 causes the control grid of V2 to go negative with respect to its cathode (which does not change appreciably). The increased bias for V2 causes the resistance of V2 to increase and most of the increase in the unregulated voltage appears across the increased dc plate resistance of V2. The efficiency of the regulator circuit depends upon the gain of dc amplifier V3 and series regulator V2. Since the μ of a 6AS7G is only 2, very little gain can be expected from the series regulator so that virtually all of the gain in the system is provided by control tube V3.

f. To illustrate the action of the voltage regulator circuit numerically, assume that the line voltage increases by an amount which causes the unregulated voltage to increase 20 volts, that the gain of V2 is 1, that the gain of V3 is approximately 500, and that the wiper arm of R6 is at the half resistance point between the +150-volt and −150-volt potentials. With these assumed values, the output voltage rises to the +150.08 volts. The regulator action is such that the grid of V3 rises .04 volts, the change at the grid is amplified by V3 so that the change in voltage at the plate of V3 is 20 volts, and the change in voltage across V2 (from plate to cathode) is almost the full 20-volt change in the unregulated voltage. For all practical purposes the output voltage from the voltage regulator remains +150 volts.

g. The regulating action is similar if the load on the regulated +150-volt supply increases. The increased load current causes an increased voltage drop across V2, L1, and V1, so that the input unregulated voltage to the voltage regulator circuit decreases. This causes the output voltage from the voltage regulator to decrease. As it decreases the voltage at the grid of V3 becomes less positive and the conduction of V3 decreases. This in turn causes the potential at the plate of V3 and the grid of V2 to rise so that the grid of V2 goes positive with respect to its cathode and the dc resistance of series regulator V2 decreases. The decreased resistance of V2 allows more current to be drawn from the rectifier and regulator circuits and still have essentially +150 volts available at the output of the voltage regulator circuit. Actually a very slight decrease in the output voltage

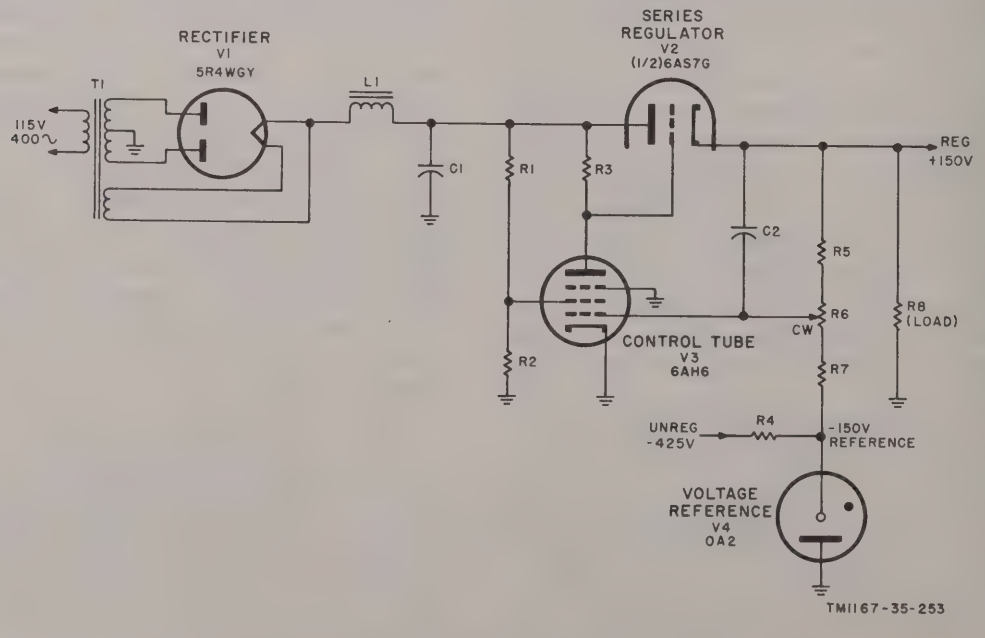


Figure 92. Voltage regulator, equivalent circuit.

takes place to provide an input to the control tube.

h. Resistors R5 and R7 establish the range over which R6 can vary the potential at the grid of V3. Capacitor C2 between the output and the grid of V3 decreases the ripple amplitude of the output voltage by increasing the response of the circuit. Since the voltage across a capacitor cannot change instantaneously, C2 causes the full change in voltage at the output to appear at the control grid of V3 until C2 can charge to the new potential across it. However, C2 cannot affect the average output voltage. To increase the output voltage from the voltage regulator circuit, R6 should be rotated clockwise. This causes the control grid of V3 to become more negative, decreases the current through V3 and R3, and causes the voltage at the plate of V3 and the grid of V2 to become more positive. A positive going voltage at the grid of V2 with respect to its cathode causes the dc plate resistance of V2 to decrease. The flow of load current across the lower dc resistance of V2 causes a decreased voltage drop across V2 and therefore the output voltage of the circuit increases. Capacitor C2 does not affect this adjustment or any relatively slow change in output voltage.

172. Plus 300-Volt Regulator (fig. 93)

The +300-volt regulator receives approximately +450 volts from the positive rectifiers and furnishes regulated +300-volt plate supply potentials to the indicating, receiving, and transmitting systems. The operation of the +300-volt regulator is the same as the equivalent circuit described in paragraph 171 except for the differences described in *a* through *d* below.

a. Three triode-connected 6Y6G beam power amplifier type tubes are used as series regulator tubes. They are connected in parallel to handle the load current drawn from the +300-volt supply. Resistors R459, R460, and R461 in the screen grid circuits; resistors R421, R422, and R423 in the control grid circuits;

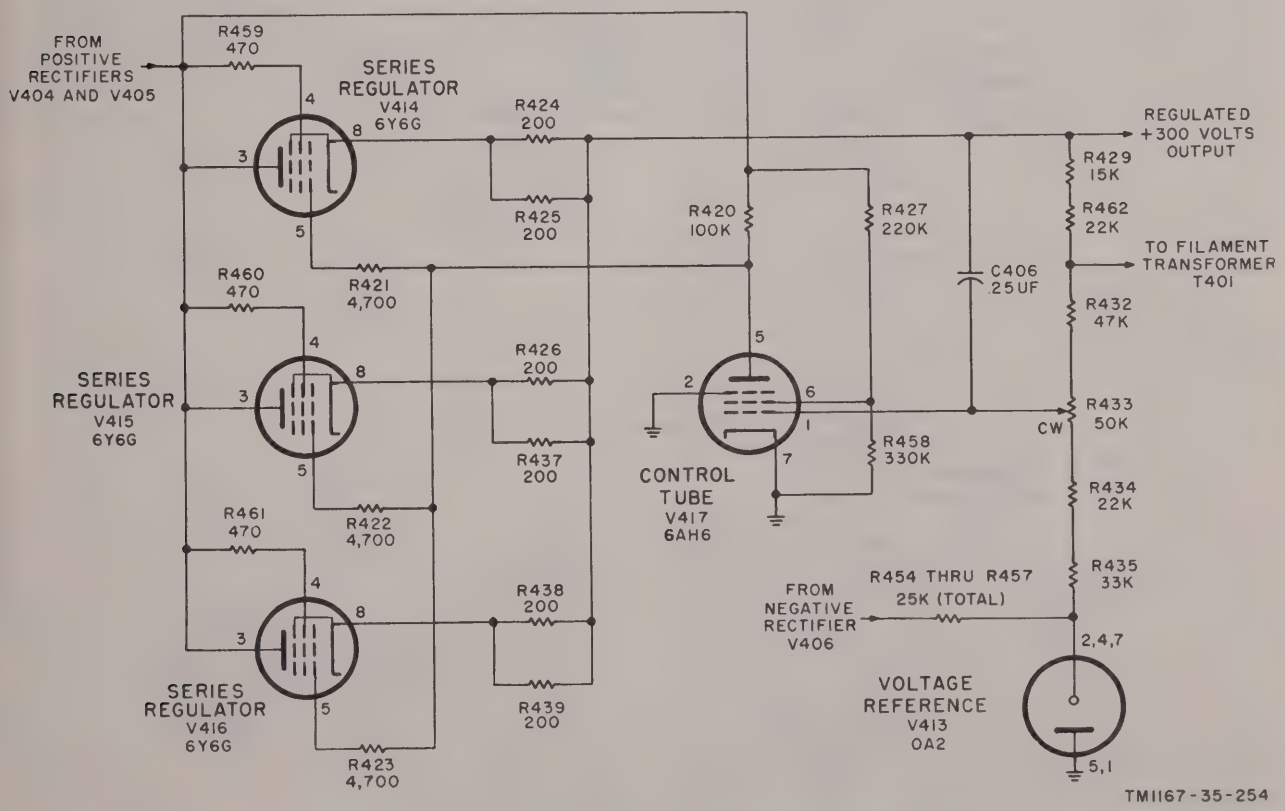


Figure 93. Plus 300-volt regulator, simplified schematic diagram.

and resistors R424, R425, R426, R437, R438, and R439 in the cathode circuits all serve to balance the currents through the three tubes. This prevents oscillations due to feedback between amplifiers.

b. Control tube V417 and voltage reference tube V413 function the same as their counterparts do in the equivalent circuit described in paragraph 171.

c. In addition to the main function of providing a means of sensing changes in the output voltage with respect to the −150-volt reference potential, voltage divider R429, R462, R432, R433, R434, and R435 is also used to establish a potential of approximately +225 volts. This potential is applied to filament transformer T401 so that the filaments of the series regulator tubes are placed closer to the cathodes from a dc standpoint to prevent breakdown between filament and cathode. The +225-volt potential is a compromise value because it is also applied to the filaments of the

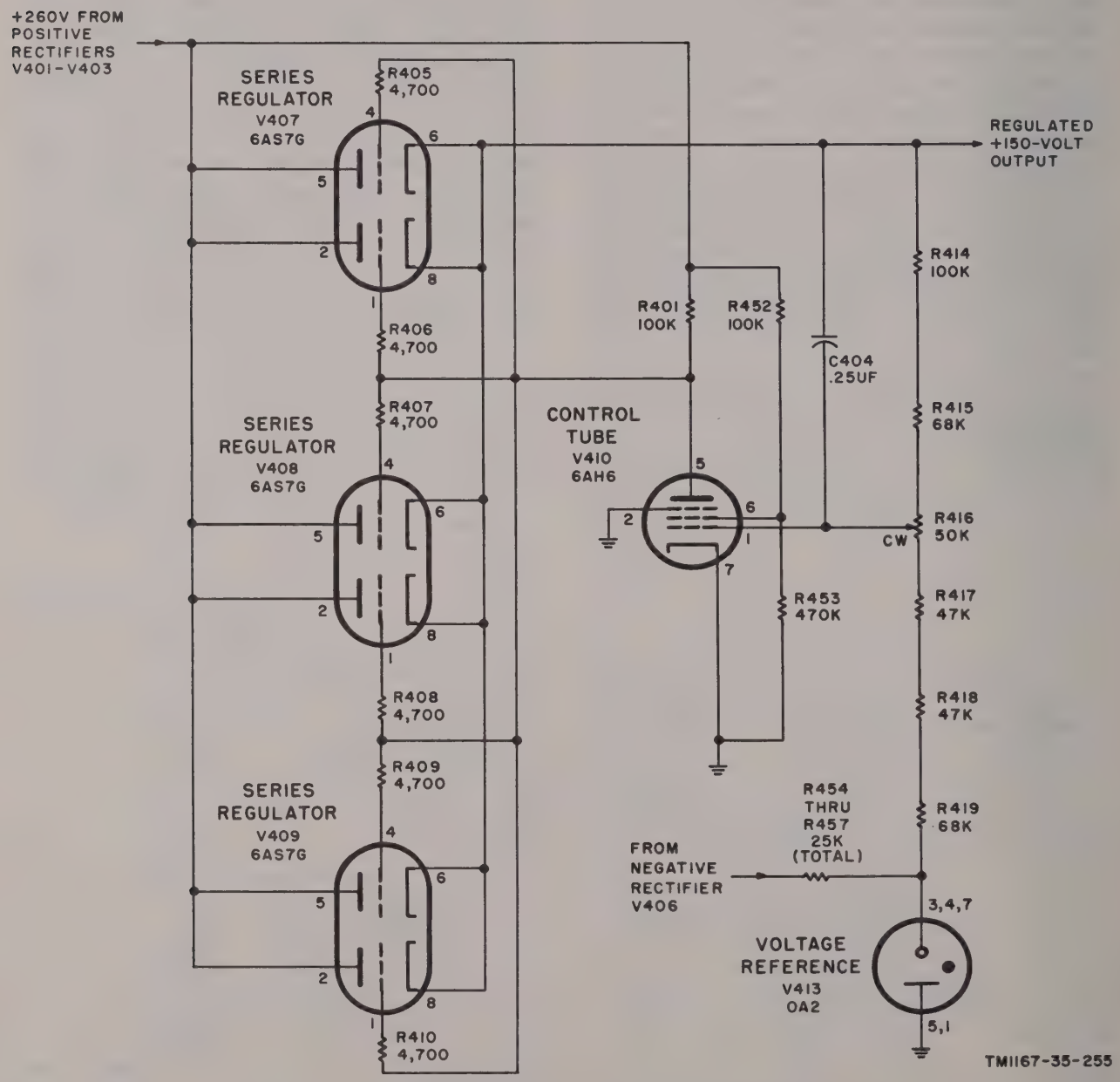


Figure 94. Plus 150-volt regulator, simplified schematic diagram.

series regulator tubes in the +150-volt regulator (fig. 233, sheet 2).

d. Potentiometer R433 is used to adjust the output from the regulator circuit for +300 volts.

173. Plus 150-Volt Regulator
(fig. 94)

The +150-volt regulator receives approximately +260 volts from the positive rectifiers and furnishes regulated +150-volt plate supply potentials to the antenna positioning, indicating, receiving, and signal comparing systems. The operation of the +150-volt regulator is the same as the equivalent circuit described in paragraph 171 except for the differences described in *a* through *c* below.

a. Three dual triode 6AS7G type tubes are used as series regulator tubes so that six triode sections in parallel are used to handle the load current drawn from the +150-volt supply. Resistors R405 through R410 in the grid circuits prevent oscillations which might arise because of unbalances in plate currents through the triode sections.

b. Control tube V410 and voltage reference tube V413 function the same as their counterparts in the equivalent circuit described in paragraph 171.

c. Potentiometer R416 is used to adjust the output from the regulator circuit for +150 volts.

174. Negative Rectifier and −150-Volt Regulators
(fig. 95)

The negative rectifier and −150-volt regulator circuits receive 115-volt, 400-cycle power from the power distribution and control system when system POWER switch S602 is placed in the ON position. Three regulated −150-volt outputs are taken from the circuit.

a. Stepped-up ac plate potentials are supplied to V406 from plate transformer T402. The dc circuit of the rectifier is completed through the secondary winding of T401 which furnishes filament voltage for the rectifier. The rectifier is a conventional full-wave rectifier. It applies pulsating dc with a ripple frequency of 800 cycles to choke input filter L402 and C409 in parallel with C410. The filter smooths the ripple frequency to a tolerable level and applies it to three shunt voltage regulators, V412, V411, and V413.

b. All three shunt voltage regulators operate the same. The operation of V413 is discussed in paragraph 171.

c. Regulated −150 volts is applied from

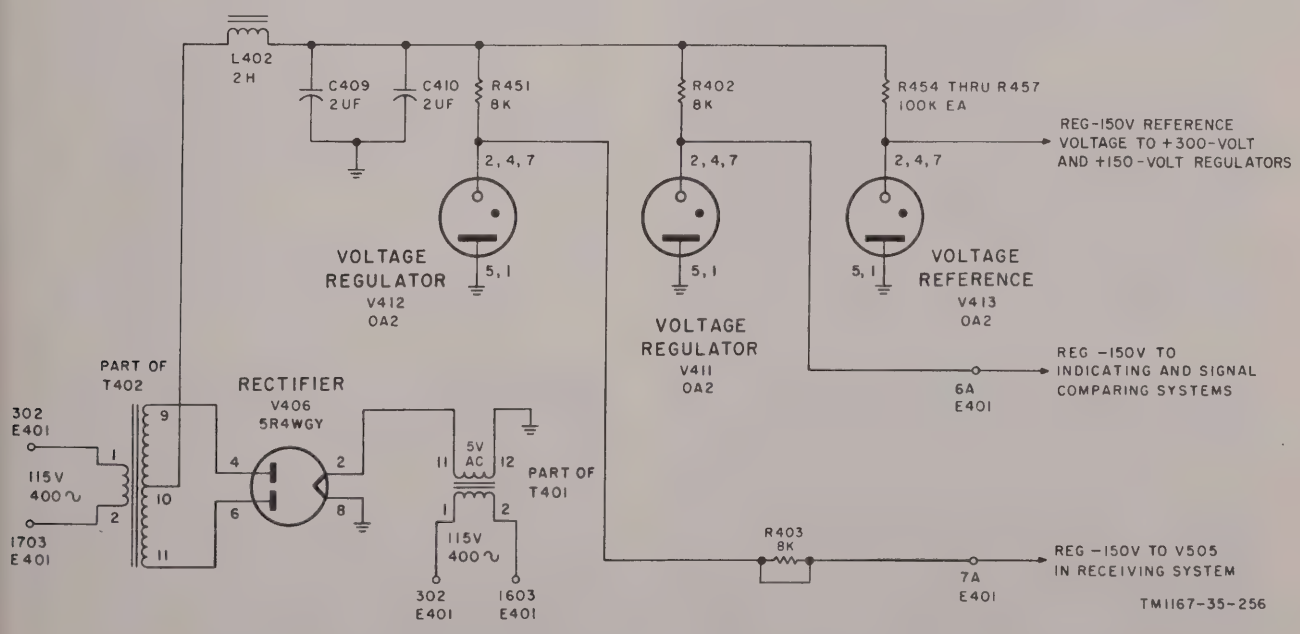


Figure 95. Negative rectifier and −150-volt regulators, simplified schematic diagram.

V412 to local oscillator V505 in the receiving system. Regulated −150 volts is applied from V411 to bias voltage divider networks in the indicating and signal comparing systems. Regulated −150 volts is applied from V413 as a reference voltage for the +300- and +150-volt regulator circuits in the dc power supply system (par. 171).

CHAPTER 10
GENERAL MAINTENANCE INFORMATION

Note. This manual contains information pertinent to field and depot maintenance. The amount of repair that can be performed by units having field and depot maintenance responsibility is limited only by the tools, test equipment, and replacement parts that are available, and the skill of the repairman.

Section I. TROUBLESHOOTING DATA AND TECHNIQUES

175. General

The information contained herein is designed to aid the repairman in detecting abnormal operation, locating and correcting equipment trouble causing abnormal operation, and checking the serviceability of repaired equipment in a minimum amount of time. Instructions for performing preventive maintenance and lubrication are contained in TM 11–1167–20. The preventive maintenance information is provided to keep the equipment in good working order so that breakdowns and needless interruptions in operation will be kept to a minimum.

176. Detecting Faulty Operation

Indications of both normal and abnormal operation are given in the various troubleshooting charts (par. 177). In addition to the indications contained in the troubleshooting charts, the following information is given in the first section of each troubleshooting and repair chapter:

a. Normal indications at test jacks.
b. Normal readings on system panel meters.
c. Function of controls and adjustments.
d. System fuses.
e. Dc resistance of inductive components.
f. System parts location.
g. Waveform charts.
h. Voltage and resistance diagrams.

177. Locating Trouble

The following types of troubleshooting charts are provided to aid in locating trouble in a minimum amount of time.

a. Troubleshooting Based on Starting Procedure. A troubleshooting chart based on the starting procedure (par. 210) is designed to enable the repairman to locate trouble based on indications obtained while starting the equipment. Use this troubleshooting chart to sectionalize trouble to a functional system of the equipment and to locate troubles in the ac power distribution and control system.

b. System Symptom Troubleshooting Charts. A system symptom troubleshooting chart is located in each system troubleshooting and repair chapter. These charts are based on symptoms which indicate the location of trouble in the system. Generally, the system symptom troubleshooting charts will isolate trouble more quickly than the step-by-step troubleshooting charts (*c* below).

c. System Step-by-Step Troubleshooting Charts. A system step-by-step troubleshooting chart is located in each system troubleshooting and repair chapter. These charts consist of a series of steps designed to evaluate all phases of operation of the particular system. Generally, the system step-by-step charts are more comprehensive than the symptom charts (*b* above) and should be used if the symptom chart does not isolate the trouble.

d. Component or Chassis Bench Troubleshooting Charts. Component or chassis bench troubleshooting charts are designed to locate trouble when the chassis or component is connected to test equipment which is provided for bench servicing. These charts are located in the troubleshooting and repair chapter covering the system in which the particular chassis or component functions.

178. Correcting Trouble

The following information is included to aid in correcting equipment trouble causing faulty operation.

a. Corrective measures are given in each troubleshooting chart.

b. Paragraphs covering the removal and replacement of parts follow the troubleshooting charts.

Note. Instructions for disassembling and reassembling mechanically complex components are contained in chapters 20 through 23 of this manual.

c. Instructions for performing alinement procedures are included after the removal and replacement of parts paragraphs.

d. Instructions for performing a complete alinement of the radar set are contained in paragraph 447.

179. Checking Serviceability

Testing procedures designed to check the serviceability of repaired items of equipment are included after the alinement procedures. Instructions for testing the complete radar set are contained in paragraph 448.

180. Troubleshooting Techniques

To be effective, troubleshooting must be systematic. It is seldom possible to observe a symptom of trouble and immediately diagnose the 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 system or a component, then to a portion of the system or component, and finally to the defective part. The sequence of steps is referred to commonly as sectionalization, localization, and isolation of trouble. The following is a list of six logical steps.

a. History of Equipment. The repairman can obtain helpful information by questioning organizational maintenance personnel, by reading the complaint notice attached to the equipment, and by reading the equipment log. For example, a radar set with a history of repeated signal mixer crystal failures is likely to have a defective tr tube. The more information the repairman can gather, the more accurate his diagnosis will be, and the sooner the repairs can be made.

b. Preliminary Examination. Preliminary examination will help in gathering evidence that may lead to the defect. Symptoms may be obtained by observing the equipment for abnormal meter readings, lighted blown-fuse indicators, the presence of smoke, and abnormal scope presentations; by smelling to detect the odor of burned insulation and parts; and by listening for high-voltage arcing.

c. Sectionalization. Sectionalization is the narrowing down of trouble to a particular functional system of the radar set. Use the information obtained from the procedures given in *a* and *b* above and the *abnormal indications* portion of the troubleshooting based on starting procedure chart (par. 210) as a quick aid in sectionalizing the trouble. Perform each step (or applicable steps) in the troubleshooting based on starting procedure chart to sectionalize the trouble to a particular system if any of the following conditions exist.

(1) The observed symptoms in the quick check do not clearly indicate which particular system is defective.

(2) The defect has caused the entire set or a major portion of the set to be inoperative.

(3) Troubleshooting of a particular system has been attempted using observed symptoms in the quick check, and the defect has not been found. Many abnormal indications can be caused by a defective part in one of several possible interrelated systems; procedures for sectionalizing to a particular system are given in the troubleshooting based on starting procedure chart.

d. Localization. After the trouble has been sectionalized to a functional system of the equipment, the next step is to localize the trouble to a stage or a group of stages by use of the procedures given in the system symptom troubleshooting chart. If the observed symptoms cannot be closely related to those listed in the system symptom troubleshooting chart, use the system step-by-step troubleshooting chart. The procedures given in the bench troubleshooting chart should be used when trouble has been sectionalized to a major component and one of the following conditions exist.

(1) It is more convenient to work at a bench than with the equipment connected normally.

(2) It is imperative that the radar set be kept operating and a good component can be installed in place of the defective one.

(3) The component is being worked on in a shop as an individual unit.

e. Isolation. After trouble has been localized to a stage or group of stages, the next step is to isolate the trouble to a particular

part. First, replace the tube or tubes in the suspected circuit. If the trouble is not corrected, use visual inspection, waveform analysis (par. 183), and voltage and resistance measurements (par. 184) to determine the defective part.

Note. The exact sequence of performing isolation steps and techniques used will depend on accessibility of parts and the best method for the particular circuit being tested.

f. Testing after Repairs. After faulty parts are located and replaced, the equipment may not necessarily be free of faults. Some other fault (which has not been detected and corrected) may have caused the failure of the part that has been replaced, or the repairman may have inadvertently injected a trouble. After parts or tubes have been replaced, the equipment should be given an overall test and the results compared with the data specified for a good set. Each troubleshooting chapter in this manual contains information for field testing the equipment and also contains procedures for checking the serviceability of a repaired component which has been bench-serviced.

181. Troubleshooting Data

a. General. In addition to the troubleshooting charts, other troubleshooting data are supplied to help the repairman rapidly locate trouble. A list of the specific troubleshooting data which would help locate troubles in each particular system is given in the *reference data* paragraph contained in the first section of each troubleshooting and repair chapter. The following type troubleshooting data are supplied and should be consulted when necessary.

b. Block Diagrams. The block diagrams give the electrical and mechanical interrelationships among the systems, components, and stages of the radar set. A functional system block diagram and a complete block diagram of the radar set is given in TM 11–1167–20. By observing the symptoms and analyzing their possible causes, it is often possible to trace the cause of faulty operation to a trouble in a particular block.

c. Cabling Diagrams. The cabling between components of the radar set is shown in figure 52, TM 11–1167–10. Figure 207 in this manual is a similar type of diagram. These diagrams can be used to check the cabling.

d. 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.

e. Simplified Schematic Diagrams. Simplified schematic diagrams which are located in the theory portion of the manual are functional segments of complete schematic diagrams. These diagrams make it possible to follow the electrical and mechanical functioning of the circuits more easily than with the complete schematic diagrams.

f. 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.

g. Ac Power Distribution Diagram. This diagram shows the interconnections between the 115-volt ac power source and all component parts of the radar set which are energized by 115 volts ac. This diagram is useful in isolating troubles in the ac circuits such as open circuits, causes of blown fuses, and defective ac control circuits.

h. +27-volt Dc Power Distribution Diagram. This diagram shows the interconnections between the 115-volt ac source and the +27-volt dc supply; and between the +27-volt dc supply and all component parts of the radar set which are energized by +27 volts dc.

i. Location of Parts Illustrations and Lists. Each system troubleshooting chapter contains illustrations, and a list of parts with references to the illustrations, which show the location of each part of the system which is mentioned in the text of this manual or shown on the partial or complete schematic diagram of the system.

j. Waveform Illustrations. Waveform illustrations are provided for the indicating, transmitting, and signal comparing systems. These illustrations give the normal waveforms at given test points throughout the system and are helpful in localizing the trouble to a specific

stage. When using these diagrams, carefully read the notes and exactly duplicate the conditions under which the waveforms were obtained.

k. Resistor and Capacitor Color Code Diagrams. These diagrams (figs. 205 and 206) are used to interpret the color codes used to indicate the values of resistors or capacitors and their tolerances. Tolerance indicates the maximum difference in resistance or capacitance that is expected between the rated value and the actual value of the resistor or capacitor.

l. Normal Panel Meter Readings. This is a list of meters that monitor the system operation and the normal readings that should be obtained on each meter for the various switch positions. Meters are usually used in circuits in which a change in current, voltage, or other values would seriously affect the proper operation of the radar set. These meters are helpful in sectionalizing and localizing equipment troubles.

m. Normal Indications at Test Points. This is a list of the test jacks and test points located in the system and the normal voltage readings or reference on illustration showing the normal waveforms that should be obtained at each test jack and test point for the various switch positions. These test points are helpful to quickly localize the trouble to a channel or stage within a system.

n. Dc Resistance of Inductive Components. This information is used when an inductive component is suspected of being faulty. The tolerance values for the resistance of inductive windings are generally not given. However, a winding that shows a resistance deviating more than 10 percent from its rated value is probably faulty. Allow the transformer to cool before making a final resistance test. The resistance values given in the dc resistance of inductive components charts in this manual are the resistances with the components (or windings) disconnected from the circuit.

182. Reference Designation Number Location Chart

To aid in parts location, a block of reference designation numbers has been assigned to each major component of Radio Set AN/TPS–1D. For example, all parts in Power Supply PP–674/TPS–1D are numbered from 401 to 499; that is, resistors in this component are designated R401, R402, etc., and capacitors are designated C401, C402, etc. The following chart lists the block of reference designation numbers assigned to each major component.

Symbol block	Common name (unit or subassembly)	Official nomenclature (unit)	Schematic (fig. No.)
101–149	Trigger circuit	P/o Radar Modulator MD–144/TPS–1D	210
150–199	Modulator	Radar Modulator MD–144/TPS–1D	210
201–299	IF preamp	P/o Radar Receiver-Transmitter RT–212/TPS–1D	212
301–349	IF amplifier	P/o Signal Comparator CM–36/TPS–1D	219
350–399	Coho	P/o Signal Comparator CM–36/TPS–1D	219
401–499	Power Supply	Power Supply PP–674/TPS–1D	233
401–499	Control chassis	P/o Power Supply PP–674/TPS–1D	233
501–599	Coho preamp	P/o Radar Receiver-Transmitter RT–212/TPS–1D	212
501–599	Local oscillator	P/o Radar Receiver-Transmitter RT–212/TPS–1D	212
501–599	Cavity assembly	P/o Radar Receiver-Transmitter RT–212/TPS–1D	212
501–599	Transmitter	P/o Radar Receiver-Transmitter RT–212/TPS–1D	212
601–699	Indicator	Azimuth-Range Indicator IP–141/TPS–1D	224
701–799	Antenna base	Antenna Base AB–221/TPS–1D	226
701–799	Transmission line	P/o Antenna Base AB–221/TPS–1D	18
801–899	Antenna	Antenna AS–548/TPS–1D	19 and 20
1100–1199	Pulse delay network	P/o Radar Modulator MD–144/TPS–1D	210
1300–1349	Delay amplifier	P/o Signal Comparator CM–36/TPS–1D	219
1350–1399	Repetition rate trigger amplifier	P/o Signal Comparator CM–36/TPS–1D	219
1600–1699	Indicator	Azimuth-Range Indicator IP–141/TPS–1D	224
2300–2349	Nondelay amplifier	P/o Signal Comparator CM–36/TPS–1D	219
2350–2399	Delay line	P/o Signal Comparator CM–36/TPS–1D	219
2600–2699	Indicator	Azimuth-Range Indicator IP–141/TPS–1D	224
3300–3349	Video balancer	P/o Signal Comparator CM–36/TPS–1D	219

183. Waveform Analysis

a. Waveforms may be observed at various test jacks and at other significant points in the circuits of Radio Set AN/TPS–1D. Oscilloscope AN/USM–24C was used to take the waveforms illustrated in this manual. The time base used and the amplitudes of the waveforms are given with the waveforms so that other types of oscilloscopes can be readily used. The normal waveforms that should be obtained at test jacks and at other significant points are shown on waveform illustrations which precede the respective main schematic diagrams for the indicating, transmitting, and signal comparing systems. 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.

b. A departure from the normal waveform indicates 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 observed to be normal at the grid and abnormal at the plate of the same stage, it is an indication that 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, take voltage and resistance measurements at the tube socket pins (par. 184).

184. Voltage and Resistance Measurements

a. Voltage and resistance measurements aid in determining circuit conditions and in evaluating clues in the course of troubleshooting. Electronic Multimeter TS–505C/U and Multimeter TS–352B/U were used to obtain the measurements in this manual.

b. Compare the measured values of voltage and resistance with the normal values given in the voltage and resistance diagrams which immediately precede the respective main schematic diagrams. If possible use the same model of the multimeter with which the normal readings were obtained. Carefully read the notes on the diagrams and exactly duplicate the conditions under which the normal readings were obtained.

c. Whenever it is necessary to measure voltages greater than 500 volts, observe the following precautions:

(1) Shut off the power.
(2) Discharge high-voltage capacitors with a shorting bar.
(3) Connect the multimeter leads to the test points.
(4) Step away from the multimeter.
(5) Turn on the power.
(6) Note the reading on the multimeter.
(7) Turn off the power.
(8) Discharge high-voltage capacitors with a shorting bar.
(9) Remove the multimeter leads.

185. Voltmeter Loading

The voltage and resistance charts in this manual are based on readings taken with meters supplied with the test equipment. The ohms-per-volt sensivity setting used is printed on the charts. The troubleshooter should use a meter having the same ohms-per-volt sensitivity. The meter used in testing for the voltage then produces the same amount of loading as the meter used to obtain the voltage measurements. If a voltmeter of lower sensitivity is used (for example, if a 1,000 ohms-per-volt meter is used instead of the required 20,000 ohms-per-volt meter), the readings are likely to be lower than those given in the chart, readings in high resistance circuits may be *much* lower than the specified values.

186. Current Measurements

a. Current measurements, other than those indicated by the panel meters, are not ordinarily required in troubleshooting the radar set. However, if current measurements are required, make use of the fact that in most cases the current flows through a resistance that either is known or can be measured with an ohmmeter. The current flowing in the circuit can be determined by dividing the voltage drop across the resistor by the resistance value. Measuring the voltage drop across the cathode resistor is a convenient method of determining the cathode current.

b. If it should be necessary to measure dc currents by inserting an ammeter in a circuit:

(1) Always set the current range to the highest value; then, if necessary de-

crease the range to give a more accurate reading. Avoid working close to full-scale reading because this increases the possibility of overloading the meter.

(2) Always insert the meter away from the rf end of the resistance. For example when measuring plate current, do not insert the meter next to the plate of a tube but insert it next to the end of the resistor that connects to the power source. This precaution is necessary to keep the meter from upsetting the RF voltages and to prevent damage to the meter.

187. Resistor, Capacitor, and Tube Checks

a. Normal Resistance Values.

(1) When a fault develops in a circuit, it may be due to a change in the resistance values of the circuit.

(2) To assist in the localization of such faults, troubleshooting data include the normal resistance values measured at the tube sockets and inductive components. These values are measured between the indicated points and ground, unless otherwise stated.

b. Grid Resistance Measurement. When measuring grid resistance, a false reading may be obtained if the tube is still warm and the cathode is emitting electrons. Allow the tube to cool, or reverse the ohmmeter test leads so that the negative ohmmeter test lead is applied to the grid.

c. High-Resistance Measurements. Many leakages do not show up when measured at low voltages. Most ohmmeters use a maximum test voltage of 15 volts on the highest resistance range. When it is necessary to measure resistance above 2 megohms or the leakage resistance between conductors of a cable or between the terminals of a capacitor, the test should be made with applied voltage of 100 volts or more. When it is possible to ground one end of the resistance being checked, one of the low-voltage power supplies in the equipment can provide 150, 300 or 450 volts for making these high-resistance measurements. The manner in which such measurements are made is indicated in *d* below. This method should be used only when the resistance being measured is very high. Be careful not to touch exposed high-voltage points.

d. High-Resistance Measurement Procedure. When making high-resistance measurements, use a meter having an ohms-per-volt sensitivity of 1,000 or more. The meter resistance is equal to the ohms-per-volt sensitivity multiplied by the range to which the meter is set. Refer to figure 96 for the meter test hookup and the formula for finding the unknown resistance. When making the measurement, the meter should be put on a high-voltage range to protect it in case R_x is very low.

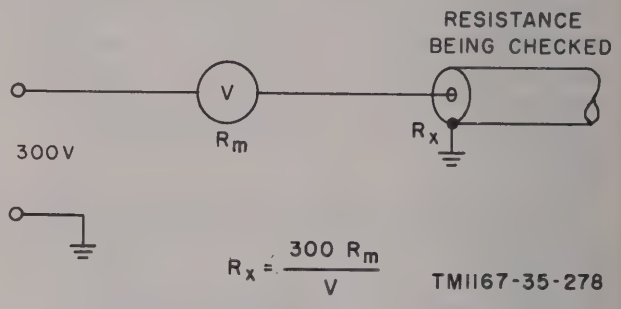


Figure 96. High-Resistance measurement.

e. Capacitor Checks.

(1) A capacitor that is suspected of being open can be found by temporarily shunting a good capacitor across it. A capacitor that is suspected of being leaky or breaking down, can best be found by disconnecting the lead which is connected to the lowest dc potential and connecting a vacuum-tube voltmeter between the disconnected end and ground. The measured voltage is the result of the leakage current.

(2) In RF and IF circuits, keep the leads to the test capacitor as short as the original capacitor leads.

(3) In video and low-frequency circuits (less than 1 mcs), the test capacitor leads may be several inches long. A standard capacitor color code is shown in figure 206.

f. Tube Checking.

(1) Tube checkers are used to check tubes for shorts and operation under special test conditions. They cannot be used to test the performance of all high-voltage tubes or rectifiers or of some

special tubes in the modulator and servo amplifier in the antenna base.

(2) Results obtained from a tube checker are not always conclusive because the conditions are not the same as those under which the tube operates in the set. For this reason, the final test of a tube must be its replacement with a tube that is known to be good.

(3) In many cases, it is quicker and more reliable to replace a suspected tube with a good one than to check it with the tube checker.

188. Blown Fuses

a. General. All fuses are connected in the ac lines and are located on power supply. When a blown fuse indicator on the power supply is lighted, it is possible that the trouble may be in one of many parts of the radar set. The trouble can be sectionalized to a system component, or chassis, by using the ac distribution diagram (fig. 229), and following the directions in *b* below.

b. Location of Trouble. When a blown-fuse indicator on the power supply is lighted, replace the fuse. If the replaced fuse blows, locate the fuse on the ac power distribution diagram (fig. 229) by using the parts location list on the figure. Sectionalize the trouble to a system by disconnecting all systems from the blown fuse except one; then reconnect the loads one at a time until the blown-fuse indicator lights again. The parts indicated on the diagram may be located on a chassis by refering to paragraph 182 and the parts location information in the troubleshooting chapters. Two examples follow:

(1) Replaced fuse F409 blows.

(*a*) Pull the receiver-transmitter and the indicator slightly out of their cases so that interlock switches S504 and S603 are opened, and replace F409.

(*b*) If I 409 lights again, the trouble is in filament transformer T401, blower B401, Z501, or the interconnecting wiring. These parts should be disconnected and checked individually.

(*c*) If I 409 does not light, push the receiver-transmitter into its case. A lighted I 409 indicates trouble in Z502.

(*d*) If I 409 does not light after the receiver-transmitter is pushed into its case, push the indicator back into its case. If I 409 lights, the trouble is in plate transformer T402 or associated parts.

(2) Replaced fuse F405 blows.

(*a*) Pull the signal comparator slightly from its case so that interlock switch S2355 is opened, and replace F405.

(*b*) If I 405 lights again the trouble is in Z2351, T2350, S2352, or the interconnecting wiring. These parts should be disconnected and checked individually.

(*c*) If I 405 does not light, the trouble is in C2350, B2350, or interconnecting wiring.

189. 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 of the leads to make the proper connections when replacing the part. Be careful not to damage other leads by pulling or pushing them away.

b. Parts that require much time and effort for replacement should be checked thoroughly before removal to determine that the fault is within the suspected part and not in the associated circuitry.

c. After replacing an electrical component, check continuity before applying power. After replacing a mechanical part, manually check for free rotation before applying power.

d. It is very important to make well-soldered joints. A carelessly soldered joint may create a new trouble and it is one of the most difficult troubles to locate. Be careful not to allow drops of solder to fall into the equipment because they may cause short circuits.

e. When replacing a part in an RF or IF circuit, 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 brands of capacitors. When replacing parts in high-frequency circuits, give particular attention to proper grounding; use the same ground as in the original wiring. Failure to observe these precautions when replacing parts in high-frequency circuits may result in decreased gain or possibly in unwanted oscillations.

f. Whenever a part has been replaced, make any 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.

g. Section III of each troubleshooting chapter gives the general precautions and directions that apply to the removal and replacement of parts within a system such as magnetrons, subchassis, deflection coils, etc. Disassembly and reassembly of mechanically complicated items such as gear trains, antenna drive motors, etc., are described in chapters 20 through 23.

190. Selenium Rectifier Warning

The failure of selenium rectifiers can result in the liberation of poisonous fumes and the deposit of poisonous selenium compounds. If a rectifier burns out or arcs over, the odor is strong. Provide adequate ventilation immediately. Avoid inhaling the fumes and do not handle the damaged rectifier until it has cooled.

191. Parts Substitution

a. Do not substitute parts indiscriminately. Substitute only when *all* of the following conditions are satisfied:

(1) The trouble has been isolated to a specific stage.
(2) The tube has been replaced.
(3) A voltage or resistance measurement indicates that a particular part may be defective. In this case, check the part with one end disconnected from the circuit.

b. When all other possibilities of trouble are ruled out, substitute a good part for the one that is suspected of being defective.

192. Intermittents

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 or meter. If the screen or meter indication remains normal, repeat the tapping process at adjoining stages until the normal indications change.

b. Following is a list of faults which may cause intermittent operation:

(1) Defective controls.
(2) Loose connections.
(3) Poorly soldered joints.
(4) Cracked resistors.
(5) Defective tubes.
(6) Grit, lint, dust, or moisture between the plates of a variable capacitor.
(7) Dirty, fractured, or imperfect insulators.
(8) Dirty or corroded fuse holders, tube sockets, relay contacts, or cable connectors.
(9) All parts, especially resistors, that may be cracked, blistered, bulged, charred, burned, or contain other similar defects.

193. Cable Check and Repair

a. Continuity. When measuring for continuity, the ohmmeter leads sometimes are not long enough to be connected to both ends of the cable. The following procedure is given as a convenient method of determining the condition of each conductor of a multiconductor cable or an RF cable.

(1) Place a resistor of known value (50,000 ohms or more) from the conductor at one end of the cable to chassis ground.
(2) Use an ohmmeter to measure the resistance between the cable conductor and chassis ground at the other end of the cable.

Note. The cable that is being checked may include the conductor which grounds the chassis to the equipment common ground. In this case, connect the 50,000-ohm resistor between the conductor being checked and

the common ground conductor at one end of the cable. At the other end of the cable, connect the ohmmeter between the conductor being checked and the common ground conductor.

(3) If the meter indicates approximately 50,000 ohms, the conductor has continuity.

(4) If the meter indicates infinite resistance, the conductor is open.

(5) If the meter indicates zero resistance, the conductor is shorted to ground.

(6) If the meter indicates much less than 50,000 ohms, but not necessarily zero, the conductor has a dc leakage path to ground.

b. Repair. A damaged cable connector cannot be repaired; it must be replaced. Splicing of broken multiconductor cables is accomplished 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 given in paragraphs 194 through 200.

194. Repair of Multiconductor Cables (fig. 97)

a. General. Army-Navy specifications recommend the removal of size 0, 4, and 8 contacts during soldering operations. The extreme heat required in soldering these large contacts might tend to damage or break down the efficiency of the dielectric material. Some connectors, containing heavy contacts, are constructed so that the contacts may be soldered to the wires while both insulating disks (inside the connector body) are removed. Most connectors are constructed so that the connector contacts must be inserted through the inner insulating disks before the wires are soldered to the contacts. Other connectors are made so that the contacts are permanently joined to the insulating disk.

b. Fabrication of Cable.

(1) Remove the cable covering to a length of 1½ inches for the straight type of connector, or 2⅝ inches for the 90° angle type.

(2) Strip ¼ inch of insulation from each wire.

(3) Tin the tip of each conductor to ⅛ inch.

(4) Assemble the clamp, washers, back shell, coupling ring, and bushing or grommet on the cable as shown in figure 97.

(5) Put vinyl sleeving on each lead; the diameters used must be of the proper size to fit snugly over the connector contact.

(6) Solder the wires to the connector contacts; attach larger wires, and wires going to the center contacts first.

(7) Slide the vinyl sleeving over the connector contacts.

(8) Turn the back shell (A, fig. 97) or the rear coupling ring (B), whichever is applicable, onto the connector body.

(9) Attach the back shell to the coupling flange (if the angle-type connector is being used).

(10) Turn the clamp (with washers in place) onto the back shell.

(11) Assemble the clamp and bushing or grommet (when used). Be sure the bushing or grommet is over the cable covering and under the edge of the clamp before tightening the clamp screws. The clamp should never be tightened on wires stripped of cable covering.

195. Repair of Electrical Special Purpose Cable Assembly CX–1999/U (W4) (fig. 98)

a. Cut the end of the cable and remove 4 inches of the outer covering.

b. Cut the colored braid of the subgroups and coaxial (coax) leads back to ½ inch from the outer covering and tape the ends of the colored braid to prevent unraveling (B, fig. 98).

c. Cut the GRN (WHT) leads 3½ inches from the outer covering.

d. Cut the coax leads 3 inches from the outer covering.

e. Break the shields of the GRN (WHT) leads in the black, orange, white, and blue groups 2½ inches from the end and cover the pigtails with 2¾ inches of vinyl impregnated glass fiber sleeving, leaving ¼ inch exposed (C, fig. 98).

Note. The diameter of sleeving used in the fabrication of the cable must be of the proper size to fit snugly over the connector contact.

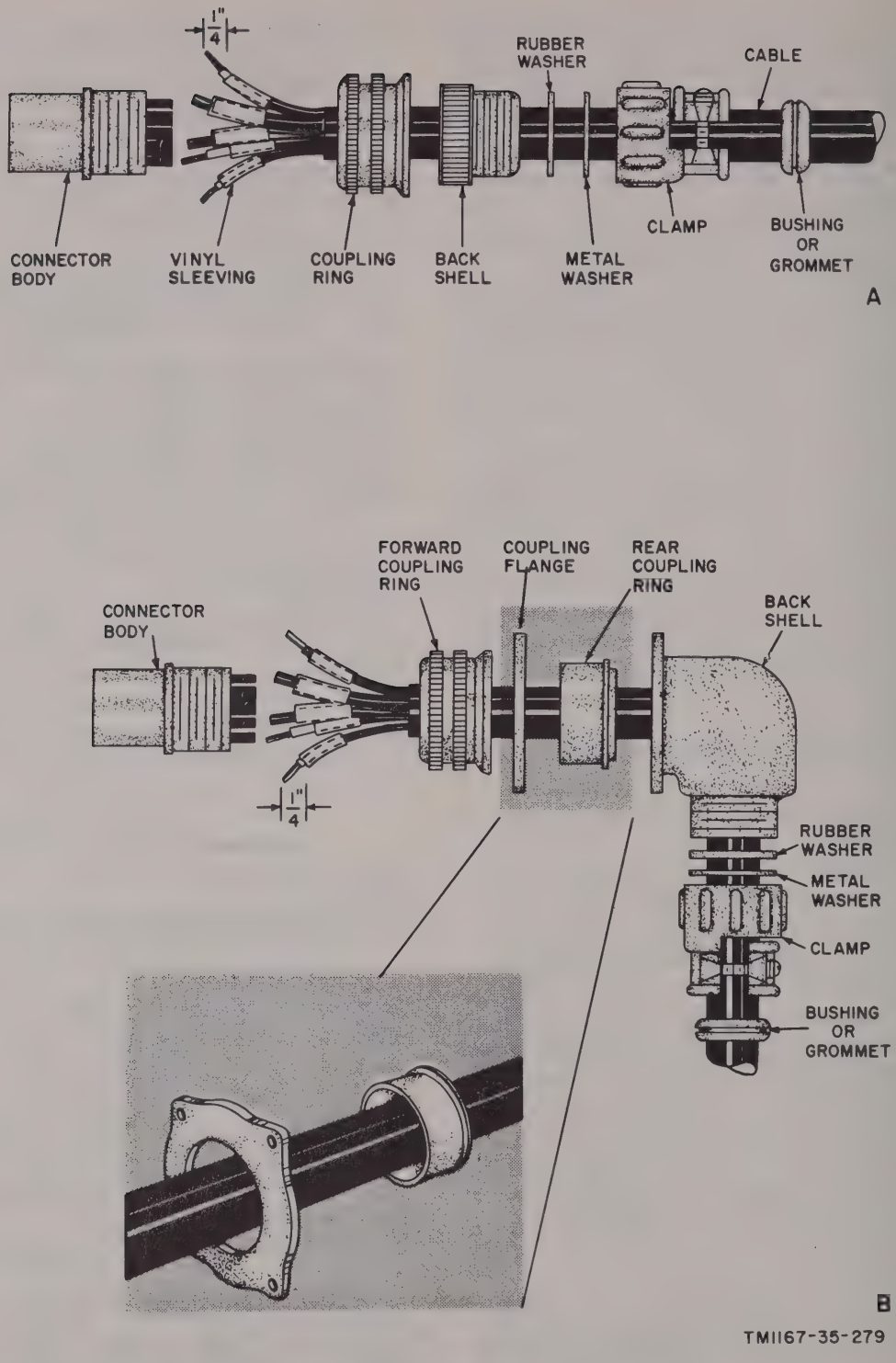


Figure 97. Repair of cable using AN-type connectors.

f. Strip the shields of the GRN (WHT) leads in the red and green groups 2 inches from the end, leaving no pigtail.

g. Break out shields of the coax leads 2 inches from the end, and cover the pigtails with 2¼ inches of vinyl sleeving.

h. Strip ¼ inch of dielectric from each of the single conductors.

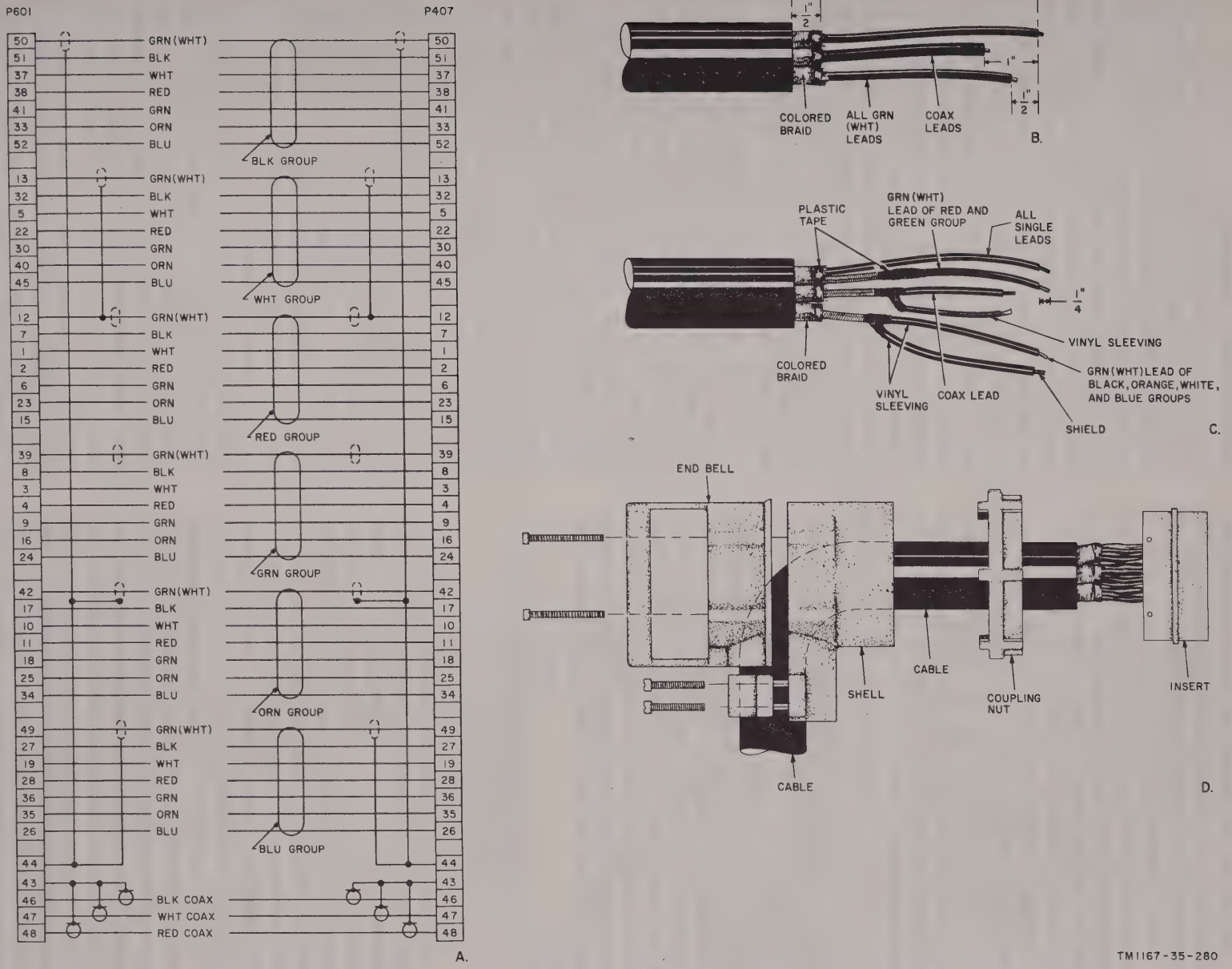


Figure 98. Repair of Electrical Special Purpose Cable Assembly CX–1999/U.

i. Tape the coax and GRN (WHT) leads (C, fig. 98).

j. Put the shell of the connector and coupling nut on the end of the cable (D, fig. 98) and slide ½ inch of plastic vinyl sleeving over all single leads except coax shields and leads to pins 12 and 44 (A, fig. 98).

k. Slide ½ inch of plastic vinyl sleeving over the shields and conductors which connect to pins 12 and 44, and on the center conductors of the coax leads.

l. Slide ½ inch of plastic vinyl sleeving over the group of three shields from the coax leads.

m. Solder the leads to the connector insert according to detail A, figure 98, starting with center pins, and slide the sleeving over the soldered connections.

n. Apply a plastic base cement (Plasgon) generously to the cable entrance groove at the front of the shell and assemble the shell and coupling nut to the insert.

o. Clamp the cable to the shell so that the end of the outer covering is approximately 1/16 inch beyond the inside wall of the connector.

p. Apply a plastic base cement generously to the cable entrance at the rear of the shell and the edges of the connector cover and attach the end bell and clamp to the connector shell. Wipe excess cement with denatured alcohol.

196. Maintenance of RF Cable Assembly CG–900/U (RF 854)
(fig. 99)

a. Generally, two different types of breakdowns occur in this cable assembly (RF Cable Assembly CG–900/U). One type of breakdown occurs as a result of poor electrical connection of the connectors with the adjoining sections of transmission line. This type is most common, and is evidenced by burning of the contact surfaces of either or both the inner and outer conductors.

b. This burning will not occur, provided good electrical connection is made around the *entire* circumference of both the inner and outer conductor. The mating surfaces of the outer conductor must be in contact at the inside edge of the contact surface, otherwise arcing can start. Once such arcing has started, it cannot be corrected without replacing both mating sections of transmission line. Note that the cleaning of any burned areas with any abrasive will alter the shape of the contact surface and arcing will continue, at least as bad, probably worse than before.

c. A damaged bullet connector can be replaced in the cable assembly, but it would be a useless expense when the mating female connector of the adjoining line section is burned.

d. The only method of correcting a burned contact surface of a connector body is to replace it with a new one. If a connector body is burned, then the mating line section is burned and must also be replaced. These parts are expensive, and more important, are at times difficult to obtain. Therefore, all possible precautions must be taken at the outset to prevent damage.

Note. If the connector body of RF Cable Assembly CG–900/U is damaged, the complete cable assembly must be replaced, since the connector body cannot be requisitioned separately. A new section of flexible cable, specially processed to fit the connector, can be requisitioned separately.

e. A few rather simple precautions can aid in preventing damage of this type. The two most important are: Be extremely careful to prevent denting or other damage to the contact surfaces, and make sure the couplings are tight when the cable is installed. Also, prior to installation, clean the contact surfaces with a good solvent (do not use an abrasive), and keep the neoprene gaskets in place to prevent moisture from entering and causing corrosion. After cleaning, wipe with a lint-free cloth to remove any film caused by cleaning.

f. The second type of damage to the cable is that caused by excessive standing wave ratio, and is evidenced by arcing between the inner and outer conductors of the line. A properly installed RF transmission system with all components in good condition will not have an excessive standing wave ratio. Note, however, that an excessive standing wave ratio can be caused by any fault in the entire RF system, from an improperly seated magnetron to defects in the antenna system.

g. A common point of arcing due to excessive standing wave ratio is at the connectors. This arcing often takes place through the dielectric of the cable at the point where the tapered inner surface of the connector ends in a small, sharp-cornered shoulder of the connector body. The bullet connector ends ap-

proximately even with this shoulder, and also forms a sharp edge plus several sharp points formed by the contact fingers. The tendency for an electrical discharge to take place at sharp edges rather than on smooth surfaces causes this point to break down.

h. One very critical point, insofar as the production of standing waves is concerned, is the coupling between the cable assembly and its mating sections of rigid coax. The fittings on the ends of RF Cable Assembly CG–900/U are constructed to form impedance matching sections between the diameters of the conductors and polystyrene dielectric of the cable (RG–19/U), and the diameters of the conductors and the air dielectric of the rigid coax sections. In this matching section, the outer conductor diameter is tapered from 1.028 to 1.527 inches ±.002 inch, the inner conductor is tapered from .300 to .625 inch, and the polystyrene is tapered to zero, all in a manner that maintains a constant impedance throughout the entire section. The tapers of the outer and inner conductors are fixed, being formed by the inner wall of the coupling section and the rear portion of the bullet connector respectively. The taper of the dielectric, however, is formed in the process of installing the fitting on the cable, and if improperly shaped, can seriously affect the characteristics of the matching section.

i. Two additional points in this fitting must be given special consideration to prevent excessive standing wave ratio: The distance the center conductor bullet connector protrudes from the front of the outer shell of the fitting (A, fig. 99), and the electrical connection between the braid of the RG–19/U and the shell of the connector (B, fig. 99).

197. Repair of RF Cable Assembly CG–900/U (RF 854) (fig. 99)

The following is a prescribed method of repair of RF Cable Assembly CG–900/U when replacing a defective cable or connector. This repair should not be done below 5th echelon.

a. Equipment and Tools Required.

(1) Sharp knife.
(2) Diagonal cutting pliers.
(3) Screwdriver for No. 6–32 screw.
(4) Silicon sealing compound (Dow Corning No. 4, FSN 5970–224–5276).
(5) Strap wrench.
(6) Bench vise (6-inch jaws minimum).
(7) Spanner wrench (D, fig. 99).

b. Removal of Cable Connector.

(1) Make sure the special processed cable (A, fig. 99) is straight for at least 1 foot from both ends.

Note. Do not bend or coil the cable at any time to more than 1 turn (minimum diameter of approximately 30 inches).

(2) Insert the cable in the bench vise behind the processed end. Use a protective cover on the cable to prevent any damage to the outer jacket.

Note. Do not attempt to process raw RG–19/U cable for use in RF Cable Assembly CG–900/U without separate specific instructions. Each dimension is measured with critical tolerances and special tools are required.

(3) Disassemble the connectors from each end of the defective cable assembly and inspect all of the disassembled parts for worn, burned or pitted plating, corrosion, dents, and any other damage that may cause a malfunction. Remove the connector (A, fig. 99) as follows:

(*a*) Remove the 8–32 by ½-inch screw from the center of the bullet connector, and remove the bullet connector.
(*b*) Loosen the armor nut and slide it back on the cable.
(*c*) Loosen the rear locking ring with the spanner wrench and slide it back on the cable.
(*d*) Slide the washer and gasket back on the cable.
(*e*) Loosen the inner locking ring with the spanner wrench.
(*f*) Remove the connector body.
(*g*) Remove the sealing ring.

c. Replacement of Connector. Following is the procedure for replacing a connector on the specially processed cable.

(1) Cut back the cable jacket (B, fig. 99). Note the critical dimensions.
(2) Slide the armor nut, rear locking ring, washer No. 1, gasket, and inner locking ring on the cable.
(3) Slide washer No. 2 over the braid and trim the braid to the outer edge of the washer.

(4) Coat washer No. 2 and the sealing ring with sealing compound.
(5) Slide the sealing ring over the cable.
(6) Slide the connector body on the cable.
(7) Turn the inner locking ring into the connector body and tighten with the spanner wrench.

Note. Hold the connector body with the strap wrench and make sure that the locking is as tight as possible.

(8) Insert washer No. 1 and the gasket, and tighten the rear locking ring.
(9) Tighten the armor nut.
(10) Insert a small amount of the sealing compound into the tapered hole of the cable dielectric and push the bullet connector in position. Install the 6–32 by ½-inch screw.
(11) After the assembly, check to see that the bullet connector protrudes not

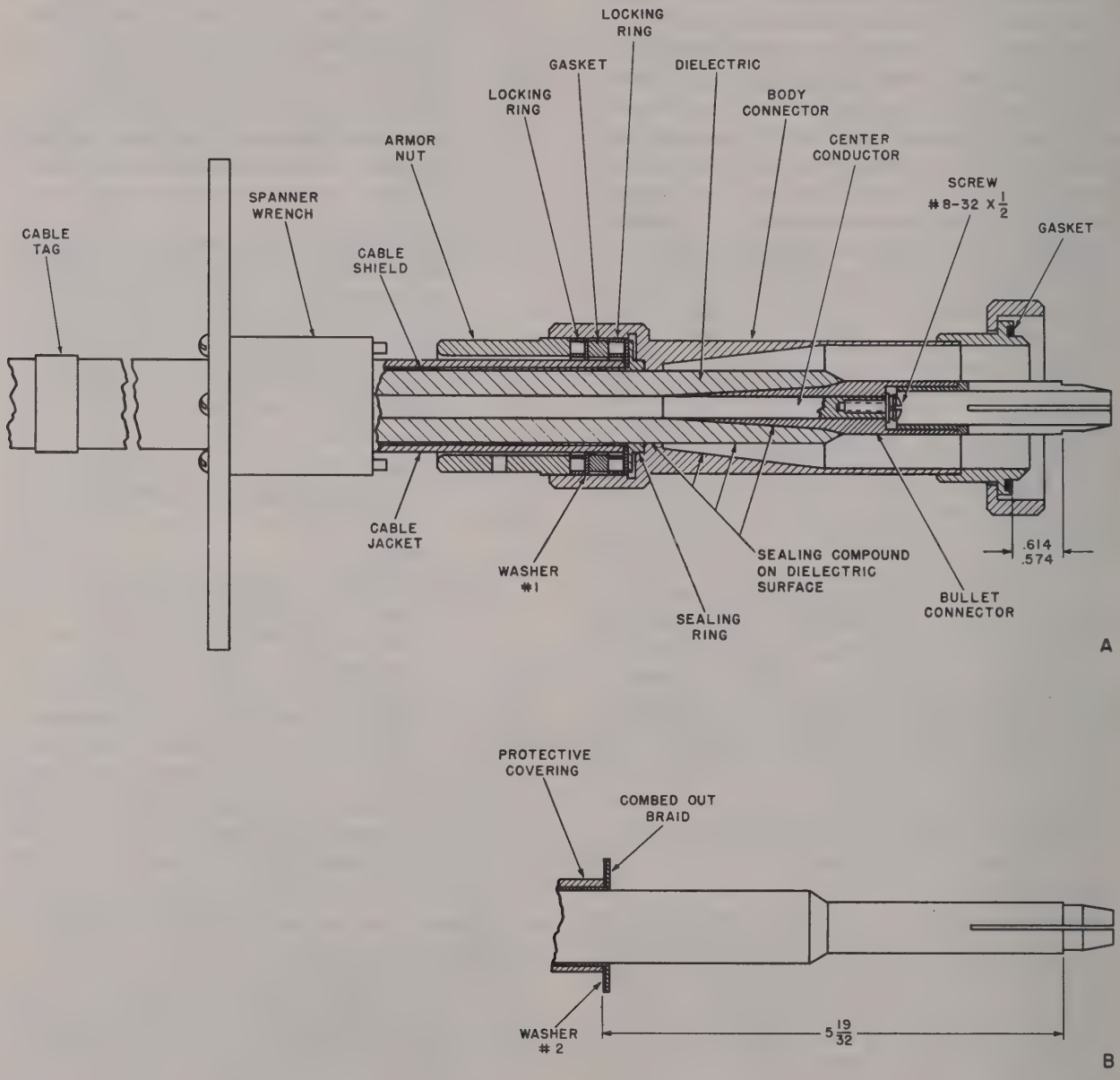
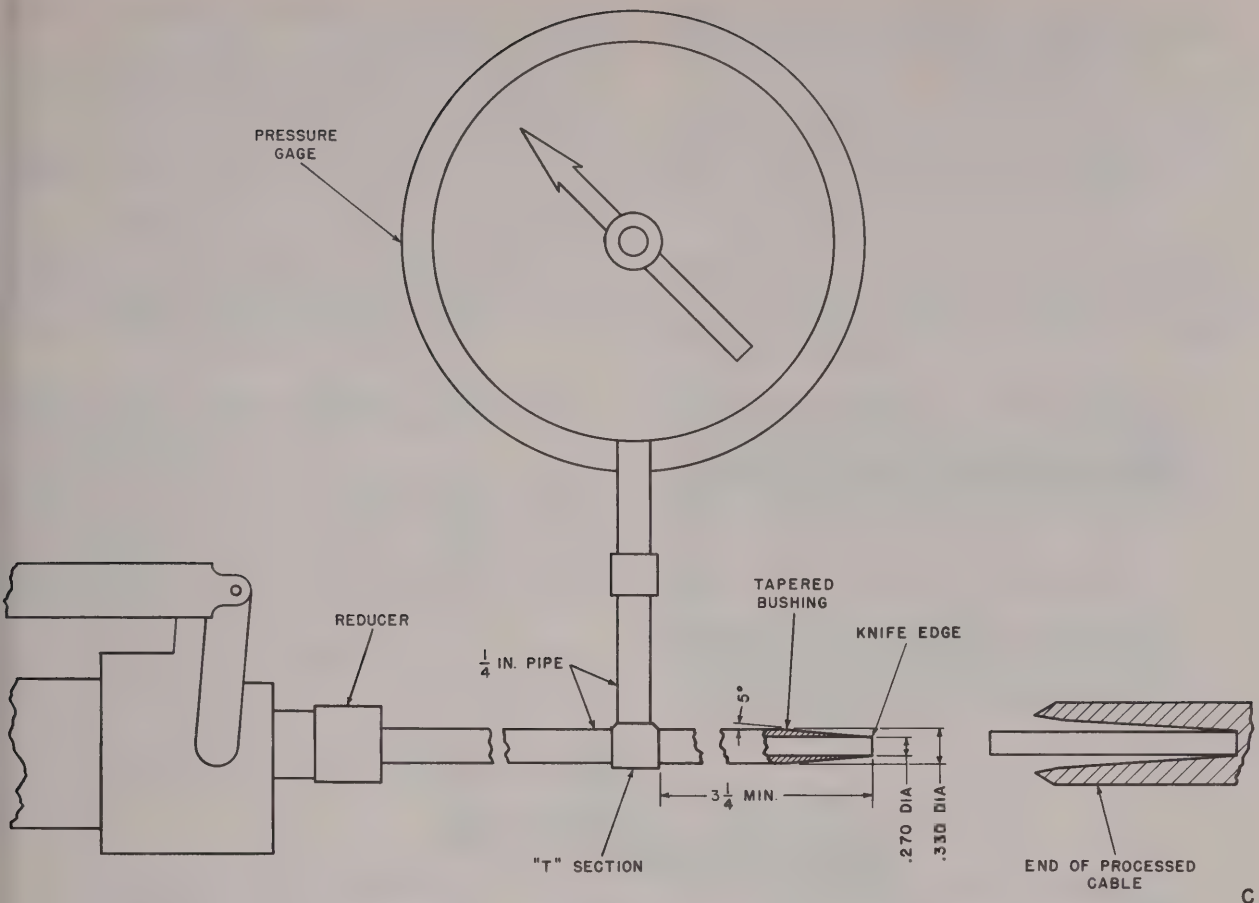
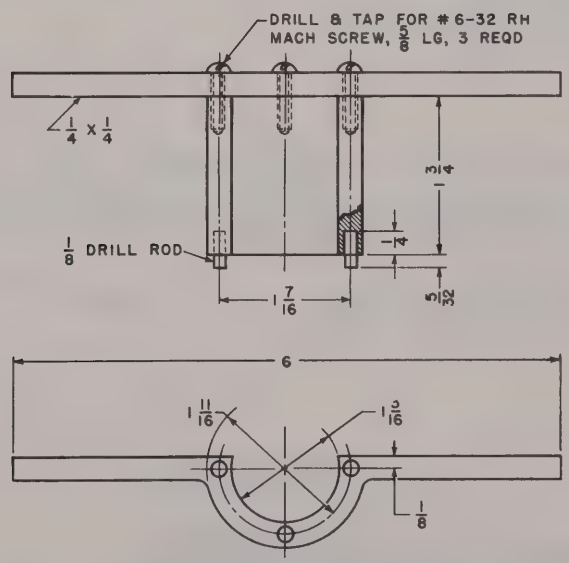


Figure 99. Repair of RF Cable Assembly CG–900/U, part 2.





NOTES:

1. BODY AND HANDLE OF SPANNER WRENCH MACHINED FROM COLD ROLLED STEEL
2. SPANNER WRENCH DRAWING SHOWS SUGGESTED DIMENSIONS. ADDITIONAL INFORMATION WILL BE ISSUED AT A LATER DATE
3. ALL DIMENSIONS ARE IN INCHES.

SPANNER WRENCH D

TM1167-35-281(2)

Figure 99—Continued, *part 2.*

more than .614 inch or less than .574 inch from the edge of the outer shell (A, fig. 99).

Note. These dimensions are critical.

(12) Before loading the grease gun with sealing compound, clean the gun, tubing, and tee section carefully to remove any grease.

(13) Assemble the grease gun, tubing, bushing, and gage (C, fig. 99).

(14) Load the grease gun with sealing compound; be careful to eliminate air pockets. Pump sealing compound out of the tapered bushing until all traces of air and dirt are gone.

(15) Be sure the cable is free of metal chips, dielectric shavings, dirt or any other foreign material before cable taper loading is begun. If moisture is present, allow enough time for its complete evaporation before beginning the sealing compound loading operation.

(16) To load the cable with sealing compound, insert the tapered bushing over the cable center conductor and push in until it rests at the bottom of the cable taper.

(17) Hold the tapered bushing and cable together, and pump the gun. The two should be held together with enough force so that 400 pounds per square inch is developed.

(18) After injecting some sealing compound at this pressure, let the cable ride slowly off the tapered bushing by using a pumping-out method. This is to let the sealing compound being pumped into the cable taper to push the cable off the tapered bushing as the cable taper fills up with sealing compound. This should con-

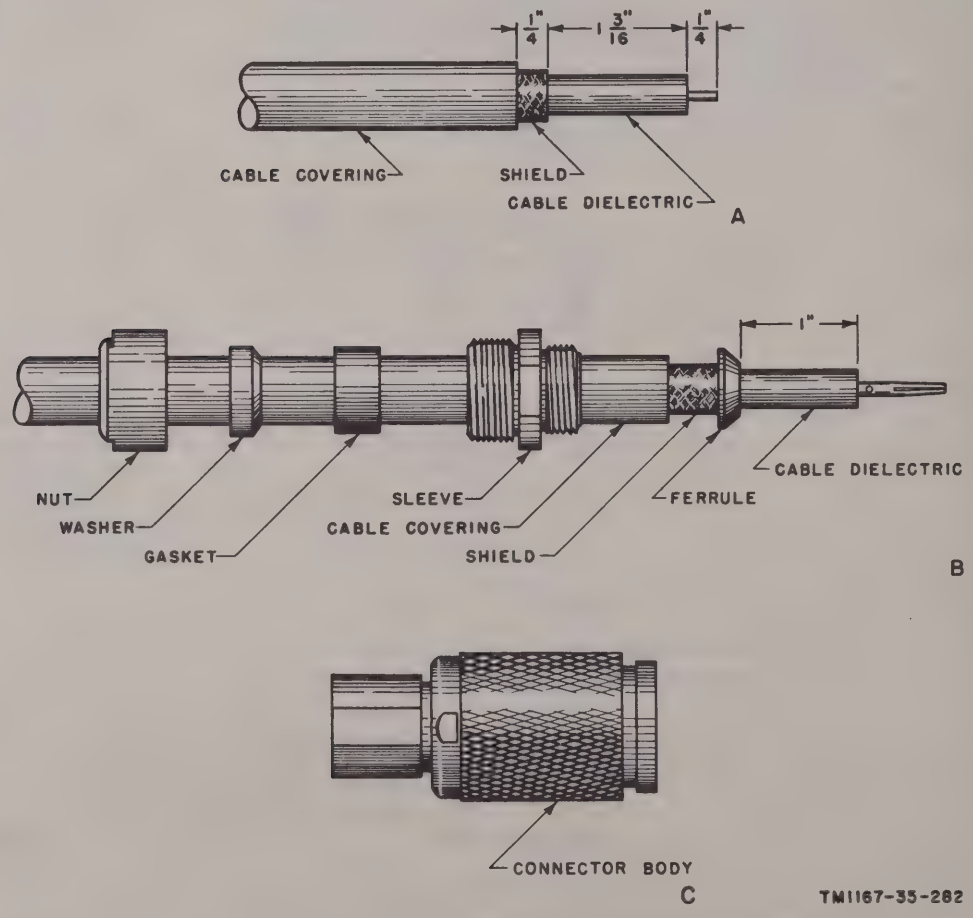


Figure 100. Repair of RF Cable Assembly CG–948/U.

tinue until the cable taper is completely filled. A smooth change from the 400-pounds per square inch condition to the low-pressure pumping-out operation should be achieved. This will completely fill the cable taper without allowing air pockets to form. It is important that the initial injection of sealing compound into the cable taper be made at 400 pounds per square inch pressure.

198. Testing of RF Cable Assembly CG–900/U

After the cable has been completely assembled and loaded with the sealing compound, the cable should be tested before it is used on an operating radar set. The following tests are recommended:

a. A voltage standing wave ratio (vswr) test as outlined in paragraph 266 for the RF transmission system.

b. An operating heat test as outlined in Signal Corps Repair Standard for Radio Set AN/TPS–1D.

199. Repair of RF Cable Assembly CG–948/U (W2)

(fig. 100)

a. Remove the cable covering and cable shield to the dimensions shown in A, figure 100. Do not cut through the cable dielectric.

b. Remove ¼ inch of dielectric and tin ⅛ inch of the center conductor.

c. Slide the nut, washer, and gasket over the cable (B, fig. 100).

d. Slide the sleeve of the ferrule between the shield and dielectric.

e. Solder the shield to the ferrule.

f. Solder the contact to the center conductor; be sure that the contact is flush against the dielectric. The end of the dielectric should be clean and the outside of the contact should be free of solder.

g. Push the end of the cable into the connector body so that the center conductor contact enters the hole in the body insulator. The face of the ferrule should fit flush against the body insulator.

Note. Use Dow Corning DC4 sealing compound on the dielectric to facilitate insertion into the connector body.

h. Slide the sleeve up to the body and tighten it.

i. Slide the gasket, washer, and nut up to the sleeve and tighten.

200. Repair of Cable Using RF Plug UG–18B/U

(fig. 101)

a. Remove ½ inch of cable covering (9/16 inch if a double shield is used). Do not cut the cable shield.

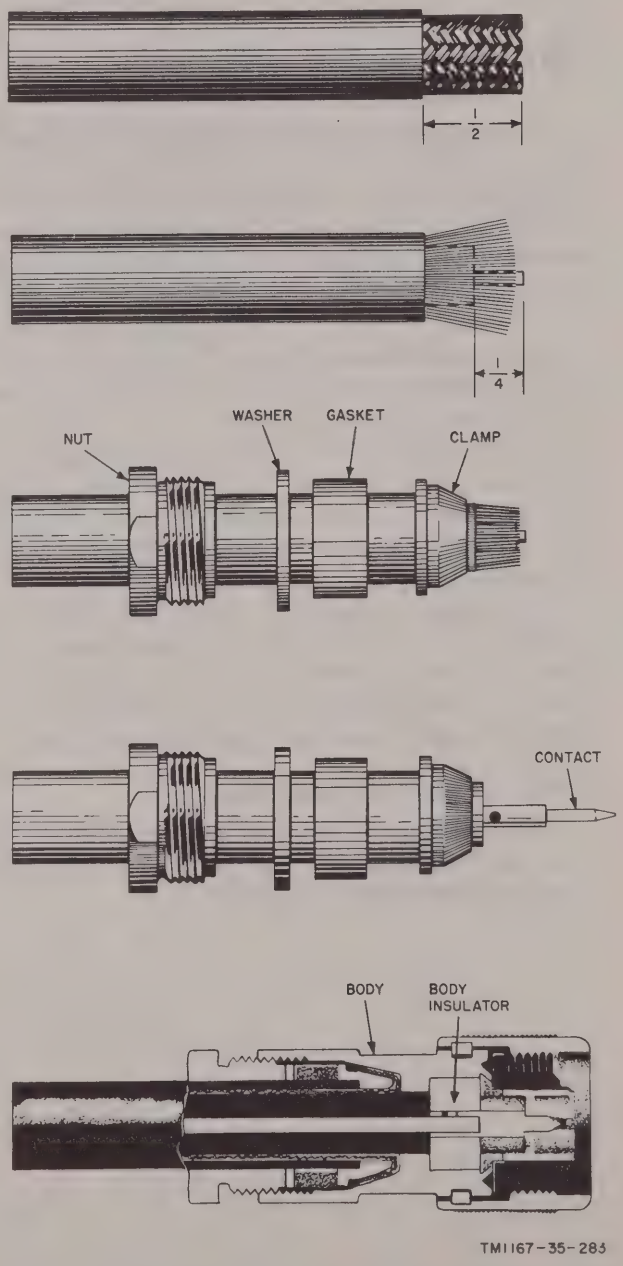


Figure 101. Repair of cable using RF Plug UG–18B/U

b. Comb out the copper braid, remove ¼ inch of dielectric, and tin about ⅛ inch of the center conductor.

c. Slide the nut, washer, and gasket over the cable. Slide the clamp over the braid so that the shoulder of the clamp is flush against the end of the cable covering.

d. Push the braid back over the clamp and trim.

e. Solder the contact to the center conductor. Avoid the use of excessive heat or solder; be sure that the contact is flush against the dielectric. The end of the dielectric should be clean and the outside of the contact must be free from solder.

f. Slide the body onto the cable so that the cable dielectric is flush against the body insulator.

g. Slide the gasket and washer into the body by pushing the nut, and tighten the nut.

Section II. TOOLS AND TEST EQUIPMENT

201. Tools Supplied With Radio Set AN/TPS–1D

A complete list of tools supplied with Radio Set AN/TPS–1D is given in TM 11–1167–10. These tools are used mainly during the installation of the radar set. Some of these tools, needed for field and depot maintenance, are described below:

a. Strap Wrench. This wrench used to turn the knurled fittings of the RF Cable.

b. Leveling Rod. This rod used to adjust the antenna leveling jacks.

c. Magnetron Tool. This tool is used to turn the ring nuts on the magnetron output connector fitting for the purpose of removing or replacing a magnetron or the RF fitting from the chassis.

d. Mirror Assembly. This assembly is clamped around the bezel of the A-scope to facilitate adjustment of parts located at the rear of the indicator and local alinement of signal comparing system for mti operation.

202. Additional Tools Required

The following tools are not supplied with, but are required for, field and depot maintenance of Radio Set AN/TPS–1D.

Quantity	Tool
1	Tool Equipment TE–113.[a]
1	Tool Equipment TE–114.[a]
1	Grip type nozzle grease gun.[b]
1	Shorting bar (FSN 6625–510–1841).[c]

[a] The tools and materials contained in TE–113 and TE–114 are listed in Department of the Army Supply Manuals SIG 6 TE–113 and SIG 6 TE–114.

[b] Used at the alemite hydraulic fittings in Antenna Base AB–221/TPS–1D.

[c] Used to ground high-voltage circuits after power has been removed.

203. Test Equipment Supplied With Radio Set AN/TPS–1D

Test Set TS–172A/UP (TM 11–1262) is supplied with the radar set to check the frequency of the transmitter and local oscillator and relative performance of the radar set.

204. Additional Test Equipment Required

The following items of test equipment are *not* supplied with, but are required to maintain Radio Set AN/TPS–1D. All test equipment items listed are the latest models of the equipment. The chart also lists the literature that covers each item and gives a brief description of the use of each item.

Test equipment	Literature	Use
Multimeter TS–352B/U[a], or ME–77/U[cd]	TM 11–5527A	To make voltage and resistance measurements.
Electronic Multimeter TS–505C/U[a]	TM 11–5511A	To make voltage measurements of high-resistance circuits.
Electron Tube Test Set TV–7B/U[c]	TM 11–5083	To check tubes.
Oscilloscope AN/USM–24C[a], or AN/USM–50[c]	TM 11–5103 TM 11–5129	To observe waveforms.
Tube Socket Adapter Kit MX–1258/U[b]	Packed with equipment.	To provide a means for making tube socket measurements conveniently on the top of the chassis.
Crystal Rectifier Test Set TS–268E/U[b]	TM 11–1242	To permit rapid qualitative tests of RF crystal rectifiers.
Dummy Antenna TS–235/UP[b]	TM 11–1093	To terminate the RF transmission line for test purposes.
Dummy Load TS–234/UP[b]	TM 11–1263	To terminate the modulator for test purposes.
Fluxmeter TS–15C/AP[b]	TM 11–2559A	To measure the magnetic flux density of the magnetron magnet.
Frequency Meter TS–328B/U[b], or Test Set, Power Electrical TS–934/U.[b]	Packed with equipment.	To check line frequencies in the range of 380 to 420 cps.
Motor Generator PU–20B/C[b]	TM 11–978	To convert the line voltage from 60 cps to 400 cps for bench testing the radar set components.
Power Supply PP–674/TPS–1D[b]	This manual.	To provide the necessary operating voltages for bench testing components of the radar set.
Pulse Generator Set AN/UPM–15[b]	TM 11–1177	To provide a sync pulse to the components of the radar set or to the test equipment for bench testing components of the radar set.
Range Calibrator TS–573/U[b]	TM 11–1228	To provide a means of accurately adjusting or checking the fixed range markers of the radar set.
Signal Generator AN/URM–64[be]	TM 11–5553	To measure the VSWR of the RF line, and to aline the local oscillator.
Signal Generator TS–497B/URR[b]	TM 11–5030	To provide RF test signals over a range of 2 to 400 mc.
Signal Generator TS–452C/U[b]	TM 11–2695	To provide sweep frequency signals for alinement of the 9- and 60-mc amplifiers.
Summation Bridge AN/URM–23[b]	TM 11–5128	To provide a means of measuring the average RF power output of the radar set.
Variable Power Transformer TF–171/USM[b]	TM 11–1250	To age the magnetron, and vary the line voltage when bench testing components of the radar set.
Adapter UG–1252/U[b]	----------	To interconnect Slotted Line IM–92/U and the RF component under test.
Slotted Line IM–92/U[b]	TM 11–5109	To measure the vswr of the RF lines.
Standing Wave Ratio Indicator IM–97/USM–37[b]	----------	To give a direct indication of the vswr of the component under test.

[a] Supplied with Test Set AN/GPM–1 (TM 11–1080A).
[b] Supplied with Test Set AN/MPM–23 (TM 11–1250 and SB 11–154).
[c] Supplied with later Test Set AN/GPM–1.
[d] Also supplied as part of Multimeter URM–105 which includes transit case and accessories.
[e] Includes Signal Generator TS–419/U, transit case and accessories.

CHAPTER 11
TROUBLESHOOTING BASED ON STARTING PROCEDURE

205. General

The troubleshooting based on starting procedure aids in detecting abnormal operation of the radar set and in locating faulty parts that cause abnormal operation.

a. The troubleshooting chart based on starting procedure (par. 210) is intended to make it possible to:

(1) Sectionalize trouble to a particular system of the equipment, such as the receiving system or the indicating system.

(2) Localize trouble to a major component when a system has parts in more than one major component; for example, parts of the receiving system are in the receiver-transmitter and parts are in the signal comparator.

(3) Isolate trouble to a particular part if it is a part of the ac power distribution and control system.

b. Before using the troubleshooting chart based on starting procedure, perform the preliminary checks, adjustments, and control settings given in paragraph 209.

c. A separate step-by-step troubleshooting chart that can be used to troubleshoot the +27-volt dc power distribution is given in paragraph 211.

206. Reference Data

The following data will be helpful when using the troubleshooting chart based on starting procedure.

Reference	Data
Fig. 52, TM 11-1167-10	Interunit cabling diagram.
Fig. 40, TM 11-1167-20	AN/TPS-1D, complete block diagram.
Fig. 207	External cabling diagram.
Fig. 229	Ac power distribution, schematic diagram.
Fig. 231	+27-volt dc power distribution, schematic diagram.
Fig. 230	Heater power distribution, schematic diagram.
Par. 207	Fuses and interlocks.
Pars. 155 through 167	Theory of circuits in the ac power distribution and control system.

207. Fuses and Interlocks

The distribution of 115-volt, 400-cycle ac power to the equipment is controlled by 16 fuses, located on the front panel of the power supply, and interlocks, located on individual units.

a. The following table gives a summary of the fuses used, their current and voltage ratings, and the circuits that are protected by each fuse. Each fuse has a blown fuse indicator that glows when the fuse burns out. The blown fuse indicator has the same symbol reference designation number as the fuse for which it indicates. The locations of all fuses and blown fuse indicators are called out in figure 173.

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.

Fuse	Rating		Zone on fig. 229	Circuit protected
	Volts	Amp		
F401*	250	1.6	A-2	Servicing outlets (when radiating).
F402*	250	1.6	A-3	CR402, C407, K402.
F403*	250	4	A-16	B501, T501, T504, T503.
F404*	250	6.25	A-21	T605, B602, B601, B752.
F405*	250	1.6	A-5	B2350, T2350.
F406*	250	6.25	A-23	B755, B702, T701, T702, CR701, B701, T403.
F407*	250	.3	B-19	T604, I 610.
F408	250	15	A-26	T704.
F409*	250	6.25	A-13	T401, B401, I 417, I 501, I 502, T402.
F410	250	6.25	A-8	T101, B151, T152, T153, I 151, I 152, I 153.
F411	250	30	A-11	T151.
F412*	250	60	A-4	All system power.
F413*	250	60	E-4	All system power.
F414	250	30	-------	All heaters.
F415	250	30	-------	All heaters.
F416*	250	6.25	A-1	Servicing outlets (when not radiating).

* Time lag type fuse.

b. The following chart lists the interlocks in the radar set. The chart also gives the operation, function, and a disabling procedure

for each interlock. All interlocks, if defeated, are restored to their normal position when the unit is replaced into its case.

Warning: The primary function of the interlocks is to protect personnel against injury from voltages greater than 500 volts. When an interlock is disabled (or defeated), observe the following:

(1) Avoid personal contact with all parts as carefully as if you were servicing a piece of rotating machinery with the safety guards removed.

(2) Do not permit any part of your body to make direct contact with ground.

(3) Make a habit of keeping both hands in your pocket or behind your back when making observations of energized high-voltage circuits.

(4) To make a high-voltage measurement, follow the procedure outlined in the system troubleshooting chapter covering the particular high-voltage circuit.

Interlock	Operation	Function	Defeating procedure
S153 (fig. 107).	Opens when the modulator is pulled from its case.	S153A (fig. 229) opens the 115-volt ac power circuit to modulator high-voltage warning lights I 151, I 152, and I 153.	Hinge the interlock defeating lever so that the lever is at right angles to the side of the chassis.
		S153B (fig. 231) opens the delay +27-volt circuit to radiate relay K152.	
S151 (fig. 107).	Closes after S153 opens.	Discharges high-voltage capacitor C153 (fig. 106).	The above procedure defeats both S151 and S153.
S402 (fig. 177).	Opens when the power supply is pulled from its case.	S402A (fig. 229) opens the 115-volt ac power circuit to high-voltage warning light I 417.	Snap INTERLOCK SHORTING SWITCH S404 which is located on the top left corner of chassis.
		S402B (fig. 229) opens the 115-volt ac power circuit to T402 (which supplies power to the +450-, +300-, +150-, and −150-volt power supplies and indicator high-voltage transformer T604.	The above procedure defeats both S402A and S402B.
S504 (fig. 125).	Opens when the receiver-transmitter is pulled from its case.	S504A (fig. 229) opens the 115-volt ac power circuit to high-voltage warning lights I 501 and I 502, plate supply transformer T402 (which supplies power to the +450-, +300-, and −150-volt power supplies), and to indicator high-voltage transformer T604.	Push in on the roller end of the S504 rocker arm (accessible through the opening in the upper right side of the chassis) and press the locking pin on the opposite end of the arm. Then release the roller end of the rocker arm and release pressure on the rocker arm pin.
		S504B (fig. 231) opens the delayed +27-volt dc circuit to radiate relay K152.	The above procedure defeats both S504A and S504B.
S603 (fig. 158).	Opens when the indicator is pulled from its case.	S603 (fig. 229) opens the 115-volt ac power circuit to plate transformer T402 (which supplies power to the +450-, +300-, +150-, and −150-volt dc power supplies) and to indicator high-voltage transformer T604.	S603 is located on the rear upper left edge of the chassis. Pull outward on the interlock pin after centering the pin in its bracket. A tapered recess in the pin holds the pin in the outward position (fig. 158).
S701 (fig. 164).	Opens when the servo amplifier is pulled out from the antenna base.	S701 (fig. 229) opens the 115-volt ac power circuit to thyratron plate transformer T704 so that the antenna cannot be rotated unless the interlock is defeated or the servo amplifier pushed back into the antenna base.	S701 is located at the rear of the servo amplifier. Push in on the roller end of the S701 rocker arm, press the locking pin on the opposite end of the arm, release the roller end of the rocker arm, and then release pressure on the rocker arm pin.
S2355 (fig. 144).	Opens when the signal comparator is pulled from its case.	S2355 (fig. 229) opens the 115-volt ac power circuit to blower motor B2350.	Blower not necessary when signal comparator is out of case.

208. Test Equipment Required

The following items of test equipment are required for troubleshooting Radio Set AN/TPS–1D, using the troubleshooting chart based on starting procedure.

Test equipment	Common name	Literature
Test Set TS–172A/UP	Echo box	TM 11–1262
Oscilloscope AN/USM–24C, or AN/USM–50	Oscilloscope	TM 11–5103 TM 11–5129
Multimeter TS–352B/U, or ME–77/U	Multimeter	TM 11–5527A
Electron Tube Test Set TV–7B/U	Tube tester	TM 11–5083
Frequency Meter TS–328B/U, or	Frequency meter	Packed with equipment.
Test Set, Power Electrical TS–934/U.	Frequency meter	Packed with equipment.
Crystal Rectifier Test Set TS–268E/U	Crystal checker	TM 11–1242
Dummy Antenna TS–235/UP	Dummy antenna	TM 11–1093
Dummy Load TS–234/UP	Dummy load	TM 11–1263

209. Preliminary Checks and Control Settings

Before using the troubleshooting chart based on the starting procedure, perform the preliminary checks and settings of controls and switches listed in the chart below.

a. 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.

(1) A replaced fuse has blown.
(2) Smoke observed coming from a component.
(3) Overheated parts observed or smelled.
(4) A defective component being serviced apart from other components of the radar set and if the nature of the trouble is not known.
(5) Abnormal symptoms reported from operational tests indicate possible partial or complete short circuits.

b. Check with the operator for indications of the location of trouble.

c. Check the cabling of the radar set (fig. 52, TM 11–1167–10) to see that all plugs are tightly connected to their jacks.

d. Make sure all units that contain interlocks (par. 207*b*) are pushed into their cases so that the interlocks are closed.

e. Connect the echo box to J501 on the receiver-transmitter.

f. Set the following switches and controls to the positions indicated:

Switch or control	Position
TRIGGER S152	EXTERNAL.
SWITCH ANT. BLOWER S401	OFF.
TEST SELECTOR S506	OFF.
Safety S753	ON.
TEST SELECTOR S2353	OFF.
OPERATION SELECTOR S2354	REMOTE.
POWER S602	OFF.
A RANGE SELECTOR	20.
PPI RANGE SELECTOR	20.
OPERATION S601	NORM.
ANTI JAM S607	OFF.
RANGE MARKS MILES S608	OFF.
ANTENNA ROTATE	0.
RECEIVER GAIN	Midposition.
DIMMER control R2617	Fully counter-clockwise.
A-SCOPE VIDEO GAIN	Midposition.
PPI VIDEO GAIN	Midposition.
RANGE STROBE	Fully clockwise.

210. Troubleshooting Chart Based on Starting Procedure

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
1	Follow the directions in TM 11–919 to start Power Unit PU–107.	Power unit voltmeter reads between 120 and 126 volts ac and power unit frequency meter reads between 384 and 416 cps.	Either or both readings are abnormal.	Refer to TM 11–919.
2	Set the 400 CYCLE CIRCUIT BREAKER on the power unit to ON.	VOLTMETER M401 reads between 110 and 120 volts ac and LINE FREQUENCY meter M403 reads between 384 and 416 cps.	Abnormal reading other than zero on either M401 or M403.	Adjust the output of the power unit (TM 11–919).
			Zero reading on M401 and no indication on M403.	Check cable W16 and wiring from POWER IN SYSTEM jack J405 to M401 (fig. 229).
			M401 reads zero.	Check M401.
			No indication on M403.	Use frequency meter to check M403.
3	Set POWER switch S602 to ON and wait for completion of 5-minute time delay.	No blown fuse indications are lighted, blower motors B401, B501, and B702 operate, and POWER ON indicator I 609 is lighted.	One or more blown fuse indicators are lighted.	Replace the fuse or fuses (par. 207*a*). *Note.* If a replaced fuse blows, see paragraph 188.
			None of the blower motors operate, and I 609 is not lighted.	Measure the voltage between terminal 102 and 103 on E403. The normal reading is between 110 and 120 volts ac. *a.* If normal, check F412 and I 412 and F413 and I 413. If either F412 or F413 is open, replace it and its blown fuse indicator. If both fuses are good, check continuity between 103 on E403 and F412 and between 102 on E403 and E413. *b.* If abnormal, measure the voltage between terminals 02 and 2103 on E403. The normal reading is between 110 and 120 volts dc. (1) If normal, check CR402, C407, and K402. (2) If abnormal, check S602 and F402 and I 402.
			Blower motor B401 does not operate.	Measure the voltage between terminals 1603 and 302 on E401. The normal reading is between 110 and 120 volts ac. *a.* If normal, check B401 and C408. *b.* If abnormal, check F409 and I 409.
			Blower motor B501 does not operate.	Measure the voltage between terminals 803 and 402 on E503. The normal reading is between 110 and 120 volts ac.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				a. If normal, check B501 and C512. b. If abnormal, check F403 and I 403, Z503, and Z507.
			Blower motor B702 does not operate.	Measure the voltage between terminals 903 and 302 on E701. The normal reading is between 110 and 120 volts ac. a. If normal, check B702 and C711. b. If abnormal, check F406 and I 406.
			I 609 is not lighted.	Measure the voltage between terminals 1 and 2 of T605. The normal reading is between 110 and 120 volts ac. a. If normal, check I 609 and T605. b. If abnormal, check F404 and I 404, Z605, and Z606.
4	Pull power supply from its case, defeat interlock S402 (par. 207*b*), and measure voltages listed under normal indications column, using multimeter.	All filaments lighted in power supply.	None of filaments lighted.	Check the primary winding of T401 and wiring to it. *Note.* It has previously been determined that power is available between terminals 1603 and 302 on E401.
		High-voltage warning indicator I 417 lighted.	I 417 does not light.	Check I 417, R445, and S402A.
		Terminal 5A on E401 to ground measures +470 volts dc.	Terminal 5A (+470) to ground measures zero.	Measure the voltage between terminals 1703 and 302 on E401. The normal reading is between 110 and 120 volts ac.
		Terminal 4A on E401 to ground measures +300 volts dc. Terminal 1A on E401 to ground measures +150 volts ac. Terminal 8A on E401 to ground measures +27 volts dc. Terminal 6A on E401 to ground measures −150 volts dc. Terminal 7A on E401 to ground measures −150 volts dc.		a. If abnormal, check to see that interlocks S504 and S603 are closed (par. 207*b*) and if normal, check continuity between terminals 1603 and 1703 on E401 (fig. 229). Note that there are low resistance paths through T402. Continuity can be checked in steps by first disconnecting P408 from J408 and then disconnecting P407 from J407.
			Terminal 5A (+450) to ground measures less than +423 volts dc but not zero.	*b*. If normal, troubleshoot the +450-volt dc power supply (par. 420, step 2*d*).
				Troubleshoot the +450-volt dc power supply (par. 420, step 2*d*).
			Terminal 4A (+300) measures zero.	Troubleshoot the +300 voltage regulator circuit (par. 420, step 5).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
			Terminal 4A (+300) abnormal, but not zero.	Adjust R433 (fig. 176) until terminal 4A to ground reads +300 volts dc. If correct output voltage cannot be obtained, troubleshoot the +300-volt dc voltage regulator circuit (par. 420, step 5).
			Terminal 1A (+150) measures zero.	Troubleshoot the +150-volt dc rectifier and filter circuit (par. 420, step 6).
			Terminal 1A (+150) abnormal, but not zero.	Adjust R416 (fig. 176) until terminal 1A to ground reads +150 volts. If correct output voltage cannot be obtained, troubleshoot the +150-volt dc voltage regulator circuit (par. 420, step 6).
			Terminal 8A (+27) measures zero.	Measure voltage between terminals 4 and 5 on T403. The normal reading is approximately 37 volts ac. *a.* If abnormal, check T403 and the wiring to its primary. *b.* If normal, troubleshoot the +27-volt dc power supply and the undelayed +27-volt dc power distribution (par. 211).
			Terminal 8A (+27) measures less than +25 volts dc.	Troubleshoot the +27-volts power supply and +27-volts power distribution (fig. 231 and par. 211). Check V406 by substitution and if it is normal, troubleshoot the −150-volt dc power supply (par. 420, step 3).
			Terminal 6A (−150) abnormal, but not zero.	Check V411 and V406 by substitution and if they are normal, troubleshoot the −150-volt dc power supply (par. 420, step 3).
			Terminal 7A (−150) measures zero.	Check R451 (fig. 176) and if it is normal, check wiring from R451 to R402 and from R451 to 7A on E401.
			Terminal 7A (−150) abnormal, but not zero.	Check V412.
5	Set TEST SELECTOR switch S506 to the MAG. FIL. position.	Meter M501 reads ¾ full scale.	Abnormal reading on M501.	Measure the voltage between terminal 1 of T504 and terminal 402 on E503. The normal reading is between 110 and 120 volts ac.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				a. If abnormal, check Z507, Z508, and the contacts of K405. The contacts of K405 should be normally closed and K405 should be normally deenergized. *b.* If normal, troubleshoot the magnetron filament power supply in the receiver-transmitter (transmitting system, par. 222, symptom 1).
6	Set TEST SELECTOR switch S506 to the COHO position and then to the SIG position.	Both positions should give red-line readings, and M601 on the indicator should read the same as M501 when S506 is in the COHO position.	Zero reading in both test positions of S506 (local oscillator V505 not oscillating).	Make the following voltage measurements in the receiver-transmitter: *a.* Terminal 7A1 on E502 to ground (−150 volts dc). *b.* Terminal 4A on E502 to ground (+300 volts dc). *c.* TP502 to ground (+27 volts dc). (1) If any reading is abnormal, check continuity from E502 back to E401 in the power supply. (2) If all readings are normal, check V505, and if it is normal, make voltage and resistance measurements at the tube socket base of V505 (fig. 211).
			SIG position reading is zero.	Check signal mixer CR503 (par. 278, symptom 2).
			SIG position is abnormal, but not zero.	Adjust local oscillator injection RF503A for red-line reading (par. 287), and if meter cannot be red-lined, troubleshoot the signal mixer stage in the receiver-transmitter (receiving system, par. 278, symptom 2).
			COHO position reading is zero.	Check coho mixer CR502 (par. 278, symptom 3).
			COHO position reading is abnormal, but not zero.	Adjust local oscillator injection (RF502) for red-line reading (par. 287), and if meter cannot be red-lined, troubleshoot the coho mixer stage in the receiver-transmitter (receiving system, par. 278, symptom 3).
			No reading on M601.	Check meter M601 and cabling to it from M501.
			Reading on M601, but not M501.	Check meter M501.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
7	Follow the TEST INSTRUCTIONS concerning TEST METER M2350, TEST SELECTOR S2353, and OPERATION SELECTOR S2354 given at the upper right-hand corner on the front panel of the signal comparator.	Red-line indication in all five numbered positions of the TEST SELECTOR switch. If all five numbered positions of the TEST SELECTOR are normal, return the OPERATION SELECTOR to the REMOTE position.	Zero reading on M2350 in all positions of S2353.	*Note.* Return the OPERATION SELECTOR to REMOTE after any troubleshooting that requires the switch to be in a different position. 1. Pull out the signal comparator from its case. ***Caution:*** Be careful not to damage the 3 cables which connect to the delay line assembly (par. 321). 2. Check to see that filaments of vacuum tubes are lighted (or that tubes are warm). *a.* If abnormal, measure the voltage between terminals 1 and 2 on T2350. The normal reading is between 110 and 120 volts ac. (1) If abnormal, disconnect P301 from J301 and check continuity of conductors A and B of cable W7 and from B on J301 to terminal 2 on T2350, and from A on J301 to terminal 1 on T2350. (2) If normal, check T2350. *b.* If normal, make the following voltage measurements in the signal comparator: (1) Terminal C on Z2351 to ground (+150 volts dc). (2) Terminal X on Z2351 to ground (−150 volts dc). (3) Terminal D on Z2351 to ground (+27 volts dc). (*a*) If any reading is abnormal, check continuity from Z2351 back to E401 in the power supply. (*b*) If all readings are normal, check M501. ***Caution:*** Do not use ohms scale, because damage to M2350 may result.
			All readings normal, except that one or more is abnormal (but not zero).	Adjust the potentiometer (or potentiometers) on the front of the signal comparator which has the same number as the meter position (or positions) which gives abnormal reading. If the meter cannot be red-lined, see appropriate symptom below.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
			No. (1) reading is abnormal and cannot be red-lined.	1. If adjustment of R2350 (IF AMPL LEVEL) can cause the meter to be almost red-lined, check V301 through V307 in the signal comparator by substitution and if normal, troubleshoot the signal comparator (receiving system, par. 279, step 12). 2. If adjustment of R2350 (IF AMPL. LEVEL) cannot cause M2350 to be almost red-lined, pull out the receiver-transmitter, defeat interlock S504, and observe whether filaments of tubes are lighted. *a.* If abnormal, check the filament transformer (T501 or T503) that supplies tubes not lighted. *Note.* It has already been established that B501 is receiving power. *b.* If normal, check V232, V224, and V225 by substitution, and if normal, troubleshoot the receiver-transmitter (receiving system, par. 278, symptom 6*a*).
			No. (2) reading is abnormal and cannot be red-lined.	Check V353 and V354 by substitution. *a.* If normal, check voltage at terminal C of coherent oscillator Z350 subassembly to ground. The normal reading is +150 volts dc. (1) If abnormal, check contacts of K3301. (2) If normal, troubleshoot the coherent oscillator circuit in the signal comparator (receiving system, par. 278, step 8). *b.* If abnormal, replace the defective tube.
			No. (3) and No. (4) readings are abnormal and cannot be red-lined.	Check V1353 through V1357 by substitution, and if normal, troubleshoot the 9-mc carrier channel in the signal comparing system (par. 322, symptom 1).
			No. (3) reading is abnormal and cannot be red-lined.	Check CR1350, R1381, R1382, C1385, R1393, and the wiring to M2350 in the No. (2) position of S2353.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
			No. (4) reading is abnormal and cannot be red-lined.	Check V2301 through C2306 by substitution and if normal, troubleshoot nondelay amplifier Z2300 in the signal comparing system (par. 322, symptom 2).
			No. (5) reading is abnormal and cannot be red-lined.	1. Check V1301 through V1306 by substitution. 2. Check V3300, V3301, and V3302 by substitution. 3. Check W2350 by substituting mercury delay line test unit Z2350 in its place. 4. Troubleshoot the delay channel and the amplitude balancing circuits in the signal comparing system (par. 322, symptom 3).
8	Place the TEST SELECTOR switch in the No. (1) IF AMPL LEVEL position and adjust RECEIVER GAIN potentiometer R608 (on front panel of indicator) for red-line indication on M2350.	Red-line indication on M2350.	M2350 reads zero or cannot be red-lined.	1. Check contacts of K3301 (7) and S2354 (D4). 2. Check resistance across R608 (2.5K) and the resistance between the wiper arm (center connection) and one end of the potentiometer as the control is rotated. 3. Check continuity from the wiper arm of R608 to ground. *a.* If normal, proceed to 4, below. *b.* If abnormal, make the following continuity measurements: (1) R608 to 44 on J601. (2) 44 on P601 to 44 on P407. (3) 44 on J407 to K on J401. (4) K on P401 to K on P301. (5) K on J301 to K on Z2351. (6) K on Z2351 to G on Z2351. (7) G on Z2351 to ground. 4. Make the following continuity measurements: *a.* D4 on S2354 to NR on Z2351. *b.* NR on Z2351 to N on J301. *c.* N on P301 to N on P401. *d.* N on J401 to 42 on J407. *e.* 42 on P407 to 42 on P601. *f.* 42 on J601 to R608.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
9	Place TEST SELECTOR switch in the No. (5) AMPL BALANCE position and adjust RECEIVER AMPL BALANCE potentiometer R2627 (on front panel of indicator) for red-line indication on M2350.	Red-line indication on M2351.	M2350 reads zero or cannot be red-lined.	1. Check continuity between FA and F4 on S2354. 2. Check the resistance across R2627 (50K) and the resistance between the wiper arm (center connection) and one end of the potentiometer as the control is rotated. 3. Check for the presence of +150 volts dc from the connection on R2627 that is not shorted from the wiper arm to ground. *a.* If normal, proceed to 4. *b.* If abnormal, make the following continuity measurements: (1) R2627 to 32 on J601. (2) 32 on P601 to 32 on P407. (3) 32 on J407 to 1A on E401. 4. Make the following continuity measurements: *a.* F4 on S2354 to R on Z2351. *b.* R on Z2351 to R on J301. *c.* R on P301 to R on P401. *d.* R on J401 to 50 on J407. *e.* 50 on P407 to 50 on P601. *f.* 50 on J601 to R2627.
10	Turn A-scope INTENSITY and ppi INTENSITY controls on the indicator clockwise until an indication appears on the screen of each scope.	Vertical trace approximately 1 inch in amplitude appears at the extreme left-hand side of the A-scope and a small intensified spot appears at the center of the ppi scope.	Both scopes are blank.	Pull out the indicator from its case and defeat interlock S603 (par. 207*b*). High-voltage warning light I 610 should light. *a.* If I 610 does not light, check continuity between N on E602 and 302 on E401 and between M on E602 and 1703 on E401. *b.* If I 610 does light, troubleshoot the high-voltage power supply in the indicating system (par. 358, symptom 1).
			No indication on A-scope.	Troubleshoot A-scope display circuits in the indicating system (par. 358, symptom 7).
			No indication on ppi scope.	Troubleshoot ppi-scope display circuits in the indicating system (par. 358, symptom 5).
11	Turn A-scope INTENSITY and ppi INTENSITY controls on the indicator counterclockwise until each presentation just disappears.	Both scopes are blank (until RADIATE ON switch is pressed, (step 12)).		

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
12	Press RADIATE ON button S616.	The reading on M501 decreases to red line, MAGNETRON CURRENT meter M502 reads between 40 and 44 ma, OPERATING HOURS meter M402 starts to run, and sweeps appear on both scopes.	The reading on M501 does not decrease to red line, MAGNETRON CURRENT meter reads 0, M402 does not run, and no sweeps appear on scopes.	Rotate ANTENNA ROTATE control R609 clockwise to see if antenna will rotate. *a.* If antenna does not rotate, troubleshoot the 5-minute time delay circuit (par. 430*c*). *b.* If antenna does rotate, return the ANTENNA ROTATE control to 0 and troubleshoot the ac power distribution and control system (par. 211, step 6).
			Meter M502 reads zero and no sweeps appear on scopes, but reading on M501 decreases to red line and M402 runs.	1. Check K152. *a.* If abnormal, replace the relay. *b.* If normal, pull out the modulator from its case and defeat interlock S153 (par. 207*b*). Modulator high-voltage warning lights and filaments of tubes should be lighted. (1) If abnormal, disconnect P151 from J151 and check Z154, Z153, and continuity between terminal 203 on E152 and 103 on E403 and between 202 on E152 and 102 on E403 in steps due to P151 and J151 being disconnected. (2) If normal, measure the voltage between terminals B1 and A2 on relay K152. The normal reading is between 110 and 120 volts ac. (*a*) If abnormal, check the continuity between B2 on K152 and terminal 103 on E403 and between terminal A1 on K152 and terminal 102 on E403. (*b*) If normal, proceed to corrective measure 2. 2. Place TRIGGER switch S152 on the modulator to the INTERNAL position.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				a. If the MAGNETRON CURRENT meter reads above zero, check V1350 through V1357 and V1301 through V1306 by substitution, and W2350 by using mercury delay line test unit Z2350. (1) If abnormal, replace defective component. (2) If normal, return TRIGGER switch S152 to EXTERNAL and troubleshoot the trigger loop circuits in the signal comparing system (par. 325, step 7). *b.* If the MAGNETRON current meter still reads zero, disconnect the cable which connects to J155 and connect dummy load to J155. (1) If output from the dummy load is normal, disconnect the dummy load, reconnect the cable which normally connects to J155, and troubleshoot the receiver-transmitter (transmitting system, par. 223, step 16). *Note.* Before troubleshooting the receiver-transmitter, check manual reset on magnetron overtemperature thermostat S501. (2) If output from the dummy load is abnormal, disconnect dummy load, reconnect cable which normally connects to J155, place S152 in the EXTERNAL position, and troubleshoot the modulator (transmitting system, par. 222, symptom 2*c* and *e*).
			The reading on M501 does not decrease to red line, and after hand is removed from S616, M402 stops running, M502 decreases to 0, and sweeps disappear from scope.	Check K405.
			M402 does not run.	Check M402.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
			MAGNETRON CURRENT meter reads zero.	Check the MAGNETRON CURRENT metering circuit in receiver-transmitter (transmitting system, par. 222, symptom 1*a*).
			No sweeps appear on scopes.	Disconnect P506 from J506 and check continuity from J506 to ground. The normal reading is less than 1 ohm. *a.* If abnormal, check T502. *b.* If normal, check continuity from P506 to P416, from J416 to terminal 48 on J407, and from terminal 48 on P407 to terminal 48 on P601, and if normal, troubleshoot the indicating system (par. 358, symptom 4).
			No sweep appears on A-scope.	Troubleshoot the indicating system (par. 358, symptom 8).
			No sweep appears on ppi scope.	Troubleshoot the indicating system (par. 358, symptom 6).
			The reading on M501 does not decrease red line.	Check R516 and contacts 3 and 13 of K405.
			MAGNETRON CURRENT meter M501 reads too high or too low.	Place TRIGGER switch S152 on the modulator to the INTERNAL position. *a.* If M501 reading changes to normal, the trouble is in the signal comparing system. Adjust carrier gate length potentiometer R–1365, following the procedure given in paragraph 332. If reading is still abnormal, troubleshoot the trigger loop circuits in the signal comparing system (par. 325, step 7). *b.* If M501 reading is still abnormal, disconnect the cable that connects to J155 and connect the dummy load to J155. Press RADIATE ON switch. (1) If output from the dummy load is normal, disconnect the dummy load, reconnect the cable which normally connects to J155, and troubleshoot the receiver-transmitter (transmitting system, par. 222, symptom 1*f*).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				(2) If output from the dummy load is abnormal, disconnect the dummy load, reconnect the cable which normally connects to J155, and troubleshoot the modulator (transmitting system, par. 222, symptom 2*e* and *f*).
			When RADIATE ON switch is pressed, the normal indications appear (or start to appear), but then the sweeps disappear from the scopes, MAG. FIL. meter reading increases above red line, MAGNETRON CURRENT meter reading decreases to zero, and M402 stops running. (Relay K151 is energizing due to an overload condition in the transmitting or RF systems.)	Disconnect cable that connects to J502 and connect the dummy antenna to J502 (RF output). *a.* If relay K151 does not energize when RADIATE ON switch is pressed, troubleshoot the RF system (par. 252, symptom (2)). *b.* If relay K151 still energizes when RADIATE ON switch is pressed, disconnect the dummy antenna from J502, reconnect the cable that normally connects to J502, disconnect the cable that connects to J155, and connect that dummy load to J155. (1) If relay K151 does not energize when RADIATE ON switch is pressed, troubleshoot the receiver-transmitter (transmitting system, par. 222, symptom 3*b*). (2) If relay K151 still energizes, disconnect the dummy load, reconnect the cable which normally connects to J155, and troubleshoot the modulator (transmitting system, par. 222, symptom 3*b*).
13	Connect the echo box to J501 and tune echo box for maximum reading on echo box meter.	Echo box meter should read maximum (approximately 60 microamperes). *Note.* Be careful not to tune to one of the maxima that give lower readings.	Abnormal reading on echo box meter.	*Note.* It has previously been established that the transmitter is functioning properly. 1. If another echo box is available, plug it into J501 (using a different cable).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				a. If normal indication can be obtained on meter by tuning echo box, proceed to step 14 and have defective echo box or cable repaired. *b.* If normal indication cannot be obtained on meter, check cable between J501 and J504. (1) If normal, check directional coupler (RF system, par. 252, symptom 8). 2. If another echo box is not available, check the crystal in the echo box, the meter, and the cable to J501. If these are normal, check cable between J501 and J504 and if this cable is normal, check directional coupler (RF system, par. 252, symptom 8).
14	Place RANGE MARKS MILES switch to the ON position and observe A-scope for range marks, grass, and ringtime.	Four vertical 5-mile range marks should appear on A-scope, ringtime should be at least 12 miles (at 1,280 mcs), maximum ringtime level (saturation level) should be approximately 1½ inches above the A-scope baseline, and the noise level (grass) should be approximately ⅓ of the saturation level. *Note.* The figure of 12 miles is based on a stable approximately midrange magnetron frequency and moderate temperature and humidity conditions. For all other operating conditions, use the slide rule scale on the echo box.	No range markers, no ringtime, and no noise on A-scope. No ringtime (noise is normal). No ringtime and no noise.	Check V612 and V619 by substitution and if normal, troubleshoot the indicating system (par. 358, symptom 10). *Note.* It has been established that the gain of the receiving system is normal (step 7), that the local oscillator and signal mixer are normal (step 6), and that the transmitting system is normal (step 12). Perform receiver tuning procedures outlined in paragraph 447. 1. If ringtime pattern appears on the ppi scope, check V619 by substitution and if it is normal, troubleshoot the indicating system (par. 359, step 34). 2. If ringtime pattern does not appear on the ppi scope, observe the waveform at pin 7 of V611 with an oscilloscope. The normal waveform is the ringtime pattern.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				a. If normal, check V611 and V612 by substitution. and if normal, troubleshoot the indicating system (par. 358, symptom 12). *b.* If abnormal, check V3306 and V3308 in the signal comparator by substitution. (1) If abnormal, replace defective tube. (2) If normal, check cabling between P601 on the indicator and P303 on the signal comparator. If cabling is normal, troubleshoot the signal comparator (signal comparing system, par. 322, symptom 5).
			No range markers	Check 40-mile sweep on A-scope and 20-mile sweep on ppi scope for range markers. *a.* If markers do not appear on any of the three sweeps, check V614, V615, V616, and V617 by substitution. (1) If abnormal, replace defective tube. (2) If normal, troubleshoot the indicating system (par. 358, symptom 9). *b.* If markers appear on the ppi scope only, check V619 by substitution and if it is normal, troubleshoot the indicating system (par. 359, step 16*e*). *c.* If markers appear on the 40-mile A-scope sweep and the ppi scope sweep, troubleshoot the indicating system (par. 359, step 15*d*).
			Ringtime is low but noise level is normal.	Perform receiver tuning procedures given in paragraph 447, and if ringtime is still low, perform RF tuning procedures given in paragraphs 257 through 260 (tr cavities and duplexer assembly).
			Ringtime is low and noise level is low.	1. Substitute a new V232, V224, V225, and V301 through V306; observe the A-scope for an improvement in ringtime as each new tube is substituted.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				a. If ringtime is still below 12 miles, check CR301 and if it is normal, proceed to the next corrective measure. 2. Check the gain of IF preamplifier U221 (par. 296). *a.* If abnormal, troubleshoot the IF preamplifier in the receiver-transmitter (receiving system, par. 278, symptom 6*a*). *b.* If normal, check the gain of signal IF amplifier Z301 (par. 298). (1) If abnormal, troubleshoot signal IF amplifier Z601 in the signal comparator (receiving system, par. 278, symptom 6*b*). (2) If normal, check the cabling between the preamplifier and the signal IF amplifier.
15	Rotate ANTENNA ROTATE control clockwise until ANTENNA SPEED indicator N604 indicates 6 RPM.	Antenna and ppi sweep rotate clockwise at a speed of approximately 6 rpm.	Neither the antenna nor the sweep rotates.	1. Check whether safety switch S753 is in the ON position. 2. Place safety switch S753 in the OFF position. Remove the servo amplifier from the antenna base, defeat interlock S701, and then throw S753 to the ON position. ***Warning:*** In troubleshooting the antenna positioning system, do not place yourself in the path of the antenna in case it suddenly starts to rotate. If you must place yourself in a position where you may be struck by the rotating antenna, position some one at safety switch S753. 3. Observe whether filaments of tubes are lighted. *a.* If abnormal, check the voltage between terminals 1 and 2 of T702. (1) If abnormal, disconnect P702 from J702 and make the following continuity measurements: (*a*) Terminal 2 on T702 to terminal J on J702. (*b*) Terminal J on P702 to terminal 903 on E753.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				(*c*) Terminal 1 on T702 to terminal G on J702. (*d*) Terminal G on P702 to terminal G on J702. (2) If normal, check T702. *b*. If normal, check the voltage between terminals 9A and 10A on E751. The normal reading is +95 volts. (1) If abnormal, check bridge rectifier CR–701. (2) If normal, proceed to corrective measure 4. 4. Measure the voltage between terminals 703 and 302 on E752. The normal reading is between 110 and 120 volts ac. *a*. If abnormal, place S753 in the OFF position and check continuity between terminal 2 on S753 and terminal 103 on E403 and between terminal 703 on E752 and terminal 1 on S753, and if these check good, check S753. *b*. If normal, measure the voltage between terminal 2 on relay K703 and terminal 302 on E752. The normal reading is between 110 and 120 volts ac. (1) If abnormal, check relay K703. (2) If normal, measure the voltage between terminal 2 on T704 and terminal 302 on E752. The normal reading is between 110 and 120 volts ac. (*a*) If abnormal, check relay K705 and C717, and if these are normal, check continuity between terminal 2 on K703 and terminal 2 on T704. (*b*) If normal, check continuity between terminals 2 and 1 on T704.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				5. If the checks made in corrective measures 2 and 3 above do not locate the trouble, troubleshoot the antenna positioning system (par. 393, symptom 1).
			Antenna rotates but sweep does not.	1. Note position of AZIMUTH knob on front of indicator and turn AZIMUTH knob. *a.* If sweep does not rotate, place AZIMUTH knob in its original position and check the mechanical connections between synchro receiver B602 and deflection yoke L601. *b.* If sweep does rotate, return sweep to its original position by turning back the AZIMUTH knob, and troubleshoot the antenna positioning system (par. 393, symptom 8).
			Antenna and ppi sweep rotate, but at incorrect speed.	1. Adjust ANTENNA SPEED potentiometer R2619 (par. 400). If adjustment of R2619 does not correct trouble, troubleshoot the antenna positioning system (par. 393, symptom 6 or 7).
16	Observe ringtime on ppi scope with antenna rotating.	Ringtime is the same on the ppi scope as it is on the A-scope and is the same in all azimuths, resulting in a symmetrical, intensified circle at the center of the ppi scope, and two range markers (circles) appear beyond the ringtime pattern. *Note.* Ringtime cannot be measured as accurately on the ppi scope as it can on the A-scope.	No ringtime and no range markers on the ppi scope.	Check V602 by substitution and if normal, troubleshoot the indicating system (par. 358, symptom 11).
			No ringtime or poor ringtime on the ppi scope.	Troubleshoot the indicating system (par. 359, step 33).
			No range markers on the ppi scope.	Turn 5–10 MILE MARKER INT potentiometer R1617 (fig. 148) completely clockwise and if range markers still do not appear on the ppi scope, troubleshoot the indicating system (par. 359, step 15).
			Ringtime pattern not completely circular (wedge or wedges missing).	This symptom indicates probable trouble due to a rotating joint in the RF system. Troubleshoot the RF system (par. 252, symptom 6).
17	Place ppi RANGE SELECTOR in the 160 position.	25-mile range markers (circles) appear on screen and the range strobe (circle) appears at approximately 150 miles. *Note.* It may be necessary to rotate the RANGE STROBE potentiometer to distinguish the range strobe from the 150-mile range marker.	No 25-mile range markers appear on the ppi scope.	1. Turn 25–10 MILE MARKER INT potentiometer R1629 (fig. 148) completely clockwise.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				2. If 25-mile range markers still do not appear, check V618 and V617 by substitution, and if the tubes are normal, troubleshoot the indicating system (par. 359, step 17).
			No range strobe on ppi	1. Rotate STROBE INT. (fig. 148) completely clockwise. 2. Check V621, V613, and V601 by substitution and, if range strobe still does not appear, troubleshoot the indicating system (par. 359, step 31).
			Range strobe appears at a range other than 150 miles.	1. Adjust STROBE LIM potentiometer R1655 (fig. 148) follow procedure in paragraph 368. 2. If R1655 cannot be adjusted to place the range strobe at 150 miles, troubleshoot the indicating system (par. 359, step 18). 3. Place ppi RANGE SELECTOR in the 20 position.
18	Detune echo box so that ringtime does not appear on either scope, observe the ppi scope for targets, and note which appear to be fixed targets and which appear to be moving targets.	The returns from nearby fixed clutter appear as relatively large intensified regions close to the center of the screen with moving targets only appearing in regions where there are no large fixed targets.	No targets, or known targets appear weaker than usual.	1. Since ringtime is normal (from the directional coupler) the only portion of the equipment which the ringtime does not check is a portion of the RF system. However, this abnormal condition can be caused by unusual weather conditions. 2. Check the RF system (par. 252, symptom 3) and if abnormal, troubleshoot the RF system.
19	Place OPERATION switch S601 in the MTI position and observe the ppi scope.	Most of the returns from fixed targets should disappear, leaving only residue which it is beyond the capability of the equipment to cancel, and all moving targets should still appear on the ppi scope.	No targets appear on the scope.	Check V3303, V3304, and V3305 by substitution and if normal, troubleshoot the signal comparing system (par. 323, symptom 6).
			Fixed targets are not cancelled. Operation is similar to what it is in the normal mode of operation.	Aline coho subchassis (pars. 14–22) and if this does not result in correct operation in the mti mode of operation, aline the entire mti mode of operation (par. 447). If alinement does not result in correct mti operation, troubleshoot the signal comparing system (par. 322, symptoms 3 and 7).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
			Poor cancellation of clutter, but targets in areas free from clutter appear normal.	1. Place the OPERATION switch in the NORM position and tune echo box for maximum ringtime. 2. Place the OPERATION switch in the MTI position and adjust MTI BALANCE potentiometer R–2618 for maximum cancellation of the ringtime pattern on the A-scope. *a.* If rotation of R2618 has no effect on the ringtime pattern or if a position of R2618 that virtually cancels all of the ringtime pattern cannot be found, aline the entire mti mode of operation (par. 447). If alinement does not result in proper mti operation, troubleshoot the signal comparing system. *b.* If adjustment of R2618 results in proper mti operation, place the OPERATION SELECTOR switch in the MTI position and adjust R2356 in the same manner as R2618. Then place the OPERATION SELECTOR switch in the REMOTE position.

211. Troubleshooting +27-Volt Power Distribution
(fig. 231)

Much of the distribution of power through the equipment is controlled by relays which are actuated by +27 volts. The troubleshooting chart in *b* below is intended to be used when the absence of +27 volts is discovered while troubleshooting the equipment using the troubleshooting chart based on starting procedure. The purpose of the chart is to insure that +27 volts is being applied to all units requiring +27 volts. If normal indications are obtained for all steps in the chart, it can be assumed that +27 volts is being applied to all units requiring this potential.

a. Figure 231 is a complete schematic diagram of the +27-volt distribution. It is the only schematic diagram referred to in the +27-volt distribution troubleshooting chart.

b. The preliminary checks and control setting listed in paragraph 209 apply to the following troubleshooting chart:

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
1	Pull out power supply from its case and defeat interlock S402 (par. 207*b*).	High-voltage warning light I 417 lighted.	I 417 not lighted.	See paragraph 210, step 4.
2	Place POWER switch S602 to ON, and allow 5- to 10-minute warmup period.	No blown fuse indicators are lighted.	One or more blown fuse indicators lighted.	Replace the fuse or fuses (par. 207*a*).

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
3	Measure the voltage from terminal 8A on E404 to ground.	The normal reading is +27 volts.	Meter reading is zero_____	1. Measure the voltage between terminals 4 and 5 on T403. *a.* If abnormal, check T403. *b.* If normal, check CR401, L403, and continuity between the +terminal of CR401 and terminal 8A on E404.
4	Note noise level on A-scope. Then place L.O. MOTOR switch S613 in the DEC position for a few seconds and observe A-scope during this time.	Noise level on A-scope increases considerably, indicating that local oscillator tuning motor B502 is running.	No change in noise level on A-scope (B502 does not run).	1. Measure the voltage from terminal 8A on E502 to ground (+27 volts). *a.* If abnormal, check continuity from 8A on E502 to 8A on E404. *b.* If normal, measure the voltage from 8A3 on E502 to ground (+27 volts). (1) If abnormal, check R518 (28 ohms), lower limit microswitch S503 (continuity), and B502 (by disconnecting its armature and applying +27 volts dc across its armature). (2) If normal, check continuity from 8A3 on E502 to ground. *Note.* S613 must be in the DEC position to obtain continuity.
5	Set TEST SELECTOR switch S506 to the COHO position and then to the SIG position.	Both positions should give red-line readings.	Zero reading in both positions of S506.	1. Measure the voltage between TP501 and TP502 in the receiver-transmitter. The normal reading is 6.3 volts dc. *a.* If normal, troubleshoot the local oscillator circuit in the receiving system. *b.* If high, check TY501 by substitution, and C503 for leakage. *c.* If low, check TY501 by substitution. *d.* If zero, check TY501 by substitution, and if still zero, check continuity from terminal 7 on TY501 to ground (fig. 231).
6	Press RADIATE ON switch S616, and then rotate ANTENNA ROTATE control R609 clockwise.	MAGNETRON CURRENT meter M502 should read approximately 43 ma and antenna should rotate.	M502 reads zero and antenna does not rotate. M502 reads normal, but antenna does not rotate.	Troubleshoot the 5-minute time delay circuit (par. 430*e*). Measure the voltage from terminal 3 on K705 to ground (+27 volts). *a.* If abnormal, check continuity between terminal 8A7 on E404 to terminal 3 on K705.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
				b. If normal, troubleshoot the antenna position system (par. 393, symptom 1).
			Antenna rotates but MAGNETRON CURRENT meter M502 gives no indication.	Note noise level on A-scope and then place L.O. MOTOR switch S613 in the INC position for a few seconds (noise level on A-scope will increase if local oscillator tuning motor B502 is running). *a.* If local oscillator motor does not run, pull out receiver-transmitter, defeat interlock S504 (par. 207*b*) and observe whether shutter gate relay K501 actuates when the 5-minute time delay elapses. (1) If K501 does not actuate, check S501 and if it is normal, check continuity from 6A6 on E502 to 8A7 on E404. (2) If K501 does actuate, check continuity from 8A6 on E502 to the INC terminals of S613. *b.* If the local oscillator tuning motor does run, replace receiver-transmitter in its case and measure the voltage from terminal 8A10 on E404 to ground (+27 volts) while pressing the RADIATE ON switch. (1) If normal, proceed to *c* below. (2) If abnormal, check continuity from terminal 1 on J601 to terminal 8A10 on E404 in steps due to S616 being normally open when power is removed from the equipment. *c.* Pull out modulator from its case, defeat interlock S153 (par. 207*b*), and measure the voltage from terminal 3 on K151 to ground (+27 volts). (1) If abnormal, check continuity from terminal 3 on K151 to terminal 8A10 on E404. (2) If normal, check K152.

Step	Procedure	Normal indications	Abnormal indications	Corrective measures
7	Press RADIATE OFF switch S615, place TEST SELECTOR S2353 in the No. 2 position, and then press RADIATE ON switch S616.	TEST METER M2350 reads red line at first, and then decreases to zero after the five-minute time delay elapses.	M2350 reading does not decrease to zero.	1. Pull out signal comparator from its case. ***Caution:*** Be careful not to damage the 3 cables that connect to the delay line assembly (par. 321). 2. Measure the voltage from terminal 1 on K3301 to ground (+27 volts). *a.* If abnormal, check continuity from terminal 1 on K3301 to terminal 8A7 on E404. *b.* If normal, check K3300 and if it is normal, check to see that S2354 and S601 are in the positions listed in paragraph 209.

CHAPTER 12

TRANSMITTING SYSTEM TROUBLESHOOTING AND REPAIR

Warning: Extremely dangerous voltages exist in Radar Modulator MD–144/TPS–1D and Radar Receiver-Transmitter RT–212/TPS–1D.

1. Defeat interlocks only for the purpose of making observations within a unit.

2. Do not make voltage measurements in the modulator or receiver-transmitter high-voltage circuits.

3. Do not make waveform checks in the modulator or receiver-transmitter high-voltage circuits except at the jacks or test points provided.

4. Before making resistance measurements or coming in contact with any high-voltage components in the receiver-transmitter, turn the equipment off and disconnect cable from PULSE INPUT jack J505.

5. Before making resistance measurements or coming in contact with any high-voltage components in the modulator, turn the equipment off and ground L152 and the junction of the leads to the plate caps of V153 and V154 with a shorting bar.

Caution: If the transmitter will not operate because of the operation of protective relay K151, do not readjust balance adjustment R168 to correct the situation; damage to the equipment may result. Refer to paragraph 229 for adjustment procedure for R168.

Section I. TROUBLESHOOTING INFORMATION

212. Reference Data

The following information will be helpful when troubleshooting or repairing the transmitting system.

Reference	Data
Fig. 5	Transmitting system, complete block diagram.
Pars. 6 through 38	Transmitting system theory.
Figs. 6 through 14	Transmitting system circuits, simplified schematic diagrams.
Fig. 210	Radar Modulator MD–144/TPS–1D, complete schematic diagram.
Fig. 212	Radar Receiver-Transmitter RT–212/TPS–1D, complete schematic diagram.
Fig. 231	+27-volt power distribution, complete schematic diagram.
Par. 213 and figs. 102 through 114.	Location of parts and adjustments.
Fig. 208	Radar Modulator MD–144/TPS–1D, waveforms.
Fig. 209	Radar Modulator MD–144/TPS–1D, voltage and resistance measurements at tube sockets.

213. Location of Parts in Transmitting System

The following table will help locate parts in the transmitting system. The chart lists, by reference symbol, the parts that can be located and gives the number of the figure on which the location is shown.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
B151	106	C516	103	J155	105
B501	103	C517	103	J156	105
C101A	112	C524	125	J157	105
C101B	112	C1101	114	J501	102
C102	112	C1103	114	J502	102
C103	112	C1104	114	J505	102
C104	112	C1106	114	J506	102
C105	112	CR501	104	J508	102
C107	112	E101	113	K151	110
C108	112	E102	113	K152	106
C153	106	E129	109	L151	108
C156	110	E152	106	L152	106
C157	110	E501	103	L502	104
C158	106	E503	103	M501	102
C504	103	E505	103	M502	102
C505	104	E508	103	O 531	102
C506	104	E1101	106	P516A	103
C507A	104	HR151	110	P516B	103
C507B	104	HR152	110	R101	112
C508	104	HR501	103	R102	112
C509	103	I 151	108	R103	112
C510	104	I 152	106	R104	112
C511	125	I 501	103	R105	112
C512	103	I 502	103	R106	112
C513	125	J151	105	R107	112
C514	125	J152	105	R108	112
C515	125	J153	105	R109	112

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
R110	112	R156	107	R515	104
R111	112	R157	107	R516	104
R112	112	R158	107	R517	104
R113	112	R159	107	R520	103
R114	112	R160	110	R1101	114
R115	112	R162	108	R1102	114
R116	112	R163	108	R1103	114
R117	112	R164	108	R1105	114
R118	112	R165	108	R1106	114
R119	112	R166	108	R1108	114
R120	112	R167	105	R1109	114
R122	112	R168	110	R1110	114
R124	112	R169	108	S151	107
R125	112	R171	108	S152	105
R126	112	R172	106	S153A	107
R128	106	R173	110	S153B	107
R151	107	R506	103	S154	106
R152	107	R508	103	S155	106
R153	107	R509	103	S501	103
R154	107	R510	125	S504A	125
R155	107	R514	125	S504B	125

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
S505	123	V151	106	XV155	107
S506	102	V152	106	XV156	106
S1101	106	V153	106	XV1101	114
T101	113	V154	106	XV1102	114
T102	113	V155	106	Z151	109
T103	113	V156	106	Z152	109
T151	106	V502	103	Z153	109
T152	107	V1101	106	Z154	109
T153	106	V1102	106	Z155	109
T502	103	XI 151	108	Z156	109
T504	104	XI 152	106	Z157	109
T1101	106	XI 153	110	Z158	109
TP101	113	XI 501	103	Z159	109
TP102	113	XV101	112	Z161	106
TP103	113	XV102	112	Z501	103
TP104	113	XV103	112	Z502	103
TP151	111	XV151	107	Z503	104
TP152	111	XV152	107	Z507	104
V101	113	XV153	107	Z508	104
V102	113	XV154	107	Z1101	106
V103	113				

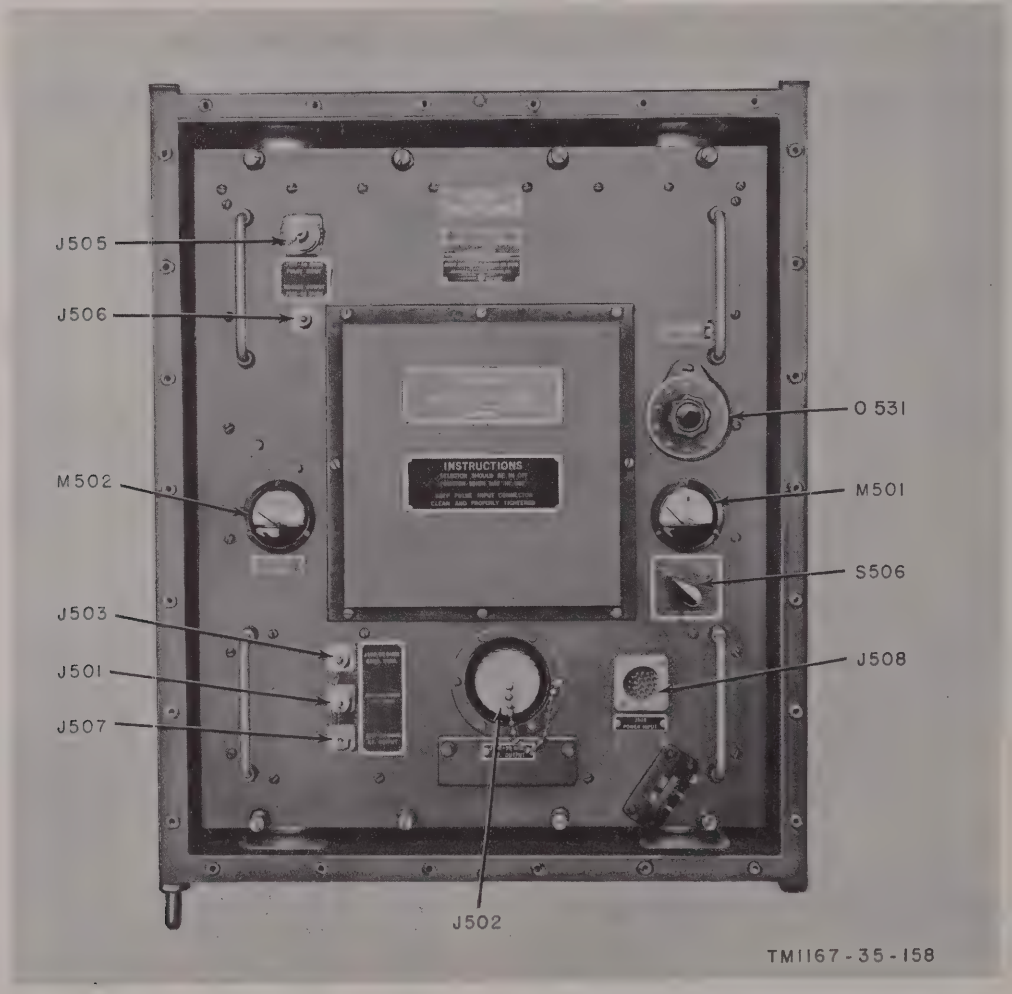


Figure 102. Radar Receiver-Transmitter RT–212/TPS–1D, front panel view.

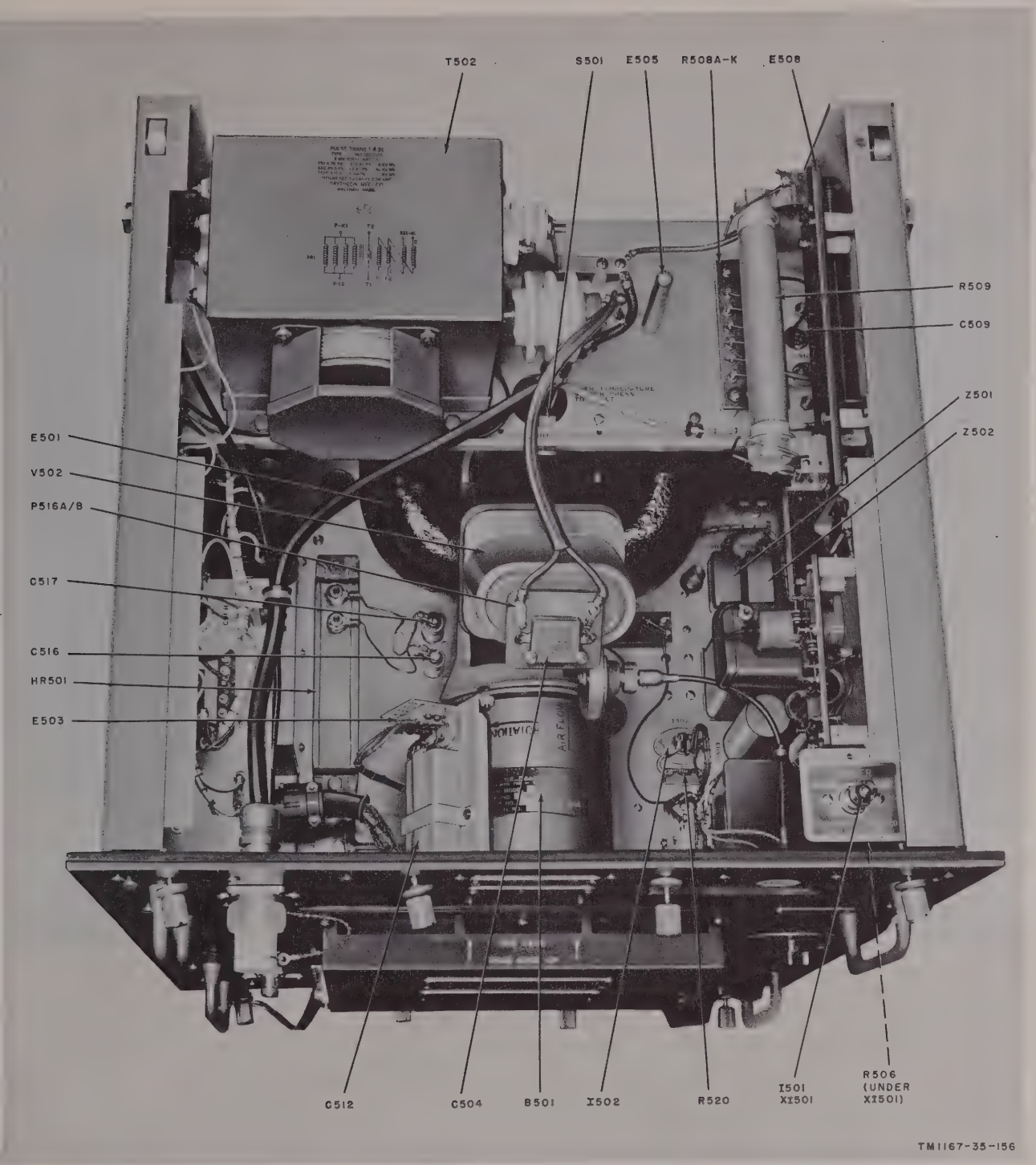


Figure 103. Radar Receiver-Transmitter RT-212/TPS-1D, top right view.

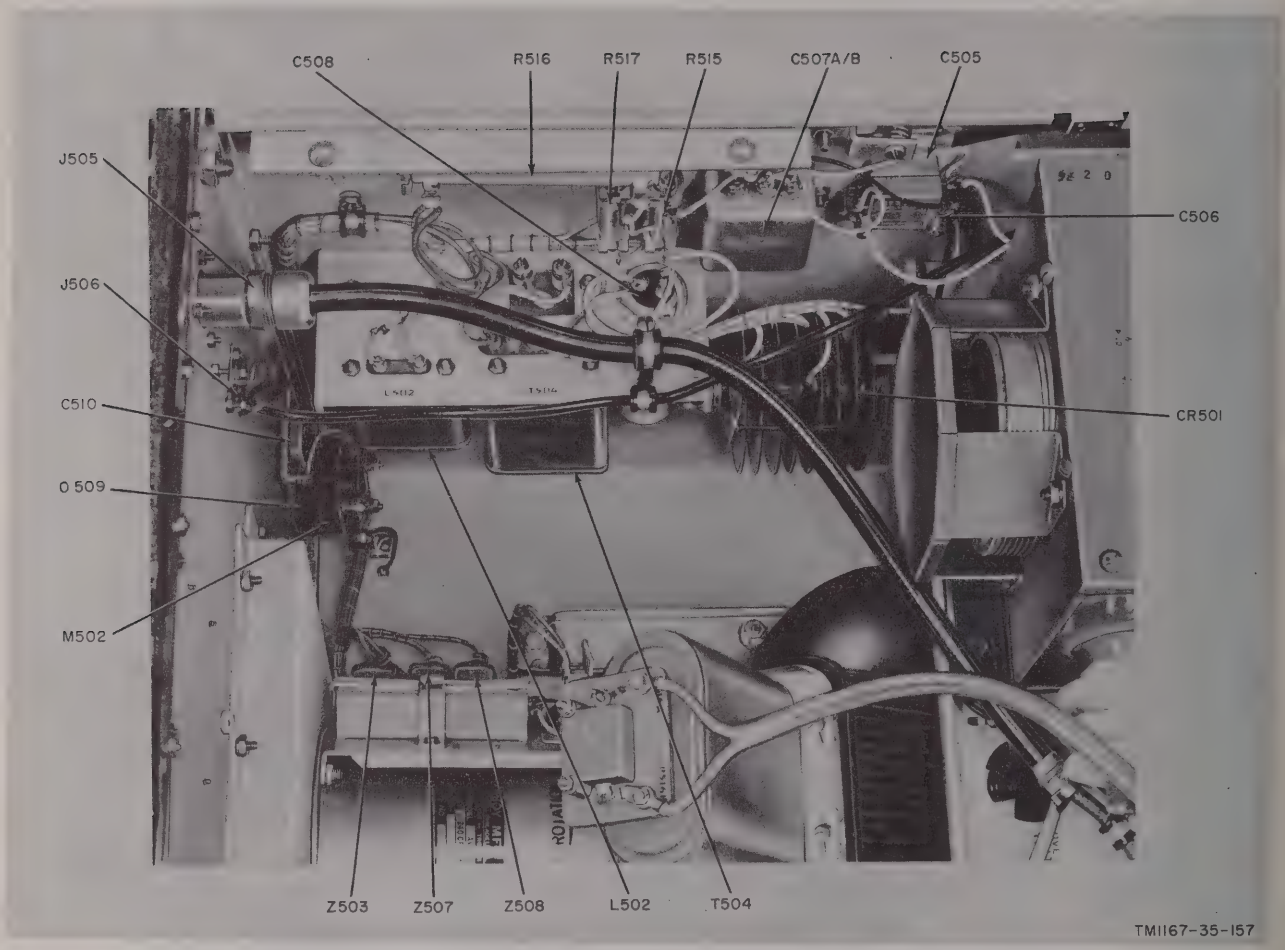


Figure 104. Radar Receiver-Transmitter RT–212/TPS–1D, top left view.

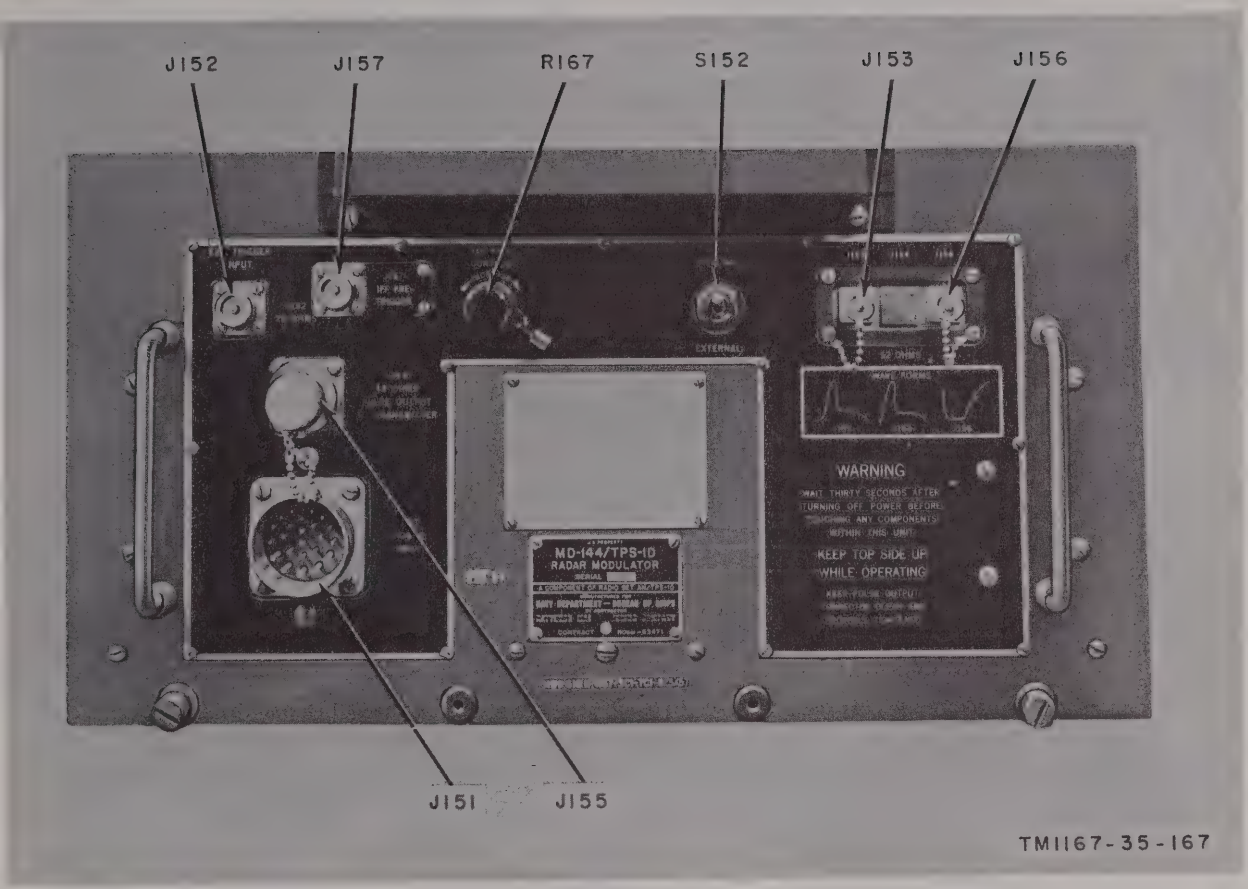


Figure 105. Radar Modulator MD–144/TPS–1D, front panel view.

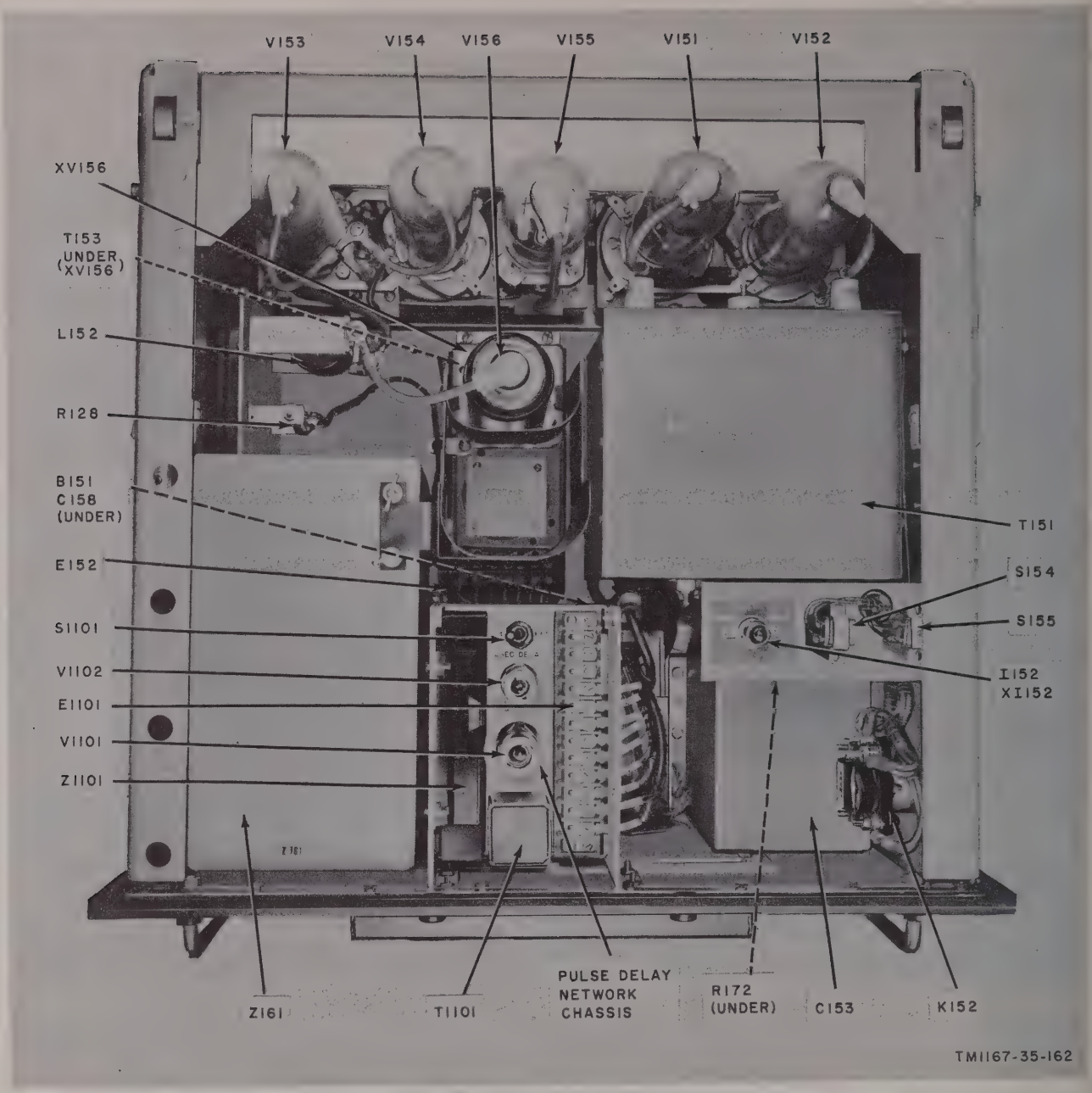


Figure 106. Radar Modulator MD–144/TPS–1D, top view.

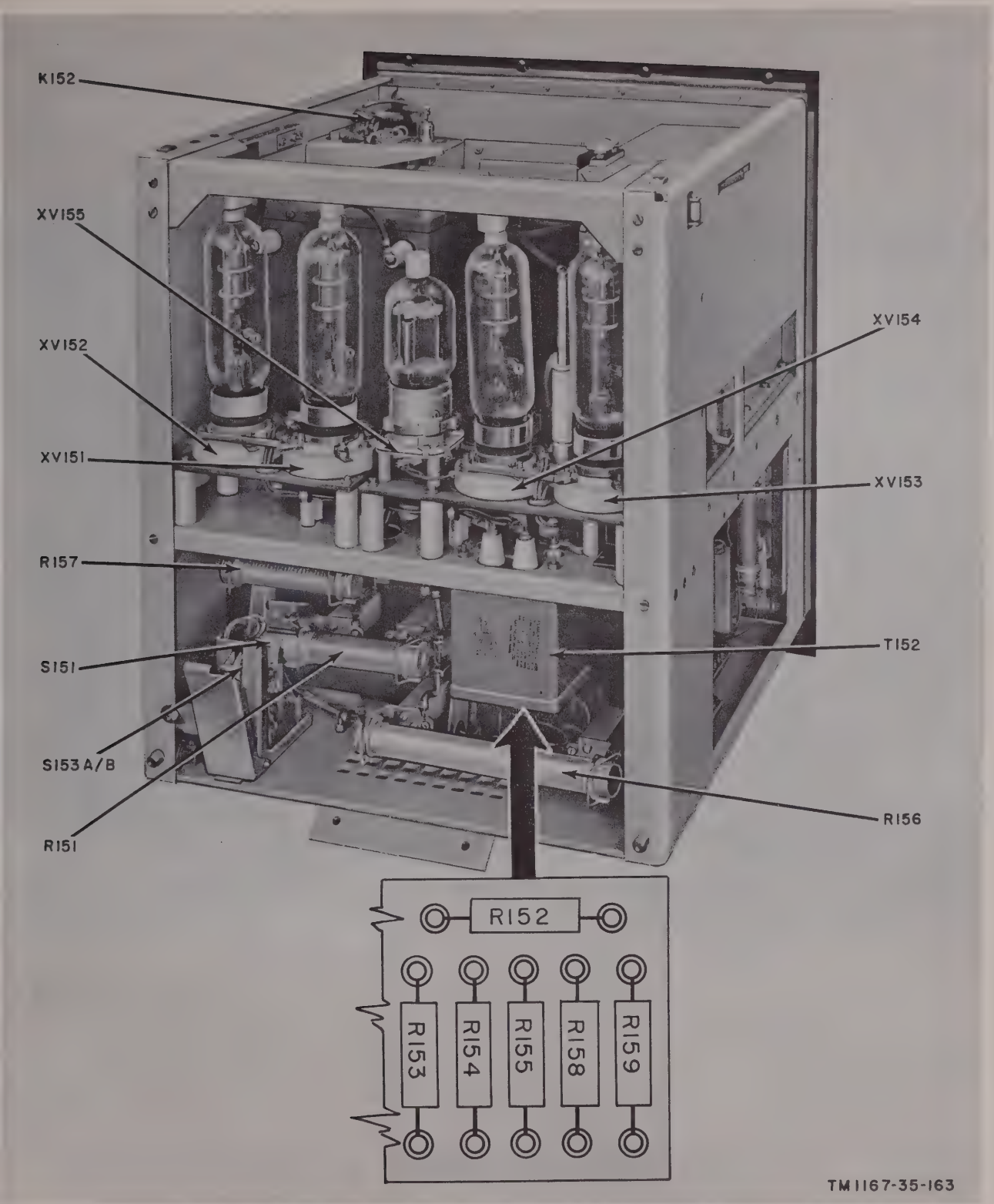


Figure 107. Radar Modulator MD–144/TPS–1D, rear view.

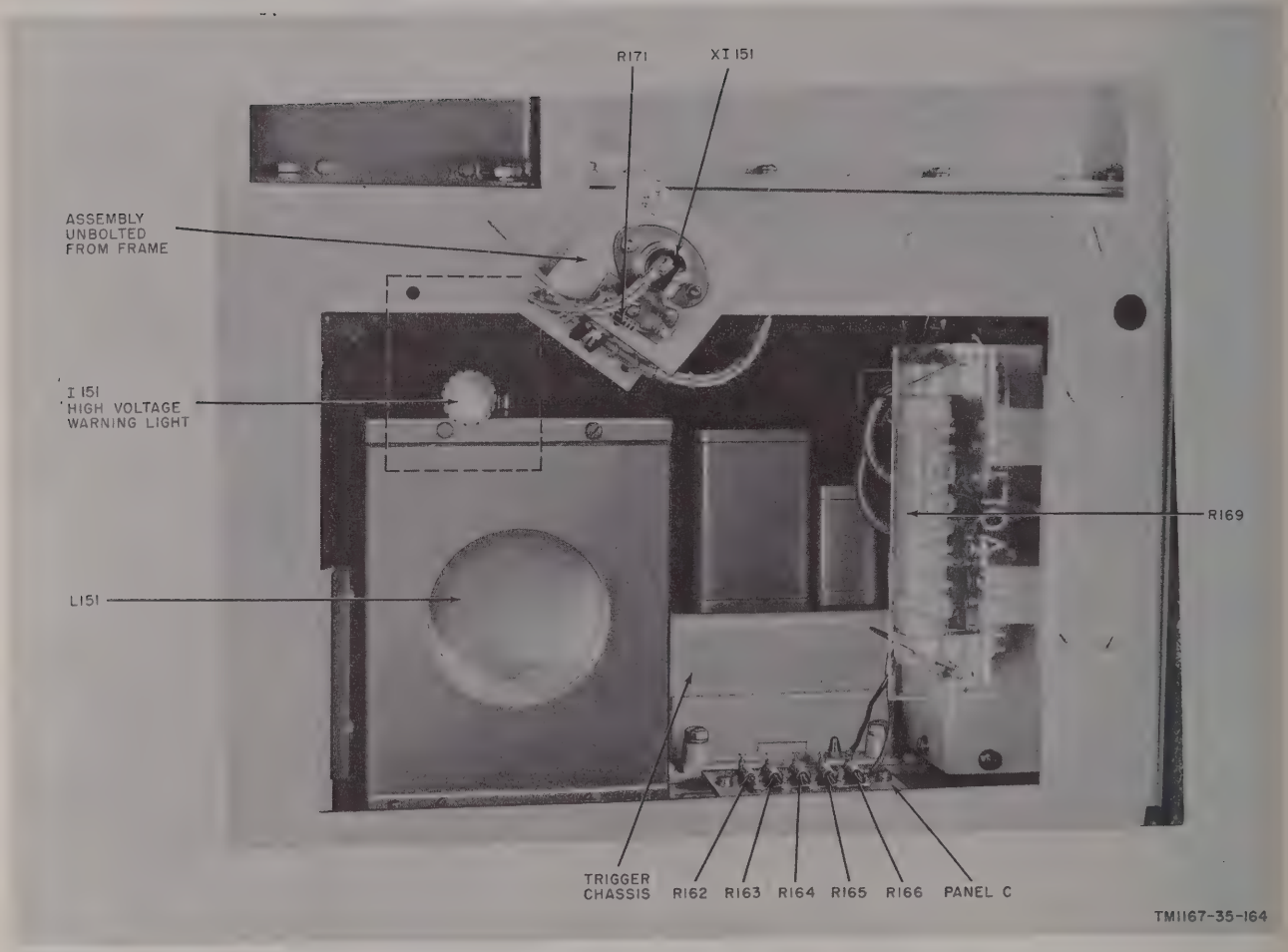


Figure 108. Radar Modulator MD–144/TPS–1D, lower left side view.



Figure 109. Radar Modulator MD–144/TPS–1D, right side view.

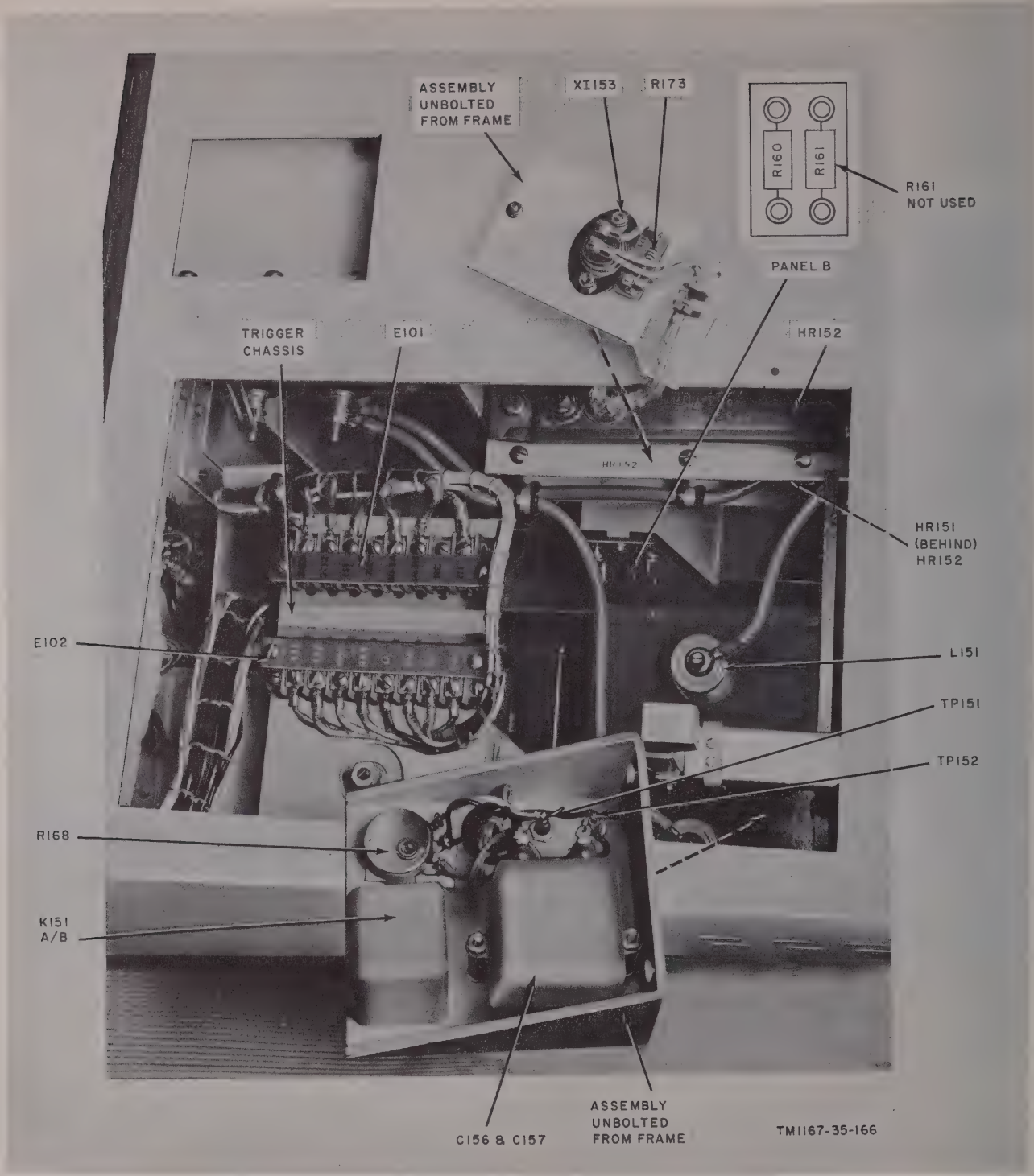


Figure 110. Radar Modulator MD–144/TPS–1D, lower right side view.

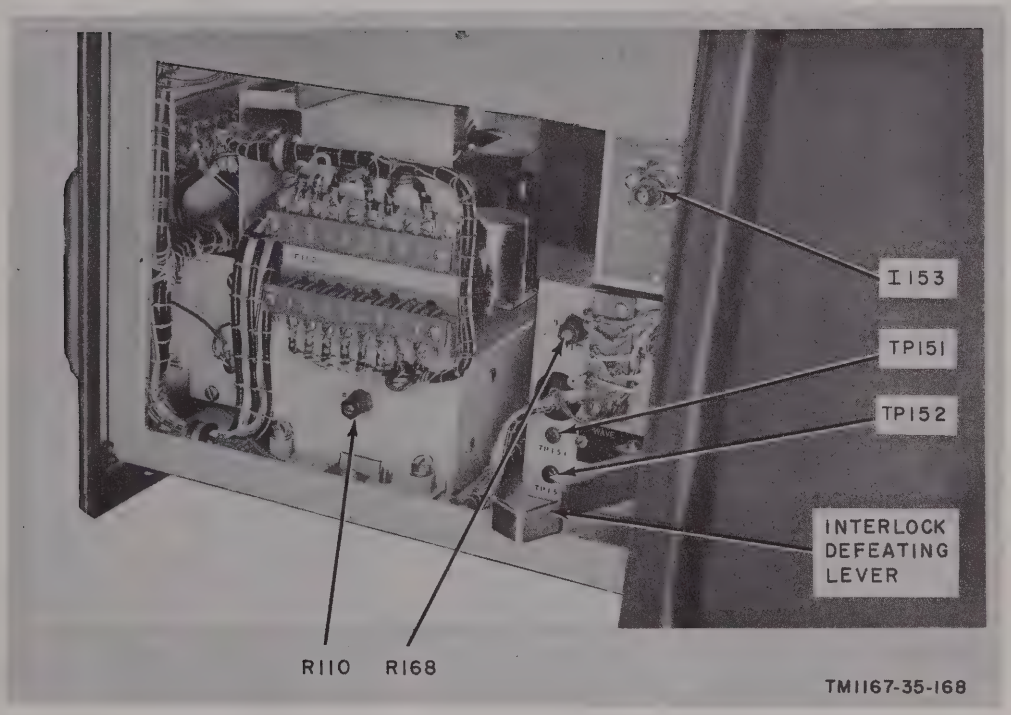


Figure 111. Radar Modulator MD–144/TPS–1D, right side view.

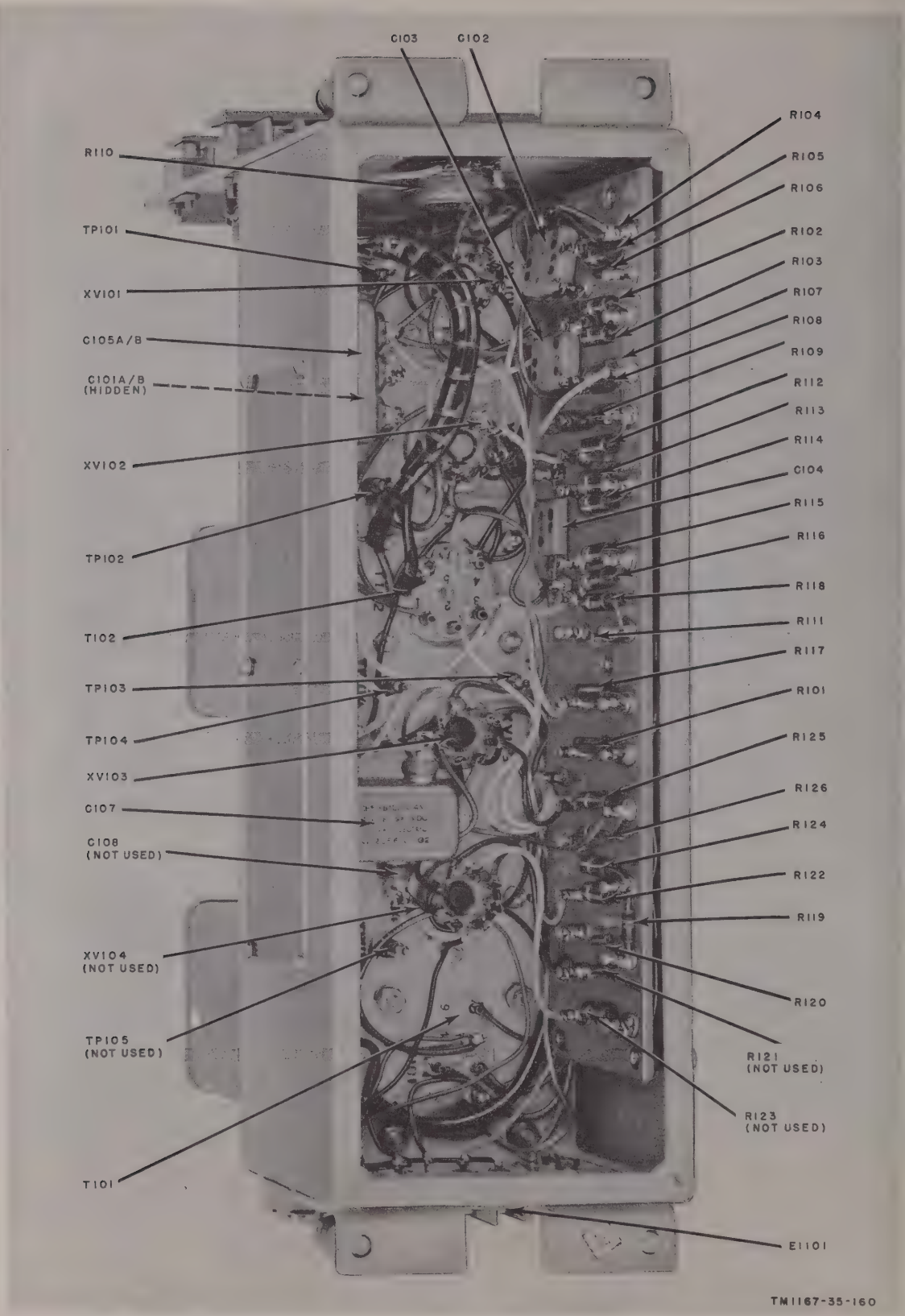


Figure 112. Radar Modulator MD–144/TPS–1D, trigger chassis, bottom view.

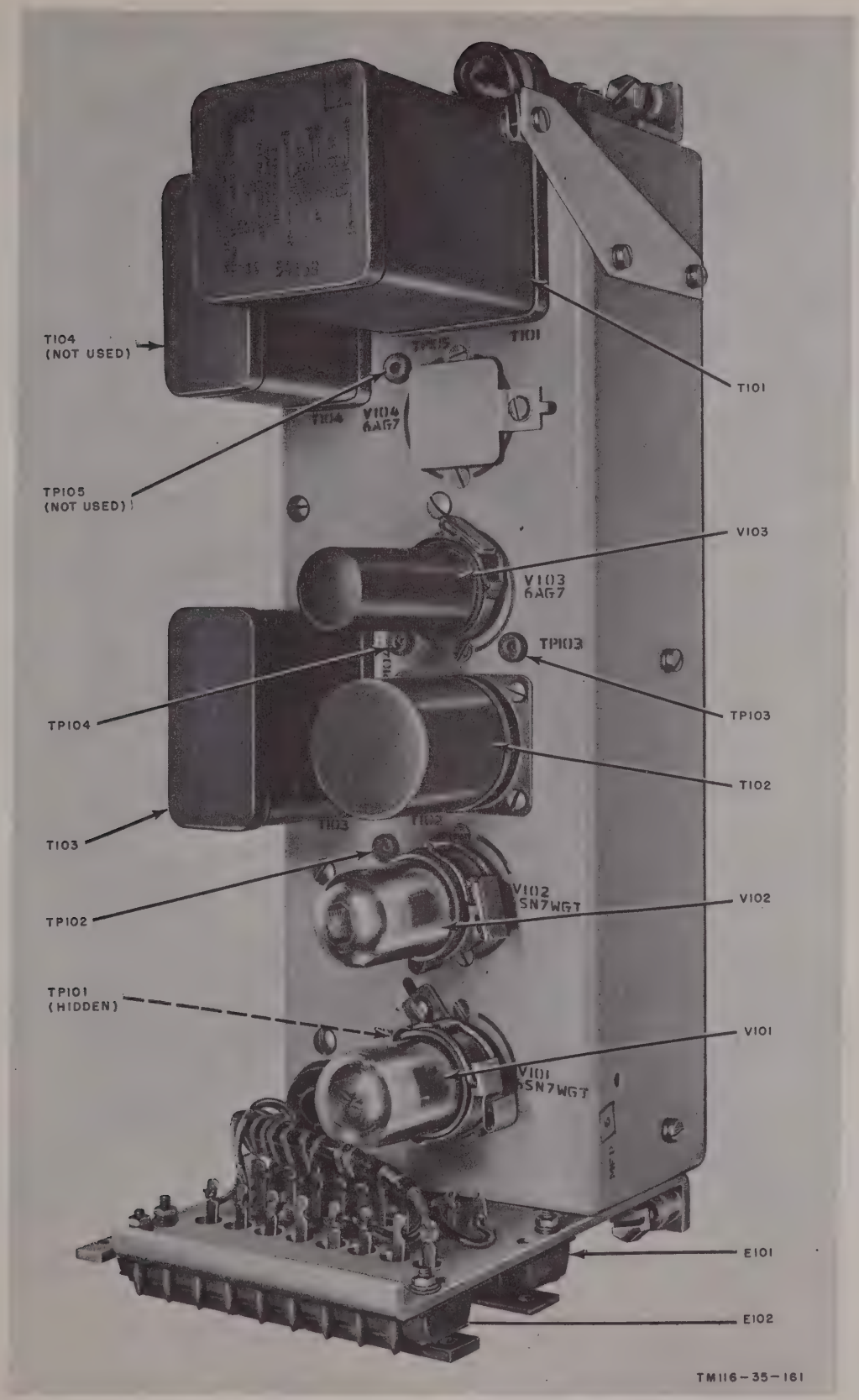


Figure 113. Radar Modulator MD–144/TPS–1D, trigger chassis, top view.

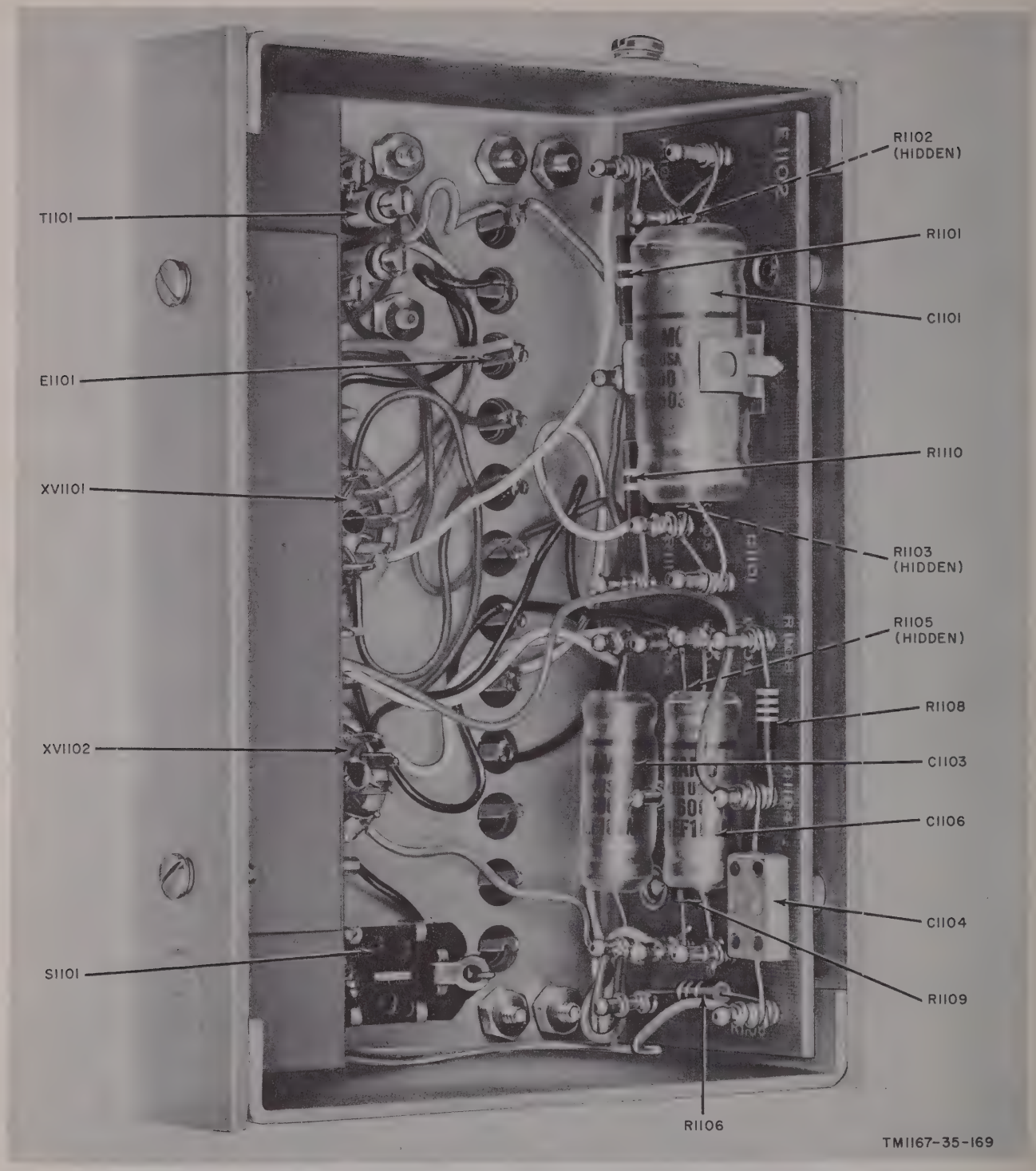


Figure 114. Radar Modulator MD–144/TPS–1D, pulse delay network chassis, bottom view.

214. Transmitting System Controls and Adjustments

The following charts list the controls and adjustments that are functionally part of the transmitting system.

a. Controls Located in Indicator.

Control	Location (fig. No.)	Function
RADIATE ON switch S616.	158	Energizes radiate relay K152 and radiate interlock relay K405, providing time delay relay K401 has completed its cycle. Relay K152 applies primary power to the high-voltage power supply. Relay K405 holds K152 energized and reduces the magnetron filament voltage to its operating value.
RADIATE OFF switch S615.	158	Deenergizes relay K152 and K405.

b. Controls Located in Receiver-Transmitter.

Control	Location (fig. No.)	Function
MAGNETRON TUNING O531.	102	Varies magnetron frequency from 1,220 to 1,350 mcs (par. 232).
TEST SELECTOR switch S506.	102	Connects meter M501 in the magnetron filament circuit when in the MAG. FIL. position.

c. Controls and Adjustments Located in Modulator.

Control or adjustment	Location (fig. No.)	Function
TRIGGER selector switch S152.	105	EXTERNAL position connects EXT. TRIGGER INPUT jack J152 to the cathode of blocking oscillator keyer tube V102 and removes the plate supply voltage from internal repetition rate multivibrator V101. INTERNAL position connects C105A as a cathode bypass for V102A, applies plate voltage to V101, and disconnects J102 from the cathode of V102.
REP. RATE CONTROL R167.	105	Controls the frequency of the internal repetition rate multivibrator by varying the time constant in the grid circuit of V101B.
SEC DELAY switch S1101.	106	Selects 12.4- or 37-microsecond delay between the IFF pretrigger and the radar transmitter trigger. Shorts out a portion of delay line Z1101 in the 12.4-microsecond position.
Balance Control R168.	110	Adjusted so that opposing magnetic fields in K151 are equal when the transmitting system is operating normally.
Coarse frequency control R110.	112	In series with REP. RATE CONTROL R167 in the grid circuit of V101B. Adjusted so that the highest repetition rate available by varying R167 is 400 pulses per second.

215. Transmitting System Fuses

The following chart lists the fuses that protect the transmitting system circuits. The chart also lists the rating of each fuse, the blown fuse indicator that lights when the fuse is blown, the circuit that each fuse protects, and the figure that shows the location of each fuse.

Fuse	Rating		Blown fuse indicator	Circuit protected	Location (fig. No.)
	Volts	Amps			
F403	250	4	I 403	Magnetron filament supply transformer T504	173
F406	250	6.25	I 406	+27-volt dc power supply transformer T403	173
F410	250	6.25	I 410	Filament transformer T152 for high-voltage rectifier tubes V151 and V152, charging diodes V153 and V154, and shunt diode V155 (T152). Filament transformer for thyratron keyer tube V156 (T153).	173
F411	250	30	I 411	High-voltage power transformer T151	173
S501				Magnetron overtemperature control. Opens at 185° F. and must be reset manually.	103

216. Normal Readings of Transmitting System Panel Meters

The following tables list the meters that monitor important phases of operation of the transmitting system, reference a figure that shows the location of each meter, and give the function of each meter.

a. Radar Receiver-Transmitter RT–212/TPS–1D.

Meter	Location (fig. No.)	Function
T meter M501 (dc, no calibration, red line at midscale).	102	With TEST SELECTOR switch in MAG. FIL. position, indicates the magnetron filament voltage. The reading should be at the red line when the set is radiating and at 65 to 83 percent of full scale when the set is not radiating.
MAGNETRON CURRENT meter M502 (0– to 100-ma dc scale).	102	Indicates the average plate current of magnetron V502. The normal reading is between 40 and 44 ma but must never exceed 46 ma.

b. Power Supply PP–674/TPS–1D.

Meter	Location (fig. No.)	Function
VOLTMETER M401 (0 to 150 volts ac).	173	Indicates the ac voltage applied to the radar set at the power supply. The normal reading is between 110 and 120 volts.
OPERATING HOURS meter M402 (electric clock calibrated from 0 to 1,000 hours).	173	Indicates the cumulative radiation time in hours.
LINE FREQUENCY meter M403 (five vibrating reeds calibrated from 380 to 420 cycles).	173	Indicates the frequency of the primary power. The normal reading is between 384 and 416 cycles.

217. Normal Indications at Transmitting System Test Points

The following tables list the test points that are provided to test the operation of circuits in the transmitting system, reference a figure that shows the physical location of each test point, and give or reference the normal indication at each test point.

a. Test Points in Radar Modulator MD–144/TPS–1D.

Test point	Location (fig. No.)	Normal indication
TP101	113	Internal repetition rate multivibrator waveform (plate V101A, A, fig. 208).
TP102	113	Internal trigger for blocking oscillator keyer (grid V102A, F, fig. 208).
TP103	113	Output of blocking oscillator V102 (2–4 winding of T102, W, fig. 208).
TP104	113	Output of cathode follower V103 (primary of T103, X, fig. 208).
TP151	111	Z161 charging waveform (junction of R157, R158, and R159, BB, fig. 208).
TP152	111	Ground connection for test equipment.
J153	105	Modulator trigger (secondary of T103, waveform shown on modulator front panel).
J156	105	Sample of pulse output to transmitter (tap on voltage divider between pulse output jack J155 and ground, CC, fig. 208).

b. Test Points in Radar Receiver-Transmitter RT–212/TPS–1D.

Test point	Location (fig. No.)	Normal indication
J501	102	Connection to directional coupler.
J506	102	Indicator trigger from T1–T2 winding of T502, A (fig. 222).

218. Dc Resistance of Transmitting System Inductive Components

The following tables list the transformers, coils, and relays in the transmitting system, reference a figure that shows the location of each, and give the dc resistance of every winding.

a. Transformers, Coils, and Relays in Radar Modulator MD–144/TPS–1D.

Transformer coil or relay	Location (fig. No.)	Terminals	Dc resistance (ohms)
K151	110	1–7	500 ±10%.
		5–6	500 ±10%.
K152	106	X1–X2	110 ±10%.
L151	108		70.
L152	106		Less than 1.
T101	113	1–2	5.2 max.
		3–4	Less than 1.
		5–6	Less than 1.

Transformer coil or relay	Location (fig. No.)	Terminals	Dc resistance (ohms)
T102	113	1–6	8.4 max.
		2–4	19 max.
		3–5	19 max.
T103	113	Primary.	20 max.
		Secondary.	34 max.
T151	106	1–2	Less than 1.
		2–3	Less than 1.
		3–4	Less than 1.
		5–6	150 max.
		6–7	150 max.
T152	107	1–2	Less than 1.
		3–4	Less than 1.
		5–6	Less than 1.
T153	106	1–2	Less than 1.
		3–4	Less than 1.
T1101	106	1–6	3.
		4–5	3.
		2–3	12.
Z151 through Z159	109		Less than 1.
Z1101	106	1–4	1,500.

b. Transformers and Coils in Radar Receiver-Transmitter RT–212/TPS–1D.

Transformer or coil	Location (fig. No.)	Terminals	Resistance (ohms)
L502	104		Less than 1.
T502	103	P–H1 to P–LO	Less than 1.
		T1–T2	Less than 1.
		F1-Sec H1	Less than 1.
		F2-Sec H1C	Less than 1.
T504	104	1–2	1.2.
		2–3	Less than 1.
		3–4	Less than 1.
		4–5	Less than 1.
		5–6	Less than 1.
		7–8	Less than 1.
Z501 and Z502	103		Less than 1.
Z503, Z507, and Z508.	104		Less than 1.

Section II. TROUBLESHOOTING CHARTS

219. General

Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the transmitting system. If you are not sure the trouble is in the transmitting system, use the troubleshooting chart based on starting procedure (par. 210) to sectionalize the trouble to a system. Then if the trouble *is* in the transmitting system, the troubleshooting chart based on starting procedure will localize the trouble to either the modulator or the receiver-transmitter.

a. Symptom Troubleshooting (par. 222). 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 paragraph 222 consist of indications on MAGNETRON CURRENT meter M502, on meter M501 when TEST SELECTOR is set at MAG. FIL; and other visible or audible indications of malfunctioning. To troubleshoot the transmitting system, using the symptom troubleshooting chart, proceed as follows:

(1) Observe all indications related to transmitter malfunctioning.
(2) Compare the indications obtained with those listed in each of the symptoms.
(3) If the indications obtained correspond to those listed in a particular symptom, follow the procedure given in the *corrective measures* column to isolate the trouble.
(4) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleshooting chart.

b. Step-by-Step Troubleshooting Chart (par. 223). The transmitting system step-by-step troubleshooting chart consists of a series of steps designed to evaluate all phases of operation of the transmitting system. In general, use this chart if the trouble cannot be isolated by symptom troubleshooting (*a* above). To troubleshoot the transmitting system, using the step-by-step troubleshooting chart, proceed as follows:

(1) Locate the test point given in step 1.
(2) Connect the test equipment and set the controls on the test equipment as directed in the *test equipment* column.

(3) Set the controls on the radar set as directed in the *radar set controls* column.
(4) Compare the indications obtained on the test equipment with the indications that are 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 are abnormal, proceed as directed in the *corrective measures* column.

220. Test Equipment Required to Troubleshoot Transmitting System

Test equipment	Common name	Literature
Oscilloscope AN/USM–24C, or USM–50.	Oscilloscope	TM 11–5103 TM 11–5129
Electron Tube Test Set TV–7B/U.	Tube tester	TM 11–5083
Dummy Load TS–234/UP.	Dummy load	TM 11–1263
Dummy Antenna TS–235/UP.	Dummy antenna	TM 11–1093
Multimeter TS–352B/U, or ME–77/U.	Multimeter	TM 11–5527

221. Preparation of System Components for Troubleshooting

a. General. The modulator and receiver-transmitter are readily accessible for most troubleshooting procedures. The interconnecting cables are long enough to allow either unit to be withdrawn far enough to change all tubes including the magnetron. Each unit is equipped with safety catches that engage when the unit has been withdrawn about 16 inches. (See TM 11–1167–10 for details on the operation of the safety catches.) It will be necessary to completely remove either unit from its case to check some components.

b. Modulator. To make the modulator accessible for troubleshooting:
(1) Loosen eight knurled and slotted-head captive screws and slide modulator out until safety catches engage.
(2) Disable the interlock.
(3) If it is necessary to remove the modulator from its case, turn off the power, disconnect the cables, remove the modulator from its case, and reconnect the cables.

c. Receiver-Transmitter. To make the receiver-transmitter accessible for troubleshooting:
(1) Loosen eight knurled and slotted-head captive screws and slide the receiver-transmitter out until the safety catches engage.
(2) Disable the interlock.
(3) If it is necessary to remove the receiver-transmitter from its case, turn off the power, disconnect the cables, remove the receiver-transmitter from its case, and reconnect the cables.

222. Transmitting System Symptom Troubleshooting Chart

Warning: Extremely dangerous voltages exist in the transmitting circuits of the receiver-transmitter and the high-voltage power supply and keyer circuits in the modulator.

a. Receiver-Transmitter. Before making voltage measurements in the receiver-transmitter, make sure that the set is not radiating, and then disconnect P505 from PULSE INPUT jack J505 on the front panel of the receiver-transmitter.

b. Modulator. Do not make voltage measurements in the high-voltage circuits of the modulator. Before making resistance measurements in the modulator, ground L152 and the junction of the plate cap leads to V153 and V154 with a shorting bar.

Symptom	Probable cause	Corrective measures
1. Abnormal reading on M501 (fig. 102) when TEST SELECTOR switch S506 is in the MAG FIL position and radar set is not radiating.		***Warning:*** Observe the precautions in the first warning notice at the beginning of this troubleshooting chart.

Symptom	Probable cause	Corrective measures
a. Meter reading is zero	Magnetron filament open; defective filament power supply or metering circuit.	Measure the voltage between P516A and P516B on the magnetron filament connector (figure 212). The normal reading is 26.5 volts dc with P516A negative. 1. If the reading is high, remove P516 and check the magnetron filament. If it is open, replace the magnetron. 2. If the reading is normal, check R514, S506, C511, M501, and associated wiring. 3. If the reading is zero, measure the voltage between terminals 7 and 8 on T504. The normal reading is 36 to 44 volts ac. *a.* If the ac voltage is normal, check C508, L502, CR501 and T502. *b.* If the reading is zero, check T504.
b. Meter reading is too high	Defective magnetron filament circuit, power supply or metering circuit.	Measure the voltage between P516A and P516B on the magnetron filament connector. The normal reading is 26.5 volts dc with P516A negative. 1. If the reading is normal, check C524 and R514. 2. If the reading is too low, check C504, C505, C507A, and T502.
c. Meter reading is too low	Contacts of holding relay K405 not shorting out R516, C508, or CR501, or metering circuit defective.	Measure the voltage between P516A and P516B on the magnetron filament connector. The normal reading is 26.5 volts dc with P516A negative. 1. If the reading is normal, check S506, R514, C511, and M501. 2. If the reading is low, check contacts of K405; also check C508 and CR501.
2. Abnormal reading on MAGNETRON CURRENT meter M502 (fig. 102). ***Caution:*** If the reading on M502 is greater than 46 ma, do not allow set to radiate until the trouble has been remedied.		
a. M502 reading is abnormal with TRIGGER switch S152 in INTERNAL but is normal with S152 in EXTERNAL.	Internal repetition rate multivibrator V101 or TRIGGER switch S152.	Check repetition rate. With REP RATE CONTROL completely clockwise, it should be 400. If it is incorrect, adjust R110. If it is impossible to adjust repetition rate to 400 pps, using R110, replace V101 and then troubleshoot the stage using voltage and resistence measurements (fig. 209). Check S152.
b. M502 reading is abnormal with S152 in EXTERNAL but is normal in INTERNAL.	Trigger cable W3, TRIGGER switch S152, or trigger channel in signal comparing system.	Check the trigger cable and S152, and if normal, refer to paragraph 210, step 12, abnormal indications, MAGNETRON CURRENT meter M501 reads too high or too low.
c. M502 reading is zero in either position of S152. No sweep on ppi or A-scope. OPERATING HOURS meter M402 is running.	High-voltage power supply, keyer circuits, pulse delay network, or trigger chassis circuits.	1. Observe tubes V151 through V156. Filaments should be lighted. *a.* If all the filaments are lighted, proceed to 2 below. *b.* If any tube is not lighted, replace it. *c.* If V151, V152, V153, V154, and V155 are not lighted, check T152. *d.* If V156 is not lighted, check T153 and R153 and R128. 2. Check the waveform at J153 (AA, fig. 208). *a.* If the waveform is normal, check voltage at TP151. The reading should be between 60 and 70 vdc.

Symptom	Probable cause	Corrective measures
		(1) If the reading is normal, check keyer tube V156 and L152. Next disconnect the lead between terminals B43A on E101 and B43A on E152 at E101 and measure the resistance from lead to ground. It should be 3,300 ohms. (2) If the reading is abnormal, replace V151 and V152 and then V153 and V154. If still abnormal make resistance measurements at tube sockets (fig. 209). *b.* If the waveform is abnormal, check V101, V102, V1101, V1102, and V103, and if they are normal, refer to step-by-step troubleshooting chart (par. 223, steps 1 through 11).
d. M502 reading is low with TRIGGER switch S152 in either INTERNAL or EXTERNAL but power output is normal.	Meter circuit	Check C506, C507B, C510 and M502.
e. M502 reading is low with TRIGGER switch S152 in either INTERNAL or EXTERNAL and power output is less than normal.	V151, V152, V153, V154, V156, or V502. Leakage from high voltage to ground due to dust, dirt, and humidity. Tap on T151.	1. Set TRIGGER switch S152 to EXTERNAL, disconnect EXT. TRIGGER INPUT cable at J152 and press RADIATE ON switch. Measure the voltage between TP151 and TP152. The reading should be between 60 and 70 volts dc, with TP151 positive. *a.* If the reading is normal, replace V153, V154, V155, and then V502. *b.* If the reading is low, replace V151 and V152. If the reading does not increase, check all high-voltage insulators and tube sockets. All high voltage parts must be thoroughly clean and dry. 2. If 1*a* or *b* above does not increase the M502 reading to normal, adjust the tap on T151 (par. 230).
f. M502 reading is too high with TRIGGER switch S152 in either INTERNAL or EXTERNAL.	Leakage from the high-voltage terminals of T502 to ground. Magnet reduced in strength.	Clean and dry high-voltage insulators on T502. Check the magnet and replace if necessary. The magnet is rated at 1,400 ±50 gausses but should be usable to down to 1,200 gausses.
3. The transmitter will not radiate when RADIATE ON is pressed. Relays can be heard clicking in the modulator and the power supply while RADIATE ON is pressed.	Defective V155, Z161, K151, pulse cable pulse transformer, magnetron, or RF system. R168 misadjusted.	***Caution:*** Do not adjust R168 to correct this condition unless adjustment is known to have been tampered with because damage to equipment may result. See paragraph 229 for adjustment of R168. *a.* Replace V155 with a new tube or with one known to be good. If the condition is not corrected, disconnect cable from RF OUTPUT jack J502. Connect the dummy antenna to J502. (Three coax adapters are packed in Case CY–1297/TPS–1D, the outer conductor adapter and the short inner conductor adapter are used with the dummy antenna.) Press RADIATE ON. (1) If the radar set operates normally, refer to troubleshooting RF System (par. 252, symptom 2). (2) If the same symptom is present disconnect the dummy antenna, connect the antenna, and proceed to *b* below. *b.* Disconnect the pulse cable at J155 on the modulator. Connect the dummy load and press RADIATE ON. (1) If set operates normally check the pulse cable, pulse transformer, magnetron and RF parts in the receiver-transmitter.

Symptom	Probable cause	Corrective measures
		(2) If the same symptom is present check Z161, K151, R152 to R156, R168, C156, and C157.
4. The transmitter operates normally for an unpredictable period of time; then it kicks off. If RADIATE ON is pressed, it comes on again.	Same as symptom 3 above	Same as symptom 3 above.
5. The transmitter operates normally for an unpredictable period of time; then it kicks off. If RADIATE ON is pressed, nothing happens.	Magnetron overtemperature control S501 operating to kick set off. It may be caused by the magnetron overheating or a defective switch S501.	Rest S501 (fig. 103) and press RADIATE ON. If the radar set operates normally for a period of time but then kicks off again: *a.* Check for proper operation of blower motor B501. *b.* Clean and/or replace the filter element. *c.* Check and/or replace S501. (should open at 185° ±7° F.)

223. Transmitting System Step-by-step Troubleshooting Chart

Step	Test point	Test equipment	Radar set controls	Normal indication	Corrective measures
1	Terminal 4A1 of E102 (fig. 103).	Set multimeter controls to measure +300 volts dc.	Set POWER switch S602 to ON.	+300 volts dc to ground.	Troubleshoot 300-volt power supply in power supply system (par. 420, step 5).
2	TP101 (fig. 103).	Oscilloscope	Set TRIGGER switch S152 to INTERNAL.	Waveform (B, fig. 208).	Check V101; make voltage and resistance measurements at the tube socket (fig. 209).
3	TP102 (fig. 103)	Oscilloscope		Waveform (F, fig. 208).	Check C104 and R111.
4	Pin 3, XV102 (fig. 102).	Oscilloscope	Set TRIGGER switch S152 to EXTERNAL.	Waveform (G, fig. 208).	Check S152; troubleshoot signal comparing system (par. 325, step 7).
5	E1101–1 (fig. 106).	Oscilloscope		Waveform (I and J, fig. 208).	Check V102 and V1101; make voltage and resistance measurements at tube sockets (fig.209).
6	IFF PRETRIGGER jack J157.	Oscilloscope		Waveform (K, fig. 208).	Check C1101 and R1103.
7	XV1101–Pin 2	Oscilloscope		Waveform (R, fig. 208).	Check V1102, C1103, C1104; make voltage and resistance measurements at the tube socket (fig. 209).
8	E153–3	Oscilloscope		Waveform (S and T, fig. 208).	Check V102 and V1101; make voltage and resistance measurements at the tube sockets (fig. 209).
9	TP103	Oscilloscope		Waveform (W, fig. 208).	Check T102.
10	TP104	Oscilloscope		Waveform (X, fig. 208).	Check V103 and C107; make voltage and resistance measurements at the tube socket (fig. 209).
11	J153	Oscilloscope		Waveform (Z and AA, fig. 208).	Check T103.
12	Terminals A1 and B1 of K152.	Connect multimeter to read 115 volts ac.		115 volts ac	Check Z151 and Z152 and if normal, refer to troubleshooting based on starting procedure (par. 210).

Step	Test point	Test equipment	Radar set controls	Normal indication	Corrective measures
13	Terminals A2 and B2 of K152.	Set multimeter controls to measure 115 volts ac.	Connect Dummy Load TS–234/UP to J155. Disable interlocks. ***Warning:*** Observe the precautions in the first warning notice at the beginning of this chapter. Press RADIATE ON.	115 volts ac	*a.* If voltage is present only while RADIATE ON is pressed, check K405. *b.* If no voltage is present, check K152; then troubleshoot the +27-volt dc power distribution (par. 211). *c.* If relay chatters while RADIATE ON is pressed or if meter drops back to zero shortly after RADIATE ON is released check V155, K151, R152 through R156, C156, C157, and Z161.
14	TP151 and TP152	Set multimeter controls to measure 60–70 volts dc.		60–70 volts dc	Check V151 through V154. Make resistance measurements at the tube sockets (fig. 209).
15	J156	Oscilloscope		Waveform (CC and DD, fig. 208).	Replace V155. Make resistance measurements at the tube socket.
16	MAGNETRON CURRENT Meter M502.		Connect receiver-transmitter to modulator. Connect Dummy Antenna TS–235/UP to J502. Press RADIATE ON.	M502 should read between 40 and 44 ma.	Check pulse cable, pulse transformer T502, and magnetron V502.
17	MAGNETRON CURRENT Meter M502.		Connect antenna to J502. Press RADIATE ON.	M502 should read between 40 and 44 ma.	Troubleshoot RF system, (par. 252, symptom 3).
18	Terminals 402 and 803 on E503.	Set multimeter control to read 115 volts ac.	POWER switch S602 to ON.	115 volts ac	Refer to paragraph 210.
19	Terminals 7 and 8 on transformer T504.	Set multimeter controls to read 36 to 44 volts ac.		36 to 44 volts ac	Check T504.
20	P516A and P516B	Set multimeter controls to read 26.5 volts dc.		26.5 volts dc	If reading is higher than normal, check magnetron filament. If reading is lower than normal check CR501, L502, C504, C505, C507A, C508 and T502.

Section III. REMOVAL AND REPLACEMENT OF PARTS

224. General

The transmitting system consists of all the parts in Radar Modulator MD–144/TPS–1D and the parts located in Radar Receiver-Transmitter RT–212/TPS–1D actually used in transmitting.

Warning: Extremely dangerous voltages exist in the modulator and receiver-transmitter. When removing and replacing parts in either of these components, heed the high-voltage warnings.

Radar Modulator MD–144/TPS–1D. The removal and replacement of all the tubes in the modulator and the magnetron in the receiver-transmitter are covered in TM 1167–20. Removal and replacement of all other parts, except filter networks Z151 through Z159 which are covered in paragraph 225, are covered in *a* and *b* below.

a. Trigger Chassis. The trigger chassis is located on the bottom shelf of the modulator chassis. To replace parts in the chassis, loosen the four hexagonal-head screws that secure it to the modulator and remove it through the right side of the modulator.

b. IFF Pretrigger Chassis. To replace parts in the pretrigger chassis, remove four bolts that secure the chassis to the modulator front panel, disconnect the cable, and remove chassis.

225. Removal and Replacement of Filter Networks Z151 Through Z159 (fig. 110)

a. Removal of Z151 Through Z159.

(1) Remove the modulator chassis (par. 221) and place it on work bench with the front panel up.
(2) Loosen four slotted hexagonal head screws that secure the trigger chassis (fig. 108).
(3) Remove the trigger chassis.
(4) Remove the screws that secure the front panel to the chassis.

Caution: Do not lift the front panel far enough to place the strain on the wiring between the front panel and the chassis.

(5) Lift the top end of the front panel far enough to expose blower motor assembly B151 (fig. 106).
(6) Disconnect the wires on terminals 202 and 303 of terminal strip E151 on the blower motor assembly.
(7) Prop the front panel up far enough to accomplish the procedure in (8) through (13) below.
(8) Remove the three screws that secure the filter cover (fig. 109).
(9) Remove the filter cover.
(10) Remove the four screws that secure the filter shield to the front panel.
(11) Remove the four screws that secure the filter assembly subchassis to the filter shield.
(12) Remove the two bolts that secure the defective filter to the subchassis.
(13) Tag the leads and remove them from the filter.

b. Replacement of Z151–159.

(1) Secure the leads to the replacement filter and remove the tags.
(2) Replace the filter and the mounting bolts.
(3) Replace the filter assembly subchassis and the mounting bolts.
(4) Replace the filter shield and the mounting bolts.
(5) Replace the filter cover and the mounting bolts.
(6) Connect the wires to terminals S202 and 303 on E151.
(7) Put the front panel in place and replace the bolts.
(8) Replace the trigger chassis and secure it.
(9) Replace the modulator chassis, and secure it and connect the cables.

Section IV. ADJUSTMENTS

226. General

a. This section covers all the adjustments in the transmitting system. These adjustments are in the modulator and receiver-transmitter. The procedure for making the magnetron filament voltage adjustment and the pulse repetition rate adjustment is the same whether the components are on the bench or interconnected with the other components of the radar set. The high-voltage power supply adjustment and the protective relay balance adjustment can be properly made only when the components are interconnected.

b. The following transmitting system adjustments are in Radar Modulator MD–144/TPS–1D.

(1) Coarse frequency (repetition rate) adjustment R110 (par. 228).
(2) Protective relay balance adjustment R168 (par. 229).
(3) Modulator high-voltage adjustment T151 (par. 230).

c. The following transmitting system adjustments are in Radar Receiver-Transmitter RT–212/TPS–1D.

(1) Magnetron filament voltage adjustment (par. 231).
(2) Magnetron frequency adjustment (par. 232).

d. Before making any of the adjustments in paragraphs 228 through 232, check for correct ac input (115 volts, 400 cycles) and +300 volts input.

227. Test Equipment Required

The following items of test equipment are required to completely aline the transmitting system.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Test Set TS–172A/UP	Echo box	11–1262

228. Coarse Frequency Adjustment R110 (fig. 112)

a. General. The coarse frequency adjustment (R110) is connected in series with REP. RATE CONTROL R167 which adjusts the pulse repetition frequency of the radar set when TRIGGER selector switch S152 is in the INTERNAL position. Coarse frequency adjustment R110 is adjusted so that the maximum repetition rate obtainable (R167 fully clockwise) is 400 pps.

b. Procedure. To adjust R110, proceed as follows:

(1) Set TRIGGER selector switch S152 to INTERNAL.
(2) Withdraw the modulator from its case until the stops engage.
(3) Rotate REP. RATE CONTROL R167 fully clockwise.
(4) Connect the oscilloscope vertical input to J153.
(5) Adjust oscilloscope controls to display two trigger pulses (Z, fig. 208).
(6) Unlock R110 and adjust it so that the pulses are 2,500 microseconds apart.
(7) Disconnect the oscilloscope leads and replace the modulator.
(8) Lock R110.

229. Protective Relay Balance Adjustment R168

a. General. Protective relay balance adjustment R168 is connected so that its resistance can be divided between the ground return of coil A and coil B of K151. R168 is correctly adjusted when coil A and coil B have equal currents flowing through them.

Caution: If the transmitter cannot be kept on the air because of the operation of protective relay K151, do not readjust R168 to correct the condition because damage to the equipment may result. Readjust R168 for the following reasons only:

(1) To compensate for changes in circuit characteristics in the protective circuit.
(2) To reset the adjustment because the control was inadvertently turned.
(3) In an emergency, to maintain operation.

b. Procedure. To adjust R168, proceed as follows:

(1) Withdraw the modulator from its case until the stops engage and disable the interlock.

Warning: High voltages are exposed when the modulator is withdrawn and the interlock is disabled.

(2) Observe the reading on MAGNETRON CURRENT meter M502 (fig. 102). The reading should be between 40 and 44 ma.
(3) Check the voltage between terminals 1 and 5 (+) and between 6 (+) and 7 on the K151 terminal board adjacent to R168.
(4) Unlock and adjust R168 so that these voltages are equal. The voltage should be between 3 and 5 volts.

230. Modulator High-Voltage Adjustment (T151)

a. General. The taps on the primary of T151 permit adjustment of the modulator high voltage. Need for adjustment is determined by the magnetron current. The magnetron current for 115-volt, 400-cycle input should be between 40 and 44 ma. For 115-volt, 400-cycle input, the taps affect the secondary voltage as follows:

Primary taps	Total secondary voltage
1–4	9,100
2–4	9,600
1–3	9,900
2–3	10,500

b. Procedure. To make the adjustment, proceed as follows:

(1) Turn on the equipment and allow at least 15 minutes warm up. (Transmitter current must not exceed 46 ma.)

(2) Adjust the line voltage to 115 volts, 400 cycles.

(3) Observe the reading on MAGNETRON CURRENT meter M502 and determine whether an increase or decrease is required.

(4) Shut down the equipment and adjust the primary taps as required. (See tap position in *a* above.)

Warning: Observe high-voltage warnings. Ground L152 and the plate cap of V153 or V154 with a shorting bar before making adjustment.

231. Magnetron Filament Voltage Adjustment (T504)

a. General. The taps on the primary of T504 permit adjustment of the magnetron filament voltage. The adjustment is made by selecting primary taps that will provide the proper filament voltage when 115-volt, 400-cycle power is applied and the set is not radiating. Proper voltage under these conditions is 26.5 ±1.4 volts. The test meter, with TEST SELECTOR switch S506 in MAG. FIL. position, should read between 65 and 83 percent of full scale with the set not radiating. For 115-volt, 400-cycle input, the taps affect the secondary voltage as follows:

Primary taps	Secondary voltage
1–6	36
2–6	38
3–6	40
4–6	42
5–6	44

b. Procedure. To make the adjustment, proceed as follows:

(1) Turn on the equipment and adjust the line voltage to 115 volts, 400 cycles.

(2) Withdraw the receiver-transmitter from its case and measure the voltage between P516A and P516B(+).

Warning: Do not defeat the interlock or allow the set to radiate. If the set is radiating, extremely dangerous voltage is present at P516.

(3) Shut down the equipment and adjust the taps as required. (See tap positions in *a* above)

232. Transmitter Frequency Adjustment (fig. 102)

a. General. The MAGNETRON TUNING control is mechanically coupled to a diaphragm, the position of which affects the electric field in the magnetron cavities. Tuning is accomplished by changing the position of the diaphragm. The approximate frequency can be determined by interpolation of the tuning dial calibration (par. 8*a*(3), TM 11–1167–10). A more accurate check can be made by using the echo box.

b. Procedure. To adjust the magnetron frequency by using the echo box, proceed as follows:

(1) Turn the radar set on. With the set radiating, allow at least 15 minutes for the set to warm up.

(2) Connect the echo box to RF TEST jack J501 (fig. 102).

(3) Tune the echo box to the desired frequency (TM 11–1262).

(4) Adjust the MAGNETRON TUNING control to give maximum deflection on the echo box meter.

Section V. FIELD TESTING

233. General

This section describes testing procedures required to check the serviceability of a repaired transmitting system when the components of the radar set are interconnected. Bench testing of Radar Modulator MD–144/TPS–1D is described in paragraph 243. Radar Receiver-Transmitter RT–212/TPS–1D can be tested only with the complete radar set. Testing procedures designed to check the serviceability of the complete radar set are covered in paragraph 448.

234. Test Equipment Required

The following items of test equipment are required to completely test the serviceability of the transmitting system.

Test equipment	Common name	Technical manual
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Dummy Load TS–234/UP	Dummy load	11–1263
Dummy Antenna TS–235/UP.	Dummy antenna	11–1093
Test Set TS–172A/UP	Echo box	11–1262
Summation Bridge AN/URM–23.	Summation bridge	11–5128

235. Transmitter Average Power Output Measurement

The average power output is an indication of peak power, provided the repetition rate is correct and the magnetron spectrum is satisfactory.

a. General. The average power output of the transmitter is measured as follows:

(1) A portion of the transmitter output is coupled out of J501 through the direction coupler.
(2) A measurement is made of the amount of power at J501.
(3) The amount of power at J501 is multiplied by a factor which is determined by consulting the power multiplication curve on the directional coupler output characteristic chart (fig. 17, TM 11–1167–20).
(4) The average power should be a minimum of 460 watts.

b. Procedure. The following procedure uses the summation bridge to measure the average power of the radar set.

(1) Connect the summation bridge input to RF TEST jack J501 using 20-db attenuator. See TM 11–5128.
(2) Energize the summation bridge and the radar set. Check the line voltage and the frequency. It should be 115 volts, and 400 cycles.
(3) Set the TRIGGER selector switch to EXTERNAL.
(4) After the time delay has completed its cycle, press the RADIATE ON button. Check the magnetron current. It should be between 40 and 44 ma.
(5) Follow instructions in TM 11–5128 to determine the amount of power at J501.
(6) Using the power multiplication curve in figure 17, TM 11–1167–20, determine the factor that the power at J501 must be multiplied by.
(7) Multiply the amount of power ((5) above) by the factor ((6) above) to determine the average power of the radar set. The minimum average power output is 460 watts.

236. Magnetron Spectrum Analysis

A spectrum analysis is used to determine that most of the energy in a radar pulse is within the band pass of the receiver. It can also be used to check the width of the pulse being applied to the magnetron.

a. General. A spectrum analysis is made as follows:

(1) A sample of the output of the transmitter is coupled to the echo box.
(2) The echo box is tuned through the range of frequencies giving a deflection on the meter.
(3) The meter readings and the dial calibrations at which they occur are used to plot the spectrum.

b. Procedure. To make a spectrum analysis with the echo box, proceed as follows:

(1) Connect the echo box to RF TEST Jack J501; use cable W–103 supplied with the echo box.
(2) Energize the transmitter and check for normal transmitter current (40–44 ma).
(3) Using instructions supplied with the echo box, plot the magnetron spectrum, determine whether the spectrum is acceptable and the pulse width is within limits. The pulse width should be between 1.95 and 2.35 sec.

Section VI. BENCH SERVICING RADAR MODULATOR MD–144/TPS–1D

237. General

This section covers bench servicing of the modulator. The following information will be helpful when bench servicing the modulator.

Information	Location
Radar Modulator MD–144/TPS–1D, complete schematic diagram.	Fig. 210
Location of parts in modulator	Par. 213 and figs. 105 through 114.
Modulator waveforms	Fig. 208
Modulator voltage and resistance diagram.	Fig. 209
Controls and adjustments	Par. 214*c*
Normal indications at test points	Par. 217*a*
Resistance of inductive components	Par. 218*a*
Removal and replacement of parts	Par. 224

238. Test Equipment Required

The following items of test equipment and cables are required to bench service Radar Modulator MD–144/TPS–1D. The cables are supplied with Test Set AN/MPM–23.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083
Dummy Load TS–234/UP.	Dummy load	11–1263
Power Supply PP–674/TPS–1D.	Power supply	This manual, chapter 8.
Motor Generator PU–20B/C.	Motor generator	11–978
Electrical Power Cable Assembly CX–2002/U.	None	11–1250
Electrical Power Cable Assembly CX–1997/U.	None	11–1250

239. Bench Servicing Connections

Follow the directions in *a* through *d* below to connect Radar Modulator MD–144/TPS–1D for bench servicing.

a. Disconnect the cables from the front panel of the modulator.

b. Release the eight captive screws on the front panel of the modulator, remove the unit from its case, and disable the interlock (par. 207*b*).

c. Make all the connections shown in figure 115. If a power supply off-on switch is desired, replace the jumper between terminals 1603 and 1703 on terminal board E401 with a single-pole, single-throw switch. The cables necessary to make the connections are supplied with Test Set AN/MPM–23.

d. When the modulator is connected as shown in figure 115, the results are as follows:

(1) The equipment is energized when the generator is running.

(2) The switch connected to terminal board E404 functions as a radiate on-off switch.

(3) The protective relay (K151) and the radiate relay (K152) will chatter in the event of an overload. If chattering occurs, the radiate on-off switch should be thrown to off until the cause of the overload is determined.

(4) The complete modulator, except the external trigger input circuit, can be checked with TRIGGER switch S152 in the INTERNAL position. The external trigger input circuit should be checked with an ohmmeter.

240. Bench Troubleshooting Radar Modulator MD–144/TPS–1D

a. Connect the modulator for bench servicing (par. 239).

b. Follow the step-by-step troubleshooting chart, steps 1 through 15 with the following changes:

(1) In step 1, power is applied to the equipment by starting the motor generator.

(2) In step 13, the RADIATE ON switch is replaced by a single-pole, single-throw switch. Eliminate corrective measures (*a*) and (*b*).

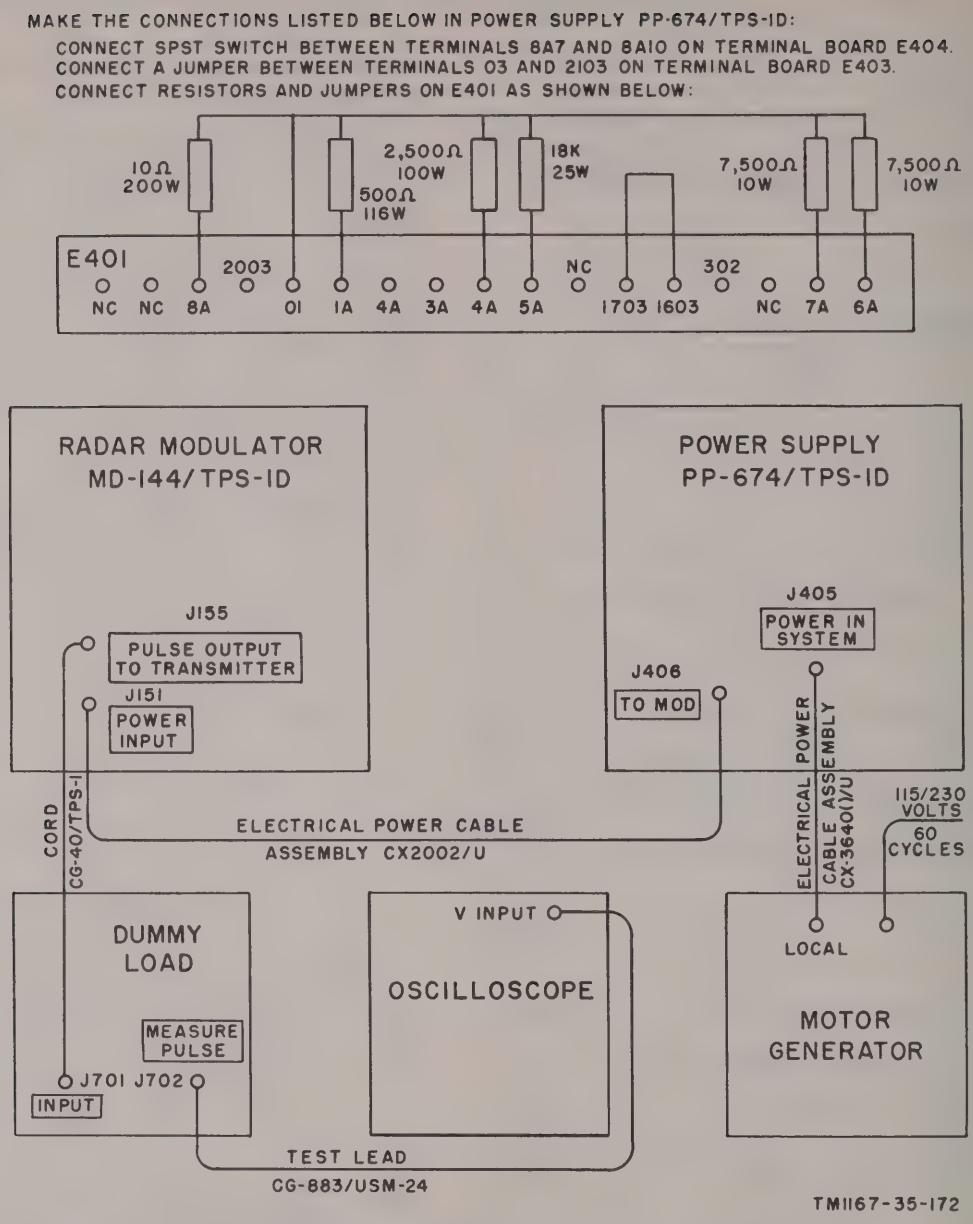


Figure 115. Radar Modulator MD–144/TPS–1D, bench servicing connections.

241. Bench Adjustment of Radar Modulator MD–144/TPS–1D

All the adjustments in the modulator can be made when the unit is connected for bench servicing (par. 239). The coarse frequency (repetition rate) control will be a final adjustment. The protective relay balance and the high-voltage adjustments should be checked after the modulator is interconnected as a complete radar set.

Adjustment	Procedure (par.)
Coarse frequency (repetition rate) adjustment R110.	228
Protective relay balance adjustment R168	229
Modulator high-voltage adjustment T151	242

242. Modulator High-Voltage Adjustment T151

The modulator high-voltage adjustment is made by selecting the taps on the primary of T151 that usually give the correct value of magnetron current when the modulator is interconnected as a complete radar set (par. 230).

243. Bench Testing Radar Modulator MD–144/TPS–1D

A check of the width and amplitude of the output pulse at the proper repetition rate is a test of the serviceability of a modulator.

a. General. The serviceability of a modulator is checked as follows:

(1) The output of the modulator is connected to a dummy load having a voltage divider provided for viewing the pulse.

(2) The attenuated pulse is presented on an oscilloscope and the time between pulses and the width and amplitude of the pulse is checked.

b. Procedure. The following procedure for testing the serviceability of a modulator makes use of the dummy load and the oscilloscope.

(1) Connect the modulator for bench servicing (par. 239).

(2) Set the TRIGGER switch to INTERNAL and the REP. RATE CONTROL completely clockwise.

(3) Energize the equipment by starting the motor generator. After 5 minutes, press the RADIATE ON switch.

(4) Adjust the oscilloscope controls to display two pulses and measure the time between pulses. It should be 2,500 microseconds.

(5) Adjust the oscilloscope controls to display one expanded pulse. Measure the pulse amplitude and width. The amplitude must be between −4,300 and −5,000 volts. The width must be between 1.95 and 2.35 microseconds measured at a level 70 percent below the zero voltage level.

Note. The actual oscilloscope waveform amplitude measured is between −43 and −50 volts because the dummy load contains a 100−1 voltage attenuator. An additional attenuation may take place if the oscilloscope probe also attenuates the waveform.

CHAPTER 13

RF SYSTEM TROUBLESHOOTING AND REPAIR

Warning: Extremely high voltages exist in the receiver-transmitter and antenna base. When servicing the RF system, observe the following precautions:

1. Do not operate the transmitter with any of the coaxial transmission line sections disconnected.

2. Turn off power and discharge capacitors C501 and C502 with a shorting bar before making resistance measurements in the keep-alive power supply.

Section I. TROUBLESHOOTING INFORMATION

244. Reference Data

The following information will be helpful when troubleshooting or repairing the RF system.

Reference	Data
Fig. 15	Rf system, functional block diagram.
Pars. 39 through 51	Rf system, theory.
Figs. 16 through 23	Rf system, simplified schematic diagrams.
Fig. 212	Radar receiver-transmitter RT–212/TPS–1D, complete schematic diagram.
Fig. 188	Antenna drive unit assembly, exploded view.
Fig. 211	Radar receiver-transmitter RT–212/TPS–1D, tube socket voltage and resistance diagram.
Figs. 116 through 121	Location of parts in the RF system.
Fig. 17, TM 11–1167–10.	RF coaxial fittings and cables.
Fig. 30. TM 11–1167–10.	Antenna spindle.
Fig. 31, TM 11–1167–10.	Antenna base lower RF lines (right side).
Fig. 68, TM 11–1167–10.	Iff antenna.
Fig. 69, TM 11–1167–10.	Iff antenna radiator arrangement.
Par. 80*d*, *e*, TM 11–1167–10.	Iff antenna feed system.
Par. 33*b*, *c*, TM 11–1167–10.	RF line sections.

245. RF System Adjustments

The adjustments that are functional parts of the RF system are listed in the following chart.

Adjustments	Location (fig.)	Function
Tr tuning, V503	120	Tunes tr cavity A 516 for maximum signal.
Tr tuning, V504	120	Tunes tr cavity A 517 for maximum signal.
Duplexer RF503	117	Position adjusted for maximum signal.
Adjusting screw, front end of RF751.	116	Positions the center conductor through the spindle in the antenna base.
Adjustment clamp, RF851.	116	Positions the center conductor through the spindle in the antenna base.

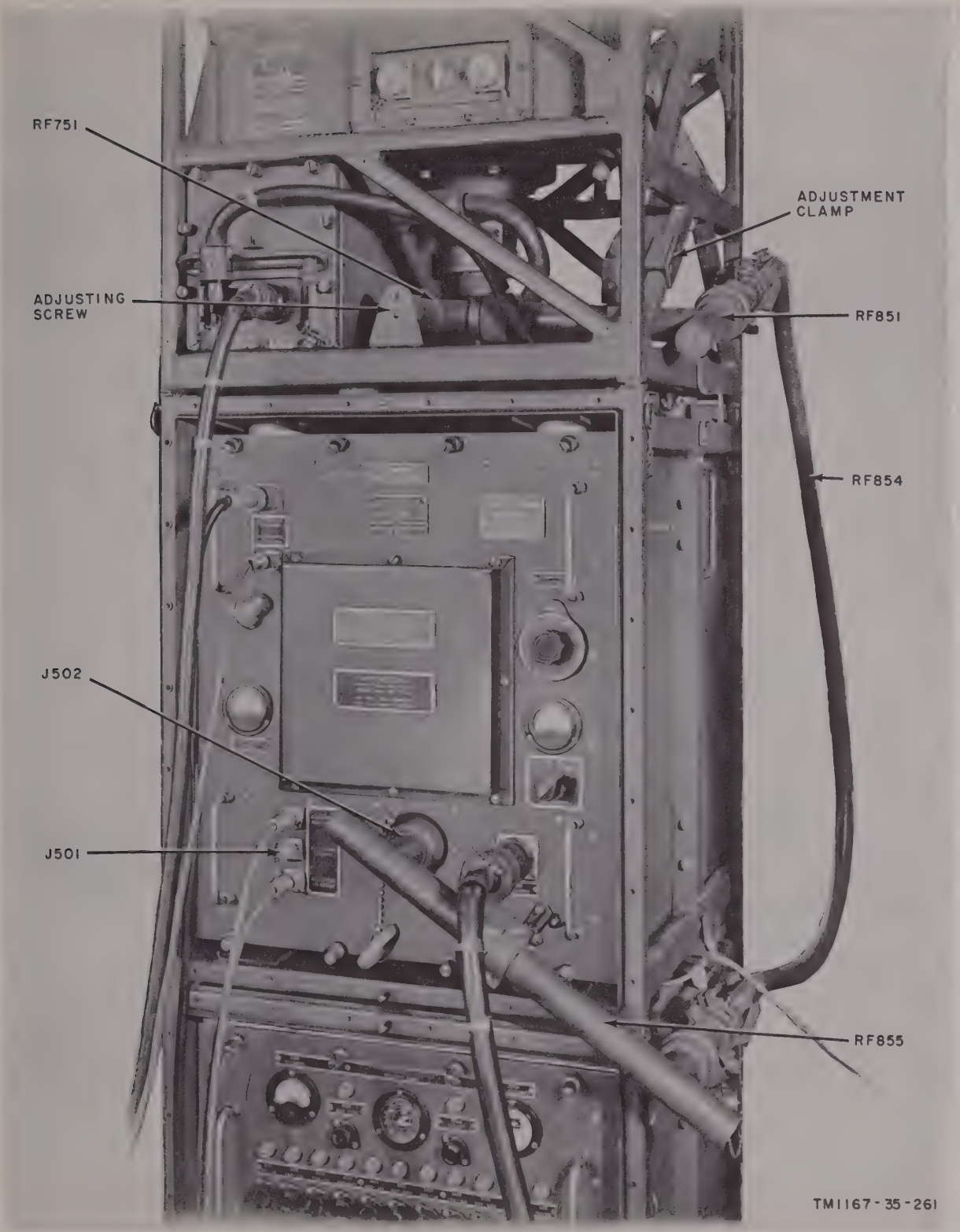


Figure 116. Radar Receiver-Transmitter RT–212/TPS/1D, front panel view.

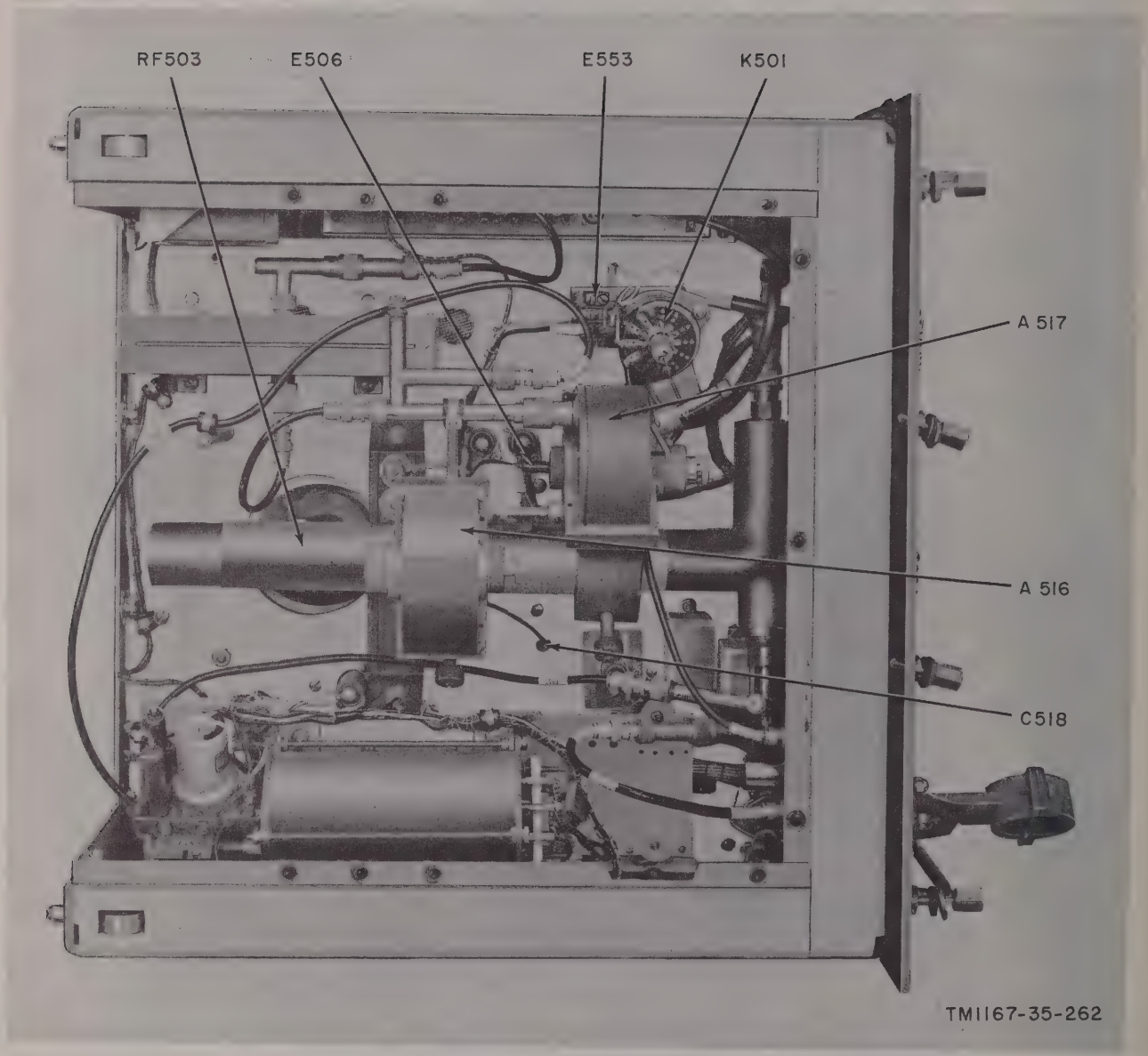


Figure 117. Radar Receiver-Transmitter RT–212/TPS–1D, bottom view.

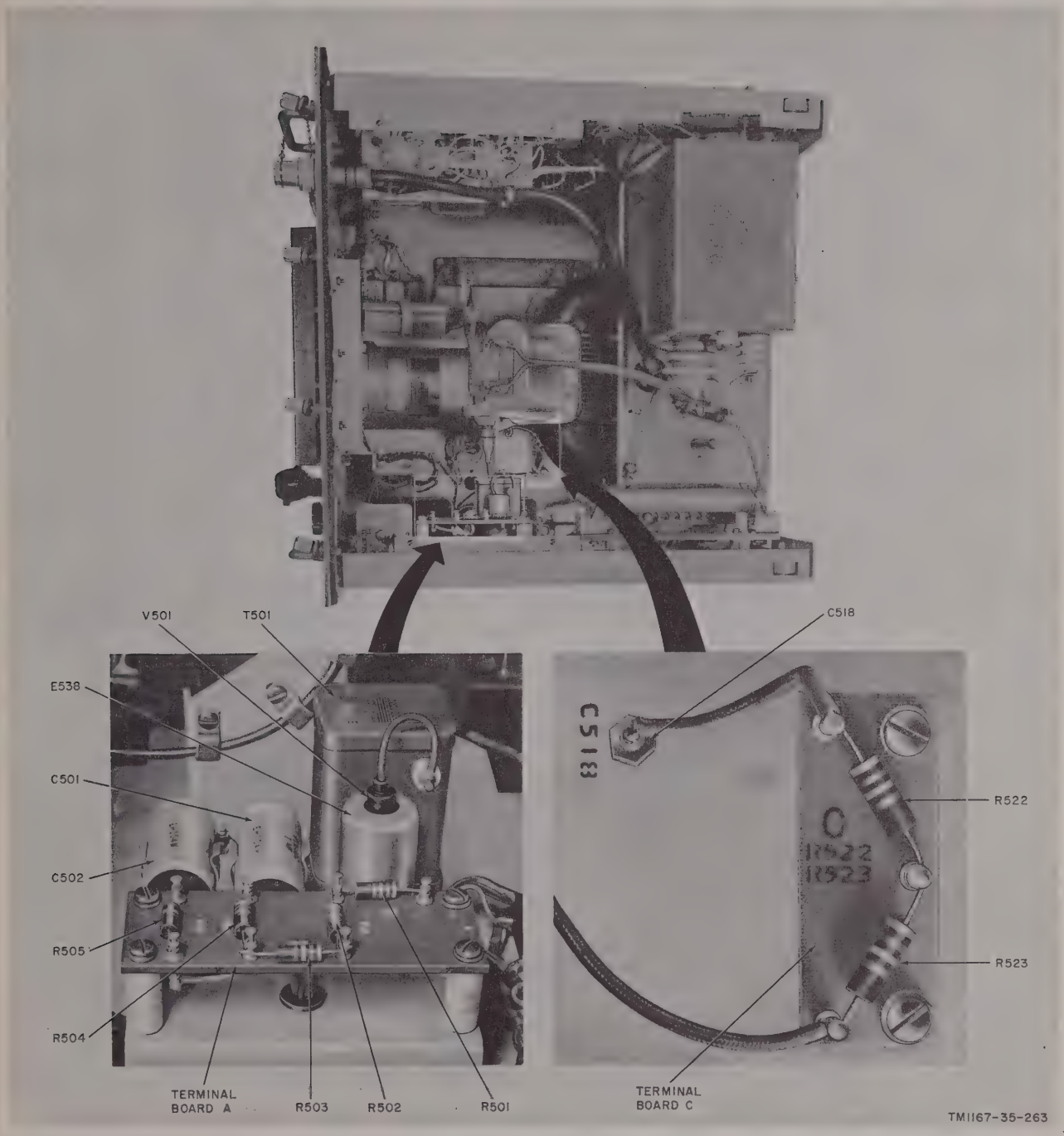


Figure 118. Radar Receiver-Transmitter RT–212/TPS–1D, keep-alive power supply subassembly.

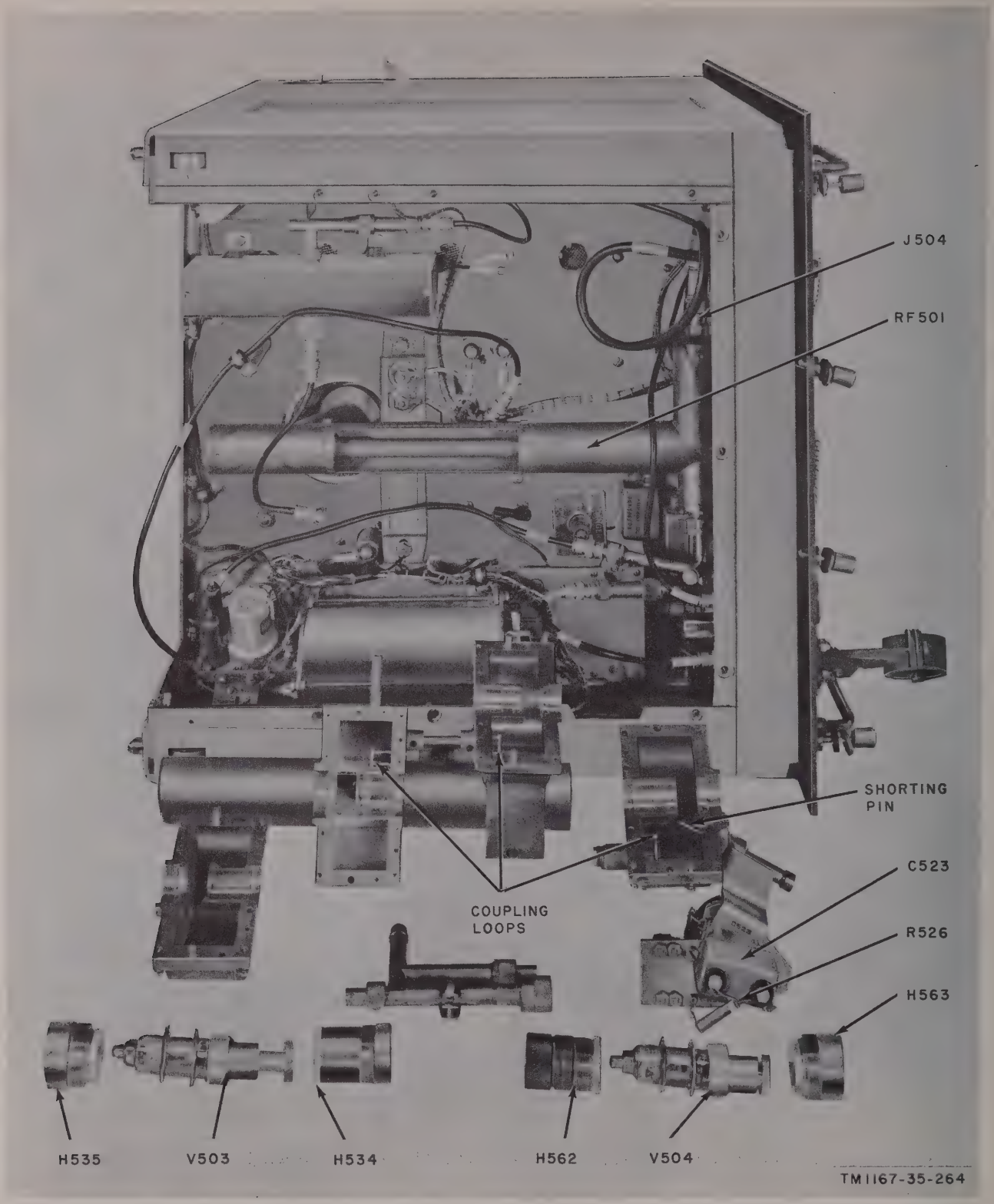


Figure 119. Radar Receiver-Transmitter RT–212/TPS–1D, duplexer assembly RF503, disassembled view.

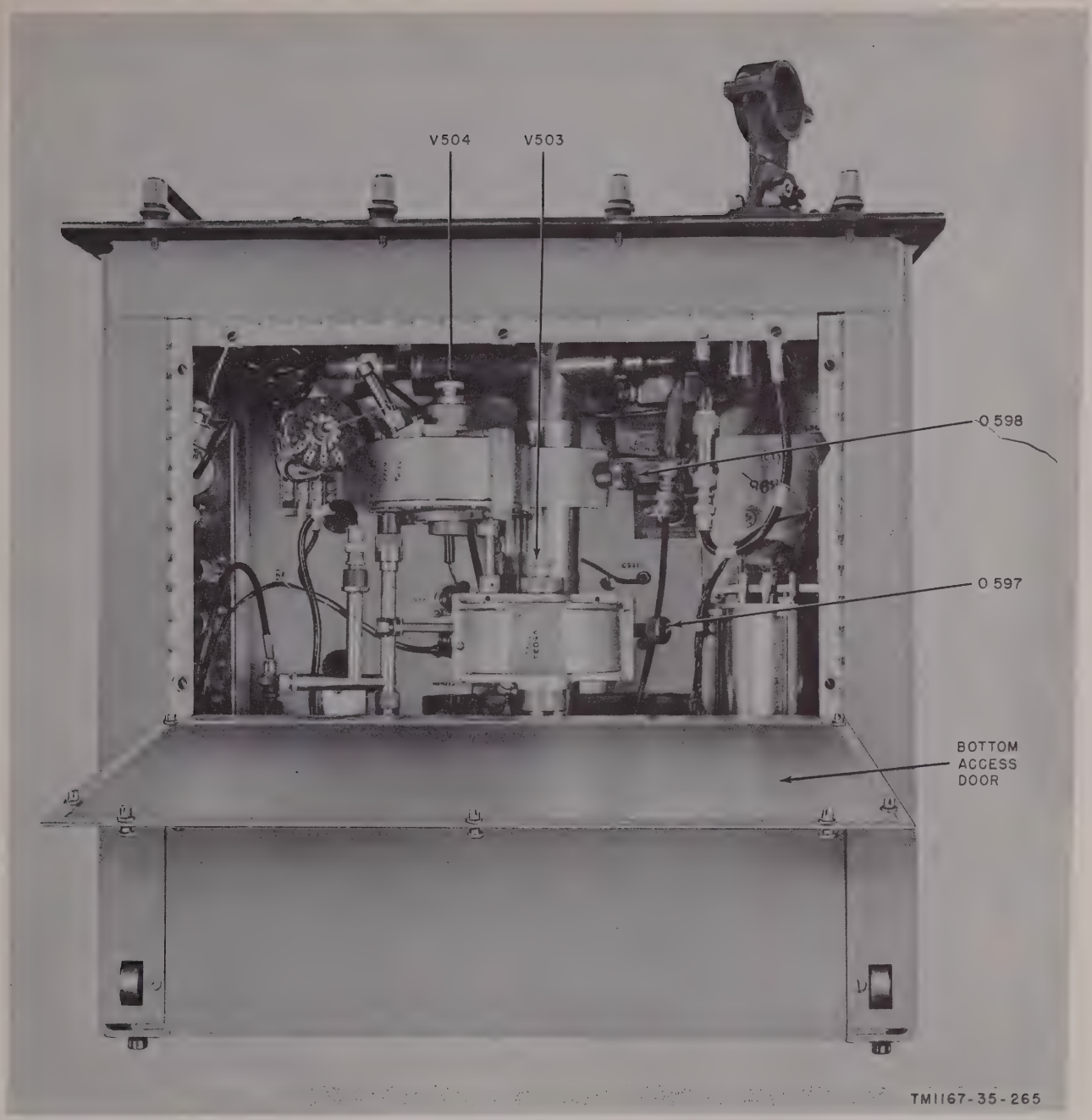


Figure 120. Radar Receiver-Transmitter RT–212/TPS–1D, bottom access door and tuning adjustments.

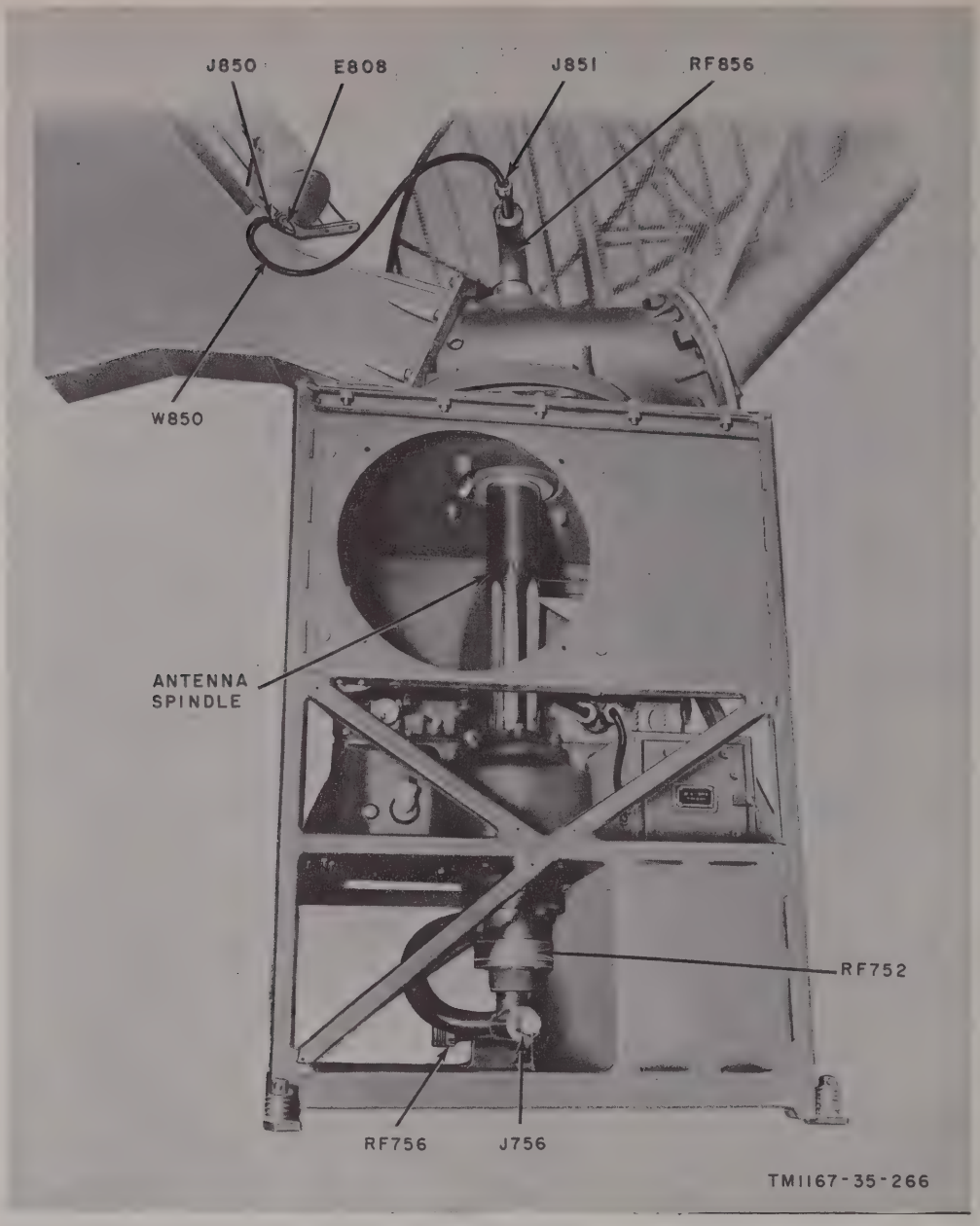


Figure 121. Antenna Base AB–221/TPS–1D, rear view with fan removed.

246. RF System Fuses

The following chart lists the fuses that protect circuits in the RF system. 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 are also listed.

Fuse	Rating		Blown fuse indicator	Circuit protected	Location (fig. No.)
	Volts	Amps			
F403	250	4	I 403	Keep-alive power supply transformer T501	173
F406	250	6.25	I 406	+27-volt power supply which provides operating power for shutter gate relay K501.	173

247. Normal Indications for RF System

a. The test jack provided for obtaining test measurements in the RF system is R.F. TEST jack J501, the directional coupler output. It is located on the front panel of the receiver-transmitter (fig. 116). With the echo box connected to J501 normal indications are observed on the A-scope as being at least 12 miles of ring time at 1,280 mc and on the ppi scope as continuous ppi sweep with no blank wedges.

b. The echo box method gives a general idea of the RF system functioning and indicates the quality of RF501. To obtain a test indication of the RF system which includes all interconnected line sections and cables from the output of RF501 to the antenna, a voltage standing wave ratio measurement is required. The normal limit of the standing wave figure is 1.65 : 1 (par. 266).

248. Dc Resistance of RF System Transformer and Relay

The following table lists the transformer and relay which are included in the RF system, references a figure that shows the location of each, and gives the dc resistance of every winding.

Transformer and relay	Location (fig. No.)	Terminals	Dc resistance (ohms)
K501	117	YEL—BLK	260.
		BLK—RED	7.
T501	118	1–2	73.
		3–4	1,760.
		5–6	Less than 1.

Section II. TROUBLESHOOTING CHARTS

249. General

Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the RF system. If you are not sure the trouble is in the RF system, use the troubleshooting chart based on starting procedure (par. 210) to sectionalize trouble to a system.

a. Symptom Troubleshooting (par. 252). Troubles that have been sectionalized to the RF system can usually be isolated most rapidly by following a procedure based on symptoms that localize the trouble to a section, assembly, or circuit. The symptoms that are given consist of indications obtained on the echo box and on the A-scope and ppi scope. To troubleshoot the RF system based on symptoms, proceed as follows:

(1) Observe the indications obtained on the echo box and on the ppi and A-scope.
(2) Compare the indications obtained with those listed in each of the symptoms.
(3) If the indications obtained correspond to those listed in the *Symptom* column, follow the procedure given in the *Corrective measures* column to isolate the trouble.
(4) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleshooting chart.

b. Step-by-Step Troubleshooting Chart (par. 253). The RF system step-by-step troubleshooting chart consists of a series of steps designed to evaluate all phases of operation of the RF system. Use this chart if the trouble cannot be isolated by symptom troubleshooting (*a* above). To troubleshoot the RF system using the step-by-step troubleshooting chart, proceed as follows:

(1) Locate the *Test point* given in *step 1.*
(2) Connect the test equipment and set the controls as directed in the *Test equipment* column.
(3) Set the controls on the radar set as directed in the *Radar set controls* column.
(4) Compare the indications obtained on the test equipment with the indications that are 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.

250. Test Equipment Required to Troubleshoot the RF System

The following items of test equipment are required to troubleshoot the RF system:

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A.
Test Set TS–172A/UP	Echo box	11–1262.
Pulse Generator AN/UPM–15.	Pulse generator	11–1177.
Signal Generator AN/URM–64.	Uhf signal generator.	11–5553.
Coaxial Slotted Line IM–92/U.	Slotted line	11–5109.
Indicator, Standing Wave Ratio IM–97/USM–37.	Vswr indicator	Packed with equipment.
Adapter, Connector UG–1252/U.	Adapter.	
Dummy Antenna TS–235/UP.	Dummy antenna	11–1093.

251. Preparation of RF System Components for Troubleshooting

a. General. Troubleshooting the RF system requires that all of the units be completely interconnected. The RF system can be divided into two sections, the RF components in the receiver-transmitter and the RF transmission lines from RF855 to, and including the antenna radiating horn. Troubles may be sectionalized by observing the effects when the RF lines are completely connected to the antenna, and then substituting the dummy antenna at R.F. OUTPUT jack J502.

Caution: Do not attempt to remove or replace any RF transmission line sections or the dummy antenna while the set is radiating. Never allow the set to radiate unless the RF system is terminated either with the dummy antenna or its own antenna.

b. Receiver-Transmitter. Many of the RF system checks and adjustments are made in the receiver-transmitter using the echo box. Some of the adjustments that are required to obtain optimum performance from the RF system include adjustments which are a part of the receiving system. All of these adjustments are located on the underside of the receiver-transmitter.

c. Gaining Access to Receiver-Transmitter. To gain access to the receiver-transmitter for troubleshooting alining, or testing, proceed as follows:

(1) Release the four captive screws on the front panel of the receiver-transmitter and remove the chassis until stopped by the safety catches.

(2) Loosen the five Dzus fasteners and open the forward part of the bottom access door.

(3) Defeat interlock switch S504, which is accessible through the small opening in the upper right side of the chassis.

d. Checking RF Lines. The best method to check the efficiency of power transfer of the RF lines is the vswr measurement. The vswr measurement does not require that power be applied to the set because the RF lines are disconnected from the set.

e. Checking by Substituting Dummy Antenna. When checking the performance of the RF system using the echo box, the RF lines should be connected. However, if the RF lines are suspected of being faulty, proceed as follows:

(1) Connect the echo box to R.F. TEST jack J501.

(2) Turn on power, POWER ON switch S602 on the front panel of the indicator.

(3) Wait for the 5-minute time delay relay to cycle in and then depress RADIATE ON switch S616 on the front panel of the indicator.

(4) Tune the echo box to obtain a maximum meter indication on the echo box tuning meter.

(5) Tune tr tubes V503 and V504, duplexer RF503, and the local oscillator for maximum ringtime on the A-scope (par. 13, TM 11–1167–20).

(6) Observe and record the echo box meter reading and the effects on the ppi- and A-scopes when the antenna is stationary and then rotated.

(7) Turn off power, POWER OFF switch S602.

(8) Disconnect RF855 from R.F. OUTPUT J502.

(9) Connect the dummy antenna to J502.

(10) Turn on power, POWER ON switch S602.

(11) Compare the results with (6) above. If the same indications exist, the fault is in the RF components in the

receiver-transmitter. If the indications are normal, the trouble is in the RF lines or the antenna which should be checked by vswr measurement (par. 266).

252. RF System Symptom Troubleshooting Chart

Warning: Extremely dangerous voltages exist in the RF sections and in the keep-alive power supply of the receiver-transmitter.

Item	Symptom	Probable cause	Corrective measures
1	Frequent failure of signal mixer CR503.	Tr tube V503 or V504 function poorly or not at all, shutter gate relay K501 shorting pin stuck in the open position.	*a.* Check output of keep-alive power supply (par. 254). *b.* If normal, replace V503 and V504 (par. 36, TM 11–1167–20). *c.* Check the action of shutter gate relay K501 for free movement of shoting pin by engaging and disengaging interlock switch S504.
2	Protective relay K151 in modulator energizes when RADIATE ON switch S616 is depressed.	Faulty RF lines or connections causing severe mismatch and possible arcing in lines.	*a.* Check all RF lines and connections from J502 through all cables up to the antenna horn for tightness and damage. *b.* Check all RF lines for warm spots caused by excessive standing waves. *c.* Check rotary joint RF752 for burned or damaged contacts (par. 256*d*).
3	Echo box indication on the A-scope shows ringtime low and echo box meter reading normal.	Duplexer assembly RF503 not properly tuned.	*a.* Check tuning of V503 and V504 (par. 13, TM 11–1167–20). *b.* If ringtime cannot be maximized, check adjustment of duplexer assembly (par. 13, TM 11–1167–20).
4	Echo box indication on the A-scope shows a pronounced dip or notch in ringtime following the pulse interval and the echo box meter reading is normal.	Poor receiver recovery time caused by faulty tr tube.	Check tr recovery time (par. 267). *Note.* Tr tubes are normally replaced every 500 to 1,000 hours of use. To replace the tr tubes refer to paragraph 36, TM 11–1167–20.
5	Echo box indication on A-scope shows ringtime erratic in range and echo box meter fluctuates. Condition becomes worse when RF lines are rapped.	Poor connections, faulty RF lines causing arcing, or defective magnetron.	*a.* Check all the connections of RF lines starting from J502 through all cables up to the antenna horn. *b.* Check all RF lines for warm spots caused by excessive standing waves. *c.* Check magnetron V502 spectrum for double moding (par. 236).
6	Echo box indications normal when antenna is stationary but ringtime and echo box meter fluctuates when antenna is rotating. Ppi indication has blank spaces.	Faulty rotating joint or reflecting object near antenna causing transmitter pulling.	*a.* Check for faulty rotating joint by stopping antenna in the direction of blank space on ppi. *b.* If normal, check rotating joint RF752 (par. 256*d*). *c.* If abnormal, check for nearby reflecting objects by substituting the dummy antenna (par. 251*e*).
7	Echo box indications normal, but known targets appear weak or no targets at all.	Faulty RF lines, may have a high-voltage standing wave ratio caused by damaged RF lines, horn or reflector. In some cases this effect may be caused by severe weather conditions.	*a.* Check RF lines, horn and reflector for damaged condition. *b.* If inspection of RF parts seems normal, check RF transmission lines voltage standing wave ratio (par. 266).

Item	Symptom	Probable cause	Corrective measures
8	Echo box meter reading and ringtime below normal or none at all, but signal returns normal.	Faulty directional coupler or coaxial line connecting between J504 and J501.	*a.* Check continuity of coaxial line between J504 and J501 for short or open. *b.* If normal, check directional coupler. *Note.* Directional coupler requires laboratory testing to determine attenuation qualities throughout frequency spectrum.
9	Weak or no targets on indicators, arcing sounds from vicinity of RF751.	Extremely cold temperatures causing moisture and frost to collect in RF751 during shutdown periods.	*a.* Check RF751 for frost or moisture. If set is being operated in arctic climate having abnormal temperature variations, moisture may collect in RF751 and form ice during shutdown periods. (Refer to par. 64, TM 11–1167–10.) *b.* Disconnect hose from servo amplifier case to RF751 while this condition exists.

253. RF System Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1	R.F. TEST J501 (fig. 116).	Echo box TS–172A/UP.	Radar set completely connected with RF lines terminated by the antenna. Apply power to radar set (S602), wait 5 minutes and depress RADIATE ON switch S616 on front panel of indicator. Set the OPERATION SELECTOR switch S–2354, on the front panel of the signal comparator to NORMAL position.	Echo box meter reads approximately 65 microamperes, ringtime on ppi- and A-scope 12 miles or more at 1,280 mc.	*a.* Tune the echo box for maximum meter reading only. *b.* Check tuning of the RF components to obtain maximum ringtime on the A-scope. (1) Tune pre-tr tube V503. (2) Tune tr tube V504. (3) Adjust duplexer RF503. *c.* Check tuning of receiving components to obtain maximum ringtime on the A-scope (par. 290). (1) Local oscillator tuning. (2) Local oscillator injector RF503A. (3) Capacitor C305 (in IF amplifier). *d.* If normal, proceed to step X.
2	R.F. TEST J501 (fig. 116).	Echo box and dummy antenna.	***Caution:*** Shut off power before disconnecting RF855. Disconnect RF855 from J502 and connect the dummy antenna. Apply power to radar set, wait 5 minutes and depress RADIATE ON switch S616 on front panel of indicator.	Echo box meter reads approximately 65 microamperes, ringtime on ppi- and A-scope 12 miles or more at 1,280 mc.	*a.* If abnormal proceed to step 3. *b.* If normal proceed to step 4.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
3	Feed-through capacitor C518 (fig. 13–2). *Note.* Follow procedure in paragraph 254.	Multimeter	Follow procedure in paragraph 254.	Approximately −800 volts dc ±10%.	If abnormal, troubleshoot the keep-alive power supply (par. 254).
4	Voltage standing wave ratio measurement of RF lines (par. 266).	Pulse generator, uhf signal generator, slotted line, vswr indicator, adapter, and dummy antenna.		Vswr, not greater than 1–65:1.	Replace any section of RF transmission line that indicates a vswr greater than 1.65:1.

254. Measurement of Keep-Alive Power Supply Voltage

Caution: The keep-alive power supply provides a voltage in excess of 800 volts.

To measure the keep-alive voltage using the multimeter, proceed as follows:

a. Shut off equipment power, POWER OFF switch S602 on the front panel of the indicator.

b. Plug the black test lead into the dc jack and connect the other end of the black test lead to a good ground connection on the chassis.

c. Turn the function switch to 20,000 ohms/volt dc reverse.

d. Plug the red test lead into the 1,000-volt dc jack and connect the other end to feed-through capacitor C518.

e. Be sure all connections are secure and properly made before turning on power.

f. Apply power to the set, POWER ON switch C602 on the front panel of the indicator.

g. Record the voltage measured at the C518 terminal. It should be approximately −800 volts ±10 percent.

h. Shut off equipment power, POWER OFF switch S602, and discharge C501 and C502 with a shorting bar before disconnecting the multimeter.

Section III. REMOVAL AND REPLACEMENT OF PARTS

255. General

The RF system consists of parts in Radar Receiver-Transmitter RT–212/TPS–1D, Antenna Base AB–221/TPS–1D, and Antenna AS–548/TPS–1D.

Warning: Extremely dangerous voltages exist in the receiver-transmitter. When removing and replacing parts, heed the high-voltage warnings. Observe the following precautions before touching any part inside the receiver-transmitter.

Make certain POWER switch S602 is OFF.

Disconnect plug P508 from POWER INPUT jack J508.

Disconnect plug P505 from PULSE INPUT jack J505.

Discharge capacitors C501, C502, and C509 with a shorting bar.

256. Removal and Replacement of Parts

a. Keep-Alive Power Supply. The keep-alive power supply subchassis is mounted on the inside of the upper-front, right hand corner of the receiver-transmitter. The high-voltage lead is fed through a feed-through capacitor (C518) to the lower section where the duplexer is located.

b. Transmission Line RF501 and Duplexer RF503. RF transmission line RF501 is located in the lower section of the receiver-transmitter. Magnetron V502 is removed prior to attempting removal of RF501. Shutter gate relay K501 is attached to the duplexer and requires

removal of the two leads (8A6 and 01) from terminal board E553 before attempting removal of duplexer assembly RF503.

c. Rigid Coaxial Line Sections. When removing and replacing rigid coaxial line sections, be careful not to damage the sections by bending or denting. Be sure that connections fit properly when the threaded connecting ends are screwed together. Be careful not to strip the threads of the connectors. If the threaded connector appears to bind, loosen and start again.

d. Rotary Joint RF752. The rotary joint is connected as a part of the antenna base. Removal and replacement is not easily accomplished. Be sure that the fault is in the rotary joint components before attempting removal of RF752 (par. 452*b*).

e. Antenna Base. The rotary joint of the transmission line is located in the antenna base. When raising, lowering or moving the antenna base, the antenna is removed. This leaves the antenna spindle exposed and possible damage to the center conductor may result. Spindle cap O 1703 is used to protect the exposed spindle whenever the antenna section is removed.

f. Antenna AS–548/TPS–1D. Removal and replacement of the antenna is made less difficult by first removing the additional sections of the antenna reflector.

Section IV. ADJUSTMENT AND ALINEMENT

257. General

a. This section covers the adjustments of the RF system with the components of the radar interconnected. These adjustments are in Radar Receiver-Transmitter RT–212/TPS–1D and Antenna Base AB–221/TPS–1D. The procedures for making the adjustments are with the set completely interconnected because the RF component parts function as an integral part of the complete radar set.

b. The duplexer is part of the RF system, but is usually alined with the local oscillator and signal mixer which are in the receiving system. The duplexer, signal mixer, and local oscillator must be alined when the set is initially installed (par. 13, TM 11–1167–20).

c. The following RF system adjustments are located in Radar Receiver-Transmitter RT–212/TPS–1D.

(1) Adjustment of duplexer assembly RF503 (par. 13, TM 11–1167–20).

(2) Adjustment of pre-tr tube V503 and tr tube V504 (par. 13, TM 11–1167–20).

d. The following RF system adjustments are made to center the inner conductor when the antenna spindle is exposed and prior to mounting the antenna section to the antenna base.

(1) Adjusting screw (par. 33*b*, TM 11–1167–10).

(2) Adjustment Clamp (par. 33*b*, TM 11–1167–10).

258. Tools and Test Equipment Required

a. Test Equipment. The following items of test equipment are required to aline the RF system.

Test equipment	Common name	Technical manual
Test Set TS–172A/UP	Echo box	11–1262.
Multimeter TS–352B/U or ME–77/U.	Multimeter	11–5527.

b. Special Tools. The following special tools are required to aline the RF system.

Tools	Reference
Strap wrench	Fig. 19, TM 11–1167–20.
Upper rotary joint alinement cap.	Fig. 19, TM 11–1167–20.

259. Centering Antenna Spindle Inner Conductor

a. General. Before attempting to place the antenna on the antenna base, be certain that the inner conductor at the antenna spindle is properly centered. If the inner conductor is off center when the antenna is lowered onto the spindle, severe damage will be caused during the connecting process or excessive and uneven wear will occur at the rotary joint during antenna rotation.

b. Procedure. Follow the procedure outlined in the paragraph of installation of the antenna base and antenna (par. 33*b*, TM 11–1167–10).

260. Adjustment of Duplexer Assembly RF503

a. General. The duplexer is adjusted to obtain maximum signal returns. Duplexer adjustment is required when making performance measurements and when RF or receiving component parts are replaced.

b. Procedure. Adjustment of the duplexer is accomplished through the use of the echo box. Tune the echo box for maximum meter reading before any other adjustment is made. Follow the procedure outlined in the paragraph on receiver alinement, normal operation (par. 13, TM 11–1167–20).

Section V. FIELD TESTING

261. General

This section describes testing procedures required to check the serviceability of the RF system. Because the arrangement of the RF system requires the interconnecting of the complete radar set, it can only be checked as a completely connected set. Essentially the tests are for receiving and transmitting performance which gives a direct indication of the effectiveness of the RF system, except for the voltage standing wave ratio (vswr) measurement which indicates the ability of the RF components to propagate RF energy efficiently. A faulty RF system gives poor results when making transmitter power output and receiver sensitivity measurements.

262. Test Equipment Required

The following items of test equipment are required to test the serviceability of the RF system.

Test equipment	Common name	Reference
Summation Bridge AN/URM–23.	Summation bridge.	TM 11–5128
Signal Generator AN/URM–64.	Uhf signal generator.	TM 11–5553
Test Set TS–172A/UP	Echo box.	TM 11–1262
Pulse Generator AN/UPM–15.	Pulse generator.	TM 11–1177
Coaxial Slotted Line IM–92/U.	Slotted line.	TM 11–5109
Indicator, Standing Wave Ratio IM–97/USM–37.	Vswr indicator.	Literature packed with equipment.
Adapter, Connector UG–1252/U.	Adapter.	
Dummy Antenna TS–235/UP.	Dummy antenna.	TM 11–1093

263. Transmitter Average Power Output Measurement

a. General. The average power from the transmitter is measured by the use of the summation bridge. The summation bridge includes a power sensitive element (bolometer) in a bridge circuit which has dc power applied. RF power applied to the bolometer causes the bridge to unbalance. The dc power is then reduced until the bridge again becomes balanced and the decrease in dc power is measured and indicated directly on the power meter. The power meter reading is in dbm and is added to the total attenuation (directional coupler, connecting cables, and attenuators) to provide the total measured average power in dbm. The measured average power is required to determine the peak power of the transmitter and the performance of the RF system components. Faulty RF components will cause a noticeable reduction in power readings.

b. Procedure. Follow the procedure outlined in the paragraph on the transmitter average power output measurement (par. 235).

264. Receiver Sensitivity

a. General. The minimum discernible signal is a measurement of the sensitivity of the receiving system. The performance of the receiving system depends on the RF system capabilities. Faulty RF components will cause poor receiver sensitivity results.

b. Method. The minimum discernible signal measurements are made by using the uhf signal generator. With the radar set operating, the uhf signal generator is connected and a pulsed RF signal fed into the set. The power

output of the uhf signal generator pulses is reduced until the video pulse on the A-scope is barely discernible in the grass. The attenuated power reading is taken from the uhf signal generator and added to the total series attenuation which gives the value of minimum discernible signal in dbm.

c. Procedure. Follow the procedure outlined in the paragraph on installation performance tests (par. 16*b*, TM 11–1167–20).

265. RF Component Measurements with Echo Box

a. General. The echo box is one of the most useful test sets for determining faults in the RF system. With the radar set operating, the echo box is connected to the output of the directional coupler. When the transmitter is keyed, an attenuated sample of the transmitter pulse is fed into the echo box cavity which has a high Q. Following the excitation interval, the echo box cavity oscillates for a period of time which is called ringtime. The oscillations are coupled back through the directional coupler and are detected during the receiving time interval. The energy is dissipated after a period of time and decreases in amplitude. The effect of the ringtime is displayed on both ppi- and A-scopes. Normal ringtime is at least 12 miles at 1,280 mc. It can be checked by the use of the range marks on the A-scope. When the radar set is known to be operating well, it is advisable to record the echo box meter reading and the ringtime for comparison with future indications.

b. Procedure. To obtain optimum results from the echo box, both the receiving and RF systems should be alined. Follow the procedure outlined in the paragraph on receiver alinement, normal operation (par. 13, TM 11–1167–20).

266. Voltage Standing Wave Ratio Measurements (fig. 122)

a. General. Voltage standing wave ratio (vswr) measurements are useful in determining the ability of RF transmission line components to propagate RF power efficiently. A vswr measurement can be made to check sections of RF transmission line either individually, in groups, or completely interconnected. The maximum allowable vswr is 1.65:1. The vswr measurement indicates the ratio of the energy fed into an RF transmission line to the energy reflected. The reflected energy travels back towards the generating source from the point of reflection causing standing waves. Energy that reflects in the RF transmission line is not radiated by the antenna and the efficiency of the line is reduced. Standing waves cause abnormally high voltage and current fields along the line which may cause arcing and a breakdown in the line. Losses due to increased leakage conductance and copper loss reduce the total power reaching the radiator. An RF system suspected of being faulty can be checked for vswr. If the vswr of the overall RF system is high (above 1.65:1) indicating abnormal line conditions, a vswr check can then be made of the individual sections to determine the faulty one.

b. Test Equipment. To perform the vswr measurement, use the following test equipments:

(1) A pulse generator which provides a pulsed video output at a 1-kc rate.

(2) A uhf signal generator that may be modulated by the pulse generator.

(3) A slotted line which has a pickup probe and detector. The probe can be moved back and forth along the line measuring the peaks and nulls of the standing waves.

(4) A vswr indicator tuned to 1-kc which amplifies the detected output from the slotted line and gives a direct vswr indication on its scale.

(5) An adapter which is required to match the coaxial connector of the slotted line at one end and the larger type connectors of the RF transmission line sections at the other end.

(6) A dummy antenna which is used to terminate the rf transmission line sections when the antenna is not used.

c. Connecting Procedures. When connecting test equipment to perform the vswr measurement, follow the procedure outlined below.

(1) Set up the pulse generator to provide an output pulse width of 10-microseconds at a 1-kc rate.

(2) Connect the output of the pulse

generator to the external modulation jack of the uhf signal generator.

(3) Adjust the uhf signal generator to provide maximum pulsed RF power output at about 1,280 megacycles.

(4) Connect the output of the uhf signal generator to the input (one end) of the slotted line.

(5) Connect the output (other end) of the slotted line with the adapter.

(6) Connect to the adapter the RF transmission line section to be tested.

(7) Terminate the RF transmission line section with either the dummy antenna or the antenna section of the radar set.

(8) Connect the slotted line carriage output to the vswr indicator.

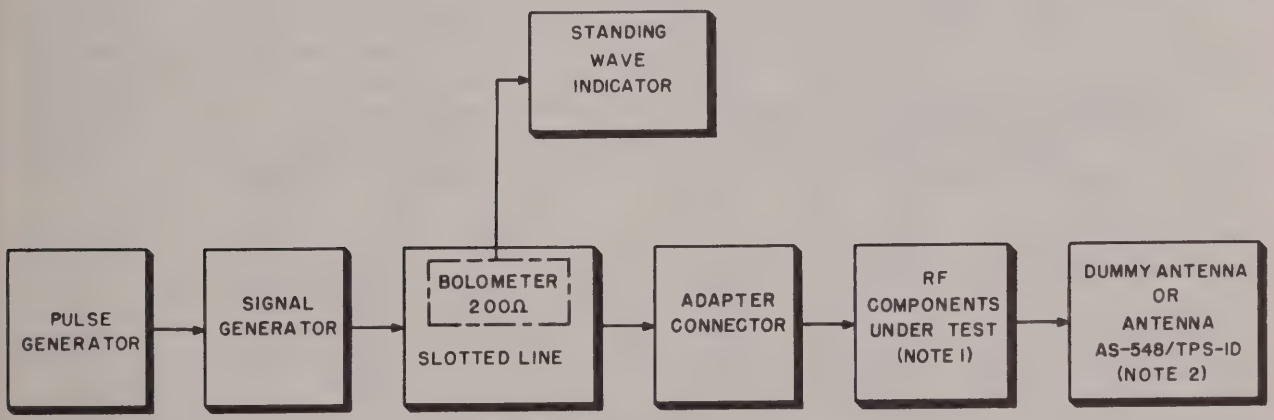
d. Procedure. To perform the vswr measurement, follow the procedures referenced below:

(1) Coaxial Slotted Line IM–92/U, paragraphs 36 and 37, TM 11–5109.

(2) Standing Wave Indicator IM–97/USM–37, literature packed with the equipment.

267. Tr Recovery Time Measurement

a. General. During the transmitting time interval, the RF pulse causes the tr tubes to arc. The arc produced in the tr tubes results in an electrical short circuit which in effect blocks RF energy in the RF transmission lines from entering the receiving system. When the transmitter pulse interval terminates, the arc in the tr tube is self-sustained for a short period. During this period received signals are blocked until the arc gradually diminishes and finally the tr tube recovers. As the recovery takes place, the receiver sensitivity increases until its normal receiving ability has been regained. Tr recovery time is considered as the time lapse between the transmitter pulse and when the receiver sensitivity has been restored to a level 3 db less than maximum. This is determined by applying a simulated echo signal of known power to the RF lines. The echo amplitude observed on the A-scope is recorded by marking a reference line. The signal power is increased by 3 db and the echo is moved towards the transmitter pulse until its amplitude is observed to drop to the premarked reference line. The echo is now located



NOTES:

1. RF COMPONENTS TESTED MAY BE INDIVIDUAL RF LINE SECTIONS OR COMPLETELY INTERCONNECTED.
2. RF TRANSMISSION LINE MUST BE TERMINATED DURING VSWR MEASUREMENT, EITHER BY THE DUMMY ANTENNA OR ANTENNA AS-548/TPS-ID.

TM1167-35-267

Figure 122. Measurement of voltage standing wave ratio (vswr).

at 3 db less than the maximum receiver sensitivity point. The distance between the transmitter pulse and the echo pulse is measured as the tr recovery time. The maximum allowable tr recovery time is approximately 25 microseconds or a distance of a little over 2 miles. The measurement can be approximated by use of the 5-mile range marks and observed on the A-scope. If the tr recovery is measured in excess of 2.5 miles, the tr tubes should be replaced.

b. Procedure. To perform the tr recovery time measurement—

(1) Turn on the radar set and allow 5 minutes for the time delay relay to cycle in before depressing the RADIATE ON switch S616 on the front panel of the indicator.
(2) Connect the output of J153 on the front panel of the modulator to the synch input jack of the uhf signal generator.
(3) Connect the pulsed RF output of the uhf signal generator to R.F. TEST jack J501 on the front panel of the receiver-transmitter.
(3) Connect the pulsed RF output of the uhf signal generator to R.F. TEST jack J501 on the front panel of the receiver-transmitter.
(4) Adjust A RANGE SELECTOR switch S609 on the front panel of the indicator for 20 miles.
(5) Turn RANGE MARKS MILES switch S608 on the front panel of the indicator to the ON position.
(6) Tune the uhf signal generator to the transmitter frequency.
(7) Adjust the pulse delay control on the uhf signal generator so that the simulated echo appears between the 15- and 20-mile range marks.
(8) Adjust the output attenuator control on the uhf signal generator until the echo amplitude on the A-scope is approximately halfway between the base line and the saturation level.
(9) Draw a horizontal reference line across the face of the A-scope at the amplitude level of the echo pulse.
(10) Note the attenuation figure on the uhf signal generator and increase the value by 3 db.
(11) Adjust the pulse delay control, moving the echo towards the transmitter pulse.
(12) When the echo amplitude decreases to the reference line (step 9 above) release the pulse delay control.
(13) Using the 5-mile range marks as a reference, determine the distance between the transmitter pulse and the echo.
(14) If the distance exceeds 2.5 miles, change the tr tubes.

CHAPTER 14

RECEIVING SYSTEM TROUBLESHOOTING AND REPAIR

Warning: Extremely dangerous voltages exist in Radar Receiver-Transmitter RT–212/TPS–1D. When servicing the receiving system observe the following precautions:

1. Do not press the RADIATE ON button unless specifically instructed.
2. If the transmitter is radiating keep clear of the magnetron and pulse transformer T502 (fig. 103).
3. Be careful when working near the keep-alive voltage (−800 volts) at C518 (fig. 117).

Section I. TROUBLESHOOTING INFORMATION

268. Reference Data

The following information will be helpful when troubleshooting or repairing the receiving system.

Reference	Data
Fig. 24	Receiving system, complete block diagram.
Chapter 4	Receiving system theory.
Figs. 25 through 39	Receiving system circuits, simplified schematic diagrams.
Fig. 212	Radar receiver-transmitter RT–212/TPS–1D, complete schematic diagram.
Par. 270	Receiving system controls and adjustments.
Par. 272	Normal readings of receiving system panel meters.
Par. 273	Normal indications of receiving system test points.
Par. 274	Dc resistance of inductive components.
Par. 269 and figs. 123 through 131.	Location of parts.
Fig. 211	Radar receiver-transmitter RT–212/TPS–1D, voltage and resistance measurements at tube sockets.
Fig. 215	60-mc IF amplifier Z301, voltage and resistance measurements at tube sockets.
Fig. 216	Coherent oscillator, voltage and resistance measurements at tube sockets.
Fig. 219	Signal comparator CM–36/TPS–1D, complete schematic diagram.

269. Location of Parts in Receiving System

The following chart lists the part numbers in the receiving system and references figure numbers showing their locations.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
B502	123	C312	131	C341	131
C222	127	C313	131	C342	131
C223	127	C314	131	C350	131
C224	127	C315	131	C351	131
C225	127	C316	131	C352	131
C226	127	C317	131	C353	131
C227	127	C318	131	C354	131
C228	127	C319	131	C355	131
C229	127	C320	131	C356	131
C230	127	C321	131	C357	131
C231	127	C322	131	C358	131
C232	127	C323	131	C359	131
C233	127	C324	131	C360	131
C234	127	C325	131	C361	131
C235	127	C326	131	C362	131
C236	127	C327	131	C363	131
C237	127	C328	131	C364	131
C239	127	C329	131	C365	131
C301	131	C330	131	C366	131
C302	131	C331	131	C367	131
C303	131	C332	131	C368	131
C304	131	C333	131	C369	131
C305	131	C334	131	C370	131
C306	131	C335	131	C371	131
C307	131	C336	131	C372	131
C308	131	C337	131	C373	131
C309	131	C338	131	C503	125
C310	131	C339	131	C511	125
C311	131	C340	131	C513	125

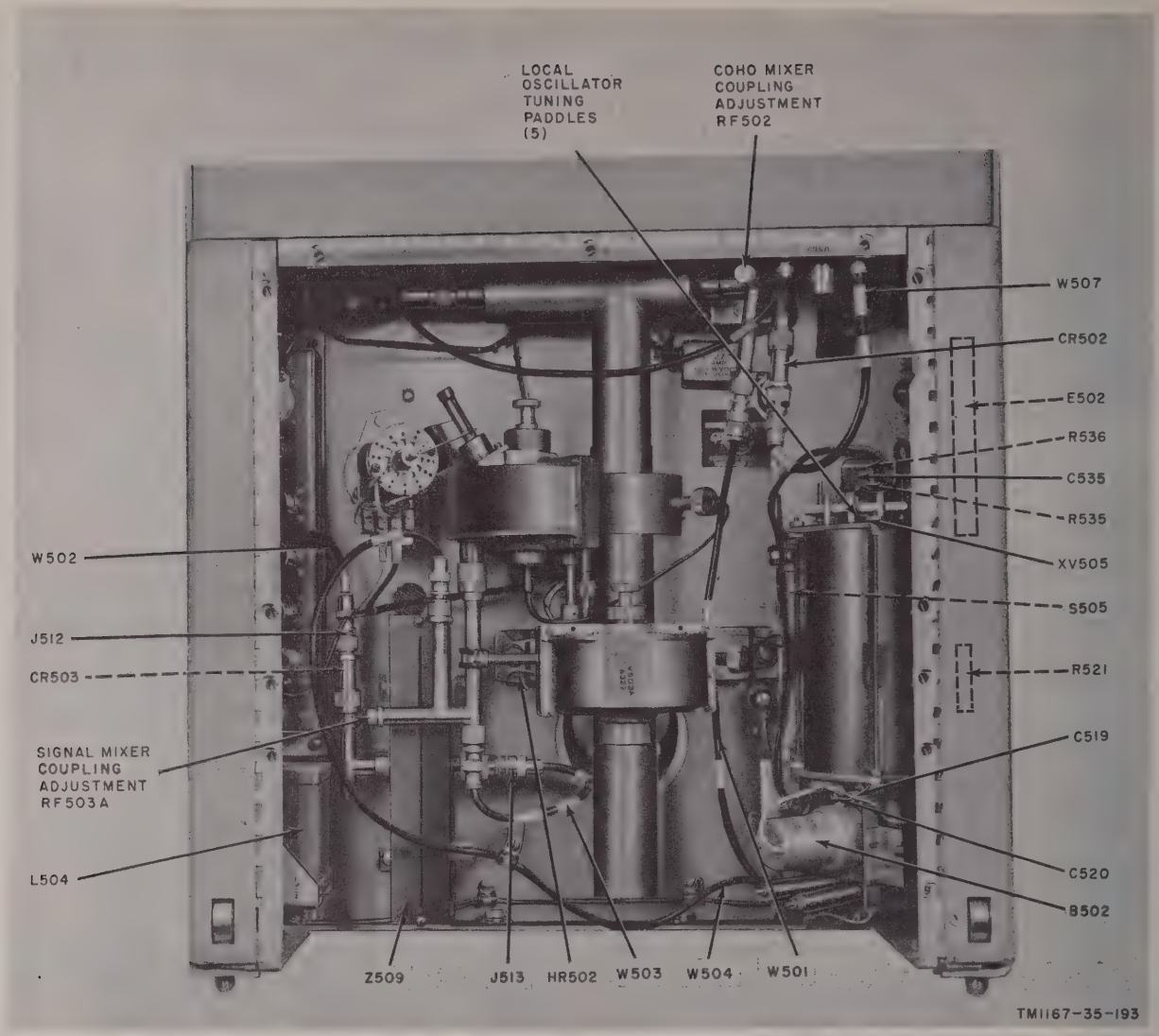


Figure 123. Radar Receiver-Transmitter RT-212/TPS-1D, full under chassis view.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
C519	123	CR302	131	J351	131
C520	123	CR303	131	J503	124
C522	125	CR502	123	J507	124
C524	125	CR503	123	J508	102
C526	128	E502	123	J510	124
C527	128	HR502	123	J511	124
C528	128	J224	124	J512	123
C529	128	J225	124	J513	123
C530	128	J227	124	J514	124
C531	124	J228	124	J515	124
C532	128	J304	129	J517	126
C534	124	J306	129	J518	126
C535	123	J307	131	J519	124
C603	153	J308	131	J521	124
CR301	131	J350	131	K3301	130

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
L224	127	L308	131	L506	128
L225	127	L350	131	L507	128
L227	127	L351	131	L508	128
L228	127	L352	131	L509	128
L230	127	L353	131	L510	128
L232	127	L354	131	M501	125
L233	127	L355	131	M601	153
L245	127	L356	131	M2350	140
L301	131	L357	131	P228	123
L302	131	L358	131	R230	127
L303	131	L359	131	R231	127
L304	131	L360	131	R233	127
L305	131	L501	125	R234	127
L306	131	L504	123	R236	127
L307	131	L505	128	R237	127

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
R259	127	R317	131	R354	131
R260	127	R318	131	R355	131
R261	127	R319	131	R356	131
R301	131	R320	131	R357	131
R302	131	R321	131	R358	131
R303	131	R322	131	R359	131
R304	131	R323	131	R360	131
R305	131	R324	131	R450	177
R306	131	R325	131	R507	124
R307	131	R326	131	R510	125
R308	131	R327	131	R514	125
R309	131	R329	131	R518	126
R310	131	R330	131	R519	126
R311	131	R331	131	R521	123
R312	131	R332	131	R531	128
R313	131	R350	131	R532	128
R314	131	R351	131	R533	128
R315	131	R352	131	R535	123
R316	131	R353	131	R536	123

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
R608	149	T223	127	XV303	131
R2350	129	T301	131	XV304	131
R2351	129	T503	125	XV305	131
R2355	129	TP501	125	XV306	131
R2358	130	TP502	125	XV307	131
R2362	129	TY501	125	XV350	131
R2363	130	U221	124	XV351	131
RF502	123	U501	124	XV352	131
RF503A	123	U502	124	XV353	131
S502	126	W501	123	XV354	131
S503	126	W502	123	XV505	123
S504	125	W503	123	XV506	128
S505	123	W504	123	Z221	127
S506	125	W507	123	Z222	127
S601	149	XV224	127	Z301	130
S613	149	XV225	127	Z350	130
S2353	129	XV232	127	Z505	124
S2354	129	XV301	131	Z506	124
T222	127	XV302	131	Z509	123

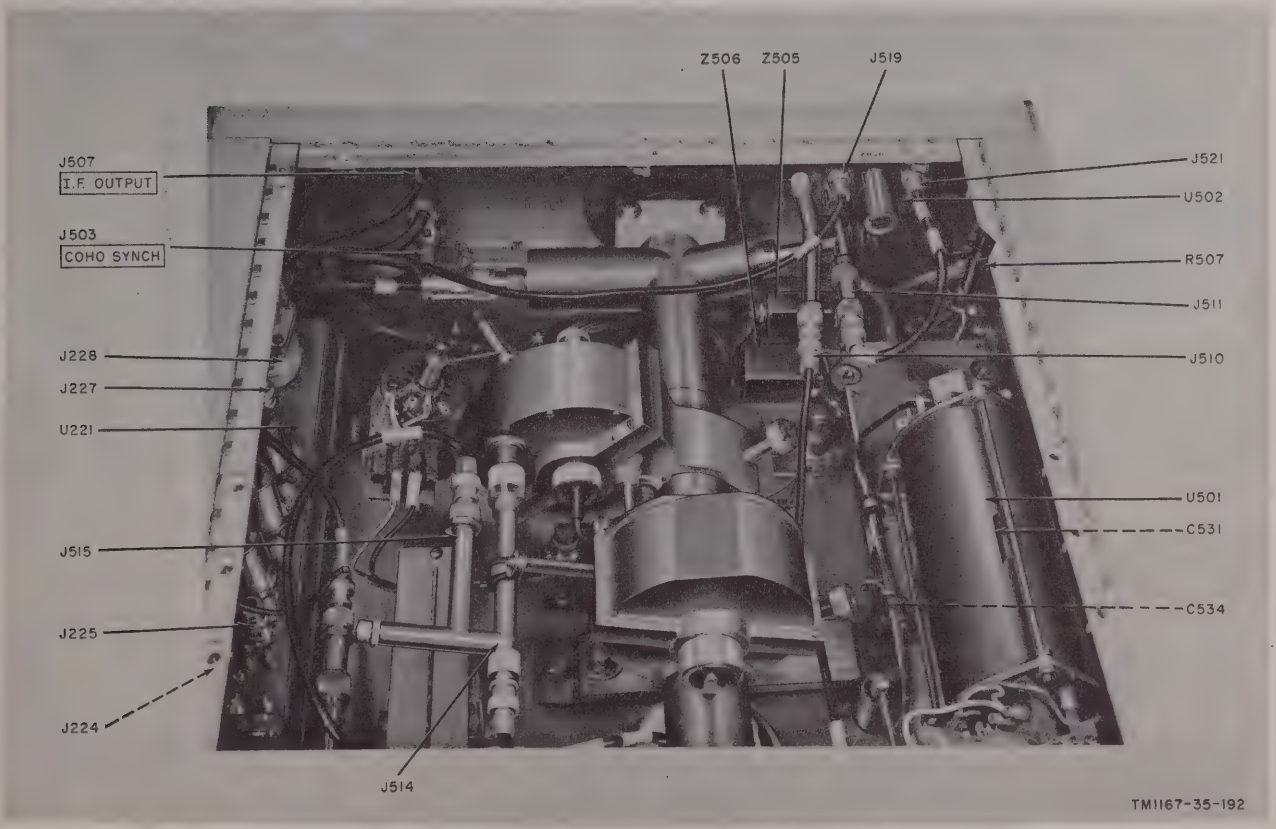


Figure 124. Radar Receiver-Transmitter RT–212/TPS–1D, front under chassis view.

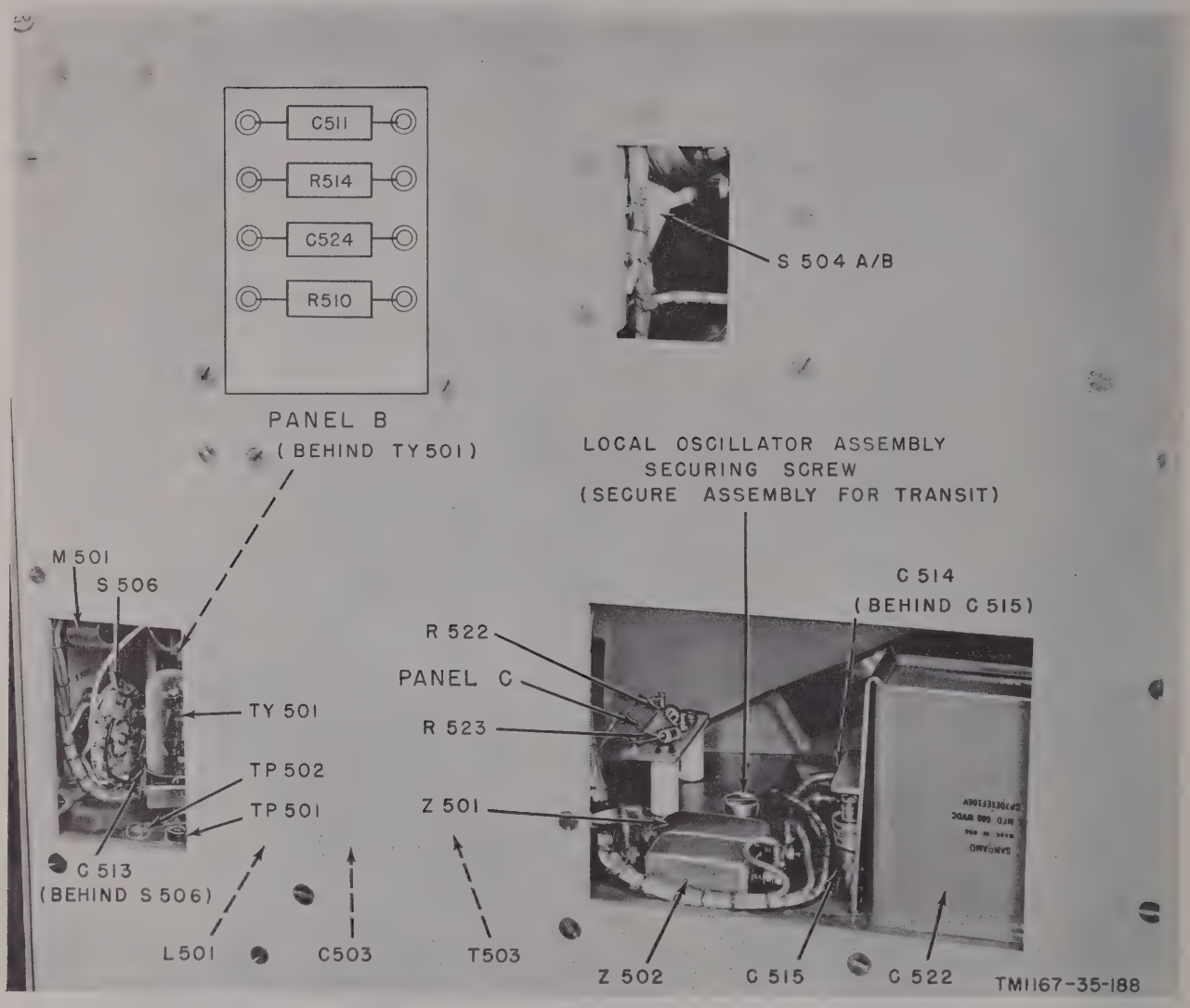


Figure 125. Radar Receiver-Transmitter RT-212/TPS-1D, right-side view.

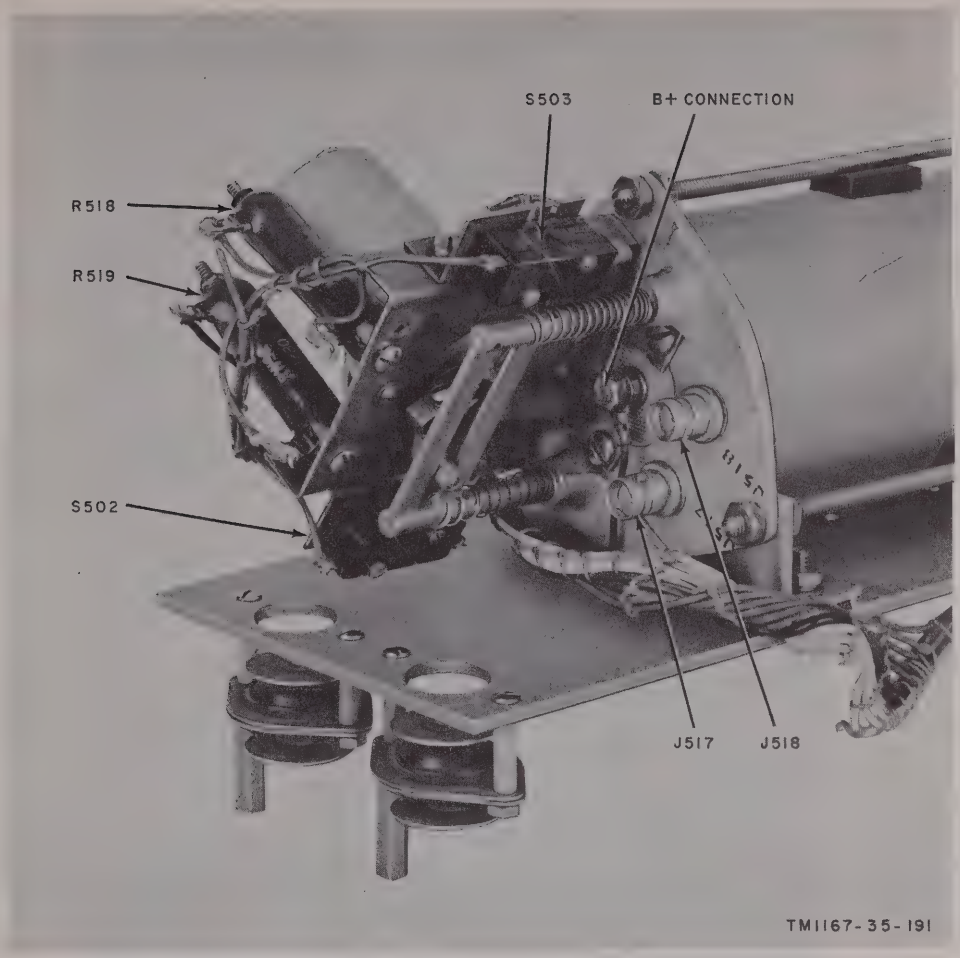


Figure 126. Local oscillator and control circuits U501, component locations.

270. Receiving System Controls and Adjustments

The following charts (*a*, *b*, and *c* below) list the controls and adjustments that are functional parts of the receiving system, reference a figure that shows the location and give the function of each.

a. Receiving System Controls and Adjustments Location in Radar Receiver-Transmitter RT–22/TPS–1D.

Controls and adjustments	Location (fig.)	Function
Signal mixer coupling (RF503A)	123	Adjusts the amount of local oscillator signal fed to signal crystal mixer CR503. Correct adjustment is indicated by a red-line reading on test meter M501 when TEST SELECTOR switch S506 is in the SIG position (par. 288).
Coho mixer coupling (E527)	123	Adjusts the amount of local oscillator signal fed to coho crystal mixer CR502. Correct adjustment is indicated by a red-line reading on test meter M501 when TEST SELECTOR switch S506 is in the COHO position (par. 288).
Local oscillator tuning paddles (5)	123	Adjusts the center frequency of the cathode tuned circuit of local oscillator V505. This adjustment requires special test equipment and should be made according to the procedure outlined in paragraph 289.

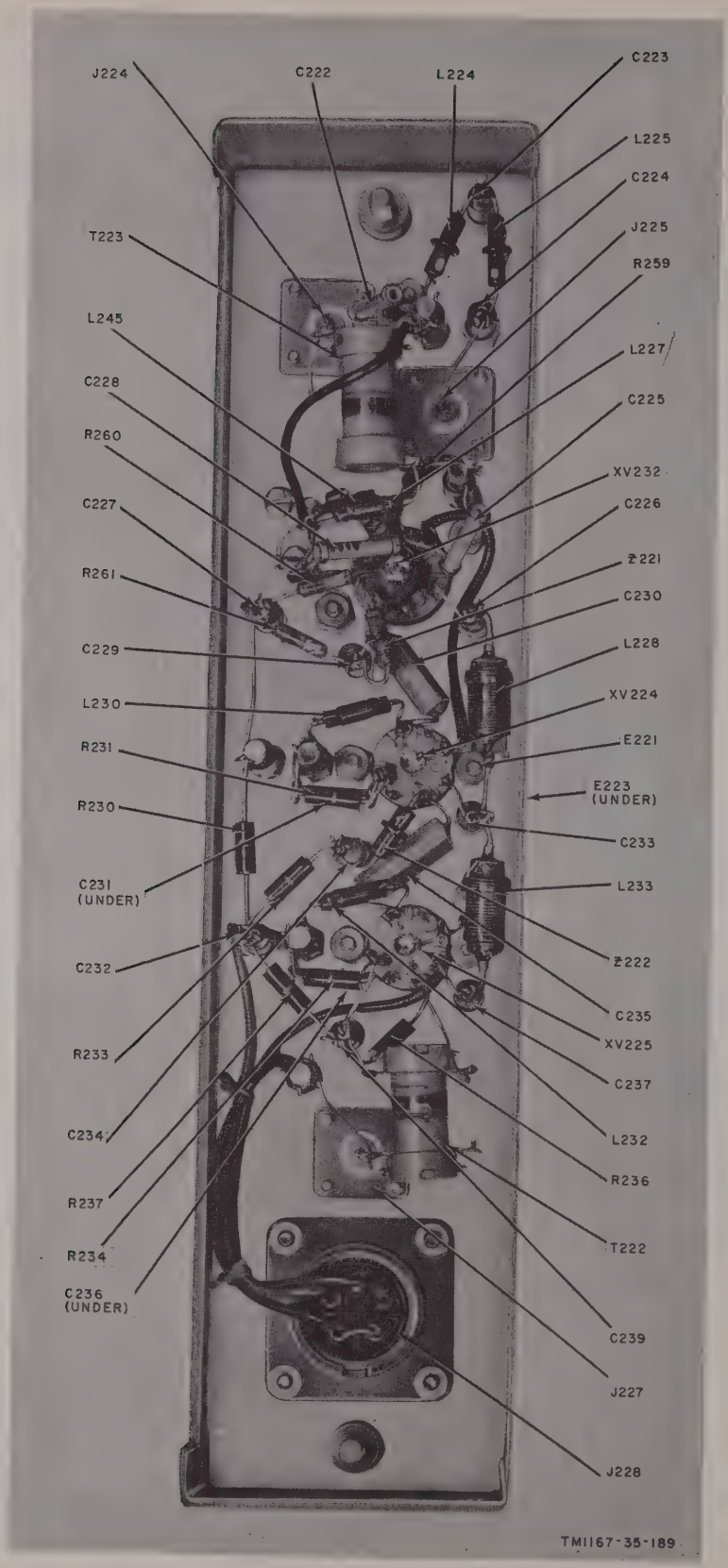


Figure 127. Signal IF preamplifier U221, under chassis view.

b. Receiving System Controls and Adjustments Located in Signal Comparator CM–36/TPS–1D.

Controls and adjustments	Location (fig.)	Function
I.F. AMPL. LEVEL R2350	129	Controls the overall gain of the signal IF amplifier by applying a variable negative bias to the first and third signal IF amplifier stages (V301 and V303). Correct setting of this control is indicated by a red-line reading on TEST METER M2350 with TEST SELECTOR switch S2353 in the (1) I.F. AMPL. LEVEL position (par. 290) with transmitter not radiating.
COHO LEVEL R2351	129	Adjusts the output amplitude of coherent oscillator V353 by varying the screen grid potential of V353. Correct adjustment should be a red-line reading on TEST METER M2350 with TEST SELECTOR switch S2353 in the (2) COHO LEVEL position (par. 291).
COHO SYNC R2355	129	Adjusts the amount of 60-mc coho sync signal applied to coherent oscillator V353 by varying the fixed cathode bias on the first coho IF amplifier V350. This adjustment should be made by using test equipment (par. 291).
Coho tuning adjustment C361	131	Tunes the frequency of coho IF amplifier V352 to coincide with the incoming 60-mc IF. This adjustment must be made by using test equipment (par. 291).
60-mc IF tuning adjustment C305	131	Selects an operating frequency within the passband of the signal IF amplifier that produces the best receiver performance. This adjustment should be made by using test equipment as outlined in paragraph 290.

c. Receiving System Controls and Adjustments Located in Azimuth-Range Indicator IP–141/TPS–1D.

Controls and adjustments	Location (fig.)	Function
RECEIVER GAIN control R608	149	Controls the gain of the signal IF amplifier when OPERATION SELECTOR switch S2354 is in the REMOTE position and when OPERATION switch S601 is in the NORM position.
L.O. MOTOR switch S613	149	Controls the direction of rotation of local oscillator tuning motor B502.

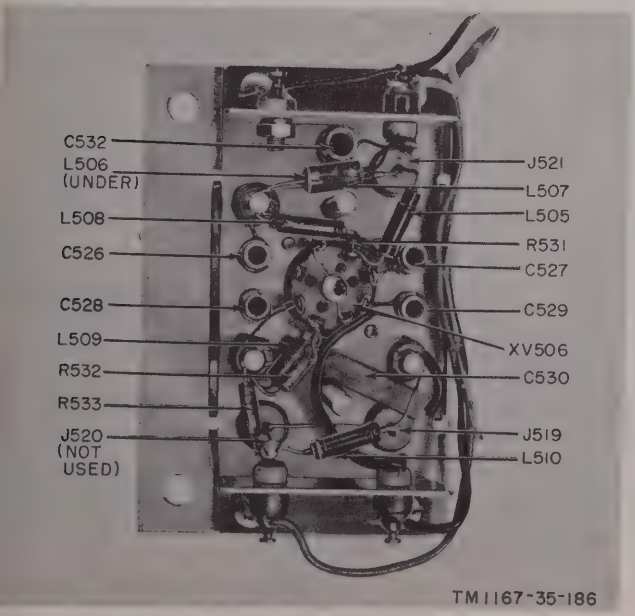


Figure 128. Coho preamplifier U502, under chassis view.

271. Receiving System Fuses

There are no fuses which protect circuits only in the receiving system. All fuses and interlocks are considered parts of the power distribution system. Refer to paragraph 207 for a listing of their locations and ratings, and the circuits they protect.

272. Normal Readings of Receiving System Panel Meters

a. Radar Receiver-Transmitter RT–212/TPS–1D. Meter M501 (fig. 102) indicates signal crystal mixer CR503 and coho crystal mixer CR502 current. Normal reading in both COHO and SIG position of TEST SELECTOR switch S506 is on the red line.

b. Azimuth-Range Indicator IP–141/TPS–1D. COHO MIXER (TUNING METER)

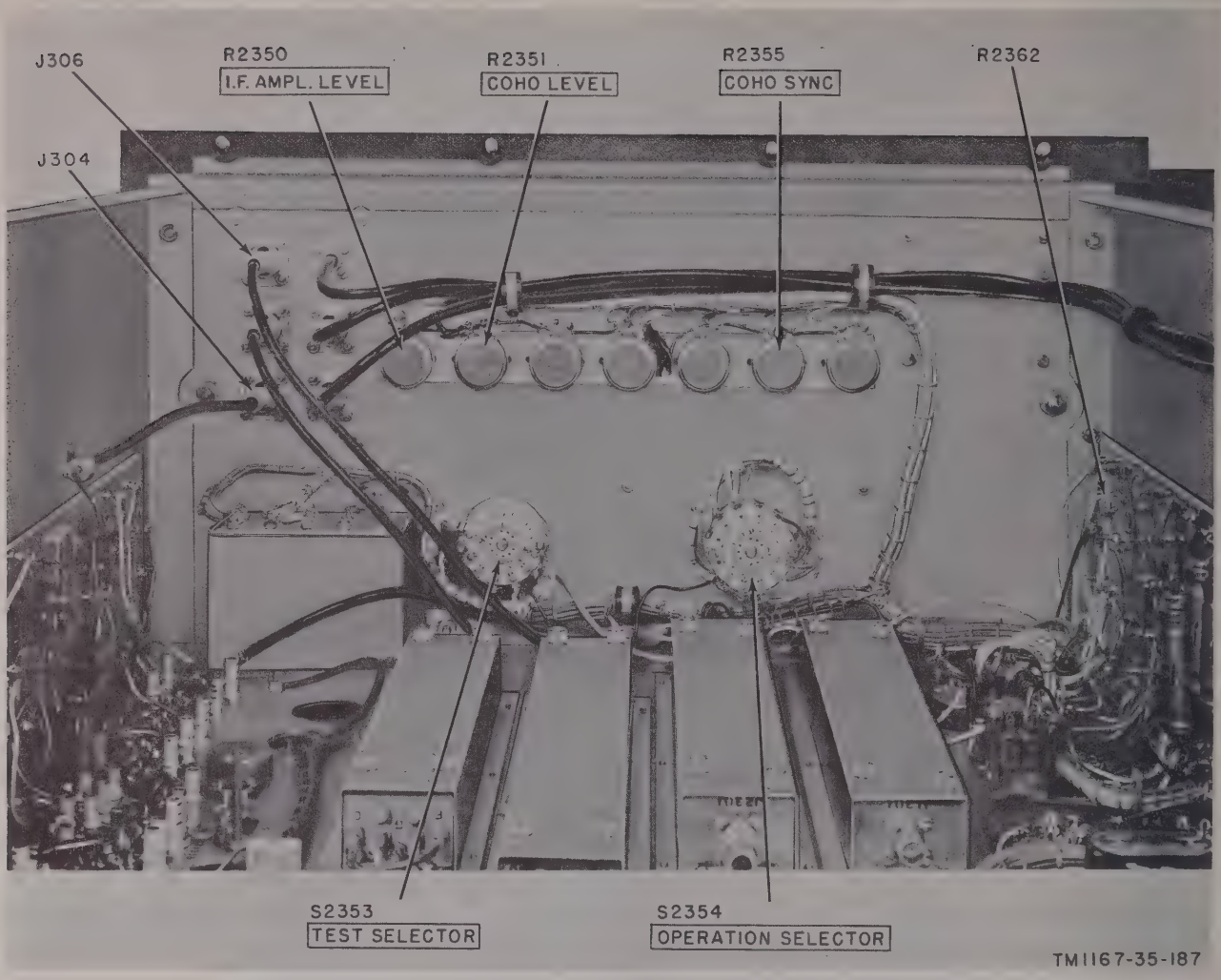


Figure 129. Signal Comparator CM–36/TPS–1D, front under chassis view.

M601 (fig. 153) indicates coho crystal mixer CR502 current. Normal reading is on the red line.

c. Signal Comparator CM–36/TPS–1D. TEST METER M2350 (fig. 140) indicates IF amplifier output level when TEST SELECTOR switch S2353 is in position (1) I.F. AMPL. LEVEL. It also indicates coherent oscillator output amplitude when S2353 is in position (2) COHO LEVEL. Normal reading for both positions of S2353 is on the red line.

273. Normal Indications at Receiving System Test Points

Test points TP501 and TP502 (fig. 125) are used to test the local oscillator filament current. With the negative lead of a dc voltmeter in TP501 and the positive lead in TP502 the meter should indicate 6.3 volts dc ±10 percent.

274. Dc Resistance of Inductive Components in Receiving System

The following chart lists the transformers, coils, and relays, location, and gives the dc resistance of each winding.

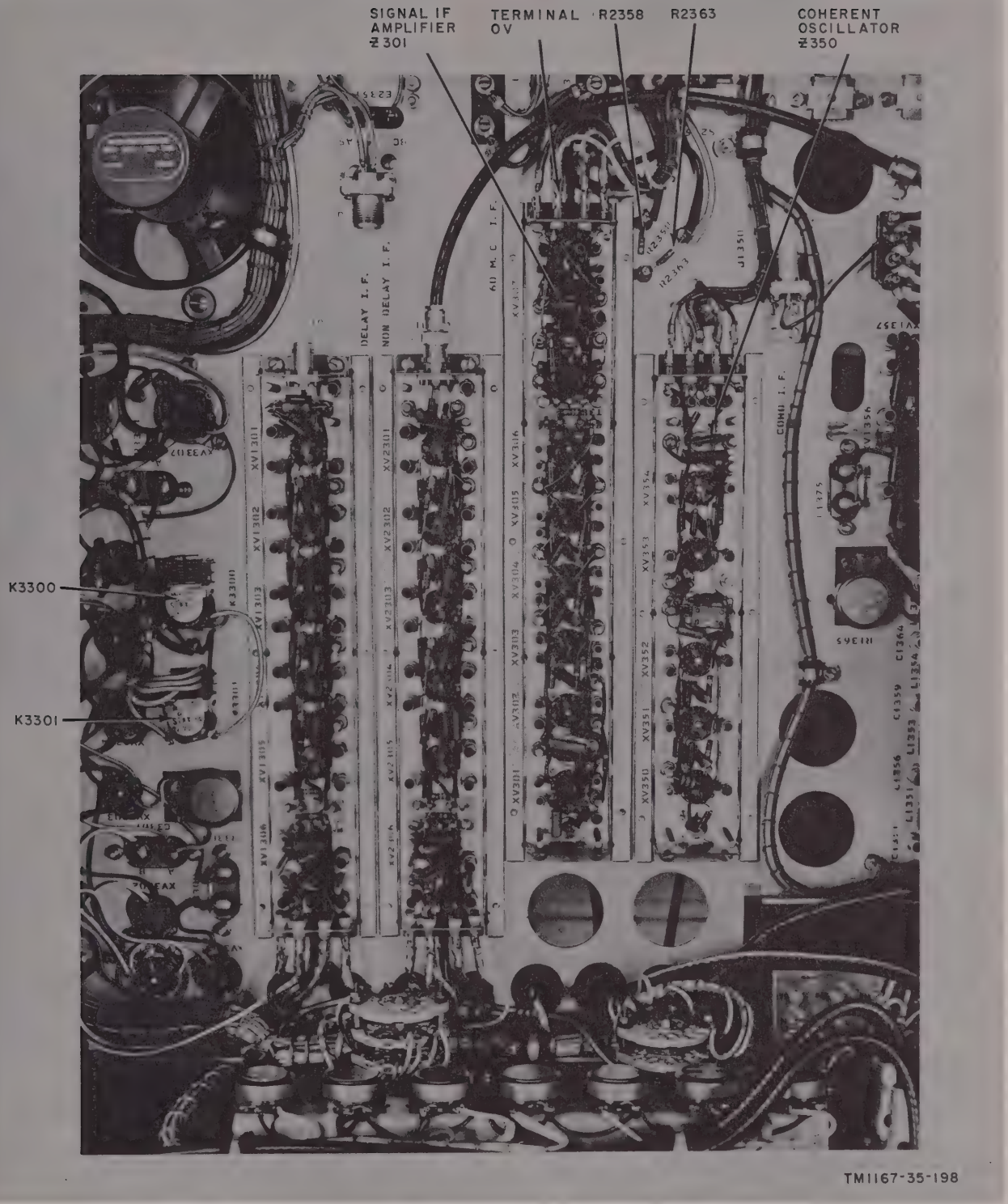


Figure 130. Signal Comparator CM–36/TPS–1D, full under chassis view.

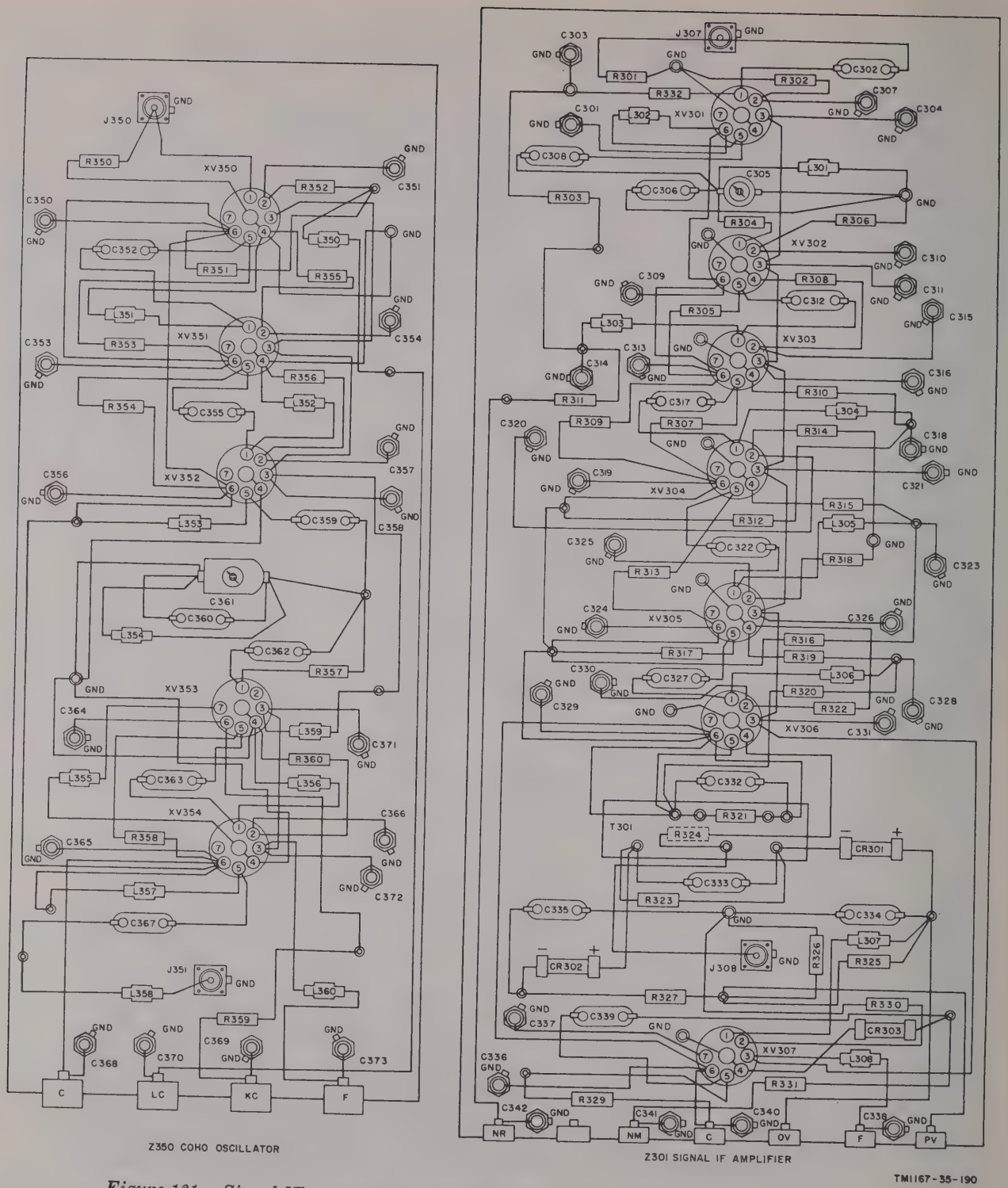


Figure 131. Signal IF amplifier Z301 and coherent oscillator Z350, parts location diagram.

Transformer, coil, or relay	Location (fig.)	Terminals	Dc resistance (ohms)
K3301	130		425.
L224, L225, L227, L228, L230, L232, L233, L245.	127		Less than 1.
L301 through L306	131		Less than 1.
L307	131		4.2.
L308	131		Less than 1.
L350 through L360	131		Less than 1.
L501	125		Less than 1.
L504	123		300.
L505, L506	128		Less than 1.
L507	128		1.
L508	128		Less than 1.
L509	128		1.
L510	128		Less than 1.
T222, T223	127	1–2	Less than 1.
		3–4	Less than 1.
T301	131	Pri	Less than 1.
		Sec	Less than 1.
T503	125	1–2	3.8.
		3–4	Less than 1.
Z221, Z222	127		Less than 1.
Z505, Z506	124		Less than 1.

Section II. TROUBLESHOOTING CHARTS

275. General

Two troubleshooting charts are provided to assist in isolating a trouble that has been sectionalized to the receiving system. If you are not sure the trouble is in the receiving system, use the troubleshooting chart based on starting procedure (par. 210) to sectionalize the trouble to a system. Then, if the trouble *is* in the receiving system, the troubleshooting chart based on starting procedure will localize the trouble to either the receiver-transmitter or the signal comparator.

a. Symptom Troubleshooting (par. 278). Troubles can usually be isolated most rapidly by following a procedure based on symptoms. Some of the symptoms shown as having a probable cause in the receiving system could be caused by a trouble in the signal comparing system (ch. 15). If the trouble cannot be isolated by using the symptoms chart, use the troubleshooting chart based on starting procedure (par. 210) to sectionalize the trouble to a particular system. To troubleshoot the receiving system based on symptoms proceed as follows:

(1) Observe the indications obtained on test meter M501 on the front panel of the receiver-transmitter, on TEST METER M2350 on the signal comparator, and on the ppi- and A-scope.

(2) Compare the indications obtained with those listed in the *Symptoms* column.

(3) If the indications obtained correspond to those listed, follow the procedure given in the *Corrective measures* column to isolate the trouble.

(4) If the trouble cannot be isolated by symptom troubleshooting and it has been definitely established the trouble is in the receiving system refer to the step-by-step troubleshooting chart.

b. Step-by-Step Troubleshooting Chart (par. 279). The receiving system step-by-step troubleshooting chart consists of a series of steps designed to evaluate the overall operation of the receiving system. Use this chart when trouble cannot be isolated by symptom troubleshooting (*a* above). To troubleshoot the receiving system using the step-by-step troubleshooting chart proceed as follows:

(1) Locate the test point given in step 1.

(2) Connect the test equipment and set the controls on the test equipment as directed in the *Test equipment* column.

(3) Set the controls on radar set as directed in the *Radar set controls* column.

(4) Compare the indications obtained on the test equipment with the indications that are 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 *Corrective measures* column.

(6) If the indications obtained are abnormal, proceed as directed in the *Corrective measures* column.

276. Test Equipment Required To Troubleshoot Receiving System

The following items of test equipment are required to troubleshoot the receiving system.

Test equipment	Common name	Reference
Signal Generator AN/URM–64.	Uhf signal generator.	TM 11–5553
Signal Generator TS–452C/U.	Sweep frequency generator.	TM 11–2695
Multimeter TS–352B/U, or ME–77/U.	Multimeter	TM 11–5527
Electronic Multimeter TS–505C/U.	Vtvm	TM 11–5571
Crystal Rectifier Test Set TS–268E/U.	Crystal checker	TM 11–1242
Electron Tube Test Set TV–7B/U.	Tube tester	TM 11–5083
Tube Socket Adapter Kit.	Tube socket adapter kit.	Literature packed with equipment.
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	TM 11–5103 TM 11–5129
Outlet Box J–45/MPM–1.	Outlet box	TM 11–1080A

277. Preparation of System Components for Troubleshooting

a. General. The units which contain receiving system components are Radar Receiver-Transmitter RT–212/TPS–1D and Signal Comparator CM–36/TPS–1D. Before preparing these units for troubleshooting compare the symptoms of the trouble with the symptoms contained in the symptom troubleshoting chart.

b. Radar Receiver-Transmitter RT–212/TPS–1D. To make the receiver-transmitter accessible for troubleshooting—

(1) Disconnect all cables from the front panel of the receiver-transmitter.

(2) Release the eight captive screws on the front panel of the unit and remove the chassis from its dust cover.

(3) Place the chassis at a suitable level or workbench close enough and connect P508 to J508 on the front panel.

(4) Defeat interlock switch S504 (par. 207*b*).

Warning: Do not press the RADIATE ON button while the unit is connected in this manner.

c. Signal Comparator CM–36/TPS–1D. To make the signal comparator accessible for troubleshooting—

(1) Disconnect all cables from the front panel of the signal comparator.

(2) Release the eight captive screws on the front panel of the unit and remove the chassis from its dust cover.

(3) Disconnect the leads going to the delay line under the chassis.

(4) Place the chassis at a suitable level or on workbench close enough to connect P301 to J301.

278. Receiving System Symptom Troubleshooting Chart

Symptom	Probable cause	Corrective measures
1. Crystal current reading on meter M501 is low or zero on both SIG and COHO positions of TEST SELECTOR switch S506.	Local Oscillator V505 weak or not oscillating. Improper crystal coupling adjustments.	*a.* Check V505 and make voltage and resistance measurements at the socket of V505 (fig. 211). *b.* Make crystal coupling adjustments (par. 288).
2. Crystal current reading on meter M501 is low or zero in the SIG position of the TEST SELECTOR switch but red-lined in the COHO position.	Improper signal mixer coupling adjustment, CR503, cables W502, W503, and W504.	Adjust signal mixer coupling (par. 288); check CR503; measure continuity of cables W502, W503, W504, and the cable from J225 to S506.
3. Crystal current reading on meter M501 is low or zero in the COHO position of the TEST SELECTOR switch but red-lined in the SIG position.	Improper coho mixer coupling adjustment, CR502, cables W507, L507.	Adjust coho mixer coupling (par. 288). Check CR502, measure continuity of cables W507, L507, and wiring from L507 to switch S506.

Symptom	Probable cause	Corrective measures
4. No video on indicators. Grass level on A-scope is normal. Signal and coho crystal currents normal.	Local oscillator off frequency----	Tune the local oscillator for echoes using L.O. MOTOR switch on the front panel of the indicator.
5. Local oscillator tuning motor does not operate. (Operation is indicated by increased grass level on A-scope while motor is running.)	Tuning motor B502 or associated circuit.	Check B502, R518, R519, C519, S502, S503, S613.
6. Red-line reading cannot be obtained on TEST METER M2350 with TEST SELECTOR switch S2353 in position (1) I.F. AMPL. LEVEL. Weak or no targets on indicator in normal or mti operation.	Faulty stage in the signal IF amplifier or preamplifier.	*a.* Check V232, V224, and V225. Check the gain of the signal IF preamplifier (par. 296*b*). (1) If normal proceed to step *b* below. (2) If abnormal: (*a*) Leave the sweep frequency generator output connected to the preamplifier as in the gain of *a* above. (*b*) Plug the 7-pin miniature tube socket adapter in the socket of V224 and plug V224 into the socket adapter. (*c*) Cut out all but 3 db of attenuation on the sweep frequency generator. (*d*) Using the traveling detector probe, check the waveform at pin 1 of the tube socket adapter. It should be essentially that of B in figure 213. *1.* If normal proceed to (*e*) below. *2.* If abnormal check stage V232, C230 and L230 (fig. 211). (*e*) Plug the 7-pin tube socket adapter into socket V225 and plug V225 into the socket adapter. (*f*) Cut in 32-db attenuation into the sweep frequency generator and check the waveform at pin 1 of the socket adapter. It should be essentially that of B in figure 213. *1.* If normal proceed to (*g*) below. *2.* If abnormal, check stages V224, C235, and L232 (fig. 211). (*g*) Cut in 44-db attenuation into the sweep frequency generator and check the waveform at pin 5 of the tube socket adapter. It should be essentially that of B in figure 213. *1.* If normal proceed to (*h*) below. *2.* If abnormal, take voltage and resistance measurements at the socket of V225 (fig. 211). (*h*) Check T222 and continuity between the secondary of T222 and J507. *b.* Check V301 through V306. Check the gain of the signal IF amplifier (par. 298*b*). (1) If normal: (*a*) Check cable W5 from J507 to J306. (*b*) Check cable from J306 to J307. (2) If abnormal: (*a*) Leave the sweep frequency generator output connected to the amplifier as in the gain test. (*b*) Follow the procedure outlined in the step-by-step troubleshooting chart (par. 279, step 18 through step 24).

Symptom	Probable cause	Corrective measures
7. Red-line reading cannot be obtained on TEST METER M2350 with TEST SELECTOR switch S2353 in position (1), I.F. AMPL. LEVEL position. Targets on indicator are normal.	Faulty stages V307, S2353, TEST METER M2350, CR303.	*a.* Turn TEST SELECTOR switch to (2) COHO LEVEL and OPERATION SELECTOR switch to COHO ADJUST and check for a reading on TEST METER M2350. (1) If a reading is obtained, proceed to *b* below. (2) If no reading is obtained, check TEST METER M2350. *b.* Check V307 and then take voltage and resistance measurements at the socket of V307 (fig. 215). *c.* Check OPERATION SELECTOR switch contacts, check continuity between terminal NM on the signal IF amplifier subchassis and TEST SELECTOR switch S2353. *d.* Check CR303, R331, and C341.
8. Red-line reading not obtained on TEST METER M2350 in the (2) COHO LEVEL position of TEST SELECTOR switch S2353. Weak or no targets present on indicators in mti operation. Targets normal in normal operation.	Faulty stage V353 or V354	Place OPERATION SELECTOR switch in the COHO ADJUST position on the signal comparator. *a.* Check V353 and V354. *b.* Turn the COHO LEVEL control fully clockwise and take voltage and resistance measurements at the socket of V353 (fig. 216). (1) Variations from the voltage and resistance chart of figure 216 are: (*a*) Pin 6 V = +150 R = 8,500 ohms (*b*) Pin 5 V = +130. *c.* Take voltage and resistance measurements at the socket of V354 (fig. 216). *d.* Check continuity of L358 and of the cable between J351 and J308.
9. No cancellation of fixed targets in mti operation. All adjustments and meter readings are normal.	Faulty coho preamplifier, coho IF stages V350, V351, or V352.	*a.* Check V506. Check the gain of the coho preamplifier (par. 297*b*). (1) If normal proceed to *b* below. (2) If abnormal: (*a*) Take voltage and resistance measurements at the socket of V506 (fig. 211). (*b*) Check continuity of L505, L506, L510, and the cable between J519 and J503. *b.* Check V350, V351, V352, V353, and V354. Check the gain of coherent oscillator Z350 (par. 299*b*). (1) If normal: (*a*) Check cable W6 from J503 to J304. (*b*) Check cable from J304 to J350. (2) If abnormal: (*a*) Leave the sweep frequency generator output connected to the coherent oscillator as in the gain test of *b* below. (*b*) Follow the procedure outlined in the step-by-step troubleshooting chart (par. 279, step 13 through step 16).

279. Receiving System Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1	P228 Terminal C (fig. 123).	Set the multimeter controls to measure 6.3 volts ac.	Turn the POWER switch S602 to ON.	6.3 volts ac	Check T503. Troubleshoot the ac power distribution system (par. 210, step 3).
2	P228 Terminal E (fig. 123).	Set the multimeter controls to measure +150 volts dc.		+150 volts dc	Troubleshoot the +150-volt power supply (par. 420, step 6).
3	Terminal 7A1 of E502 (fig. 123).	Set the multimeter controls to measure −150 volts dc.		−150 volts dc	Troubleshoot the −150-volt power supply (par. 420, step 3).
4	Terminal 4A of E502 (fig. 123).	Set the multimeter controls to measure +300 volts dc.		+300 volts dc	Check L504. Troubleshoot the +300-volt power supply (par. 420, step 5).
5	TP 502 (fig. 125).	Set the multimeter controls to measure +27 volts dc.		+27 volts dc	Troubleshoot the +27-volt dc power supply (par. 420, step 7).
6	M501 (fig. 125)	Check the reading on M501.	Turn TEST SELECTOR switch S506 to the SIG position then to the COHO position.	Red-line readings	*a.* If no reading in either SIG or COHO position of the TEST SELECTOR switch check voltage and resistance measurements at the socket of V505 (fig. 211). Check meter M501 and switch S506. *b.* If normal reading is obtained at the COHO position of the TEST SELECTOR switch but not at the SIG position check CR503 and its couplings, W504, W503, RF503A, W502, check primary winding of T223, L224, L225, R510, and the cable from J225 to S506. *c.* If normal reading is obtained at the SIG position of the TEST SELECTOR switch but not at the COHO position, check W501, CR502 and its couplings, RF502, W507, L507, L506, L505, L508, R450 (fig. 177), and continuity from terminal 62 on coho preamplifier U502 to S506.
7	J503 (fig. 124)	Set up the sweep frequency generator for gain testing the coho preamplifier (par. 297*b*).	TEST SELECTOR switch S506 in OFF position.	Waveform (A, fig. 213) 5 squares in amplitude.	Check V506. Take voltage and resistance measurements at the socket of V506. Check L510, L505, L506, L508, C527, C528 and C530.
8	Pin 1 of V224 (fig. 127).	Set up the sweep frequency generator for gain testing the signal IF preamplifier (par. 296*b*). Steps (1) through (5). Set in 3 db of attenuation on the sweep frequency generator. Use the traveling detector probe to check waveform.		Waveform 5 squares in amplitude.	Check V232. Take voltage and resistance measurements at the socket of V232 and pin 1 of V224 (fig. 211). Check the secondary of T223, L245, L227, C228, C229, and C230.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
9	Pin 1 of V225 (fig. 127).	Same as step 8 except use 32 db of attenuation.	----------	Waveform 5 squares in amplitude.	Check V224. Take voltage and resistance measurements at the socket of V224 and pin 1 of V225. Check C231, C234, and C235 (fig. 211).
10	Pin 5 of V225 (fig. 127).	Same as step 8 except use 44 db of attenuation.	----------	Waveform (B, fig. 213) 5 squares in amplitude.	Check V225. Take voltage and resistance measurements at the socket of V225. Check V236 and C239 (fig. 211).
11	J507 (fig. 124)---	Same as step 8 except use 57 db of attenuation.	----------	Same as step 10-----	Check T222 and cable between J227 and J507.
12	TEST METER M2350 (fig. 140).	Check reading on TEST METER M2350.	Turn TEST SELECTOR switch S2353 to (1) I.F. AMPL. LEVEL and OPERATION SELECTOR switch S2354 to NORMAL and check reading on the TEST METER. Turn the TEST SELECTOR switch to (2) COHO LEVEL and the OPERATION SELECTOR switch to COHO ADJUST and check the reading on the TEST METER.	Red-line reading-----	*a.* If both readings are normal proceed to step 13. *b.* If abnormal in (1) I.F. AMPL. LEVEL and normal in (2) COHO LEVEL proceed to step 17. *c.* If abnormal in (2) COHO LEVEL and normal in (1) I.F. AMPL. LEVEL proceed to step 15. *d.* If abnormal in both positions of the TEST SELECTOR switch: (1) Check filament voltage at terminal 3 of T2350 (fig. 140). (2) Check the +150-volt dc input at terminal C of Z2351 (fig. 140). (3) Check CR301, CR302, secondary of T301, R325, R326, R327, and M2350.
13	Pin 1 of V351 (fig. 131).	Set up the sweep frequency generator for gain testing coherent oscillator Z350 (par. 299, steps (1) through (7), disregard step (5)). Cutout all attenuation on the sweep frequency generator. Use the traveling detector probe to check waveform.	OPERATION SELECTOR switch at NORMAL position. COHO SYNC control R–2355 in maximum clockwise position.	Waveform 1 square in amplitude at 60 mc.	*a.* Check V350. Take voltage and resistance measurements at the tube socket of V350 and pin 1 of V351 (fig. 216). *b.* Check R351, C351, and R2355.
14	Pin 1 of V352 (fig. 131).	Same as step 13 except use 6 db of attenuation.	Same as step 13-----	Waveform 5 squares in amplitude.	*a.* Check V351. Take voltage and resistance measurements at the tube socket of V351 and pin 1 of V352 (fig. 216). *b.* Check C354.
15	Pin 1 of V353 (fig. 131).	Same as step 13 except use 27 db of attenuation.	Same as step 13-----	Waveform 5 squares in amplitude.	*a.* Check V352. Take voltage and resistance measurements at the tube socket of V352 (fig. 216). *b.* Check C357.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
16	J351 (fig. 131)	Same as step 13 except use 37 db of attenuation.	Same as step 13	Waveform 5 squares in amplitude.	*a.* If abnormal, check V354: (1) Take voltage and resistance measurements at the tube socket of V354 (fig. 216). (2) Check C366, C367, and L358. *b.* If normal, turn the OPERATION SELECTOR switch to (2) COHO ADJUST position. (1) Check V353. Check voltage and resistance measurements at the socket of V353 (fig. 216). (2) Check C360, C361, C362, C364, R2358, and R2363. (3) Check cable from J351 to J308.
17	Pin 1 of V303 (fig. 131).	Set multimeter controls to measure −50 volts dc.	I.F. AMPL. LEVEL control R2350 fully counterclockwise. OPERATION SELECTOR switch S2354 in NORMAL.	−10 volts dc	*a.* Check R2362, R2350, R311, C303, C314, C342, and relay K3301. *b.* Check the −150-volt dc power supply (par. 420, step 3).
18	Pin 1 of V302 (fig. 131).	Set up the sweep frequency generator for gain testing signal IF amplifier Z301 (par. 298*b*) (1) through (8), disregard (6)). Cutout all attenuation on the sweep frequency generator. Use the traveling detector probe to check the waveform.	TEST SELECTOR switch in (1) I.F. AMPL. LEVEL position. OPERATION SELECTOR switch in NORMAL position. I.F. AMPL. LEVEL control maximum clockwise.	Waveform 1 square in amplitude.	*a.* Check V301. Take voltage and resistance measurements at the tube socket of V301 and pin 1 of V302 (fig. 215). *b.* Check R301, C305, C306, C307, C308, and M2350 (fig. 140).
19	Pin 1 of V303 (fig. 131).	Same as step 18 except use 12 db of attenuation.	----------	Waveform 5 squares in amplitude.	*a.* Check V302. Take voltage and resistance measurements at the tube socket of V302 and pin 1 of V303 (fig. 215). *b.* Check C310 and C312.
20	Pin 1 of V304 (fig. 131).	Same as step 18 except use 30 db of attenuation.	----------	Waveform 5 squares in amplitude.	*a.* Check V303. Take voltage and resistance measurements at the tube socket of V303 and pin 1 of V304 (fig. 215). *b.* Check C315 and C317.
21	Pin 1 of V305 (fig. 131).	Same as step 18 except use 42 db of attenuation.	----------	Waveform 5 squares in amplitude.	*a.* Check V304. Check voltage and resistance measurements at the tube socket of V304 and pin 1 of V305 (fig. 215). *b.* Check C318, C320 and C322.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
22	Pin 1 of V306 (fig. 131).	Same as step 18 except use 56 db of attenuation.	----------	Waveform 5 squares in amplitude.	*a.* Check V305. Take voltage and resistance measurements at the tube socket of V305 and pin 1 of V306 (fig. 215). *b.* Check C323, C325, and C327.
23	Pin 5 of V306 (fig. 131).	Same as step 18 except use 70 db of attenuation.	----------	Waveform 5 squares in amplitude.	*a.* Check V306. Take voltage and resistance measurements at the tube socket of V306 (fig. 215). *b.* Check C328, C330, and C332.
24	Terminal junction of terminal OV and R2358 (fig. 130).	Connect the alligator clip of the special test lead (fig. 136) to the test point. Connect the special 5-foot coaxial cable (fig. 136) to the input of the sweep frequency generator and to the UG–290/U connector of the special test lead. Insert 87 db of attenuation into the sweep frequency generator.	----------	Waveform (A, fig. 213) 5 squares in amplitude.	*a.* If abnormal, check T301, R323, R325, R326, R327, C333, C334, C335, CR301, and CR302. *b.* If normal, check V307: (1) Take voltage and resistance measurements at the socket of V307 (fig. 215). (2) Check C337, C339, C-341, R331, and CR–303.

Section III. REMOVAL AND REPLACEMENT OF PARTS

280. General

a. The receiving system parts are located in Radar Receiver-Transmitter RT–212/TPS–1D, Signal Comparator CM–36/TPS–1D, and Azimuth-Range Indicator IP–141/TPS–1D. The removal and replacement of tubes and crystal mixers are covered in TM 11–1167–20. Paragraphs 281 through 284 cover the removal and replacement of all other receiver parts.

b. When replacing parts in any of the receiver subchassis which carry a 60-mc frequency care must be taken to replace the part with one that is identical both electrically and physically. Leads must be placed as near to the original placement as possible. If these precautions are not observed, the amplifier may be detuned which would result in a serious loss of efficiency.

Warning: Extremely dangerous voltages exist in each of the units that house the receiving system components. When removing and replacing parts in these units, be sure that all power has been removed and that high voltage capacitors have been discharged with a shorting bar. Heed the high voltage warning plates in each unit.

c. When replacing cable W502 in the receiver-transmitter, care must be taken to replace it with a cable length identical to the original one.

281. Signal IF Preamplifier Subchassis U221

The signal IF preamplifier parts are made accessible by removing preamplifier subchassis U221. This subchassis is located in the receiver-transmitter (fig. 124). Parts location and identification are shown in figure 127.

a. Removal.

(1) Remove the three coaxial cables from their associated jacks on the subchassis.
(2) Remove power cable connector P228.
(3) Loosen the knurled captive nut at each end of the subchassis.
(4) Remove the subchassis from the unit.

b. Replacement.

(1) Place the subchassis in position and tighten the knurled captive nuts evenly.

(2) Connect power cable connector P228 to J228.

(3) Connect coaxial cable plugs P224, P225 and P227 to J224, J225, and J227 respectively.

282. Coho Preamplifier Subchassis U502

The coho preamplifier subchassis is mounted at the lower right front of the receiver-transmitter (fig. 124). Parts location and identification are shown in figure 128. Parts can be exposed by removing the two machine screws from the subchassis and dropping it as far as the leads permit. If it becomes necessary to completely remove the subchassis follow the procedure below:

a. Complete Removal of U502.

(1) Remove the terminal identification plate from terminal board E502 (fig. 123). Note its orientation so that it may be replaced properly.

(2) Trace the four power leads from the preamplifier subchassis to E502.

(3) Loosen, remove, and tag the spade lugs of the four power leads and remove the leads.

(4) Remove the two coaxial leads from their jacks on the subchassis.

(5) Remove the coho preamplifier subchassis.

b. Replacement of U502.

(1) Connect the four power leads to the proper terminals of terminal strip E502 as marked.

(2) Replace the terminal identification plate of E502.

(3) Replace the subchassis and secure it with the two machine screws.

(4) Replace coaxial plugs P519 and P521 to J519 and J521 respectively.

283. Local Oscillator Assembly U501

The local oscillator assembly is located on the lower-right side of the receiver-transmitter (fig. 124).

a. Removal.

(1) Remove the four hexagonal nuts located on the shock mounts in each corner of the assembly.

(2) Remove the two coaxial cables from J517 and J518.

(3) Remove the terminal identification plate on E502 (fig. 123).

Note. Observe the placement of the terminal identification plate on E502 so that it may be replaced properly.

(4) Loosen the screws that hold the spade lug connectors of the local oscillator assembly power leads, and tag the leads.

(5) Remove the local oscillator assembly.

b. Replacement.

(1) Replace the spade lug connectors on the proper terminals of E502 as marked.

(2) Replace the terminal identification plate on E502 with the two mounting screws.

(3) Replace coaxial cable plugs P517 and P518 to J517 and J518 respectively.

(4) Replace the local oscillator assembly, placing the four shock mounts over the chassis screw posts and secure them with four hexagonal nuts.

284. Removal and Replacement of L501, C503, and T503

L501, C503, and T503 are located on the top side of the receiver-transmitter directly above the local oscillator assembly (fig. 125). Access for removal and replacement is obtained by removing the local oscillator assembly (par. 283).

285. Removal and Replacement of Parts on Signal IF Amplifier and Coho Subchassis

a. The signal IF amplifier and coho subchassis are located in Signal Comparator CM–36/TPS–1D (fig. 130). To reach these parts, loosen the knurled captive nuts on the covers on the underside of the subchassis and remove the covers.

b. Parts location and identification are shown on figures 130 and 131. When replacing parts on these subchassis be sure to follow the precautions given in paragraph 280*b*.

286. General

a. This section covers the alinement and adjustment of the receiving system when the components of the radar set are interconnected. Alinement and adjustment procedures for receiving system components in Radar Receiver-Transmitter RT–212/TPS–1D when bench servicing are contained in paragraph 304.

b. Before making receiver adjustments and alinements make certain that the RF system is properly alined. RF system mechanical adjustments and alinements are described in paragraph 13, TM 11–1167–20. The following adjustments and alinements are given in this section:

(1) Coupling adjustment of coho mixer RF502 and signal mixer RF503A (par. 288).
(2) Alinement of local oscillator V505 (par. 289).
(3) Alinement of signal IF amplifier (par. 290).
(4) Alinement of coherent oscillator Z350 (par. 291).

c. Before performing any of the procedures in paragraphs 288 through 291, check the +150-volt dc and +300-volt dc outputs of the dc power supply system. Adjustment of the +150-volt dc supply is outlined in paragraph 427. Adjustment of the +300-volt dc supply is outlined in paragraph 428.

287. Test Equipment Required to Aline Receiving System

The following test equipment is required to aline the receiving system.

Test equipment	Common name	Technical manuals
Adapter UG274/U (part of AN/USM–24C).	T-connector	11–5103
Test Set TS–172A/UP	Echo box	11–1262
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103, 11–5129
Signal Generator AN/URM–64.	Uhf signal generator.	11–5553
Signal Generator TS–452C/U	Sweep frequency generator.	11–2695

288. Coupling Adjustment of Coho Mixer RF502 and Signal Mixer RF503A

a. General. Coupling of the local oscillator output to the signal and coho mixers is made adjustable to obtain the correct signal to local oscillator voltage mixing ratio. This is done so that the crystal mixers operate in a linear region of their characteristic curve and provide the best signal-to-noise ratio. The following procedure is necessary only if a red-line reading of ±10 percent is not obtained on test meter M501 in the SIG and COHO positions of the TEST SELECTOR switch located on the front panel of the receiver-transmitter.

b. Procedure. To adjust the coho and signal crystal mixer coupling proceed as follows:

(1) Loosen the knurled captive thumbscrews on the front panel of the receiver-transmitter and pull the unit out of its case as far as the stops will allow.
(2) Open the hinged access door beneath the unit by loosening the Dzus fasteners.
(3) Close interlock switch S504 (fig. 125) and turn the radar set on.
(4) Allow the set to warm up for at least 10 minutes. *Do not press the RADIATE ON button.*

Warning: Dangerous voltages are present in this unit.

(5) Set the TEST SELECTOR switch on the receiver-transmitter to the COHO position.
(6) Loosen the knurled locknut which locks the coupling adjustment on the coho mixer assembly (fig. 123).
(7) Turn the coho mixer coupling adjustment thumbscrew for a red-line reading on the front panel test meter.
(8) Tighten the knurled locknut to lock the adjustment.
(9) Set the TEST SELECTOR switch on the receiver-transmitter to the SIG position.
(10) Loosen the knurled locknut which locks the coupling adjustment on the signal mixer assembly.
(11) Turn the signal mixer coupling adjustment thumbscrew for a red-line reading on the front panel test meter.

(12) Tighten the knurled locknut to lock the adjustment.
(13) Turn the main power switch off.
(14) Secure the receiver-transmitter.

289. Alinement of Local Oscillator V505

a. General. The local oscillator is an ultra-high frequency oscillator which tunes over the range of 1,265 mc to 1,420 mc. Its output is fed to the signal and coho crystal mixers where it is heterodyned with the received RF signal and produces a 60-mc IF output. The following adjustment is necessary only if the local oscillator tube has been replaced or repairs made to the local oscillator assembly. This adjustment is confined to tuning the cathode resonant circuit with five tuning paddles which change the path of the magnetic field in the cathode cavity of the local oscillator circuit.

b. Procedure. To adjust the local oscillator proceed as follows:

(1) Remove all cables from the front panel of the receiver-transmitter, pull the unit out of its case and place the unit on its side.
(2) Reconnect the power input cable plug P508 to J508.
(3) Remove the bottom cover from the unit by loosening the Dzus fasteners and disable interlock switch S504 (par. 207*b*).
(4) Turn on the radar set and allow a 20-minute warmup period. *Do not press the RADIATE ON button.*
(5) Disconnect P514 from J514 (fig. 124) and connect the **T**-connector to J514 (fig. 132).
(6) Connect P514 to the **T**-connector.
(7) Adjust the signal mixer coupling adjustment (fig. 123) for a red-line reading on test meter M501.
(8) Connect the RF output cable of the uhf signal generator to the open end of the **T**-connector.
(9) Disconnect P512 from J512 (fig. 123).
(10) Set the output of the uhf signal generator for a cw signal at 1,345 mc and the output amplitude to maximum.
(11) Connect the vertical input of the oscilloscope to J512 and place the oscilloscope in a position to observe the screen from the indicator.
(12) Tune the local oscillator, using the L.O. MOTOR switch on the front panel of the indicator, for a minimum number of beat note cycles on the oscilloscope.
(13) Disconnect the oscilloscope and the uhf signal generator and connect P512 to J512.
(14) Readjust the signal mixer coupling for a red-line reading on test meter M501.
(15) Adjust the five tuning paddles for a maximum reading of signal crystal current on test meter M501.
(16) Remove the **T**-connector from J512 and connect P514 to J514.
(17) Readjust the signal crystal current for a red-line reading on M501.
(18) Replace the bottom cover on the receiver-transmitter and slide the unit back into its case.

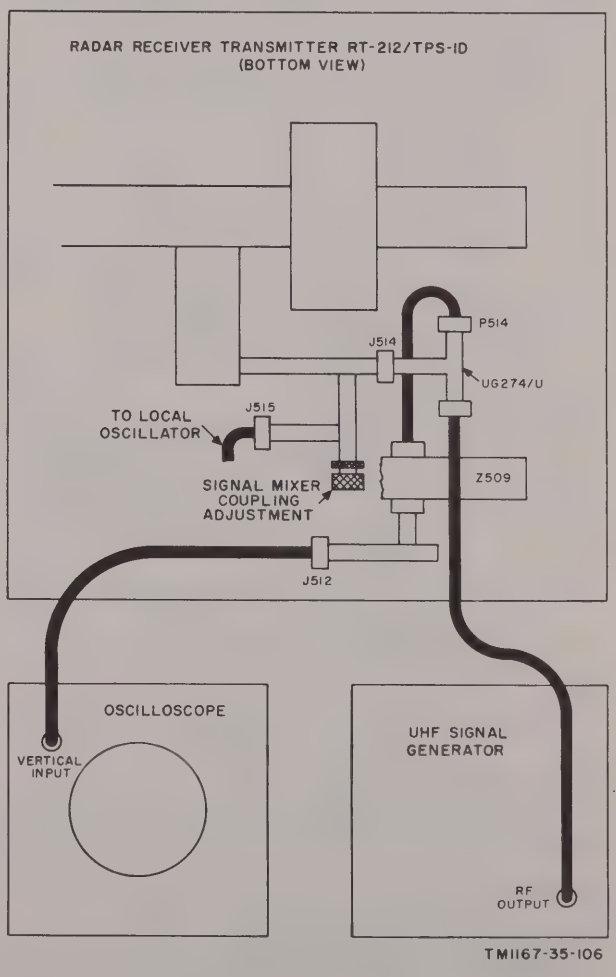


Figure 132. Local oscillator alinement connections.

(19) Connect all cables removed from the front panel of the unit.

290. Alinement of Signal IF Amplifier

a. General. The signal IF amplifier is located in the signal comparator (fig. 130). It amplifies the signal received from the signal IF preamplifier in the receiver-transmitter. Alinement of this amplifier strip is confined to one adjustment, C305, located in the grid circuit of the second IF amplifier stage.

b. Procedure.

(1) Loosen the four captive thumbscrews at the top and bottom of the signal-comparator and pull the unit out of its case until stopped by the chassis catch.

(2) Turn the main power switch to the ON position and after the five-minute time delay, press the RADIATE ON button. Allow 20 minutes for warm-up.

(3) Attach the echo box to RF TEST jack J501 using the cable provided with the echo box.

(4) With the echo box switch on the TUNE position, tune the echo box for maximum meter deflection.

(5) Set the following switches and controls to the positions indicated:

(*a*) TUNE-READ switch on the echo box to READ.

(*b*) INTERNAL-EXTERNAL switch on the modulator to EXTERNAL.

(*c*) OPERATION SELECTOR switch on the signal comparator to REMOTE.

(*d*) TEST SELECTOR switch on the signal comparator to OFF.

(*e*) OPERATION switch on the indicator to NORM.

(*f*) A RANGE SELECTOR switch to 20.

(*g*) ANTIJAM switch to OFF.

(*h*) A VIDEO GAIN control to midposition.

(6) Adjust C305 (fig. 131) for maximum grass on the A-scope.

(7) Adjust the RECEIVER GAIN control on the front panel of the indicator for a grass level of 1/3 the saturation level of the A-scope.

Note. Best results are obtained with the A RANGE SELECTOR switch on the 160 position for this adjustment.

(8) Hold the L.O. MOTOR switch in the INC position for approximately 30 seconds or until the local oscillator motor stops running.

(9) Decrease the frequency of the local oscillator in small steps using the L.O. MOTOR switch.

(10) Adjust the local oscillator for maximum ringtime with the L.O. MOTOR switch.

(11) Readjust C305 for maximum ringtime.

(12) Slide the signal comparator back into its case and secure it with the front panel thumbscrews.

(13) Disconnect the echo box.

(14) Readjust the signal mixer coupling for a red-line meter reading (par. 288).

291. Alinement of Coherent Oscillator Z350

a. General. The coho oscillator strip amplifies the 60-mc output from the coho preamplifier and uses this frequency to synchronize a 60-mc coherent oscillator. Therefore the coho oscillator output is phase-locked to the difference frequency between the local oscillator and magnetron outputs. Before the proper results can be obtained from alinement of the coho oscillator, the signal channel must be correctly alined (par. 290). For complete mti alinement refer to paragraph 14, TM 11–1167–20.

b. Procedure.

(1) Loosen the four captive thumbscrews at the top and bottom of the signal comparator and pull it out of its case until stopped by the chassis catch.

(2) Turn the main power switch to the ON position and after the 5-minute time delay, press the RADIATE ON button. Allow 20 minutes for warm-up.

(3) Attach the echo box to RF TEST jack J501 using the cable provided with the echo box.

(4) With the echo box switch on the TUNE position, tune the echo box for maximum meter deflection.

(5) Check the coho crystal current on the receiver-transmitter (adjustment procedure outlined in paragraph 288).
(6) Set the TEST SELECTOR switch on the signal comparator to the (2) COHO LEVEL position and adjust COHO LEVEL R2351 (fig. 129) for a red-line reading on the TEST METER.
(7) Set the following switches and controls to the positions indicated.
(*a*) TUNE-READ switch on the echo box to READ.
(*b*) INTERNAL-EXTERNAL switch on the modulator to EXTERNAL.
(*c*) OPERATION SELECTOR switch on the signal comparator to REMOTE.
(*d*) TEST SELECTOR switch on the signal comparator to OFF.
(*e*) OPERATION switch on the indicator to COHO ADJ.
(*f*) A RANGE SELECTOR switch to 20.
(*g*) ANTIJAM switch to OFF.
(*h*) A-SCOPE VIDEO GAIN control to midposition.
(8) Adjust C361 (fig. 131) until a minimum number of square waves (or sine waves) are seen on the A-scope.
Note. This adjustment should be made with a nonmetallic screwdriver if available.
(9) Turn COHO SYNC potentiometer R2355 (fig. 129) completely counterclockwise.
(10) Rotate R2355 clockwise until the ringtime on the A-scope stops jittering and note the position of the shaft.
(11) Continue to rotate R2355 in a clockwise direction until the pattern falls out of sync (becomes unstable).
(12) Return the shaft position to R2355 to a point halfway between the unstable points.
(13) Slide the signal comparator back into its case and secure it with the front panel thumbscrews.
(14) Readjust COHO LEVEL control R2351 slightly for a minimum number of square waves (or sine waves) on the A-scope.
Note. A straight line is the ideal indication.
(15) Disconnect the echo box.

Section V. FIELD TESTING

292. General

a. This section describes the testing procedures required to check the serviceability of a repaired receiving system when the components of the radar set are interconnected. The first test to be made of the receiving system is the minimum discernible signal (mds) test to check the receiver sensitivity. The MDS test procedure is covered in paragraph 16*b*, TM 11–1167–20.

b. Bench testing of the receiving components in the receiver-transmitter is outlined in paragraph 305 and bench testing of the receiving components in the signal comparator is outlined in paragraph 311. Testing procedures designed to check the serviceability of the complete radar set are covered in paragraph 448.

293. Test Equipment Required

The following items of test equipment are required to completely test the serviceability of the receiving system.

Test equipment	Common name	Technical manual
Adapter UG274/U	T-connector	11–5103
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103, 11–5129
Signal Generator AN/URM–64.	Uhf signal generator.	11–5553
Signal Generator TS–452C/U	Sweep frequency generator.	11–2695
Signal Generator TS–497B/URR.	Vhf signal generator.	11–5030

294. Local Oscillator Testing

a. General. After the local oscillator stage has been repaired it should be tested for the proper frequency range and output amplitude.

b. Procedure (fig. 132).

(1) Remove all cables from the front panel of the receiver-transmitter; pull the unit out of its case and place it on its side.

(2) Reconnect the power input cable plug P508 to J508.
(3) Remove the bottom cover from the unit by loosening the Dzus fasteners and disable interlock switch S504 (par. 207*b*).
(4) Turn on the radar set and allow a 20-minute warm up period. *Do not* press the RADIATE ON button.
(5) Disconnect P514 from J514 (fig. 124) and connect the **T**-connector to J514.
(6) Connect P514 to the **T**-connector.
(7) Turn the L.O. MOTOR switch on the indicator to the DEC position and allow the local oscillator tuning motor to reach the low limit.
(8) Adjust the signal mixer coupling adjustment (fig. 123) for a red-line reading on test meter M501.
(9) Connect the RF output cable of the uhf signal generator to the open end of the **T**-connector.
(10) Disconnect P512 from J512 (fig. 123).
(11) Set the RF output of the uhf signal generator for a cw signal of maximum amplitude as indicated on the RF output dial.
(12) Connect the vertical input of the oscilloscope to J512.
(13) Tune the uhf signal generator frequency until a minimum number of beat note cycles appear on the oscilloscope.
(14) Read the frequency on the dial of the uhf signal generator. This is the lowest frequency of oscillation of the local oscillator and should be at least 1,265 mc.
(15) Disconnect the uhf signal generator from the **T**-connector and the oscilloscope from J512.
(16) Connect P512 to J512.
(17) Turn the L.O. MOTOR switch to the INC position and watch the signal crystal current indication on meter M501. If the reading falls below red line, readjust the signal crystal coupling adjustment to be certain a red-line reading can be obtained throughout the tuning range of the local oscillator.
(18) When the upper limit of the local oscillator tuning motor is reached, connect the uhf signal generator RF output to the **T**-connector.
(19) Disconnect P512 from J512 and connect the vertical input of the oscilloscope to J512.
(20) Tune the uhf signal generator until a minimum number of beat note cycles appear on the oscilloscope.
(21) Read the frequency on the dial of the uhf signal generator. This is the highest frequency of oscillation of the local oscillator and should not be lower than 1,420 mc.
(22) Disconnect the test equipment and remove the **T**-connector from J514.
(23) Connect P514 to J514 and P512 to J512.
(24) Run the local oscillator tuning motor until its frequency is approximately in the center of the range.
(25) Readjust the signal crystal current for a red-line reading on M501.
(26) Replace the bottom cover on the receiver-transmitter and replace the unit in its case.
(27) Connect all cables removed from the front panel connectors of the unit.

295. Calibration of the Sweep Frequency Generator for Gain Tests

a. General. Gain tests of the signal IF and coho amplifier stages require the calibration of the sweep frequency generator. The following procedure should be used prior to testing any of the 60-mc IF amplifiers in the receiving system.

b. Procedure.
(1) Ground the sweep frequency generator to the radar set.
(2) Connect the power cable of the sweep frequency generator to power receptacle J409 on the power supply of the radar set.
(3) Warm up the radar set without radiation and the sweep frequency generator for 15 minutes.
(4) While the equipment is warming up adjust the positive 150-volt supply of the radar set (par. 427).

(5) Install the appropriate oscillator coil in the sweep frequency generator.
(6) Cut out all attenuation of the sweep frequency generator.
(7) Connect the traveling detector to the input jack of the sweep frequency generator.
(8) Connect the output cable to the RF output jack.
(9) Adjust the scope controls under the small access panel on top of the sweep frequency generator to center the beam.
(10) Turn the horizontal amplifier gain control fully clockwise.
(11) Turn the motor switch on.
(12) Turn the sweep speed control fully clockwise.
(13) Decrease the horizontal amplifier gain control clockwise until the sweep just extends the length of the graph.
(14) Connect the traveling detector probe to the free end of the output cable on the sweep frequency generator.
(15) Decrease the sweep speed until the test pattern of figure 133 is observed.
(16) Adjust the vertical amplifier gain control until the signal is 5 squares high in amplitude.

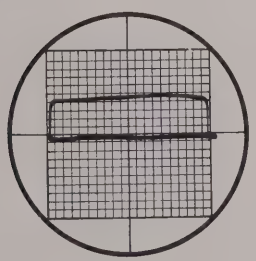

TM1167-35-200

Figure 133. Sweep frequency generator calibration pattern.

(17) If the pattern of figure 133 is not observed adjust the multivibrator reset and avc reset controls until the correct pattern is obtained.

296. Signal IF Preamplifier Test

a. General. The signal IF preamplifier test consists of testing the gain, band pass and center frequency using the sweep frequency generator.

b. Procedure for Testing Gain.
(1) Pull the receiver-transmitter out of its case as far as the drawer stops.
(2) On the underside of the unit open the hinged access door by loosening the Dzus fasteners.
(3) Calibrate the sweep frequency generator as outlined in paragraph 295.
(4) Disconnect input plug P224 from J224 on the signal IF preamplifier.
(5) Connect the output of the sweep frequency generator to J224 using the output cable.
(6) Turn on the radar set and allow a 20-minute warmup period.
(7) Disconnect P507 from I.F. OUTPUT J507 on the front panel of the receiver-transmitter.
(8) Connect the input jack of the sweep frequency generator to J507 using the traveling detector probe.
(9) Cut in attenuation on the sweep frequency generator until the scope presentation is 5 squares in amplitude.
(10) Add all the attenuation set in on the sweep frequency generator.
(11) The sum of the attenuation is equal to the gain of the preamplifier and should be 57 db ±3 db.

c. Procedure for Testing Band Pass.
(1) Reduce the attenuation and adjust the vertical gain control on the sweep frequency generator until the pattern is equal to half the scope diameter.
(2) Check to see that there is no limiting.
(*a*) Insert 3 db of attenuation and note the decrease in amplitude.
(*b*) Insert an additional 3 db of attenuation and note the decrease in amplitude.
(*c*) If the second decrease is less than the first there is no limiting.
(*d*) Cut out the 6 db of attenuation.
(3) Cut in 3 db of attenuation and mark the −3-db amplitude on the scope.
(4) Cut out the 3 db of attenuation.
(5) Using the sweep frequency generator wavemeter marker check the center frequency of the response curve.

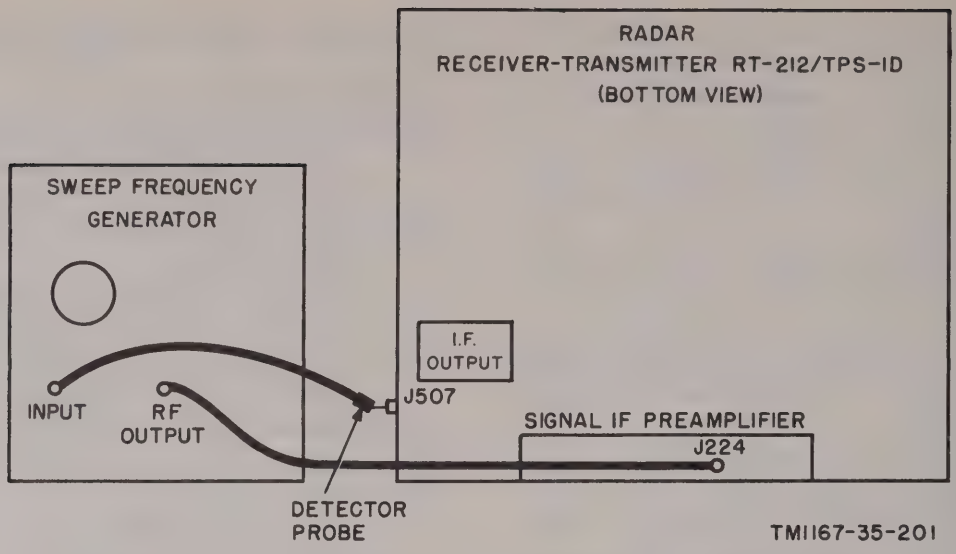


Figure 134. Test equipment connections, signal IF preamplifier.

(6) The center frequency should be 60 mc ±1 mc.

(7) Adjust the wavemeter marker to the upper 3-db point of the response curve and note the frequency of the marker.

(8) Adjust the wavemeter marker to the lower 3-db point of the response curve and note the frequency of the marker.

(9) Subtract the lower marker frequency from the higher marker frequency.

(10) The difference is the band pass of the signal IF preamplifier and should be 2.5 mc ±.5 mc.

(11) Disconnect the sweep frequency generator and connect P224 to J224 and P507 to J507.

(12) Secure the access door beneath the receiver-transmitter and slide the unit back into its case.

297. Coho Preamplifier Test

a. General. The coho preamplifier test consists of testing the gain, center frequency and band pass using the sweep frequency generator.

b. Procedure for Testing Gain.

(1) Pull the receiver-transmitter out of its case as far as the drawer stops.

(2) On the underside of the unit open the hinged access door by loosening the Dzus fasteners.

(3) Calibrate the sweep frequency generator as outlined in paragraph 295.

(4) Disconnect P521 from J521 on the coho preamplifier subchassis.

(5) Connect the output of the sweep frequency generator to J521 using the 5-foot output cable.

(6) Turn on the radar set and allow a 20-minute warmup period.

(7) Disconnect P503 from COHO SYNC jack J503 on the front panel of the receiver-transmitter.

(8) Connect the input jack of the sweep frequency generator to J503 using the traveling detector probe.

(9) Cut in attenuation on the sweep frequency generator until the scope presentation is 5 squares in amplitude.

(10) Add all the attenuation set in on the sweep frequency generator.

(11) The sum of the attenuation is equal to the gain of the preamplifier and should be 27 db ±2 db.

c. Procedure for Testing Band Pass.

(1) Reduce the attenuation and adjust the vertical gain control on the sweep frequency generator until the pattern is equal to half the scope diameter.

(2) Check to see that there is no limiting.

(*a*) Insert 3 db of attenuation and note the decrease in amplitude.

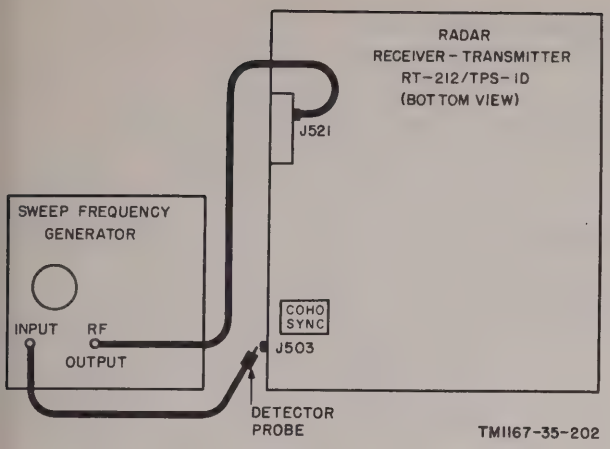


Figure 135. Test equipment connections, coho preamplifier.

(*b*) Insert an additional 3 db of attenuation and note the decrease in amplitude.

(*c*) If the second decrease is less than the first there is no limiting.

(*d*) Cut out the 6 db of attenuation.

(3) Cut in 3 db of attenuation and mark the −3-db amplitude on the scope.

(4) Cut out the 3 db of attenuation.

(5) Using the sweep frequency generator wavemeter marker, check the center frequency of the response curve.

(6) The center frequency should be 60 mc ±1 mc.

(7) Adjust the wavemeter marker to the upper 3-db point of the response curve and note the frequency of the marker.

(8) Adjust the wavemeter marker to the lower 3-db point of the response curve and note the frequency of the marker.

(9) Subtract the lower marker frequency from the higher marker frequency.

(10) The difference is the band pass of coho preamplifier and should be 1 mc ±.2 mc.

(11) Disconnect the sweep frequency generator and connect P521 to J521 and P503 to J503.

(12) Secure the access door beneath the receiver-transmitter and slide the unit back into its case.

298. Signal IF Amplifier Test

a. General. Testing the signal IF amplifier consists of testing the gain, center frequency, band pass, and limit level. These items must meet specific requirements before the amplifier can be considered as operational. To test the amplifier proceed as follows:

b. Procedure for Testing Gain.

(1) Turn on the radar set and allow a 20-minute warmup period.

(2) On the front panel of the signal comparator set the controls as follows:

(*a*) TEST SELECTOR switch — (1) I.F. AMPL. LEVEL.

(*b*) OPERATION SELECTOR switch — NORMAL.

(*c*) I.F. AMPL. LEVEL control — Red-line reading.

(3) Pull the signal comparator out of its case. Be sure to disconnect the delay line.

(4) Adjust C305 on the signal IF amplifier for a maximum reading on the signal comparator TEST METER.

(5) Set up the sweep frequency generator (par. 295).

(6) Disconnect the traveling detector probe from the sweep frequency generator.

(7) Disconnect P307 from J307 on the signal IF amplifier.

(8) Connect the output of the sweep frequency generator to J307 by means of the output cable.

(9) Connect the alligator clip of the special test lead (fig. 136) to the terminal junction of R2358 and terminal OV on the underside of the signal IF amplifier subchassis (fig. 130).

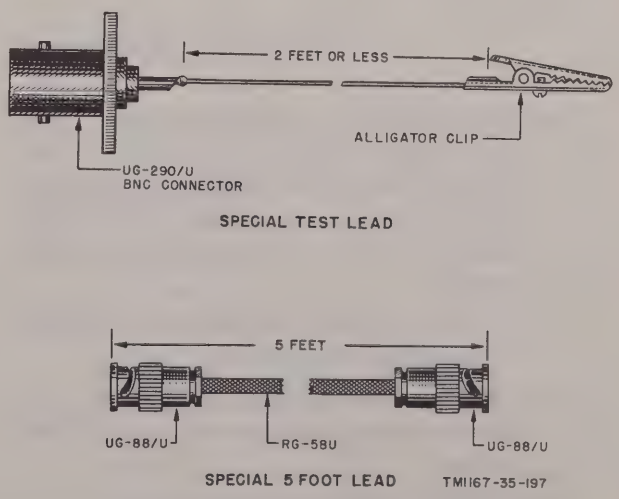


Figure 136. Special test leads.

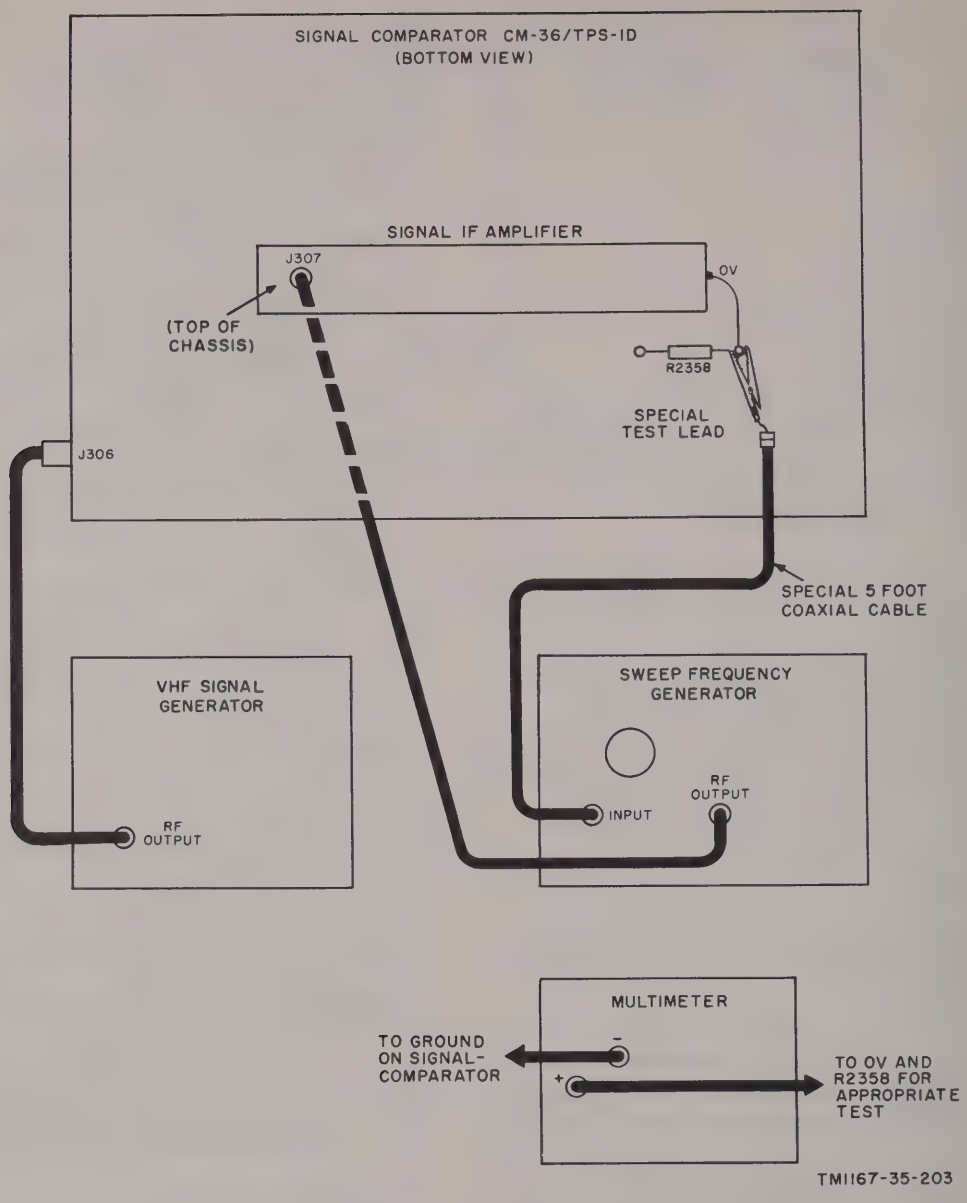


Figure 137. Test equipment connections, signal IF amplifier.

(10) Connect the UG–290/U end of the special test lead to the special 5-foot coaxial cable (fig. 136). Connect the other end of the cable to the input jack of the sweep frequency generator.

(11) Turn the TEST SELECTOR switch on the signal comparator to OFF.

(12) Turn the I.F. AMPL. LEVEL control on the signal comparator fully clockwise.

(13) Cut in attenuation on the sweep frequency generator until the scope presentation is 5 squares in amplitude.

(14) Add all the attenuation set in on the sweep frequency generator.

(15) The sum of the attenuation is equal to the gain of the amplifier and should be 87 ±5 db.

c. Procedure for Testing Band Pass.

(1) Reduce the attenuation and adjust the vertical gain on the sweep frequency generator until the pattern is equal to half of the scope diameter.

(2) Check to see that there is no limiting.
(*a*) Insert 3 db of attenuation and note the decrease in amplitude.
(*b*) Insert an additional 3 db attenuation and note the decrease in amplitude.
(*c*) If the second decrease is less than the first there is no limiting.
(*d*) Cut out the 6 db of attenuation.
(3) Cut in 3 db of attenuation and mark the −3-db amplitude on the scope.
(4) Cut out the 3 db of attenuation.
(5) Using the sweep generator wavemeter marker check the center frequency of the response curve.
(6) If the center frequency is not 60 mc adjust C305.
(7) Adjust the wavemeter marker to the lower 3-db point of the response curve and note the frequency of the marker.
(8) Adjust the wavemeter marker to the upper 3-db point on the response curve and note the frequency of the marker.
(9) Subtract the lower marker frequency from the higher marker frequency.
(10) The difference is the band pass of the signal IF amplifier and should be 1 mc ±.1 mc.
(11) Adjust C305 until the amplitude of the response curve drops to the −3-db point.
(12) Using the wavemeter marker note the center frequency of the response curve.
(13) Vary C305 until the response curve amplitude drops to the −3-db point at the other extreme frequency.
(14) Using the wavemeter marker, note the center frequency of the response curve.
(15) Subtract the lower frequency from the higher frequency.
(16) The difference is the band pass of the last five stages and should be 5 mc ±1 mc.
(17) Disconnect the sweep frequency generator and connect P307 to J307 on the amplifier.

d. Procedure for Testing Signal IF Amplifier Limit Level.

(1) Turn on the vhf signal generator.
(2) Set the vhf signal generator to 60-mc cw and 0-microvolt output.
(3) Allow the vhf signal generator sufficient time to warmup and become stable.
(4) Connect the multimeter to the terminal junction of terminal OV and R2358 (fig. 130).
(5) Set the multimeter controls to measure −.1 volt.
(6) With no signal input adjust I.F. AMPL. LEVEL control R2350 for a reading of −.1 volt on the multimeter.
(7) Set the multimeter controls to measure −5 volts.
(8) Disconnect P306 from J306 on the front panel of the signal comparator and connect the RF output cable of the vhf signal generator to J306.
(9) Turn up the RF output level on the vhf signal generator until the multimeter indicates approximately one-third scale.
(10) Adjust the output frequency of the vhf signal generator until a peak reading is obtained on the multimeter.
(11) Turn the output amplitude of the vhf signal generator to maximum and check the voltmeter reading.
(12) This reading is the limit level of the signal IF amplifier and should be 4 volts ±.6 volts.
(13) Secure the test equipment and slide the signal comparator back into its case. Do not forget to connect the delay line.

299. Coherent Oscillator Z350 Testing

a. General. Testing the coho IF amplifier consists of testing the gain, center frequency and band pass. These items must meet specific requirements before the amplifier can be considered as operational. To test the amplifier proceed as follows.

b. Procedure for Measuring Gain.

(1) Turn on the radar set and allow a 20-minute warmup period.
(2) Set the controls on the front panel of the signal comparator as follows:

Control	Position
TEST SELECTOR switch	OFF.
OPERATION SELECTOR switch	NORMAL.
COHO SYNC control	Fully clockwise.

(3) Pull the signal comparator out of its case. Be sure to disconnect the delay line.
(4) Set up the sweep frequency generator as outlined in paragraph 295.
(5) Disconnect the traveling detector probe from the sweep frequency generator.
(6) Disconnect P350 from J350 on the coho oscillator subchassis and P307 from J307 on the signal IF amplifier subchassis.
(7) Connect the RF output of the sweep frequency generator to J350 with the output cable.
(8) Connect the alligator clip of the special test lead (fig. 136) to the terminal junction of R2358 and terminal OV on the underside of the signal IF amplifier subchassis (fig. 130).
(9) Connect the UG–290/U end of the special test lead to the special 5-foot coaxial cable (fig. 136) and connect the free end of the cable to the input jack of the sweep frequency generator.
(10) Cut in attenuation until the pattern of A, figure 213 is observed.
(11) Adjust C361 on the coho IF amplifier subchassis for maximum amplitude of the displayed pattern.
(12) Cut in attenuation until the scope pattern is 5 squares in amplitude.
(13) Add all the attenuation set in on the sweep frequency generator.
(14) The sum of the attenuation is equal to the gain of the amplifier and should be 37 db ±2 db.

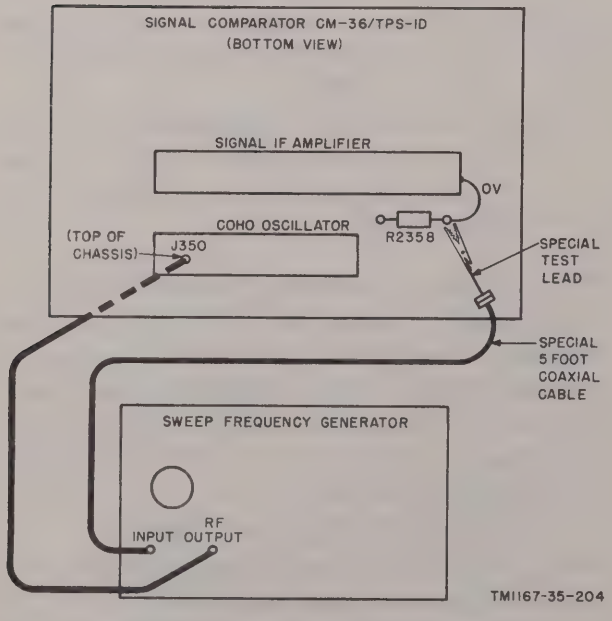


Figure 138. Test equipment connections, coho oscillator.

c. Procedure for Measuring Band Pass.
(1) Mark the amplitude of the pattern obtained in *b*(12) above.
(2) Cut out 3 db of attenuation.
(3) Set the sweep frequency generator wavemeter marker at the peak of the waveform.
(4) This is the center frequency and should be 60 mc ±1 mc.
(5) Set the wavemeter marker at the right side of the response curve on the −3-db point previously marked and record the wavemeter frequency.
(6) Set the wavemeter marker to the left −3-db amplitude of the response curve and record the wavemeter frequency.
(7) Subtract the second recorded frequency from the first recorded frequency.
(8) The difference is the band pass of the amplifier and should be 1 mc ±.2 mc.
(9) Adjust C361 until the amplitude of the response curve falls to the upper −3-db point.
10) Using the wavemeter marker, note the center frequency of the response curve.
(11) Adjust C361 until the amplitude of the response curve falls to the lower −3-db point.
(12) Using the wavemeter marker note the center frequency of the response curve.
(13) Subtract the first frequency from the second frequency.
(14) The difference frequency is the tuning range of the coho IF amplifier and should be 4.5 mc ±1 mc.

(15) Disconnect the sweep frequency generator and connect P350 to J350 and P307 to J307.

(16) Secure the test equipment and connect the delay line, then slide the signal comparator back into its case.

Section VI. BENCH SERVICING RECEIVER-TRANSMITTER

300. General

This section covers bench servicing of the receiving circuits located in the receiver-transmitter. Bench servicing of the receiving circuits located in the signal comparator is covered in section VII. The following information will be helpful when bench servicing the receiving circuits in the receiver-transmitter.

Information	Location
Radar Receiver-Transmitter RT–212/TPS–1D, complete schematic diagram.	Fig. 212.
Receiving system theory	Pars. 52 through 72.
Location of parts in the receiver-transmitter.	Par. 269 and figs. 123 through 128.
Receiver-transmitter voltage and resistance diagram.	Fig. 211.
Receiver-transmitter waveforms	Fig. 213.
Receiving system controls and adjustments.	Par. 270.
Normal readings of receiving system panel meters.	Par. 272.
Normal indications at receiving system test points.	Par. 273.
Dc resistance of inductive components in receiving system.	Par. 274.
Removal and replacement of part in receiving system.	Pars. 280 through 285.

301. Test Equipment Required

The following items of test equipment and cables are required to bench service the receiving circuits in the receiver-transmitter. The cables are supplied with Test Set AN/MPM–23.

Test equipment	Common name	Reference
Power Supply PP–674/TPS–1D	Power supply	This manual, chapter 8.
Motor Generator PU–20B/C	Motor generator	TM 11–978.
Signal Generator AN/URM–64	UHF signal generator	TM 11–5553.
Signal Generator TS–452C/U	Sweep frequency generator	TM 11–2695.
Multimeter TS–352B/U, or ME–77/U	Multimeter	TM 11–5527.
Crystal Rectifier Test Set TS–268E/U	Crystal checker	TM 11–1242.
Electron Tube Test Set TV–7B/U	Tube tester	TM 11–5083.
Tube Socket Adapter Kit MX–1258/U	Tube socket adapter kit	Literature packed with kit.
Electrical Power Cable Assembly CX–3640/U	None	TM 11–1250.
Electrical Power Cable Assembly CX–2000/U	None	TM 11–1250.
Outlet Box J–45/MPM–1	Outlet box	TM 11–1080A.
Oscilloscope AN/USM–24C, or AN/USM–50	Oscilloscope	TM 11–5103 TM 11–5129.

302. Bench Servicing Connections

Follow the procedure in *a* through *g* below to connect Radar Receiver-Transmitter RT–212/TPS–1D for bench servicing the receiving circuits.

a. Disconnect all cables connected to the front panel of the receiver-transmitter.

b. Release the eight captive screws on the front panel of the receiver-transmitter, remove the chassis from its case, and disable the interlock (par. 207*b*).

c. Connect the dummy load resistors to terminal E401 (fig. 179) in the power supply as shown in B, figure 139.

d. Connect a single-pole, single-throw switch or jumper wire to terminals 03 and 2103 on terminal strip E403 (fig. 179) in the power supply as shown in C, figure 139.

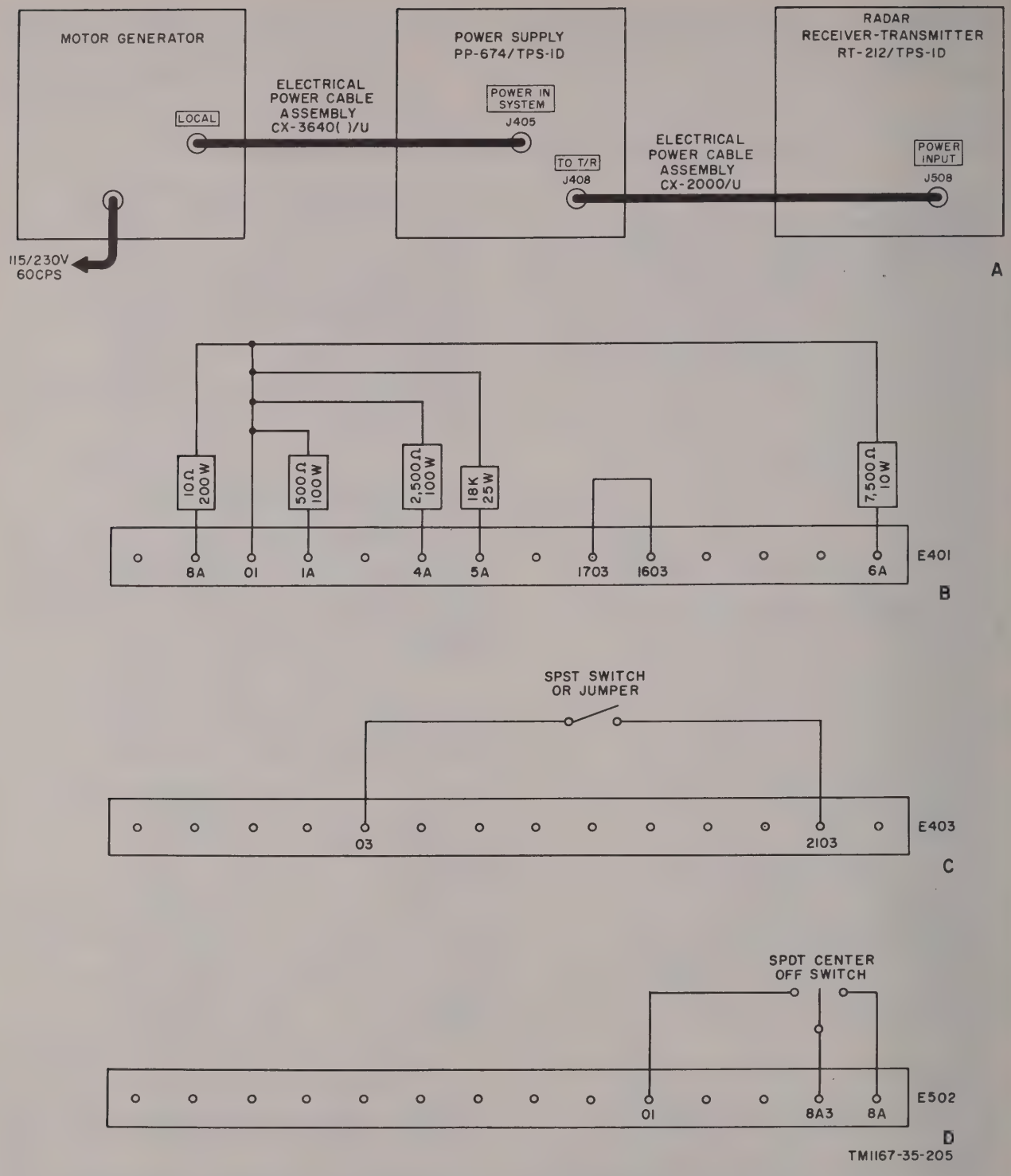


Figure 139. Bench servicing connections for Radar Receiver-Transmitter RT–212/TPS–1D.

e. Connect the receiver-transmitter for bench servicing as shown in A, fig. 139.

(1) Connections for individual items of test equipment required for troubleshooting, alinement, and testing procedures are shown in the appropriate paragraphs referenced for the procedure desired.

(2) When power is required for more than one item of test equipment use the outlet box for the test equipment power connections and plug the outlet box into J409 115 V 400 outlet on the power supply.

f. When the receiver-transmitter is connected for bench servicing the switch connected to terminals 03 and 2103 on E403 functions as POWER switch S602 on the indicator. If desired, a jumper may be used in place of the switch and the power controlled by turning the motor generator off and on.

g. When performing the local oscillator troubleshooting, alinement, and test procedures, connect a single-pole, double-throw, center-off switch to terminal E502 (fig. 123) in the receiver-transmitter as shown in D, fig. 139. This switch functions as L. O. MOTOR switch S613 on the front panel of the indicator.

303. Bench Troubleshooting Receiver-Transmitter

a. Connect the receiver-transmitter for bench servicing (par. 302).

b. Follow the procedure of the receiving system step-by-step troubleshooting chart (par. 279, steps 6 through 11).

304. Bench Alinement and Adjustment

The receiving portion of the receiver-transmitter can be alined when connected for bench servicing (par. 302). This alinement and adjustment consists of the crystal coupling adjustments and local oscillator alinement.

a. For adjustment of the signal and coho crystal mixers refer to paragraph 288.

b. For alinement procedure of the local oscillator assembly refer to paragraph 289.

305. Bench Testing Receiver-Transmitter

To bench test the serviceability of the repaired receiving circuits in the receiver-transmitter, connect the receiver-transmitter for bench servicing (par. 302). The following chart lists the testing procedures required to completely test the receiver-transmitter receiving circuits and references a paragraph that contains detailed step-by-step directions for making each test.

Test	Procedure
Local oscillator testing	Par. 294.
Signal IF preamplifier test	Par. 296.
Coho preamplifier test	Par. 297.

Section VII. BENCH SERVICING COMPARATOR

306. General

This section covers bench servicing of the receiving circuits in the signal comparator. These circuits are coho oscillator Z350 and signal IF amplifier Z301. Bench servicing the receiving circuits located in the receiver-transmitter is covered in section VI. The following information will be helpful when bench servicing the receiving circuits in the signal comparator.

Information	Location
Signal Comparator CM–36/TPS–1D, complete schematic diagram.	Fig. 219.
Receiving system theory	Pars. 52 through 72.
Location of parts in the signal comparator.	Figs. 129 through 131.
Signal comparator voltage and resistance diagrams.	Figs. 215 and 216.
Signal comparator waveforms	Fig. 213.
Receiving system controls and adjustments.	Par. 270.
Test equipment connections special test lead.	Figs. 136, 137, and 138.
Dc resistance of inductive components.	Par. 274.
Removal and replacement of parts	Par. 285.

307. Test Equipment Required

The following items of test equipment and cables are required to bench service the receiving circuits in the signal comparator. The cables are supplied with Test Set AN/MPM–23.

Test equipment	Common name	Reference
Power Supply PP–674/TPS–1D	Power supply	This manual, chapter 8.
Motor Generator PU–20B/C	Motor generator	TM 11–978.
Signal Generator TS–452C/U	Sweep frequency generator	TM 11–2695.
Multimeter TS–352B/U, or ME/77/U	Multimeter	TM 11–5527.
Electron Tube Test Set TV–7B/U	Tube tester	TM 11–5083.
Electronic Multimeter TS–505C/U	Vtvm	TM 11–5511.
Tube Socket Adapter Kit MX–1258/U	Tube socket adapter kit	Literature packed with kit.
Electrical Power Cable Assembly CX–3640/U	None	TM 11–1250.
Electrical Power Cable Assembly CX–2001/U	None	TM 11–1250.

308. Bench Servicing Connections

Follow the procedure in *a* through *g* below to connect Signal Comparator CM–36/TPS–1D for bench servicing.

a. Disconnect all cable connected to the front panel of the signal comparator.

b. Release the eight captive screws on the front panel of the signal comparator and remove the chassis from its case. Do not forget to disconnect the delay line.

c. Connect the dummy load resistors to terminal E401 (fig. 179) in the power supply as shown in figure 147.

d. Connect a single-pole, single-throw switch or jumper wire to terminal 03 and 2103 on terminal strip E403 (fig. 179) in the power supply as shown in figure 147.

e. Connect the signal comparator for bench servicing (C, fig. 147).

f. Test equipment connections required for troubleshooting, alinement, and testing procedures are described in the appropriate paragraphs referenced for the desired procedure.

g. When the signal comparator is connected for bench servicing the switch connected to terminals 03 and 2103 on E403 functions as POWER switch S602 on the indicator. If desired a jumper may be used in place of the switch and the power controlled by turning the motor generator on and off.

309. Bench Troubleshooting Receiving System Components in Signal Comparator

a. Connect the signal comparator for bench servicing (par. 308).

b. Follow the procedures in steps 13 through 24 of the receiving system step-by-step troubleshooting chart (par. 279).

310. Bench Alinement and Adjustment

To properly aline the receiving system components in the signal comparator all components of the receiving system must be interconnected and alined as a system, therefore no useful purpose can be accomplished by alining these components individually. Alinement of the receiving system is covered in section IV of this chapter.

311. Bench Testing Signal Comparator

To bench test the serviceability of the repaired receiving circuits in the signal comparator, connect the signal comparator for bench servicing (par. 308).

a. To bench test the signal IF amplifier follow the step-by-step procedure in paragraph 298 disregarding *b*(1) through (4) and adjust C305 for maximum amplitude between steps (12) and (13).

b. To bench test the coho follow the step-by-step procedure in paragraph 299 disregarding *b*(1) through (3).

CHAPTER 15

SIGNAL COMPARING SYSTEM TROUBLESHOOTING AND REPAIR

Section I. TROUBLESHOOTING INFORMATION

312. Reference Data

The signal comparing system of Radio Set AN/TPS–1D is closely related to the receiving system and the transmitting system during normal and mti operation. Because of this relationship, the repairman should be thoroughly familiar with the theory of operation discussed in chapter 5, Signal Comparing System. The following references will aid in troubleshooting and repair of the signal comparing system contained in Signal Comparator CM–36/TPS–1D, component of Radio Set AN/TPS–1D.

Reference	Data
Fig. 40	Signal comparing system, block diagram.
Fig. 219	Signal comparing system, complete schematic diagram.
Fig. 41	9-mc carrier channel, waveforms.
Chapter 5	Signal comparing system theory.
Figs. 40–57	Signal comparing system, simplified schematic diagrams.
Par. 314	Signal comparing system, controls and adjustments.
Par. 316	Normal readings on meters.
Par. 318	Dc resistance of inductive components.
Par. 313 and figs. 140–145.	Location of parts.
Fig. 217	Signal Comparator CM–36/TPS–1D, main chassis, voltage and resistance measurements at tube sockets.
Fig. 218	Signal Comparator CM–36/TPS–1D, delay amplifier and nondelay amplifier, voltage and resistance measurements at tube sockets.

313. Location of Parts in Signal Comparing System

The following chart lists the parts contained in the signal comparing system and references a figure showing their physical location. Parts contained in Pulse Delay Network MX–1207/TPS–1D are called out in chapter 22.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
B2350	140	C1366	143	C2327	141
C1301	141	C1367	143	C2328	141
C1302	141	C1368	143	C2329	141
C1303	141	C1370	143	C2330	141
C1304	141	C1371	143	C2331	141
C1305	141	C1372	143	C2350	140
C1306	141	C1374	143	C2351	140
C1307	141	C1375	143	C2352	140
C1308	141	C1376	143	C2360	140
C1309	141	C1377	143	C2361	140
C1310	141	C1378	143	C3300	145
C1311	141	C1379	143	C3301	145
C1312	141	C1380	143	C3302	145
C1313	141	C1381	143	C3303	145
C1314	141	C1382	143	C3304	145
C1315	141	C1383	143	C3305	145
C1316	141	C1384	143	C3306	145
C1317	141	C1385	143	C3307	145
C1318	141	C1386	143	C3308	145
C1319	141	C1387	143	C3309	145
C1320	141	C1388	143	C3310	145
C1321	141	C2301	141	C3311	145
C1322	141	C2302	141	CR3300	145
C1323	141	C2303	141	CR3301	145
C1324	141	C2304	141	CR3302	145
C1325	141	C2305	141	E2350A	144
C1326	141	C2306	141	E2351B	144
C1327	141	C2307	141	E2351	140
C1328	141	C2308	141	J302	144
C1329	141	C2309	141	J303	144
C1330	141	C2310	141	J304	144
C1350	143	C2311	141	J305	144
C1351	143	C2312	141	J306	144
C1352	143	C2313	141	J1301	144
C1353	142	C2314	141	J1350	144
C1354	143	C2315	141	J2350	190
C1355	143	C2316	141	J2351	190
C1356	143	C2317	141	J2354	144
C1357	143	C2318	141	HR2350	144
C1358	143	C2319	141	HR2351	201
C1359	143	C2320	141	K3300	144
C1360	143	C2321	141	K3301	144
C1361	143	C2322	141	L1301	141
C1362	143	C2323	141	L1302	141
C1363	143	C2324	141	L1303	141
C1364	143	C2325	141	L1304	141
C1365	143	C2326	141	L1305	141

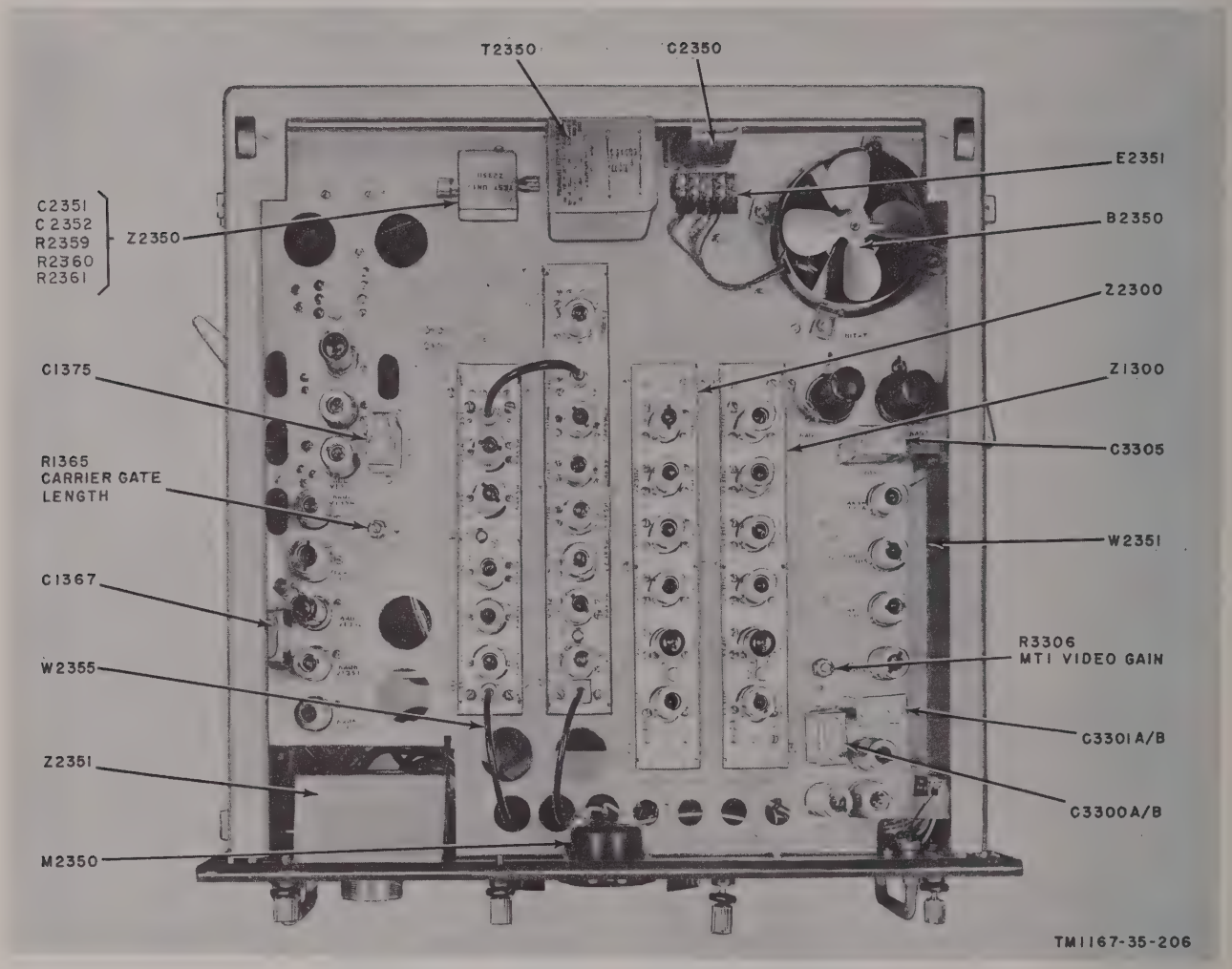


Figure 140. Signal comparator chassis, top view.

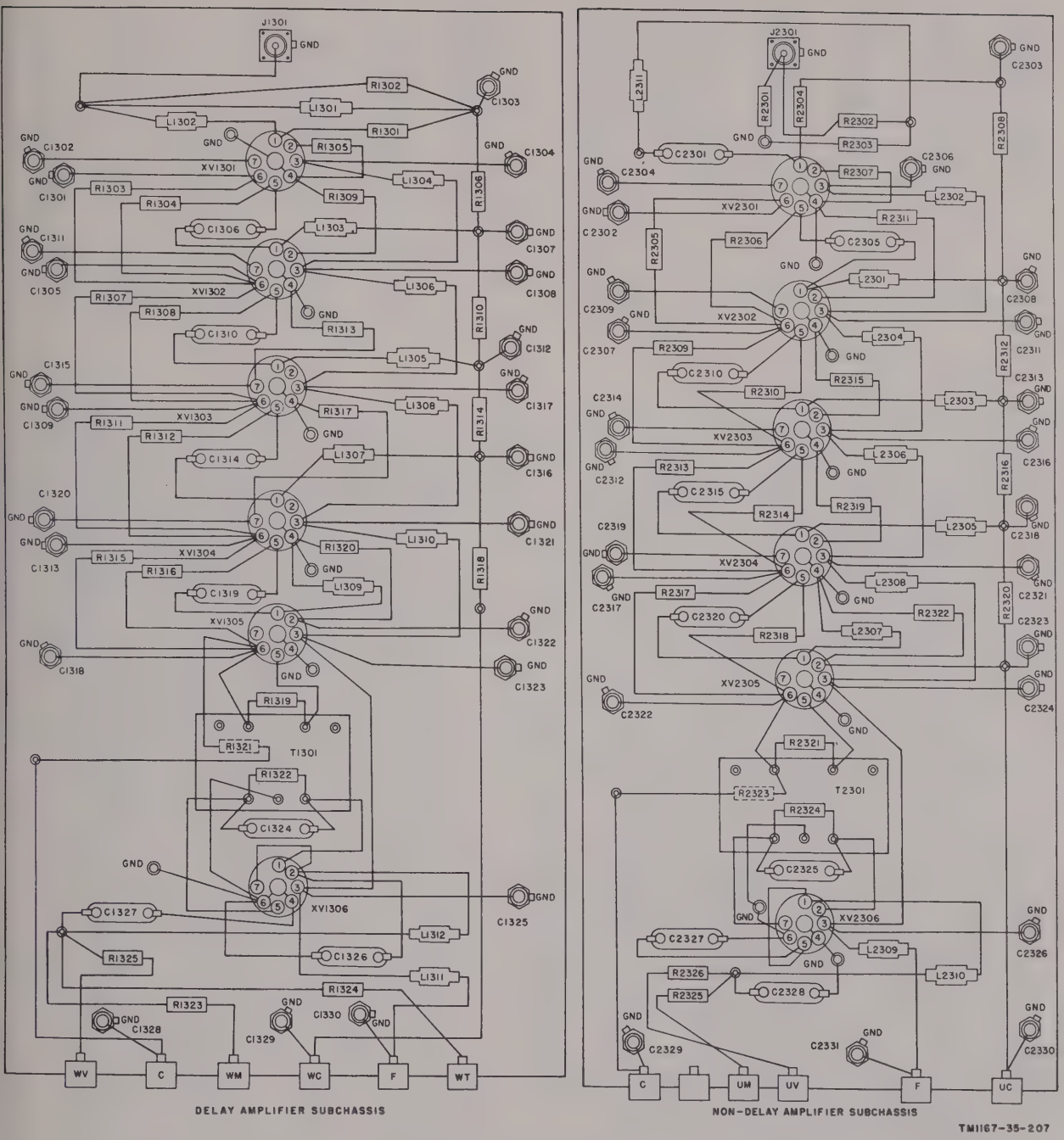
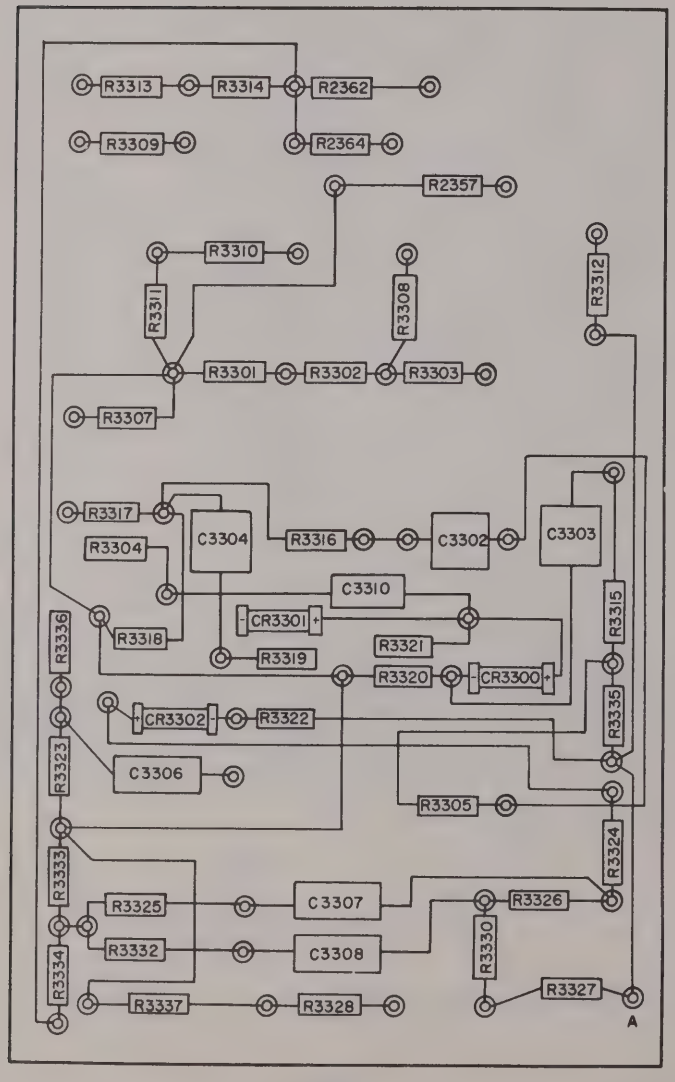


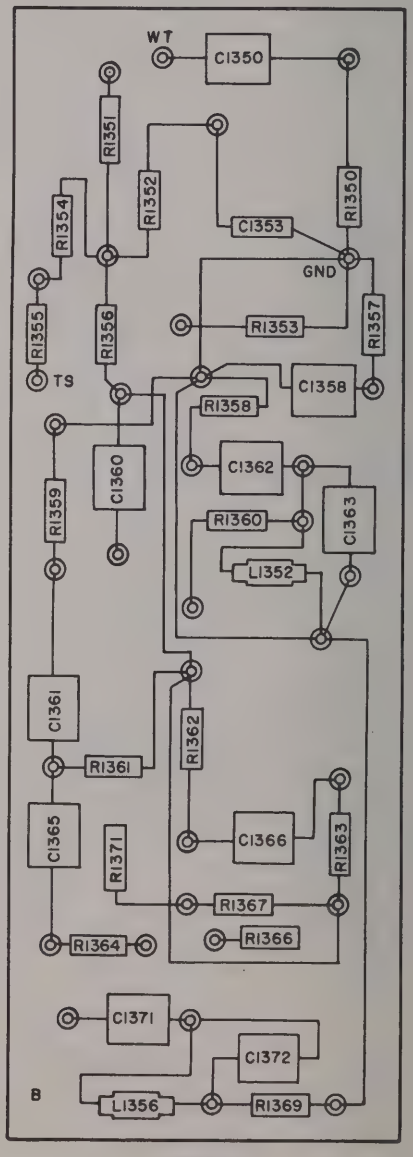
Figure 141. 9-mc amplifiers, delay and nondelay, line drawing.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
L1306	141	L1351	143	L1359	143
L1307	141	L1352	143	L1360	143
L1308	141	L1353	143	L1361	143
L1309	141	L1354	143	L1362	143
L1310	141	L1355	143	L1363	143
L1311	141	L1356	143	L1364	143
L1312	141	L1357	143	L1365	143
L1350	143	L1358	143	L2301	141

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
L2302	141	L2310	141	R1306	141
L2303	141	L2311	141	R1307	141
L2304	141	M2350	140	R1308	141
L2305	141	R1301	141	R1309	141
L2306	141	R1302	141	R1310	141
L2307	141	R1303	141	R1311	141
L2308	141	R1304	141	R1312	141
L2309	141	R1305	141	R1313	141



PANEL A
E2350A
A. SUB ASSEMBLY IN VIDEO BALANCER & AMPL CIRCUIT



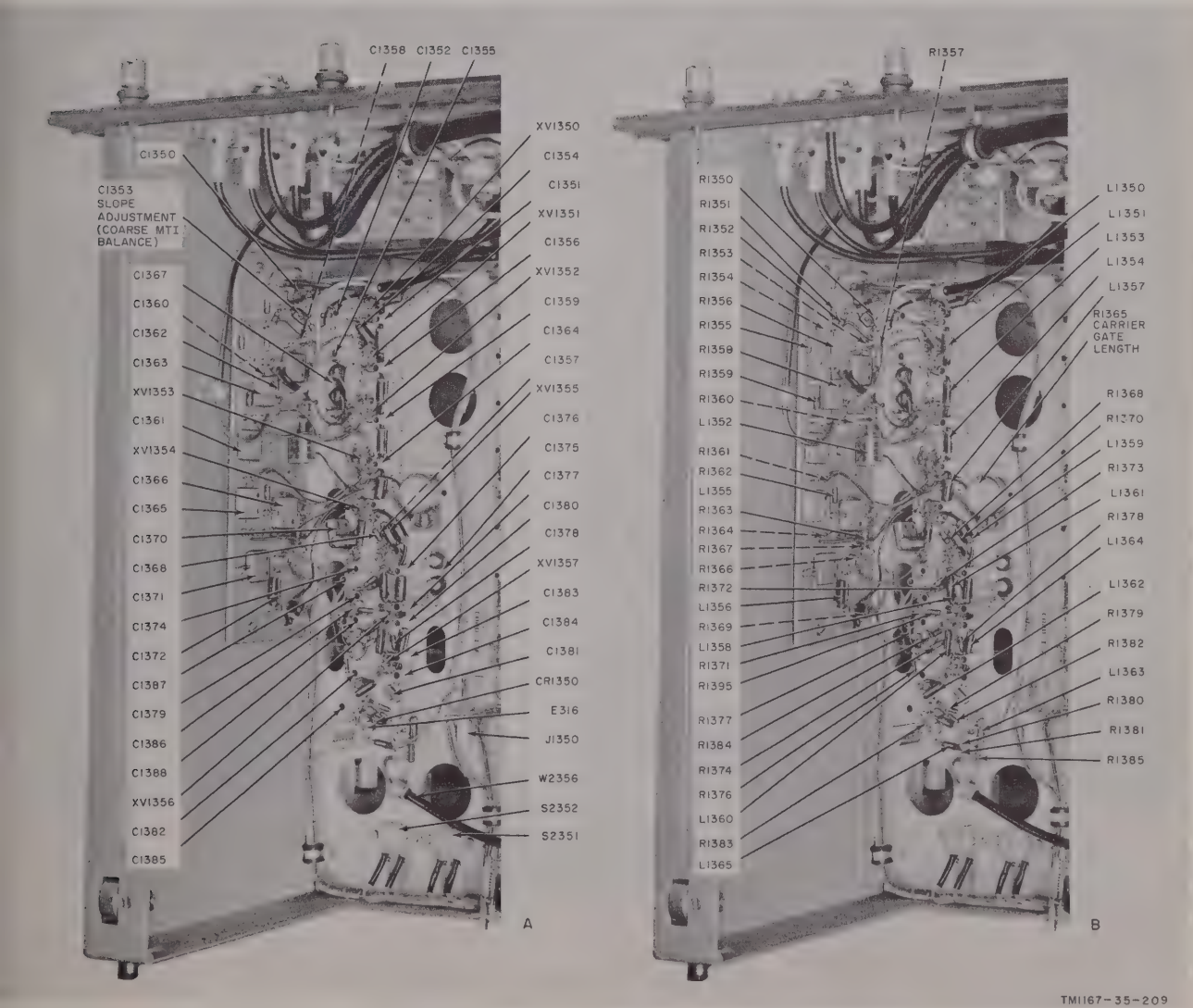
PANEL B
E2351A
B. SUB ASSEMBLY IN MTI REP RATE TRIGGER AMPL CIRCUIT

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Figure 142. Panel A and panel B subassemblies, line drawing.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
R1314	141	R1352	143	R1366	143
R1315	141	R1353	143	R1367	143
R1316	141	R1354	143	R1368	143
R1317	141	R1355	143	R1369	143
R1318	141	R1356	143	R1370	143
R1319	141	R1357	143	R1371	143
R1320	141	R1358	143	R1372	143
R1321	141	R1359	143	R1373	143
R1322	141	R1360	143	R1374	143
R1323	141	R1361	143	R1375	143
R1324	141	R1362	143	R1376	143
R1325	141	R1363	143	R1377	143
R1350	143	R1364	143	R1378	143
R1351	143	R1365	140	R1379	143

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
R1380	143	R2309	141	R2323	141
R1381	143	R2310	141	R2324	141
R1382	143	R2311	141	R2325	141
R1383	143	R2312	141	R2326	141
R1384	143	R2313	141	R2352	144
R1385	143	R2314	141	R2353	144
R2301	141	R2315	141	R2354	144
R2302	141	R2316	141	R2356	144
R2303	141	R2317	141	R2357	142
R2304	141	R2318	141	R2358	144
R2305	141	R2319	141	R2359	140
R2306	141	R2320	141	R2360	140
R2307	141	R2321	141	R2361	140
R2308	141	R2322	141	R2362	145



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Figure 143. MTI repetition rate trigger amplifier, parts location.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
R2364	145	T1301	141	XV1303	141
R2618	149	T2301	141	XV1304	141
R2627	149	T2350	140	XV1305	141
S601	149	TP301	144	XV1306	141
S2350	196	W2350	190	XV1307	141
S2351	143	W2351	140	XV1350	143
S2352	143	XV1301	141	XV1351	143
S2355	144	XV1302	141	XV1352	143

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
XV1353	143	XV2304	141	XV3304	145
XV1354	143	XV2305	141	XV3305	145
XV1355	143	XV2306	141	XV3306	145
XV1356	143	XV2307	141	XV3307	145
XV1357	143	XV3300	145	XV3308	145
XV2301	141	XV3301	145	Z2350	145
XV2302	141	XV3302	145		
XV2303	141	XV3303	145		

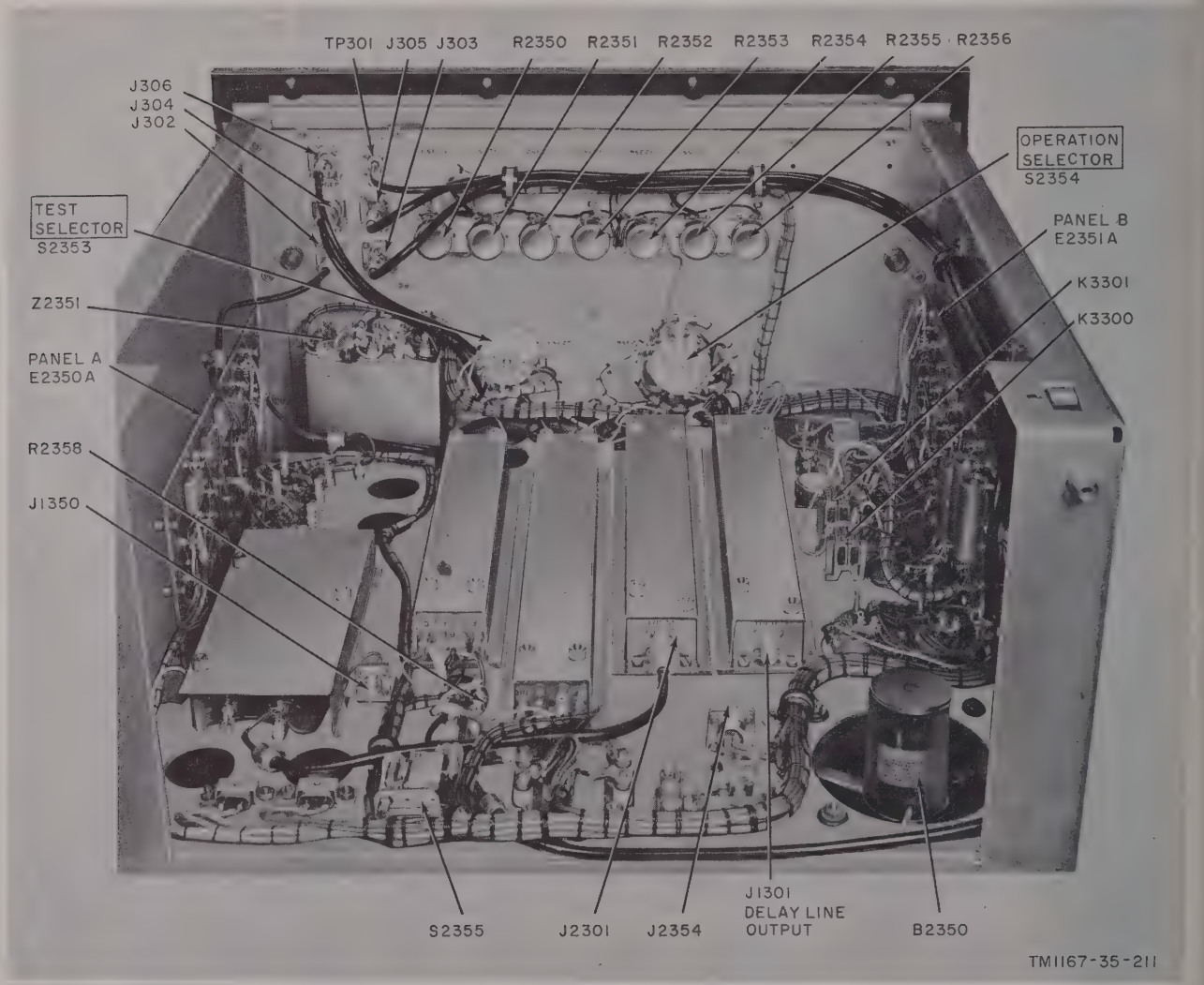


Figure 144. Signal comparator chassis, bottom view, parts location.

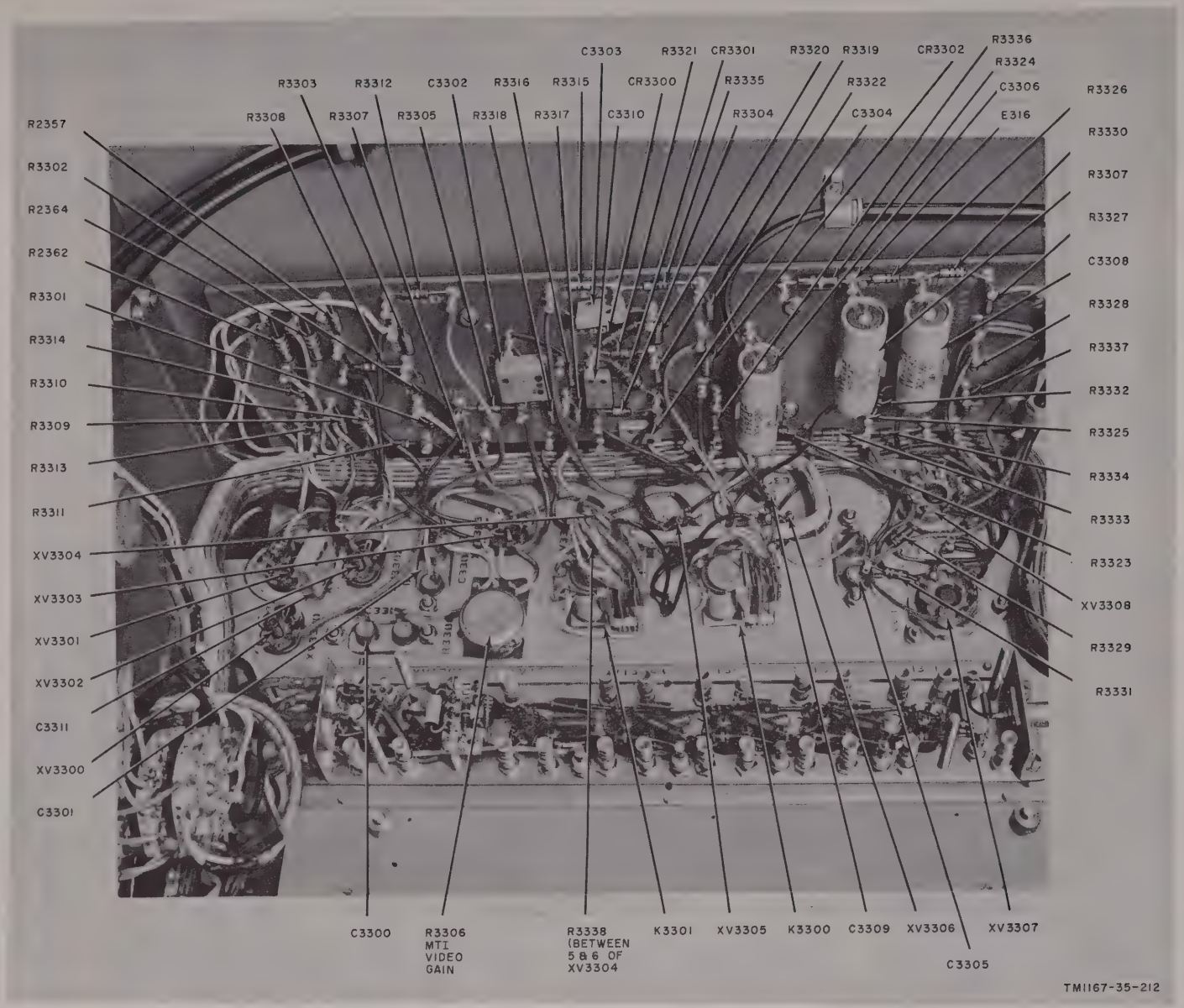


Figure 145. Video balancer and amplifier, parts location.

314. Signal Comparing System Controls and Adjustments

The charts (*a* and *b* below) list the controls and adjustments that are functional parts of the signal comparing system. They reference a figure that shows their location, and give the function of each. Figure 220 will aid the repairman in following the control functions given in the various switch positions listed in the chart below.

a. Front Panel Controls and Adjustments.

Controls and adjustments	Locations (fig.)	Function
TEST SELECTOR switch S2353.	144	Switches meter into proper circuit for adjusting the front panel controls using TEST METER M2350.
(1) I.F. AMPL. LEVEL position.	------	Permits metering the noise level of the signal IF amplifier.
(2) COHO LEVEL position.	------	Permits metering the output amplitude of coherent oscillator Z350.
(3) DELAY LINE INPUT position.	------	Permits metering the output amplitude of 9 mc output amplifier V1357.
(4) NON DELAY AMPL. OUT position.	------	Permits metering the output amplitude of nondelay amplifier Z2300.
(5) AMPL. BALANCE position.	------	Permits metering the output amplitude of delay amplifier Z1300.
OFF position	------	Grounds both terminals of meter M2350.
OPERATION SELECTOR switch S2354.	144	Selects the mode of operation of the radar set.
NORMAL position:		
Section A	------	Energizes Relay K3300.
Section B	------	Energizes Relay K3301.
Section C	------	Not used.
Section D	------	Connects terminal 7 of relay K3301 to I.F. AMPL. LEVEL control.
Section E	------	Connects terminal TS of mti repetition rate trigger amplifier subassembly to MTI BALANCE control R2356.
Section F	------	Connects R3309 to AMPLITUDE BALANCE control R2354.
COHO position:		
Section A	------	Same as NORMAL position section A.
Section B	------	Open circuit.
Section C	------	Grounds terminal NM of signal IF amplifier Z301.
Section D	------	Same as NORMAL position section D.
Section E	------	Same as NORMAL position section E.
Section F	------	Same as NORMAL position section F.
MTI position:		
Section A	------	Open circuit.
Section B	------	Open circuit.
Section C	------	Same as COHO position section C.
Section D	------	Same as NORMAL position section D.
Section E	------	Same as NORMAL position section E.
Section F	------	Same as NORMAL position section F.
REMOTE position:		
Section A	------	Places control of relay K3300 at SYSTEM SELECTOR switch S601 in the indicator unit.
Section B	------	Places control of relay K3301 at SYSTEM SELECTOR switch S601 in the indicator unit.
Section C	------	Same as COHO position section C.
Section D	------	Connects RECEIVER GAIN control on the indicator unit to the signal IF amplifier.
Section E	------	Connects MTI BALANCE control on the indicator unit to the mti repetition rate trigger amplifier.
Section F	------	Connects AMPL. BALANCE control on the indicator unit to the video balancer and amplifier circuits.

b. Other Signal Comparing System Controls.

Controls and adjustments	Location (fig.)	Function
Slope adjustment capacitor C1353 (coarse mti balance).	140	Establishes the range (time balance) of MTI BALANCE control R2356. (MTI BALANCE control R2618 on the indicator unit when OPERATION SELECTOR switch S2354 is in REMOTE.)
Carrier gate length adjustment R1365.	140	Adjusts the prf of the radar set in normal and mti modes of operation when the set is operated with modulator TRIGGER switch S152 set to EXTERNAL.
Mti video gain R3306.	140	Adjusts the amplitude of video through the mti video amplifier.

315. Signal Comparing System Fuses

Fuses affecting the signal comparing system are listed below. Voltage and current rating, blown-fuse indicator, circuits protected and the physical location of each fuse are given. These fuses are located on Power Supply PP–674/TPS–1D.

Fuse	Rating		Blown-fuse indicator	Circuit protected	Location (fig.)
	Volts	Amps			
F405	250	1.6	I 405	Filament transformer T2350	173
F414	250	30	I 414	Pulse delay network heater H2350, unit heater H2351	173
F415	250	30	I 415	Same	173

316. Normal Readings on Signal Comparing System Front Panel Meter M2350

The following chart lists the normal readings obtained on TEST METER M2350 (fig. 58, TM11–1167–10) in the positions of TEST SELECTOR switch S2353 (fig. 58, TM11–1167–10) that monitor the operation of the signal comparing system. This chart also gives the function of each reading.

TEST SELECTOR switch position	Function of TEST METER
(3) DELAY LINE INPUT	Indicates the output amplitude of 9-mc output amplifier V1357. Normal reading is on the red line.
(4) NON DELAY AMPL OUT	Indicates the output amplitude of the 9-mc carrier from nondelay amplifier Z2300. Normal reading is on the red line.
(5) AMPL BALANCE	Indicates the output amplitude of the 9-mc carrier from delay amplifier Z1300. Normal reading is on the red line.

317. Signal Comparing System Test Points

Test point TP301 (fig. 144) is provided for viewing the video signal supplied to the remote ppi. In order to view the video signal when a remote indicator is not used, a 220-ohm, 1-watt resistor should be used to terminate J305.

318. Dc Resistance of Inductive Components in Signal Comparing System

The chart below lists the transformers and coils used in the signal comparing system with their location and the dc resistance of every winding.

Transformer, coil or relay	Location (fig.)	Terminals	Dc resistance (ohms)
K3300	145	1–2	450
K3301	145	1–2	450
L1301	141		(1)
L1302	141		1.75
L1303	141		(1)
L1304 through L1311	141		(1)
L1312	141		3.9
L1350	143		(1)
L1351	143		(1)
L1352	143		108
L1353 through L1361	143		(1)
L1362	143		2.2
L1363 through L1365	143		(1)
L2301	141		(1)
L2302 through L2305	143		(1)
L2306 through L2309	141		(1)
L2310	141		4
L2311	141		1.4
T1301	141	Primary	(1)
		Secondary	(1)
T2301	141	Primary	(1)
		Secondary	(1)
T2350	140	1–2	2.2
		3–4	(1)

[1] Less than one.

Section II. TROUBLESHOOTING CHARTS

319. General

Two troubleshooting charts are provided to enable the repairman to quickly isolate trouble in the signal comparing system in a logical sequence.

a. Before using the signal comparing system troubleshooting charts, the repairman should definitely establish that the trouble is in the signal comparing system. If any doubt exists, proceed to the troubleshooting chart based on starting procedure (par. 210).

b. Troubles that have been isolated to the signal comparing system may be evidenced by an improper reading on TEST METER M2350 when OPERATION SELECTOR switch S2354 and TEST SELECTOR switch S2353 are set in the positions indicated in the TEST INSTRUCTIONS on the front panel of Signal Comparator CM–36/TPS–1D.

c. Troubles may exist in the video, amplitude balance or time balancing circuits when all meter readings are normal.

d. Using the symptom troubleshooting chart (par. 322), locate under the *Symptom* column the conditions existing in the signal comparing system. Follow the instructions given in the *Corrective measures* column provided with each symptom.

e. If the trouble cannot be located, use the symptom troubleshooting chart to determine in which section(s) the trouble exists and proceed to the step-by-step troubleshooting chart(s) listed below.

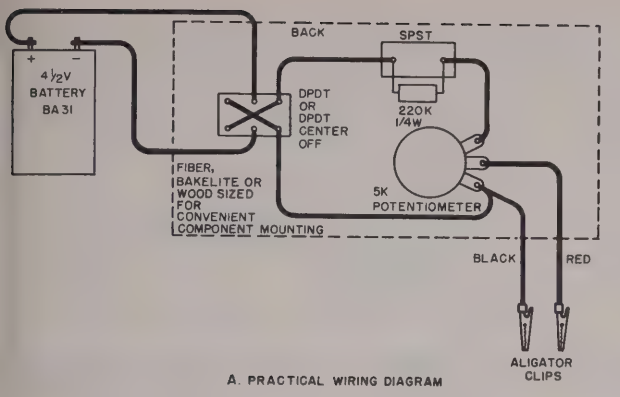
(1) Nondelay amplifier step-by-step troubleshooting chart (par. 323).
(2) Delay amplifier step-by-step troubleshooting chart (par. 324).
(3) Mti repetition rate trigger amplifier step-by-step troubleshooting chart (par. 325).
(4) Video balancer and amplifier step-by-step troubleshooting chart (par. 326).

320. Test Equipment Required to Troubleshoot Signal Comparing System

The following items of test equipment are required to troubleshoot the signal comparing system:

Test equipment	Common name	Technical manual
Electron Tube Test Set TV–7B/U	Tube tester	11–5083.
Electronic Multimeter TS–505C/U	Vtvm	11–5511A.
Multimeter TS–352B/U, or ME–77/U	Multimeter	11–5527.
Oscilloscope AN/USM–24C, or AN/USM–50	Oscilloscope	11–5103A.
		11–5129.
Pulse Generator AN/UPM–15	Pulse generator	11–1177.
Signal Generator TS–452C/U	Sweep frequency generator	11–2695.
Tube Socket Adapter Kit MX–1258/U	Tube socket adapter kit	Packed with equipment.

Note. Additional test equipment consists of special test leads (fig. 136) and bias power supply (fig. 146).



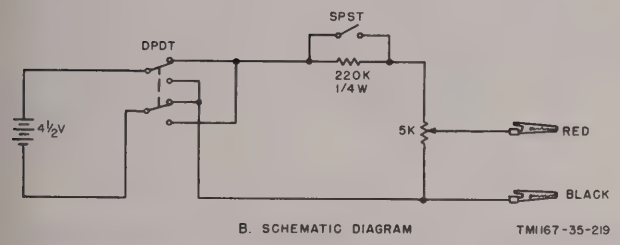


Figure 146. Bias power supply.

321. Preparation of Signal Comparing System for Troubleshooting

a. The signal comparing system is dependent upon Power Supply PP–674/TPS–1D for all operating voltages; therefore, the cable from the power supply (W7) to J301 must be connected during troubleshooting. All other external cables may be disconnected when troubleshooting.

b. Mercury delay line W2350 is mounted on the bottom of the signal comparator housing. When removing the signal comparator chassis completely, care must be taken not to place strain on the cables to the mercury delay line.

c. The procedure for removing Signal Comparator CM–36/TPS–1D:

(1) Disconnect all cables to the signal comparator.
(2) Loosen the eight captive screws around the unit and pull the chassis out to its stops.
(3) Place the two stop arms perpendicular to the sides of the chassis so as to disable the stops.
(4) Move the unit out sufficiently to disconnect the cables to the mercury delay line.
(5) Position the unit for troubleshooting close to its housing and reconnect the cables to the mercury delay line.
(6) Should it be necessary to remove the delay line, follow the procedure given in paragraph 459.
(7) Connect plug P301 of power cable W7 to J301.

322. Signal Comparing System Symptom Troubleshooting Chart

Symptom	Probable cause	Corrective measures
1. Unable to obtain red-line reading on meter M2350 when adjusting DELAY LINE INPUT R2352.	Faulty meter and/or associated circuits, switch contacts and wiring.	*a.* Place TEST SELECTOR switch S2353 in position (4) NONDELAY AMPL. OUT. Adjust NONDELAY AMPL. OUT control R2353 for red-line reading. (1) If red-line reading is obtained in position (4): (*a*) Check switch contacts and wiring for position (3) DELAY LINE INPUT. (*b*) Check meter rectifier CR1350, coupling circuits C1381, R1379, coils L1363, L1365, voltage dividers R1381, R1382, and filters C1385, R1383. (2) If red-line reading is not obtained proceed to *b* below.
	Absence of 9-mc carrier signal	*b.* Substitute tubes for 9-mc carrier oscillator V1355, 9-mc amplifier V1356, and 9-mc amplifier output V1357. *c.* Make voltage and resistance measurements of V1355, V1356 and V1357.

Symptom	Probable cause	Corrective measures
2. Unable to obtain red-line reading on meter M2350 when adjusting NONDELAY AMPL. OUT control R2353.	Faulty meter and/or associated circuits, switch contacts and wiring.	*a.* Place TEST SELECTOR switch S2353 in position (5) AMPL. BALANCE, adjust AMPL. BALANCE control R2354 for red-line reading. (1) If red-line reading is obtained— (*a*) Check switch contacts and wiring circuit for position (4) NONDELAY AMPL. OUT. (*b*) Check cable from junction of R1385 and R1380 to P2301. (2) If red-line reading is not obtained proceed to *b* below.
	Absence of 9-mc carrier signal, faulty nondelay amplifier Z2300.	*b.* Check for red-line reading with switch in position (3) DELAY LINE INPUT while adjusting DELAY LINE INPUT R2352. (1) If red-line reading is obtained, return TEST SELECTOR switch to (4) NONDELAY AMPL. OUT, adjust NONDELAY AMPL. OUT control R2353 ¾ cw, substitute tubes in nondelay amplifier Z2300 subchassis while observing TEST METER. Return original tubes if no improvement is seen. (2) Make voltage and resistance measurements of V2301 through V2306 (fig. 218). *c.* If red-line reading is not obtained, refer to *b* and *c* under symptom 1.
3. Unable to obtain red-line reading on TEST METER M2350 when adjusting AMPL. BALANCE control R2354.	Faulty meter and/or associated circuits, switch contacts and wiring.	*a.* Check meter by determining whether or not it reads in other positions of TEST SELECTOR S2353. (1) If normal, proceed to *b* below. (2) If abnormal, troubleshoot the metering circuit affecting the AMPL. BALANCE meter reading.
	Faulty delay amplifier Z1300	*b.* While observing test meter, substitute tubes in delay amplifier Z1300 and adjust AMPL. BALANCE R2354 ¾ cw. Return original tubes if no improvement is seen. *c.* Make voltage and resistance measurements at tube bases for V1301 through V1306 (fig. 218).
	Low +150v supply	*d.* Check +150v supply.
	Faulty dc amplifier V3301	*e.* Check V3300, V3301, V3303, make voltage and resistance measurements at tube bases (fig. 217).
	Absence of 9-mc carrier signal	*f.* Refer to *b* and *c* under symptom 1.
	Excessive attenuation of the mercury delay line W2350.	*g.* Substitute mercury delay line test unit Z2350 for mercury delay line W2350. Adjust AMPL. BALANCE control R2354 for red-line reading. (1) If red-line reading is not obtained check P/J1350, P/J2350, P/J2351, P/J1301. (2) If red-line reading is obtained— (*a*) Check delay line attenuation (par. 340). (*b*) Refer to procedure on mercury delay line disassembly and replacement (pars. 458–461).
4. Video weak or absent in NORMAL and MTI operation.	Inoperative video cathode follower V3307.	Check V3307, make voltage and resistance measurements at tube base (fig. 217).
5. NORMAL video weak or absent.	Inoperative normal video limiter V3306.	*a.* Check V3306, make voltage and resistance measurements at tube base (fig. 217).
	Faulty video relay K3300	*b.* Check relay K3300. (1) OPERATION SELECTOR switch S2354 in MTI, relay not energized, cathode of V3305 grounded. (2) OPERATION SELECTOR switch S2354 in NORMAL relay energized, cathode of V3306 grounded through contacts 6 and 8 of relay K3301.

Symptom	Probable cause	Corrective measures
6. MTI video weak or absent	Inoperative video amplifier V3303.	*a.* Check V3303, make voltage and resistance measurement at tube base (fig. 217).
	Inoperative video polarizer V3304.	*b.* Check V3304, make voltage and resistance measurement at tube base (fig. 217).
	Faulty rectifier CR3300 and/or CR3301.	*c.* Check CR3300 and CR3301.
	Insufficient or absence of modulation of 9-mc carrier oscillator.	*d.* Check V1355, make voltage and resistance measurements at tube base (fig. 217).
		e. Refer to chapter 14, troubleshooting charts for the receiving system.
7. Unable to obtain MTI BALANCE (time balance) when adjusting R2356.	Trigger switch S152 (on modulator) set to INTERNAL.	*a.* Place switch S152 in EXTERNAL, adjust MTI BALANCE control R2356.
	Carrier gate length control R1356 improperly adjusted.	*b.* Follow procedure outlined in paragraph 332 for carrier gate length adjustment.
	Erratic operation of carrier gate multivibrator ½ V1353 and V1354.	*c.* Check V1353 and V1354, make voltage and resistance measurements at tube bases (fig. 217).

323. Nondelay Amplifier Subchassis Z2300 Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
1.	Terminal C of Z2300 to ground.	Multimeter set to measure +150 v.	OPERATION SELECTOR switch in NORMAL TEST SELECTOR switch in OFF.	+150 v	Troubleshoot wiring to terminal C of Z2351, Z2351 and wiring to dc power supply.
2.	Terminal UC of Z2300 to ground.	Multimeter set to measure −150 v. Decrease scale to obtain normal indication.	Same as step 1	0 to −11 v	Troubleshoot wiring to D of Z2351, Z2351, and wiring to dc power supply.
3.	Terminal F of Z2300 to ground.	Multimeter set to measure 6.3 v ac.	Same as step 1	6.3 v ac	Check for 115 v ac between A and B of Z2351. Check transformer T2350.
4.	Pin 5 of V2301 through traveling detector, using tube socket adapter.	Sweep generator alined, using procedure given in par. 295*b*. Rf output applied to J2301, *short across R2302*.	Same as step 1 and NONDELAY AMPL. OUT R2353 fully cw.	Approximately 0 db gain at a point between 8 and 9 mc.	Check V2301, R2301, R2303, L2311, and C2301.
5.	Pin 1 of V2302 through traveling detector, using tube socket adapter.	Same as step 4	Same as step 4	Approximately 7 db gain at a point between 8 and 9 mc.	Check V2301. Make voltage and resistance measurements at tube base (fig. 218).
6.	Pin 1 of V2303 through traveling detector, using tube socket adapter.	Same as step 4	Same as step 4	Approximately 25 db gain at a point between 8 and 9 mc.	Check V2302. Make voltage and resistance measurements at tube base (fig. 218).
7.	Pin 1 of V2304 through traveling detector, using tube socket adapter.	Same as step 4	Same as step 4	Approximately 43 db gain at a point between 8 and 9 mc.	Check V2303. Make voltage and resistance measurements at tube base (fig. 218).

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
8.	Pin 1 of V2305 through traveling detector, using tube socket adapter.	Same as step 4	Same as step 4	Approximately 55 db gain at a point between 8 and 9 mc.	Check V2304. Make voltage and resistance measurements at tube base (fig. 218).
9.	Pin 5 of V2305 through traveling detector, using tube socket adapter.	Same as step 4	Same as step 4	Approximately 81 db gain at a point between 8 and 9 mc.	Check V2305. Make voltage and resistance measurements at tube base (fig. 218).
10.	Junction of R3301 and R3302 using special test lead (fig. 136).	Same as step 4	Same as step 4	Approximately 74 db gain at a point between 8 and 9 mc.	Check V2306, T2301, C2327, C2328, R2326 and R2301.
11.	Same as step 10.	Same as step 4 with short across R2302 removed.	Same as step 4	Approximately 45 db gain at a point between 8 and 9 mc.	Check R2302 and R2303.

324. Delay Amplifier Z1300 Step-by-Step Troubleshooting Chart

When performing steps 4 through 9, remove nondelay detector V2306 and apply a +3-volt bias voltage using bias power supply (fig. 146) or fabricate as follows: Across a 4½-volt battery (BA–31) place 2,500 ohms to 5K potentiometer. Ground the negative terminal of the battery to the signal comparator chassis and wire the wiper arm of the potentiometer to the ungrounded terminal of C3301B. Using a multimeter, adjust the wiper arm for +3 volts. Maintain this voltage for steps 4 through 9.

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
1.	Terminal C of Z1300 to ground.	Multimeter set to measure +150 v.	OPERATION SELECTOR switch in NORMAL, TEST SELECTOR switch OFF.	+150 v	Troubleshoot wiring to terminal C of Z2351 and/or dc power supply (ch. 18).
2.	Terminal F of Z1300 to ground.	Multimeter set to measure 6.3v ac.	Same as step 1	6.3 v ac	Check for 115 v ac between A and B of Z2351. Troubleshoot transformer T2350.
3.	Terminal WC of Z1300 to ground.	Vtvm set to center scale to measure −150 v to +3 v.	Same as step 1 and rotate AMPLITUDE BALANCE control R2354 through entire range.	−150 v to +3 v.	Check for −150 v at D of Z2351 and at C3301 after removing V3302.
4.	Pin 5 of V1301 through traveling detector using tube socket adapter.	Sweep frequency generator alined, using procedure given in paragraph 295*b*. RF output applied to J1301.	Same as step 1	Approximately 0 db gain at a point between 8 and 9 mc.	Check V1301, L1301, L1302, R1302 and R1301.
5.	Pin 1 of V1302 through traveling detector using tube socket adapter.	Same as step 4	Same as step 1	Approximately 7 db gain at a point between 8 and 9 mc.	Check V1301, make voltage and resistance measurements at tube base (fig. 218).

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
6.	Pin 1 of V1303, through traveling detector using tube socket adapter.	Same as step 4	Same as step 1	Approximately 27 db gain at a point between 8 and 9 mc.	Check V1302, make voltage and resistance measurements at tube base (fig. 218).
7.	Pin 1 of V1304 through traveling detector using tube socket adapter.	Same as step 4	Same as step 1	Approximately 49 db gain at a point between 8 and 9 mc.	Check V1303, make voltage and resistance measurements at tube base (fig. 218).
8.	Pin 1 of V1305 through traveling detector using tube socket adapter.	Same as step 4	Same as step 1	Approximately 60 db gain at a point between 8 and 9 mc.	Check V1304, make voltage and resistance measurements at tube base (fig. 218).
9.	Junction of WV of Z1300 and R2357 using special test lead shown in figure 136.	Same as step 4	Same as step 1	Approximately 77 db gain at a point between 8 and 9 mc.	Check V1305, V1306, T-1301, L1312, C1326, C-1327 and R2357. Make voltage and resistance measurements at tube bases (fig. 218).

325. Mti Repetition Rate Trigger Amplifier Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
1.	Terminal C of mti repetition rate trigger amplifier subassembly to ground.	Multimeter set to measure +150 v.	OPERATION SELECTOR switch in NORMAL, TEST SELECTOR switch in OFF.	+150 v	Troubleshoot wiring to C of Z2351, Z2351, and connections to dc power supply.
2.	Terminal F of mti repetition rate trigger amplifier subassembly to ground.	Multimeter set to measure 6.3 v ac.	Same as step 1	6.3 v ac	Troubleshoot wiring to T2350. Check T2350 between terminals 1 and 2 for 115 v ac, terminals 3 and 4 for 6.3 v ac. Troubleshoot ac distribution.
3.	Pin 1 of V1350 with V1350 removed using 10:1 attenuator probe.	Oscilloscope, set for hor sweep of 2,500 usec per in., vert sensitivity 15 v per in.	Same as step 1 and DELAY LINE INPUT R2352 fully ccw.	C, fig. 214	Check for waveform A. Check cable from delay amplifier. Troubleshoot delay amplifier (par. 324).
4.	Pin 5 of V1350 through 10:1 attenuator probe.	Oscilloscope, set for hor sweep of 2,500 usec per in., vert sensitivity of 150 v per inch.	Same as step 3	D, fig. 214	Check for waveform B. Make voltage and resistance measurements at tube base of V1350 (fig. 217).
5.	Pin 5 of V1351 through 10:1 attenuator probe.	Same as step 4	Same as step 3	H, fig. 214	Check for waveform G. Make voltage and resistance measurements at tube base of V1351 (fig. 217).

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
6.	Pin 6 of V1354 through 10:1 attenuator probe.	Oscilloscope, set for hor sweep of 2,500 usec per in. and vert sensitivity of 50 v per in.	Same as step 3	J, fig. 214	Check V1353 and V1354. Make voltage and resistance measurements at tube bases (fig. 217).
7.	Junction of R1360 and C1362 through 10:1 attenuator probe.	Oscilloscope, set for hor sweep of 2,500 usec per in. and vert sensitivity of 150 v per in. Delay in (sweep speed multiplied 10 times).	Same as step 3	Q, fig. 214	Check C1363, C1362, L 1352, R1358 and R-1360. Make voltage and resistance measurements at bases of V1352 and V1353 (fig. 217).
8.	Pin 5 of V1352 through 10:1 attenuator probe.	Same as step 4	Same as step 3	Q, fig. 214	Check V1352. Make voltage and resistance measurements at tube base (fig. 217).
9.	Pin 2 of V1352 through 10:1 attenuator probe.	Same as step 6	Same as step 3	T, fig. 214	Check C1358 and R1357.
10.	J302 through 10:1 attenuator probe.	Same as step 6	Same as step 3	S, fig. 214	Check C1360 and cable to J302.
11.	Pin 5 of V1355 through 10:1 attenuator probe.	Oscilloscope, set for hor sweep of 2,500 usec per in. and vert sensitivity of 5 v per in.	Same as step 3	U, fig. 214	Check V1355. Make voltage and resistance measurements at tube base (fig. 217).
12.	Pin 5 of V1356 through 10:1 attenuator probe.	Same as step 11	Same as step 3	W, fig. 214	Check V1356. Check for waveform V. Make voltage and resistance measurements at tube base (fig. 217).
13.	Pin 5 of V1357 through 10:1 attenuator probe.	Same as step 6	Same as step 3	X, fig. 214	Check V1357. Make voltage and resistance measurements at tube base (fig. 217).

326. Video Balancer and Amplifier Step-by-Step Troubleshooting Chart

In steps 5 through 12 the pulse generator and oscilloscope are used. Initial pulse generator control settings and connections, as well as procedures for the pulse generator and oscilloscope adjustments are given in *a*, *b*, and *c* following this chart.

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
1.	Pin 8 of V3307 or V3308 to ground using tube socket adapter.	Multimeter set to measure +150 v.	OPERATION SELECTOR switch in MTI, TEST SELECTOR switch OFF, mti video gain R3306 fully cw.	+150 v	Check wiring to C of Z2351, Z2351, and wiring to dc power supply.
2.	Pin 2, 4, or 7 of V3302, with V3302 removed, to ground.	Multimeter set to measure −150 v.	Same as step 1	−148 v	Check R3314, wiring to D of Z2351, Z2351, and wiring to dc power supply.
3.	Terminal 2 of Relay K3300 to ground.	Multimeter set to measure +27 v.	Same as step 1	+27 v	Check relay K3300 (450 ohms), wiring to E of Z2351, and Z2351. Troubleshoot 27 v power supply (par. 211).

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
4.	Terminal 2 of relay K3301 to ground.	Same as step 3	Same as step 1	+27 v	Check relay K3301 (450 ohms), wiring to E of Z2351, and Z2351. Troubleshoot 27 v power supply (par. 211).
5.	Pin 5 of V3303 to vertical input of oscilloscope direct.	Pulse generator to pin 1 of V3301. Pulse generator set using adjustment and procedure given in subparagraph *a* and *b*.	Same as step 1	Positive pulse of approximately 1.1 v measured using procedure given in subparagraph *c*.	Check V3303. Make voltage and resistance measurements at tube base (fig. 217).
6.	Pin 1 of V3304 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Same as step 5	Check V3304, C3302 and R3316.
7.	Pin 5 of V3304 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Negative pulse of approximately 1.1 v measured, using procedure given in subparagraph *c*.	Check V3304, make voltage and resistance measurements at tube base (fig. 217).
8.	Pin 2 or 7 of V-3304 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Same as step 5	Check V3304, R3318 and C3304.
9.	Pin 1 of V3305 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Negative pulse of approximately .36 v measured using procedure given in subparagraph *c*.	Check C3301, C3303, CR-3300, R3320, R3321 and V3305.
10.	Pin 5 of V3305 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Positive pulse of approximately 12 v measured using procedure given in subparagraph *c*.	Check V3305, make voltage and resistance measurements at tube base (fig. 217).
11.	Same as step 10	Same as step 5 with coarse attenuation set to .01 (.35 v input pulse).	Same as step 1	Positive pulse of approximately 20 v measured using procedure given in subparagraph *c*.	Check CR3302.
12.	Pin 5 of V3307 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Positive pulse of approximately 2 v.	Check V3307, make voltage and resistance measurements at tube base (fig. 217).
13.	J303 to vert input of oscilloscope direct.	Same as step 5	Same as step 1	Positive pulse of approximately 1 v.	Check V3307, J303 and R337.

Step	Test point	Test equipment	Signal comparator controls and switches	Normal indications	Corrective measures
14.	TP301 to vert input of oscilloscope direct.	Same as step 5. Connect cable from J303 to J-315. (Places R3337 in cathode circuit of V-3308.) Remove V3307.	Same as step 1	Positive pulse of approximately 75 v.	Check V3308, J305, and TP301 to pin 5 of V3308.
15.	Vtvm applied across C3301B to measure 0 v to −20 v. (40 v range set to midscale.) AMPLITUDE BALANCE control set to −10 v across C3301B without bias supply connected.	Bias power supply, figure 219. Set for +.05 v switched to −.05 v during test.	Same as step 1	Approximately 15 v change when bias power supply is switched from +.05 v to −.05 v.	Check V3301, V3302, V-3300. Make voltage and resistance measurements at tube bases (fig. 217).

a. Pulse generator initial control settings and connections for checking the mti video amplifiers and the normal video amplifiers are given below.

Pulse generator control	Initial setting
Sync—out (switch)	Switch set to B.
Sync (jack)	From sync output of pulse generator through coax cable connector to sync input of oscilloscope.
Delay (switch)	Long.
Delay (dial)	Adjusted for convenient waveform viewing on oscilloscope.
Pulse No. 2 (switch)	Out.
Separation	Not used.
Width (switch)	Nar.
Width (dial)	5 (dot between 4 and 6).
Polarity (switch)	Neg.
Coarse attenuation	.01.
Fine attenuation	Used when calibrating input pulse voltage.
Output	Coax cable to input of circuits under test.
Rise time (dial)	Set at midpoint.
Bias	Not used.
Pulse rate	.4 on scale B.

b. The input pulse to pin 1 of V3303 is to be set to .035 v calibrated with the oscilloscope in the following manner: Remove delay amplifier detector V1306 and nondelay amplifier detector V2306. Place the output of the pulse generator and the vertical input of the oscilloscope together at pin 1 of V3303. Using the voltage calibrator on the oscilloscope, calibrate the vertical sensitivity of the oscilloscope for .35 volt per inch. Place the coarse attenuation switch on the pulse generator to .01 and adjust the pulse amplitude using the fine attenuation dial for 1-inch pulse amplitude. Place polarity switch to positive. A positive pulse of the same amplitude should appear. Return polarity switch to negative. Place coarse attenuation switch to .001 position. The input pulse amplitude is now .035 volt.

c. To measure oscilloscope input signal voltage, proceed as follows: Adjust the vertical gain and V multiplier for 1-inch vertical deflection produced by the signal. Remove signal input to the oscilloscope. Place calibration switch to ON and adjust the calibration dial for 1-inch calibration voltage. Multiply the calibration dial reading by the vertical multiplier switch setting. This is the input signal voltage.

Section III. REMOVAL AND REPLACEMENT OF PARTS

327. General

The delay amplifier and nondelay amplifier are placed on subchassis which may be removed entirely. The mti repetition rate trigger amplifier and video balancer and amplifier are mounted on the main chassis with the major number of their components mounted on removable fiberboard subassemblies.

a. Should it be necessary to remove a subchassis, proceed as follows:

(1) *Nondelay amplifier Z2300.*

(*a*) Disconnect P22301 from J2301.

(*b*) Remove underside cover and the screws that hold the subchassis to the main chassis.

(*c*) Unsolder terminals C, UV, UM, UG and F (label leads if labels do not already exist).

(2) *Delay amplifier Z1300.*

(*a*) Disconnect P1301 from J1301.

(*b*) Remove underside cover, remove the screws that hold subchassis to main chassis.

(*c*) Unsolder terminals C, WT, WV, WM, WC and F (label leads if labels do not already exist).

b. Should it be necessary to remove a subassembly associated with the mti repetition rate trigger amplifier or video balancer and amplifier, remove the mounting insulators and screws. Label and unsolder all leads to the subassembly being removed.

c. When removing and replacing components from a subchassis, take extreme care not to disrupt other nearby components. Obtain identical components for replacement and maintain, as near as possible, the same position and lead length of the original component. Although the components on the main chassis and subassemblies are somewhat more accessible, the same considerations must be given when component replacement is necessary.

328. Removal and Replacement of Mercury Delay Network

Normally the mercury delay network may remain in the signal comparator case and be reconnected after the signal comparator has been removed for troubleshooting. Should it be necessary to remove the mercury delay network for bench servicing, refer to the procedure given in paragraph 459. Paragraphs 458 through 461 give the complete disassembly and reassembly instructions for the mercury delay line.

Section IV. ADJUSTMENT AND ALINEMENT

329. General

Although the frequency determining components in the signal comparing system are fixed-tuned, some small amount of tuning may be accomplished by substituting tubes and repositioning components. Subparagraph *a* below lists the references for checking the 9-mc amplifiers. Subparagraph *c* lists the references for other adjustments in the signal comparing system.

a. Bandwidth, center frequency, gain and attenuation checks of the 9-mc signal amplifiers are given in the paragraphs referenced below.

(1) Checking the bandwidth, center frequency and gain of the mti repetition rate trigger amplifier, 9-mc amplifiers (par. 337).

(2) Checking the bandwidth, center frequency and gain of nondelay amplifier Z2300 (par. 338).

(3) Checking the bandwidth, center frequency and gain of delay amplifier Z1300 (par. 339).

(4) Checking the attenuation of mercury delay line W2350 (par. 340).

b. The front panel controls and sequence of adjustment are provided in the TEST INSTRUCTIONS on the signal comparator front panel, which appears as follows:

TEST INSTRUCTIONS

ROTATE TEST SELECTOR CONSECUTIVELY FROM ONE TO FIVE. ADJUST METER TO RED LINE BY CONSECUTIVELY NUMBERED CONTROLS AT

EACH POSITION. TURN METER OFF WHEN NOT IN USE.

No.	*Function*	*Operation Selector*
1.	I.F. AMPL. LEVEL	NORMAL
2.	COHO LEVEL	MTI
3.	DELAY LINE INPUT	MTI
4.	NON DELAY AMPL. OUT	MTI
5.	AMPL. BALANCE	MTI

c. The signal comparing system adjustments other than front panel adjustment that are not covered in the TEST INSTRUCTIONS are as follows:

(1) Slope adjustment capacitor C1353, (par. 331).
(2) Slope adjustment capacitor and MTI BALANCE check (par. 341).
(3) Carrier gate length adjustment check (par. 332).
(4) Mti video gain control R3306 adjustment check (par. 333).
(5) Checking amplitude balance and dc amplifier V3301 gain (delay amplifier agc voltage) (par. 342).

330. Test Equipment Required for Adjustment and Alinement of Signal Comparing System

Test equipment	Common name	Technical manual
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527
Electronic Multimeter TS–505C/U.	Vtvm	11–5511A
Pulse Generator AN/UPM–15.	Pulse generator	11–1177
Signal Generator TS–452C/U.	Sweep frequency generator.	11–2695
Tube Socket Adapter Kit MX–1258/U.	Tube socket adapter kit.	Packed with equipment.

Note. Additional test equipment consists of special test lead (fig. 136) and bias power supply (fig. 146).

331. Slope Adjustment Capacitor C1353 (fig. 143)

a. Slope adjustment capacitor C1353 is a factory adjusted component and should not need readjustment. Should adjustment of C1353 be needed, because of the inability to obtain mti balance and all indications are that C1353 is in need of readjustment, use the following procedure.

b. Field adjustment of slope adjustment capacitor C1353 is made as follows. With the radar set operating in mti, place MTI BALANCE control R2356 at midpoint. While observing the A-scope, adjust slope adjustment capacitor C1353 for minimum fixed target amplitude.

332. Carrier Gate Length Adjustment R1365 (fig. 140)

Adjust carrier gate length adjustment R1365 with the components of the radar set interconnected. Use the A-scope as a means of determining the proper setting. Use an oscilloscope when the signal comparing system is being bench tested (*b* below).

a. Carrier gate length adjustment when the components of the radar set are interconnected.

(1) With OPERATION SELECTOR switch in NORMAL, adjust R1365 for a double image on the A-scope (ccw rotation). Turn control R1365 cw until the right-hand image locks in with the left-hand side of the indicator.
(2) Continue cw rotation of R1365 until the prf of the radar set is counted down (prf equal to 200 pps), indicated by a sudden drop in magnetron current.
(3) Set R1365 halfway between the points where the double image locked in and the prf was counted down.

b. Carrier gate length adjustment with the signal comparator disconnected from the Radar Set.

(1) Remove P1350 and connect the vertical input of the oscilloscope to J1350 with an RG–62/U cable.
(2) Calibrate the oscilloscope for horizontal sweep speed of 2,500 μsec per inch.
(3) Adjust R1365 so that the 9-mc carrier oscillator *on* time is 2,150 μsec and the *off* time is 350 μsec (Y, fig. 214).

333. Mti Video Gain Control R3306 Adjustment

a. General. This adjustment is normally made with the radar set in operation. The radar set is placed in the normal mode of operation and the receiver gain control adjusted for

¼-inch grass (noise) level on the A-scope. The radar set is then placed in the mti mode of operation and mti video gain control R3306 is adjusted for the same grass level.

b. Mti Video Gain Control Check. Follow the procedure given in paragraph 326*a* for setting up the pulse generator and paragraph 326*c* for pulse amplitude measurement using the oscilloscope.

(1) Apply a 5-μsec .035 v 400 pps pulse to pin 1 of V3303. Rotate R3306 fully cw.
(2) Place the oscilloscope at pin 5 of V3303. The pulse amplitude should be approximately 1.1 v.
(3) Rotate R3306 ccw. The pulse amplitude should decrease smoothly without jump or jitter.

Section V. FIELD TESTING

334. General

This section lists the testing procedures required to check the serviceability of a repaired signal comparing system when the components of the radar set are interconnected.

a. Bench testing the signal comparing system components in the signal comparator is outlined in paragraphs 343 through 347.

b. Testing procedures designed to check the serviceability of the complete radar set are covered in paragraph 448.

335. Test Equipment Required

The following list of test equipment is required to completely test the serviceability of the signal comparing system.

Test equipment	Common name	Technical manual
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083.
Electronic Multimeter TS–505C/U.	Vtvm	11–5511A.
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103. 11–5129.
Pulse Generator AN/UPM–15.	Pulse generator	11–1177.
Signal Generator TS–452C/U.	Sweep frequency generator.	11–2695.
Tube Socket Adapter Kit MX–1258/U.	Tube socket adapter kit.	Packed with equipment.

Note. Additional test equipment consists of special test leads (fig. 136) and bias power supply (fig. 146).

336. Procedure

The following chart lists the reference paragraph and the adjustment and/or measurements necessary to completely test the serviceability of the signal comparing system.

Adjustment or measurement	Reference (par.)
Slope adjustment capacitor C1353	331
Carrier gate length R1365	332
Mti video gain control R3306	333
Checking bandwidth, center frequency and gain of the mti repetition rate trigger amplifier, 9-mc amplifiers.	337
Checking bandwidth, center frequency and gain of nondelay amplifier Z2300.	338
Checking bandwidth, center frequency and gain of delay amplifier Z3100.	339
Checking attenuation of mercury delay network W2350.	340
Checking slope adjustment capacitor C1353 and MTI BALANCE control R2356.	341
Checking amplitude balance and dc amplifier V3301 (delay amplifier agc voltage).	342

337. Checking Bandwidth, Center Frequency, and Gain of 9-mc Carrier Channel

a. Aline the sweep generator with the 5–10 mc oscillator coil installed; use the procedure given in paragraph 295*b*.

b. Set DELAY LINE INPUT R2352 cw, OPERATION SELECTOR switch to NORMAL and TEST SELECTOR switch to OFF.

c. Place 9-mc amplifier V1356 in a tube socket adapter, remove carrier gate multivibrator V1354 and disconnect J2301.

d. Apply the RF output of the sweep generator to pin 1 of V1356; use the special test lead and coax lead (figure 136).

e. Disconnect P1350 and connect the vertical input of the sweep generator oscilloscope through the traveling detector to J1350.

f. Add attenuation until the amplitude of the response curve is 5 scale divisions, (equal to the vertical amplitude adjustment in *a* above). The amount of attenuation required to reduce

the response curve to the amplitude set in *a* above is the gain of the amplifier, which should be 21 ±2 db.

g. For bandwidth and center frequency measurements, decrease the attenuation so as to present a greater amplitude display.

(1) Check for limiting by adding 3-db attenuation and note the decrease in amplitude; then add an additional 3 db. The second decrease in amplitude should be less than the first.

(2) Should limiting be apparent, increase RF attenuation, readjust the vertical oscilloscope control and repeat (1) above.

(3) Remove the 6-db attenuation added to check for limiting.

h. Add 3-db attenuation and place a horizontal line across the crt at the peak amplitude of the display. Remove the 3-db attenuation.

i. With the sweep generator wavemeter, using band A, measure the frequency at the two points where the response curve passes through the horizontal line marked in *h* above, and measure the frequency at a point halfway between (center frequency).

j. The difference in frequency of the two extreme readings is the bandwidth, which should be 1.4 ±.2 mc and the center frequency 8.5 ±.3 mc.

338. Checking Bandwidth, Center Frequency, and Gain of Nondelay Amplifier Z2300

In *a* through *g* below the overall gain is measured. The input to the first amplifier is attenuated and some attenuation is present in the detected output. A stage-by-stage measurement is given in the nondelay amplifier step-by-step troubleshooting chart (par. 323), steps 4 through 11.

a. Aline the sweep generator with the 5–10-mc oscillator coil installed; use the procedure given in paragraph 295*b*.

b. Place OPERATION SELECTOR switch in NORMAL, TEST SELECTOR switch in OFF, and remove delay amplifier detector V1306.

c. Remove P2301 and apply the RF output of the sweep generator through a 5-foot RG–58/U cable to J2301.

d. Using the special test lead and coax lead, figure 136, connect the vertical input of the sweep generator oscilloscope to the junction of R3301 and R3302.

e. Add attenuation until the amplitude of the waveform is 5 scale divisions (equal to the amplitude set in *a* above). The amount of attenuation required to reduce the response curve to the amplitude set in *a* above is the gain of the amplifier, which should be 42 ±3 db.

f. For bandwidth and center frequency measurements use procedure given in paragraph 337*g* through *i*.

g. The difference in frequency of the two extreme readings is the bandwidth which should be 1.1 ±.2 mc and center frequency 8.5 ±.3 mc.

h. Reconnect P2301 to J2301.

339. Checking Bandwidth, Center Frequency, and Gain of Delay Amplifier Z1300

a. Aline the sweep generator with the 5–10-mc oscillator coil installed; use the procedure given in paragraph 295*b*.

b. Place OPERATION SELECTOR switch S2354 in NORMAL, TEST SELECTOR switch S2353 in OFF, remove nondelay amplifier detector V2306, dc amplifier V3301, and P1301.

c. Using the bias power supply, figure 146, apply a +3-volts bias across capacitor C3301B to ground and maintain this voltage throughout the delay amplifier check.

d. Apply the RF output of the sweep generator through a 5-foot RG–58/U cable to J1301.

e. Using the special test lead and coax lead, figure 136, connect the junction of lead WV and R2357 to the vertical input of the sweep generator oscilloscope.

f. Add attenuation until the amplitude of the response curve is 5 scale divisions (equal to the vertical amplitude adjustment in *a* above). The amount of attenuation required to reduce the oscilloscope display to the point set in *a* above is the gain of the amplifier which should be 75 ±3 db.

g. For bandwidth and center frequency measurements use the procedure given in paragraph 337*g* through *i*. The difference in frequency of the two extreme readings is the

bandwidth, which should be 1.4 ±.1 mc and the center frequency 8.5 ±.3 mc.

h. Replace V2306, reconnect P1301 to J1301 and remove the bias power supply.

340. Checking Attenuation of Mercury Delay Line W2350

a. Aline the sweep generator with the 5–10-mc oscillator coil installed; use the procedure given in paragraph 295*b*.

b. Place OPERATION SELECTOR switch S2354 in NORMAL; place TEST SELECTOR switch S2353 in OFF; remove nondelay amplifier detector V2306 and dc amplifier V3301 and P1301.

c. Using the bias power supply, figure 146, apply a +3-volt bias across capacitor C3301B to ground and maintain this voltage throughout measurement.

d. Apply the RF output of the sweep generator through a 5-foot RG–58/U cable to J1301.

e. Using the special test lead and coax lead, figure 136, connect the junction of lead WV and R2357 to the vertical input of the sweep generator oscilloscope.

f. Attenuate the RF signal 75 to 80 db and adjust the oscilloscope for 5 scale divisions. Note the amount of attenuation used.

g. Reconnect P1301 to J1301, remove P2350 and apply the RF signal to J2350.

h. Decrease the attenuation until the amplitude of the display is the same as *e* above. Note the amount of attenuation remaining.

i. The difference between the attenuation noted in *f* and *g* above is the attenuation of the mercury delay line, which should be less than 70 db.

341. Checking Slope Adjustment Capacitor C1353, and MTI BALANCE Control R2356

(figs. 143 and 144)

a. Adjust the pulse generator for a 2-μsec, 10-v, 400-pps pulse and apply the pulse to pin 1 of V1350, using the special coax and test lead shown in figure 136.

b. Remove V1353 and place the vertical input of the oscilloscope at pin 1 of V1353.

c. Use the sync output jack of the pulse generator to synchronize the oscilloscope.

d. Adjust the oscilloscope to show one waveform and a sweep speed of 10 μsec per inch.

e. Set the MTI BALANCE control R2356 fully ccw.

f. Rotate slope adjustment capacitor C1353 1 complete turn and note the maximum horizontal displacement on the oscilloscope.

g. Using the time markers on the oscilloscope, measure the displacement noted in *f* above. This displacement should be approximately 4 μsec.

h. Set MTI BALANCE control R2356 fully cw.

i. Repeat *f* above.

j. The horizontal displacement should be approximately 9 μsec.

342. Checking Amplitude Balance and Dc Amplifier V3301 Gain (Delay Amplifier Agc Voltage)

a. Remove nondelay detector V2306, delay detector V1306 and mti video amplifier V3303.

b. With a vtvm placed at the junction of R3313 and C3301B, adjust AMPL. BALANCE control R2354 (front panel) for a reading of −10 volts.

c. Disconnect the vtvm.

d. Place the bias power supply, figure 146, at the junction of R3308 and C3311.

e. Place the vtvm across the output of the bias power supply and adjust for .05 volts.

f. Remove the vtvm and reconnect to the junction of R3313 and C3301B. Record the vtvm reading.

g. Reverse the double-pole, double-throw switch on the bias power supply. Record the vtvm reading.

h. The voltage change for *f* and *g* above should be approximately 15.5 volts.

Section VI. BENCH SERVICING SIGNAL COMPARATOR

343. General

This section covers the bench servicing of the signal comparing system. A major portion of the receiving system is also contained on the same chassis (Signal Comparator CM–36/TPS–1D) and its operation is closely associated with that of the signal comparing system. Bench servicing of the receiving system is

covered in paragraphs 306 through 311. The following information will aid the repairman in bench servicing the signal comparing system.

Information	Location
Signal Comparator CM–36/TPS–1D, complete schematic diagram.	Fig. 219.
Signal comparing system, location of parts.	Figs. 140 through 145.
Signal comparing system, voltage and resistance measurements.	Figs. 217, 218.
Mti repetition rate trigger amplifier waveforms.	Fig. 214.
Bench power supply connections and power supply PP–674/TPS–1D dummy loads.	Fig. 147.
Bias power supply for delay amplifier gain and alinement check and agc test.	Fig. 146.
Fuses protecting Signal Comparator CM–36/TPS–1D.	Par. 315.

344. Test Equipment

The following items of test equipment, cables and special test equipment are required to bench service the signal comparing system.

Test equipment	Common name	Technical manual
Electron Tube Test Set TV–7B/U.	Tube Tester	11–5083
Electronic Multimeter TS–505C/U.	Vtvm	11–5511A
Motor Generator PU–20B/C	Motor generator.	11–978
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Power Supply PP–674/TPS–1D.	Power Supply	This manual
Pulse Generator AN/UPM–15.	Pulse generator.	11–1177
Signal Generator TS–452C/U.	Sweep frequency generator.	11–2695
Tube Socket Adapter Kit MX–1258/U.	Tubesocket adapter kit.	Packed with equipment.
Electrical Power Cable Assembly CX–3640/U.	None	11–1250
Electrical Power Cable Assembly CX–2001/U.	None	11–1250

Note. Additional equipment consists of special test leads (fig. 136) and bias power supply (fig. 146).

345. Bench Servicing Connections

Follow the directions in *a* through *e* for connecting the signal comparator for bench servicing the signal comparing system.

a. Disconnect all cables from the front panel of the unit.

b. Loosen the eight captive screws on the front panel and remove the unit.

(1) It is necessary to disable the stops to remove the unit completely.

(2) Care must be taken to avoid damaging the mercury delay line cables.

c. Disconnect P1350, P1301 and P2354.

(1) It should not be necessary to remove the mercury delay line W2350 from its housing unless its attenuation is excessive. Paragraph 340 gives the attenuation check for the delay line.

(2) To remove the mercury delay line, refer to paragraph 459.

d. Connect the dummy load resistors and single-pole, single-throw switch as shown in figure 147. The single-pole, single-throw switch serves as an on-off switch for the power supply.

e. Connect the Signal Comparator CM–36/TPS–1D unit to the power supply as shown in figure 147. When connecting more than one item of test equipment for a given test, plug the outlet box into J409 and use the outlet box for test equipment power source.

346. Bench Troubleshooting Signal Comparing System

a. Connect Signal Comparator CM–36/TPS–1D to the power supply for bench servicing, figure 147.

b. Use the single-pole, single-throw switch installed on the power supply for applying power to the unit.

c. A separate step-by-step troubleshooting chart is furnished for each section of the signal comparing system:

(1) Nondelay amplifier step-by-step troubleshooting chart (par. 323).

(2) Delay amplifier step-by-step troubleshooting chart (par. 324).

(3) MTI repetition rate trigger amplifier step-by-step troubleshooting chart (par. 325).

(4) Video balancer and amplifier step-by-step troubleshooting chart (par. 326).

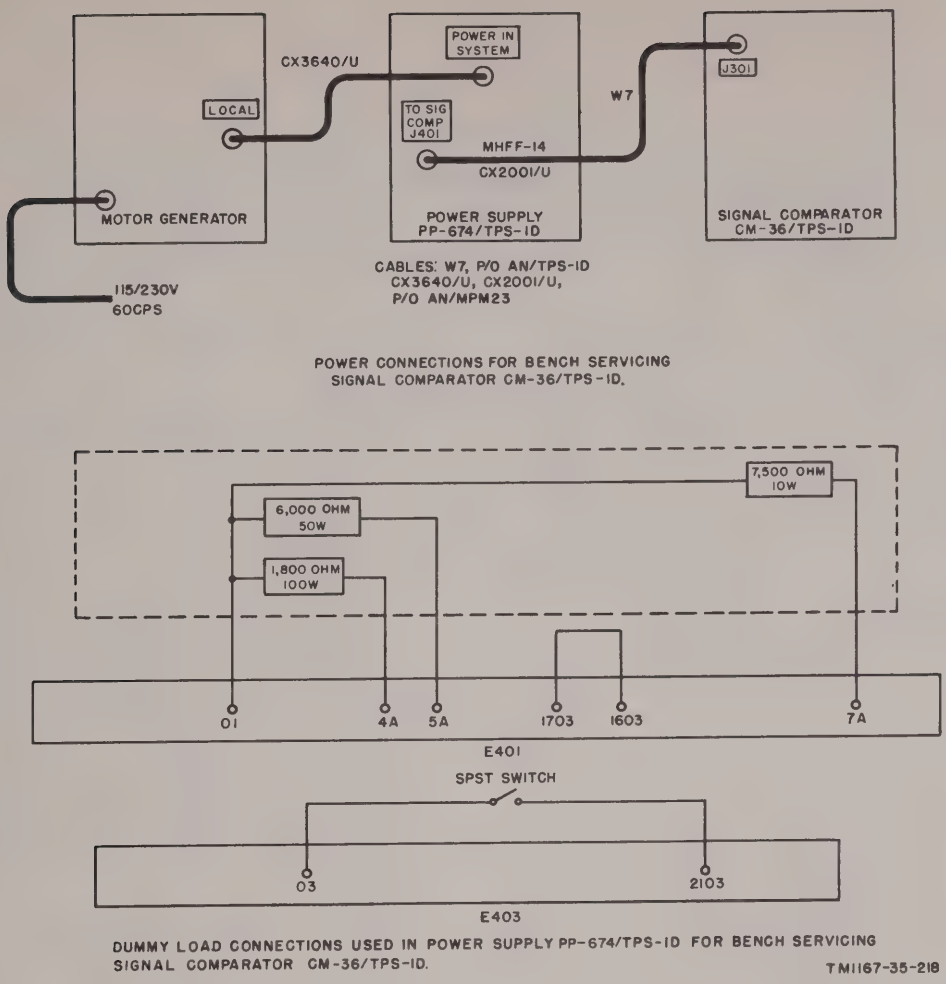


Figure 147. Signal comparing system, bench servicing connections.

347. Bench Alinement and Adjustment of Signal Comparing System

a. The signal comparing system may be completely alined and adjusted during bench servicing.

b. Use attenuator Z2350 (fig. 140) in place of the mercury delay line if the delay line has not been removed from its housing.

c. Follow the adjustment given in the TEST INSTRUCTIONS on the front panel.

d. The adjustments not given in the TEST INSTRUCTIONS are as follows:

(1) MTI BALANCE (par. 341).

(2) Slope adjustment capacitor (par. 341).

(3) Carrier gate length adjustment (par. 332).

CHAPTER 16

INDICATING SYSTEM TROUBLESHOOTING AND REPAIR

Warning: Extremely dangerous voltages exist in Azimuth-Range Indicator IP–141/TPS–1D: 5,000 volts are found at ppi-scope V609 and rectifier V626 and 1,500 volts are found at A-scope V625.

1. Do not apply power to the set with the phenolite cover removed from the high-voltage power supply chassis (fig. 156).

2. Use the test points that are provided for checking the 1,500 and 5,000 volts.

3. Turn off the power and ground capacitors C665 through C668 with a shorting bar before making resistance measurements in the high-voltage power supply chassis.

Section I. TROUBLESHOOTING INFORMATION

348. Reference Data

The following information will be helpful when troubleshooting or repairing the indicating system.

Reference	Data
Fig. 58	Indicating system, complete block diagram.
Pars. 106–142	Indicating system theory.
Figs. 59–78	Indicating system, simplified schematic diagrams.
Fig. 224	Indicating system, complete schematic diagram.
Par. 349	Location of parts in indicating system.
Figs. 148–158	Azimuth-Range Indicator IP–141/TPS–1D, location of parts and adjustments.
Figs. 159 and 160	Azimuth-Range Indicator IP–141/TPS–1D, resistor and capacitor panels.
Fig. 223	Indicating system, voltage and resistance chart.
Par. 353	Dc resistance of indicating system transformers, coils, and filters.
Fig. 222	Waveforms of ppi sweep and range strobe circuits.
Fig. 221	Waveforms of A-sweep and fixed marker circuits.
Par. 351	Indicating system fuses.

349. Location of Parts in Indicating System

a. The following is a list of indicator parts and the figures on which these parts can be located.

b. The figures listed after test points illustrate the top view of the test point. The bottom views of test points are called out in figure 157.

c. Subassemblied Z607 and Z608 are composite components. Subassembly Z607 is switch S606 and the resistors and capacitors that are mounted on it. Subassembly Z608 is switch S609 and the resistors and capacitors are mounted on it.

d. The numbers and letters (A, B, C, Z607, etc.) preceding a figure number indicate the panel or subassembly which are found on the figure.

Reference symbol	Fig. No.	Reference symbol	Fig. No.
B601	152	C625	C, 159
B602	152	C626	C, 159
C601	156	C627	A, 159
C602	156	C628	A, 159
C603	153	C629	A, 159
C604	B, 159	C630	155
C605	155	C631	155
C606	B, 159	C632	A, 159
C607	B, 159	C633	A, 159
C609	C, 159	C634	A, 159
C610	Z607, 160	C635	A, 159
C611	Z607, 160	C636	A, 159
C612	Z607, 160	C637	A, 159
C613	Z607, 160	C638	A, 159
C614	C, 159	C639	B, 159
C615	Z607, 160	C640	B, 159
C616	Z607, 160	C641	B, 159
C617	Z607, 160	C642	155
C618	Z607, 160	C643	C, 159
C619	155	C644	155
C620	B, 159	C645	C, 159
C621	C, 159	C646	C, 159
C622	C, 159	C647	D, 160
C623	155	C648	Z608, 160
C624	B, 159	C649	Z608, 160

Reference symbol	Fig. No.
C650	Z608, 160
C651	Z608, 160
C652	Z608, 160
C653	D, 160
C654	Z608, 160
C655	Z608, 160
C656	Z608, 160
C657	Z608, 160
C658	Z608, 160
C659	E, 160
C660	E, 160
C661	155
C662	155
C664	149
C665	156
C666	156
C667	156
C668	156
CR601	C, 159
E601	152
E602	156
E604	150
E617	150
E618	150
E628	155
E629	155
E630	155
E631	155
E632	155
E633	155
E634	156
E635	156
E638	156
E639	158
HR601	149
I 601	158
I 602	158
I 603	158
I 604	158
I 605	158
I 606	158
I 607	158
I 608	158
I 609	153
I 610	153
J601	153
J602	158
J603	158
L601	150
L602	158
L603	B, 159
L604	A, 159
M601	153
R601	E, 160
R608	149
R609	158
R610	154
R611	B, 159
R612	B, 159
R613	B, 159
R614	B, 159
R615	B, 159
R616	B, 159
R617	B, 159
R618	B, 159
R619	C, 159
R620	C, 159
R621	C, 159
R622	C, 159
R623	C, 159
R624	C, 159
R625	C, 159
R626	154
R627	Z607, 160
R628	C, 159
R629	C, 159
R630	C, 159
R631	C, 159
R632	C, 159
R633	C, 159
R634	Z607, 160
R635	C, 159
R636	C, 159
R637	C, 159
R638	C, 159
R639	B, 159
R640	B, 159
R641	B, 159
R642	C, 159
R643	C, 159
R644	B, 159
R645	B, 159
R646	B, 159
R647	B, 159
R648	B, 159
R649	B, 159
R650	B, 159
R651	154
R652	Z607, 160
R653	Z607, 160
R654	Z607, 160
R655	Z607, 160
R656	C, 159
R657	C, 159
R658	154
R659	154
R660	154
R661	A, 159
R662	150
R663	158
R664	149
R665	150
R666	B, 159
R667	B, 159
R668	B, 159
R669	B, 159
R670	B, 159
R671	154
R672	B, 159
R673	154
R674	B, 159
R675	B, 159
R676	B, 159
R678	B, 159
R679	B, 159
R680	A, 159
R681	A, 159
R682	154
R683	154
R684	C, 159
R685	154
R686	C, 159
R687	C, 159
R688	C, 159
R689	A, 159
R690	A, 159
R691	154
R692	A, 159
R693	A, 159
R694	A, 159
R695	A, 159
R696	A, 159
R697	A, 159
R698	A, 159
R699	A, 159
R1601	A, 159
R1602	A, 159
R1603	A, 159
R1604	A, 159
R1605	A, 159
R1606	A, 159
R1607	A, 159
R1608	A, 159
R1609	A, 159
R1610	154
R1611	154
R1612	154
R1613	A, 159
R1614	A, 159
R1615	A, 159
R1616	A, 159
R1617	154
R1618	154
R1619	A, 159
R1620	A, 159
R1621	A, 159
R1622	A, 159
R1623	A, 159
R1624	A, 159
R1625	A, 159
R1626	A, 159
R1627	A, 159
R1628	A, 159
R1629	154
R1630	A, 159
R1632	A, 159
R1633	Z607, 160
R1634	Z608, 160
R1635	B, 159
R1636	B, 159
R1637	B, 159
R1638	B, 159
R1639	B, 159
R1640	B, 159
R1641	B, 159
R1642	B, 159
R1643	B, 159
R1644	B, 159
R1645	B, 159
R1646	B, 159
R1647	C, 159
R1648	C, 159
R1649	C, 159
R1650	C, 159
R1651	C, 159
R1652	C, 159
R1653	C, 159
R1654	C, 159
R1655	154
R1656	C, 159
R1657	154
R1658	C, 159
R1659	C, 159
R1660	Z608, 160
R1661	Z608, 160
R1662	Z608, 160
R1663	Z608, 160
R1664	D, 160
R1665	C, 159
R1666	C, 159
R1667	D, 160
R1668	D, 160
R1669	154
R1670	Z608, 160
R1671	C, 159
R1672	C, 159
R1673	C, 159
R1674	C, 159
R1675	C, 159
R1676	154
R1677	Z608, 160
R1678	D, 160
R1679	D, 160
R1680	D, 160
R1681	D, 160
R1682	E, 160
R1683	E, 160
R1684	D, 160
R1685	D, 160
R1686	D, 160
R1687	154
R1688	D, 160
R1689	154
R1690	D, 160
R1691	E, 160
R1692	E, 160

Reference symbol	Fig. No.	Reference symbol	Fig. No.
R1693	154	R2620	A, 159
R1694	F, 160	R2621	154
R1695	F, 160	R2622	A, 159
R1696	154	R2623	154
R1697	D, 160	R2624	156
R1698	D, 160	R2625	154
R2601	154	R2626	A, 159
R2602	D, 160	R2627	149
R2603	156	S601	149
R2604	156	S602	156
R2605	156	S603	158
R2606	156	S606	155
R2607	156	S607	155
R2608	156	S608	149
R2609	156	S609	155
R2610	156	S610	156
R2611	156	S611	156
R2612	156	S612	150
R2613	156	S613	149
R2614	156	S615	158
R2615	156	S616	158
R2616	156	S617	158
R2617	149	S618	158
R2618	149	T601	155
R2619	158	T602	155

Reference symbol	Fig. No.	Reference symbol	Fig. No.
T603	155	XV611	157
T604	156	XV612	157
T605	155	XV613	157
TP601	152	XV614	157
TP602	152	XV615	157
TP603	158	XV616	157
TP604	152	XV617	157
TP605	151	XV618	157
TP606	151	XV619	157
TP607	151	XV620	157
TP608	151	XV621	157
TP609	152	XV622	157
TP610	156	XV623	157
TP611	156	XV624	157
TP612	156	XV625	157
XV601	157	XV626	156
XV602	157	Z601	155
XV603	157	Z602	153
XV604	157	Z603	153
XV605	157	Z604	153
XV606	157	Z605	156
XV607	157	Z606	156
XV608	157	Z607	160
XV609	157	Z608	160
XV610	157		

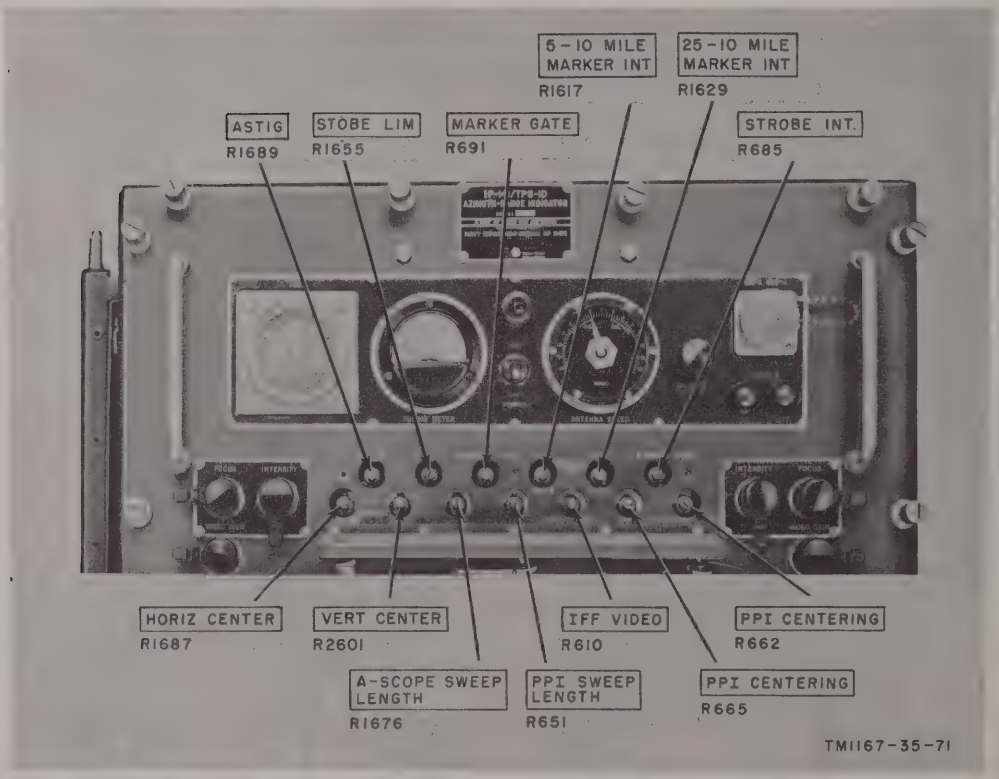


Figure 148. Azimuth-Range Indicator IP–141/TPS–1D, panel screw driver adjustments.

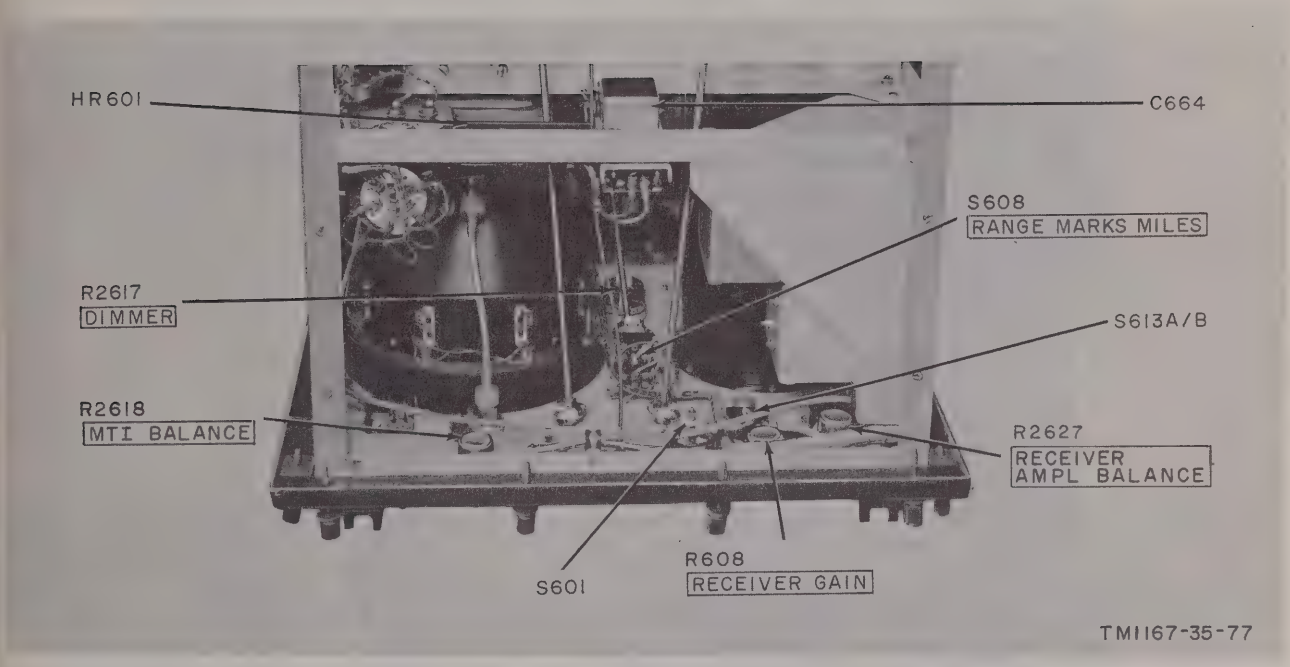


Figure 149. Azimuth-Range Indicator IP–141/TPS–1D, partial bottom view.

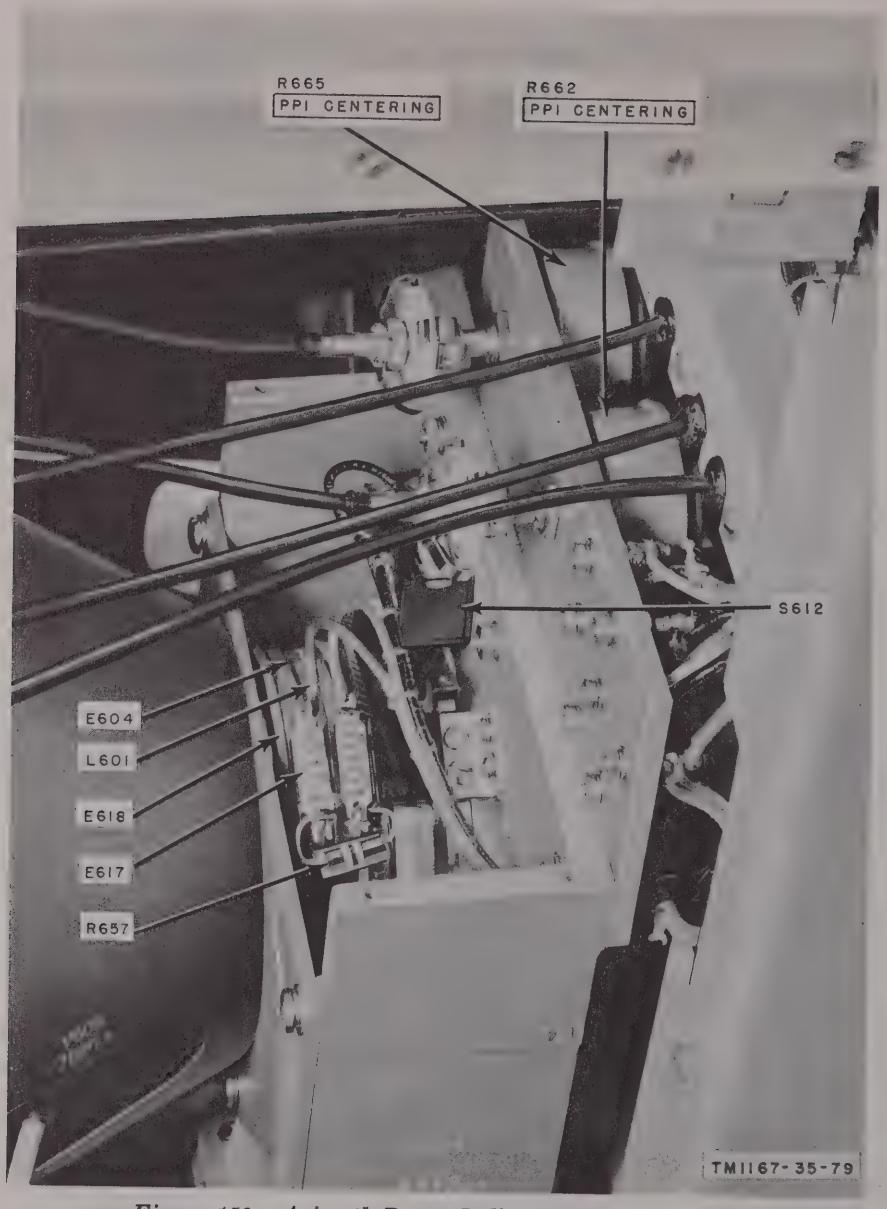


Figure 150. Azimuth-Range Indicator IP–141/TPS–1D, partial view of right side.

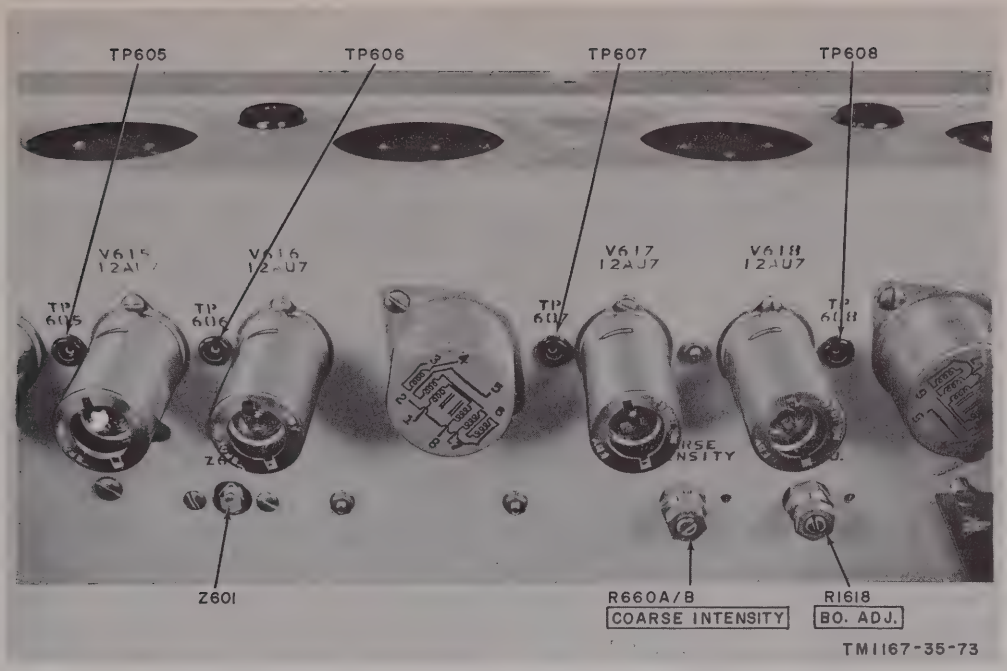


Figure 151. Azimuth-Range Indicator IP–141/TPS–1D, adjustments and test points, top view.

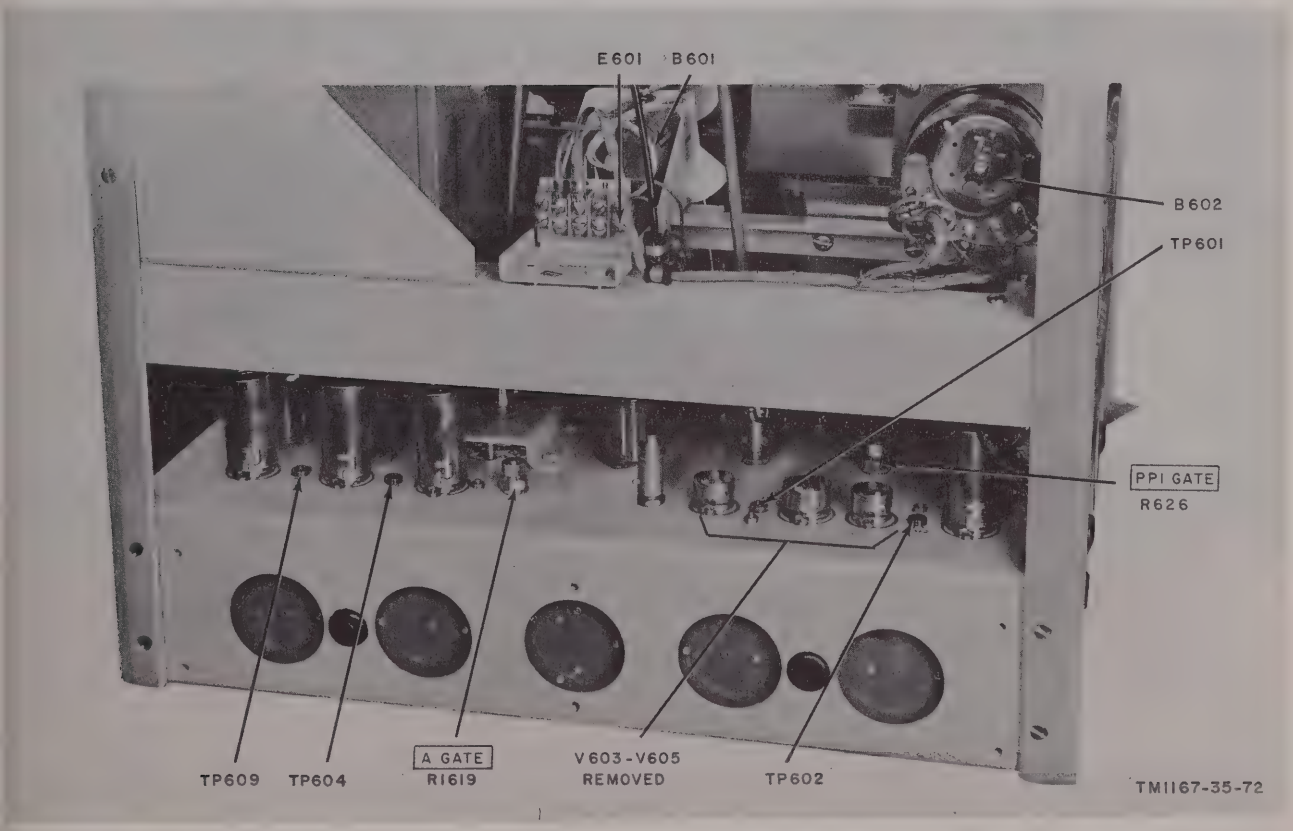


Figure 152. Azimuth-Range Indicator IP–141/TPS–1D, adjustments and test points, bottom view.

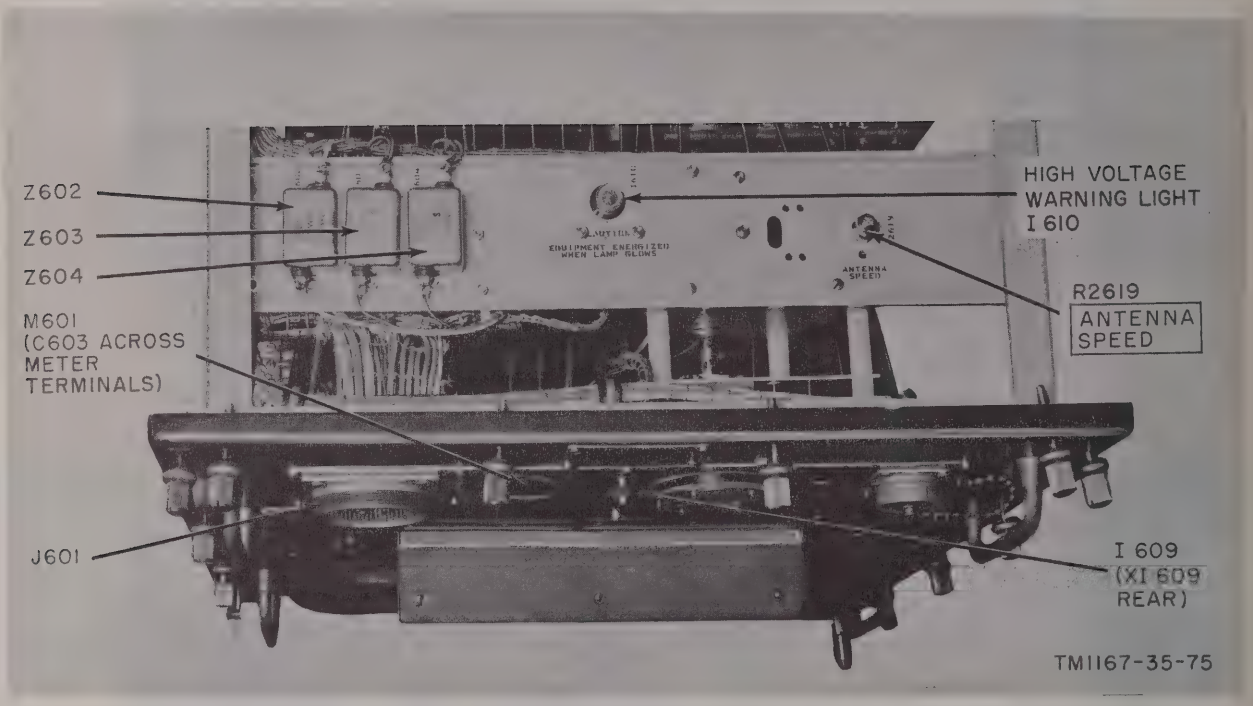


Figure 153. Azimuth-Range Indicator IP–141/TPS–1D, parts location, top view.

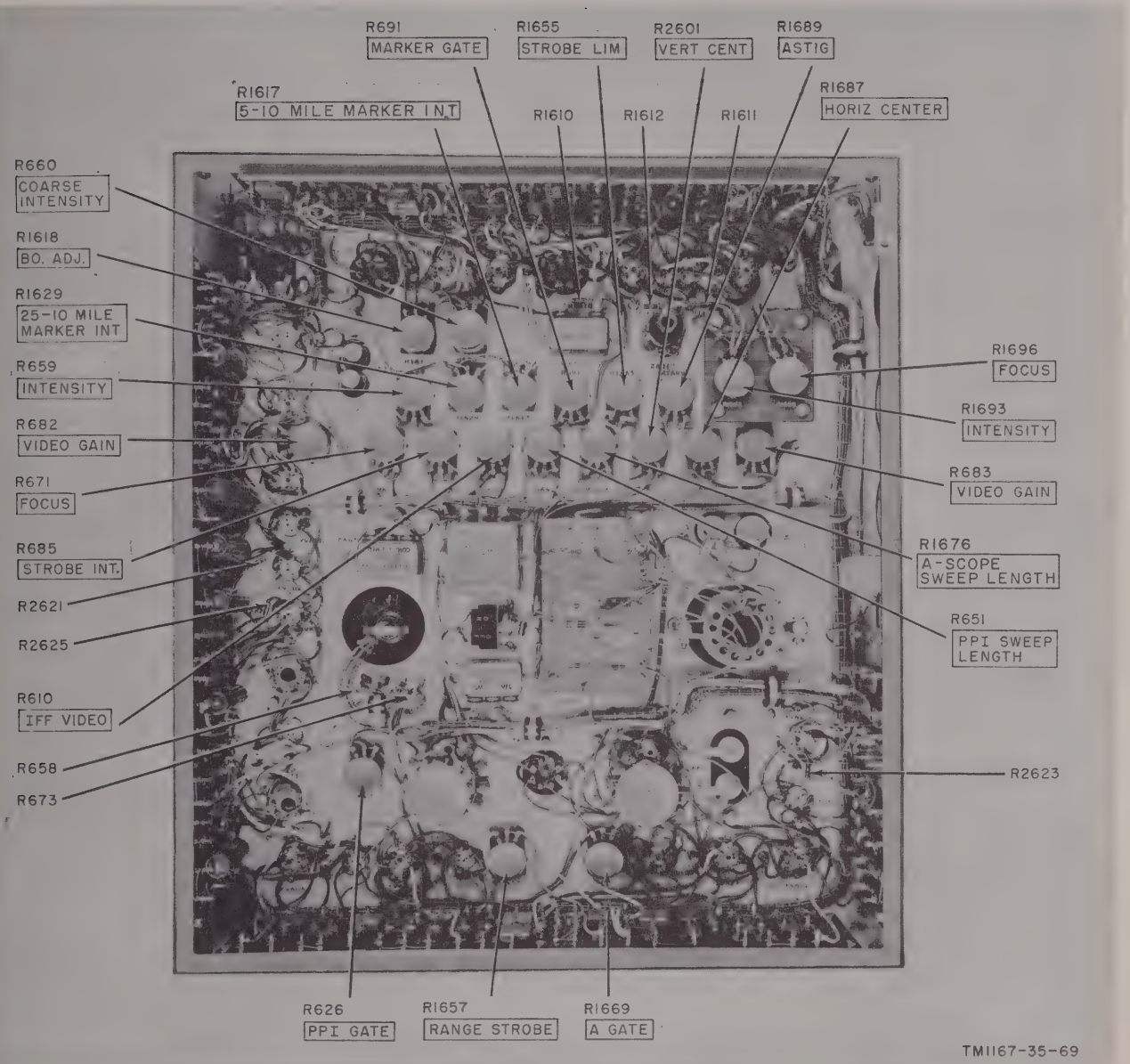


Figure 154. Azimuth-Range Indicator IP–141/TPS–1D, location of controls and adjustments, under chassis view.

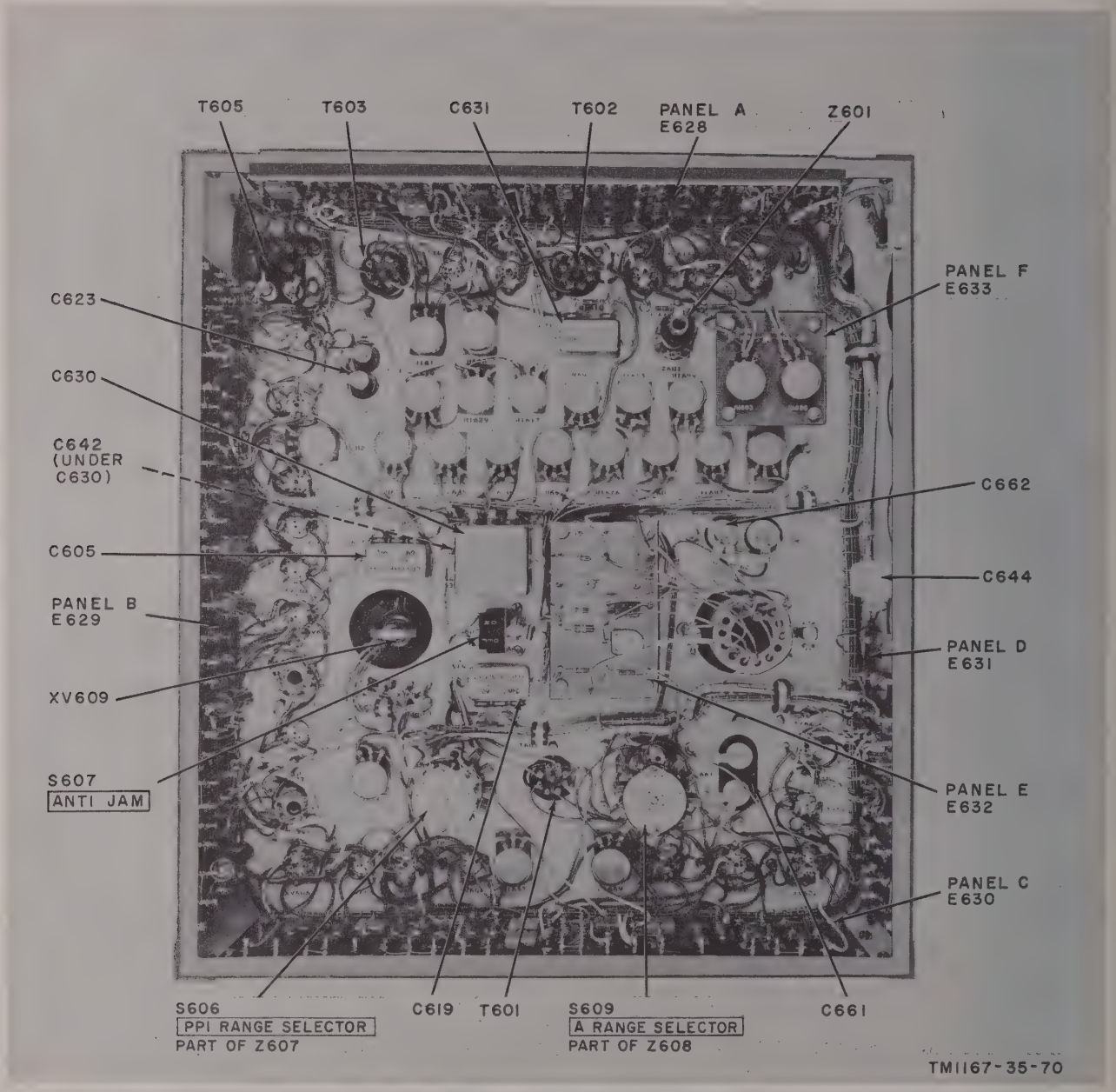


Figure 155. Azimuth-Range Indicator IP–141/TPS–1D, location of parts, under chassis view.

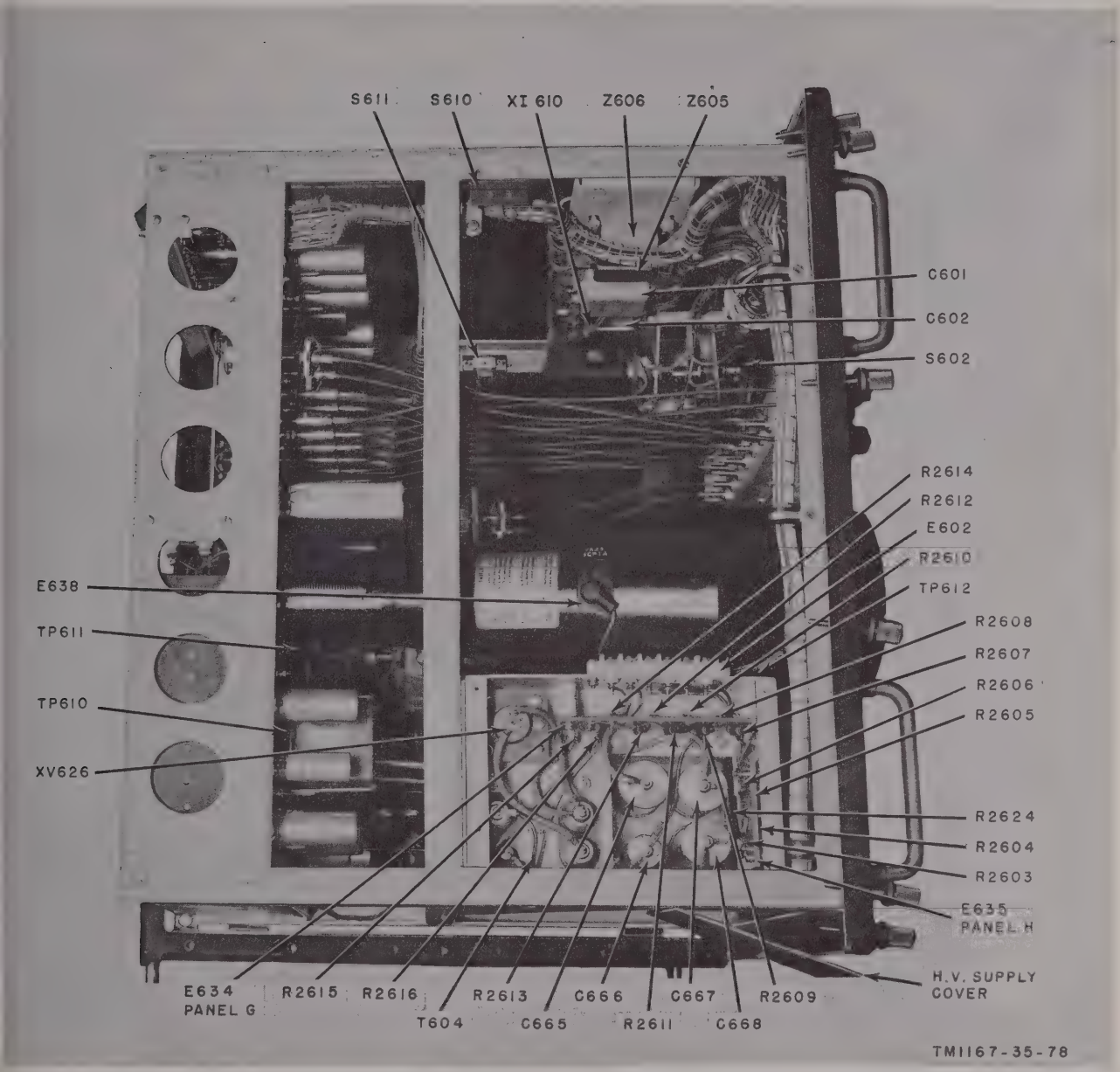


Figure 156. Azimuth-Range Indicator IP–141/TPS–1D, location of parts, left side.

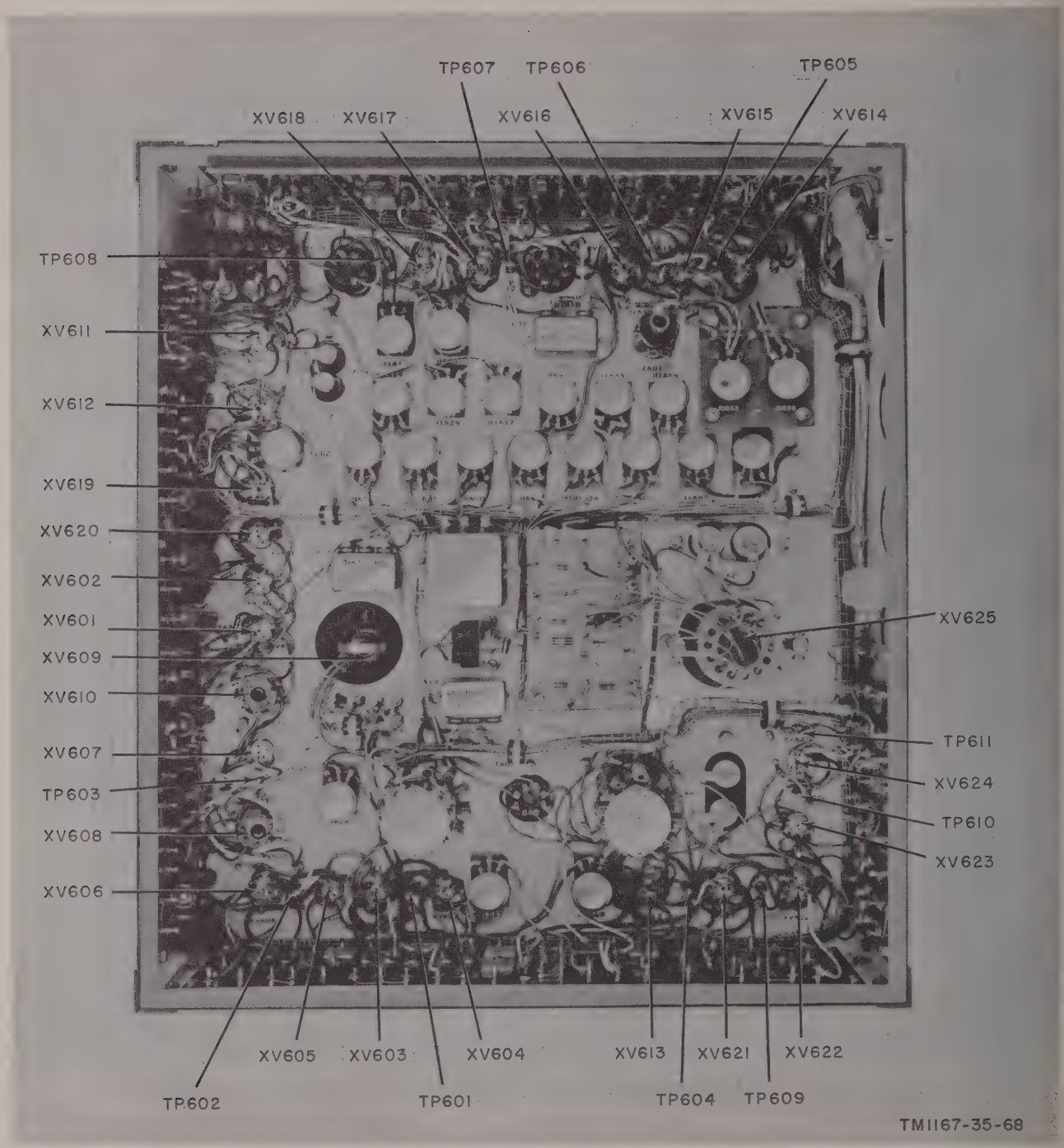


Figure 157. Azimuth-Range Indicator IP–141/TPS–1D, location of tube sockets and test points, under chassis view.

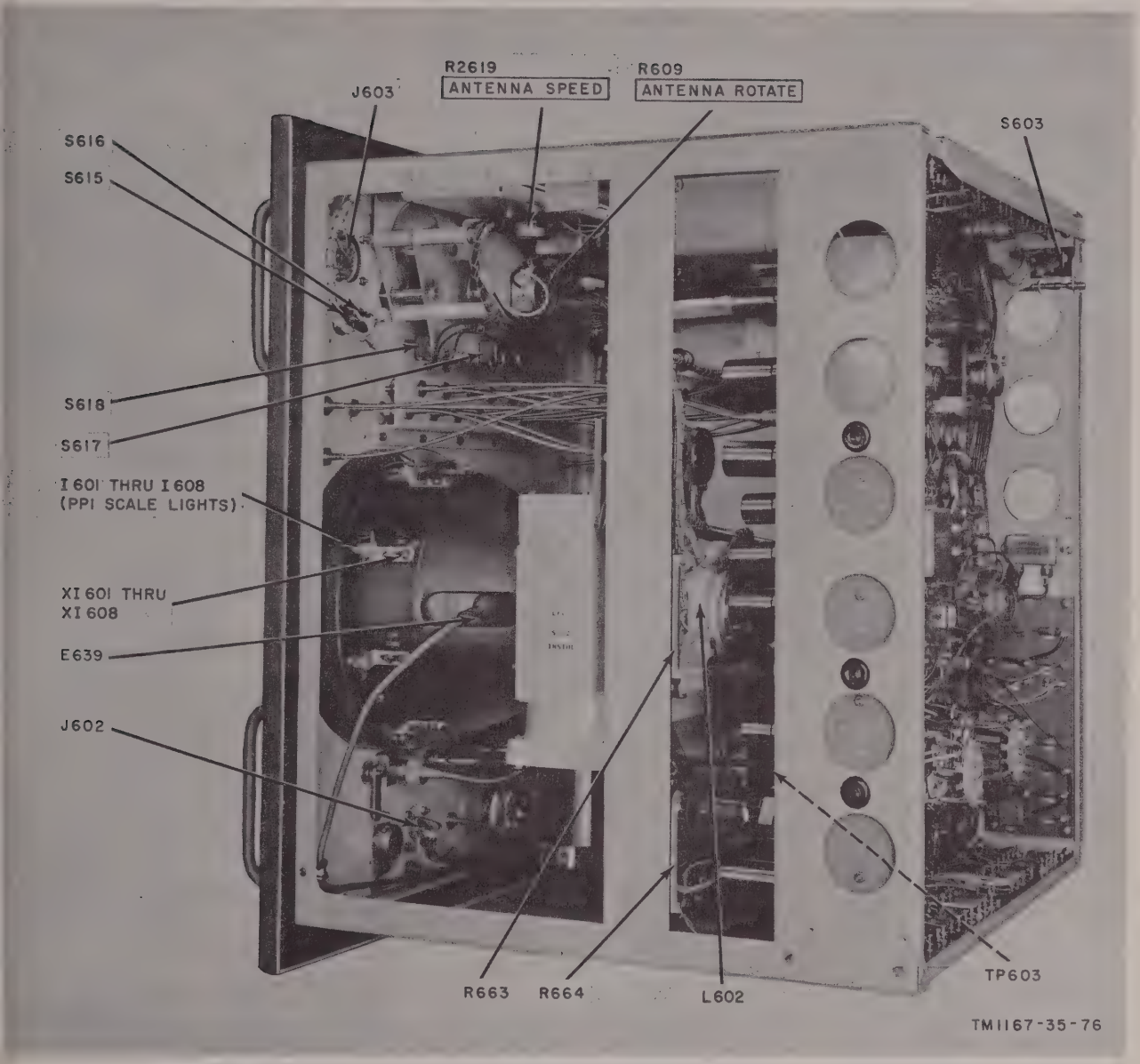


Figure 158. Azimuth-Range Indicator IP–141/TPS–1D, location of parts, right side.

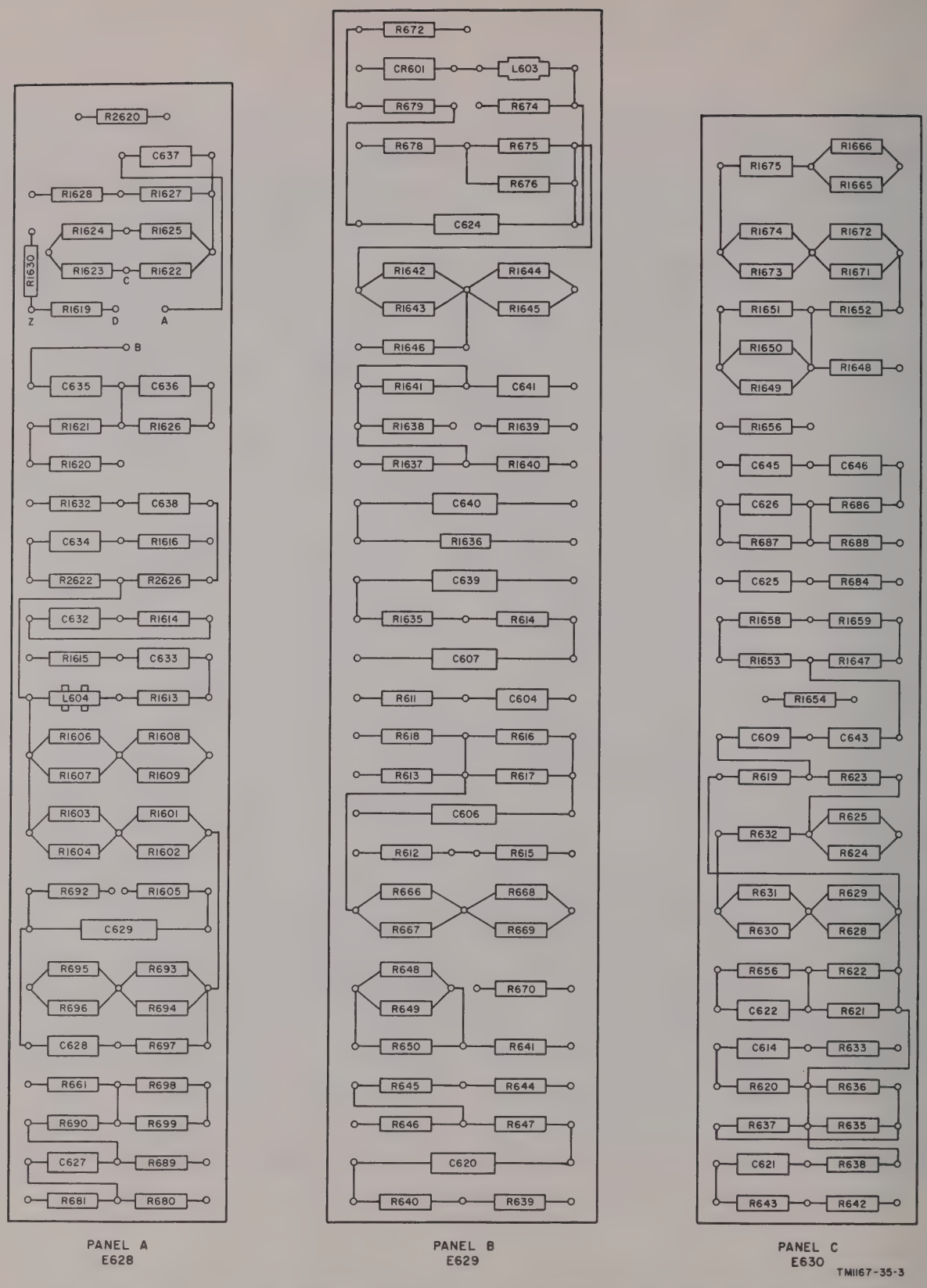


Figure 159. Azimuth-Range Indicator IP–141/TPS–1D, resistor and capacitor panels A, B, and C.

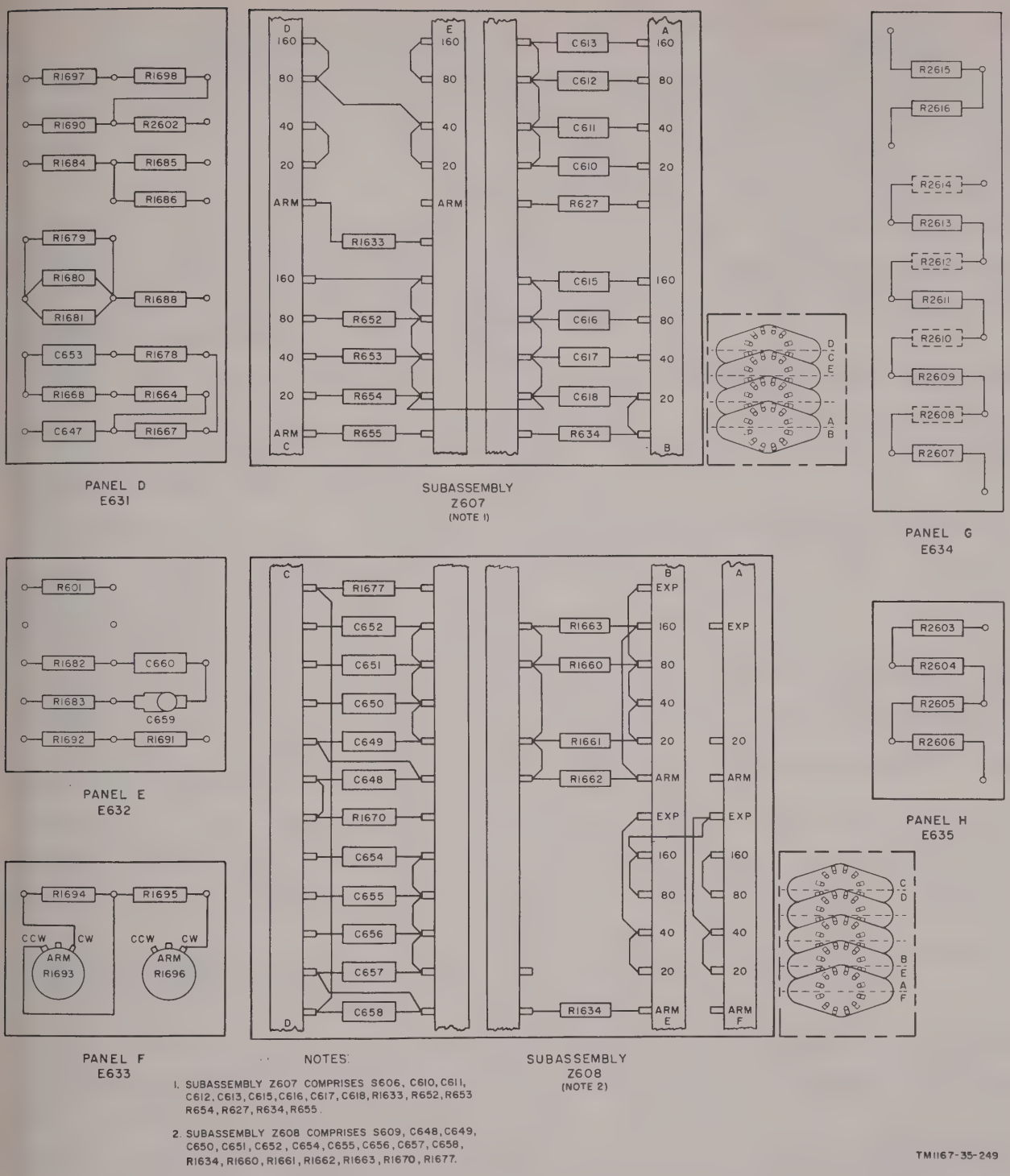


Figure 160. Azimuth-Range Indicator IP–141/TPS–1D, resistor and capacitor panels D through H, and subassemblies Z607 and Z608.

350. Indicating System Controls and Adjustments

The following chart lists the controls and adjustments that are functional parts of the indicating system. Controls which are located on the indicator but are not part of the indicating system are listed in the chapters covering the system in which the controls function.

Controls and adjustments	Location (fig.)	Function
A-scope FOCUS control R1696	148	Determines sharpness of the A-scope display by controlling the voltage applied to the focusing anode (pin 5) of V625.
A-scope INTENSITY control R1693	148	Determines brightness of the A-scope display by controlling the voltage on the cathode (pin 2) of V625.
A-scope VIDEO GAIN control R683	148	Controls amplitude of the video signals on the A-scope display by varying the input level of the video signals fed from video cathode follower V612A.
A-scope HORIZ CENTER control R1687	148	Controls horizontal position of the A-scope display by varying the bias on V624B.
A-scope VERT CENTER control R2601	148	Controls vertical position of the A-scope display by varying the fixed voltage on the lower vertical deflection plate (pin 8) of V625.
A-scope ASTIG control R1689	148	Corrects for an out-of-focus condition which may be present on portion of the A-scope by adjusting the voltage on the accelerating anode (pin 9) of V625.
A-scope SWEEP LENGTH control R1676	148	Controls physical length of A-scope display by varying the time constant of sweep circuits at V623.
PPI SWEEP LENGTH control R651	148	Controls physical length of ppi-scope display by varying the conductance of sweep amplifier V608.
PPI CENTERING controls R662 and R665	148	Control position of the zero-range end of the ppi sweep by varying the amplitude and polarity of the average current through the coils which are part of focus coil assembly L602.
Ppi-scope INTENSITY control R659	148	Determines brightness of the ppi-scope display by controlling the voltage on the cathode (pin 7) of V609.
Ppi-scope FOCUS control R671	148	Determines sharpness of the ppi-scope display by controlling the current through ppi-focus coil L601.
Ppi-scope VIDEO GAIN control R682	148	Controls intensity of the video signals on the ppi-scope display by varying the input level of the video signals fed from video cathode follower V612A.
MARKER GATE control R691	148	Controls number of range markers seen on the ppi- and A-scopes by varying the charging time of capacitor C628 at V614.
5–10 MILE MARKER INT control R1617	148	Controls intensity of the 5- or 10-mile markers on the ppi scope and the height of the markers on the A scope by varying the voltage divider consisting of R1616 and R1617 at the output of V617A.
25–10 MILE MARKER INT control R1629	148	Controls intensity of the 25- or 10-mile markers on the ppi scope and the height of the markers on the A scope by varying the voltage divider consisting of R1632 and R1629 at the output of V618B.
STROBE INT. control R685	148	Controls intensity of the strobe on the ppi scope by varying the amplitude of the strobe fed into V601.
STROBE LIM control R1655	148	Determines limits of the range in which the strobe can be varied by RANGE STROBE control R1657, by varying the charging time of capacitor C645 at V621.
IFF VIDEO control R610	148	Controls input level of the IFF video signal to V601.
RANGE STROBE control R1657	154	Controls position of the strobe on the ppi scope by varying the charging time of capacitor C645 at V621.
PPI RANGE SELECTOR switch:		
S606	155	Sets range displayed on ppi scope.
S606A		Changes the time constant of ppi gate multivibrator V603, to vary the gate length.
S606B		Changes the time constant of ppi sweep generator V605, to vary the sweep length.

Controls and adjustments	Location (fig.)	Function
S606C		Changes the value of grid resistance at the ppi scope so that the intensity of the sweep will not vary as the sweep range is changed.
S606D		In the 20- or 40-mile position, feeds the 5-mile markers to V602. In the 80- or 160-mile position, the 25-mile markers are fed to V602 when the RANGE MARK MILES switch S608 is ON. The 5- and 25-mile markers are fed to V602 when S608 is in the TEST position.
S606E		In the 20- or 40-mile position, grounds the 25-mile marker input to V602. In the 80- or 160-mile position, the 5-mile marker input to V602 is grounded when the RANGE MARKS MILES switch S608 is ON.
RANGE MARKS MILES switch:		
S608	149	Turns markers on and off. TEST position used for checking 25-mile markers. A 25-mile marker should coincide with every fifth 5-mile marker.
S608A		In the TEST or ON position, applies 51 volts to the grid (pin 2) of V614A, for normal operation. In the OFF position, V614 is disabled.
S608B		In the ON position, grounds the 5-mile marker input to V602 when PPI RANGE SELECTOR switch S606 is in the 80- or 160-mile position. In the TEST position, both 5- and 25-mile range marks are fed to V602.
S608C		In the ON position, grounds the 5-mile marker input to V619B.
A RANGE SELECTOR switch:		
S609	155	Sets range of A scope.
S609A		In the EXP position, causes A-gate multivibrator V622, to be triggered by a delayed pulse from V621; in all other positions, V622 is triggered by the trigger from the transmitting system.
S609B		Selects the proper resistor to be used as a shunt with the plate load of V622B so that the A-scope intensity remains constant when the sweep range is changed.
S609C		Selects the proper combination of feedback capacitors to be used in A-gate multivibrator V622.
S609D		Selects the proper combination of sweep capacitors to be used by A-sweep generator V623.
S609E		In the 20- or 40-mile position, feeds the 5-mile markers to A video-marker mixer V619. In the 80- or 160-mile position, the 25-mile markers are fed to V619 when RANGE MARKS MILES switch S608 is ON. The 5- and 25-mile markers are fed to V619 when S608 is in the TEST position.
DIMMER control R2617	149	Adjusts ppi azimuth scale illumination.
PPI GATE control R626	154	Determines the time duration of the ppi-scope sweeps by varying the time duration of the ppi gates.
A GATE control R1669	154	Determines the time duration of the A-scope sweeps by varying the time duration of the A-scope gates.
COARSE INTENSITY control R660	154	Determines the limits of the range in which illumination can be controlled by ppi INTENSITY control R659.
BO. ADJ. control R1618	154	Controls the stability of the 25- or 10-mile markers by controlling the triggering time of the 25-mile blocking oscillator.
A-scope deflection balance control C659	160	Controls the electrostatic balance of the A-scope horizontal deflection plates in relation to the vertical deflection plates. Slight adjustment may be necessary when the A-scope is replaced.
Marker calibration control Z601	155	Determines the accuracy of the 5-mile markers by tuning the tank circuit of the 16-kc blocking oscillator so that the period of each cycle is 10,000 yards or 5 miles.

351. Indicating System Fuses

The following chart lists the fuses that protect circuits in the indicating system.

Fuse	Rating		Blown fuse indicator	Circuit protected	Location (fig. No.)
	Volts	Amps			
F401	250	1.6	I 401	Convenience outlet J603, when radiating	173
F404	250	6.25	I 404	Indicator filaments and blower motor	173
F407	250	.3	I 407	High-voltage power supply	173
F409	250	6.25	I 409	Filaments and high-voltage power supply	173
F412	250	60.0	I 412	Primary power	173
F413	250	60.0	I 413	Primary power	173
F414	250	30.0	I 414	Heater	173
F415	250	30.0	I 415	Heater	173
F416	250	6.25	I 416	Convenience outlet J603, when not radiating	173

352. Normal Indications at Indicating System Test Points

The following chart lists the test points that are provided to test the operation of circuits in the indicating system.

Test point	Location (fig. No.)	Normal indication
TP601	152	Ppi gate (plate V603B, fig. 222).
TP602	152	Ppi-sweep voltage (cathode V608, fig. 222).
TP603	158	Ppi-sweep voltage (grid V608, fig. 222).
TP604	152	Delayed trigger (grid V613, fig. 222).
TP605	151	Marker gate (grid V615, fig. 221).
TP606	151	16-kc gated oscillator output (cathode V615, fig. 221).
TP607	151	5-mile blocking oscillator (transformer T602, pin 7, fig. 221).
TP608	151	25-mile blocking oscillator (transformer T603, pin 7, fig. 221).
TP609	152	A-gate (plate V622, fig. 221).
TP610	156	A-sweep voltage (cathode V624, fig. 221).
TP611	156	Negative 430 volts ±10 percent (voltage divider from −1,500 volts).
TP612	156	Positive 300 volts ±10 percent (voltage divider from 1,500 volts).

353. Dc Resistance of Indicating System Transformers, Coils and Filters

The following chart lists the transformers, coils, and filters in the indicating system, the figure on which the components can be located, and the dc resistance of each winding of the component.

Coil, transformer, or filter	Location (fig.)	Terminals	Dc resistance (ohms)
L601	150		230
L602	158	1–2	5,260
		3–4	3,400
		5–6	3,400
L603	Panel B, fig. 159		88
L604	Panel A, fig. 159		36
T601, T602, T603	155	2–7	1.9
		3–8	1.75
		5–6	2.05
T604	156	1–2	5.6
		3–4	10,000
		5–6	(1)
T605	155	1–2	1.5
		3–4	(1)
		5–6	(1)
		7–8	(1)
Z601	155	F–S	210
Z602, Z603, Z604	153		(1)
Z605, Z606	156		(1)

[1] Less than 1.

Section II. TROUBLESHOOTING CHARTS

354. General

Two troubleshooting procedures are provided to assist in isolating trouble that has been sectionalized to the indicating system. If you are not sure the trouble is in the indicating system, use the troubleshooting chart based on starting procedure (par. 210) to sectionalize the trouble to a system.

a. Symptom Troubleshooting (par. 358). Troubles that have been sectionalized to the in-

dicating system can usually be isolated most rapidly by following the procedure based on symptoms that localize the trouble to a channel, circuit, or stage. To troubleshoot the indicating system based on symptoms, proceed as follows:

(1) Observe the indications obtained on the scopes.

(2) Compare the indications obtained with those listed in each of the symptoms.

(3) If the indications obtained correspond to those listed in a particular symptom, follow the procedure given in that particular subparagraph to isolate the trouble.

(4) If the trouble cannot be isolated by symptom troubleshooting, refer to the step-by-step troubleshooting chart.

b. Step-by-Step Troubleshooting Chart (par. 359). The indicating system step-by-step troubleshooting chart is designed to evaluate the performance of every stage during any type of operation of the indicating system. The step-by-step troubleshooting chart is used as follows:

(1) Locate the test point given in step 1.

(2) Connect the test equipment and set the controls on the test equipment as directed in the *Test equipment* column.

(3) Set the controls on the radar set as directed in the *Radar set controls* column.

(4) Compare the indication obtained on the test equipment with the indications that are given or referenced in the *Normal indications* column.

(5) Proceed as directed in the *Corrective measures* column.

Note. All voltages are measured to ground unless otherwise indicated.

355. Multivibrator and Blocking Oscillator Resistor Replacement

Wherever two or more carbon resistors are used in combinations, such as in a grid bias voltage divider, there is a possibility of having an unfavorable piling up of resistor value tolerances. Several instances of this possibility exist in the indicator. The ppi-gate multivibrator, for example, has a voltage divider consisting of R619 and R623 in the grid circuit. While the multivibrator would not fail if one of these resistors were to deviate 10 percent from its center value, it could fail if both resistors should deviate by 10 percent in opposite directions. To avoid possible marginal operation of a multivibrator or blocking oscillator, make sure that a low-limit resistor is paired with another low-limit resistor and that the resistors are within ±5 percent of the specified value when replacing any of the following resistors:

Resistor	Circuit	Location
R619, R623	Ppi-gate multivibrator	Panel C, fig. 159
R628 through R632.	Ppi-gate clamper	Panel C, fig. 159
R1664, R1667	A-gate multivibrator	Panel D, fig. 160
R1671 through R1675.	A-gate clamper	Panel C, fig. 159
R1647, R1653	Range strobe multivibrator.	Panel C, fig. 159
R689, R690	Marker gate multivibrator.	Panel A, fig. 159
R687, R688	Strobe blocking oscillator.	Panel A, fig. 159
R1622, R1623	5-mile blocking oscillator.	Panel A, fig. 159
R1624, R1625	Marker clamper	Panel A, fig. 159

356. Test Equipment Required to Troubleshoot Indicating System

The following items of test equipment are required to troubleshoot the indicating system.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U or ME–77/U.	Multimeter	11–5527A
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Range Calibrator TS–573/U	Range calibrator	11–1228
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083

357. Preparation of Indicating System for Troubleshooting

a. General. When the radar set is properly installed, the indicator is inaccessible for troubleshooting, alining, and field testing.

b. Removal of Azimuth-Range Indicator IP–141/TPS–1D.

(1) Disconnect all cables that are connected to the receptacles on the front

panel of the Azimuth-Range Indicator IP–141/TPS–1D.

(2) Remove the indicator chassis entirely from its inner case after loosening the 16 captive panel screws.

(3) Place the chassis on a suitable work area about 5 feet from the dust cover.

(4) Reconnect cable between the power supply (J407) and indicator (J601).

(5) Disable interlock S603 (fig. 158) by pulling outward on the interlock pin after centering the pin in its bracket.

358. Indicating System Symptom Troubleshooting Chart

Warning: Voltages as high as 5,000 volts exist in the circuits of the indicating system.

1. The scope anode high-voltage circuits are located on the lower left front corner of the chassis. Keep clear of this area, especially ceramic terminal strip E602 (fig. 156).

2. Do not operate the unit with the phenolite cover removed.

3. The A-scope uses a +1,500-volt and a −1,500-volt dc potential. The ppi scope uses a +5,000-volt potential. All voltages are obtained from the high-voltage supply (V626). This supply is capable of sustaining lethal currents, and as means are provided for checking the supply at a safe voltage, direct measurement of the high voltage is not recommended.

4. Test points (fig. 156) TP611 and TP612 provide means for checking the −1,500 and +5,000 voltages, respectively. The measurement of TP612 is indicative of the +1,500 and +5,000 voltages. For normal voltages the average readings to ground at the test points, with a 20,000-ohms-per-volt meter, should be as follows:

TP611 ..... −430 volts dc
TP612 ..... +300 volts dc

If readings within ±10 percent of the given values are obtained at TP611 and TP612, the high-voltage power supply can be eliminated as the cause of trouble.

5. If readings other than ±10 percent are obtained, the power supply components should be checked with an ohmmeter, after first fully discharging capacitors C665 through C668 (fig. 156) with a shorting bar.

Symptom	Probable cause	Corrective measures
		Warning: Observe the precautions in the first warning notice at the beginning of this troubleshooting chart.
1. Both scopes blank (INTENSITY controls turned up), and indicator panel lights functioning normally.	1. High-voltage power supply	*a.* Replace rectifier tube V626. Check voltage and resistances at V626 (fig. 223). *b.* Check the transformer resistances (par. 353).
2. Both scopes blank (INTENSITY controls turned up), and indicator panel lights not functioning normally.	2. Filament transformer T605	*a.* Check the voltage between terminals 1 and 2 of T605. The voltage should be 115 volts ac. *b.* Check the continuity of the windings of T605 (par. 353).
3. A-scope sweep is erratic	3. A-scope sweep gate adjustment.	3. Follow the procedure in paragraph 367.
4. Ppi-scope sweep is erratic	4. Ppi-gate adjustment	4. Follow the procedure in paragraph 366*h*.
5. No sweep on either scope. Bright spot appears on each scope when INTENSITY controls are turned up.	5. Trigger circuit	5. Check the waveshape at J601, terminal 48. *a.* If abnormal, check the trigger waveform at the TRIGGER OUTPUT J506. Check the continuity between J506 and J601, terminal 48. It should be less than 1 ohm. *b.* If normal, check R681, C609, C627, and C643.
6. Ppi-scope is blank when ppi INTENSITY control is turned up. Filament glow is not seen at neck of ppi tube.	6. Ppi-scope circuit V609	*a.* Turn system POWER switch S602 to OFF. (1) Remove the ppi tube socket and check the filament circuit. ***Warning:*** Observe the precautions in the first warning notice at the beginning of this troubleshooting chart. (2) If continuity is not present replace the ppi-scope (TM 11–1167–20).

Symptom	Probable cause	Corrective measures
		(3) If continuity is present, replace the ppi-tube socket and check the continuity between the connector on the aquadag coating and the hv rectifier (fig. 224). *b.* Check the voltages and resistances at V609 (fig. 223).
7. No sweep on ppi scope or distorted ppi sweep.	7. Ppi-sweep channel	7. If scope is blank increase the ppi-scope intensity and if a spot does not appear refer to symptom 6 above. If a spot appears proceed as follows: Check the waveform (D, fig. 222) at TP601. *a.* If abnormal, proceed with *c* below. *b.* If normal check the waveforms (J and H, fig. 222) at TP602 and TP603. (1) If the waveform amplitudes are much larger than normal, check V608, check the voltage and resistances at V608 (fig. 223). (2) If the waveform amplitudes are smaller than normal, check V606, check the voltages and resistances at V606. (3) If the waveform is missing check V605, check the voltage and resistances of V605 (fig. 223). Check switch S606B. *c.* Check V603, check the voltages and resistances of V603 (fig. 223) and switch S606A.
8. A-scope is blank when A-scope INTENSITY control is turned up.	8. A-scope V625, or associated parts.	*a.* Turn system POWER switch S602 to OFF, remove the A-scope tube socket and check for filament continuity. *b.* Turn S602 to ON and check the voltages and resistances at V625 (fig. 223). ***Warning:*** Observe the precautions in the first warning notice at the beginning of this chart.
9. No sweep, or distorted sweep, on the A scope.	9. A-scope sweep channel	9. Check the waveform (E, fig. 221) at TP610. *a.* If normal, proceed with *c* below. *b.* If abnormal, check the waveform (B, fig. 221) at TP609. (1) If normal, proceed with (5) below. (2) If abnormal, check V622, check the voltages and resistances at V622 (fig. 223). (3) Check V609 (figs. 159 and 224). (4) Check S609B and S609C. (5) Check the waveform (D, fig. 221) at pin 5 of V623. (*a*) If abnormal, check V623, take the voltage and resistance readings of V623 (fig. 221). Check switch S609D (fig. 155). (*b*) If normal, check V624, take the voltage and resistance readings of V624 (fig. 223). *c.* Check the connections between V624 and V625.
10. No markers on the A-scope or ppi scope.	10. Fixed marker channel	*a.* Check the waveform (H, fig. 221) at TP605. (1) If normal, proceed with *b* below. (2) If abnormal, check V614, measure the voltages and resistances at V614 (fig. 223). Check switch S608. *b.* Check the waveform (J, fig. 221) at TP606. (1) If normal, proceed with *c* below. (2) If abnormal, check V615, measure the voltages and resistances at V615 (fig. 223). *c.* Check the waveform (L, fig. 221) at TP607. If abnormal, proceed as follows: (1) Check V616 and V617.

Symptom	Probable cause	Corrective measures
		(2) Check the voltages and resistances of V616 and V617 (fig. 223). (3) Check the resistances of T602.
11. No markers or video on A-scope.	11. A-video amplifiers V612 and V619.	11. Check V612 and V619, measure the voltages and resistances at V612 and V619 (fig. 223).
12. No markers or video on ppi scope.	12. Ppi video-marker mixer V602.	12. Check V602, measure the voltage and resistances at V602 (fig. 223).
13. Markers on both scopes are unstable.	*a.* Marker blocking oscillator adjustment.	*a.* Follow the procedure in paragraph 365*f*.
	b. Fixed marker channel	*b.* Follow the procedures in symptom 10, *b* and *c*.
	c. MARKER GATE (R691) adjustment.	*c.* Follow the procedures in paragraph 365.
14. No video on A-scope or ppi scope.	*a.* Video amplifier V611 or video cathode follower V612.	*a.* Check V611 and V612 and then measure the voltages and resistances at V611 and V612 (fig. 223).
	b. Video input line	*b.* Check the continuity between J601, terminal 47, and J303 on the signal comparator chassis.
15. No iff video or strobe on ppi scope.		15. Check V601, measure the voltages and resistances at V601 (fig. 223).
	a. Iff video-strobe mixer V601	*a.* Check R610 and R601.
	b. Iff video input	*b.* Check the continuity between J601, terminal 46, and J417 on the front panel of the power supply.
16. No 25-mile markers on A scope or ppi scope.	*a.* 25-mile blocking oscillator keyer V617B, or	*a.* Check V617 and V618, measure the voltages and resistances at V617 and V618 (fig. 223).
	b. 25-mile blocking oscillator V618B.	*b.* Measure the resistance of T603 (par. 353).
17. No strobe on ppi and no expanded sweep on A scope.	Range strobe multivibrator V621.	Check V621, measure the voltages and resistances at at V621 (fig. 223).
18. No strobe on ppi, expanded sweep on A scope normal.	Strobe blocking oscillator keyer V613.	Check V613, measure the voltages and resistances at V613 (fig. 223).
19. No (or distorted) expanded sweep on A scope, ppi strobe normal.	A RANGE SELECTOR switch S609A.	Check the waveform (B, fig. 221) at TP609, if abnormal check S609A.
	S609C or S609D	Check the waveform at TP610 (E, fig. 221), if abnormal, check C652, C654, S609C and S609D.
20. Ppi sweep does not rotate	Synchro receiver B602	Follow the procedures in paragraph 393, symptom 8.

359. Indicating System Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1.	Between terminals 1 and 2 of T605.	Set multimeter controls to measure 115 volts ac.	Set system POWER switch S602 to ON, wait 5 minutes and then press RADIATE button S616. Turn DIMMER control to maximum CW position.	I 609 and I 610 glow, 110 to 120 volts ac on multimeter. Panel lights I 601 through I 608 glow. Filaments of all tubes in the indicator glow.	*a.* If all indications are normal, proceed with step 2. *b.* If all indications are abnormal, check Z605 and the ac power distribution and control system (par. 210). *c.* If blower motor B601 operates normally but all filaments and lights (except I 610) are not glowing, turn the system POWER switch S602 to OFF and check T605 (par 353).

tep	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
				Blower motor B601 operates.	*d.* If all indications are normal but I 610 does not glow, check I 610, and R2620. *e.* If all indications are normal but the blower motor does not operate, check S610 and B601.
2.	Terminal of Z602 nearest to the front panel.	Set multimeter controls to measure 115 volts ac.	----------	−150 volts dc--	*a.* If the voltage is normal, proceed with step 3. *b.* If the voltage is abnormal, proceed as follows: (1) Check Z602 (par. 153). (2) Troubleshoot (par. 420, step 3) and interconnecting wiring.
3.	Ungrounded terminal of C601 (fig. 156).	Set the multimeter controls to measure +300 volts dc.	----------	+300 volts dc--	*a.* If the voltage is normal, proceed with step 4. *b.* If the voltage is abnormal, proceed as follows: (1) Check C601. (2) Check Z603 (par. 353). (3) Troubleshoot the power supply (par. 420, step 5) and interconnecting wiring.
4.	Ungrounded terminal of C602 (fig. 156).	Set multimeter controls to measure +450 volts dc.	----------	+450 volts dc--	*a.* If the voltage is normal, proceed with step 5. *b.* If the voltage is abnormal, proceed as follows: (1) Check C602. (2) Check Z604 (par. 353). (3) Troubleshoot the power supply (par. 420, step 2) and interconnecting wiring.
5.	TP611 (fig. 156)--	Set the multimeter controls to measure −430 volts dc.	----------	−430 volts dc--	*a.* If the voltage is normal, proceed with step 6. *b.* If the voltage is abnormal, follow the corrective measures of par. 358, symptoms 1 and 2.
.	TP 612 (fig. 156)-	Set the multimeter controls to measure +300 volts dc.	----------	+300 volts dc--	*a.* If the voltage is normal, proceed with step 7.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
					b. If the voltage is abnormal, follow the corrective measures of par. 358, symptoms 1 and 2.
7.	J601 terminal 48	Set the oscilloscope to measure the waveform (A, fig. 221) at terminal 48, J601.	Set the PPI RANGE SELECTOR and A RANGE SELECTOR switches to 40 miles.	A, figure 222	*a.* If normal, proceed with step 8. *b.* If abnormal, remove the cable from J506 and measure the resistance between terminal 48, J601 and ground. It should be 78 ohms.
8.	TP603 (fig. 152)	Set the oscilloscope to measure the waveform (fig. 222) at TP603.	----------	H, figure 222	*a.* If normal, proceed with step 9. *b.* If abnormal, proceed with step 21.
9.	TP610 (fig. 156)	Set the oscilloscope to measure the waveform (fig. 221).	----------	E, figure 221	*a.* If normal, proceed with step 10. *b.* If abnormal, proceed with step 27.
10.	TP608 (fig. 151)	Set the oscilloscope to measure the waveform (Q, fig. 221) at TP608.	RANGE MARKS MILES switch S608 to ON.	Q, figure 221	*a.* If normal, proceed with step 11. *b.* If abnormal, proceed with step 28.
11.	Terminal 3 of T601 (fig. 155).	Set the oscilloscope to measure the waveform (N, fig. 222) at T601.	Turn the RANGE STROBE control about ¼ turn from the extreme ccw position.	N, figure 222	*a.* If normal, proceed with step 12. *b.* If abnormal, proceed with step 31.
12.	Pin 3 of V612 (fig. 157).	Set the oscilloscope according to the notes on figure 221.	ANTI JAM switch to OFF, and RECEIVER GAIN to maximum cw position. RANGE MARKS MILES switch to OFF.	Positive transmitter pulse and grass.	*a.* If normal, proceed with step 13. *b.* If abnormal, proceed with step 32.
13.	Ppi- and A-scope presentations.	----------	Adjust ppi- and A-scope INTENSITY and FOCUS controls for normal sweep. Ppi- and A-scope VIDEO GAIN controls maximum cw.	Sharp sweeps, transmitter pulse, and grass.	*a.* If all indications are normal, proceed with step 14. *b.* If sweeps are normal but transmitter pulse and grass are abnormal on the ppi scope, proceed with step 33. *c.* If both scopes are blank, follow corrective measures of par. 358, symptoms 1 and 2. *d.* If no sweep or abnormal sweep is present on the ppi scope, proceed with step 21. *e.* If sweeps are normal but transmitter pulse and grass are abnormal on the A scope, proceed with step 34. *f.* If no sweep or abnormal sweep is present on the A scope, proceed with step 35.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
14.	Ppi- and A-scope presentations.	Multimeter	RANGE MARKS MILES switch to ON. Ppi- and A-scope VIDEO GAIN controls maximum ccw.	8 5-mile markers on each scope.	*a.* If both scopes are normal, proceed with step 15. *b.* If the ppi scope is abnormal, check R1616 and C634 and proceed with step 33. *c.* If the A scope is abnormal, check switches S608C, S609E, and S609F.
15.	Ppi- and A-scope presentations.	Multimeter	PPI-RANGE SELECTOR and A-RANGE SELECTOR switches to 20 miles. RANGE MARKS MILES switch to TEST.	4 5-mile markers on each scope.	*a.* If both scopes are normal, proceed with step 16. *b.* If the ppi scope sweep is abnormal, check S606A, S606B, and S606C and C610, C618, and R654. *c.* If the A scope is abnormal, check S609A, S609B, S609C, and S609D and C649 and C657. *d.* If the ppi markers are abnormal, check S606D. *e.* If the A-scope markers are abnormal, check S609E.
16.	Ppi- and A-scope presentations.	Multimeter	RANGE MARKS MILES switch to TEST. PPI-RANGE SELECTOR and A-RANGE SELECTOR switches to 80 miles.	16 5-mile markers and 3 25-mile markers on each scope.	*a.* If both scopes are normal, proceed with step 17. *b.* If the ppi-scope sweep is abnormal, check S606A, S606B, and S606C and C612, C616 and R652. *c.* If the A-scope sweep is abnormal, check S609A, S609B, S609C, and S609D and R1660, C651, and C655. *d.* If the ppi markers are abnormal, check S606D and S606E. *e.* If the A-scope markers are abnormal, check S609E and S609F.
17.	Ppi- and A-scope presentations.	Multimeter	PPI-RANGE SELECTOR and A-RANGE SELECTOR switches to 160 miles. RANGE MARKS MILES switch to TEST.	6 25-mile markers on each scope and 4 5-mile markers between adjacent 25-mile markers.	*a.* If both scopes are normal, proceed with step 20. *b.* If the ppi-scope sweep is abnormal, check switch S606A, S606B, and S606C and C613 and C615.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
					c. If the A-scope sweep is abnormal, check S609A, S609B, S609C, S609D and C652 and C654. *d.* If the ppi markers are abnormal, check S606D and S606E. *e.* If the A-scope markers are abnormal, check S609E and S609F.
18.	Ppi- and A-scope presentations.	Multimeter	PPI-RANGE SELECTOR switch to 160 miles. RANGE MARKS MILES switch to ON. A-RANGE SELECTOR switch to EXP. Turn RANGE STROBE control slowly from maximum cw to maximum ccw position.	The range strobe should move from the 160-mile position to approximately the 15-mile position on the ppi sweep and the A-scope markers should move from left to right.	*a.* If all indications are normal, proceed with step 19. *b.* If both scopes are abnormal, check V621, make voltage and resistance measurements at V621. *c.* If the ppi scope is abnormal, proceed as follows: (1) Check V601, make voltage and resistance measurements at V601. (2) Check R685, R684, and C625 (fig. 223). *d.* If the A scope is abnormal, proceed as follows: (1) Check S609A, S609B, S609C, S609D. (2) Check C648 and C658.
19.	Pin 5 of V601 (fig. 157).	Set the oscilloscope to measure the waveform at pin 5 of V601.	If iff equipment is in use feed the iff video pulse into J417 (fig. 150). If iff equipment is in use disconnect the cable from J415 (fig. 150) and connect it to J417. Turn RANGE MARKS MILES switch to OFF.	Video signals	*a.* If the indications are normal, proceed with step 20. *b.* If the indications are abnormal, proceed as follows: (1) Check V601, make voltage and resistance measurements at V601. (2) Check R610 and R601. (3) Check the iff equipment and interconnecting wiring.
20.	Ppi-scope presentation.		Turn ANTENNA ROTATE control to cw.	ANTENNA SPEED dial indicates cw rotation. Ppi sweep rotates cw.	Troubleshoot the antenna positioning system (par. 393, symptom 8).

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
				ANTENNA SPEED dial indicates ccw rotation. Ppi sweep rotates ccw.	
21.	Ppi-scope presentation.		Increase ppi INTENSITY.	Spot in center of ppi scope or abnormal sweep.	*a.* If the sweep is abnormal, proceed with step 24. *b.* If only a spot is present, proceed with step 25. *c.* If scope is blank, proceed with step 23.
22.	TP602 (fig. 152)	Set the oscilloscope to measure the waveform (J, fig. 222) at TP602.		J, figure 222	*a.* If the waveform is missing, proceed with step 25. *b.* If the waveform is smaller than normal, proceed with step 26. *c.* If the waveform is larger than normal, proceed as follows: (1) Check V608, make voltage and resistance measurements at V608 (fig. 223). (2) Check the dc resistance of L601 (par. 353).
23.	High-voltage rectifier V626.	Multimeter ***Warning:*** Discharge capacitors C665 through C668 (refer to par. 358, warning 5). Check the continuity of the cable between the ppi-scope aquadag connector and R2624.	Press RADIATE button S616 to OFF. Set power switch S602 to OFF.		*a.* If continuity is not present, replace the cable. *b.* If continuity is present, check R2616, R2624, C667, and C668.
	Ppi scope V609 (fig. 157).	Multimeter			*a.* Turn system POWER switch S602 to OFF. (1) Remove the ppi tube socket and check the filament circuit. (2) If continuity is not present replace V608 (TM 11–1167–20). (3) If continuity is present reconnect the ppi tube socket. *b.* Check the voltages and resistances at V609 (fig. 223).

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
24.	Ppi-focus current regulator V610 (fig. 157). Focus coil assembly L602 (fig. 158) C619 (fig. 155). Blanking circuit.	Tube tester. Multimeter.			*a.* Check V610, make voltage and resistance measurements at V608 (fig. 223). *b.* Check PPI CENTERING controls R662 and R665. Disconnect terminal 3, 4, 5, or 6 from focus coil assembly L602, and check the dc resistance between terminals 3 and 4 and between terminals 5 and 6 (par. 353). Check capacitor C619B. Check R656 and C622; switch S606, R655 and C653.
25.	TP601 (fig. 155)	Set the oscilloscope to measure the waveform (D, fig. 222) at TP601.		D, figure 222	*a.* If normal, proceed with step 26. *b.* If abnormal, proceed as follows: (1) Check V603 and V604, make the voltage and resistance measurements on V603 and V604 (fig. 223). (2) Check switch S606A and C610 and C611.
26.	Pin 2 of V606 (fig. 157).	Set the oscilloscope to measure the waveform (E, fig. 222) at pin 2 of V606.		E, figure 222	*a.* If normal, proceed with *c* below. *b.* If abnormal, proceed as follows: (1) Check V605, make the voltage and resistance measurements at V605. (2) Check switch S606B and C617 and C618. *c.* Check V606 and V607, make the voltage and resistance at V606 and V607.
27.	TP609	Set the oscilloscope to measure the waveform (B, fig. 221) at TP609.		B, figure 221	*a.* If normal, proceed with *c* below. *b.* If abnormal, proceed as follows: (1) Check V622, make the voltage and resistance measurements at V622.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
					(2) Check S609B and S609C and R1661, R1662, C649, C650, and R1663. *c.* Check V623 and V624, make the voltage and resistance measurements at V623 and V624 (fig. 223). *d.* Check switch S609D and C656 and C657.
28.	TP605	Set the oscilloscope to measure the waveform (H, fig. 221) at TP605.		H, figure 221	*a.* If normal, proceed with step 29. *b.* If abnormal, proceed as follows: (1) Check V614, make the voltage and resistance measurements at V614 (fig. 223). (2) Check S608A.
29.	TP606 (fig. 151)	Set the oscilloscope to measure the waveform (J, fig. 221) at TP606.		J, figure 221	*a.* If normal, proceed with step 30. *b.* If abnormal, proceed as follows: (1) Check V615, make voltage and resistance checks at V615 (fig. 223). (2) Check the resistance of Z601 (par. 353).
30.	TP607 (fig. 151)	Set the oscilloscope to measure the waveform (L and M, fig. 221) at TP607.		L and M, figure 221.	*a.* If normal, proceed with *c* below. *b.* If abnormal, proceed as follows: (1) Check V617, make the voltage and resistance measurements at V616 (fig. 223). (2) Check the resistances of T602 (par. 353). *c.* Check V618, make the voltage and resistance measurements at V618 (fig. 223). *d.* Check the resistances of T603 (par. 353). *e.* Check the connections at A, B, C, D, and Z (fig. 224).

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
31.	TP604 (fig. 152)	Set the oscilloscope to measure the waveform (M, fig. 222).		M, figure 222	*a.* If normal, proceed with *c* below. *b.* If abnormal, check V621, make voltage and resistance measurements at V621 (fig. 223). *c.* Check V613, make voltage and resistance measurements at V613 (fig. 223). *d.* Check the resistance of T601 (par. 353).
32.	Pin 7 of V611 (fig. 157).	Set the oscilloscope to measure the waveform at pin 7 of V611.		Positive transmitter pulse and grass.	*a.* If abnormal, trouble may be in the receiving system or the signal comparing system (refer to par. 210). *b.* If normal, proceed as follows: (1) Check V611 and V612, make voltage and resistance measurements at V611 and V612 (fig. 223). (2) Check the resistance of L603 (par. 353). (3) Check CR601 (par. 190).
33.	Pin 5 of V602 (fig. 157).	Set the oscilloscope to measure the waveform at pin 5 of V602.		Negative transmitter pulse and grass.	*a.* Check V602 and V607, make voltage and resistance measurements at V602 and V607 (fig. 223). *b.* Check switch S606D and R1617. *c.* Check C607 and R682.
34.	Pin 6 of V619 (fig. 157).	Set the oscilloscope to measure the waveform at pin 6 of V619.		Negative transmitter pulse and grass.	*a.* If normal, proceed with *c* below. *b.* If abnormal, proceed as follows: (1) Check V612 and V620, make voltage and resistance measurements at V612 and V620 (fig. 223). (2) Check C659 and C660. *c.* Check V619, make voltage and resistance measurements at V619 (fig. 223).

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
35.	A-scope V625 (fig. 157).	Multimeter			*a.* Turn system POWER switch S602 to OFF. (1) Remove the A-scope tube socket and check the filament circuit. (2) If continuity is not present replace the A scope (TM 11–1167–20). (3) If continuity is present reconnect the A-scope socket. *b.* Check the voltages and resistance at V625 (fig. 223).

Section III. REMOVAL AND REPLACEMENT OF PARTS IN INDICATING SYSTEM

Warning: Extremely dangerous voltages exist in Azimuth-Range Indicator IP–141/TPS–1D. When removing and replacing parts in this component, be careful of the high voltage.

360. Removal and Replacement of Ppi- and A-Scope Tubes

The procedures for removal and replacement of the ppi- and A-scope tubes are covered in paragraph 37, TM 11–1167–20.

361. Removal and Replacement of Subassemblies Z607 and Z608

The removal and replacement of parts from subassembly Z607 or Z608 are performed as follows:

a. Disconnect the flexible shaft from the subassembly.

b. Remove the retaining nut from the mounting bushing.

c. Unsolder and tag the wires leading from the subassembly to the chassis.

d. Reverse the procedure to replace the subassembly.

362. Removal and Replacement of Parts in Ppi-Deflection Coil Assembly

Procedures for removal and replacement of parts in the ppi-deflection coil assembly are covered in chapter 23.

Section IV. INDICATING SYSTEM ADJUSTMENTS

363. General

a. This section covers the adjustment of the indicating system. These adjustments are the same whether the components are on the bench or interconnected with the other components of the radar set.

b. The following adjustments are given in TM 11–1167–20:

(1) Adjustment of intensity (par. 12).

(2) Adjustment of focus (par. 12).

(3) Adjustment of centering (par. 12).

(4) Adjustment of AZIMUTH control (par. 15).

c. The following adjustments are given in this section:

(1) Adjustment of the fixed range marker circuits (par. 365).

(2) Adjustment of the ppi-scope sweeps (par. 366).
(3) Adjustment of the A-scope sweeps (par. 367).
(4) Adjustment of the strobe circuits (par. 368).

d. Before making the adjustments in paragraphs 365 through 368 make the following checks:

(1) On the power supply (fig. 173) check the VOLTMETER for a reading of 110 to 120 volts and LINE FREQUENCY meter for a reading of 384 to 416 cycles.
(2) Check the voltages to ground at TP611 (−430 volts dc ±10 percent) and TP612 (+300 volts dc ±10 percent). Refer to figure 156.
(3) Adjust R433 (fig. 178) for 300 volts dc at Z603.
(4) Check the voltage at Z604. It should be approximately +450 volts dc (unregulated).
(5) Check the voltage at Z602. It should be −150 volts dc.

364. Test Equipment Required

The following items of test equipment are required to completely adjust the indicating system.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Range Calibrator TS–573/U	Range calibrator	11–1228

365. Adjustment of Fixed Range Marker Circuits

a. MARKER GATE R691 (fig. 148) sets the length of the marker gate. If R691 is set for too short a gate length, one or more markers will be missing on the far end of the A-scope and ppi-scope traces when the ranges are set at 160 miles. If R691 is set for too long a gate, the markers will jitter or appear to be blurred. To adjust R691, proceed as follows:

(1) Turn A-scope VIDEO GAIN control R683 fully counterclockwise to remove video signals.
(2) Set the A RANGE SELECTOR switch to the 160-mile position and the RANGE MARKS MILES switch to TEST.
(3) Unlock and turn R691 counterclockwise until the effective position of R691 is observed by the progressive elimination of markers on the right end of the A-scope sweep trace.
(4) Turn R691 clockwise to a position slightly beyond the 160-mile range point of the sweep trace, as determined by the reappearing range marks.
(5) Lock R691.

Note. If it is impossible to obtain the adjustment as given, check the waveform at TP605 (fig. 151) and check V614 and the voltage and resistance measurements at the tube socket of V614 (fig. 223).

b. Marker calibration control Z601 is used to adjust the fixed markers. The equipment is shipped with Z601 adjusted to produce 10,000-yard markers, which are approximately equal to markers with a 5-nautical-mile spacing. Actually, this initial adjustment represents a −2 percent error when the markers are interpreted in nautical miles.

(1) Adjustment of Z601 is necessary if the measured range of objects is not within the allowable tolerance, or if nautical-mile measurements are to be used and it is desired to eliminate the −2 percent error of the initial factory adjustment.
(2) The allowable tolerance is ±(.03R+K). If the range is measured in nautical miles, R is in miles and K is equal to 1 mile. If the range is measured in yards, R is in yards and K is equal to 2,000 yards. If the range is 10 miles, the allowable range error is ±(.03 × 10+1) miles, or ±1.3 miles. If measurements are made in yards, the allowable range error is ±2,600 yards at a range of 20,000 yards.
(3) If recalibration is contemplated because of range errors, first determine, if possible, whether or not the error is approximately a fixed amount at all ranges. If it is, the range marker calibration is quite likely to be correct, but a defect in triggering the marker oscillator exists. In this event, check

the waveform (H, fig. 221) at TP605 (fig. 151). If the waveform at TP605 is abnormal, troubleshoot 16-kc gated oscillator V614.

c. To adjust Z601 with oscilloscope proceed as follows:

Note. For greater accuracy proceed with *d* below.

(1) Adjust MARKER GATE control, R691, to give a 2,000-microsecond gate as observed at TP605.

(2) Observe the signal at TP606 and adjust Z601 to give 32½ to 32¾ oscillations (fig. 161).

Note. This sets Z601 to 16.39 kc to furnish triggers for the 5-mile blocking oscillator at 61-microsecond intervals.

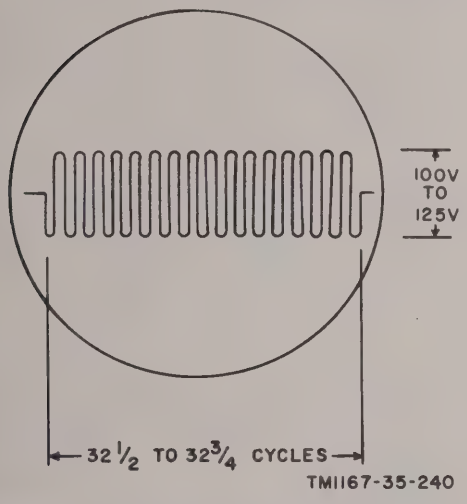


Figure 161. Gated oscillator waveform, 16-kc.

d. To adjust Z601 with the range calibrator proceed as follows:

(1) Interconnect the range calibrator and indicating system as shown in figure 162. The connections and adjustments are the same whether the indicating system is on the bench (fig. 163) or interconnected with the other components of the radar set.

(2) Set the range calibrator for the following conditions:

(*a*) Turn on the power and adjust the range calibrator power input switch according to the amplitude of the input line voltage.

(*b*) Positive output strobe.

(*c*) Positive external sync from the radar set.

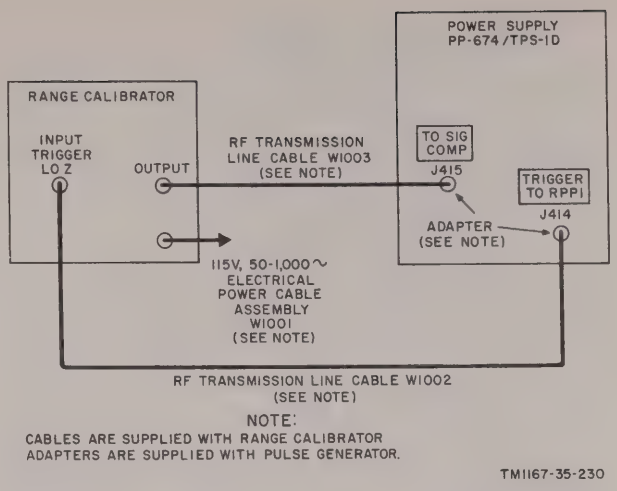


Figure 162. Interconnections between range calibrator and indicating system.

(*d*) Output amplitude adjusted for a pip of about the same size as the range marks on the A scope.

(3) Adjust the range calibrator for a strobe range of 40,000 yards and adjust Z601 until the fourth 5-mile marker coincides with the range calibrator marker.

Example: Four 5-mile (or two 10-mile) markers equal 40,000 yards. Zero error of the range calibrator is assumed to be 240 yards. Therefore the range calibrator will be adjusted for a range strobe of 40,000 minus 240 or 39,760 yards. Z601 will be adjusted until the fourth 5-mile (2d 10-mile) marker coincides with the pulse from the range calibrator.

e. Connections for 5- and 25-mile markers or 10-mile markers.

(1) The link connections in the grid circuits of the marker blocking oscillators, V617A and V618B, can be connected so that V617A produces 5-mile markers for the 20- and 40-mile ranges while V618B produces 25-mile markers for the 80- and 160-mile ranges. The links also can be connected so that 10-mile markers are produced by both V617A and V618B for all ranges.

(2) To produce 5- and 25-mile markers, make link connections as follows (A, fig. 159):

(*a*) Connect A to D.
(*b*) Connect B to C.
(*c*) No jumper from D to Z (R1619 unshorted).

(3) To produce 10-mile markers, make link connections as follows:
(*a*) Connect A to C.
(*b*) Connect B to D.
(*c*) Connect D to Z (R1619 shorted).

(4) It is necessary to adjust R1618 for the marker link connections in use. Refer to *f* below for adjustment of R1618.

f. When 5-mile (10,000-yard) and 25-mile (50,000-yard) markers are in use and the 25-mile markers are blurred or erratic, BO. ADJ. control R1618 (fig. 151) may require adjustment. When 10-mile markers are in use, all markers may be blurred or erratic if R1618 requires adjustment.

(1) Resistor R1618 should be adjusted to provide steady 25- or 10-mile markers, as the case may be. Resistor R1618 can be adjusted to a position which produces steady markers, but the markers may have incorrect spacing. When using 5- and 25-mile markers, the spacing of 25-mile markers can be checked by use of the TEST position of the RANGE MARKS MILES switch and the A-scope 80- or 160-mile range. The 5-mile markers are then superimposed on the 25-mile markers, and thus, the 25-mile markers can be checked against the 5-mile markers.

(2) When 10-mile markers are used, the markers can be checked by observing the number of markers for each scale. If R1618 is correctly adjusted, there should be 2 markers on the 20-mile scale, 4 on the 40, 8 on the 80, and 16 on the 160.

g. Marker intensity controls R1617 and R1629 (fig. 148) adjust the intensity of the markers on the ppi scope only. The amplitude of the A-scope markers depend on the circuit values, which cause a deflection of approximately 1 inch. Adjust R1617 or R1629 only when the range markers are normal on the A-scope.

(1) Resistor R1617 adjusts the marker intensities on the 20- and 40-mile scales, while R1629 adjusts the marker intensities on the 80- and 160-mile scales. This is true whether the marker link connections discussed in *e*, above, are connected for 5- and 25-mile markers or are connected for 10-mile markers.

(2) To adjust R1617 and R1629, unlock these controls and adjust for clean-cut markers of moderate intensity. If the marker intensity is set for too high a level, the markers are likely to interfere with small images on the ppi scope.

(3) If it is impossible to obtain proper adjustment of R1617 or R1629, check the control and its associated circuit, which includes RANGE MARKS MILES switch S608.

366. Adjustment of Ppi-Sweep Circuit

a. Adjust PPI-GATE R626 (fig. 152) and PPI-SWEEP LENGTH R651 (fig. 148) controls to the center of their range.

b. Turn the A-scope and ppi-scope VIDEO GAIN controls to maximum ccw.

c. Adjust the ppi-INTENSITY control (fig. 148) until a sweep appears on the scope.

d. Adjust the ppi-FOCUS control (fig. 148) until the sweep is sharp.

e. When it is found that the ppi-INTENSITY control R659 is near either end of its travel when adjusted for the desired ppi illumination, COARSE INTENSITY control R660 (fig. 154) requires adjustment.

(1) To adjust R660 proceed as follows:
(*a*) With the antenna rotating, set R659 to its midposition.
(*b*) Unlock and adjust R660 for the average illumination used on the ppi scope.

(2) Lock R660.

f. To adjust the ppi-sweep centering, unlock and adjust R662 and R665 so that the zero-range end of the ppi sweep is located at a fixed point in the center of the screen, as viewed with the sweep trace rotating.

g. If the sweep traces are short or long physically and yet the sweep ranges are correct electrically, as measured by the markers, PPI

SWEEP LENGTH R651 (fig. 148) may require adjustment.

(1) Readjustment may be required because of a defective resistor in the circuit of V608, or the tube itself could be at fault. If considerable correction appears necessary, check these components.

(2) To adjust R651, proceed as follows:

(*a*) With the antenna stopped and the PPI RANGE SELECTOR switch on the 160-mile range, unlock and adjust R651 so that the sweep trace extends to the full radius of the ppi scope.

(*b*) Check the sweep lengths on the 20-, 40-, and 80-mile ranges as determined by the range markers.

(*c*) If any sweep length is not more than ¼ inch short, readjust R651 for coverage of the shortest trace.

Note. If more than ¼ inch short, check for the cause, using TP602 (fig. 152) and TP603, (fig. 158) and the indicating system waveforms (H, and J, fig. 222).

(*d*) Lock R651 when the adjustment is complete.

h. If PPI-GATE control R626 is set for too long a gate period, erratic triggering of the ppi sweep trace on all ranges may result. If set for too short a period, the sweeps of all ranges will be short in both physical length and range length as determined by counting markers. If considerable readjustment appears necessary or if frequent adjustment is required, check for a value change in the resistors of the V603 circuit.

(1) To adjust R626 proceed as follows:

(*a*) With the antenna stopped, set the PPI RANGE SELECTOR switch to the 160-mile position.

(*b*) Unlock and adjust R626 so that the sweep extends slightly beyond 160 miles, as measured by the markers.

Note. If the indicator is preset for 10-mile markers, the sweep should extend slightly beyond the 16th marker. If the indicator is preset for 5- and 25-mile markers, set the sweep to extend beyond the 6th marker, a distance equal to half the spacing of the 5th and 6th markers.

(*c*) Check the sweep length by markers on the 20-, 40-, and 80-mile ranges, and readjust R626 if a slight readjustment will correct any short sweep lengths.

Note. If any sweep lengths are short by more than 5 percent, check the related gate length capacitor (C610 through C613) for leakage or change in value. Note that capacitors are added in parallel to increase the sweep range.

(*d*) Lock R626.

(2) Readjust and lock R651 at the position which gives a full sweep on all scales.

367. Adjustment of A-Scope Sweep Circuit

a. If the A-scope sweep trace is too short, too long, or erratic on any or all ranges, adjustment of A-GATE control R1669 may be necessary. If it is apparent that a considerable amount of readjustment is necessary, check the V622 circuit for a defective resistor which may have changed value. If a component of V622 circuit has been replaced, it is quite likely that R1669 will require readjustment to compensate for the allowable variations in component tolerances.

(1) To adjust R1669, proceed as follows:

(*a*) Set the A RANGE SELECTOR switch to the 160-mile position, with the A-scope VIDEO GAIN control turned down so that no signals are present on the A-scope trace.

(*b*) Unlock and adjust A SCOPE SWEEP LENGTH control R1676 (fig. 148) so that the right end of the sweep trace can be seen.

(*c*) Unlock and adjust R1669 so that the sweep trace extends slightly beyond 160 miles, as determined from the range markers.

(*d*) Check the 20-, 40-, and 80-mile sweeps for adequate sweep length, as determined by the range markers.

(2) If all sweeps are about the same length, readjust R1669 so that the shortest trace just covers the indicated range.

Note. If one or more sweep lengths are more than 5 percent short, check the contacts of S609C. Also check the gate length capacitors, C649 through C652. Note that these capacitors are added in parallel to increase gate length.

(*a*) Lock R1669.

(*b*) Adjust and lock A SCOPE SWEEP LENGTH control R1676 in a posi-

tion which produces a sweep trace length almost equal to the diameter of the A scope.

b. If all sweep lengths are short physically but correct in range length, as measured by the markers, A SCOPE SWEEP LENGTH control R1676 may require adjustment. Also, adjustment of R1676 may be necessary if all sweep lengths extend beyond the face of the A-scope. This latter condition may be detected by counting the number of markers on each range.

(1) When R1676 is correctly adjusted, the sweep traces should almost cover the tube diameter. If considerable readjustment of R1676 is required, check the waveform at TP610 (E, fig. 221) and the components of V623 and V624.

(2) To adjust R1676, proceed as follows:

(*a*) With the A-scope VIDEO GAIN control turned down, unlock and adjust R1676 so that the shortest of the four range sweeps just covers the diameter of the A scope. (Recenter the trace if necessary; see *c* below for procedure.)

(*b*) Lock R1676 and adjust the VIDEO GAIN control for approximately 1 inch of signal deflection.

c. Unlock the HORIZ CENTER control R1687 and VERT CENTER control R2601 (fig. 148) and position the trace across the center of the A scope, with the left end of the sweep just visible at the left side of the scope. Lock R1687 and R2601 when the adjustment is complete.

d. A-scope ASTIG control R1689 (fig. 148) corrects for an out-of-focus condition which may be present on a portion of the A scope.

(1) Unlock and set this control for the best overall focus, readjusting the A-scope FOCUS control R1696 as required to effect the optimum adjustment.

(2) If R1689 requires a considerable degree of readjustment, check R1689 and R1690 at the A scope (fig. 148 and 159).

e. A-scope deflection balance control C659 controls the electrostatic balance of the A-scope horizontal deflection plates in relation to the vertical deflection plates. If the two sets of deflection plates are unbalanced, the vertical deflection will not be at right angles to the baseline trace, and signals and markers will appear to lean. Adjust C659 as follows:

(1) Turn A-scope VIDEO GAIN control R683 fully counterclockwise to remove radar signals.

(2) Turn the RANGE MARKS MILES switch to ON.

(3) Adjust C659 so that the range marks are at right angles to the baseline trace.

368. Adjustment of Range Strobe Circuit

Determine the limits of range through which the strobe can be varied by RANGE STROBE control R1657. Adjustment is required if the extreme strobe positions are not at 160 and approximately 15 miles, as determined by the strobe marker on the ppi scope.

a. Procedure for adjustment is as follows:

Set the PPI RANGE SELECTOR switch to the 160-mile position, and the A RANGE SELECTOR switch to EXP.

Turn RANGE STROBE control R1657 to its extreme clockwise position.

Unlock and adjust STROBE LIM control R1655 so that the ppi-strobe marker is at 160 miles, as determined by the ppi markers.

Note. If it is impossible to obtain the required adjustment, check the voltages and components of V621 (fig. 223).

b. Lock R1655 when the adjustment is complete.

Section V. FIELD TESTING

369. General

This section describes testing procedures required 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 paragraph 448.

370. Test Equipment Required

The following items of test equipment are required to completely test the serviceability of the indicating system.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Range Calibrator TS–573/U	Range calibrator	11–1228

371. Fixed Range Markers

a. General. The accuracy of the range markers is tested as follows:

(1) A calibrated range strobe is fed into the common video circuits of the indicating system.

(2) The position on the fourth 5-mile (or second 10-mile) marker on the A-scope is checked with the calibrated range strobe from the range calibrator.

b. Procedure.

(1) Interconnect the range calibrator and indicating system through the power supply as shown in figure 162.

(2) Turn on the power and adjust the range calibrator power switch according to the amplitude of the input line voltage.

(3) Adjust the range calibrator for the following conditions:

(*a*) Positive output strobe.

(*b*) Positive external sync from the radar set.

(*c*) Output amplitude adjusted for a pip of about the same size as the range marks on the A-scope.

(4) Adjust the range calibrator for a strobe range of 40,000 yards.

Example: Zero error of the range calibrator is assumed to be 240 yards. Therefore the range calibrator will be adjusted for a range strobe of 40,000 minus 240 or 39,760 yards.

(5) The position of the strobe from the range calibrator should coincide with the position of the fourth 5-mile (or second 10-mile) marker.

(6) The allowable tolerance is ±3,200 yards.

(7) Disconnect the range calibrator from the indicating system.

372. Visual Check of Fixed Range Markers

a. General. The ppi scope and A-scope are observed for proper presentation of the 5- and 25-mile markers.

b. Procedure.

(1) Set the PPI RANGE SELECTOR and A RANGE SELECTOR switches to the 160-mile positions.

(2) Adjust the ppi INTENSITY control so that the sweep is barely visible.

(3) Set the RANGE MARKS MILES switch to ON.

(4) Adjust 25–10 MILE MARKER INT control R1629 (fig. 148) for normal intensity of the 25-mile markers.

(5) Adjust STROBE INT. control R685 (fig. 148) for normal level.

(6) There should be six 25-mile markers on both scopes.

(7) Set the RANGE MARKS MILES switch to TEST.

(8) Both 5- and 25-mile markers should appear on the ppi scope and A-scope. As compared to the 25-mile markers, the 5-mile markers on the ppi scope are considerably less bright and on the A-scope they are lower in amplitude than the 25-mile markers.

(9) Each fifth 5-mile marker should coincide with a 25-mile marker.

(10) Set the PPI RANGE SELECTOR and A RANGE SELECTOR switches to the 80-mile positions.

(11) Set the RANGE MARKS MILES switch to ON.

(12) There should be three 25-mile markers on both scopes.

(13) Set the RANGE MARKS MILES switch to TEST.

(14) The markers should appear as in (8) and (9) above.

(15) Set the PPI RANGE SELECTOR and A RANGE SELECTOR switches to the 20-mile positions.

(16) Set the RANGE MARKS MILES switch to ON.

(17) There should be four 5-mile markers on each scope.

373. Ppi Sweep Display

a. General.

(1) The waveforms at the test points in the ppi channel are checked and compared with given waveforms and tolerances.

(2) The controls of the ppi sweep channel are checked for proper operation.

b. Procedure. The tolerances referred to in (1) through (6) below are found in the chart included in figure 222. The switch mentioned is PPI RANGE SELECTOR switch S606.

(1) Set switch S606 to the 40-mile position.

(2) Check the waveform at TP601 (fig. 152), the waveform should conform with D, figure 222 and the tolerances for the 40-mile position of the switch.

(3) Set the switch in the 20-mile position. The width of the waveform at TP601 should be within the tolerances for the 20-mile position of the switch.

(4) Set the switch in the 80-mile position. The width of the waveform at TP601 should be within the tolerances for the 80-mile position of the switch.

(5) Set the switch in the 160-mile position. The width of the waveform at TP601 should be within the tolerances for the 160-mile position of the switch.

(6) Set the switch in the 40-mile position.

(7) The waveform at TP602 should conform with the normal waveform given in J, figure 222.

(8) The waveform at TP603 should conform with the normal waveform given in H, figure 222.

(9) Adjustment of PPI CENTERING controls R662 and R665 (fig. 148) should center the beginning of the sweep.

(10) The ppi FOCUS and INTENSITY controls R671 and R659 (fig. 148) should rotate freely and the INTENSITY control should increase the intensity when it is rotated in a clockwise direction.

(11) The ppi FOCUS control should cause a sharp sweep trace to appear at approximately midrange, so that the sweep can be defocused on either side of focus position.

(12) Adjustment of COARSE INTENSITY control R660 (fig. 154) should allow ppi INTENSITY control R659 to be adjustable from a position which results in a barely visible pattern to a position which results in a bright pattern.

374. A-Scope Sweep Display

a. General.

(1) The waveforms at the test points in the A-sweep display circuits are checked and compared with given waveforms.

(2) The controls of the A-sweep display circuits are checked for proper operation.

b. Procedure. The tolerances referred to in (1) through (6) below are found in the chart in figure 221. The switch mentioned is A RANGE SELECTOR switch S609.

(1) Set the switch in the 40-mile position.

(2) Check the waveform at TP609 (fig. 152). The waveform should conform with B, figure 221 and the tolerances for the 40-mile position of the switch.

(3) Set the switch in the 20-mile position. The width of the waveform at TP609 should be within the tolerances for the 20-mile position of the switch.

(4) Set the switch in the 80-mile position. The width of the waveform at TP609 should be within the tolerances for the 80-mile position of the switch.

(5) Set the switch in the 160-mile position. The width of the waveform at TP609 should be within the tolerances for the 160-mile position of the switch.

(6) Set the switch in the 40-mile position.

(7) The waveform at TP610 should conform with the normal waveform given in E, figure 221.

(8) A-scope FOCUS control R1696 (fig. 148) should rotate freely and cause a sharp sweep trace to appear at approximately midrange, so that the sweep can be defocused on either side of focus position.

(9) A-scope INTENSITY control R1693 should rotate and increase function in the clockwise direction. Control

R1693 should be adjustable from just below sweep visibility to a bloom.

375. Strobe Channel

a. General.

(1) The waveforms at the test points in the strobe channel and the A-gate multivibrator are checked against given standards.

(2) The adjustment of the strobe control is checked for proper operation.

b. Procedure.

(1) Set the A RANGE SELECTOR switch S609 to the EXP position.

(2) Turn RANGE STROBE control R1657 fully clockwise.

(3) The waveform at TP604 (fig. 152) should be a differentiated wave of 20 to 30 volts peak (positive portion) and should conform to M, figure 221.

(4) Set PPI RANGE SELECTOR switch S606 to the 160-mile position.

(5) The RANGE STROBE control should be capable of moving the range strobe from 160 miles to approximately 15 miles.

(6) Observe the waveform at TP609 (fig. 152). The waveform should be a positive square wave 25 to 40 volts in amplitude, and 125 to 140 microseconds in duration.

376. Video Channel

a. General. A pulse generator is used to apply a signal to the video channel and the ppi- and A-scopes are observed for proper presentation.

b. Procedure.

(1) Set system POWER switch S602 to OFF.

(2) Unsolder the wire between C627 and the junction of R680 and R681 (Panel A, fig. 159).

(3) Connect the pulse generator to the indicating system as shown in figure 163.

(4) Set the system POWER switch to ON.

(5) Turn on the pulse generator.

(6) Adjust the pulse generator for a pulse rate of 400 pulses per second.

(7) Set the pulse generator for a positive output sync pulse.

(8) Adjust the pulse generator for a positive delayed output pulse of 2 volts and 2-microsecond duration.

(9) Observe the video pulse on the A scope and adjust the A-scope VIDEO GAIN control so that the amplitude of the signal barely reaches limit level. The VIDEO GAIN control should not be more than 90 percent of its maximum clockwise position.

(10) The ppi VIDEO GAIN control should be capable of adjusting the spot on the ppi scope to proper brilliance.

(11) Increase the input pulse width from the pulse generator to 10 microseconds.

(12) Set the ANTIJAM switch to ON.

(13) Observe the vertical deflection on the A-scope. The vertical deflection should appear as a differentiated signal with no negative overshoot.

(14) Disconnect Cord CG–409/U from J415 and connect it to J417 (fig. 163).

(15) Adjust the pulse generator for a positive 5-volt pulse of 1-microsecond duration.

(16) The IFF VIDEO control R610 (fig. 148) should be capable of adjusting the spot on the ppi sweep to proper brilliance.

(17) Set the system POWER switch to OFF.

(18) Disconnect the pulse generator.

(19) Resolder the wire between C627 and the junction of R680 and R681 (Panel A, fig. 159).

377. Synchronization of Ppi Sweep With Antenna

The synchro transmitter and 24-speed synchro components necessary to mechanically rotate the ppi deflection yoke in synchronism with the antenna are part of the antenna positioning system.

a. If the ppi sweep rotates smoothly, but there is a constant error between the position of the antenna and the ppi sweep, adjust the AZIMUTH control on the front panel of the indicator following the procedure in paragraph 15, TM 11–1167–20.

b. If the ppi sweep rotates erratically or does not rotate at all, troubleshoot the antenna positioning system (par. 393, symptom 8).

378. General

The following information will be helpful when bench servicing the indicating system.

Location		Description
Fig.	Par.	
58		Indicating system, complete block diagram.
224		Azimuth-Range Indicator IP–141/TPS–1D, complete schematic diagram.
	349	Location of parts in indicating system.
148–158		Azimuth-Range Indicator IP–141/TPS–1D, location of parts and adjustments.
159 and 160		Azimuth-Range Indicator IP–141/TPS–1D, resistor and capacitor panels.
223		Azimuth-Range Indicator IP–141/TPS–1D, voltage and resistance measurements at tube sockets.
	353	Dc resistance of indicating system transformers, coils, and filters.
222		Azimuth-Range Indicator IP–141/TPS–1D, ppi sweep and range strobe circuits, waveforms.
221		Azimuth-Range Indicator IP–141/TPS–1D, A-sweep and fixed range marker circuits, waveforms.
	351	Indicating system fuses.

379. Test Equipment Required

The following items of test equipment, cables, and adapters are required to bench service the circuits in Azimuth-Range Indicator IP–141/TPS–1D.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A.
Oscilloscope AN/USM–24C, or AN/USM–50.	Oscilloscope	11–5103 11–5129
Pulse Generator Set AN/UPM–15.	Pulse generator	11–1177.
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083.
Range Calibrator TS–537/UP.	Range calibrator	11–1228.
Motor Generator PU–20B/C.	Motor generator	11–978.
Power Supply PP–674/TPS–1D.	Power supply	This manual.
Electrical Special Purpose Cable Assembly CX–1999/U.	None	11–1167–10 (W4).
Electrical Power Cable Assembly CX–1997/U.	None	11–1167–10 (W15).
Cord CG–409/U	None	11–1177.
Cord CG–521A/U	None	11–1177.
Adapter UG–273/U	Adapter	11–1177.
Resistor, 7,500-ohm 10-watt.	None.	
Resistor, 10-ohm 200-watt.	None.	

380. Bench Servicing Connections for Azimuth-Range Indicator IP–141/TPS–1D

a. Disconnect all the cables that are connected to the indicator.

b. Release the 16 captive screws on the front panel of the indicator and remove the chassis from its case.

c. Place the chassis on a suitable work area about 5 feet from the dust cover.

d. Install the following parts on E401 (fig. 179) of Power Supply PP–674/TPS–1D:

(1) Install a jumper between terminals 1603 and 2003.

(2) Install a 7,500-ohm 10-watt resistor between terminals 6A and 01.

(3) Install a 10-ohm 200-watt resistor between terminals 8A and 01.

e. Connect the indicator to the power supply and the pulse generator as shown in figure 163.

f. Disconnect the wire between C627 and the junction of R680 and R681.

g. Disable interlock S603 (fig. 158) by pulling outward on the interlock pin after centering the pin in its bracket.

h. When the connections are made as shown in figure 163 the results are as follows:

(1) The triggering pulse and video pulse are obtained from the pulse generator.

(2) The RADIATE buttons on the indicator are not used.

381. Bench Troubleshooting Azimuth-Range Indicator IP–141/TPS–1D

a. Connect the indicator for bench servicing (par. 380).

b. Turn system POWER switch S602 to ON.

c. Turn on the pulse generator.

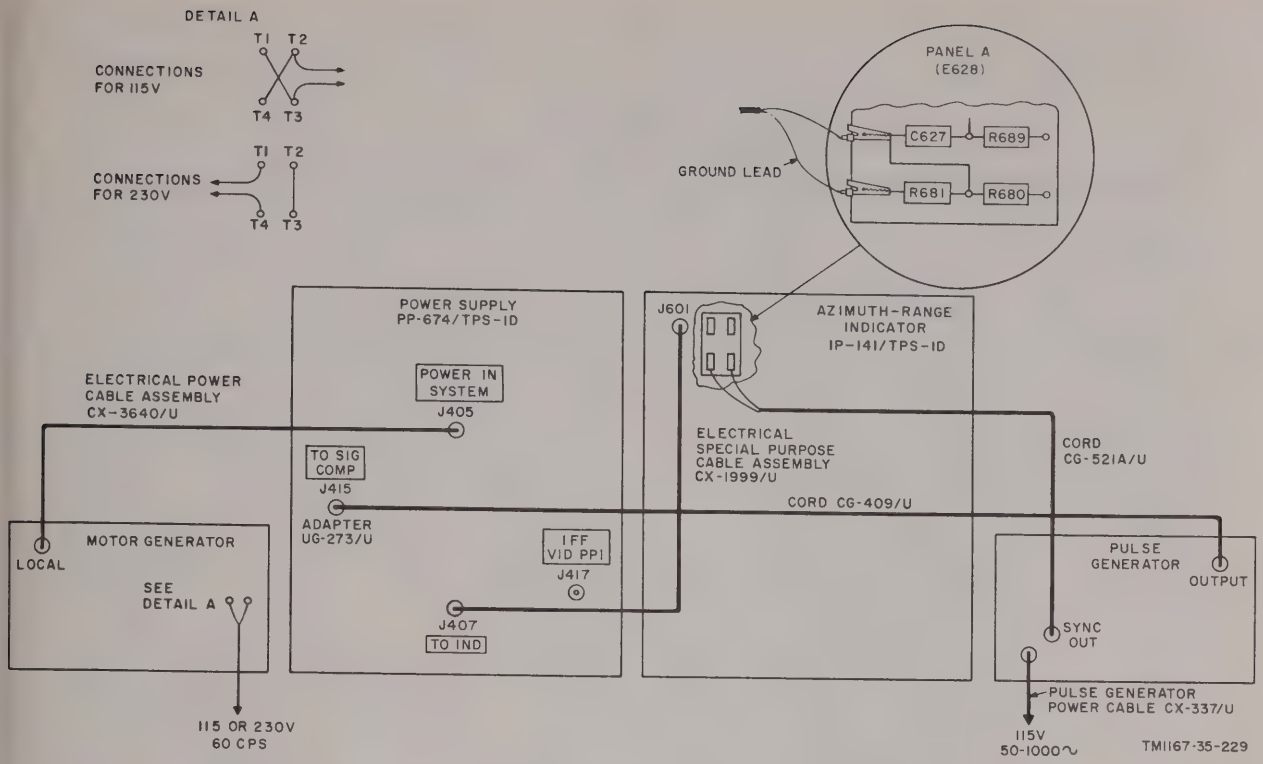


Figure 163. Azimuth-Range Indicator IP–141/TPS–1D, bench servicing connections.

d. Adjust the pulse generator for a pulse rate of 400 pulses per second.

e. Set the pulse generator for a positive output sync pulse.

f. Adjust the pulse generator for a positive delayed output pulse of 2 volts and 2-microsecond duration.

g. Follow the procedures in paragraph 359 with the following exceptions:

(1) Neither the transmitter pulse nor grass will be seen on the test oscilloscope and A scope, but the delayed pulse mentioned in *f* above will be seen (par. 359, steps 12 and 13).

(2) Disconnect Cord CG–409/U from J415 and connect it to J417 (fig. 163) in paragraph 359, step 19.

(3) Adjust the pulse generator for a positive 5-volt pulse of 1-microsecond duration.

(4) Resolder the wire between C627 and the junction of R680 and R681 (Panel A, fig. 159).

h. Remove the jumper and the 10-ohm and 7,500-ohm resistors from E401 (fig. 179).

382. Bench Adjustment of Azimuth-Range Indicator IP–141/TPS–1D

The indicator can be completely adjusted when connected for bench servicing (par. 380). The following chart lists the adjustments that are required to completely aline the indicator and references the paragraphs that contain detailed step-by-step directions for making each adjustment.

Adjustment	Procedure
Fixed range marker circuits	Par. 365.
Ppi-sweep circuits	Par. 366.
A-sweep circuits	Par. 367.
Range strobe circuits	Par. 368.

383. Bench Testing of Azimuth-Range Indicator IP–141/TPS–1D

To bench test the serviceability of the repaired indicator, connect the indicator for bench servicing (par. 380) and follow the procedures in paragraphs 371 through 377. This procedure includes checking the fixed range markers, ppi-sweep channel, A-sweep channel, strobe channel and video channel.

CHAPTER 17

ANTENNA POSITIONING SYSTEM TROUBLESHOOTING AND REPAIR

Section I. TROUBLESHOOTING INFORMATION

384. Reference Data

The following information will be helpful when troubleshooting or repairing the antenna positioning system.

Reference	Data
Fig. 79	Antenna positioning system, block diagram.
Pars. 143–154	Antenna positioning system theory.
Figs. 80–89	Antenna positioning system circuits, simplified schematic diagrams.
Fig. 226	Antenna Base AB–221/TPS–1D, schematic diagram.
Fig. 228	Synchro components, composite schematic diagram.
Fig. 227	Antenna positioning system, composite schematic diagram.
Fig. 188	Antenna drive assembly, exploded view.
Fig. 225	Antenna servo amplifier, voltage and resistance measurements at tube sockets.
Par. 385 and figs. 164–168.	Location of parts and adjustments.
Par. 386	Antenna positioning system, controls and adjustments.
Par. 387	Antenna positioning system fuses.
Par. 388	Normal indications at test points.
Par. 389	Dc resistance of inductive components.

385. Location of Parts in Antenna Positioning System

Antenna positioning system parts are located in either Antenna Base AB–221/TPS–1D or in Azimuth-Range Indicator IP–141/TPS–1D. The location of the parts in the antenna base is shown in figures 164 through 168. To locate parts that are in the indicator, refer to paragraph 349.

386. Antenna Positioning Systems Controls and Adjustments

The charts (*a* and *b* below) list the controls and adjustments that are functionally part of the antenna positioning system.

a. Antenna Base AB–221/TPS–1D.

Control or adjustment	Location (fig. No.)	Function
Voltage feed-back adjustment R707.	164	Determines the amount of voltage that is fed back to the grid of control tube V703A.
Current feed-back adjustment R710.	164	Determines the amount of current feed-back voltage that is introduced into the feed-back circuit. Proper adjustment is for no oscillation or hunting at low speeds.
Overload adjustment R717.	164	Determines the bias on sustained overload tube V706. When properly adjusted, the bias on V706 is about 80 volts.
Thyratron bias control R721.	164	Determines the bias on control rectifier tubes V701 and V702. The proper adjustment is for no thyratron ionization when the ANTENNA ROTATE control is set at 0 rpm.
Safety switch S753	167	Disables antenna drive system by opening the 115-volt supply to thyratron plate transformer T704. Reduces shock hazard by disconnecting the 115-volt supply from the rotors of B752 and B753 and the heater circuits.

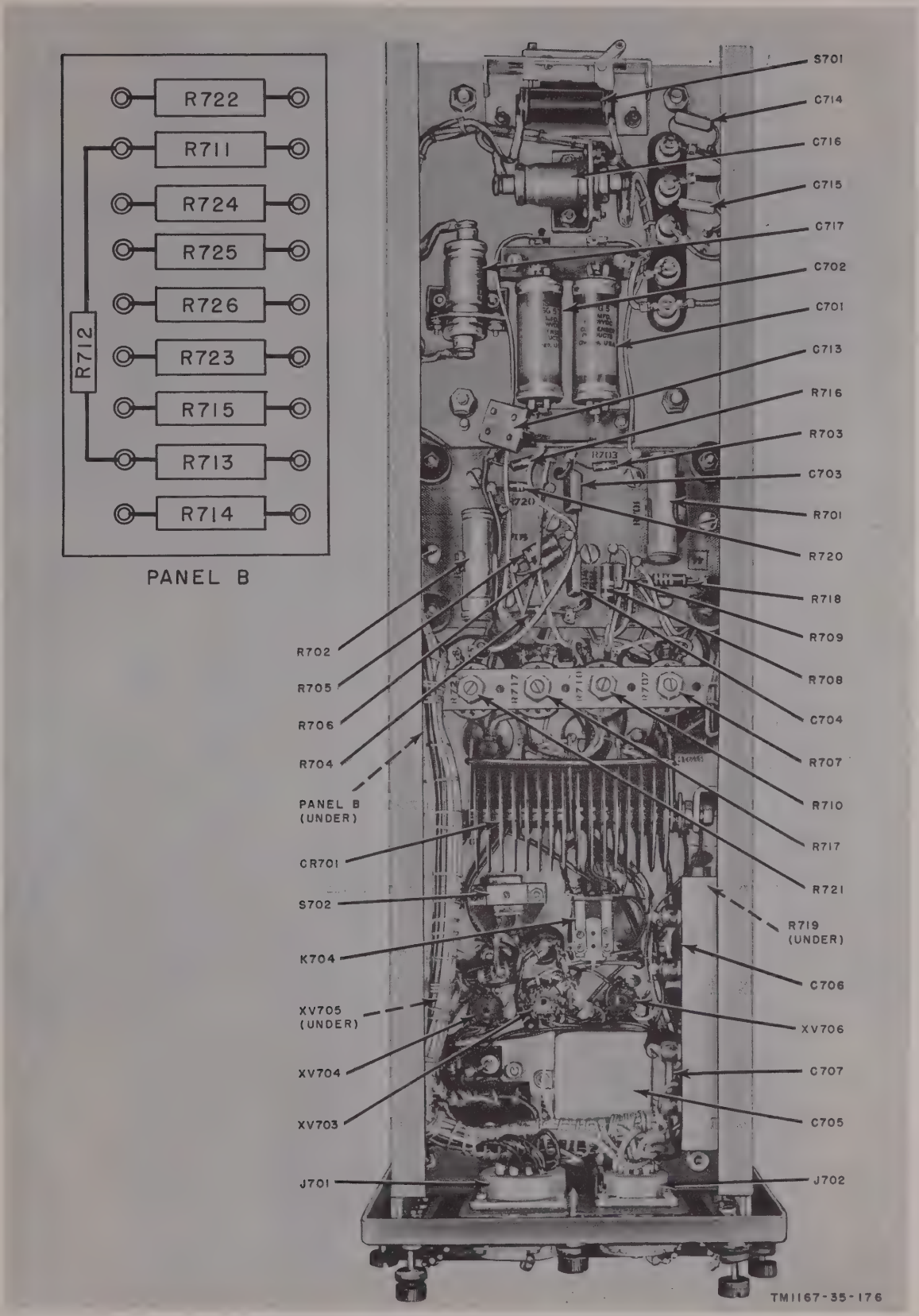


Figure 164. Antenna servo amplifier, bottom view.

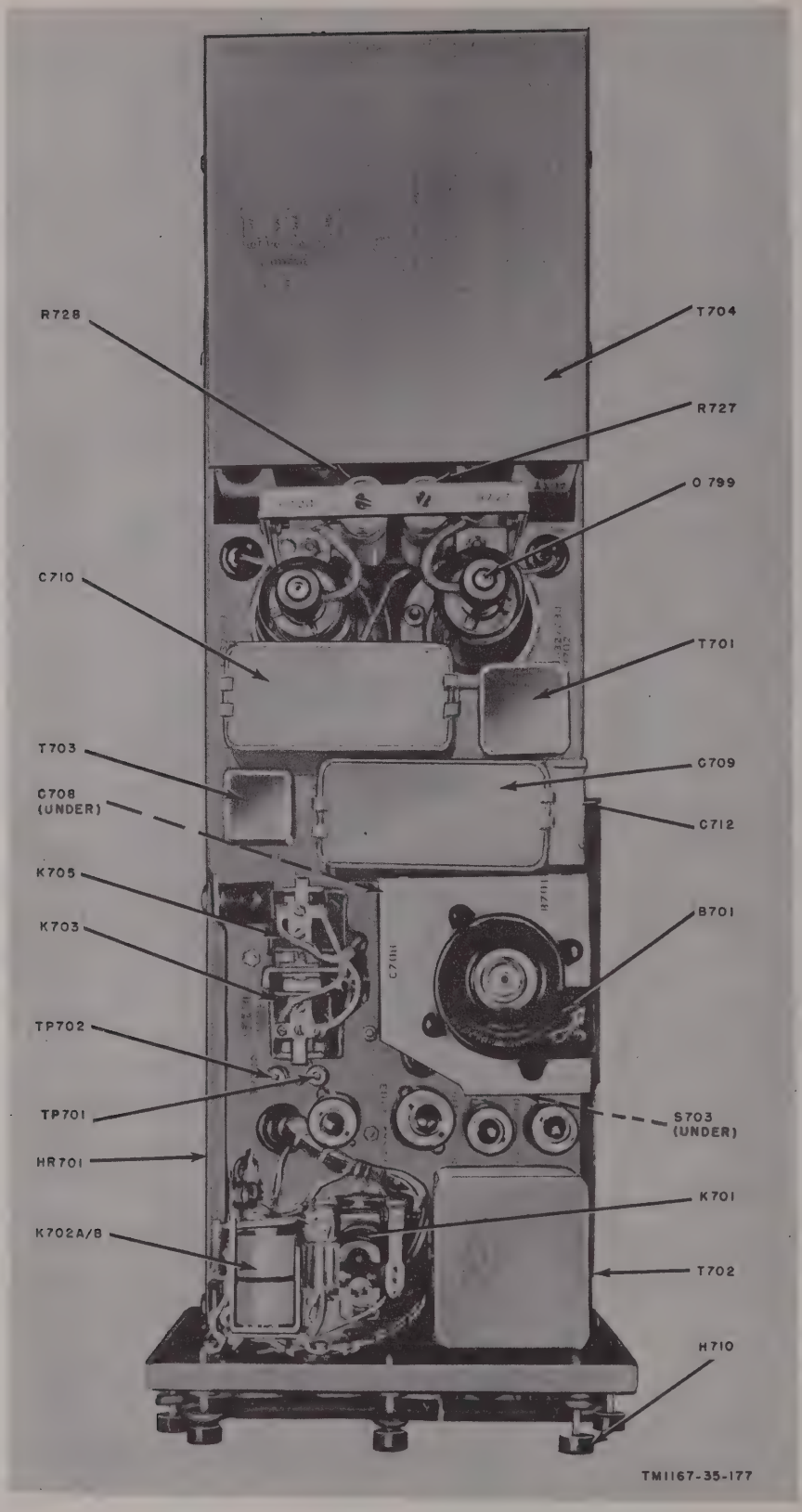


Figure 165. Antenna servo amplifier, top view.

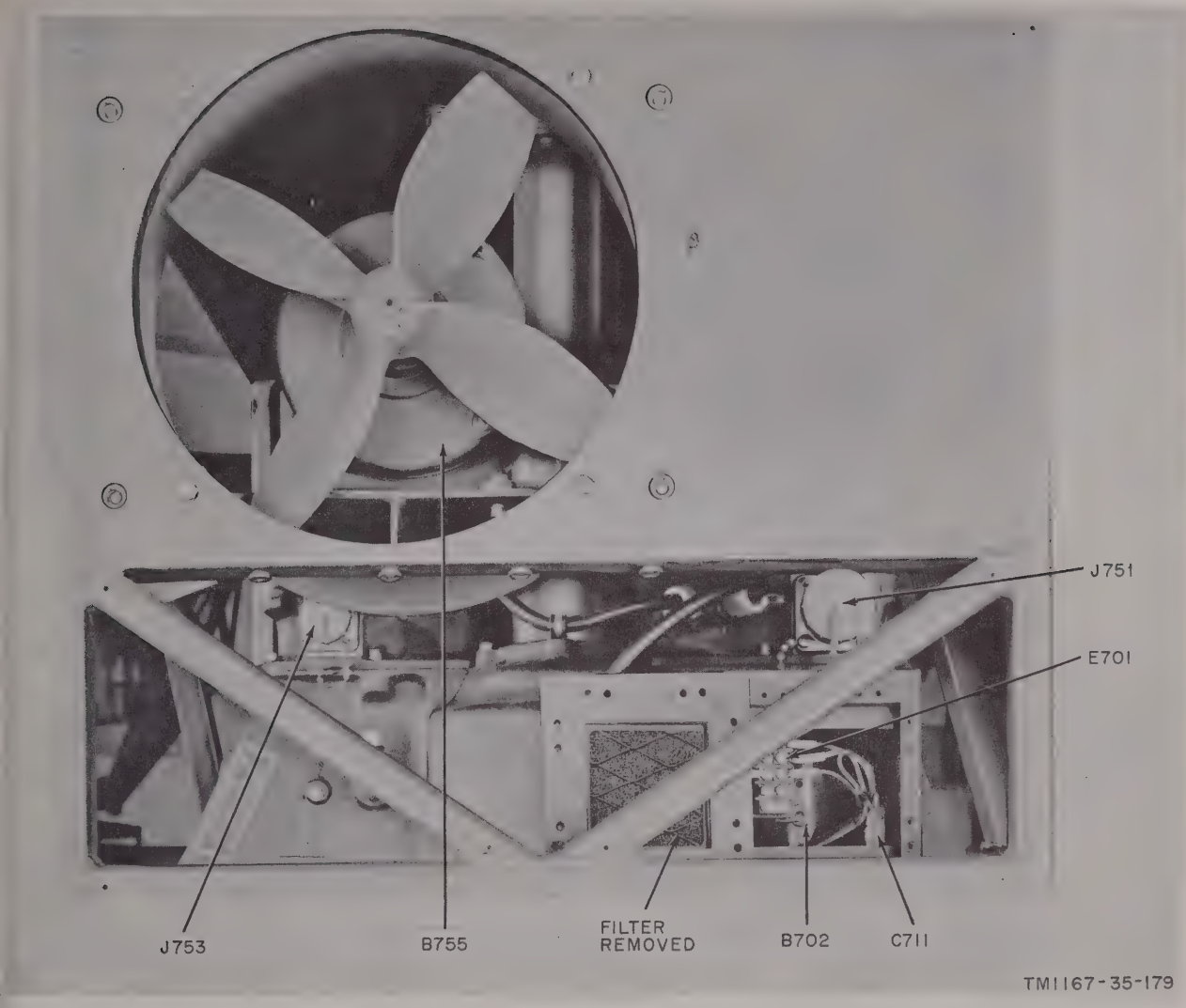


Figure 166. Antenna Base AB–221/TPS–1D, rear view.

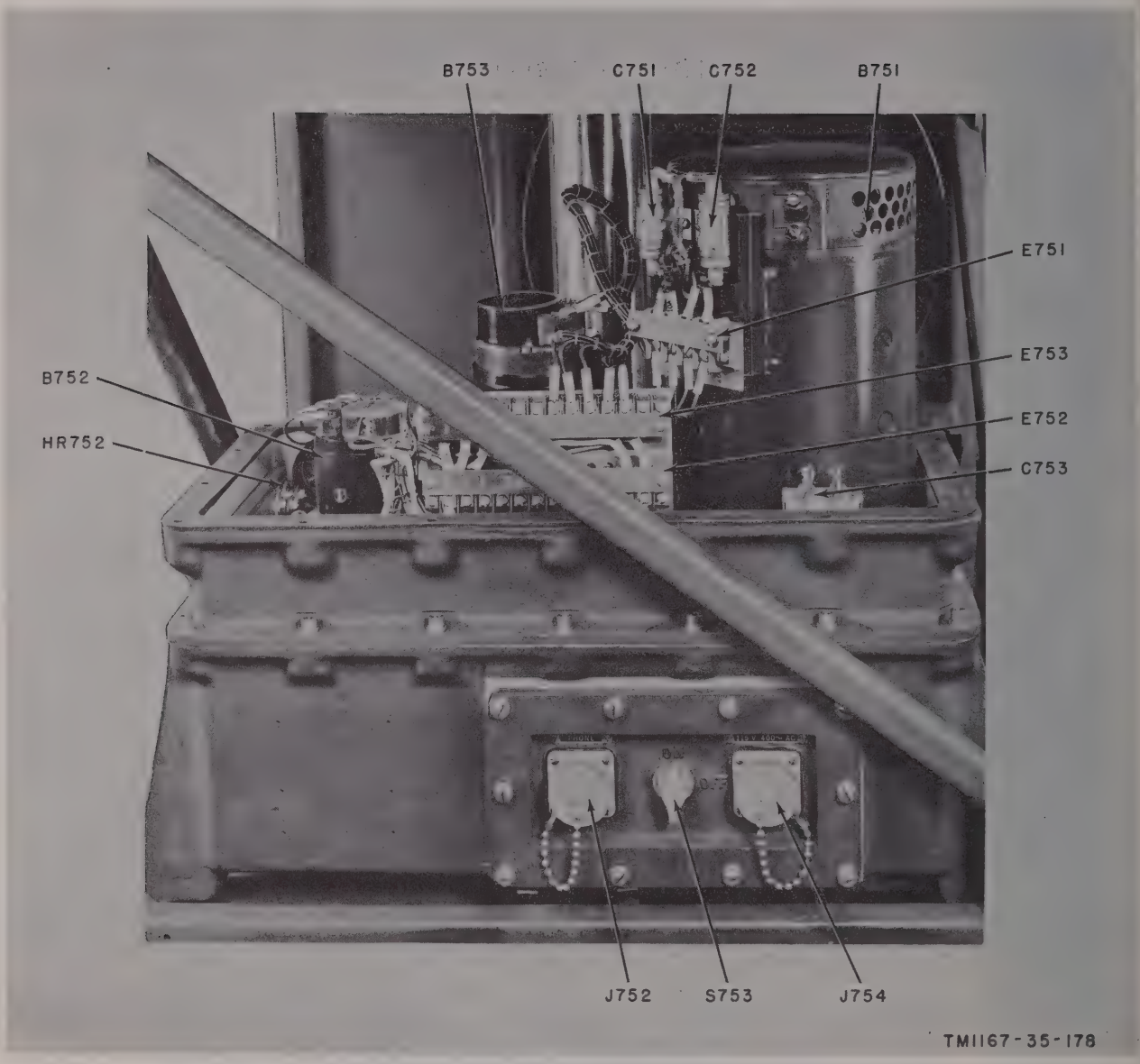


Figure 167. Antenna drive assembly, front view.

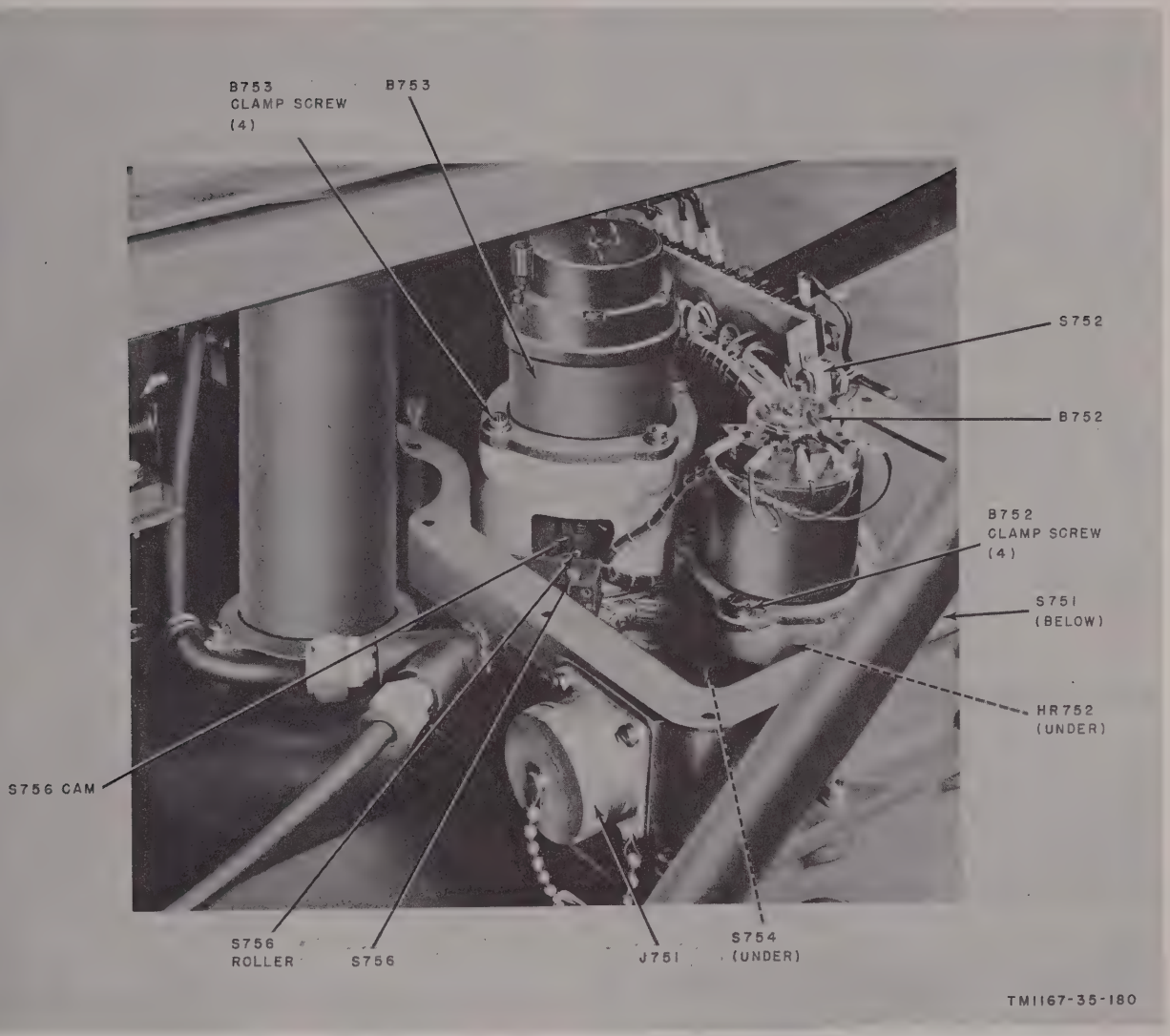


Figure 168. Antenna drive assembly, rear view.

b. Azimuth-Range Indicator IP–141/TPS–1D (fig. 158).

Control or adjustment	Function
ANTENNA ROTATE control R609	Controls the speed and direction of rotation of the antenna. Operates a relay to control the direction and adjusts the bias on control tube V703 A to determine the speed.
ANTENNA SPEED R2619	Adjusts the range of control available with ANTENNA ROTATE control R609.

387. Antenna Positioning System Fuses

The fuses that protect the antenna positioning system are located in Power Supply PP–674/TPS–1D. For troubleshooting involving blown fuses, refer to paragraph 210.

388. Normal Indications at Antenna Positioning System Test Points (fig. 165)

The following chart lists the test points that are provided to test the operation of circuits in the antenna positioning system and gives the normal indication at each test point.

Test point	Normal indication
TP701	Zero voltage when ANTENNA ROTATE control R609 is at 0 rpm. Voltage should be increasingly positive as R609 is turned in either direction.
TP702	Maximum of +60 to +70 volts for normal operation. Maximum voltage for an overload condition should be +80 volts.

389. Dc Resistance of Inductive Components in Antenna Positioning System

The following chart lists the transformers, relays, and motors in the antenna positioning system, references a figure that shows the location of each, and gives the dc resistance of every winding.

Transformer, relay, or motor	Location (fig. No.)	Terminals	Dc resistance (ohms)
K701	165	3–4	240
K702	165	3–5	240
		4–6	(1)
K703	165	3–4	4,000
K704	164	9–10	230
K705	165	3–4	400
T701	165	1–2	145
		3–4	1,000
T702	165	1–2	1.6
		2–3	(1)
		4–5	(1)
		6–7	(1)
		8–9	(1)
		10–11	(1)
T703	165	1–2	(1)
		3–4	(1)
		5–7	630
T704	165	1–2	(1)
		3–5	1.3
B701	167	Red to yellow	180
B702	166	Orn-yel (62A) to red (302)	32
		Blk (903) to red (302)	55
B751	167	Armature	3.66
		Field	119
B752		S1 to S2	1
		S1 to S3	1
		S2 to S3	1
		R1 to R2	1.5
B753	167	S1 to S2	26
		S1 to S3	26
		S2 to S3	26
		R1 to R2	13.5
B755	166	J757, A to B	2.3
		J757, A to G	10.8
		J757, B to G	8.5
B602	152	S1 to S2	1
		S1 to S3	1
		S2 to S3	1
		R1 to R2	1.5

[1] Less than 1.

Section II. TROUBLESHOOTING CHART

390. General

Troubles that have been sectionalized to the antenna positioning system usually can be isolated by following a procedure based on symptoms that localize the trouble to a channel, circuit, or stage. If you are not sure the trouble is in the antenna positioning system, use the troubleshooting chart based on starting

procedure to sectionalize the trouble to a system. The symptoms that are given in paragraph 393 consist of indications that are obtained when the antenna is rotated or an attempt is made to rotate the antenna. To troubleshoot the antenna positioning system, proceed as follows:

a. Observe the action of the antenna as the ANTENNA ROTATE control is turned.

b. Compare the indications obtained with those listed in the Symptom column.

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.

391. Test Equipment Required to Troubleshoot Antenna Positioning System

The following items of test equipment are required to troubleshoot the antenna positioning system:

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A.
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083.

392. Preparation of System Components for Troubleshooting

a. General. When the radar set is properly installed, the indicator and the antenna base are inaccessible for troubleshooting, alining, and field testing. The parts in the indicator that are functionally part of the antenna positioning system can be made available for servicing by partly withdrawing the indicator from its case. The antenna base consists of the servo amplifier and the drive assembly. The parts in the servo amplifier are made available for servicing by removing the chassis. The parts in the drive assembly are made available for servicing by removing the cover.

Warning: Before following the procedure given in *b* below, disable the antenna servo system by turning safety switch S753 (fig. 167) to OFF.

b. Antenna Base. To make the antenna base accessible for troubleshooting, alining, and/or field testing, proceed as follows:

(1) Disconnect the cables that are connected to the receptacles on the front panel of the servo amplifier.

(2) Release the 10 captive screws on the front panel of the amplifier and remove the chassis.

(3) Place the chassis in a suitable position, reconnect the cables, and defeat the interlock (par. 207*b*).

(4) Release the 17 captive screws on the antenna drive assembly cover and remove the cover.

c. Indicator. To make the indicator accessible for troubleshooting, alining, and/or field testing, proceed as follows:

(1) Release the 16 captive screws on the indicator front panel.

(2) Withdraw the indicator from the case and disable interlock S603 (par. 207*b*).

393. Antenna Positioning System Symptom Troubleshooting Chart

Warning: Dangerous voltages exist in the indicator and in the antenna base. Unexpected rotation of the antenna can cause bodily injury.

1. Indicator. Troubleshoot the antenna positioning circuits in the indicator with an ohmmeter and with the power off.

2. Antenna Base. Whenever possible, check the antenna base circuits with safety switch S753 (fig. 167) in the OFF position. Perform all work while standing firmly on a platform or ladder. Do not touch any part of the antenna base that is not obviously at ground potential. Be prepared for unexpected antenna rotation at all times.

Symptom	Probable cause	Corrective measures
1. Antenna will not rotate in either direction.	Servo amplifier circuits, drive motor circuits, rotate control circuits, or relay circuits.	***Warning:*** Observe the precautions in the warning notice at the beginning of this paragraph. *a.* Observe the filaments of V701 through V706. (1) If all the filaments are lighted, proceed to *b* below. (2) If all the filaments are not lighted, check the primary of T702.

Symptom	Probable cause	Corrective measures
		b. Measure the voltage at the plate cap of V701 and V702. The normal reading is 310 volts ac. (1) If normal, proceed to *c* below. (2) If abnormal, measure the voltage between terminals 1 and 2 of T704. The normal reading is 115 volts ac. (*a*) If normal, check T703 and T704. (*b*) If abnormal, refer to troubleshooting based on starting procedure (par. 210). *c.* Measure the voltage between TP701 (+) and ground. The normal reading is 0 volt with the rotate control at 0 rpm, increasing to about 120 volts at 15 rpm. (1) If normal, proceed to *d* below. (2) If abnormal, check the mechanical coupling to R609. Check the wiring from V703A pin 3 to R609 for a short to ground. *d.* Visually check the operation of K702. It should be energized when the rotate control is at 0 rpm and should de-energize when the control is advanced in either direction. (1) If normal, proceed to *e* below. (2) If abnormal, check and/or adjust S617 and cam O 1601 (par. 400). Check the wiring from K702 to S617 for a short to ground. *e.* Measure the voltage across C701 or C702. The normal reading is between 30 and 33 volts (junction of C701 and C702 positive) when the rotate control is at 0 rpm. The reading should decrease as the rotate control is advanced in either direction. (1) If normal, proceed to *f* below. (2) If abnormal, check V705A, R720, R721, and the associated wiring. *f.* Turn off the radar set power and disconnect P702. (1) Measure the resistance between pin C of J702 and ground. The normal reading is 0 ohm. (*a*) If normal, proceed to (2) below. (*b*) If abnormal, check K702 and connection from J702 pin C to K702 terminal 1. (2) Measure the resistance between pins C and D of P702. The normal reading is less than 1 ohm. (*a*) If normal, proceed to (3) below. (*b*) If abnormal, check conductors C and D in cable W12, connections between pins C and D of J753 and the motor, the brushes and armature of the motor. (3) Measure the resistance between pin D of J702 and ground. The normal reading is 35K. *Note.* The meter reading will be very low when first connected but will increase to 35K as C709 and C710 charge. (*a*) If normal, proceed to (4) below. (*b*) If abnormal, check C709, C710, C713, K701, R705 through R710, and the connections between these parts. (4) Measure the resistance between pins A and B of P702. The normal reading is 120 ohms. (*a*) If normal, proceed to (5) below. (*b*) If abnormal, check the field of B751 and the connections from J702 to the field.

Symptom	Probable cause	Corrective measures
		(5) Measure the resistance between pins A and B of P753. The normal reading is less than 4,000 ohms. (*a*) If normal, proceed to *g* below. (*b*) If abnormal, check the connections between J702 and CR701. *g*. Reconnect the cable to J702 and turn on the power. Measure the voltage between pin 2 or 5 (+) of V706 and ground. The normal reading is 70 volts. (1) If normal, proceed to *h* below. (2) If abnormal, check R717, R722, R723, and the connections to E401 terminal 1A. *h*. Measure the voltage between Pin 8 (+) of V703B and ground. The normal reading is 35 volts. If abnormal, check R711 through R715.
2. Antenna rotates clockwise when rotate control is turned either clockwise or counterclockwise.	Antenna reversing circuit	Check reversing relay K701, check and/or adjust S618 and cam O 1606 (par. 400). Check for continuity between +27 volts dc and ground through K701 and S618.
3. Antenna rotates counterclockwise when rotate control is turned either clockwise or counterclockwise.	Antenna reversing circuit	Check S618. Check wiring between K701 and S618 for a short to ground.
4. Antenna rotates clockwise but will not rotate counterclockwise.	Short circuit to ground in the armature circuit of B751.	Check C751, K701, and the wiring between B751 and K701 for a short circuit to ground.
5. Antenna rotates counterclockwise but will not rotate clockwise.	Short circuit to ground in the armature circuit of B751.	Check C752, K701, and the wiring between B751 and K701 for a short circuit to ground.
6. The antenna rotates in either direction but the speed is excessive and cannot be controlled.	Control circuit defective	Check and/or replace V703A. Check for continuity from V703 pin 3 to ground.
7. The antenna rotates in either direction but the speed is reduced.	V701 or V702 defective. Loss of 150 volts to rotate control.	*a*. Observe V701 and V702 while the antenna is rotating. They should both be ionized. (1) If both are ionized, proceed to *b* below. (2) If either V701 or V702 is not ionized, replace it. *b*. Measure the voltage between TP701 (+) and ground as the rotate control is advanced. The normal reading is 0 volt at 0 rpm, increasing to 120 volts at 15 rpm. If abnormal, check R2619 and the wiring from R609 through R2619 to terminal 1A of E401.
8. The antenna rotates normally but the ppi sweep does not follow properly.	Synchro circuits or synchro zeroing circuit.	*a*. Measure the voltage between S1 and S2, S1 and S3, and S2 and S3 of B602, with the antenna rotating. The normal reading is an ac voltage that varies in amplitude from 0 to 90 volts as the antenna rotates. (1) If normal, proceed to *b* below. (2) If all three measurements indicate ac is present and the amplitudes are different but constant, check the mechanical coupling to B752. (3) If one or more of the measurements indicate ac of varying amplitude but the readings differ in amplitude, check the connections from B602 through K704 to B752. Check B752. (4) If the S1–S2 and the S2–S3 readings indicate a constant 78 volts and the S1–S3 reading indicates 0 volt, check K704 and the wiring from S756 to K704 for a short to ground. Check and/or adjust S612 and S756 (pars. 398 and 399).

Symptom	Probable cause	Corrective measures
		b. Observe the worm gear on the B602 shaft while the antenna is rotating. The gear should be turning. (1) If normal, check the mechanical coupling between the worm gear and the deflection coil. (2) If abnormal, check B602.

Section III. REMOVAL AND REPLACEMENT OF PARTS

394. General

The antenna positioning system consists of most of the parts in Antenna Base AB–221/TPS–1D. The parts in Azimuth-Range Indicator IP–141/TPS–1D are associated with the antenna rotate control mechanism and torque receiver synchro B602.

Warning: Dangerous voltages exist in the antenna base and in the indicator. When removing and replacing parts in either of these components, heed the high-voltage warnings.

395. Removal and Replacement of Parts

a. Antenna Base AB–221/TPS–1D. The removal and replacement of tubes in the servo amplifier chassis are covered in TM 11–1167–20. The removal and replacement of all other parts is shown in (1) and (2) below.

(1) *Servo amplifier chassis.* The servo amplifier chassis is mounted in the lower left hand corner of the antenna base. The parts located on both the top and bottom of the chassis are accessible when the chassis is removed.

(2) *Antenna drive assembly.* The parts in the antenna drive assembly are accessible when the cover is removed. Chapter 20 in this manual covers disassembly and assembly of the antenna drive assembly.

b. Azimuth-Range Indicator IP–141/TPS–1D. The parts in the indicator are accessible when it is removed from its case. Chapter 21 covers disassembly and assembly of the antenna rotate control mechanism.

Section IV. ADJUSTMENT AND ALINEMENT

396. General

a. This section covers the adjustment and alinement of the antenna positioning system when the components of the radar set are interconnected. These adjustments are in the antenna base and the indicator and can only be properly made when the antenna base is interconnected with the other components of the radar set. The complete adjustment and alinement of the radar set is covered in paragraph 447.

b. The following adjustments are made when the set is initially installed. The procedures are given in paragraphs 10 and 11 in TM 11–1167–20.

(1) ANTENNA SPEED adjustment R2619.

(2) Thyratron bias control adjustment R721.

(3) Voltage feed-back adjustment R707.

(4) Current feed-back adjustment R710.

(5) Overload adjustment R717.

(6) Synchro alinement B602, B752, and B753.

c. Cams O 1601 and O 1606 and switches S617 and S618 usually require adjustment only if the antenna rotate mechanism is disassembled. Synchro zeroing switches S612 and S756 require adjustment when they are replaced or to compensate for wear. Need for adjustment of S612 or S756 will be indicated by erratic operation of the ppi sweep. The following adjustments are covered in this section:

(1) Synchro zeroing switch S612 (par. 398).

(2) Synchro zeroing switch S756 (par. 399).

(3) Antenna rotate control mechanism (par. 400).

397. Tools and Test Equipment Required

The only test equipment required to adjust the synchro zeroing switches is Multimeter TS–352B/U (or Multimeter ME–77/U). There are no special tools required.

398. Adjustment of Synchro Zeroing Switch S612 (fig. 169)

a. General. Synchro zeroing switch S612 is connected in series with S756 in the ground return for synchro relay K704. The adjustment is made so that S612 is closed for not more than 6° of deflection coil rotation.

b. Procedure. To adjust S612, proceed as follows:

(1) Withdraw the indicator from its case and connect the multimeter across S612 to measure low ohms.

(2) Rotate the deflection coil by turning the worm gear on indicator subassembly O 614 to position S612 roller on its actuating cam (fig. 169).

(3) Loosen the two screws securing S612, position the switch so that it just actuates (zero resistance), and tighten the screws.

(4) Determine the arc through which S612 is actuated by rotating the deflection coil. Observe the teeth on bevel gear O 611 (fig. 169) to accurately determine degrees of rotation. The teeth on O 611 are 3° apart. The switch should be actuated for not more than 6°.

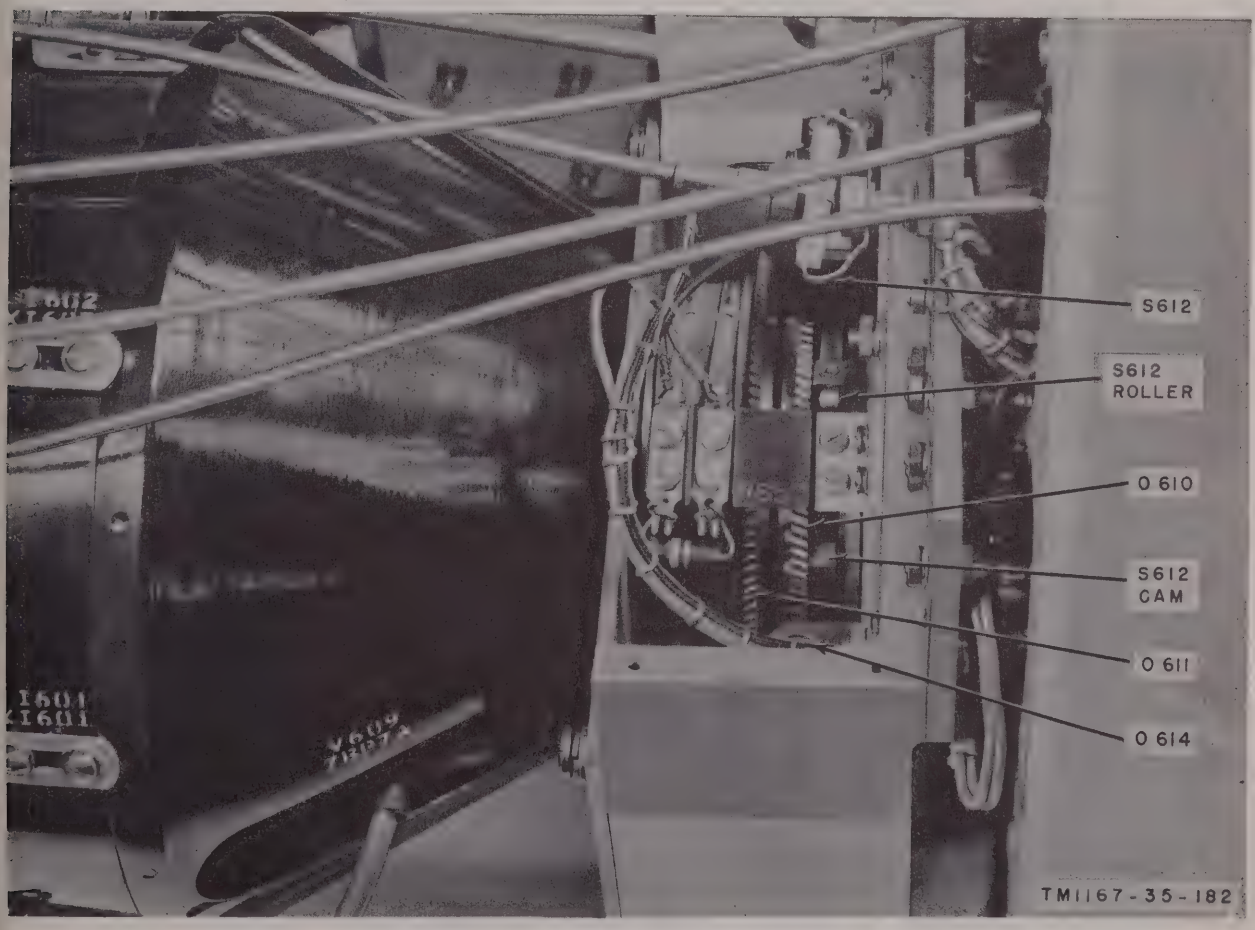


Figure 169. Deflection coil mechanism.

(5) If the check given in (4) above shows the arc for which S612 is actuated to be more than 6°, reposition S612 to reduce the pressure of the cam on the switch roller.

(6) Repeat (4) and (5) above until S612 is actuated for not more than 6°.

399. Adjustment of Synchro Zeroing Switch S756

(fig. 168)

a. General. Synchro zeroing switch S756 is connected in series with S612 in the ground return of synchro relay K704. The adjustment is made so that S756 is actuated (opened) for 10 to 12° of antenna rotation.

b. Procedure. To adjust S756, proceed as follows:

(1) Withdraw the indicator from its case and defeat the interlock.

(2) Remove the cover from the ppi deflection assembly (L601).

Warning: High voltage is present on the slip ring terminals when the equipment is energized.

(3) Disconnect the lead from tie point X (terminal on S612 on the end opposite the roller).

(4) Connect the multimeter between the disconnected lead and ground to read 27 volts dc (lead is positive).

(5) Remove the cover from the antenna drive assembly.

(6) Make a preliminary adjustment of S756 by loosening the three screws securing the mounting plate, positioning it in the center of the range of adjustment, and tightening the screws.

(7) Turn on the radar set power. After the 5-minute time delay has elapsed, turn on the transmitter.

(8) Rotate the antenna in small increments until S756 actuates (voltmeter reads zero).

(9) Note the exact position of the ppi sweep.

(10) Continue rotating the antenna in small increments in the same direction until S756 deactuates (meter reads 27 volts).

(11) Note the exact position of the ppi sweep. The difference between this position and (9) above is the arc through which S756 is actuated. It should be 10 to 12° (177 to 212 mils).

(12) If the results obtained in (8) through (11) above are not within limits, readjust S756 (move the cam toward the roller to increase the arc) and repeat (8) through (11) above.

(13) Repeat (12) above until the results obtained are within limits.

(14) Disconnect the voltmeter and reconnect the wire to tie point X ((3) above).

400. Adjustment of Antenna Rotate Control Mechanism

(fig. 170)

a. General. The antenna rotate control mechanism consists of braking switch S617, reversing switch S618, rotate potentiometer R609, the dial and pointer, and the gears, cams, and shafts necessary to operate these parts. When the mechanism is properly adjusted and set for 0 rpm, the conditions are as follows:

(1) Cam O 1601 is positioned so that detent O 655 is engaged.

(2) Braking switch S617 is positioned so that it is deactuated but will actuate if the ANTENNA ROTATE control is moved in either direction.

(3) Reversing switch S618 and its cam (O 1606) are positioned so that S618 is deactuated but will actuate if the ANTENNA ROTATE control is turned slightly counterclockwise.

(4) Rotate potentiometer R609 is positioned so that the voltage at the wiper arm is zero.

b. Procedure. To adjust the antenna rotate control mechanism, proceed as follows:

(1) Set the rotate control so that S618 is deactuated and a slight turn counterclockwise will cause it to actuate.

(2) Loosen the screw securing dial pointer H664 and set it to zero while holding the control in the position in (1) above. Tighten the screw.

(3) Adjust braking cam O 1601 so that detent is centered in its notch and centered on the cam, with the dial reading zero. Tighten the screw.

(4) Adjust the position of S617 so that its roller is centered in its notch on O 1601 and deactuated.
(5) See that S617 actuates when the rotate control is turned both clockwise and counterclockwise. Return the control to 0 rpm.
(6) Connect the multimeter between the wiper contact of R609 (center of three) and ground to measure low ohms.
(7) Loosen the Allen setscrew that clamps coupling O 1602 to R609.

Caution: When R609 is loose, there is considerable end play in the shaft that drives it. Do not allow the shaft to move or the cam will be off center under the detent.

(8) Insert a piece of stiff wire, to be used as a lever, in the hole in the shaft of R609.
(9) Adjust R609 so that the multimeter reads zero resistance.
(10) Tighten the coupling to R609 and disconnect the multimeter.

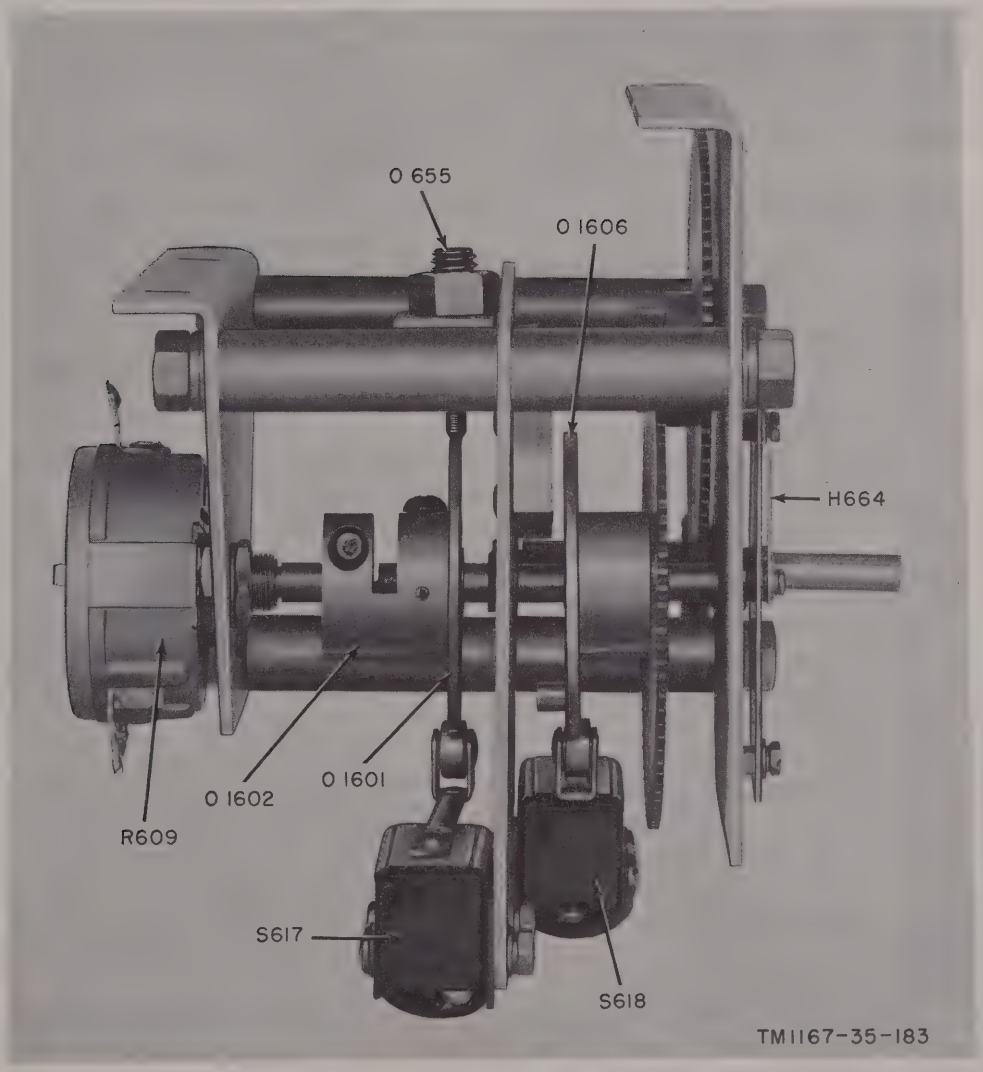


Figure 170. Antenna rotate control mechanism.

Section V. FIELD TESTING

401. General

This section describes testing procedures required to test the serviceability of a repaired antenna positioning system when the components of the radar set are interconnected. Bench testing of Antenna Base AB–221/TPS–1D is described in paragraph 409. Testing procedures designed to check the serviceability of the complete radar set are covered in paragraph 448.

402. Test Equipment Required

The only test equipment required to completely test the serviceability of the antenna positioning system is Multimeter TS–352B/U (or Multimeter ME–77/U). A means of accurately tuning antenna rotation is also required, preferably a stopwatch, but a watch or clock with a second hand is accurate enough. A piece of rope must be available to tie the antenna to the base.

403. Antenna Positioning System Performance Test

a. General. The performance of the antenna positioning system is tested as follows:

(1) The ANTENNA ROTATE control is set to indicate a speed of 15 rpm.
(2) The actual speed is checked by counting the revolutions in 1 minute.
(3) The ANTENNA ROTATE control is set at 2 rpm and the voltage at TP702 is checked. A fluctuating meter reading indicates hunting and that the system needs adjustment and/or repair.

b. Procedure. To determine whether the performance of the antenna positioning system is acceptable, proceed as follows:

(1) Disconnect the cables that are connected to J701 and J702 on the front panel of the antenna servo amplifier and remove the amplifier from its case.
(2) Reconnect the cables and defeat the interlock.
(3) Turn on the radar set power.
(4) After the 5-minute time delay has elapsed, set the rotate control to indicate 15 rpm.
(5) Check the actual rpm by counting the revolutions in 1 minute. It should be 15 plus or minus ½ rpm.
(6) Reduce the antenna speed to 1 rpm.
(7) Measure the voltage between TP702 (+) and ground. It should be less than 10 volts and the reading must not fluctuate.

404. Sustained Overload Test

a. General. The performance of the sustained overload circuit is tested as follows:

(1) The antenna is tied so that it cannot rotate.
(2) The ANTENNA ROTATE control is advanced.
(3) The voltage at TP702 is checked to determine whether the overload circuit is operating properly.

b. Procedure. To test the operation of the sustained overload circuit, proceed as follows:

(1) Tie the antenna to the antenna base.
Caution: Tie only framework to framework so that the antenna trying to rotate will not place a strain on the transmission line, cables, or fittings.
(2) Prepare the radar set (par. 403*b*(1)–(3)).
(3) Connect the multimeter between TP702 (+) and ground to measure 250 volts dc.
(4) Advance the rotate control until the multimeter indicates 70 volts.
(5) Wait 10 seconds and then slowly advance the control in the same direction in increments that produce a 2-volt change in meter reading, until the meter reading suddenly decreases to less than 5 volts. The decrease in voltage should occur at 80 volts plus or minus 2 volts.
(6) Advance the rotate control to 15 rpm. The antenna should not try to rotate.
(7) Set the rotate control to 0 rpm and wait 5 seconds.
(8) Advance the rotate control again and the antenna should try to turn. Return the control to zero.
(9) Disconnect the multimeter, turn off the radar set, and replace the amplifier.

Section VI. BENCH SERVICING ANTENNA BASE

405. General

This section covers bench servicing of the antenna positioning circuits in the antenna base. The antenna positioning system also includes the rotate control assembly and the synchro receiver in the indicator. Servicing the antenna positioning circuits which are in the indicator can be accomplished by using an ohmmeter with no power applied. Refer to paragraph 400 and antenna positioning system composite schematic diagram (fig. 227). The following information will be helpful when bench servicing the antenna positioning circuits in the antenna base.

Information	Location
Antenna Base AB–221/TPS–1D, complete schematic diagram.	Fig. 226.
Antenna positioning system, composite schematic diagram.	Fig. 227.
Location of parts in the antenna base	Figs. 164–168.
Antenna servo amplifier, voltage and resistance chart.	Fig. 225.
Controls and adjustments	Par. 386.
Normal indications at test points	Par. 388.
Resistance of transformers, coils, and relays.	Par. 389.
Removal and replacement of parts	Pars. 394–395.

406. Test Equipment Required

The following test equipment, cables, and adapters are required to service Antenna Base AB–221/TPS–1D. The Prony brake listed is a device for measuring torque. If this is not available, the spring scale listed, together with the torque device shown in figure 172, is a satisfactory substitute. Cables CX–1997/U and CX–1998/U are furnished with Test Set AN/MPM–23. The cable adapter must be fabricated as shown in figure 171.

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A.
Power Supply PP–674/TPS–1D.	Power supply	This manual (ch. 9).
Electrical Power Cable Assembly CX–1997/U.	None	11–1250.
Electrical Power Cable Assembly CX–1998/U.	None	11–1250.
Cable adapter fabricated as shown in figure 171.	None	None.
Prony brake	None	None.
Spring scale (if Prony brake is not available).	None	None.
Motor Generator PU–20B/C.	Motor generator	11–978.

407. Bench Servicing Connections

Follow the directions given in *a* through *d* below to connect Antenna Base AB–221/TPS–1D for bench servicing.

a. Disconnect the cables that are connected to J751 and J753 on the antenna base.

b. Remove the antenna drive assembly cover and the servo amplifier chassis. Disable the interlock.

c. Make the connections in the power supply as shown in figure 115. If a power supply off-on switch is desired, replace the jumper between terminals 1603 and 1703 on terminal board E401 with a single-pole, single-throw switch.

d. Connect the antenna base as shown in figure 171.

e. When the connections to the power supply and the antenna base are properly made, the results are as follows:

(1) The power supply and the antenna base are energized when the motor generator is running.

(2) The potentiometer connected between pins F, G, and H on P701 functions to control the antenna speed.

(3) Switch S1 functions as a braking switch.

(4) Switch S2 functions as a reversing switch.

Caution: Reversing or braking action should not be applied at speeds greater than 1 rpm.

(5) Switch S3 functions to actuate synchro relay K704.

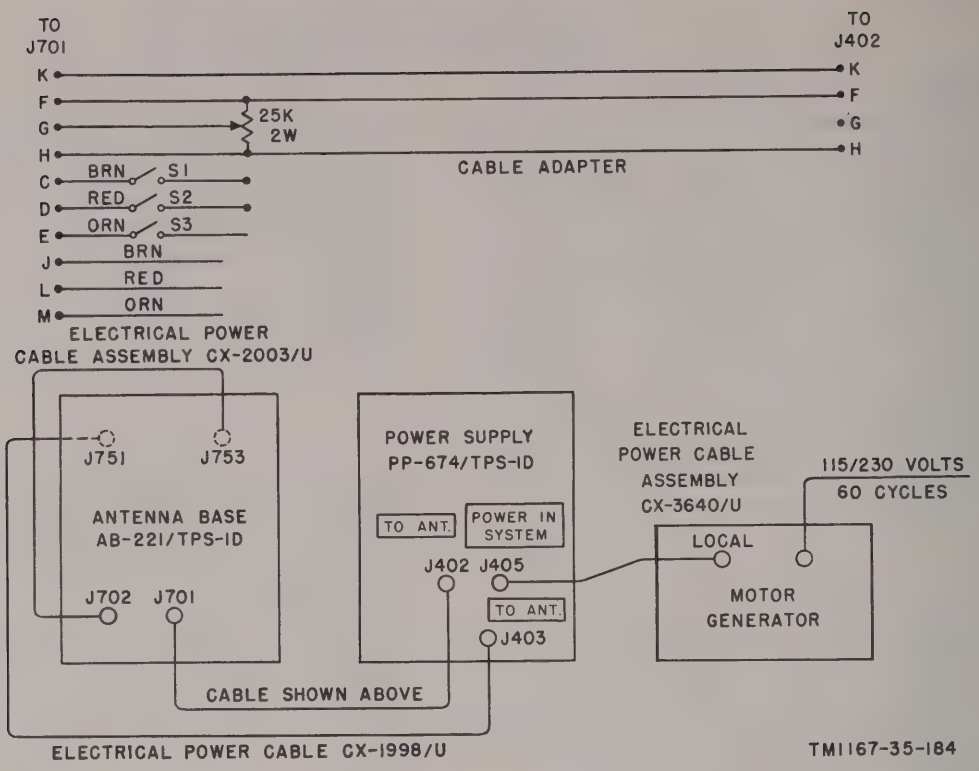


Figure 171. Antenna Base AB–221/TPS–1D, bench servicing connections.

408. Bench Troubleshooting Antenna Base AB–221/TPS–1D

a. Connect the antenna base for bench servicing (par. 407).

b. Observe the following deviations and follow the procedures given in the symptoms troubleshooting chart (par. 393).

(1) Operate the controls on the power supply that replace the rotate control on the indicator (fig. 171).

(2) When a corrective measure refers to parts in, or connections to, the indicator, ignore that corrective measure.

409. Bench Testing of Antenna Base AB–221/TPS–1D

To bench test the serviceability of a repaired antenna base, connect the antenna base for bench servicing (par. 407) and follow the procedure given in *a* through *d* below. This procedure includes testing the torque of the antenna mechanism, the overload circuits, the current feedback, and the dynamic braking.

a. To test the torque of the antenna mechanism, proceed as follows:

(1) Insert a 0- to 10-ampere meter in the motor armature circuit (60A or 61A on E751).

(2) Attach the Prony brake to the output shaft and adjust the tightness to give an armature current of 2.5 to 3.0 amperes at 15 rpm of the output shaft. A minimum torque of 82 foot-pounds should be obtained in both the cw and ccw directions.

b. To test the overload circuits, proceed as follows:

(1) Set the speed control to give an output shaft speed of 7 rpm.

(2) Momentarily stall the drive motor as abruptly as possible by tightening the Prony brake. Disregarding the meter overshoot, the armature current should be between 5 and 7 amperes.

(3) Load the antenna drive shaft with the Prony brake until the armature current is between 4.0 and 4.1 amperes at 7 rpm.

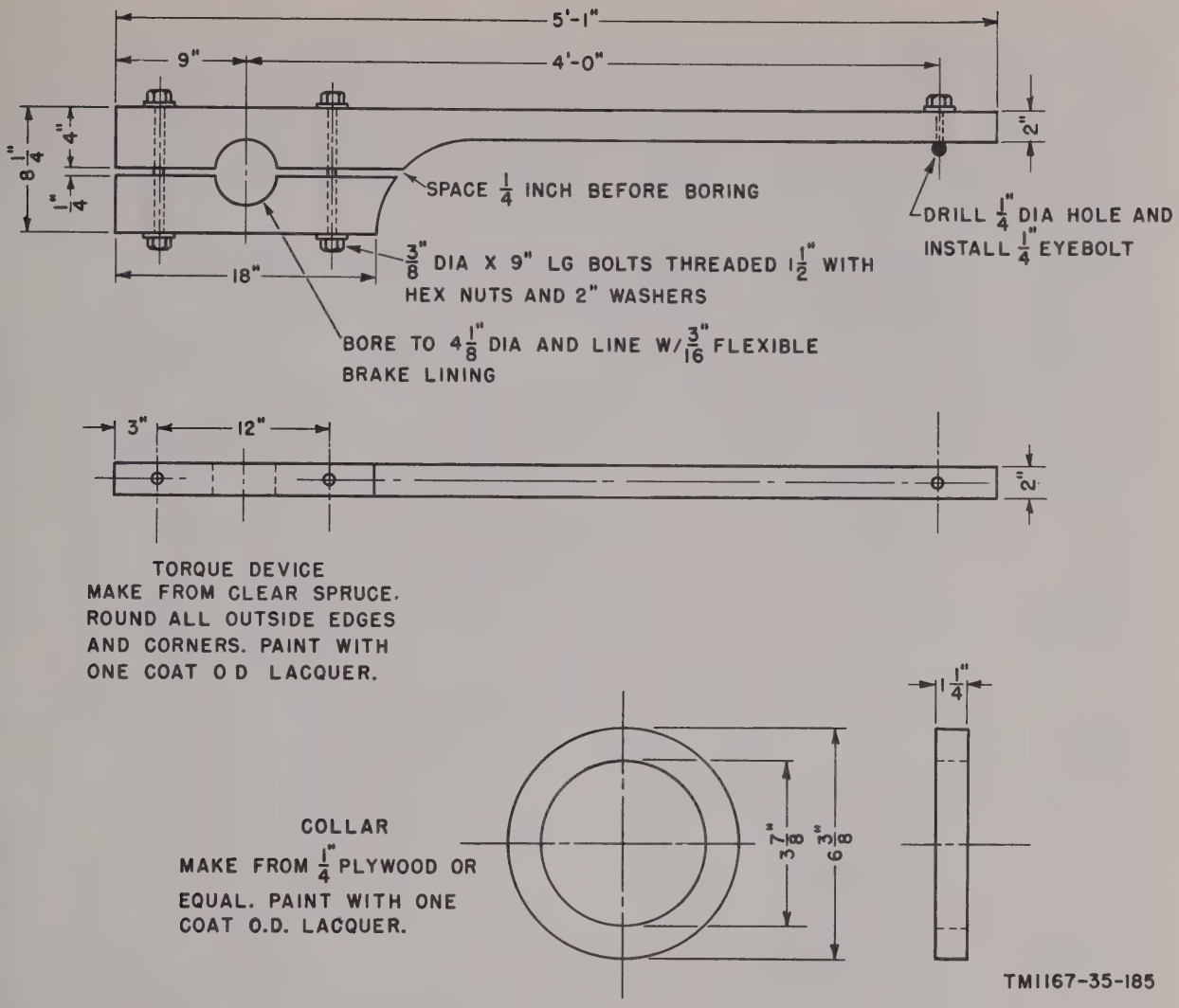


Figure 172. Torque device construction details.

(4) Rotate overload adjustment R717 ccw in small increments until V706 ionizes. When V706 ionizes, the armature current should drop.

(5) Without returning the speed control to 0 rpm, remove the load.

(6) Rotate the speed control from its present position to 15 rpm. The antenna shaft should not rotate.

(7) Return the speed control to 0 rpm and then advance it to 15 rpm. The antenna shaft should not rotate.

c. To check the current feed back circuits, proceed as follows:

(1) Adjust the speed control and the Prony brake for 1.9 to 2.1 amperes of armature current at 7.5 to 8.0 rpm.

(2) Measure the voltage between TP702 (+) and ground. The voltage should be between 60 and 70 volts.

d. To test the dynamic braking circuit, proceed as follows:

(1) Adjust the speed for 7.5 to 8.5 rpm with no load.

(2) Ground pin C of J701 momentarily by throwing S1 (fig. 171) on and then off. The drive motor should slow down to almost a stop and then return to its original speed.

CHAPTER 18

DC POWER SUPPLY SYSTEM TROUBLESHOOTING AND REPAIR

Section I. TROUBLESHOOTING INFORMATION

410. Reference Data

The following information will be helpful when troubleshooting or repairing the power supply.

Reference	Data
Fig. 90	Power supply PP–674/TPS–1D, block diagram.
Pars. 168–174	Power supply theory.
Figs. 91–95	Power supply circuits, simplified schematic diagrams.
Fig. 233	Power Supply PP–674/TPS–1D, complete schematic diagram.
Par. 411 and Figs. 173–180.	Location of parts in the power supply.
Fig. 181	Power Supply PP–674/TPS–1D, partial view of right side, timing relay adjustments.
Fig. 232	Power Supply PP–674/TPS–1D, voltage and resistance chart.
Par. 412	Power supply controls and adjustments.
Par. 416	Power Supply PP–674/TPS–1D, dc resistance of inductive components.
Par. 413	Power Supply PP–674/TPS–1D, list of fuses.
Part. 414	Normal readings on power supply panel meters.
Par. 415	Normal indications at power supply test points.

411. Location of Parts in Power Supply

The following is a list of power supply parts and the figures on which these parts can be located.

Reference symbol	Fig. No.	Reference symbol	Fig. No.	Reference symbol	Fig. No.
B401A	177	C406	176	E401	179
B401B	177	C407	178	E403	179
C401	176	C408	177	E404	179
C402	176	C409	176	E405	177
C403	176	C410	176	E406	51[a]
C404	176	CR401	176	E410	179
C405	176	CR402	178	E417	175
F401	173	J414	174	R438	176
F402	173	J415	174	R439	176
F403	173	J416	174	R443	178
F404	173	J417	174	R444	175
F405	173	J418	174	R445	179
F406	173	J419	174	R446	49[a]
F407	173	J420	174	R447	49[a]
F408	173	K401	178	R448	49[a]
F409	173	K402	178	R449	49[a]
F410	173	K403	178	R450	177
F411	173	K405	178	R451	176
F412	173	L401	176	R452	176
F413	173	L402	176	R453	176
F414	173	L403	176	R454	176
F415	173	L404	179	R455	176
F416	173	M401	173	R456	176
H402	173	M402	173	R457	176
HR401	177	M403	173	R458	176
I 401	175	R401	176	R459	176
I 402	175	R402	176	R460	176
I 403	175	R403	176	R461	176
I 404	175	R404	176	R462	176
I 405	175	R405	176	S401	174
I 406	175	R406	176	S402	177
I 407	175	R407	176	S403	179
I 408	175	R408	176	S404	179
I 409	175	R409	176	T401	179
I 410	175	R410	176	T402	179
I 411	175	R414	176	T403	179
I 412	175	R415	176	XV401	178
I 413	175	R416	176	XV402	178
I 414	175	R417	176	XV403	178
I 415	175	R418	176	XV404	178
I 416	175	R419	176	XV405	178
I 417	179	R420	176	XV406	178
J401	174	R421	176	XV407	180
J402	174	R422	176	XV408	180
J403	174	R423	176	XV409	180
J404	174	R424	176	XV410	180
J405	174	R425	176	XV411	180
J406	174	R426	176	XV412	180
J407	174	R427	176	XV413	180
J408	174	R429	176	XV414	180
J409	174	R432	176	XV415	180
J410	174	R433	176	XV416	180
J411	174	R434	176	XV417	180
J412	174	R435	176		
J413	174	R437	176		

[a] TM 11–1167–10.

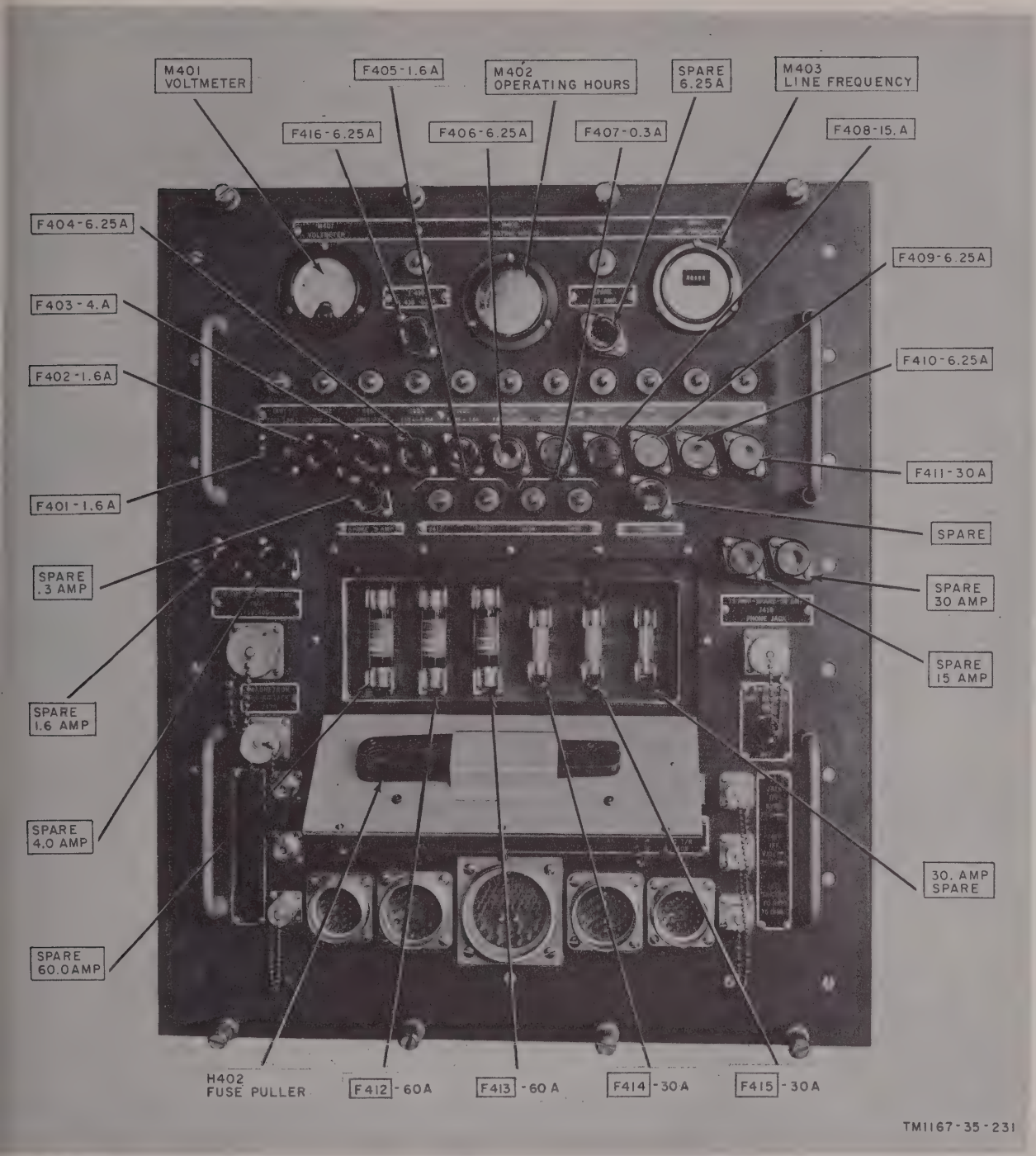


Figure 173. Power Supply PP–674/TPS–1D, fuses and meters.

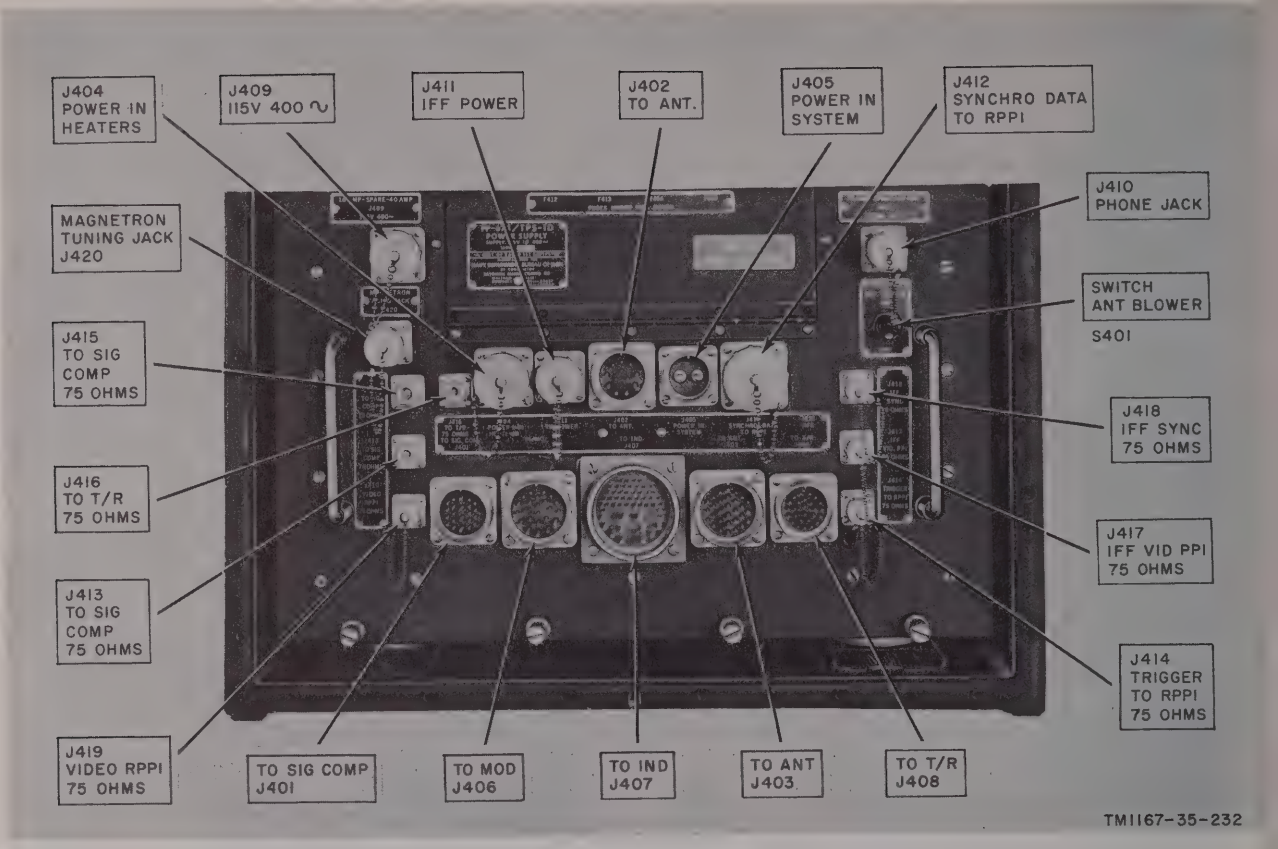


Figure 174. Power Supply PP–674/TPS–1D, jacks and antenna blower switch.

412. Power Supply Controls and Adjustments

The following chart lists the controls and adjustments that are functional parts of the power supply.

Controls and adjustments	Location (fig. No.)	Function
+150-volt adjustment R416.	179	Adjusts the output voltage from the +150-volt supply.
+300-volt adjustment R433.	179	Adjusts the output voltage from the +300-volt supply.
Timing relay (K401) adjustment R443.	178	Adjusts the time duration of timing relay K401.

413. Power Supply Fuses (fig. 173)

The following chart lists the fuses that protect circuits in the power supply. The chart lists the rating of each fuse, the blown-fuse indicator that lights when the fuse is blown, and the circuit that each fuse protects. Fuses F403, F404, F405, F407, F408, F410, F411, F412, and F413, located on the power supply, protect circuits in other systems. A complete list of fuses in the equipment is given in paragraph 207*a*.

Fuse	Rating		Blown fuse indicator	Circuit protected
	Volts	Amps		
F401	250	1.6	I 401	Convenience outlet J409, when radiating.
F402	250	1.6	I 402	Main power control relay K402.
F406	250	6.25	I 406	27-volt dc supply.
F409	250	6.25	I 409	Power supply filaments and blower motor B401 and power supply plates.
F414	250	30.0	I 414	Heater HR401.
F415	250	30.0	I 415	Heater HR401.
F416	250	6.25	I 416	Convenience outlet J409, when not radiating.

414. Normal Readings of Power Supply Panel Meters (fig. 173)

The following chart lists the meters that monitor the input line voltage and frequency to the power supply.

Meter	Function
VOLTMETER M401 (0- to 140-volt ac scale).	Indicates the ac line voltage applied to the radar set. The normal reading is 110 to 120 volts.
LINE FREQUENCY M403 (380- to 420-cycle scale).	Indicates the frequency of the line voltage applied to the radar set. The normal reading is 384 to 416 cycles.

415. Normal Indications at Power Supply Test Points (fig. 179)

The following chart lists the test points that can be used to test the operation of circuits in the power supply and gives the normal indication at each test point.

Test point	Normal indication
1A, E401	Positive 150 volts.
4A, E401	Positive 300 volts.
8A, E401	Positive 27 volts.

416. Dc Resistance of Power Supply Inductive Components

The following chart lists the transformers, coils, and relays in the power supply, refer-

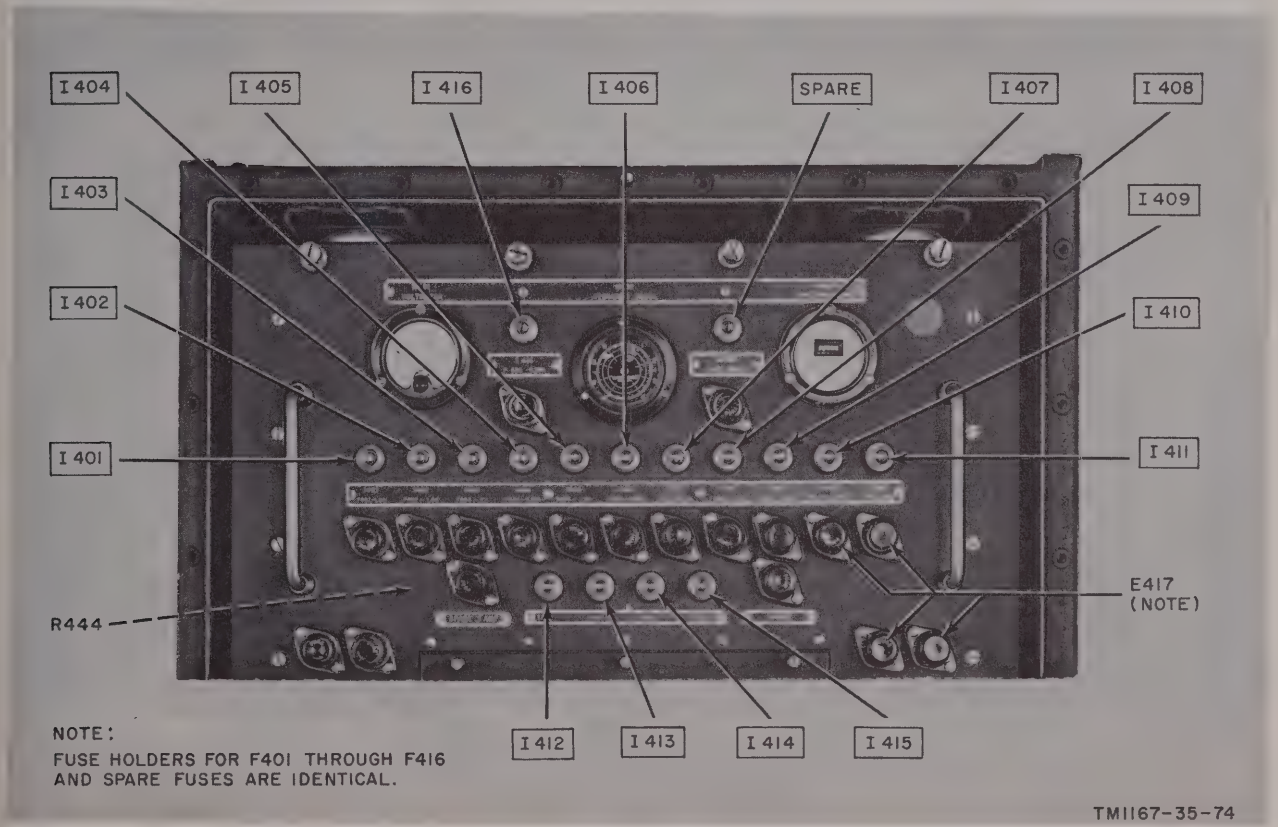


Figure 175. Power Supply PP-674/TPS-1D, blown-fuse indicators.

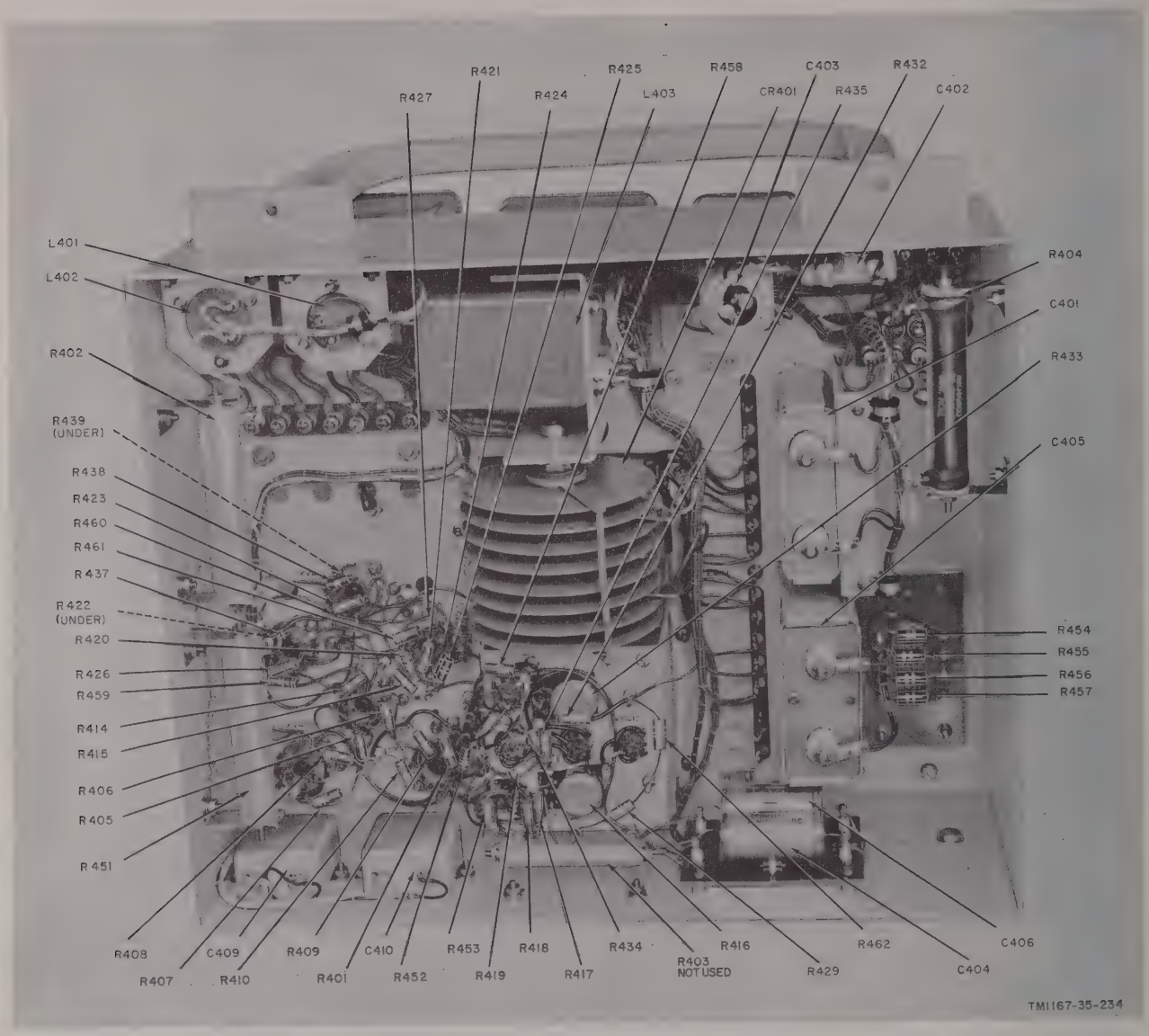


Figure 176. Power Supply PP–674/TPS–1D, location of parts, bottom view of main subchassis.

ences a figure that shows the location of each, and gives the dc resistance of every winding.

Transformer, coil, or relay	Location (fig. No.)	Terminals	Dc resistance (ohms)
T401	179	1–2	(1)
		4–6	(1)
		7–8	(1)
		9–10	(1)
		11–12	(1)
		13–14	(1)
T402	179	1–2	(1)
		5–7	11
		4–8	18
		9–11	200
T403	179	1–2	(1)
		4–5	(1)
L401	179		10
L402	179		170
L403	179		(1)
L404	179		4.5
K401	178	10–11	45 to 75
K402	178	X1–X2	110
K403	178	7–8	255
K405	178	9–10	230

[1] Less than 1.

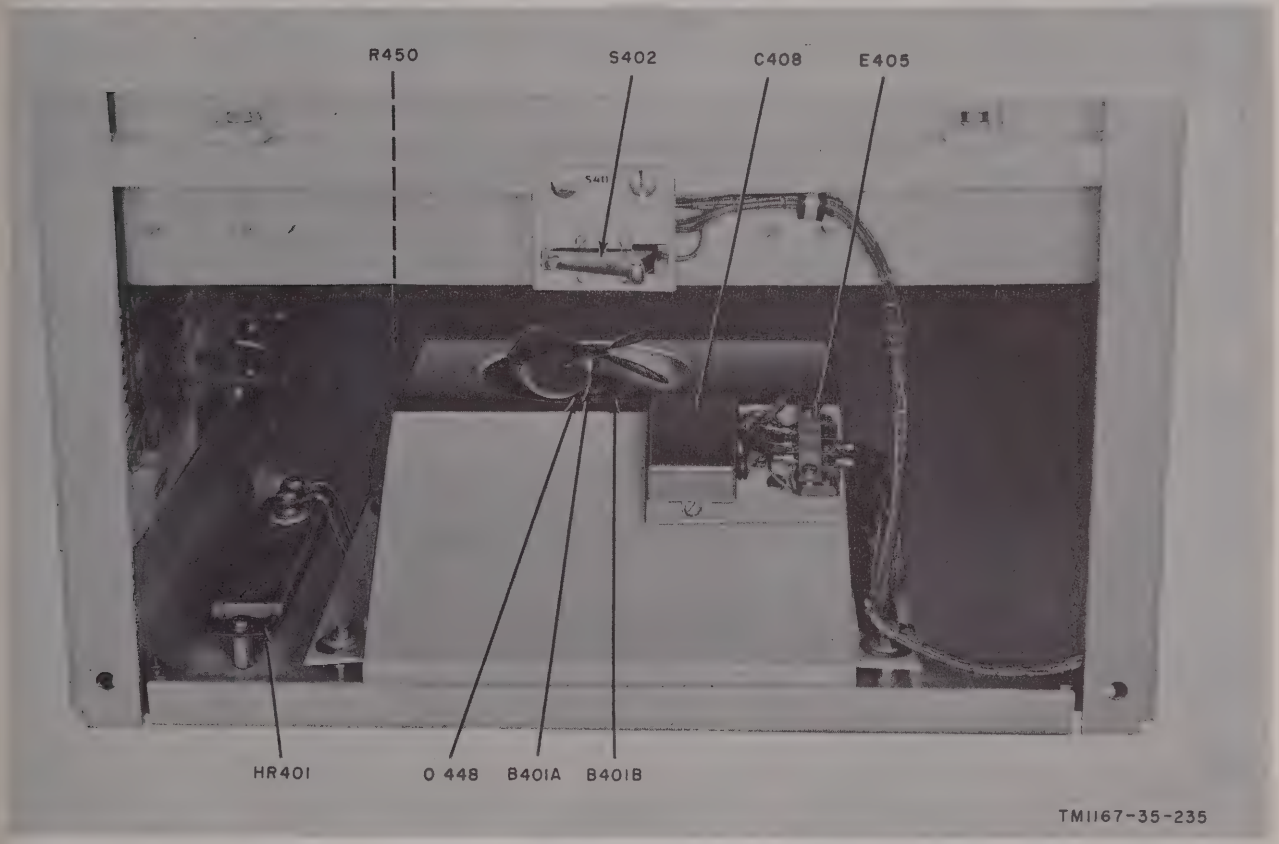


Figure 177. Power Supply 674/TPS–1D, location of parts, partial rear view.

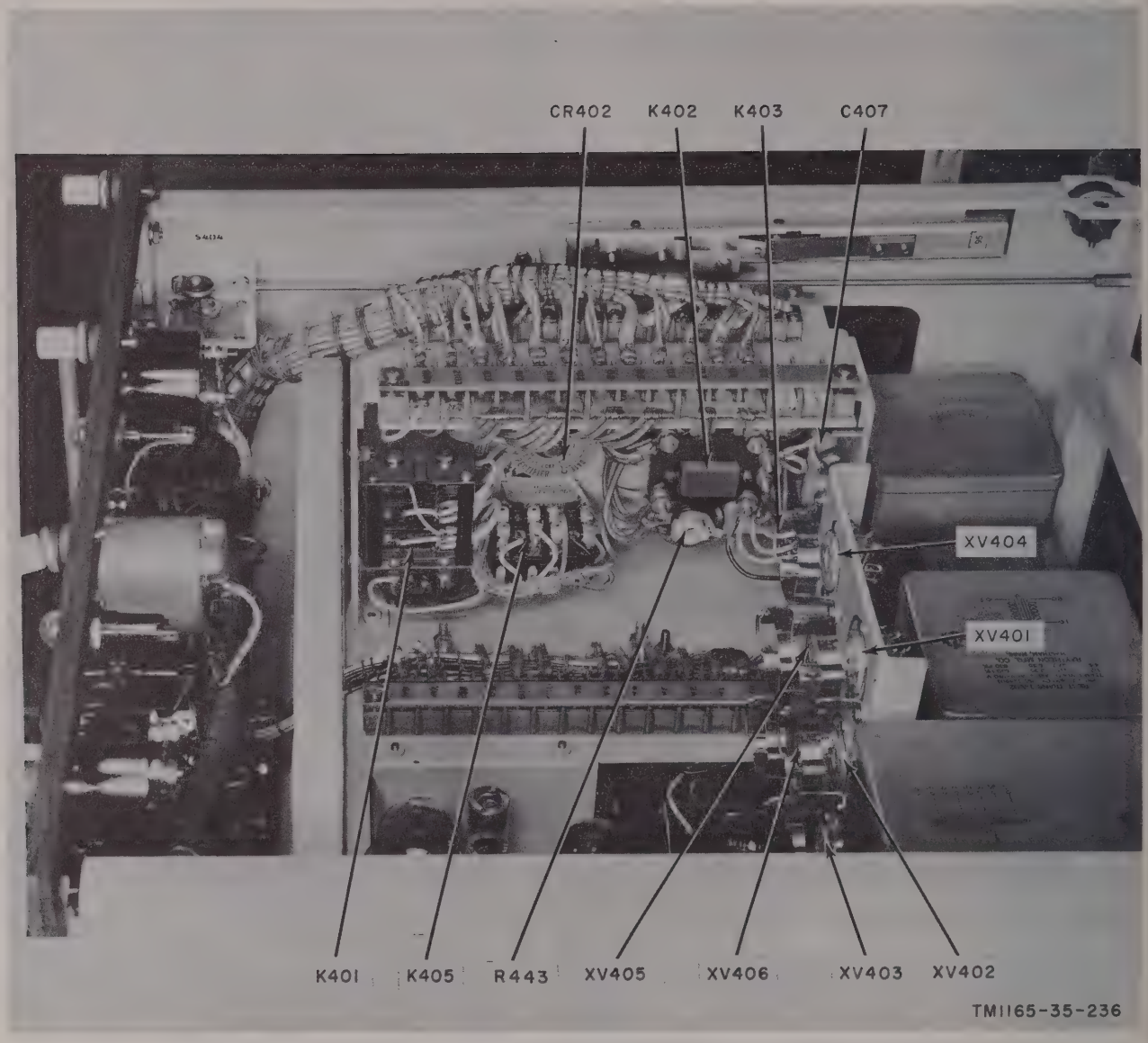


Figure 178. Power Supply PP–674/TPS–1D, location of parts, partial top view.

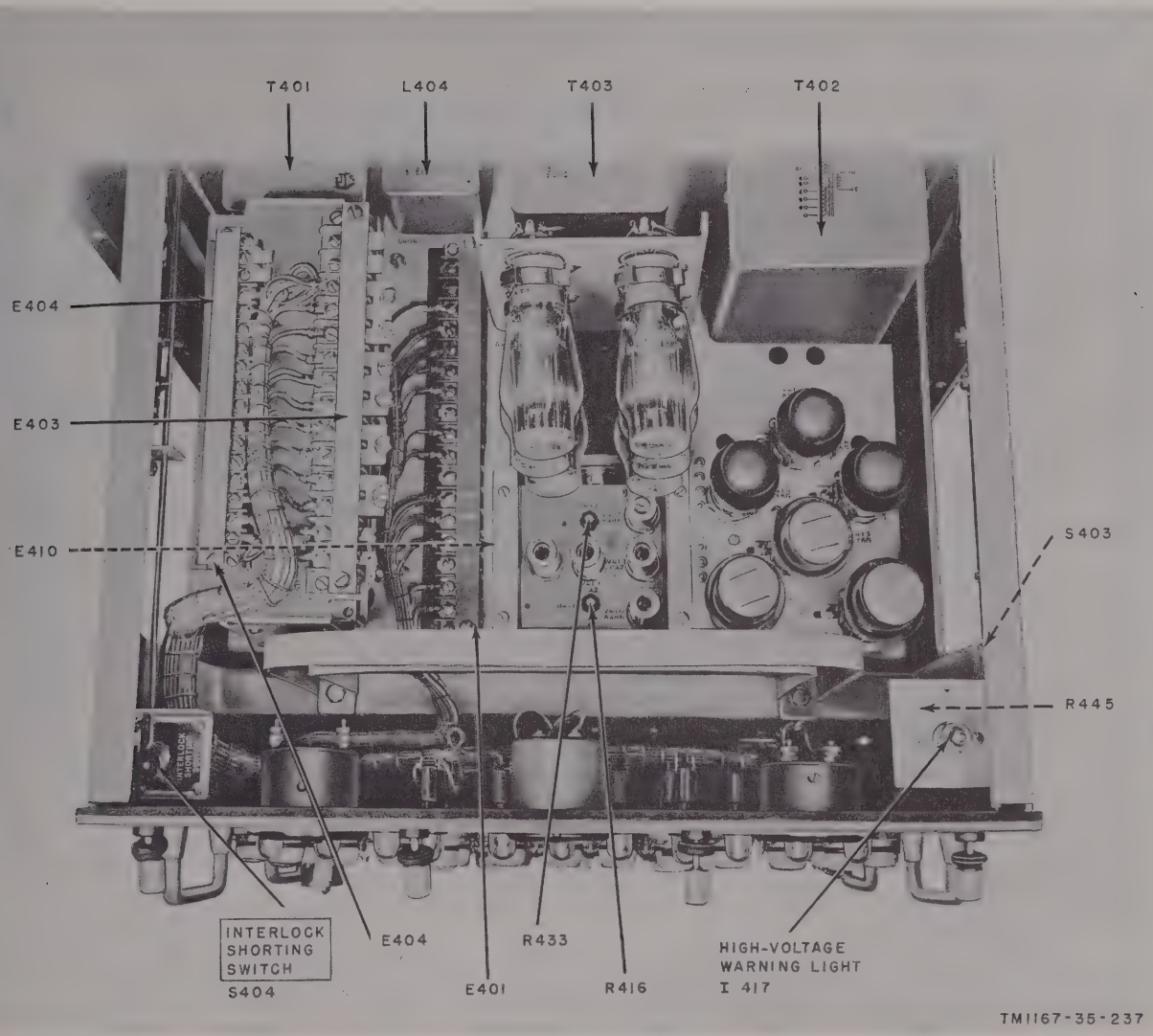


Figure 179. Power Supply PP–674/TPS–1D, location of parts, partial top view.

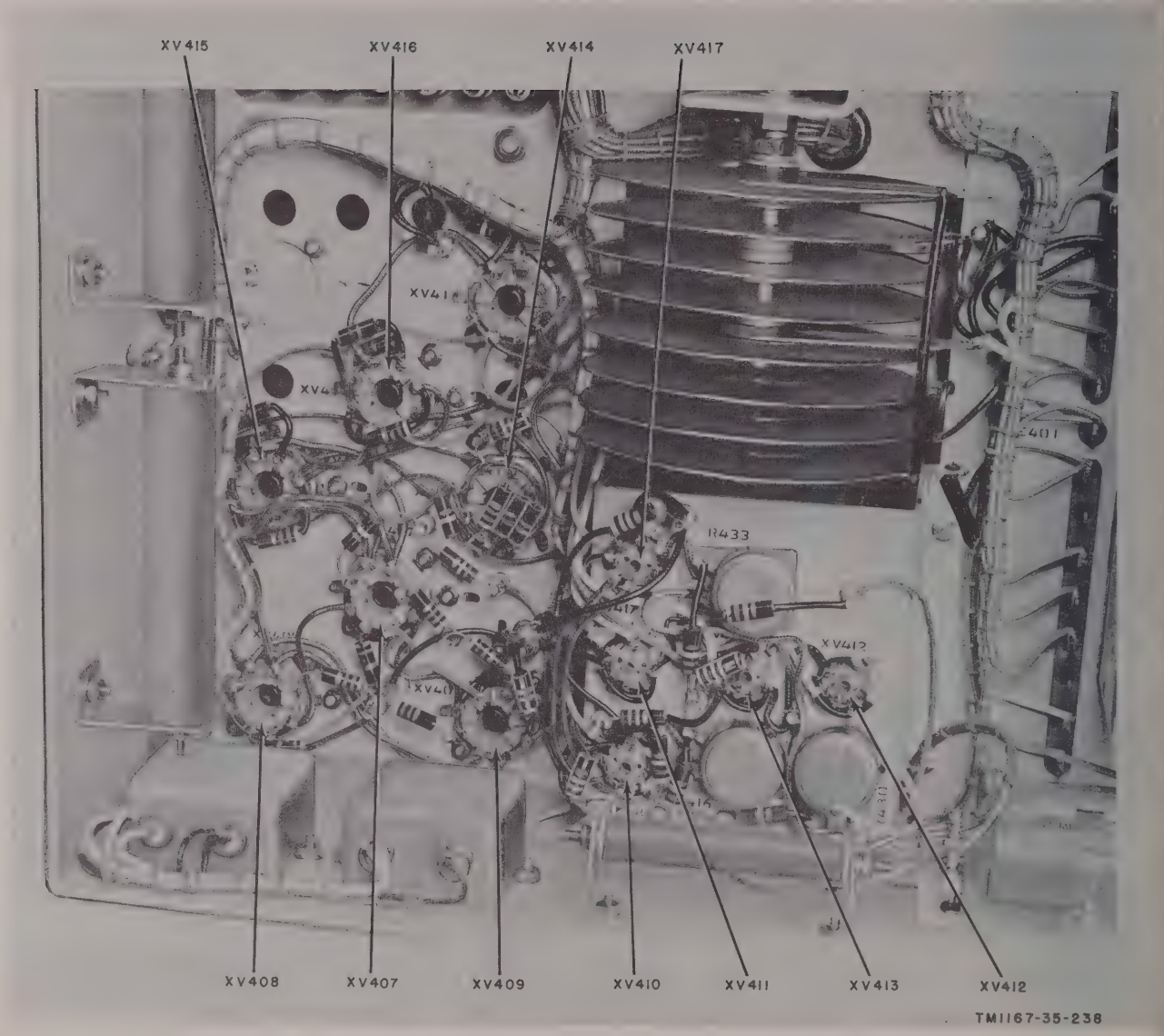


Figure 180. Power Supply PP–674/TPS–1D, location of parts, partial top view.

Section II. TROUBLESHOOTING CHART

417. General

a. When a blown-fuse indicator (fig. 175) on the power supply is lighted, refer to paragraphs 188 and 210 to determine whether the trouble is in the power supply or another system. If the trouble is in the power supply, proceed as directed in *b* below.

b. The power supply step-by-step troubleshooting chart (par. 420) consists of a series of steps to be used in localizing troubles in the power supply which cannot be localized by other methods. To troubleshoot the power supply, using the step-by-step troubleshooting chart, proceed as follows:

Warning: To make voltage measurements of circuits which operate above 500 volts, proceed as follows:

1. Set system POWER switch S602 to OFF.
2. Connect the voltmeter to the circuit, making certain that the meter and the meter leads are properly insulated.
3. Defeat the interlock.
4. Set the system POWER switch to ON.
5. Observe the reading on the voltmeter.
6. Set the system POWER switch to OFF.
7. Disconnect the voltmeter.
   (1) Locate the test point given in step 1.
   (2) Connect the test equipment and set the controls as directed in the *Test equipment* column.
   (3) Set the controls on the radar set as directed in the *Radar set controls* column.
   (4) Compare the indications obtained on the test equipment with the indications that are given or referenced in the *Normal indications* column.
   (5) Proceed as directed in the *Corrective measures* column.

418. Test Equipment Required to Troubleshoot Power Supply

The following items of test equipment are required to troubleshoot the power supply:

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A.
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083.
Tube Socket Adapter Kit MX–1258/U.	Adapter kit.	

419. Preparation of Power Supply for Troubleshooting

When the power supply is located on a low level, troubleshooting can be facilitated by removing the power supply from its case as follows:

a. Loosen the captive knurled screws around the panel edge.

b. Pull the power supply out of its case and release the chassis catches by hinging the stop levers out at right angles to the side of the chassis.

c. Place the power supply on a table or floor immediately in front of its case.

d. Use the adapter kit to facilitate tube socket measurements.

e. The main subchassis may be removed from the power supply (par. 422) to check parts that are not readily accessible.

Note. If it is not practical to troubleshoot the power supply with all cables interconnected, follow the procedures given in paragraphs 439 through 443 for bench troubleshooting.

420. Power Supply Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1.	----------	----------	Remove fuse F403. Set system POWER switch S602 to ON. Snap INTERLOCK SHORTING SWITCH S404 off.	All filaments glow. Regulator tubes do not glow. High-voltage warning lamp I 417 *does not glow*. Blower motor B401 operates.	*a.* If all indications are normal, proceed with step 2. *b.* If blown-fuse indicator I 409 lights, set the system POWER switch to OFF and proceed with step 8. *c.* If the blower motor is operating normally but any or all filaments do not glow, proceed with step 10. *d.* If the filaments are normal but the blower motor does not operate normally, set the system POWER switch to OFF and proceed as follows: (1) Check the fan blade; it should rotate freely. (2) Check C408. (3) Check the continuity of the motor windings between terminals 1603 and 1903 and between terminals 1603 and 302 of E401.
2.	Between terminal 5A of E401 (fig. 179) and ground.	Set the multimeter to measure +450 volts dc.	Snap INTERLOCK SHORTING SWITCH S404 on.	High-voltage warning lamp I 417 glows. Multimeter reads approximately +450 volts dc.	*a.* If all indications are normal, proceed with step 3. *b.* If I 409 glows, proceed with step 11. *c.* If the voltage is normal but I 417 does not glow, check I 417, R445, and S404. *d.* If I 417 glows normally but the voltage is not normal, proceed as follows: (1) Check V404 and V405. Make voltage and resistance measurements at V404 and V405 (fig. 232). (2) Check L401 and T402 (par. 416).
3	Between terminal 6A of E401 and ground.	Set the multimeter to measure −150 volts dc.	----------	−150 volts dc--	*a.* If the voltage is normal, proceed with step 4. *b.* If the voltage is abnormal, proceed as follows:

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
					(1) Check V411 and make voltage and resistance measurements (fig. 232). (2) Check C409 and C410. (3) Check L401 (par. 177). (4) If the trouble is not found, proceed with step 11.
4	Between terminal 7A of E401 and ground.	Same as step 3		−150 volts dc	*a.* If the voltage is normal, proceed with step 5. *b.* If the voltage is abnormal, check V412 and R451.
5	Between terminal 4A of E401 and ground.	Set the multimeter to measure +300 volts dc.		+300 volts dc	*a.* If the voltage is normal, proceed with step 6. *b.* If the voltage is abnormal, proceed as follows: (1) Check C402. (2) Check V413 and make the voltage and resistance measurements (fig. 232). (3) Check V414, V-415, V416, and V417 and make the voltage and resistance measurements (fig. 232).
6	Between terminal 1A of E401 and ground.	Set the multimeter to measure +150 volts dc.		+150 volts dc	*a.* If the voltage is normal, proceed with step 7. *b.* If the voltage is abnormal, proceed as follows: (1) Check V407, V-408, V409, and V410 and make the voltage and resistance measurements. (fig. 232). (2) Check L404 (par. 177). (3) Check V401, V-402, and V403 and make the voltage and resistance measurements.
7	Between terminal 8A of E401 and ground.	Set the multimeter to measure +27 volts dc.		+27 volts dc	If the voltage is abnormal, follow the procedure given in paragraph 211.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
8	Disconnect T401 from terminal 1603 of E401 (fig. 179).	----------	Set the system POWER switch to ON (replace fuse F409).	Blower motor B401 operates normally.	*a.* If the blower motor operates normally, set the system POWER switch to OFF and proceed with step 9. *b.* If blown-fuse indicator I 409 lights, check C-408 and B401.
9	Reconnect T401 to terminal 1603 of E401. Remove and check all tubes in the power supply.	----------	Set the system POWER switch to ON.	Blower motor B-401 operates normally.	If blown-fuse indicator I 409 lights, check the wiring to T401. If the wiring is normal, replace T401.
10	Filaments of all tubes in the power supply (except V411, V412, and V-413).	Multimeter----------	----------	Filaments of all tubes glow.	*a.* If no filaments glow, check the voltage between terminals 1 and 2 of T401. (1) If normal, replace T401. (2) If abnormal, set the system POWER switch to OFF and check the continuity between terminals 1 and 2 of T401 and terminals 302 and 1603 of E-401. *b.* If the filament of any one tube does not glow, replace the tube. *c.* If the filament of V406 does not glow, check the continuity between terminals 11 and 12 of T401, check the wiring between T401 and XV-406. *d.* If the filaments of V404 and V405 do not glow, check the continuity between terminals 9 and 10 of T401, check the wiring between T401 and XV404 and XV405. *e.* If the filaments of V410 and V417 do not glow, check the continuity between terminals 13 and 14 of T401, check the wiring between T-401 and XV410 and XV417.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
					f. If the filaments of V401, V402, and V403 do not glow, check the continuity between terminals 7 and 8 of T401, check the wiring between T401 and XV401, XV402, and XV403. *g.* If the filaments of V-407, V408, V409, V414, V415, and V416 do not glow, check the continuity between terminals 4 and 6 of T401, check the wiring between T401 and XV407, XV408, XV409, XV-414, XV415, and XV-416.
11	Disconnect the wires from terminals 1A, 4A (both), 5A, 6A, 7A, and 8A from E401 which lead to the power supply front panel.	Set the multimeter to measure resistance.	Set the system POWER switch to OFF.	Approximate resistances to ground from each wire should be as follows: 1A–3,800 ohms. 4A–12K. 4A–infinity. 5A–infinity. 6A–7,500 ohms. 7A–infinity. 8A–12 ohms.	*a.* If any of the resistance readings are abnormal, proceed as follows: (1) Reconnect all wires to E401 except the wire from which the abnormal reading was obtained. (2) Connect the multimeter to the remaining wire. (3) Disconnect the cables from J401, J402, J403, J406, J407, and J408 one at a time and in any sequence until the multimeter reading is approximately correct for the wire being checked. (4) The last cable disconnected should lead to the defective system. *b.* If the resistance readings are normal, proceed with step 12. *Do not reconnect the wires to E–401.*
12	Terminal 5A to ground.	Set the multimeter to measure 550K.	Set the system POWER switch to OFF.	Approximately 550K.	*a.* If the resistance is normal, proceed with step 13. *b.* If the resistance is abnormal, check C401, L-401, and T401 (par. 177).

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
13	Terminals 4A to pin 2 of V412.	Set the multimeter to measure 222K.	----------	Approximately 222K.	*a.* If the resistance is normal, proceed with step 14. *b.* If the resistance is abnormal, check C406, V414 through V417, and the interconnecting wiring.
14	Terminal 7A to ground.	Set the multimeter to its highest resistance scale.	----------	Infinite resistance.	*a.* If the resistance is normal, proceed with step 15. *b.* If the resistance is abnormal, check R451, C409, and C410; check L402 and T402 (par. 177).
15	Terminal 1A to pin 2 of V412.	Set the multimeter to measure 413K.	----------	Approximately 413K.	*a.* If the resistance is normal, check C405, L404 (par. 177), V401, V402, V403, and T402 (par. 177). *b.* If the resistance is abnormal, check C404; check V407 through V-410; make resistance measurements at V407 through V410.

Section III. REMOVAL AND REPLACEMENT OF PARTS

421. General

All parts and subassemblies can be removed and replaced from the power supply after the main subchassis is removed from the power supply frame (par. 422).

Warning: Dangerous voltages exist in the power supply. When removing and replacing parts in the power supply, set system POWER switch S602 to OFF and disconnect the cables from POWER IN HEATERS jack J404 and POWER IN SYSTEM jack J405 (fig. 174). If an interlock is disabled, avoid personal contact with all circuits.

a. When first pulling the power supply out of its case, stops on each side of the chassis engage with the chassis 16 inches out of the case. To release the catches, hinge the stop release levers out at right angles to the side of the chassis. The chassis may then be removed entirely from its case.

b. To disable interlock S402 (fig. 177), snap INTERLOCK SHORTING SWITCH S404 (fig. 179). High-voltage warning lamp I 417 (fig. 179) glows when the plate supply circuits are energized.

422. Removal and Replacement of Main Subchassis

a. Disconnect all leads to terminal boards E401, E403, and E404 (fig. 179).

b. Remove the two chassis safety catches.

c. Loosen the four subchassis securing bolts, withdraw the main subchassis from the power supply and place it on a test bench.

d. Reverse the procedure to replace the main subchassis.

423. Removal and Replacement of Relay Subchassis

a. Disconnect all leads from E403 and E404 (fig. 179).

b. Remove the four screws from the bottom of the relay chassis.

c. Reverse the procedure to replace the relay subchassis.

424. Removal and Replacement of Blower Motor B401

a. Disconnect the leads from E405 (fig. 177) which lead to the motor.

b. Pull the leads through the grommet in the motor housing.

c. Turn the power supply on its side and remove the four screws which hold the motor to the housing.

d. Reverse the procedure to replace the motor.

Section IV. ADJUSTMENTS

425. General

a. This section covers all of the adjustments in the power supply. The procedures for making these adjustments are the same whether the components are on the bench or interconnected with the other components of the radar set.

b. The following adjustments are given in this section:

(1) The +150-volt supply (par. 427).
(2) The +300-volt supply (par. 428).
(3) The timing relay (K401) period (par. 429).
(4) The timing relay (K401) cams (par. 430).

c. Before making adjustments given in paragraphs 427 through 430, make the following checks and preparations:

(1) Loosen the eight captive panel screws and pull the power supply from its case so that the control shafts of R416, R433 (fig. 179), and R443 (fig. 178) are accessible.
(2) Snap INTERLOCK SHORTING SWITCH S404.
(3) Set system POWER switch S602 to ON, wait 5 minutes and press RADIATE button S616.
(4) The VOLTMETER (fig. 173) should read between 110 and 120 volts.
(5) The LINE FREQUENCY meter (fig. 173) should read between 384 and 416 cycles.

426. Test Equipment Required

Multimeter TS–352B/U (or Multimeter ME–77/U) is required for the adjustments of the power supply.

427. Adjustment of +150-Volt Supply

a. Set the multimeter to measure +150 volts dc.

b. Connect the multimeter between terminal 1A (positive) on E401 (fig. 179) and ground.

c. Unlock and adjust R416 for a reading of +150 volts dc.

d. Lock R416.

428. Adjustment of +300-Volt Supply

a. Set the multimeter to measure +300 volts dc.

b. Connect the multimeter between terminal 4A (positive) on E401 and ground.

c. Unlock and adjust R433 for a reading of +300 volts dc.

d. Lock R433.

429. Adjustment of Timing Relay Period

a. Set the multimeter to measure +27 volts dc.

b. Set system POWER switch S602 to OFF.

c. Connect the multimeter between terminal 8A7 (positive) on E404 (fig. 179) and ground.

d. Turn the system POWER switch to ON and time the period required for the voltage (+27 volts dc) to appear on the multimeter.

e. If the period is not within 5 minutes ±30 seconds, unlock and adjust R443 (fig. 178) to correct the timing. Clockwise rotation of R443 shortens the period, and counterclockwise rotation lengthens the period.

f. Follow the procedure given in subparagraphs *a* through *e* above until the period is correct.

g. When the period is correct, the normal voltage applied to the motor of the timing relay is approximately 4.5 volts dc. This voltage can be measured between terminal 11 (positive) and ground on K401 (fig. 178).

430. Adjustment of Timing Relay Cams (fig. 181)

a. Removal of Relay Subchassis. To more readily repair, adjust, or test K401, the relay

subchassis can be removed from the power supply. This can be done as follows:

(1) Disconnect all leads from E403 and E404 (fig. 179).

(2) Remove the four screws from the bottom of the relay subchassis.

(3) The timing relay may be energized and tested by interconnecting terminal 8A on E401 and E404 (fig. 179) and terminal 01 on E401 and E404. These interconnections supply +27 volts dc to K401.

Notes. 1. Before adjusting the relay cams, the timing relay period should be adjusted (par. 429).

2. Switches 1, 2, and 3 (*b*, *c*, and *d* below) are the microswitches (fig. 181) actuated by timing relay cams 1, 2, and 3, respectively.

3. A diagram of the terminals on timing relay assembly K401 and the three microswitches are shown on figure 232.

b. Adjustment of Cam 1.

(1) Remove the power from K401 by disconnecting the wire from terminal 8A of E404.

(2) Disconnect the wire from terminal 8 of K401 (fig. 178).

(3) Rotate the cams (fig. 181) by hand until the actuating arm of switch 1 just drops into the cam slot.

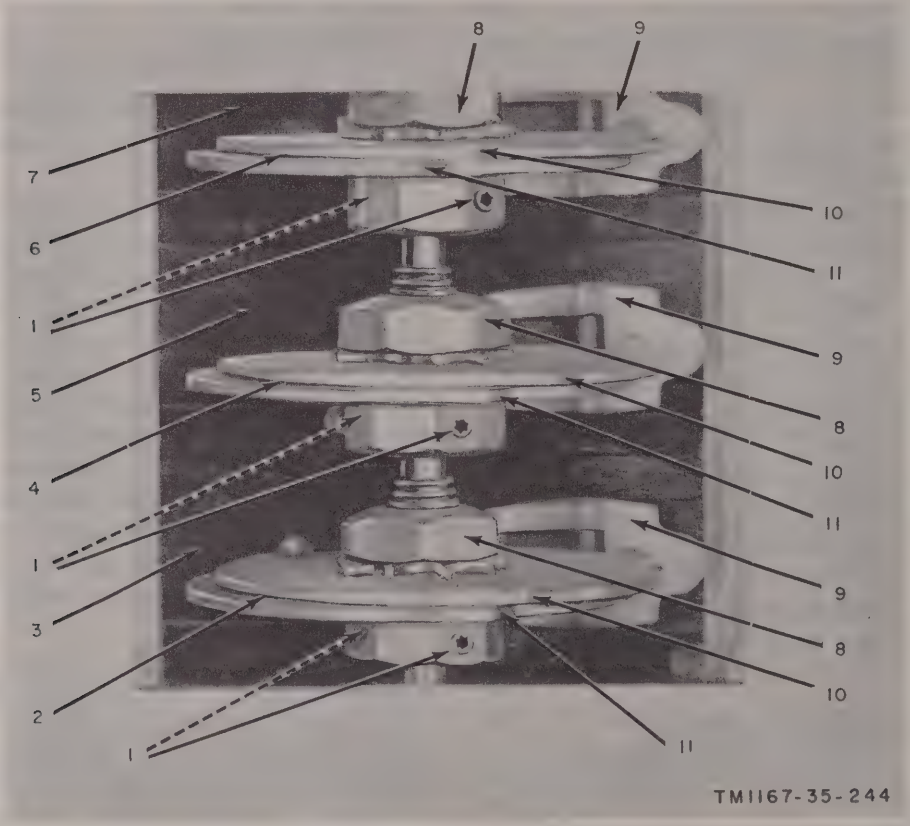
(4) Reconnect the wire to terminal 8A of E404. The timing relay motor should run for 5 seconds, then stop. If the time interval is wrong, adjust the slope of cam 1 by loosening the nut above the cam.

(5) Repeat the test until the conditions mentioned in (3) above are met. *Do not* replace terminal 8 of K401.

c. Adjustment of Cam 2.

(1) Disconnect the wire from terminal 8A of E404.

(2) Release the Allen setscrew on the lower part of cam 2 (fig. 181) and rotate the cam until its straight edge is about 1/16 inch to the right of the



1 Allen setscrews
2 Cam 1
3 Switch 1
4 Cam 2
5 Switch 2
6 Cam 3
7 Switch 3
8 Clamping nut
9 Actuating arm
10 Straight edge
11 Slope

Figure 181. Power supply timing relay adjustments.

straight edge of cam 1. Check the adjustment by hand-rotating the cams; the actuating arm of switch 2 should drop into its slot slightly before switch 1 arm drops into its slot.

(3) Adjust the slope of cam 2 so that the slot is the same length as that of cam 1.

(4) Hand-rotate the cams until the actuating arms of switches 1 and 2 just drop into their respective slots.

(5) Set the multimeter to measure continuity and connect it between terminals 2 and 6 of K401.

(6) Reconnect the wire to terminal 8A of E404. The timing relay motor should run for 5 seconds, then stop. Switch 2 should change from a normally closed to an open condition. This change can be checked on the multimeter.

(7) If the time interval is wrong, adjust the spacing of the slope.

(8) Repeat the test until the conditions mentioned in (6) above are met.

(9) Disconnect the wire from terminal 8A of E404.

(10) Reconnect the wire to terminal 8 of K401.

d. Adjustment of Cam 3. Adjustment of the time elements of cam 3 (fig. 181) is not very critical.

(1) Adjust the slope of cam 3 so that the slot is the same length as that of cams 1 and 2.

(2) Release the Allen setscrew on the lower part of cam 3 and rotate the cam until its straight edge is about ¼ inch to the left of the straight edge of cam 1.

(3) Set the multimeter to measure continuity and connect it between terminals 3 and 5 of K401.

(4) Hand-rotate the cams until the actuating arms of switches 1 and 2 just drop into their respective slots.

(5) Reconnect the wire to terminal 8A of E404. The actuating arm of switch 3 should drop into its slot in approximately 10 seconds. Switch 3 should change from a normally closed to an open condition in approximately 15 seconds. This can be checked on the multimeter.

(6) If the time intervals are wrong, repeat the test until the conditions mentioned in (5) above are met.

e. Test of K401 and K403 Operation.

(1) Disconnect the wire from terminal 8A of E404.

(2) Set the multimeter to measure +27 volts dc.

(3) Connect the multimeter between terminal 8A7 (positive) and 01 of E404.

(4) Reconnect the wire to terminal 8A of E404.

(5) The cams should turn smoothly. In 10 seconds, K403 (fig. 178) should be heard to close. In 5 minutes, ±15 seconds, the timing relay motor should stop and the multimeter should read +27 volts dc.

(6) Repeat the test several times.

f. Test of Interrupted Cycling Action.

(1) Repeat the test given in *e* above (the multimeter is not necessary). After K403 is heard to close, remove the wire from terminal 8A on E404 momentarily; reconnect the wire. K403 should drop out and the motor should complete that 5-minute cycle and pass by the stopping point.

(2) Repeat the test several times.

g. Replacement. Replace and reconnect the relay subchassis.

Section V. FIELD TESTING

431. General

This section describes testing procedures required to check the serviceability of a repaired power supply when the components of the radar set are interconnected. Bench testing of the power supply is described in paragraphs 439 through 443. Testing procedures designed to check the serviceability of the complete radar set are covered in paragraph 448.

432. Test Equipment Required

The following items of test equipment are required to completely test the serviceability of the power supply:

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A 11–5562.
Electronic Multimeter TS–505C/U.	Vtvm	11–5511A.
Electron Tube Test Set TV–7B/U.	Tube tester	11–5083.
Variable Power Transformer TF–171/USM.	Variac	11–1250.

433. Power Supply Filament Voltage Test

a. General.

(1) The power supply is connected to a 115-volt ac line voltage source through a variable power transformer.

(2) The voltage outputs of the filament transformer are measured at the tube sockets and checked for proper tolerances.

b. Procedure.

(1) Loosen the eight captive panel screws and pull the power supply from its case. Do not close INTERLOCK SHORTING SWITCH S404.

(2) Pull V403, V404, V406, V407, and V410 out of their sockets.

(3) Connect the variac and vtvm to the power supply as shown in figure 182 and adjust the variac for an output of 115 volts.

(4) Set the multimeter to measure 7 volts ac.

(5) Disconnect the lead from terminal 1603 and E401.

(6) Turn system POWER switch S602 to ON.

(7) Adjust the variac for a reading of 115 volts on the ac voltmeter (fig. 182).

(8) Measure the voltage between the tube socket terminals indicated in the following chart. The voltage should be within the tolerance given in the chart.

Tube socket terminals	Terminals of E401 being measured	Voltage (ac)
7–8, XV407	4–6	6.3 volts ±.3 volt.
2–8, XV403	7–8	5 volts ±.25 volt.
2–8, XV404	9–10	5 volts ±.25 volt.
2–8, XV406	11–12	5 volts ±.25 volt.
3–4, XV410	13–14	6.3 volts ±.3 volt.

(9) Replace the tubes in the power supply.

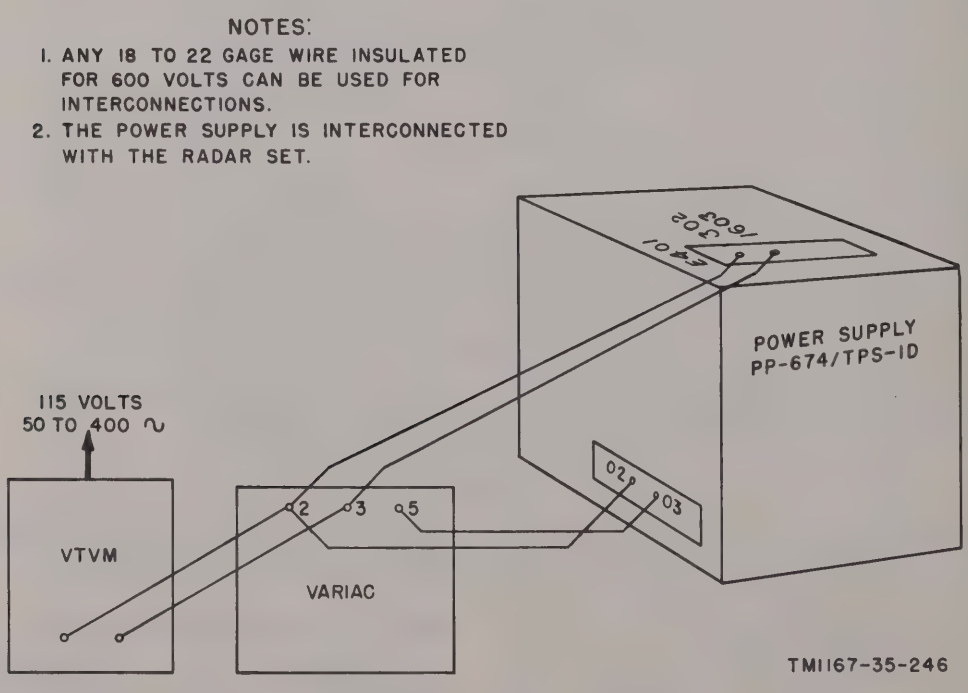


Figure 182. Field testing the power supply.

434. Power Supply Output Voltage Test

a. General.

(1) The power supply is connected to a 115-volt ac line voltage source through a variable power transformer.

(2) The output voltages of the power supply are measured and checked for proper tolerances.

b. Procedure.

(1) Connect the variac and vtvm to the power supply as shown in figure 182 and disconnect the lead from terminal 1603 of E401.

(2) Set R416 and R433 (fig. 176) to their counterclockwise positions.

(3) Set the multimeter to measure +200 volts dc.

(4) Connect the multimeter between terminals 1A (+) and 01 on E401.

(5) Adjust the variac for an output of 115 volts.

(6) After a warmup period of 10 minutes, snap INTERLOCK SHORTING SWITCH S404, turn R416 to its clockwise position and observe the reading on the multimeter. The voltage should vary from +110 volts ±20 percent to +190 volts ±20 percent.

(7) Readjust R416 for a reading of +150 volts.

(8) Set the multimeter to measure +400 volts.

(9) Turn R433 to its clockwise position and observe the reading on the multimeter. The voltage should vary from +115 volts ±20 percent to +390 volts ±20 percent.

(10) Readjust R433 for a reading of +300 volts.

(11) Check the voltage between the terminals given in the following chart while the output of the variac is varied from 109 to 121 volts. The voltages should remain within the tolerances shown in the chart.

Terminals	Voltage	Tolerance
1A–01 of E401	+150 volts	±1.5 volts.
4A–01 of E401	+300 volts	±3 volts.
5A–01 of E401	+470 volts (unregulated)	±47 volts.
6A–01 of E401	−150 volts	±2 volts.
7A–01 of E401	−150 volts	±2 volts.
8A–01 of E401	+27 volts	±2.8 volts.
Across C405	+245 volts	±24.5 volts.
Across C409	−427 volts	±42.7 volts.

Note. Terminal 01 is ground. Set system POWER switch S602 to OFF and check C405 and C409 to determine the grounded terminal, then set and connect the multimeter to the capacitors before setting the system POWER switch to ON.

435. Time Delay Relay (K401) Test

a. General. The time delay relay is tested for proper operation by checking the voltage at its output terminals and timing its period of operation.

b. Procedure.

(1) Set system POWER switch S602 to OFF.

(2) Set the multimeter to measure 27 volts.

(3) Connect the multimeter between terminal 8A7 (+) and ground.

(4) Turn the system POWER switch to ON and time the period required for +27 volts to appear on the voltmeter. The period should be 5 minutes ±15 seconds.

436. Radiate Interlock Relay (K405) Test

a. General. The operation of relay K405 is checked while the voltage applied to the relay is varied.

b. Procedure.

(1) Set the system POWER switch to OFF.

(2) Connect the variac and vtvm to the power supply as shown in figure 182 and disconnect the lead from terminal 1603 and E401.

(3) Set the multimeter to measure +30 volts dc.

(4) Connect the multimeter between terminals 8A11 (+) and 01 of E404.

(5) Set the system POWER switch to ON.
(6) Increase the variac output until the multimeter reads 24 volts. Relay K405 should become energized at 24 volts.
(7) Set the system POWER switch to OFF, remove the variac connections, and reconnect the lead to terminal 1603 on E401.

437. Power Supply Interlock Circuit Test

a. Push the power supply completely into its case, then pull it out of its case until it is stopped by the chassis safety catches.

b. Set the system POWER switch to ON.

c. Set the multimeter to measure 115 volts ac.

d. Connect the multimeter between terminals 1703 and 302 of E401 (fig. 179). There should be no voltage present. High-voltage indicator light I 417 should not glow.

e. Close INTERLOCK SHORTING SWITCH S404. There should be 115 volts ac between terminals 1703 and 302 of E401, and high-voltage indicator light I 417 should glow.

f. Open INTERLOCK SHORTING SWITCH S404, release the chassis safety catches and pull the power supply out of its case until interlock switch S402 is accessible.

g. Connect the multimeter between terminals 1703 and 302 of E401.

h. When S402 is pushed in, 115 volts ac should appear on the multimeter.

i. Insert the power supply into its case.

438. Additional Tests of Power Supply

a. Blower motor B401 (fig. 177) should function when the system POWER switch is ON.

b. The LINE FREQUENCY meter (M403) should be checked for an accuracy of 400 cycles ±25 cycles.

c. The VOLTMETER (M401) should be checked for a full scale accuracy of ±5 volts.

d. The OPERATING HOURS meter (M402) should be checked for proper operation.

Section VI. BENCH SERVICING

439. General

The following information will be helpful when bench servicing the power supply.

Information	Location
Power Supply PP–674/TPS–1D, complete schematic diagram.	Fig. 233.
Location of parts in the power supply	Par. 411.
Power Supply PP–674/TPS–1D, voltage and resistance chart.	Fig. 232.
Controls and adjustments	Par. 412.
Power Supply PP–674/TPS–1D, list of fuses.	Par. 413.
Power supply test points	Par. 415.
Dc resistance of power supply inductive components.	Par. 416.
Removal and replacement of parts	Pars. 422 and 423.

440. Test Equipment Required

a. The following items of test equipment are required to troubleshoot the power supply:

Test equipment	Common name	Technical manual
Multimeter TS–352B/U, or ME–77/U.	Multimeter	11–5527A. 11–5562.
Electronic Multimeter TS–505C/U.	Vtvm	11–5511A.
Variable Power Transformer TS–171/USM.	Variac	11–1250.
Motor Generator PU–20B/C.	Motor generator	11–978.

b. The following additional items are required to troubleshoot the power supply:

Item	Rating
10-ohm resistor	200 watts.
500-ohm resistor	100 watts.
2,500-ohm resistor	100 watts.
18K resistor	25 watts.
7,500-ohm resistor	10 watts.
100K resistor	2 watts.
Spst switch	5 amperes.

NOTES:

1. THE DUMMY LOAD RESISTOR BOARD IS MADE UP BY THE USING ORGANIZATION.
2. RESISTANCES ARE IN OHMS.
3. ANY 18 TO 22 GAGE WIRE WITH INSULATION RATED AT 600 VOLTS MAY BE USED FOR INTERCONNECTIONS EXCEPT AS INDICATED.
4. USE 16 GAGE WIRE, OR LARGER, INSULATED FOR 600 VOLTS.

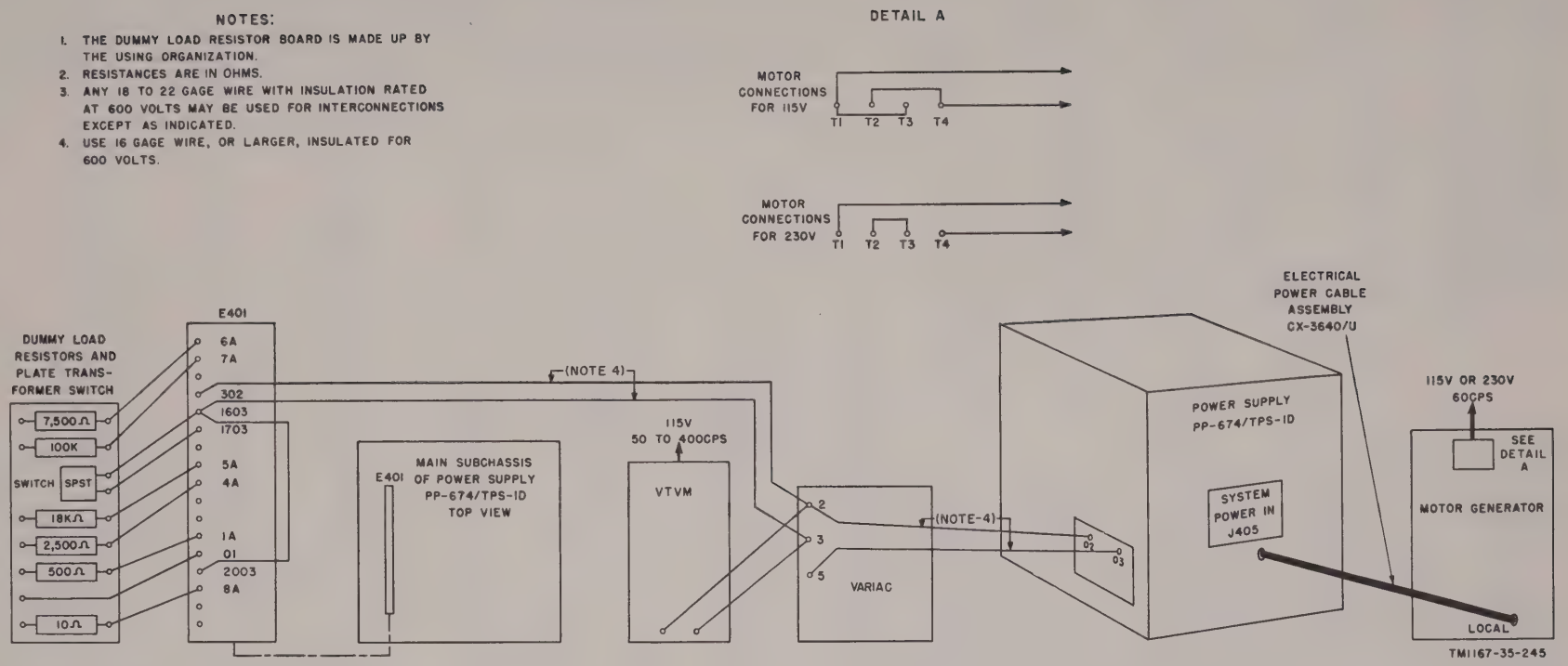


Figure 183. Power supply, bench servicing connections.

441. Bench Servicing Connections

Follow the directions given in *a* through *f* below to connect the power supply for bench servicing.

a. Disconnect all the cables from the front panel of the power supply.

b. Remove the power supply from its case after loosening the 8 captive panel screws.

c. Disconnect all leads to terminal boards E401, E403, and E404 (fig. 179).

d. Remove the two chassis safety catches.

e. Loosen the four subchassis securing bolts, withdraw the main subchassis from the power supply and place it on a test bench.

f. Remove and test all tubes from the power supply. Do not replace the tubes.

g. Turn the control knob of the variac to its extreme counterclockwise position and connect the power supply as shown in figure 183.

h. When the power supply is connected as shown in figure 183, the results are as follows:

(1) Power is applied to the main subchassis of the power supply when Electrical Power Cable CX–3640/U is connected to the power source and the control knob on the variac is turned from its extreme counterclockwise position.

(2) Dummy load resistors are substituted for the normal load on the power supply.

(3) None of the circuits in the power supply are supported by fuses.

(4) The spst switch removes primary power from plate transformer T402 (fig. 179).

(5) The vtvm measures the variac output.

442. Bench Troubleshooting Power Supply PP–674/TPS–1D

a. Connect the power supply for bench servicing (par. 441).

b. Follow the procedures given in paragraph 443.

443. Power Supply Step-by-Step Troubleshooting Chart

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
1	Between terminals 4 and 6 of T401.	Set the multimeter to measure 6.3 volts ac.	Set the spst switch to its open position.	6.3 volts ac	*a.* If the voltage is normal, reduce the output from the variac to zero immediately and proceed with step 2.
			Raise the output of the variac slowly toward 115 volts.		*b.* If the voltage fails to rise, reduce the output from the variac to zero and check T401 (par. 416). Check the interconnecting wires.
2	Between terminals 7 and 8 of T401.	Same as step 1	Same as step 1	5 volts ac	*a.* If the voltage is normal, reduce the output from the variac to zero and proceed with step 3.
					b. Same as *b* in step 1.
3	Between terminals 9 and 10 of T401.	Same as step 1	Same as step 1	5 volts ac	*a.* If the voltage is normal, reduce the output from the variac to zero and proceed with step 4.
					b. Same as *b* in step 1.
4	Between terminals 11 and 12 of T401.	Same as step 1	Same as step 1	5 volts ac	*a.* If the voltage is normal, reduce the output from the variac to zero and proceed with step 5.
					b. Same as *b* in step 1.
5	Between terminals 13 and 14 of T401.	Same as step 1	Same as step 1	6.3 volts ac	*a.* If the voltage is normal, reduce the output from the variac to zero and proceed with step 6.
					b. Same as *b* in step 1.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
6	Between the terminals of C405 (fig. 176).	Set the multimeter to measure resistance.	----------	570K----------	*a.* If normal, proceed with step 7. *b.* If abnormal, check L-404 (par. 416), C405, R452, and R453.
7	Between the terminals of C404 (fig. 176).	----------	Disconnect the 400-ohm resistor from terminal of E401.	Approximately 200K.	*a.* If normal, reconnect the 400-ohm resistor and proceed with step 8. *b.* If abnormal, check C-404, R414, R415, and R416.
8	Between the terminals of C406 (fig. 176).	----------	Disconnect the 1,400-ohm resistor from terminal 4A of E401.	Approximately 110K.	*a.* If normal, reconnect the 1,400-ohm resistor and proceed with step 9. *b.* If abnormal, check C-406, R429, R432, R433, and R462.
9	Between the terminals of C401 (fig. 176).	----------	----------	6,000 ohms----	*a.* If normal, proceed with step 10. *b.* If abnormal, check C-401. Check L401 (par. 416).
10	Between the terminals of C409 (fig. 176).	----------	----------	Approximately 5,500 ohms.	*a.* If normal, proceed with step 11. *b.* If abnormal, check C-409, C410, R402, and R451. Check L402 and T402 (par. 416).
11	Between the terminals of C403 (fig. 176).	----------	Disconnect the 10-ohm resistor from terminal 8A of E401. Snap the spst switch on--	50 ohms------- ----------	*a.* If normal, reconnect the 10-ohm resistor and proceed with step 12. *b.* If abnormal, check C-403. Check L403 (par. 416).
12	Between terminals 4 and 6 of T402 (fig. 176). *Note.* See paragraph 417*b*.	Set the multimeter to measure 580 volts ac.	Raise the output of the variac slowly toward 115 volts.	Vtvm reads 115 volts. Multimeter reads 580 volts ac.	*a.* If normal, snap the spst switch off and proceed with step 13. *b.* If abnormal, check T-402 (par. 416).
13	Between terminals 6 and 8 of T402.	Same as step 12----------	Snap the spst switch on--	Same as step 12-	*a.* If normal, snap the spst switch off. Proceed with step 14. *b.* If abnormal, check T-402 (par. 416).
14	Between terminals 9 and 10 of T402.	Set the multimeter to measure 520 volts ac.	Snap the spst switch on---	Vtvm reads 115 volts. Multimeter reads 520 volts ac.	*a.* If normal, snap the spst switch off and proceed with step 15. *b.* If abnormal, check T-402 (par. 416).
15	Between terminals 10 and 11 of T402.	Same as step 14----------	Snap the spst switch on--	Same as step 14-	*a.* If normal, snap the spst switch off and proceed with step 16. *b.* If abnormal, check T-402 (par. 416).
16	Between terminals 4 and 5 of T403 (fig. 176).	Set the multimeter to measure 38 volts ac.	Snap the spst switch on--	Vtvm reads 115 volts.	*a.* If normal, snap the spst switch off and install all tubes in the power supply; proceed with step 17.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
				Multimeter reads 38 volts ac.	*b.* If abnormal, follow the procedure given in paragraph 211.
17	Terminal 5A (positive) of E-401 and ground.	Set the multimeter to measure 500 volts dc.	Snap the spst switch on.	Vtvm reads 115 volts.	*a.* If normal, proceed with step 18.
				Multimeter reads between +423 and +497 volts dc.	*b.* If abnormal, check C-401. Check L401 (par. 416).
18	Terminal 4A (positive) of E-401 and ground.	Set the multimeter to measure +300 volts dc.	Adjust R433 until the multimeter reads +300 volts dc.	Vtvm reads 115 volts. Multimeter reads +300 volts dc.	*a.* If normal, proceed with step 19. *b.* If abnormal, check C-406, C409, and C410.
19	Terminal 1A (positive) of E401 and ground.	Set the multimeter to measure +150 volts dc.	Adjust R416 until the multimeter reads +150 volts dc.	Vtvm reads 115 volts.	*a.* If normal, proceed with step 20.
				Multimeter reads +150 volts dc.	*b.* If abnormal, check C-404 and C405.
20	Terminal 6A (negative) of E-401 and ground.	Set the multimeter to measure −150 volts dc.	----------	Vtvm reads 115 volts.	*a.* If normal, proceed with step 21.
				Multimeter reads −150 volts dc.	*b.* If abnormal, check C-409, R402, C410, and V411.
21	Terminal 6A (negative) of E401 and ground.	Same as step 20.	Vary the output of the variac so that the multimeter reads between 109 and 121 volts.	Vtvm reads between 109 and 121 volts.	*a.* If normal, proceed with step 22.
				Multimeter reads between −85 and −120 volts dc.	*b.* If abnormal, check R-451 and V412.
22	Terminal 8A (positive) of E401 and ground.	Set the multimeter to measure +35 volts.	Same as step 21.	Vtvm should read between 109 and 121 volts.	If normal, connect a jumper from terminal 8A of E404 to 8A of E401 and proceed with paragraph 430*e*.
				Multimeter reads between +24 and +30 volts dc.	(1) If normal, proceed with step 23.
					(2) If abnormal, follow the procedures given in paragraphs 429 and 430, then proceed with step 23.
23	----------	Disconnect the jumper from 8A of E404 and connect it to 8A11 of E404.	----------	Relay K405 becomes energized.	*a.* If normal, reduce the output of the variac to zero, and proceed with step 24. *b.* If abnormal, check K405 and the interconnecting wires.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
24	----------	Disconnect the variac output from terminals 302 and 1603 and connect them to terminals 2103 and 02 of E403.	Raise the output of the variac to 115 volts.	Vtvm reads 115 volts. Relay K402 becomes energized.	*a.* If abnormal, check K-402 and the interconnecting wires; check CR402 (par. 190). *b.* If normal, proceed as follows: (1) Reduce the output of the variac to zero. (2) Disconnect the variac from the ac source and E-403. (3) Disconnect the jumper between terminals 1603 and 2003 of E401 and remove the spst switch. (4) Install the main subchassis in the power supply and tighten the four securing bolts. (5) Replace the safety catches. (6) Reconnect the leads to E403 and E404. (7) Proceed with step 25.
25	----------	Connect the spst switch (snapped to off) between terminals 03 and 2103 of E403.	----------	VOLTMETER M401 reads 115 volts ±5 volts.	*a.* If normal, proceed with step 26.
		Turn on the power to the motor generator.	----------	LINE FREQUENCY meter M403 indicates 400 cycles ±16 cycles.	*b.* If abnormal, check the meters and the interconnecting wires.
26	----------	Snap the spst switch on. Snap INTERLOCK SHORTING SWITCH S404 to on.	----------	High-voltage warning light I 417 glows brightly. Blower motor B401 operates.	*a.* If normal, proceed with step 27. *b.* If I 417 is abnormal, check S404, I 417, and R445. *c.* If the blower motor is inoperative, check B-401, C408, and the interconnecting wiring.
27	----------	Snap the INTERLOCK SHORTING SWITCH to off.	----------	High-voltage warning light I 417 does not glow brightly.	*a.* If normal, proceed with step 28. *b.* If abnormal, check S-404 and the interconnecting wiring.

Step	Test point	Test equipment	Radar set controls	Normal indications	Corrective measures
28	----------	Push Interlock switch S-402 in.	----------	High-voltage warning light I 417 glows brightly.	*a.* If normal, disconnect the power from the motor generator, disconnect the dummy load resistors, jumpers, and variac from E401, and reconnect the wires to E401. *b.* If abnormal, check S-402 and the interconnecting wiring.

444. Bench Adjustment of Power Supply PP–674/TPS–1D

The power supply can be completely adjusted when connected for bench servicing (pars. 440 through 443). The following chart lists the adjustments that are required to completely adjust the power supply, and references a paragraph that contains detailed step-by-step directions for making each adjustment.

Adjustment	Procedure
The +150-volt supply	Par. 427.
The +300-volt supply	Par. 428.
The timing relay period	Par. 429.
The timing relay cams	Par. 430.

445. Bench Testing of Power Supply PP–674/TPS–1D

To bench test the serviceability of a repaired power supply, connect the power supply for bench servicing (par. 441), and follow the procedure given in paragraphs 433 through 437. This procedure includes checking the filament voltages of the power supply, output voltages and tolerances, timing relay, control relays, and interlock circuit.

CHAPTER 19

COMPLETE ALINEMENT AND TESTING OF RADIO SET AN/TPS–1D

446. Introduction

The information in this chapter is to be used as a guide to completely test and aline Radio Set AN/TPS–1D. Complete testing and alinement are required when the radar set has been either out of operation for a prolonged period or extensively repaired. Perform the procedures in the order given and refer to the referenced paragraphs for detailed step-by-step directions.

447. Radio Set AN/TPS–1D, Complete Alinement

The following chart lists the alinement and adjustment that should be performed to completely aline Radio Set AN/TPS–1D. Step-by-step directions for performing the procedures listed in the *Alinement or adjustment* column are contained in the paragraphs referenced in the *Procedure* column. To completely aline the set, perform the procedures in the order listed below:

Alinement or adjustment	Procedure
Line frequency and line voltage adjustments.	TM 11–919.
Line voltage adjustment	Par. 7, TM 11–1167–20.
Five-minute time delay adjustment R443.	Par. 429.
Timing relay cams adjustment K401.	Par. 430.
Positive 150-volt adjustment R416.	Par. 427.
Positive 300-volt adjustment R433.	Par. 428.
Coarse frequency adjustment R110.	Par. 228.
Protective relay balance adjustment R168.	Par. 229.
Modulator high-voltage adjustment T151.	Par. 230.
Magnetron filament voltage adjustment T504.	Par. 231.
Magnetron frequency adjustment	Par. 8, TM 11–1167–20.
Indicator intensity, focus, and centering adjustments.	Par. 12, TM 11–1167–20.
Fixed range marker circuit adjustments.	Par. 365.
Ppi-sweep adjustments	Par. 366.
A-sweep adjustments	Par. 367.
Strobe circuit adjustments	Par. 368.
Local oscillator alinement V505	Par. 289.
Signal IF alinement	Par. 290.
Signal mixer coupling adjustment RF503A.	Par. 288.
Duplexer adjustment RF503	Par. 13, TM 11–1167–20.
Tr tube adjustments	Par. 13, TM 11–1167–20.
Coho mixer adjustment RF502	Par. 288.
Coho adjustments	Par. 291.
Signal comparator front panel adjustments R2350, R2351, R2352, R2353, and R2354.	Front panel instructions, Signal Comparator CM–36/TPS–1D.
Normal alinement	Par. 13, TM 11–1167–20.
Carrier gate length adjustment R1365.	Par. 332.
Mti video gain adjustment R3306	Par. 333.
MTI BALANCE adjustment R2356.	Par. 14, TM 11–1167–20.
Slope adjustment (capacitor C1353).	Par. 331.
Mti alinement	Par. 14, TM 11–1167–20.
Servo amplifier adjustments	Par. 11, TM 11–1167–20.
Synchro zero switch adjustment S612.	Par. 398.
Synchro zero switch adjustment S765.	Part. 399.
Antenna rotate control mechanism adjustment.	Par. 400.
Synchro alinement	Par. 10, TM 11–1167–20.
Azimuth control adjustment	Par. 15, TM 11–1167–20.

448. Radio Set AN/TPS–1D, Testing

The following chart lists the testing procedures that should be performed to test the operation of Radio Set AN/TPS–1D. Step-by-step directions for testing the items listed in

the *Test* column are contained in the paragraphs referenced in the *Procedure* column. Perform the procedures in the order listed below:

Test	Procedure
Power unit output	TM 11–919.
Ac power input	Par. 53, TM 11–1167–10.
Timing relay K401	Par. 430.
Dc power supply outputs	Par. 415.
Synchronizing trigger J302	Par. 325.
Transmitting system test points	Par. 217.
MAGNETRON CURRENT meter M502.	Par. 216.
Test meter M501	Par. 216.
Magnetron frequency check J501	Par. 8, TM 11–1167–20.
Transmitter power output	Par. 235.
Magnetron spectrum analysis	Par. 236.
Local oscillator testing	Par. 294.
Signal IF preamplifier test	Par. 296.
Coho preamplifier test	Par. 297.
Signal IF amplifier test	Par. 298.
Coherent oscillator Z350 test	Par. 299.
Indicating system test points	Par. 352.
Receiver sensitivity measurement.	Par. 16, TM 11–1167–20.
Minimum discernible signal measurement.	Par. 16, TM 11–1167–20.
Tr recovery time measurement	Par. 267.
Voltage standing wave ratio	Par. 266.
TEST METER M2350	Front panel instructions, Signal Comparator CM–36/TPS–1D.
MTI repetition rate trigger amplifier (9-megacycle amplifier).	Par. 337.
Nondelay amplifier Z2300	Par. 338.
Delay amplifier Z1300	Par. 339.
Mercury delay line W2350, attenuation measurement.	Par. 340.
Slope adjustment capacitor and MTI BALANCE check.	Par. 341.
Dc amplifier V3301 measurement.	Par. 342.
Mti subclutter visibility measurement.	Par. 449.
Antenna performance test	Par. 403.
Sustained overload test	Par. 404.
Antenna bench testing	Par. 409.

449. Subclutter Visibility Measurement (fig. 184)

The radar set must be operating in a satisfactory manner in order to obtain the desired subclutter visibility measurement. Signal Generator TS–419/U or AN/URM–64 is used to simulate a moving target and this signal is measured with a fixed target return of the radar set in any azimuth.

a. Initial adjustment and set-up procedure for Signal Generator AN/URM–64 are as follows:

(1) Connect power cable CX–337/U to the power input receptacle and a 115-volt, 50 to 1,600-cps power source. Place the power switch on and allow a 10-minute warm-up period.

(2) Connect video cable CG–409/U from the sync input jack of the signal generator to J153 on the radar set modulator unit.

(3) Connect RF cable CG–546/U from rf output jack of the signal generator to J501 on the receiver transmitter.

(4) Place the pulse width control at 2.

(5) Place the pulse delay control at approximately 100.

(6) Place the signal frequency control at the approximate frequency of the transmitter.

(7) Place the output attenuator at − 3 dbm.

(8) Place the selector switch in zero set position and adjust the zero set control for zero set reading on the meter.

(9) Place the selector switch in clockwise position and adjust the power set control for a red-line meter reading. Because of interaction of these adjustments, repeat steps (8) and (9) above until the meter indicates the proper readings.

(10) Place the selector switch in positive sync position.

b. Use the procedure given in paragraphs 13 and 14 TM 11–1167–20 and tune the radar set for optimum normal and mti operation. Perform the following procedure to determine the subclutter visibility measurement.

(1) Place the radar set in normal operation and rotate the antenna to an azimuth of minimum ground clutter.

(2) Tune the signal frequency control on the signal generator for maximum signal pulse amplitude while observing the A-scope.

(*a*) Rotate the pulse delay control slightly cw and ccw to identify the signal on the A-scope.

(*b*) Repeat the procedures in *a*(8) and (9) above.

(3) Determine the minimum discernible signal (mds) power of the receiver. Use the procedure given in paragraph 16 of TM 11–1167–20.

(4) Reposition the antenna to an azimuth that presents a strong *fixed* target.

(5) Rotate the receiver gain control ccw until the fixed target is reduced from the saturation level of the receiver.

(6) Adjust the signal generator output attenuator until the pulse is clearly visible. Position the pulse with the pulse delay control next to the fixed target and readjust the output attenuator for a pulse amplitude equal to the amplitude of the fixed target.

(7) Total all attenuation used, as in (1) above, and subtract this fixed target signal power from the minimum discernible signal power. The difference is the *level* of the clutter signal above the minimum discernible signal.

(8) Using the signal generator pulse delay control, superimpose the signal generator pulse (simulated moving target) upon the fixed target and readjust RECEIVER GAIN control for normal receiver gain (normal grass level on the A-scope).

(9) Place the radar set in mti operation and increase the signal generator OUTPUT ATTENUATOR until the moving target is just perceptible above the A-scope base line residue. Determine the total attenuation and subtract from it the signal power of the fixed target. This is the subclutter visibility figure.

(10) From the chart given in figure 184, the subclutter visibility figure should fall no more than 2 db below the desired curve when plotting the subclutter visibility figure on the vertical axis and the level of the clutter signal above the minimum discernible signal on the horizontal axis.

c. Select another fixed target on a different azimuth and repeat the procedures in (5) through (10) above.

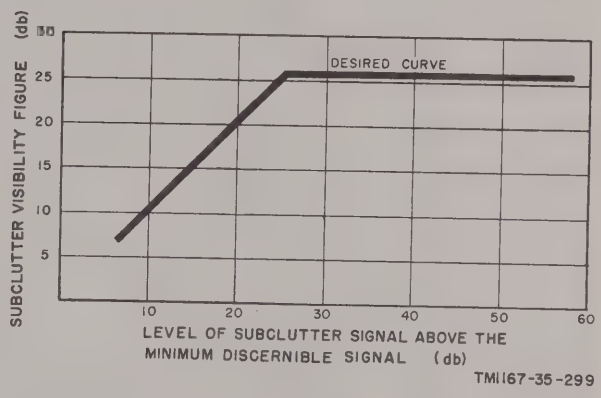


Figure 184. Subclutter visibility measurement curve.

CHAPTER 20

DISASSEMBLY AND REASSEMBLY OF ANTENNA DRIVE UNIT ASSEMBLY

Section I. DISMOUNTING AND MOUNTING

450. General

a. The antenna drive unit assembly is a part of the antenna base. Paragraph 451 covers dismounting and mounting of the antenna drive unit assembly, and paragraphs 452 and 453 cover the disassembly and assembly of the antenna drive unit assembly.

b. Figure 188 shows an exploded view of the antenna drive unit assembly. Each numbered part is identified in a legend. The legend describing each number appears in text near the figure. In the legend (except for common hardware) each numbered part is identified by its symbol reference designation or its Raytheon part number (unless some other manufacturer is specified).

c. Before the antenna drive unit assembly can be disassembled, the antenna must be removed. To remove the antenna from the antenna base, proceed as follows:

Note. If additional information is needed, refer to paragraph 33, TM 11–1167–10.

(1) Remove the two sets of outer and intermediate antenna reflector sections.

(2) Remove the coaxial fittings from the antenna (fig. 185).

(3) Loosen the four captive bolts at the base of the antenna horn casting (fig. 185).

(4) Carefully raise and remove the antenna from the antenna spindle. Replace the captive spindle cap.

451. Dismounting and Mounting Antenna Drive Unit Assembly

a. General. The antenna drive unit assembly is mounted in the upper part of the antenna base. This assembly consists of a drive unit which contains the drive motor, two synchros, gears, and heater; a spindle shaft and RF conductors (fig. 185).

b. Dismounting (fig. 186). To dismount the antenna drive unit assembly from the antenna base, proceed as follows:

(1) Drain the oil from the drive unit gear case by removing the oil drain cap. Replace the cap.

(2) Disconnect all cables and fittings to the antenna drive unit assembly.

(3) If the antenna base is part of a normal installation, release the four captive locking pins (fig. 31, TM 11–1167–20) and lift the antenna base from the component underneath. Lay the antenna base on its side.

(4) Loosen the hose clamp and hose attached to inner conductor RF751. Unscrew the knurled fitting which attaches RF751 to the antenna drive unit (fig. 186) and carefully withdraw RF751.

(5) Set the antenna base upright and remove the four bolts located on top of the antenna spindle (fig. 30, TM 11–1167–10) and lift off the antenna spindle. Remove the spindle cap from the antenna spindle base plate and replace the spindle cap on the outer conductor to prevent damage to the outer conductor threads.

(6) Remove the bolts around the edge of the top plate of the antenna base, also remove the four bearing housing bolts (fig. 185) at the center of the top plate. Lift off the spindle shaft top bearing assembly and the top plate.

(7) Remove the four mounting bolts in the feet of the antenna drive unit assembly and lift the antenna drive

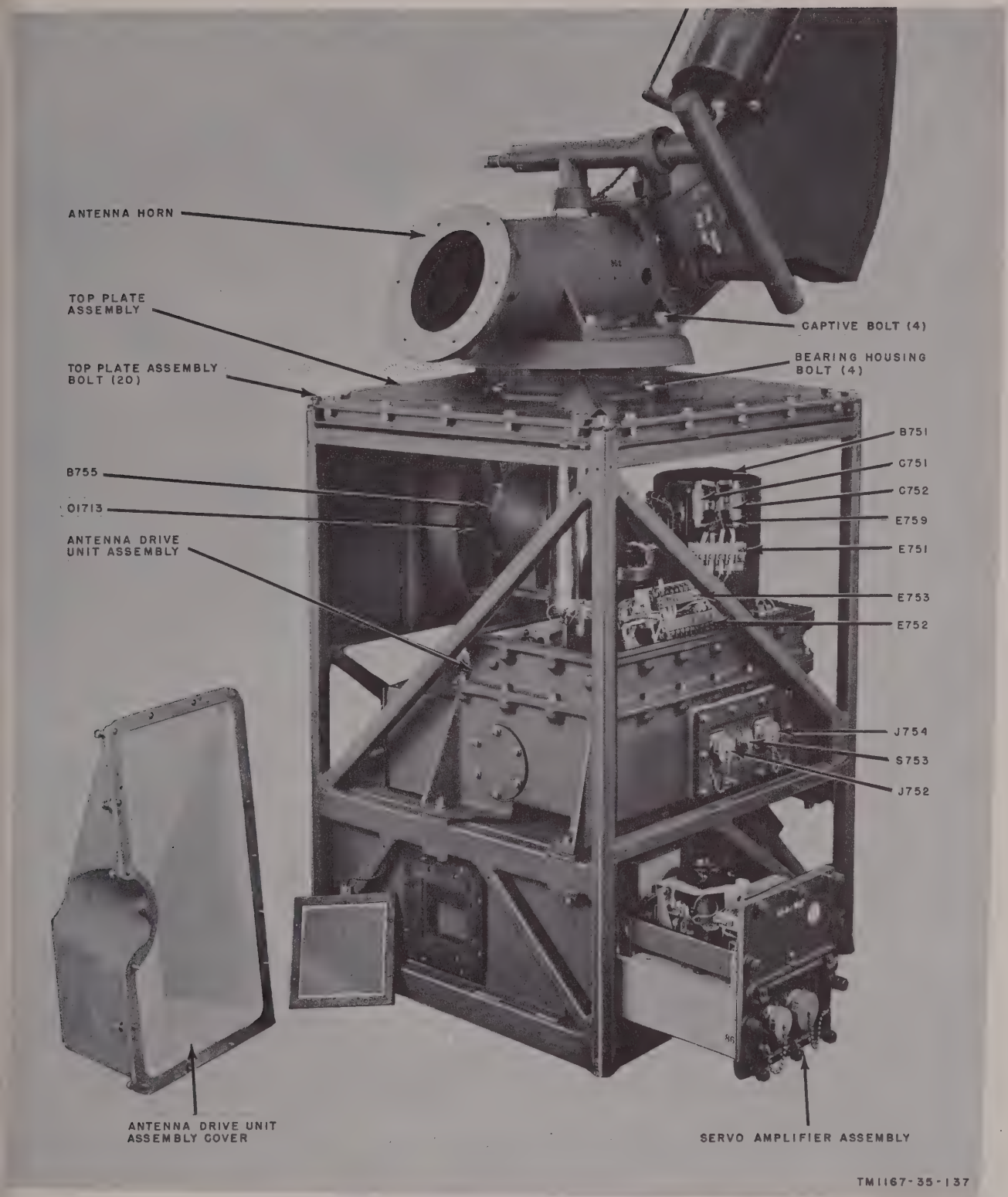


Figure 185. Antenna base, left side view.

unit assembly out off the antenna base.

c. Mounting (fig. 186). To mount the antenna drive unit assembly on the antenna base, proceed as follows:

(1) Replace the antenna drive unit assembly on the upper shelf of the antenna base and fasten the feet with the four mounting bolts.

(2) Replace the top plate on the antenna base and fasten with bolts around the edge of the top plate (fig. 185).

(3) Replace the spindle shaft top bearing assembly and fasten with the four bolts (fig. 30, TM 11–1167–10).

(4) Remove the spindle cap from the outer conductor and replace the antenna spindle on the spindle shaft. Fasten with the four bolts. Replace the spindle cap and fasten the chain that holds the spindle cap captive to the antenna spindle base.

(5) Lay the antenna base on its side.

(6) Carefully replace inner conductor RF751 through the rotary bearing joint and tighten the knurled fitting.

Caution: After replacing the inner conductor (RF751), remove the spindle cap and carefully center the upper contact fingers by adjusting the inner conductor centering clamp and screw (fig. 8, TM 11–1167–10), so that the contact fingers rest equidistant from the edge of the outer conductor. If the center conductor is not properly centered, excessive pressure of the contact fingers on the oilite bearing will cause premature failure of both the contact fingers and the oilite bearing.

(7) Set the antenna base upright and remove the filler plug. Fill the antenna drive unit with the proper grade oil (listed on the instruction plate) until the oil reaches the proper level in the oil level indicator. Replace the filter.

(8) Connect all cables and fittings to the antenna drive unit assembly.

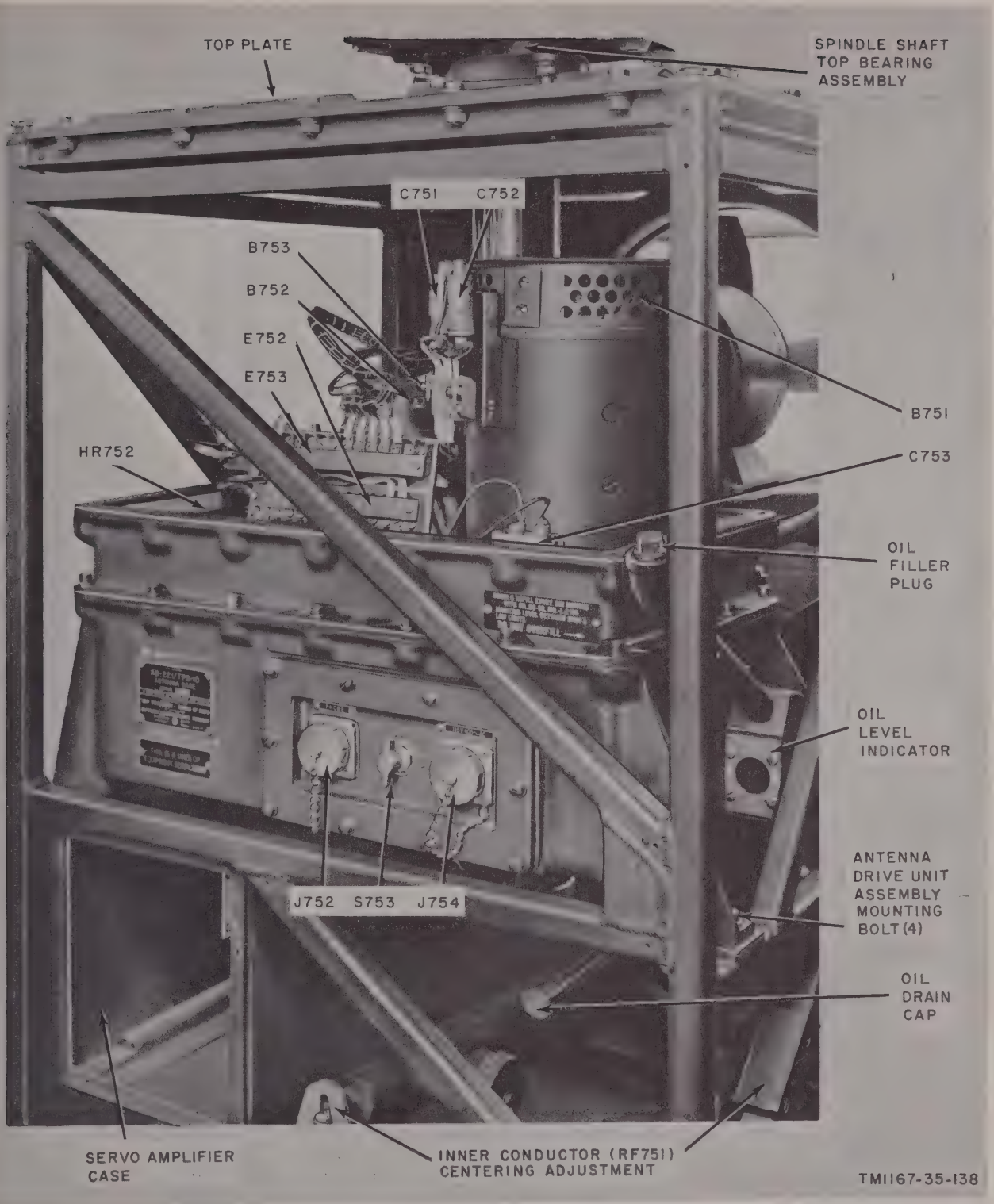


Figure 186. Antenna base, front view.

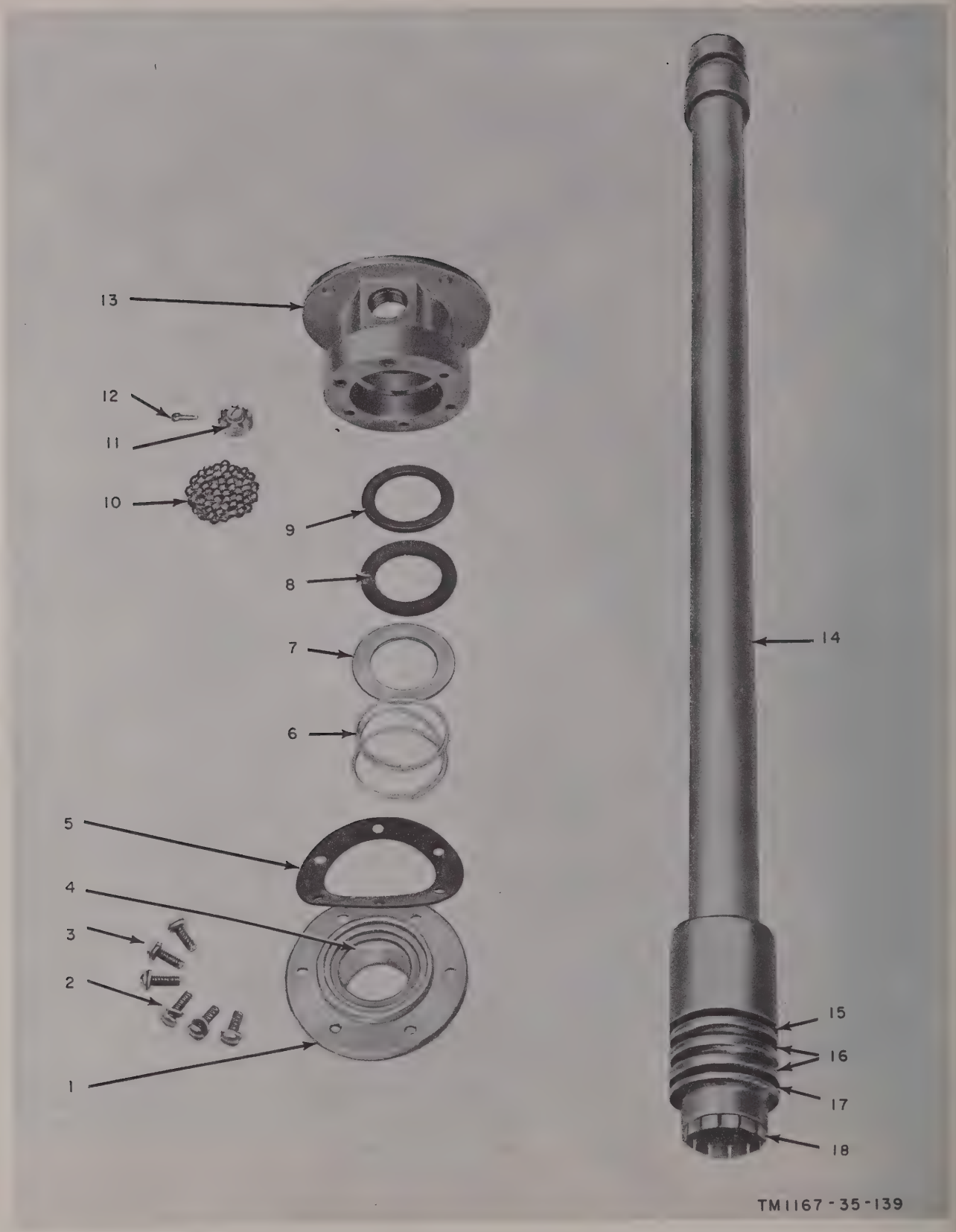


Figure 187. Rotary joint, exploded view.

No.	*Item*	*Raytheon Part No.*
1	Coupler RF752	
2	Lockwasher ¼	
3	Roundhead screw ¼–20 by ¾	
4	Packing (gasket) O 1710	
5	Gasket	Chickson Dwg R28D1–42B–A
6	Helical tension spring	Chickson Dwg R1D1–31D
7	Packing (brass retainer) O 1707	
8	Packing (felt retainer) O 1706	
9	Packing (bakelite retainer)	Chickson Dwg R28D3–31A
10	Ball bearings ¼	
11	Ball retainer plug	Chickson Dwg S–1534–2
12	Cotter pin 7/64 by ¾	
13	Housing (rotary joint housing) A 712	
14	Outer conductor	Chickson Dwg R28011–775
15	Gasket (O-ring) (neoprene grease seal)	Chickson Dwg R1D1–42A
16	Ball bearing races	Chickson Dwg R28D10–83
17	Gasket (O-ring) (neoprene grease seal)	Chickson Dwg R1D1–42A
18	Contact fingers	Chickson Dwg R28D1–35

Figure 187—Continued.

452. Disassembly of Antenna Drive Unit Assembly

a. Removing Contact Fingers and Outer Conductor (fig. 187). To remove the contact fingers and outer conductor, proceed as follows:

(1) Remove the six roundhead screws (3) and six lockwashers (2) from the RF coupler (1) and carefully pull off the RF coupler which also contains the oilite bearing. Remove the helical tension spring (6) that holds the brass (7), felt (8), and bakelite (9) retainers in place.

(2) Grasp the contact fingers (18) firmly with a suitable tool and pull straight out from the outer conductor (14).

(3) Remove the four fillister-head machine screws (37, fig. 188), four lockwashers (38) and four flatwashers (39) from the rotary bearing joint. Remove the spindle cap from the outer conductor.

(4) Grasp the rotary joint housing (13, fig. 187) firmly and carefully withdraw the outer conductor (14) from the spindle shaft.

b. Removing Rotary Joint from Outer Conductor (fig. 187). To remove the rotary bearing joint from the outer conductor, after the outer conductor has been removed from the spindle shaft and the RF coupler removed from the rotary joint, proceed as follows:

(1) Remove the cotter pin (12) from the ball retainer plug (11) and unscrew the ball retainer plug.

(2) Pour out the ball bearings (10) on a clean surface. Be careful not to lose any of the ball bearings.

(3) Remove the entire rotary joint housing (13) from the outer conductor (14).

c. Removing Motor Assembly and Synchros (fig. 188). To remove the drive motor and synchros, proceed as follows:

(1) Remove the antenna drive unit assembly cover by loosening the captive bolts surrounding the cover (fig. 185).

(2) Loosen and remove the four hexagonal-socket cap screws (44, fig. 188) four lockwashers (45) and four flatwashers (46) at the base of the drive motor. Remove the leads from drive motor terminal board E751 (fig. 185). Tag each lead for easy reassembly. Lift the drive motor assembly B751 (43, fig. 188) from the antenna drive unit assembly.

(3) Remove each synchro by first removing and tagging the leads, then removing the four fillister-head screws (51 and 121), four lockwashers (52 and 120), and four flatwashers (53 and 119) at the base of each synchro. Lift the synchros (92 and 117) from the antenna drive unit assembly.

d. Removing Heater Unit, Gears, and Worm Shaft (fig. 188). To remove heater unit HR751, gears, and worm shaft, proceed as follows:

(1) Remove the leads and two hexagonal nuts (162 and 163) from the tubular heating unit (164).

(2) Remove the switch and cover assembly (156) containing the phone jack, safety switch, and ac outlet. Disconnect and mark all leads from this assembly to enable the cable harness to be removed with the intermediate housing (131).

(3) Remove the 17 socket-head cap screws (64), lockwashers (65), and flatwashers (66) that secure the intermediate housing (131). Lift the intermediate housing (131) from the gear case (151).

(4) Remove the C and E gears (68 and 75) from the bottom of the intermediate housing (131) by cutting the safety wire and removing the fillister-head machine screw (71 or 72), lockwasher (70 or 73), and flatwasher (69 or 74) from the end of each gear shaft.

(5) Remove the spur gear (80) from the bottom of the intermediate housing (131) by straightening the teeth of

the castellated washer (78) and removing the castellated nut (77).

(6) Remove the tubular heating element (164) by cutting the safety wire and removing the eight fillister-head machine screws (160 and 165) and lockwashers (159 and 166) that fasten the clips (167) and bracket (161).

(7) Remove the gears on the worm shaft as follows:

(*a*) Remove the oil level indicator and end plate (177 and 152) by removing the 12 fillister-head machine screws (175 and 1), 12 lockwashers (176 and 2), and 12 flatwashers (174) from the gear case (151).

(*b*) Cut the safety wire and remove the two fillister-head machine screws (132 and 149) and lockwashers (133 and 148) at each end of the worm shaft (141). Remove the worm shaft end washers (136 and 147).

(*c*) Remove the B gear (137) which is fitted on a spline.

(*d*) Remove the D gear (145) which is fitted over a key (146).

(*e*) Cut the safety wire and remove the four drilled-head bolts (134) and four lockwashers (135) that hold the plates (138 and 140). The two plates will fall away from the bearing housing and permit the ball bearing (139) to be removed.

(*f*) Withdraw the worm shaft (141) from the gear case (151) through the oil level indicator opening.

(*g*) Remove the roller bearing (144) from the worm shaft (141) by releasing and removing the retaining ring (211) and internal retaining ring (210).

e. Removing Spindle Shaft (fig. 188). To remove the spindle shaft, proceed as follows:

(1) Remove the ring clamp (171) and washer (172) by removing the three fillister-head machine screws (168), three lockwashers (169), and three flatwashers (170) from the gear case (151).

(2) Remove the six fillister-head machine screws (180), six lockwashers (181), and six flat washers (182) from the housing (183).

(3) Remove the four fillister-head machine screws (202) and four lockwashers (201) located in the gear case (151) above the F gear (193).

(4) Remove the spindle shaft (200) by sliding the spindle shaft out through the bottom of the gear case (151).

f. Removing Spindle Shaft Gears and Ball Bearings (fig. 188). To remove the spindle shaft gears and ball bearings, proceed as follows:

(1) Loosen the plug (205). Remove the six fillister-head machine screws (203) and six lockwashers (204) and pull away the housing (183) and gasket (184).

(2) Straighten the tabs on the bearing lockwasher (186) and remove the bearing locknut (185), bearing lockwasher (186), ball bearing (187), two shims (188), plate (189), and H gear (190) together with its key (191). Do *not* misplace the key.

(3) Release and remove the retaining ring (192).

(4) Remove the F gear (193), key (194), washer (195), gasket (196), plate (197), and roller bearing (198) from the spindle shaft (200).

Figure 188. Antenna drive unit, exploded view.
(Contained in separate envelope)

453. Reassembly of Antenna Drive Unit Assembly

a. Replacing Spindle Shaft Gears and Ball Bearings (fig. 188). To replace the spindle shaft gears and ball bearings, proceed as follows:

(1) Be sure the retaining ring (199) is in place on the spindle shaft (200).

(2) Replace the roller bearing (198), plate (197), gasket (196), washer (195), key (194), and F gear (193). Secure with the retaining ring (192).

(3) Replace the key (191), H gear (190), plate (189), two shims (188), ball

bearings (187), bearing lockwasher (186), and bearing locknut (185). Secure the bearing locknut by bending the tabs on the bearing lockwasher (186).

(4) Replace the gasket (184) and housing (183). Secure the plate (189) to the housing (183) by replacing the six fillister-head machine screws (203) and six lockwashers (204).

(5) Tighten the plug (205) and replace the oil seal (206).

b. Replacing Spindle Shaft (fig. 188). To replace the spindle shaft, proceed as follows:

(1) Slide the spindle shaft (200), complete with gears and bearings, up through the bottom of the gear case (151).

(2) Secure the housing (183) to the bottom of the gear case (151) with the six flatwashers (182), six lockwashers (181), and six fillister-head machine screws (180).

(3) Secure the plate (197) to the gear case (151) by replacing the four lockwashers (201) and four fillister-head machine screws (202).

(4) Replace the washer (172) and ring clamp (171). Secure with the three flatwashers (170), three lockwashers (169), and three fillister-head machine screws (168).

c. Replacing Worm Shaft and Gears (fig. 188). To replace the worm shaft and gears, proceed as follows:

(1) Secure the retaining ring (142) and internal retaining ring (143) on the worm shaft (141). Place the roller bearing (144) against the internal retaining ring (143). Secure the roller bearing with the internal retaining ring (210) and retaining ring (211). Place the ball bearing (139) in place on the worm shaft (141) near the spline end.

(2) Replace the worm shaft (141) with bearings attached, through the oil level indicator opening. Hold the plate (140) in its place behind the large bearing mount while replacing the worm shaft (141).

(3) Replace the plate (138) and fasten both plates (138 and 140) with the four lockwashers (135) and four drilled-head bolts (134). Safety wire the drilled-head bolts.

(4) Replace the B gear (137) over the spline end of the worm shaft. Replace the worm shaft end washer (136) and fasten with the two lockwashers (133) and two fillister-head machine screws (132). Safety wire the screws.

(5) Replace the D gear (145). Be sure that the key (146) is in place. Replace the worm shaft end washer (147) and fasten with the two lockwashers (148) and two fillister-head machine screws (149). Safety wire the screws.

(6) Replace the end plate (177), oil level indicator (152), and gaskets (178) and (150). Secure with the 12 flatwashers (174), 12 lockwashers (176 and 2), and 12 fillister-head machine screws (175 and 1).

d. Replacing Tubular Heating Element, E Gear, C Gear, and Spur Gear (fig. 188). To replace the tubular heating element, E gear, C gear, and spur gear, proceed as follows:

(1) Place the tubular heating element (164) in the bottom of the gear case (151) and fasten with the six clips (167) and bracket (161). Secure the clips (167) and bracket (161) with the seven lockwashers (159 and 166) and seven fillister-head machine screws (160 and 165). Safety wire the seven screws that hold the clips and bracket.

(2) Replace the spur gear (80). Secure with the flatwasher (79), castellated washer (78), and castellated nut (77). Bend the tabs on the castellated washer.

(3) Replace the key (76) and E gear (75). Secure with the flatwasher (74), lockwasher (73), and fillister-head machine screw (72). Secure the fillister-head machine screw with the safety wire.

(4) Replace the key (67) and C gear (68). Secure with the flatwasher (69), lockwasher (70), and fillister-head ma-

chine screw (71). Secure the fillister-head machine screw with the safety wire.

(5) Replace the intermediate housing (131). Carefully feed the cable harness through the opening in the intermediate housing for the switch and cover assembly (156). Be sure that the gaskets (158, 157, and 173), and tubular heating element terminal gaskets are properly in place. Secure the intermediate housing (131) with the 21 flatwashers (66), 21 lockwashers (65), and 21 socket-head cap screws (64).

(6) Seat the gasket (157) and connect the leads to the switch and cover assembly (156). Be careful to make proper connections. Secure the switch and cover assembly (156) with the 10 flatwashers (155), 10 lockwashers (153), and 10 fillister-head machine screws (154).

(7) Replace the hexagonal nuts (162 and 163) on the tubular heating element terminals and connect the proper leads to the terminals.

e. Replacing Synchros and Drive Motor Assembly (fig. 188). To replace the synchros and drive motor assembly, proceed as follows:

(1) Replace the synchros (92 and 117) in their proper sockets on the intermediate housing (131). Place the ring clamp (93) over the synchro (92) and the ring clamps (118) over the synchro (117). Secure the ring clamp (93) with the four flatwashers (53), four lockwashers (52), and four fillister-head machine screws (51). Secure the ring clamps (118) with the four flatwashers (119), four lockwashers (120), and four fillister-head screws (121).

(2) Replace the drive motor (43) in its proper receptacle. Secure with the four flatwashers (46), four lockwashers (45), and four hexagonal-socket cap screws (44). Replace all leads to the drive motor terminal board.

(3) Make certain that all leads are connected properly.

(4) Replace the cover (50) and secure with the 17 captive screws (49).

f. Replacing Rotary Bearing Joint (fig. 187).

(1) Be sure that the two neoprene grease seals (15 and 17) are installed with the grooved edges facing away from the contact fingers.

(2) Butter the ball bearing races (16) on the outer conductor and the rotary joint housing (13) with the proper high temperature grease.

(3) Replace the rotary joint housing (13) on the outer conductor (14) over the neoprene grease seals (15 and 17).

(4) Roll the ball bearings (10) in grease and replace the ball bearings through the access opening on the rotary joint housing (13). Be sure that the ball bearings (10) seat properly in their races.

(5) Replace the ball retainer plug (11). Tighten until snug, then back off, or loosen the ball retainer plug ¼ turn (2 slots), and replace the cotter pin (12).

Caution: Do not overgrease the ball bearings or overtighten the ball retainer plug. Overgreasing will cause leaking past the seals, and overtightening of the ball retainer plug will cause premature failure of the rotary bearing joint.

(6) Replace the packing, first the bakelite (9), then the felt (8), and finally the brass (7).

Note. The felt grease retainer should be dry except for a light coating of Dow Corning DC–4 to prevent dropping of felt fibers.

(7) Replace the gasket (5) on the RF coupler (1). Aline the holes of the gasket with those of the RF coupler.

(8) Hold the helical tension spring (6) against the brass retainer (7) and press the RF coupler against the spring. Secure the RF coupler with the six roundhead screws (3) and six lockwashers (2).

Note. The bearing joint should rotate freely. There should be no roughness or binding.

g. Replacing Outer Conductor and Contact Fingers (fig. 188).

(1) With the spindle cap (21) removed and the rotary bearing joint attached, replace the outer conductor (27) through the bottom of the spindle shaft. Fasten the rotary bearing joint to the bottom of the spindle shaft with the four flatwashers (39), four lockwashers (38), and four fillister-head machine screws (37).

Caution: Be sure that the key (212) is in place between the spindle shaft and the outer conductor. Operation without the key (212) can result in twisting of the outer conductor.

(2) Replace the contact fingers (18, fig. 187) by placing them in the bottom of the outer conductor and pressing in firmly.

(3) Replace the RF coupler (36, fig. 188) by performing *f*(7) and (8) above.

CHAPTER 21

DISASSEMBLY AND REASSEMBLY OF ANTENNA ROTATE CONTROL MECHANISM

Section I. DISMOUNTING AND MOUNTING

454. General

a. The antenna rotate control mechanism is a part of the indicator. Paragraph 455 covers the dismounting and mounting of the antenna rotate control mechanism, and paragraphs 456 and 457 cover the disassembly and reassembly of the antenna rotate control mechanism.

b. Figure 189 shows an exploded view of the antenna rotate control mechanism. Each part is identified by a number that appears on the illustration. Each numbered part is identified in a legend for the illustration. In the legend (except for common hardware) each numbered part is identified by its symbol reference designation or its Raytheon part number.

c. Before the antenna rotate control mechanism can be dismounted for disassembly, the indicator must be removed from its case as follows:

(1) Loosen the 16 captive screws located on the front panel of the indicator.
(2) Carefully withdraw the indicator from its case until the rack stops are hit.

455. Dismounting and Mounting Antenna Rotate Control Mechanism

a. General. The antenna rotate control mechanism is mounted in the upper right-hand corner of the indicator. The mechanism consists of a pointer and indicator, reduction gears, cam, coupling, two microswitches, and a potentiometer.

b. Dismounting (fig. 158). To dismount the antenna rotate control mechanism from the indicator, proceed as follows:

(1) Remove the ANTENNA ROTATE control from the front panel of the indicator by first loosening the Allen screw.
(2) Remove two mounting screws from the front mounting plate.
(3) Remove two mounting screws from the rear mounting plate.
(4) Carefully tag and remove the leads from the two antenna control switches and ANTENNA SPEED control.
(5) Pull back and lift out the antenna rotate control mechanism.

c. Mounting (fig. 158). To mount the antenna rotate control mechanism on the indicator, proceed as follows:

(1) Replace the antenna rotate control mechanism in the upper right side of the indicator.
(2) Position the antenna rotate control mechanism by alining the holes for the mounting screws with those on the indicator chassis; secure with two mounting screws on the rear plate and two mounting screws on the front plate.
(3) Replace the leads to the two antenna control switches and the ANTENNA SPEED control as indicated on tagged instructions made during dismounting.
(4) Replace the ANTENNA ROTATE control on the front panel of the indicator, and tighten the Allen screw on the control knob.
(5) Adjust the antenna rotate control mechanism as instructed in paragraph 400.

456. Disassembly of Antenna Rotate Control Mechanism

(fig. 189)

a. Removing Antenna Control Switches S617 and S618, and Antenna Speed Control R609. To remove the antenna control switches and ANTENNA SPEED control, proceed as follows:

(1) Remove the antenna control switches (8) and (22) by removing four hexagonal nuts (12), four lockwashers (11), four flatwashers (10), two shims (9), and four pan-head screws (6) with their insulating washers (7).

Caution: Insulating washers (7) must be replaced in their proper positions in order to insulate the antenna control switches from the center plate.

(2) Remove the antenna speed control (19) by loosening the Allen setscrew on the coupling (O 602, fig. 170); then loosen the hexagonal nut (21) and pull out the antenna speed control (19) from the rear plate (18). Set aside the lockwasher (20) and hexagonal nut (21).

b. Removing Front and Rear Plates, Gear Assembly, and Spur Gear. To remove the front and rear plates (5) and (18), gear assembly (13), and spur gear (15), proceed as follows:

(1) Remove the pointer (33) by first removing the pan-head screw (30), lockwasher (31), and flatwasher (32).

(2) Remove the front and rear plates (5) and (18) by first removing the six hexagonal nuts (1), six lockwashers (2) and six flatwashers (3). Pull away the rear plate (18) and the front plate (5). Remove the three long spacers (17), three short spacers (14), and three double threaded shafts (4).

(3) Remove the gear assembly (13) and the spur gear (15) by pulling them free from the center plate (16).

c. Removing Dial Drive Assembly. To remove the dial drive assembly, proceed as follows:

(1) Remove the pin (26) from coupling (O 1602, fig. 170).

(2) Hold the coupling (23); grasp the dial drive assembly (28) and pull it away from the center plate (16).

(3) Remove the cam (O 1601, fig. 170) from the coupling (23) by loosening the roundhead screw on the coupling (O 1602, fig. 170) and pulling the cam away from the coupling.

No.	*Item*	*Raytheon Part No.*
1	Hexagonal nut (6)	
2	Lockwasher (6)	
3	Flatwasher (6)	
4	Double-threaded shaft (3)	1593–1174P1
5	Front plate	1593–1198P1
6	Pan-head screw (4)	
7	Insulating washer (4)	
8	Antenna control switch S618	
9	Shim O 693	
10	Flatwasher (4)	
11	Lockwasher (4)	
12	Hexagonal nut (4)	
13	Gear assembly O 699	
13A	Spur gear O 1604	
13B	Spur gear O 1603	
13C	Idler shaft	1593–1188P1
13D	Locking pin H667	
14	Short spacer (3)	1593–1170P1
15	Spur gear O 697	
16	Center plate	
17	Long spacers (3)	1593–1170P2
18	Rear plate	1593–1192P1
19	ANTENNA SPEED control R609	
20	Lockwasher	236–1016P1
21	Hexagonal nut H660	
22	Antenna control switch S617	
23	Coupling O 1602	
24	Allen setscrew (fig. 170)	207–1004P3
25	Adjusting screw (fig. 170)	207–1020P3
26	Pin (fig. 170)	293–1022P9
27	Cam O 1606 (fig. 170)	
28	Dial drive assembly O 698	
28A	Cam O 1601	1593–1205P1
28B	Coupling spacer (fig. 170)	
28C	Spur gear O 1604	
28D	Dial shaft	1593–1180P1
28E	Locking pin	1593–1185P1
29	ANTENNA SPEED dial N604	
30	Pan-head screw	207–1005P3
31	Lockwasher	236–1015P1
32	Flatwasher	236–1018P1
33	Pointer H664	

Figure 189. Antenna rotate control mechanism, exploded view. →

457. Assembly of Antenna Rotate Control Mechanism

(figs. 189 and 170)

a. Replacing Dial Drive Assembly. To replace the dial drive assembly, proceed as follows:

(1) Replace the cam (O 1601, fig. 170) on the coupling (23) by pressing the cam onto the coupling and tightening the roundhead screw on the coupling.

(2) Replace the dial drive assembly (28) by placing the dial drive assembly shaft through the hole located toward the middle of the center plate (16) and pressing onto the coupling (23).

(3) Replace the pin (26) in the coupling (O 1602, fig. 170).

b. Replacing Spur Gear, Gear Assembly, and Front and Rear Plates. To replace the spur gear (15), gear assembly (13), and front and rear plates (5) and (18), proceed as follows:

(1) Replace the spur gear (15) by placing the thicker part of the spur gear shaft through the hole located near the edge of the center plate (16).

(2) Replace the gear assembly (13) by placing idler shaft (13C) through the remaining bearing hole located on the center plate (16).

(3) Replace the front and rear plates (5)

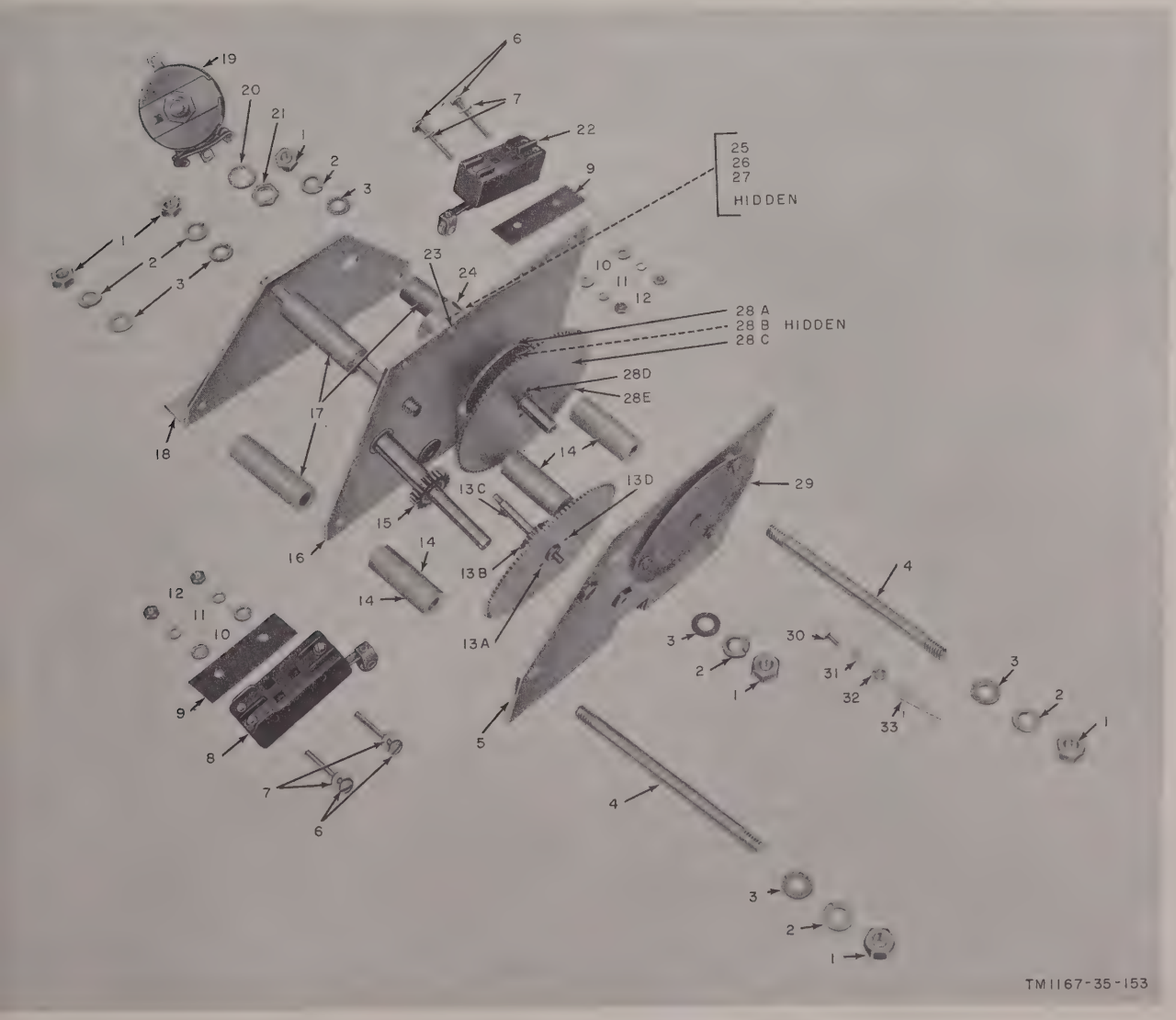


Figure 189—Continued.

and (18) by first placing three double-threaded shafts (4) through holes in the center plate (16), then placing three long spacers (17) over the double-threaded shafts on the coupling (23) side of the center plate (16), and the short spacers (14) over the double-threaded shafts on the gear side of the center plate. Place the rear plate (18) over the double-threaded shafts (4) and then place the front plate (5) over the same double-threaded shafts; be careful to aline the ends of the idler shaft (13C), the spur gear (15), and the dial drive assembly (28). Secure the front and rear plates with six flatwashers (3), six lockwashers (2), and six hexagonal bolts (1).

(4) Replace the pointer against the ANTENNA SPEED dial (29) and secure it with the flatwasher (32), lockwasher (31), and pan-head screw (30).

c. Replacing ANTENNA SPEED Control and Antenna Control Switches S617 and S618. To replace the antenna speed control and the antenna control switches, proceed as follows:

(1) Replace the antenna speed control (19) by placing the shaft end through the large hole in the rear plate (18). When the antenna speed control shaft appears through the hole in the rear plate, place the lockwasher (20) and hexagonal nut (21) over the antenna speed control shaft. Tighten the hexagonal nut (21) and, at the same time, guide the antenna speed control shaft into the coupling (23) and tighten the Allen screw on the coupling (O 1602, fig. 170).

(2) Replace antenna control switches S617 and S618 by placing the shim (9) and S618 (8) on the gear side of the center plate (16), and shim (9) and S617 (22) on the coupling (23) side of the center plate (16). Place the four insulating washers (7) over the four pan-head screws (6) and push them through the holes in S617 and S618 and secure them with four flatwashers (10), four lockwashers (11), and four hexagonal nuts (12).

CHAPTER 22

DISASSEMBLY AND REASSEMBLY OF DELAY NETWORK TANK

Section I. DISMOUNTING AND MOUNTING

458. General

a. The delay network tank is housed in a case which in turn is housed in the same case that holds the signal comparator. The signal comparator chassis virtually enfolds the delay network. Paragraph 459 covers the dismounting and mounting of the delay network tank, and paragraphs 460 and 461 cover the disassembly and reassembly of the delay network tank; the procedure for filtering mercury is also included under assembly of the delay network tank.

b. Figure 196 shows an exploded view of the delay tank network. Each part is called out on the illustration.

c. Before the delay network tank can be disassembled, it must be removed from its case which in turn must be removed from the signal comparator case. To remove the delay network tank and its case from the signal comparator case, proceed as follows:

(1) Disconnect the panel cables from the signal comparator and withdraw the signal comparator chassis as far as the drawer catches.

(2) Disconnect the three cables at J1301, J1350, and J2354 (fig. 190) on the underside of the signal comparator chassis.

(3) Release the signal comparator chassis drawer catches and remove the signal comparator chassis.

(4) Remove the six mounting bolts and lift out the delay network from the signal comparator case.

Caution: Remove the delay network with care because it is comparatively heavy. The mercury alone weighs 30 pounds.

459. Dismounting and Mounting Delay Network Tank

a. General. Before attempting repair or service on the delay network tank, consider the following:

(1) The mercury used in the tank must be free of any impurities.

(2) The tank surfaces which contact the mercury must be clean to the point of being free from all contamination, which includes lint and such transparent film as might be left by smoke fumes, or personal contact.

(3) The inclosure used for repair or service of the delay network tank should be as follows:

(*a*) Small dust-free room with no windows.

(*b*) Forced exhaust ventilation, with a filtered inlet on the opposite side of the room.

(*c*) Room temperature steady at 70° to 75° F.

(*d*) Humidity maintained at approximately 50 per cent.

(4) Become thoroughly familiar with the disassembly and assembly procedures before attempting service or repair; this will result in minimum time for exposure of delay network tank parts to contamination.

(5) Materials required for repair and servicing are as follows:

30 pounds of mercury, ASC standard purity within .0001 percent nonvolatile residue per pound.
1 bottle (8 oz) ether.
1 bottle (8 oz) acetone.
1 tube of lubricant.

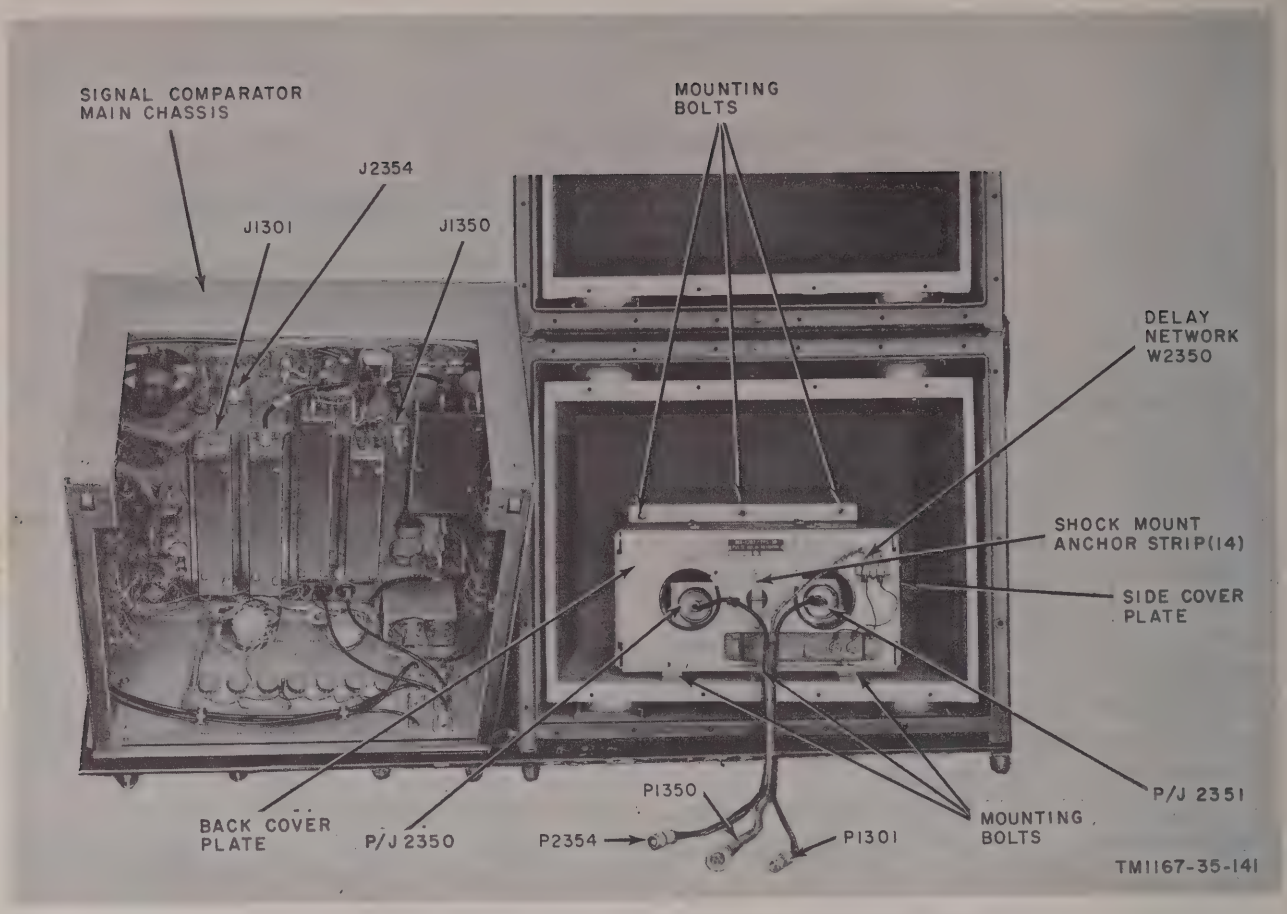


Figure 190. Delay network with signal comparator chassis removed.

1 spool of nylon or linen thread.
3 600-milliliter (ml) Pyrex beakers with covers.
4 250-ml Pyrex beakers with covers.
1 piece of glass tubing, ½ inch id (inside diameter) and 12 inches long.
1 tank of compressed dry nitrogen with air hose and dusting nozzle.
1 set of Allen wrenches.
1 screwdriver, 6-inch long blade from Tool Kit TE–114.
50 sheets (19 by 19 in.) of Dextilose tissue.

b. Dismounting (fig. 190). To remove the delay network tank from its case, proceed as follows:

(1) Begin at the bottom of the delay network and remove 2 roundhead machine screws and lockwashers from each of the 14 shock-mount anchor strips.
(2) Slide out each strip which in turn will release the 14 shock-mounting springs.
(3) Remove the cables from the delay network tank by unfastening the plugs at J2350 and J2351.
(4) Remove 13 roundhead machine screws and lockwashers from the top of the side and back cover plates.
(5) Remove the top cover plate and carefully lift the delay network tank out of its case (fig. 191).
(6) Remove the rubber shock mountings (figs. 192 and 193); remove the 2 tank mounting brackets (fig. 192) by removing 10 roundhead machine screws and lockwashers from each tank mounting bracket.

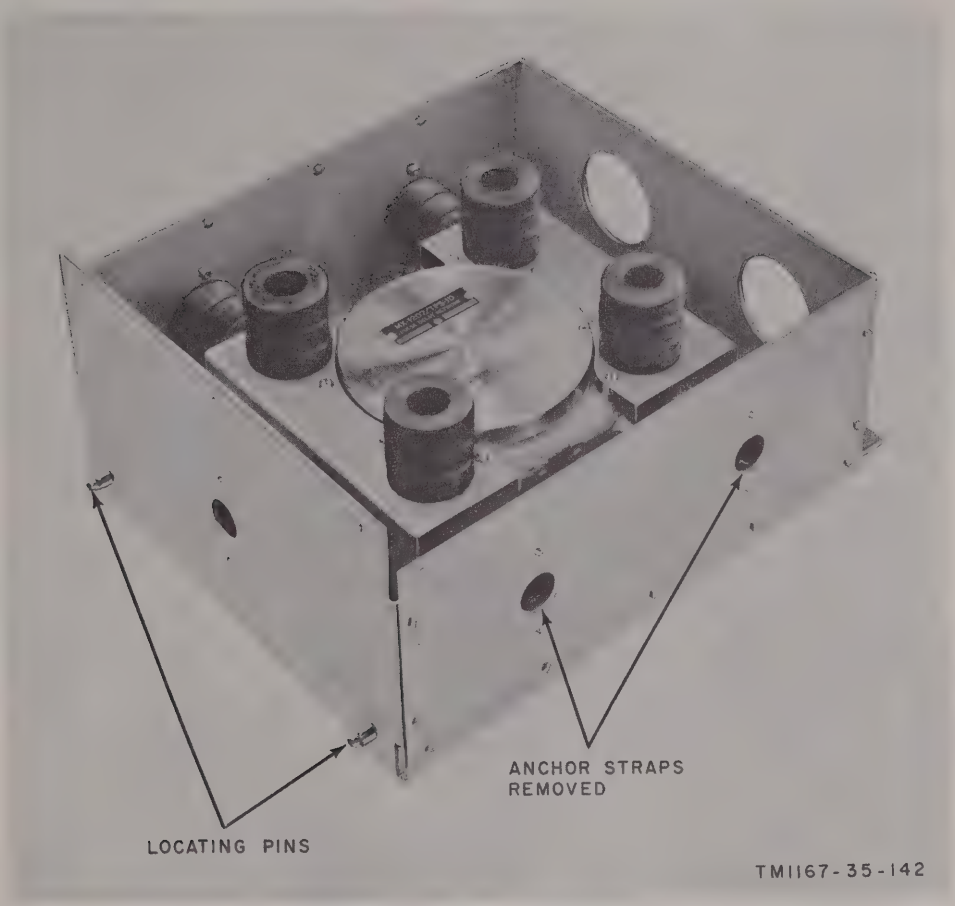


Figure 191. Delay network, top cover plate removed.

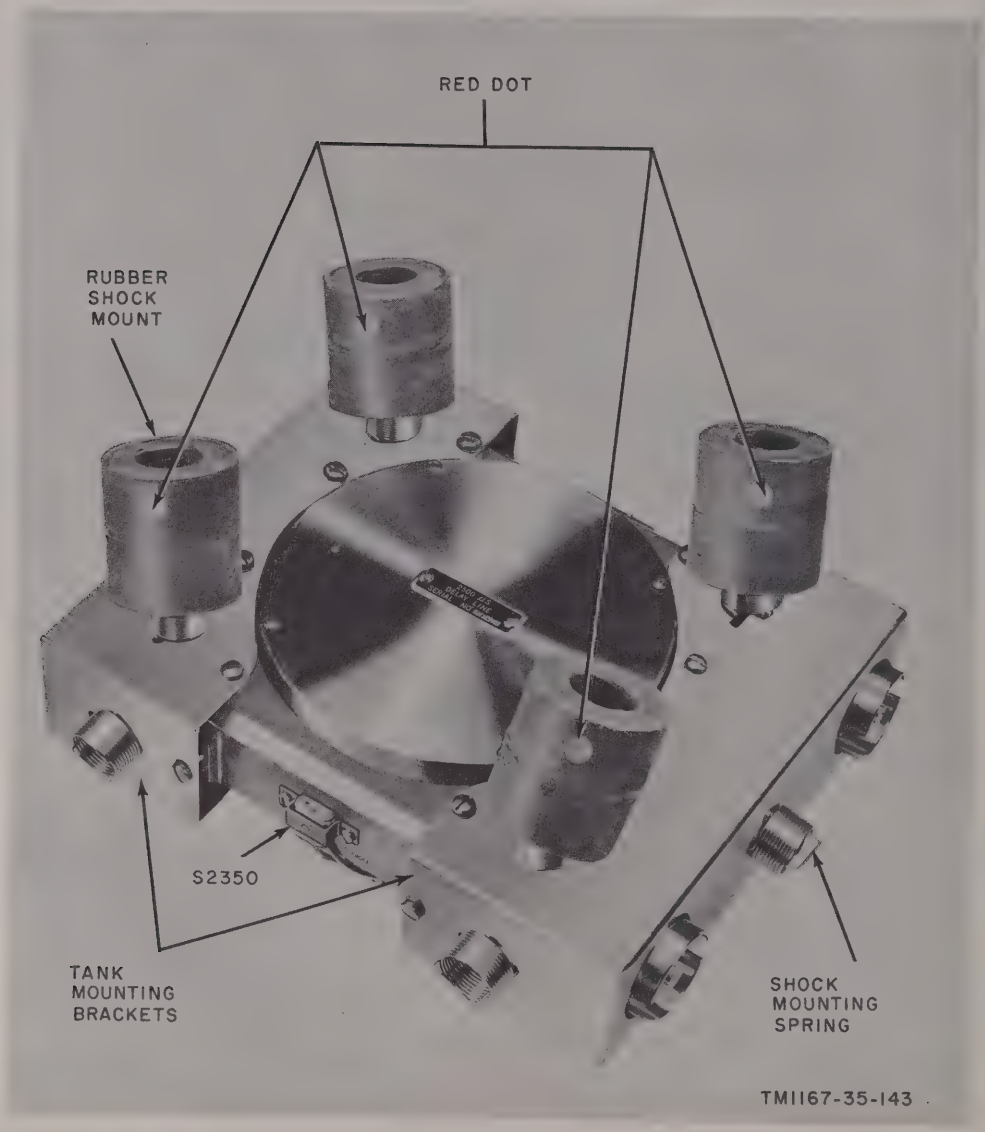


Figure 192. Delay network tank, red dot rubber shock-mount placement.

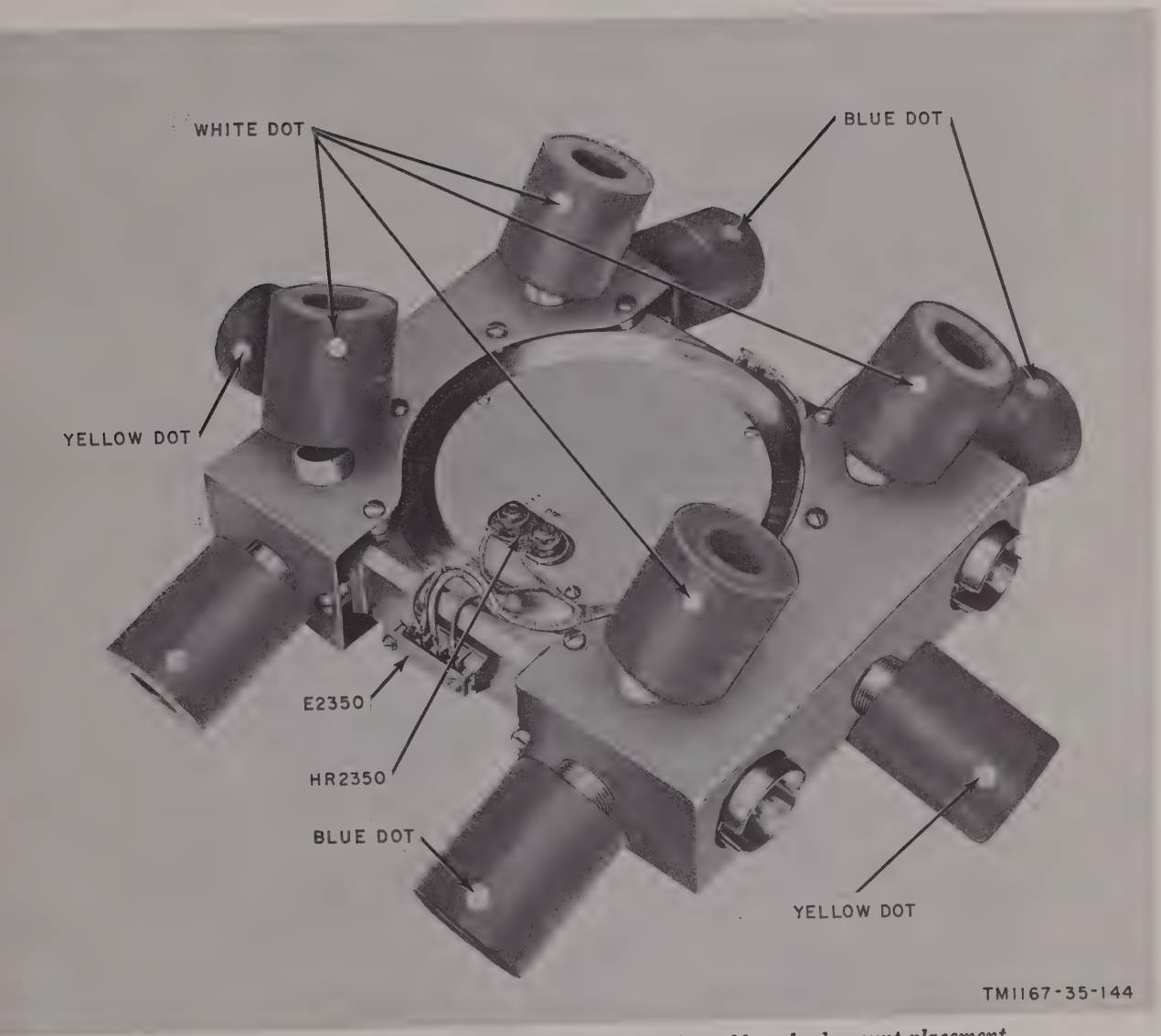


Figure 193. Delay network tank, yellow and blue dot rubber shock-mount placement.

c. Mounting (figs. 192 and 193). To mount the delay network tank in its case, proceed as follows:

(1) Replace the 2 tank mounting brackets and secure each with 10 roundhead machine screws and lockwashers.
(2) Replace the rubber shock mounts; note the position of the red, white, yellow, and blue dots.
(3) Lift the delay network tank and carefully place it in its case. Make sure that all rubber shock mountings are in place (fig. 191).
(4) Grasp each shock-mounting spring and stretch it until the end fits through its small access opening. Insert a shock-mount anchor strip. Repeat this procedure until all the shock-mounting springs are secured, except the four that fit into the top cover plate (fig. 191).
(5) Replace the top cover plate on the delay network tank and secure it with 13 roundhead machine screws and lockwashers. Secure the remaining four shock-mounting springs to the top cover plate with the shock-mount anchor strips.
(6) Secure each of the 14 shock-mount anchor strips with 2 roundhead screws and lockwashers.
(7) Replace the cables by securing the plugs at J2350 and J2351.
(8) Carefully lower the delay network into the signal comparator case and secure it with six mounting bolts (fig. 190).

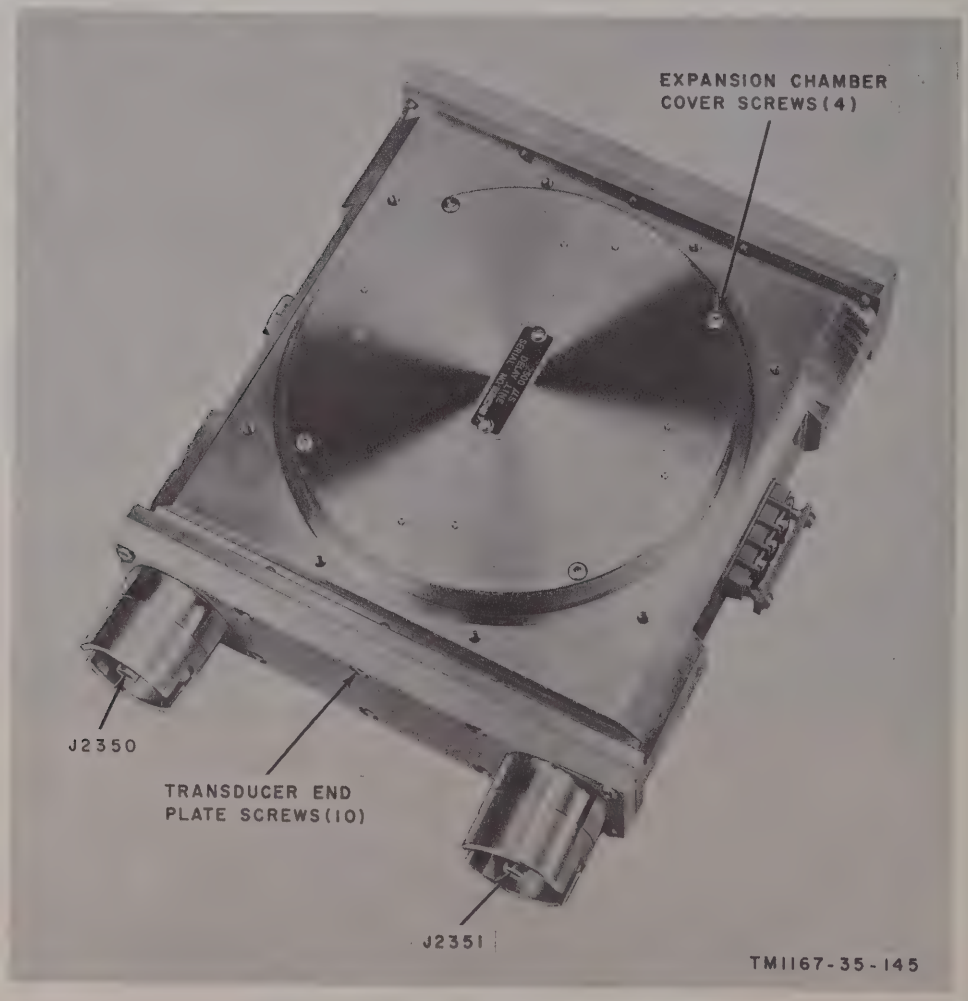


Figure 194. Delay network tank, top view.

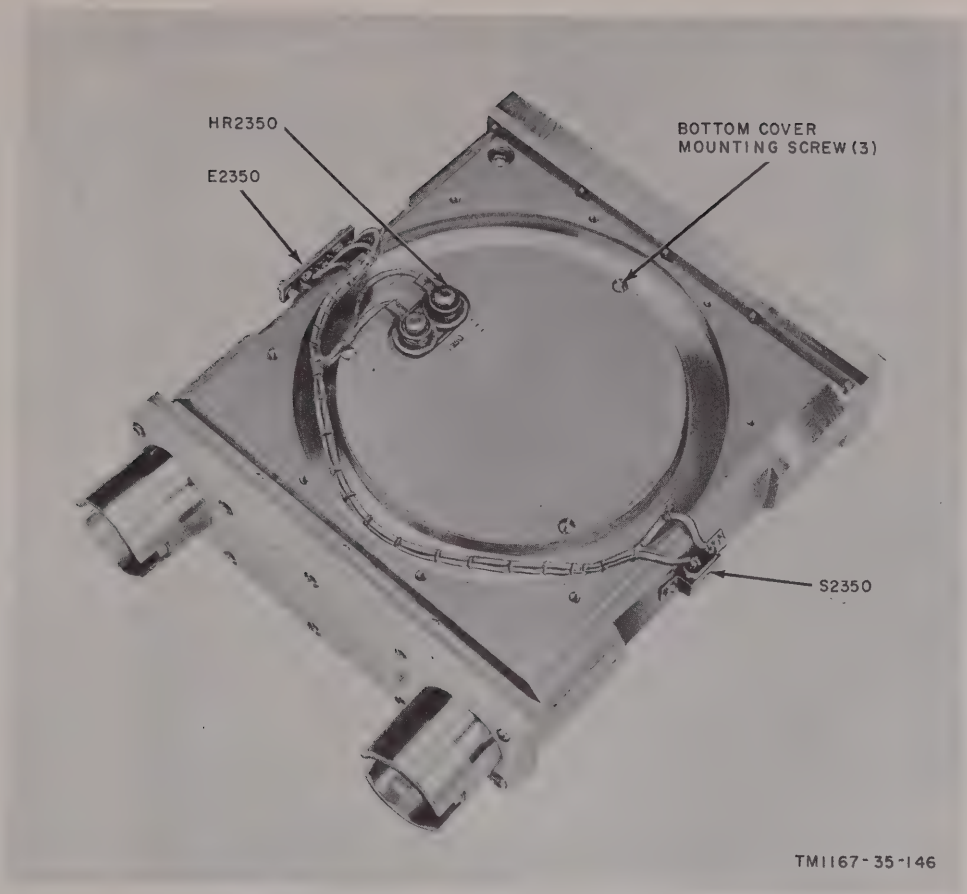


Figure 195. Delay network tank, bottom view.

Section II. DISASSEMBLY AND REASSEMBLY

460. Disassembly of Delay Network Tank

Note. If any of the screws used in assembly of the delay network tank cannot be loosened, apply a small quantity of carbon tetrachloride around the heads of those screws. If the tapped threads are damaged, the hole should be drilled and tapped for the next larger screw size.

a. Removing Bottom Cover and Heater (fig. 195). To remove the bottom cover and heater, proceed as follows:

(1) Remove the three bottom cover mounting screws, two screws from E2350, and two screws from S2350.
(2) Lift off the bottom cover, the insulator disk, and heater HR2350.
(3) Remove heater HR2350, terminal strip E2350, and thermostat S2350 as a single assembly complete with wiring.

b. Removing Expansion Chamber Cover. To remove the expansion chamber cover, proceed as follows:

(1) Remove the tank filler plug assembly (fig. 199).
(2) Pour the mercury from the delay network tank into two 600-ml beakers which have been cleaned with acetone and ether (par. 461*a*).

Caution: Keep the beakers containing the mercury covered.

(3) Remove the expansion chamber cover by first removing four expansion chamber cover screws (fig. 195).
(4) Carefully press the diaphragm several times so as to force as much mercury out of the chamber as possible (fig. 200).

c. Removing End Plates, Crystals, and Diaphragm (fig. 196). To remove end plates, crystals, and diaphragm, proceed as follows:

(1) Set the delay network tank upright on the protecting shields that surround the two jacks on the transducer or front end of the delay network tank (fig. 195).

(2) Remove the rear cover (12) by first removing 10 socket-head cap head screws (6) and 10 lockwashers (7) and shake free any mercury in the rear cover.

(3) Pour out any remaining mercury left in the tank housing (14).

(4) Set the delay network tank upright with the opened rear cover end resting on one or two sheets of Dextilose tissue paper.

Note. If a broken crystal is encountered while disassembling, carefully remove as many pieces as can be found.

(5) Remove the jack (34) and jack shield (31) from each transducer assembly (28) by removing four fillister-head machine screws (36), four lockwashers (35), two socket-head cap screws (33), and two lockwashers (32).

Caution: The transducer assembly containing the crystals is an extremely critical part of the delay network tank. Remove only if necessary.

(6) Carefully remove the two crystal backing plates so that the crystal beneath will not become damaged.

(7) Remove the two crystals (21) and O-rings (27) from the transducer assembly, and put the crystals in a place where they will not be lost or broken.

(8) Remove the front cover (26) of the tank by first removing 10 socket-head cap screws (6), 10 lockwashers (7), and shake free any mercury remaining on the front cover.

(9) Remove the large O-ring gaskets (24) and (13) set in the grooves at each end of the delay network tank.

(10) Remove eight socket-head cap screws (45) and eight lockwashers from the diaphragm retaining ring.

(11) Lift off the retainer ring (47), the diaphragm (44), and the gasket (43); shake off any mercury remaining on the diaphragm.

No.	*Parts and assemblies*	*Raytheon Part No.*
1	Socket-head cap screw (3)	207–1020P75
2	Lockwashers No. 8 (3)	236–1082P13
3	Bottom cover A 2350	
4	Insulator disk E2353	
5	Heater HR2350	
6	Socket-head cap screws (20)	207–1020P75
7	Lockwashers No. 10 (20)	236–1082P13
8	Filler plug O 2351	
9	Lockwasher	
10	Packing O 2350	
11	Centering pins (rear) (2)	
12	Rear cover A 2364	
13	Gasket (O-ring)	287–1037P4
14	Tank housing A 2366	
15	Roundhead machine screw (2)	
16	Washers (2)	
17	Plates (for E2350) (2)	
18	Terminal board E2350	
19	Identification plate N2352	
20	Screws (2)	
21	Crystals Y2350 and Y2351 (2)	
22	Washers (2)	
23	Fillister-head machine screw (2)	
24	Gasket (O-ring)	287–1037P4
25	Centering pins (front) (2)	
26	Front cover A 2362	
27	Packing (O-ring) O 2353 (2)	
28	Transducer assembly O 2362 (2)	
29	Lockwashers (4)	236–1082P9
30	Socket-head cap screws (4)	207–1020P14
31	Jack shields A 2361 (2)	
32	Lockwashers	236–1082P11
33	Socket-head cap screws	207–1020P38
34	Jacks J2350 and J2351 (2)	
35	Lockwashers (8)	236–1015P3
36	Fillister-head machine screws (8)	207–1009P38
37	Screws (2)	
38	Lockwashers (2)	
39	Identification plate N2353	
40	Lockwashers (2)	
41	Screws (2)	
42	Thermostat S2350	
43	Gasket O 2354	
44	Diaphragm O 2357	
45	Socket-head cap screws (8)	207–1020P13
46	Lockwashers (8)	236–1082P11
47	Retainer ring O 2355	
48	Expansion chamber cover A 2359	
49	Socket-head cap screws (4)	207–1020P39
50	Lockwashers (4)	236–1082P11

Figure 196. Delay line tank, exploded view.

→

461. Reassembly and Filling Tank of Delay Network

a. Cleaning Parts. Parts are cleaned with Dextilose tissue acetone, and ether. As parts are cleaned, wrap them in a piece of Dextilose tissue. Always cut the large sheets of tissue to obtain a small piece, because tearing the tissue may produce tissue fragments which will contaminate parts. For cleaning, use a piece of Dextilose tissue approximately 9 by 9 inches, folded twice into a pad 4½ by 4½ inches. Make each wiping stroke with an unused portion of the pad, folding and refolding the pad as required to obtain an unused surface. Do not wipe parts on areas of the tissue which have been touched by the fingers. Discard used tissue so that it will not be re-used. To wet the pads with acetone or ether, hold the pad over the opened mouth of the acetone or ether container (usually a bottle with a mouth less than ¾ in. in diameter) and invert the container twice. Briefly swing the pad in an arc to distribute the liquid throughout the pad. Before starting to clean the parts, wipe the fingers first with acetone and then with ether, followed by wiping with dry tissue. Clean each part as follows:

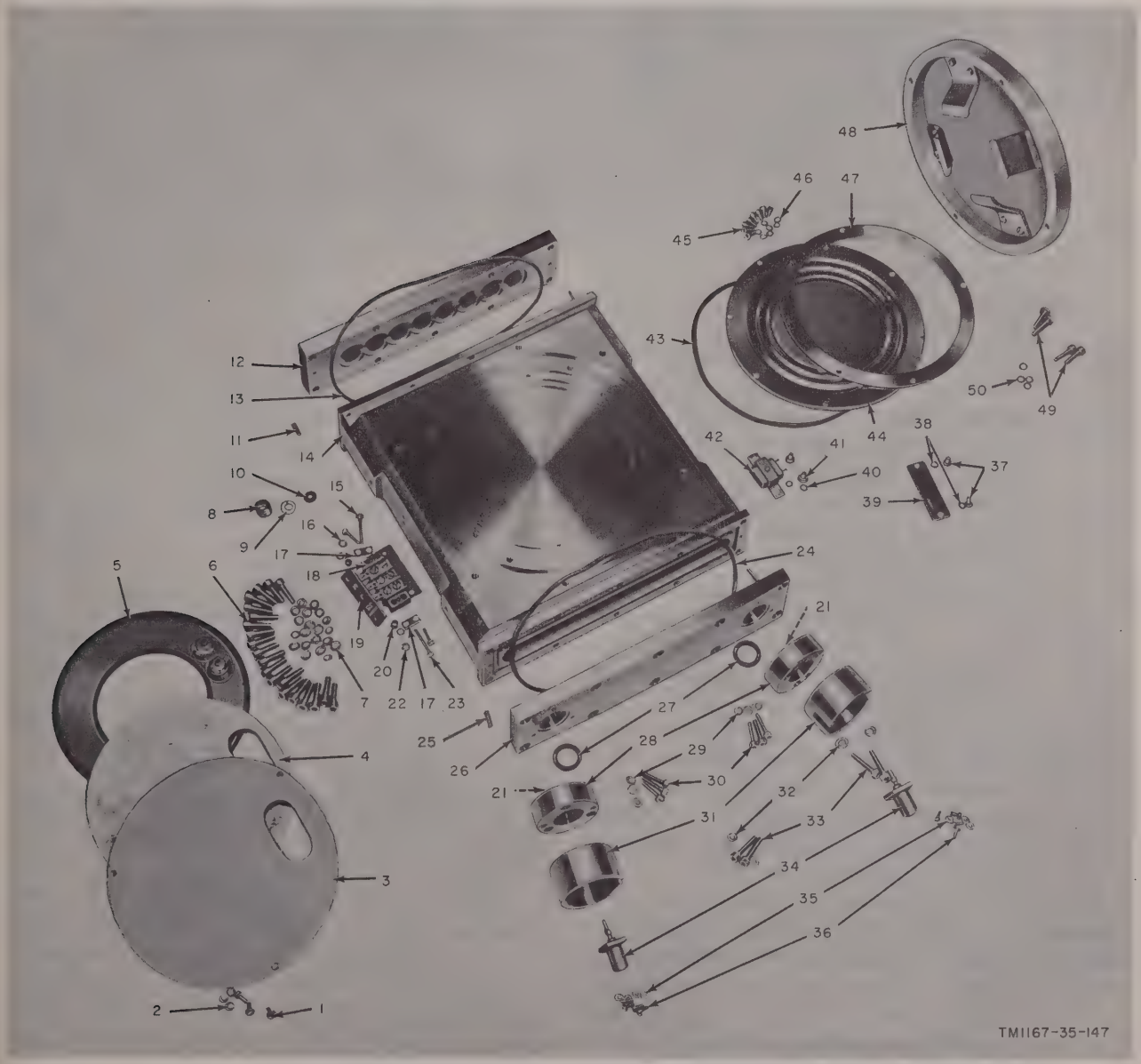


Figure 196—Continued.

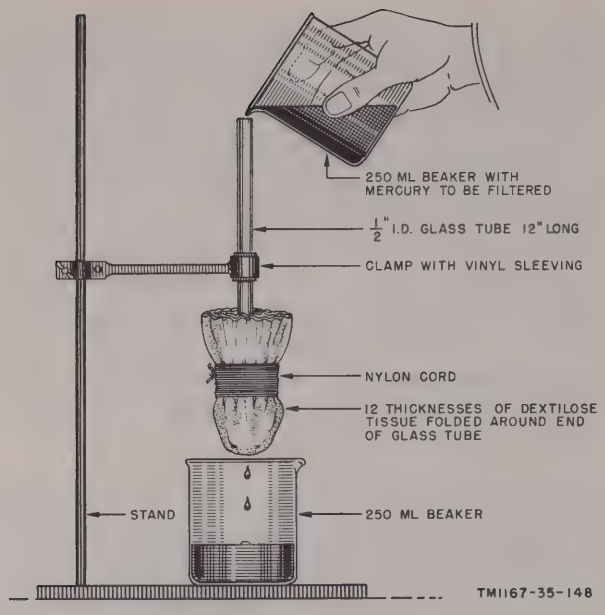


Figure 197. Setup for filtering mercury.

(1) Clean part with Dextilose pad wet with acetone.
(2) Clean part with Dextilose pad wet with ether.

Warning: Ether is extremely toxic, especially when inhaled. Keep the ether container closed at all times except when wetting the Dextilose pads. Avoid breathing the fumes as much as possible. Ether is extremely flammable and ether vapors are extremely explosive when mixed with air. Take all precautions possible against ignition. (No smoking, brushless fan motors, inclosed switches, etc.). Place used Dextilose pads in metal container in exhaust air stream.

(3) Wipe part dry with Dextilose tissue.
(4) Wrap part in Dextilose tissue.

Caution: The two crystals in the transducer assemblies are fragile. Be extremely careful when cleaning or handling these items.

b. Replacing Diaphragm, End Plates, and Crystals (fig. 196). To replace the diaphragm, end plates, and crystals proceed as follows:

(1) Replace the gasket (43) and the diaphragm (44).
(2) Replace the retainer ring (47) and fasten with eight socket-head cap screws (45) and eight lockwashers (46).
(3) Set the tank upright, resting the rear cover end of the tank housing (14) on a sheet of Dextilose tissue.
(4) Replace the large O-ring gasket (24) in the groove on the front cover end of the tank housing (14).

Note. The tank body and front and rear covers are made of stainless steel as are the socket-head cap screws (6). When reassembling apply a very thin coat of Dow Corning No. 4 lubricant to the threads of the stainless steel screws to prevent like metals from seizing.

(5) Replace the front cover (26) and secure with 10 lockwashers (7) and 10 socket-head cap screws (6).
(6) Replace the O-rings (27), the crystals (21), and the crystal backing plates. Place each transducer assembly (28) in place on the front cover and secure with three lockwashers (29), and three socket-head cap screws (30).
(7) Replace the jacks (32) and secure each with four lockwashers (35) and four fillister-head machine screws (36).
(8) Replace the jack shields (31) and secure each with two lockwashers (32) and two socket-head cap screws (33).
(9) Set the tank upright, resting the tank on the jack shields (31).
(10) Replace the large O-ring (13) in the groove on the rear cover end of the tank housing (14).
(11) Replace the rear cover (12) and secure with 10 lockwashers (7) and 10 socket-head cap screws (6). Tighten the screws evenly.

Note. The front and rear covers (12) and (26) are interchangeable end-for-end and may be installed either way.

c. Replacing Heater and Bottom Cover (fig. 195). To replace the heater and bottom cover, proceed as follows:

(1) Replace the heater HR2350, the terminal strip E2350, and thermostat S2350, insulator disk (4, fig. 196), and bottom cover (3, fig. 196) on the tank.
(2) Secure the bottom cover with three bottom cover mounting screws and lockwashers.

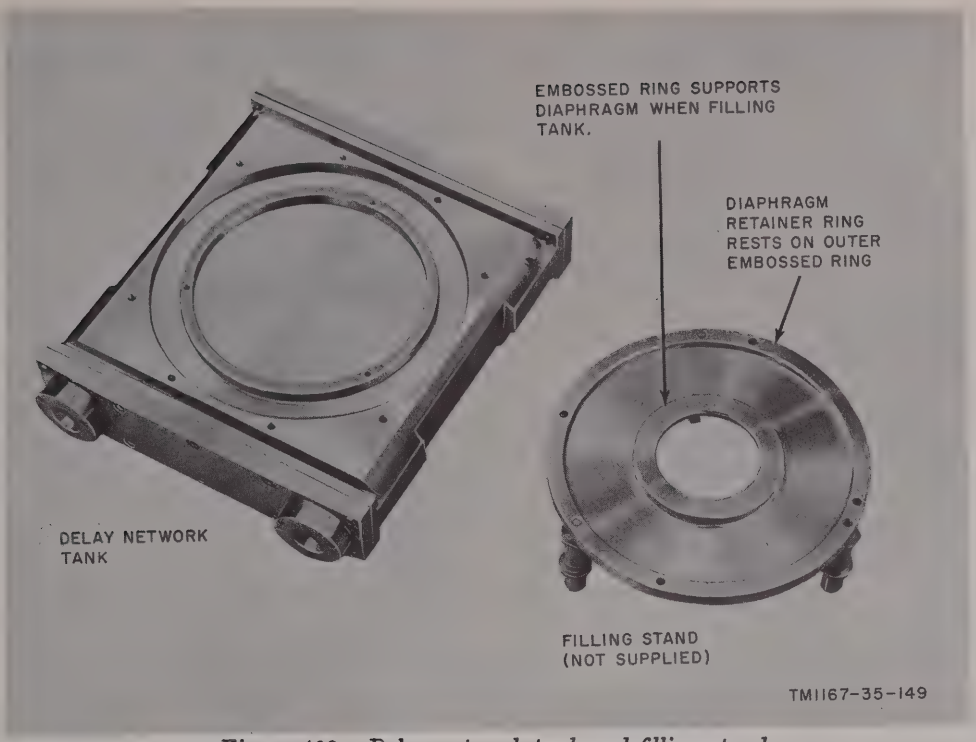


Figure 198. Delay network tank and filling stand.

(3) Secure thermostat S2350 with two screws and lockwashers and terminal strip E2350 with four screws and lockwashers.

d. Filtering Mercury (fig. 197). To filter mercury removed from a delay line, proceed as follows:

(1) Use an arrangement as shown in figure 197. Do not use glass tubing of larger dimensions than that shown. These dimensions keep the amount of mercury being filtered small enough to prevent tearing the tissue paper.

(2) Construct the filter as follows:

(*a*) Fold three thicknesses of 19- by 19-inch Dextilose tissues twice to form a square 9½ by 9½ inches.

(*b*) Lay one end of the ½-inch glass tube from one corner to the center of the square.

(*c*) Fold the tissue at right angles to the tube and over the end of the tube.

(*d*) Fold the far ends of the tissue around the tube in such a manner that open folds from which mercury might leak are as far up on the tube as possible.

(*e*) Wind nylon or linen cord around the folds to bind the tissue as tight as possible to the tube.

(3) Handle the mercury in small amounts in 250-ml beakers.

(4) Fill the ½-inch tube to about ¾ inches from the top of the tube, and allow most of this to filter before refilling.

(5) Change the beakers used for collecting the filtered mercury when they are about two-thirds full. Keep the beakers with the filtered mercury covered.

Note. When properly filtered, the surface of the mercury should appear absolutely clear. If any detectable scum or particles appear on the surface, refilter the mercury.

e. Filling Delay Network Tank with Mercury and Checking Operation (figs. 198 through 201). To fill the tank with mercury, proceed as follows:

(1) Set the tank on the filling stand, with the filler hole on top (fig. 199).

(2) Adjust the legs of the filling stand so that the tank is tipped about 30° with the filler hole on the highest corner.

(3) Pour about 2 pounds of mercury into a 250-ml beaker (about 1/3 full) and check the surface of the mercury for scum and foreign matter.

Note. Do not use the mercury if any foreign substance can be detected with the naked eye.

(4) Carefully pour the mercury in the filler hole (avoid spilling).

(5) Pick up the tank with the fingers supporting the diaphragm and the tank in its same relative horizontal position.

(6) Slowly press the diaphragm inward about 1/8 inch and slowly release the pressure to suck mercury into the expansion chamber beneath the diaphragm (fig. 200).

(7) Repeat this procedure until a gurgling sound, heard during the process, is no longer heard.

(8) Replace the tank on the stand in its original position and add 2 pounds more of mercury.

(9) Expel the trapped air as directed in (5) through (7) above.

(10) Repeat steps (4) through (7) until the tank is full. Nearly 30 pounds of mercury is required to fill the tank.

(11) With the tank supported by the filling stand, slowly rock the tank from side to side to expel any remaining air pockets.

(12) Set down the tank and stand, and if necessary, add mercury to bring the mercury level up in the filler hole so that no air will be trapped beneath

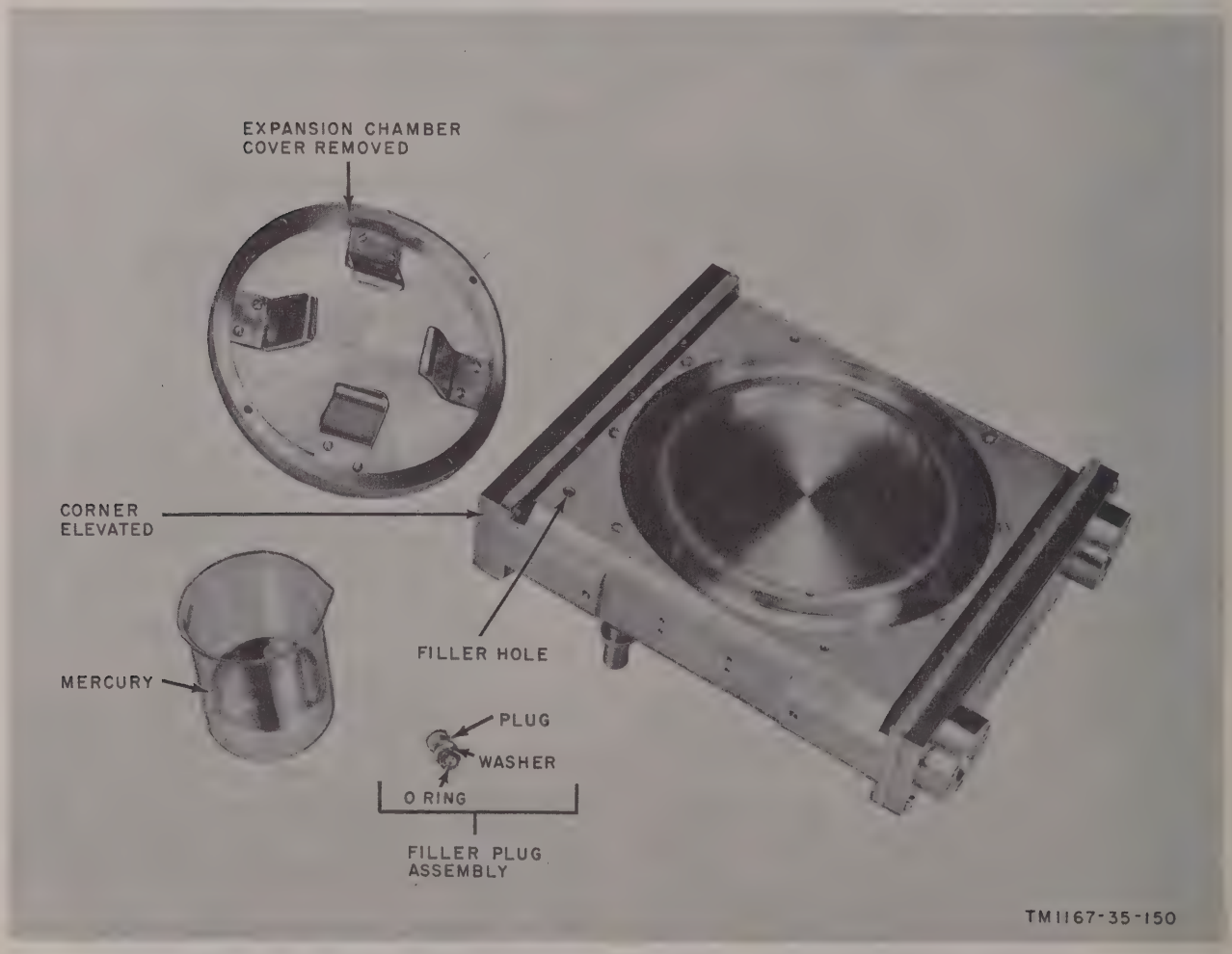


Figure 199. Delay network tank in position for filling, heater assembly removed.

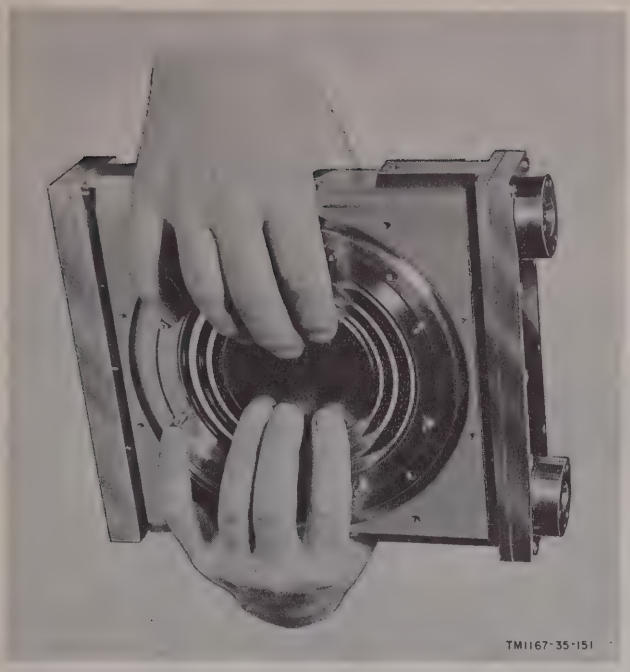


Figure 200. Expelling air from delay network tank.

the filler plug when the plug is inserted.

Note. Use an eye dropper with a curved end to force the last bit of mercury into the area around the filler hole where air may be trapped. Do not allow mercury to contact the rubber bulb of the eye dropper.

(13) Refer to figure 196. Replace the packing (10), lockwasher (9) and filler plug (8).

(14) Supporting the tank with the stand, turn the tank over on the filler plug side.

(15) Remove the stand, install the expansion chamber cover (48), and secure it in place with the four lockwashers (50) and four socket-head cap screws (49).

(16) Before mounting the tank in its case, allow the tank to stand 24 hours and then check as follows:

(*a*) Connect the test attenuator unit, Z2350, to P2350 and P2351 as shown in figure 201.

(*b*) Warm up the equipment for 15 minutes and adjust the signal comparator for red-line readings on test meter M2350 (signal comparator).

(*c*) Set the TEST SELECTOR switch (signal comparator) to the AMPL. BALANCE position and turn off the equipment.

(*d*) Disconnect Z2350, lay the tank on the floor of the signal comparator cabinet (diaphragm side up), and connect the tank to P2350 and P2351 (normal operating connections).

(*e*) Turn on the equipment; after a 5-minute warm up, check the test meter deflection on the signal comparator.

Note. If the deflection is one half the red-line deflection or greater, the delay network is restored to its original condition. If the deflection is below half of the red-line deflection, the network may or may not be usable, as determined by the next step.

(*f*) Adjust AMPL. BALANCE Control R2354 (signal comparator) for a red-line reading.

Note. The position of R2354 should not be more than three-fourths of its full clockwise position (assuming midposition for the test attenuator; see *b* above). If R2354 is close to full clockwise position, subsequent increase of attenuation of the delay network will require repair of the delay network again within a short time. A second attempt to repair the delay network as outlined above is recommended.

(*g*) As a final check, set the delay network upright, with the input and output jacks on top, and observe test meter M2350.

(*h*) If the deflection of the test meter drops not more than one-eight of the red-line deflection and remains constant when the line is rocked slightly, the delay network is satisfactory and can be reinstalled in its case as directed in paragraph 459*c*.

Note. If the test meter deflection drops more than one-eight of the red-line deflection, probably a small amount of air is trapped in the tank.

(*i*) To remove trapped air, hold the tank in the filling position and add more mercury with the eye dropper, rocking the tank as required to bring the air to the filler hole.

(*j*) Replace the filler plug.

(*k*) Recheck the network as given in (*a*) through (*h*) above.

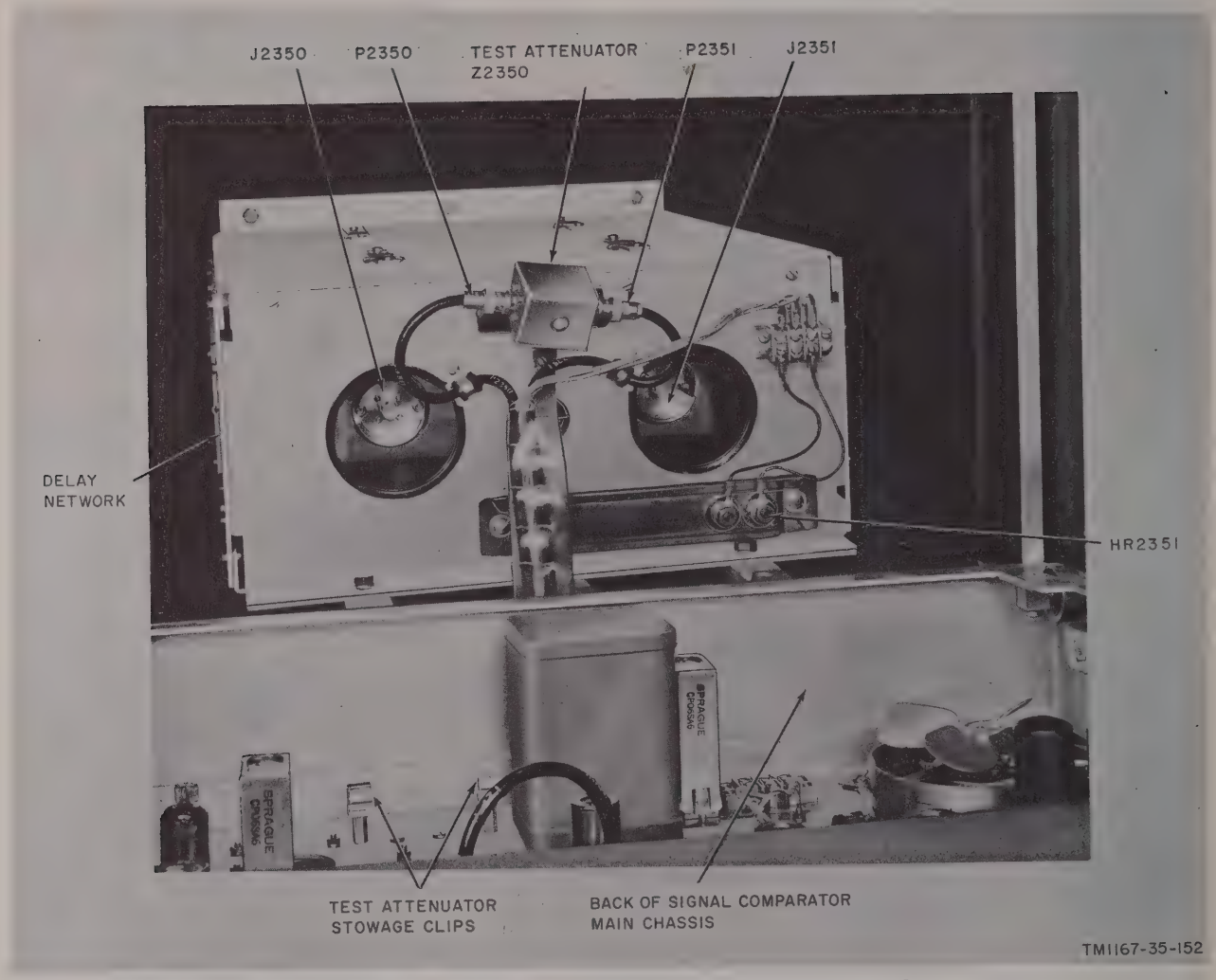


Figure 201. Test setup for testing repaired delay network.

CHAPTER 23
DISASSEMBLY AND REASSEMBLY OF PPI DEFLECTION ASSEMBLY

462. General

a. This chapter covers the removal and replacement of electrical and mechanical parts and assemblies of the ppi deflection system.

b. The following procedures are given in this chapter.

(1) Removal and replacement of focus coil L602.
(2) Removal and replacement of deflection coil L601.
(3) Removal and replacement of worm gear shaft assembly O 618.

463. Removal and Replacement of Focus Coil L602
(fig. 202)

a. Removal of Focus Coil L602.

(1) Remove ppi-scope V609 as instructed in TM 11–1167–20.
(2) Remove the tubes from the right side of the indicator chassis.
(3) Remove the four positioning screws (1) from the corners of the focus coil housing (A).
(4) Hold the focus coil housing (A) and remove the two screws (4) washers (2) and lockwashers (3) at the bottom of the focus coil housing (A).
(5) Move the focus coil housing (A) away from the deflection coil housing (D) and remove the end shield (C).
(6) Unsolder and tag the seven leads on the focus coil (B).
(7) Remove the focus coil.

b. Replacement of Focus Coil L602 (fig. 202).

(3) Replace the end shield (C).
(1) Insert the focus coil (B) into the focus coil housing (A) so that the numbers on the coil coincide with the numbers on the housing.
(2) Solder the seven leads to the focus coil assembly.

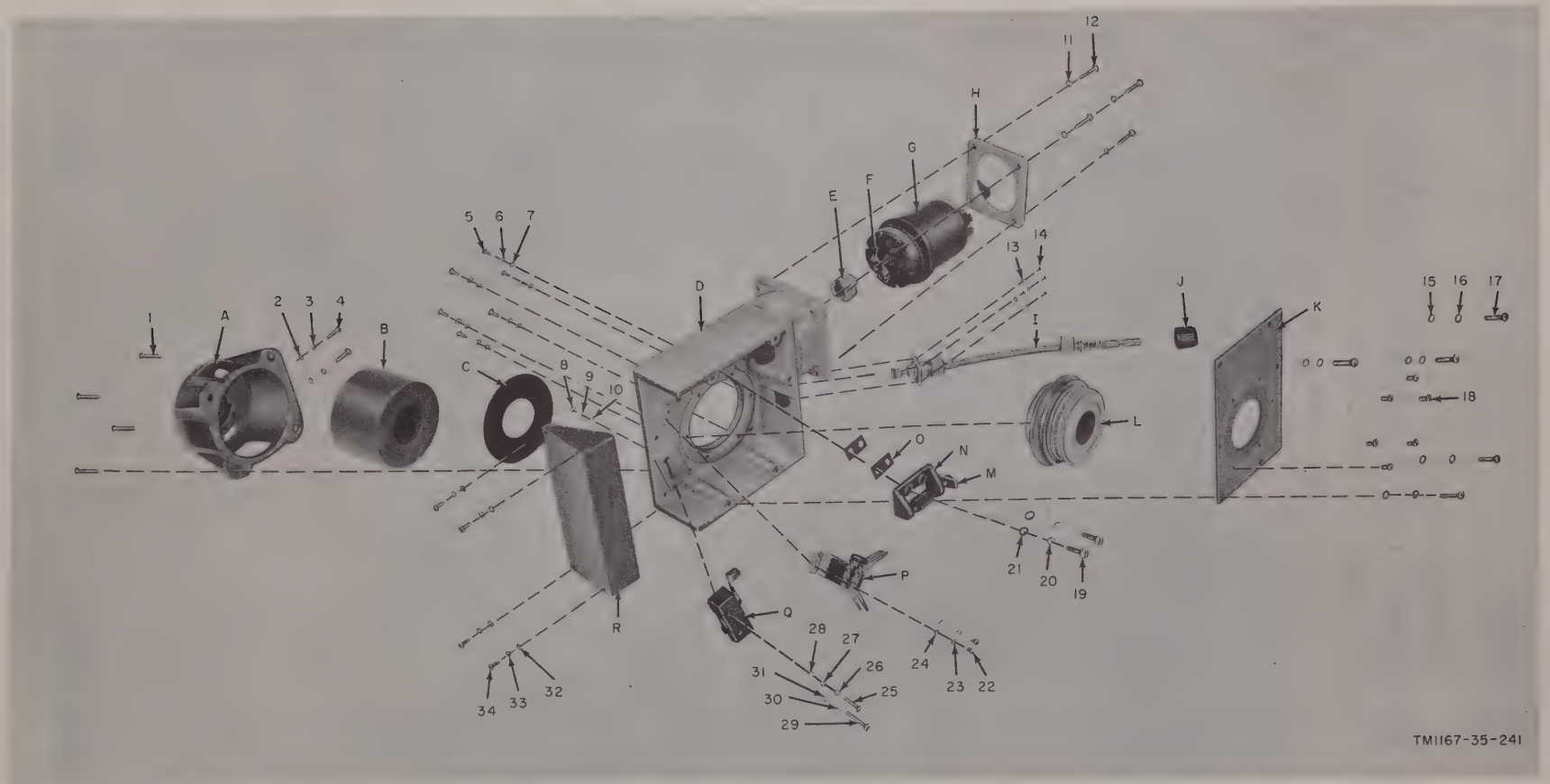
Note. A piece of tape can be used to hold the end shield to the deflection coil housing.

(4) Replace the focus coil housing (A) but do not tighten the four positioning screws (1).
(5) Replace the two screws (4) washers (2) and lockwashers (3) at the bottom of the focus coil housing (A). Do not tighten these screws.
(6) Replace the tubes at the right side of the indicator chassis.
(7) Replace ppi-scope V609 as instructed in TM 11–1167–20.
(8) Set the system POWER switch S602 to the ON position.
(9) Disable interlock S603 (fig. 158).
(10) Set the ppi CENTERING controls R662 and R665 (fig. 150) to the center of their rotation.
(11) Increase the ppi INTENSITY until the beam can be seen on the ppi scope.
(12) Adjust the four positioning screws (1) at the focus coil housing (A) until the beam is as close to the center of the scope as possible.
(13) Tighten the two screws (4) at the bottom of the focus coil housing.
(14) Adjust the PPI CENTERING controls to the center beam on the scope.

464. Removal and Replacement of Deflection Coil L601
(fig. 202)

a. Removal of Deflection Coil L601.

(1) Remove L602 and the ppi tube (par. 463*a*(1) through (5)).
(2) Remove the synchro receiver (G) by removing the four screws (12) from the motor mounting (H).
(3) Remove the cylindrical coupling (E).
(4) Remove the flexible cables from R662 and R665 (fig. 150).
(5) Remove the top cover (R) from the deflection coil housing (D).
(6) Unsolder, remove and tag the four leads which enter the deflection coil housing (D).



Parts and assemblies

A—Focus coil housing A 613.
B—Focus coil L602.
C—End shield O 618.
D—Deflection coil housing A 614.
E—Cylindrical coupling.
F—End coupling O 662.
G—Synchro receiver B 602.
H—Motor mounting A 601.
I—Flexible shaft assembly consisting of:
Shaft assembly O 613.
Shaft adapter O 616.
Bevel gear O 617.
J—Azimuth knob E608.
K—Side cover A 603.

Parts and assemblies

L—Deflection coil yoke assembly E605.
M—End coupling O 662.
N—Worm gear shaft assembly O 614. (Indicator subassembly O 614.)
O—Shims (when used).
P—Contact assembly consisting of:
Resistor R657.
Spring contact E618.
Contact assembly E617.
Q—Switch S612.
R—Top cover A 602.

Hardware:

1 Screws 8–32 by ⅞ (4).
2 Washers No. 12 (2).

Hardware:

3 Lockwashers No. 12 (2).
4 Screws 12–24 by ⅝ (2).
5 Screws 4–40 by ½ (6).
6 Lockwashers No. 4 (6).
7 Washers No. 4 (6).
8 Nut, hexagonal 4–40 by ¼.
9 Lockwasher No. 4.
10 Washer No. 4.
11 Lockwashers No. 12 (4).
12 Screws 12–24 by ¾ (4).
13 Lockwashers No. 4 (4).
14 Screws 4–40 by ⅜ (4).
15 Washers No. 12 (5).
16 Lockwashers No. 12 (5).
17 Screws 12–24 by 7/16 (5).
18 Screws 8–32 by ¼ (6).

Hardware:

19 Screws 12–24 by ¾ (2).
20 Lockwashers No. 12 (2).
21 Washers No. 12 (2).
22 Screws 4–40 by 5/16 (2).
23 Lockwashers No. 4 (2).
24 Washers No. 4 (2).
25 Screw 4–40 by 1.
26 Lockwasher No. 4.
27 Washer No. 4.
28 Washers A 669.
29 Screw 4–40 by 1¼.
30 Washer No. 4.
31 Lockwasher No. 4.
32 Washers No. 4 (4).
33 Lockwashers No. 4 (4).
34 Screws 4–40 by ⅜ (4).

Figure 202. Ppi deflection system, exploded view.

(7) Remove the three screws, washers, and nuts which hold the terminal board (fig. 150) to the top of the deflection coil housing (D).
(8) Remove the AZIMUTH knob (J).
(9) Hold the deflection coil housing (D) and remove the six screws (18) which hold the housing to the ppi shield.
(10) Rotate the deflection coil housing (D) slightly from its original position while pulling the flexible shaft assembly (I) from the front panel of the indicator and remove the deflection coil housing (D).
(11) Remove the side cover (K) from the deflection coil housing (D).
(12) Remove the spring contact assembly (P) from the deflection coil housing (D).
(13) Remove the six screws (7) from the side of the deflection coil housing (D) while holding the deflection coil yoke assembly (L).

Note. Refer to figure 203 during the following steps.

(14) Remove the six screws (18) and the 3⅛-inch retaining ring (17).
(15) Remove the phenolic shim (16).
(16) Remove the phenolic collector support ring (15).
(17) Unsolder the outer collector ring (14) from the deflection coil terminal and remove the ring.
(18) Remove the phenolic spacer ring (13).
(19) Unsolder the inner collector ring (12) from the deflection coil terminal and remove the ring.
(20) Remove the phenolic collector support ring (11).
(21) Remove the six screws (1) and retaining ring (2).
(22) Remove the ball bearing assembly (3).
(23) Remove the retaining ring (4).
(24) Remove the worm gear (5).
(25) Remove the spring washer (6).
(26) Remove the bevel gear (7).
(27) Remove the phenolic shim (8).
(28) Remove the key (10).

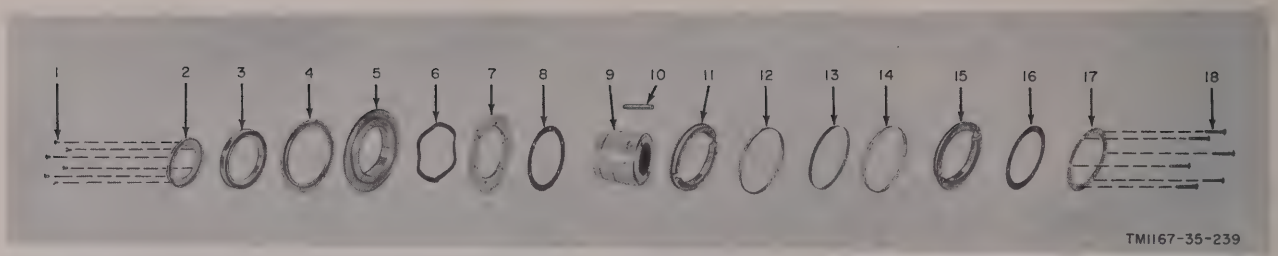
b. Replacement of Deflection Coil L601.

Note. Refer to figures 203 and 204 for the following steps.

(1) Replace the key (10).
(2) Replace the phenolic shim (8).
(3) Replace the bevel gear (7).
(4) Replace the spring washer (6).
(5) Replace the worm gear (5).
(6) Replace the retaining ring (4).
(7) Replace the ball bearing assembly (3).
(8) Replace the retaining ring (2).
(9) Replace the six screws (1).
(10) Replace the phenolic collector support ring (11).
(11) Replace the collector ring (12) and solder the inner deflection coil terminal.
(12) Replace the phenolic spacer ring (13).
(13) Replace the second collector ring (14) and solder to the outer deflection coil terminal.
(14) Replace the outer phenolic collector support ring (15).
(15) Replace the phenolic shim (16).
(16) Replace the 3⅛-inch retaining ring (17) with the six screws (18).

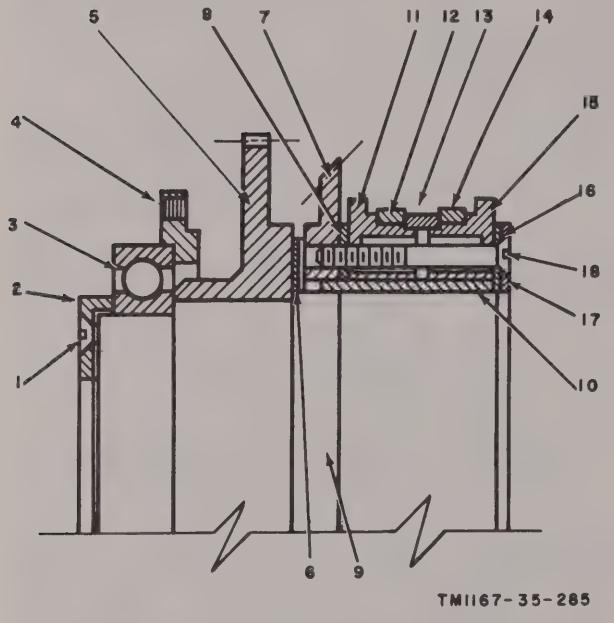
Note. Refer to figure 202 for the following steps.

(17) Attach the yoke assembly (L) to the deflection coil housing (D) by inserting six screws (5) washers (6) and lockwashers (7) through the side of the deflection coil housing (D) and the retaining ring (4, fig. 203).
(18) Replace the spring contact assembly (P) with the two screws (22) washers (24) and lockwashers (23).
(19) Replace the side cover of the deflection coil housing with the five screws (17) washers (15) and lockwashers (16).
(20) Hold the deflection coil housing at its normal position behind the ppi shield and insert the end of the flexible shaft (I) into the AZIMUTH control opening in the front panel.
(21) Replace the six screws (18) which hold the deflection coil housing (D) to the ppi shield.
(22) Replace the AZIMUTH knob (J) and tighten the set screw.
(23) Replace the terminal board (fig. 150) to the top of the deflection coil housing with the three 8–32 by ¾-inch screws, 5/16-inch hexagonal nuts, washers, and lockwashers.
(24) Resolder and replace the four leads to the spring contact assembly (P) and switch (Q).



1 Screws 4–40 by 3/16 (6).
2 Retaining ring O 608.
3 Ball bearing assembly O 607.
4 Retaining ring O 609.
5 Worm gear O 610.
6 Spring washer H602.
7 Bevel gear O 611.
8 Phenolic shim O 612.
9 Deflection coil L601.
10 Key O 663.
11 Phenolic collector support ring.*
12 Collector ring.*
13 Phenolic spacer ring.*
14 Collector ring.*
15 Phenolic collector support ring.*
16 Phenolic shim O 612.
17 Retaining ring O 666.
18 Screws 4–40 by 1 (6).
*Part of collector ring assembly E604.

Figure 203. Deflection coil yoke assembly, exploded view.



1 Screws 4–40 by 3/16 (6).
2 Retaining ring O 608.
3 Ball bearing assembly O 607.
4 Retaining ring O 609.
5 Worm gear O 610.
6 Spring washer H602.
7 Bevel gear O 611.
8 Phenolic shim O 612.
9 Deflection coil L601.
10 Key O 663.
11 Phenolic collector support ring.
12 Collector ring.
13 Phenolic spacer ring.
14 Collector ring.
15 Phenolic collector support ring.
16 Phenolic shim O 612.
17 Retaining ring O 666.
18 Screws 4–40 by 1 (6).

Figure 204. Deflection coil yoke assembly, cross sectional view.

(25) Set the cylindrical coupling (E) on the coupling plate (F) of the synchro receiver (G), insert the assembly into the deflection coil housing (D), and engage the cylindrical coupling with the coupling plate (M) on the worm gear shaft assembly (N).

(26) Replace the top cover (R) to the deflection coil housing (D) with the four screws (34) washers (32) and lockwashers (33).

(27) Attach the flexible cables to R662 and R665 (fig. 150).

(28) Replace the four screws (12) and lockwashers (11) and the motor mounting (H).

(29) Replace the focus coil (par. 463*b*).

465. Removal and Replacement of Worm Gear Shaft Assembly O 614
(fig. 202)

a. Removal of Worm Gear Assembly O 614.

(1) Follow the procedure given in paragraph 464*a*(1) through (11).

(2) Remove the two screws (19) washers (21) and lockwashers (20) holding the worm gear shaft assembly (N) and shims (O).

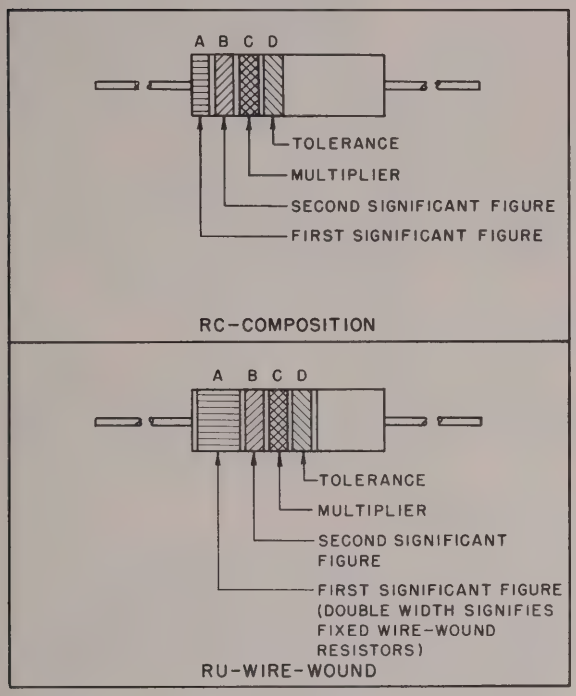
b. Replacement of Worm Gear Shaft Assembly.

(1) Replace the worm gear shaft assembly (N) and shims (O), if used, with the two screws (19) washers (21) and lockwashers (20).

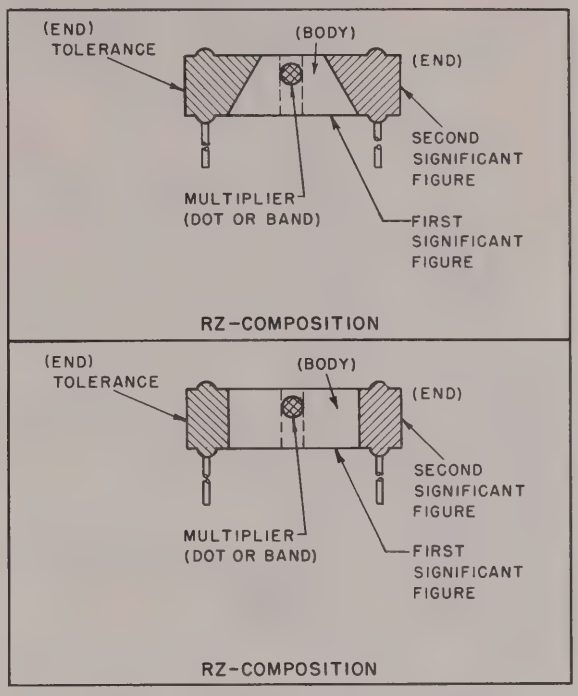
(2) Follow the procedure given in paragraph 464*b*(19) through (29).

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)

AXIAL-LEAD RESISTORS (INSULATED)



RADIAL-LEAD RESISTORS (UNINSULATED)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

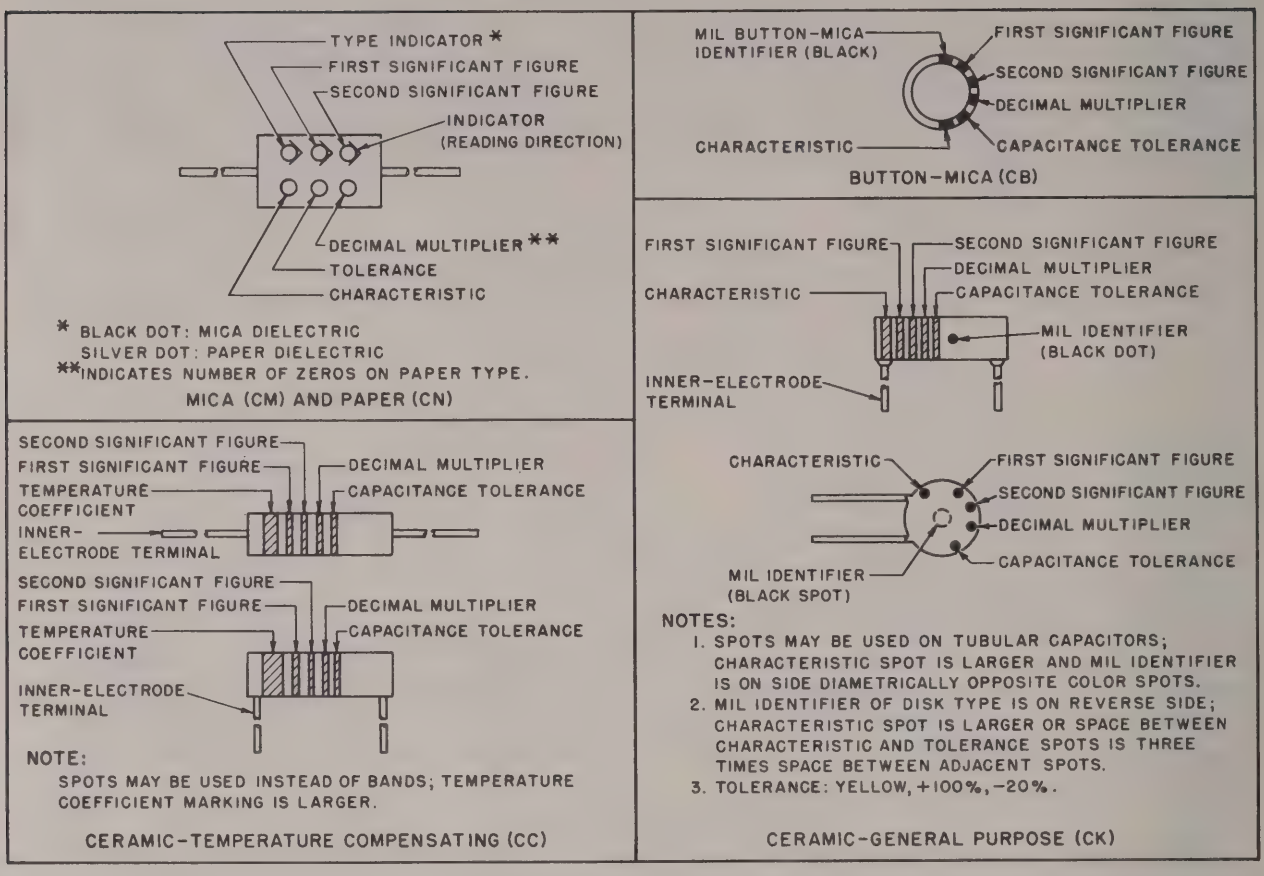
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-R1

Figure 205. Resistor color code markings.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



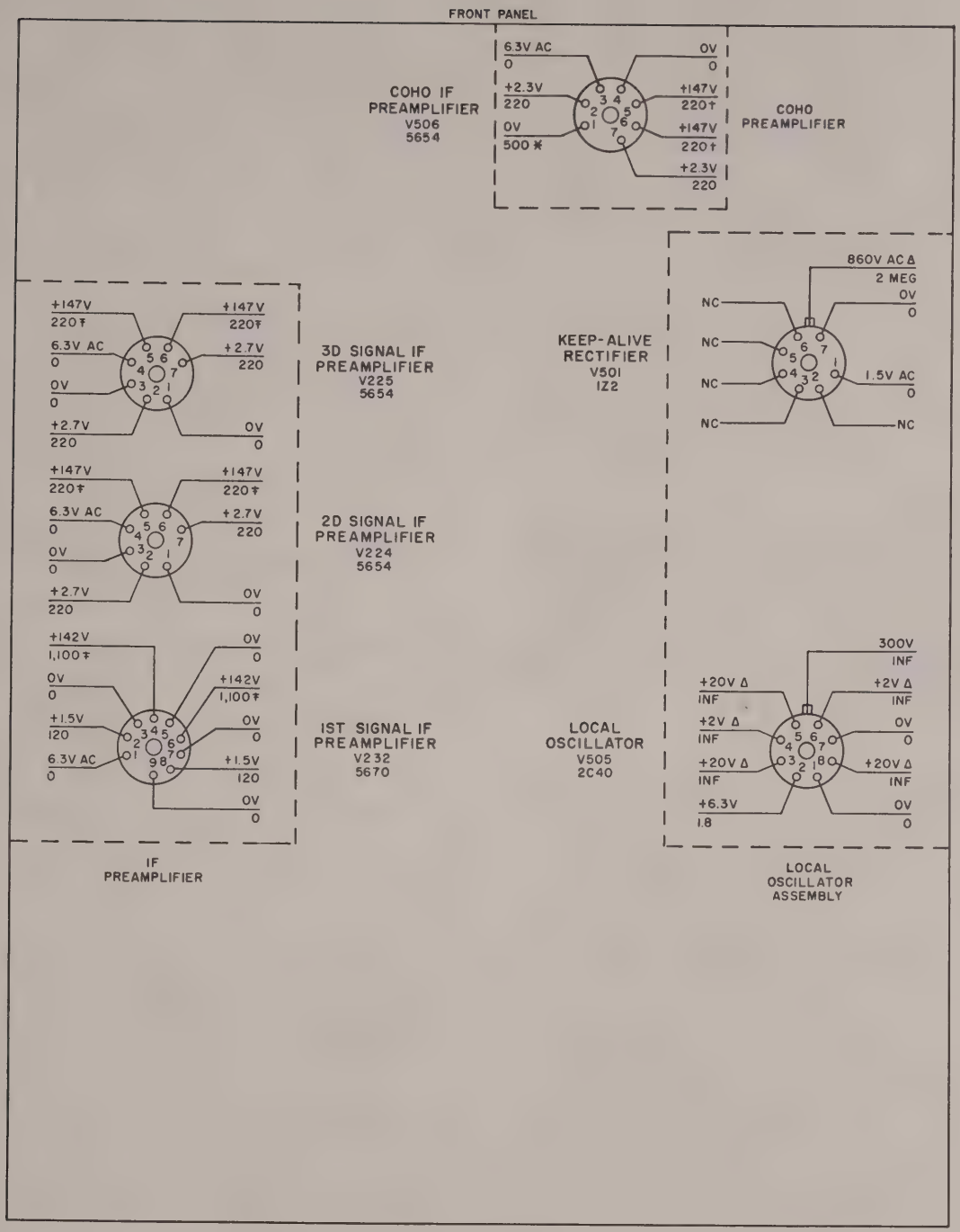
CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE [2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500) [3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

Figure 206. Capacitor color code markings.



NOTES:

1. VOLTAGE AND RESISTANCE MEASUREMENTS TAKEN TO GROUND WITH MULTIMETER TS-352B/U (20,000 OHMS-PER-VOLT) UNLESS OTHERWISE INDICATED.
2. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.
3. METER SCALE (VOLTAGE): HIGHEST SCALE THAT GIVES NEAREST TO ONE-THIRD DEFLECTION.
4. METER SCALE (RESISTANCE): SCALE THAT GIVES NEAREST TO ONE-HALF DEFLECTION.
5. RESISTANCE MEASUREMENTS TAKEN WITH TEST SELECTOR SWITCH IN OFF POSITION AND ALL FRONT PANEL CABLES DISCONNECTED.
6. RESISTANCE MEASUREMENTS OF V232, V224, AND V225 TAKEN WITH PLUG P228 DISCONNECTED.
7. † INDICATES MEASURED TO PIN b OF J508.
8. ‡ INDICATES MEASURED TO PIN E OF J228.
9. * SHOULD BE 500 Ω OR LESS. IF HIGH READING OBTAINED REVERSE METER LEAD.
10. Δ THIS VOLTAGE IS APPROXIMATE AND VARIES WITH CONDUCTION OF V505, THEREFORE IT WILL VARY WITH THE FREQUENCY OF OSCILLATION.
11. Δ MEASURED FROM CAP V501 TO PIN 3 OF T501.

TM1167-35-194

Figure 211. Radar Receiver-Transmitter RT-212/TPS-1D, voltage and resistance measurements at tube sockets.

Figure 207. Radio Set AN/TPS–1D, external cabling diagram.
(Contained in separate envelope)

Figure 208. Radar Modulator MD–144/TPS–1D, troubleshooting waveforms.
(Contained in separate envelope)

Figure 209. Radar Modulator MD–144/TPS–1D, voltage and resistance measurements at tube sockets.
(Contained in separate envelope)

Figure 210. Radar Modulator MD–144/TPS–1D, complete schematic diagram.
(Contained in separate envelope)

Figure 212. Radar Receiver-Transmitter RT–212/TPS–1D, complete schematic diagram.
(Contained in separate envelope)

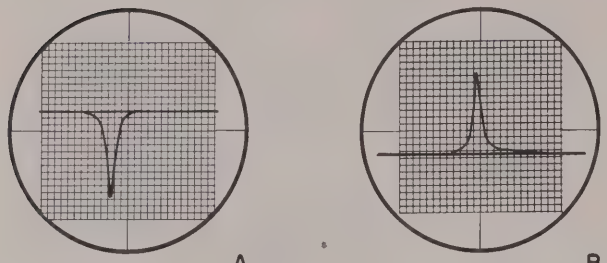


Figure 213. Receiving system bandpass waveforms.

Figure 214. Signal Comparator CM–36/TPS–1D, troubleshooting waveforms.
(Contained in separate envelope)

Figure 217. Signal Comparator CM–36/TPS–1D, main chassis, voltage and resistance measurements at tube sockets.
(Contained in separate envelope)

Figure 218. Signal Comparator CM–36/TPS–1D, delay amplifier Z1300 and nondelay amplifier Z2300, voltage and resistance measurements at tube sockets.
(Contained in separate envelope)

Figure 219. Signal Comparator CM–36/TPS–1D, complete schematic diagram.
(Contained in separate envelope)

Figure 219—Continued.
(Contained in separate envelope)

Figure 220. Metering and mode switching circuits in receiving and signal comparing system, composite schematic diagram.
(Contained in separate envelope)

Figure 221. Indicator IP–141/TPS–1D, A-sweep and fixed range marker circuits, troubleshooting waveforms.
(Contained in separate envelope)

Figure 222. Indicator IP–141/TPS–1D, Ppi-sweep and range strobe circuits, troubleshooting waveforms.
(Contained in separate envelope)

Figure 223. Indicator IP–141/TPS–1D, voltage and resistance measurements at tube sockets.
(Contained in separate envelope)

Figure 224. Indicator IP–141/TPS–1D, complete schematic diagram.
(Contained in separate envelope)

Figure 226. Antenna Base AB–221/TPS–1D, complete schematic diagram.
(Contained in separate envelope)

Figure 227. Antenna positioning system, composite schematic diagram.
(Contained in separate envelope)

Figure 228. Synchro components, composite schematic diagram.
(Contained in separate envelope)

Figure 229. Ac power distribution, composite schematic diagram.
(Contained in separate envelope)

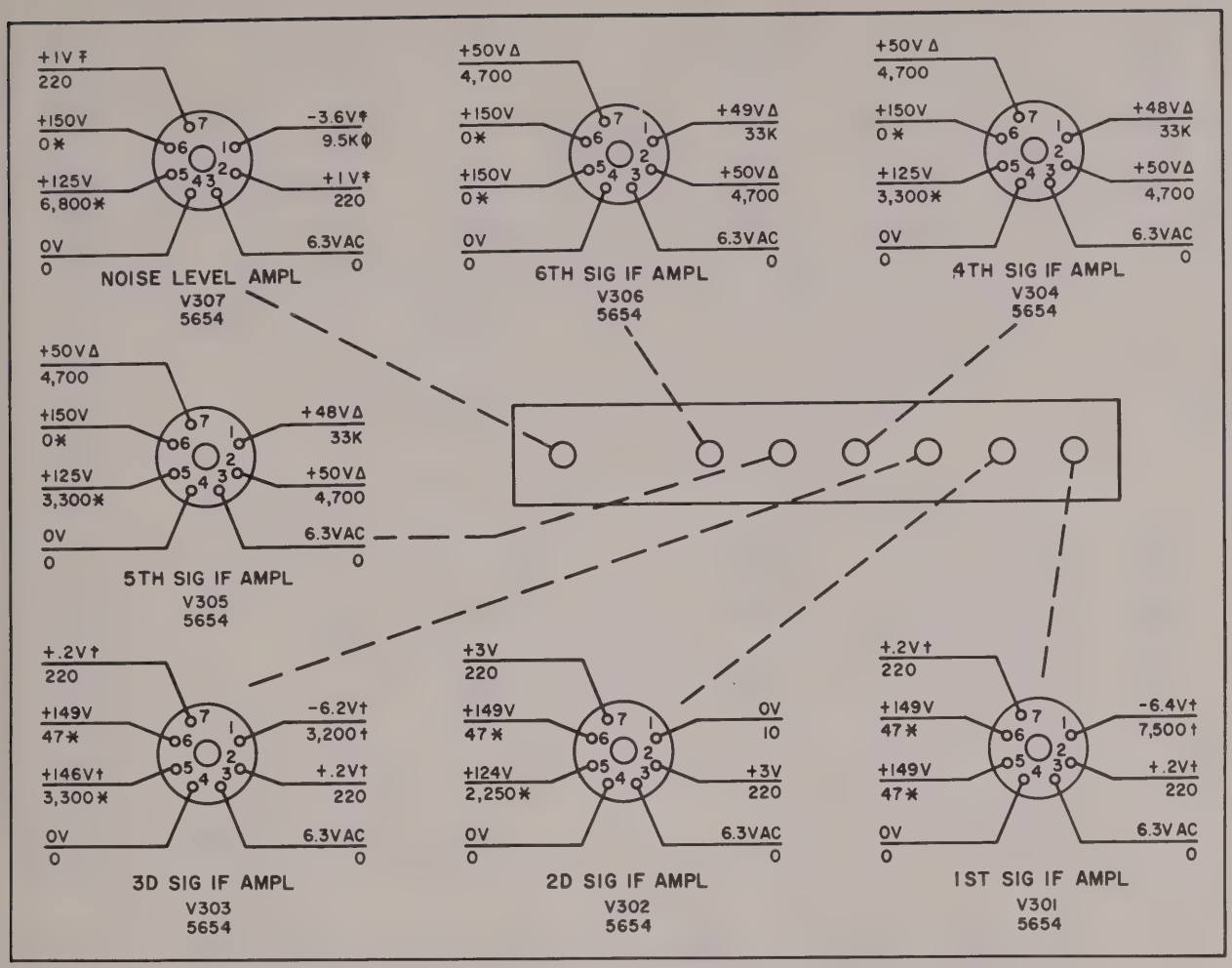
Figure 229—Continued.
(Contained in separate envelope)

Figure 231. Distribution of +27 volts dc power, composite schematic diagram.
(Contained in separate envelope)

Figure 232. Power Supply PP–674/TPS–1D, voltage and resistance measurements at tube sockets.
(Contained in separate envelope)

Figure 233. Power Supply PP–674/TPS–1D, complete schematic diagram.
(Contained in separate envelope)

Figure 233—Continued.
(Contained in separate envelope)



NOTES:

1. VOLTAGE AND RESISTANCE MEASUREMENTS TAKEN TO GROUND WITH MULTIMETER TS 352B/U (20,000 OHMS-PER-VOLT) UNLESS OTHERWISE INDICATED.
2. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.
3. METER SCALE (VOLTAGE): HIGHEST SCALE THAT GIVES NEAREST TO ONE-THIRD DEFLECTION.
4. METER SCALE (RESISTANCE): SCALE THAT GIVES NEAREST TO ONE-HALF DEFLECTION.
5. RESISTANCE MEASUREMENTS TAKEN WITH ALL FRONT PANEL CABLES DISCONNECTED.
6. ALL MEASUREMENTS TAKEN WITH THE CONTROLS SET AS FOLLOWS:

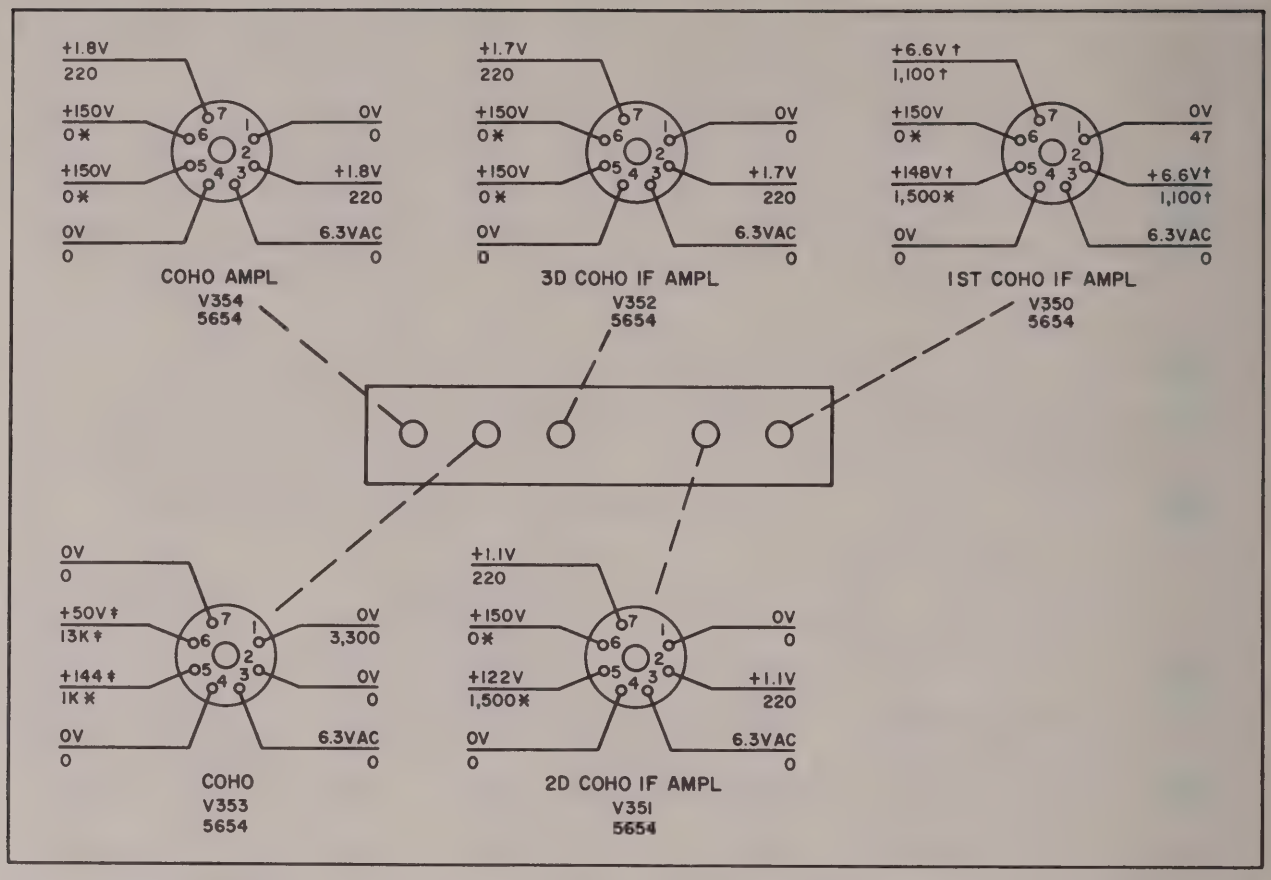
OPERATION SELECTOR	COHO ADJUST
RADIATE	OFF
TEST SELECTOR	OFF

ALL OTHER FRONT PANEL AND CHASSIS CONTROLS IN NORMAL OPERATING POSITIONS.

7. * MEASURED TO PIN 8 OF V3307 OR TERMINAL C OF Z301.
8. † VARIES WITH SETTING OF I.F. AMPL. LEVEL R2350.
9. Δ MEASURED WITH TS-505/U (VTVM).
10. ‡ VARIES WITH SETTING OF COHO LEVEL R2351 AND I.F. AMPL. LEVEL R2350.
11. Φ IF INCORRECT READING IS OBTAINED, REVERSE METER LEADS.

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Figure 215. Signal Comparator CM-36/TPS-1D, 60 mc IF amplifier Z301, voltage and resistance measurements at tube sockets.



NOTES:

1. VOLTAGE AND RESISTANCE MEASUREMENTS TAKEN TO GROUND WITH MULTIMETER TS 352B/U (20,000 OHMS-PER-VOLT) UNLESS OTHERWISE INDICATED.
2. VOLTAGE READINGS ABOVE LINE, RESISTANCE READINGS BELOW LINE.
3. METER SCALE (VOLTAGE): HIGHEST SCALE THAT GIVES NEAREST TO ONE-THIRD DEFLECTION.
4. METER SCALE (RESISTANCE): SCALE THAT GIVES NEAREST TO ONE-HALF DEFLECTION.
5. RESISTANCE MEASUREMENTS TAKEN WITH ALL FRONT PANEL CABLES DISCONNECTED.
6. ALL MEASUREMENTS TAKEN WITH THE CONTROLS SET AS FOLLOWS:

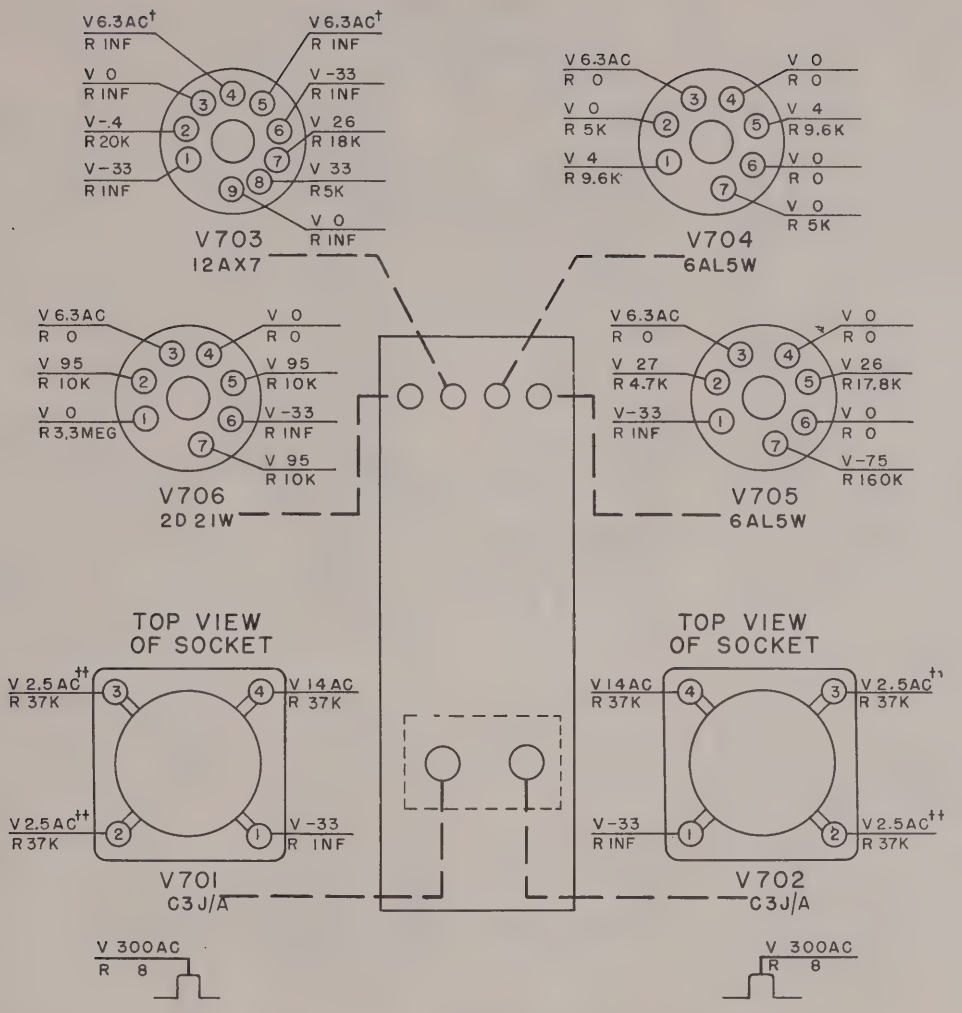
OPERATION SELECTOR	COHO ADJUST
RADIATE	OFF
TEST SELECTOR	OFF

ALL OTHER FRONT PANEL AND CHASSIS CONTROLS IN NORMAL OPERATING POSITIONS.

7. * MEASURED TO PIN 8 OF V3307 OR TERMINAL C OF Z350.
8. † VARIES WITH SETTING OF COHO SYNC R2355.
9. † VARIES WITH SETTING OF COHO LEVEL R2351.

TM1167-35-195

Figure 216. Signal Comparator CM-36/TPS-1D, coherent oscillator Z350, voltage and resistance measurements at tube sockets.



NOTES:

1. ALL MEASUREMENTS TAKEN FROM DESIGNATED PIN TO GROUND UNLESS OTHERWISE STATED USING A 20,000 OHM-PER-VOLT METER. ALL VOLTAGES ARE D-C UNLESS OTHERWISE STATED. ANTENNA NOT ROTATING. ALL CONTROLS ARE SET AT NORMAL ADJUSTED POSITIONS.

2. ALL RESISTANCE READINGS ARE IN OHMS AND TAKEN WITH THE UNIT REMOVED FROM THE EQUIPMENT. MEASUREMENTS FOR V701 AND V702 ARE TAKEN FROM TOP SIDE OF TUBE SOCKET.

3. †6.3VAC MAY BE MEASURED BETWEEN PINS 4 AND 9 AND ALSO PINS 5 & 9.

   †† 2.5VAC MEASURED BETWEEN PINS 2 AND 3.

TM1167-35-181

Figure 225. Antenna Base AB-221/TPS-1D, voltage and resistance measurements at tube sockets.

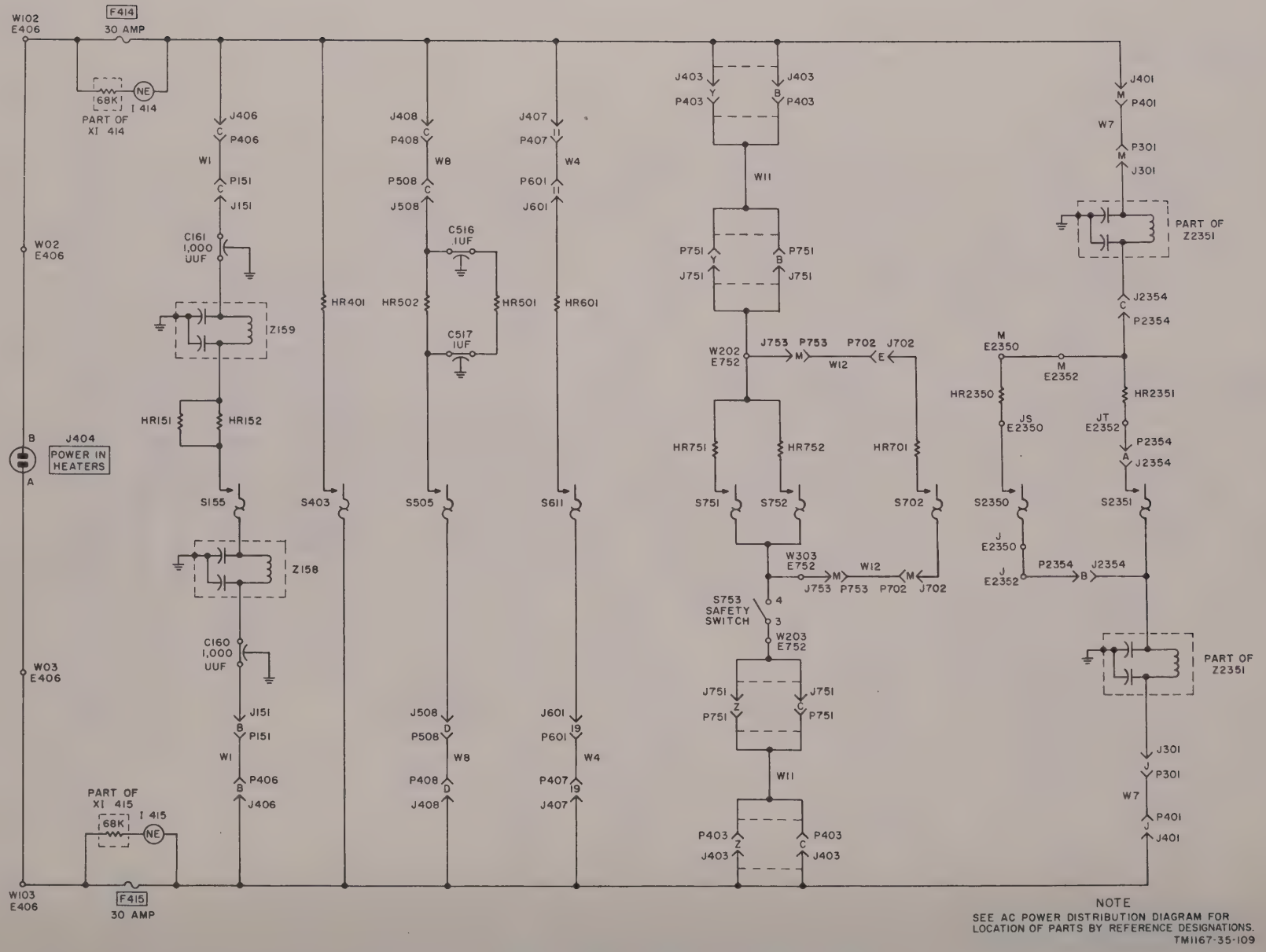


Figure 230. Heater circuits, complete schematic diagram.

APPENDIX

REFERENCES

Following is a list of references applicable and available to the field and depot maintenance repairman of Radio Set AN/TPS–1D.

SIG 6–TE–113	Tool Equipment TE–113
SIG 6–TE–114	Tool Equipment TE–114
TB SIG 225	Radioactive Electron Tube Handling
TM 11–919	Gasoline Engine Generator Set, PU–107/U
TM 11–978	Motor Generators PU–20/C, PU–20A/C, and PU–20B/C.
TM 11–1080A	Test Set AN/GPM–1
TM 11–1093	Dummy Antenna TS–235/UP
TM 11–1167–10	Radio Set AN/TPS–1D Operator's Manual
TM 11–1167–20	Radio Set AN/TPS–1D Organizational Maintenance
TM 11–1177	Pulse Generator Set AN/UPM–15
TM 11–1228	Range Calibrator TS–573/U
TM 11–1242	Crystal Rectifier Test Set TS–268/U, TS–268A/U, TS–268B/U, TS–268C/U, TS–268D/U and TS–268E/U.
TM 11–1250	Test Set AN/MPM–23
TM 11–1262	Test Set TS–172A/UP
TM 11–1263	Dummy Load TS–234/UP
TM 11–2559A	Fluxmeter TS–15C/AP
TM 11–2695	Signal Generator TS–452C/U
TM 11–5030A	Signal Generator TS–497B/URR
TM 11–5083	Electron Tube Test Set TV–7B/U
TM 11–5103A	Oscilloscope AN/USM–24C
TM 11–5109	Coaxial Slotted Line IM–92/U
TM 11–5112	Azimuth and Range Indicator IP–345/TPS–1D
TM 11–5128	Summation Bridge AN/URM–23; Operating, Service and Overhaul Instructions
TM 11–5129	Oscilloscope AN/USM–50
TM 11–5511A	Electronic Multimeters TS–505A/U, TS–505B/U and TS–505C/U
TM 11–5527	Multimeter TS–352/U, TS–352A/U and TS–352B/U
TM 11–5553	Signal Generator TS–419/U, Maintenance Instructions

GLOSSARY

Section I. ABBREVIATIONS

The following abbreviations supplement those given in Section I of the glossaries of TM 11–1167–10 and TM 11–1167–20:

cemf	counter electromotive force
scv	subclutter visibility
sync	synchronizing
vswr	voltage standing wave ratio

Section II. DEFINITIONS

The following definitions supplement those given in Section II of the glossaries of TM 11–1167–10 and TM 11–1167–20:

Blind speed—The radial velocity of an aircraft that produces minimum response from the pulse-to-pulse method of mti because the target moves exactly ½ wave length between transmitted pulses.

Clutter residue—Returns from stationary targets displayed on the indicators of a radar set due to the inability of the mti circuits to completely cancel the returns from stationary targets.

Radial velocity—The velocity at which an aircraft moves with respect to a fixed point, such as the antenna of a radar set.

Subclutter visibility—The detection of small moving targets flying over larger stationary targets. A quantitative measurement in units of decibels. An equipment with a scv rating of 26 db can detect a moving target flying over a stationary target which produces 20 times more input to the antenna of the radar set.

Trigger loop—A term applied to a group of timing stages in the signal comparing system of the AN/TPS–1D. The trigger loop is a signal path that is used to accurately establish the time between transmitted pulses of the equipment.

Voltage standing wave ratio—The ratio of maximum voltage to minimum voltage measured on a transmission line and expressed as a ratio of the maximum voltage to the minimum voltage.

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[AG 413.44 (31 Mar 58)]

BY ORDER OF *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR,
General, United States Army,
Chief of Staff.

OFFICIAL:
HERBERT M. JONES,
Major General, United States Army,
The Adjutant General.

Distribution:

Active Army:

ASA (2)
CNGB (1)
Technical Stf, DA (1) except CSigO (30)
Technical Stf Bd (1)
USA Arty Bd (1)
USA Armor Bd (1)
USA Inf Bd (1)
USA Air Def Bd (1)
USA Abn & Elct Bd (1)
USA Avn Bd (1)
USA Armor Bd Test Sec (1)
USA Air Def Bd Test Sec (1)
USA Arctic Test Bd (1)
USCONARC (5)
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OS Maj Comd (5)
Log Comd (5)
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Armies (5)
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Div (2)
USATC (2)
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Gen Depots (2) except Atlanta Gen Depot (None)
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Sig Depots (17)
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Port of Emb (OS) (2)
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Yuma Test Sta (2)
USA Elct PG (1)
Sig Fld Maint Shops (3)
Sig Lab (5)
Mil Dist (1)
US Army Corps (Res) (1)
Sectors, US Army Corps (Res) (1)
JBUSMC (2)
Units org under fol TOE:
11–7
11–16
11–57
11–127
11–128
11–500 (AA–AE)
11–557
11–587
11–592
11–597

NG: State AG (6); units—same as Active Army except allowance is one copy to each unit.

USAR: None.

For explanation of abbreviations used, see AR 320–50.